Upper Santa Ana River Integrated Model Summary Report

Part 5 of 5: Appendices

DRAFT

Prepared For: San Bernardino Valley Municipal Water District

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GEOSCIENCE Support Services, Inc. | P (909) 451-6650 | F (909) 451-6638

620 Arrow Highway, Suite 2000, La Verne, CA 91750 | Mailing: P.O. Box 220, Claremont, CA 91711

www.gssiwater.com

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APPENDIX A

Comments and Responses on Draft Technical Memoranda and Model Calibration

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APPENDIX A:

COMMENTS AND RESPONSES ON DRAFT TECHNICAL MEMORANDA AND MODEL CALIBRATION

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Comments Received and GEOSCIENCE Responses for Draft TM No. 1: Model Integration

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
1	OCWD	Section 4	32	1. On page 32, the draft Tech Memo states "The Integrated SAR Model, on the other hand, only accounts for evapotranspiration from the saturated aquifer system (i.e., below the water table)." It is understandable that the model would not account for losses in the vadose zone, but it seems that the model should account for losses in surface water bodies. Is there a method that can be used to account for water losses due to evaporation from ponds or other surface water bodies?	The riparian vegetation maps and the groundwater model ET package derived from these maps contain an ET zone for open water. Where the groundwater table is at or near land surface, ET is accounted for in the groundwater model.
2	OCWD			2. Do the acreage values in Table 4-1 include the portion of Prado Basin that is in the Temescal Basin (outside the Chino Basin)?	Yes, the computed acreages include the Temescal Basin.
3	OCWD			3. How are the acreages for the riparian vegetation area mapped by WEI in Table 4-1 used? Is there a water demand/loss associated with these acres? How is the water demand estimated?	The mapped acreages are used to assign a riparian vegetation type in the groundwater model. Each riparian vegetation type has a maximum ET rate and extinction depth associated with it. The groundwater model simulates ET extraction from groundwater based on this maximum rate and extinction depth. The WEI and BGW acreage were a assigned the properties of deep-rooted riparian vegetation.
4	OCWD			4. How are the acreages for the shallow groundwater area identified by BGW in Table 4-1 used? Is there a water demand/loss associated with these acres? How is the water demand estimated?	The BGW acreage is being incorporated into the integrated model in a similar manner to the WEI acreage in Question 3. Per the 8-Nov-17 Riparian Subcommittee meeting (held at CA Dept Fish and Wildlife), the group decided that the evapotranspiration areas for the Integrated SAR Model will include (1) Aspen's riparian mapping, (2) WEI's riparian extent in the Chino Basin, and (3) areas with shallow depth to groundwater (<20 ft) developed by the Balleau Groundwater.
5	OCWD			5. In Table 4-1, it would be helpful to separate the acreage shown for Prado Basin from those in the Riverside-Arlington Basin. This would allow for comparison to other published reports. Please present the acreages for Prado Basin separate from the Riverside-Arlington Basin. (For comparison, the written testimony of Tony Bomkamp on behalf of the City of Riverside to the State Water Resources Control Board, Riverside Exhibit 3.0, May 2007, states "Prado Basin supports about 6,121 acres of willow-dominated riparian habitat,…")	A further division was made to show Prado Basin acreage, distinct from other areas. This area is provided on Table 4.2 in TM No. 3.
6	OCWD			6. For the Prado Basin area, it would be helpful to present the estimated annual water demand from the riparian area acreages shown in Table 4-1. This would allow for comparison to other published reports. Please present the estimated water demand for the same categories as shown in Table 4-1 (Aspen Riparian Vegetation Area in Chino Basin and Riverside-Arlington Basin, WEI (2017) Riparian Vegetation Area in Chino Basin and Riverside Arlington Basin), BGW Shallow Groundwater Area, SBBA area and Yucaipa area). (For comparison, the written testimony of Tony Bomkamp on behalf of the City of Riverside to the State Water Resources Control Board, Riverside Exhibit 3.0, May 2007, states "The total water needed for riparian vegetation in Reach 3 and Prado Basin could be up to 37,232 acre-feet per year; however this represents the maximum use and as such is a "conservative" estimate.")	Additional tables of riparian acreage and maximum water demand (for both the entire model area and Prado Basin alone) were included in Section 4.1.7 of TM No. 3.
7	OCWD			7. When the model is developed and providing results, it would be helpful to present a Prado Basin area water budget using the model – this could be developed with the USGS ZONE BUDGET module or other tools.	Noted. Separate water budgets were prepared for Prado Basin and shown on Figure 167 of TM No. 3.
1	OCWD - Tim Sovich			Add category for Prado Basin riparian acreage. (Similar to #5 above)	Separate riparian acreage for just Prado Basin was included in TM No. 3 in Table 4-2.

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2	OCWD - Tim Sovich			Updated Yucaipa Basin model mean residual approx. 5 times higher than original model. How is it that the relative percent error is the same?	The previous simulation was from 1998 -2015. The new simulation period covers a longer period from 1966-2016. Additional targets have also been added. These two factors have likely extended the range of observations. The relative percent error takes into account the range of observations.
3	OCWD - Tim Sovich			Table 1-7: For comparison, show calibration statistics from original WEI model of Chino Basin.	We can provide statistics from the WEI report for comparison, once they are provided by WEI. Unlike other models, we weren't able to run the WEI model for Chino. Comparison statistics provided in TM No. 3 represent values from the modeling report.
4	OCWD - Tim Sovich			Update model areas where Temescal Basin and Riverside-Arlington Basins connect with each other per my previous comment on draft TM No. 2, or explain why the alluvium that connects these basins on the geology map is excluded from the active model domain.	Active areas have been updated in the lithologic and integrated model domains to connect these areas, as shown on the figures showing the Integrated SAR Model active area in TM No. 3.
5	OCWD - Tim Sovich			Annotate all the cross-sections with geographic features and landmarks, such as the SAR channel, various hills, and label the faults. Also, bedrock color in legend should be white, not black. I believe the black lines on the cross-sections are model layers but they are not defined or called out.	The cross-sections were annotated with geographic features.
6	OCWD - Tim Sovich			I did not see a cross-section that follows along the SAR across the entire model domain yet, as I had requested in my TM No. 2 comments. Do you still plan to add this?	A cross-section along the SAR was provided as Figure 63 in TM No. 3.
7	OCWD - Tim Sovich			According to Table 1, model layer 2 in the SBBA is supposed to be a confining layer, but the lithology in the SBBA cross-section within layer 2 appears to be largely coarse-grained.	The confining member is present only in certain areas of the SBBA, as shown in the hydraulic conductivity figures (Figures 67 and 68) in TM No. 3.
8	OCWD - Tim Sovich			It would be helpful if model layer colors matched the colors in Table 1; also, use same layer colors for calibration target well symbols for each basin in other figures showing the maps of the target calibration wells.	Colors in Table 1 were updated so they correspond with colors in the model layer cross-sections.
9	OCWD - Tim Sovich			Why is layer 1 so thick in most of Chino Basin (600-800 ft deep)? How deep is the water table in this area? The bottom of layer 1 does not match the structure of the lithologic model correlation lines. Also, why is layer 2 so thin? Seems like it would give better vertical resolution to raise the bottom of layer 1/top of layer 2 in the Chino Basin area if there is no geologic reason for the current vertical location.	Saturated thickness in the Chino model is 0-200 ft in the Chino Basin in some areas. If we raise the bottom of Layer 1 appreciably, we will cause the bottom of layer 1 to be above the water table. Layer 1 was subdivided into two model layers in the integrated model, and we tried to avoid placing the bottom of Layer 1 above the water table.
10	OCWD - Tim Sovich			Why is the riparian area larger (farther upstream) in 2015-16 than prior years?	In general, riparian habitat increases throughout the simulation period. In the 2004 riparian vegetation mapping, some upstream areas were absent. For this reason, the 1998 mapping was extended forward for this period.
11	OCWD - Tim Sovich			The very large mean residual of 27.5 ft for the updated Yucaipa model should be discussed or addressed in the text.	Model calibration/performance was improved through further calibration.
12	OCWD - Tim Sovich			The scatter plot shows that the simulated heads are significantly too low in the upgradient portion of the Rialto-Colton Basin and should be addressed in the text. This is also evident in the calibration hydrographs in Appendix F (see comment 26).	Model calibration/performance was improved in this area.
13	OCWD - Tim Sovich			Add the word "simulated" to the legend, i.e., Simulated Cumulative Change in Groundwater Storage.	Figures were updated in TM No. 3 (see Figures 168 through 173).
14	OCWD - Tim Sovich			Simulated change in storage does not look delayed with respect to cumulative rainfall departure curve as stated in the text. Rather, a few individual years don't show the same trend as rainfall, e.g., 1984-85 is increasing in the model but decreasing on rainfall curve.	Text in TM No. 3 (Section 6.4.3.5) was modified.
15	OCWD - Tim Sovich			Does not show any boundary conditions for underflow to/from the Riverside-Arlington model.	Figure was updated in the final TM No. 1.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
16	OCWD - Tim Sovich			Typo in legend for 0.1 – 1.0 category	Typo was corrected in the final TM No. 1
17	OCWD - Tim Sovich			Text in Sections 6.1.1.2 and 6.1.1.3 should discuss how the K and S values compare to the original WEI model of the Chino Basin.	Comparison by BGW is provided in Appendix A. Reference to this analysis was made in the text.
18	OCWD - Tim Sovich			Are the newly modeled boundary conditions consistent with or handled differently than the original WEI Chino Basin model?	In general, newly modeled boundary conditions are consistent with the original WEI model. Where possible, information from the WEI modeling report was referred to when setting up the boundary conditions for the Chino Basin model. For specified-flux boundaries, the WEL package was used instead of the FHB package. For general head boundaries, the GHB package was used instead of the FHB package.
19	OCWD - Tim Sovich			Please explain why the riparian vegetated area increases in the later years of the study period.	Some discussion was added to the text on the increasing riparian vegetated area. The vegetation is likely responding to an increase in water availability and timing of flows in the Santa Ana River and tributaries.
20	OCWD - Tim Sovich			If possible, add newer OCWD Prado shallow monitoring wells to calibration target list. These wells have 2016 water level data which would overlap with the final year of the calibration period. These shallow groundwater levels are very stable with only minor seasonal variation (wells OCWD-PD10 through –PD16, and OCWD-PDE4). OCWD can provide the data for these wells upon request.	Hydrographs from IEUA Prado Basin Sustainability wells along the SAR were added (refer to Appendix F in TM No. 3).
21	OCWD - Tim Sovich			Discuss in the text the poor calibration fit shown on the scatter plot in the upgradient portion of the model where simulated heads appear to be 200-400 ft too low. This is also supported by the calibration hydrographs in Appendix H (see comment 28).	The local Chino model was updated to capture water levels in this area along the boundary with the Rialto-Colton model. Two USGS monitoring locations show water levels 200-400 feet higher than elsewhere in the domain.
22	OCWD - Tim Sovich			Discuss in the text the large simulated storage decline during the first 10 years of the simulation, which is inconsistent with the cumulative rainfall departure curve.	The simulated storage decline is a result of a combination of inflows and outflows. Higher pumping and other outflows cause a larger simulated storage decline during this period. Additional text on change in storage was added to Section 6.4.3.5 in TM No. 3.
23	OCWD - Tim Sovich			Do the “reference” ET rates (ETo) in the HSPF model only represent evaporation of surface soil moisture, or does it also include transpiration from plants in the vadose zone? If the latter, should the sum of the groundwater model ET plus the HSPF surface water model ETo add up to approximately the Aspen/BGW total ET amounts?	The surface water model has many components, so the comparison of Aspen/BGW ET estimates to surface water model calculated ET would not be appropriate.
24	OCWD - Tim Sovich			Yucaipa model calibration hydrographs: Overall, rather poor looking calibration graphs that do not meet the eyeball test for matching observed water level trends. Simulated heads are too dampened relative to the observed long-term trends and don’t seem to respond sufficiently to varying hydrology of wet versus dry years. Some examples of poor calibration are listed below. Page D-3: (well name not shown, problem with graph template) poor calibration first 20-30 years, initial heads approx. 200 ft too high Page D-5: poor match of long-term trends Pages D-16 to D-20: wrong trend the last couple years of simulation Pages D-8, D-10, D-12 to D-15: simulated heads too low	Model calibration/performance was improved through further calibration.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
25	OCWD - Tim Sovich			SBBA model calibration hydrographs: Overall, rather poor looking calibration graphs that do not satisfactorily match observed water levels. Similar to Yucaipa model, the SBBA model does not appear to respond sufficiently to varying hydrology for wet versus dry years; the simulated heads are often too dampened. Some examples of poor calibration hydrographs are listed below. Pages E-3, E-64, and E-65: simulated heads too dampened or not matching long-term trends, e.g., page E-65 well 150 ft too low because of not responding to 1982-83 wet year. Pages E-5, E-7, E-53, E-54, E-55: simulated heads too low; in fact, on page E-53, the simulated heads are significantly below the screened interval of the well. Page E-35: simulated heads too low at this critical location near southern model boundary close to SAR (specified flux used in model to represent underflow could be inaccurate).	Model calibration/performance was improved through further calibration.
26	OCWD - Tim Sovich			Rialto-Colton model calibration hydrographs: Good overall calibration with very good fit on the majority of calibration graphs, except along the northern mountain-front boundary where the model appears to be over-responding to rainfall. See examples below. Pages F-27 to F-38 and F-48 to F-55: simulated heads too high; appear to be over-responding to rainfall along northern mountain-front boundary. Page F-14: simulated heads approx. 100 ft too low due to insufficient rise in response to 1997-98 wet year.	Model calibration/performance was improved through further calibration.
27	OCWD - Tim Sovich			Riverside-Arlington model calibration hydrographs: Good overall calibration except for the last 5 years or so of the simulation period near the northern and southern model boundaries. See examples below. Pages G-18, G-46, G-47, and G-49: simulated heads declining too much during the last 10 years of the simulation at the southern end of the model area; simulated heads approx. 50 ft too low by end of run. Pages G-28, G-29, G-32 to G-34, and G-39: simulated heads too flat during the last 5 years of the simulation near the northern model boundary, causing end of run heads to be too high.	Model calibration/performance was improved through further calibration.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
28	OCWD - Tim Sovich			Chino Basin model calibration hydrographs: simulated heads are largely too low throughout much of the model area, especially near the northern model boundary. See examples below. Pages H-1, H-5 to H-7, H-15 to H-17, H-24 to H-26, H-31 to H-34: simulated heads approx. 50 feet too low. Pages H-45 to H-49: simulated heads 100 to 300 ft too low near the northern model boundary in model layer 1; specified flux from Rialto-Colton model may be too low? Pages H-27 to H-30: simulated heads not responding to late 1970s/early 1980s wet periods. Page H-27: the observed water levels are lower than the screens, indicating that this could be the wrong observed hydrograph shown on this page or the screened interval is wrong.	Additional local model runs were conducted to address some of the comments on the calibration hydrographs. With respect to the observed water levels being lower than the screened interval, data from the uppermost screened interval was added to the hydrographs as an interpretation aid. The water level data is correct, but not all screened intervals are shown.
29	OCWD - Tim Sovich			It would be helpful to show an annual water budget for each year of the simulation for each of the models (based on either calendar year or water year) rather than just showing the long-term (1966-2016) average budget for each basin, especially since some of the models do not appear to be responding properly to individual wet and dry years.	Water budgets were presented on an annual basis in table form (see Tables 8 through 13 in TM No. 3). These include water budgets for each model area.
1	WEI	General	-	The amount of detail provided in the TM is insufficient for rigorous stakeholder and peer reviews.	Additional detail was included in the summary report to address comments made. Overall, we think the stakeholder and peer review process has been helpful and rigorous.
2	WEI	General	-	The text comprises just ten pages that when adjusted for formatting, would be about 6 pages. Most of the map figures are demonstrative and do not allow for critical review and comparison to the prior reported work for the Watermaster.	See response to Comment #1.
3	WEI	6.1.2.3	50	There is not enough detail in the description of the deep infiltration of precipitation and applied water: there is merely a statement of what the results are. There is no discussion of changes in cultural conditions (land use, channel lining, etc.) and how this was addressed in the calibration. The estimation of return flows from ag water use do not distinguish between irrigation and dairy uses. As to urban irrigation returns, they assume that returns are 10 percent of municipal pumping: this assumption is not technically defensible. And, some of the water used by Chino Basin municipal pumpers is exported.	Deep infiltration of precipitation and applied water is presented as a lumped volume , consistent with the presentation of this flux in the 2015 WEI modeling report and allowing for comparison. Additional description was added. Also, changes in land use are reflected in the surface water model inputs (land use), and the raw data inputs to the groundwater model. The 10 percent referenced is based on an assumption regarding percentage of outdoor water use of 50% and an assumed irrigation efficiency for urban irrigation of 20%.
4	WEI	6.1.2.1	49	The subsurface inflows should be broken down to boundaries and method and estimation.	Comment noted.
5	WEI	6.2.3	53	There is no water budget table showing the time of history of the recharge and discharge components. Ideally, water budget tables should be provided separately for the Chino and Temescal Basins.	Water budgets were provided for each basin in TM No. 3, Tables 8 through 13 and Figures 161 through 166.
6	WEI	6.2.3	53	The Temescal Basin is included in the Chino Basin model. It is unclear from the discussion in the text and the water budget figure (figure 82) if the reported recharge and discharge information includes Temescal Basin or not	In TM No. 3, water budgets were broken out for each basin (see response to WEI Comment #5).
7	WEI	6.1.2.5	51	Watermaster records of agricultural pumping are incomplete through the early 2000's and if used directly will result in underestimation of pumping in the Chino Basin.	Watermaster records were not used directly. Agricultural pumping was updated to reflect pumping reported by WEI.

Comments Received and GEOSCIENCE Responses for Draft TM No. 1: Model Integration

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
8	WEI			It is unclear as to whether the uppermost layer in the model was simulated as an unconfined or confined aquifer. Due to the significant changes in groundwater elevation, the uppermost layer should be simulated as an unconfined aquifer.	The water table aquifer was simulated as an unconfined aquifer.
9	WEI			There is no indication as to whether sensitivity analysis was used to assist in calibration or that PEST or other optimization approaches were used to calibrate the model	Manual calibration, including hydrograph and residual analysis, was performed. PEST was not used to calibrate the Chino Basin groundwater model. This was clarified in the summary report.
10	WEI	Figures	Figure 79	Figure 79 is a scatter plot of measured and model-estimated groundwater elevations. The information in this figure clearly indicates that the model results contain significant bias. Inspection of the graphic indicates that the model under-estimates groundwater elevations at wells with measured elevations greater than 600 feet and-over estimates groundwater elevations at wells with measured groundwater elevations less than 600 feet.	Further calibration of the Chino Basin groundwater model was conducted to reduce this bias.
11	WEI			The quality of the calibration is characterized by the authors' version of relative error. In this report, the relative error is computed as the standard deviation of the residuals divided by the difference of the maximum observed groundwater elevation minus the minimum observed groundwater elevation. Per the report, the standard deviation of the residuals is about 59 feet. Based on Figure 79, the apparent difference between the maximum observed groundwater elevation and minimum observed groundwater elevation is about 890 feet (~1,110 - 220). The authors report the relative error to be 5.2 percent. Based on the information shown in Figure 79, the relative error is about 6.7 percent. Considering the "quality" of the measured data used in calibration, a more accurate range of the difference between the maximum observed groundwater elevation and minimum elevation is about 400 feet (~840 - 440), producing a relative error of about 14.8 percent: failing their 10 percent acceptable relative error criteria. Interestingly, no R-squared value, a common goodness of fit metric, was reported for groundwater elevation matching.	The computed statistics were correct; there were a few observations that plotted off the chart. These observations are outliers from the northeastern portion of the model at the USGS observation wells. These statistics are superceded by the calibration results presented for the Integrated Model. Action Item:WEI to provide the calibration dataset used in the Watermaster Chino Basin groundwater model for computation of calibration statistics. R2 was added to scatter plots of water levels for the Integrated SAR Model calibration (see Figures 90 through 93 in TM No. 3).

Comments Received and GEOSCIENCE Responses for Draft TM No. 1: Model Integration

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
12	WEI			We commented previously on the relative error criteria proposed in draft TM No. 2: Flow Model Calibration Plan (TM2). An updated version of this comment is repeated herein. On page 25 of TM2, in the first full paragraph, the authors state that: "In general, model calibration is acceptable with a relative error (the standard deviation of the groundwater level residuals divided by observed head range; (Zheng and Bennett, 2002) of 10%." It is unclear from a literal reading of TM2 if this criterion will be used to determine that the calibration is "acceptable". We commented that TM2 needs to be precise as to the criteria used to assess calibration performance. Attached is a pdf of the section of the Zheng and Bennett citation regarding assessment of model calibration. The citation describes various quantitative approaches to assessing calibration that include, among others, relative error. It is our professional opinion that relative error criterion is not appropriate: it is misleading, it involves a value judgment that stakeholders to the modeling effort should fully understand and that the stakeholders, based on full understanding of relative error, have a chance to accept or reject it as the calibration criterion. The second full paragraph on page 320 of the attached citation characterize the use of relative error method: "it might be acceptable", "might be more meaningful" and "crude". The expressions "it might be acceptable" and "might be more meaningful" suggest that the stakeholders should be fully informed as to what the relative error implies. For example, would the stakeholders accept a 100-ft value of standard deviation of the groundwater level residuals over a range of observed heads of 1,000 ft that yielded a relative error of 10 percent?	Relative error is only one measure of model performance. Additional quantitative and qualitative techniques were also used to assess model calibration, as presented in TM No. 3.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
13	WEI			It is our professional opinion that given the level of model calibration that has historically been achieved in the Chino Basin, that the relative error criterion is not acceptable (see Section 6 of 2013 Chino Basin Groundwater Model Update and Recalculation of Safe Yield Pursuant to the Peace Agreement (WEI, 2015). Zheng and Bennett in the cited reference do not offer guidance that a relative error less than 10 percent is acceptable as a criterion to assess calibration. In the subject report (i.e., Upper Santa Ana River Integrated Model TM No. 1: Model Integration) the authors cite different references to support their assertion that a relative error less than 10 percent indicates a "good fit". The Spitz and Moreno citation from A Practical Guide to Groundwater and Solute Transport Modeling (a 22-year old reference) is not relevant in the current setting and in the manner that it was applied. The Spitz and Moreno citation reads: "Paired-data testing (i.e., comparing predicted and observed values for corresponding locations in time and space). Common examples of such testing are variance between predicted and observed data should be less than 10% of the range of observed data (relative error), standard deviation between predicted and observed data should range from 0.7 to 1 depending on the number and quality of data points, and bias between predictions and observations should be random rather than systematic." From a literally reading of Spitz and Moreno, it is unclear whether they intended the relative error criterion to apply to an individual well or an entire model domain. Spitz and Moreno provide no basis for 10 percent criterion. And, the TM1 authors seemingly ignored the other Spitz and Moreno criteria related to the standard deviation and bias. Also, Spitz and Moreno have only three pages of text related to model calibration. They do not present a theoretical discussion on calibration and definitive calibration criteria.	Relative error is only one measure of model performance. Additional quantitative and qualitative techniques were also used to assess model calibration, as presented in TM No. 3.
14	WEI			The same is true for the Environmental Solutions, Inc. citation to Guide to Using Groundwater Vistas. The exact text from this reference reads: "The residual standard deviation can be compared to the overall range in target value (e.g., head) as a further comparison. For head targets, this value shows how the errors relate to the overall gradient across the model. Normally, this value should be less than 10 percent for a good calibration." (emphasis added) This begs the question, what does "normally" mean? Environmental Solutions, Inc., provide no basis for their opinion or any qualifications on the limitations of relative error. Environmental Solutions does not provide a technical reason or citation to support their statement. And, interestingly, Groundwater Vistas does not compute and report out relative error. Environmental Solutions characterized relative error "as a further comparison" suggesting that other criteria should be used: in TM1, relative error is the only criterion. Also, the Guide is a user guide to application of Groundwater Vistas and is meant to inform users of how to apply Groundwater Vistas. It assumes the user has an understanding of models and calibration. The Guide does not contain theoretical discussion on calibration and definitive calibration criteria.	Relative error is only one measure of model performance. Additional quantitative and qualitative techniques were also used to assess model calibration, as presented in TM No. 3. Note on discussion of GWV: GWV does compute and report maximum and minimum residuals, range of observation, and Scaled Residual Standard Deviation (relative error), Scaled Absolute Mean, and Scaled RMS

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
15	WEI			How does the relative error, as used by the TM1 authors, indicate that the model can accurately predict surface and ground water interaction when the model is demonstrably biased as shown in Figure 79 and the time history charts in Appendix H? The simple answer is that it cannot. Modern groundwater model practice does not use relative error (see for example, Effective Groundwater Model Calibration: With Analysis of Data, Sensitivities, Predictions, and Uncertainty, 2010, Hill and Tiedeman, an entire book that focuses on groundwater model calibration).	See above response. Analysis and assessment of residuals are part of groundwater model calibration regardless of approach. The inclusion of relative error is not to the exclusion of other methods. (Refer to Section 6.4 of TM No. 3).
16	WEI	Appendices	Appendix H	Appendix H contains time-series charts that compare model-estimated groundwater elevations to observed values. The charts are confusing. Under the title there is an indication of the model layer being represented. Many wells are perforated in more than one layer (see for example wells Cal-speed1, CDA I-10, C_13, CH_HIL_15, CH_HIL_17, ONT_09, ONT_20, ONT_31, ONT_36 and others). So, are the model estimated groundwater elevations from the specified layer or are they something else? If the former, then the comparison to observed groundwater elevations is meaningless. If the latter, then the charts are mis-labeled.	The hydrographs have been labeled with model layer information (which layer the computed water levels are from), and screened interval information to assist in interpretation of the hydrographs. Per discussion during a modle update conference call, WEI to provide calibration dataset.
17	WEI			Review of the time-series charts in Appendix H indicate that the model under-predicts groundwater elevations in the northern part of the basin and over-predicts them in the southern part of the basin. This is also clear in the scatter plot in Figure 79. This systematic bias should be described in the text and the implications of this bias on predicting surface/ground water interaction should be fully understood prior to using the model to evaluate projects. The stakeholders to the ISARM process need to determine if the bias observed in the model calibration is acceptable (and for that matter the other models that are being integrated into the ISARM) and they need to require that when the ISARM is used for predictive purposes that tools be provided to estimate the impact of the bias on the model predictions.	Additional calibration was conducted to improve the groundwater model calibration in Chino Basin.

Comments Received and GEOSCIENCE Responses for Draft TM No. 2: Calibration Plan

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
1	BGW	Section 1.0	2	Page 2 states *"The preliminary model calibration presented in this calibration plan may be altered during the process of assessing model calibration results and according to suggestions from the TAC."* This is a good overall approach as integration of the five independent models is anticipated to provide a degree of insight to modeling the Upper Santa Ana River (SAR) and aquifer system that may not have been apparent when each of the five models was developed. Flexibility in a calibration plan is generally good, but perhaps particularly good in this setting.	Comment noted.
2	BGW	Sections 2.4 through 2.4.5	5-17	The description of the geologic conceptual model (Sections 2.4 through 2.4.5) is very good. Section 2.4.4 describes unification of model layers from the five separate models into a seven-layer structure for the Integrated SAR Model. Consider implementing a grid layer structure in the integrated model that represents SAR wash deposits downstream of the narrows into the Chino Valley as discussed at the January 30, 2018 model workshop. Slide 11 from the BGW presentation at that workshop is below for reference. *"OBSERVATION: Shallow groundwater and riparian vegetation are spatially coincident with Upper Santa Ana River wash deposits along specific reaches of the river.* *This suggests the groundwater model layer representing the Upper Santa Ana River should incorporate the width of the river wash deposits to account for shallow groundwater interaction with the river and with ET.* *A single model layer representing the river and shallow groundwater processes throughout the integrated model domain may have utility in this setting. It also would facilitate moving shallow groundwater through multiple basins.* *Model development (integration) work is anticipated to guide this process and decision."* BGW recognizes that model development is in progress and insight Geoscience develops during the model integration process should be the overriding factor that guides the model-layer approach for simulation of shallow groundwater in the area of the SAR.	Please refer to response to USGS Comment #16.
3	BGW	Section 2.4.3	12-14	The top of Page 12 describes *"non-water bearing"* rocks and the bottom of Page 14 describes *"water-bearing"* sediments. At the January 30, 2018 workshop, Wes Danskin recommended using a term that may be more appropriate in terms of hydrogeology. The language *low-permeability consolidated* and *high-permeability unconsolidated* might be an approach.	Please refer to response to USGS Comment #11.
4	BGW	Section 2.5.6.1	21	Section 2.5.6.1 describes groundwater consumption by riparian vegetation. We consider the Aspen Environmental Group (Aspen) estimate of groundwater consumption to be reasonable. As discussed at the January 30, 2018 workshop, we independently estimated ET using a simplified surface energy balance approach and derived values that are in the same range as Aspen. BGW plans to use both estimates to evaluate the shallow groundwater budget of the Integrated SAR Model from a perspective of peer review.	As noted in TM No. 3, ET estimates from BGW and Aspen were included in the Integrated SAR Model.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
5	BGW	Section 3.2.2	25	Section 3.2.2 indicates that with regard to flow through Prado Basin *"a correction for evaporation losses may be needed to ensure a proper calibration. This correction factor will be based on estimated evaporation rates, historical storage-elevation data and surface area data for Prado Basin."* Planning ahead for a correction factor is prudent. Since the factors that affect the correction factor relate closely to a basic reservoir water balance, it may be straightforward to simulate Prado Basin with the Lake (USGS WRIR 00-4167) package. BGW recognizes that observations during model development are the best guide for that decision.	Comment noted.
1	OCWD	-	-	You may want to consider doing some MODPATH runs during or near the end of calibration to help determine and visualize where the groundwater is flowing, especially in the vicinity of the SAR. For example, you could start particles along the SAR in Layer 1 and see if they migrate vertically into deeper layers.	If the TAC wishes to include this extra work for the Integrated SAR Model, and budget remains to do so, MODPATH runs can be conducted and added to the list of qualitative calibration techniques.
2	OCWD	-	-	I recommend doing some level of sensitivity analysis at the end of transient calibration. For example, you could try global changes in K or S to determine the sensitivity of the head and SAR flows to these changes. Also, you could try sensitivity changes in the natural recharge and ET parameters.	If the TAC wishes to include this extra work for the Integrated SAR Model, and budget remains to do so, sensitivity runs can be conducted and added to the list of qualitative calibration techniques.
3	OCWD	Figure 3	-	Figure 3 model domain: Consider connecting active model cells near 91 freeway in southern area near Corona between Arlington Mtn and La Sierra Hills based on the geologic map (Figure 5) showing alluvium in this area. Also, please explain in the memo why a large portion of the Upland area showing alluvium in Figure 5 was excluded from the model. If the reason is that the previous local model excluded this area, then please explain why.	The area between Arlington and Temescal Basins were connected in the Integrated SAR Model. In the Upland area, the Chino Basin Model active area follows the Red Hill Fault. Underflow inflow is simulated by a specified flux boundary. An explanation was provided in Section 4.1.6 of TM No. 3.
4	OCWD	Figure 5	-	Would be helpful to show the ISAR model boundary on the geology map of Figure 5.	The model boundary was added to Figure 7a in TM No. 3.
5	OCWD	Section 2.4.4	16	As discussed in today meeting, please consider revamping Tables 2-1 and 2-2 to make them conceptually more understandable. Also, it would be helpful to provide additional text (couple paragraphs) to describe the model layering in Table 2-2, especially aquifers versus confining layers or aquitards. In general, there does not seem to be separate model layers for intervening aquitards between aquifer layers, except for local confining units in Rialto-Colton (layer 4) and SBBA (layers 3 and 5). So, you should explain in the text how you will model vertical head differences throughout the model domain, e.g., with vertical leakance terms?	Tables 2-1 and 2-2 were revised as Table 1 in TM No. 3. Vertical K was used to simulate vertical leakage between model layers, as discussed in Section 6.2.2 of TM No. 3.
6	OCWD	Figures 6 through 8	-	I recommend reformatting the model layer cross-sections in Figures 6, 7, and 8. Consider numbering and/or color shading each model layer from top to bottom. Currently, showing the top of each layer does not work in areas where layers are pinching out.	Model layer cross-sections were revised for TM No. 3(Figures 58 through 63).
7	OCWD	Figures	-	Add another model layer cross-section figure (similar to Figures 6 through 8) along the SAR across the entire model domain from the upstream extent down to Prado.	The cross-section along the SAR is included in TM No. 3 as Figure 63.
8	OCWD	Model Layers	-	I'm not convinced that layer 7 is really necessary. Is there any pumping from this deep layer? How about any monitoring wells with head data to use for calibration? Section 2.4.3.2 states that these undifferentiated consolidated deposits are essentially non-water-bearing. It would save computation time to exclude layer 7. You could do a couple sensitivity runs at the start of calibration to see if it makes a noticeable difference in model results.	Seven model layers were presented in Table 1 of TM-1. However, only the first 5 were modeled in this iteration of the Integrated SAR Model (see Section 6.1.3 of TM No. 3).

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
9	OCWD	Model Layers	-	As we discussed during the conference call today, consider combining model layers 1 and 2 in some fashion such that model layer 1 exists throughout the majority of the domain. Per separate email that I sent to the entire group a couple hours ago, you could have the layer 1 thickness remain unchanged directly under the SAR (river channel deposits), but then extend layer 1 horizontally or parallel to the land surface moving out away from the river, thus incorporating the upper portion of your current model layer 2 (younger/older alluvium).	Please refer to response to USGS Comment #16.
10	OCWD	Section 2.5.1	17	Section 2.5.1 and Table 2-4: Please specify the vertical assignment of mountain-front recharge, i.e., is it only assigned to model layer 1 or also to deeper layers representing deep fracture flow contributions from the mountains in the northern area of the model.	Additional explanation was added in the summary report.
11	OCWD	Sections 2.5.1 and 2.5.2	17-18	Sections 2.5.1 and 2.5.2 should also describe the methodology for calculating or estimating the mountain-front and areal recharge values to begin the calibration and then these estimated can be adjusted during calibration if necessary.	Methodologies vary between the existing models. This was noted in the summary report
12	OCWD	Section 2.5.3	18	Section 2.5.3: Please state whether or not the artificial recharge values are measured or estimated, and if the data is monthly.	Additional explanation was added in the summary report.
13	OCWD	Section 2.5.4	19	Section 2.5.4: Explain how the applied water term is estimated and what it includes in various regions of the model area.	Methodologies vary between the existing models. This was noted in the summary report
14	OCWD	Section 2.5.7	21	Section 2.5.7: Please state if all historical pumping is from monthly metered measurements or if older pumping (what years?) was less frequent or estimated.	Methodologies vary between the existing models. This was noted in the summary report
15	OCWD	Sections 2.5.5 and 2.5.8	19 and 22	Recommend combining Sections 2.5.5 and 2.5.8 since they both are for the streamflow package.	Text was modified in the summary report.
16	OCWD	Section 2.0	-	Recommend adding a water budget table at the end of Section 2 showing your initial annual estimates of each water budget term, including a column for estimated outflow from the model and change in groundwater storage which would be the sum of all the inflows and outflows. The values in this table would then be revised/refined at the end of calibration for tech memo 3 and could then be compared to this tech memo 2 initial values to see how much these items changed during calibration.	We will consider a way to present initial estimates, but any water budget put together for this phase of the work would be incomplete due to the recharge/discharge terms needed to be calculated by the groundwater model.
17	OCWD	Section 3.1	23	Section 3.1: Depending on the frequency of older available pumping records and older historical water level data, you may want to consider trying coarser (e.g., quarterly) stress periods for the earlier years, such as 1966-86. This would shorten the transient calibration run times considerably. If the observed water level data is sparse anyway during those early years, this could be acceptable.	There are some good monthly records available for this time period.
18	OCWD	Section 3.2.1	24	Section 3.2.1: Regarding the scatter plot of model vs. simulated heads mentioned in this section, I would recommend adding separate scatter plots for each model layer, and possibly also a couple separate scatter plots for different time periods, such as first 10 years, middle 10 years, and last ten years.	Additional scatter plots were added as Figures 91 through 93 in TM No. 3.
19	OCWD	Figure 11	-	Figure 11: Recommend using more calibration target wells	Additional calibration well hydrographs were added (refer to appendices in TM No. 3)
20	OCWD	Figure 13	-	Figure 13: Recommend using a couple more target wells, especially the two northeastern-most wells if they have sufficient well construction screen depths and water level histories.	Additional calibration well hydrographs were added (refer to appendices in TM No. 3)
21	OCWD	Figures 11 through 14	-	Figures 11 through 14: Recommend color coding the calibration target wells by model layer. Try to use same color coding as the cross-sections in Figures 6 through 8 (see my comment #6).	Target wells were color-coded in figures of residuals in TM No. 3.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
22	OCWD	Figures	-	Consider presenting any available water level elevation contour maps for the various basins in this tech memo to illustrate the groundwater flow patterns. These maps could then be used during calibration to compare with simulated head contours for the same selected time periods to ensure that the model is reproducing reasonable flow directions and gradients.	Water level elevation contours were added to the summary report.
23	OCWD	Tables 1 through 5	-	Tables 1 through 5: Recommend including columns for the following: screened interval depth, model layer number represented by each well, the top and bottom depth of that model layer (for comparison with the screened interval depth), and the approximate frequency of the observed water level data.	Additional columns were added to Tables 2 through 6 in TM No. 3.
24	OCWD	General	-	Final general comment: At the end of this modeling project, if more detail is deemed necessary in the Prado riparian wetlands area, a follow-up future task or scope could potentially include doing a zoomed-in Telescopic Mesh Refinement (TMR) sub-model within the larger Integerated SAR Model.	Comment noted.
1	USGS	General	-	**Project objective is challenging.** The USGS acknowledges that the primary project objective— developing an integrated surface-water and groundwater numerical model of the Upper Santa Ana River Basin—is challenging, and would be for any group of technical individuals.	Comment noted.
2	USGS	General	-	**Future model revisions may be required.** Because this effort is the first to create an integrated model, future iterations and improvements in the model may be required in order to achieve some of the stated goals of integrating geology and hydrology throughout the basin, and creating a predictive numerical tool. These limitations are common for an initial hydrologic model, regardless of the effort involved in planning and development. Some of the inherent hydrogeologic complexity of the area will not be known, or understood, until the initial modeling effort is complete.	Comment noted.
3	USGS	General	-	**Organizational change.** "Section 2.0 Conceptual model …" includes much that is not strictly the conceptual model of the basin. In a final report, it will be good to separate out the physical conceptual model of the basin, from any attempt to simulate those features. Admittedly, this approach is a bit cumbersome to write because it may seem a bit redundant and long winded, for example, to write about streamflow in the conceptual model, then in a subsequent section to write about how streamflow is simulated. But this approach is better in that it separates what is real, from what is simulated. Comingling the two can cause an unintentional transference of ideas from one to the other. For example, streams have important physical features that we just don't, or can't, simulate. But it is good to acknowledge those features up front, then put our inability to simulate them in as caveats in a Use and Limitations section.	Text was modified in the summary report
4	USGS	General	-	**Order of hydrology.** A standard organizational approach is to talk about geology, from old (Paleozoic) to young (Quaternary), and hydrology from top (precipitation), to bottom (groundwater). Many authors write about groundwater and surface water, in that order; but this reverses the natural order of things: top to bottom. Admittedly, this topic may be a detail to some, but it keeps the thought processes ordered in both the writer and reader.	The geology in TM No. 3 and the summary report was discussed from old to young (Section 3.3.2).
5	USGS	General	-	**All locations on a map.** A cumbersome requirement of USGS writing is that any location identified in the text, must be shown on a map figure. In general, the TM2 does this, but it may be a topic to check for final publication; it will make a final report much more useful and timeless. A similar requirement is that any symbol or abbreviation noted on a figure is described in an explanation/legend on that figure; again, cumbersome especially in borrowed figures, e.g. Figure 2-3, but of critical aid to a reader.	Figures in TM No. 3 and the summary report were reviewed for completeness and locations discussed in the text were added, where appropriate (e.g., Figures 1 and 6).

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
6	USGS	General	-	**Figures fully documented.** The USGS requires that all figures must be able to stand alone, meaning they are fully described and documented either in explanations or figure captions. Yes, this is painful and time-consuming, but it ensures that the figures, when copied by themselves from a published report, retain all the necessary information to be useful. In many ways, the Geoscience reports for the SARIM will function in the same archival way as USGS reports, so we encourage Geoscience to consider this publication standard.	Figures in TM No. 3 were reviewed for completeness and references were added, where appropriate (e.g., Figures 7a and 7b).
7	USGS	Geology	-	**Geologic setting.** Geoscience has done a great job in TM2 honoring the suggestion to include a good geologic history and description of the geologic setting. This effort can be improved with some reorganization, additional details about the physiography of certain basins, and clarification of the relationship between bedrock and old (less-permeable) versus young (more-permeable) sediment.	The geology in TM No. 3 was revised (Section 3.0).
8	USGS	Section 2.4.1	5	**Basin physiography.** This section nicely details the geographic and tectonic setting of the Upper Santa Ana River groundwater basin, appropriately focusing on the Peninsular Ranges Province. The discussion is limited, however, to the Perris and Santa Ana Blocks, and only the Chino Basin is described in detail. The Peninsular Ranges Province, as defined by Morton and Miller, 2006, encompasses the entire Upper Santa Ana River groundwater basin, so it seems reasonable that the discussion should be expanded to include equivalent descriptions of the shape, structure, and provenance of the Temescal, Riverside-Arlington, Rialto-Colton, San Bernardino, and Yucaipa Basins. Some of these descriptions have been written, such as in text describing the sedimentary formations and changing paleogeography of the Yucaipa Basin on page 10, or the San Bernardino Basin on page 11. Perhaps these descriptions can be moved or copied to this section. The USGS feels that describing the details of each basin is necessary to highlight the unique geology and structures that are present.	The basin physiography in TM No. 3 was revised (Section 3.2).
9	USGS	Section 2.4.2.1	10	**General geology.** Figure 5 is the only geologic map in this report, and, therefore, needs to be presented in such a way so that logical connections between the geologic formations described in this section and hydrostratigraphic layers can be visualized and understood. We recommend grouping the geologic units as follows, or something similar to what is currently written in the Hydrostratigraphy section, and describing each unit in the text in a similar fashion: - Santa Ana River river-channel deposits - Younger alluvium - Older alluvium - More permeable Plio-Pleistocene – Fernando Group and Live Oak Canyon Formation - Less permeable Plio-Pleistocene – San Timoteo Formation - Miocene Sedimentary units – Mt. Eden	The geologic units were regrouped in TM No. 3 (Figures 7a and 7b).
10	USGS	Section 2.4.2.2	10	**Basement geologic structure.** The description of intra-basin faults in the San Bernardino and Yucaipa Basins is very good. Consider indicating the presence, or lack, of similar structural features in the other groundwater basins.	The structural geology in TM No. 3 was revised (Section 3.3.3).

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
11	USGS	Section 2.4.2.2	11	**Accounting for geologic structures.** Some ambiguity is present in how low and very low flow values will be assigned to units. It appears that low flow values are assigned based only on outcrop locations. However, similar units with corresponding low or very low flow values probably are present at depth. Consider clarifying the age of units that you determine to be poorly permeable. These units should correspond to those mapped in Figure 5. Note that the USGS prefers the term poorly permeable, or a similar term related to average hydraulic conductivity, versus non-water-bearing which these days we recognize is inaccurate for sedimentary units, and most crystalline rock.	This terminology was incorporated in the summary report.
12	USGS	Section 2.4.3	12	**Hydrostratigraphy.** Descriptions of hydrostratigraphic units need to correlate with general geologic unit descriptions, ages, and rock types. Consider combining Tables 2-1 and 2-2. Figure 2-2 indicates that some geologic units, such as the Shallow Aquifer unit in Chino Basin, and Live Oak Canyon Formation in Yucaipa are broken out into several layers. However, cross-sections A, B and C show that this is not the case: the Shallow Aquifer unit is represented by Layer 2, whereas the Live Oak Canyon Formation is broken into layers 3, 4, 5, and 6. Please clarify the unit versus layer breakdown in Table 2-2 and perhaps explain these topics in the final report.	TM No. 3 contains a revised table correlating geologic units, hydrogeologic units, and model layers (Table 1).
13	USGS	Section 2.4.2.2	11	**Geologic structure.** The critically important discussion of faulting and angle of deposits (page 11), both of which can influence groundwater flow, is much appreciated. But despite assurances that these features can and will be simulated in the model, this wish may or may not be true. Much of the subsurface geology is unknown, and many physical features and human effects can produce similar hydrogeologic results. Perhaps consider how you present limitations on important, but unknown items.	Comment was incorporated in the summary report.
14	USGS	Section 2.4.3	12	**Less permeable layers.** Buried stratigraphic folds and eroded land surfaces can have significant effects on groundwater flow, as discussed on page 12, item 3. For horizontal, or nearly horizontal layers, this effect may be observed by differences in vertical heads, and can be simulated in a model by using a reduced vertical conductance. But for dipping deposits, the effect may be mostly on horizontal groundwater flow, and in unknown ways. Identifying, much less accurately simulating, this effect will be challenging. One way to accommodate this uncertainty is to identify areas of the basin where these geologic features are known to occur. These will be areas where hydrogeologic understanding may be weaker, and the simulation model may be less accurate, especially at depth where hydrogeologic data from boreholes are limited or absent.	Comment was incorporated in the summary report.
15	USGS	Section 2.4.3	12	**Assigning flow.** Flow probably is not assigned to areas of a basin (p. 12, item 2), even in a computer model, unless specified fluxes are used; rather, more likely, the author means that lower transmissive characteristics (permeability or hydraulic conductivity) are assigned in the computer model. This illustrates the importance of separating out estimated physical characteristics (low permeability), from the likely, but unknown result (low flow).	Comment was incorporated in the summary report.
16	USGS	Section 2.4.3	13	**River-channel deposits.** A key part of the integration will be to correctly conceptualize and then simulate river-channel deposits. As illustrated in Table 2-1, this may be a challenge if a similar conceptualization was not present in each of the individual basins. The more permeable river-channel deposits, however, will provide key areas of groundwater transport, both vertically and possibly horizontally across the landscape, even though the areas are well above the water table. Mapping the presence of these deposits, along with stream courses, may aid in identifying where stream recharge occurs, and possibly groundwater discharge.	The river channel deposits were delineated in TM-1 (Figure 6a) and Model Layer 1 was modified to include these deposits throughout the model domain. This change was also incorporated in TM No. 3 and the summary report.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
17	USGS	Section 2.5.4	19	**Return flow.** A full and accurate groundwater budget requires keeping track of gross pumpage and return flow, separately. This approach allows for both understanding and simulation of where groundwater is extracted and where it is recharged, in particular with respect to depth below land surface. This advisable approach appears to be the one used for the integrated model, in contrast to using a net-pumpage approach, which has been used for some studies in the Upper Santa Ana River Basin.	The gross pumping and separate return flow approach were used in the Integrated SAR Model.
18	USGS	Section 2.5.6	20	**Evapotranspiration.** Although evapotranspiration commonly is conceptualized in modeling studies in relatively simple terms as being dependent on depth to groundwater, in reality, evapotranspiration is a much more complex phenomenon. Some accounting for gross evapotranspiration, which will be greater than evapotranspiration from the water table, may be necessary in order to match field evapotranspiration data. Developing a water budget for both gross precipitation and gross evapotranspiration may be helpful. Similarly, developing graphs and figures showing gross evapotranspiration and net (simulated) evapotranspiration may be helpful to demonstrate that the simulation model is doing a credible job of taking enough, but not too much, groundwater discharged via the evapotranspiration package. This accounting approach will become even more important when considering riparian vegetation, which may be extracting surface water.	The Integrated SAR Model already uses gross evapotranspiration.
19	USGS	Section 3.2.2	25	**Flow into Prado.** This time-series of discharge values, although calculated from other measurements and estimates, will be one of the most important items for calibration of the model. As such, the methodology of calculating the discharge needs to be explained insufficient detail so that all readers of the final report will understand how it was done and used.	Flow into Prado was considered in the watershed model calibration, as discussed in TM No. 3 (Section 5.4).
20	USGS	Section 3.2.1	25	**Manual adjustment of initial heads.** This approach seems like a problematic way to hide discrepancies in the steady-state formulation, or fluxes in the transient simulation. At the very least, the area of the adjustment should be indicated on figures for all layers, along with some explanation of why it was necessary.	Initial heads were not manually adjusted. Results from the initial condition run were used, as discussed in Section 6.4.2 of TM No. 3.
21	USGS	Section 3.2.1	24	**Exclude wells from calibration.** Though perhaps justified, this is a dangerous path that could hide important errors in conceptualization, fluxes in the simulation, or biases in calibration. Perhaps an acceptable approach would be to place these wells in a separate file, but continue to compare the measured and simulated heads, and present these results in some fashion in the final report. At the very least, these wells may indicate where the data or the model are ambiguous.	Comment was incorporated in the summary report.
22	USGS	Computer Modeling	-	**Vertical groundwater flow.** An important part of calibration is a comparison of real and simulated areas of vertical groundwater flow—where groundwater is flowing up, and where it is flowing down. And perhaps an even more important part is to identify real and simulated areas where groundwater is rising into the Santa Ana River.	Areas of real and simulated rising groundwater were identified in Section 4.1.3.4 of TM No. 3.
23	USGS	Computer Modeling	-	**River-channel deposits.** As described above, a discontinuity of conceptualizing and mapping river-channel deposits, and assigning to model layers (figure 4, layer 1), may produce uncertain, unclear results from a groundwater flow model. Consider rethinking this topic.	Please refer to response to USGS Comment #16.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
24	USGS	Computer Modeling	-	**Simulated evapotranspiration.** Simulated evapotranspiration (ET) is an important part of many groundwater systems with a water table that is close to the land surface. But, simulated ET can be a strong hydraulic buffer that effectively controls the simulated water table to a predesigned range of depths. To be used effectively, the ET package must produce credible evapotranspiration from the water table, which will be a subset of the total evapotranspiration of the phreatophytic plants. Demonstrating the reasonableness of simulated ET values will be as important as, or more important than, showing a credible water-table elevation.	Comment noted.
25	USGS	Computer Modeling	-	**Water budgets.** Because of the complexity of the integrated model it may be desirable to develop water budgets for different items, e.g. for the entire watershed, for the surface-water system, for the groundwater system, and for the entire simulated hydrologic system, which may include both surface-water and groundwater budgets. In an ideal world, no water will be left out of one of these budgets. This approach is not simple, but will simplify review, enhance credibility, and provide for greater use of the model.	Water budgets were created for the different basin areas as well as Prado Basin (Figures 161 through 167 in TM No. 3). Additional water balances can be created at the discretion of the TAC.
26	USGS	Computer Modeling	-	**Hydrographs available.** Hydrographs should be available for all USGS multiple-depth monitoring-well sites, and likely would be among the most valuable calibration data. Table 1 (column 6, hydrographs) does not include all of these sites indicated as hydrographs, but it is not stated why not.	Hydrographs for the USGS multi-depth monitoring wells were provided in Appendices B through F in TM No. 3.
27	USGS	Section 2.4	5	1st paragraph. List the six basins. Use these names throughout the report.	Change was made. The following comments/responses pertain to Section 3.0 in TM No. 3.
28	USGS	Section 2.4	5	1st paragraph. The use of "conceptual geologic models" in this sentence implies that all 6 groundwater basins have similar geologic histories and that the basins developed in similar fashion. Is this what is meant? Or is the intent to say that each basin has geologic units that are similar? Clarify your use of "conceptual geologic model".	Conceptual geologic model was clarified.
29	USGS	Seciton 2.4.1	5	1st paragraph. basins?	We are referring to the geography in this sentence
30	USGS	Section 2.4.1	5	1st paragraph. Make sure names discussed in this paragraph are shown in Figure 1. See comment on figure 1 about adding groundwater basin boundaries to that figure	Figure was revised
31	USGS	Section 2.4.1	5	2nd paragraph. The Upper Santa Ana Groundwater Basin. ^ better I think to refer to the groundwater basin (a physical feature)when discussing the geology, rather than the model which is a computer rendering.	Noted. Upper Santa Ana Valley Groundwater Basin was used.
32	USGS	Section 2.4.1.1	6	Careful, this text is taken verbatim from Morton and Miller, 2006. Consider adding quotations, or changing the language slightly.	Added reference and quotes
33	USGS	Section 2.4.1.1	6	as well as the San bernardino Basin and Crafton Hills Blocks, and portions of the San Jacinto Mountains Block (cite Morton and Miller, 2006)	Section was rewritten.
34	USGS	Figure 2-1	7	Consider adding lines delineating the approximate boundaries between the Transverse Ranges and Peninsular Ranges provinces. The colors on this figure show the different basement rock assemblages (Penisular, San Gabriel Mts, San Bernardino Mts), which mostly coincide with the Provinces, but not quite.	New figure was created showing the geomorphic provinces (Figure 5 of TM No. 3).

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
35	USGS	Figure 2-2	8	Expand this figure to encompass the entire Upper SAR gw basin. Need to see (and discuss) the San Bernardino and Yucaipa basins as well. Consider overlaying the gw basin boundaries on this figure.	New figure was created showing the structural assemblages for the entire Upper SAR Groundwater Basin (Figure 6 of TM No. 3).
36	USGS	Figure 2-3	9	Put cross-section line location on Figure 2-2	Section was rewritten.
37	USGS	Section 2.4.1.1	9	First paragraph: Give a brief description about the shape and depth of bedrock in Rialto-Colton Basin. Implication from previous text is that bedrock under Rialto-Colton should be shallow because it is part of the Perris Block. Is this correct?	Section was rewritten.
38	USGS	Section 2.4.1.1	9	Second Paragraph: I'm not sure I understand this paragraph. Are you saying that some part of the groundwater model is part of the Perris Block, but that portion of the groundwater model is outside the watershed? If this paragraph is describing an area outside the groundwater model domain entirely, I think you can remove this text. Better to focus on areas within the model domain	Section was rewritten.
39	USGS	Section 2.4.1.1	9	This section does a good job describing the Chino Basin and and how it relates to the underlying Perris Block. But there is little to no mention of the other groundwater basins and their relationship to the blocks shown in Figure 2-2. Expand this section to describe the other groundwater basins.	Section was rewritten.
40	USGS	Section 2.4.1.2	10	First paragraph: Add a couple sentences describing the geologic map in Figure 5, pointing out locations of each unit, and orienting the reader to the local geology (the second paragraph does this - add to it, especially talking about the younger unconsolidated sediments)	Section was rewritten.
41	USGS	Section 2.4.1.2	10	Second Paragraph: Following the introductory pargraph above, this paragraph implies that the Mt. Eden, San Timoteo, and Live Oak Canyon formations are part of bedrock. I don't think this is what you mean. Clarify that you consider the Miocene Mt Eden formation part of bedrock (if true), and that the San Timoteo and Live Oak Canyon units are active gw layers.	Clarified in text.
42	USGS	Section 2.4.1.2	10	Third Paragraph: I think this paragraph is better suited to be in a discussion about Yucaipa groundwater basin, or perhaps the unit descriptions later in this section. The changes in paleogeography are key to the structural development of the Yucaipa and San Bernardino Basins. Make this part of the conceptual model discussion	Section was rewritten.
43	USGS	Section 2.4.2.2	11	Second Paragraph: Move this paragraph to conceptual modeling section.	Section was rewritten.
44	USGS	Section 2.4.2.2	11	SAR recharge basins in Third Paragraph: Unclear where you are referring. San Bernardino Basin? Be more explicit.	Clarified in text.
45	USGS	Section 2.4.2.2	11	Third Paragraph: This paragraph needs to be re-written. Unclear which beds are dipping, where they are located, and what "similar-aged sediments" are being referenced. Are you strictly talking about one basin? Similar-aged sediments in all basins?	Section was rewritten.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
46	USGS	Section 2.4.2.2	12	non-water-bearing rocks in second point: Does this include the Live Oak Canyon Formation? Based on earlier text and the hydrostratigraphy tables, the nonpwater bearing units are Miocene (i.e. Mt eden) and Pliocene (San Timoteo).	Clarified in text.
47	USGS	Section 2.4.2.2	12	non-water-bearing rocks in second point: Assigning limited flow to these rocks at the surface, also means that you need to assign limited flow where these rocks are present at depth; therefore there needs to be some acknowledgement, or awareness, of where these low-flow rocks are present and how they are incorporated into the layering scheme.	Clarified in text.
48	USGS	Section 2.4.2.2	12	Third point: Consider assigning layer horizons to coincide with some of these dipping paleosol layers	Model layers were revised.
49	USGS	Section 2.4.3.2	14	I think this is good. Note that in the introductory paragraphs of this section (pg 10), you talk about the Mt Eden, San Tim, and Live Oak units together. Make clear in this paragraph that the Mt Eden rocks are part of your bedrock unit. List any other sedimentary formations that you consider bedrock	Section was rewritten.
50	USGS	Section 2.4.3.3	14	Are there any marine rocks? The San Timoteo and Live Oak formations are terrestrial. I don't know about the Fernando Group - verify that this has some marine components.	Section was rewritten.
51	USGS	Section 2.4.3.3	14	Discuss geology from old to young, bottom to top	Section was rewritten.
52	USGS	Section 2.4.3.3	14	So what about the San Timoteo Formation? Describe if it's part of the Live Oak/Fernando layering, or if it's lumped into the Pre-Pliocene group.	Clarified in text.
53	USGS	Section 2.4.3.4	14	Re: Water-Bearing Sediments. Call these something different. Like "young unconsolidated sediments". Keeps the same geologic naming convention as the previous paragaphs (makes clear you're going from oldest to youngest)	Clarified in text.
54	USGS	Section 2.4.3.4	15	Most older alluvial deposits are not "beneath" the river, since the SAR is confined to an narrow ares; some of these other deposits may be contemporaneous with the river deposits as well.	Text was revised.
55	USGS	Table 2-2	16	Make a note in the caption or in the text that the Live Oak Canyon Formation is divided into five layers, whereas other units are NOT subdivided into multiple layers (such as the Shallow and Lower Deep Aquifers in Chino Basin)	Table 1 was revised.
56	USGS	Table 2-2	16	Are basement/pre-pliocene rocks part of layer 7? Make this clear	Table 1 was revised.
57	USGS	Figure 1	-	Put the groundwater basin boundaries on this map. Will help reader locate each of the basins relative to geography. Especially useful for Physiography section.	Basin boundaries were added to Figure 1.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
1	WEI	Section 3.0	23	Because the stakeholders consist of largely non-groundwater model professionals, it would be useful for the stakeholders for the authors to elaborate on the important features included in the references cited on page 23 (first full paragraph) that they will adhere to in the model build and calibration. And, that the documentation that reports the calibration results demonstrate adherence.	Additional text was added in Section 6.4.1.
2	WEI	Section 3.2.1	25	On page 25, in the first full paragraph, the authors state that: "In general, model calibration is acceptable with a relative error (the standard deviation of the groundwater level residuals divided by observed head range; Zheng and Bennett, 2002) of 10%". It is unclear from the literal reading the TM if this criterion will be used to determine that the calibration is "acceptable". The TM needs to be precise as to the criteria used to assess calibration performance. Attached is a pdf of the section of the Zheng and Bennett citation regarding assessment of model calibration. The citation describes various quantitative approaches to assessing calibration that include, among others, relative error. It is our professional opinion that relative error is not appropriate: it is misleading, it involves a value judgment that stakeholders to the modeling effort should fully understand and that the stakeholders, based on full understanding of relative error, have a chance to accept or reject it as the calibration criterion. The second full paragraph on page 320 of the attached citation characterize the use of relative error method: "it might be acceptable", "might be more meaningful" and "crude". The expressions "it might be acceptable" and "might be more meaningful" suggest that the stakeholders should be fully informed as to what the relative error implies. For example, would the stakeholders accept a 100-ft value of standard deviation of the groundwater level residuals if the range of observed heads was 1,000 ft that yielded a relative error of 10 percent. It is our professional opinion that given the level of modeling that has historically occurred in the watershed that relative error criterion is not unacceptable. Zheng and Bennett in the cited reference do not offer guidance that relative errors less than 10 percent are acceptable as a criterion to assess calibration.	Relative error is only one measure of model performance. Additional quantitative and qualitative techniques were also used to assess model calibration, as presented in TM No. 3. Reference was corrected in TM No. 3.
3	WEI	Section 3.2.1	-	In all the workshops and writings to date there has substantial discussion on geology and aquifer geometry and vary little discussion on hydrologic methods and assumptions used to determine recharge and discharge terms that are used directly in the IM. The hydrology of the IM is what drives the groundwater-surface water interaction that seems to the driver for the development and application of the IM. There should be written documentation for the recharge and discharge components that are directly inputted to the IM and it should be reviewed and validated prior to calibration.	Existing models were only updated for this project. Recharge and discharge terms for the existing models are described in their modeling reports. Terms for the newly constructed Chino Basin Model are discussed in the summary report.

Comments Received and GEOSCIENCE Responses for Draft TM No. 3: Model Calibration

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
1	BGW			Specific storage appears high in some areas.	Some areas, particularly in the upgradient portions of Rialto-Colton Basin, were assigned semi-confined storage properties based on observed water level data. Other areas were updated with lower specific storage in the refined model. OCWD also commented on storativity values in Layer 2 in Chino Basin being low. We updated these areas as well.
2	BGW			Transmissivity distribution at locations of specific capacity tests appear to be higher than the model transmissivity distribution.	Some selection bias is present when comparing specific capacity data to the model distribution of hydraulic conductivity because wells are preferentially completed in productive portions of the aquifer, while the model domain covers all areas. Overall, the range of hydraulic conductivity observations is consistent with the range in the model.
3	BGW			One area of shallow groundwater ET was identified that was inconsistent with the land cover for that area.	This area was updated with no groundwater ET based on land cover information.
4	BGW			Some areas adjacent to the stream boundary have high water levels.	Streambed conductance was adjusted during the additional calibration. Stream elevations and numbering were updated. The LPF package was updated (primary storage coefficient in Layer 1) and the stream elevations adjusted to reduce high water levels near the stream in the GW model.
1	Flow Science		Figure 12	Figure 12 in the TM states that recharge from precipitation is 1,990 af/y in the Rialto Colton Basin (RCB) and 26,690 af/y in the Chino Basin. According to DWR Bulletin 118 (p.153) the area of the Chino Basin is 154,000 acres and the area the of the RCB 30,000 acres. This means that the implied recharge from precipitation averages 0.066 ft/yr (0.8 inches/yr) in the RCB and 0.175 f/yr (2.1 inches/yr) in the Chino Basin, or 2.6 times that in the RCB. It seems likely that the precipitation would be higher in the RCB (higher latitude) than in the Chino Basin so it is not clear why the rate of recharge from precipitation is so much higher in the Chino Basin.	The scope of the work for the Integrated SAR Model is to integrate the five existing models (Yucaipa, SBBA, Rialto-Colton, Riverside-Arlington, and Chino) with unified model layers. However, the recharge and discharge terms remain largely similar to the existing models except for ET and streambed percolation. Differences in recharge from precipitation result from differences in estimation methodology between the two groundwater basins. In the Chino Basin, the HSPF watershed model was used to estimate deep percolation from precipitation since the existing Chino Basin model data (WEI, 2015) is not available. In Rialto-Colton, an empirical approach was used (i.e. 0.5 in/yr plus additional water added in very wet years).
2	Flow Science		Figure 8	Figure 8 shows average mountain front inflow to the RCB from the San Gabriel Mountains of 3,370 af/y, while Figures 20 and 75 show underflow inflow to the Chino Basin of 32,370 af/y and the text (Section 6.3.6) states that the majority of this flow was across the northern boundary of the Chino Basin, and thus from the San Gabriel Mountains The length of this northern boundary in the Chino Basin appears to be about 6 times that of the San Gabriel Mountain inflow boundary into the RCB, which implies that the rate of inflow per unit length of boundary in the Chino Basin is about 1.6 times that into the RCB, which again seems unlikely given the more northern location of the RCB.	The upslope contributing area for the Rialto-Colton basin boundary (yellow) is only approximately 1,400 acres with annual precipitation ranging from approximately 25 in/yr to 35 in/yr. However, the upslope contributing area north of the Chino Basin (green) is almost 50,000 acres (more than 30 times Rialto-Colton upslope area) with annual precipitation ranging from approximately 20 in/yr to 45 in/yr.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
3	Flow Science			I note your comments below about the NW Chino Basin and thought you may have an interest in an analysis that I did some 9 years ago to try and get some idea as to whether the Rialto-Colton Fault Zone was in fact impervious in this area, which has long been the accepted wisdom, but seems to be inconsistent with the groundwater contouring in the Chino Basin. The second part of the attached memorandum is a description of a mass balance I performed on a section of the NW Chino Basin adjacent to the RC Fault in an attempt to answer this question. So far as I am aware this analysis has never been refuted, apart from criticism that WEL and the USGS perhaps did not draw the GW contours correctly. More recently the USGS (John Izbicki) did some spinner log studies in FWC Well F-26 and showed that water was in fact welling up near the base of the well, obviously driven by some excess pressure and the only apparent source of this excess pressure is the high ground water levels in the Rialto Colton Basin across the adjacent RCF. Izbicki's isotope and chemical analysis also tended to show that this water was similar in nature to the RCB ground water.	The mass balance presented offsets the groundwater deficit with inflow from the RC fault. Decline in groundwater storage as a result of this groundwater pumping would extend well outside the control volume shown and would induce flow into the control volume and decline in groundwater storage outside the control volume. Because of these factors, we don't think the control volume analysis conducted can be applied to infer inflow across the Rialto Colton fault. Also, water levels in USGS wells to the northwest show water levels of 950 to 1000 feet, indicating possible inflow from the northwest.
1	OCWD	General	-	We are very pleased with the level of effort and results so far by Geoscience and their inclusion of comments by the TAC. Transient calibration of the Integrated SAR Model has noticeably improved the model accuracy throughout much of the model domain, and Geoscience is to be commended. However, there are still some areas of the model in which the match between simulated and observed heads still needs improvement, primarily in the upgradient portions of the model closer to the mountain-front areas in the Yucaipa and San Bernardino basins (SBBA). The calibration appears to be better farther downgradient but there still appear to be a few other localized areas requiring fine-tuning, such as the upgradient portion of Rialto-Colton Basin and a couple areas in Riverside-Arlington and Chino Basins, especially near the model boundaries.	We have further refined the calibration of the model. Further refinements in calibration in upgradient areas may require updated methodology for estimating boundary inflows from bordering catchments, which is out of the scope of the current integration effort.
2	OCWD	General	-	The groundwater modeling standard repeated numerous times in TM3 regarding the relative percent error being less than 10% is not a sufficient calibration metric on its own and should not be described as such. It is a referenced guideline and is more applicable to site models than large regional models such as the Integrated SAR Model (ISARM). For example, in the ISARM, observed heads range from approximately 400 to 2,400 ft above msl from Prado to Yucaipa Basin. Thus, 10% of this 2,000-ft head range would be 200 feet, and I don't think anyone would agree that the model calibration would be acceptable if the average residual (difference between simulated and observed heads) were as large as 200 feet. So, maybe adding some text to qualify this calibration guideline would be warranted.	It is not the intention of the report or the text to present relative error as a singular calibration metric. A substantial portion of the calibration discussion is devoted to the analysis of the distribution of residuals in both space and time. We will remove language on the calibration plots themselves and provide some additional discussion on relative error. Normalized error metrics are useful for comparing between groundwater basins because RMSE is inherently higher when the observed variation in natural water levels is larger.
3	OCWD	General	-	It seems to be implied throughout TM3 that a calibration fit in which the head residual is within +/- 30 feet at individual wells is quite good. In some outlying less critical areas of the model, or at wells that have very large temporal head variations, this may indeed be the case. However, in sensitive areas such as Prado Basin where groundwater levels do not vary as much and a groundwater elevation difference of even 5 to 10 feet can be critical to riparian habitat, a head residual within +/- 30 feet is not a sufficient barometer.	As a general guideline for our figures, we pick and maintain a scale and consistency of presentation throughout the report. We focused on calibration in the shallow wells in sensitive areas. The root mean square error (RMSE) for all water level observations in a given groundwater basin or in the entire model domain is a metric discussed in the calibration section. A head residual of +/-30 ft at individual wells is not a calibration metric used in the calibration of the groundwater model.
4	OCWD	General	-	Related to comment 3 above, I recommend that the residual head histograms (e.g., Figures 102, 110, 119, 128, 137, and 146) should have 20-foot groupings rather the existing 30-foot and 60-foot groupings. The existing 60-foot grouping in the center (+/- 30 ft) does not provide enough detail. For example, you could use the following categories: <-100, -100 to -80, -80 to -60, -60 to -40, -40 to -20, -20 to 0, 0 to 20, 20 to 40, 40 to 60, 60 to 80, 80 to 100, and >100.	Figures were updated to have a 20 foot bin size.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
5	OCWD	General	-	Were calibration hydrographs prepared for all of the calibration target wells listed in Tables 2 through 6 or just the ones shown in appendices B, C, D, E, and F? If so, did Geoscience use all of the calibration hydrographs for evaluating the calibration and making adjustments?	Calibration hydrographs were prepared for a subset of all observations based on period of record and geographic distribution.
6	OCWD		Page 8	The statement that the calibration is acceptable because 58% of simulated heads were within 30 feet of observed heads is not a sufficient metric in my opinion. A residual of 30 feet is still a significant difference when reviewing most calibration hydrographs. Also, 58% within 30 feet means that 42% were greater than 30 feet, and 19% were greater than 60 feet, indicating that further calibration fine-tuning may likely be warranted prior to using the model as a predictive tool.	We have performed additional model calibration. Additional calibration improvement in certain areas may still be possible. Viewed in comparison with the calibration results from previous individual basin models, the calibration metrics (mean residual, RMSE) are comparable to previous modeling studies. For the overall region, even if some areas are improved, large changes in the overall calibration metrics are not anticipated.
7	OCWD		Table 1.6 - 1.10	Please add R-squared statistic. I believe Farid had asked for that to be added at a prior workshop. Tables 1-6 and 1-7 indicate that the ISARM calibration is likely less accurate than the original local models for Yucaipa and SBBA.	R-squared has been added to the tables. We have added root mean square error (RMSE) to the calibration statistics based on Dr. Boushaki's suggestion, as well as Nash-Sutcliffe Efficiency (NSE) to the stream calibration statistics.
8	OCWD		Page 8	What is the acreage and square miles of the active portion of the model? Although it is not stated, I believe the acreage reported here is for the entire rectangular model domain that includes inactive cells.	The model active area is approximately 505 square miles or 322,925 acres.
9	OCWD		Figure 16	Areas of rising groundwater are not visible except for Prado Dam area.	Rising groundwater areas figure was modified so that the areas are visible.
10	OCWD		Figure 17	No artificial recharge locations shown for Riverside-Arlington Basin but Figure 18 shows approx. 12,000 AFY of artificial recharge.	We have updated Figure 17 to show the RIX percolation ponds.
11	OCWD		Page 39	The draft tech memo says "As shown in the tables above, riparian habitat generally increases throughout the simulation period. The vegetation is likely responding to an increase in water availability (due to reduced agricultural diversions and increased discharges from upstream users) and timing of flows in the SAR and its tributaries." Since 2005, inflows into Prado Dam Basin have generally been declining due to decreased discharges from some upstream agencies and the drought. Suggest revising this text to more clearly define different time frames when flows increased or decreased.	Text was updated.
12	OCWD		Figure 21	Please provide figures zoomed into the Prado area showing riparian areas (Figures 21 and following have too large of a map extent to see the details in Prado Basin).	We have updated the Prado Basin figures to show more detail in an inset map.
13	OCWD		Figure 21-25	Why are shallow GW areas only shown on Figure 26 (for 2015-16) but not on Figures 21 through 25? According to Table 4-1, the shallow GW areas also existed during the previous years as well.	We have updated Figures 21 – 25 to show the shallow groundwater areas on the previous years as well
14	OCWD		Addtnl Fig	Please provide a map to document the location of pumping wells in Prado Basin that occurs in the model period of 1966-2016 and the annual pumping values (this could be shown on the figures for Prado Basin riparian areas mentioned in the previous comment).	An additional figure has been added.
15	OCWD		Table 4-2	Some of the numbers in the bottom row of table 4-2 do not add up correctly compared to the values in sub-totals in the table.	Sub-totals and numbers in Table 4-2 have been corrected.
16	OCWD		Fig 29 to 33	See previous OCWD (Tim Sovich) comments 5 and 6 on TM1	We have annotated figures with geographic references.
17	OCWD		Fig 56 to 63	add geographic references or features to cross-sections, such as SAR crossing, hill names, fault names, etc.	We have annotated figures with geographic references.
18	OCWD		Fig 63	In central portion of cross-section (Pedley Hills outcrop?), it seems like the layering should pinch out instead of not showing any layering, and should the red layer 6 outcrop at ground surface?	Water becomes rising groundwater at MWD crossing.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
19	OCWD		Fig 64	Recommend having a separate figure for each layer since the images are too small; possibly show structural contours or a more detailed color ramp display to provide more detail of the structure throughout the model domain. It is not clear if Figures 67 through 70 are initial or final calibrated aquifer parameters. If initial, then an additional set of figures should be added to show final aquifer parameter surfaces at end of transient calibration. Also, recommend adding a summary table of final aquifer parameters (K and S), showing the min, max, and average values for each model layer.	A summary table of aquifer parameters was added.
20	OCWD		Section 6.2.2	How were the vertical hydraulic conductivities (Kv) originally determined? Typically, common modeling practice assumes Kv is approximately 10 times smaller than horizontal conductivity (Kh). Your Kv values seem very small. For example, your max Kh of 450 ft/day would typically correlate to a Kv of approximately 45 ft/day for most depositional environments. However, your small Kv values of less than 0.001 ft/day seem more indicative of an aquitard.	Methodology to derive Kv varies by individual basin model. Some areas of the model have clay layers that act as aquitards in the vertical, but do not inhibit horizontal flow.
21	OCWD		Section 6.2.3	It would be helpful to discuss in the text what areas of the model and in what layers (layer 1 only?) do unconfined water table conditions exist.	Additional text was added.
22	OCWD		Section 6.2.4	Storativity or primary storage coefficient (S) of Layer 2 in Chino Basin looks unusually small at less than 10-6. Typically, S gets smaller with each successively deeper layer (increasing amount of confinement), but in Chino Basin the Layer 2 S values are lower than layers 3, 4, and 5.	S was updated in Layer 2 of the Chino Basin. When Layer 1 was subdivided into two layers, the S assigned to Layer 2 was incorrect. S does not necessarily decrease with depth, both due to depositional patterns and the linear relation to layer depth. For example, if Layer 5 were to be 500 feet thick and Layer 4 were 50 feet, all other things being equal, Layer 5 would have 10 times the storage coefficient
23	OCWD		Section 6.3.7	Add a paragraph and/or table comparing Table 4-4 Prado ET demand with model calibrated ET.	The text was updated in the summary report.
24	OCWD		Page 63	The draft tech memo says "ET extinction depths for riparian plant functional groups were developed from literature values (Maddock et al., 2012). The extinction depths ranged from a minimum of 3.28 ft (1 meter) up to almost 20 ft, depending on the type of riparian vegetation present. The majority of vegetation in the model simulation area was deep rooted riparian vegetation, as shown in Table 4-1." Please provide a table listing the extinction depths for each type of riparian vegetation.	A table of extinction depths was added.
25	OCWD		Figure 77, Table 4-4	The green line shown in Figure 77 does not match some of the values in Table 4-4 (for example, one of the values in the bottom row of Table 4-4 is greater than 30,000, but this does not match Figure 77).	The 2004 mapping did not cover the entire study area and values from the earlier snapshot were used. A note was added to the table.
26	OCWD		Text Update Fig 77	Please provide an explanation of why the Prado evapotranspiration rate changes a relatively small amount in Figure 77 from about 1993 to 2016; explain what this indicates about groundwater conditions in Prado Basin.	Vegetation coverage remains similar in overall acreage. Also, reductions in groundwater pumping for agriculture and water availability may contribute to more stable groundwater conditions along the SAR.
27	OCWD		Fig 77	It would be helpful to show monthly variations in the Prado evapotranspiration so that the monthly variations can be evaluated; please present a figure showing monthly evapotranspiration for the last five years of the simulation period.	We have prepared a figure showing monthly ET for the last five years of the simulation period.
28	OCWD		New Table	It would be helpful to present the summation of the groundwater evapotranspiration and surface water evapotranspiration - please present a table showing the combined surface water and groundwater evapotranspiration by month for the last five years; and a table showing the annual value of combined surface water and groundwater evapotranspiration for the model period.	A breakdown of ET by land cover type can be provided.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
29	OCWD		Section 6.4.1.1	Visual comparison of simulated to observed water level contour maps should be added to the list of calibration metrics so as to make sure that the simulated lateral gradients and groundwater flow patterns are reasonably consistent with those observed.	Figures showing groundwater contours have been added to the TM.
30	OCWD		Figure 89	Calibration target wells not shown.	Figure 89 has been updated to show calibration target wells.
31	OCWD		Figure 93	The last 10 years of the model period has the largest mean residual (-8 ft), likely due to a poorer fit at the larger number of available target wells during these more recent years. Model appears to be over-estimating heads during this time (2007-16).	Comment noted. We agree but do not think an -8 ft mean residual is excessively large.
32	OCWD		Tables 2 through 6	Recommend sorting by layer number. Also, how is the representative layer chosen for the calibration with observed heads for wells without known screened interval?	We can sort the tables by layer number. Other well completion information such as drilled depth and well type can be used to assign representative layer.
33	OCWD		Figure 94	Layer 1 average residuals too large in upgradient areas of model near mountain-front. Further calibration seems warranted in these areas. Also, gradient seems to be off moving just downgradient from mountain-front areas. May need to add more water along mountain-front and/or adjust Kh.	Comment noted. We have conducted additional calibration of streambed conductance and hydraulic conductivity, but calibration has not improved significantly immediately adjacent to the mountain front. Additional improvements to the methodology for estimating mountain front recharge are outside of the scope of the current integration effort, and higher residual in these areas should not adversely affect the results of the scenario simulations.
34	OCWD		Figure 95 and 96	Layer 2 and layer 3 average residuals too large in Yucaipa Basin, respectively.	Relative error has improved slightly and RMSE of the Yucaipa model has also improved.
35	OCWD		Figure 97 and 98	Layer 4 and 5 average residuals being opposite in sign going downstream suggests that the lateral gradient is likely off, may need to adjust Kh in this area.	We have conducted additional Kh calibration in the SBBA area. Some improvement has been realized in this area.
36	OCWD		Table 6-7	Magnitude of mean residual (-16ft) nearly double that of the original SBBA model. ISARM calibration appears to be worse than original SBBA model for that area.	The mean residual is 5 feet higher than the original SBBA model. However, both RMSE and relative error metrics have been improved.
37	OCWD		Figure 112 through 117	Simulated heads appear to be too low upgradient in the area where observed heads range from 1500 to 1900 ft msl and too high in the downgradient area where observed heads range from 800 to 1100 ft msl. This implies that the lateral gradient in this area is too flat and that Kh may need to be decreased.	Comment noted. We have reduced Kh in zones in the northwest middle area of the model area in Layers 4 and 5. This has improved both RMSE and relative error.
38	OCWD		Figure 120 (a,b)	Simulated heads not responding enough to high wet years such as 2005 and 2011.	Some improvements have been made in hydrograph response with additional calibration of hydraulic conductivity and streambed conductance in some wells.
39	OCWD		Table 6-8	Mean residual for Rialto-Colton Basin of 21.4 ft seems too high and is worse than original model for that area.	Mean residual has been improved in the updated model. Overall, model performance has been improved with both RMSE and relative error metrics reduced as compared to previous models.
40	OCWD		Figure 121	Simulated heads too low in upgradient portion of Layer 1 in the Rialto-Colton Basin. Are these truly "perched" water levels? Or possibly the model is not allowing enough water to pass through the Rialto-Colton Fault in Layer 1.	We think these water levels represent perched condition. The estimate of flux from SBBA into Rialto Colton is consistent or higher than other estimates. If more water was allowed to pass through the Rialto-Colton Fault (RC to Chino Basin), water levels would be lower and the simulated heads would exhibit even higher water level residuals.
41	OCWD		Figure 125	Simulated heads show a bias of being mostly too low in Layer 4 in Rialto-Colton Basin.	This bias has been improved in the updated model.
42	OCWD		Table 6-9	Relative error of 8.6% is quite large and higher than local Riverside-Arlington model. 8.6% of the range in heads across the entire ISARM domain (~2,000 ft) would be 172 ft, which is a large discrepancy between simulated and observed. Not sure why the relative error is so large since most of the calibration hydrographs in Appendix E look good.	Relative error is normalized by the range of observed water levels. The range of observed water levels in Riverside-Arlington is smaller than elsewhere in the model domain.
43	OCWD		Fig 131, 134, and 135	Which calibration target well(s) are responsible for causing the scatter plots to be biased with simulated heads too high in the upgradient portion of Riverside-Arlington Basin? The selected hydrographs in Figure 138 look good however.	A few USGS wells are contributing to the observed bias in this area in Riverside Arlington.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
44	OCWD		Figure 140	Simulated heads skewed too high in upgradient portion of Chino Basin. Are these data points from the two USGS multilevel monitoring wells? Can the fault properties in this area be adjusted to achieve a better fit?	We have calibrated to these wells and reduced the error significantly in this area. The water levels in these wells are 200 - 300 feet above other groundwater observations in the area. These water levels may represent perched conditions (200 – 300 ft higher than basin groundwater levels).
45	OCWD		Figures 148 and 149	Suggest adding word "simulated" to Groundwater Elevation in legend. I like these two figures but suggest combining into one figure with both wet and dry curves for easier comparison. Figure 149 title block should read "wet" hydrology rather than "dry."	Typo in title was corrected.
46	OCWD		Figure 158	I believe this should be E Street, not MWD crossing.	Good catch. The title was updated.
47	OCWD		Section 6.4.3.1.5	Recommend adding a separate section on Prado Basin calibration. Even though it is a part of Chino Basin, it would be helpful to have it broken out separately if possible.	A sub-section on Prado Basin calibration was added to the TM.
48	OCWD		Appendix B	Yucaipa Basin calibration hydrographs: Recommend additional calibration refinement.Examples of hydrographs needing improvement are listed below: o SMWC_Well_1 (p.B-3): simulated heads approx. 250 ft too low, trend Ok. o Equestrian Park_1,2,3,4 (pp. B-5 through B-8): too much amplitude, S too small? o USGS_MonWell_6 (p.B-19): simulated heads approx. 150 ft too low o Wilson Creek wells (pp. B-20 to B-23): amplitude too small from low to high years o YVWD_Well_51 (p.B-37): simulated heads approx. 150 ft too low	Some amplitude improvement was realized at Wilson Creek wells. USGS MonWell_6 is 150 above other observations at the same well.
49	OCWD		Appendix C	SBBA calibration hydrographs: Recommend additional calibration refinement. Examples of hydrographs needing improvement are listed below:	Some refinement of hydrographs is shown in the final TM.
				23rd_E (p.C-8) and several other wells: amplitude too small between wet and dry periods	
				LeRoy (p.C-14): simulated heads approx. 100 ft too high in later years	
				Model does not appear to be simulating downward trend sufficiently from 2000-16.	
				Cone Comp_3,4,5,6 (pp. C-52 to C-55): simulated heads approx. 150 ft too low at the last two high water level periods (2006 and 2012)	
50	OCWD		Appendix D	Rialto-Colton calibration hydrographs: Most of the hydrographs look good, except for the following that could possibly use improvement:	We have made calibration refinements to address this comment.
				CMW-05A,B,C (pp. D-9 to D-11): simulated heads 30 to 50 ft too low	
				F10C (p.D-16): simulated heads approx. 100 ft too low in later years	
				1N/5W-21K and -22N (pp. D-27 to D-35): simulated heads approx. 50 to 100 ft too low in later years, trending downward too steeply and missing wet period peaks	
				WVWD-23 (p. D-79): simulated heads approx. 200 ft too low and too much seasonal variation. Observed water levels are unusually flat; could they be perched?	
51	OCWD		Appendix E	Riverside-Arlington calibration hydrographs: Most of the hydrographs look good, except for the following that could possibly use improvement:	We have been able to refine the calibration in some areas.
				Buchanan (p.E-4): simulated heads approx. 50 ft too low last 10 years	
				01S/4W-29H and 1S/4W-29K (pp. E-26 to E-34): simulated heads 50 ft too high at end of run because head decline not steep enough the last 10 years of run.	
52	OCWD		Appendix F	Chino Basin calibration hydrographs: Most of the hydrographs look good, except for the following that could possibly use improvement:	P_16 matches during most of the period. We have not made local changes to flux terms to improve the overall calibration at individual wells.
				P_16 (p. F-26): later trends good but not matching the decline during the 70s drought	
				1N/6W-26A035 (p.F-44): simulated head trend is good but approx. 50 ft too low overall	1N/6W-26A035 has been improved hundreds of feet and may represent perched water level

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53	OCWD		Add a Table 14	Figure 167 presents a graphical display of the average water budget for Prado Basin for 1966 to 2016; it would be helpful to evaluate how the water budget terms vary from year to year; please present a table (suggest adding a Table 14) showing the annual values for the period from 1966 to 2016 as was done for each groundwater basin.	A table added as suggested.
54	OCWD		Figure 167	Please include a map showing the boundary of the Prado Basin area that was used for the Prado Basin water budget.	We have included a map showing the Prado Basin Boundary.
1	RPU		General	I would suggest in future TM's especially if the document is large with high-resolution figures (TM3 is 671 pages), that the document needs to be broken into sections (main document, appendices, and such). It was tedious to navigate the whole document for review (especially when you get to the figures, took long time to move from one figure to the next).	We have updated our report pdf process to make a smaller .pdf without vector graphics that take longer to render.
2	RPU	1.3	3	The word accuracy In order to simulate the streamflow accurately" is a strong word to describe this exercise given the complexity and variability that exist in such a scope, I suggest using "Reliably" or "as accurate as possible" (will depend on the model performance criteria used and the calibration results that will be discussed in detail below).	Language was updated.
3	RPU	5.4	4	The calibration approach was not comprehensively discussed. How did the calibration been performed (Systematic search algorithm used if any (i.e. PEST) or manual calibration, was a sensitivity analysis performed pre calibration to narrow the parameters pool which will make the calibration more efficient? what objective function minimized?). Also, the standard model calibration criteria are not used except for the statistical comparison and R-square and a qualitative performance such as "good", "very good",... In addition, The Nash-Sutcliffe efficiency (NSE) index, a normalized statistic that determines the relative magnitude of the residual variance ("noise") compared to the measured data variance ("information") (Nash and Sutcliffe, 1970). The NSE index indicates how well the plot of observed versus simulated data fits the "perfect-fit" line. The Nash-Sutcliffe Efficiency model (Nash and Sutcliffe, 1970) is used to assess the predictive power of hydrological models. In this method, a value of one indicates a perfect model, a value of zero indicates that the model results are no better than the mean measured value, and a value less than zero indicates that using model estimates would be worse than using the mean. The Percent Bias (%Bias) should be a good measure especially in the integrated GW model as we see some systematic errors appear between the modeled and measured data (in appendices B-F)	We used a combination of model performance metrics during the calibration process. Hydrographs and water balances were prepared and analyzed following each model run. Streamflow performance was assessed using hydrographs and statistical metrics. Residual plots, statistical measures including mean residual, RMSE, and relative error were assessed each run to evaluate improvements. Spatial and temporal distribution of residuals were also assessed. NSE has been added to the summary statistics for each basin.
4	RPU			A discussion on the gains from model integration vs the increase in complexity as the scale of the model is getting bigger will be beneficial to the stakeholders to make a better decision on what project is better fit for using the integrated model or not as mentioned in the RFP goals."	Comment noted. Discussion was added in the Uses and Limitations section of the summary report.
5	RPU			Include an appendix describing the calibration process in more detail as it can be too technical in the main document (As mentioned in Page 8 of Key issue #6 in Geoscience Proposal): i.e.: calibration process as discussed above, target parameters to be improved, objective functions, description of different performance measures. This will increase the value of this acclaimed tremendous effort.	Comment noted. Additional discussion was added.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
6	RPU			How is Key issue #5 on Page 7 in Geoscience Proposal being resolved or determined with regard to the underflow from Riverside Basin to Chino Basin?, knowing that the difference range is quite substantial from previous models.	The fluxes are now explicitly simulated between the two basins. Previously, the flux was either a specified flux or head boundary of some type.
7	RPU			Model calibration and validation are necessary steps in any model application, along with a warmup period. The warmup period is a necessary phase in most hydrologic modeling in order to reduce the impact of the initial conditions of the state variables and to stabilize model convergence. This process has been performed by Geoscience under what they called Pseudo-steady-state simulation. The calibration phase is an iterative procedure for finding the optimum parameters (coefficients in this study) that reduces the objective function chosen when comparing simulated and observed values of interest. Model validation could be seen as an extension of the calibration process to ensure that the calibrated model properly assesses all of the variables and conditions, which can affect model results, and to demonstrate the ability to predict observations for periods that were independent from the calibration period. Please refer to an original paper discussing the importance of these steps for a successful model calibration exercise by V. KLEMEŠ (1986) Operational testing of hydrological simulation models, Hydrological Sciences Journal https://www.tandfonline.com/doi/pdf/10.1080/02626668609491024	Comment noted. That approach was not taken here. All data from 1966 to 2016 was used to calibrate the groundwater model.
1	USGS			Geologic map (Figure 7a) needs revised: Live Oak and San Timoteo colors need switched. Update map with new geology (some older San Timoteo Formation relabeled as Live Oak) and cite written/oral communications."	We have updated Figure 7a.
2	USGS			The water budget should be clean and unambiguous; identical terms should refer to identical things.	Terms were clarified.
3	USGS			Key milestones should be noted on hydrographs (e.g., when Seven Oaks Dam was installed, when discharge from San Bernardino Water Reclamation Plant transferred to RIX, etc.).	We have annotated hydrographs to show key events.
4	USGS			The "bounce" in streamflow in the 1990s is worth describing. May relate to bank storage and aquifer interaction, or it may be that discharges at RIX slowly increased during this period.	Text was updated.
5	USGS			Create a new figure with imbedded pie charts illustrating the relative contribution of various flux terms and their locations.	Figures were added with pie charts illustrating relative contributions.
6	USGS			Revise model figures to allow the hillshade and geographic features to be visible (similar to the style used on Figure 14).	We have updated the figures to adopt this style.
7	USGS			In the conceptual model section, create a map illustrating where geology is uncertain (gray out all geology and highlight uncertain areas in red).	We updated the report to include these figures.
8	USGS			Refer to initial model run as "initial condition simulation" instead of "pseudo steady-state".	The text has been updated accordingly.
9	USGS			Color code dots on residual plots by model layer.	The residual plots have been color coded.
10	USGS			Add text indicating model over/under-estimation on histograms.	The histograms were annotated accordingly.
11	USGS			Create a figure illustrating vertical movement of water: 5-panel figure (1 for each model layer). Make as simple as possible (remove unnecessary text). Calculate average head per model cell over the entire calibration period. Subtract top layer from layer below to determine gradient direction.	Report was updated to include these figures.

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				Use 2 colors (e.g., blue down, orange up) to indicate movement direction.	
				Should match trends seen in multi-depth wells."	
				Also select 3-5 areas of interest or dynamic areas (e.g., Prado, E Street, marshland, etc.) over the transient period to illustrate vertical movement of water.	
12	USGS			Create a figure illustrating spatial distribution of change in groundwater storage:	Report was updated to include these figures.
				5-panel figure (1 for each model layer).	
				Calculate change in storage per model cell over the entire calibration period."	
				Should be able to see where storage depletion is occurring.	
				Make as simple as possible (remove unnecessary text).	
				Use 3-5 colors. Try to keep the same color range for all confined conditions. See if the same colors can be used to represent 10x that range for unconfined conditions.	
13	USGS			Identify key changes made during model calibration to help future investigations. The method of solution may not be right, but the perception of the problem is.	Additional discussion was added
14	USGS			Point out and describe number of zero flow at the SAR at E. Street Gaging Station (Figure 155).	Additional discussion was added
15	USGS			Add a footnote stating where fluxes may be off (e.g., unsure of underflow from Yucaipa, precipitation and mountain front runoff may be too high, etc.).	Additional discussion was added
16	USGS			Change in storage in the SBBA warrants investigation. Underflow outflow to Rialto-Colton may be too high. The mountain block should be draining, but the model lacks a mechanism to simulate this effect.	Comment noted. We will take a look at change in storage in SBBA.
17	USGS			Calculate some ratios or percentages for recharge/discharge terms (e.g., What percent of streamflow is mountain front runoff? What percent of underflow? etc.).	Figures were added with pie charts illustrating relative contributions.
1	Waterboard			In general, using the names of SBBA, Bunker Hill and Lytle basin was confusing to me and maybe for everyone who was not involved from the beginning and/or is not familiar with the hydrogeology of the Upper Santa Ana River watershed. All figures shown only SBBA basin, text and some tables include SBBS or Bunker Hill and Lytle basin. DWR's Bulletin 118 does not even list Lytle basin. The report needs a figure to show these basins.	Figure 1 was updated and clarifications were added to the text.
2	Waterboard			Clarify "no-flow" Also confusing are maps showing "no-flow area" from which underflow is calculated and included in the basin budget. I understand that hills and mountains formed by low permeability bedrock are no-flow areas but it would be better for a reader to call some of this "no-flow areas" as "adjacent basins" or out of model basins if this is a case such as San Gabriel Valley, Cucamonga or San Timoteo basins.	No-flow area is somewhat synonymous with "Inactive" area in MODFLOW. This was clarified the text.
3	Waterboard			Reference to underflow graphics (figs. 150 through 154); these graphs do not include underflow from out of basins; can these graphs be created or those underflow were kind of constant throughout the simulated period?	These figures show boundary conditions, and in this case, the underflow boundaries are inflow boundaries. Internal to the model domain, underflow between basins is explicitly simulated.
4	Waterboard			No calibration Water Level Target Well are shown in this figure.	Figure 89 has been updated.
5	Waterboard			Could underflow inflow along north-west boundary of the Chino basin be used to improve model calibration in this area? Model peer review presented on July 18th indicates some potential for improvement in the north-north-west part of the Chino basin.	We have taken a look at the calibration in this area. The model undersimulated water levels in this area in previous versions of the individual Chino Basin model, but has since been updated with higher boundary inflows along the northern model boundary, which has addressed the undersimulation bias. Boundary inflow and return flows are areas of the water budget with some uncertainty.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
1	WEI			The comments presented herein cover two topics: the ISARM model calibration and the application of the ISARM to evaluate the various planning scenarios included in so-called Scenario 2. The comments on the ISARM calibration report were developed in the fall of 2018 and for various reasons were not shared outside of the Chino Basin Watermaster (Watermaster) and Inland Empire Utilities Agency (IEUA). The intent of this document is to informally share our concerns regarding the ISARM and the way it is being used to evaluate the HCP covered projects with Geoscience and the Valley District.	Draft TM-3 was delivered to the group on June 29th, 2018. Comments from the TAC on draft TM-3 were requested by July 20th, 2018 and extended to July 27th, 2018 at the July conference call. Comments from other TAC members (USGS, BGW, RPU, OCWD, Flow Science, and the Water Board) were reviewed at the September 14th, 2018 workshop. Comments regarding draft TM-3 and the calibrated model not received on-time are more difficult to incorporate, cause project delays, and increase cost. The reason for the delay is unclear.
2	WEI			Per Watermaster and IEUA requests, we reviewed and subsequently prepared several comments on the Upper Santa Ana River Integrated Model TM No. 3: Model Calibration (TM3), and these are contained below. Initially, our review was limited to the Chino Basin, but we subsequently expanded it to the entire document. We reviewed the entire report in detail. Our overall opinion is that contrary to the conclusions of the TM3, the ISARM is not ready for use for its intended purpose. Additionally, we would consider pre-mature any use of the ISARM for watershed-scale salinity management investigations or other applications as may be contemplated by several basin stakeholders. Our comments follow two themes: technical comments/concerns to the work presented in TM3 and objections to certain representations stated in the TM3.	We disagree with the opinion that the model is not ready for use and do not believe it is supported by the comments made here-in regarding the model calibration. Based on the consensus from the modeling subcommittee meeting, The Integrated SAR Model seems to be well suited for its intended purpose, and likely is capable of providing guidance in identifying the hydrologic effects of different water-management projects. Additional calibration is not warranted at this time.
3	WEI			Page 18, Section 2.1, the first bullet reads: “Develop a tool that will better serve efforts to conserve and protect riparian habitat and endangered species in the vicinity of the SAR.” How is “better served” defined? One conclusion in the executive summary is that “[o]verall, the calibration results indicate that the standard of calibration achieved in the Integrated SAR Model is suitable for the scale and purpose for which it was developed,” while failing to provide any scientific basis. One of the initial uses of the ISARM is to determine the impact of planned projects on habitat. Surface water discharge is calibrated at three points in the system. For the habitat that may be critical between these points, there are no surface water discharge data for calibration, and there is a paucity of groundwater levels to calibrate to.	The scientific basis is provided in the remainder of the report and discussion on model calibration. Nominally speaking, surface water discharge is calibrated to available data and measurements of discharge aren't available in between. This is true of any monitoring network, regardless of number of monitoring locations. Groundwater levels are similarly calibrated to available data. A monitoring plan is being developed for the HCP. The model is calibrated to streamflow at 3 locations and 888 water level target locations. In Chino Basin, the model is calibrated to additional water level information surrounding Prado Basin and at a monthly stress period and achieves a very similar, in some cases superior level of calibration. (See Table 6-10 in TM-3) The model standard deviation is slightly lower and the mean residual is with the range of values reported for the calibration and validation periods in Chino Basin. Additional language can be added to TM-3 to clarify this point.
4	WEI			Page 18, Section 2.1, the second bullet reads: “Be able to identify locations of perennial rising or shallow groundwater and assess how these areas might be affected by current and proposed projects.” We agree that the model will estimate rising groundwater, streambed infiltration, and reaches underlain with shallow groundwater. That said the model predictions may not be unique and need to be verified with field observations. Otherwise, with a few exceptions, the predicted groundwater interaction at specific locations between the USGS gaging stations is speculative and the impacts to habitat implied by the model are not defensible.	We agree that predictions may not be unique, but this is the case with all numerical models of natural systems. A monitoring plan will accompany the HCP. Additional language was added.
5	WEI			Page 18, Section 2.1, the third bullet reads: “Enhance the HCP baseline condition to include both streamflow and groundwater levels in the Upper SAR region.” What does “Enhance the HCP baseline condition” mean? It seems that this may mean to enhance the understanding of the baseline conditions. If this is true, it should be stated as such, and how the baseline condition is defined should be described; is it a static condition, is it characterized statistically, or is it something else?	Language was updated.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
6	WEI			Page 18, Section 2.1, the fifth bullet reads: “Reliably predict how proposed projects and mitigation measures addressed in the HCP, and potential projects outside of the HCP, will impact flow in the SAR and groundwater levels in the area – particularly in locations of perennial rising or shallow groundwater.” The term “reliably predict” has not been defined. Surface water discharge is calibrated at three points in the system. For the habitat that lies between these points, there are no surface water discharge data to calibrate to, and there is a paucity of groundwater levels to calibrate to: how can it be claimed to reliably predict “how proposed projects and mitigation measures addressed in the HCP, and potential projects outside of the HCP, will impact flow in the SAR and groundwater levels in the area “?	Language was updated.
7	WEI			Page 19, Section 2.3, the text reads: “Since model files were not available for the WEI Chino Basin Model, GEOSCIENCE constructed a separate version of the model based on the approach and data presented in WEI’s modeling report (2015).” And, the fifth bullet reads: “Chino Basin Model (WEI, 2015; reconstructed by GEOSCIENCE for this project).” This is factually incorrect. Geoscience did not reconstruct the WEI model for the Chino Basin. The Chino Basin representation in the ISARM is hydrologically different, is calibrated different, and has poorer calibration results. The paragraph that follows the cited text is also factually incorrect and needs to be modified. As to calibration, WEI uses the approach recommended in Effective Groundwater Model Calibration: With Analysis of Data, Sensitivities, Predictions, and Uncertainty (Hill and Tiedeman, 2010) and more specifically uses sensitivity analysis, optimized parameter identification, and statistical evaluation of residuals techniques using PEST and other tools. Geoscience developed its own hydrogeology and hydrology conducted a trial and error calibration and relied on the relative error statistic to characterize the quality of the calibration.	As explained in the report text, Geoscience constructed a "separate version of the model based on the approach and data presented in WEI's modeling report (2015)" since the WEI model files were not made available. We can add text to explain the differences. We do refer the reader to TM-1 for additional description of the Chino Basin model development and integration. In Chino Basin, the model is calibrated to additional water level information surrounding Prado Basin and at a monthly stress period. The Chino Basin Model used in the Integrated SAR Model achieves a very similar, in some cases superior, level of calibration as that seen in WEI's model (see Table 6-10 in TM-3). The model standard deviation is slightly lower and the mean residual is with the range of values reported for the calibration and validation periods. The text was clarified to this effect.
8	WEI			Page 20, Section 2.5, first paragraph, the text reads: “[…] the Chino Basin Model was constructed and calibrated in the Integrated SAR Model grid based on the approach and data presented in WEI’s model report (2015).” This is factually incorrect. See comment immediately above.	The Chino Basin Model used in the Integrated SAR Model was initially based on information available in WEI's 2015 model report. Fluxes that were unavailable were developed according to the approach outlined in TM-1 and model parameters were modified during model calibration. The text of TM-3 was clarified to reflect this.
9	WEI			Page 32, Section 4.1.2, second paragraph, the last sentence reads: “Previous models include areal recharge from precipitation in various ways. These estimates of areal recharge were incorporated into the Integrated SAR Model.” This is not true for the Chino Basin implemented in the ISARM. TM3 should be corrected and updated to describe the methodology used. A table should be included that shows the areal recharge from precipitation for each groundwater basin. The scale of Figure 12 should be adjusted so that meaningful information can be obtained from it.	This information is included in Tables 8-13 in the report. Additional text was added in the summary report to clarify the approach used in the Chino Basin Model. The scale on Figure 12 was modified.
10	WEI			Page 34, Section 4.1.5, first paragraph, the text reads: “Each of the individual models that make up the Integrated SAR Model include assumptions for anthropogenic return flow, based on previous studies. These estimates, which are detailed in the individual model reports, were included in the Integrated SAR Model.” This is not true for the Chino Basin implemented in the ISARM. The anthropogenic return flows used in the ISARM are not the same as those used in the existing Watermaster model. TM3 provides no information on the methods to develop anthropogenic return flows for the Chino Basin in the ISARM. TM3 should be corrected and updated to describe the methodology used by Geoscience. A table should be included that shows the time series of annual anthropogenic return flows for each groundwater basin. The scale of Figure 19 should be adjusted so that meaningful information can be obtained from it.	Tables 8 - 13 have a time series of annual anthropogenic return flows for each groundwater basin. TM-1 describes in more detail the methodology used to estimate return flow in Chino Basin. Additional text was added in the summary report to clarify approach. The scale on Figure 19 was modified

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11	WEI			Page 34, Section 4.1.6, first paragraph, the text reads: "However, because the northern boundary of the Chino Basin area in the Integrated SAR Model starts below the Redhill Fault (refer to Figure 6), underflow inflow (including contributions from the upgradient groundwater basin area and mountain front recharge) at this point was incorporated into the Integrated SAR Model according to the methodology outlined in the Chino Basin Model report (WEI, 2015)." This is not true for the Chino Basin implemented in the ISARM. The reported subsurface inflows on the northern boundary of the Chino Basin are not the values used in the Watermaster model. The text goes on to say, "Underflow inflow volumes were modified during model calibration (refer to Section 6.3.6 for quantification of this inflow term)." The text in Section 6.3.6 merely states that the initial subsurface flow estimates were increased to improve the appearance of the calibration and provides no other justification or discussion of whether the adjustment of other recharge terms was considered and the rationale for excluding or adjusting other recharge terms. The scale of Figure 20 should be adjusted so that meaningful information can be obtained from it.	The values were incorporated in TM-1 based on the annual values and distribution reported in WEI, 2015 and increased during the calibration. Additional discussion on the rationale behind the increase was provided in the summary report. The scale on Figure 20 was modified.
12	WEI			Most of the production wells in the Chino Basin are perforated in multiple model layers. There is no discussion on how the model-estimated groundwater elevations in each model layer are converted to composite groundwater elevations for comparison to observed groundwater levels. TM3 Table 6 shows the Chino Basin wells that were used in calibration, their perforated intervals, and model layer assignment. It appears that the wells were assumed to be perforated in only one layer even when if they are perforated in more than one layer. The model documentation should be expanded to explain the validity of this assumption and how pumping was assumed to be distributed among the layers.	It is unclear if the comment is primarily referring to groundwater pumping, or groundwater level targets. Groundwater pumping is distributed based on transmissivity. Targets are assigned to the layers based on screened interval information, if available. If a single target was screened in multiple layers, we assigned the target to the shallowest screened layer. This was clarified in the summary report.
13	WEI			During the conceptualization of the Chino Basin for the ISARM and its initial calibration, Geoscience used the same subsurface boundary inflow values (about 19,200 afy) from the Chino/Puente Hills, Six Basins, and Cucamonga Basin as WEI (about 19,200 afy) (see Figure 3). However, this subsurface inflow was increased to 32,269 afy, as reported in the TM3 report (average value from 1966-2016). As mentioned above in Comment 12, the text in Section 6.3.6 merely states that the initial subsurface flow estimates were increased to improve the appearance of calibration and provides no other justification or discussion of whether the adjustment makes sense hydrologically, of whether the adjustment of other recharge terms were considered, or of the rationale for excluding adjustments to other recharge terms.	Additional discussion was added in the summary report. Uncertainties in underflow inflow and areal recharge are discussed in the Sources of Uncertainty section of the summary report.
14	WEI			Groundwater pumping in the Temescal Basin impacts the riparian habitat in the Prado Basin area. There is no discussion of quality of the Temescal Basin calibration. TM3 should be expanded to include the Temescal Basin calibration. We cannot complete our review the of ISARM calibration until this information is provided.	Hydrographs for wells in Temescal basin are presented along with residuals. See Figure 94 for spatial distribution of residuals and Appendix F has well hydrographs in Temescal.

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15	WEI			Page 49, Section 5.3.7 Stream Channel Characteristics, the text reads: "Stream channel characteristics (e.g., lined or unlined) were used to determine the degree to which streamflow is able to infiltrate in stream reaches within the model area. The type of stream channel for each stream reach segment was analyzed to determine the hydraulic behavior through the use of an FTABLE (hydraulic table). FTABLEs determine the infiltration volume of stream reaches by using the HSPF BMP Toolkit created by the USEPA, which takes into account the lining type, slope, Manning's Roughness Coefficient (used for flow calculations), and the length of the stream reach. Each sub-watershed was assigned model parameter values based on the available data in the area." This is basically the same text included in TM1. This discussion refers to the HSPF surface water model used to estimate tributary discharge to the Santa Ana River and has no bearing the ISARM groundwater model. There is no discussion in either TM1 or TM3 of the construction of the streamflow routing package or its data for the ISARM. The source of the channel geometric information is not included in the discussion of the surface water model or the ISARM. The report should be expanded to provide this information (segmentation, cross sections, Mannings "n") and specifically how the surface water discharge and streambed recharge in the HSPF model is related to the ISARM groundwater model.	Additional detail on parameterization of the SFR package was provided in the summary report.
16	WEI			Since this model is supposed to estimate surface and ground water interaction in the stream channel, the channel geometry is very important. The source of the channel geometry should be provided in TM3. The implementation of the streamflow routing package in the ISARM should be carefully described. Also, note that the Santa Ana River tributaries that drain the Chino Basin were concrete lined gradually over time between 1958 and 2000; many retention basins were constructed during this same period, and other improvements were made after 2004 to substantially increase stormwater recharge. TM3 needs to describe how the drainage improvements that occurred over time were included in the surface water model and the ISARM.	Additional detail on parameterization of the SFR package was provided in the summary report.
17	WEI			The Spitz and Moreno citation from A Practical Guide to Groundwater and Solute Transport Modeling is not relevant in the current setting and in the manner that it was applied. The Spitz and Moreno citation reads: "Paired-data testing (i.e., comparing predicted and observed values for corresponding locations in time and space)[section title]. Common examples of such testing are variance between predicted and observed data should be less than 10% of the range of observed data (relative error), standard deviation between predicted and observed data should range from 0.7 to 1 depending on the number and quality of data points, and bias between predictions and observations should be random rather than systematic." From a literal reading of Spitz and Moreno, it is unclear whether they intended the relative error criterion to apply to an individual well or an entire model domain. Spitz and Moreno provide no basis for a 10 percent criterion. TM3 ignores the other Spitz and Moreno criteria related to standard deviation and bias. Careful review of the scatter plots indicates that the ISARM produces systematic bias (error) throughout the model domain. (See comment 19 above.) Furthermore, Spitz and Moreno have only three pages of text related to model calibration. They do not present a theoretical discussion on calibration and definitive calibration criteria.	Additional references that discuss relative error include Zheng, Hill, Ma, 2012, among others. While TM-3 does not compare the standard deviation of predicted and observed data, it does discuss random vs. systematic distribution of residuals in time and space. Additional statistics (R2) were added to TM-3 and the summary report.

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18	WEI			The same is true for the Environmental Solutions, Inc. citation from Guide to Using Groundwater Vistas. The exact text from this reference reads: “The residual standard deviation can be compared to the overall range in target value (e.g., head) as a further comparison. For head targets, this value shows how the errors relate to the overall gradient across the model. Normally, this value should be less than 10 percent for a good calibration.” (emphasis added) “As a further comparison” means the relative error is not the main criterion. And, what does “normally” mean? Environmental Solutions, Inc., provide no basis for their opinion or qualifications on the limitations of relative error. Environmental Solutions does not provide a technical reason or citation to support its statement. Also, the Guide is a user guide for the application of Groundwater Vistas and is meant to inform users on how to apply Groundwater Vistas. It assumes that the user has an understanding of models and appropriate calibration methods. The Guide does not contain a theoretical discussion on calibration or definitive calibration criteria.	A key point to keep in mind when discussing residual statistics is the following (from Zheng, Hill, et al., 2012): "A 'perfect' calibration, as defined by minimal residual errors, is an elusive goal and thus can go on forever, as there are always some other parameter values to be adjusted or new parameters to be added. Models can also match observations too closely, such that errors start to dominate the results (Hill, 2006, 2010). In addition to the statistical criteria, there are other, harder to quantify factors that should be considered in assessing the quality of model calibration. For example, an important factor to consider in model calibration is the robustness of the model predictions relative to the model objectives or vice versa. It is possible that, under certain circumstances, changes in some model input parameters that have a large effect on certain statistical criteria will have almost no effect on the model predictions relative to the model objectives." Text was clarified to this effect and R2 values were added.
19	WEI			The most authoritative document on groundwater model calibration is Effective Groundwater Model Calibration: With Analysis of Data, Sensitivities, Predictions, and Uncertainty (Hill and Tiedeman, 2010)—an entire book that focuses on groundwater model calibration. Hill and Tiedeman provide no mention of relative error.	The absence of relative error from Hill and Tiedeman does not indicate that its use is not supported in literature. Hill and Tiedeman focus on an error-based weighting methodology in the book referenced, which is another means for compensating for the range of observations. Hill has co-authored at least one paper that discusses the use of relative error (see Zheng, Hill, et al., 2012). The implication of this critique, that relative error is not used to assess residuals in "modern" groundwater practice, is false, as is the idea that one piece of literature represents the entire body of literature or thought on a subject. Text was clarified to this effect and R2 values were added.
20	WEI			We pointed out in the beginning of the presentation that the increase in surface diversions to recharge needed to be offset with a plan to recover (pump) it; otherwise: • groundwater storage would increase, • rising groundwater in stream systems would increase, • surface water discharge would increase partially offsetting the reduction in discharge due to the diversions from covered projects and subsequently underestimate downstream impacts on habitat, • no one would construct and operate these projects without a recovery plan, and • it matters how the new recharge is recovered. We also pointed out, using information from the Geoscience presentation, that with all covered projects, the upper watershed recharge would increase 59,200 afy or 1,480,000 af over the 25-year planning period. In the absence of a recovery plan, rising groundwater would increase and reduce the impact of the diversion projects and provide misleading results. Geoscience and VD responded that their goal was to determine what the direct diversion impact of the covered projects would be on the river and habitat and that in a subsequent set of scenarios they would try to optimize recovery. We responded that the present set of planning scenarios included in Scenario 2 were being used to evaluate the HCP covered project impacts, that they would not be able to state what the impacts were unless there was a recovery plan, and that some of the projects (e.g. VD/RPU rubber dam project in Riverside Basin, SAR diversion in the SBBA) would not work in the absence of a recovery plan. It appears clear that provisions for associated recovery plans still needs to be addressed. Geoscience and VD chose to defer consideration of our comment, and the meeting continued.	This concern was addressed in Scenario 4. We worked with the TAC to develop likely management actions that would result from HCP implementation, as there are many possible alternatives or plausible assumptions.

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21	WEI			In our opinion, the 25-year planning period is not sufficient to capture the long-term effects of the HCP covered projects on groundwater and surface- groundwater interaction in habitat areas. The planning period used for the evaluation of the HCP covered projects runs from 1966 through 1990, includes the wettest six-year period in the historical record (1978 through 1983) and excludes the recent drought of record (1999 through 2016). This planning period was determined prior to ISARM development and application.	The planning period was the subject of discussion and agreement among members of the the TAC and presented in TM-4. The planning period coincides with the planning horizon in the UWMP's, and the HCP base period. In addition, it includes wet, dry, and average conditions. In general, the HCP activities are in close vicinity to the stream channel and changes to diversion and wastewater discharge affect streamflow and water levels in the vicinity of the stream fairly immediately. This was discussed at the January 29th, 2019 model workshop. Based on the discussion at the modeling subcommittee meeting, extending the future predictive period from 25 to 50 years might be instructive, but is not necessary to evaluate current projects.
22	WEI			Page 31, Section 4.1.1 second paragraph, the text reads: “Each of the individual models that make up the Integrated SAR Model include assumptions for recharge from mountain front runoff, based on previous studies. These estimates, which are detailed in the individual model reports, were included in the Integrated SAR Model.” Based on how the information is presented, it cannot be determined if this statement is true. A table should be included that shows the annual time series of the mountain front inflows (if there is more than one) for each groundwater basin. The scale of Figure 9 should be adjusted so that meaningful information can be obtained from it.	Currently, annual volumes are shown by groundwater basin. Mountain front runoff in Chino Basin is shown by individual boundary in TM-1 Figure 61 and 62. This information was updated in the summary report, so no additional action was necessary to address this comment. The scale on Figure 9 was modified.
23	WEI			Page 32, Section 4.1.3.1. through page 34 Section 4.1.3.5. There is not enough information presented in these sections specifically and the TM in general to understand the methods and values developed for calibration. We recommend that the document be expanded to include greater explanation and that tables be prepared that characterize the surface water budget for each basin in enough detail such that a peer review can be done. Additional related comments are presented in the discussion of water budget tables in Section 6.	We disagree with the opinion that there is not enough detail in the report. Each flux term is explained with supporting graphs, maps and annual tabular data to document model assumptions. In addition to this TM, more information on the individual basin models is provided in TM-1. Where appropriate, the reader is referred to the existing model documentation and reports that detail the assumptions of the surface water model or previous modeling efforts. The level of detail provided meets or exceeds the level of detail provided in previous reports, particularly given the scope of this TM, which is intended to specifically focus on the integrated model calibration. We can add additional explanation of the surface water model and calibration at the direction of the TAC if desired.
24	WEI			Page 34, Section 4.1.4. Figures 17 and 18 are not adequate for determining whether or not the artificial recharge values used in the model calibration are correct. Figure 17 should be replaced with a set of maps that show the location and name of each recharge facility, and Figure 18 should be replaced with a set of tables that list the time series of the annual amount of artificial recharge by recharge water type (storm, dry-weather, imported, and recycled). If multiple facilities are involved in a basin, the tables should be expanded to the facility level for each basin. If Figure 18 were to remain, its scale should be adjusted so that meaningful information can be obtained from it.	In Chino Basin, the volumes were provided by CBWM, IEUA or derived from the WEI (2015) model report. The fluxes were presented for Chino Basin as storm, imported, and recycled water flow in TM-1 figures 63 and 64. The scale on Figure 18 was modified

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25	WEI			Page 37, Section 4.1.7.2, first paragraph, the last sentence reads: "This area of shallow groundwater is also shown on Figures 21 through 26." Areas of shallow groundwater are not shown on Figures 21 through 26 in the pdf that was provided to WEI. Also, the technical documentation for BGW's work should be included in this report as it is not provided in TM1. The second paragraph of this section reads: "BGW also compared the SSEBop estimated ET to the ET estimates from Aspen (refer to slide 59, Appendix C in TM1; GEOSCIENCE, 2018a). The ET estimates by Aspen fall within the range of historical variability derived from BGW's SSEBop estimates." This statement appears to not be appropriately reflective as the Aspen ET estimates are substantially less than the BGW estimates.	As discussed at the September model workshop, we have updated Figures 21 – 25 to show the shallow groundwater areas on the previous years as well (per OCWD Comment 13). Also, the description of the ET ranges refers to the figure referenced and accurately describes it.
26	WEI			Model parameters are updated based on the fit between simulated system responses and corresponding measurements of the groundwater system at discrete points in space and time—the calibration data points. Thus, the selection of calibration data points is a key element to the success or failure of model calibration. The differences between the calibration data and the computed system responses at these calibration points are known as residual vectors. Calibration is the process of minimizing the sum-of-the-squares weighted-residuals by adjusting the model parameters either through automatic and/or manual methods. The selection of calibration data points should follow these criteria (WEI, 2007, 2015; Hill and Tiedeman, 2007) a. Measurement locations with time-series data should have sufficient sensitivities. The observed variability in measured values must be related to the recharge and discharge stresses imposed on the basin. b. Calibration wells should be evenly distributed spatially in the basin, if possible. c. Calibration wells should be evenly distributed vertically in model layers, if possible. d. Measurements should be relatively evenly distributed over time, if possible. Criterion "a" (the sensitivity requirement) is required. Otherwise, calibration is a process of garbage in, garbage out. Criteria "b," "c," and "d" are necessary to ensure that the calibration represents the entire model domain over the entire calibration period. Ignoring criteria "b," "c," and "d," will result in poor calibration in specific parts of the model domain and generally poor calibration throughout the domain even though the calibration metrics appear satisfactory. In the WEI 2015 model, about 10,500 water-level measurements from 67 wells were used in the model calibration, and all of these calibration data points met the aforementioned selection criteria.	We previously requested WEI's calibration dataset for the comparison of model statistics (see Action Item 42 from April 19th, 2018 - July 18th, 2018). The data were not provided by WEI, IEUA, or CBWM. While we were not able to use an identical set of targets, our target dataset includes the list of targets in the WEI 2015 report, with some additional wells (including shallow wells near Prado Basin). Data available for calibration are almost never evenly distributed in time, spatially or vertically. It is unclear if the suggestion is to remove data from the calibration dataset, and if so, how this would improve the quality of the calibration. We have provided plots of the spatial, temporal and vertical distribution of residuals in TM-3. Regarding water-level measurements used in WEI 2015, it is unclear how they meet all of the aforementioned criteria, particularly C and D. See Table 6-2 of WEI (2015), which indicates there are only 3 targets in Layer 3, and Appendix C-1, where most observations fall in the second half of the simulation period. As mentioned above, an even distribution of available calibration measurements is almost never possible in practice. Particularly in the case of manual calibration, eliminating information from the calibration dataset for the sake of uniformity does not help the modeler achieve a better model calibration. However, calibration statistics were provided with downsampled observations at these shallow wells.

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27	WEI			These criteria were not applied in the Chino Basin model part of the ISARM calibration. Geoscience used groundwater level data from 111 wells and 22,176 water level measurements. However, 9,563 of these calibration water level measurements (43 percent of all measurements used in the calibration) are from one-year of measured groundwater level records (2015-2016) at the Inland Empire Utilities Agency monitoring wells in Prado Basin. Groundwater levels in these wells show little variation in time because they are controlled by the ground surface elevation in stream channels and the Santa Ana River. The groundwater levels at these wells are insensitive to the groundwater system, and these wells are clustered in a small part of the basin. This violates criteria "a" through "d" above. Another 2,051 calibration water level measurements (nine percent of all measurements used in the calibration) are from Jurupa Community Services District wells, which are also distributed in a small area. In total, 53 percent of all calibration water level measurements are from two small areas of the basin, and 42 percent of these measurements are from one year in an area where groundwater levels are nearly constant and insensitive to the upstream groundwater system. The ISARM calibration statistics presented in the Table 6-10 are misleading. The calibration statistics should be re-estimated using data from wells that meet the criteria stated above. The use of the relative error statistic is inappropriate.	We find the suggestion that we should not use additional data from shallow wells in the vicinity of the Santa Ana River to be unfounded. These calibration data were added to the dataset given the focus on the SAR and based on discussions with the TAC. Given the focus on groundwater levels in the vicinity of the SAR, we do not think these data should be removed from the calibration dataset. However, we would be happy to compare the calibration of the Integrated SAR Model to the existing WEI 2015 calibration dataset, if provided. We recommend that WEI consider adding shallow wells near Prado Basin to their calibration dataset in the future. However, calibration statistics were provided with downsampled observations at these shallow wells.
28	WEI			Note that Figure 89, entitled "Model Calibration Water Level Targets," does not show the wells used in calibration: they appear to have been left off the map. Figure 89 should be corrected.	Figure 89 has already been corrected per a similar comment by OCWD (comment 30 presented at the September model workshop).
29	WEI			Calibration is the process of adjusting model parameters to produce the best-fit between simulated and observed groundwater system responses. Geoscience used a trial and error (manual) method and used the following metrics (Page 66): • Hydrographs of observed versus model-simulated groundwater levels • Scatterplots of observed versus model-simulated groundwater levels • Spatial and temporal distribution of groundwater level residuals • Hydrographs of observed versus model-simulated streamflow • Residual statistics • Histograms of groundwater level residuals. The ISARM is too complex to be calibrated by trial and error and considered reliable. As noted above, most of the independent models combined to make the ISARM are better calibrated than the ISARM. TM3 does not reveal any values of calibrated hydraulic parameters and their distributions, so we do not know if the calibrated hydraulic parameters are within acceptable ranges and, most importantly, if the spatial distribution of the hydraulic parameters can be explained by hydrogeology. The report should be revised to include tables and maps that show the calibrated hydraulic parameters and make the demonstrations cited above. The report should include tables and maps that show the initial pre-calibration values of the hydraulic parameters and their final calibrated values. The number of trial and error calibration simulations should also be included to demonstrate the amount of effort used to calibrate the model.	We disagree with the statements regarding the calibration methodology and level of detail provided in the report. Trial and error calibration is appropriate and results in a level of calibration similar to previous work, including in Chino Basin. Ranges of values are discussed in the text. Maps of parameter distributions are shown in Figures 67 through 70. Also, for additional reference, see BGW peer review documentation from July 18th conference call for additional information on the peer review of hydraulic parameters. Additional text/clarification on the calibration level of effort and process were included in the summary report.

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30	WEI			Page 77, Section 6.4.3.2 Underflow across Basin Boundaries, the text reads: "In contrast to the previous individual groundwater models, the Integrated SAR Model explicitly simulates underflow between adjacent groundwater basins for the first time. Instead of treating boundary inflows between groundwater basins as boundary conditions, the boundaries between adjacent groundwater basins were removed – allowing the groundwater model to solve for underflow across basin boundaries." This is not the first time an integrated model was constructed and used in the upper Santa Ana groundwater system. For the period 1970 through 1994, SAWPA's Basin Planning Model was used to evaluate groundwater management activities. The ISARM is not a breakthrough: it's a modern attempt at integrated modeling for the upper Santa Ana River watershed. Note that when comparing groundwater elevations from contour maps to groundwater elevation measurements at wells in the Bloomington Divide area, the ISARM under predicts groundwater elevations by about 50 feet. It cannot be concluded that the calibrated ISARM can predict the subsurface inflow through the Bloomington Divide (from Riverside Basin to Chino Basin) with a consistently large residual. In fact, it does not appear that any wells in the vicinity of the Bloomington Divide were used in model calibration. The values of the final calibrated hydraulic parameters in the Bloomington Divide area and subsurface flow through it are not defensible.	The residual in the Bloomington Divide does not average 50 feet. Near the Bloomington Divide, the mean residual at nearby wells ranges from -2 at F-35 to approximately 20 to 25 feet at Colton24 and WVWD-20. In this area of Chino Basin, the model calibration is generally quite good. This error, relative to the standard deviation of residuals for the groundwater basin, is not excessive. The previous individual groundwater models did not explicitly simulate underflow between groundwater basins. The boundaries were treated as boundaries of various kinds (head/flux boundaries). Additional calibration in the Bloomington Divide is possible to improve the residual at wells in the area. Based on the consensus from the modeling subcommittee meeting, additional calibration is not warranted at this time.
31	WEI			TM1 reported the Chino Basin water budget in summary form in a graphic chart. TM3 includes a water budget table but does not clearly define the terms in the table. The Chino Basin water budget shown in Table 12 should include separate columns for stormwater recharge in channels, stormwater recharge in recharge facilities, imported water recharge, recycled water recharge, and Santa Ana River recharge.	Artificial recharge in spreading basins is grouped in one term in TM-3. The individual terms are already provided in TM-1 Figures 63 and 64.
32	WEI			Figures 90 through 93 are scatter plots that show "Measured vs Model-Calculated Water Levels" for various periods of time. Inspection of these plots reveals clusters of scatter points at wells where either the model-calculated values are not changing, and the observed values are (horizontal groupings of scatter points for a well) or the opposite (vertical groupings of scatter points at a well). The vertical and horizontal groupings of scatter points at wells indicate systematic bias (errors) in the conceptual and numerical models such that the model is incapable of replicating the groundwater behavior at these wells. These figures should be replaced with several scatter plot figures where the scatter points at individual wells are clearly indicated (e.g., using different color and or marker types). Once completed, these figures should be used to inform changes in the conceptual and numerical models, and the model should be recalibrated to reduce this systematic bias.	880 calibration wells are already broken down by basin and by layer. Hydrographs for individual wells and maps of residuals also provide this level of detail if desired. It is not feasible to label every well in a summary scatterplot. The level of detail and analysis of residuals (time, space, by layer, by basin) already exceeds the level of detail in previous work.
33	WEI			Figures 94 through 98 are maps that show the "Spatial Distribution of Water Level Residuals" for ISARM model layers 1 through 5, respectively. As mentioned in Comment 14 above, it appears, for calibration purposes, that the individual wells were assumed to be perforated in only one model layer in the Chino Basin. Virtually all of the wells used to calibrate the Chino Basin shown were assumed to be perforated in model layer 1 (96 wells in layer 1, six wells in layer 2, eight wells in layer 3, and one well in layer 4). The hydraulic parameters in the layers underlying layer 1 cannot be assumed to be calibrated.	Targets were assigned based on screened interval information, if available. It is unclear how this issue would be remedied, as we do not control the physical location or distribution of available monitoring wells. Data available for calibration are almost never evenly distributed in time, spatially or vertically. A similar distribution of wells is also observed in the WEI (2015) model report - with three calibration wells in Layer 3 (Table 6-2). We have made an attempt to compare the level of calibration of the Chino Basin Model used in the Integrated SAR Model with that developed by WEI, in response to a request/comment made by OCWD (see Action Item 42 from April 19th, 2018 - July 18th, 2018 project meetings). However, these data were never provided by WEI, IEUA, or CBWM.

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34	WEI			TM3 contains sets of scatter plots for each groundwater basin for each model layer. For the individual basins and layers within them, the observation made in Comment 19 above is more obvious. These figures should be replaced with several figures where the scatter points at individual wells are clearly indicated (e.g., using different color and or marker types). Once completed, these figures should be used to inform changes in the conceptual and numerical models and the model should be recalibrated. The table below summarizes observations from these charts, which indicate significant errors in the conceptual and numerical models that should be addressed through improvements in the conceptual and numerical models, followed by recalibration.	See response to Comment 32, above.
35	WEI			In addition to the comments stated above on calibration, we continue to be concerned that the use of relative error is inappropriate in modern groundwater model calibration in that: it ignores observable systematic errors in the conceptual and numerical models that are clearly evident in the scatter plots and that it can be gamed by well selection. While we have focused our comments primarily on the Chino Basin, our objection to the use of relative error applies to all the basins included in the ISARM. Geoscience replied to our prior comments on the use of relative error in TM Nos. 1 and 2 by stating that “Relative error is only one measure of model performance. Additional quantitative and qualitative techniques were also used to assess model calibration, as presented in TM3.” While TM3 is full of charts and maps, it is clear that the relative error criterion is the primary tool used to assess calibration performance. It is listed in all tables and charts that describe calibration performance. The text and all the scatter plots explicitly state, “Common modeling practice is to consider a good fit between historical and model-generated data if the relative error is below 10% (Spitz and Moreno, 1996 and Environmental Solutions, Inc., 1999).”	This is not the case. The reasons presented that 1) "it ignores observable systematic errors in the conceptual and numerical model," and 2) "it can be gamed by well selection," are not reasons to not present relative error, along with additional information on the calibration. Relative error incorporates model error (the larger the error, the larger the relative error). The second point is largely moot, because 1) that could be said of any approach that uses residuals and 2) we did not "game" the statistic by well selection. Relative error is not the primary tool used to assess the calibration. Relative error and other scaled statistics are used in modern groundwater model calibration and mentioned in numerous texts on groundwater modeling calibration. Text and Figures were modified to reflect this and R2 values will be added.
36	WEI			As to assessing the relative error, the table below summarizes some of the statistics used by Geoscience to estimate relative error. These statistics were taken directly from the scatter plots for each basin. Recall from comment 14 above that the selection of wells and associated data used in calibration did not follow modern calibration practice. For most of the scatter plots, there are a small amount of scatter points with low and high elevations that significantly increase the range of observed groundwater elevations (the denominator) in the relative error computation. Using small amounts of data at the extreme ends of the scatter plots exaggerates the useful data range and arbitrarily reduces the relative error by increasing the denominator. The table below shows, for each basin, the reported RMSE, the reported range of groundwater elevations in the calibration data, and the relative error (equal to the RWSE divided by the range of observed groundwater elevations). The table also shows the reasonable range of groundwater elevations from the calibration data and the associated relative error. Using the reasonable range, the calibration is unacceptable (using the metric of TM3) for two basins and close to failing in two more basins.	To our knowledge, the use of "reasonable range" or "useful range" is not supported in literature or through common modeling practice. Eliminating calibration wells with low or high water level measurements, which provide useful water level information, artificially increases relative error statistic.

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37	WEI			The project descriptions for some of the HCP covered projects appear to be either incorrect or in some cases, not complete. For example, it was evident at the January 29th workshop when discussing the proposed IEUA dry-weather flow diversion projects, the seasonal nature of the proposed dry-weather diversions was not being reflected appropriately. Based on the presentation's description of the facilities and operating plans for the facilities assumed in each scenario and the subsequent questions and answers in the ensuing discussion, it was clear that there was significant uncertainty on how several of the HCP projects would be implemented and how they should be analyzed in the HCP.	Several projects have already been updated, including IEUA dry weather flows. We will update others based on input received from TAC members.
38	WEI			These challenges appear to be process driven. Each HCP covered project needs to have a precise facility plan and set of operating assumptions. The precise facility plan and set of operating assumptions should be provided by the project proponent in enough detail to enable it to be simulated with the ISARM. If this information cannot be provided, then variations of the proposed project covering the range of locations and operations need to be provided and the range evaluated in the modeling work. As of this writing (April 19th), these challenges may have been overcome. That said, we recommend the following or functionally-similar process be done to provide certainty to the HCP development process and to avoid surprises.	We have been reviewing scenario assumptions at monthly project review meetings and workshops since July 2018. Therefore, we do not feel that an additional formal review is necessary. However, we will implement additional review or changes based on input from TAC members.
				Geoscience should have each project proponent verify the precise location of each project, diversion point, and the operating assumptions (diversion time history, points of recharge and recovery/use, etc.).	
				Geoscience should provide a precise description of how each covered project will be simulated, the assumptions made, and the model's limitations on the evaluation of the covered project.	
				Project proponents should review Geoscience's work in step "b" above and work with Geoscience to ensure that it fully understands their projects and that the project is represented correctly in the planning scenario.	
				Geoscience should evaluate the covered projects after all project descriptions are complete.	

Comments Received and GEOSCIENCE Responses for Draft TM No. 4: Major Assumptions of Predictive Scenarios

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
1	IEUA			Given the descriptions of Scenarios 1a, 1b and 1c there does not seem to be any value in evaluating them. What is the nexus of the information produced from this scenario to the development of the HCP?	Scenario 1 runs were intended to identify any factors that may be causing reduced flows in the Santa Ana River. Results from these model runs can be used to establish relationships between various sources of inflow and outflow to the Santa Ana River and identify which reaches are recharging to or discharging from the groundwater system (e.g., gaining reach and losing reach). To address this comment, a revised approach was developed.
2	IEUA			The general description seeks to evaluate “any” factors but the individual scenarios (1a, 1b and 1c) speak to only three. The scenarios do not include how the individual factors being changed in each scenario will be compensated for in the real world (see specific comments below).	Management scenarios (Scenario 4) were developed with the TAC to evaluate response scenarios.
3	IEUA			The main point of all these comments on Scenario 1 is that the proposed scenarios are based on large-scale changes in water management that are unrealistically assumed to occur in isolation and they are not integrated with water management changes that would have to be implemented in response to them. The model results will not provide reliable characterizations of the "factors that contribute to reduced streamflow in the SAR."	Management scenarios (Scenario 4) were developed with the TAC to evaluate response scenarios.
4	IEUA			Scenario 1a Decreased Pumping. Scenario 1a will evaluate the groundwater response and change in Santa Ana River discharge, relative the historical calibration, due to an arbitrary reduction in historical pumping over the period of January 1966 through December 2016. Table 1 characterizes "major assumptions of Scenarios 1a, 1b and 1c." For Scenario 1a, Table 1 states that the "Area and volume of reduced pumping needs to be developed by the TAC." No other details are provided, so it is impossible to appreciate how the pumping reduction will be accomplished and by whom. Simply reducing groundwater pumping to predict the impacts of groundwater pumping on the Santa Ana River will not provide useful information as it does not reflect the water management response to a pumping reduction. Will the reduction in each basin be reducedby the same relative amount or some otherarbitrary amount and which pumpers willreduce pumping? If pumping is reduced, will replacementsupplies be assumed to be provided? Ifgroundwater pumping is reduced and noreplacement supply is provided, then thedeep infiltration of precipitation andapplied water will be reduced. This wouldviolate the assumption stated on page 3that areal recharge from precipitation andreturns from use would be identical to thatestimated in the model calibration. If recycled water was used to replace thereduced groundwater pumping, therewould be less recharge of recycled waterand potentially less discharge of recycled water to the Santa Ana River. If pumping is reduced in the Chino Basin,the artificial recharge of imported waterand possibly storm water would also bereduced as these artificial recharges areused to offset replenishment obligations inthe Chino Basin pursuant to the Judgment.In modern times, recycled water rechargecould also be reduced if pumping werereduced for the same reason, which wouldincrease discharge to the Santa Ana River. There are storage programs in the ChinoBasin that include in-lieu and wet waterrecharge; simply reducing pumping in thehistorical record as proposed will strandstored water that will eventually dischargeto the Santa Ana River.	Scenario 1 methodology was revised following discussions with the TAC.

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No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
5	IEUA			Scenario 1b No Artificial Recharge. Scenario 1b will evaluate the groundwater response and change in Santa Ana River discharge, relative to the historical calibration, due to the elimination of artificial recharge over the period of January 1966 through December 2016. For Scenario 1b, Table 1 states that the "Artificial recharge will be removed throughout the model area." Simply eliminating artificial recharge to predict the impacts of artificial recharge on the Santa Ana River will not provide useful information as it does not reflect the water management response that would be required by eliminating artificial recharge. What types of artificial recharge would be eliminated? Recycled water? Importedwater? Storm water? If recycled water recharge is eliminated,would the reduction in recharge beassociated with an increase in recycledwater discharged to the river? A reduction in artificial recharge in theChino Basin would require a reduction inpumping; how would the reduction inpumping be calculated and how would it beallocated among the pumping entities? What assumptions would be maderegarding replacement water supplies forthe reduced pumping required from theelimination of artificial recharge? There are storage programs in the ChinoBasin that include recharge and thesubsequent recovery of supplementalwater recharge through groundwaterpumping-simply eliminating artificialrecharge in the historical record asproposed without reducing the historicalpumping associated with the storageprograms will cause overdraft inconsistentwith the Chino Basin Judgment. In theabsence of artificial recharge, groundwaterstorage programs would not occur and thusthe pumping associated with the storageprograms needs to be removed from thehistorical record if its associated artificialrecharge is eliminated.	Scenario 1 methodology was revised following discussions with the TAC.
6	IEUA			Scenario 1c No Discharges to Streamflow. Scenario 1c will evaluate the groundwater response and change in Santa Ana River discharge, relative to the historical calibration, due to the elimination wastewater discharges to the Santa Ana River and its tributaries during the period of January 1966 through December 2016. For Scenario 1c, Table 1 states that the "Wastewater discharges to streamflow will be removed throughout the model area." Simply modeling the elimination of recycled water discharge to streamflow will not provide useful information as it does not reflect the water management response that would be required by eliminating wastewater discharge. Where would the recycled water go if thedischarge were eliminated? Would it berecharged, put to direct use, and orexported from the watershed in a pipeline? If the avoided recycled water dischargewere recharged in the Chino Basin, it islikely that pumping would be increased toexploit some of the new recharge, and theremainder would become risinggroundwater and increase the discharge inthe river. If the avoided recycled water discharge wasput to direct use, groundwater pumpingwould be reduced, imported water usewould be reduced, or both could occur. How would the change in groundwaterpumping required by the elimination ofrecycled water recharge be calculated andhow would it be allocated among thepumping entities?	Scenario 1 methodology was revised following discussions with the TAC.

Comments Received and GEOSCIENCE Responses for Draft TM No. 4: Major Assumptions of Predictive Scenarios

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
7	IEUA			The general description of Scenario 2 reads: Scenario 2 will evaluate proposed HCP Covered Activities. It is anticipated that five (5) model runs will be made, including a baseline run (i.e., no HCP Covered Activities - Scenario 2a), one model run with all HCP Activities (Scenario 2b), and three model runs simulating selected individual HCP Covered Activities and/or a combination of HCP Covered Activities (Scenarios 2c, 2d, and 2e). Tables 3, 4, and 5 contain lists of projects to be included in these scenarios, most of which reduce discharge in the Santa Ana River by either diverting storm water discharge to recharge facilities or reducing recycled water discharges to the river. The TM makes the following assumptions regarding the hydrology that should be reconsidered. The TM states: "Groundwater pumping projections are also available in the UWMPs listed in Table 6. Pumping will be applied to wells in the model area using the average pumping distribution observed over the last five years." The groundwater supply projections in the UWMP may not be reliable predictors of actual pumping. Some UWMP water supply plans providemore water supply than demand; in thiscase, what would be the logic to estimatinggroundwater pumping? How will pumping projections be modifiedduring dry years when local surface watersand imported supplies are reduced? Do the projected pumping plans in theUWMPs include recovery of the newrecharge anticipated in the all the HCPother planned projects? If not, the newrecharge will go into storage and increasethe rising water discharge to the river. Given the recent drought, how reasonableis it to assume Pumping will be applied towells in the model area using the averagepumping distribution observed over thelast five years"" will represent the futurespatial and temporal distribution ofgroundwater pumping? What aboutgroundwater pumping from planned new wells? Are the land use and associated watermanagement practices assumed in theUWMP consistent with the hydrology andcultural conditions during the 1966 to 1990period? The answer is no.	We acknowledge that future water use is uncertain. However, this uncertainty is recognized and inherent in all predictions made about the future. UWMPs offer a standardized methodology for developing these projections for long term planning purposes. Any assumptions are common to the baseline (no HCP activities run) and HCP activities runs. The results of these runs were subtracted from one another to quantify the impacts on flows and water levels. This methodology tends to reduce the influence of individual assumptions as the same assumptions are common to the baseline (no HCP) and HCP activities model runs. Generally, to demonstrate reliability of future supply, water supply plans need to demonstrate more available water supply than forecasted demand. As a result, the "available" supply is not a projected groundwater demand. In most cases, we are not using the proposed available supply from the UWMP, but the forecasted increase in water demand over time checked against the available supply by source. Based on past records of surface water and imported water supply availability which reflect the wet and dry hydrology of the HCP base period, we incorporate the variability in these supplies by meeting the total projected raw and potable water demand using these supplies, and then meeting the remaining demand with groundwater pumping. When less surface water or imported supplies are available, groundwater pumping will increase to meet the remainder of the forecasted demand in dry years. We incorporated additional assumptions into the baseline and HCP activities runs based on suggestions made by the TAC. The UWMPs projected "raw and potable water" demand based on projected increases in population in the service area and per capita water use estimates. The demand projected is not based on recovery of new recharge "anticipated in all the HCP other planned projects." Selection of the last five years to establish the average pumping distribution is a compromise using the available data. We think it is a reasonable one. The last five years reflect the current infrastructure and use patterns. The further back in the historical pumping record, the less representative of current infrastructure and use patterns the historical pumping will be. Pumping patterns have changed dramatically over time based on land use changes and urbanization. We acknowledge there is inherent uncertainty in making predictions about future groundwater pumping. The UWMPs project future water demand and supply and are nominally not based on past 1966-1990 cultural conditions. The HCP base period was selected because it captured wet and dry periods in the historical record with no overall departure from mean precipitation. Past hydrology is used in conjunction with modern land use/water management practices to develop scenario assumptions.
8	IEUA			The TM states: "Artificial recharge not included in the HCP Covered Activities will be determined based on available projections in urban water management plans (UWMPs) for agencies servicing the model area." None of the UWMPs for agencies in the Chino Basin include complete estimates of the artificial recharge required by the Chino Basin Judgment nor the expected new recharge from the implementation of the 2013 Recharge Master Plan Update. What will be done to ensure that artificial recharge estimates are consistent with the water management practices and recharge plans in each groundwater basin?	To address this comment in the Chino Basin, we used estimates of pumping and artificial recharge provided by CBWM/WEI. Information in the UWMPs will be used as the "best available published information" in the absence of other data sources in other groundwater basins. Geoscience also worked with the other agencies to develop appropriate pumping estimates for the scenario runs.

Comments Received and GEOSCIENCE Responses for Draft TM No. 4: Major Assumptions of Predictive Scenarios

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
9	IEUA			The TM states: "Return flow will be determined based on the approach used in the model calibration, which is different for each basin." It is unclear in the TM if the return flow estimates in the calibration period are being used in Scenario 2 or if new estimates of irrigation return flows will be estimated consistent with UWMPs, current and projected land uses, and projected cultural conditions. Please state precisely what will be done.	Scenario estimates of return flows were prepared based on the prior methodology used in each basin. For example, in Chino Basin, return flows were estimated based on relationships to water use volumes and types. In Riverside-Arlington, a land surface model (IDC) was used to estimate return flows.
10	IEUA			The TM states: “Areal recharge from precipitation will also be based on historical conditions and applied with the same approach used for the model calibration.” Estimates “based on historical conditions and applied with the same approach used for the model calibration” will not be consistent with UWMPs, current and projected land uses, or projected cultural conditions. This assumption will reduce the reliability of the model results.	The text was updated to specify that historical conditions refer to the HCP base period hydrology. Where land use or surface water models were used to develop the original estimates of areal recharge from precipitation, those methods were used along with modern land use to develop areal recharge estimates for future scenarios. For example, in Chino Basin, areal recharge from precipitation was estimated from the HSPF surface water model by subwatershed. In Rialto-Colton, an empirical relationship with additional water in wet years was used to estimate areal recharge from precipitation for the basin.
11	IEUA			The TM states: "Scenario 3 will evaluate impacts from other projects not included in the HCP Covered Activities. This scenario will include HCP Covered Activities to provide cumulative results, along with other projects recommended by the TAC. Scenarios 4 and 5 will be conducted at the recommendation of the TAC to evaluate other groundwater management activities and changes in groundwater pumping." The TM states that Scenario 3 will be based on Scenario 2 plus other projects not included in the HCP Covered Projects with the stated intention of evaluating cumulative impacts. Scenarios 3, 4, and 5 will be constructed, modeled, and evaluated pursuant to direction from the TAC. There is no other information available in the TM to describe these scenarios. All of the comments presented herein for Scenario 2 apply to these scenarios. A new TM should be prepared for review when these scenarios can be defined with the precision requested above for Scenario 2.	An updated table of scenarios based on input from TAC members and the October 10th conference call was provided to the TAC for review. Final scenario assumptions were developed through discussions with the TAC.

Comments Received and GEOSCIENCE Responses for Draft TM No. 4b: Major Assumptions of Management Scenarios

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
1	OCWD			1.In addition to the two sets of scenarios using the 25-year hydrologic base period 1966-1990 and the 18-year prolonged drought period, it seems that it would be prudent for analyzing worst case conditions for rejected recharge and liquefaction to also do a third set of runs using a wet period such as 1978-1998 or a shorter period such as 1991-1998 that lies in between your other two periods.	Rejected recharge (shallow groundwater) and liquefaction potential were assessed relative to a wet period within the simulation period.
2	OCWD			2.It seems that the memo needs additional detail describing the upper and lower limits of the magnitude and distribution (spatial and temporal) of the expected pumping adjustments that will be made for these scenarios, unless you plan to provide that at a later date. I understand it may be an iterative process for each scenario to determine the amount of pumping to input into the model to balance out the recharge and achieve desirable results until you get a run that is a keeper. Are there limitations on the maximum amount of additional pumping allowable in each basin per their respective adjudications? Maybe a summary table would be good for each of the pertinent basins showing the maximum allowable annual pumping, unless there are no pumping limitations as long as water level elevations thresholds are met.	Locations and amounts of adjusted pumping were provided in the summary report. These adjustments indicate the direction and the nature of the management actions taken.
3	OCWD			3.How about considering addition of a scenario that includes a mix of prioritized HCP activities, SWP recharge by SBBA, and pumping adjustments with the goal of maintaining baseline conditions at Prado (i.e., negligible change in ET, rising water, and/or shallow GW conditions at Prado as compared to the baseline run).	Due to time and budget constraints, the TAC decided not to conduct additional managment runs at this time.

Comments Received and GEOSCIENCE Responses for Draft TM No. 5a: Predictive Scenarios Part 1

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
1	Waterboard	Figures	Figure 3	The only comments that I have regarding the TM5a draft report is about Figure 3 and "surface discharge" vs. "artificial discharge" from the SNRC. In this Figure 3 - "EV.4.03 the Redlands Recharge Basin (location) is named as "EV.4.03 Sterling Natural Resource Center" Also, I am not sure why the same treated water from the SNRC is called surface recharge if recharge to the City Creek and "artificial recharge" if (overflow) is discharged to the Redlands Recharge Basin. This will not affect modeling results but made the problem more complicated.	Figure was revised for clarification.
1	OCWD	General		We found Draft TM 5a to be well written and well organized but somewhat lacking with regards to Geoscience's interpretation of the model results, particularly relating to the cause and effect of various model inputs in the scenarios presented.	Thank you! Additional discussion regarding cause and effect of various model inputs were added to the report.
2	OCWD	General		In relation to comment 1 above, we feel it would be helpful to add a Findings and/or Summary & Conclusions section at the end of TM 5a. In this added section or elsewhere in TM 5a, please add a summary table showing the various basin water budgets for each presented scenario, including the calibration and baseline scenario run 2a. This will assist with comparing results among the presented scenarios.	Good suggestion! A summary table and Findings/Summary & Conclusions section to aid in the comparison of scenario results was added to the summary report.
3	OCWD	General		For each scenario, please add an additional average annual water budget figure for the entire ISARM model domain.	Comment noted. Water budget figures are currently subdivided by individual groundwater basins and Prado, at the request of the TAC.
4	OCWD	General		For each scenario, please add 25-year monthly bar graph figures for Prado evapotranspiration (ET) and the change in ET from the baseline scenario run 2a. This would help evaluate the seasonal fluctuation in simulated ET rather than just the year to year variation. For example, for scenario 2b.1, these two monthly bar graph figures could come immediately following Figures 91 and 92.	Annual ET, annual change in ET, and seasonal ET at Prado were presented in the summary report for each scenario run.
5	OCWD	General		For each scenario, please add a simulated groundwater elevation (head) contour map figure and a change in head (from baseline run 2a) contour map figure for both Prado Basin and the entire model domain. We recommend using the same chosen stress period for all scenarios for comparative purposes if possible, or the stress period with the maximum head difference for each scenario, preferably near the latter part of the 25-year model period. This would help assess if there are changes in groundwater flow directions.	Shallow depth to groundwater contours were provided to ICF for their analysis and report.
6	OCWD	2		Section 2 diversion and artificial recharge amounts for proposed HCP projects: It would be helpful to add a paragraph specifically explaining how the assumed artificial recharge amounts for model input were determined. The bar graph for each recharge basin shows more recharge in the wet years and less in dry years, so it appears that the actual distribution of storm flow was used to develop these data sets. Was the HSPF surface water model used along with 1966-90 hydrology to determine the varying streamflow diversion and artificial recharge amounts? And if so, were all HCP diversion and recharge projects included together in the same HSPF run so as to ensure there was ample storm flows to satisfy all projects? For example, the annual artificial recharge bars in Figure 66 should be less than or equal to the sum of the annual bars in Figure 70 (tributary inflows) and Figure 71 (runoff within the model area).	Yes, daily distribution of streamflow was used to determine operations of diversion projects. The HSPF surface water model was updated with each project. Yes, artificial recharge should be less than the tributary inflow and runoff.
7	OCWD	3.2.3		Why was a different method used for areal recharge in the Riverside-Arlington Basin? The annual average is only about half that of the 1966-90 calibration period. Is this reduction due to increased urbanization (impervious cover) since that earlier time period?	An IDC model was used in the calibrated individual basin model. Areal recharge methods remained consistent with the approach of the original calibrated individual models. Increased urbanization reduced the areal recharge as compared to the 66-90 period.

Comments Received and GEOSCIENCE Responses for Draft TM No. 5a: Predictive Scenarios Part 1

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
8	OCWD	Figures	Figure 65	Add more description to either the figure title and/or legend to indicate that these recharge basins are planned baseline non-HCP projects.	This recharge is described as non-HCP in the summary text in Section 10.4.2.5.
9	OCWD	3.2.5	Figure 66	What is the distinction between non-HCP projects in baseline scenario 2a versus HCP projects in scenario 2b.1? Has CEQA been completed already for all baseline non-HCP projects? For baseline scenario 2a, Figure 66 shows 121,290 afy of artificial recharge from inclusion of these non-HCP planned projects, which is significantly more than the 54,000 afy average of the entire calibration period. While the calibration period average is likely skewed lower due to the earlier years, Figure 66 visually indicates that the last 10 years (2006-16) of artificial recharge were still significantly less than the baseline projected amounts. Therefore, it may be worth discussing having a second or alternate baseline run in which only currently existing recharge projects are included for the 25-year predictive period. Then, the change between the two baseline runs could be evaluated to determine the cumulative effect of the planned non-HCP projects.	Imported and recycled water recharge increase in the baseline scenario 2a as compared with the calibration period.
10	OCWD	3.2.10		Figure 76 shows projected annual pumping for the 25-year baseline run 2a period increasing approximately linearly and independent of the (1966-90) hydrology. However, historical annual pumping shows some correlation to rainfall, with higher pumping during dry years and lower pumping during wet years. As such, it may be prudent to adjust the pumping projections to the 1966-90 hydrology.	The correlation is not direct (depending on source of supply i.e. imported water, surface water, and water use), and because the future groundwater pumping estimate is subject to other adjustments based on water rights, the process would be difficult. The pumping assumptions are the same in the baseline and scenario 2 alternatives and subtract out in the Scenario 2 change analysis.
11	OCWD	3.2.10		As shown in Figure 76, Chino Basin pumping for the 25-year baseline run 2a was noticeably less than historical pumping for the 1966-2019 calibration period as well as the earlier 1966-1990 HCP period. As discussed in later comments herein, scenario results at Prado (e.g., rising water and ET) appear to be relatively sensitive to modeled conditions within the Chino Basin due to proximity to the Prado area. Please describe the Chino Basin baseline run 2a pumping assumptions in more detail.	In Chino Basin, groundwater pumping projections developed by WEI for the CBWM Storage Framework Scenario 1A baseline condition were used to be consistent with prior modeling. Additional detail on Chino Basin pumping was added.
12	OCWD	3.2.10		Do the UWMP-based pumping projections include potential reductions for conservation, especially considering DWR conservation goals that may become mandatory?	Yes, per capita water use estimates that include conservation are used to generate future water demand. In some cases, some providers are in compliance already with SB X7-7 targets. UWMPs discuss conservation measures in detail. UWMPs were last updated in 2015 and projections are based on that UWMP update.
13	OCWD	Figures	Figure 73	For the inset table on this graph, please separate the average annual ET for calibration into two columns for the 1966-2016 and 1966-1990 periods as was done with other similar figures.	Figure 73 was updated with the averages for each period.
14	OCWD	3.3.2		Please add a few more hydrographs, including a shallow well in the Prado area. Why were no hydrographs included for the SBBA area?	Additional hydrographs were added in Appendix S in the summary report.
15	OCWD	Tables	Tables 5 and 6	Add two rows at the top of each table for the 1966-2016 and 1966-1990 calibration periods for comparing the results with the scenarios.	Calibration rows were added to tables in TMs 5b and 5c. These will be updated in the final summary report.
16	OCWD	3.3.4		Please briefly discuss that the rising water at Prado was approximately 2,000 afy less in baseline scenario run 2a than in the comparable 1966-90 calibration period despite Chino Basin pumping being less in scenario 2a than in the earlier calibration period. Is the reduction in rising water at Prado likely due to reduced stream flows resulting from the planned non-HCP projects included in baseline run 2a? On the inset table in Figure 78, does the entire amount of rising water for Chino Basin occur within the Prado area?	Rising water for Chino Basin occurs within the Prado Area. It is likely a combination of water level gradients in Chino Basin being lower than the initial condition in 1966 and contributions form other fluxes.

Comments Received and GEOSCIENCE Responses for Draft TM No. 5a: Predictive Scenarios Part 1

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
17	OCWD	Figures	Figures 91, 108, 125, etc.	The figures that show Prado Basin annual ET for each predictive scenario (Figures 91, 108, 125, etc.) should have an inset table like other bar graph figures with three columns to show the average annual Prado Basin ET amount for: (1) the 1966-2016 calibration period, (2) the 1966-1990 calibration period, and baseline scenario run 2a to compare with the scenario in question.	Inset tables were added.
18	OCWD	4.2.1		Please add a couple sentences discussing the reduction in ET at Prado Basin, and this discussion could be added to the suggested Findings/Summary/Conclusions section also. The reduced ET in scenario 2b.1 seems to be the result of a 64 cfs reduction in stream flow and approximately 1,000 afy reduction in rising water, which could likely be caused by HCP recharge/diversion projects in the Chino Basin (see comment 16).	Other factors in addition to recharge/diversion projects affect scenario 2b.1.
19	OCWD	4.2.2		Last sentence of this paragraph refers to shallow Prado wells PB-2 and PB-7 hydrographs in Appendix B, but Appendix B shows only one well at Prado named PB7_2 which appears to be screened several hundred feet deep. Is this the wrong well in Appendix B? Can one or two more shallow well hydrographs be added to Appendix B for the Prado area? Based on comment 13 above, if ET and rising water both decreased at Prado in scenario 2b.1, then it seems that shallow groundwater levels would have also decreased rather than remaining unaffected as stated in the text.	PB-7_2 is screened from 65 -80 feet bgs and is screened in model layer 1.
20	OCWD	9.1		Please add a sentence or two stating that scenario 2d.7 is essentially the same as 2b.1 but without the 8,660 afy of HCP diversion/recharge projects in Chino Basin (i.e., the SBBA and Rialto-Colton HCP recharge/diversion project amounts are the same in these two runs).	2d.7 evaluates the Valley District Stormwater Activities only, so it is not essentially the same as 2b.1 minus Chino Basin activities. Also, absent from 2d.7 are all the effluent reductions/relocations and non-Valley District Stormwater Activities.
21	OCWD	9.2.1		Please add a couple sentences discussing that the average annual ET decrease at Prado was negligibly small for scenario 2d.7 (10 afy) but was much larger for scenario 2b.1 (940 afy). Since these two runs are very similar except for the Chino Basin HCP projects, the ET decrease at Prado in scenario 2b.1 is likely due to the Chino Basin HCP projects rather than the larger amount of HCP projects farther upstream in the SBBA.	2d.7 evaluates the Valley District Stormwater Activities only, so it is not essentially the same as 2b.1 – without Chino Basin activities. Also, absent from 2d.7 are all the effluent reductions/relocations and non-Valley District Stormwater Activities.
22	OCWD	Figures	Figures 166-172	Recommend adding the water budget results for scenario 2b.1 to these water budget figures due to the similar input conditions as scenario 2d.7 as discussed above, especially for the SBBA water budget Figure 167.	Scenario 2d.7 streamflow and rising water results are presented with Scenario 2b.1 results in Tables 20 and 21 of the summary report.
1	USGS	General		Permanent archive of the current model(s) is not defined. The current SARIM and the several component models represent a significant achievement by Geoscience and members of the TAC; a significant expenditure of public funds; and a significant probable loss if a well-designed, adequately-funded archive is not instituted before the end of the current work. Ideally, an electronic archive should be maintained by a public agency or possibly a local Watermaster. The archive should include all preparatory files, all input files, selected output files, computer codes, and meeting notes. This procedure is not cheap or easy, but it is, for example, a requirement for all USGS models because it provides the ability to resurrect the models, to distribute the publicly-funded models to other interested parties, and to document the methods and results in case of future lawsuits. The TAC would be an appropriate group to discuss and potentially to define this archive and the responsible party.	Comment noted. The TAC is considering archive options.

Comments Received and GEOSCIENCE Responses for Draft TM No. 5a: Predictive Scenarios Part 1

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
2	USGS	General		Procedure for acquiring the final model(s) is not defined. The final SARIM and the several component models are likely to become popular tools for a variety of entities, for a variety of uses. No procedure, however, has been defined for how they can be distributed or to whom. Because the models were developed with public funds and in a public forum, maintaining the models in the public domain seems prudent or necessary. But there are risks to a free-for-all approach, so it may be prudent to have a formalized checkout procedure to ensure that the models are obtained correctly, an appropriate statement of uses and limitations is obtained with the model datasets, and any future improvements are tracked. The TAC would be an appropriate group to discuss the appropriate procedures for acquiring the models.	Comment noted. The TAC is considering model access options.
3	USGS	General		Procedure for updating the model(s) is not defined. Future updates to the SARIM or to the several component models is likely, but no procedure has been defined for how these updates could be done, or by whom. Future updates are likely by Geoscience, possibly using knowledge learned from the current predictive scenarios; by the USGS related to their ongoing work in the Yucaipa or other basins; by other members of the TAC; or by third parties. The TAC would be an appropriate group to discuss the appropriate procedures, technical resources, and possible funding to update the models.	Comment noted. Management of change will be important for future improvements of the SAR Model.
4	USGS	General		Predictive scenarios are useful, but difficult to integrate. The large number of scenarios presented at the SARIM meeting on December 20, 2018, were impressive, but overwhelming in several ways. Many scenarios were in essence response functions—model response to a single change in recharge. Some scenarios included more complex combinations of recharge and discharge. Some members of the TAC suggested that more holistic scenarios would be useful—adding recharge, along with a commensurate change in pumpage, and possibly other changes in water use. TAC members also queried the reasonableness of combining several recharge scenarios, which might exceed the available supply of local runoff or imported water. The following suggestions may help address these several concerns: • Consider using different words to refer to response functions versus scenarios. Each has a different purpose and complexity. Response functions are outstanding for showing the effect of one change, but are limited because they do not include any of the many other human-induced changes that might be done commensurate with the simple response. Scenarios are much more difficult to design and the simulated results are much more difficult to dissect, but scenarios can present more realistic, composite results of the many inter-related natural and human-induced changes. • Create a table to summarize all the response functions, including response name, purpose, advocating entity, amount of recharge, and source of the recharge water. Using this table will enable a quick overview of all suggested changes in water management; a critique of whether some responses can be added together without exceeding available supplies and demand; and an artful combination of different responses into topical scenarios. • Create a table to summarize each of the scenarios. A few scenarios may be all that are necessary to show general options for water management. Using this table will enable a quick review of the components of each scenario, the differences between the scenarios, and possibly which scenarios can be enacted together.	Comment noted. Tables were added to the summary report listing scenarios, HCP activities modeled, HCP activity impacts, and summary tables of key response functions (i.e., streamflow and rising water).

Comments Received and GEOSCIENCE Responses for Draft TM No. 5b: Predictive Scenarios Part 2

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
1	OCWD	General		My only comment on TM5b is similar to OCWD comment #2 from TM5a, that is, that it would be helpful to add a Findings and Conclusions section at the end of TM5b to summarize the results of the scenarios presented and possibly include a summary table to facilitate comparing the effects of one scenario versus another. Also, some text explaining the significance of the results and simulated changes from the baseline would be helpful.	A summary section was provided in the Summary Report.

Comments Received and Aspen Responses for Draft Riparian Consumptive Use TM

No.	Commenter	Section	Pg.	Comment	Aspen Response
1	CA Dept. of Fish and Wildlife	General		I may have missed it, but is there a description for each of the eight vegetation cover types? E.g., what does “deep-rooted” refer to? What depth? What about “shallow-rooted”, etc.	Written description of the classifications is in prep., to be provided in final report.
2	CA Dept. of Fish and Wildlife	Attachment A	Slide 1	For consistency I recommend revising the vegetation cover categories in Attachment A, Slide 1, to match the categories listed under Section 2.0.	While the presentation slides were not modified from the original presentation, the categories from the ET TM were used in the summary report
3	CA Dept. of Fish and Wildlife	Attachment A	Slide 2	Attachment A, Slide 2, I recommend adding some text describing what categories (from Section 2.0) each of the various types of vegetation graphically presented relate to.	While the presentation slides were not modified from the original presentation, text was added to the summary report.
4	CA Dept. of Fish and Wildlife	General	-	Recommend adding a slide that graphically shows where each of the mapped areas are within the HCP area (e.g., depict location of riparian corridor, Prado, and Riverside Narrows).	While the presentation slides were not modified from the original presentation, similar figures were provided in the summary report
5	CA Dept. of Fish and Wildlife	Attachment A	Slides 3 & 4	Attachment A, Slides 3 and 4, list a date range of 1965 through 2015, but Section 2.0 lists January 1966 through December 2016. Recommend making consistent, or clarifying.	While the presentation slides were not modified from the original presentation, time frames were clarified in the summary report
6	CA Dept. of Fish and Wildlife	Attachment B	Table 1	Attachment B, revise Table 1 to include all eight habitat categories listed in Section 2.0. Also ensure text is consistent throughout Attachment B, with respect to the categories.	Aspen will make edits in written report.
7	CA Dept. of Fish and Wildlife	Attachment B	Page 1, Paragraph 2	Attachment B, page 1, paragraph 2. States “…literature search revealed a wide range of information regarding evapotranspiration for deep-rooted riparian…” But the next sentence states, “little or no information was found (for)…deep-rooted riparian.”	Aspen will make edits in written report.
8	CA Dept. of Fish and Wildlife	Attachment B	Page 1, Paragraph 2	Attachment B, page 1, paragraph 2, add reference for “in consultation with biologists” – who was consulted?	Aspen will make edits in written report.
9	CA Dept. of Fish and Wildlife	Attachment B	Page 6	Additional justification needed for why irrigated crops were considered as proxies. There is some information presented on page 6, but it is not very explanatory. Why were these particular surrogates selected? What makes them appropriate surrogates?	Aspen will make edits in written report.
10	CA Dept. of Fish and Wildlife	Attachment B	Page 5	May need to include some narrative as to reasons for arundo ET rates being all over the place. Not sure that is possible, but it is a question I have. Were the ET rates measured at similar times of year? Was there a drought, less/more precipitation? Perhaps add this information on page 5, with text between tables 2 and 3.	Aspen will make edits in written report.
11	CA Dept. of Fish and Wildlife	Attachment B	-	ET rates for managed wetland and unvegetated sandy wash? I don’t see these categories included in the document.	Aspen will make edits in written report.
12	CA Dept. of Fish and Wildlife	Attachment C	-	Attachment C, All landsat slides. I don’t recall what the two different polygons represent (i.e., the solid green line, and the dashed reddish line). Can that be clarified on the first slide?	The solid green line represents the estimated area of shallow (<20 ft) depth to water (the data sources are shown on Slide #8). The red dashed polygon represents the elevation of the Prado Dam spillway crest (~543 ft). We used the elevation of the spillway to generally define an area near the dam (we refer to it on slides #58 and #59). Labels (clarification) for the polygons are now added to the first LANDSAT slide (Slide #19).
13	CA Dept. of Fish and Wildlife	Attachment C	Slide 53	Attachment C, slide 53, no scale on the Y axis. Also, I can’t recall the source for each of the plotted WTP effluent. Does Prado represent all WTP’s located upstream? Does the Riverside Narrows only represent discharge from Riverside, or does it represent cumulative upstream discharge?	We have added a scale to the y-axis on Slide #53. The WTP discharge locations are shown on Figure 96 of Draft TM No. 1

Comments Received and Aspen Responses for Draft Riparian Consumptive Use TM

No.	Commenter	Section	Pg.	Comment	Aspen Response
1	OCWD	Attachment A	Slides 1 & 3	Slide 1 from Aspen (page 5 of PDF) appears to be their original slide only showing veg acreage inside their arbitrary rectangle. If this is the case, it should be updated to include the entire riparian area as well as the acreage numbers on page 7.	The current model accounts for the expanded area. Aspen and Geoscience will coordinate to expand the overall mapping area to be described and mapped in ET write-up.
2	OCWD	ET Estimates		Aspen's ET rate of 63.4 inches/year for Giant Reed (arundo) seems a bit low in comparison with the other referenced studies, especially the two high California studies. The chosen value of 63.4 does not appear to be mid-range of the other studies as stated. Unless the other two very high California studies can be disqualified for some reason, I suggest using a value over 100 inches/year.	For discussion with team - Arguments can be made for both higher and lower values.
3	OCWD	BGW Energy-Based ET Study		From the BGW energy-based ET study, the more recent satellite imagery from 2013-16 shows lower ET rates per unit area in the riparian areas than previous years, indicating that the riparian habitat may already be in a stressed state prior to any of the proposed upstream projects for which this modeling study was undertaken. This should be taken into consideration when determining a baseline condition for future scenarios. It is possible that an appropriate baseline could be from a prior condition with higher ET prior to the recent SAR base flow reductions due to existing recycling projects.	Reasonable point, but the recent reduction in ET is anticipated to also be related to less precipitation due to drought conditions. It would not be good to develop a baseline without drought conditions that have been observed in the past. The planned approach is to calibrate the model to historical conditions, which includes effects from multiple components: drought, less flow from recycling projects, and river depletion from regional groundwater pumping. The calibrated model can then be used to estimate how much each component contributes to reduced ET and baseflow (if that turns out to be a question of interest).
4	OCWD	BGW Energy-Based ET Study		BGW's slides state that the groundwater model-simulated ET should generally be less than their total ET estimates because a portion of the ET is from the vadose zone which is not included in the model. I agree with this but it would be helpful to try to estimate the proportion of ET from the vadose zone versus from below the groundwater table prior to the modeling. One idea I had is that if shallow groundwater level data exists in the Prado wetlands area, a depth to groundwater contour map could be constructed (unless one already exists). Then, the depth to water contours could be overlaid with the riparian veg type map to see which veg types have sufficient root depths to reach the water table. Where the root depth of a veg type is greater than or equal to the water table depth, you could assume 100% of ET is from groundwater for that veg type. Otherwise, if average root depth less than groundwater depth, 100% of ET for that veg type is from vadose zone….just a thought that may be worth running by the group for consideration.	This is generally a way to try and account for partitioning between ET from above and below the regional water table. Wes made a similar comment (USGS Comment #18) in the conference call presentation of Feb 22, 2018. The technical committee should probably consider options for how this partitioning will be done with results from the gw model. It seems possibilities are use of a general potential ET (such as estimated by Aspen), use of a remote sensing approach, or a basic water balance based on HSPF modeling to derive a reasonable upper bound for total ET. Then basic partitioning could be done by subtracting the ET derived by the groundwater model from the upper bound ET estimated by one of those methods. Perhaps this should be discussed in greater detail with the TAC to come up with a suitable approach.
5	OCWD	Mapping Extent		Regarding mapping the extent of riparian vegetation, an earlier estimate by Aspen seemed to not include all the riparian vegetation areas. As mentioned in the comments below from Tim Sovich, slide 1 from Aspen (page 5 of PDF) appears to be their original slide only showing veg acreage inside their arbitrary rectangle; in the other draft tech memo regarding the Flow Model Calibration Plan (dated 1-29-2018), Figure 10 has polygons showing the extent of riparian vegetation. The 2016 WEI Total Riparian Extent shown on Figure 10 of the 1-29-2018 draft TM includes areas we felt we not included previously. There has been some back and forth between OCWD staff and Aspen regarding the extent and associated acreage of riparian vegetation.	Per the 8-Nov-17 Riparian Subcommittee meeting (held at CA Dept Fish and Wildlife), the group decided that the evapotranspiration areas for the Integrated SAR Model will include (1) Aspen's riparian mapping, (2) WEI's riparian extent in the Chino Basin, and (3) areas with shallow depth to groundwater (<20 ft) developed by the Balleau Groundwater. The model ET areas were shown on Figures 23 through 28 of Draft TM No. 1.

Comments Received and GEOSCIENCE Responses for Draft Database Plan

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
1	OCWD	Tables	Table 1	Will this structure be able to handle multi-depth nested monitoring wells? If so, I assume that each casing of a nested well will have a unique SWN number even though they are constructed within the same borehole?	Yes, each casing of a nested well will have a unique SWN. For example, multi-depth nested monitoring wells 01N/06W-26A01S, 01N/06W-26A02S, and 01N/06W-26A03S are constructed in the same location with depth of 870 ft, 660 ft, and 550 ft, respectively.
2	OCWD	Tables	Table 1	Add a field for Cased Depth	Table 1 was revised.
3	OCWD	Tables	Table 1	Split Perfs into two fields: Perfs_Top and Perfs_Bot (this way they can be queryable numerical fields rather than a text string)	Table 1 was revised.
4	OCWD	Tables	Table 1	What about production wells with multiple screened intervals within a single well casing? Retain all the detailed intervals or only store topmost and bottommost perf as in #3 above?	All detailed intervals will be provided. Table 1 shows new fields for Top_1 and Bot_1. Additional fields will be added to accommodate the screened intervals of all wells in the database.
5	OCWD	Tables	Table 1	Possibly could add yes/no fields for lithlog, elog, and aquifer test results (these fields have been helpful in our OCWD database)	Table 1 was revised.
6	OCWD	Tables	Tables 2 - 4	Change State Well Number field name to SWN to be consistent with Table 1.	Tables 2 through 4 were revised.
7	OCWD	Tables	Table 3	Add a field for WL Method (e.g., electric sounder, steel tape, automated transducer, etc.)	Table 3 was revised.
8	OCWD	Tables	Table 3	Add a field for WL Status (static, pumping, or unknown)	Table 3 was revised.
9	OCWD	Tables	Table 6	Change field name from Rch to Rch_afm to be consistent with monthly pumping field in Table 2.	Table 6 was revised.
10	OCWD	Tables	Table 10	Change field names from Flow to Flow_cfs to be consistent with previous volumetric rate names above including the units.	Tables 8 and 9 were revised.
11	OCWD	General	-	In addition to the four Access databases proposed in the memo (groundwater, surface water, meteorological, and GIS), you might want to consider having a fifth "Documents Database," which would include PDF files of documents such as DWR well logs, elogs, well construction reports for key wells, historical maps, aquifer test analyses, and project files such as meeting minutes and final tech memos.	An additional documents database was added on Page 3, Section 4.0 and Page 5, Section 4.6.

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
California Water Science Center
San Diego Projects Office
4165 Spruance Road, Suite 200
San Diego, California 92101-0812
Office: (619) 222-2243 Fax: (619) 225-6101
http://water.wr.usgs.gov

July 22, 2019

Mr. Douglas Headrick, General Manager
Attention: Messrs. Bob Tincher and Wen Huang
San Bernardino Valley Municipal Water District
380 East Vanderbilt Way
San Bernardino, California 92408

Subject: Summary of review of IEUA/CBWD comments by the technical modeling subcommittee for Upper Santa Ana River Integrated Model

Dear Mr. Headrick,

This letter is the sixth of several, which will provide interim review comments by the United States Geological Survey (USGS) scientists, about the ongoing development of the Upper Santa Ana River Integrated Model (SARIM). A final review document, synthesizing our major observations and suggestions, will be provided at the end of the project. ***Our objective in providing these interim review comments is to provide timely feedback so that our observations and suggestions can be incorporated in the model design, development, calibration, and documentation.***

The comments below result from attendance by USGS scientists at a modeling subcommittee of the Technical Advisory Committee charged with development of the SARIM. The subcommittee was tasked with reviewing comments by IEUA/CBWD concerning the SARIM, in particular the methods of calibration and the suitability of the model for use, especially in the Chino Basin. The subcommittee meeting was held on July 10, 2019, at the San Bernardino Valley Municipal Water District, and was attended by members of the SARIM that have groundwater modeling expertise. Wes Danskin of the USGS attended; Claudia Faunt of the USGS did not attend, but was consulted regarding the meeting and the content of this letter.

This letter has 3 sections: ***Conclusions*** succinctly states major findings from the subcommittee meeting, as determined by the USGS. ***Path Forward*** describes steps to be taken by Geoscience, which are believed by the USGS to represent an informal consensus of the subcommittee. ***Background*** presents additional information related to the subcommittee meeting and discussions.

CONCLUSIONS

1. **The SARIM seems to be well suited for its intended purpose, and likely is capable of providing guidance in identifying the hydrologic effects of different water-management projects.**

2. **Additional calibration, including by using an automated technique, does not seem warranted at this time.**

3. **In the Chino Basin, the SARIM performs as well as, possibly better than, the WEI Chino Basin model.**

4. **Extending the future predictive period from 25 to 50 years might be instructive, but is not necessary to evaluate current projects.**

PATH FORWARD

1. **Obtain and provide a better description, if possible, of the biologic requirements that define the required accuracy of the SARIM.** Admittedly, these values can be challenging to know or to obtain from biologists, but the values are critically important in determining the required accuracy of the model for effective use.

2. **Provide a better description of the accuracy of the SARIM to simulate heads and flows, both in space and time.** In particular, add the following to the model report:

    a. **Relative error**, as already included in the Geoscience presentations. Possibly annotate data or graphs to indicate where anomalies of fit occur. In particular, concerns expressed by WEI focused on skewing this value based on the many recent measurements near the Santa Ana River in the Chino Basin, which can hide problems of fitting water levels in other areas.

    b. **Coefficient of variation**, or other calibration-quality indicators, as suggested by WEI or others, or as found in the literature. A table may be helpful to summarize different calibration indicators for the entire model, and for different areas of the model that are most important for biologic management.

    c. **Maps and graphs showing areas of model problems**, as suggested by the USGS and others. This approach synthesizes results of items 2a and 2b above, but perhaps more importantly, archives the semi-quantitative impressions of the model developers and reviewers developed over the long process of model development and calibration. For example: Where was creating similar geologic units and related model layers more difficult and problematic? Where did choices to develop a regional model degrade quality available in the smaller basin models? Where/when did simulated and measured water levels not match no matter what changes were made in model parameters and fluxes during calibration?

3. **Add a report section on *Uses and Limitations*.** This section is one of the most important parts of a model writeup, and states *what* the model can be used for, *how* it can be used, and what it should *not* be used for. Many of these observations will not be obvious to anyone unless stated clearly and succinctly.

4. **Add a report section on *Future Work*.** This section describes the next incremental steps that can be made to enhance reliability or use of the model, and why each step is important. The value and relative priority of these steps will not be obvious to most managers, nor to many modeling experts, even to those involved with review of the SARIM.

BACKGROUND

General Topics of Concern, as expressed by IEUA/CBWD

Although the IEUA/CBWD review comments were numerous, five general topics seemed to be of greatest concern:

1. **Use of a less rigorous calibration technique** (trial and error), instead of an automated regression technique to calibrate the model (e.g. PEST).

2. **Use of an inappropriate parameter** (relative error) to establish quality of the model for use.

3. **Lack of statements defining what quality of calibration is needed** for the purpose of the model.

4. **Conclusion that the SARIM is not of sufficient quality** to be used for management, at least in the Chino Basin.

5. **Concern that the SARIM model would be used for water-quality management**, in particular in the Chino Basin.

Topics Discussed, at the SARIM subcommittee meeting

1. **Choices of calibration method.**
   As articulated well by Dave Romero from Balleau Groundwater, this is a continuing debate in the modeling community, not likely to be resolved anytime soon. An opinion shared by many USGS scientists who are well experienced in creating and calibrating models is that trial and error is the appropriate initial calibration method, used until a reasonably good model is achieved that honors basic hydrogeologic concepts. Then, an automated regression technique can be used to polish the model and to produce quantitative criteria of model results, in particular to demonstrate the effects of model parameters on each other and on model results.

2. **Inclusion of additional data points** which influenced the calibration "goodness of fit."
   Many recent water-level measurements along the Santa Ana River were used to calibrate the SARIM, and were used to calculate relative error of the model. WEI objected to including these many, seemingly redundant data in the relative error calculation because adding these data produces a better relative error, with only a minimal improvement in the model calibration. Geoscience made the point that the relative error calculation was not significantly influenced by the additional data points, and was willing to report both values.

3. **Comparison of the WEI model and SARIM model in the Chino area.**
   Dave Romero from Balleau Groundwater presented a fairly extensive comparison of the two models, including parameters, hydrographs, and water budget. The two models produce remarkably similar results, despite having differences in parameter values and distribution of parameter values. Dave's conclusion was that the two models are basically two realizations

of the hydrogeology of the Chino Basin, such as might be achieved from a stochastic modeling approach. This conclusion seems reasonable: the models are different, but it is hard to argue one is better.

4. **Use of a calibration and verification period for the Chino model.**
Wenbin Wang of WEI made the point that separate time periods were used for calibration and verification of the Chino model. This approach is recognized in the modeling literature as being one way to demonstrate quality of a model, *i.e.* ability to reproduce measured data during a simulation period that is not used for calibration. Wes Danskin of the USGS, who has used this approach, noted that it is difficult to observe model inaccuracies in a verification period and then not to go back and to change model parameters to improve the overall model fit, in essence making the verification period into another calibration period. Wenbin stated this was not done; the observed vertical offset of measured and simulated water levels near the Santa Ana River in the verification period was not used to improve the model. Danskin observed that this was curious to leave a model with observed inaccuracies, based solely on this modeling philosophy, especially in an area of great significance in managing biologic resources.

5. **Define quality of the SARIM in multiple ways**
Members of the subcommittee discussed at length the best way to calculate and represent quality of the SARIM. The consensus/compromise was to use 3 methods, as described and used by the 3 research teams, respectively:

    a. Geoscience – Relative error. Perhaps display relative error for different areas of the model or time frames to illustrate where/when the model does better and worse.

    b. WEI – Coefficient of variation. Use this technique to quantify model goodness of fit between measured and simulated water levels, and ideally fluxes, such as streamflow.

    c. USGS – Areas of goodness of fit. Although this technique is a more qualitative assessment, it has the advantage of using the model developers' and reviewers' expertise and experience to synthesize geologic understanding, hydrographs, and fluxes of the SARIM. Areas, topics, and time frames with either a good or bad fit, defined in some semi-quantitative way, can be illustrated further with hydrographs or streamflow graphs. A similar technique was used by Danskin in the Bunker Hill model report, figure 43 (Danskin and others, 2007, Hydrology, description of computer models, and evaluation of selected water-management alternatives in the San Bernardino area, California).

6. **Define uses of the SARIM for water-quality management**
WEI expressed concerns that the SARIM would be used for water-quality management, in particular in the Chino Basin. Bob Tincher of SBVMWD responded by saying that SBVMWD had no plans to use the model for any water-quality issues in the Chino Basin. Further, Bob indicated that managing water-quality issues in the Chino Basin was not of interest to SBVMWD.

    This topic might have been prompted by *ad hoc* discussions about possible future use of the SARIM for salt management. Members of the subcommittee acknowledged that this use might be a logical next step for a regional hydrologic model such as the SARIM, but additional work would need to be done to determine: (1) if the SARIM was designed and structured for this type of work, and (2) what modifications would need to be made to use the SARIM effectively.

Convening a Technical Advisory Committee similar to the present one used to develop the SARIM would seem appropriate for a topic with substantial technical complexity and sensitive political issues. For other water-quality uses, such as tracking contaminants, an even greater upfront effort would be required. Describing these future possible applications of the SARIM in the *Uses and Limitations* section and/or in a *Future Work* section in the final SARIM report was recommended to Geoscience.

Thank you for your long-standing support of our collective efforts to better understand the geology and water resources of the San Bernardino Valley.

Sincerely,

Wesley R. Danskin /s/ /s/

Wesley R. Danskin	Geoff Cromwell	Claudia Faunt
Research Hydrologist	Geologist	Supervisory Hydrologist

cc: Johnson Yeh, Geoscience
Technical Advisory Committee

July 24, 2019

Mr. Bob Tincher
Deputy General Manager - Resources
San Bernardino Valley Municipal Water District
380 East Vanderbilt Way
San Bernardino, CA 92408

Subject: Inspection of Chino Basin Model Analysis – SAR Integrated Model and Chino Basin Water Master Model

Dear Mr. Tincher:

This letter describes a summary of slides that Balleau Groundwater, Inc. (BGW) presented at a meeting of the modeling subcommittee of the Technical Advisory Committee (TAC) for development of the Upper Santa Ana River Integrated Model (SARIM). The meeting was held on July 10, 2019 at San Bernardino Valley Municipal Water District. Attendees included Mr. Bob Tincher of SBVMWD and Mr. Ron Craig on behalf of IEUA along with technical representatives with expertise in groundwater modeling from Geoscience Support Services, Inc. (Geoscience), Wildermuth Environmental, Inc. (WEI), Orange County Water District (OCWD), the U.S. Geological Survey (USGS) and BGW. The purpose of the meeting was to discuss comments from IEUA/CBWM regarding concerns generally with calibration of the SARIM and its applicability for use in certain planning scenarios.

In preparation for the meeting, BGW examined results of the SARIM and the CBWM models within the Chino Basin. The purpose of the examination was to provide context for discussions related to the calibration approach implemented in the SARIM in a comparative setting with the CBWM[1] model. Observations from our examination are prepared in a set of slides (attached). A brief summary of the slides and a description of our observations is below.

[1] The CBWM model was developed by WEI.

Model Examination

Our model examination covered four categories: A) water-level residuals, B) water-level hydrographs, C) the groundwater flow budget, and D) simulated aquifer properties (transmissivity and unconfined storage coefficient). Each category is discussed below.

A. *Water-Level Residuals*: A map of well locations and water-level residuals are shown on **slides 5 through 17**. The term "residual" refers to a difference (in feet) between the simulated and observed (actual) values at a well. The slides examine the differences in residuals during the calibration periods of both the SARIM and the CBWM models, which were calibrated with different techniques.[2] **Our observation is that, in general, the residual statistics are not appreciably different between the models even though the calibration techniques differ. The method implemented in the CBWM model has an advantage in achieving a lower residual; however, we have observed cases where multiple models calibrated separately with automated and manual techniques achieve very good performance in periods decades after the modeled calibration period.**

B. *Water-level Hydrographs* - The examination of water-level hydrographs (time-history plots) is presented in two PDF files (**separate from the presentation slides**). One file includes the wells used in the calibration of the CBWM model and the other includes wells used in the verification of the CBWM model. Each page of the PDF files shows a side-by-side comparison of the simulated water levels in the CBWM and SARIM models at the same well. **Our observation is that there are local differences between the models in some areas, but overall the simulated water levels and the historical changes (trend) in water levels are similar in both models.**

C. *Groundwater Flow Budget* - Groundwater flow budgets from both the CBWM and SARIM models are shown in **slides 20 through 23**. A comparison of the difference between total inflows and total outflows in both models reveals that the annual average difference between the aquifer storage accounting from 1966 to 2011 in each model is 6,800 acre feet per year (AF/y). That is, the difference in storage accounting is a few percent of the total flow through the models (which is on the order of 200,000 AF/y). Comparing the two models in terms of rising groundwater and evapotranspiration (ET) (from 1966 to 2011) shows annual average differences totaling 4,500 AF/y in ET and -3,200 AF/y in rising groundwater.[3] Summing those

[2] The CBWM model was calibrate with an automated parameter estimation (PEST) technique; the SARIM was calibrated with a manual adjustment technique. Although the CBWM model was calibrated with an automated PEST technique, we observed some operational choices that are compatible with a degree of manual adjustment (such as zoning and aggregation of zones).

[3] The difference in ET is positive because the SARIM has 4,500 AF/y more average annual ET than the CBWM model; rising groundwater is negative because the SARIM model has 3,200 AF/y less rising groundwater than the CBWM model.

differences, they almost cancel out to 1,300 AF/y (4,500 - 3,200) indicating that the combined average annual total surface-water interaction (rising groundwater combined with ET) is almost the same in both models from 1966 to 2011. **Our observation is that the average annual groundwater flow budgets (including interaction with surface water) between the two models are remarkably similar.**

D. *Simulated Aquifer Properties* - A comparison of simulated transmissivity (*T*) and unconfined storage coefficients (specific yield) is shown on **slides 25 and 26**. It is interesting to find that the two models have differences in the values and in the spatial distribution of *T* but the geometric mean of *T* in the two models is similar (SARIM $T = 25{,}000$ ft^2/d; CBWM $T = 20{,}000$ ft^2/d). The average unconfined storage coefficient in the two models are also similar (SARIM $S_y = 0.11$; CBWM $S_y = 0.09$). **Based on those observations, we conclude that the two models are different realizations of the Chino Basin hydrogeologic system. A stochastic simulation technique would result in many more realizations of the same system capable of producing different, but similar results.**[4]

Conclusions

1. The SARIM and CBWM models were calibrated with methods that have differences (manual adjustment vs. automated parameter estimation).
2. The model responses during the calibration periods of the SARIM and CBWM models are different, but similar. Strong similarities exist particularly with regard to the average annual regional flow budgets, the geometric mean of aquifer transmissivity and the average specific yield.
3. The ISARM and CBWM models are two different realizations of the Chino Basin hydrogeologic system. A stochastic simulation technique would result in many more realizations of the same system capable of producing different, but similar results.
4. These observations imply that, despite different calibration methods, the two models are part of a set of similar representations of the Chino Basin hydrologic system. Model responses in specific areas differ, but could be refined with additional calibration (if it became needed) as additional monitoring data is collected in key areas of interest for either model. Accordingly, it appears that either model can have utility in examining specific basin management decisions in specific areas of interest with consideration of local model performance.

[4] The idea behind a stochastic simulation approach is to simulate thousands of realizations (models with different parameters) that are within a plausible range based on probabilistic functions. The model results from the thousands of simulations can then be evaluated with statistics to assess factors such as uncertainty.

Please call with any questions you may have or if you would like to discuss any aspect of our Chino Basin model examination in greater detail.

Very truly yours,

BALLEAU GROUNDWATER, INC.



Dave M. Romero
President

cc: Johnson Yeh Ph.D, PG, CHG
Technical Advisory Committee (TAC)

Attachments: 190710_ChinoBasinRvw.pdf
190710_ChinoBasinRvw.pptx
CalibrationHydrographs.pdf
ValidationHydrographs.pdf

The attachments are available from a secure link provided to the TAC by Geoscience Support Services, Inc.

Inspection of Chino Basin Model Analyses (Preliminary)

ISARM Model

and

Chino Basin Water Master (CBWM) Model

SETTING

1. Inspect results of ISARM and CBWM models

2. Provide context for difference in model calibration methods

DISCUSSION

Inspection of ISARM and CBWM model results

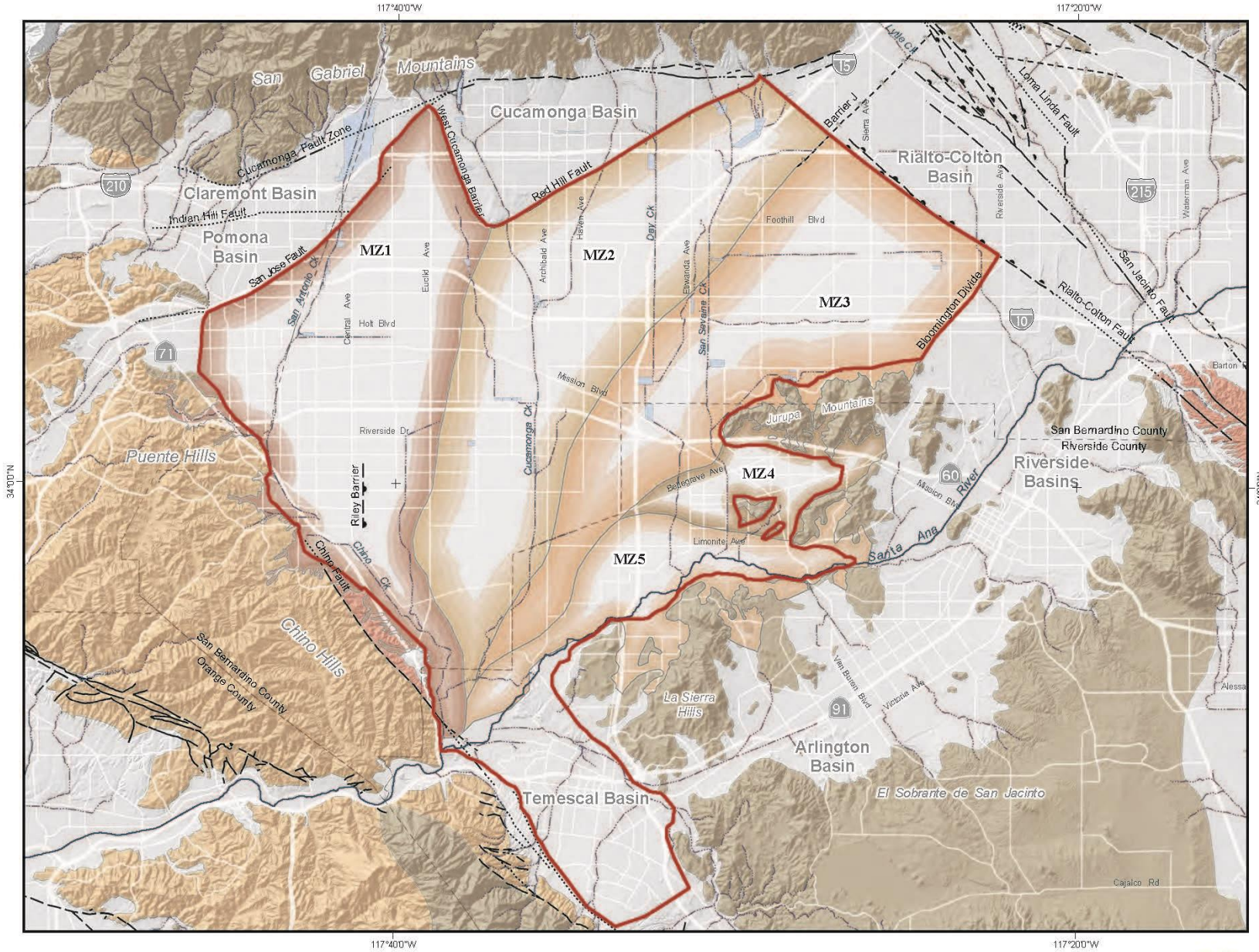
1. Water-level residuals
2. Water-level hydrographs
3. Groundwater flow budget
4. Simulated aquifer T

DISCUSSION

Inspection of ISARM and CBWM model results

1. Water-level residuals
2. Water-level hydrographs
3. Groundwater flow budget
4. Simulated aquifer T

Figure from WEI Oct 2015 report



Chino Basin Management Zones as Defined in the OBMP

Boundary of the Groundwater Flow Model

Streams & Flood Control Channels

Flood Control & Conservation Basins

Geology

Water-Bearing Sediments

Quaternary Alluvium

Consolidated Bedrock

Plio-Pleistocene Sedimentary Rocks

Cretaceous to Miocene Sedimentary Rocks

Pre-Tertiary Igneous and Metamorphic Rocks

Faults

Location Certain

Location Approximate

Approximate Location of Groundwater Barrier

Location Concealed

Location Uncertain



Produced by:

WEI Wildermuth Environmental, Inc.

Author: MJC
Date: 10/1/2015
Document Name: Figure_2-1_20131230

0 1 2 3 4 5 Miles

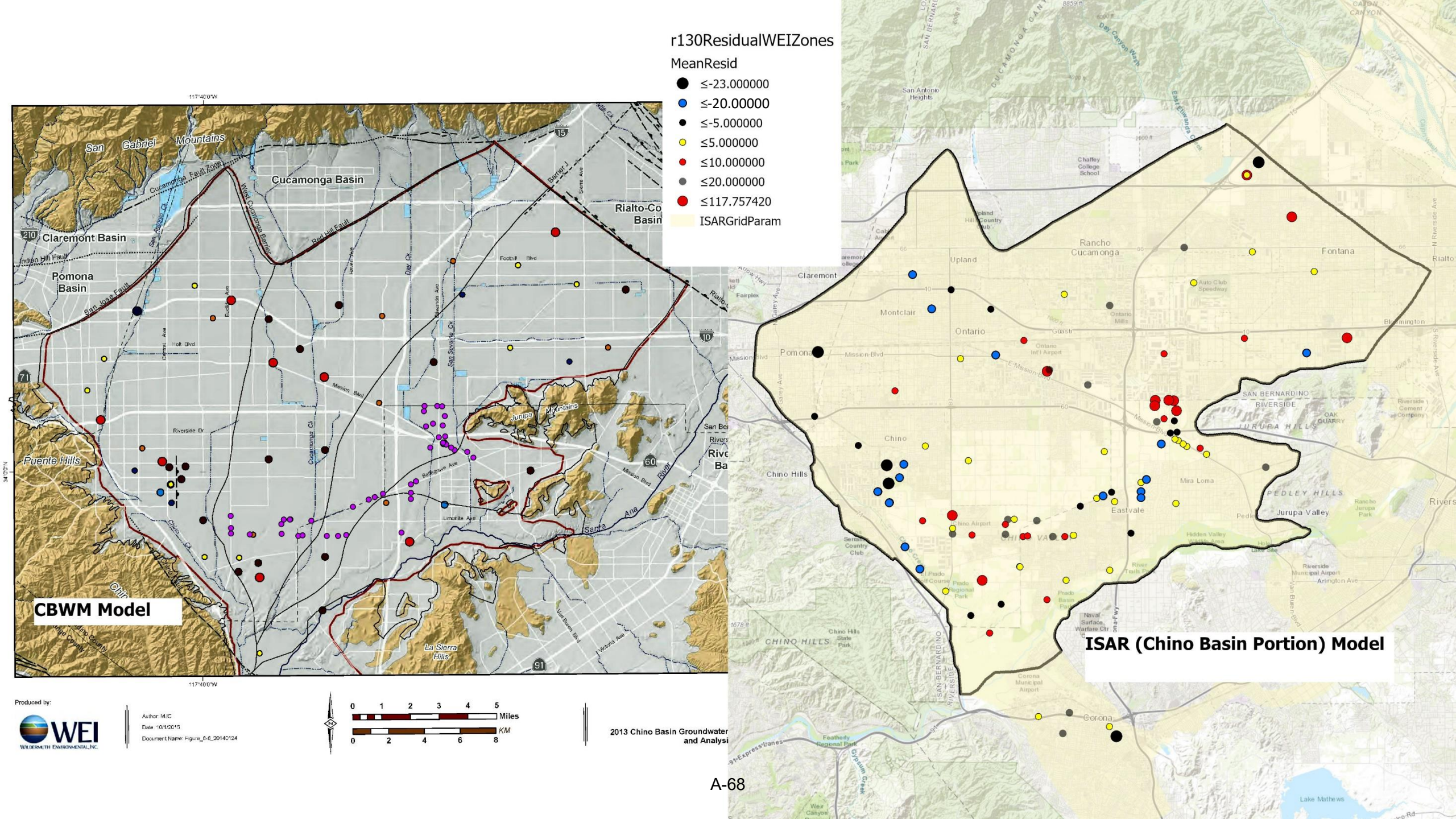
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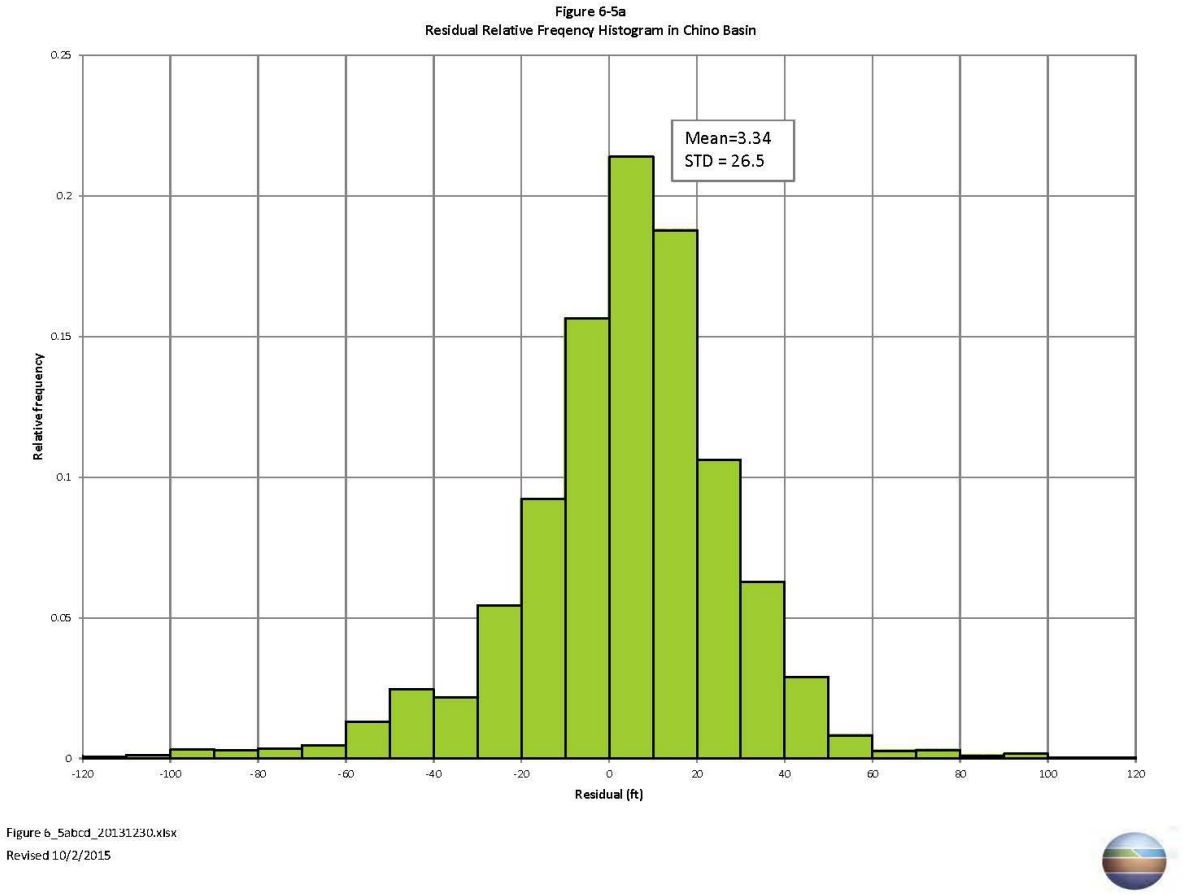
A-67

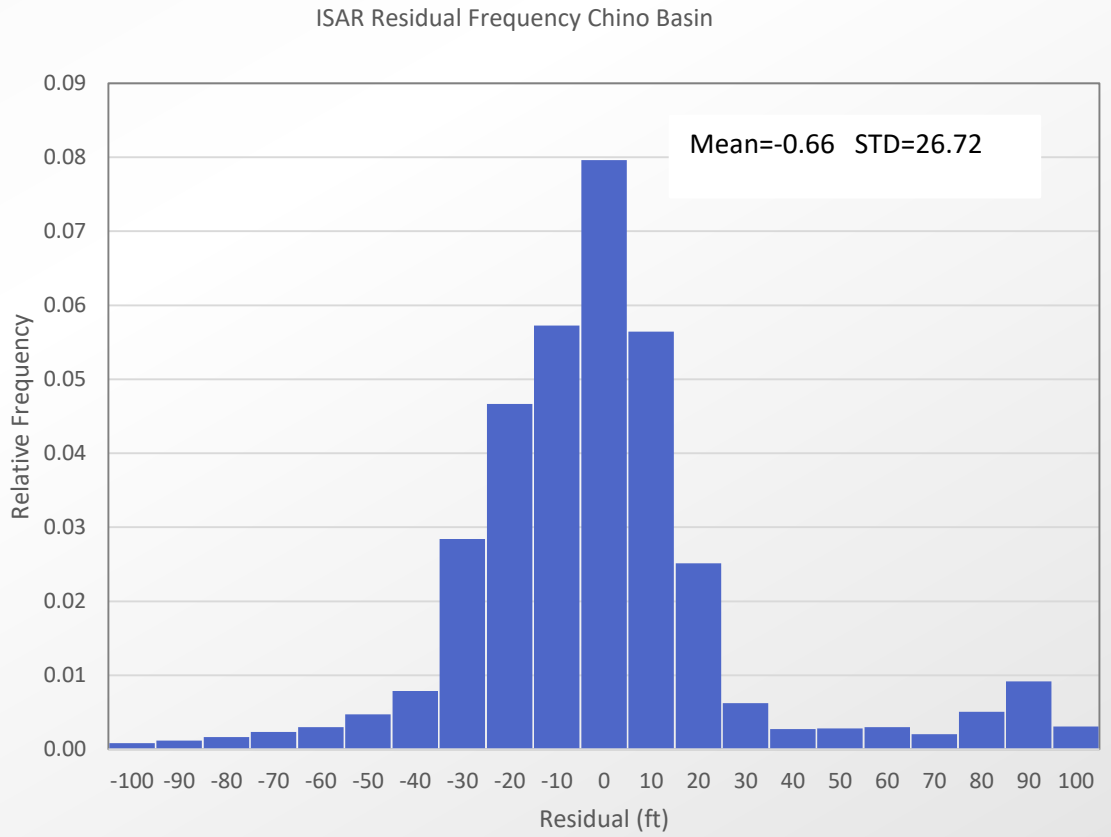
2013 Chino Basin Groundwater Model Update and Analysis of Safe Yield

Geologic Map and Boundaries of the Chino Basin

Figure 2-1


r130ResidualWEIZones
MeanResid
≤-23.000000
≤-20.00000
≤-5.000000
≤5.000000
≤10.000000
≤20.000000
≤117.757420
ISARGridParam
CBWM Model
ISAR (Chino Basin Portion) Model
San Gabriel Mountains
Cucamonga Basin
Claremont Basin
Pomona Basin
Rialto-Co Basin
Puente Hills
La Sierra Hills
Jurupa Mountains
Chino Hills
Rancho Cucamonga
Fontana
Upland
Claremont
Montclair
Ontario
Pomona
Chino
Eastvale
Mira Loma
Jurupa Valley
Corona
Produced by:
WEI
Author: MJC
Date: 10/1/2015
Document Name: Figure_6-8_20140124
0 1 2 3 4 5 Miles
0 2 4 6 8 KM
2013 Chino Basin Groundwater and Analysi





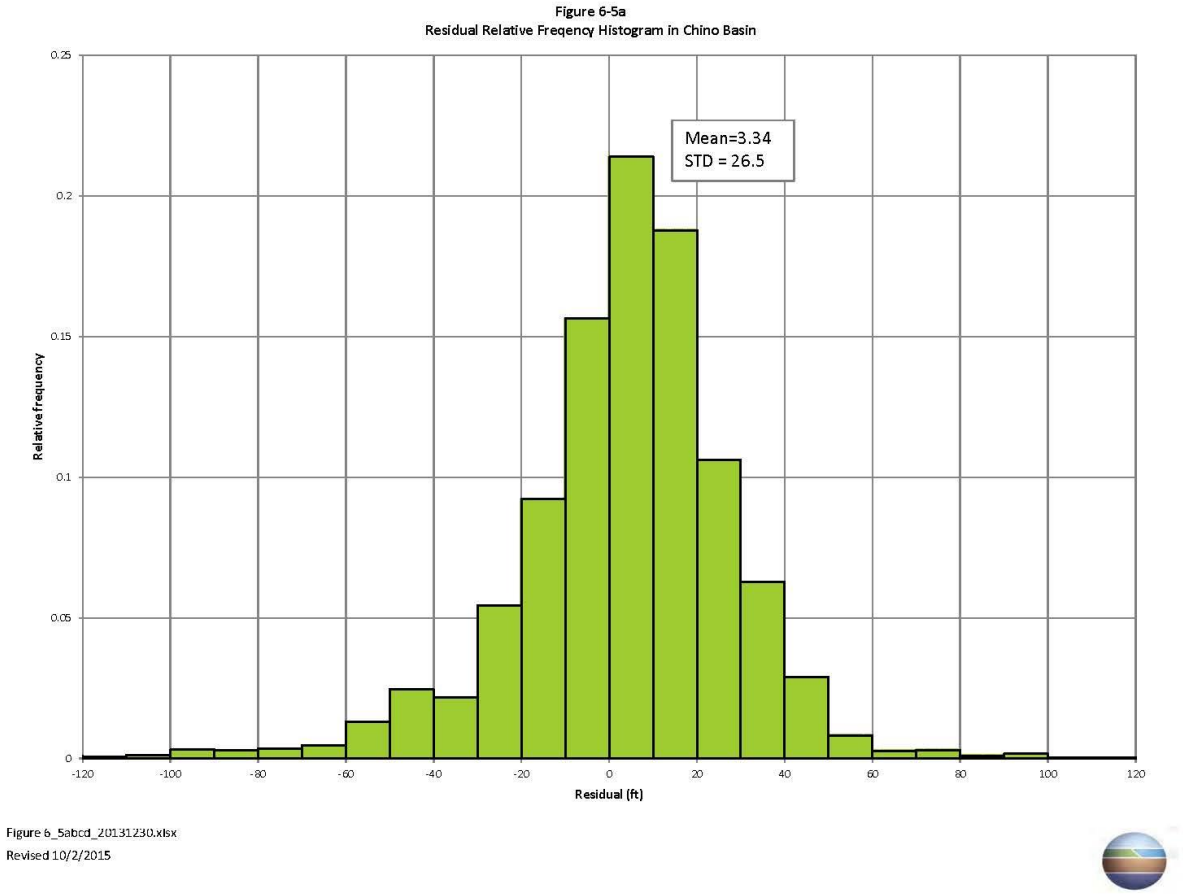
CBWM

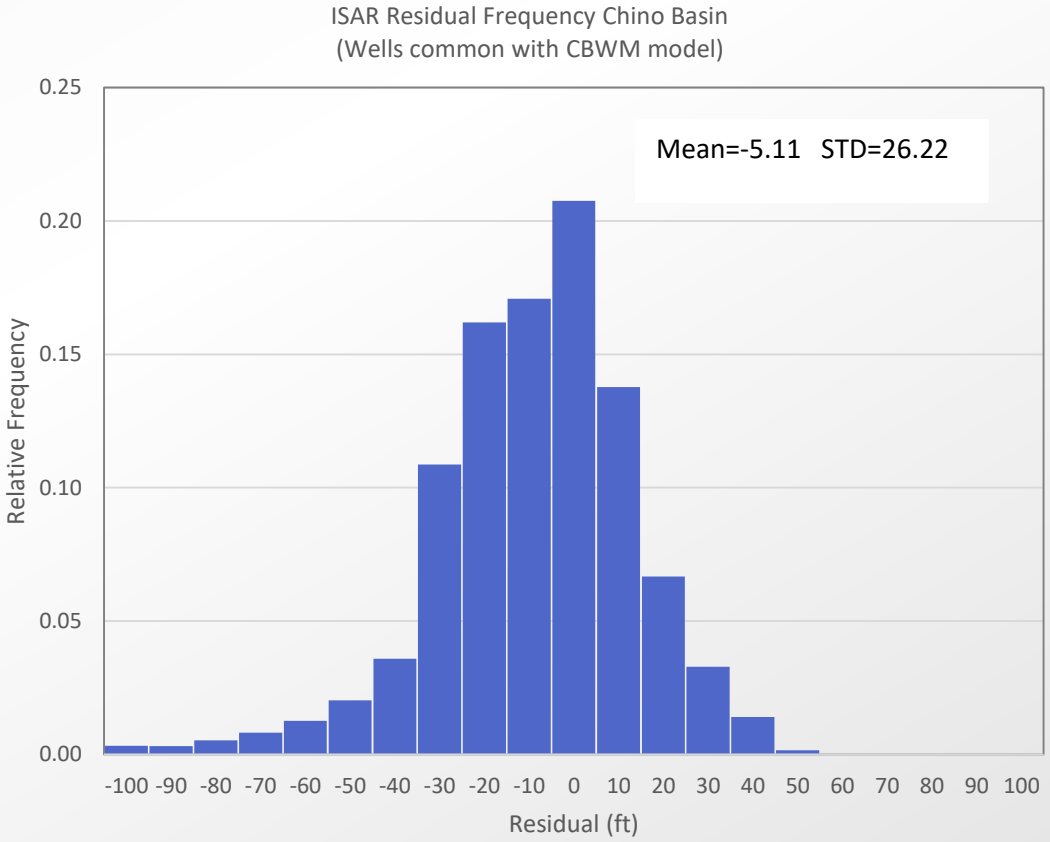
Mean = 3.34 ft, STD = 26.5 ft

ISARM

Mean = -0.66 ft, STD = 26.7 ft

Chino Basin - All





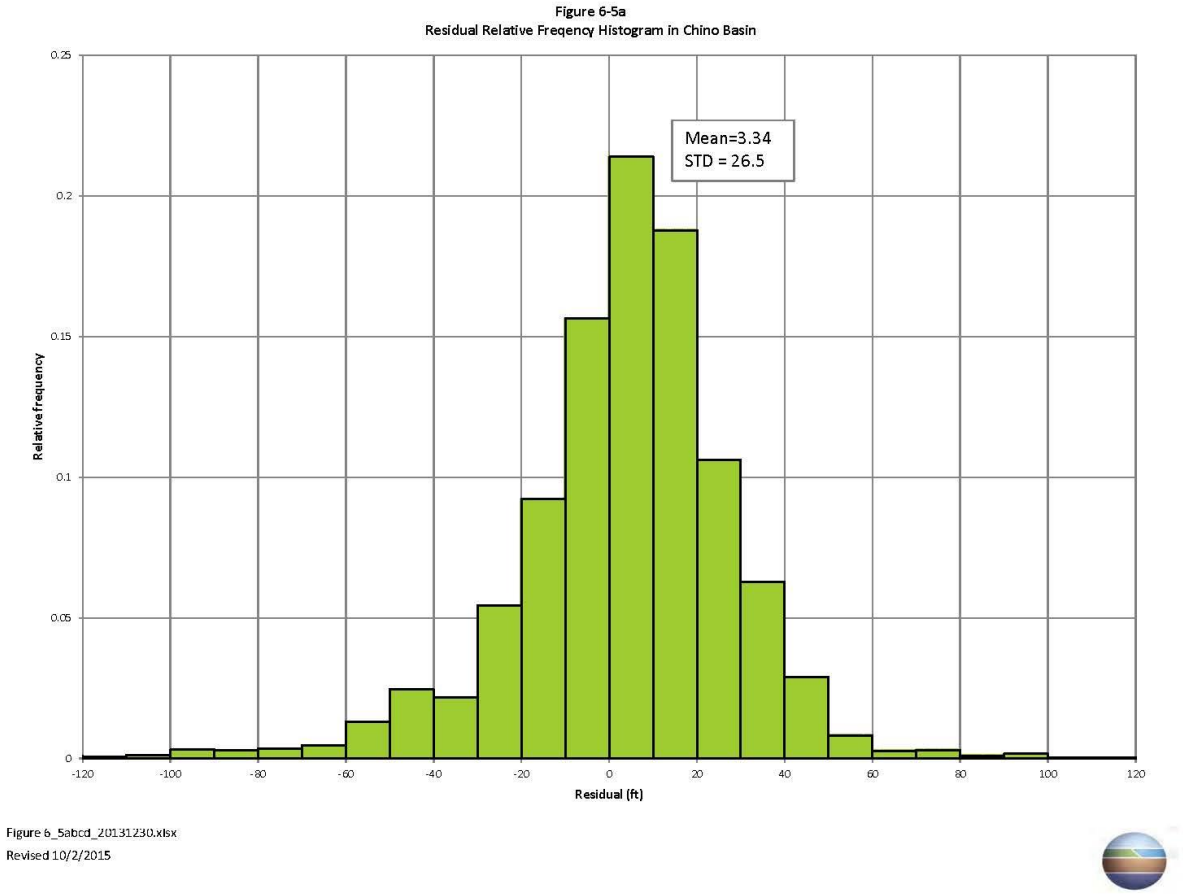
CBWM

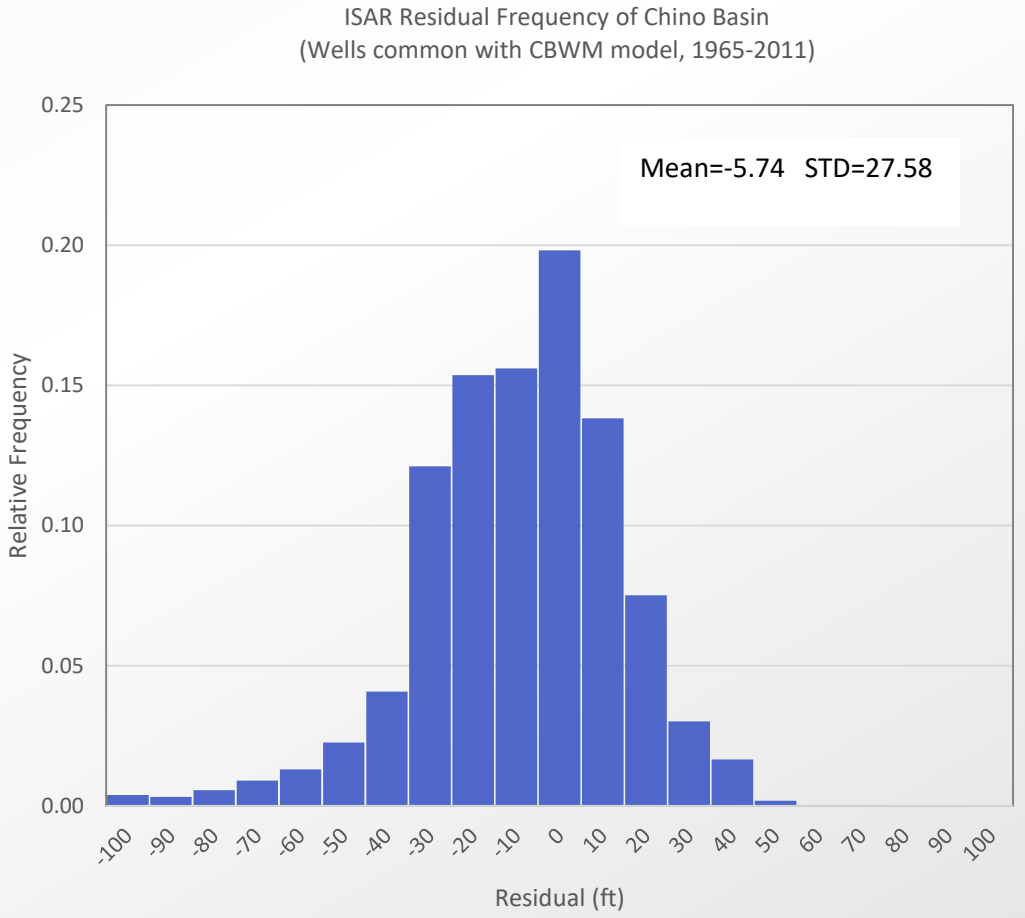
Mean = 3.34 ft, STD = 26.5 ft

ISARM

Mean = -5.11 ft, STD = 26.2 ft

Chino Basin - All (common wells)





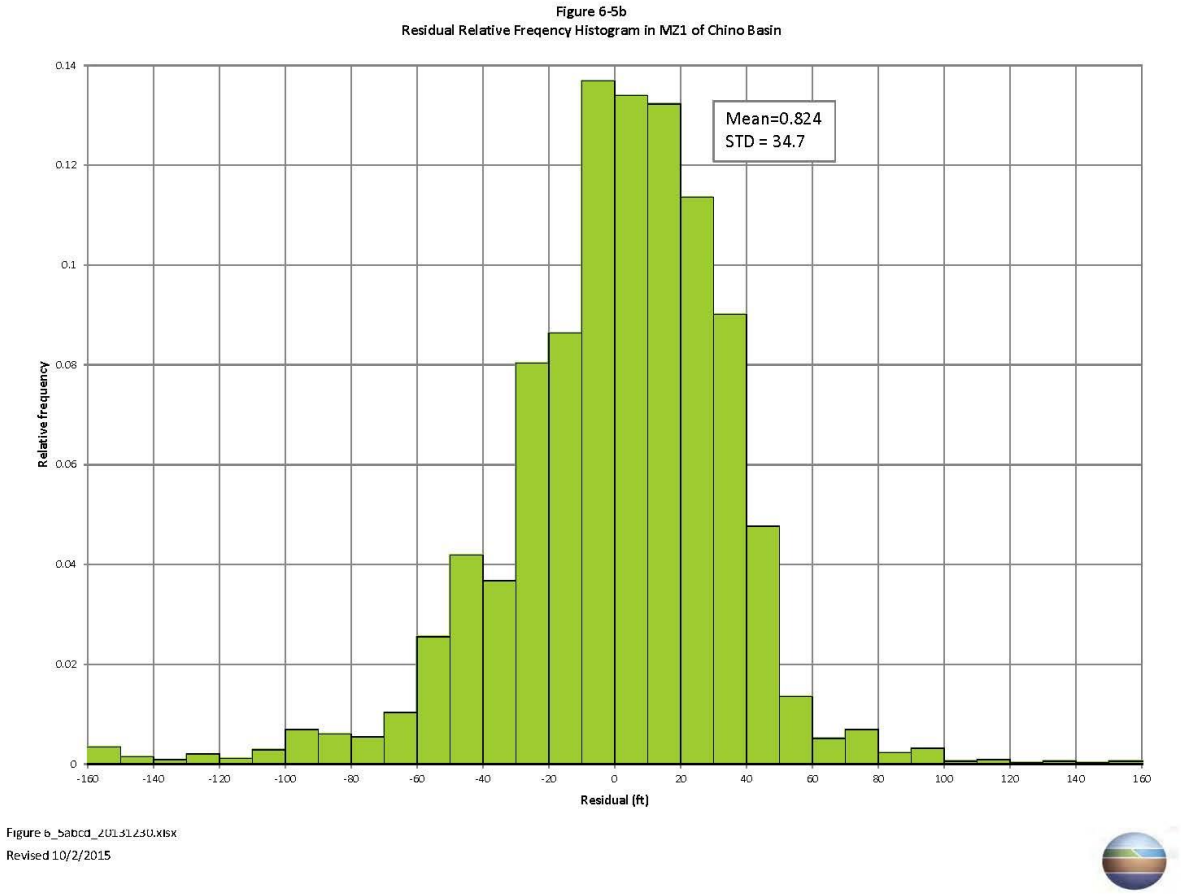
CBWM

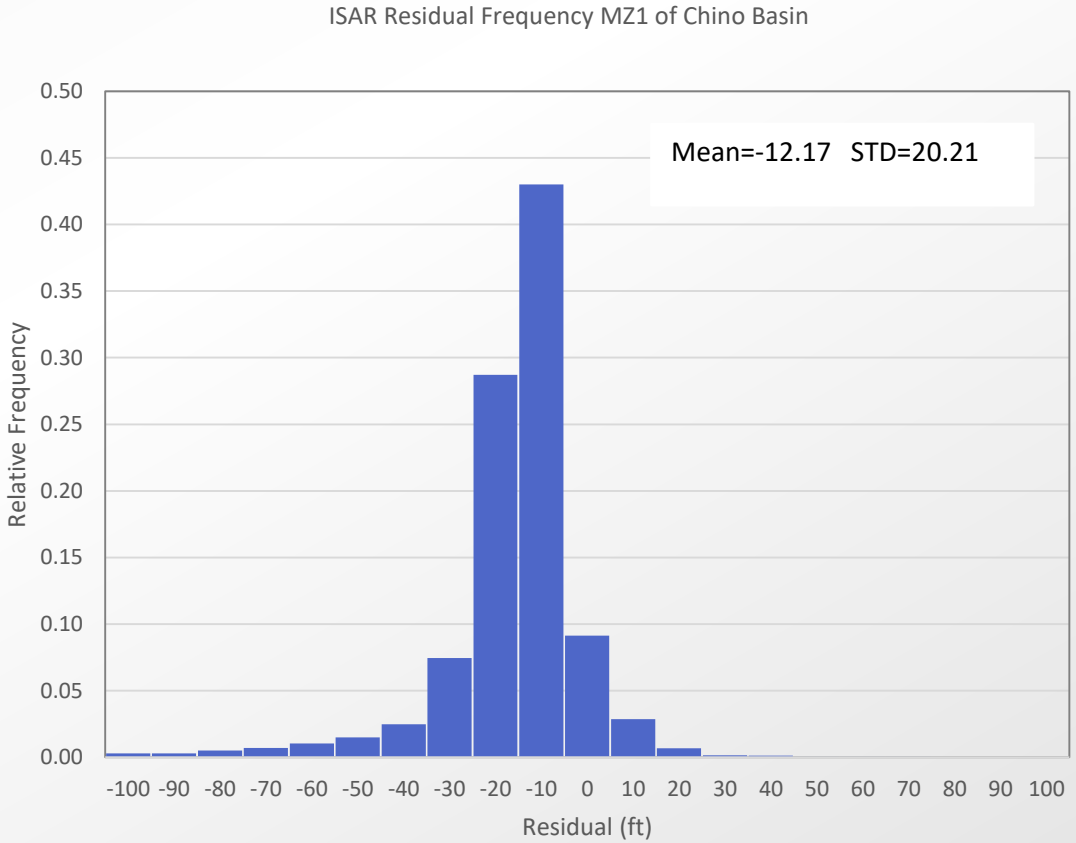
Mean = 3.34 ft, STD = 26.5 ft

ISARM

Mean = -5.74 ft, STD = 27.6 ft

Chino Basin - All (common wells, 1965 - 2011)





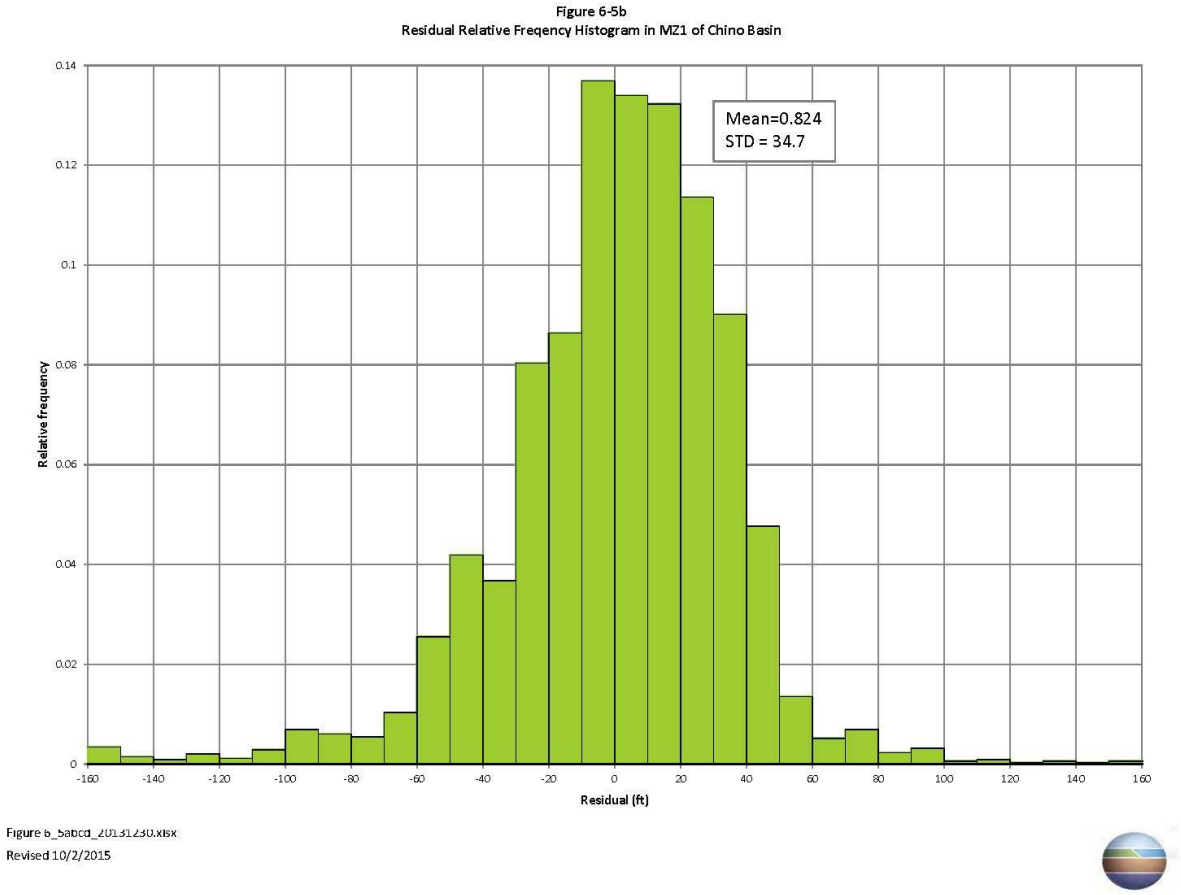
CBWM (calibration period)

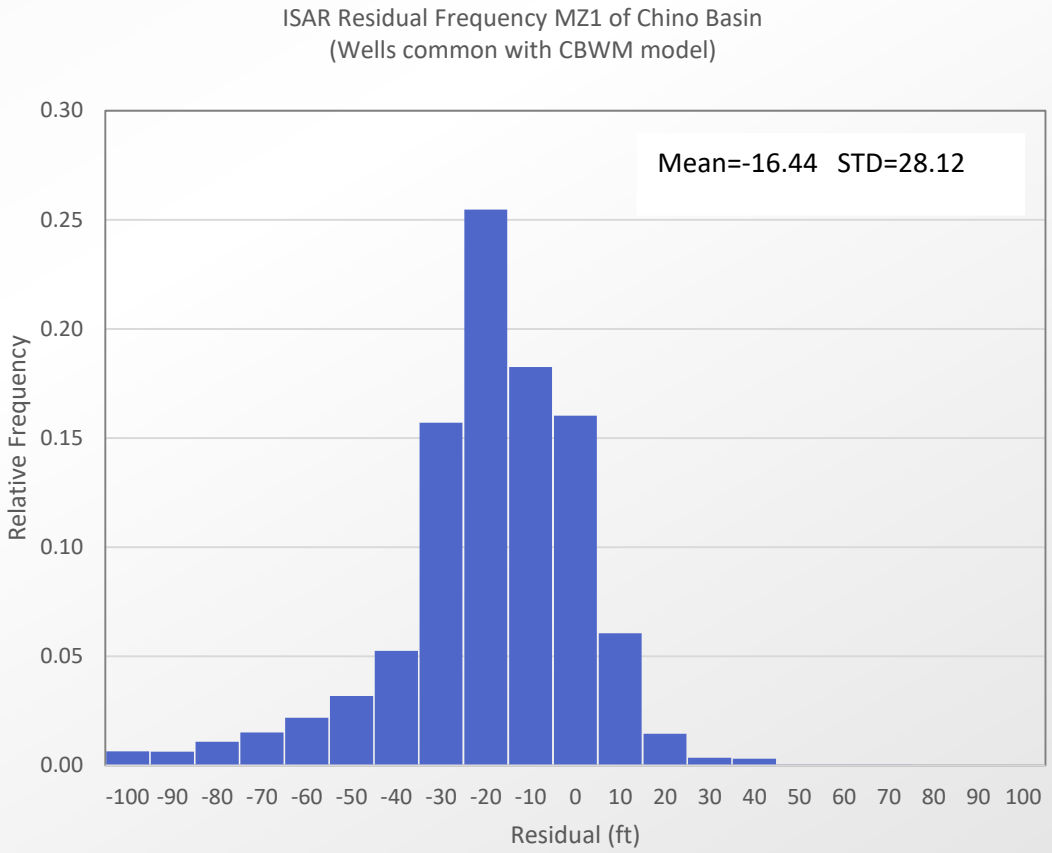
Mean = 0.824 ft, STD = 34.7 ft

ISARM (calibration period)

Mean = -12.17 ft, STD = 20.2 ft

Chino Basin - Mgt Zone 1





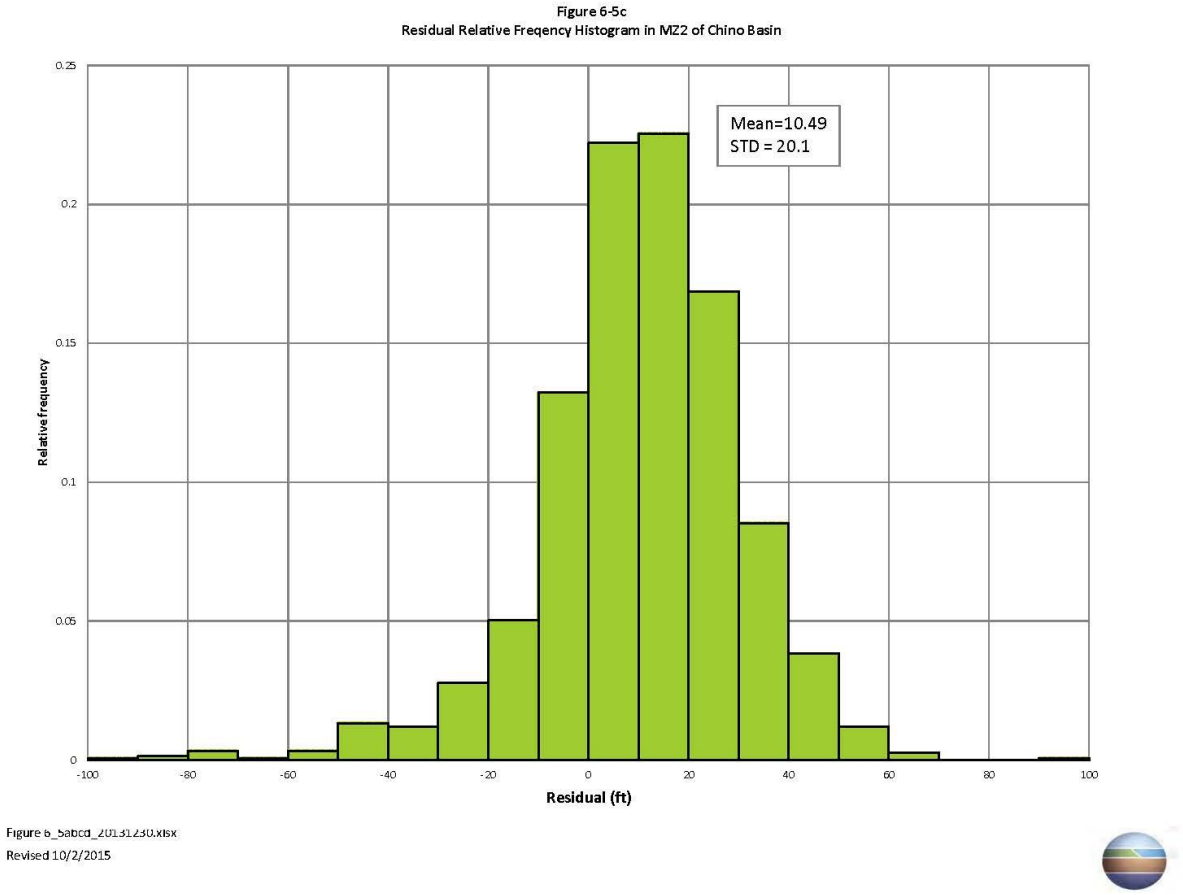
CBWM (calibration period)

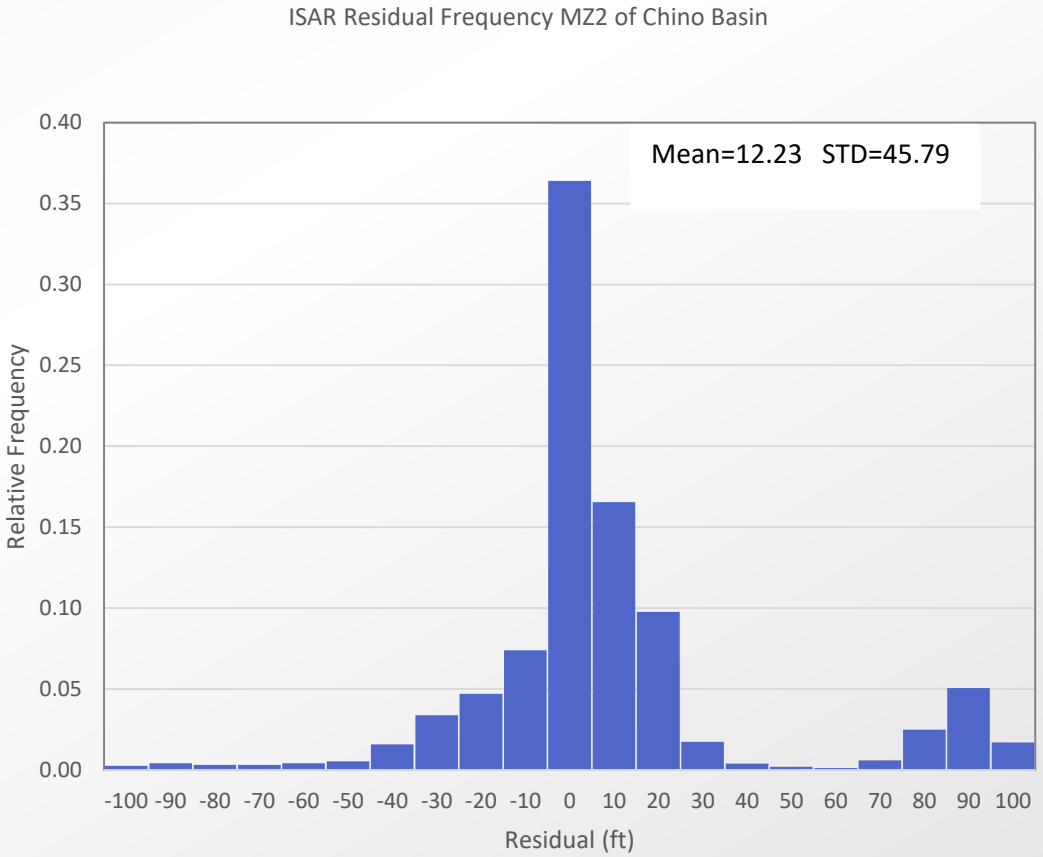
Mean = 0.824 ft, STD = 34.7 ft

ISARM (calibration period)

Mean = -16.44 ft, STD = 28.1 ft

Chino Basin - Mgt Zone 1 (common wells)





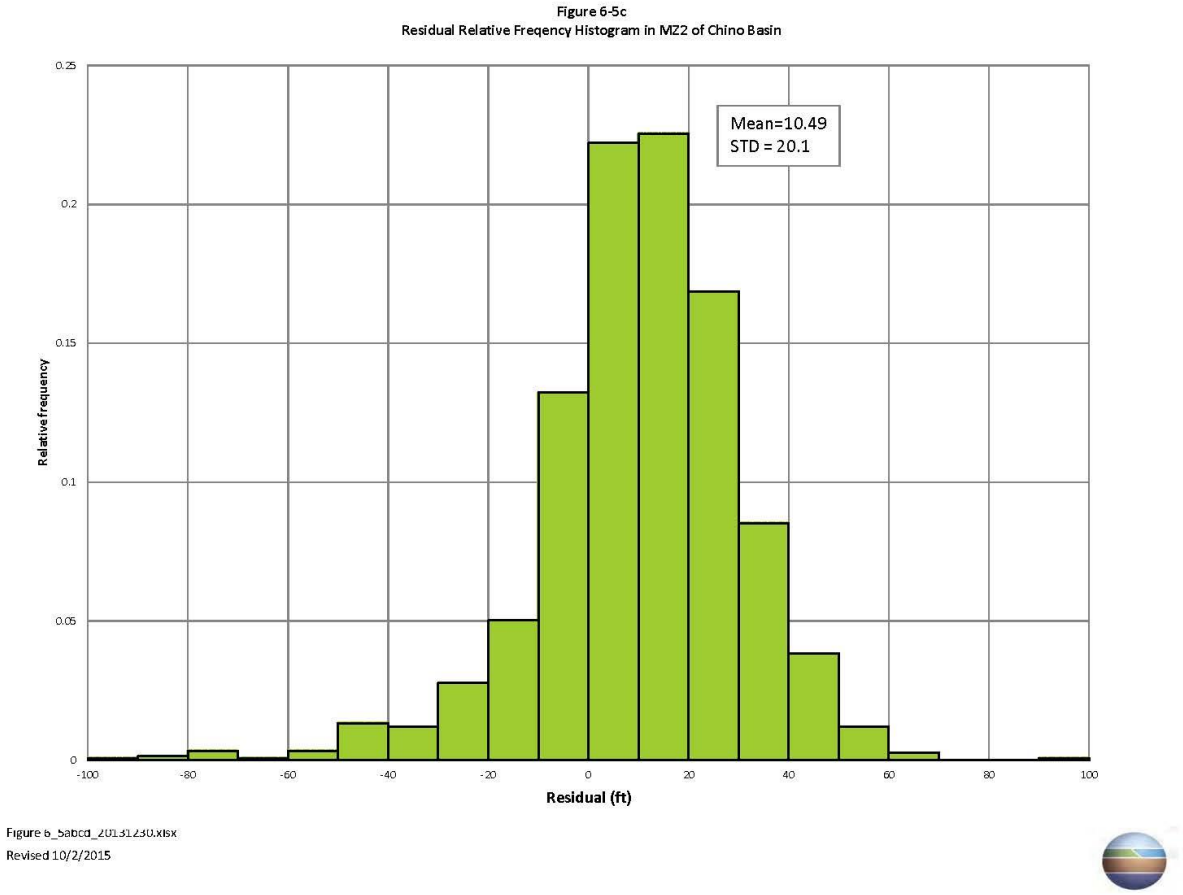
CBWM (calibration period)

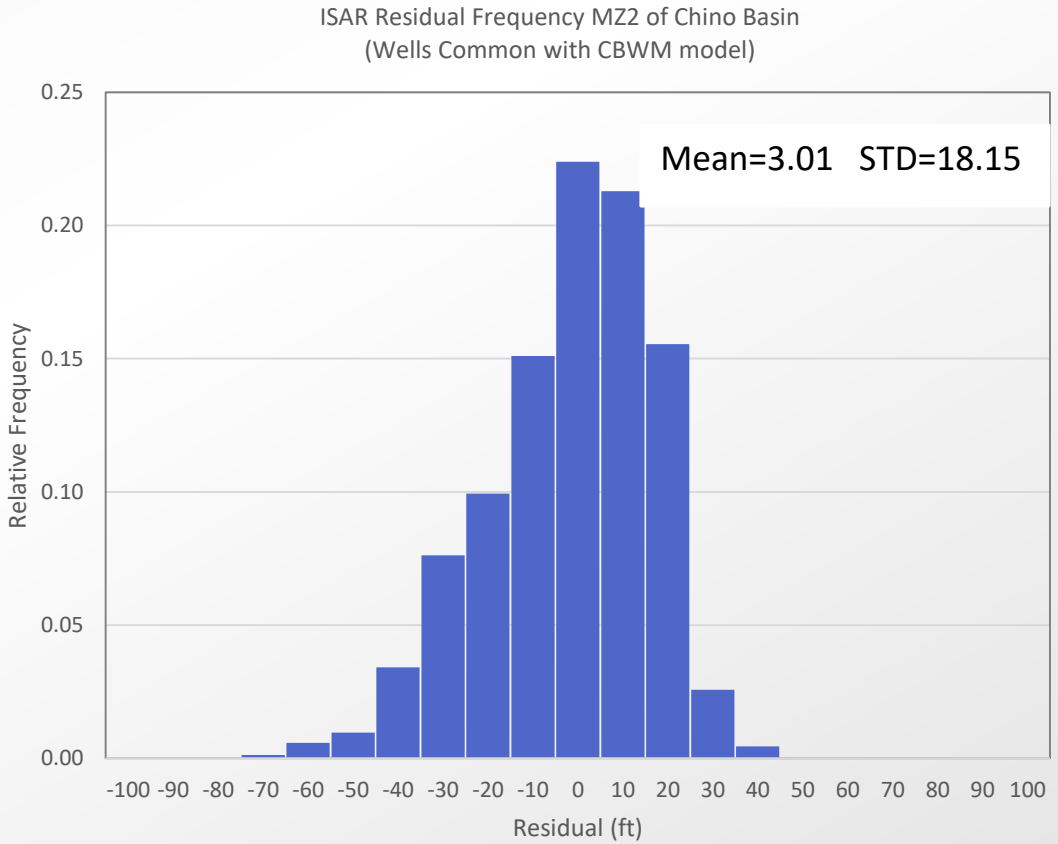
Mean = 10.49 ft, STD = 20.1 ft

ISARM (calibration period)

Mean = 12.23 ft, STD = 45.8 ft

Chino Basin - Mgt Zone 2





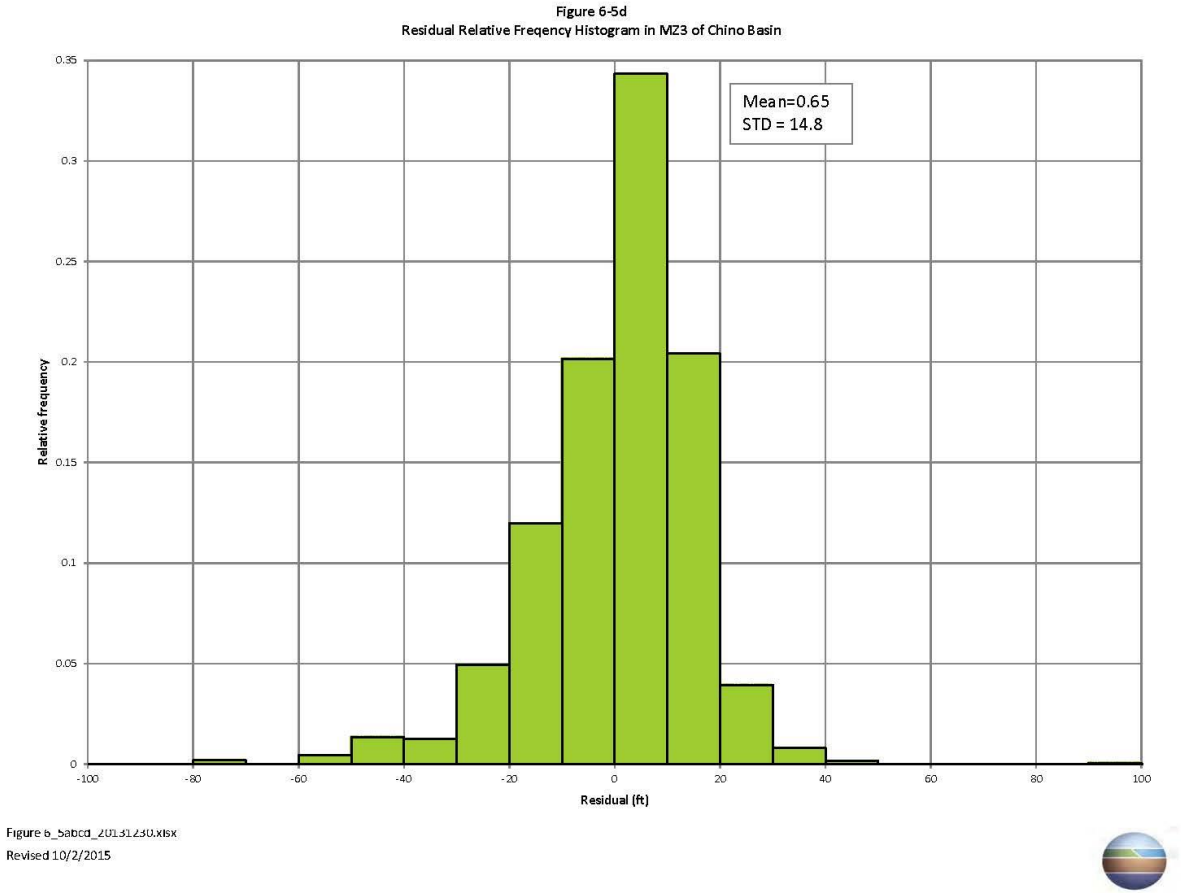
CBWM (calibration period)

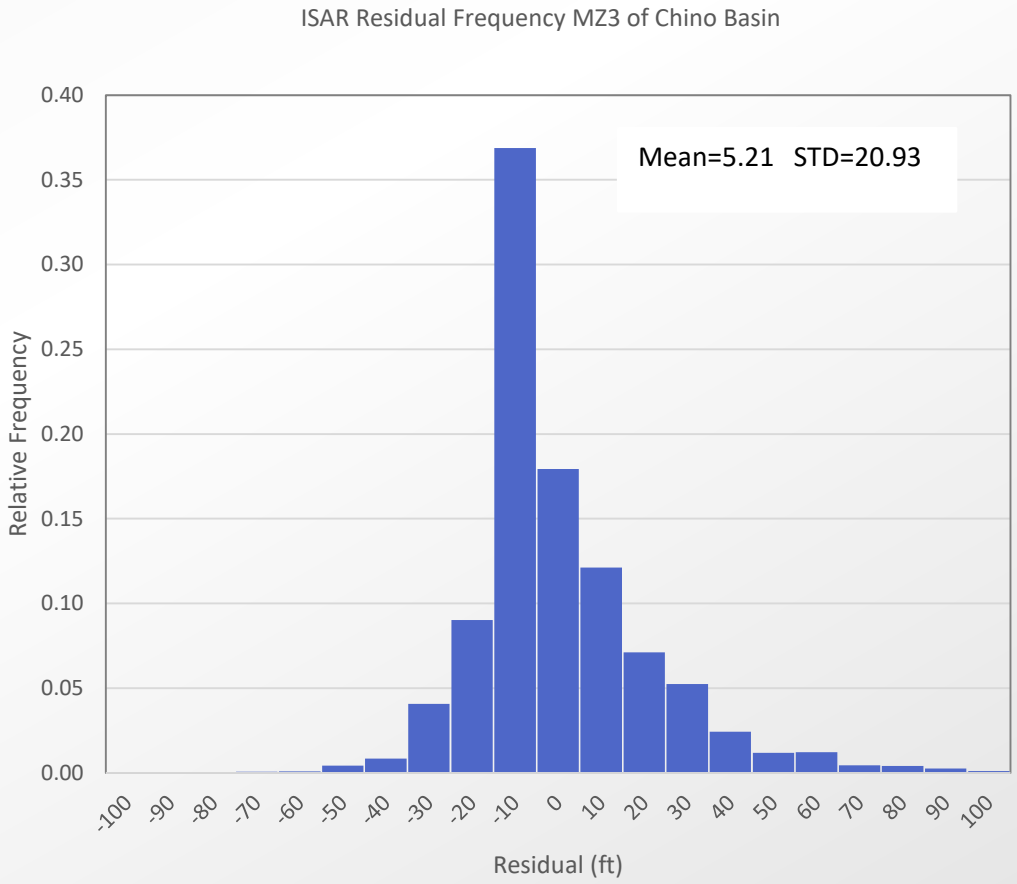
Mean = 10.49 ft, STD = 20.1 ft

ISARM (calibration period)

Mean = 3.01 ft, STD = 18.2 ft

Chino Basin - Mgt Zone 2 (common wells)





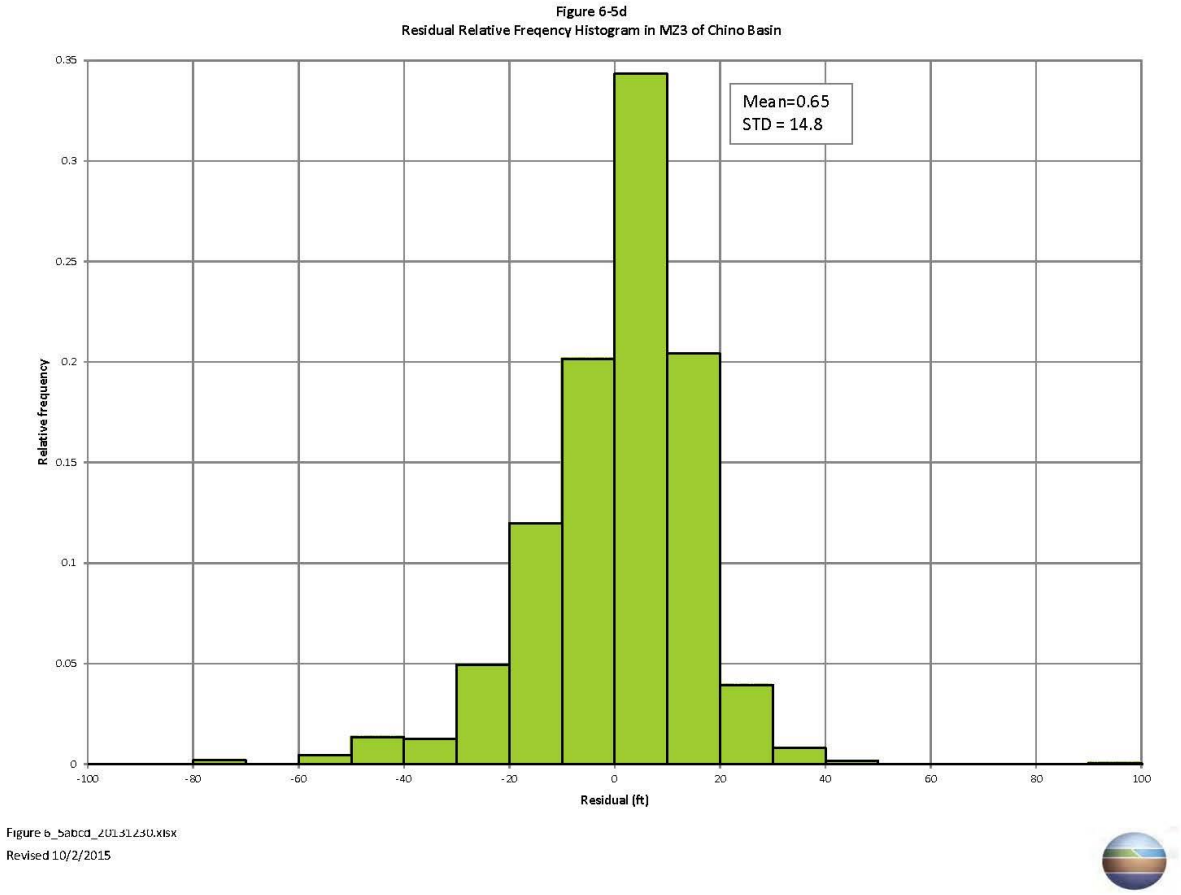
CBWM (calibration period)

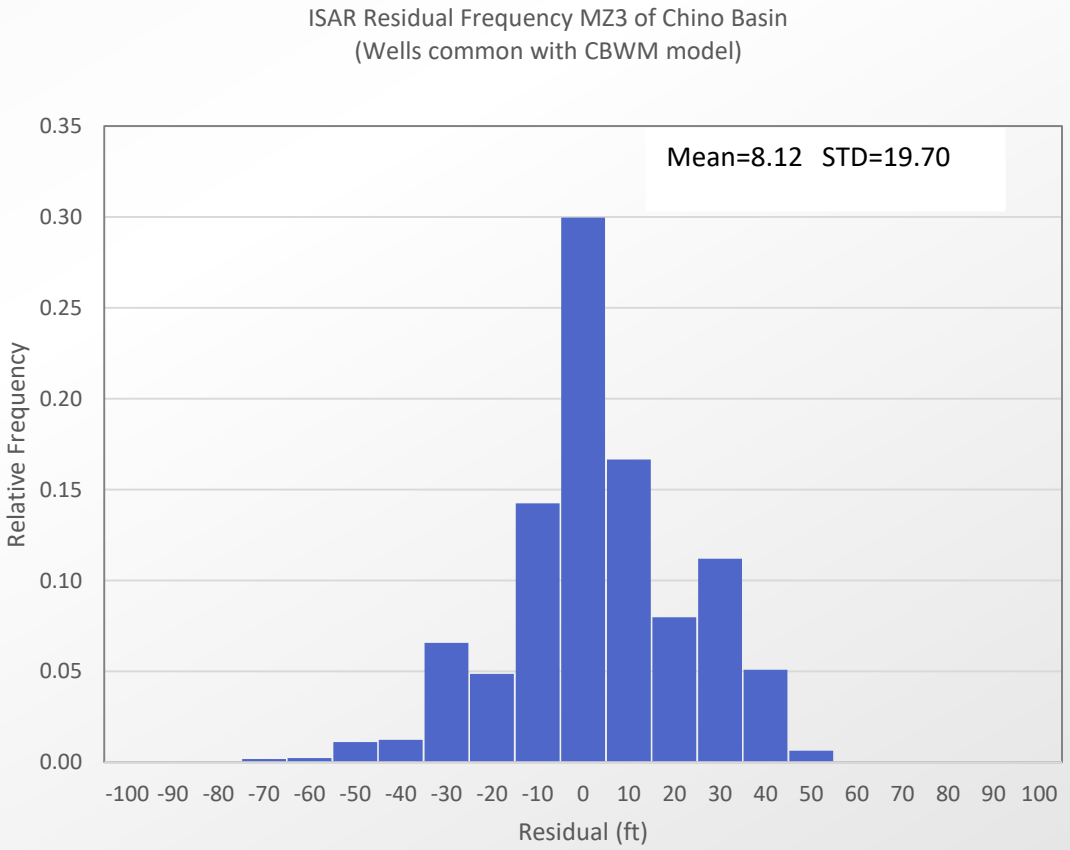
Mean = 0.65 ft, STD = 14.8 ft

ISARM (calibration period)

Mean = 5.21 ft, STD = 20.9 ft

Chino Basin - Mgt Zone 3





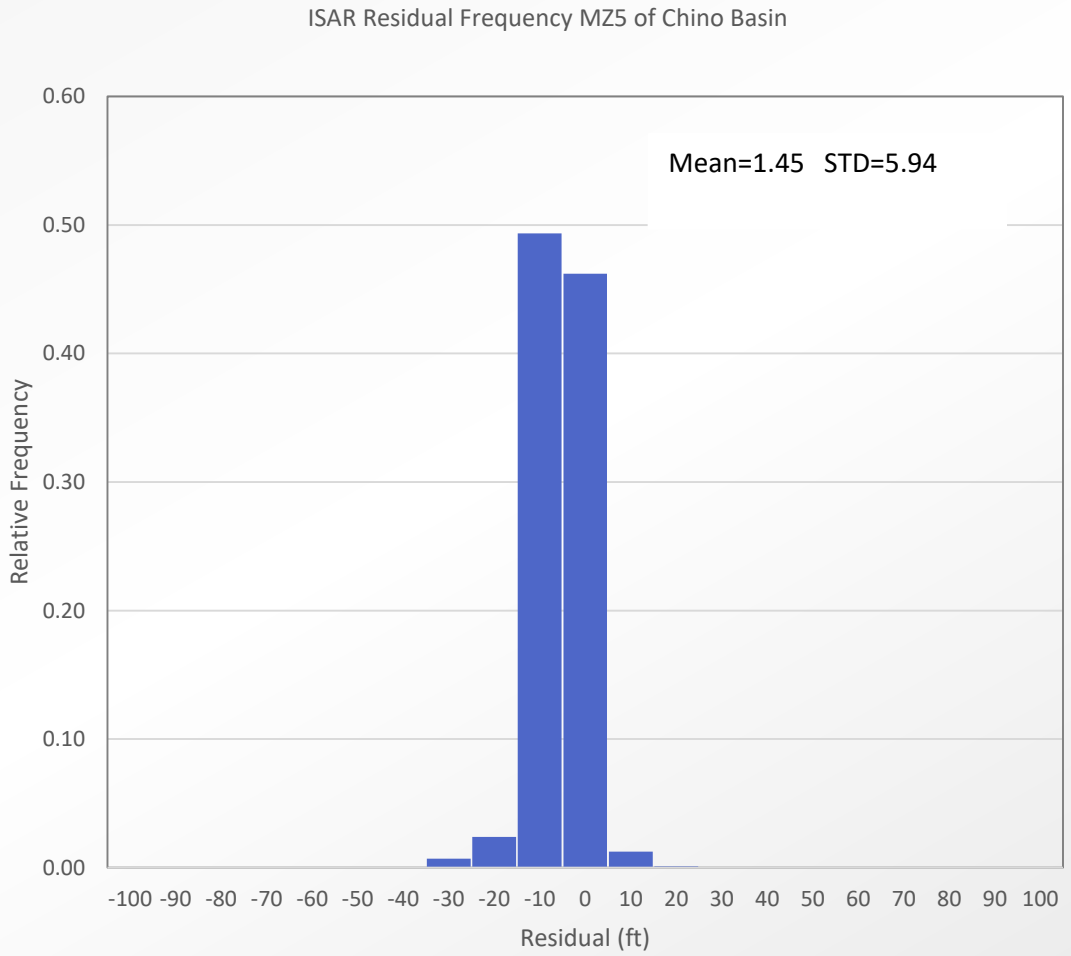
CBWM (calibration period)

Mean = 0.65 ft, STD = 14.8 ft

ISARM (calibration period)

Mean = 8.12 ft, STD = 19.7 ft

Chino Basin - Mgt Zone 3 (common wells)



Chino Basin - Mgt Zone 5 (ISARM)

Summary of Residual Frequency Histograms

Location within Chino Basin	Chino Basin Model			
	CBWM (ft)		ISARM (ft)	
	mean	stand. dev.	mean	stand. dev.
All	3.34	26.5	-0.66	26.7
All (common wells)	3.34	26.5	-5.11	26.2
All (common wells, 1965 - 2011)	3.34	26.5	-5.74	27.6
Mgt Zone 1	0.82	34.7	-12.17	20.2
Mgt Zone 1 (common wells)	0.82	34.7	-16.44	28.1
Mgt Zone 2	10.49	20.1	12.23	45.8
Mgt Zone 2 (common wells)	10.49	20.1	3.01	18.2
Mgt Zone 3	0.65	14.8	5.21	20.9
Mgt Zone 3 (common wells)	0.65	14.8	8.12	19.7

The mean residuals are similar between the two models. Comparisons in Mgt Zones 1 and 3 indicate lower mean residuals in the CBWM model. Achieving a lower residual is an advantage of using a parameter estimation technique; however it is necessary to achieve good model performance.

DISCUSSION

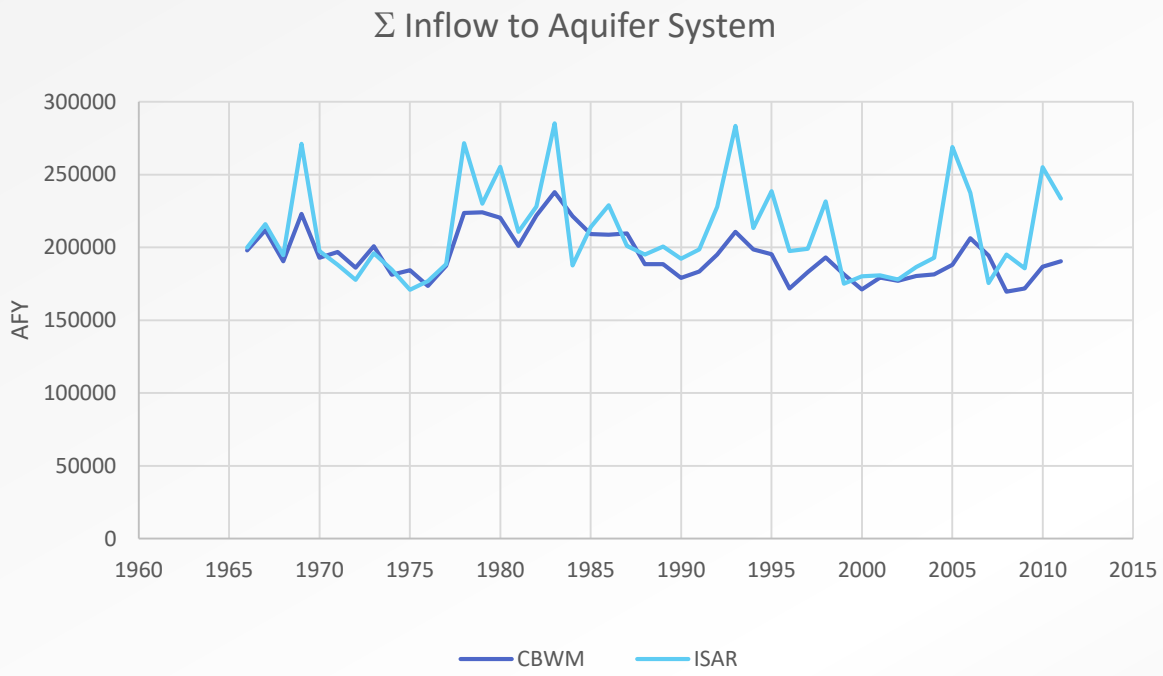
Inspection of ISARM and CBWM model results

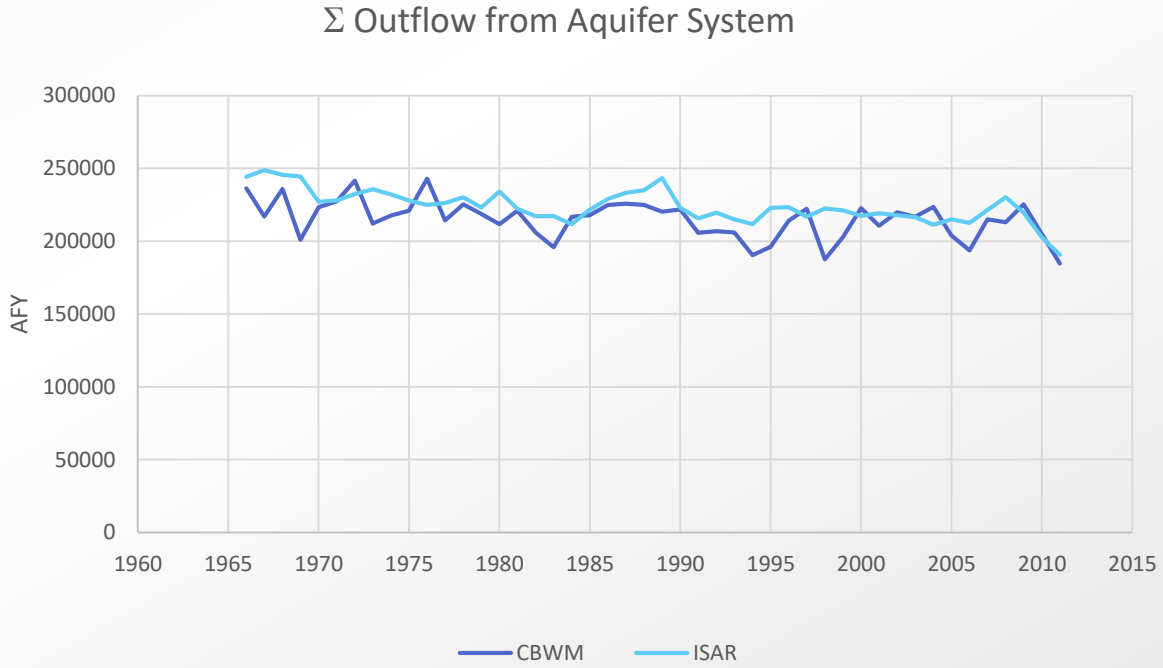
1. Water-level residuals
2. Water-level hydrographs
3. Groundwater flow budget
4. Simulated aquifer T

DISCUSSION

Inspection of ISARM and CBWM model results

1. Water-level residuals
2. Water-level hydrographs
3. Groundwater flow budget
4. Simulated aquifer T



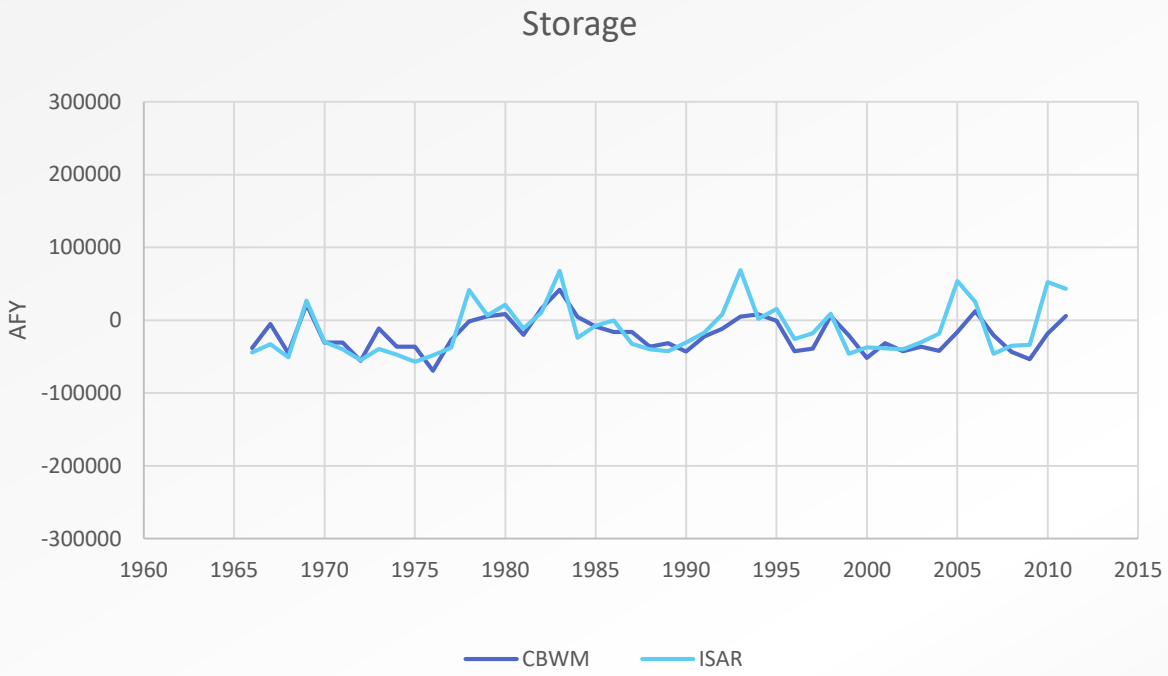


Average Inflow (AF/y)

CBWM	194,981
ISAR	210,801
Difference	15,820

Average Outflow (AF/y)

CBWM	214,954
ISAR	223,951
Difference	8,997



The difference between total inflows and total outflows between the models is attributed to a change in aquifer storage.

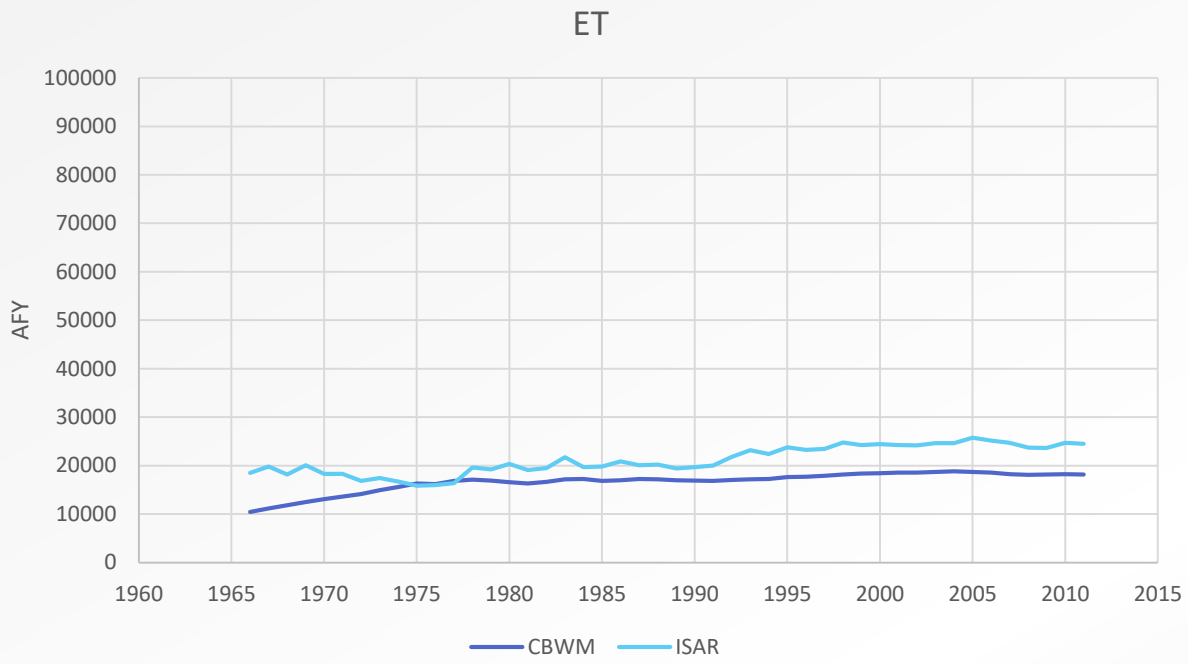
Difference in average storage is a few percent of total flow through models.

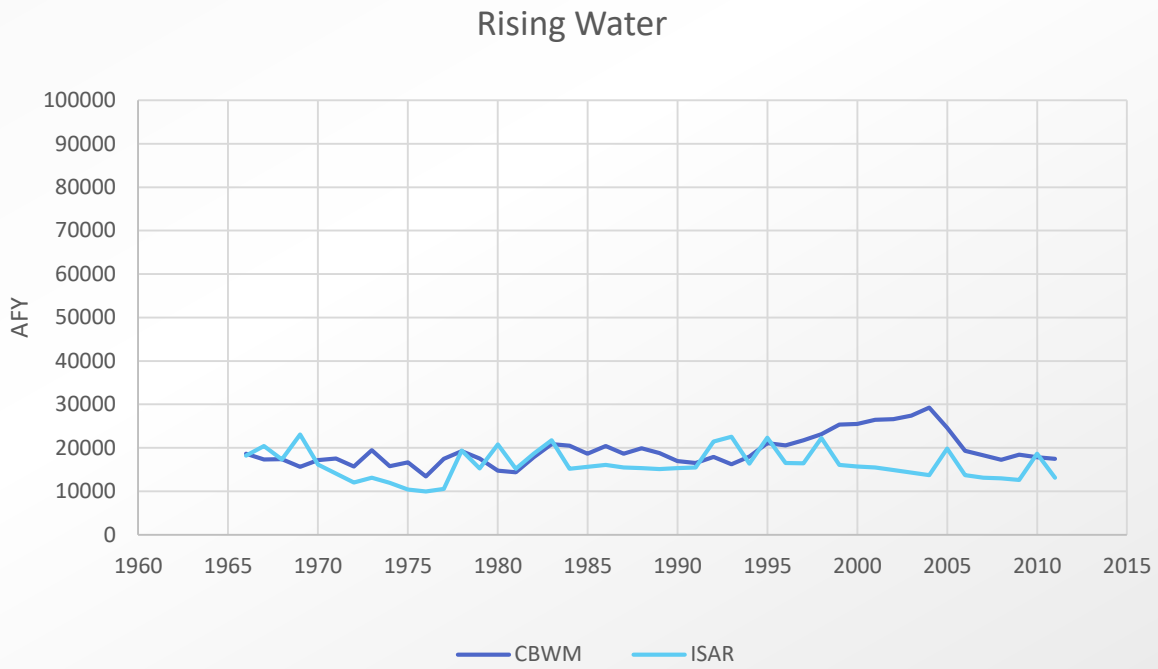
Average Storage (AF/y)

CBWM	-19,973
ISAR	-13,149
Difference	6,824

FLOW BUDGET

INTERACTION BETWEEN **SURFACE WATER** AND **GROUNDWATER**





Average ET (AF/y)

CBWM	16,647
ISAR	21,148
Difference	4,501

Average Rising Water (AF/y)

CBWM	19,337
ISAR	16,169
Difference	-3,168

The modeled differences between average ET and average rising water almost cancel out (4,501 - 3,168 = 1,333 AF/y). The models represent approximately 200,000 AF/y of flow through the basin implying these average differences are on the order of two percent or less of total flow.

DISCUSSION

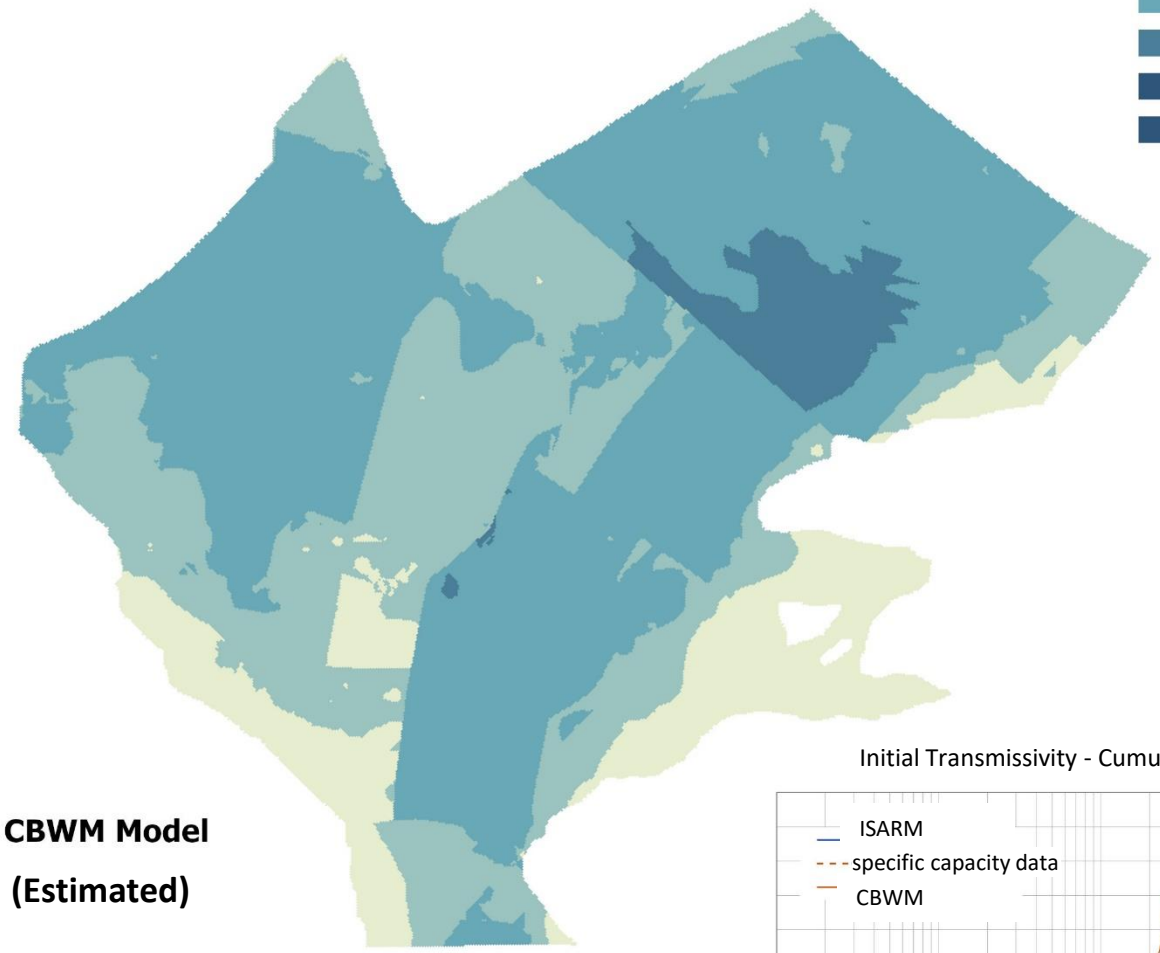
Inspection of ISARM and CBWM model results

1. Water-level residuals
2. Water-level hydrographs
3. Groundwater flow budget
4. Simulated aquifer T

Transmissivity ft^2/d

≤5000
≤10000
≤20000
≤50000
≤100000
≤150000
≤207850

Geometric Mean = 20,000 ft^2/d

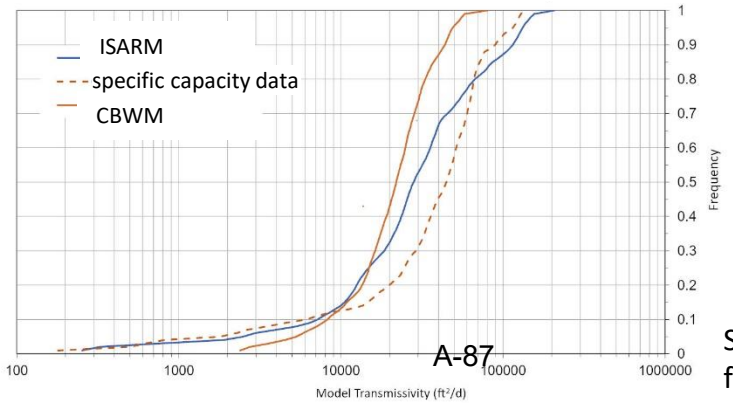


CBWM Model

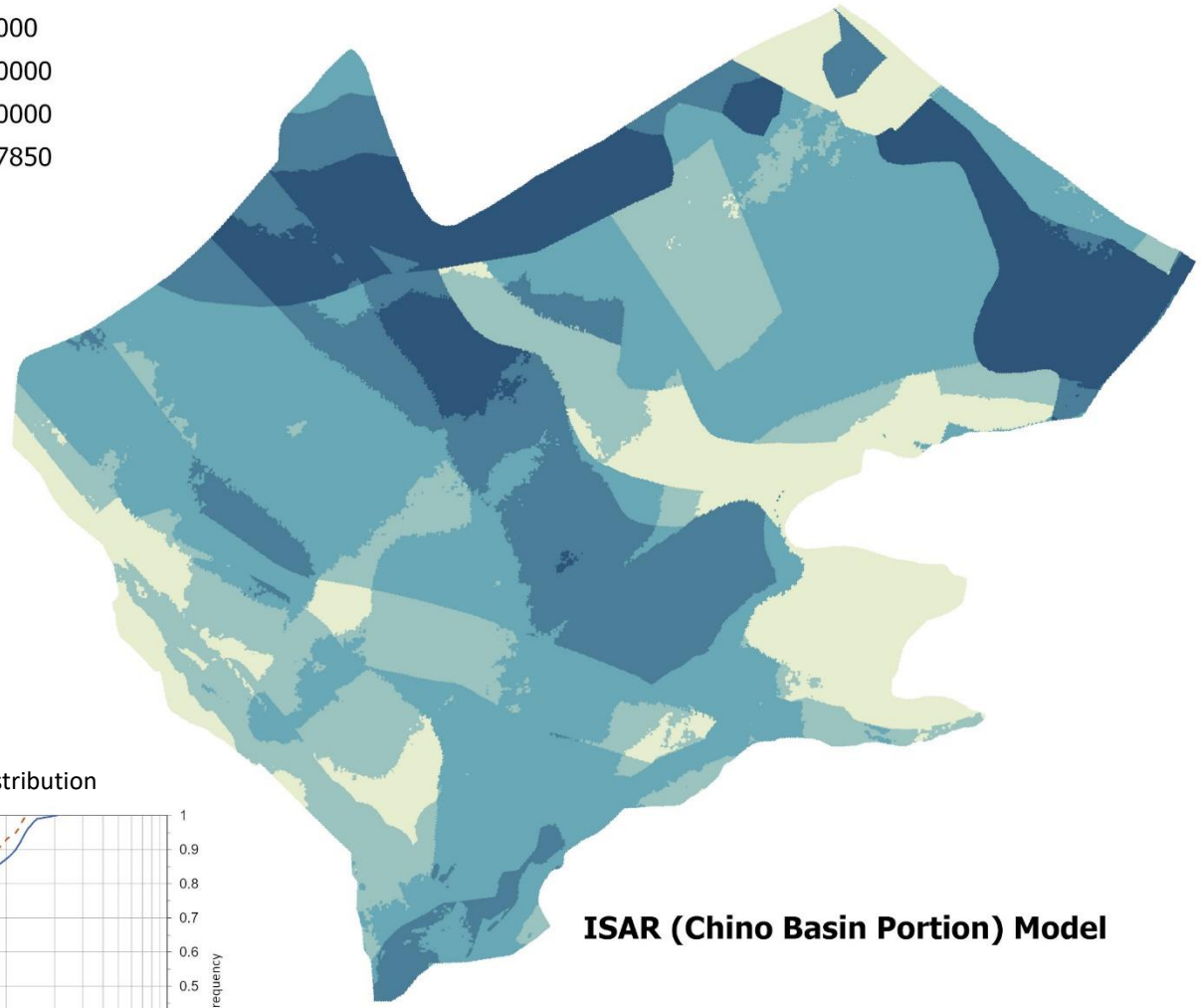
(Estimated)

(Estimate is calculated from figures in WEI Oct 2015 report)

Initial Transmissivity - Cumulative Distribution



Geometric Mean = 25,000 ft^2/d



ISAR (Chino Basin Portion) Model

Specific capacity data from CADWR well tests

0 1.75 3.5 7 Miles

Modeled Specific Yield

Although not shown herein, we estimated specific yield in the CBWM model using the figures in the WEI Oct 2015 report. The average (model-wide) specific yield is 0.09.

In the ISARM, the average specific yield is 0.11.

OBSERVATION

1. The ISARM and CBWM models were calibrated with methods that have differences (automated PEST vs. manual adjustment).

2. The model responses during the calibration periods of the ISARM and CBWM models are different, but similar. Strong similarities exist particularly with regard to the average regional flow budgets, the geometric mean of aquifer transmissivity and the average specific yield.

3. The ISARM and CBWM models are two different realizations of the Chino Basin hydrogeologic system. A stochastic simulation technique would result in many more realizations of the same system capable of producing different, but similar results.

4. These observations imply that, despite different calibration methods, the two models are part of a set of similar representations of the Chino Basin hydrologic system. Model responses in specific areas can be refined with additional calibration (if needed) as additional monitoring data is collected in key areas of interest for either model.

Water-Level Hydrographs (WEI – Appendix C1)

WEI (2015, Appendix C1) shows time-history plots (water-level hydrographs) from 66 wells used for calibration of the Chino Basin Watermaster model (CBWM). We developed water-level hydrographs from the Integrated Santa Ana River model (ISARM) for a qualitative (visual) comparison. Out of the 66 wells used in calibration of the CBWM, 49 are in the ISARM calibration dataset. A side-by-side comparison for each of the 49 hydrographs is attached.

On each page, the upper hydrograph shows observed water-level data and simulated water levels from the ISARM; simulated water levels from each model layer are presented for a complete view of model response. The lower hydrograph is taken from WEI (2015, Appendix C1).[1] The vertical axes on hydrographs are scaled the same to facilitate visual comparison.

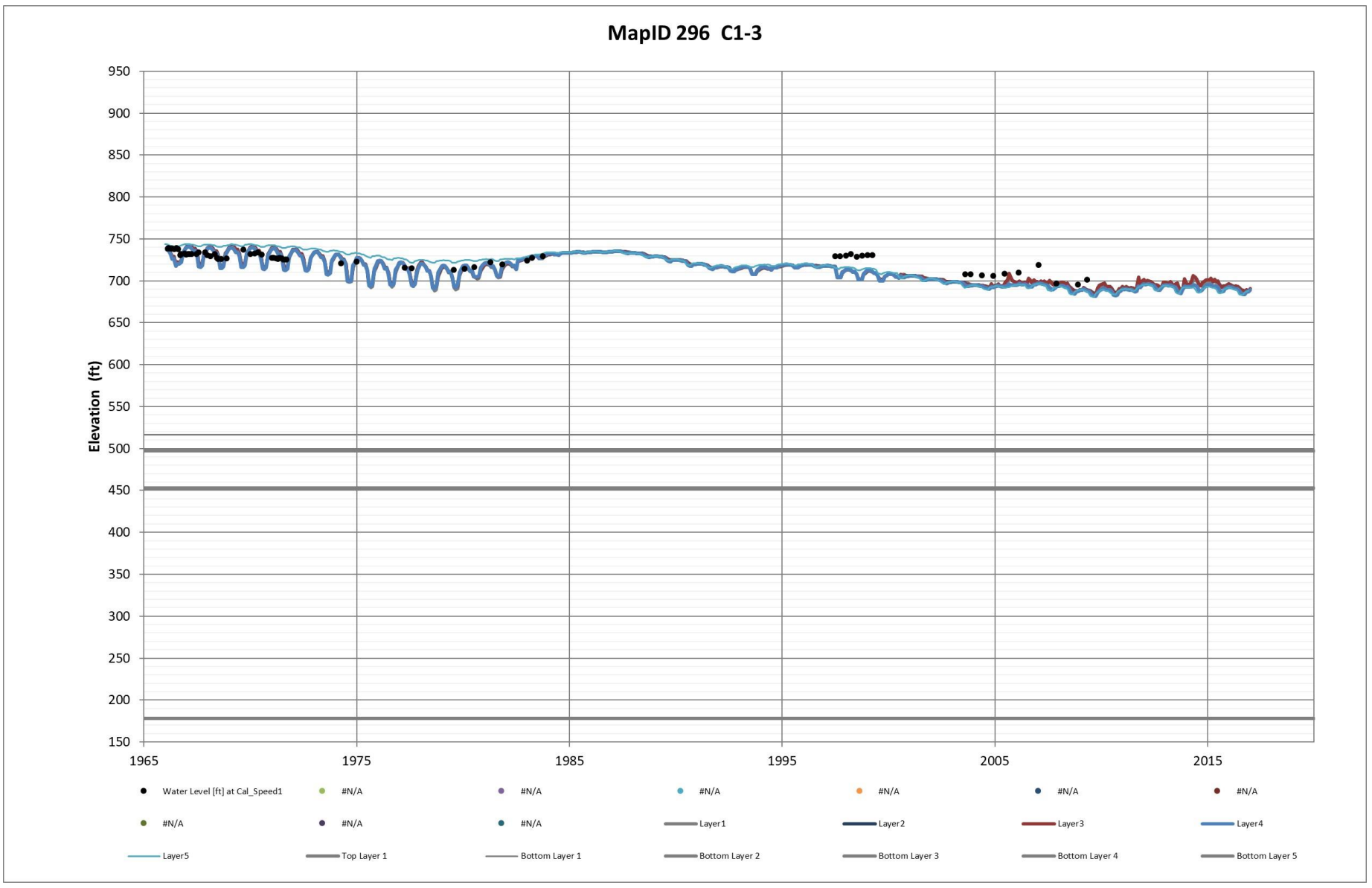
The hydrograph presentation can be refined if needed. The intent of this document is to present a simple comparison for inspection by the Model Group Subcommittee of the Technical Advisory Committee.

Attachment: Hydrographs (49 wells)

Reference

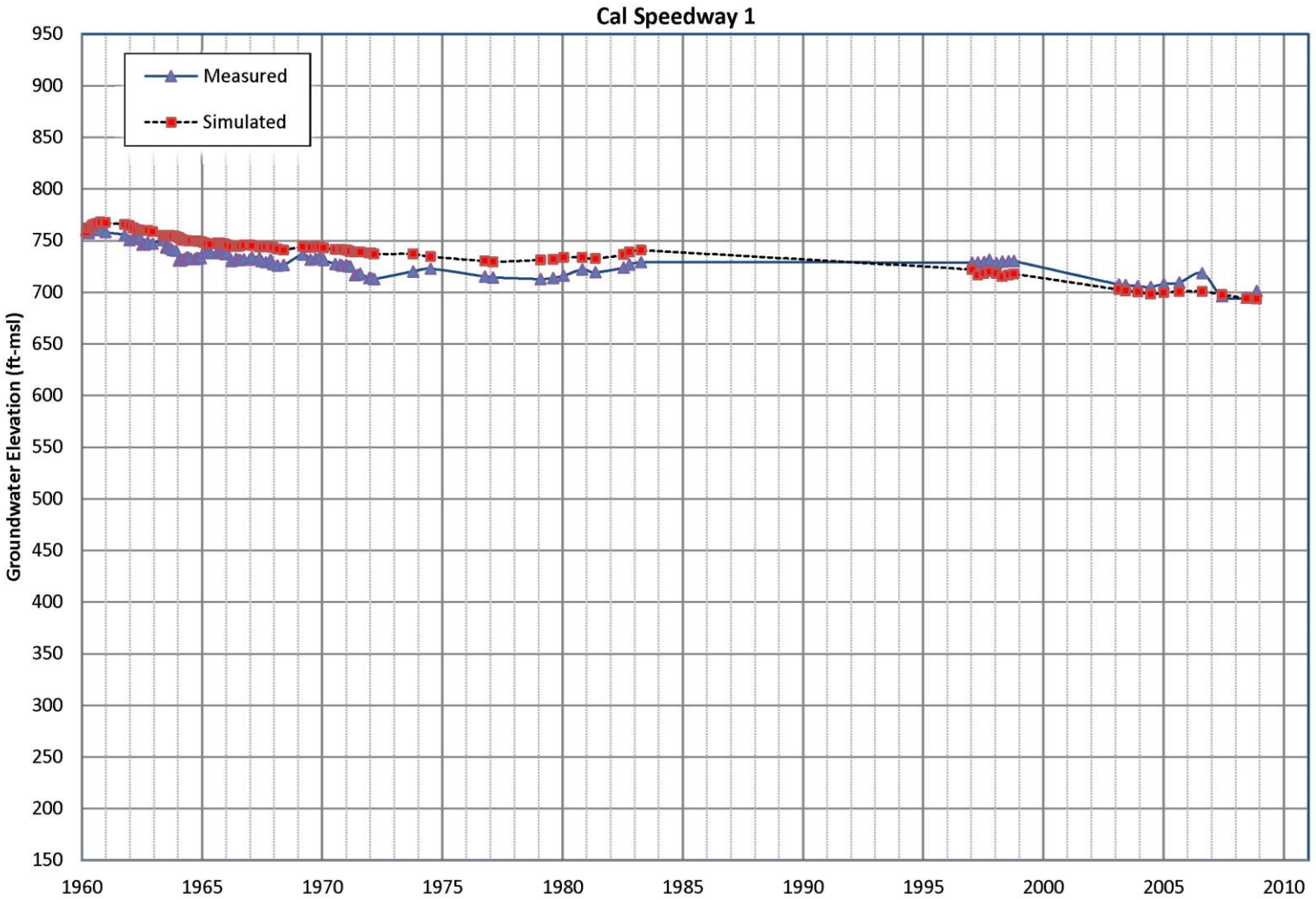
Wildermuth Environmental, Inc., 2015, 2013 Chino Basin Groundwater Model Update and Recalculation of Safe Yield Pursuant to the Peace Agreement: Prepared for Chino Basin Watermaster, report dated October 2015.

[1] We do not have the WEI (2015) model so the hydrographs are directly from the WEI (2015) report.

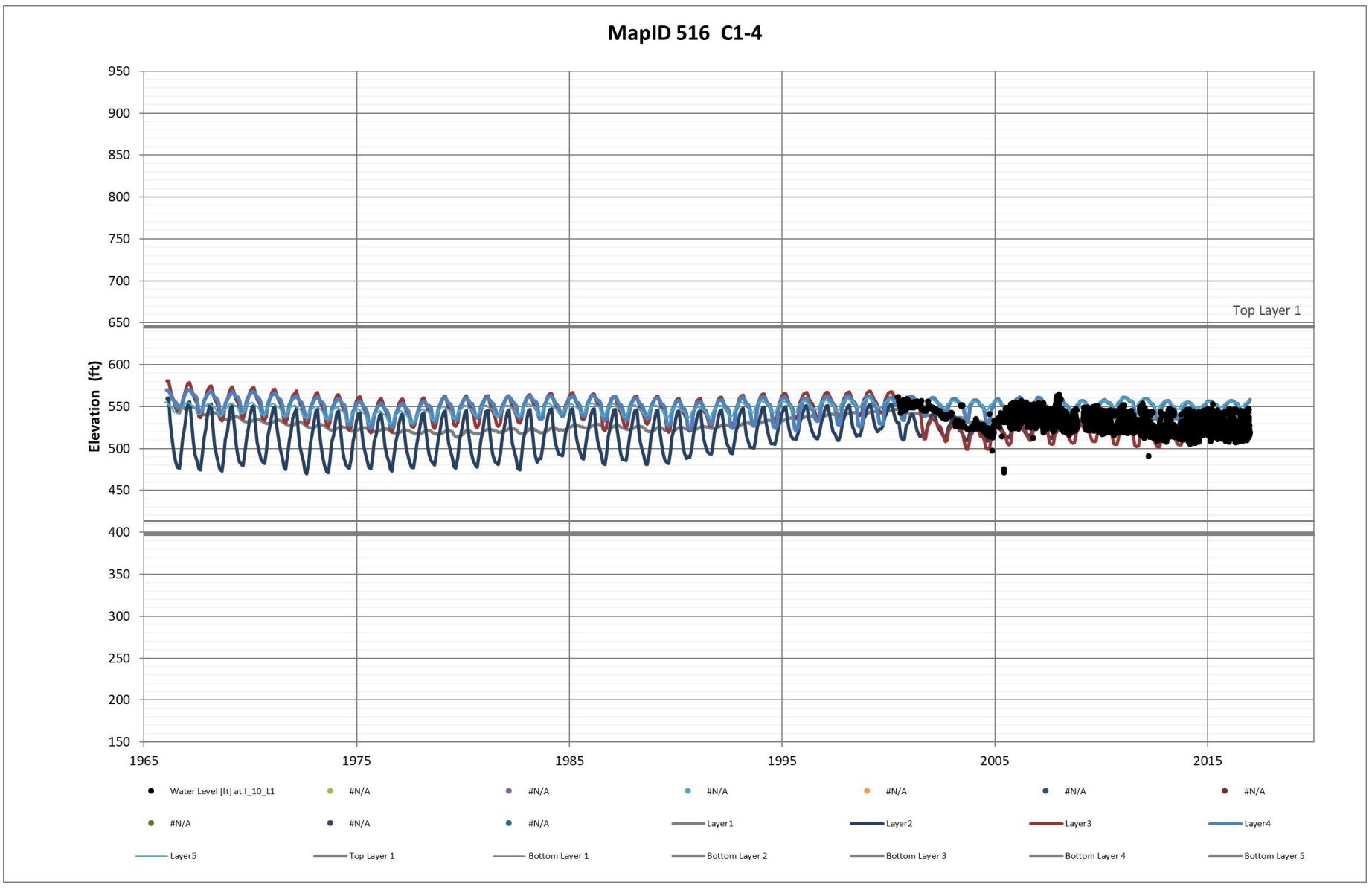


ISARM

Figure C1-3
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
Cal Speedway 1

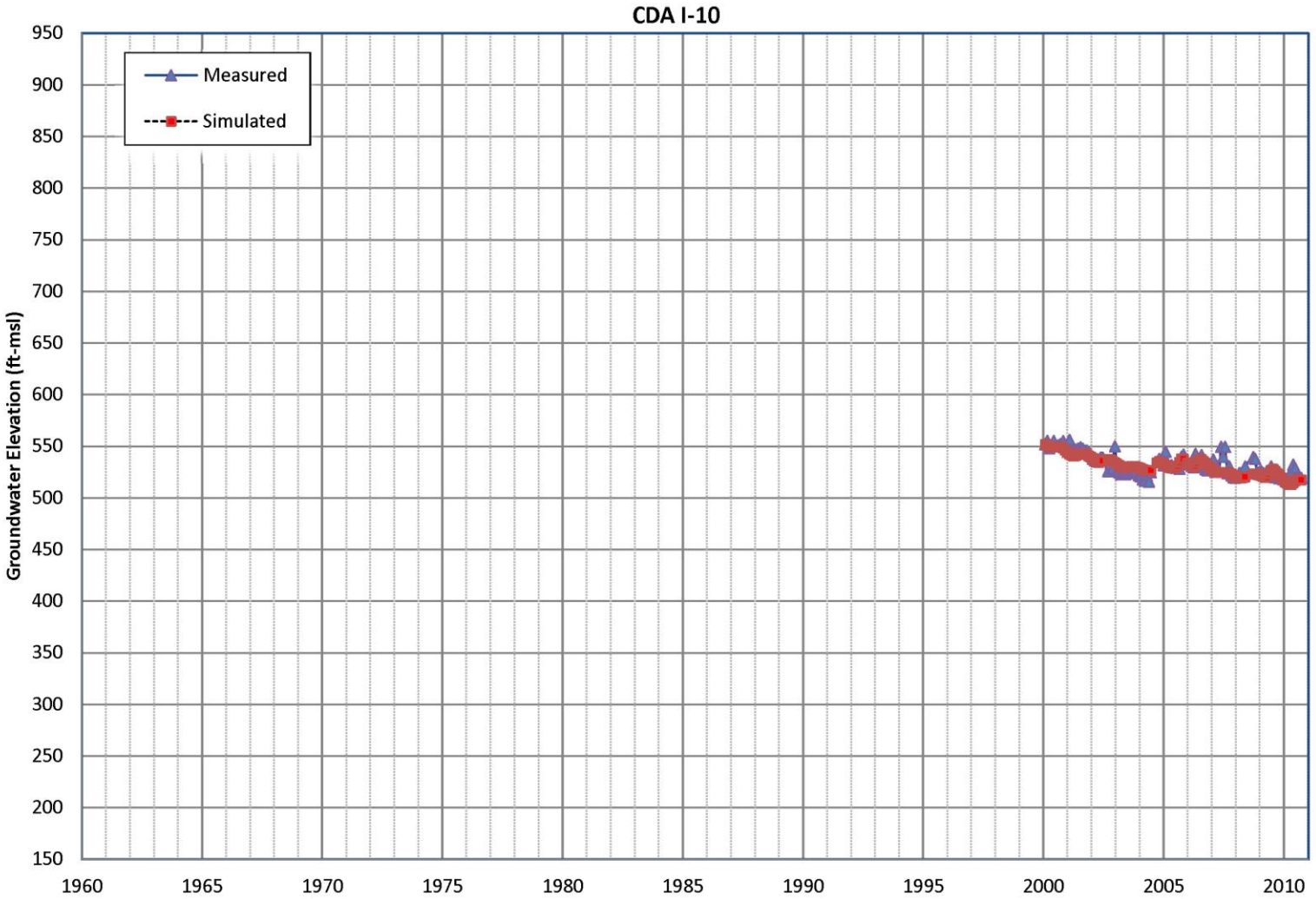


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

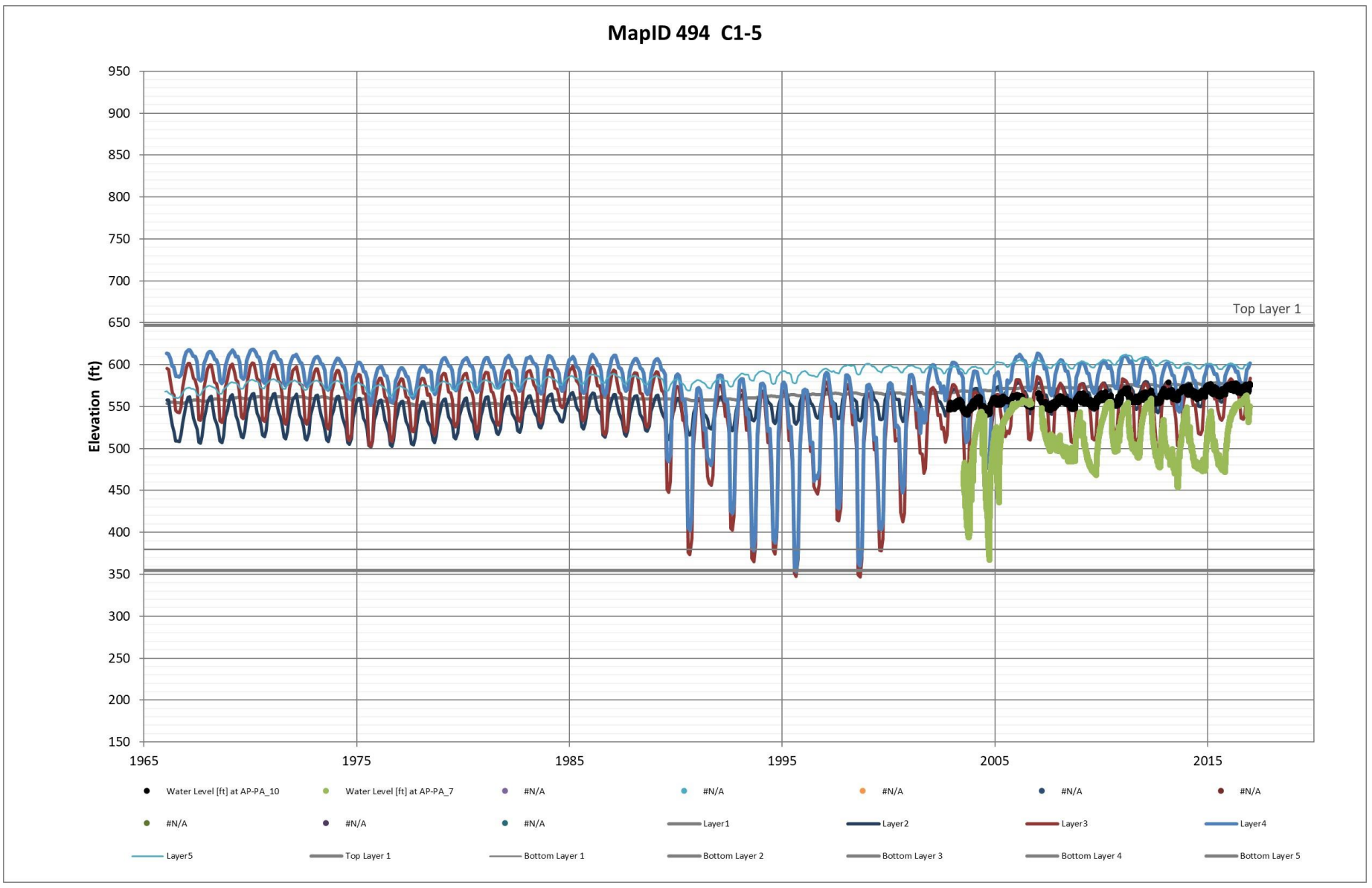


ISARM

Figure C1-4
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
CDA I-10

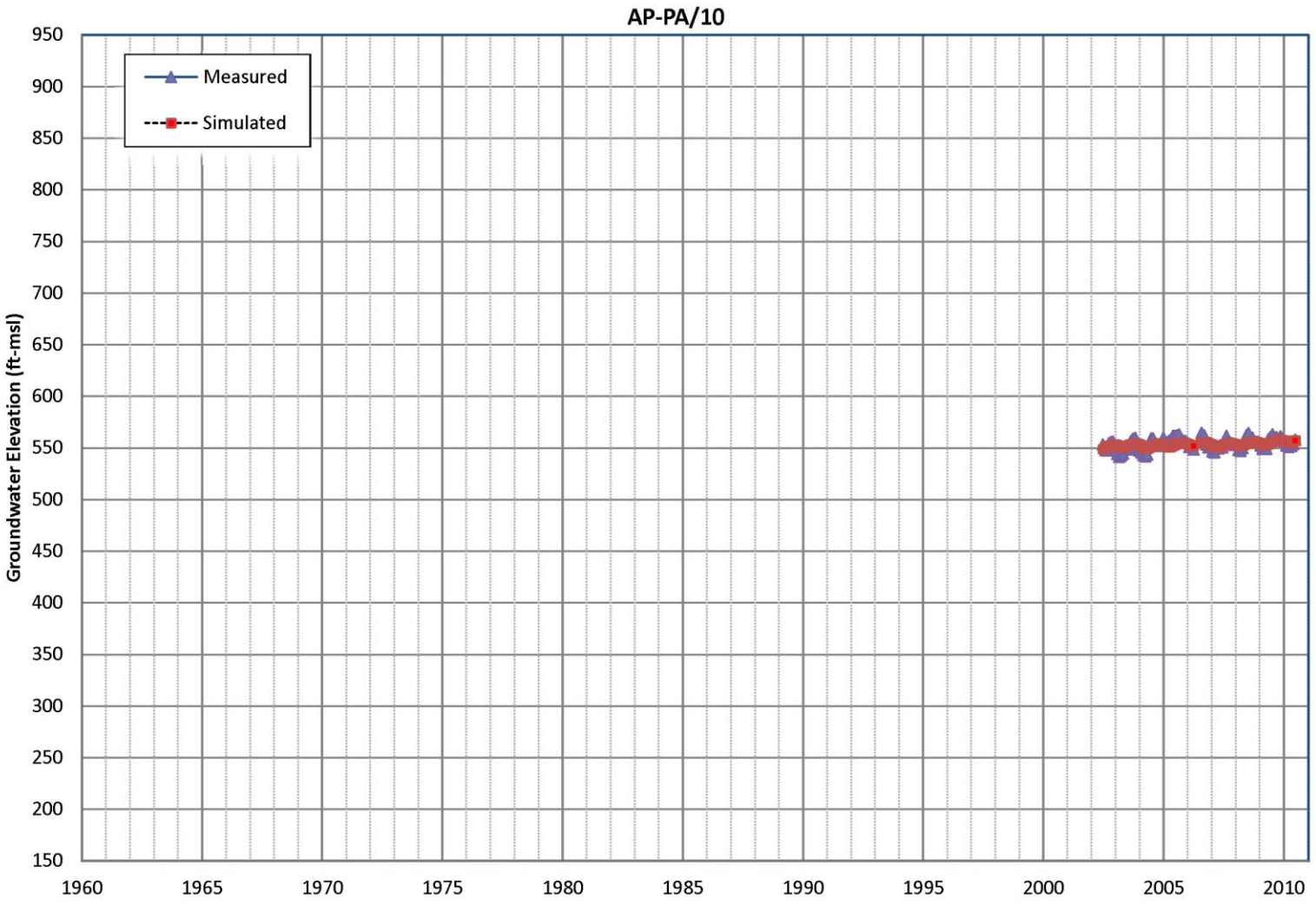


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

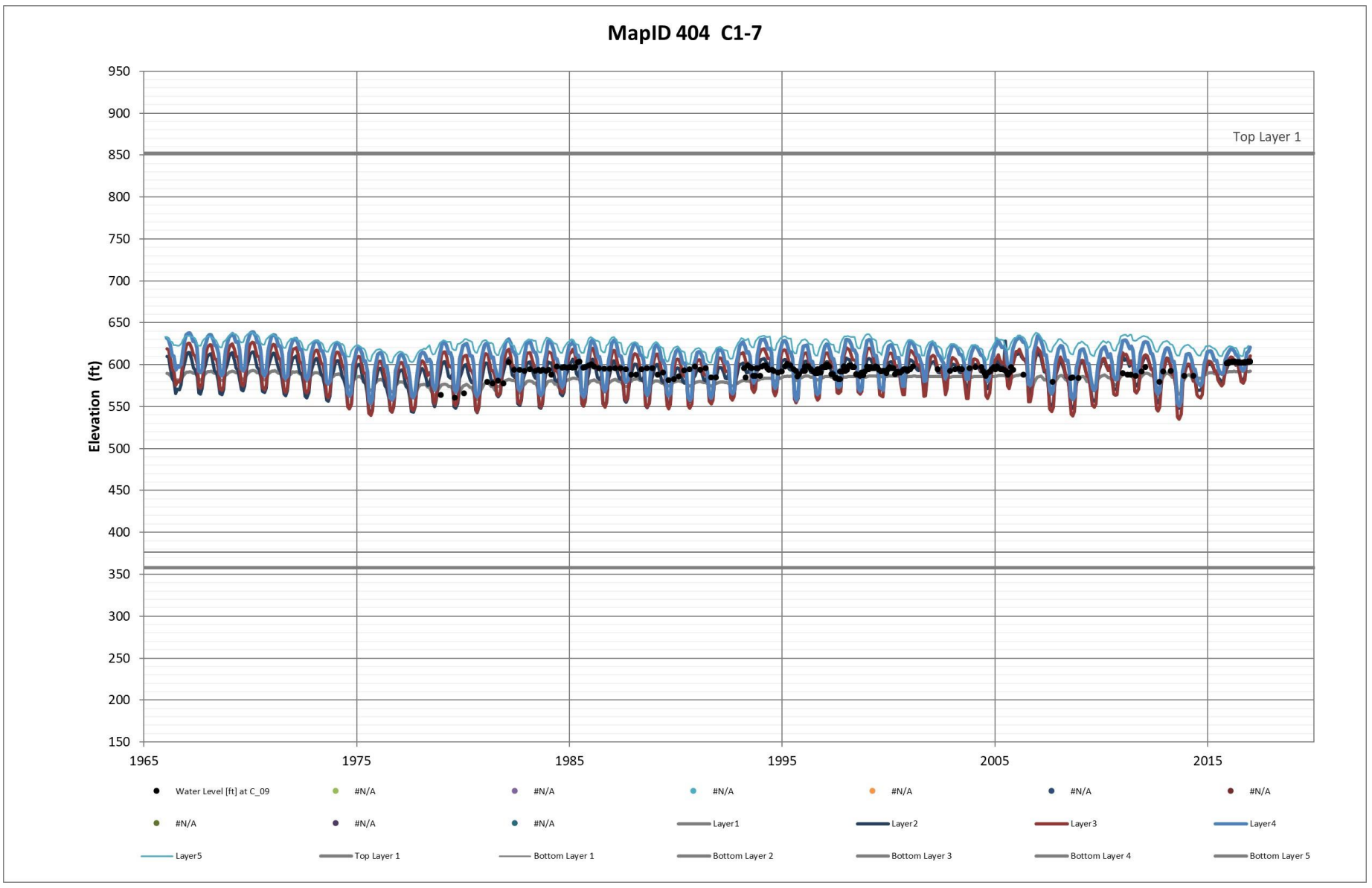


ISARM

Figure C1-5
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
AP-PA/10

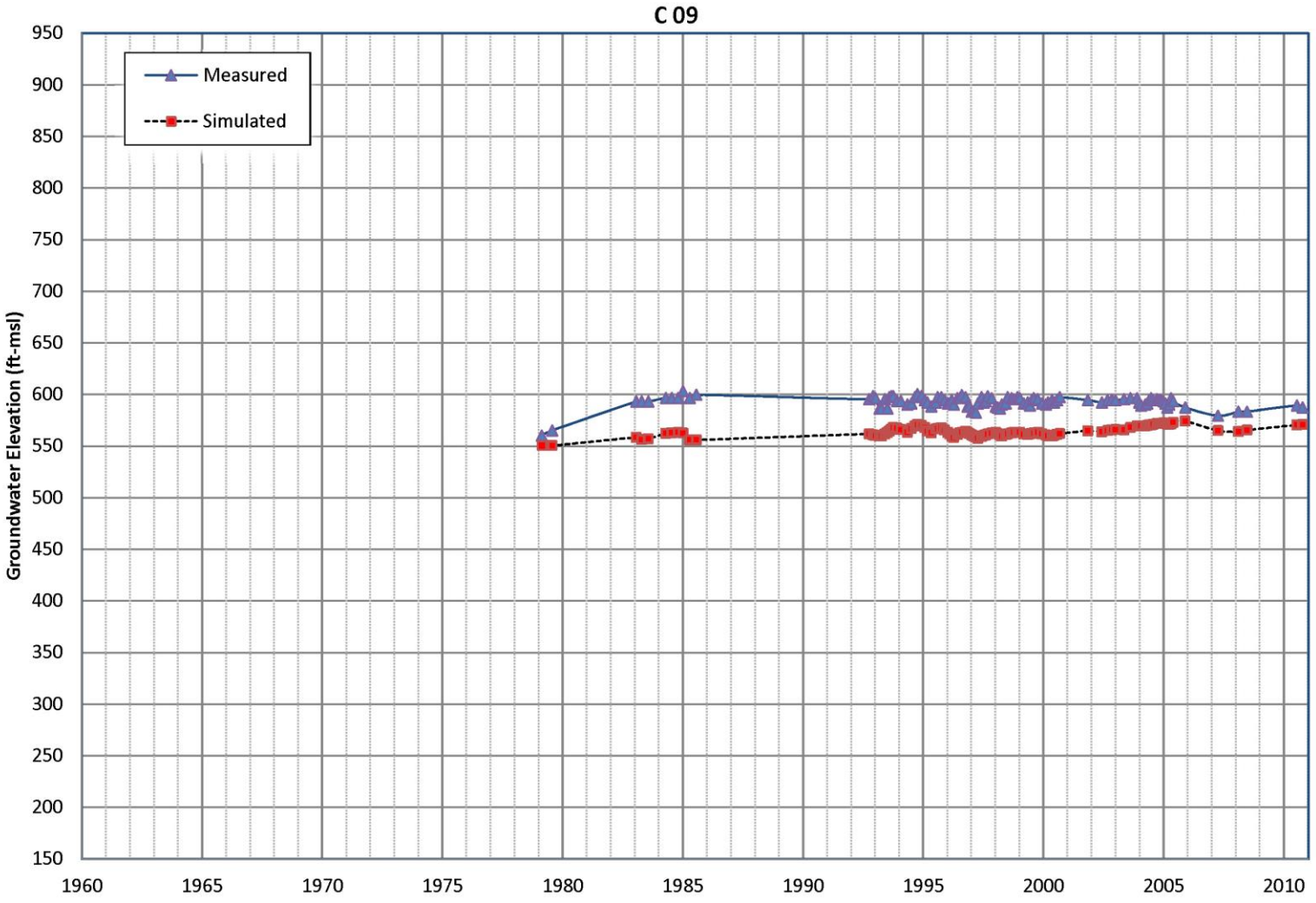


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

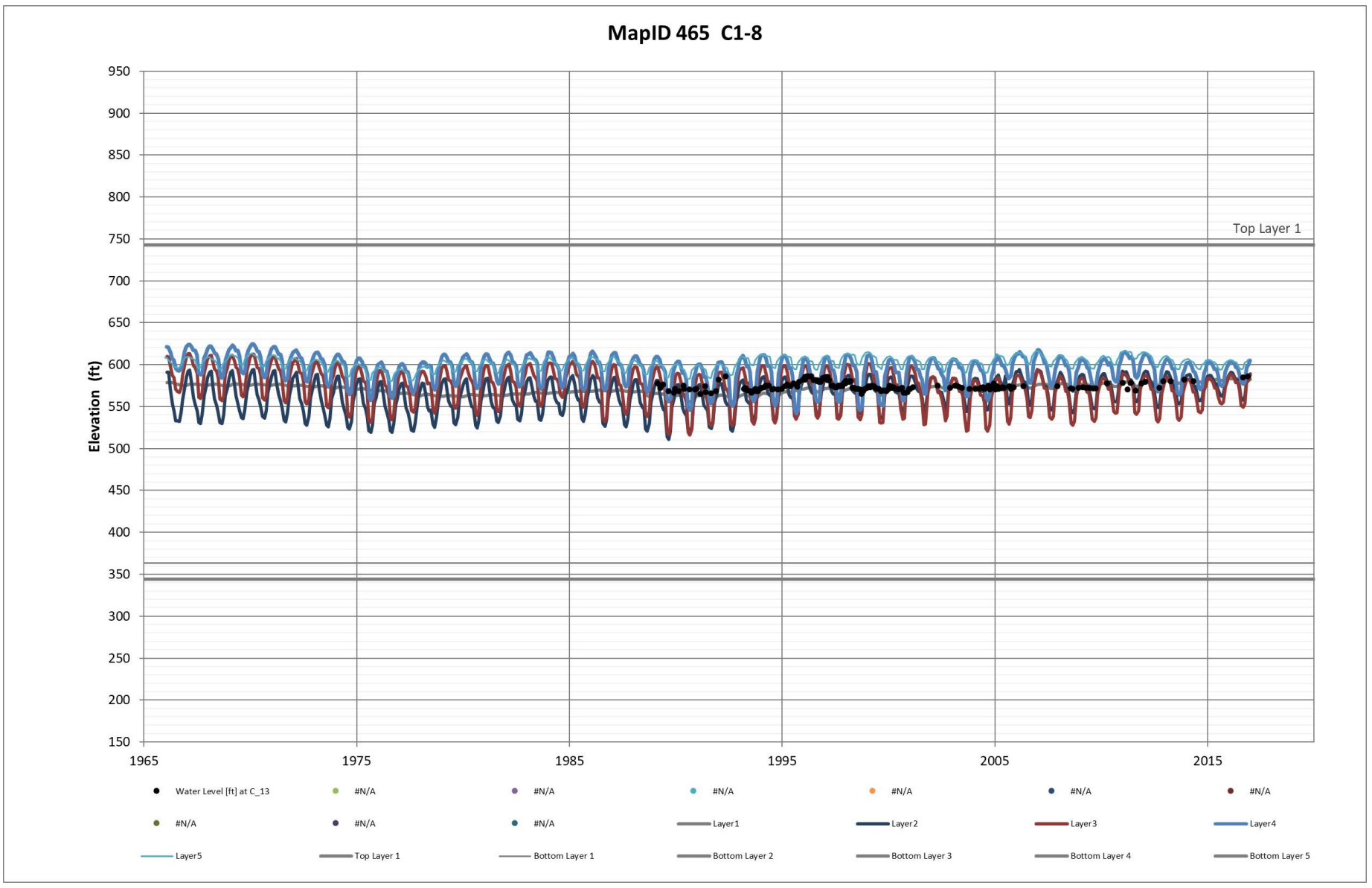


ISARM

Figure C1-7
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
C 09

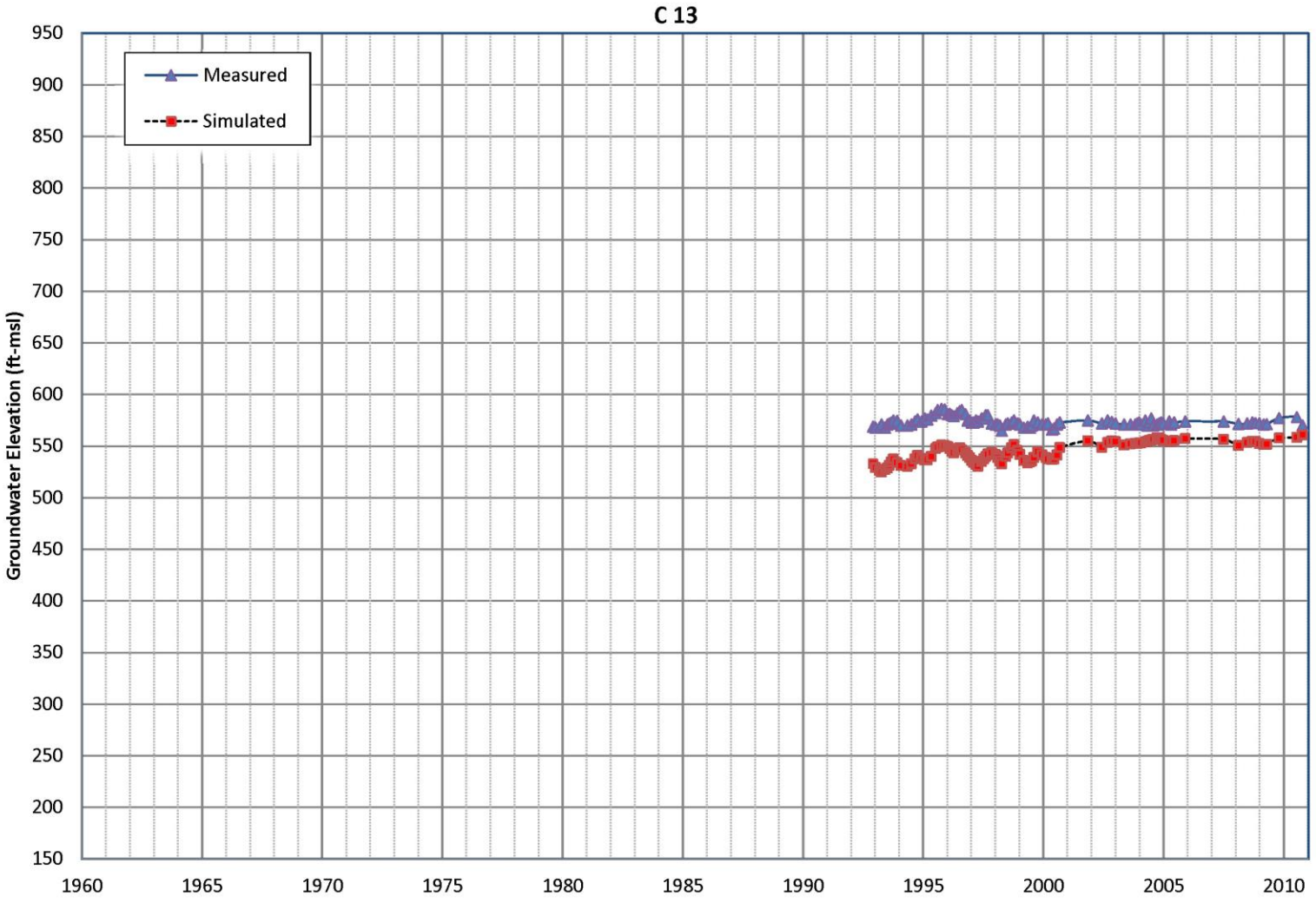


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

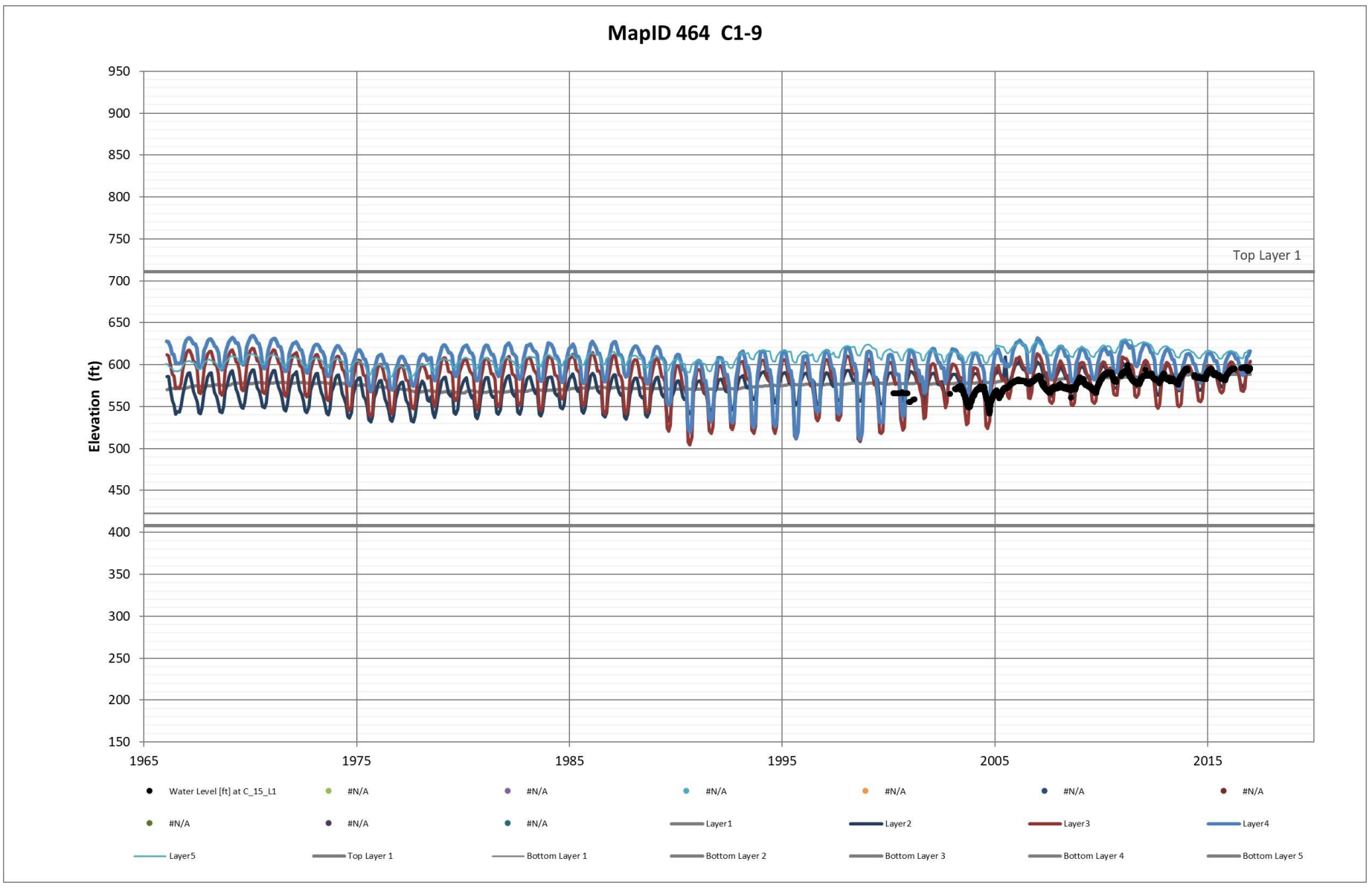


ISARM

Figure C1-8
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
C 13

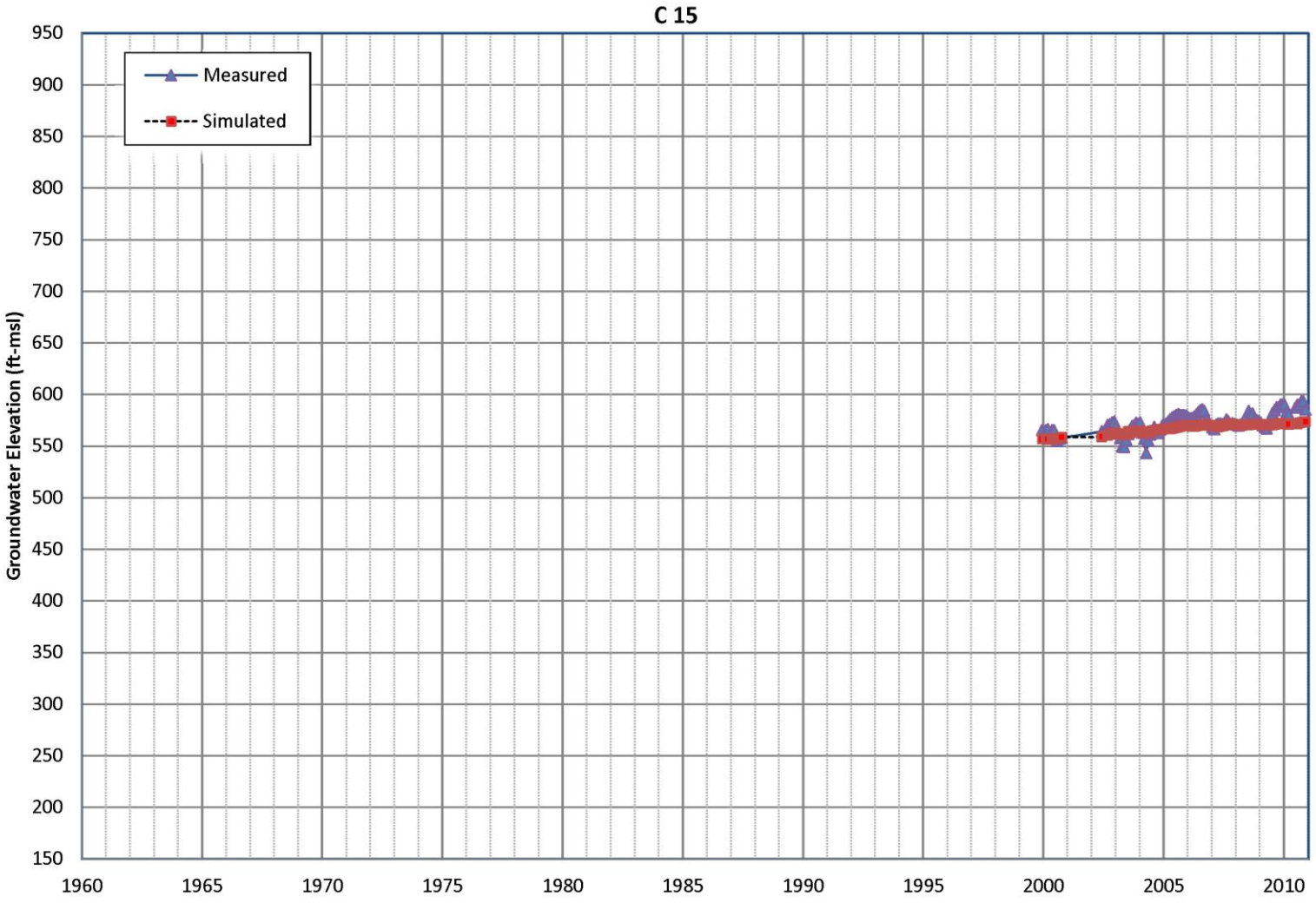


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

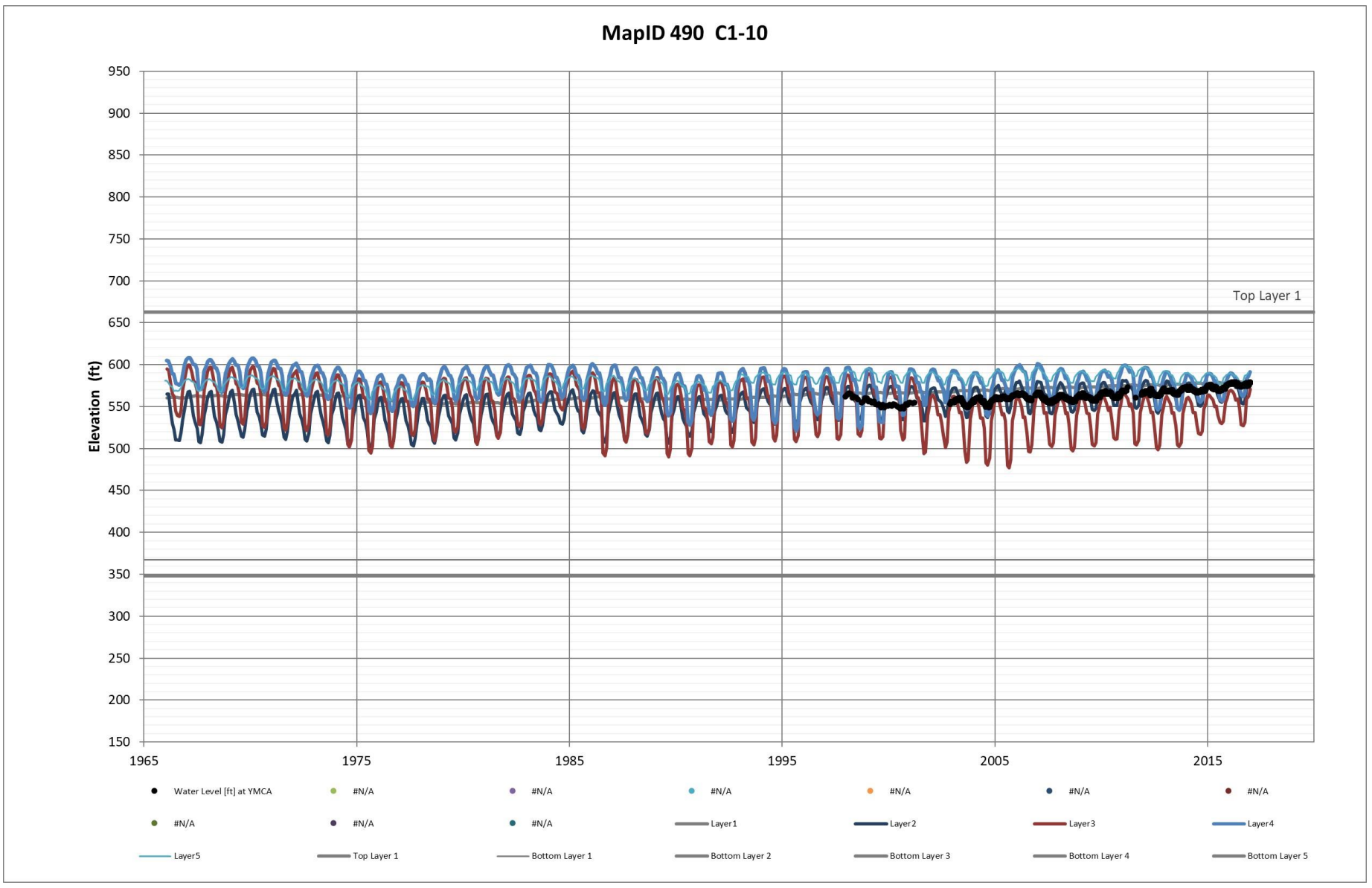


ISARM

Figure C1-9
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
C 15

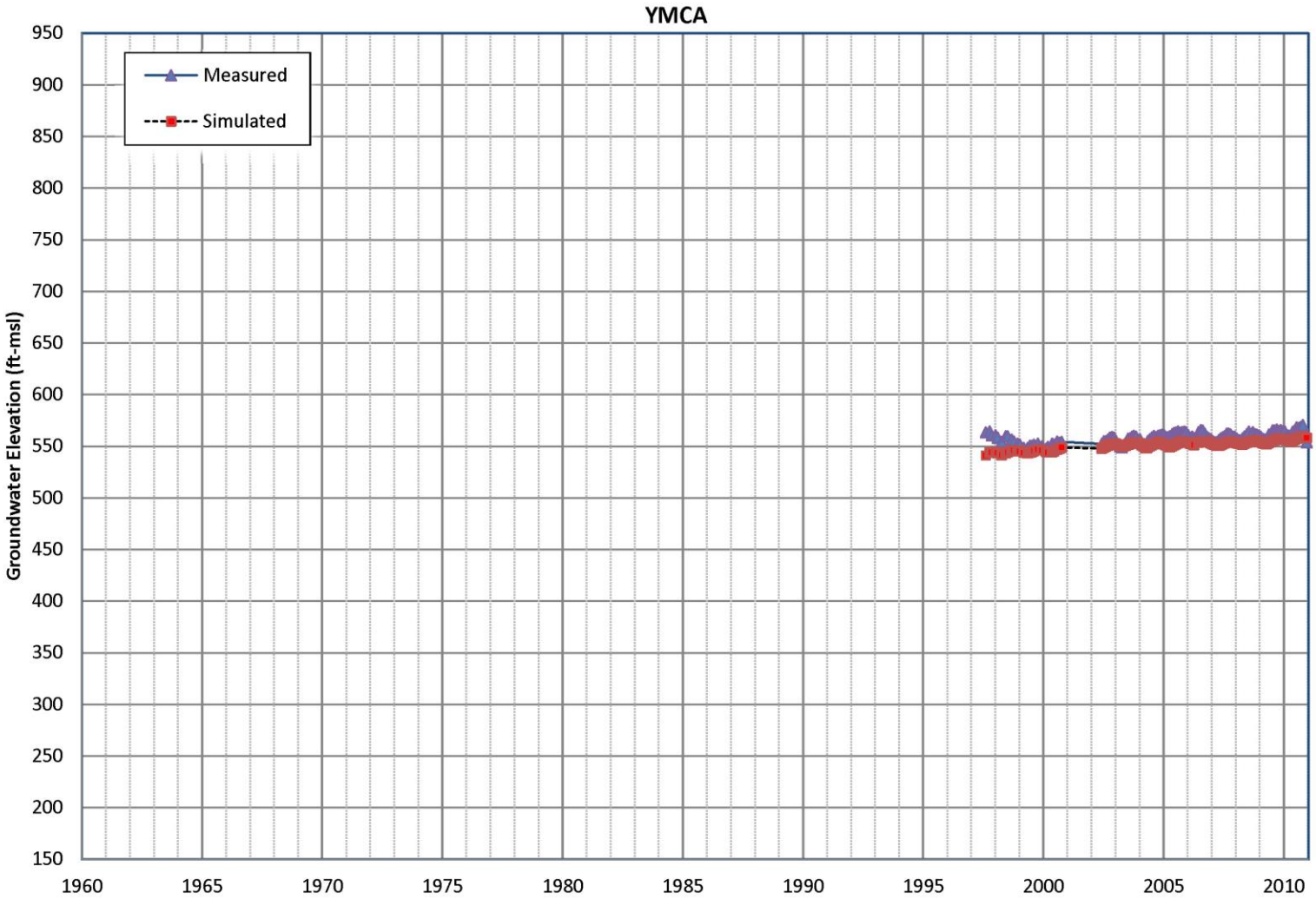


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

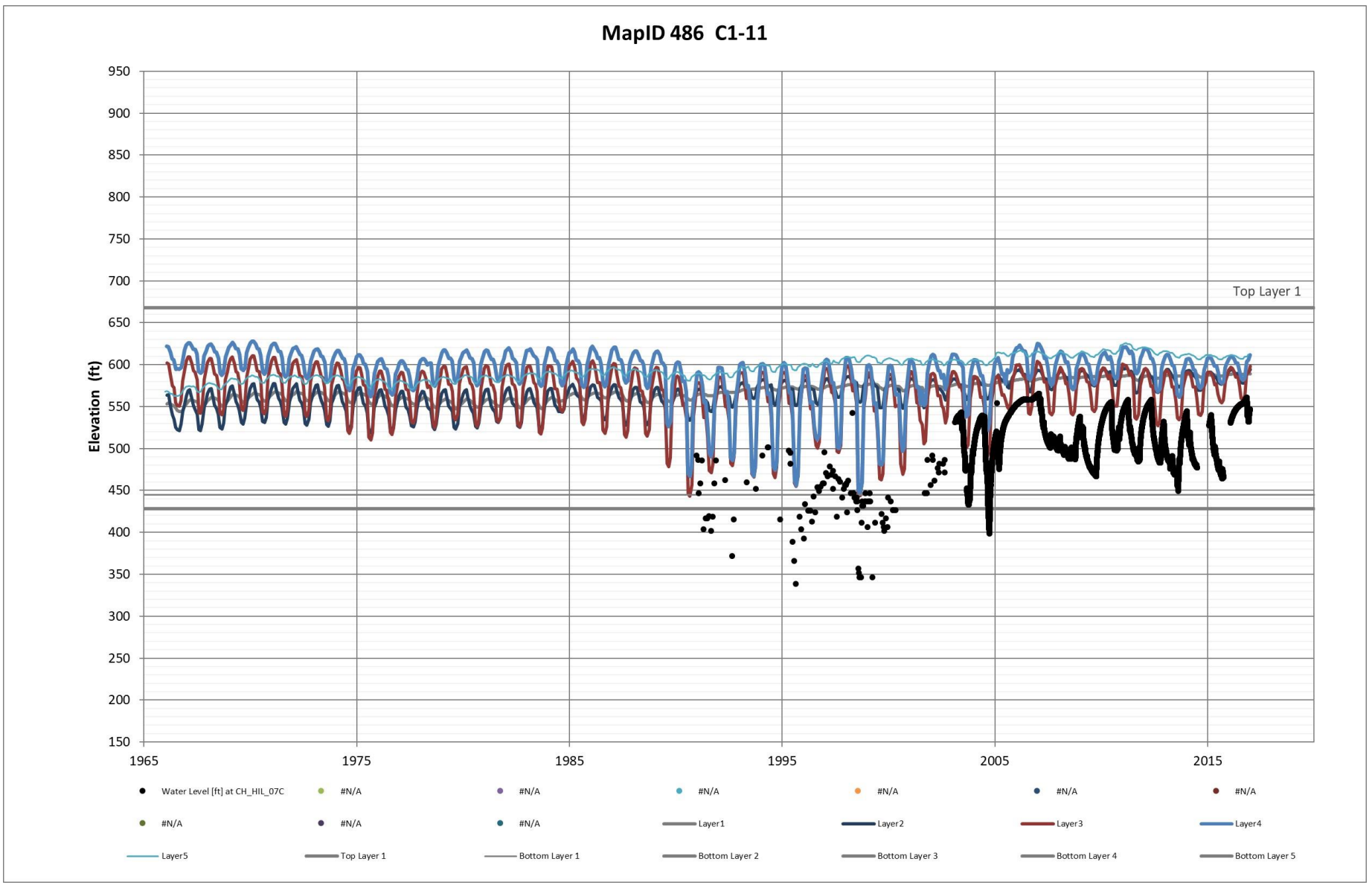


ISARM

Figure C1-10
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
YMCA

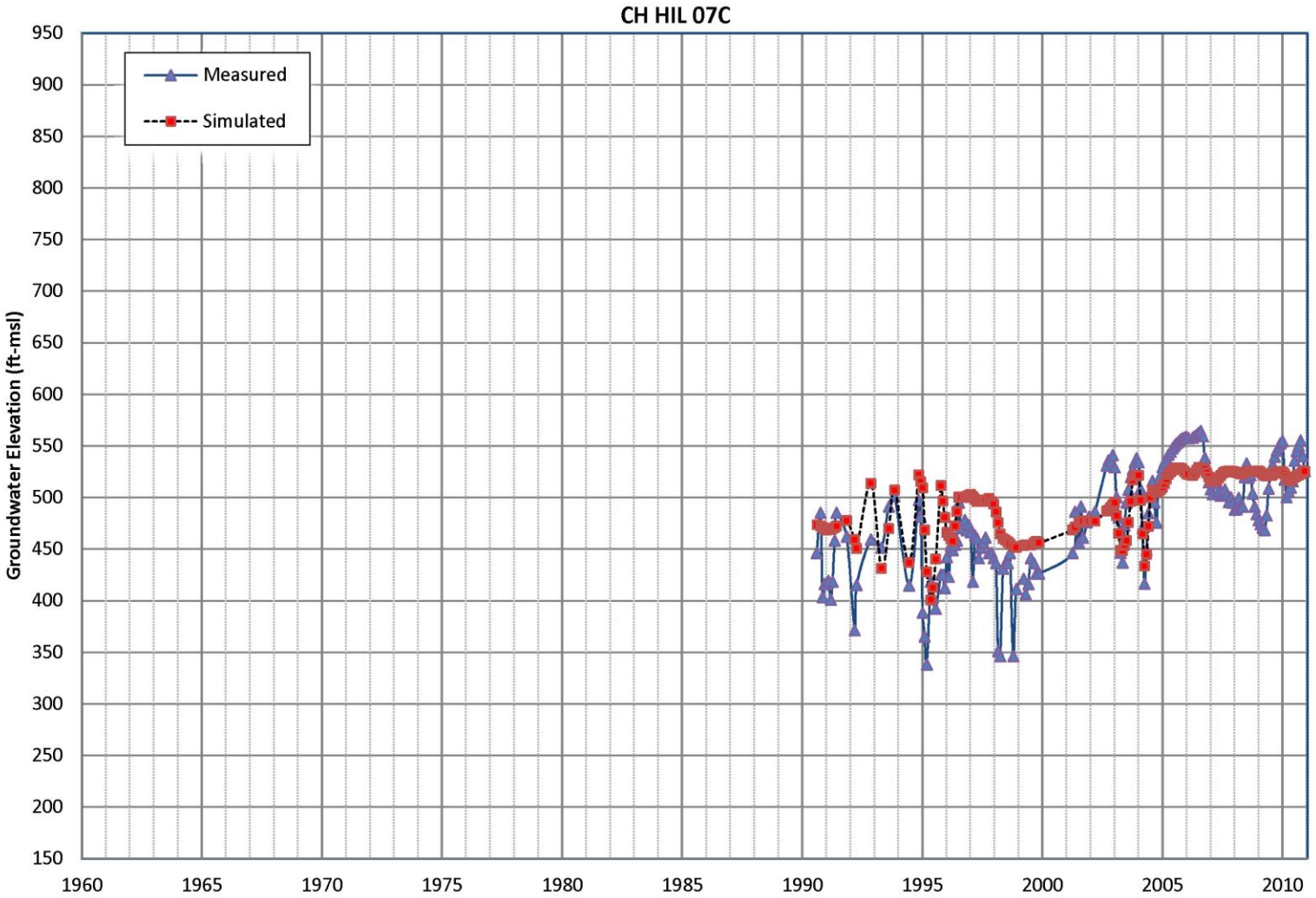


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

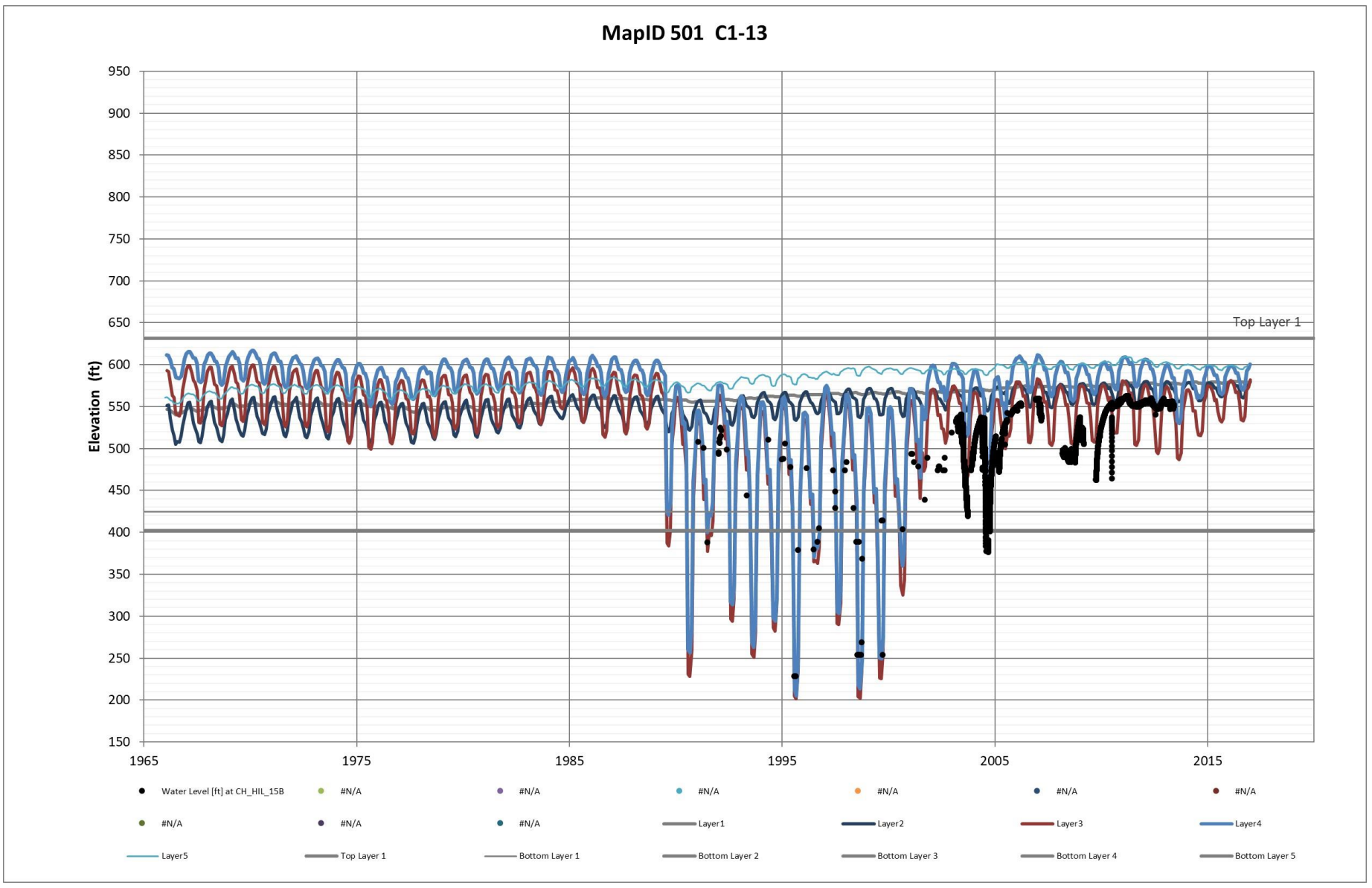


ISARM

Figure C1-11
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
CH HIL 07C

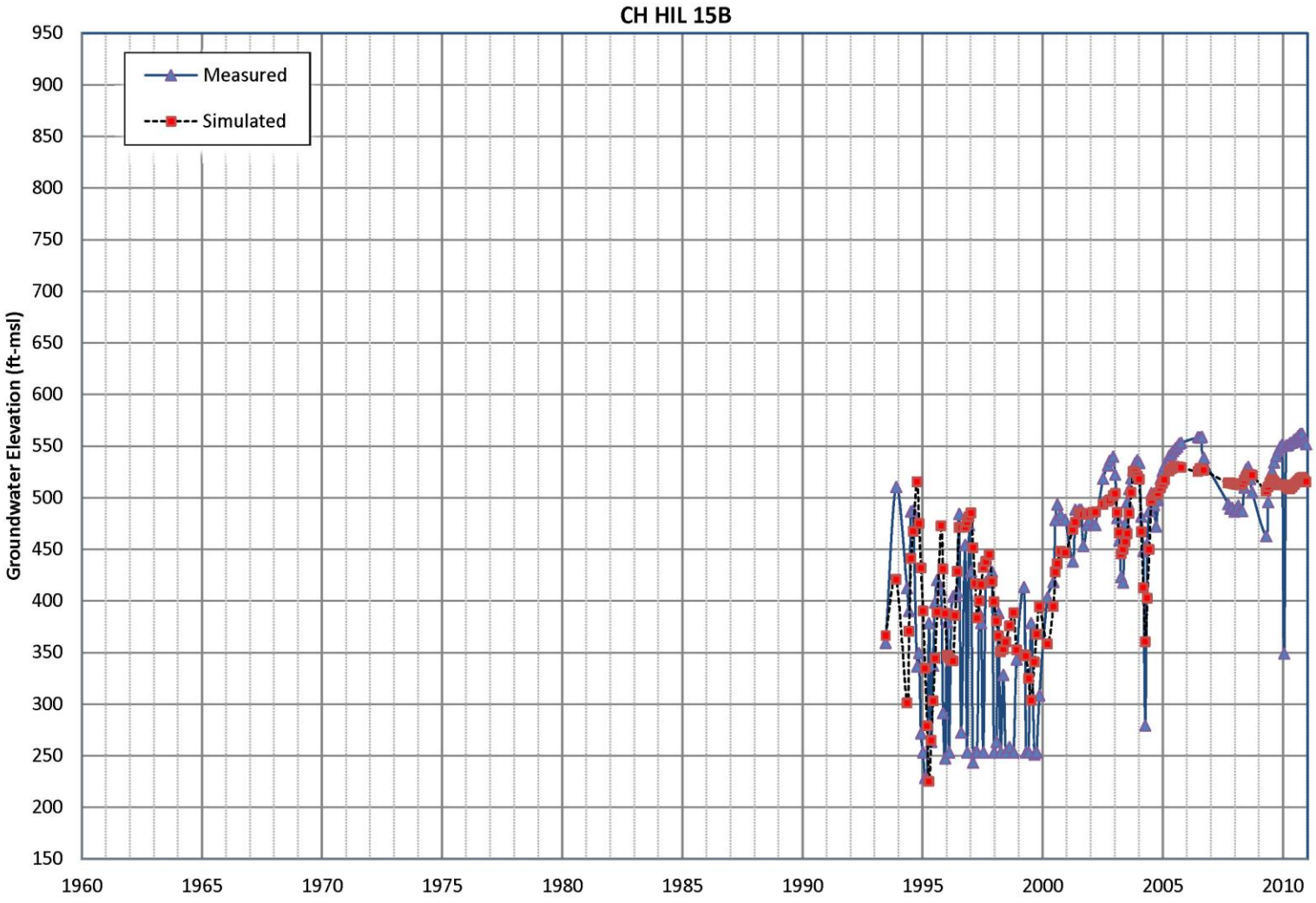


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

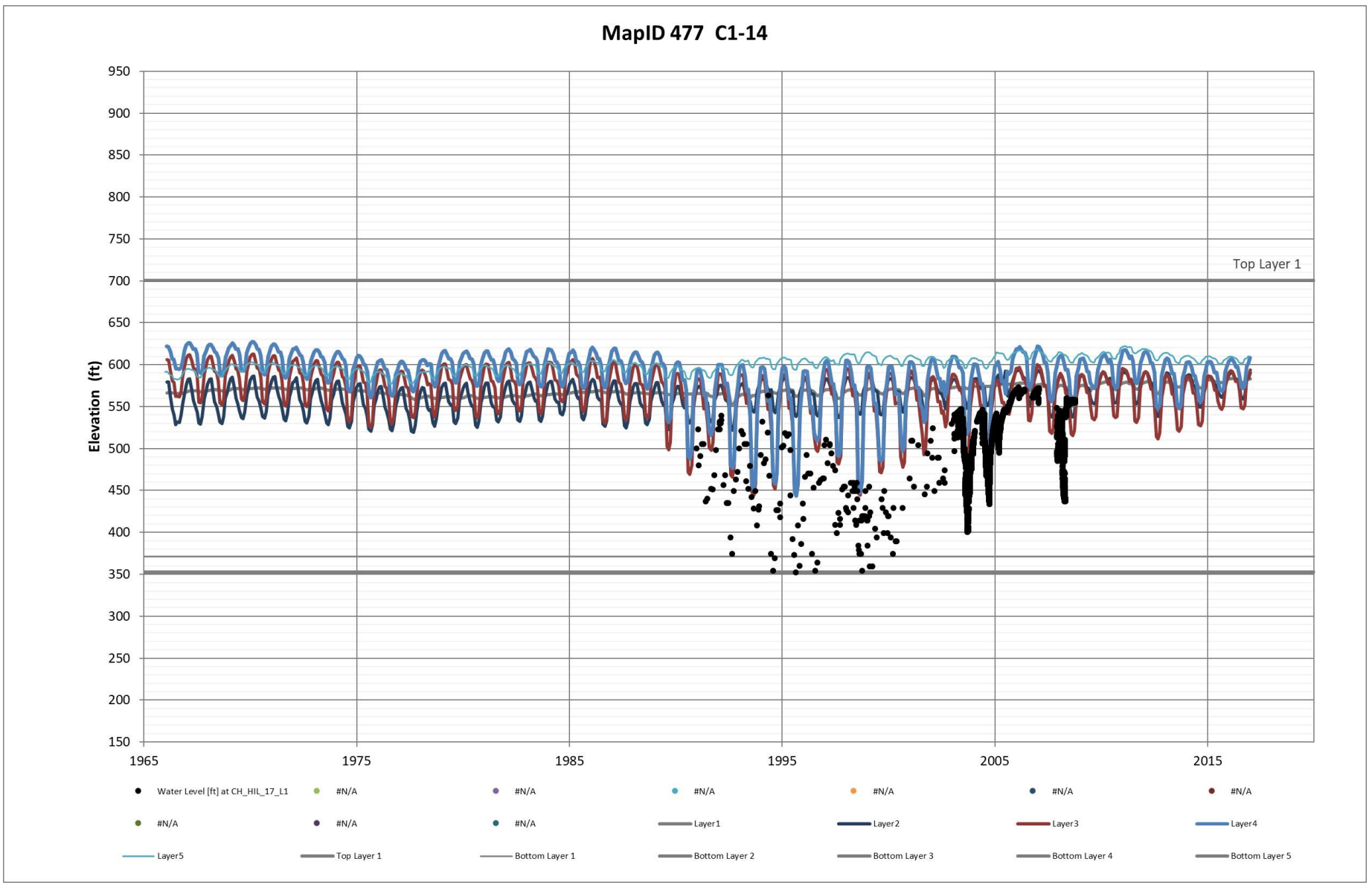


ISARM

Figure C1-13
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
CH HIL 15B

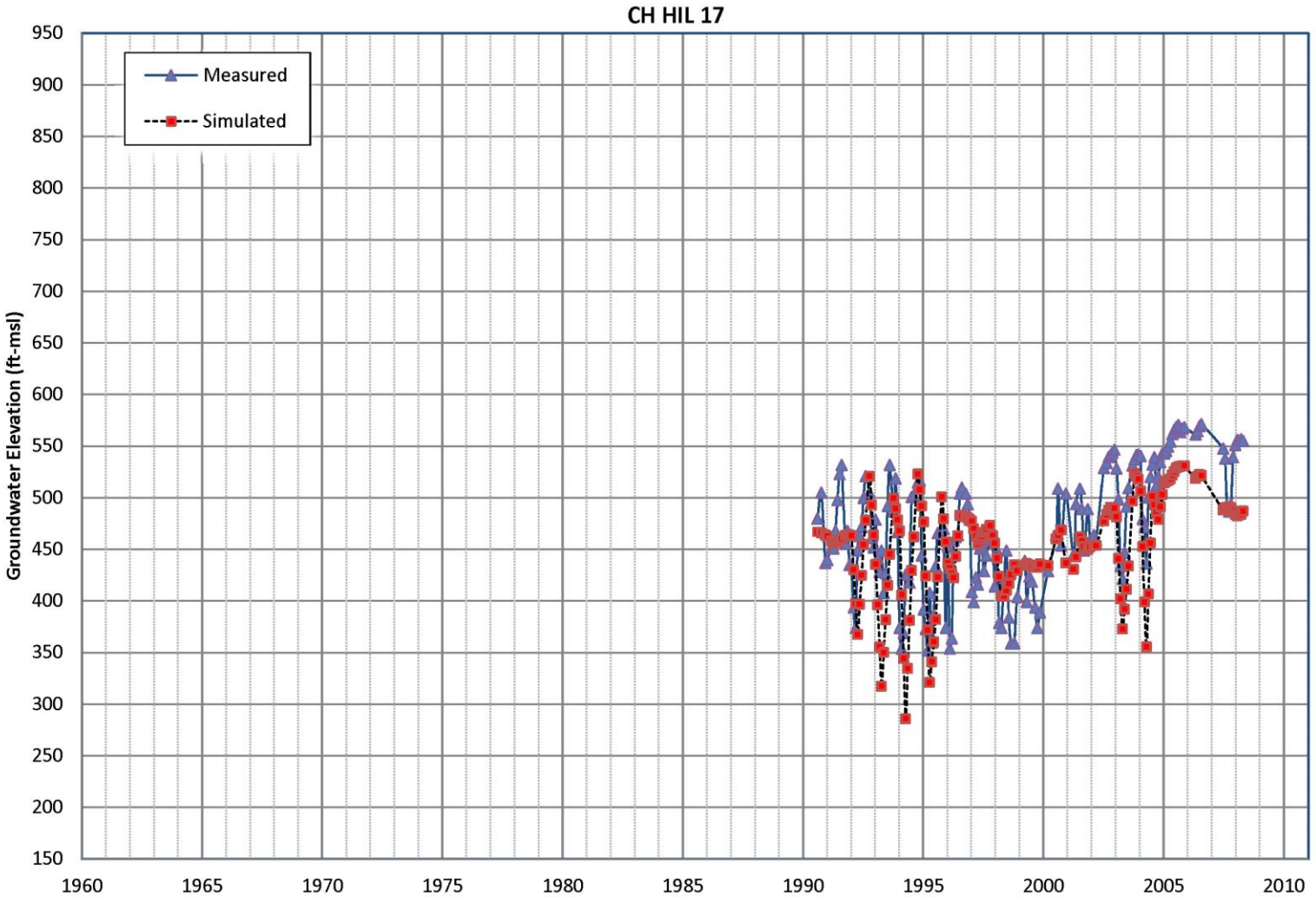


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

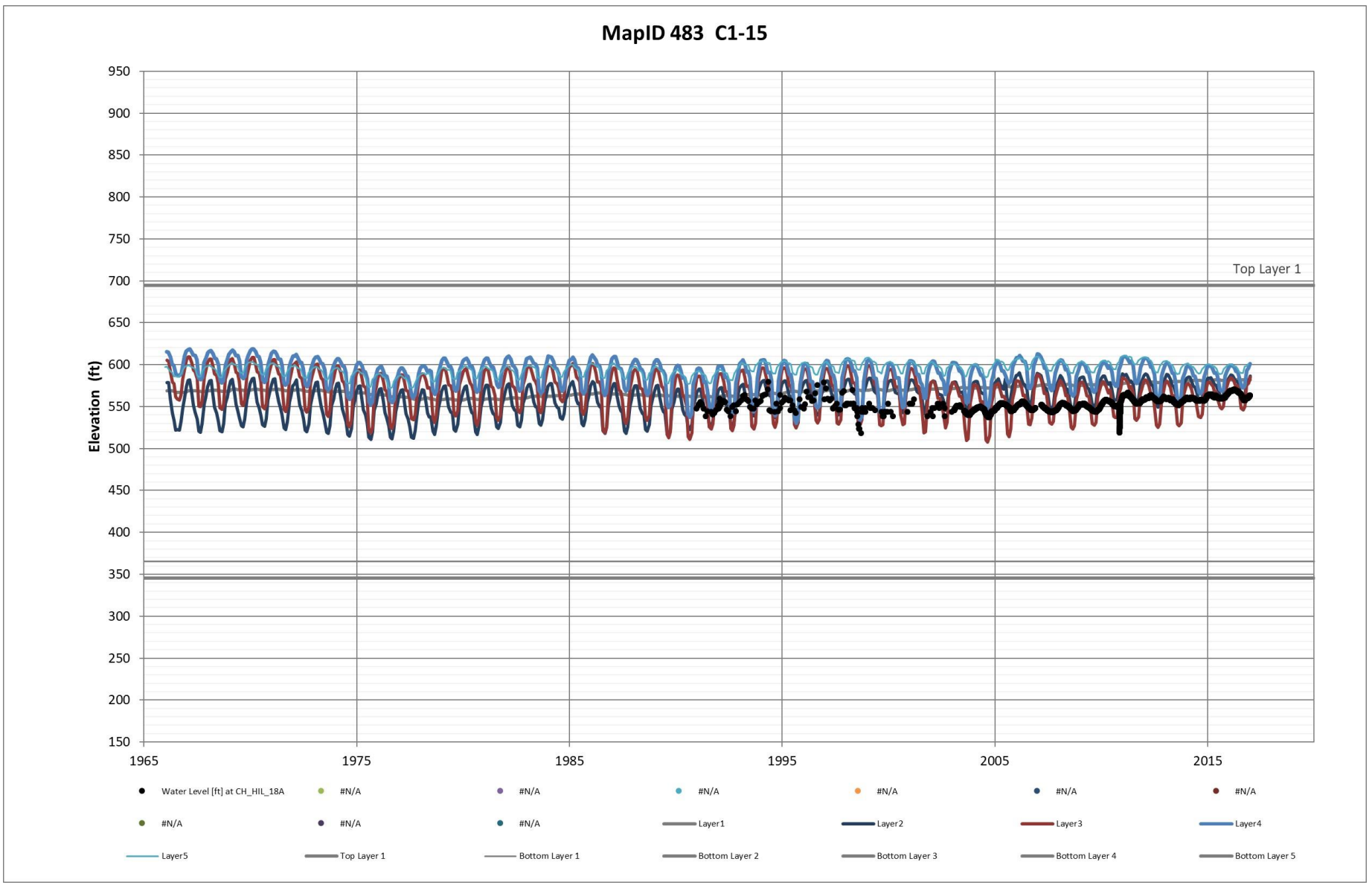


ISARM

Figure C1-14
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
CH HIL 17

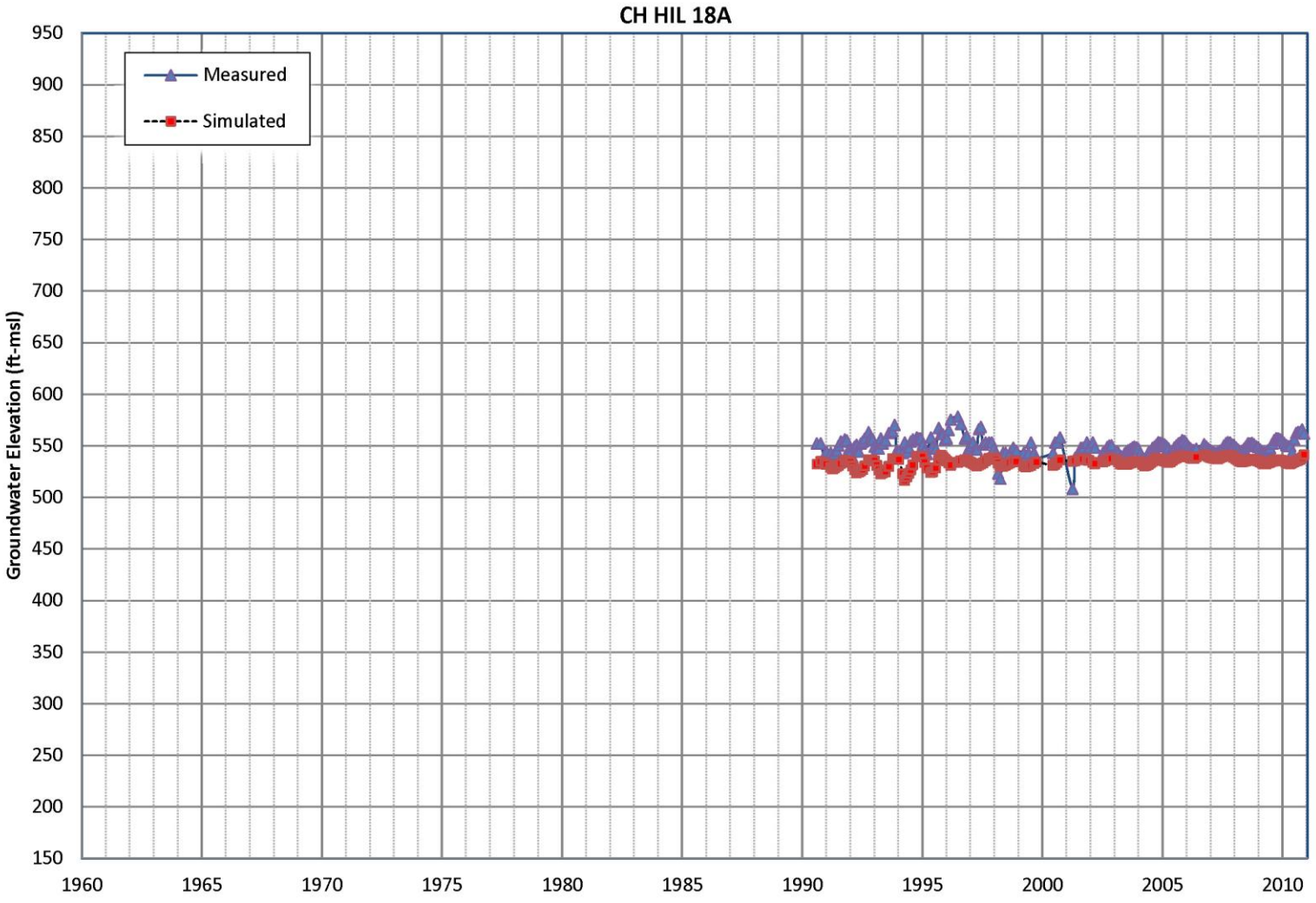


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

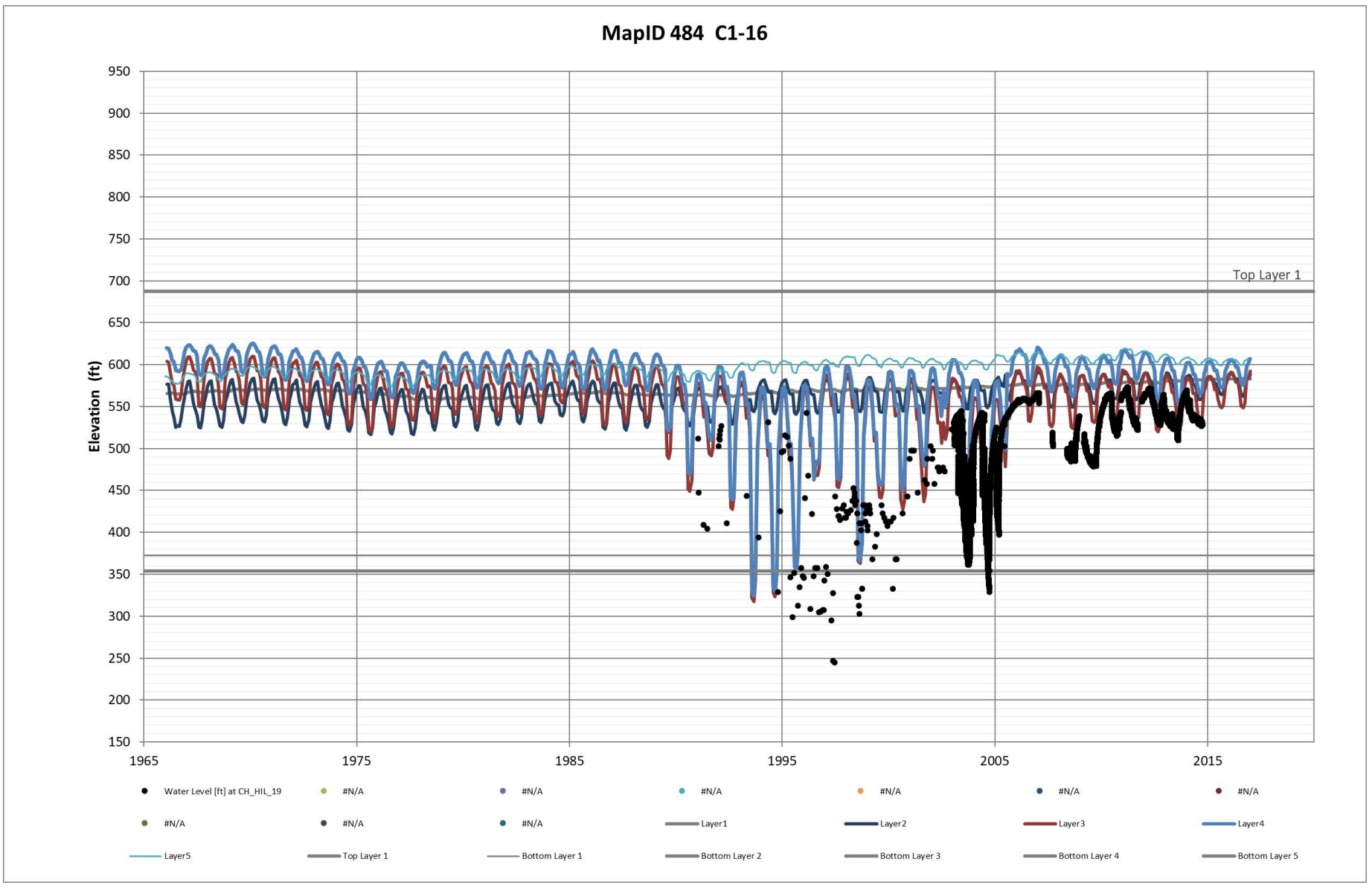


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Figure C1-15
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
CH HIL 18A

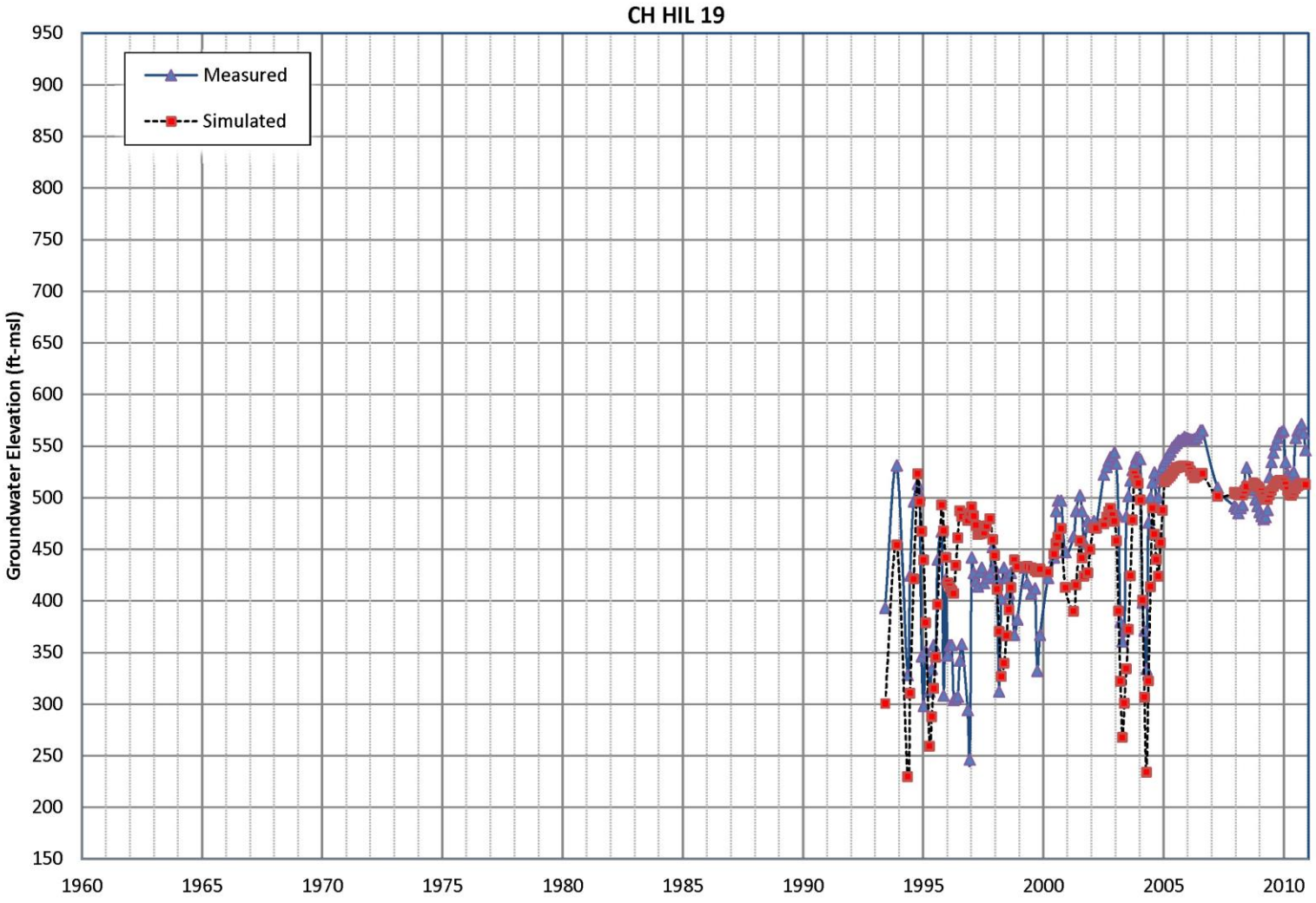


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

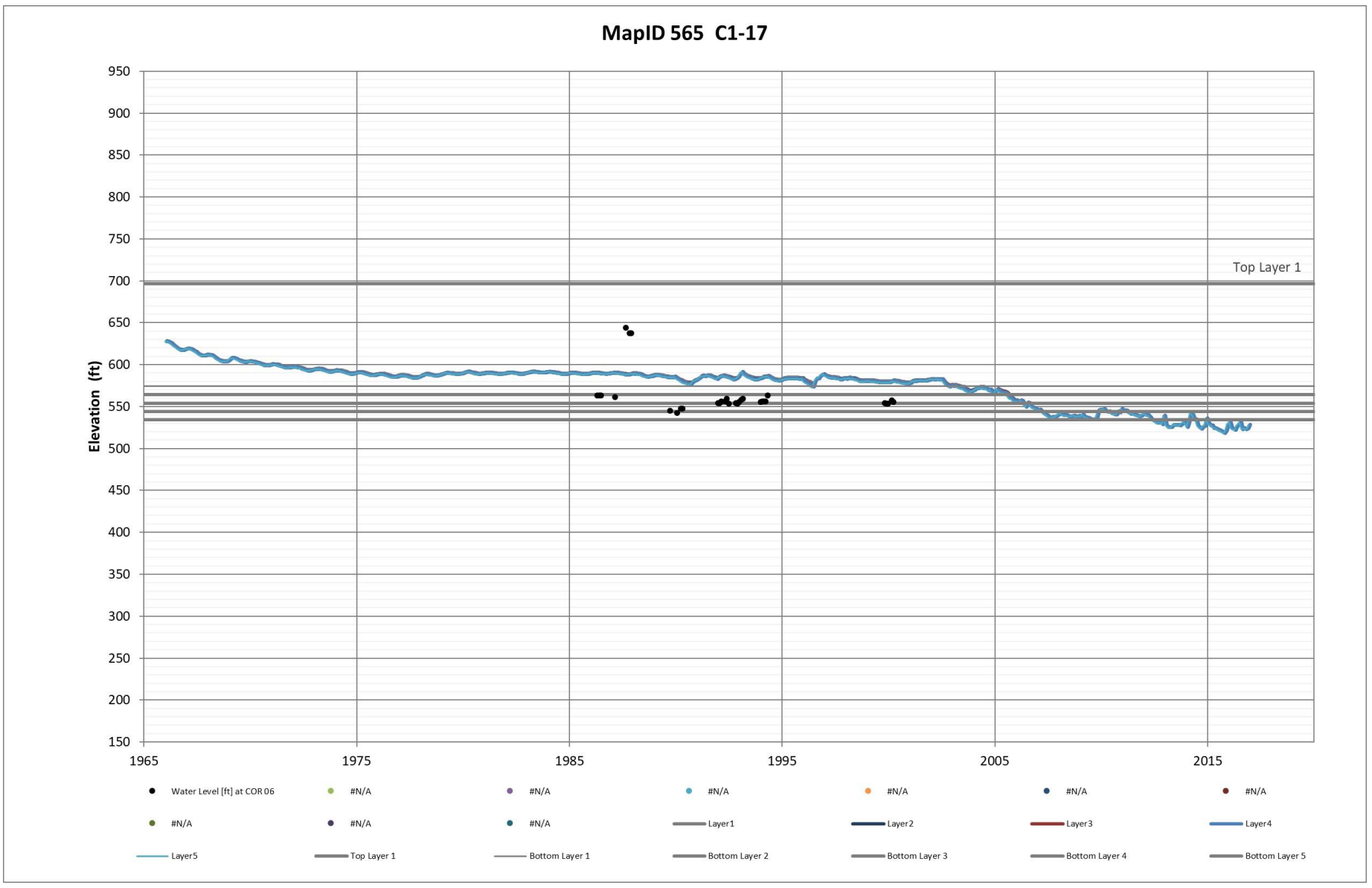


ISARM

Figure C1-16
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
CH HIL 19

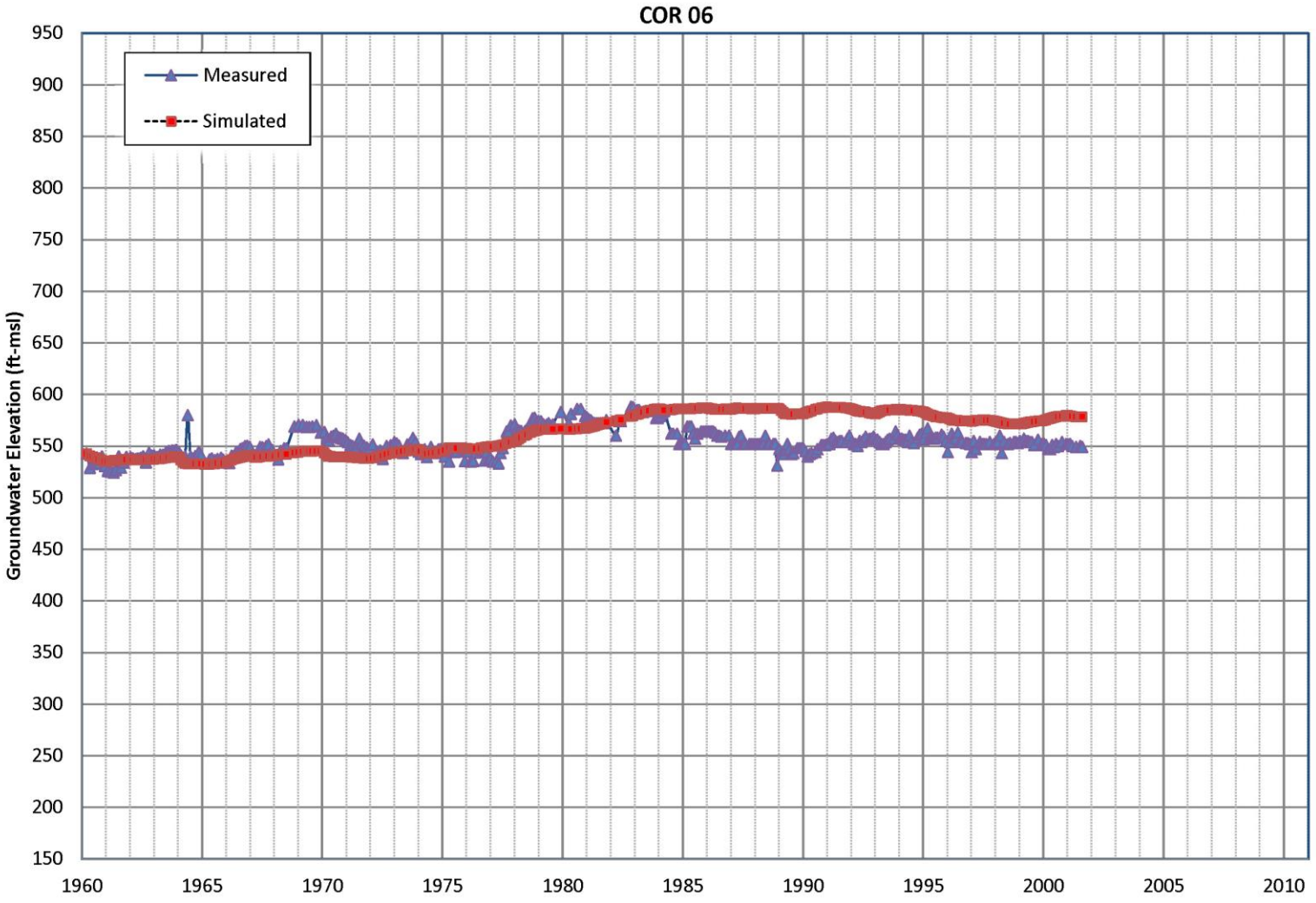


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

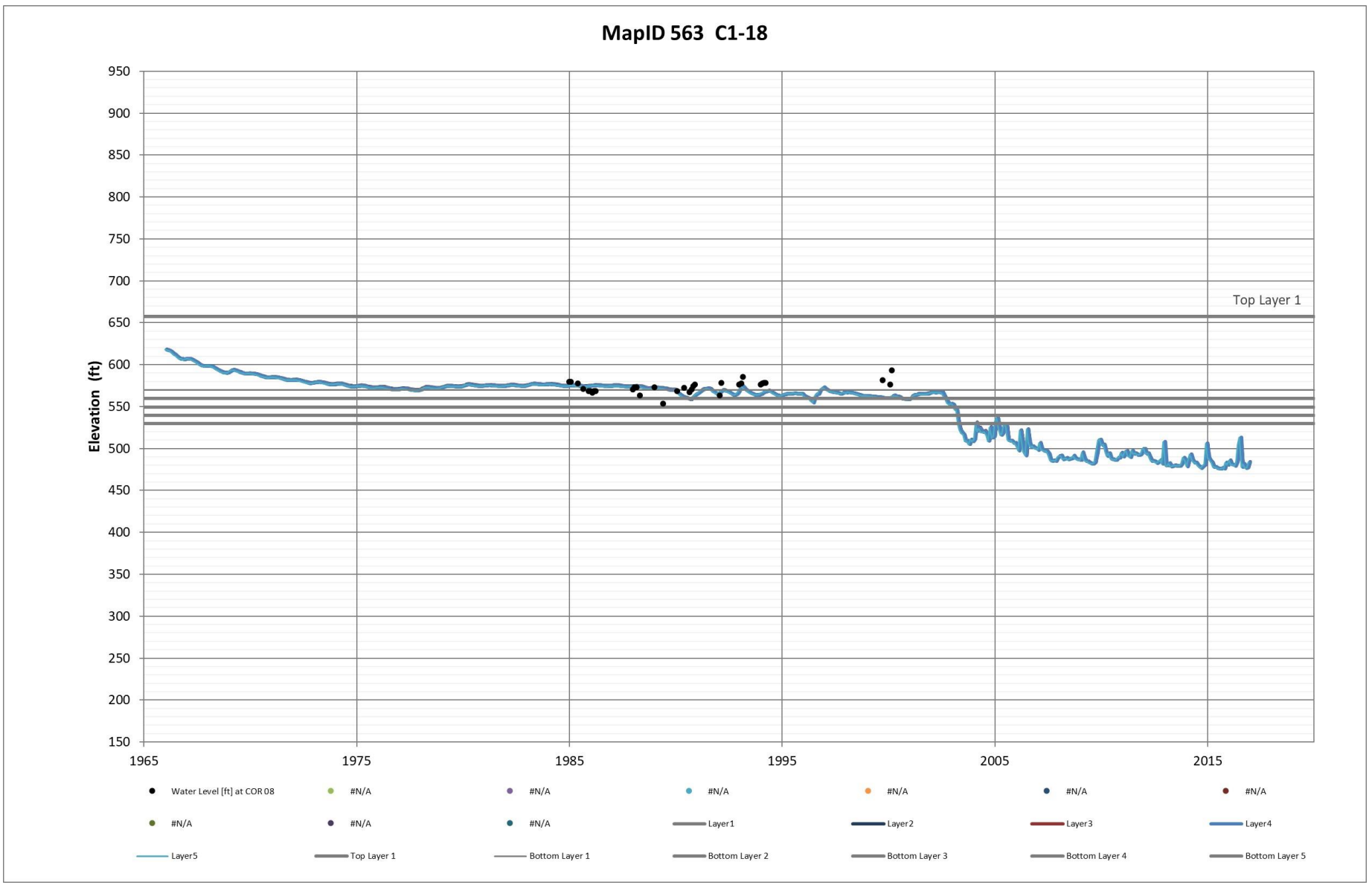


ISARM

Figure C1-17
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
COR 06

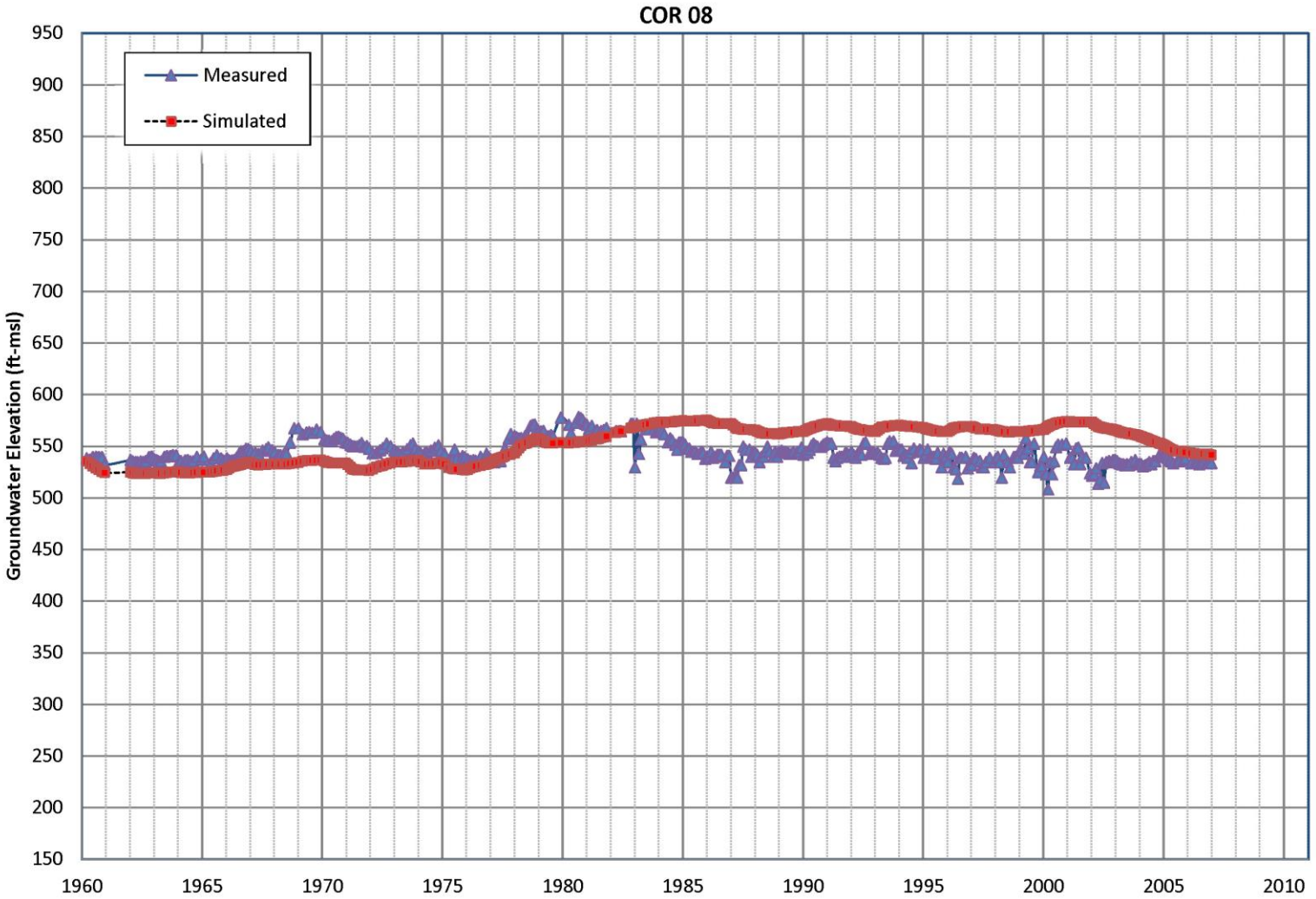


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

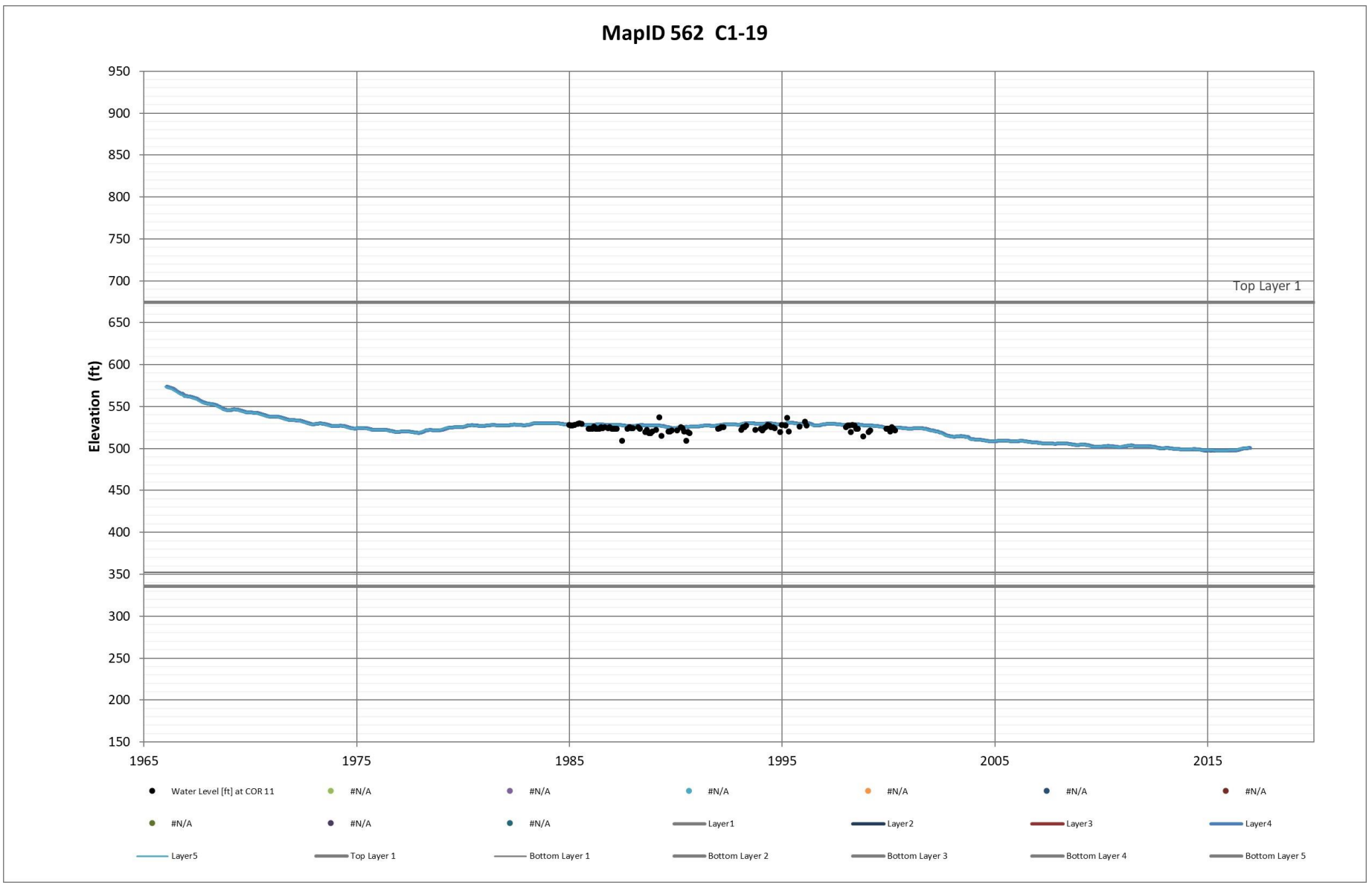


ISARM

Figure C1-18
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
COR 08

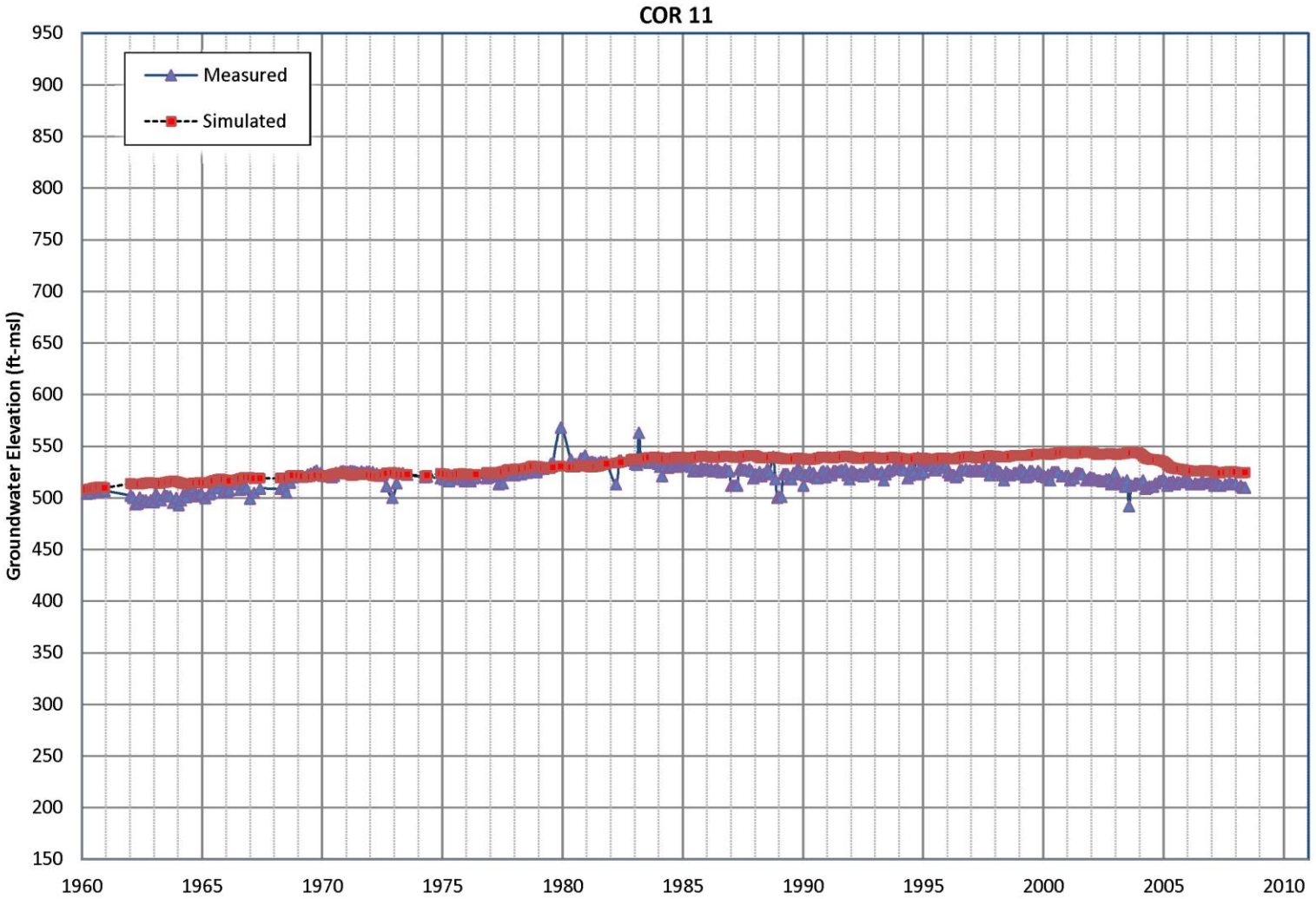


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

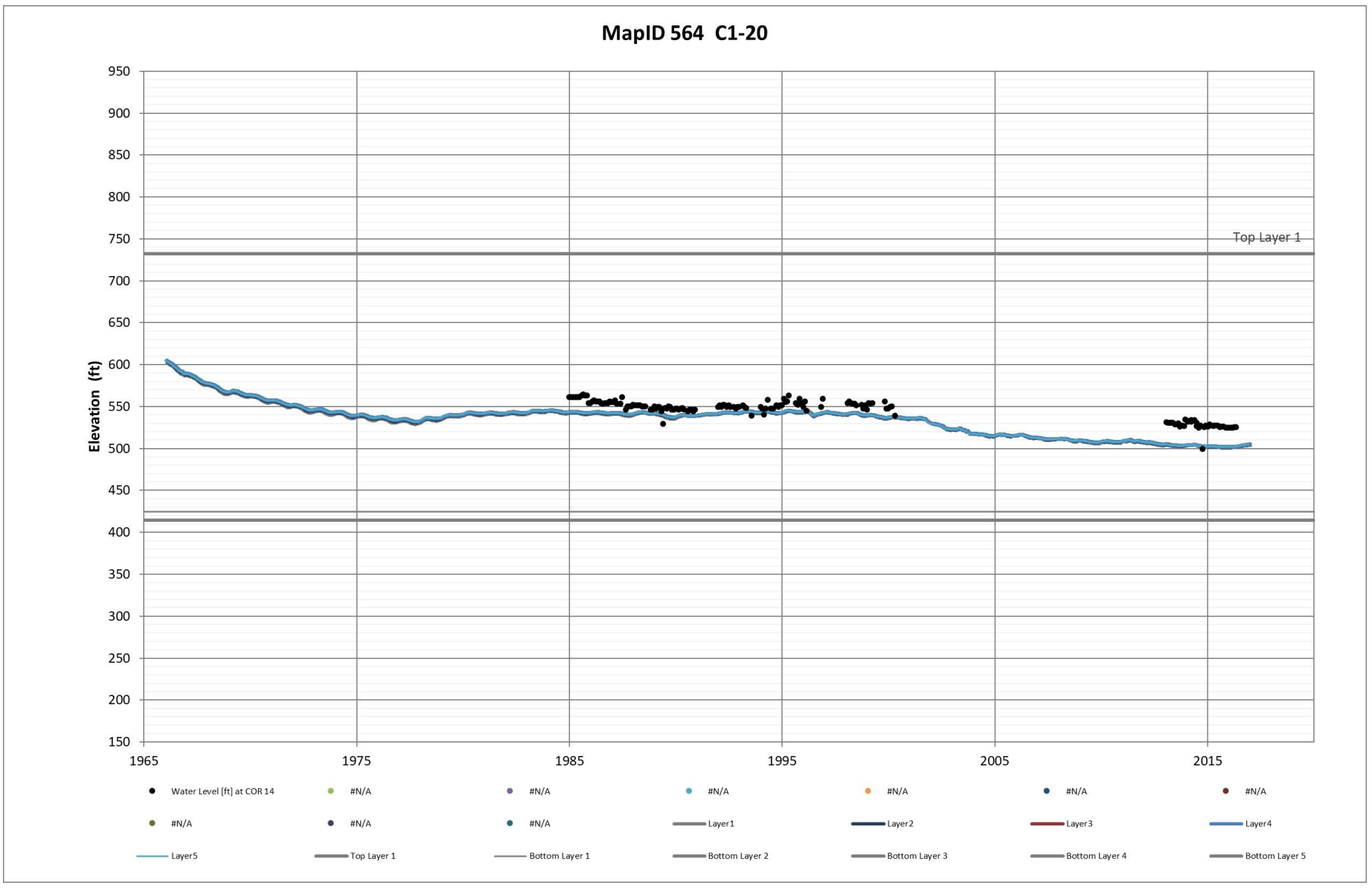


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Figure C1-19
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
COR 11

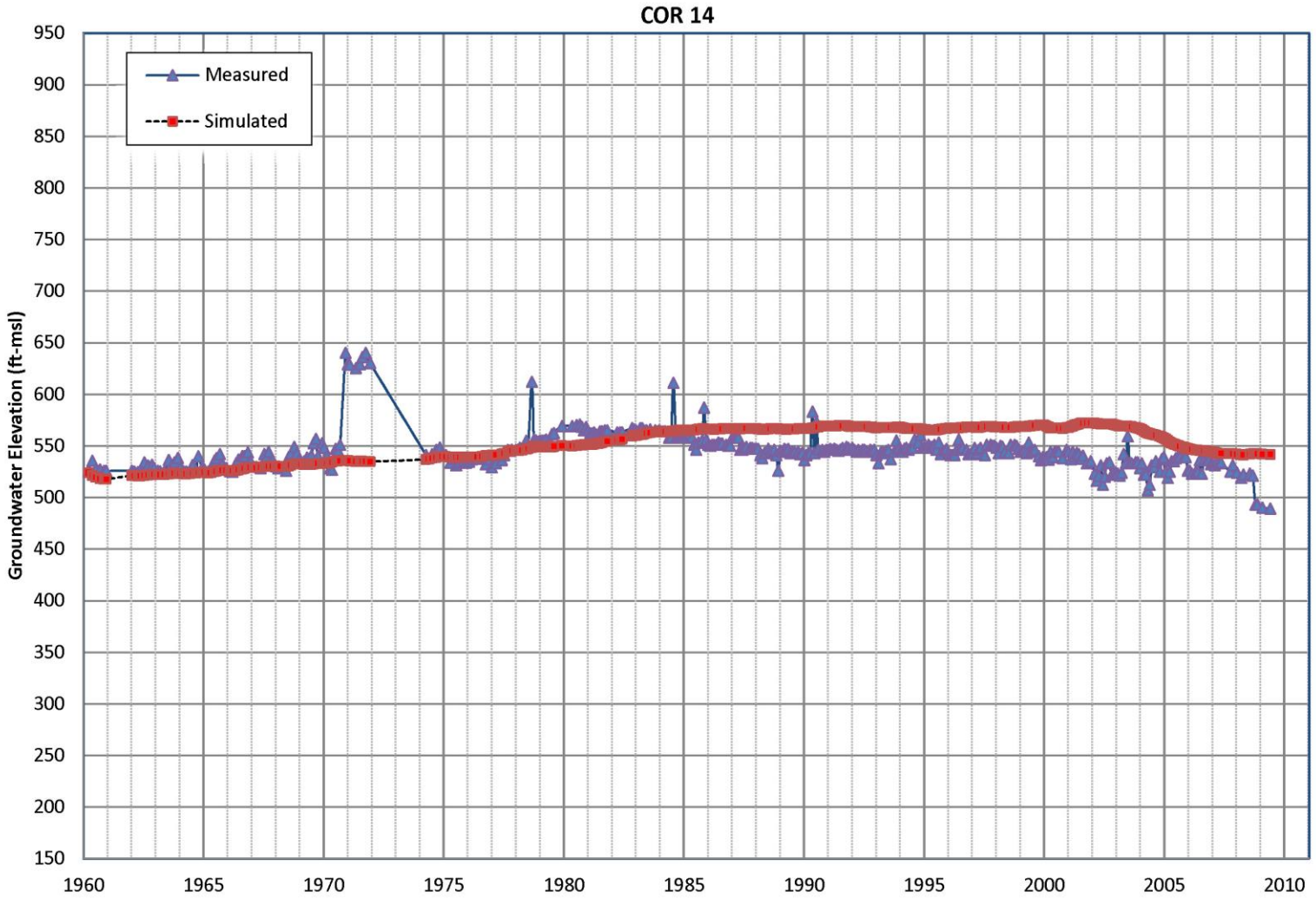


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

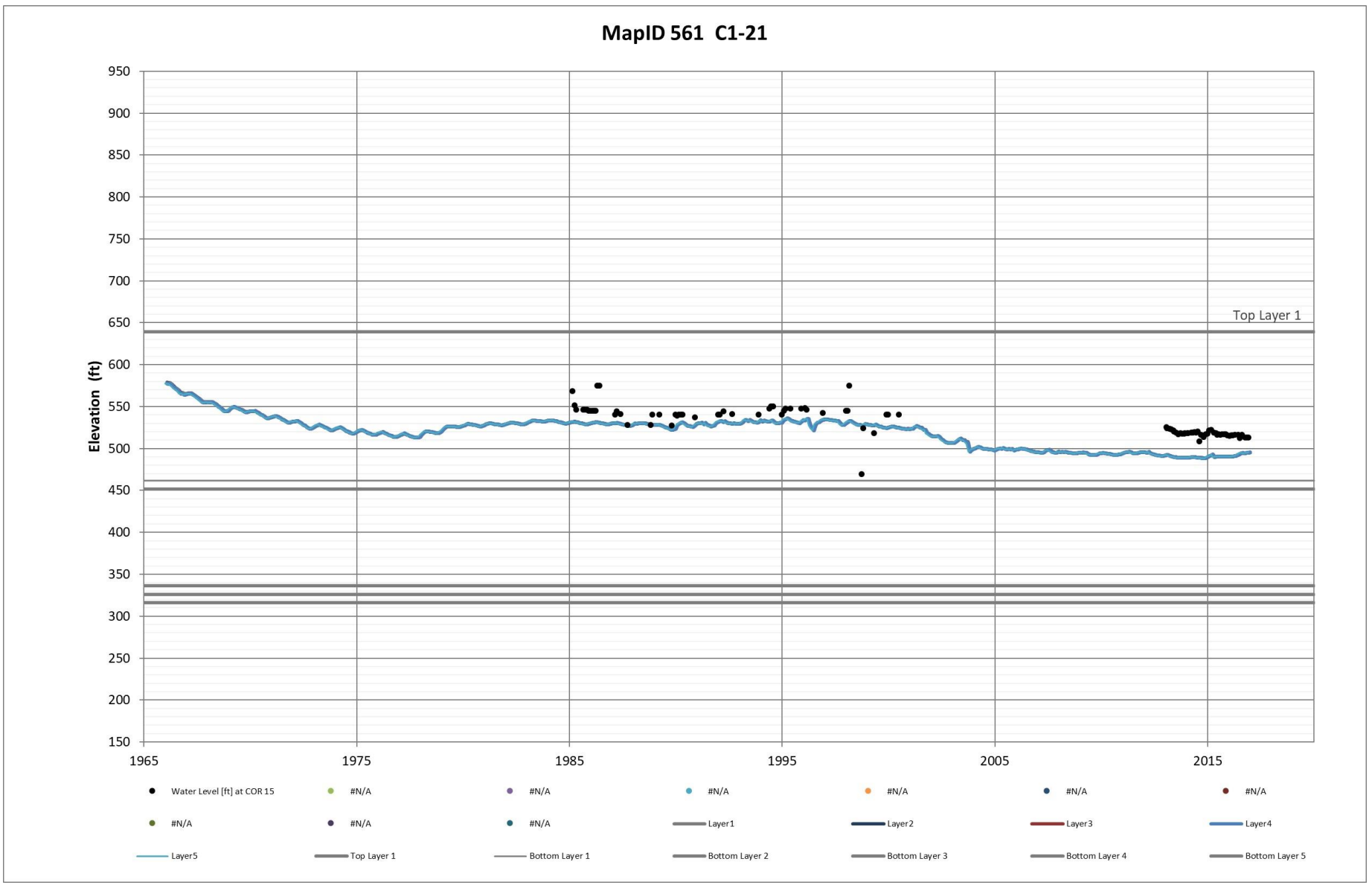


ISARM

Figure C1-20
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
COR 14

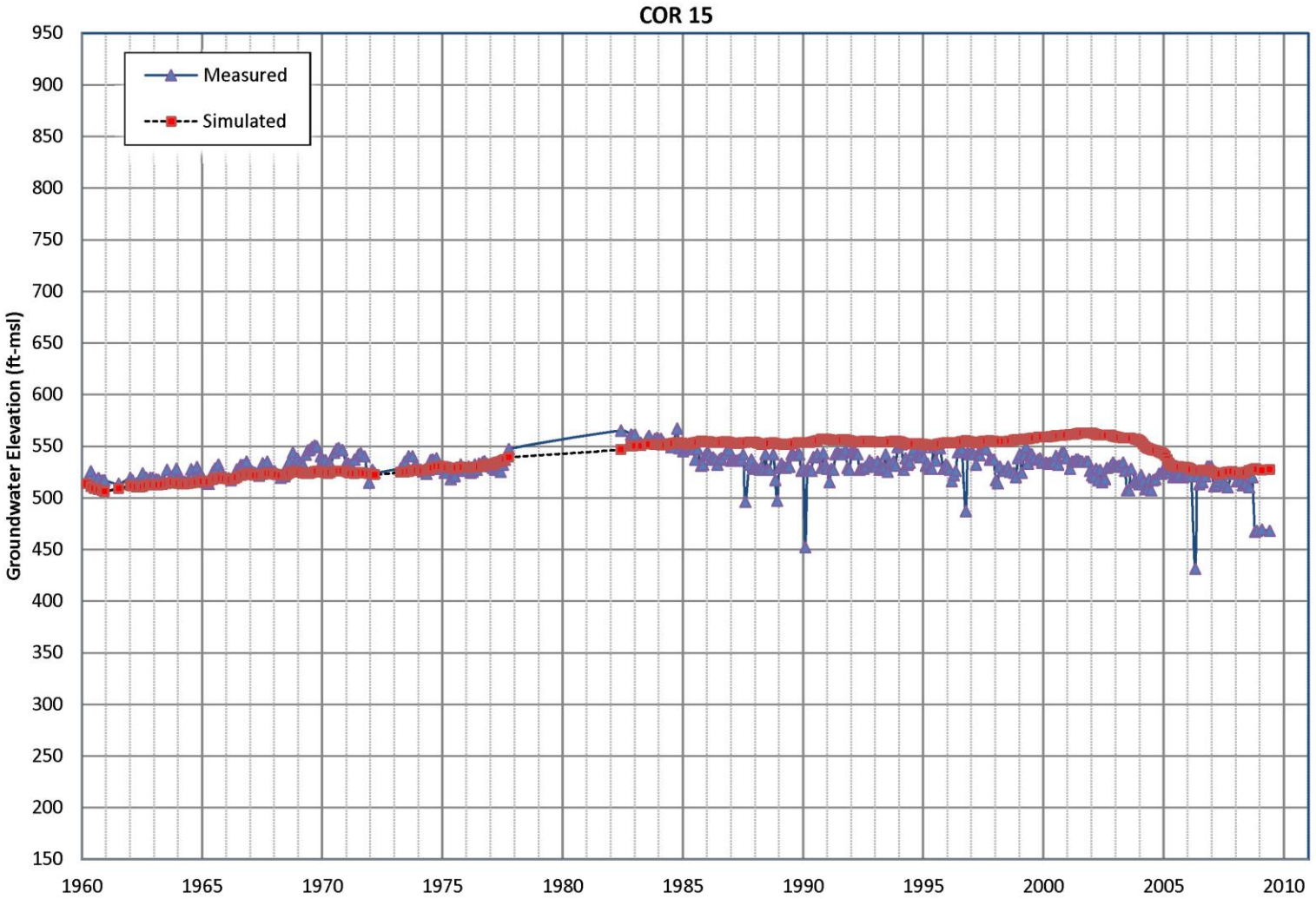


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

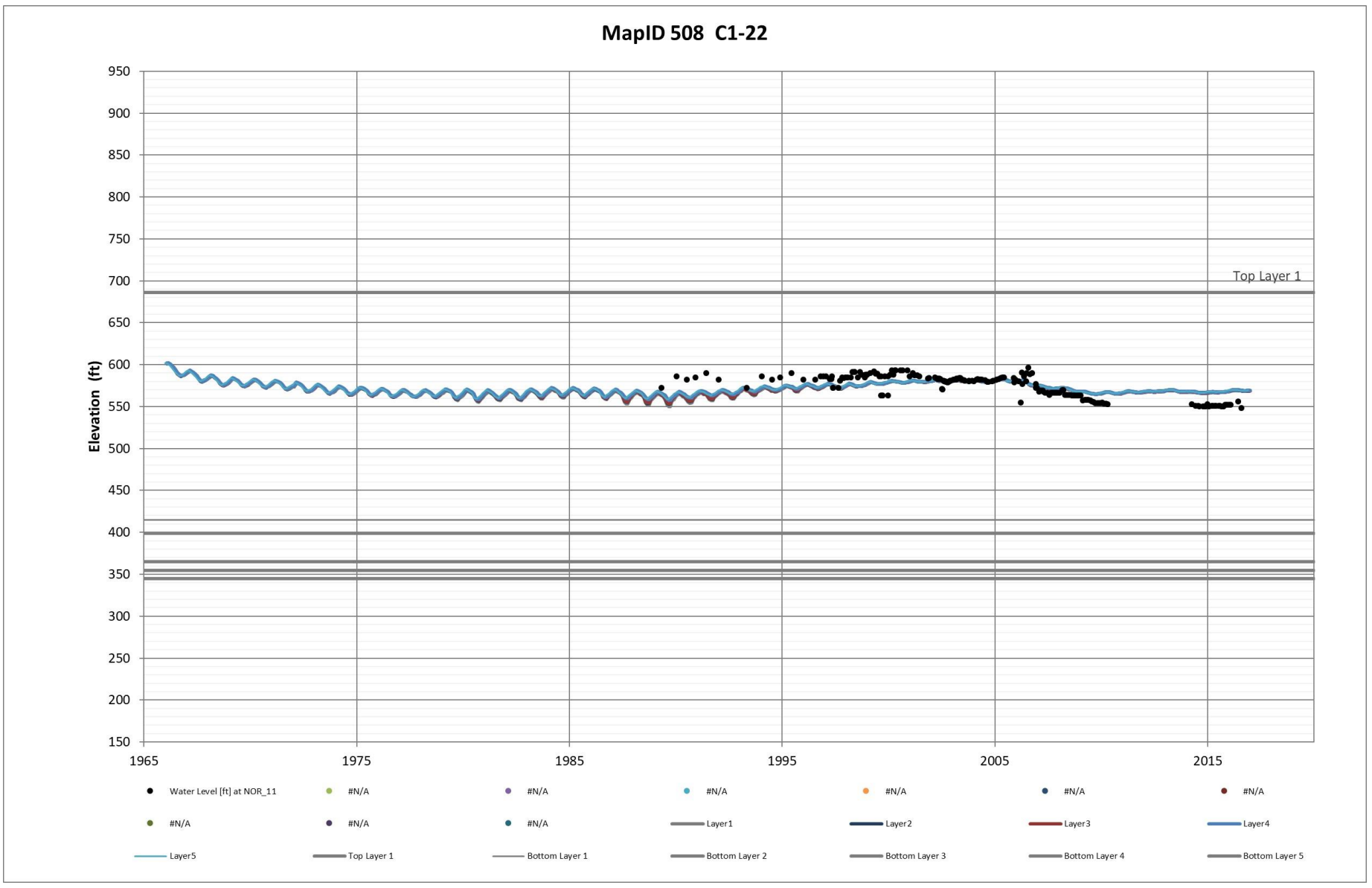


ISARM

Figure C1-21
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
COR 15

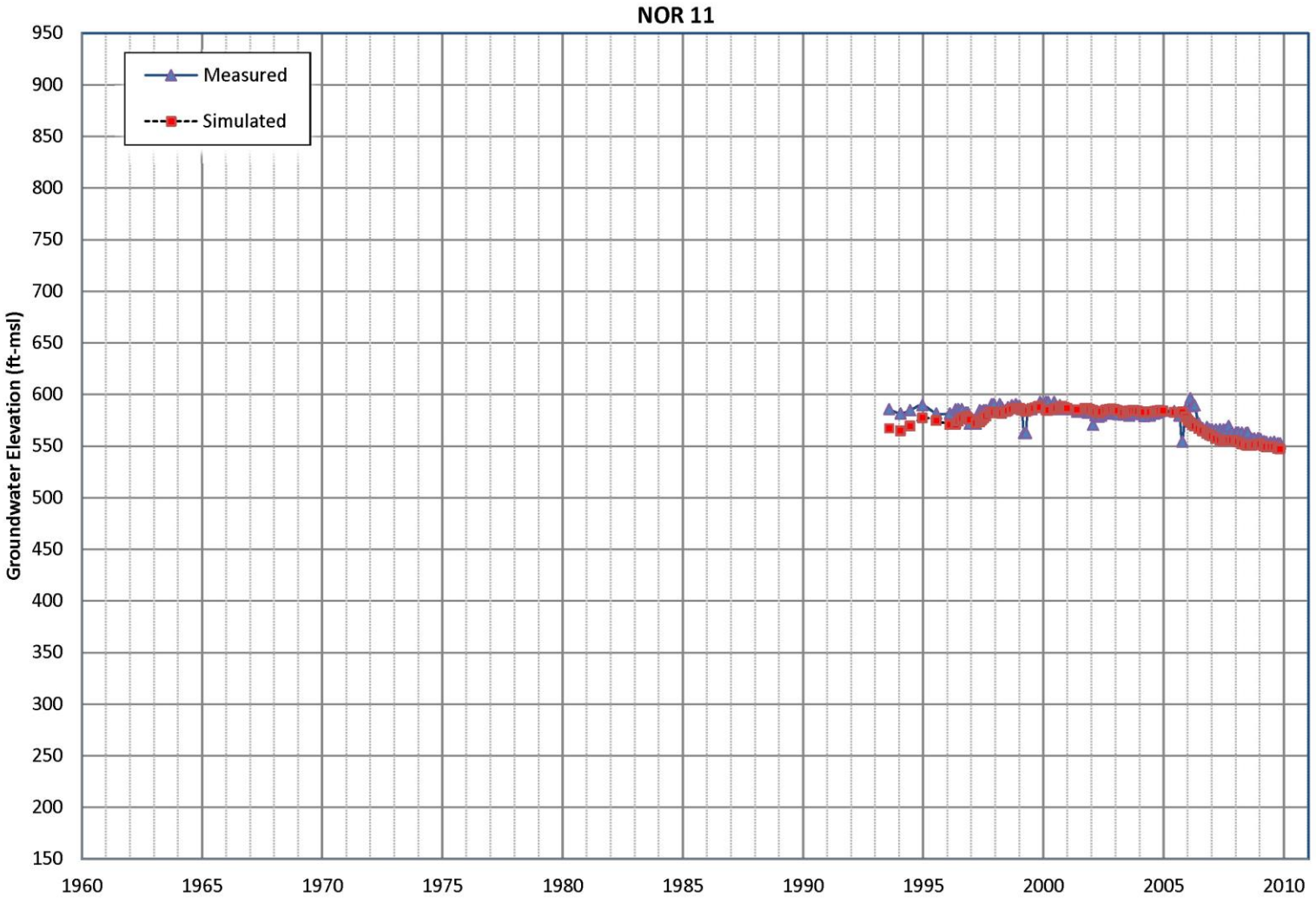


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

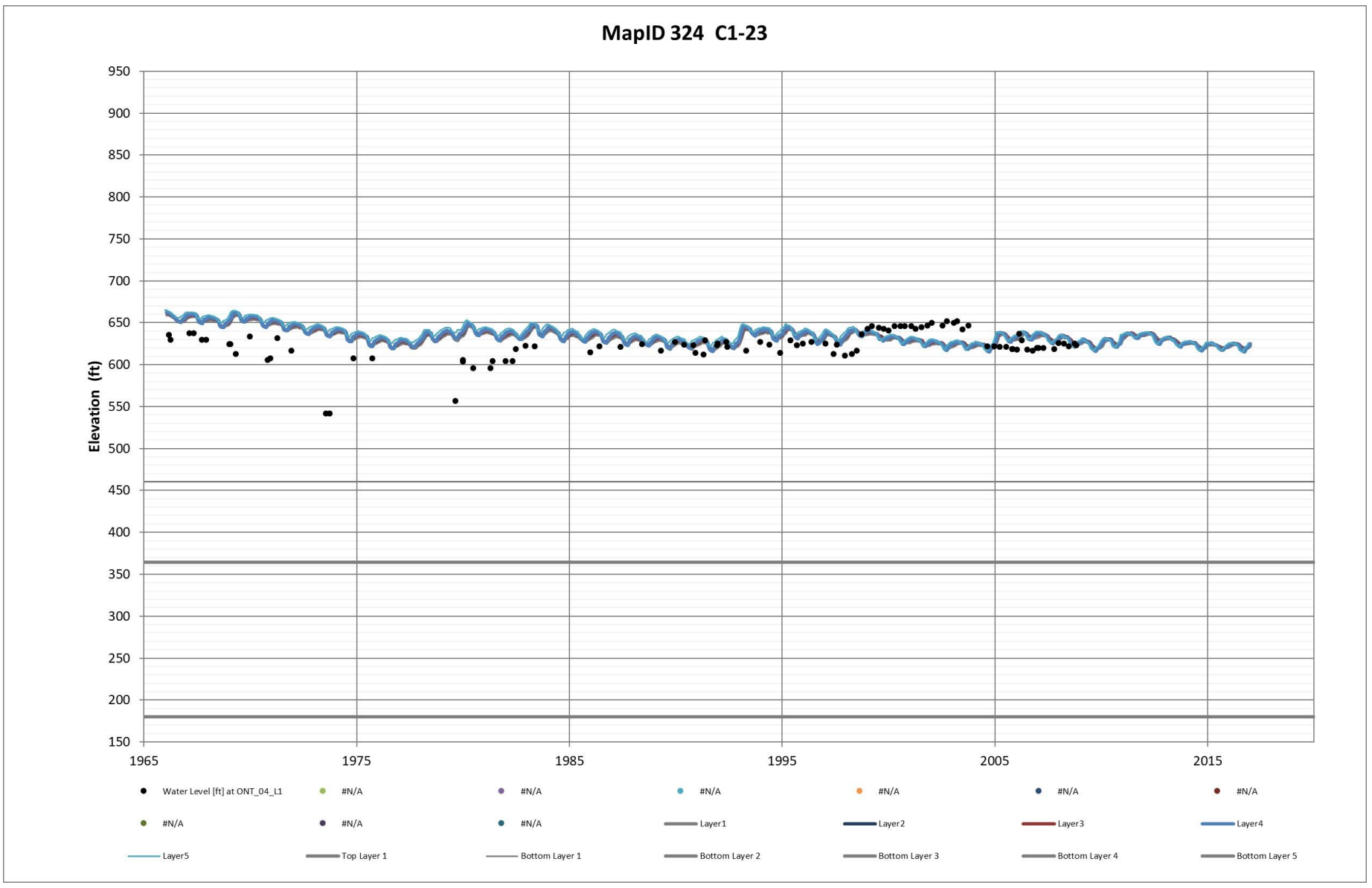


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Figure C1-22
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
NOR 11

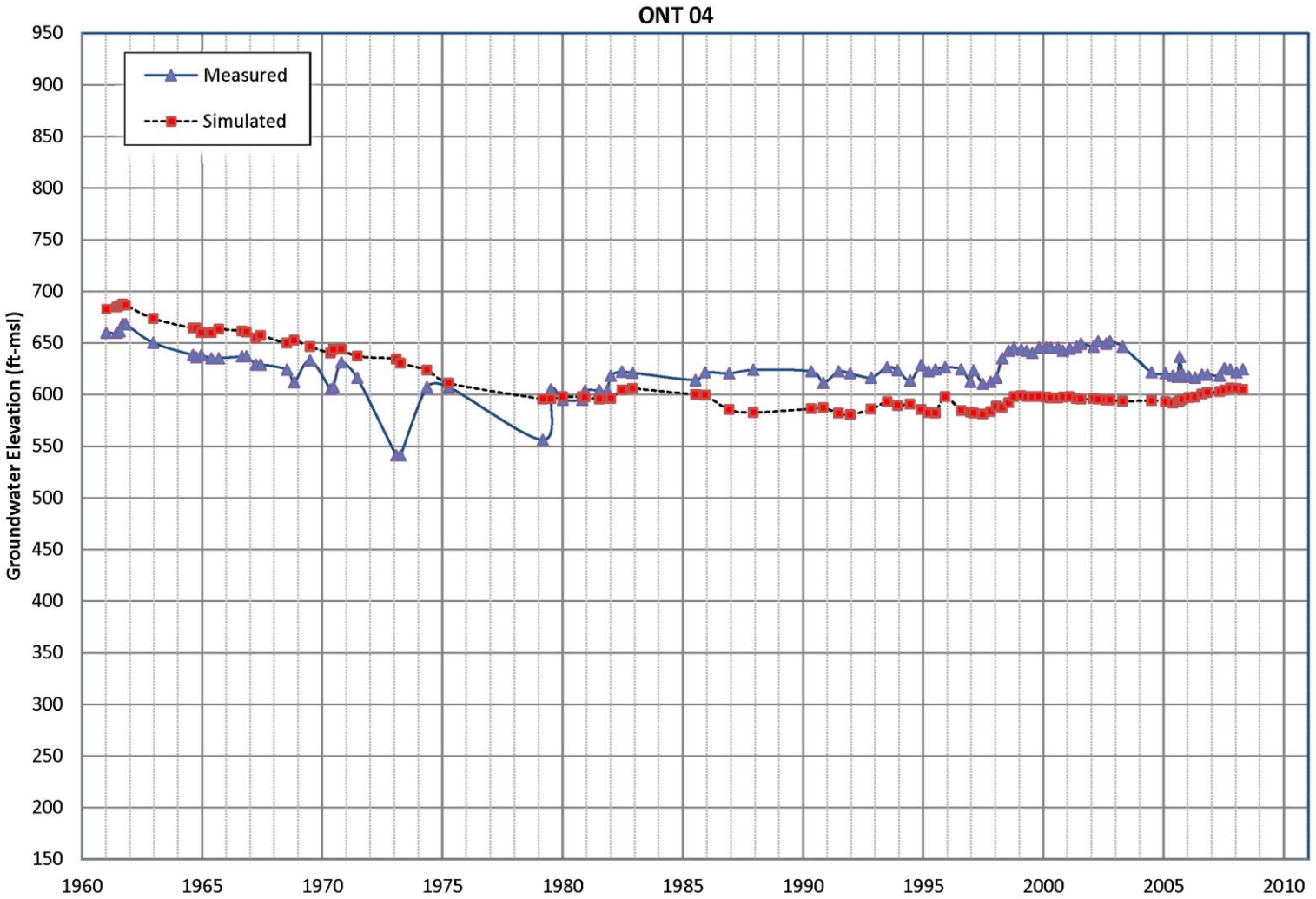


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

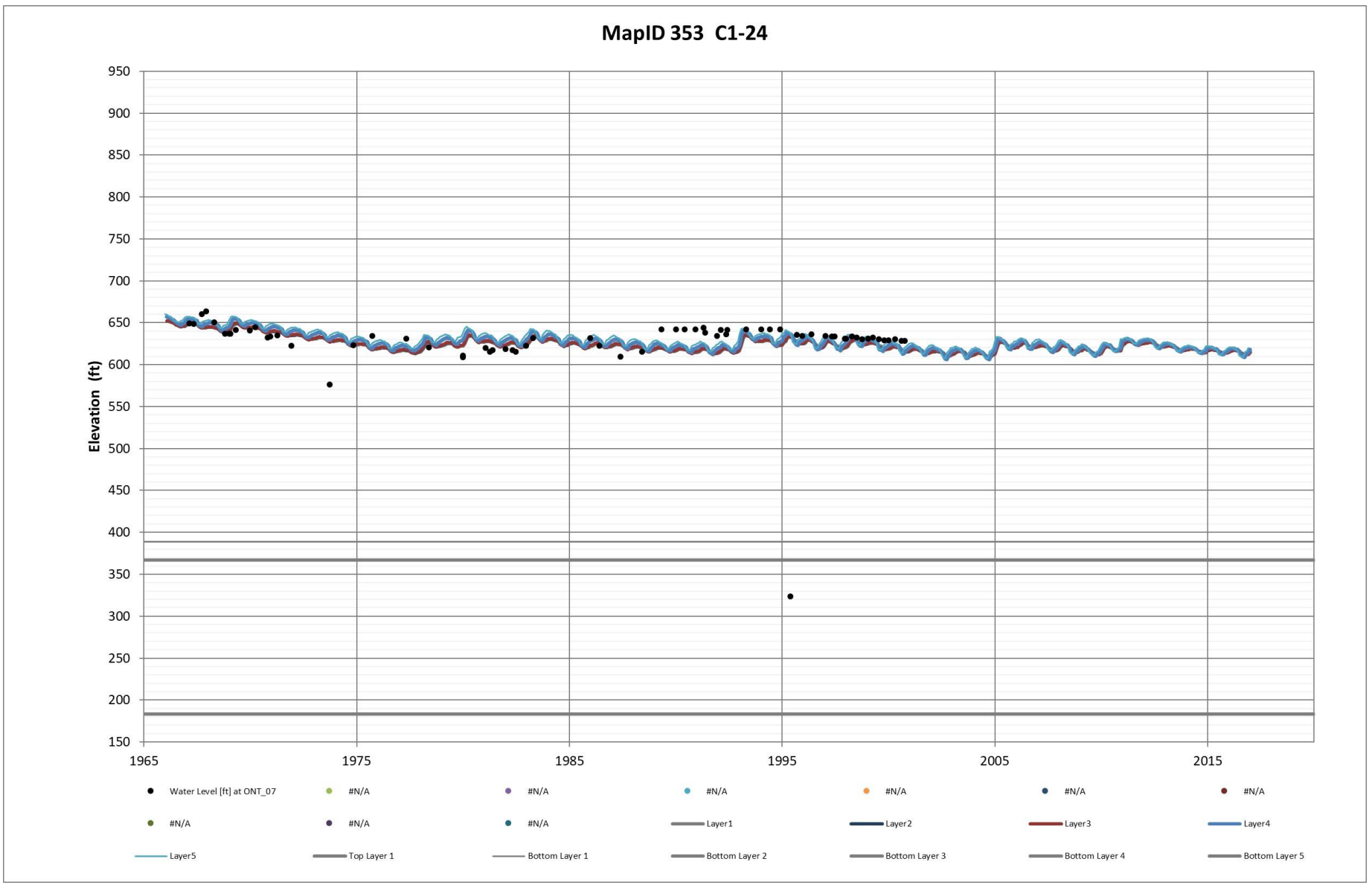


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Figure C1-23
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
ONT 04

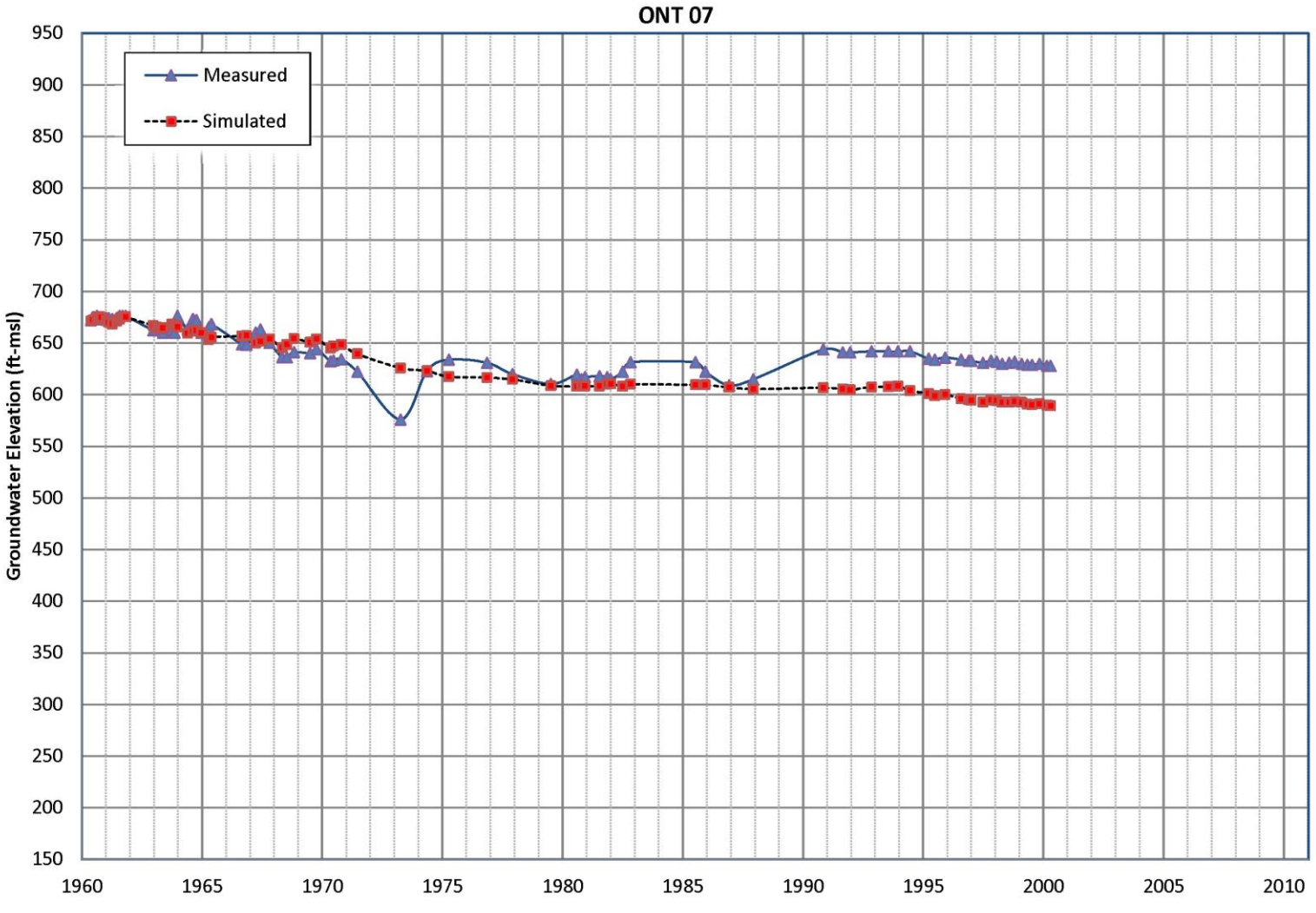


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

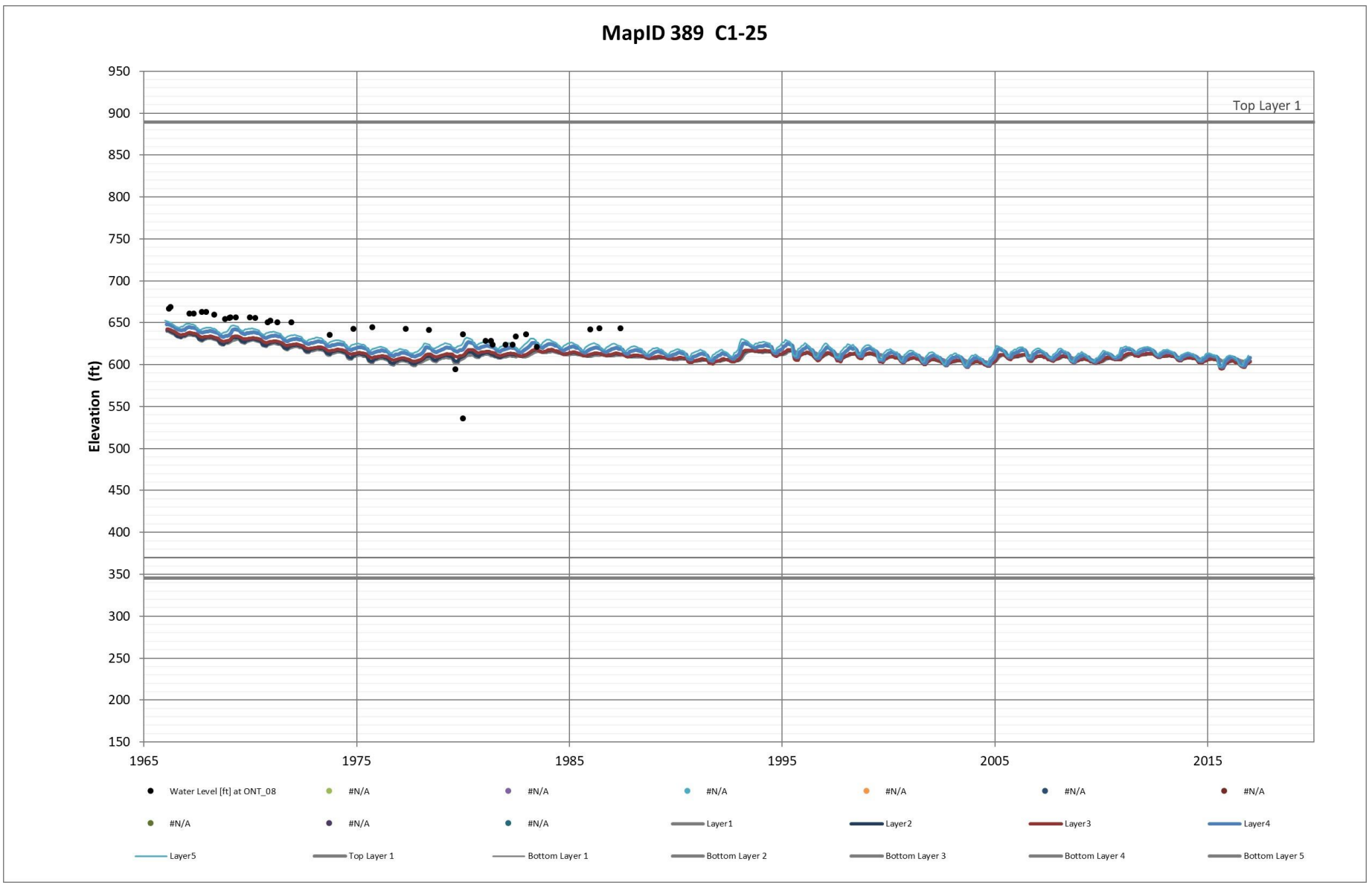


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Figure C1-24
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
ONT 07

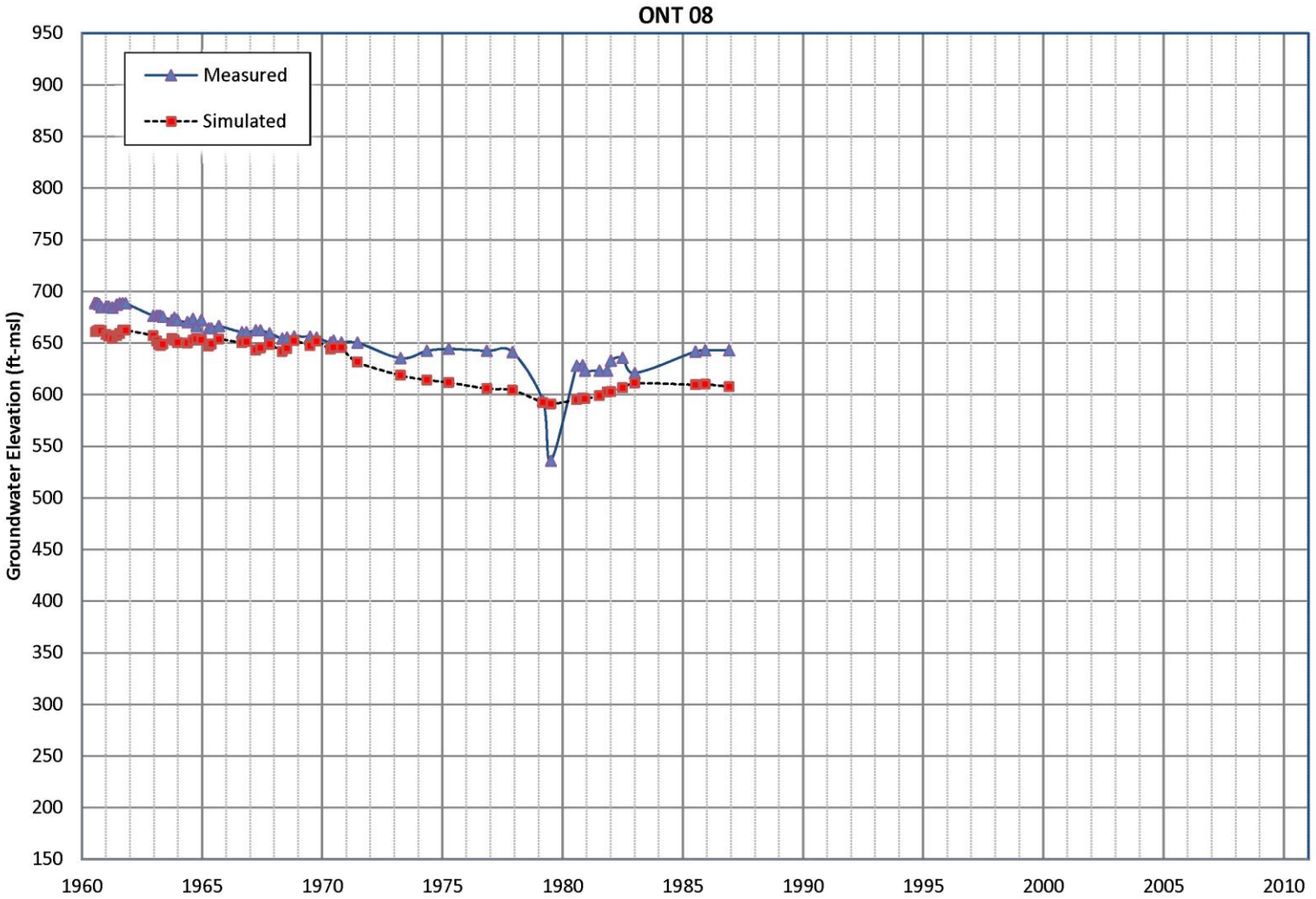


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

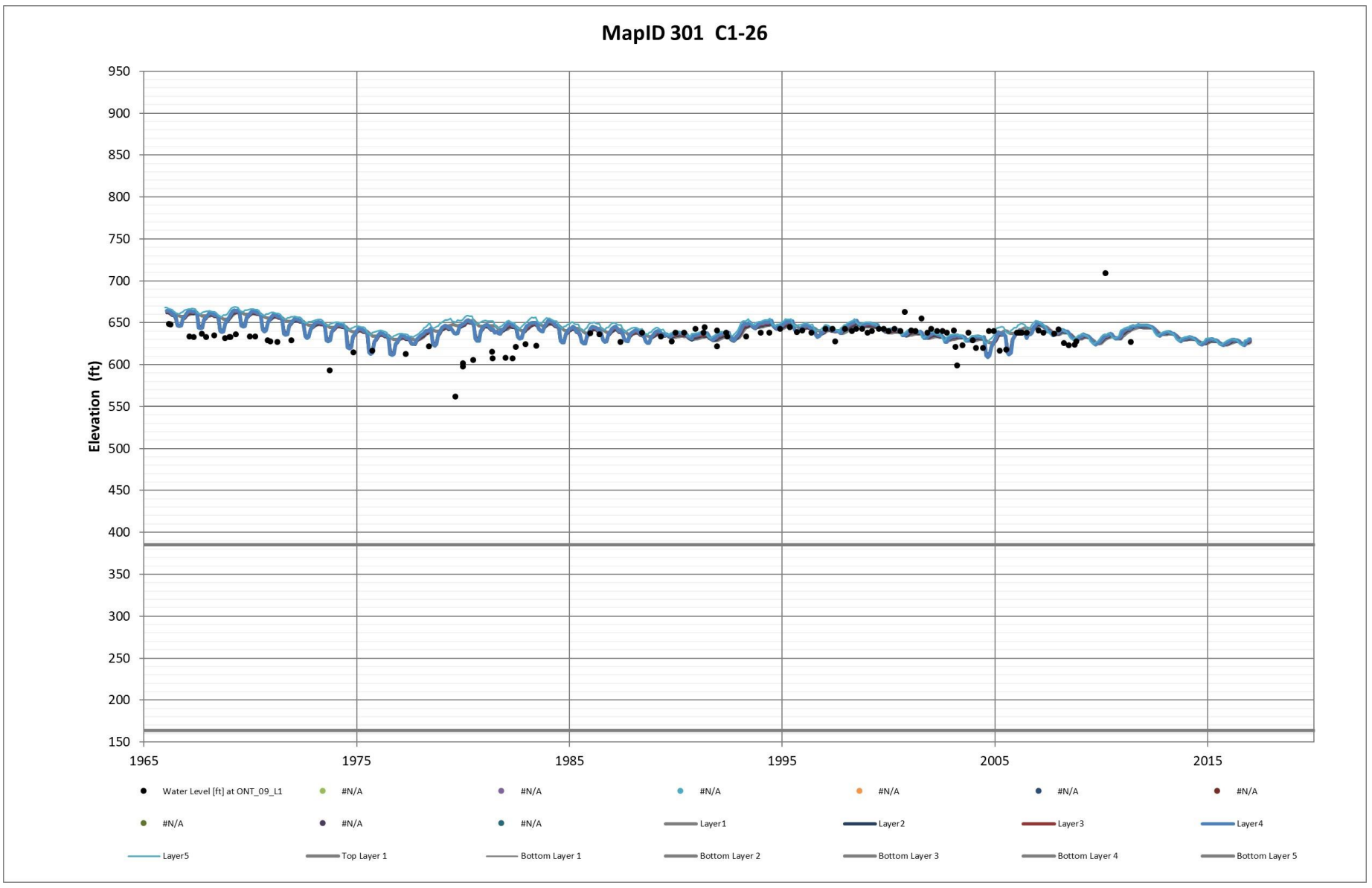


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Figure C1-25
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
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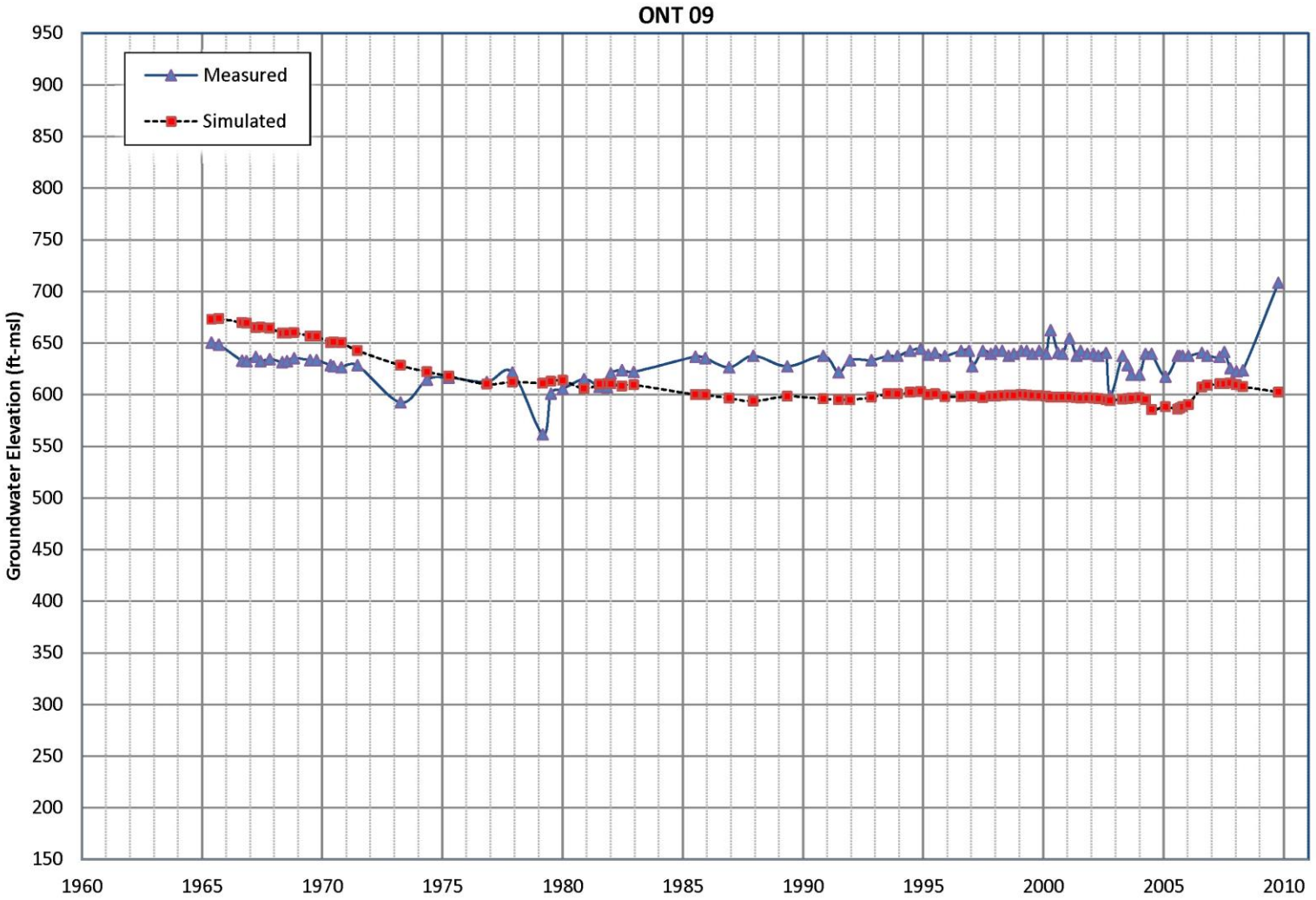


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

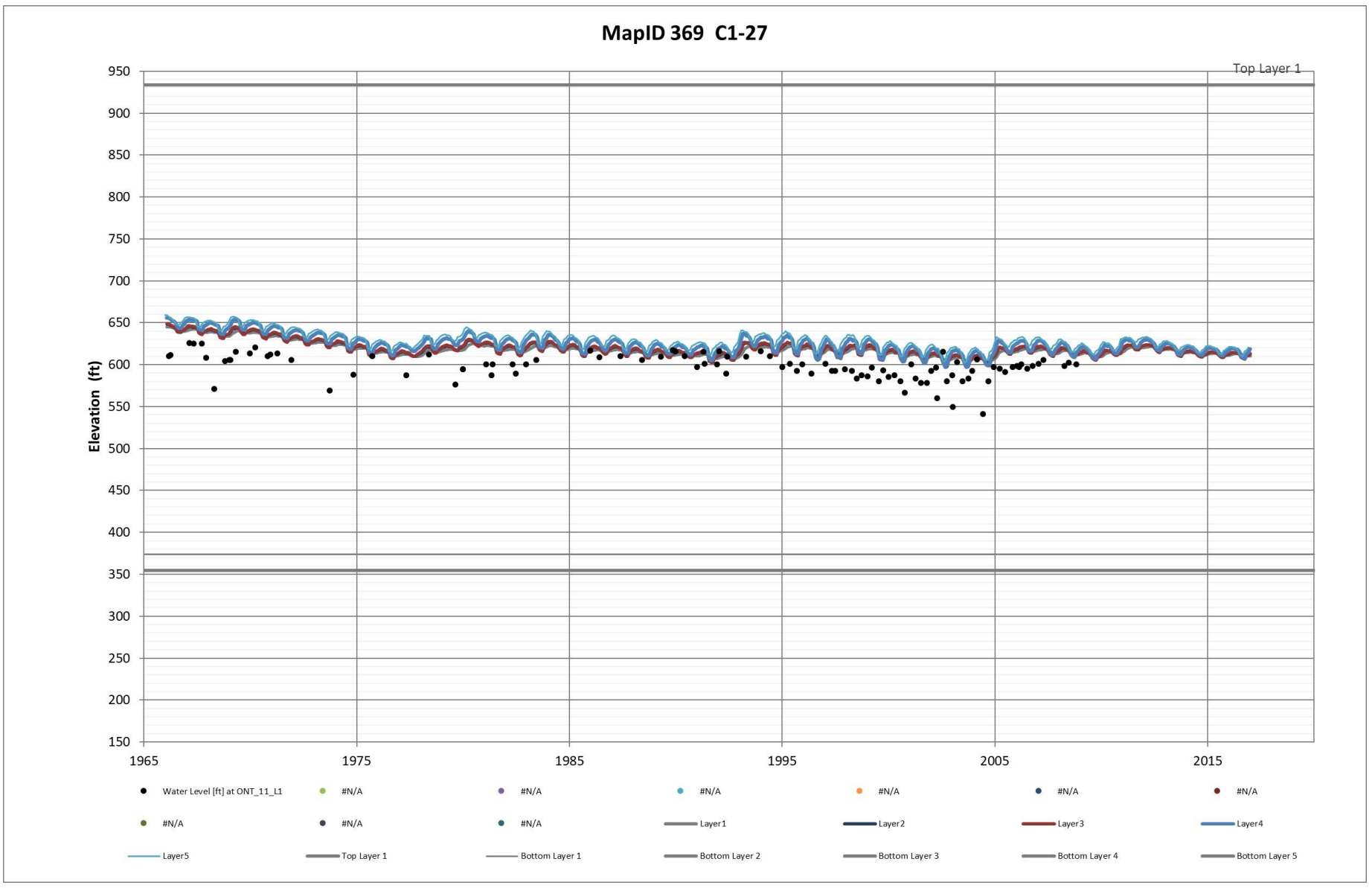


ISARM

Figure C1-26
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
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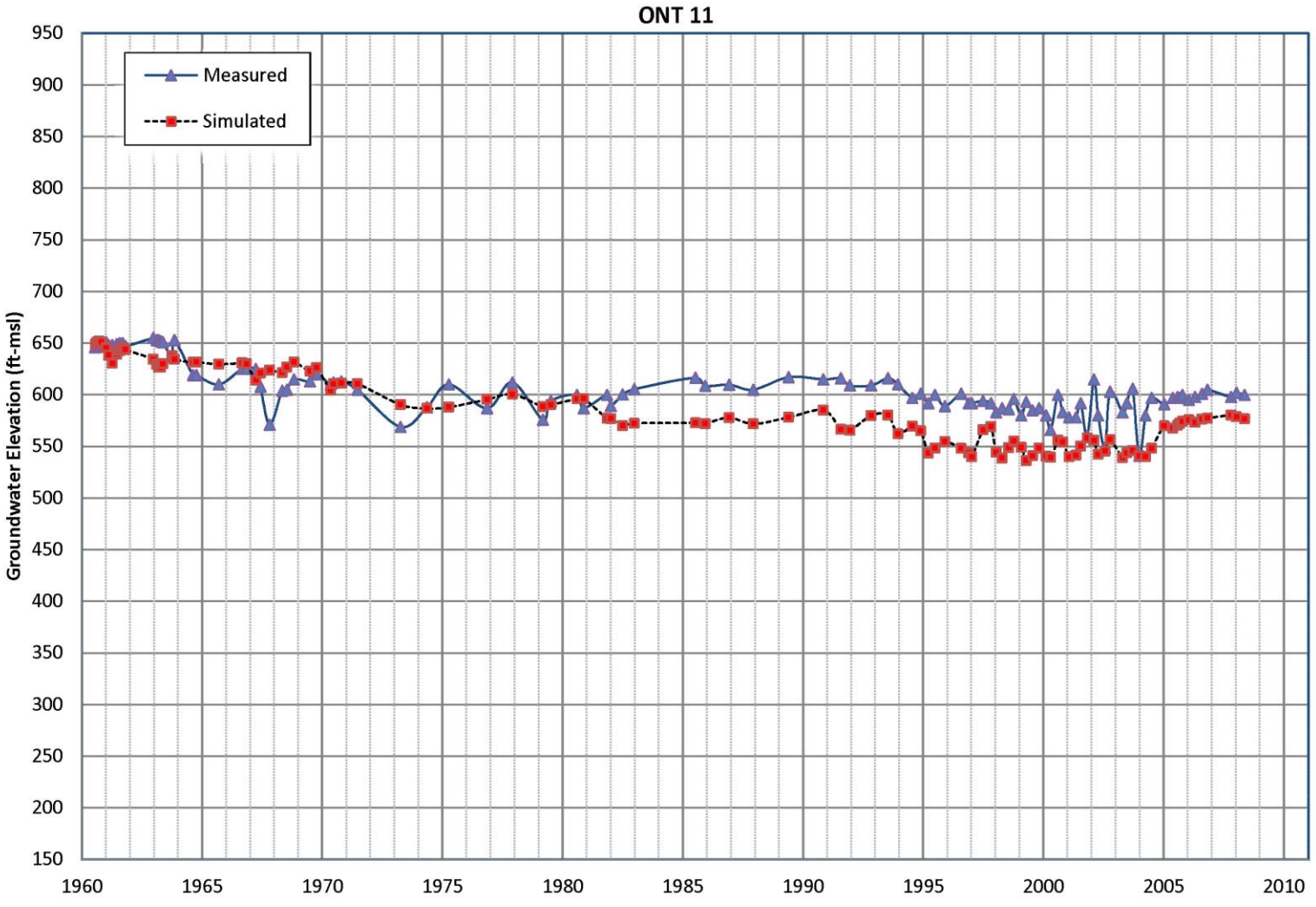


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

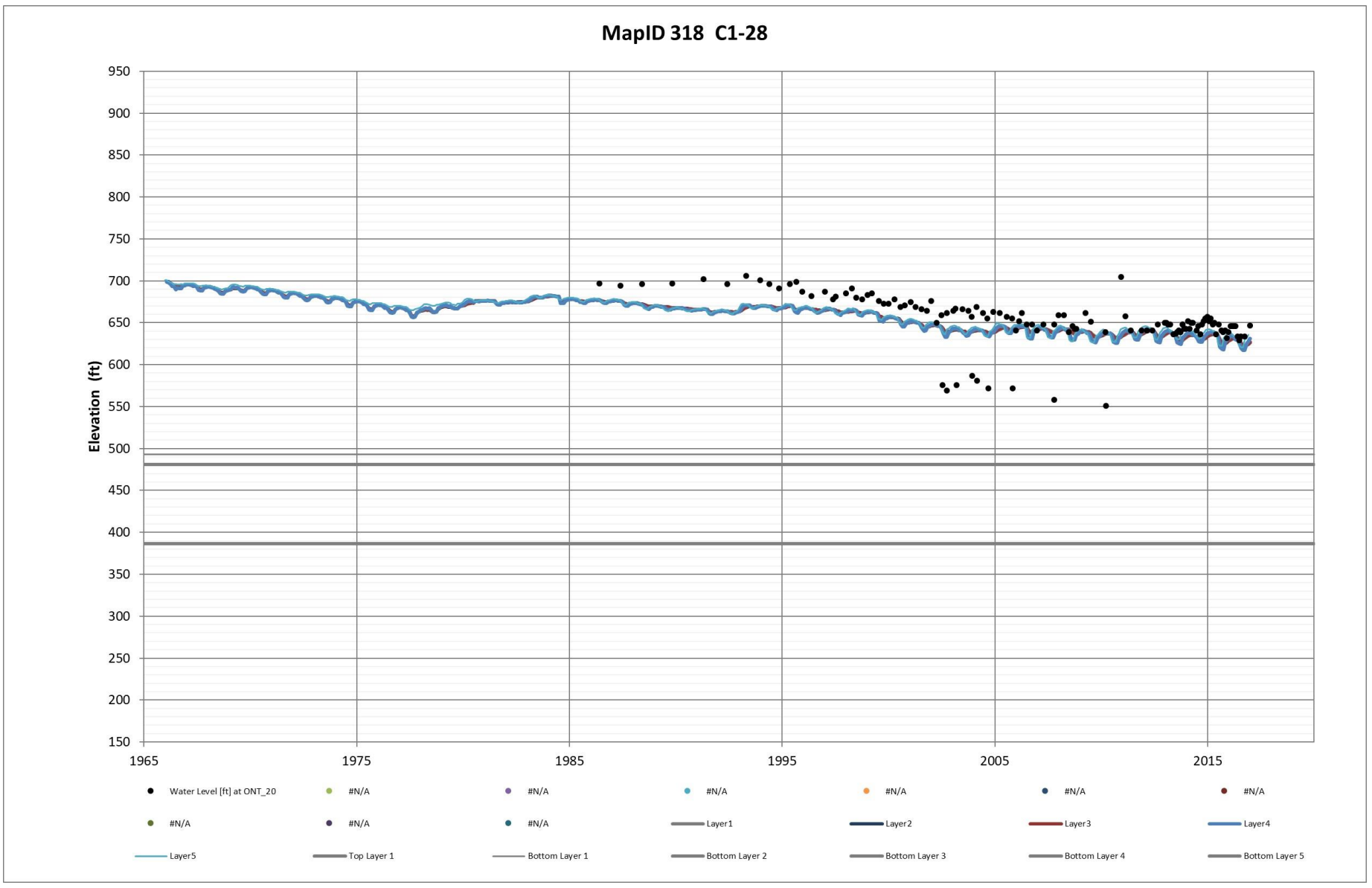


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Figure C1-27
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
ONT 11

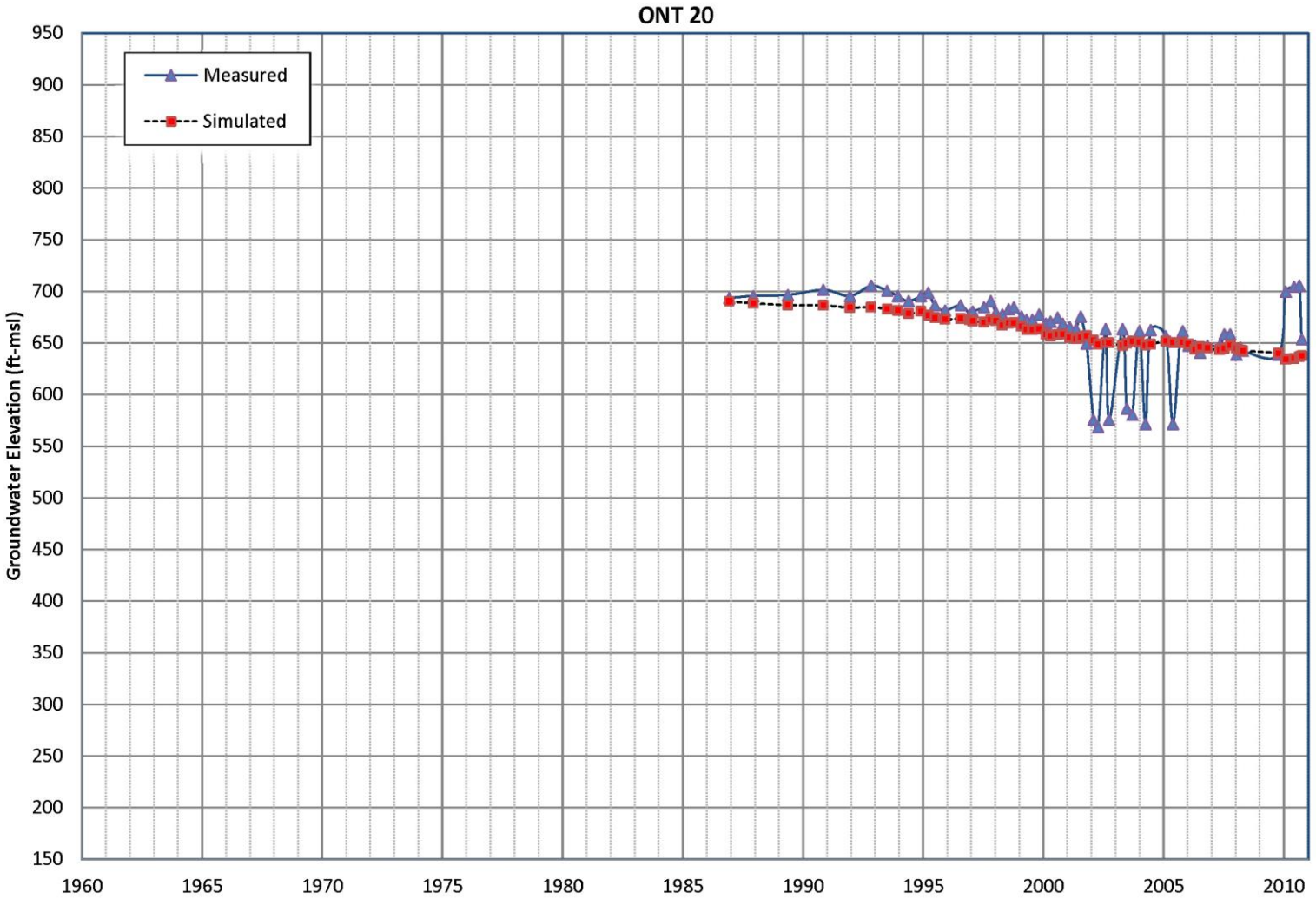


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

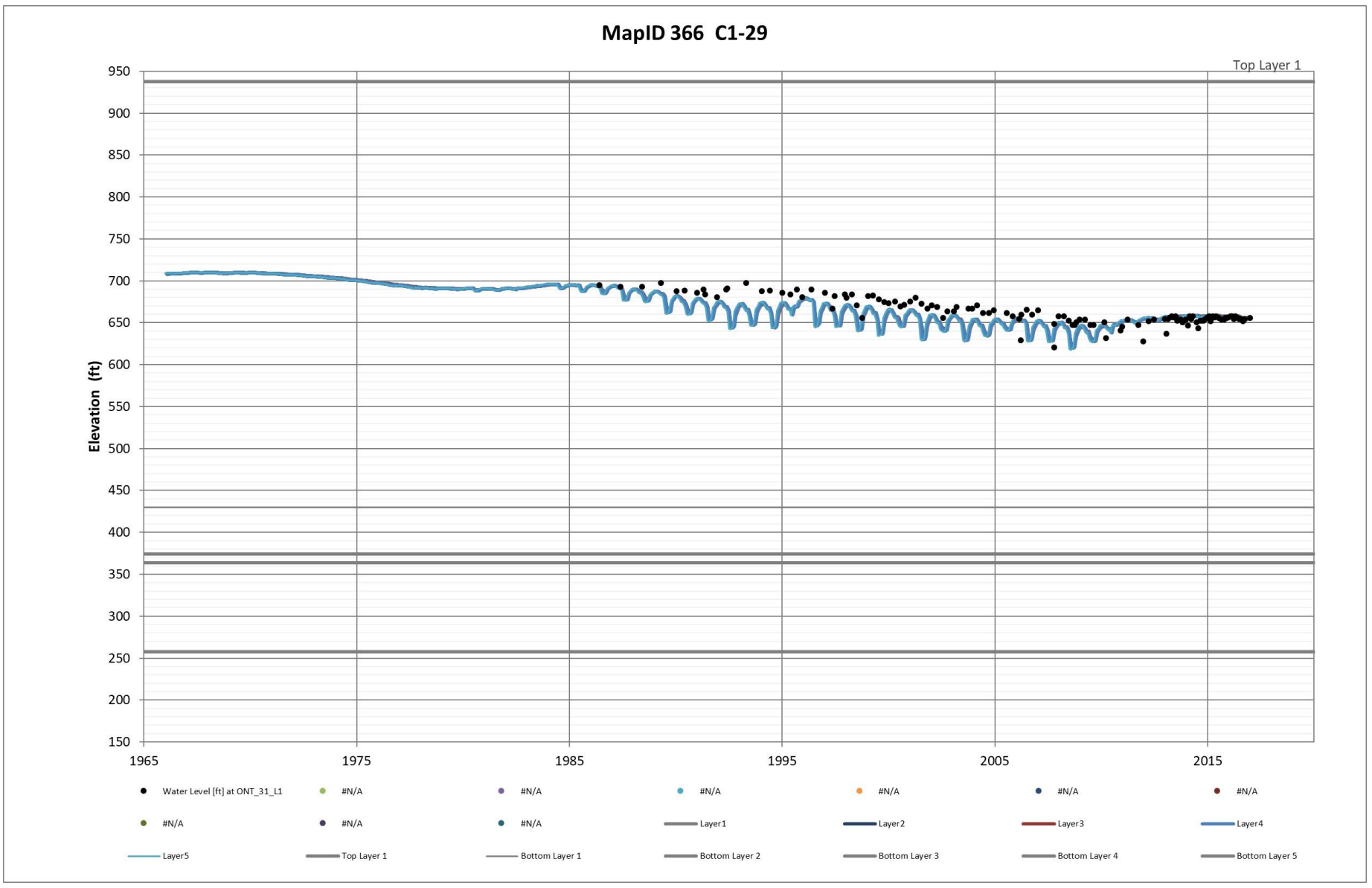


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Figure C1-28
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
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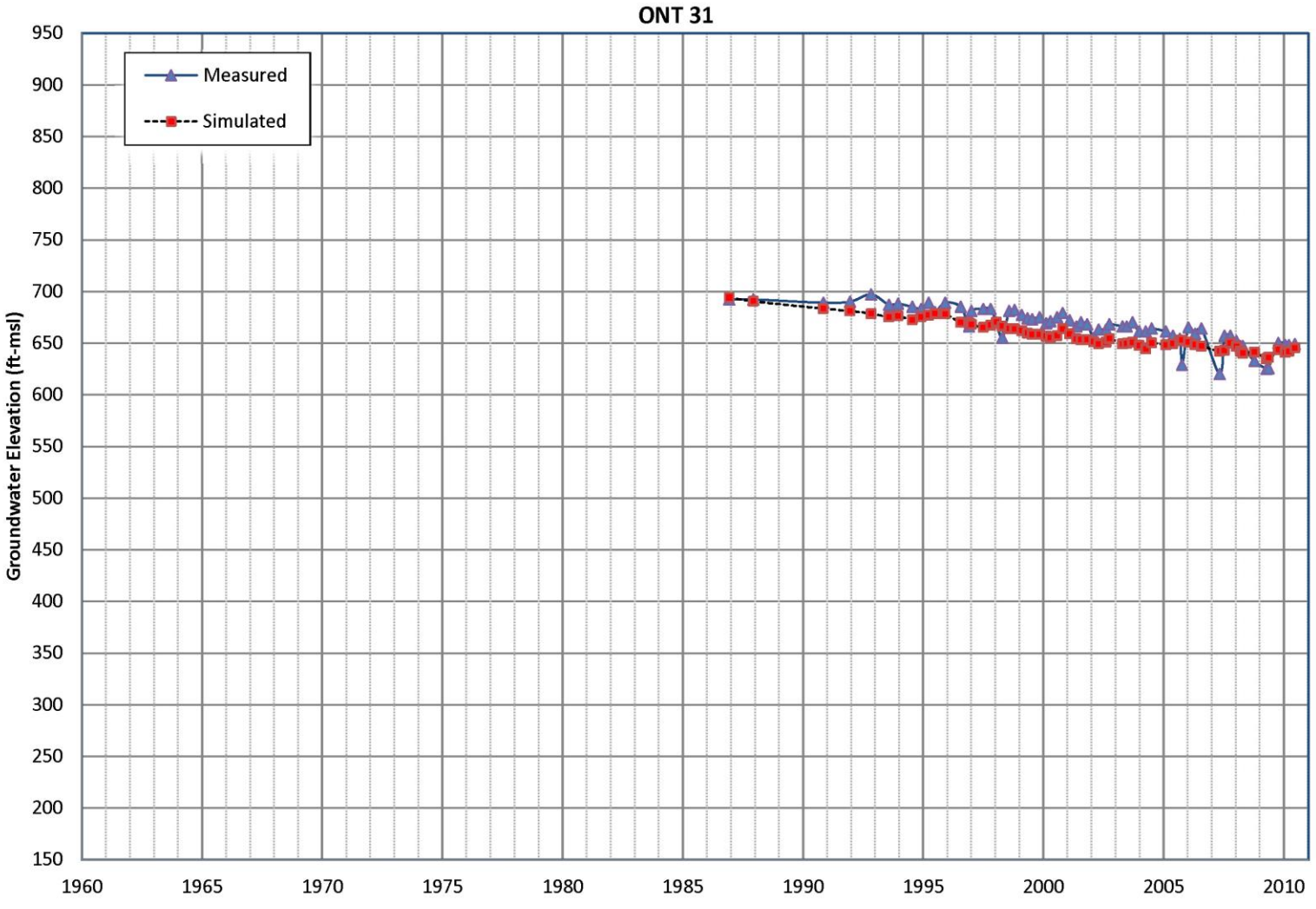


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

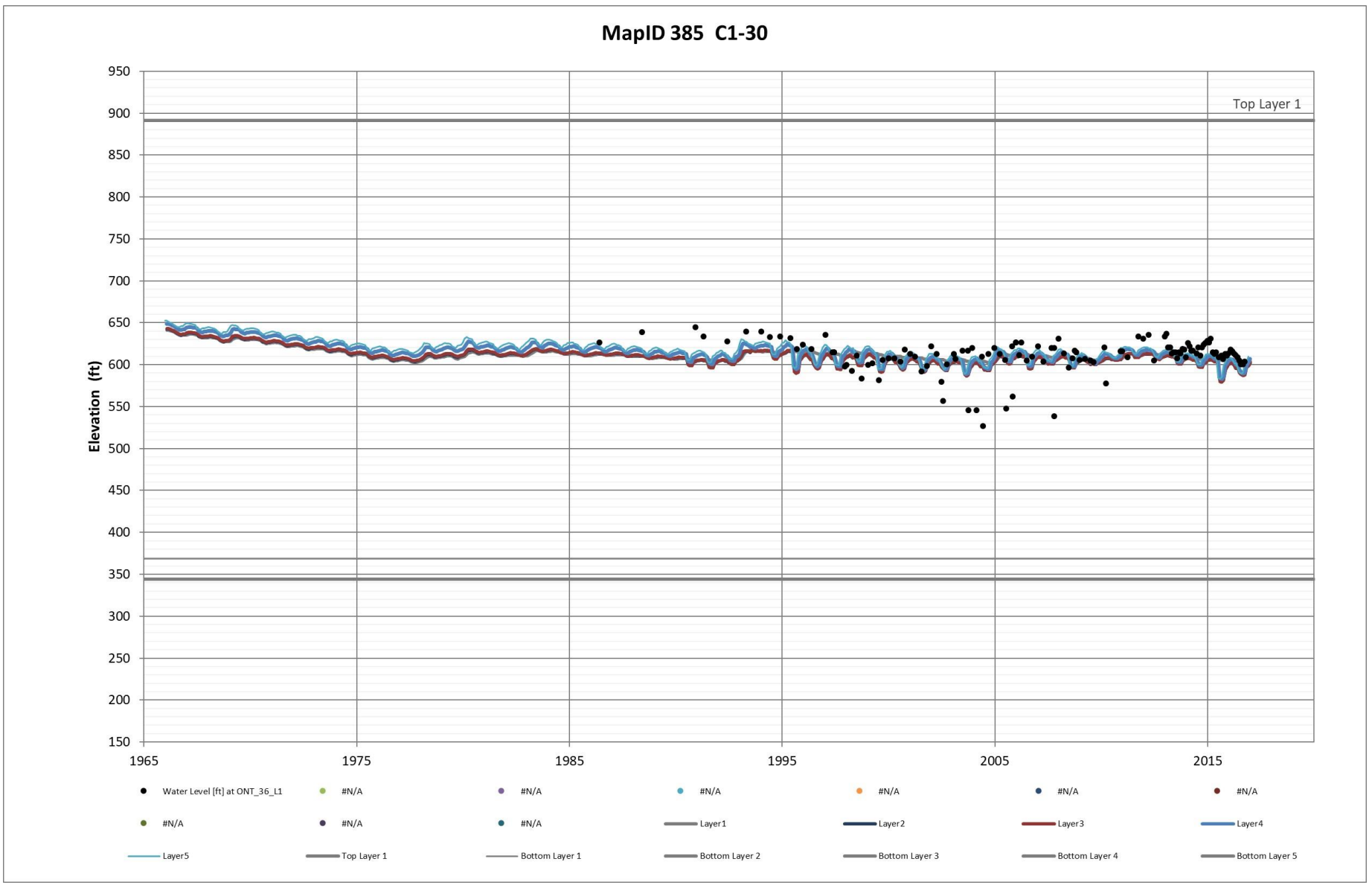


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Figure C1-29
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
ONT 31

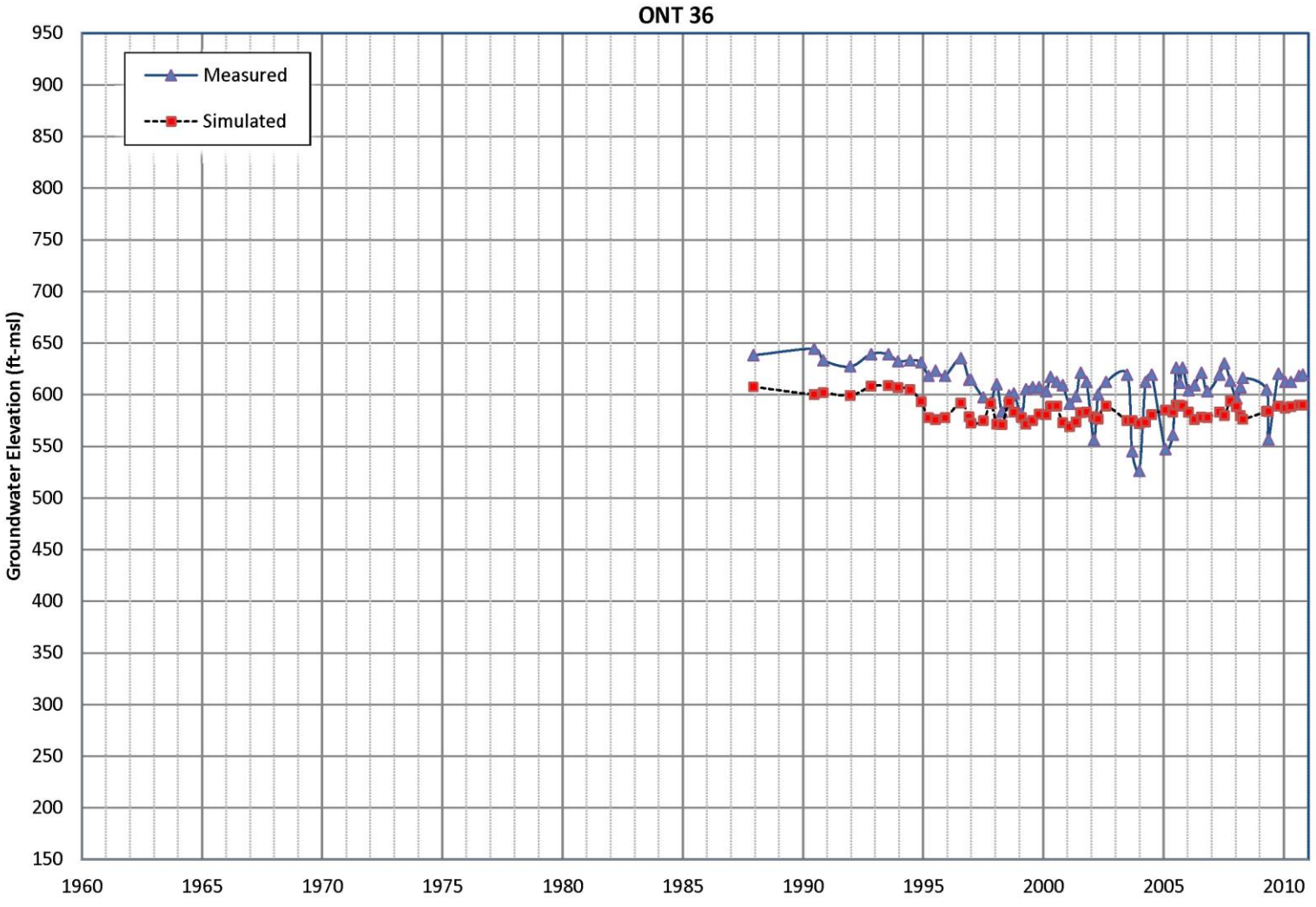


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

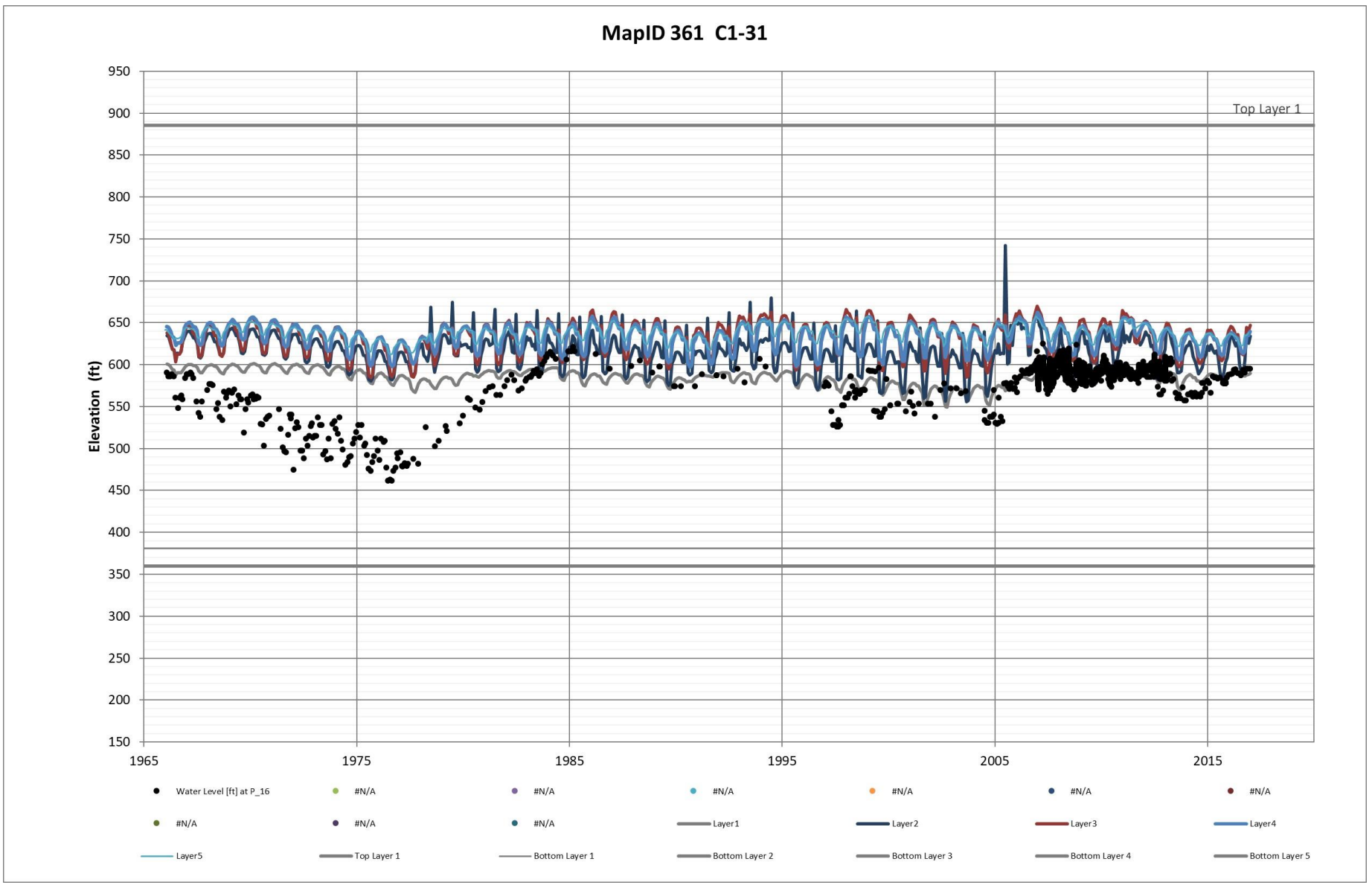


ISARM

Figure C1-30
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
ONT 36

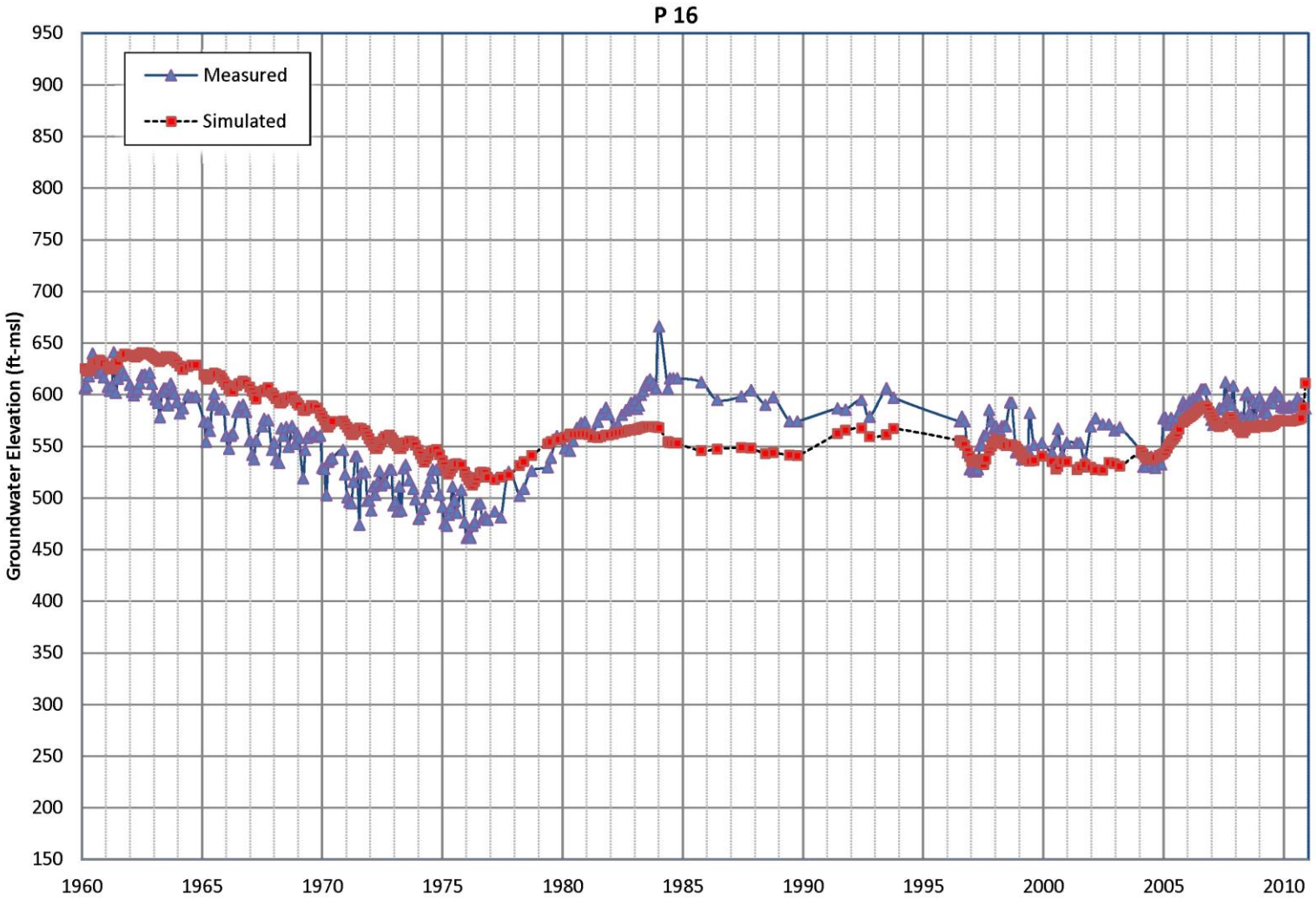


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

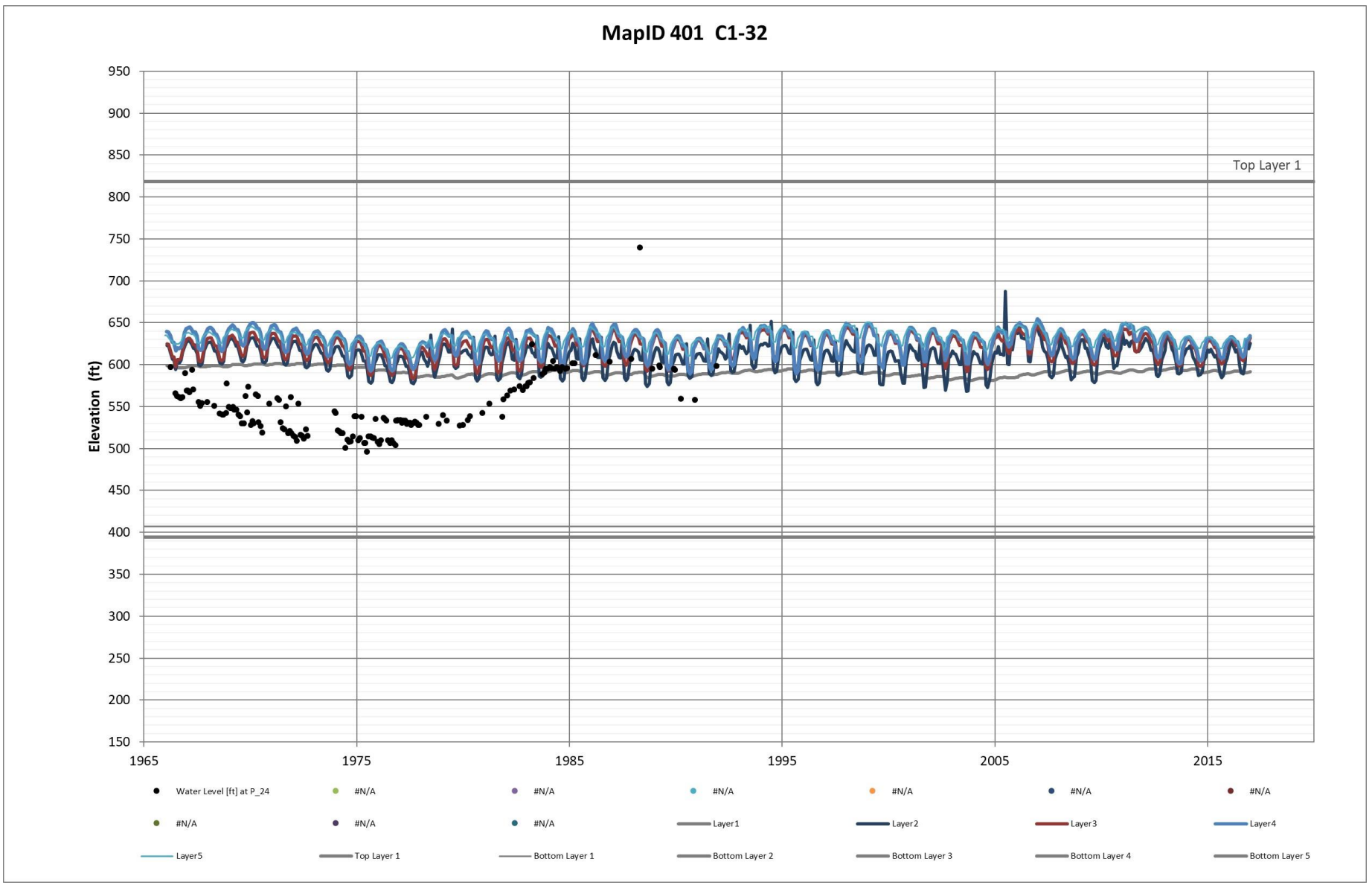


ISARM

Figure C1-31
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
P 16

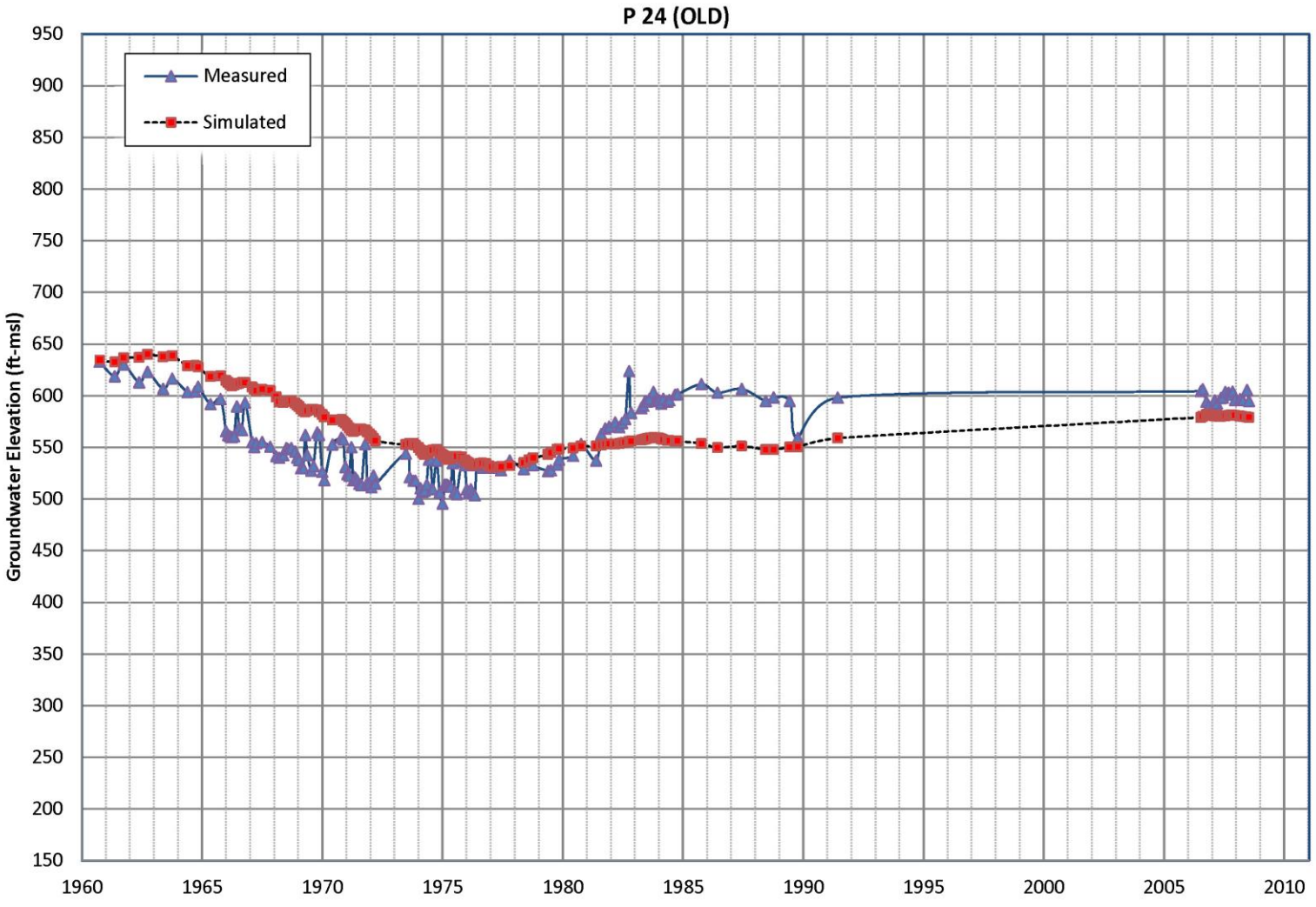


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

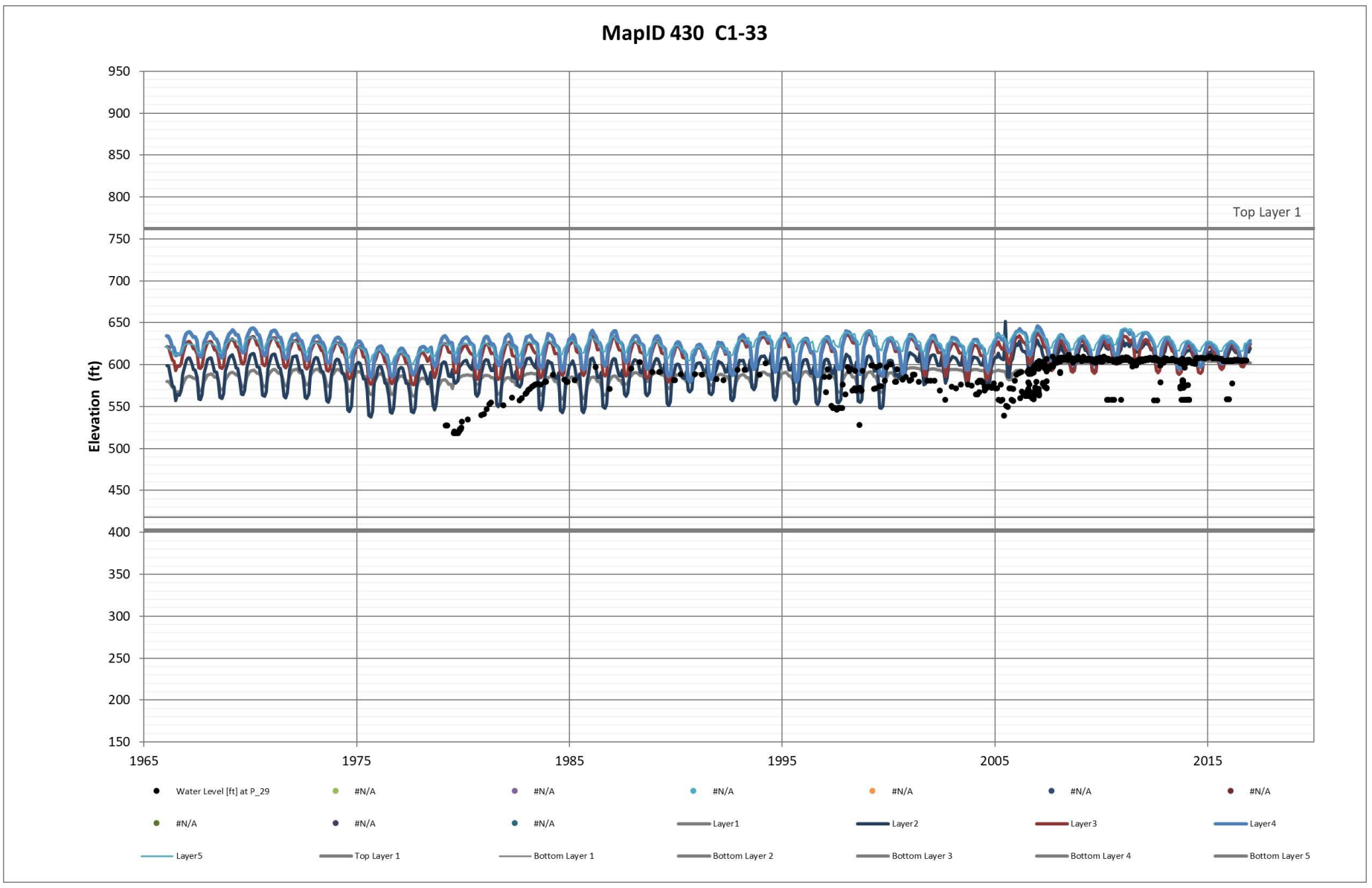


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Figure C1-32
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
P 24 (OLD)

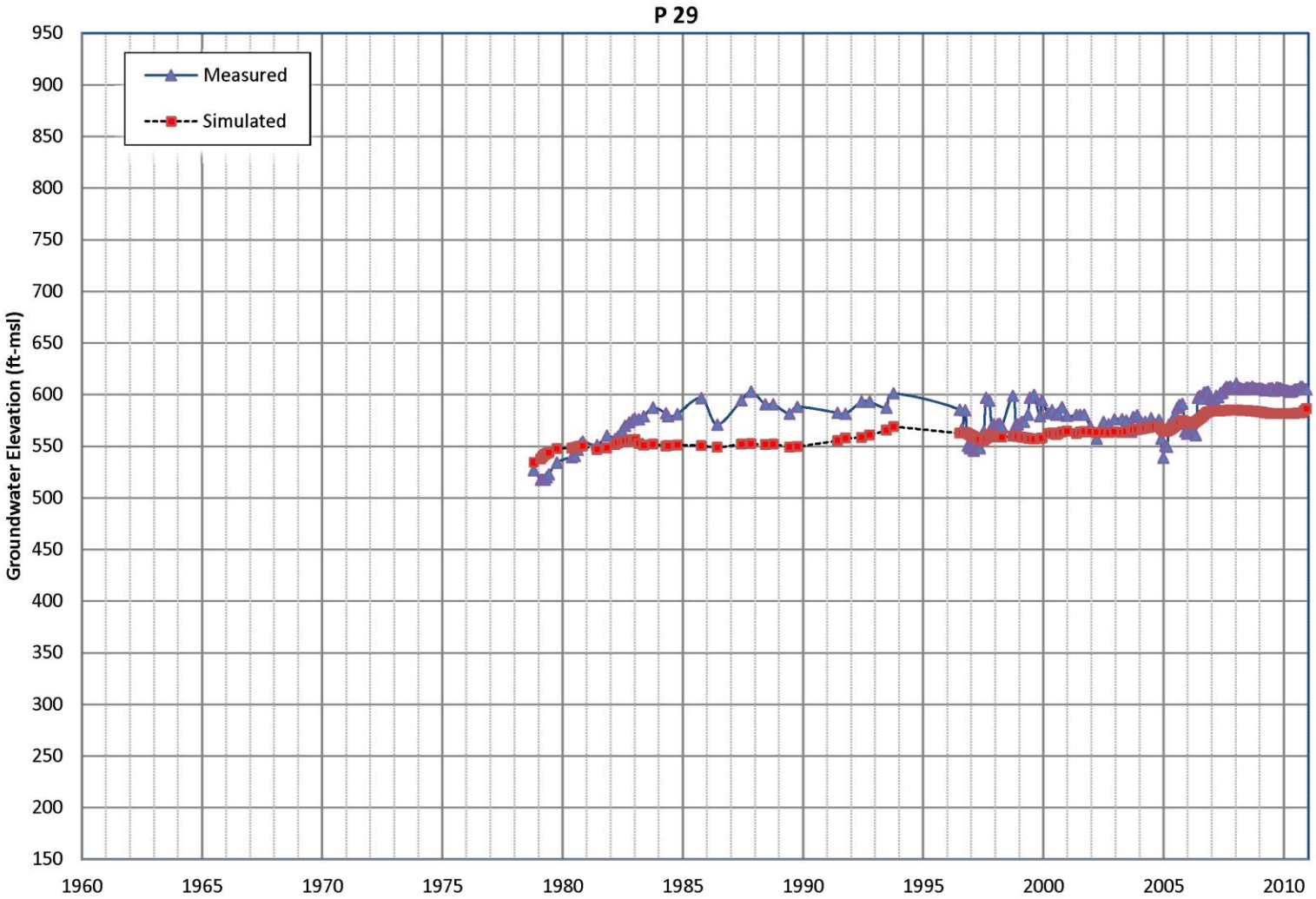


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

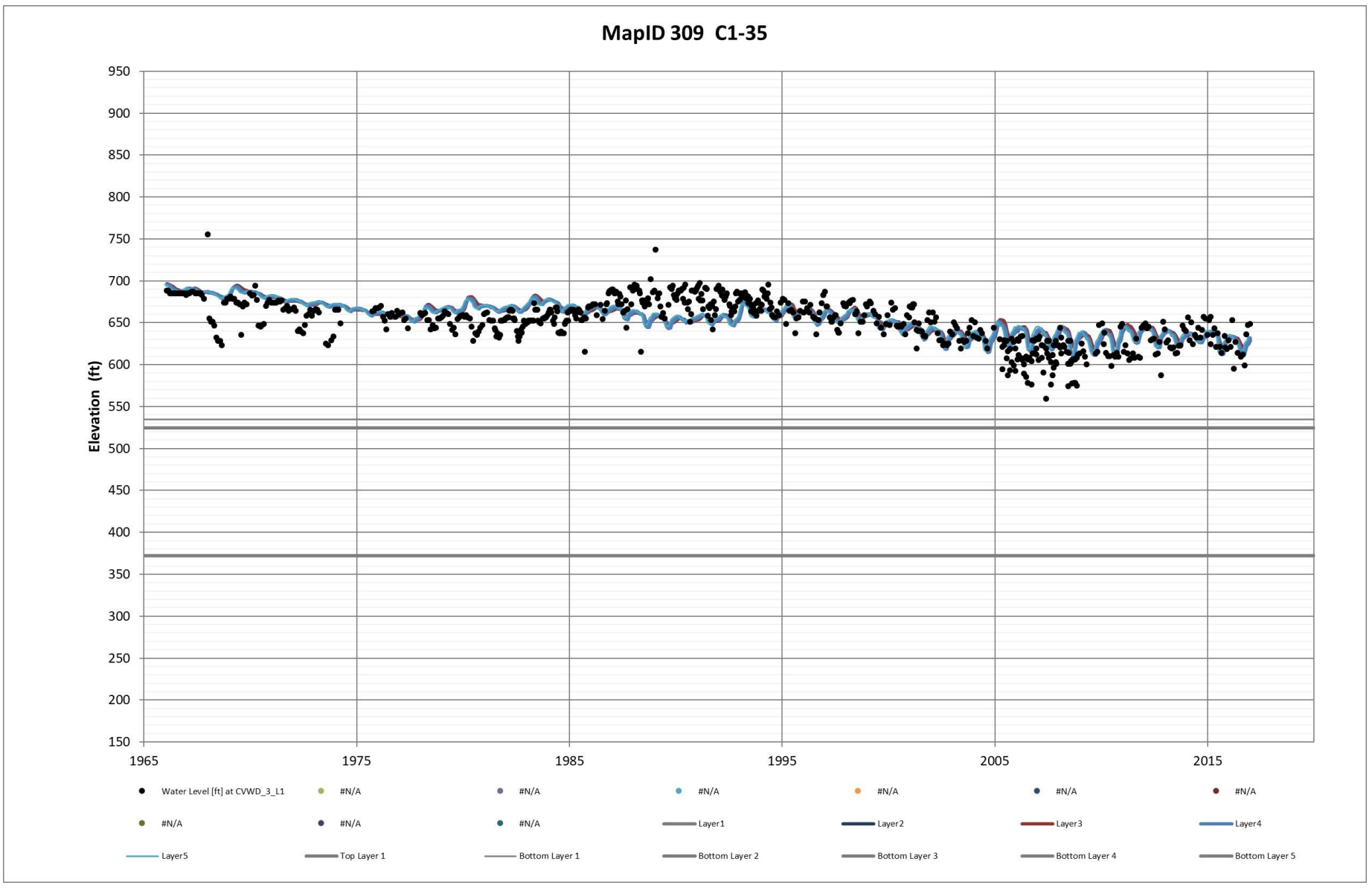


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Figure C1-33
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
P 29

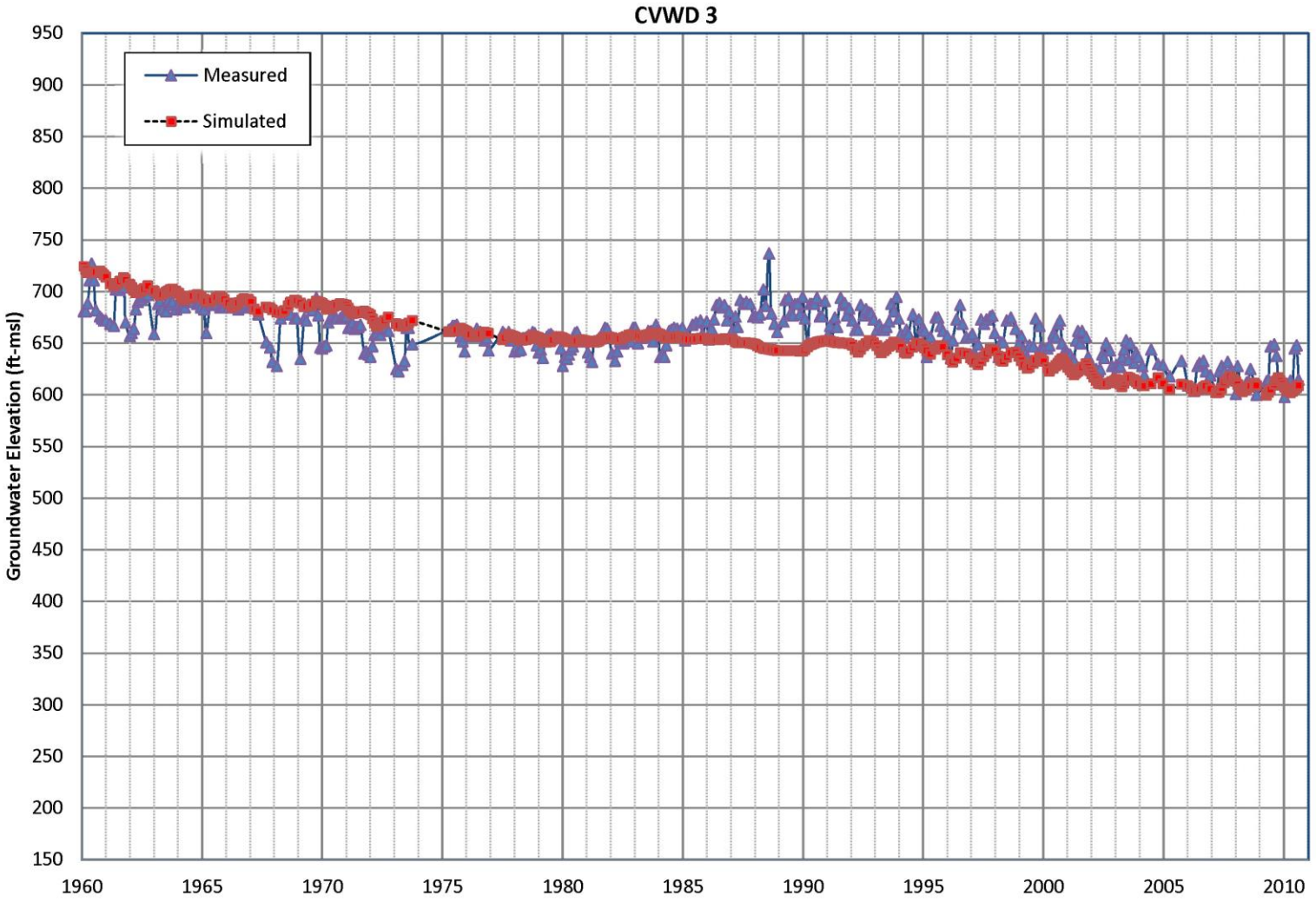


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

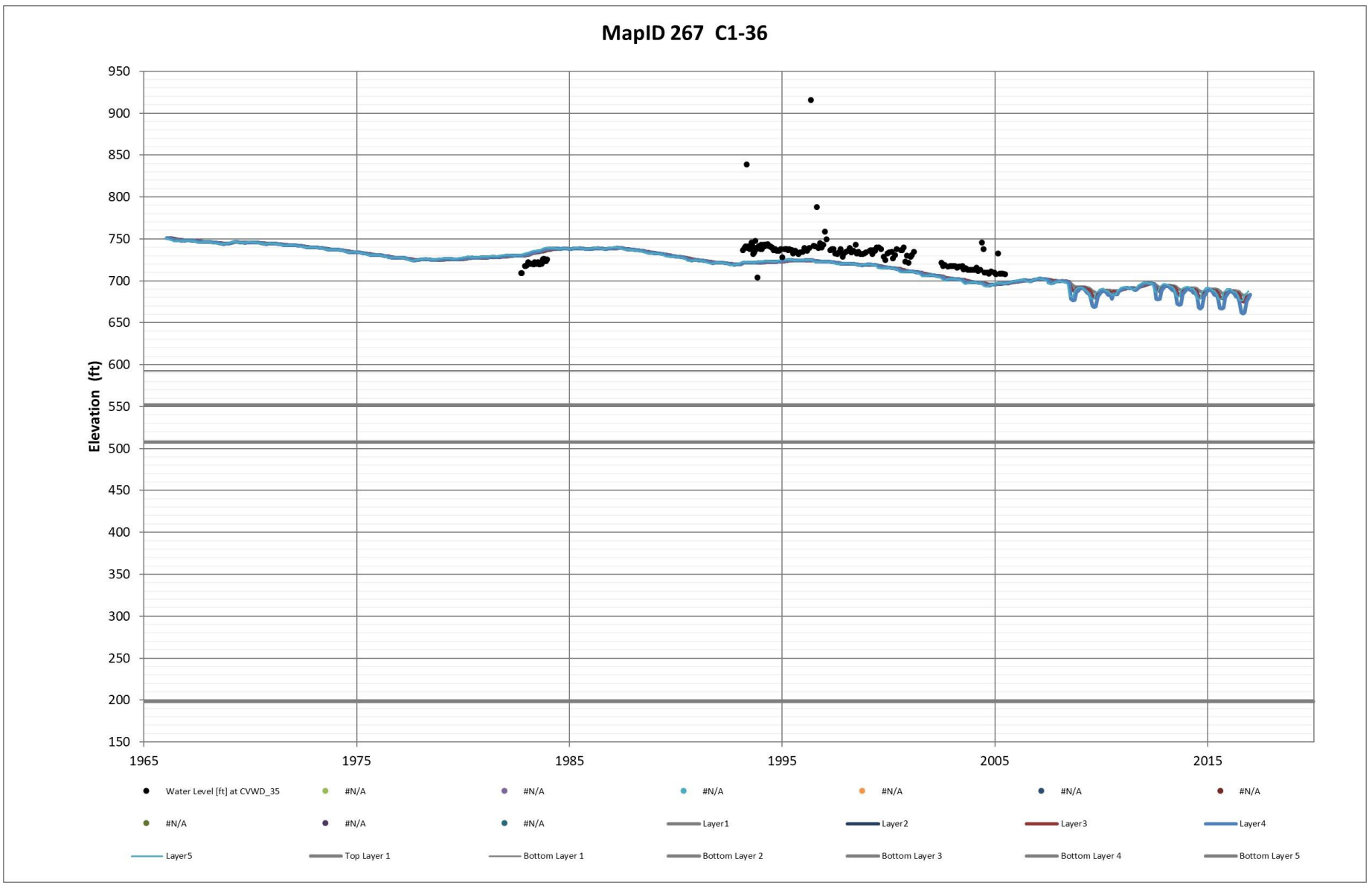


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Figure C1-35
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
CVWD 3

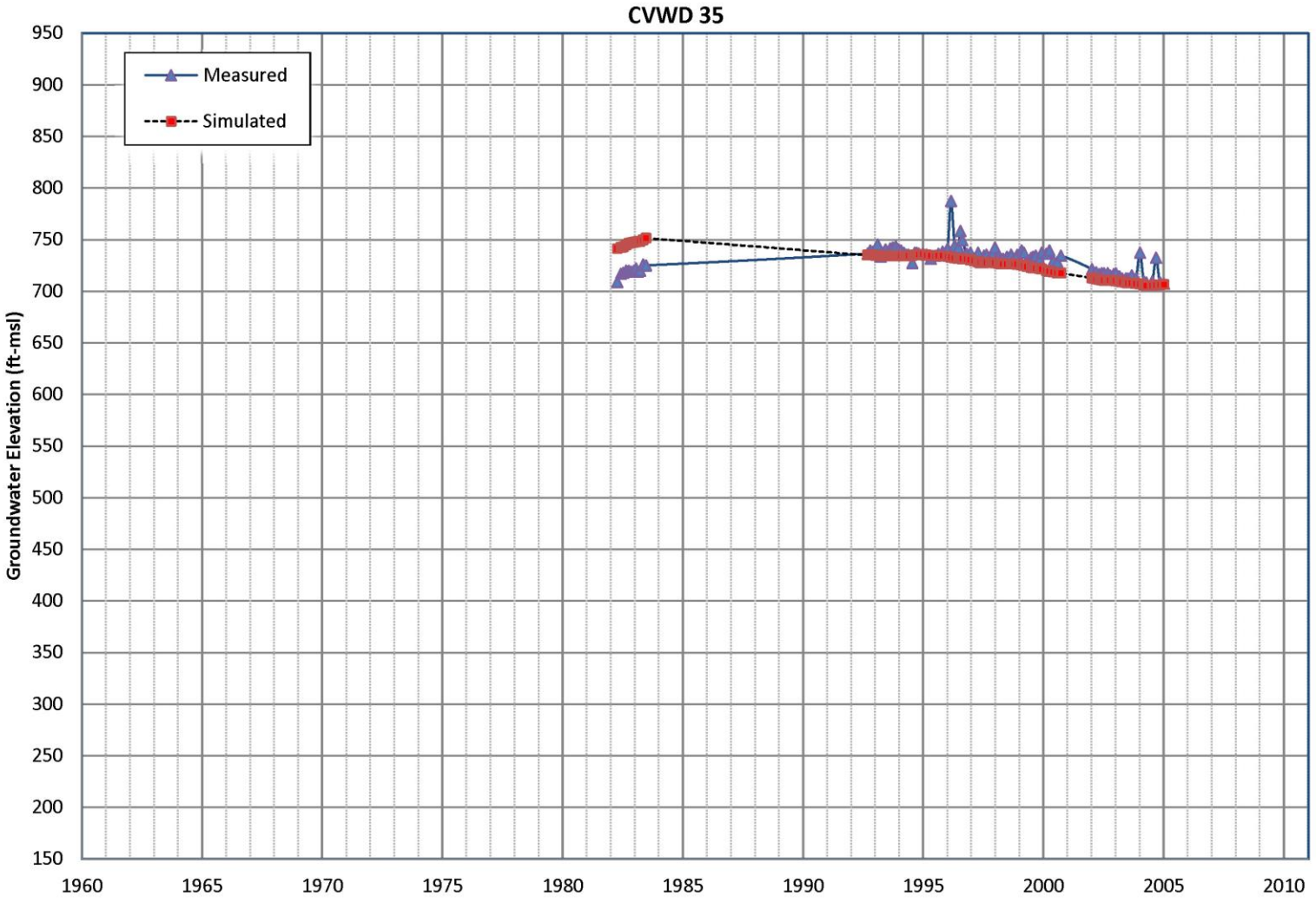


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

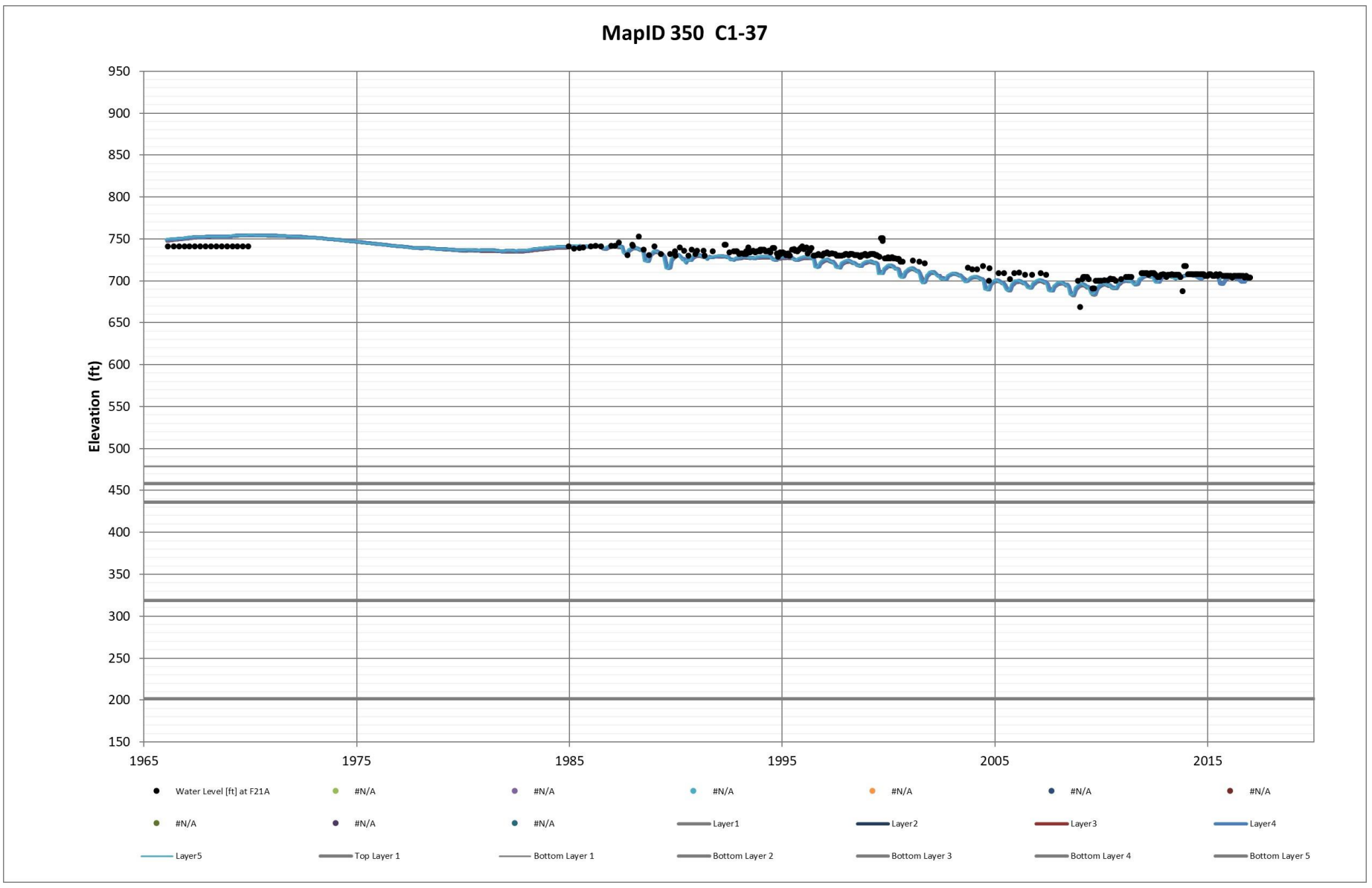


ISARM

Figure C1-36
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
CVWD 35

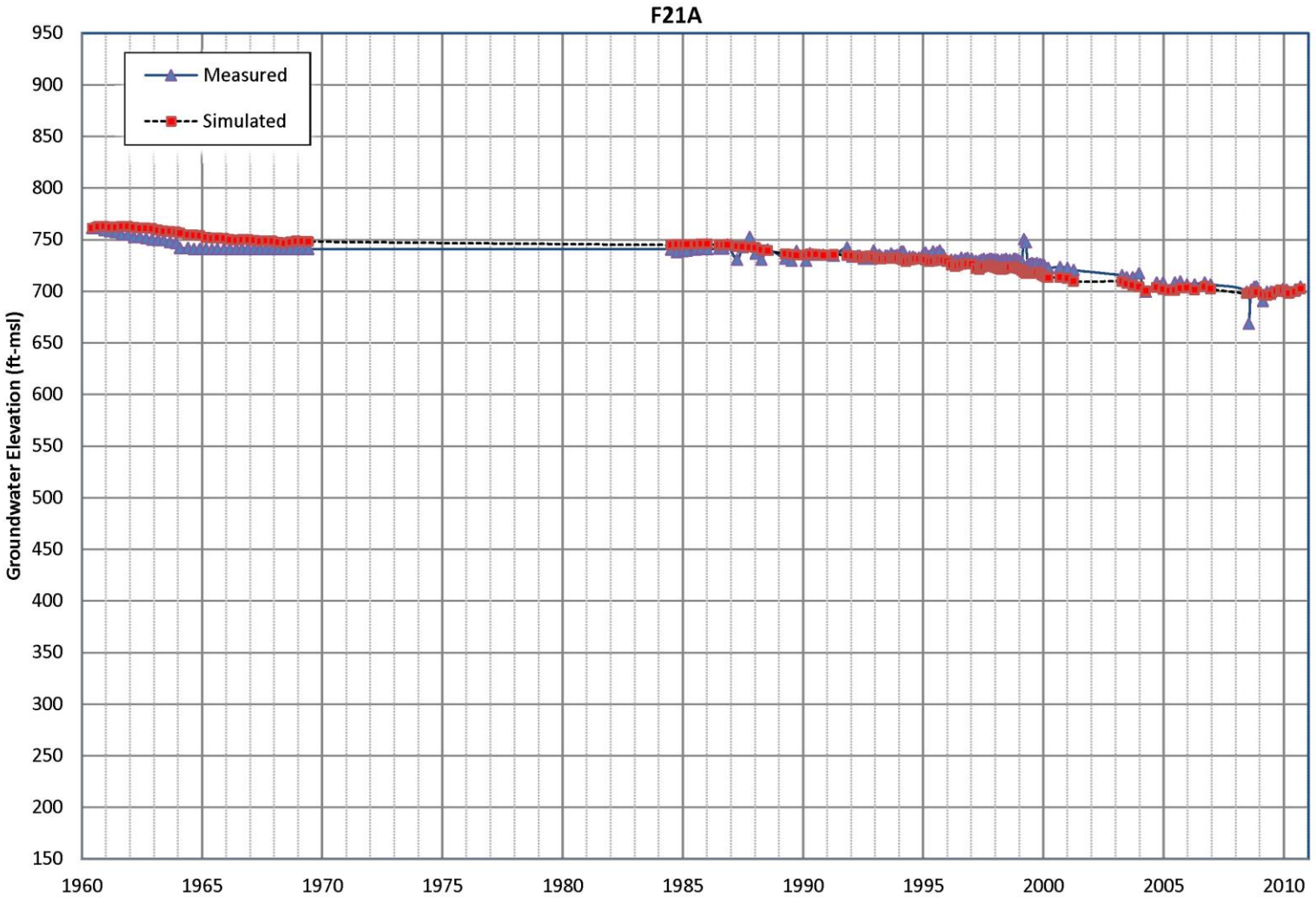


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

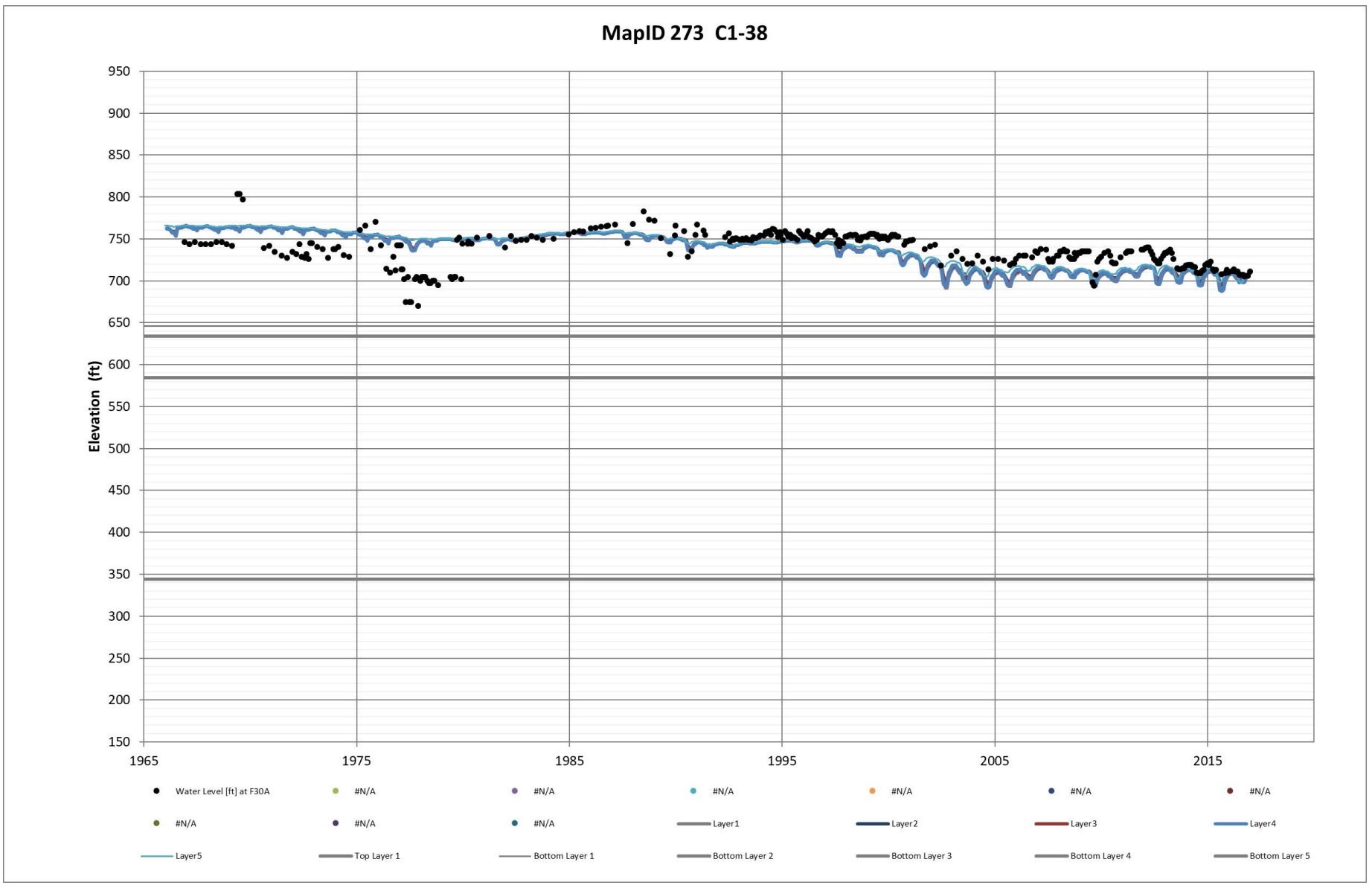


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Figure C1-37
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
F21A

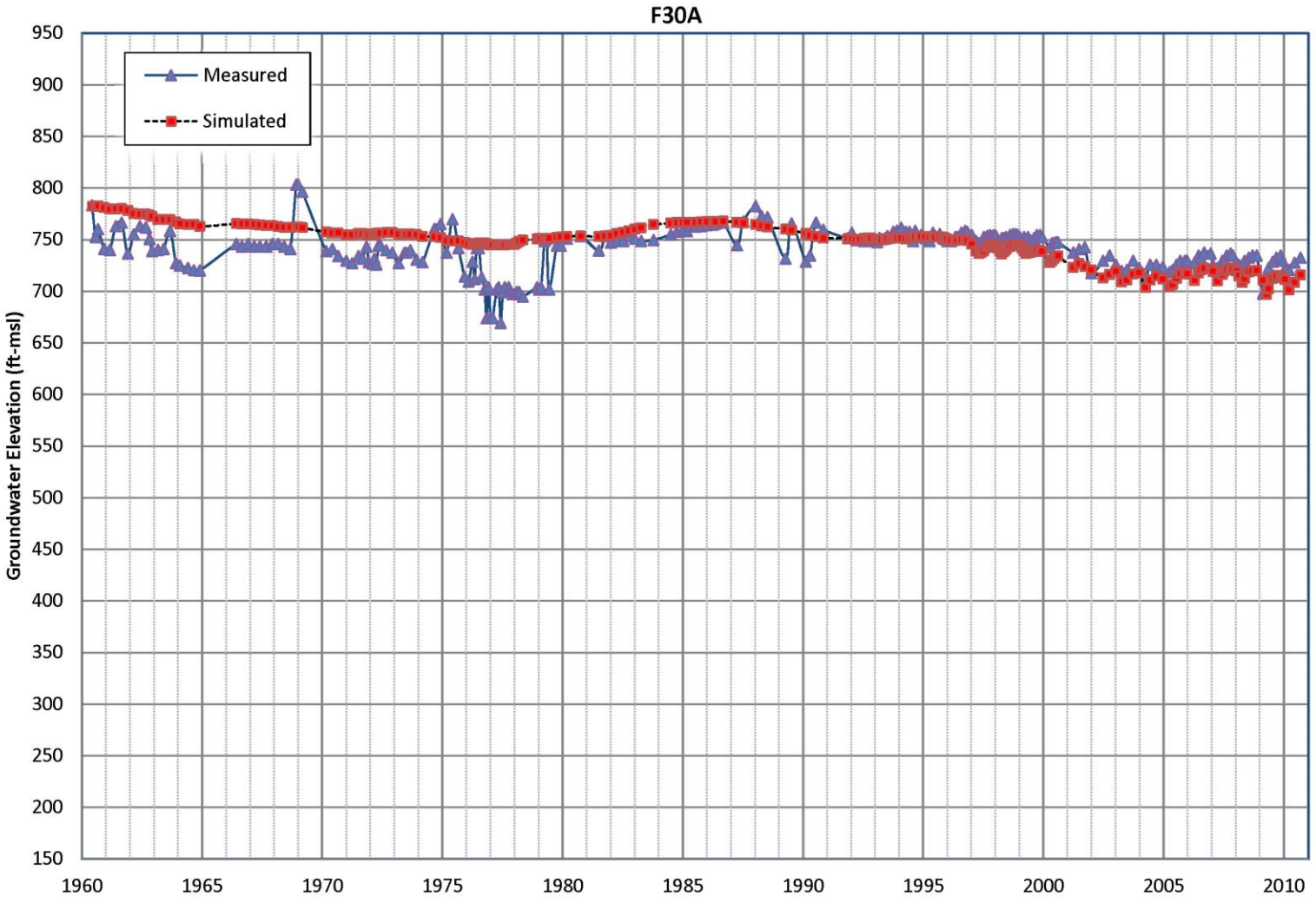


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

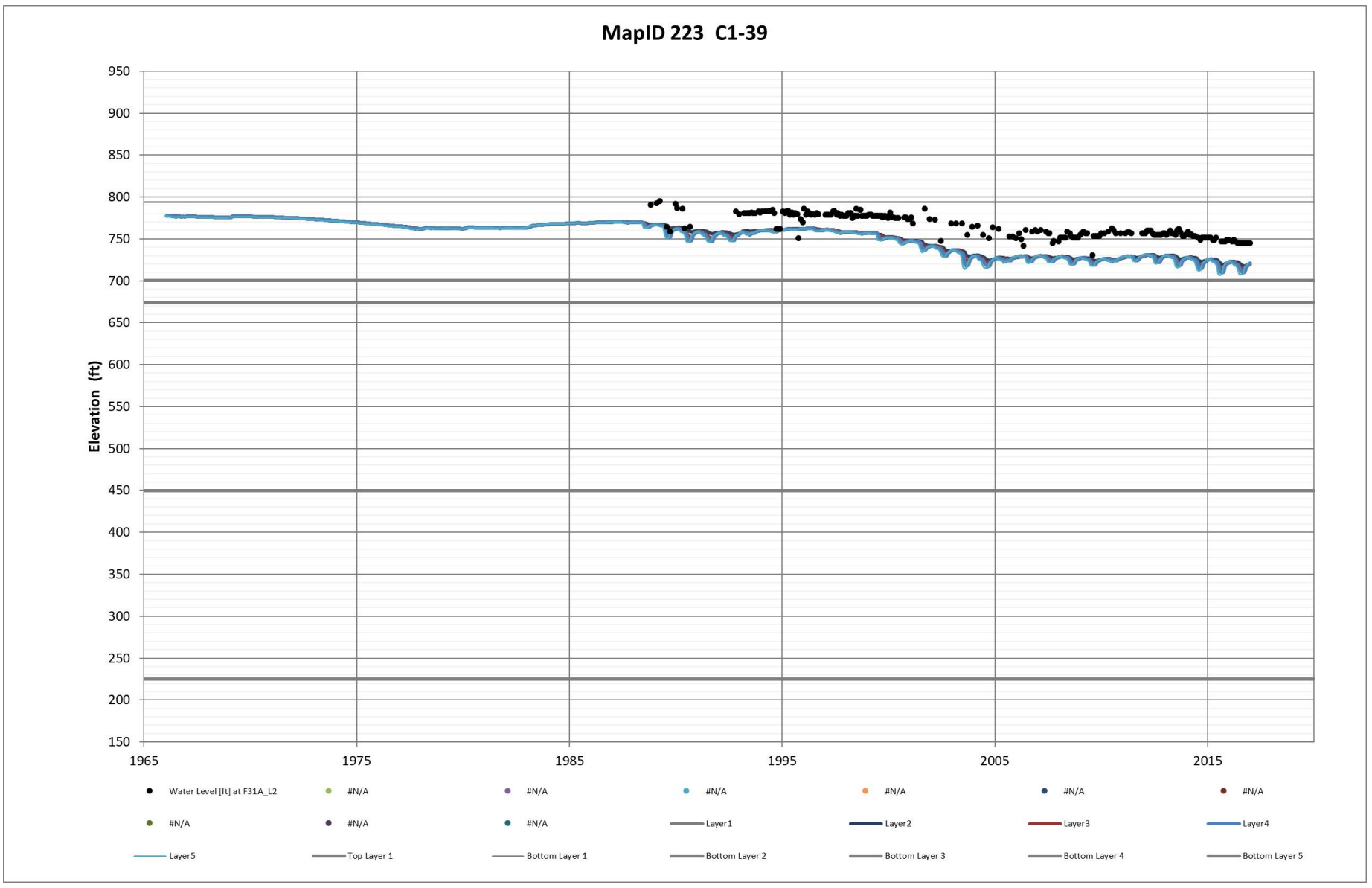


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Figure C1-38
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
F30A

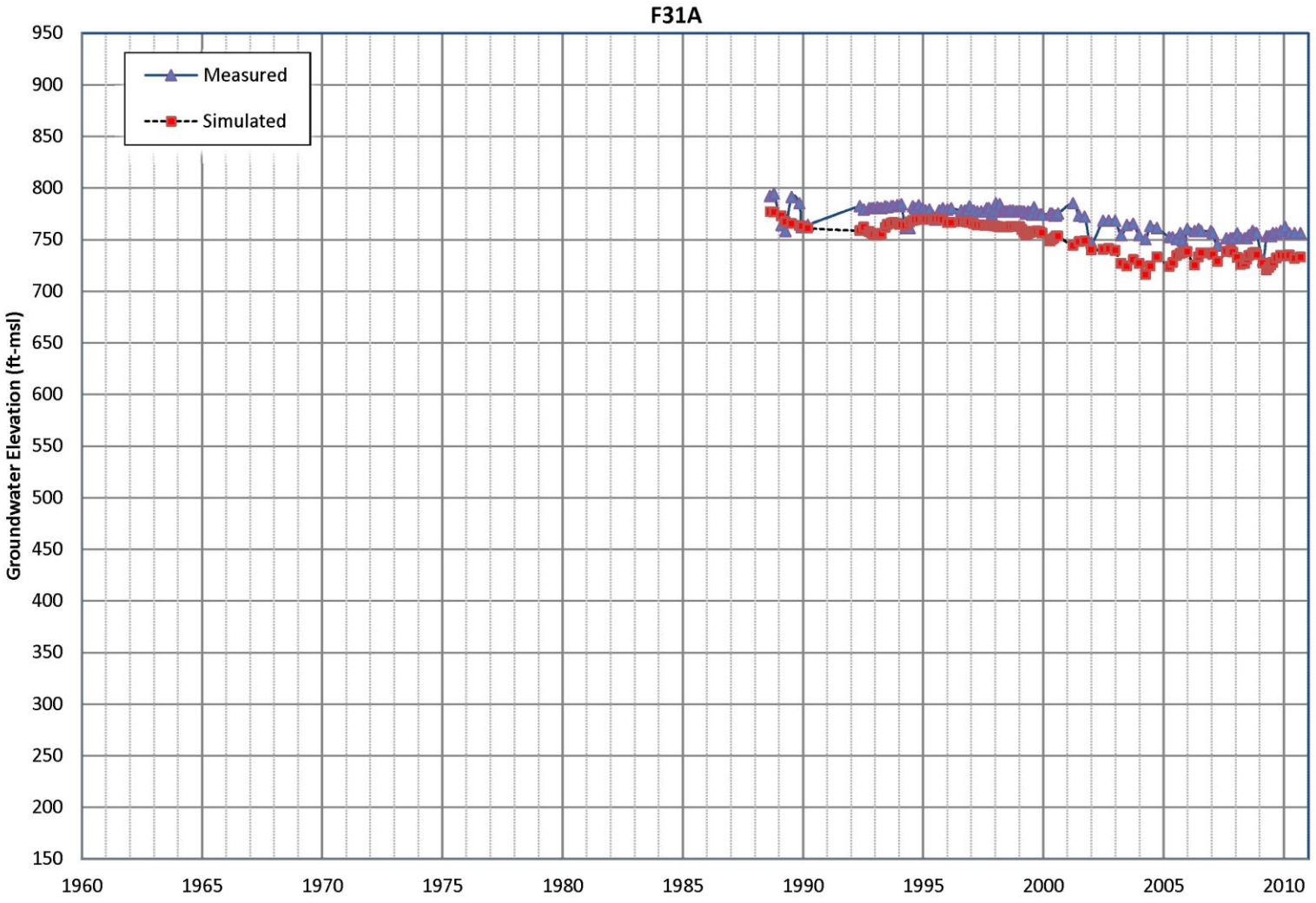


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

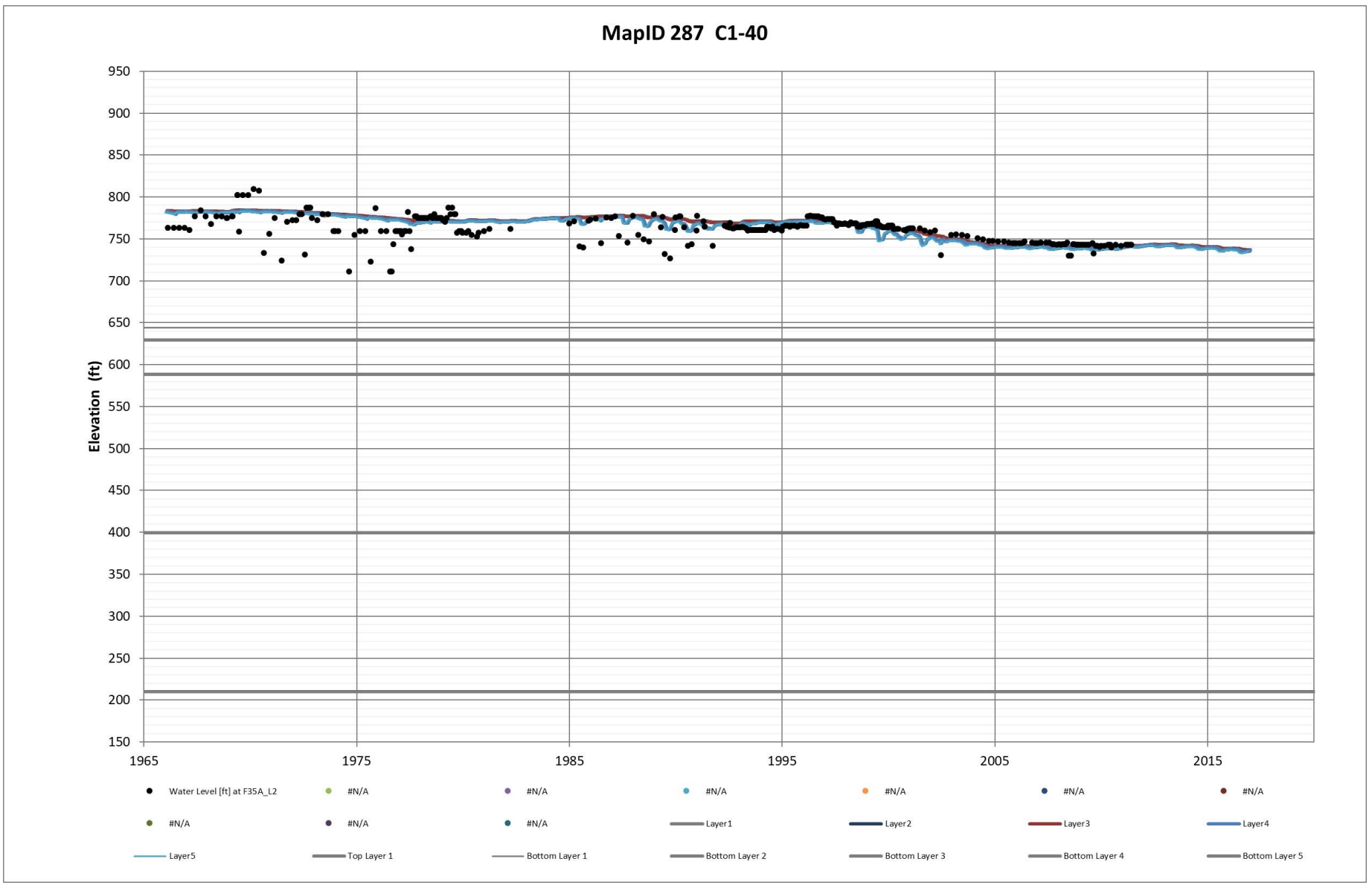


ISARM

Figure C1-39
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
F31A

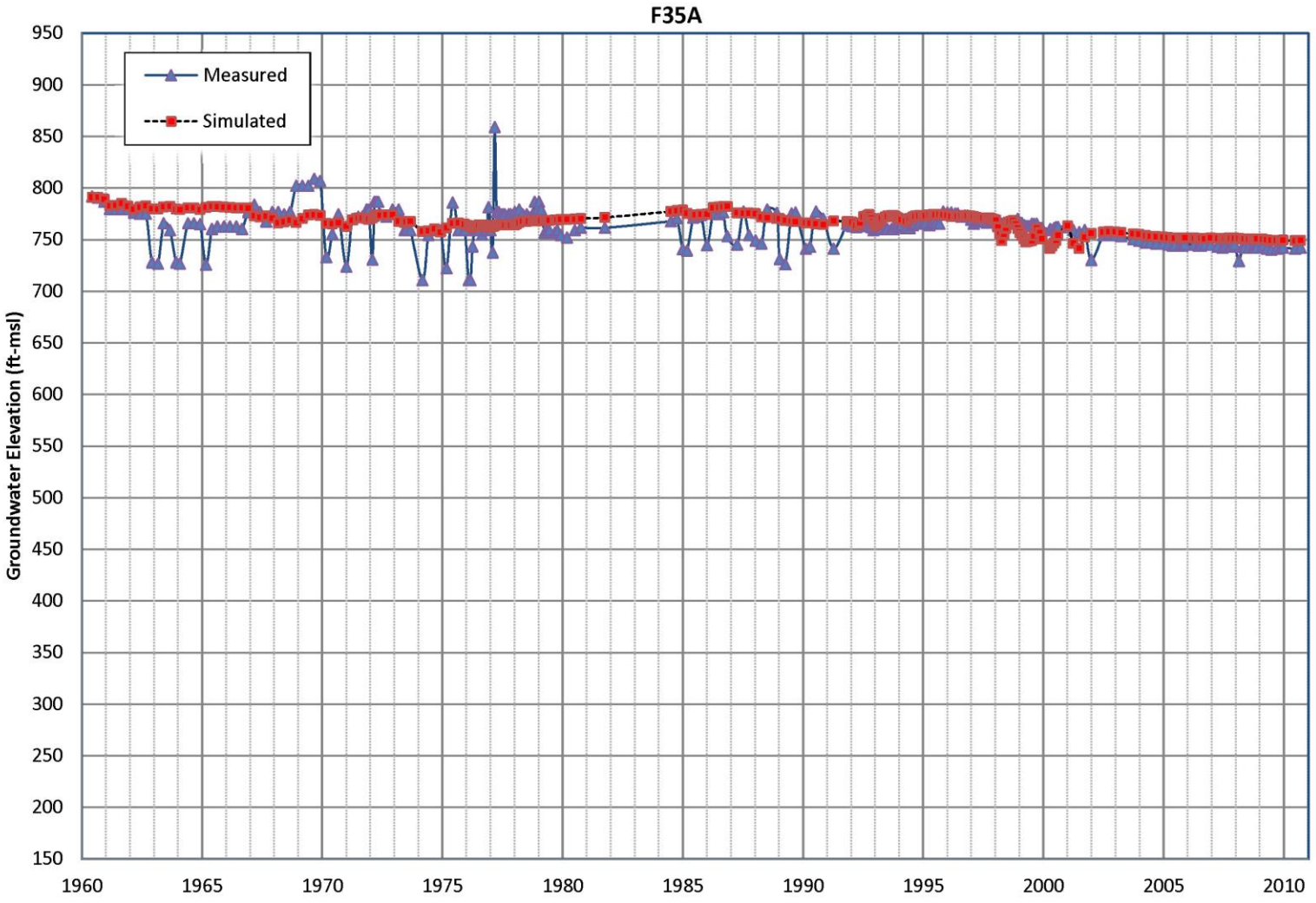


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

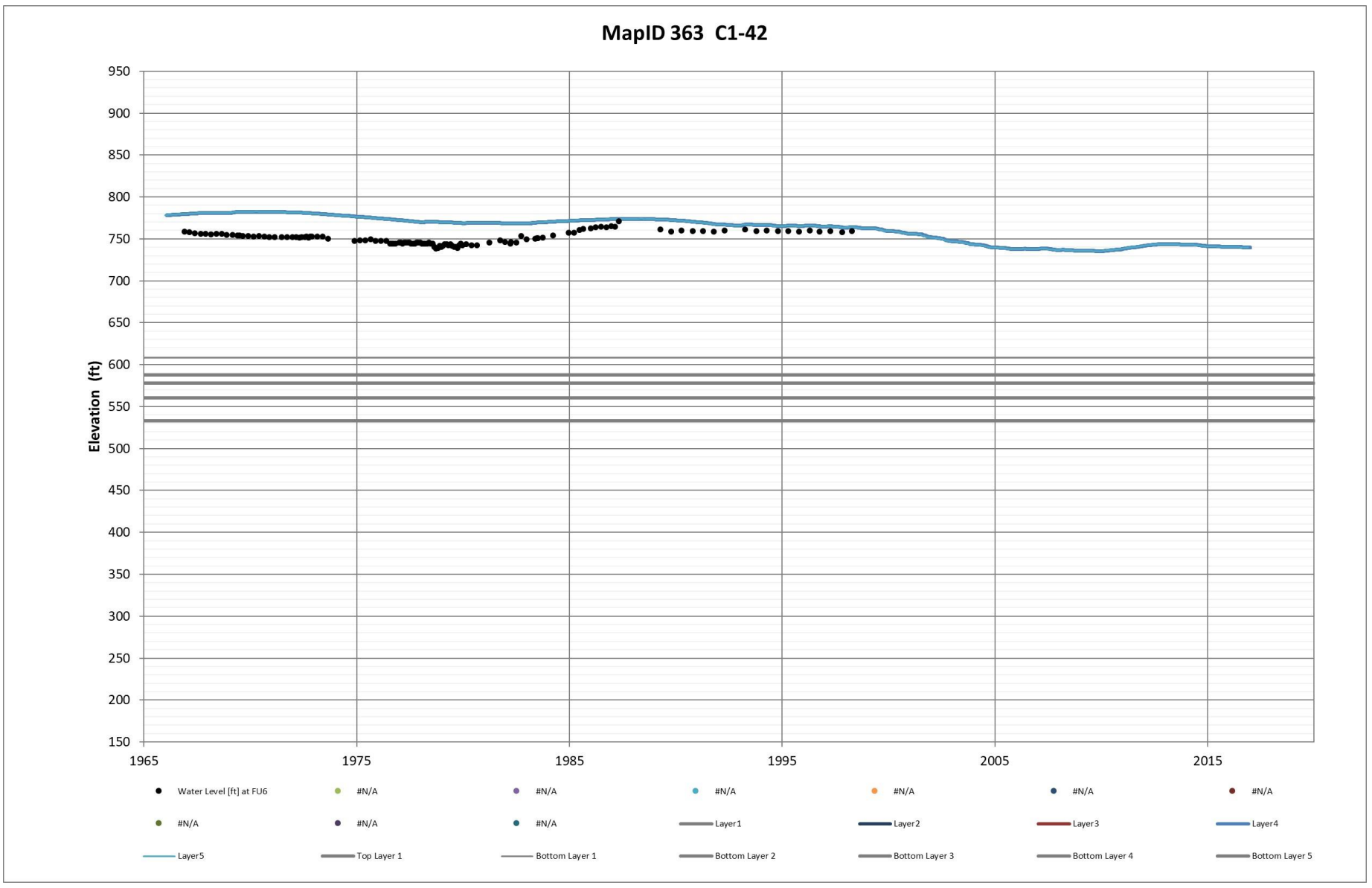


ISARM

Figure C1-40
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
F35A

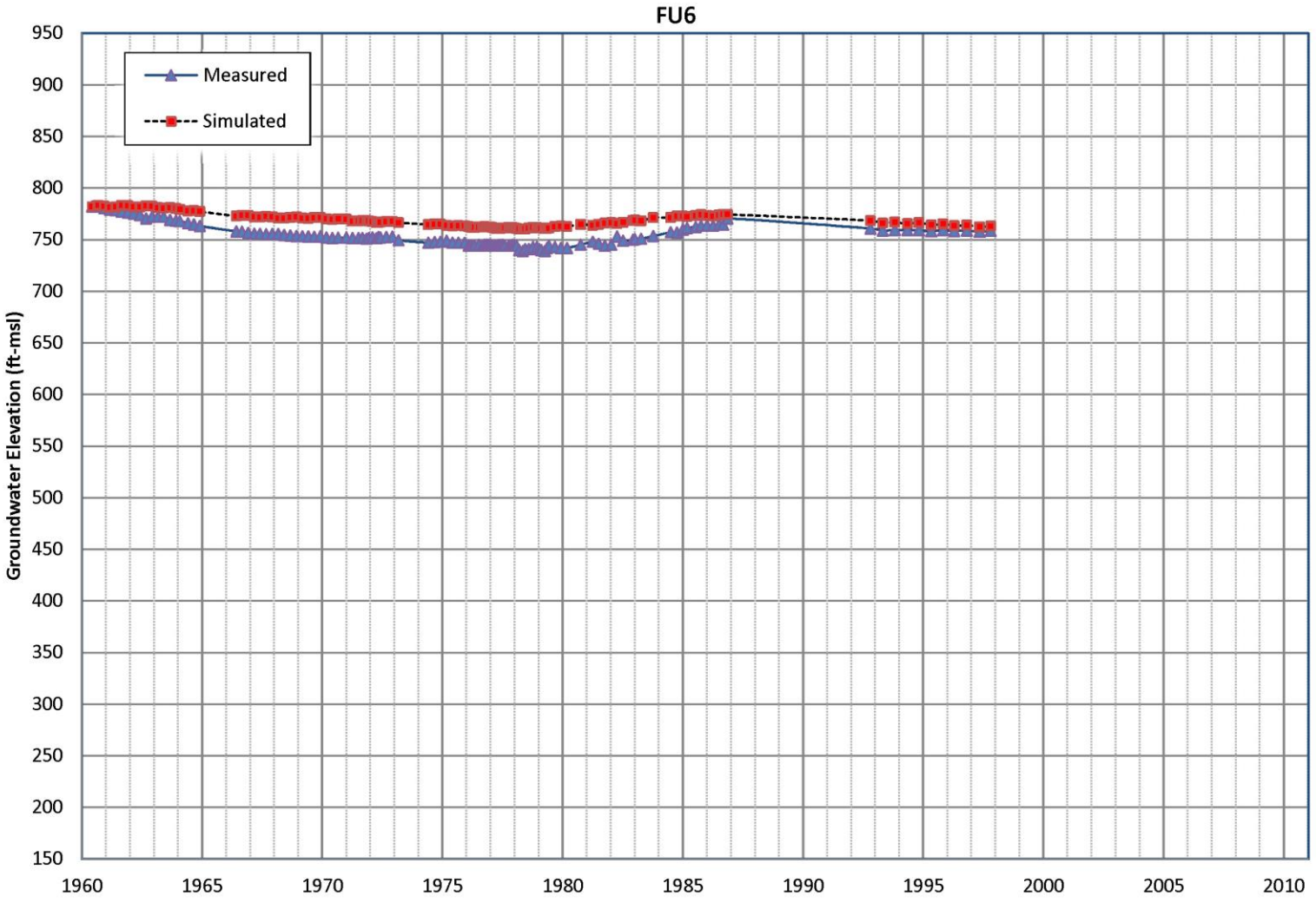


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

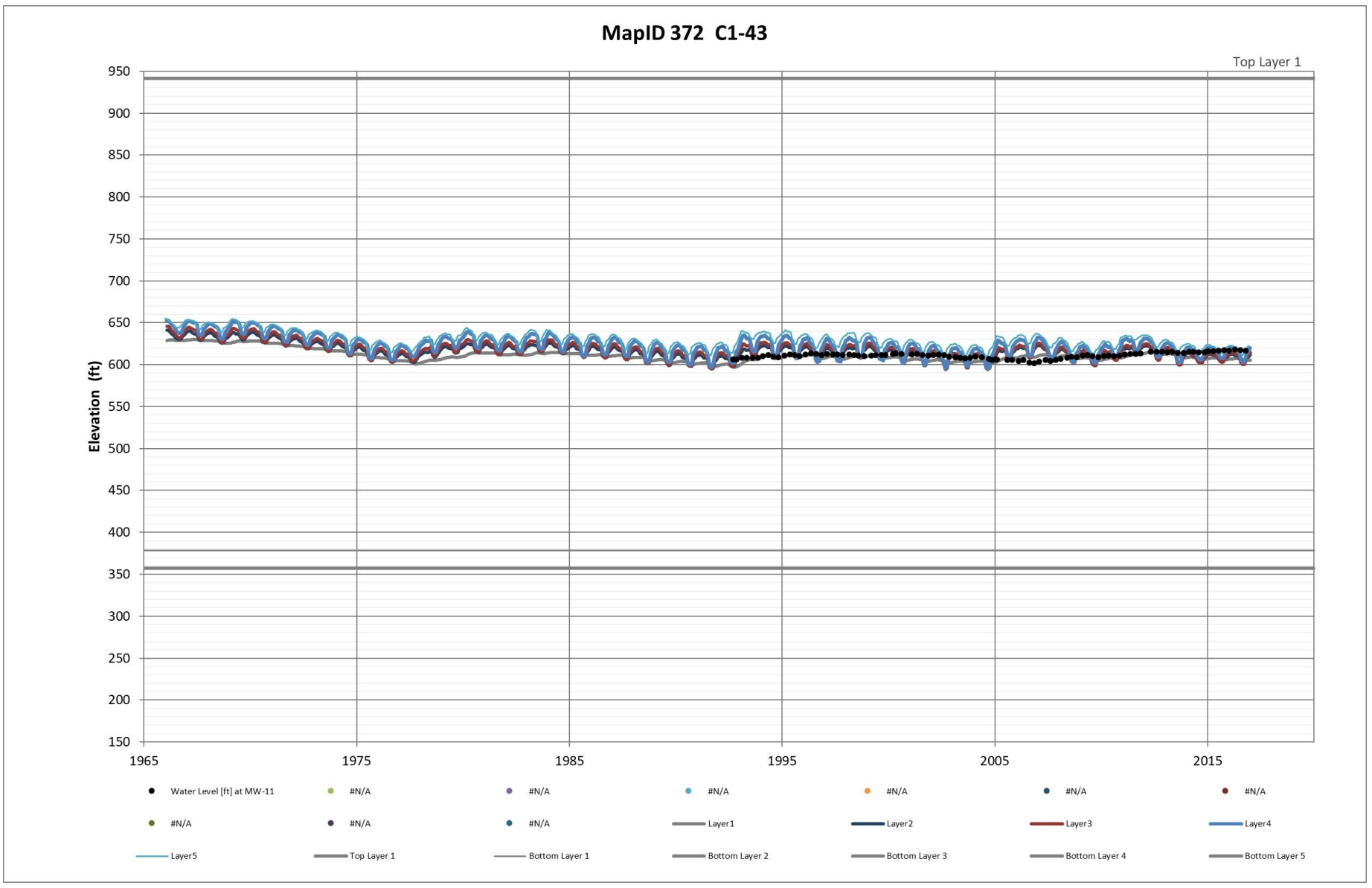


ISARM

Figure C1-42
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
FU6

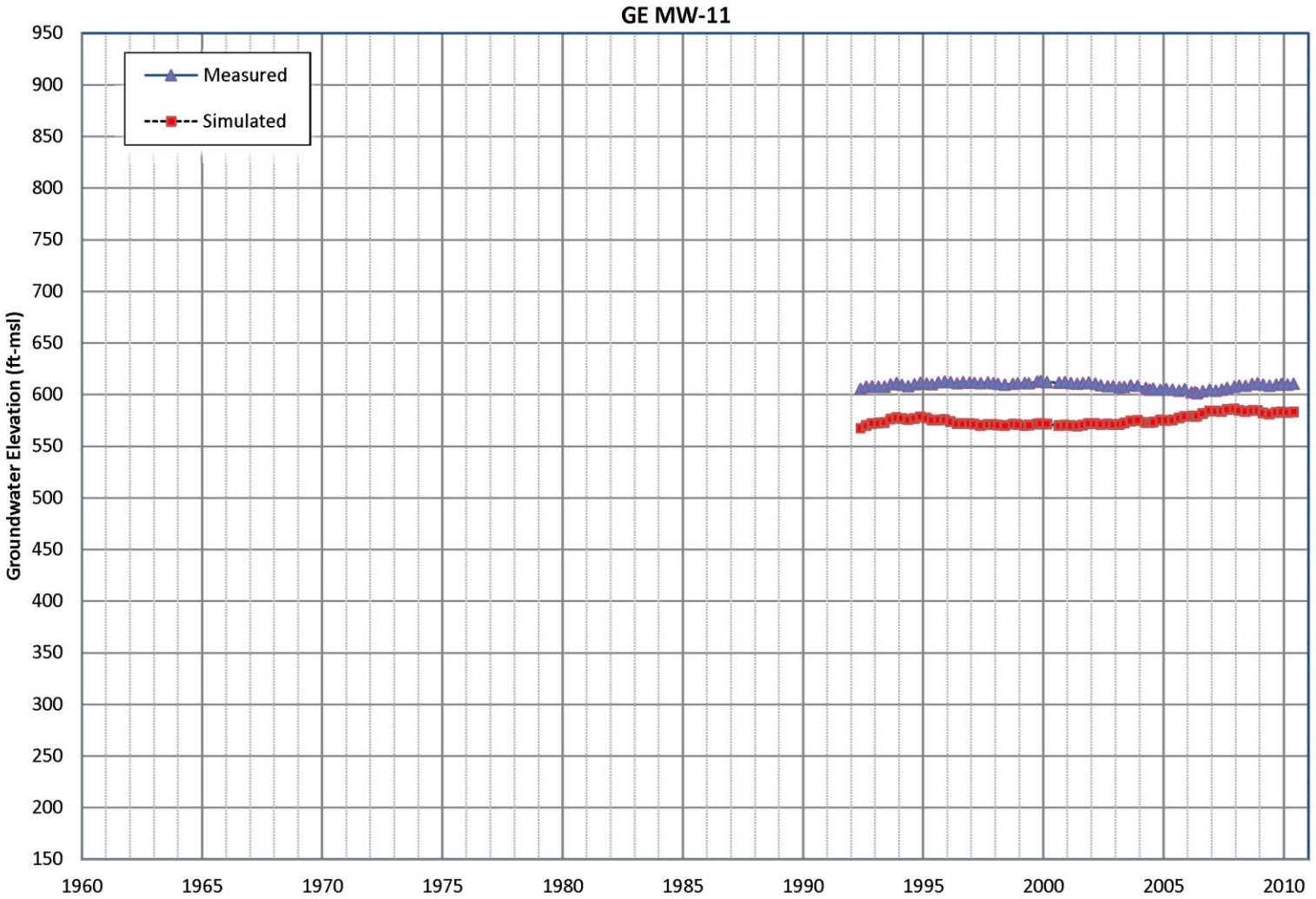


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

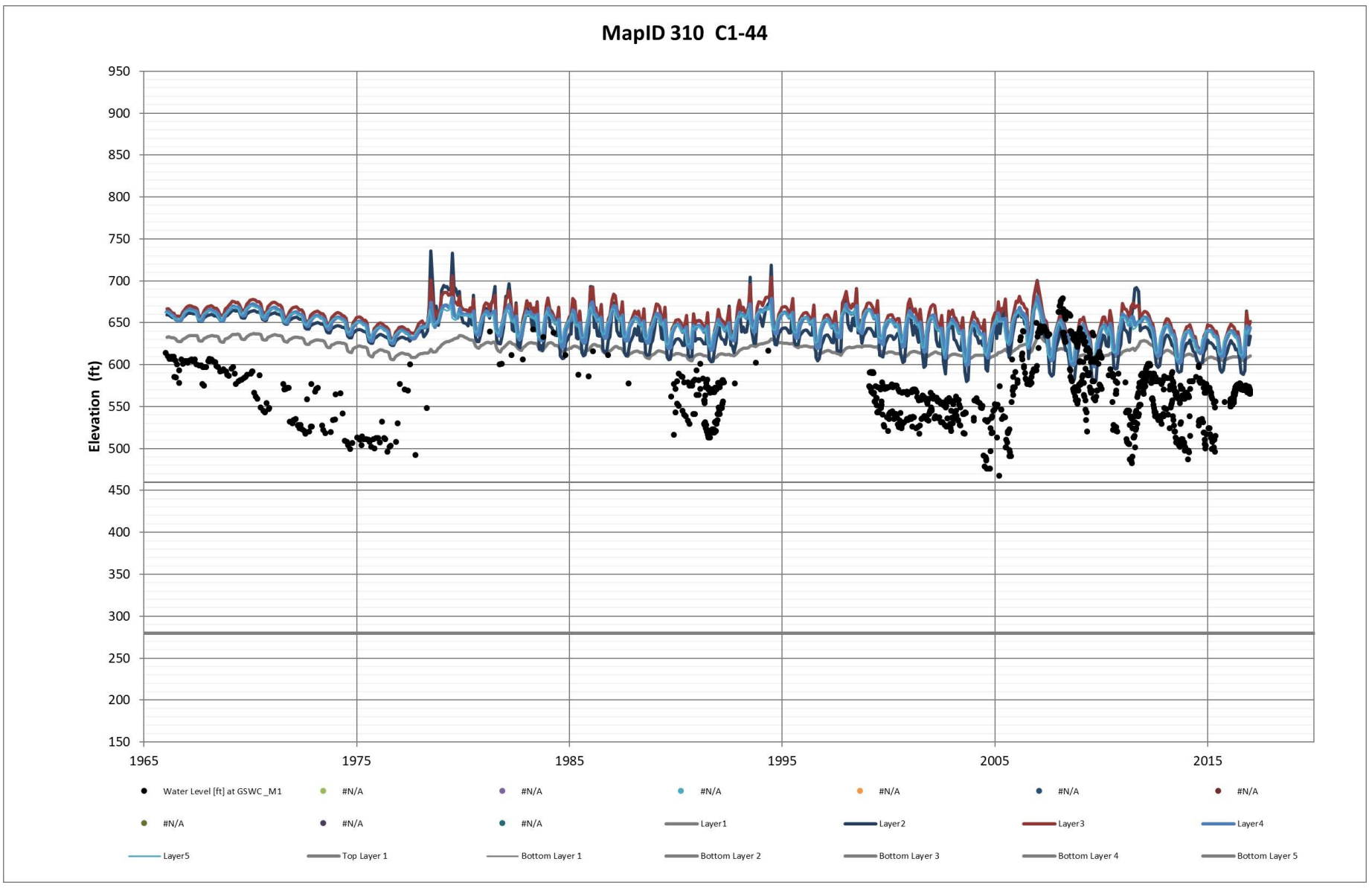


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Figure C1-43
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
GE MW-11

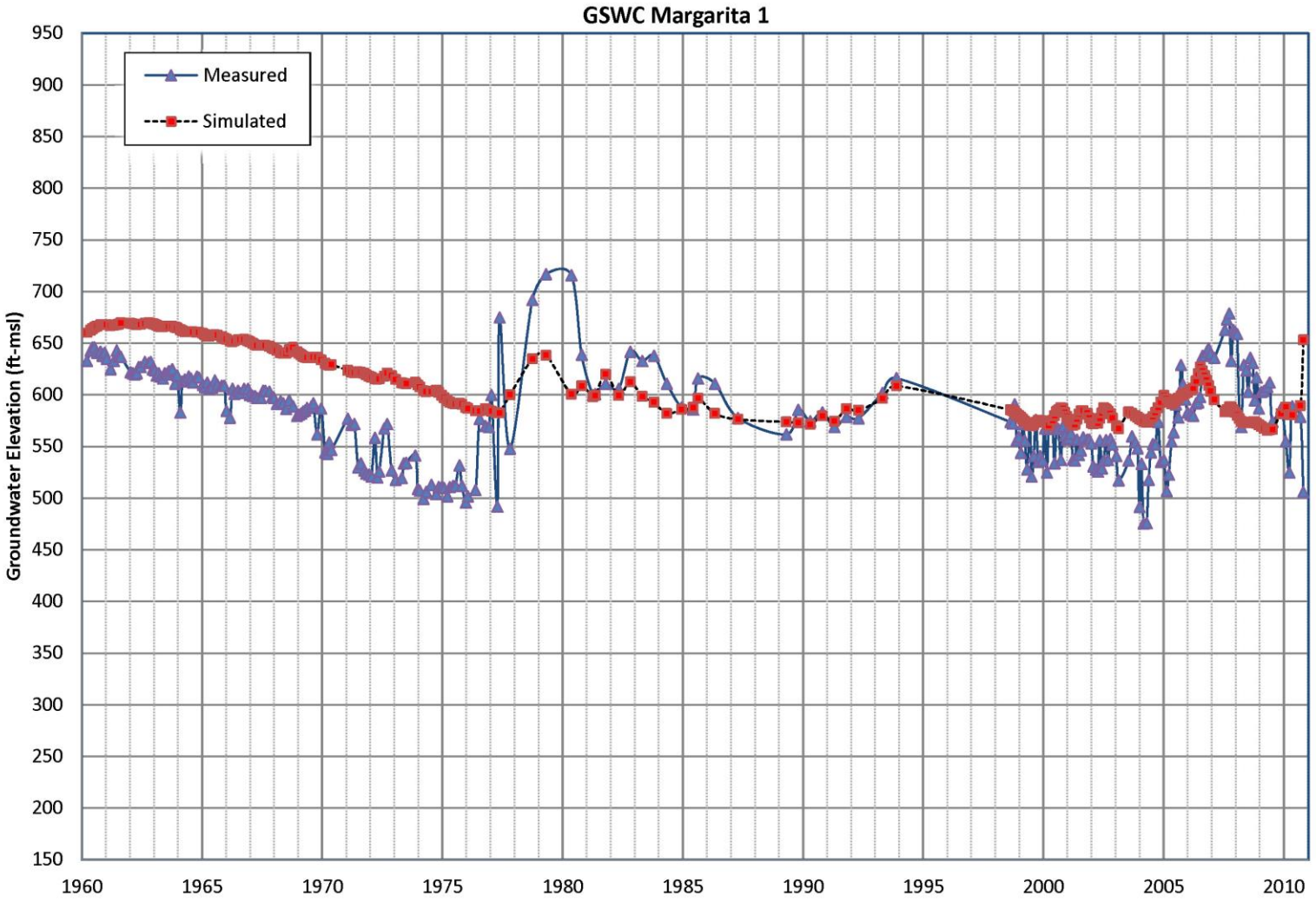


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

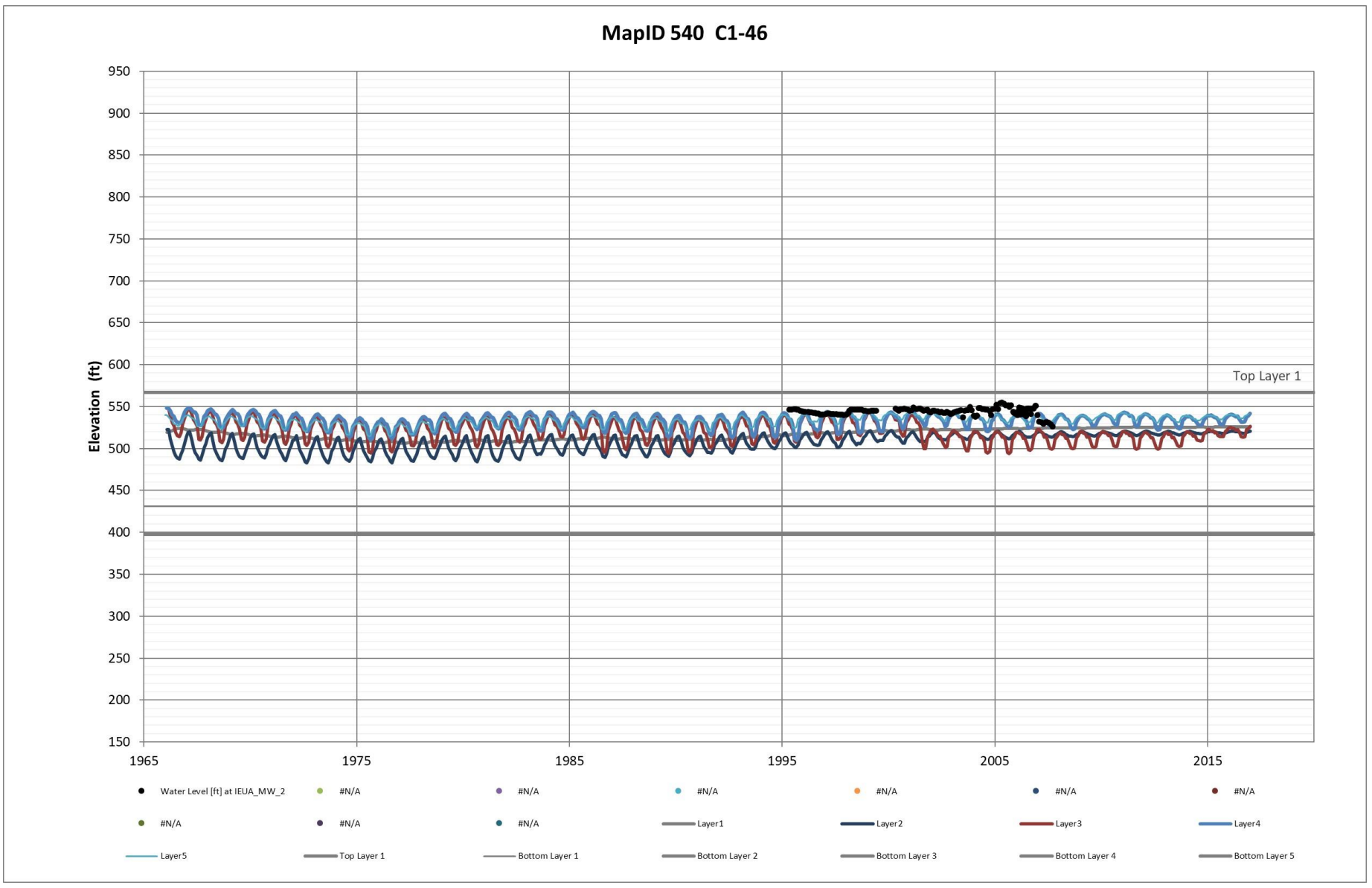


ISARM

Figure C1-44
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
GSWC Margarita 1

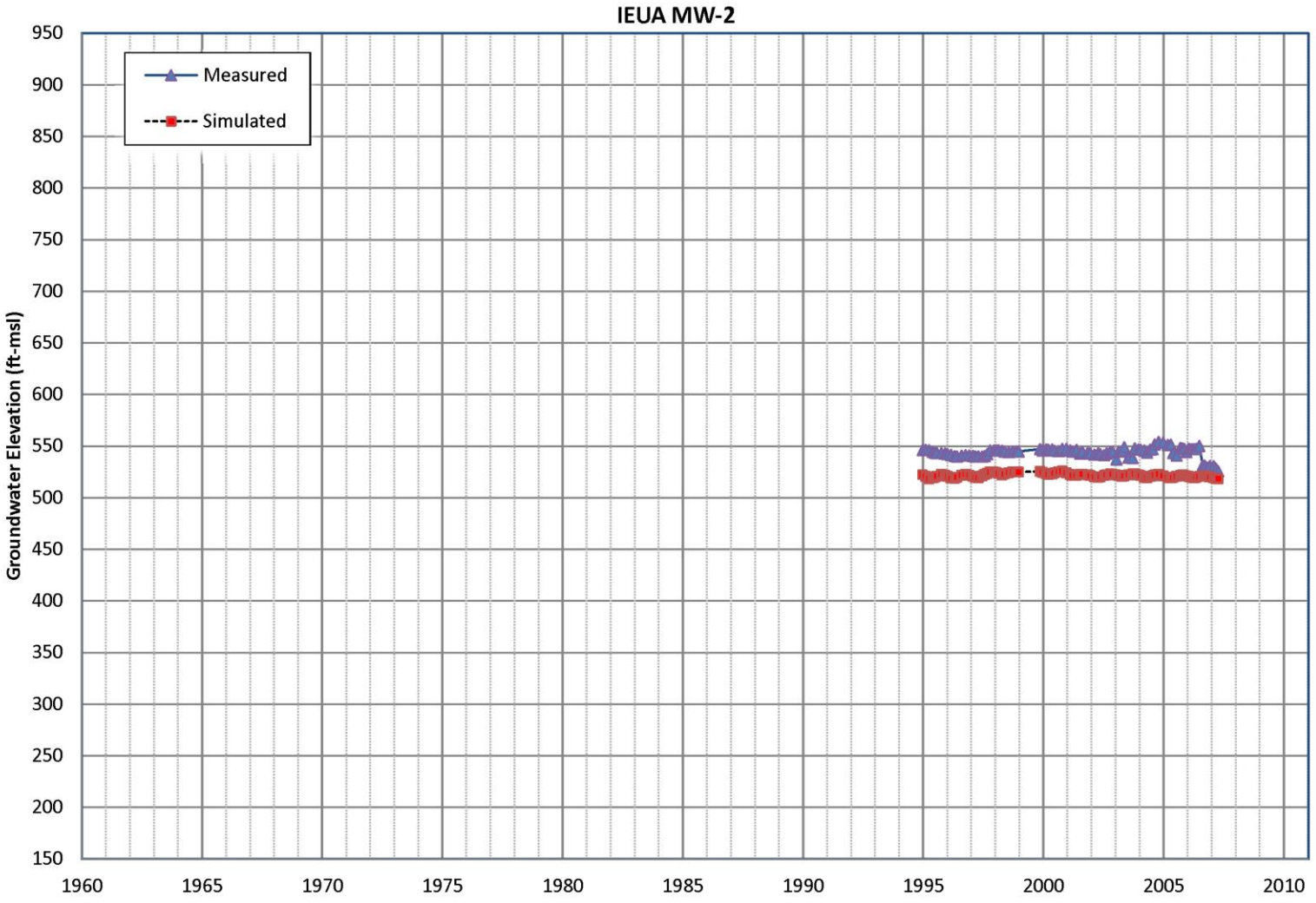


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

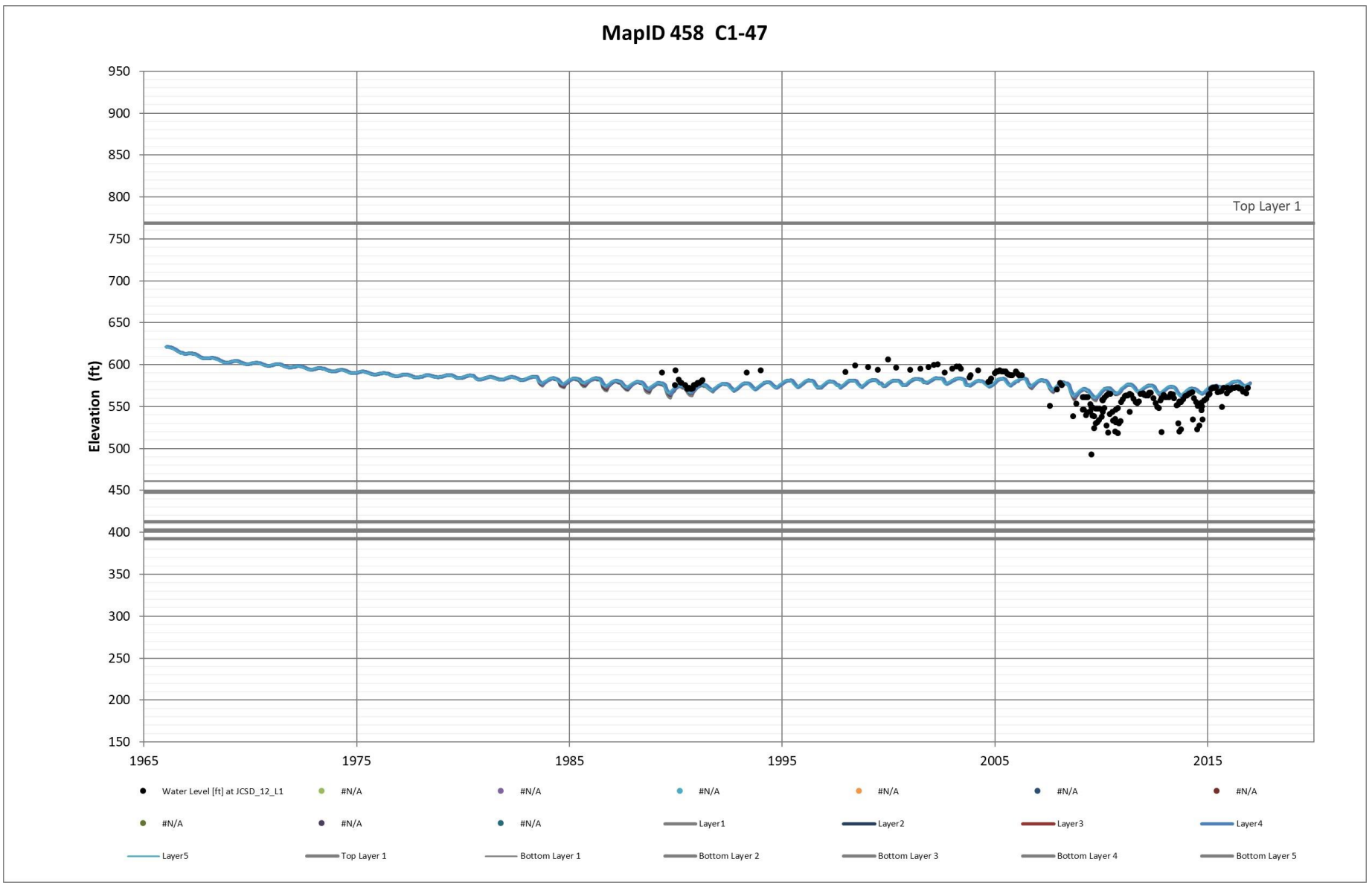


ISARM

Figure C1-46
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
IEUA MW-2

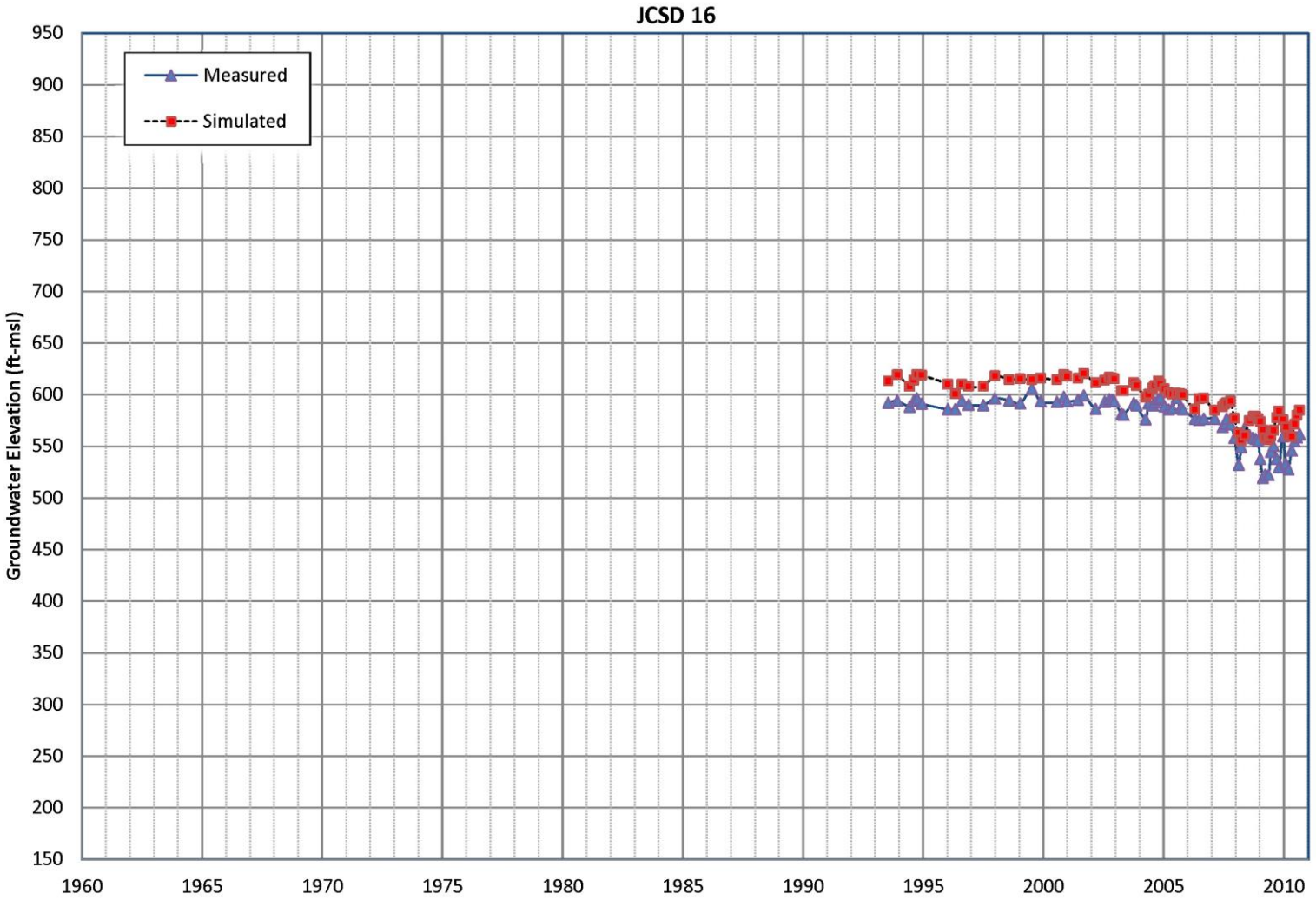


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

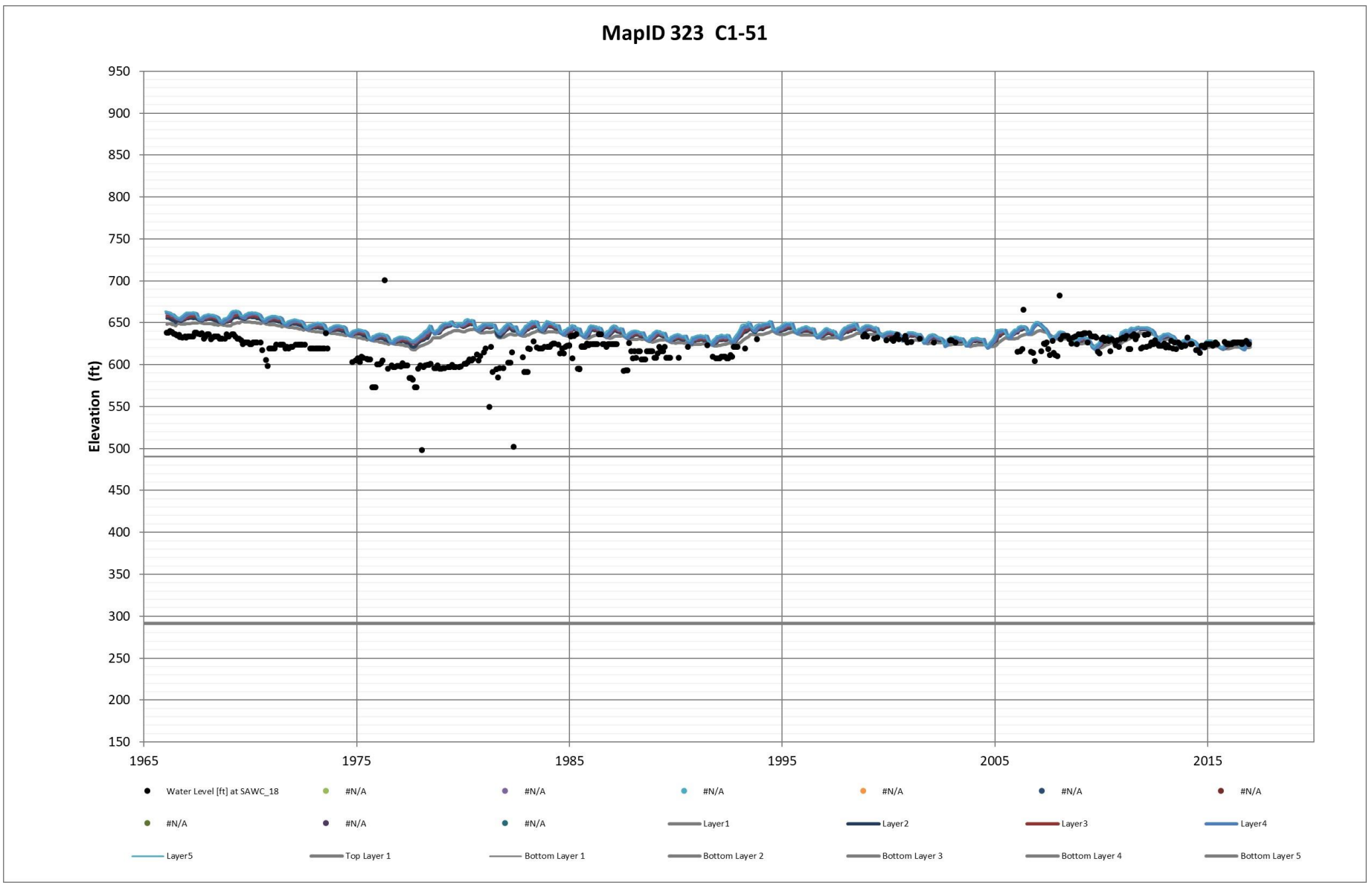


ISARM

Figure C1-47
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
JCSD 16

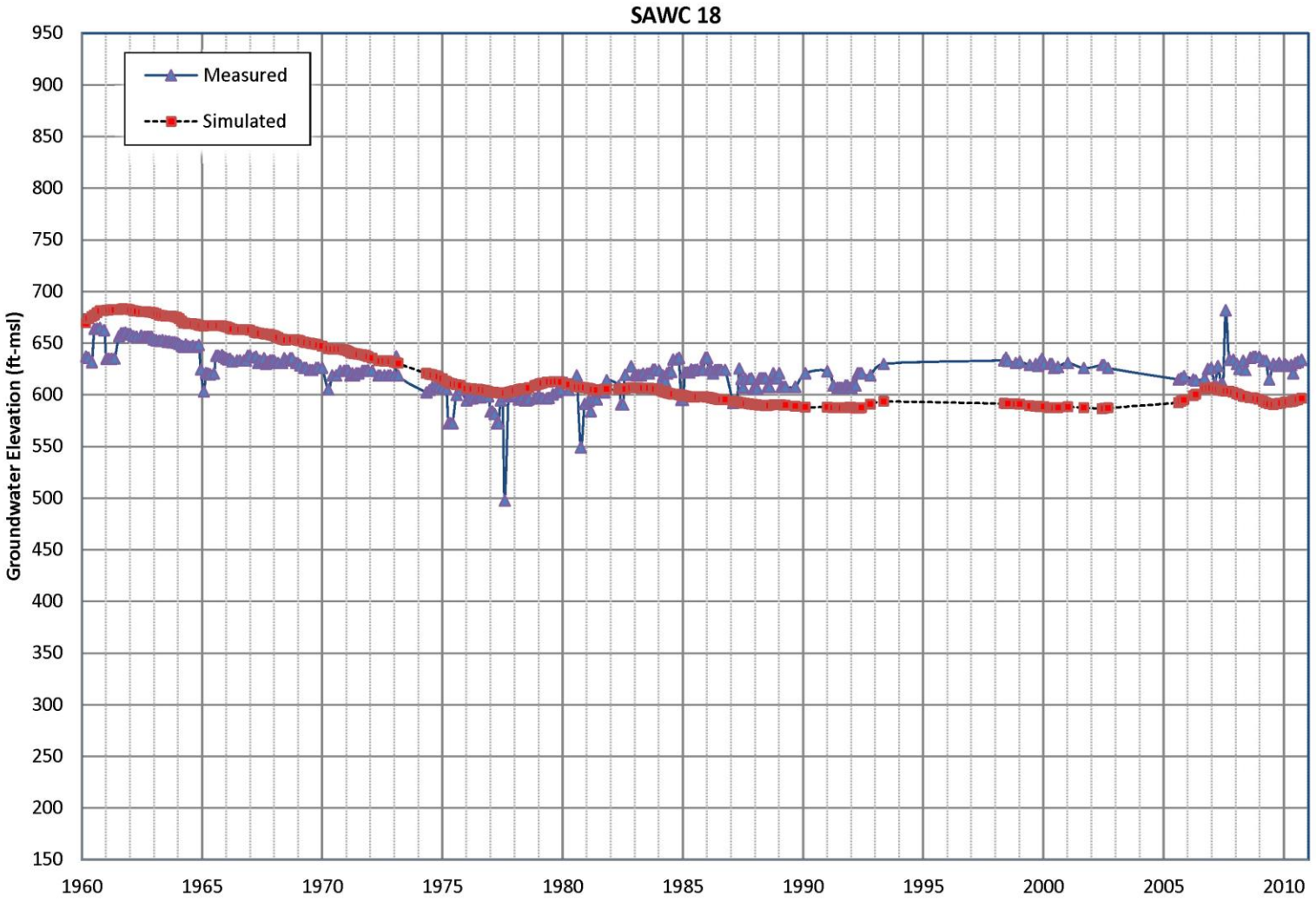


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

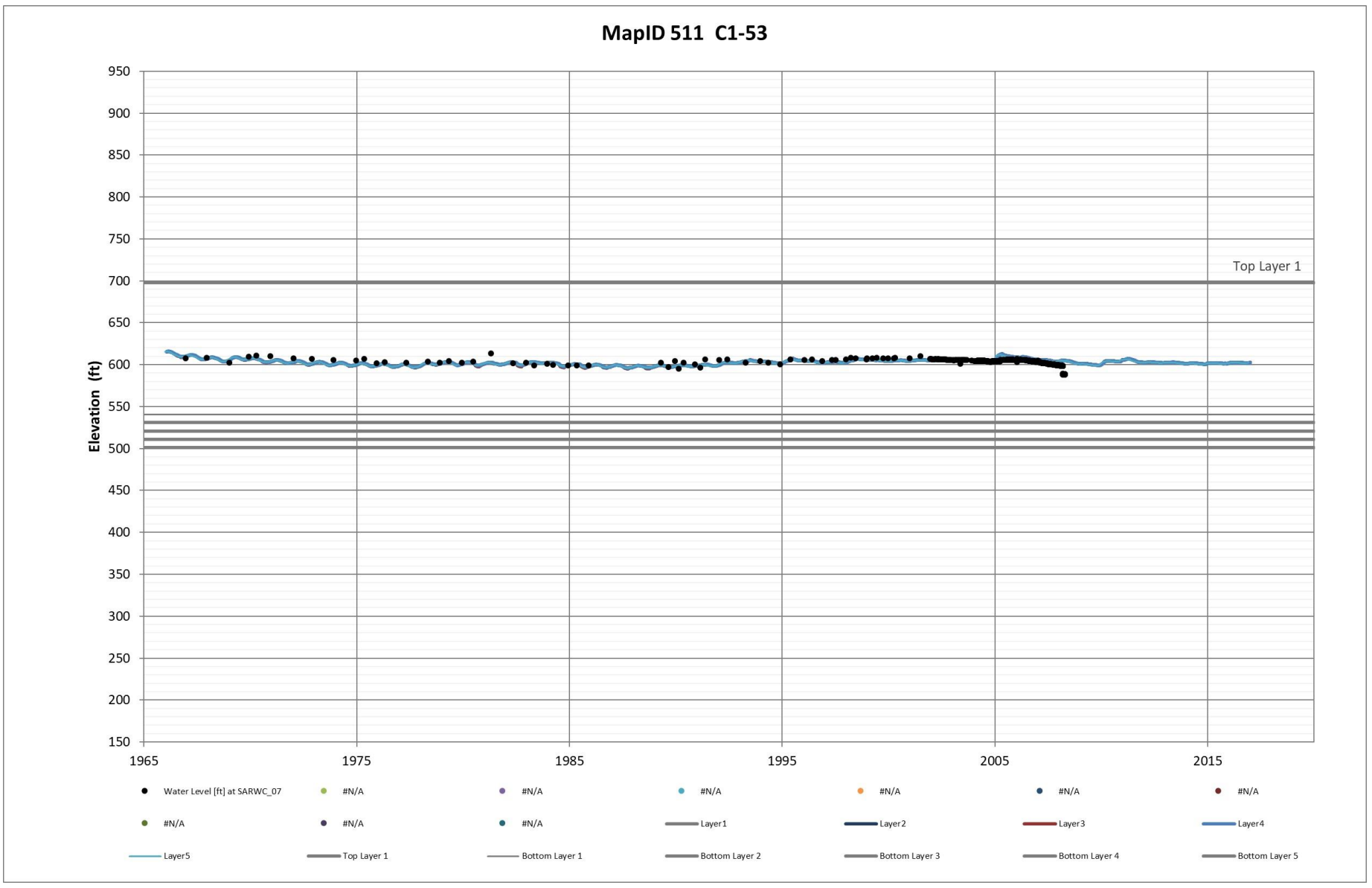


ISARM

Figure C1-51
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
SAWC 18

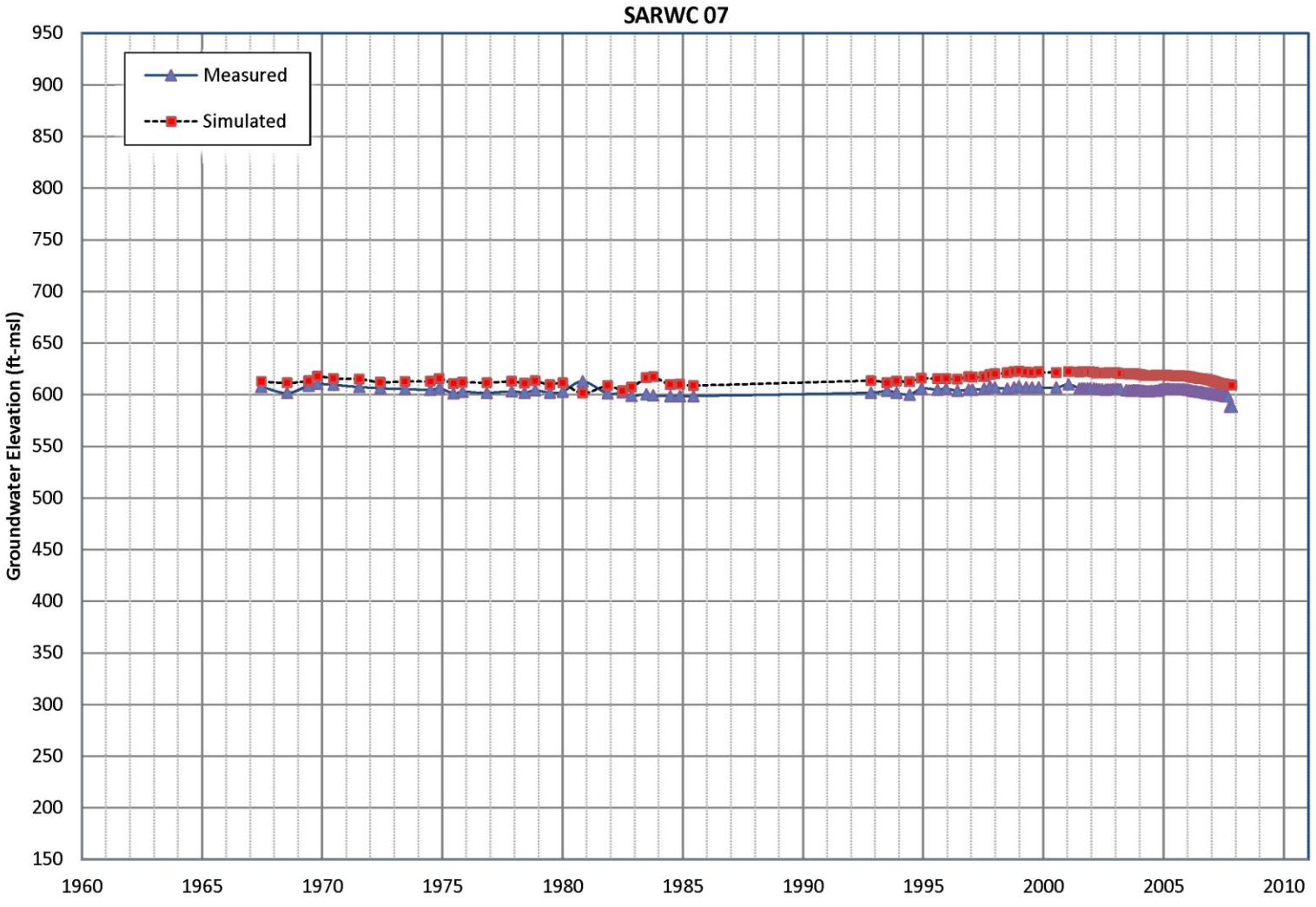


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

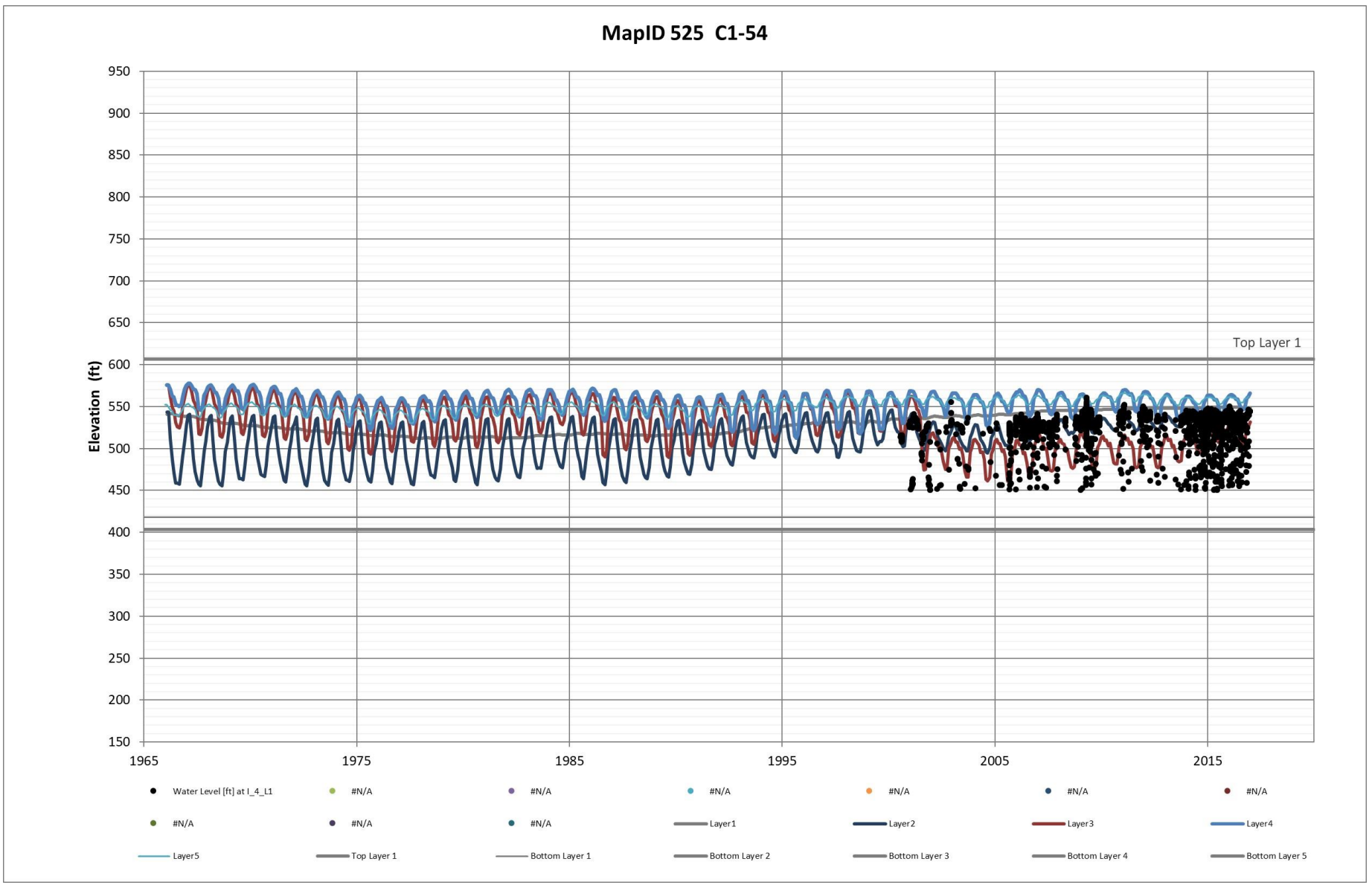


ISARM

Figure C1-53
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
SARWC 07

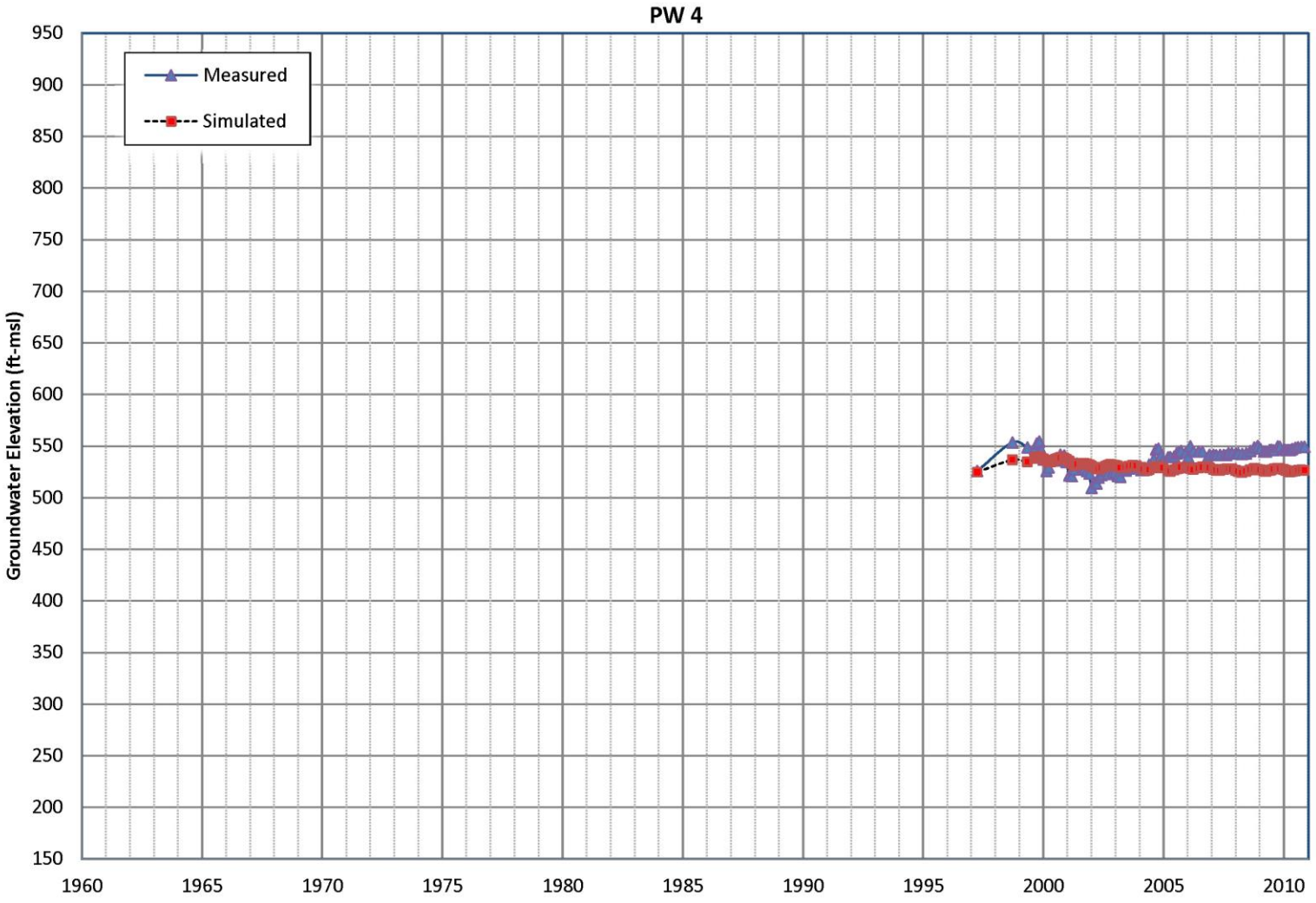


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

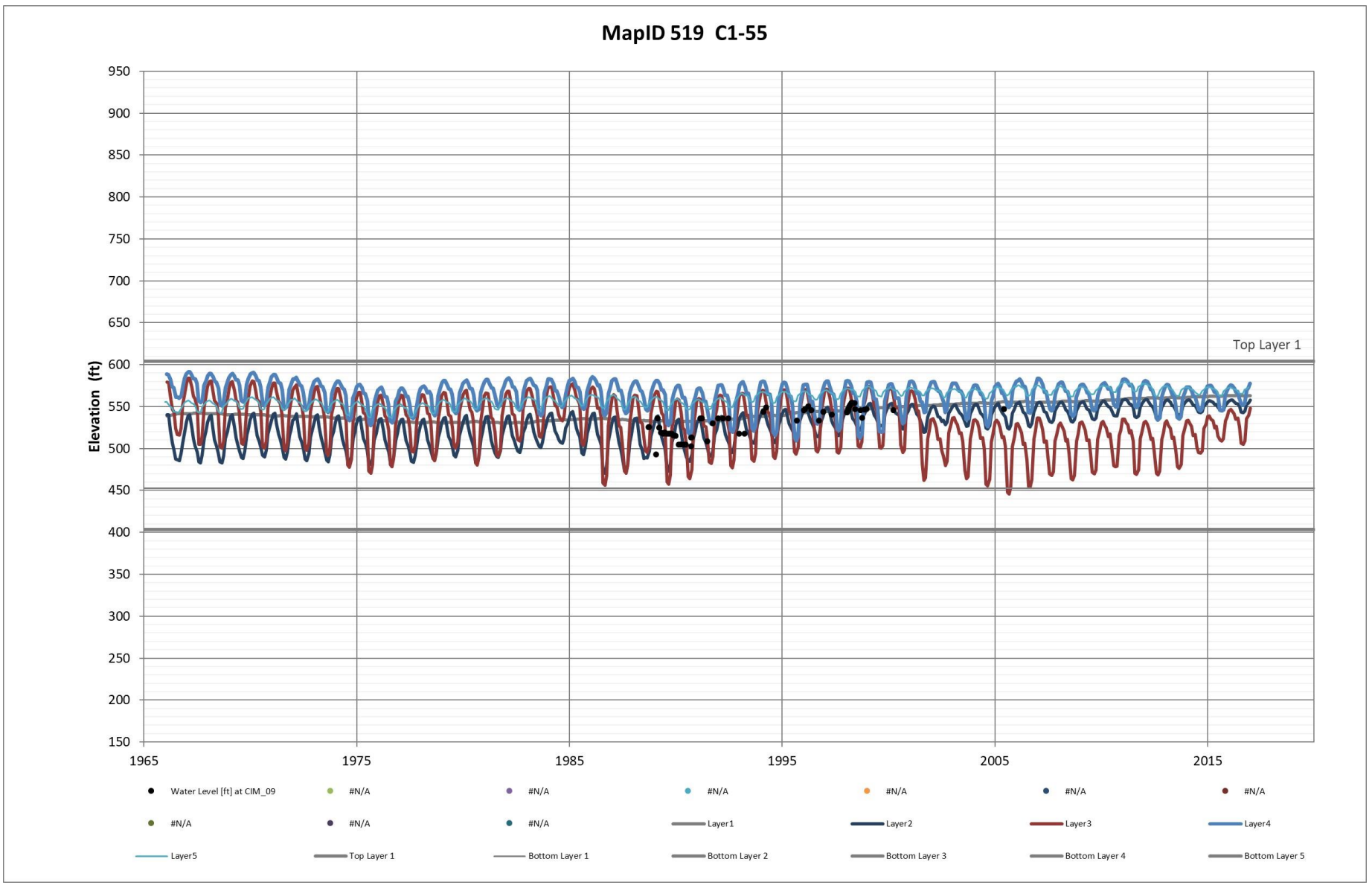


ISARM

Figure C1-54
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
PW 4

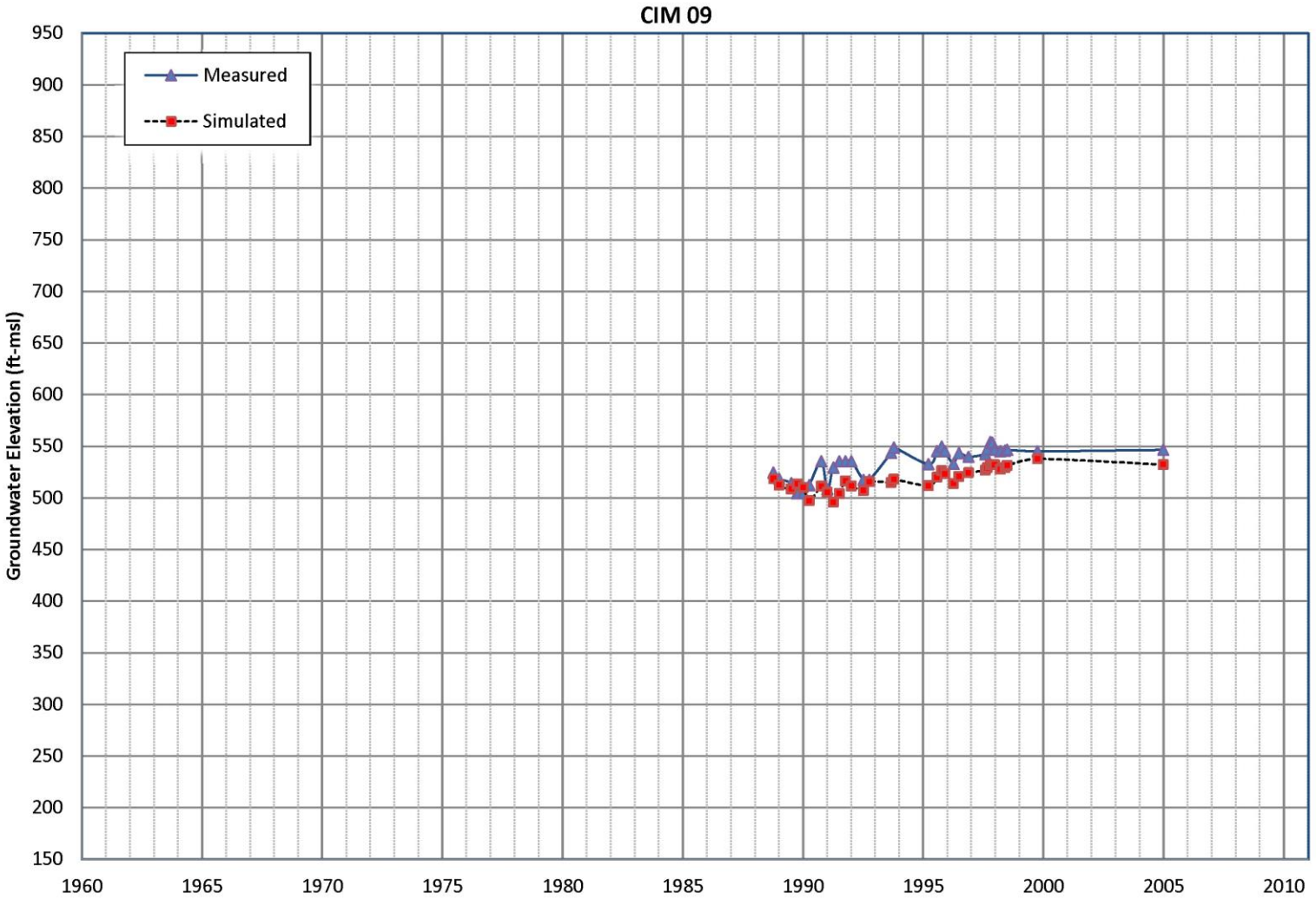


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

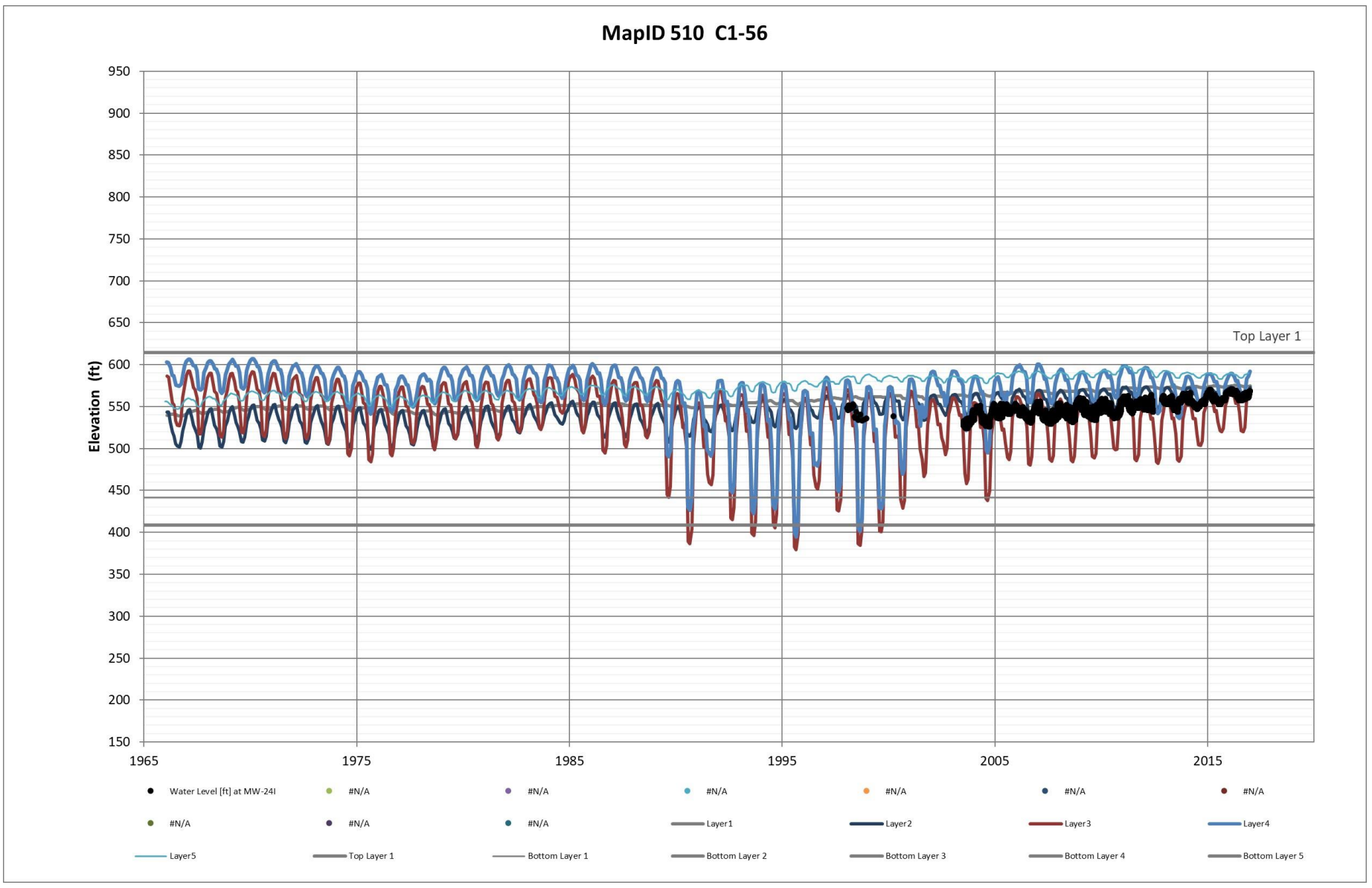


ISARM

Figure C1-55
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
CIM 09

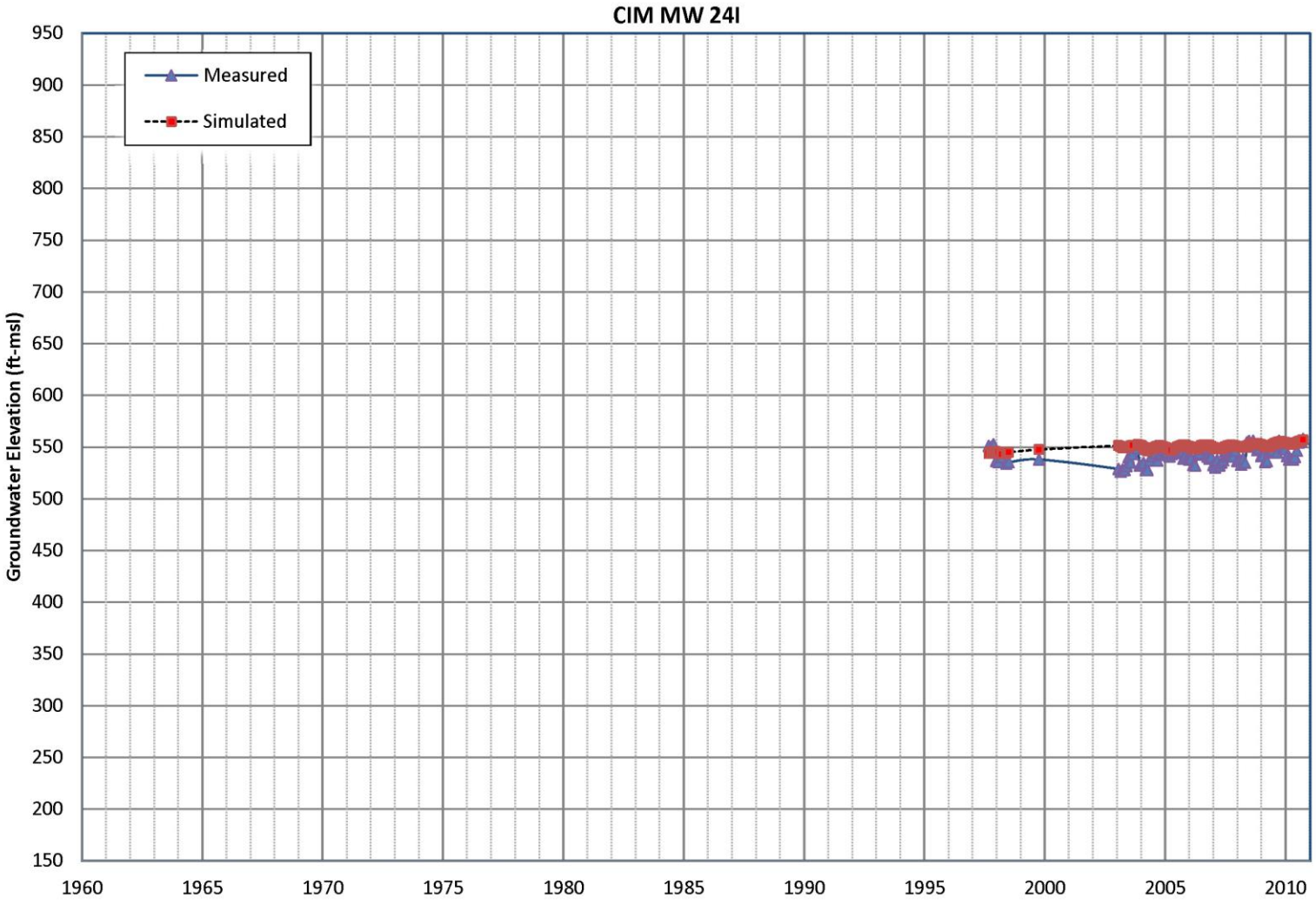


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

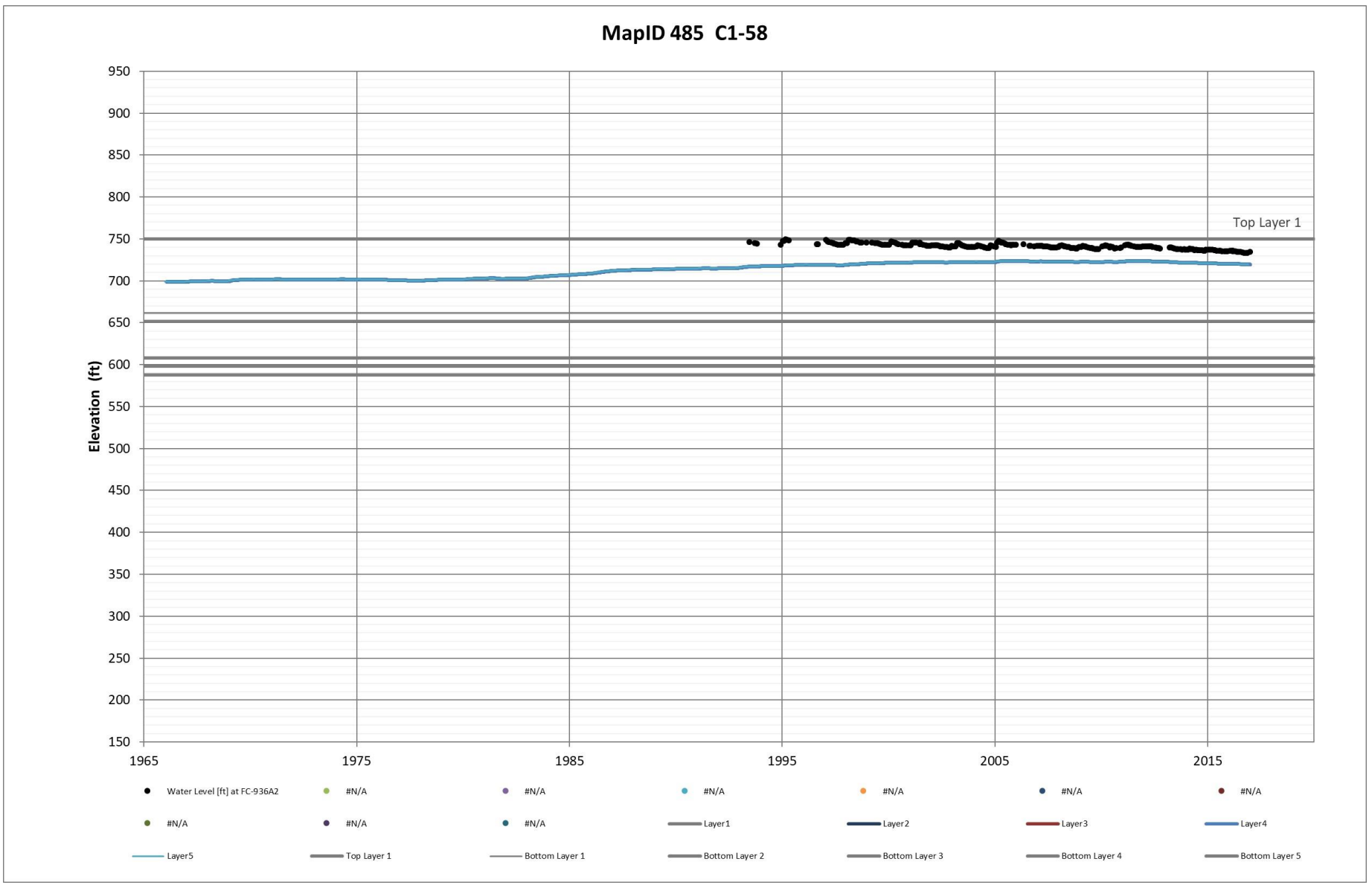


ISARM

Figure C1-56
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
CIM MW 24I

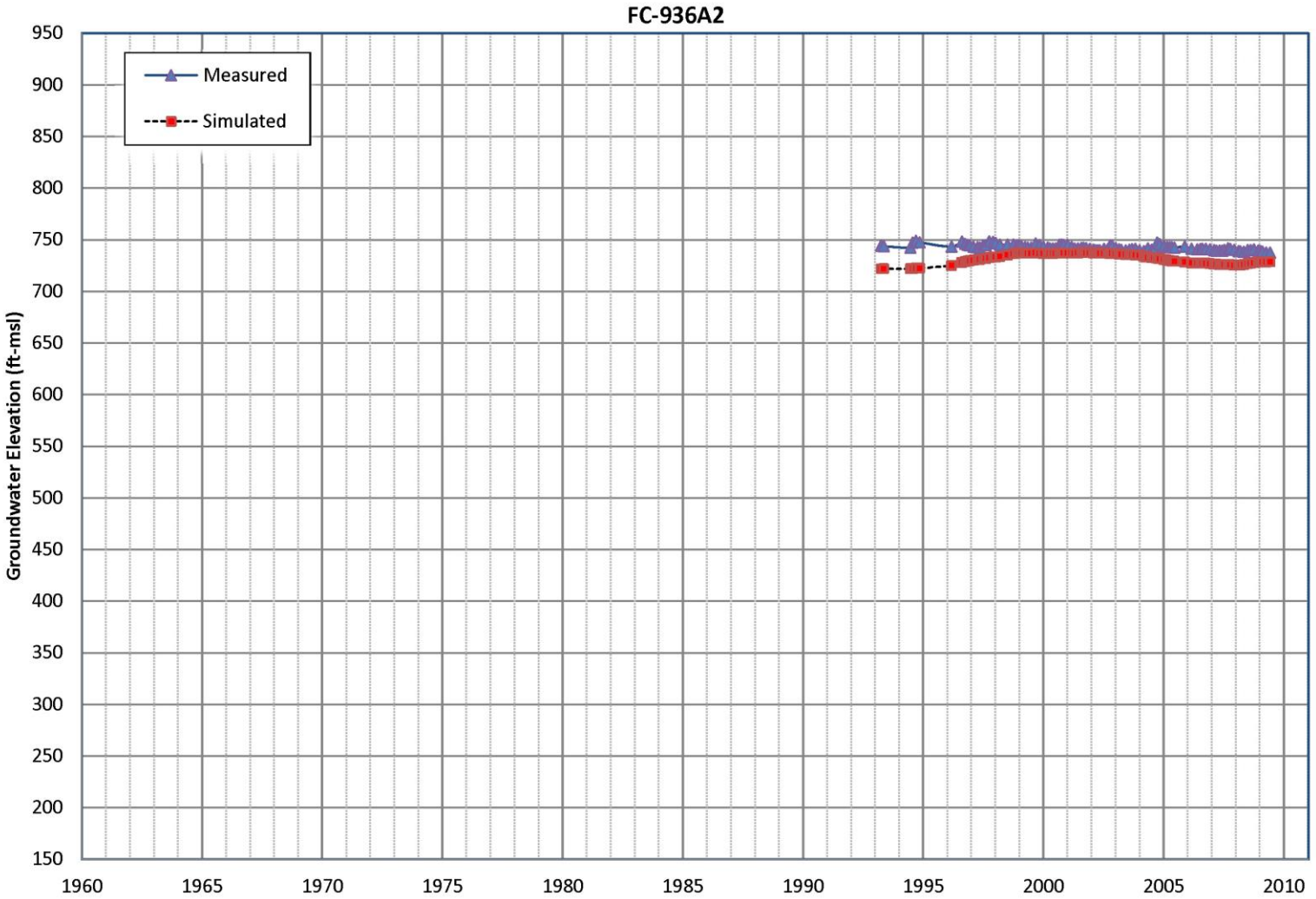


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

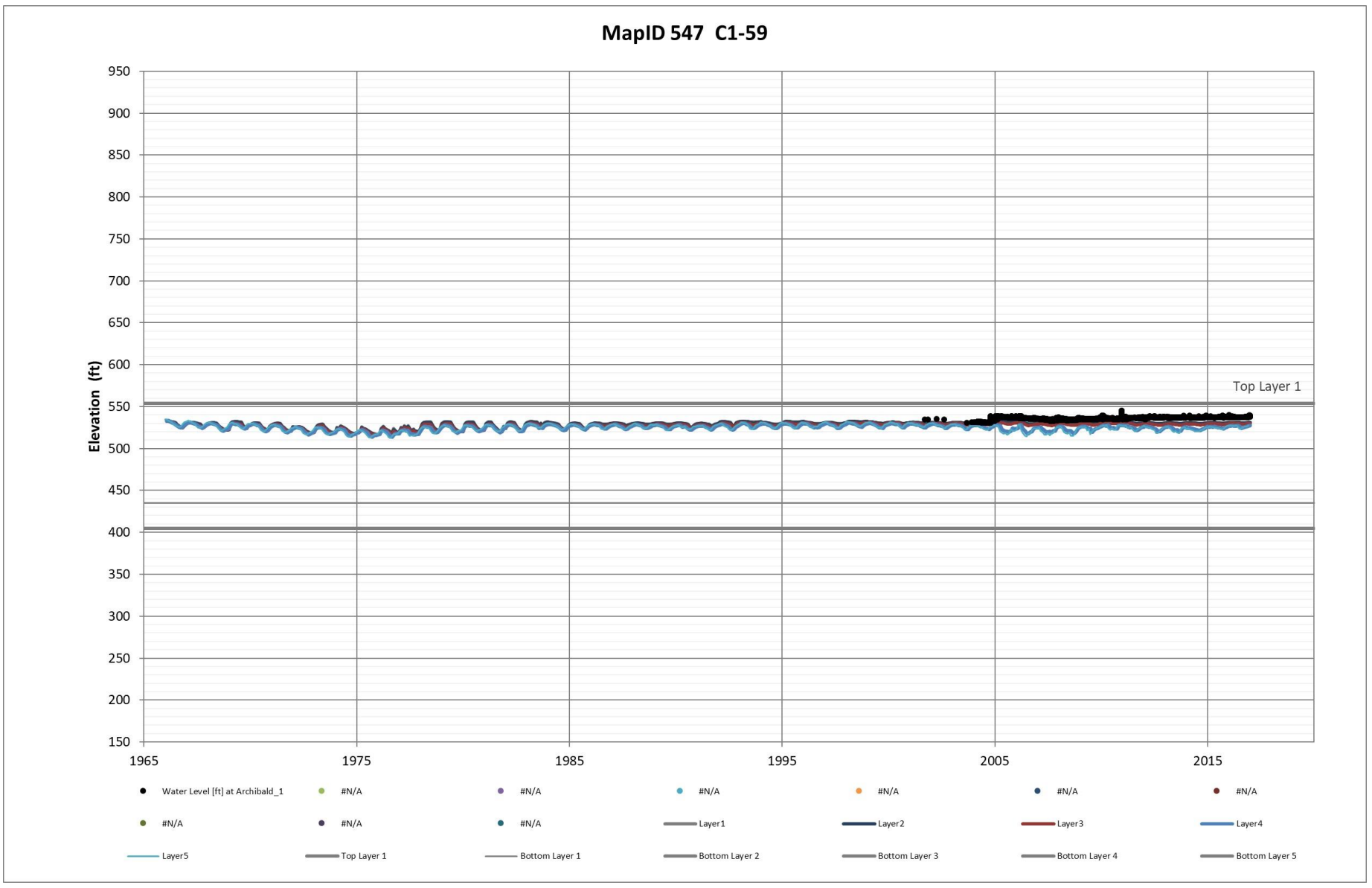


ISARM

Figure C1-58
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
FC-936A2

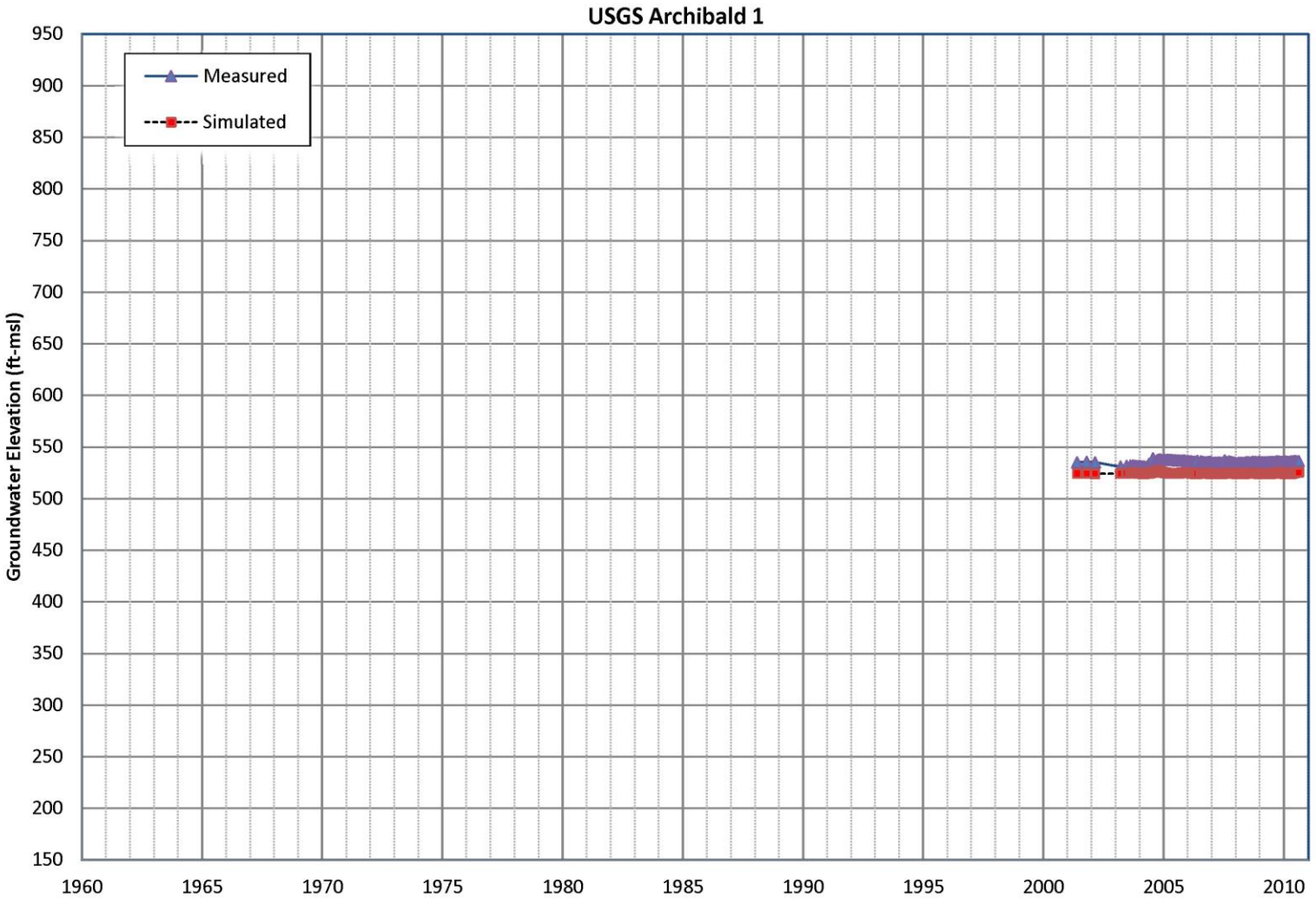


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

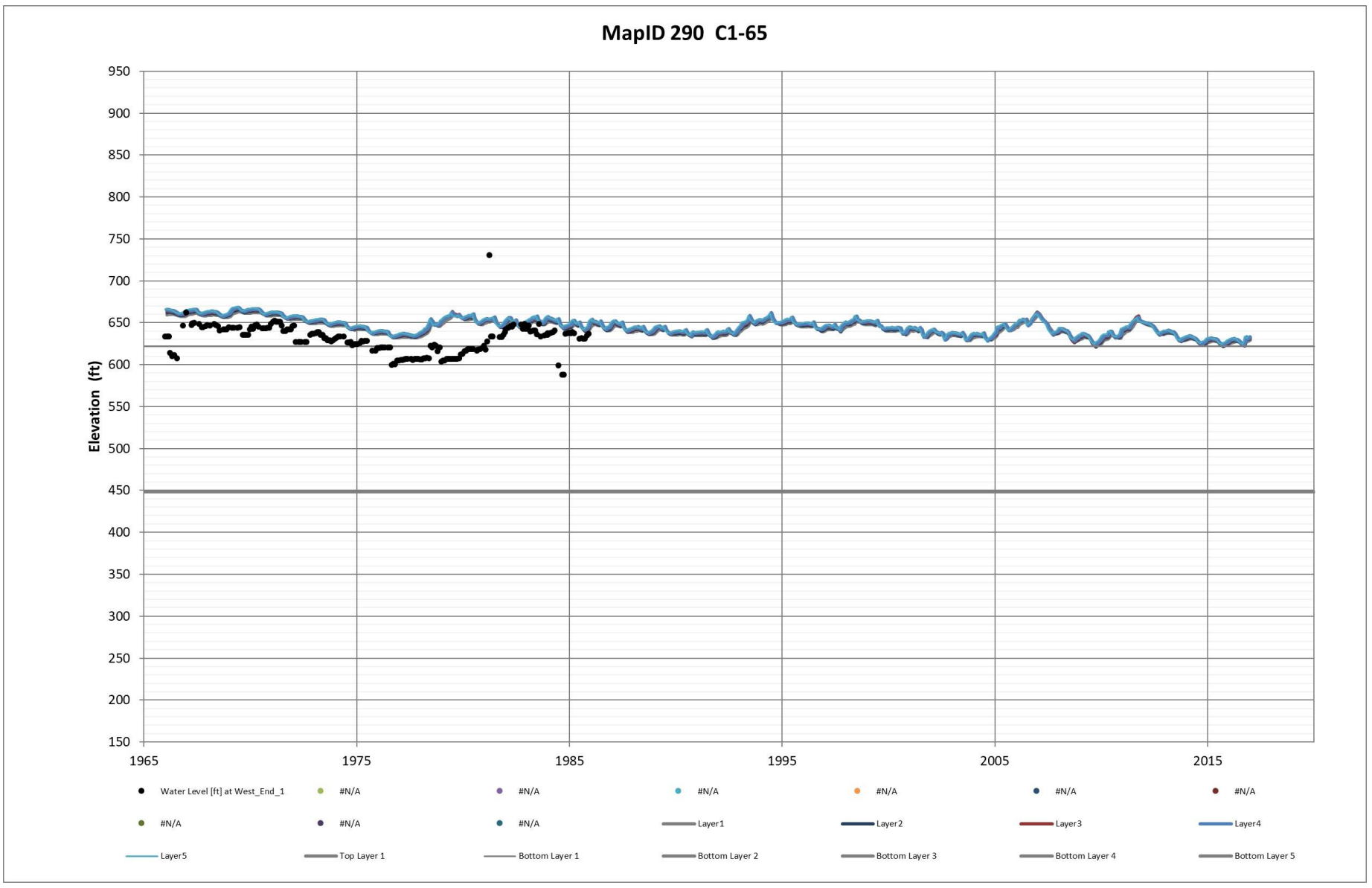


ISARM

Figure C1-59
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
USGS Archibald 1

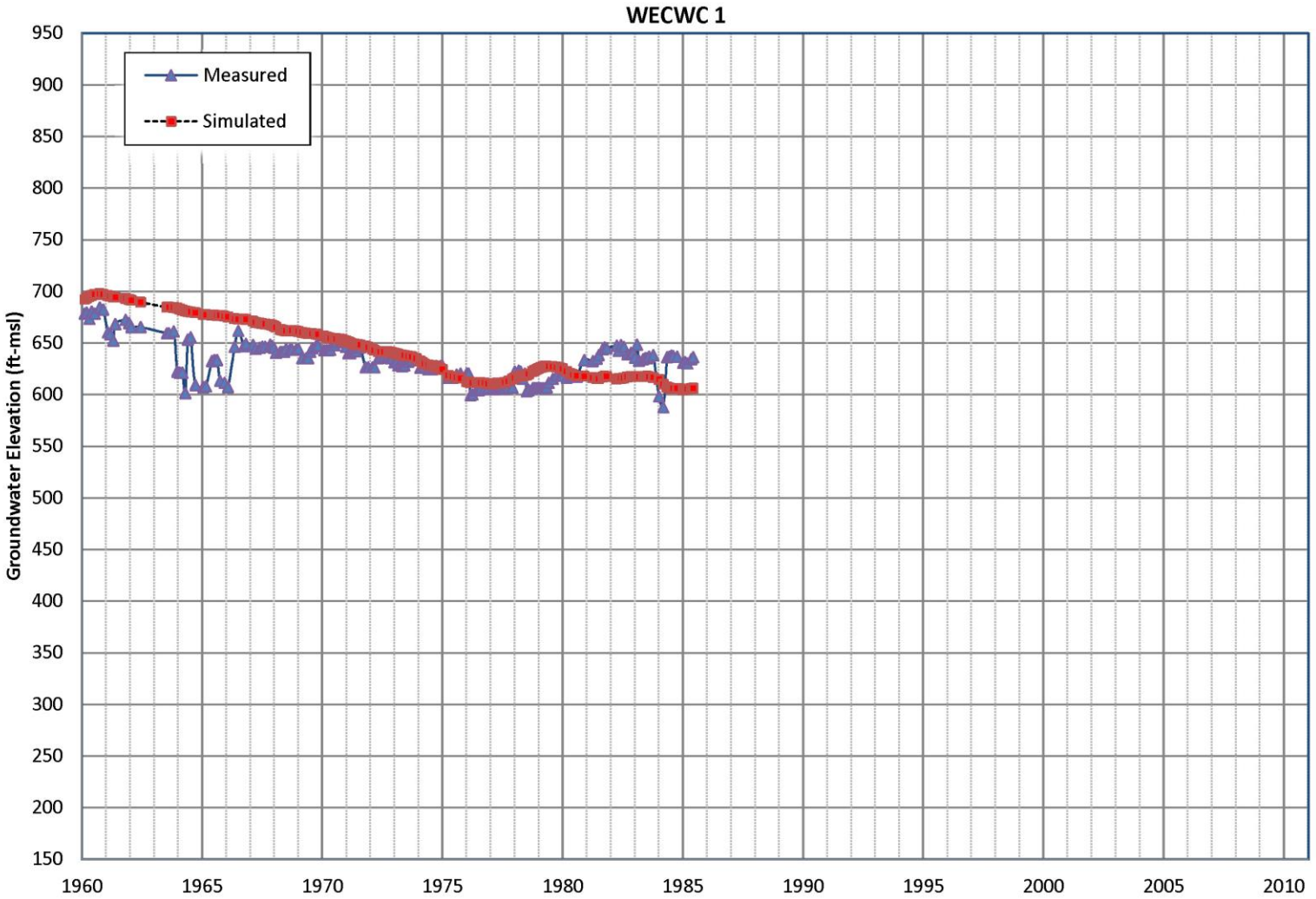


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

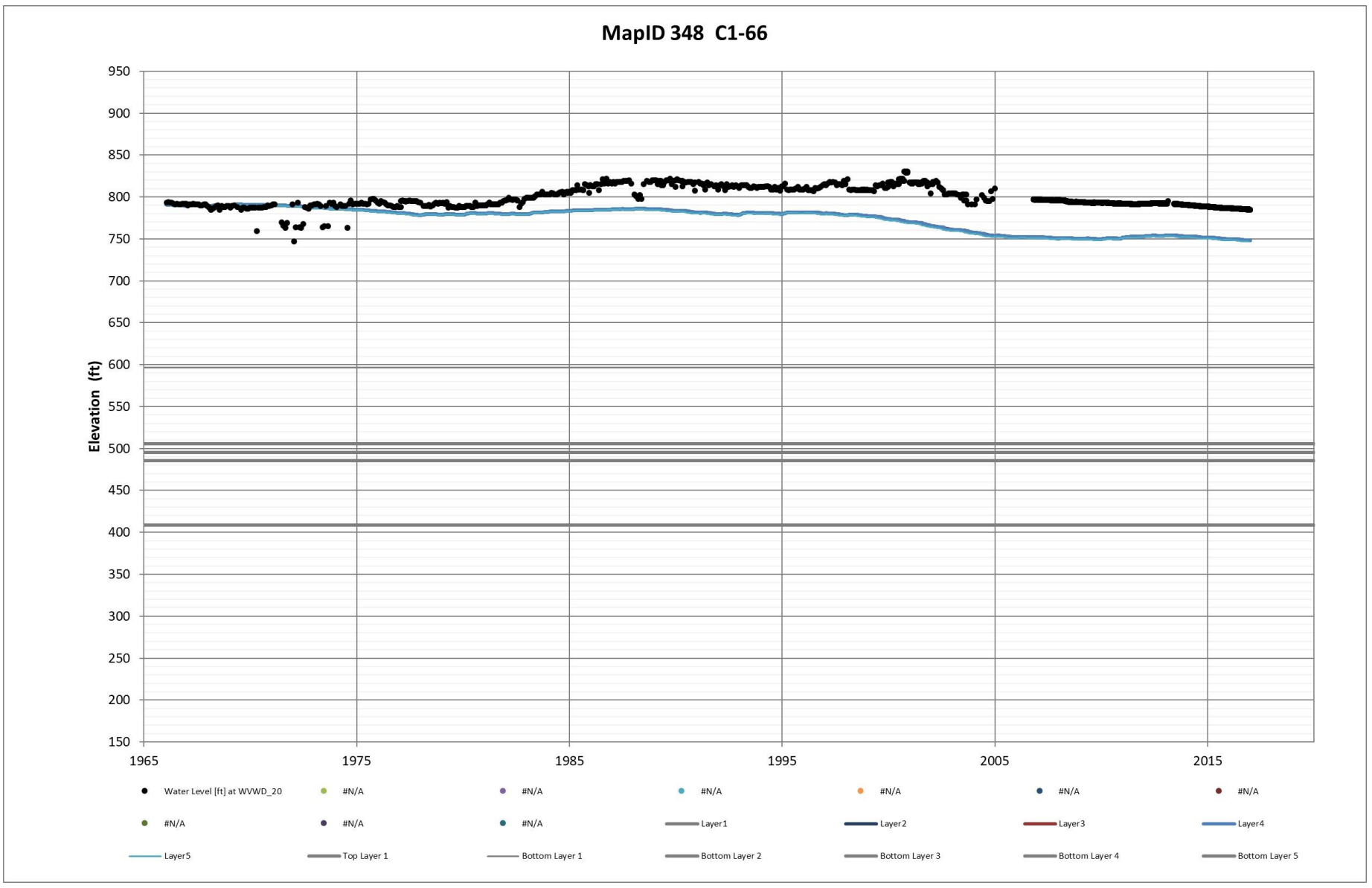


ISARM

Figure C1-65
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
WECWC 1

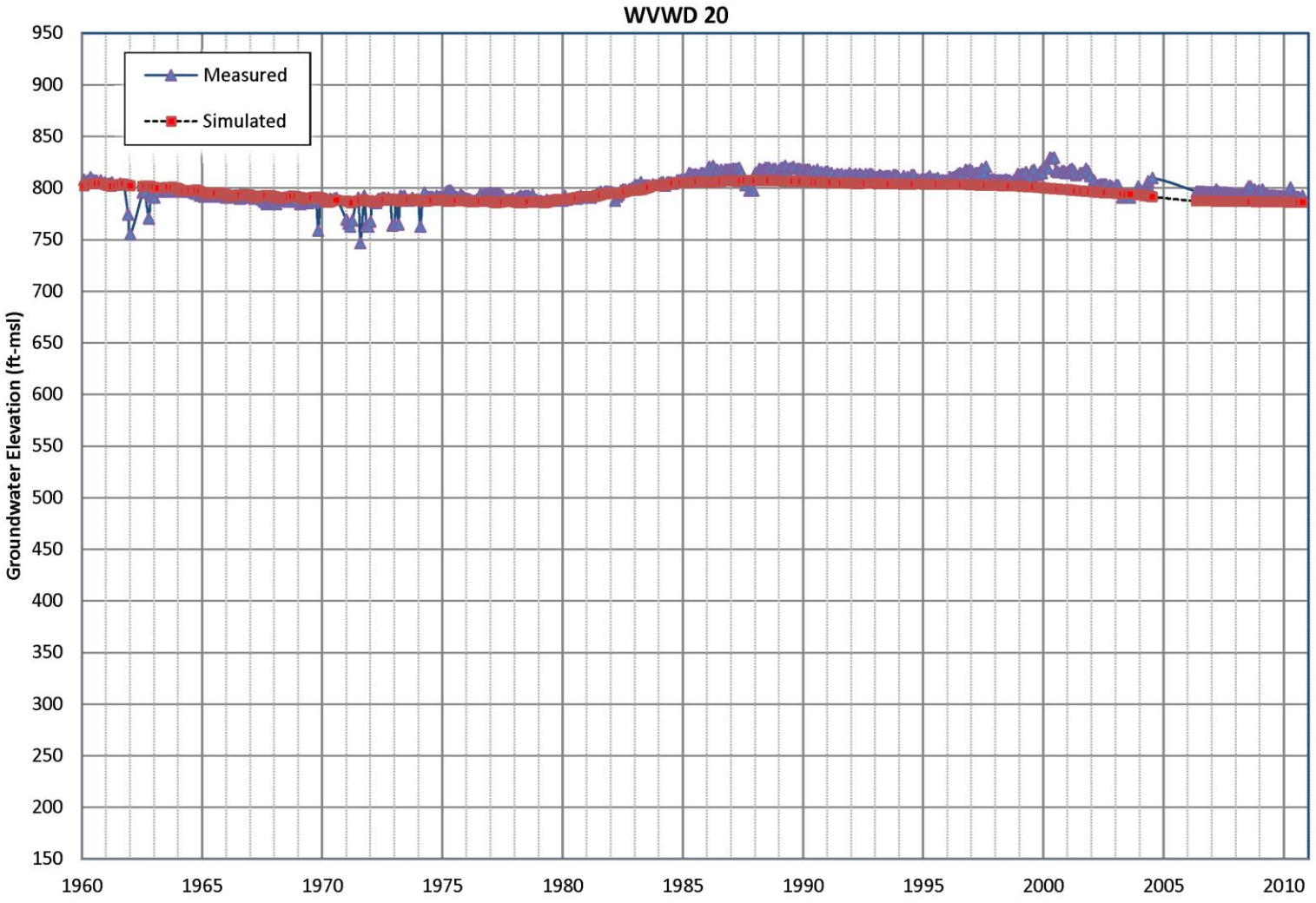


Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm



ISARM

Figure C1-66
Simulated and Measured Groundwater Elevations in the Wells Used in Model Calibration 1961 - 2011
WVWD 20



Appendix_C1_20150915_WW_WellHydrograph_calibrationwell_format.xlsm

Water-Level Hydrographs (WEI – Appendix C2)

WEI (2015, Appendix C2) shows time-history plots (water-level hydrographs) from 41 wells used for validation of the Chino Basin Watermaster model (CBWM). We developed water-level hydrographs from the Integrated Santa Ana River model (ISARM) for a qualitative (visual) comparison. Out of the 41 wells used in calibration of the CBWM, 40 are in the ISARM calibration dataset. A side-by-side comparison for each of the 40 hydrographs is attached.

On each page, the upper hydrograph shows observed water-level data and simulated water levels from the ISARM; simulated water levels from each model layer are presented for a complete view of model response. The lower hydrograph is taken from WEI (2015, Appendix C2).[1] The vertical axes on hydrographs are scaled the same to facilitate visual comparison.

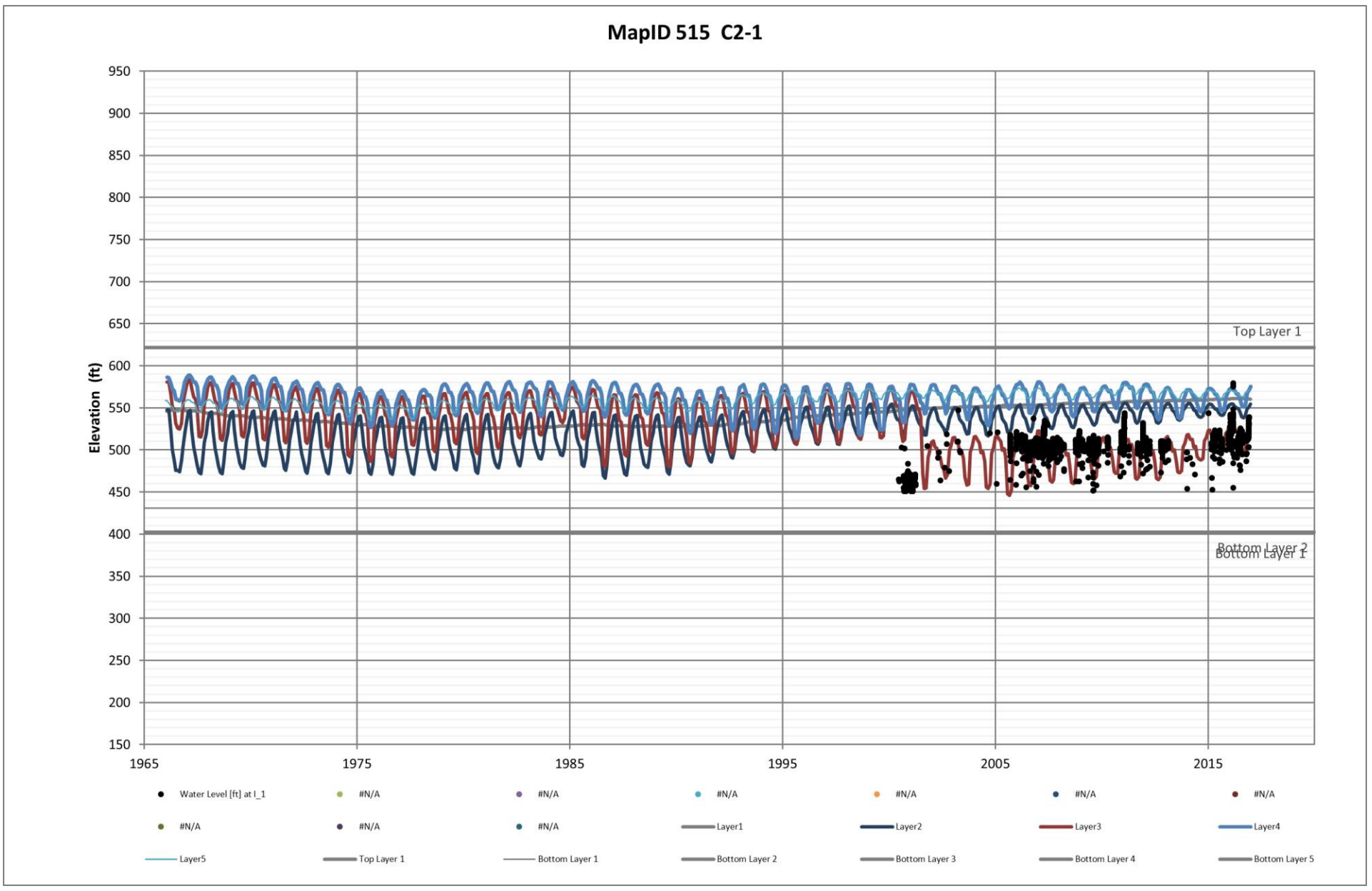
The hydrograph presentation can be refined if needed. The intent of this document is to present a simple comparison for inspection by the Model Group Subcommittee of the Technical Advisory Committee.

Attachment: Hydrographs (40 wells)

Reference

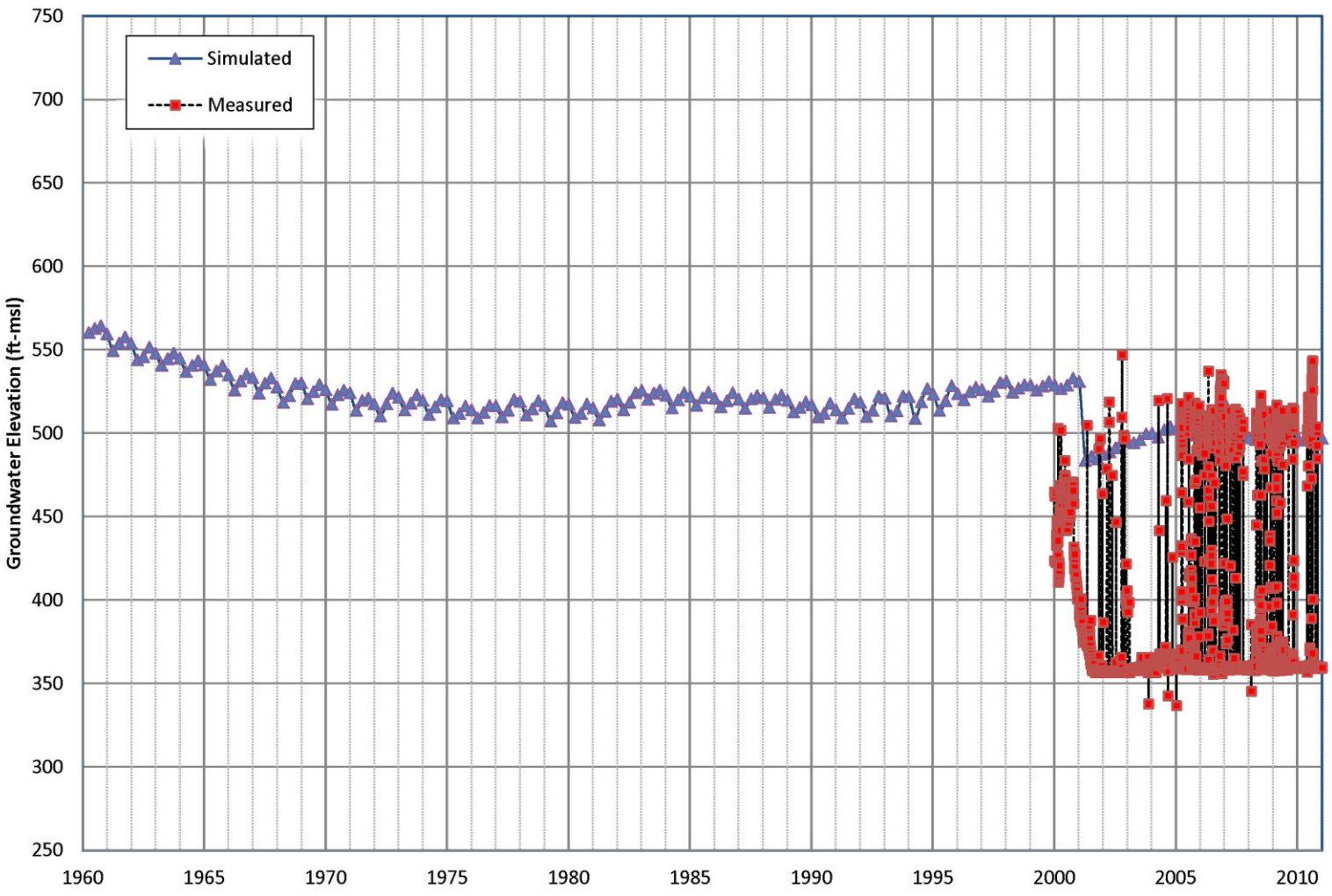
Wildermuth Environmental, Inc., 2015, 2013 Chino Basin Groundwater Model Update and Recalculation of Safe Yield Pursuant to the Peace Agreement: Prepared for Chino Basin Watermaster, report dated October 2015.

[1] We do not have the WEI (2015) model so the hydrographs are directly from the WEI (2015) report.

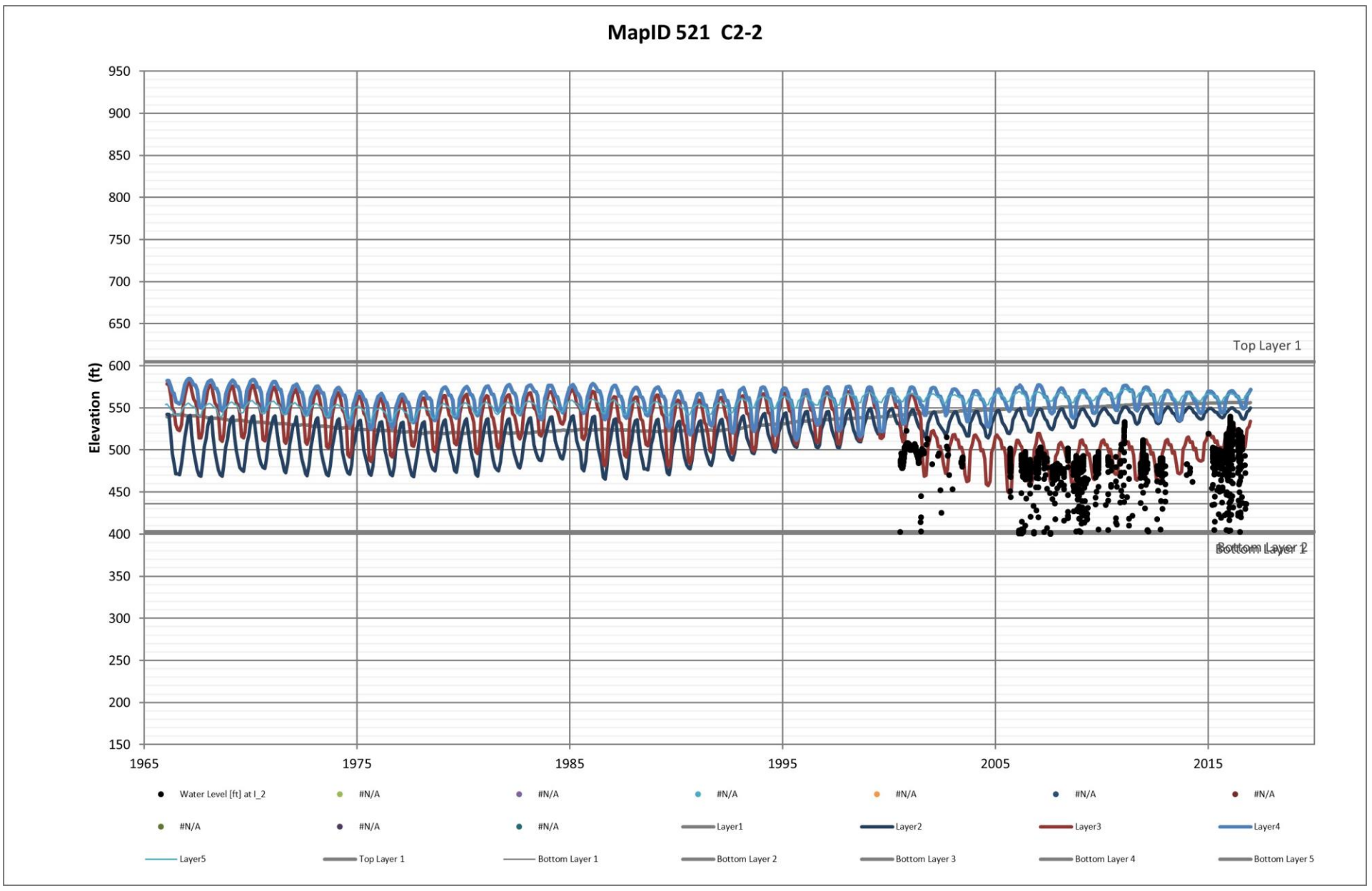


ISARM

Figure C2-1
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-1

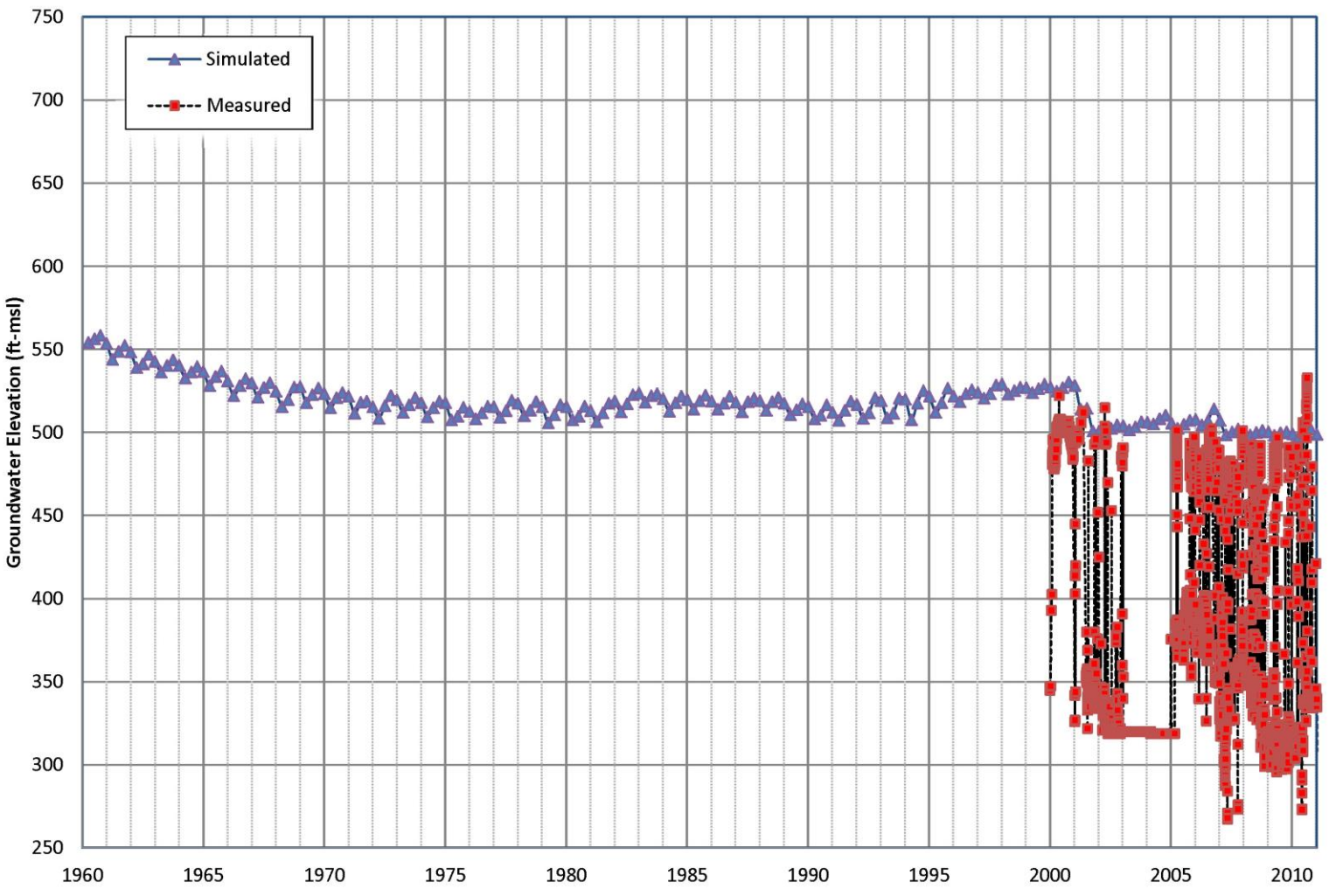


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

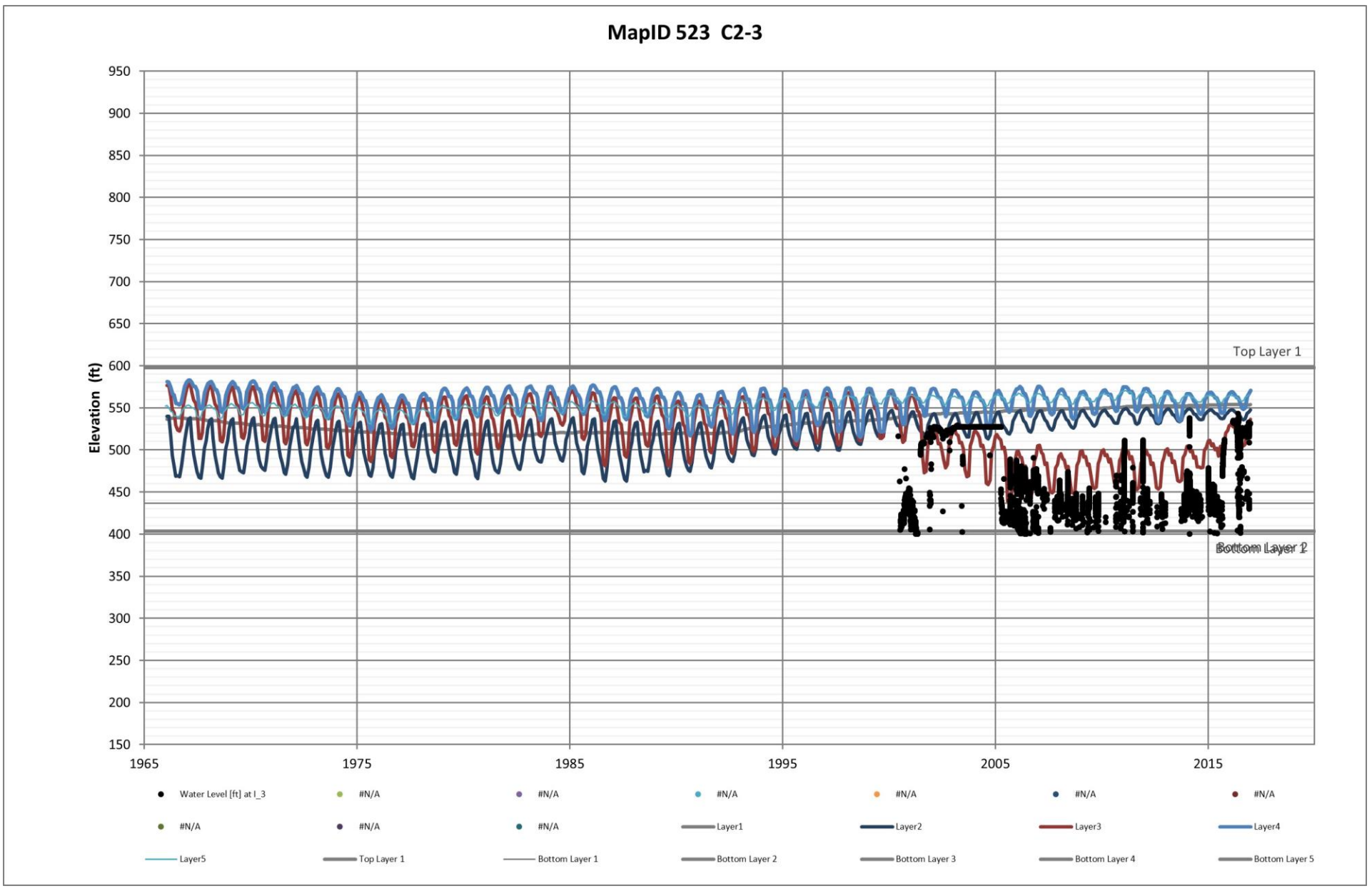


ISARM

Figure C2-2
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-2

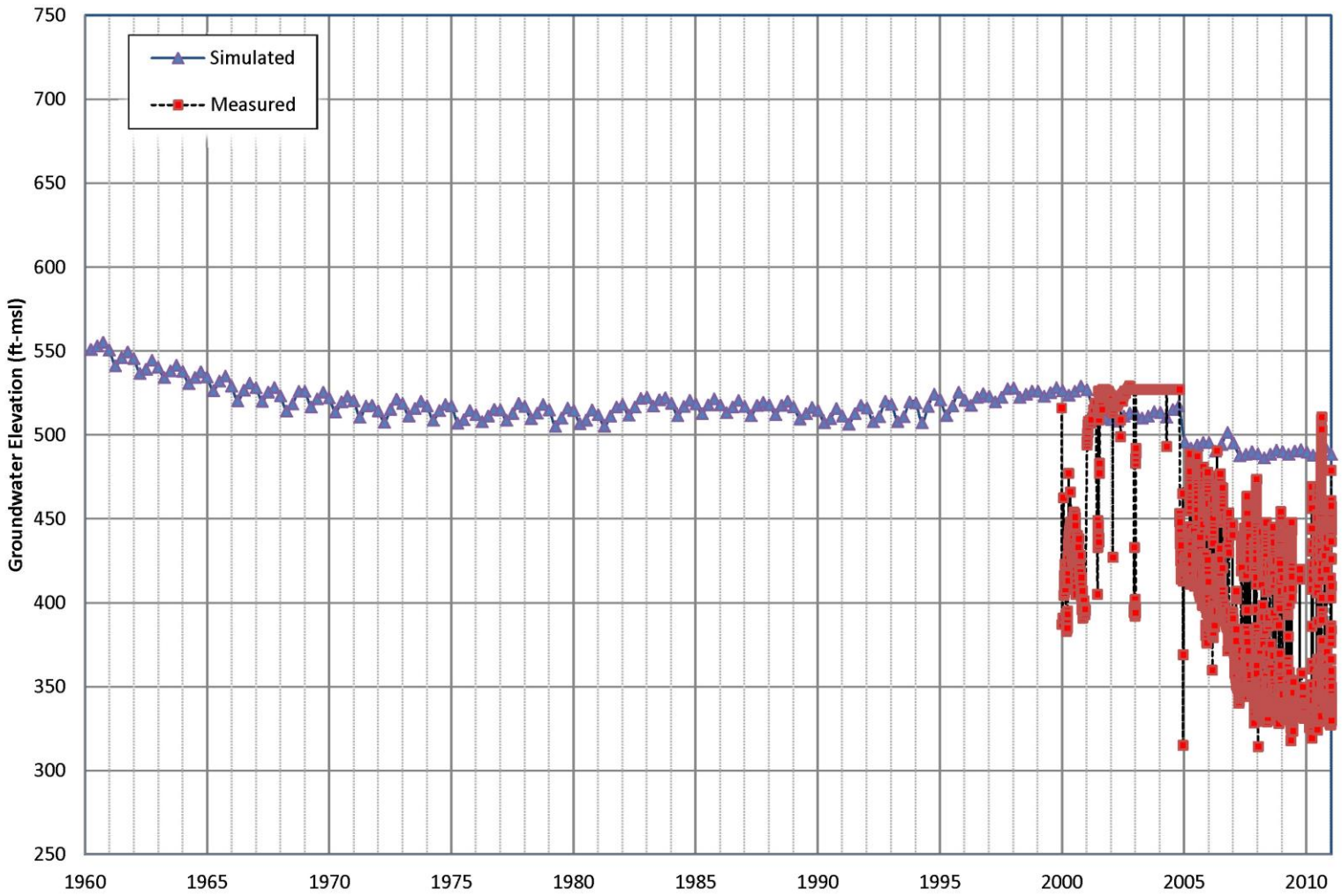


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

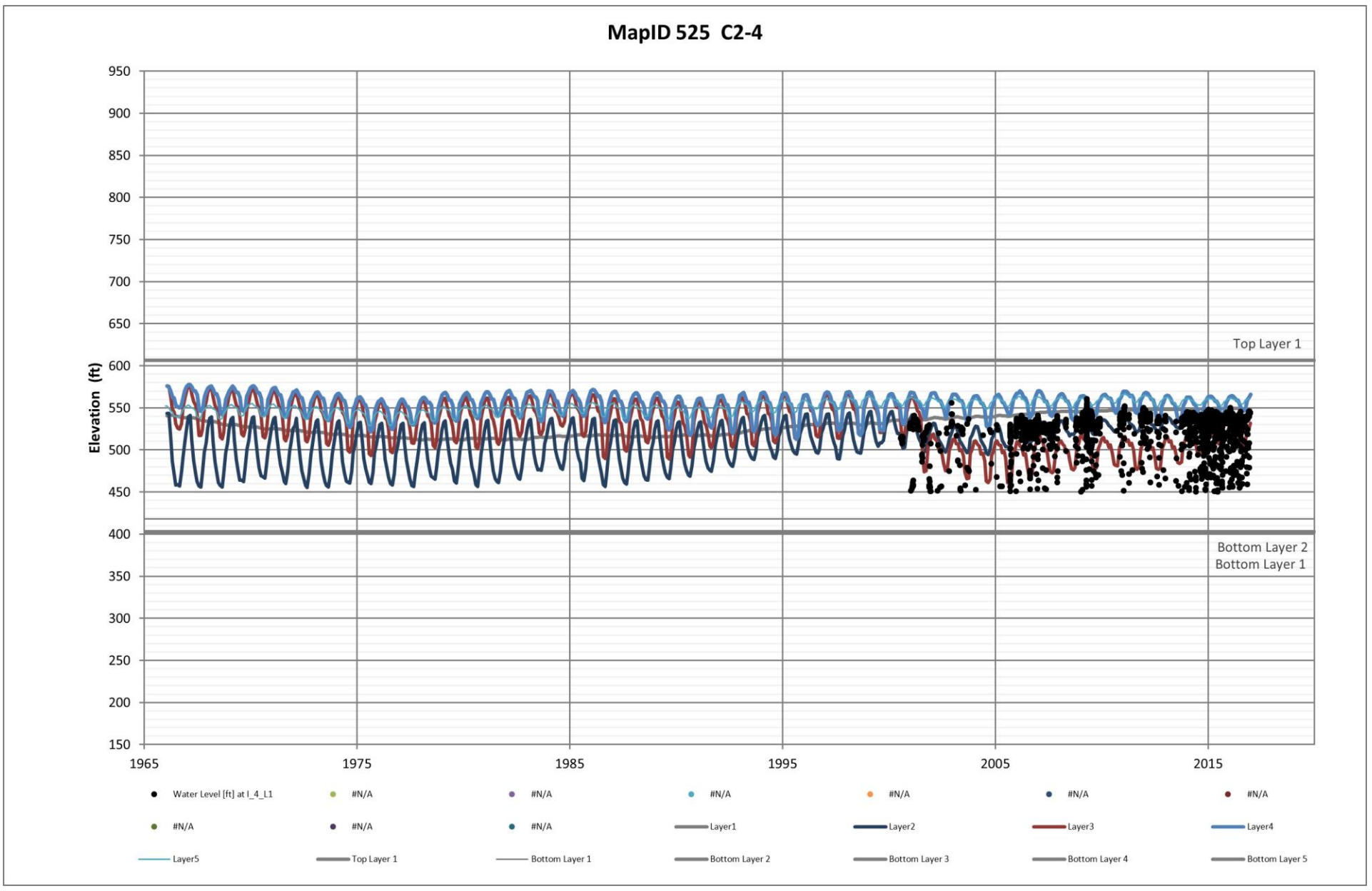


ISARM

Figure C2-3
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-3

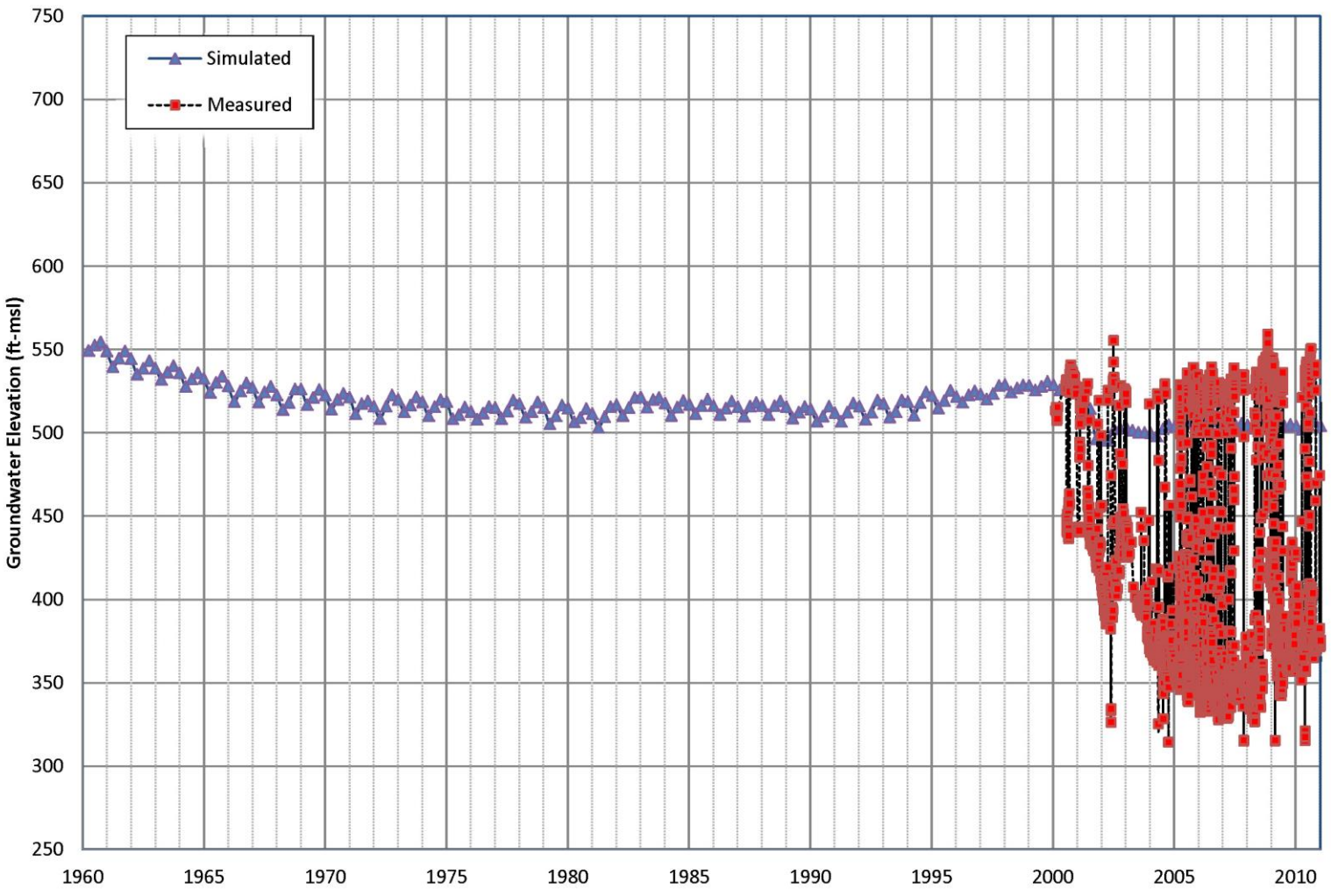


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

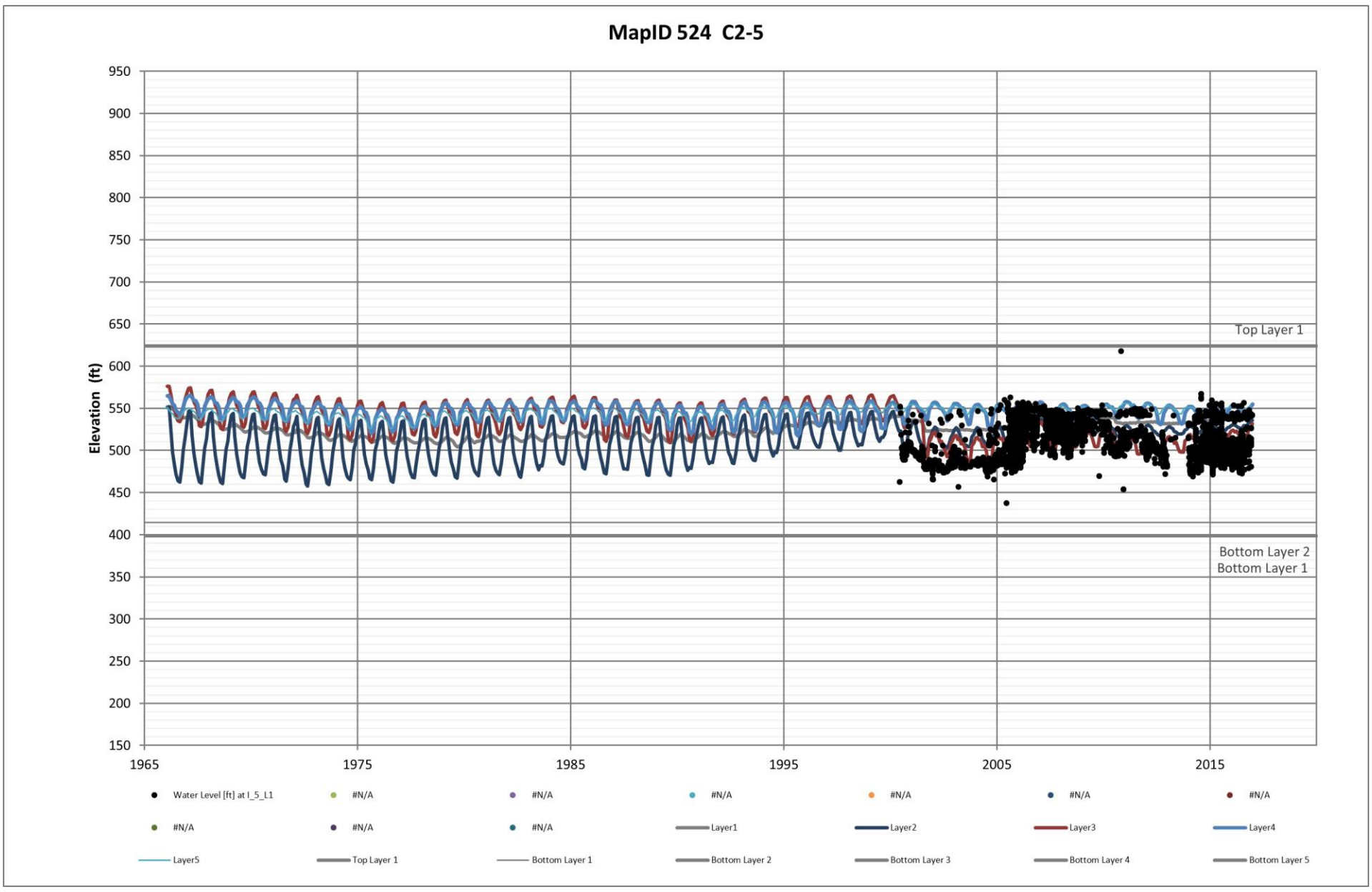


ISARM

Figure C2-4
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-4

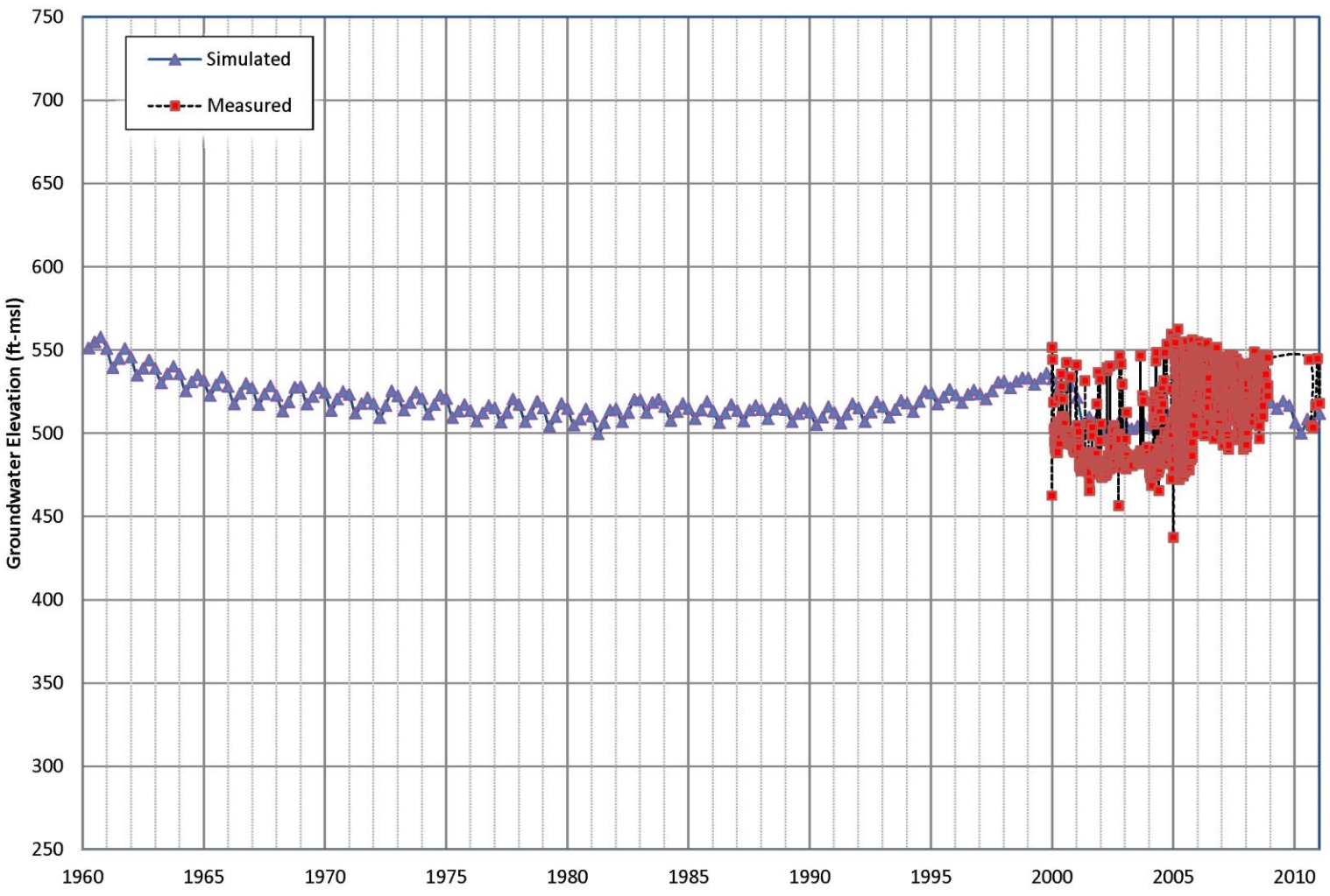


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

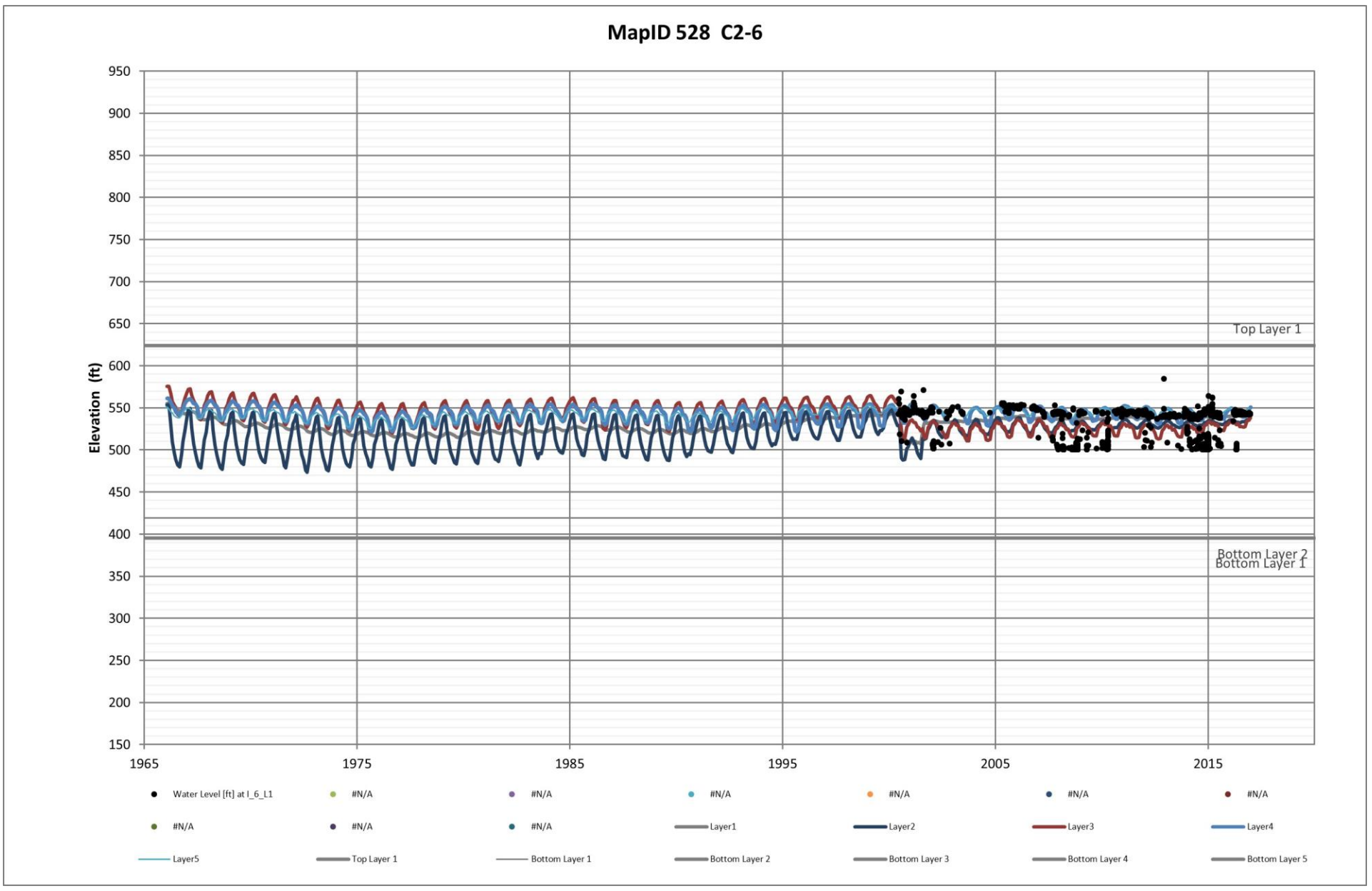


ISARM

Figure C2-5
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-5

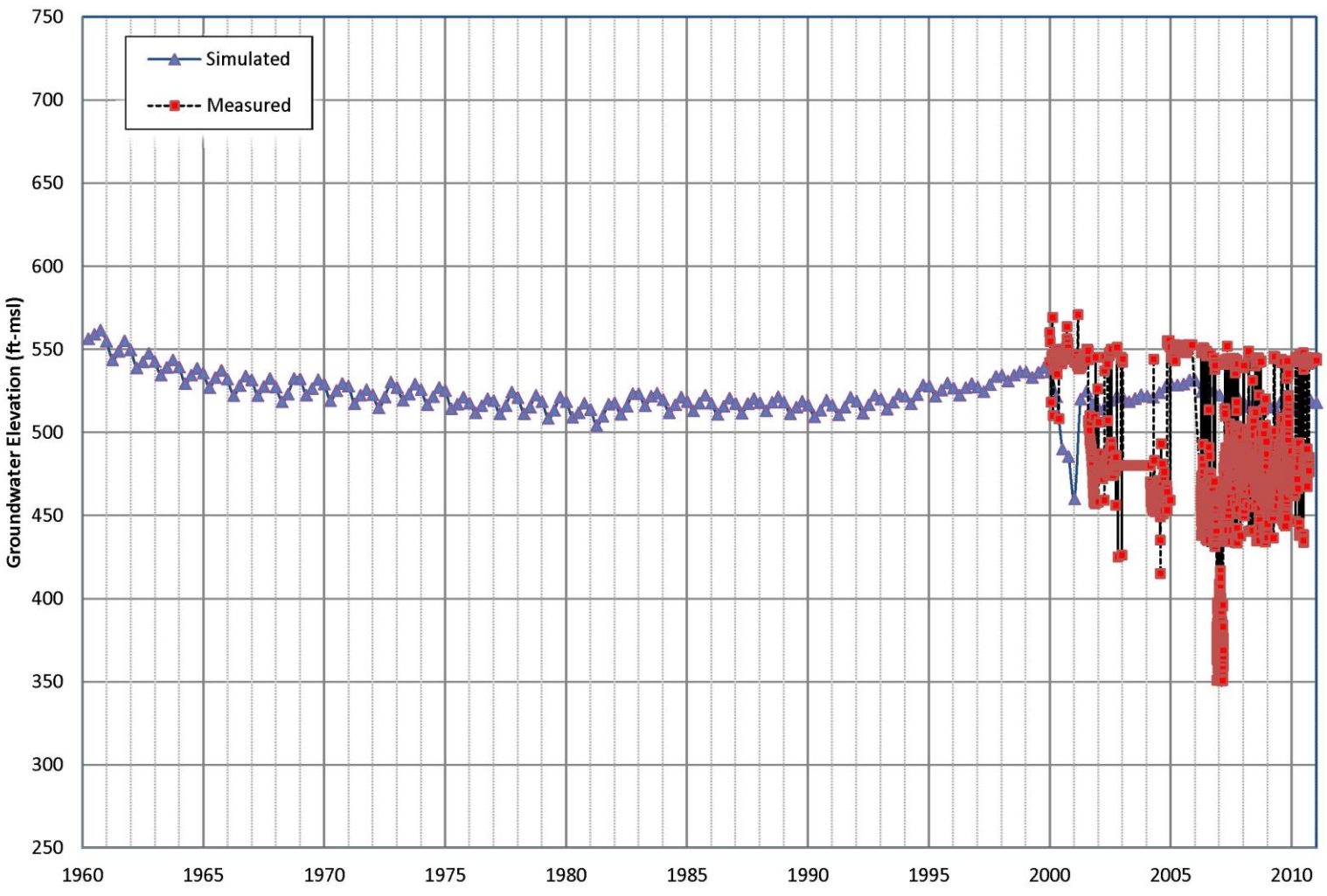


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

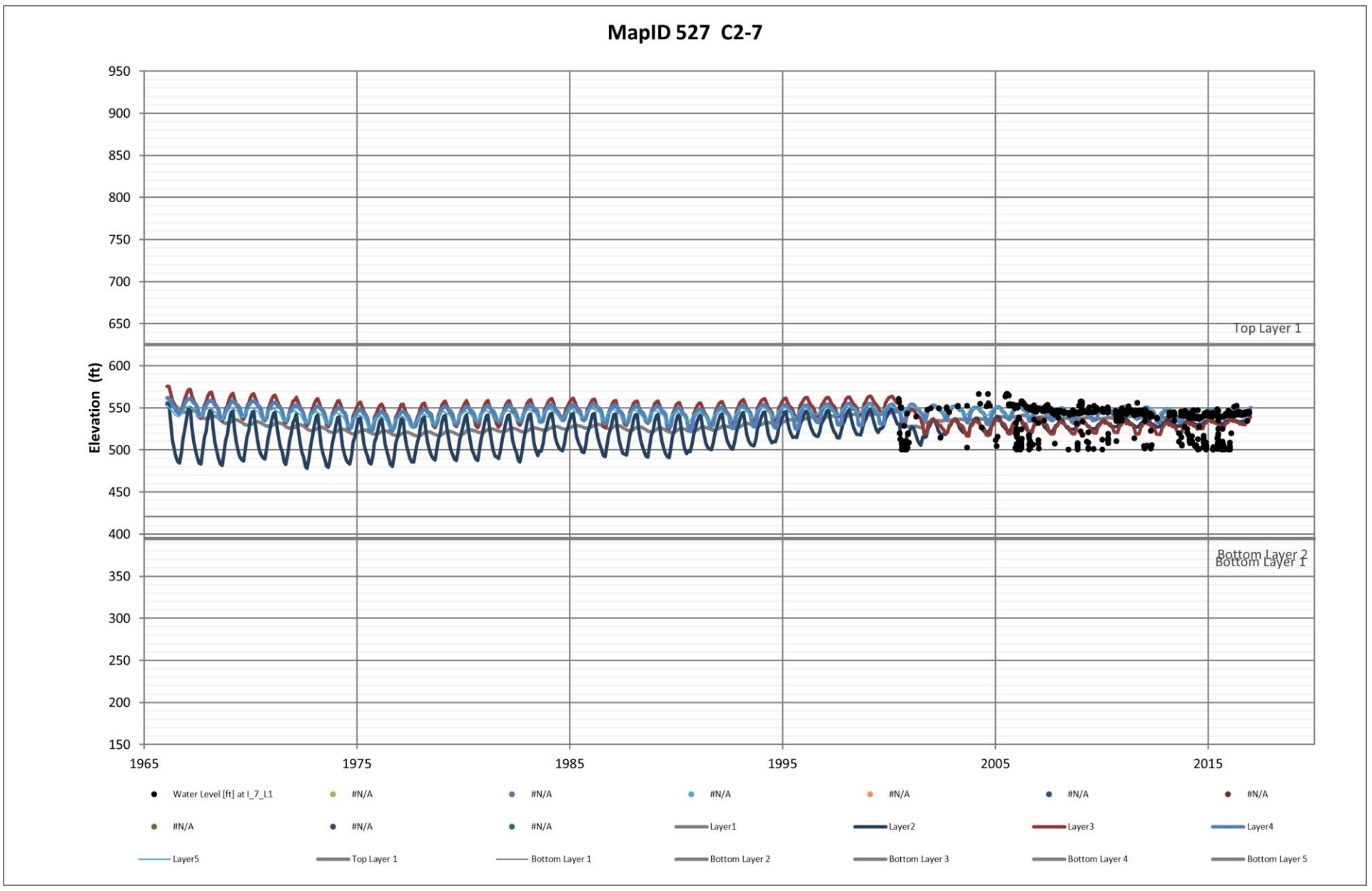


ISARM

Figure C2-6
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-6

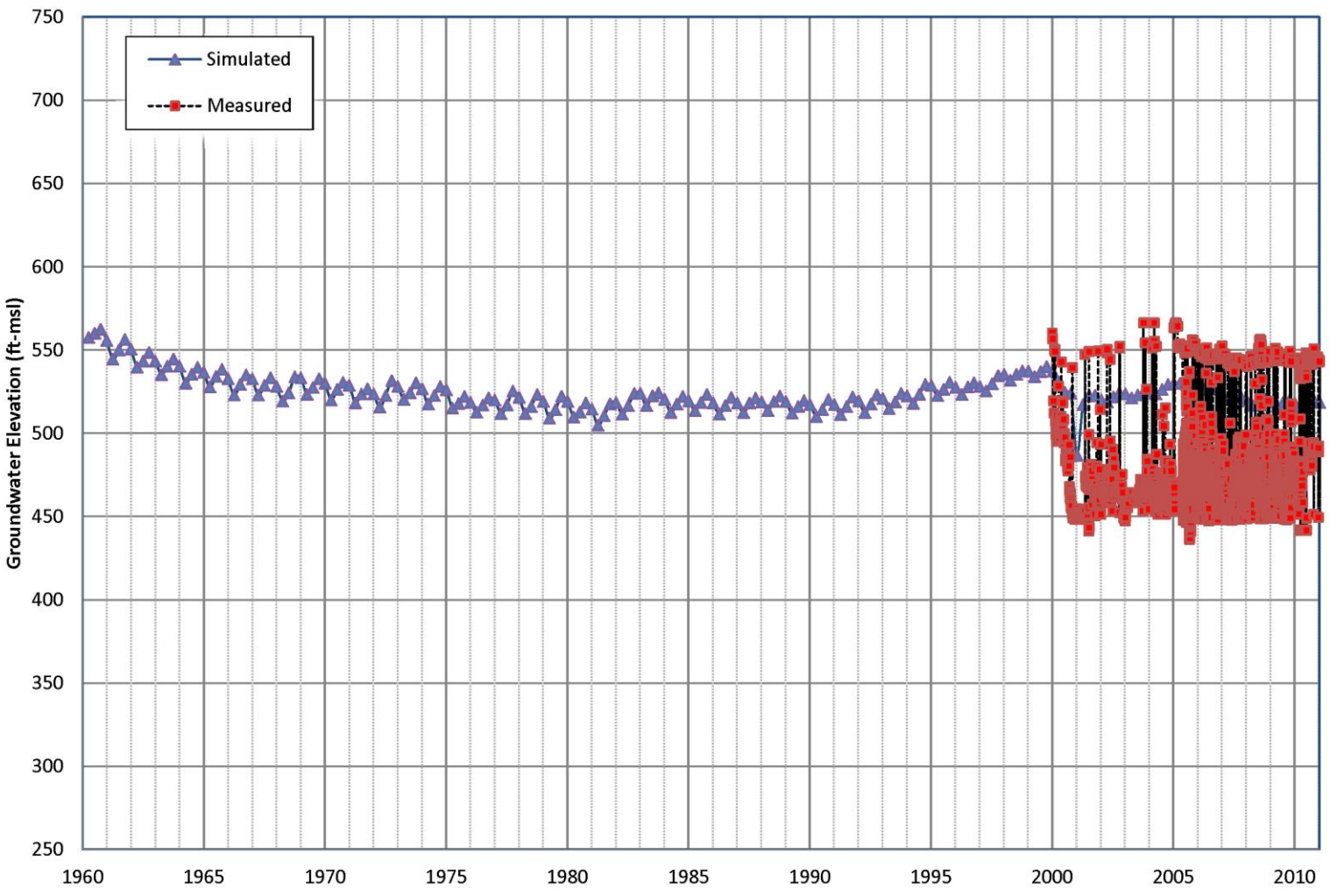


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

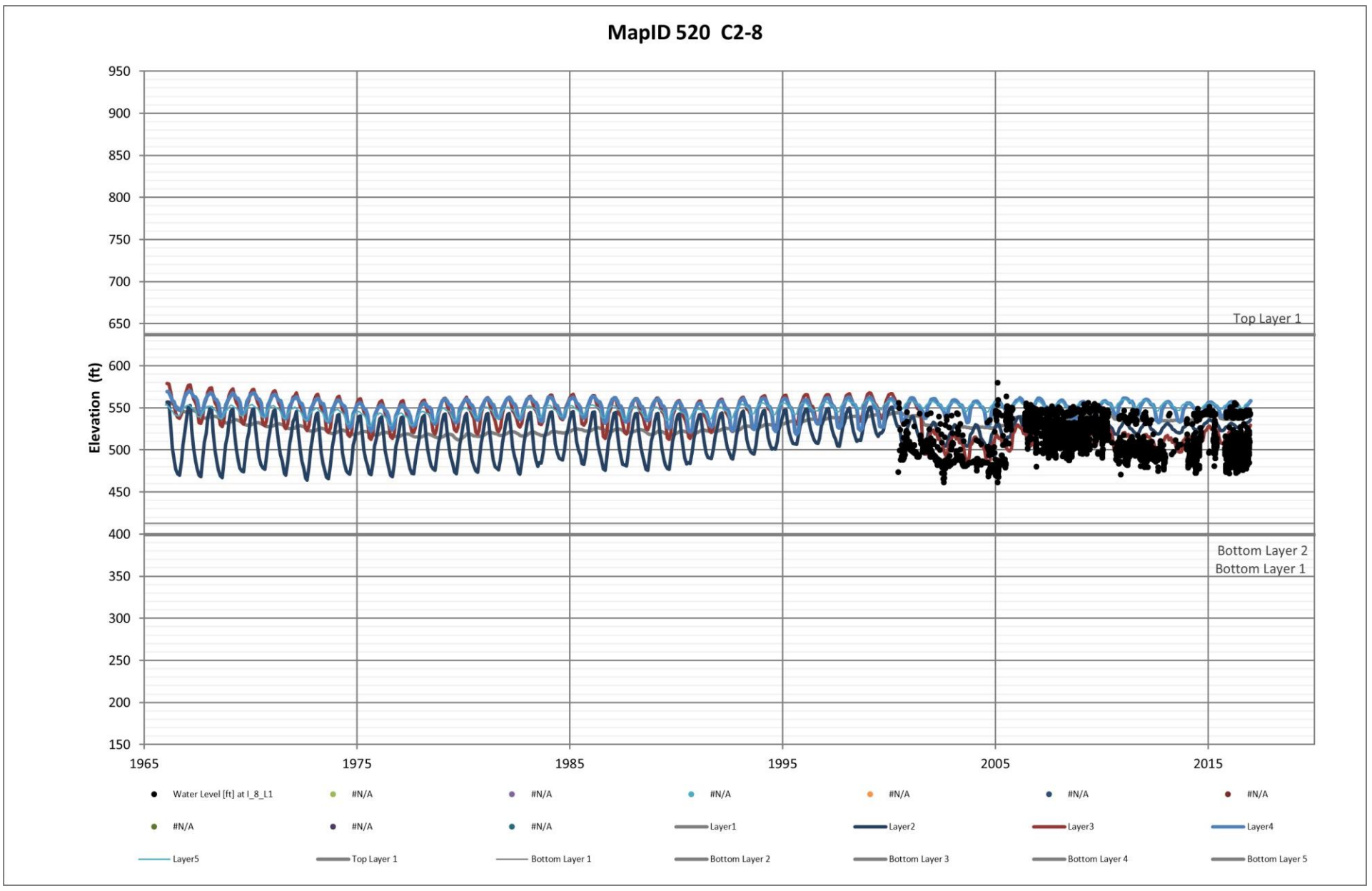


ISARM

Figure C2-7
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-7

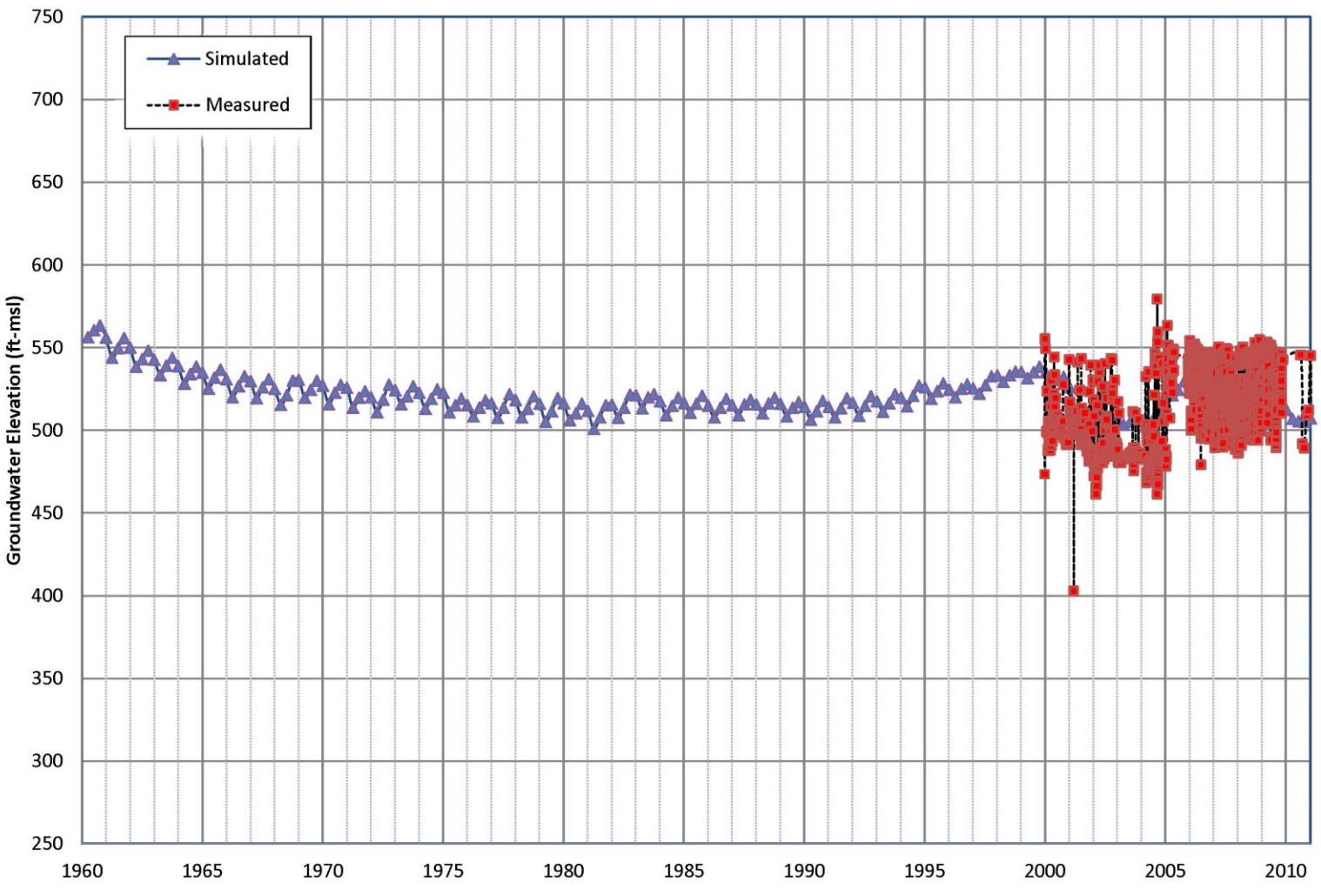


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

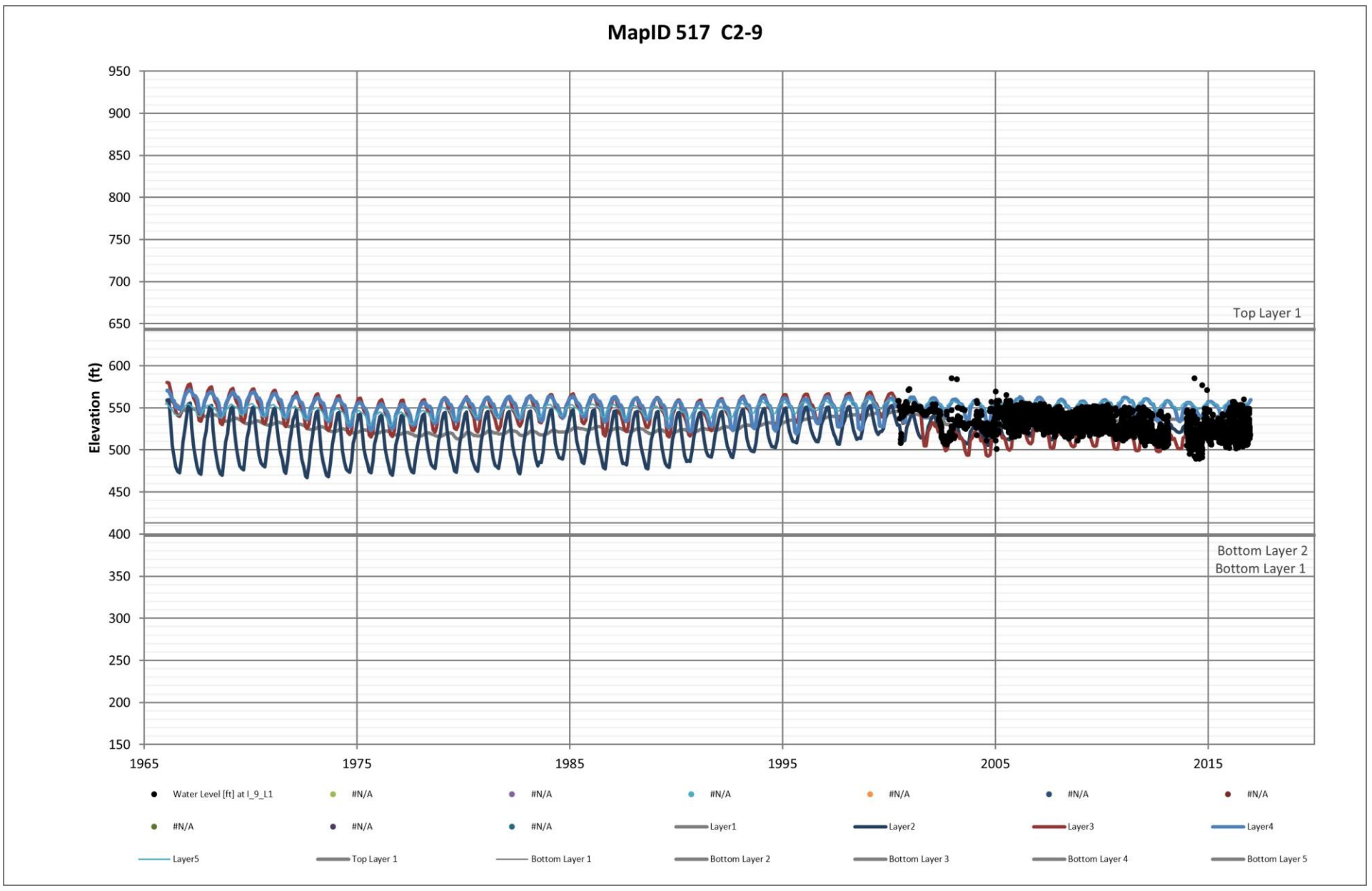


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Figure C2-8
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-8

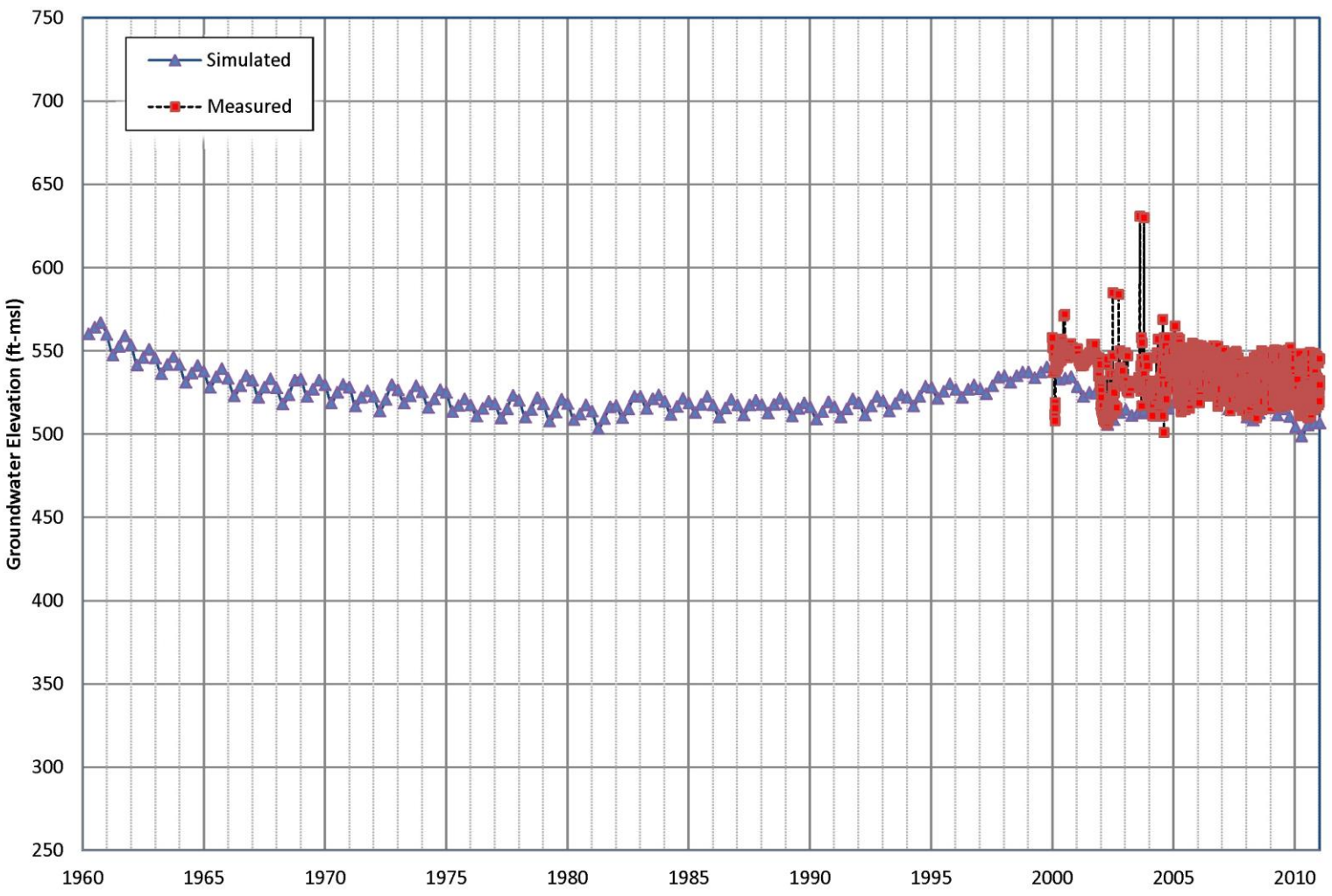


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

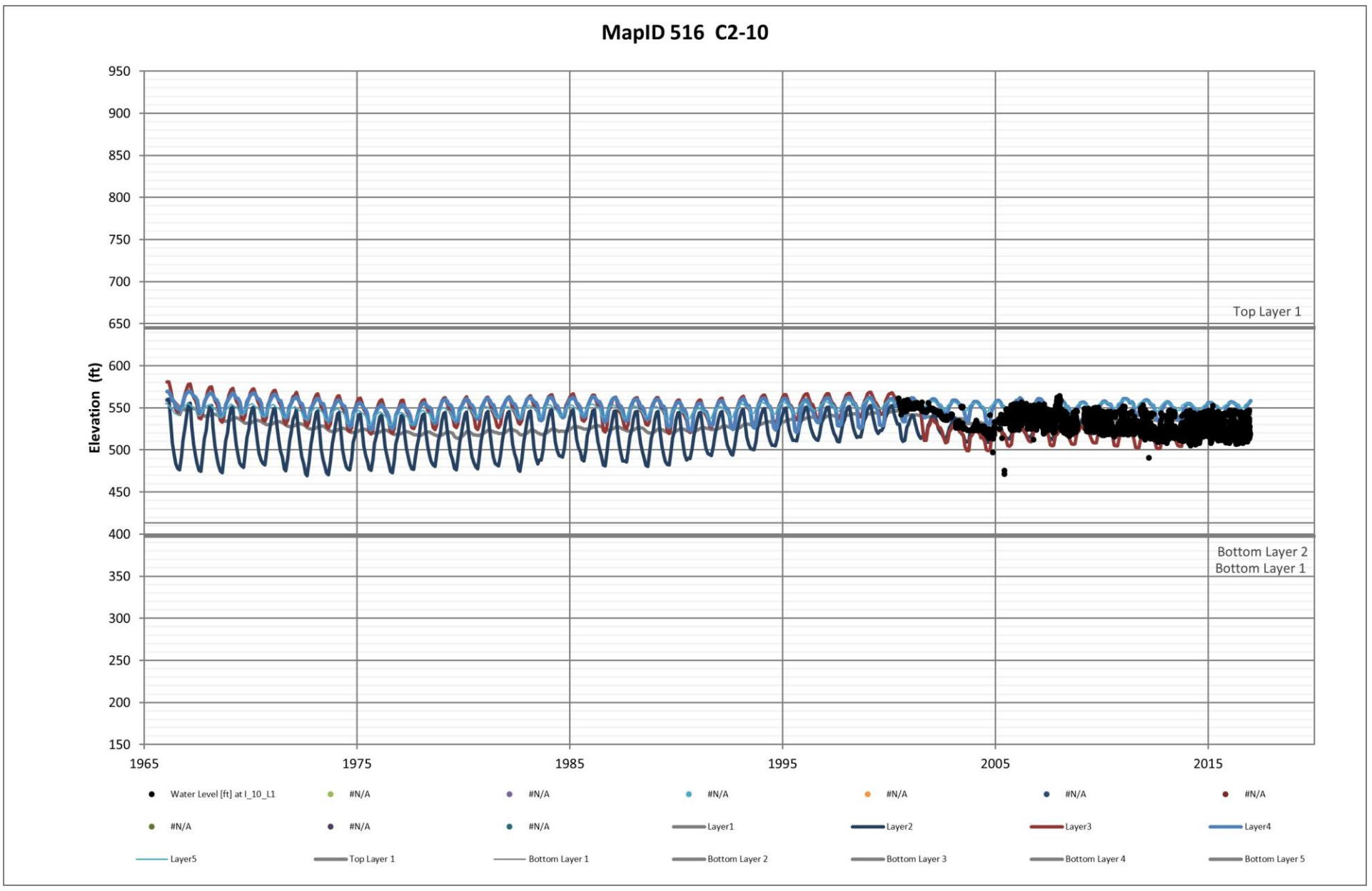


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Figure C2-9
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-9

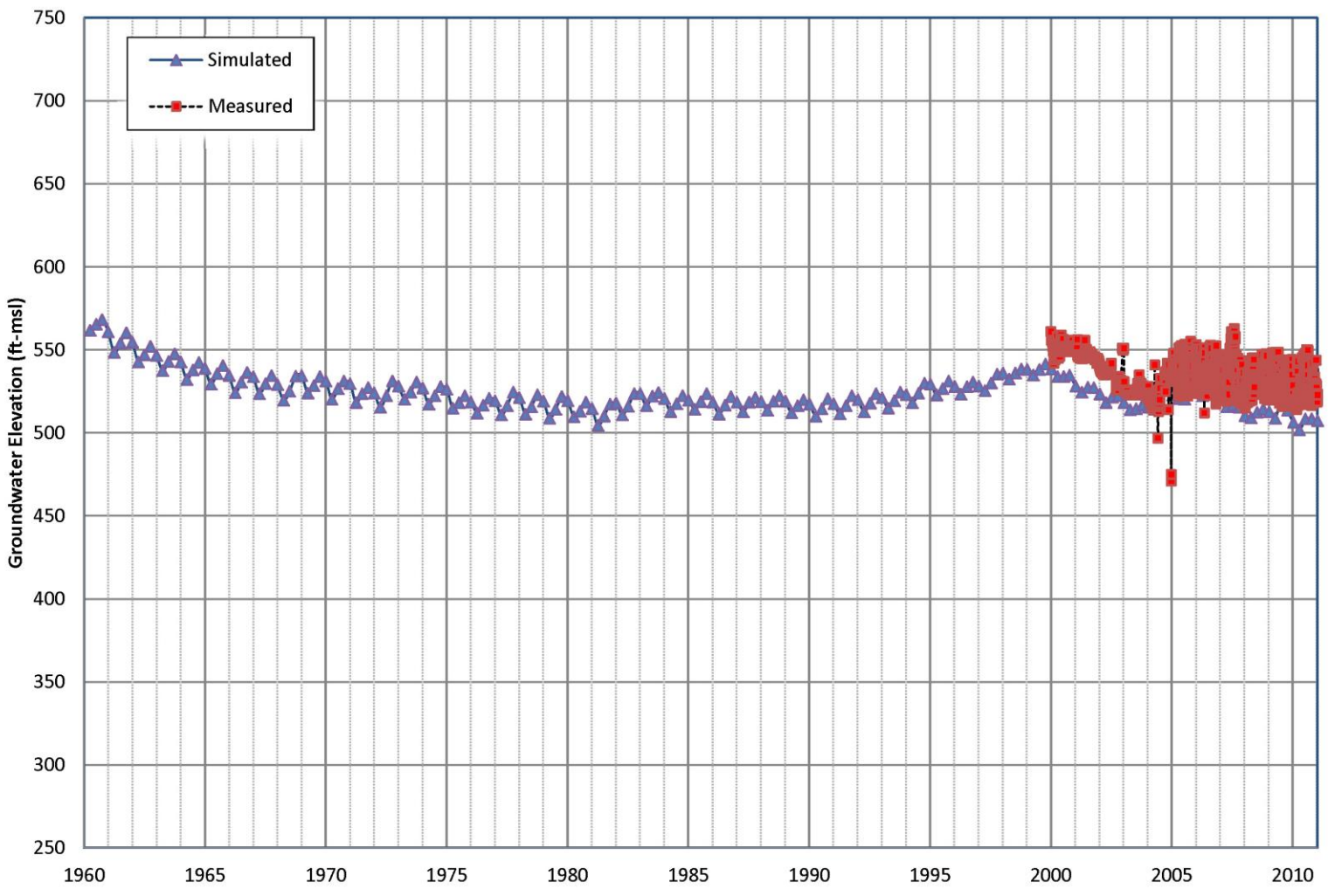


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

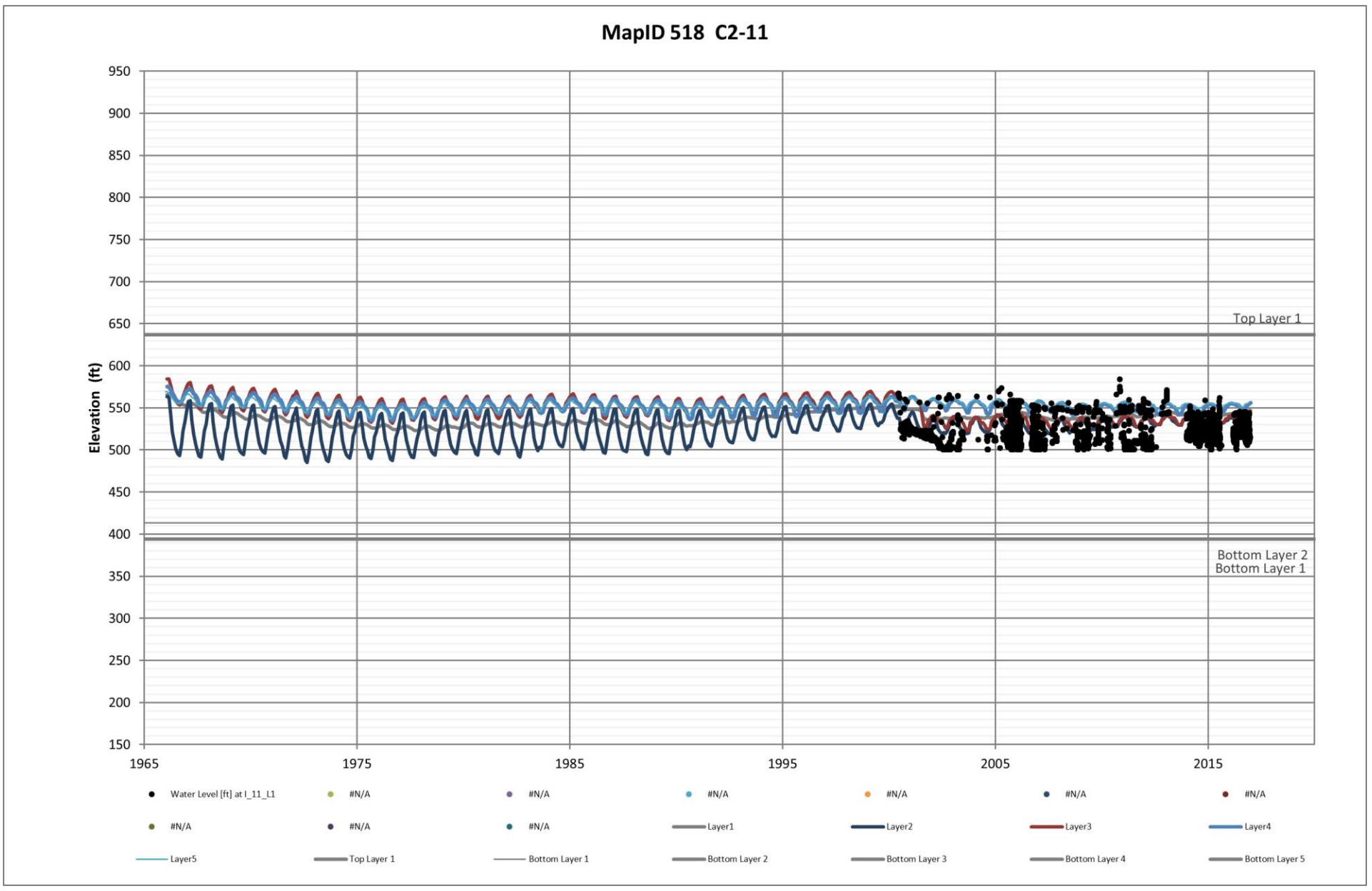


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Figure C2-10
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-10

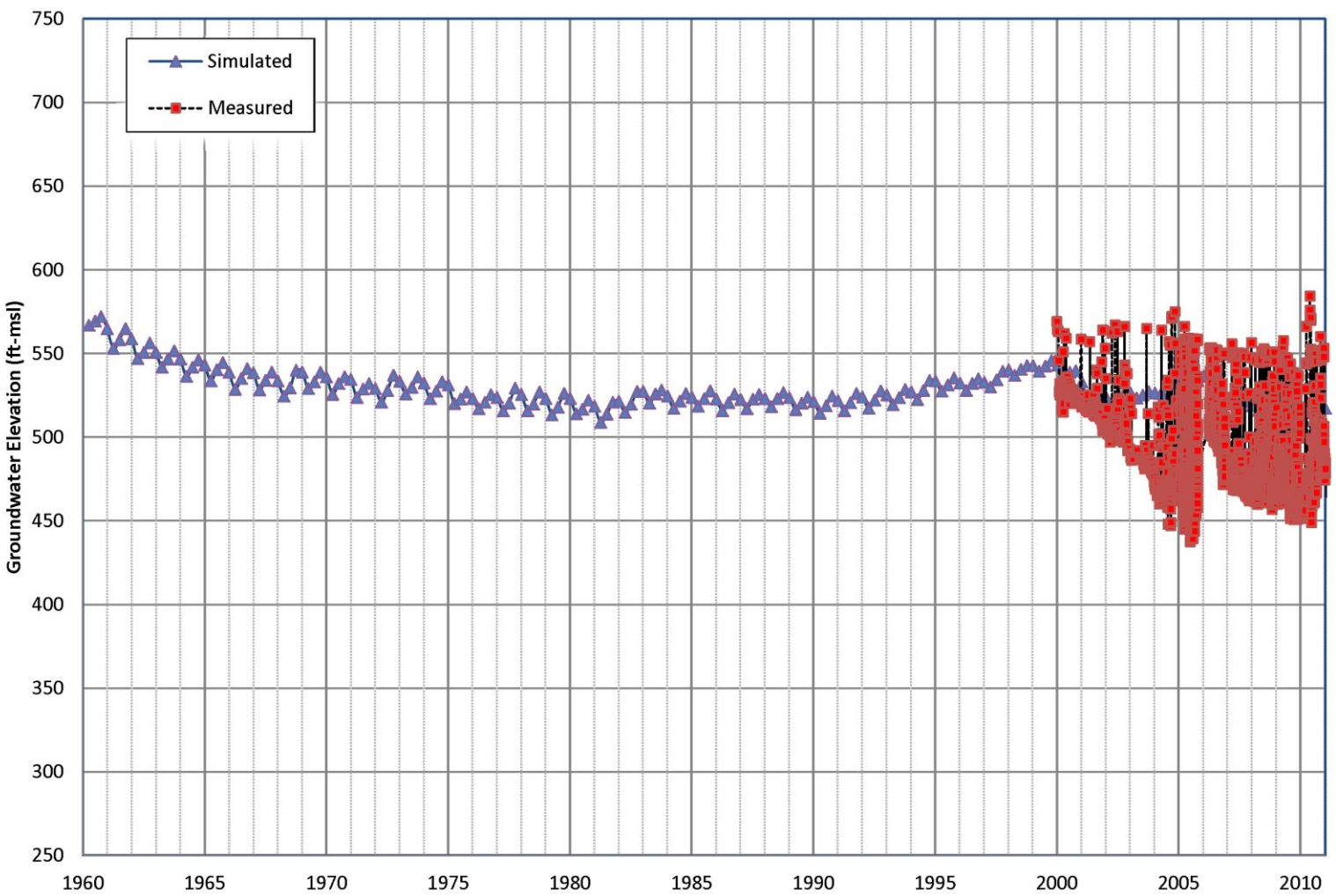


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

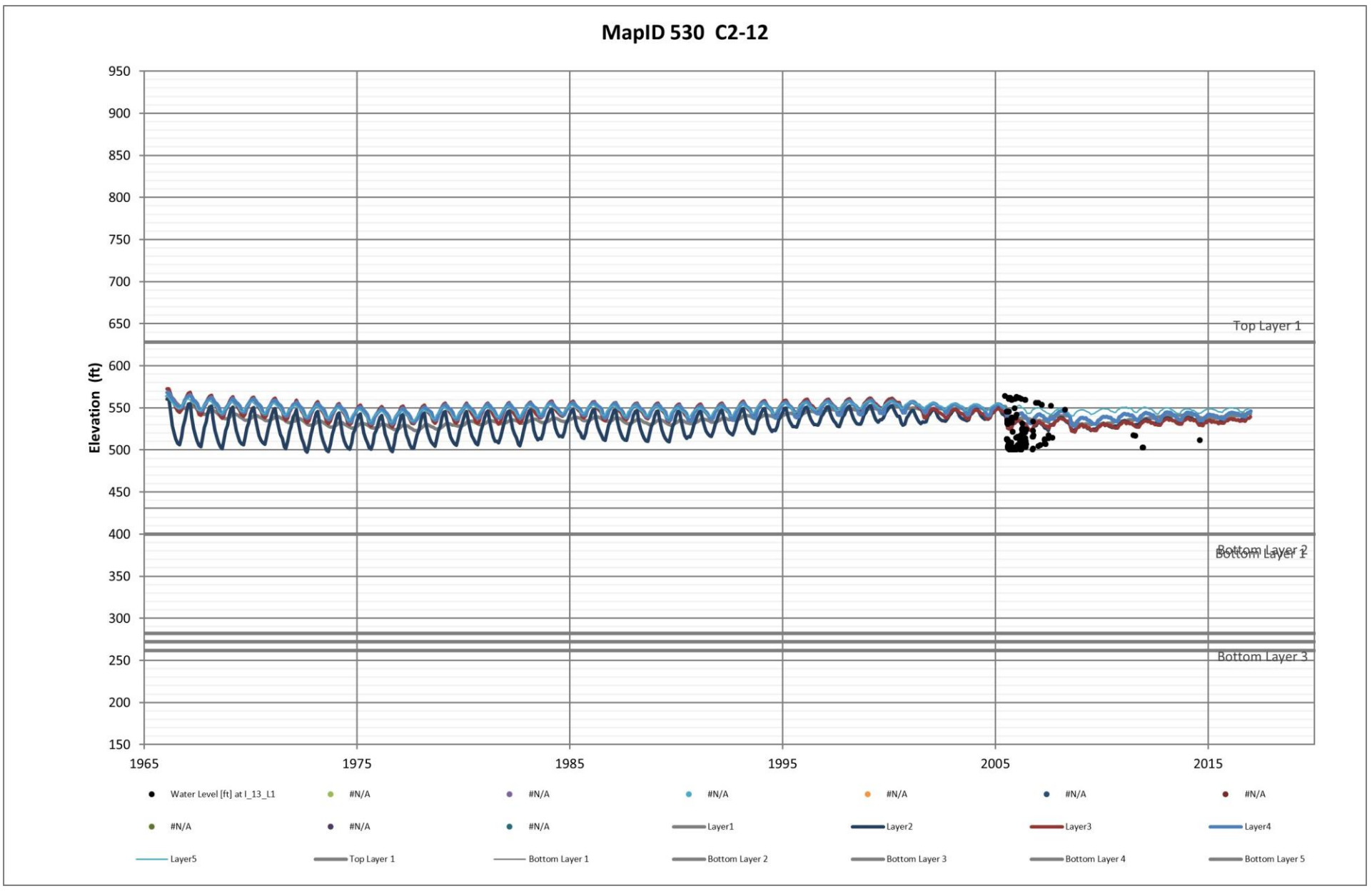


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Figure C2-11
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-11

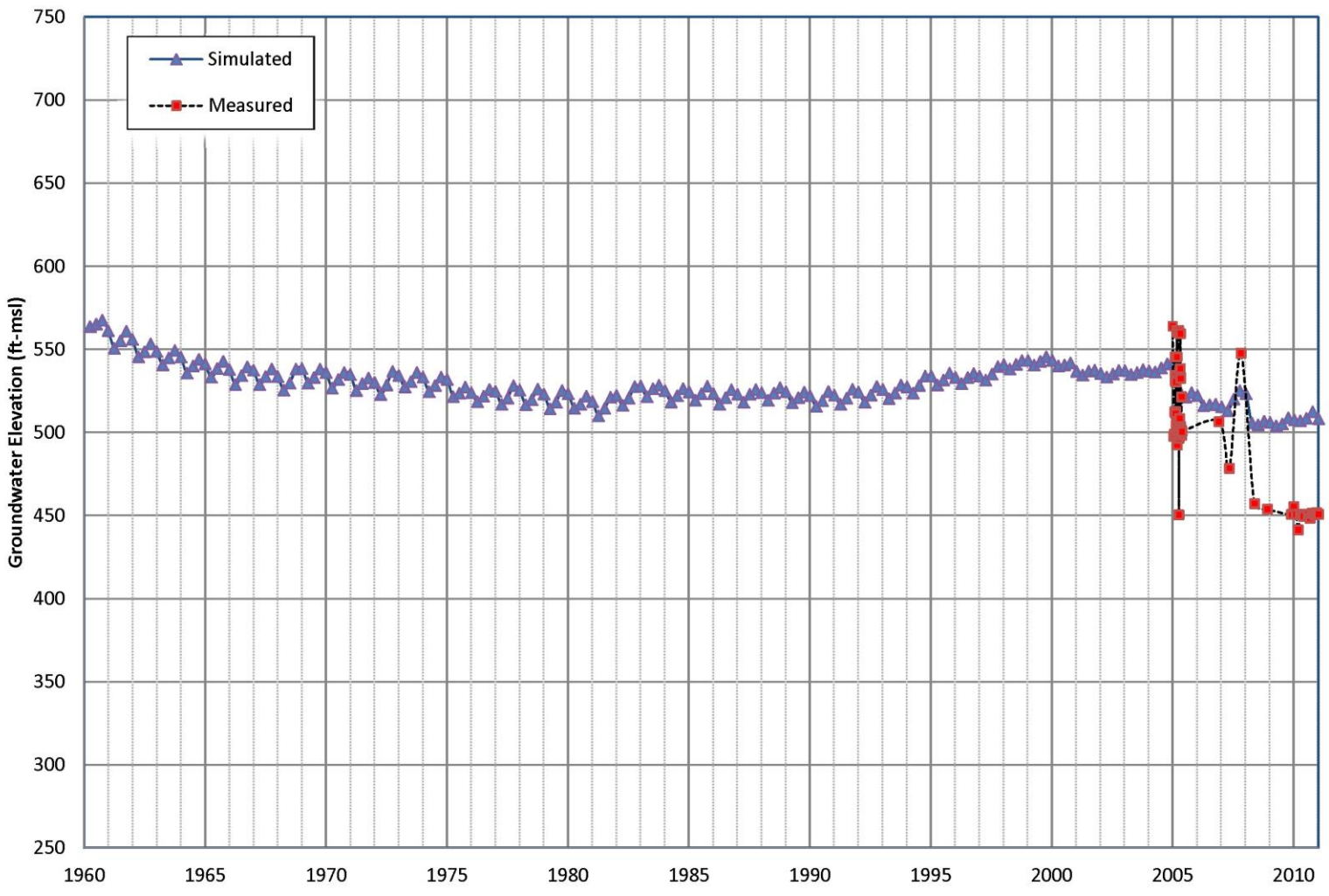


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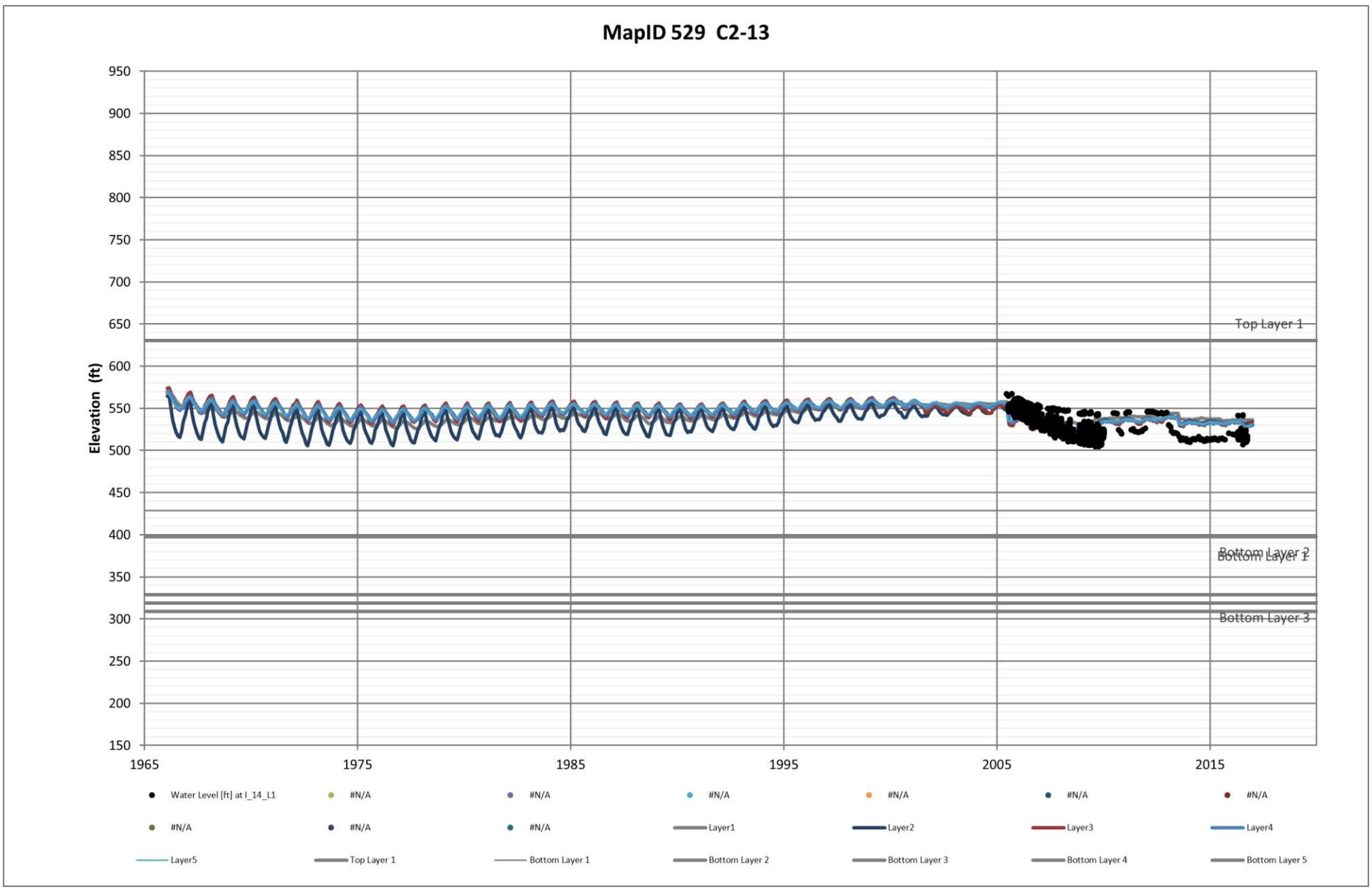


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Figure C2-12
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-13

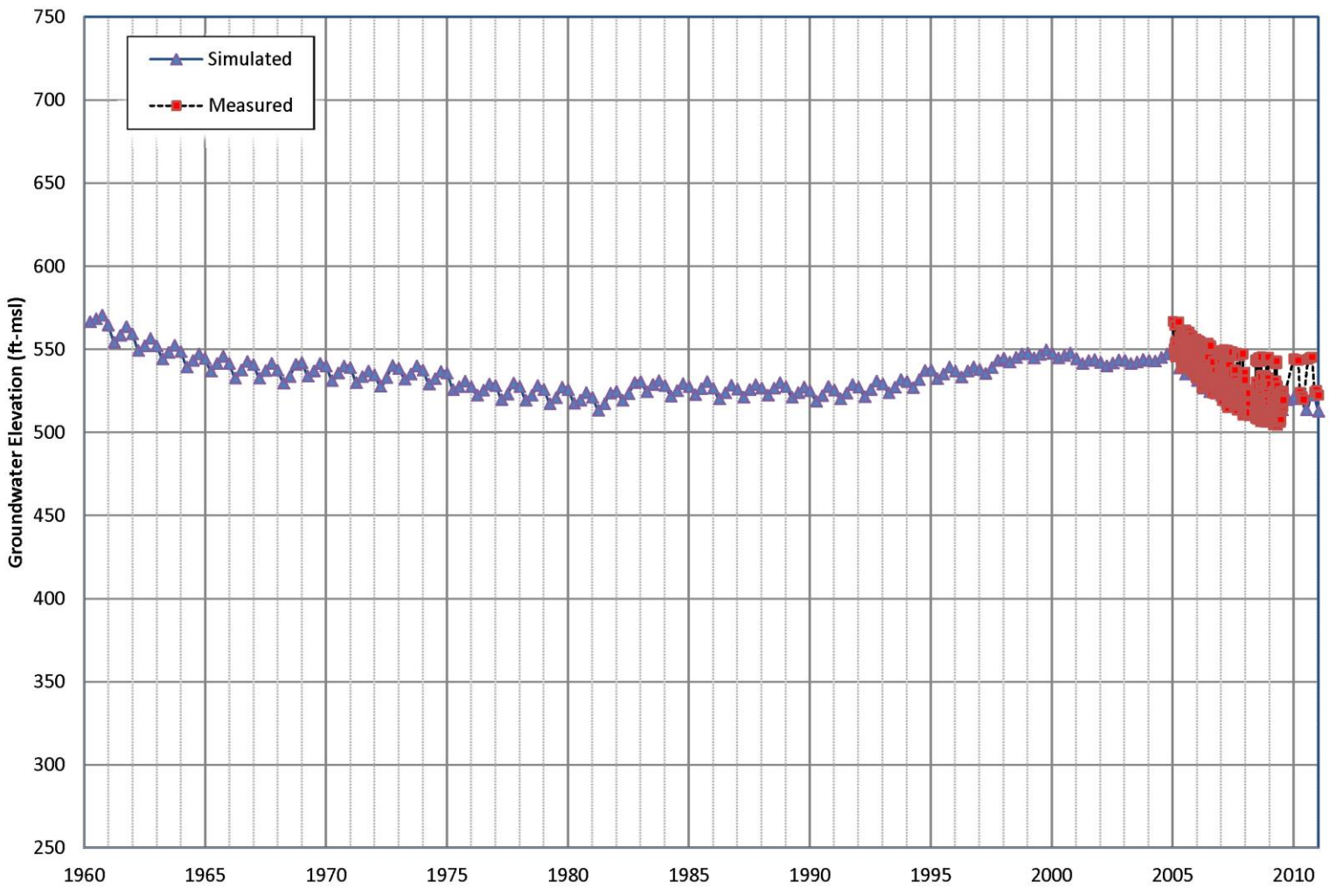


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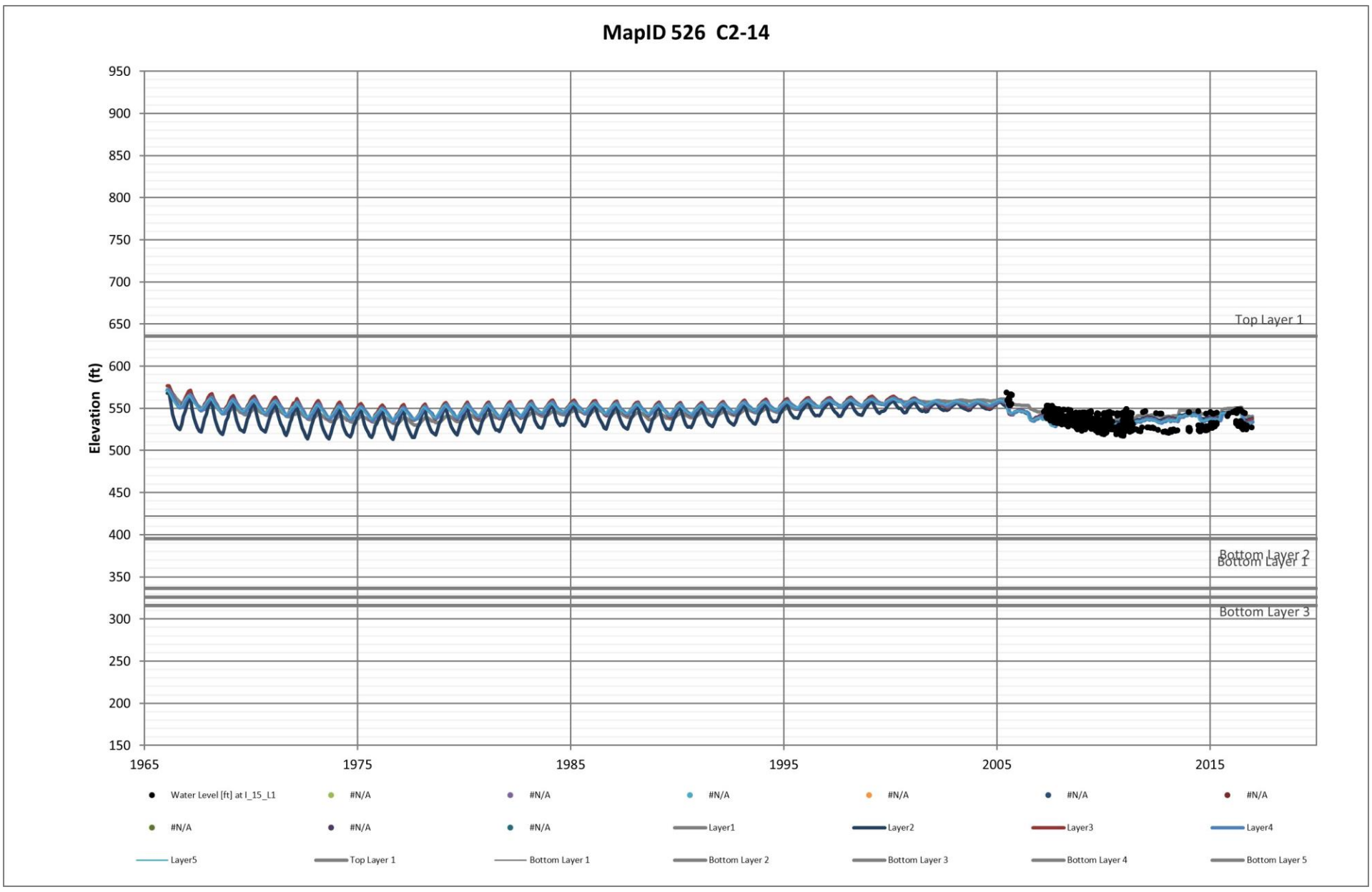


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Figure C2-13
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-14

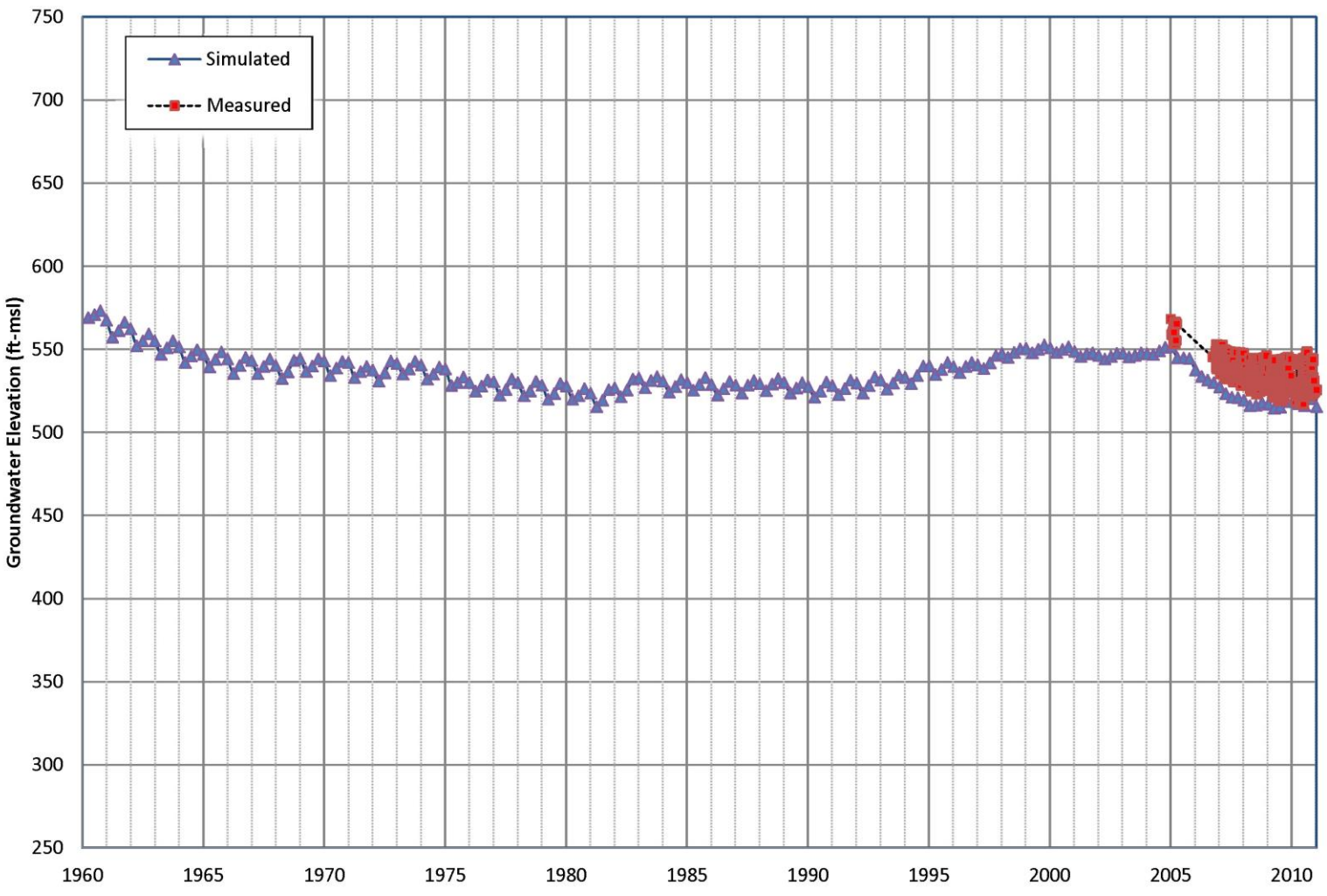


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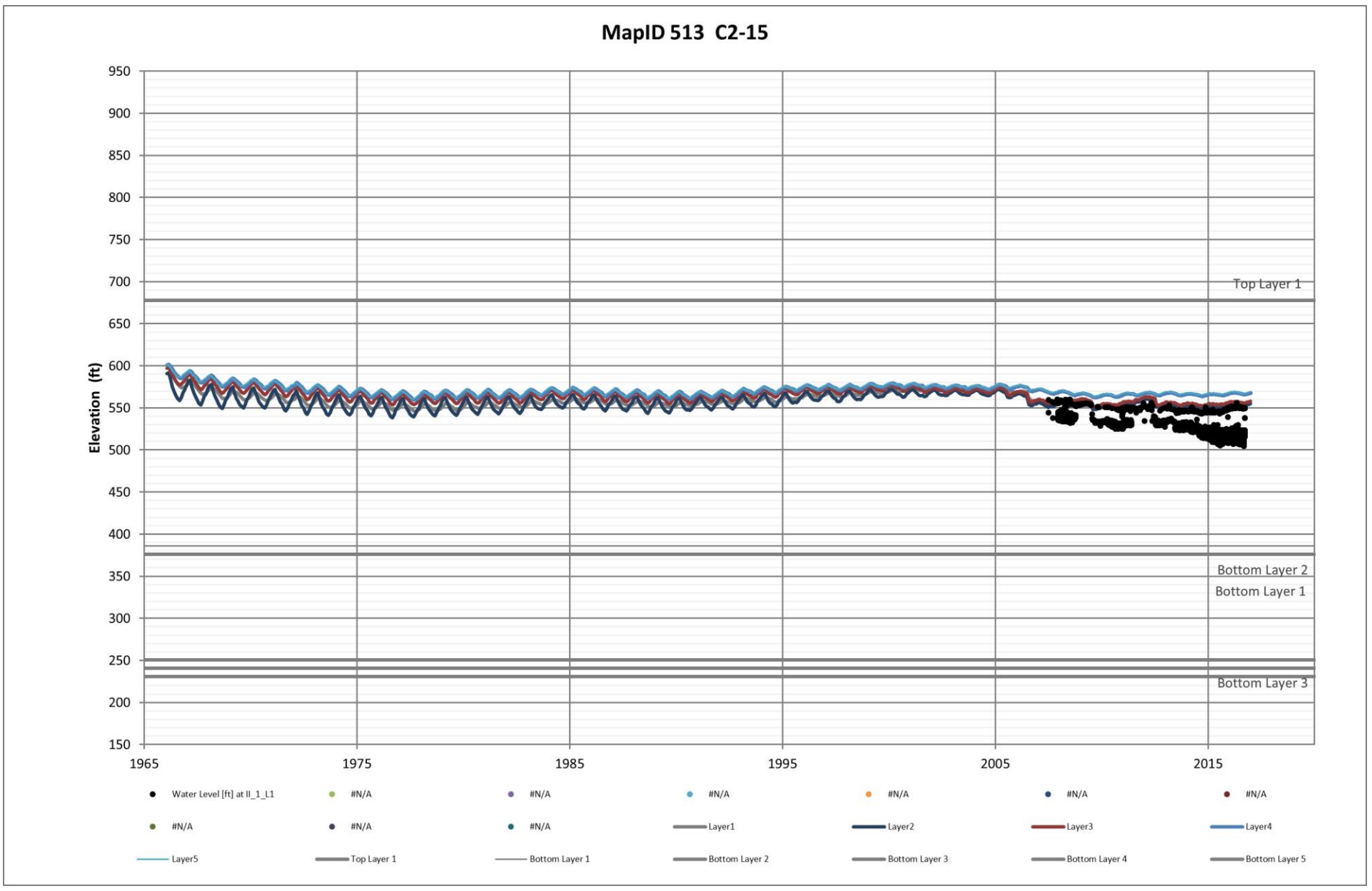


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Figure C2-14
Comparison of Measured and Simulated Groundwater Levels in CDA Well I-15

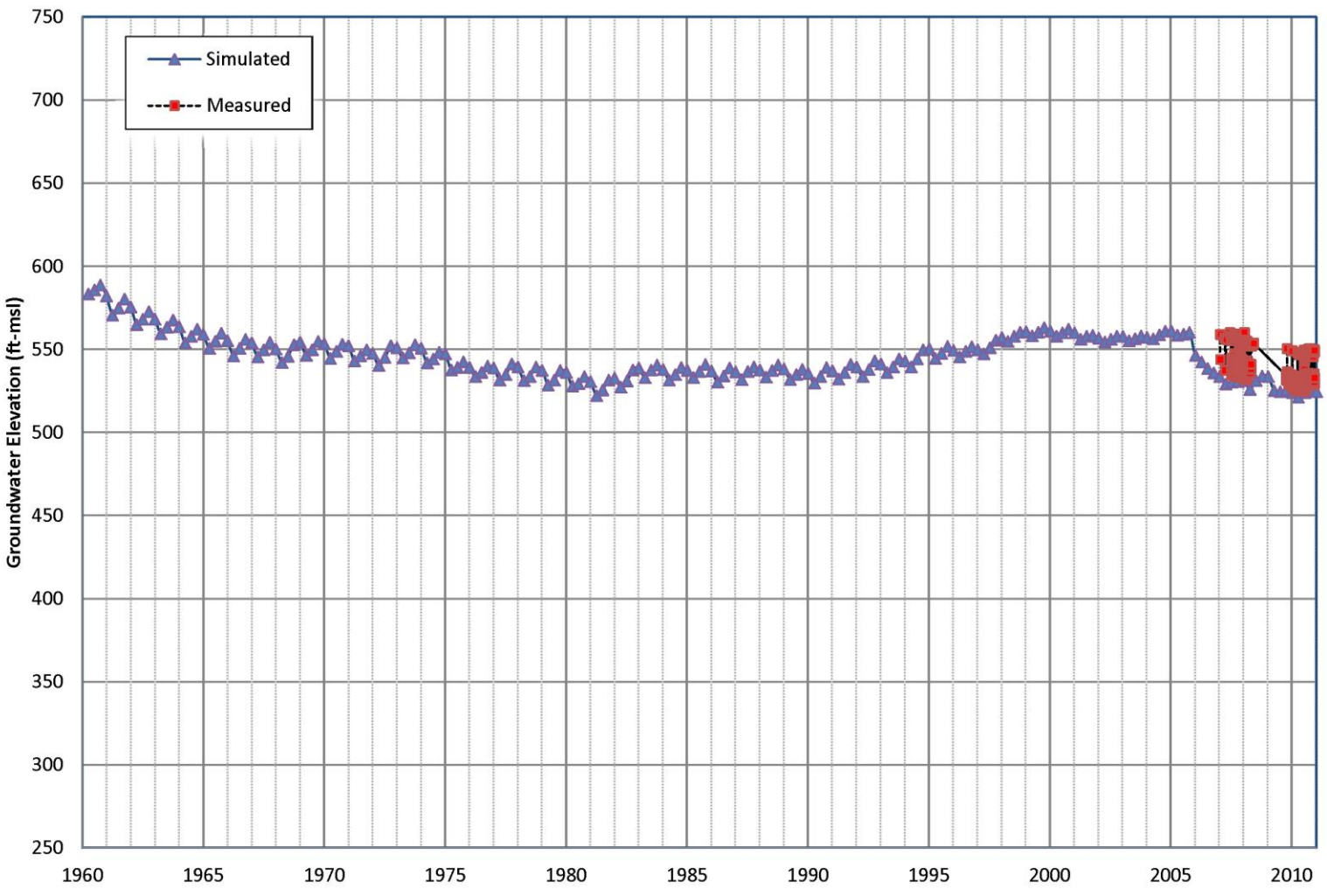


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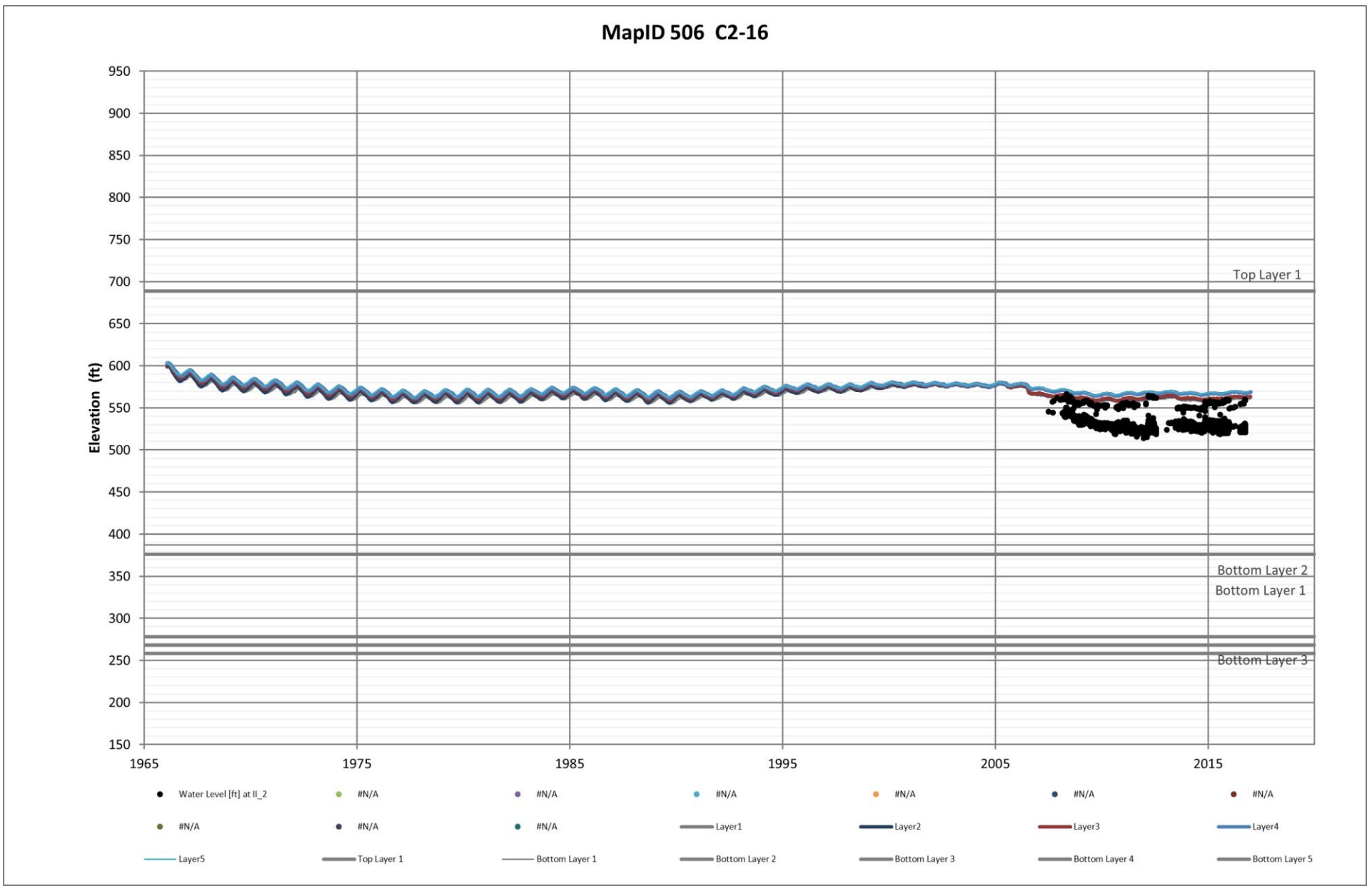


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Figure C2-15
Comparison of Measured and Simulated Groundwater Levels in CDA Well II-1

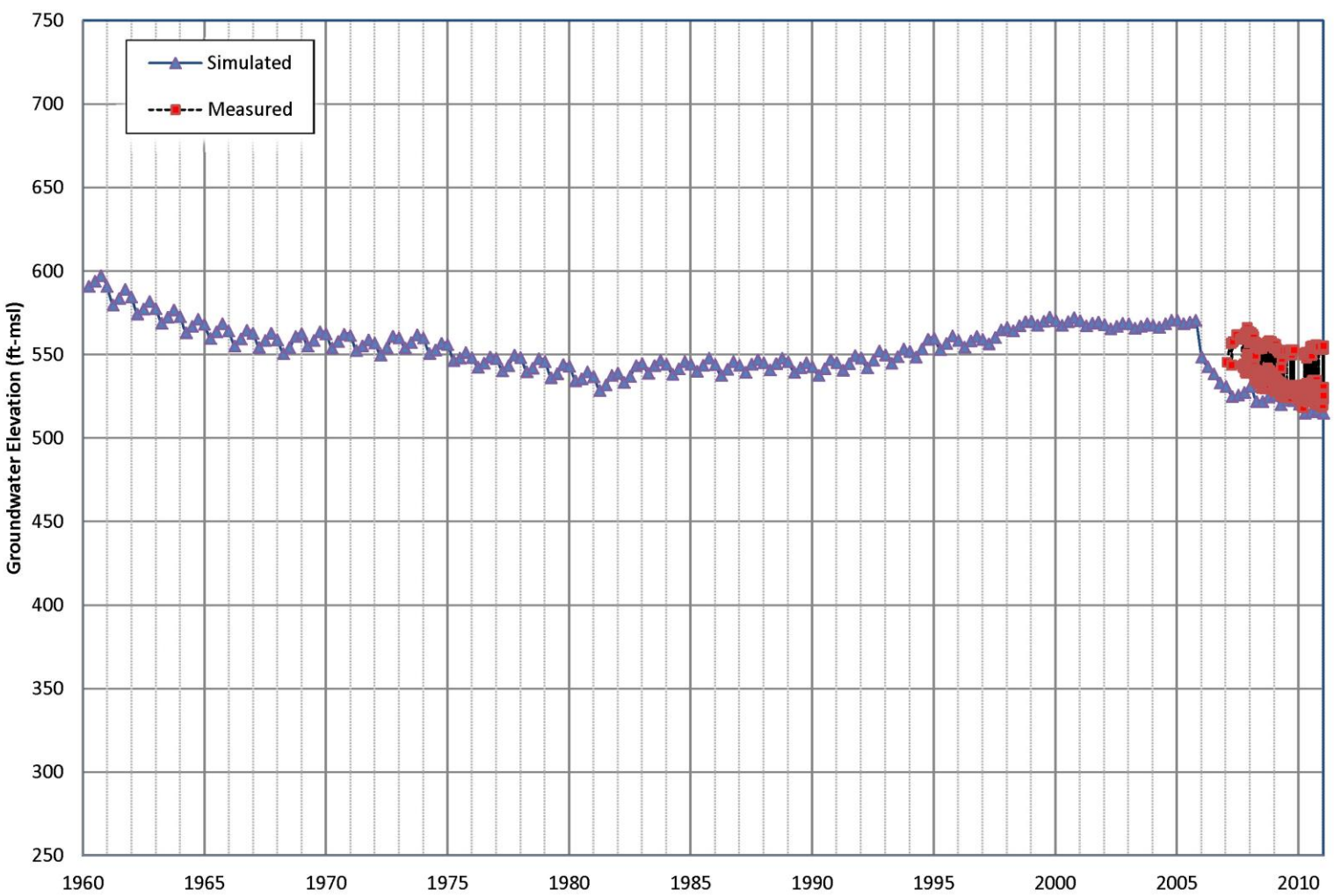


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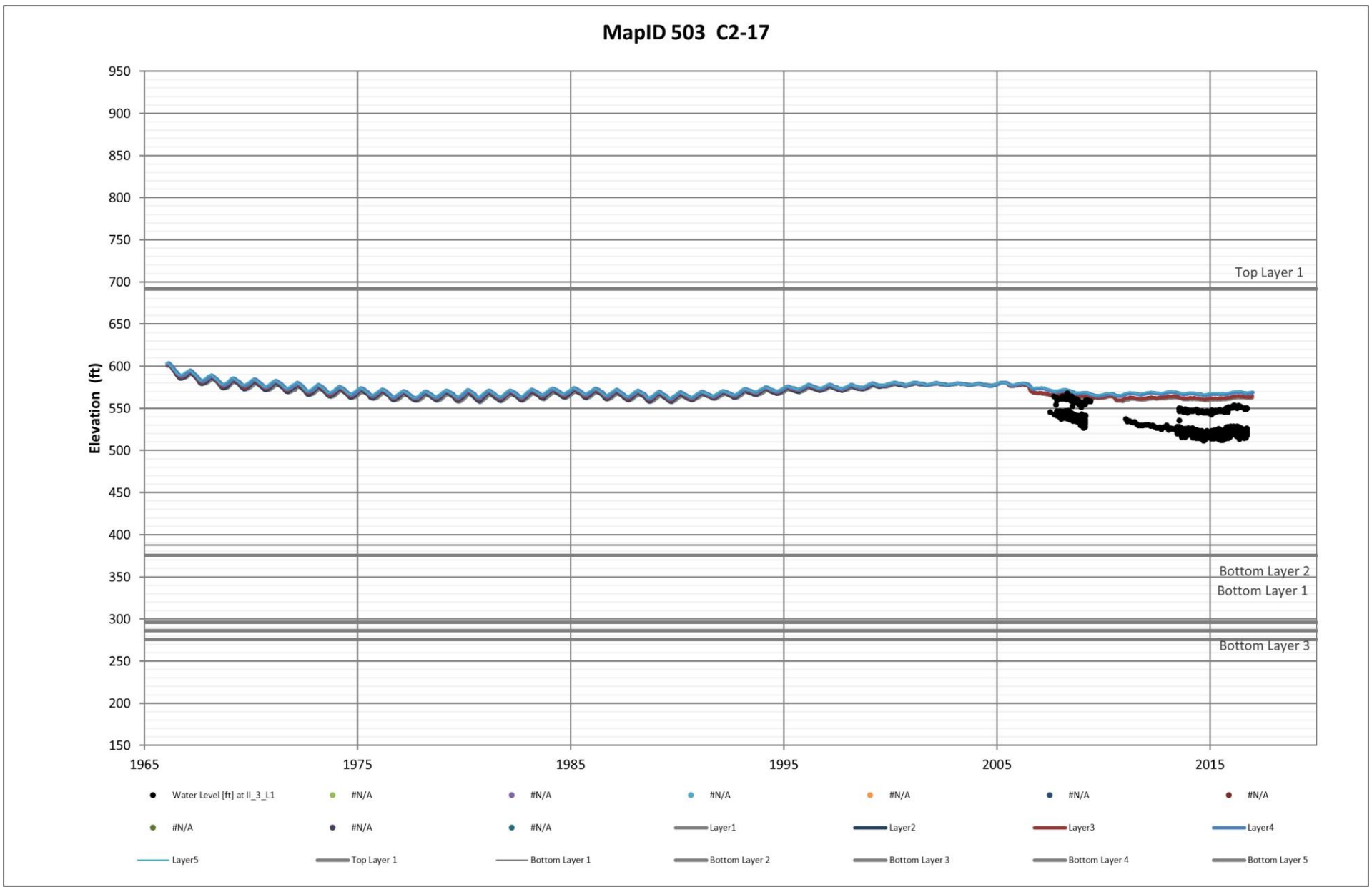


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Figure C2-16
Comparison of Measured and Simulated Groundwater Levels in CDA Well II-2

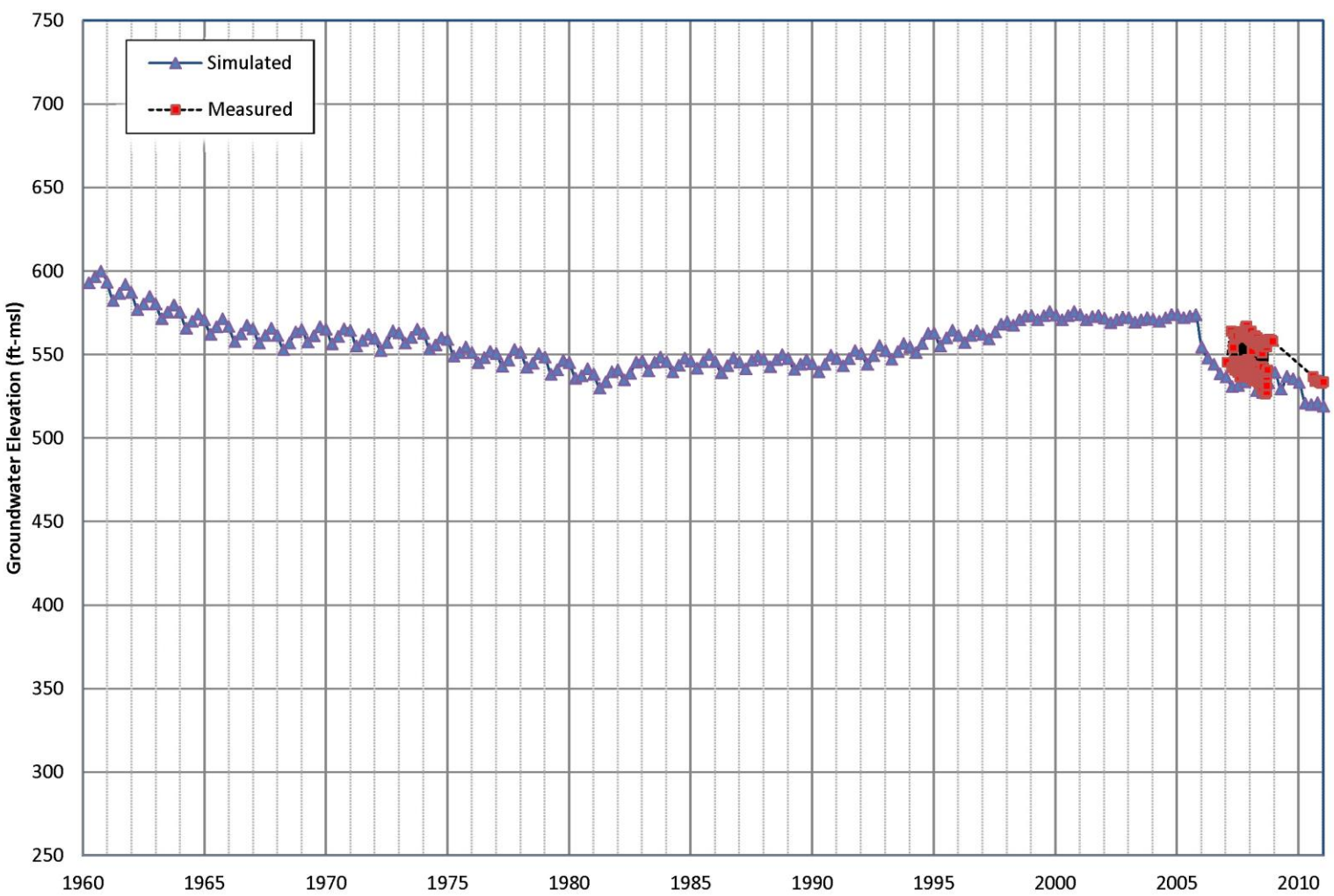


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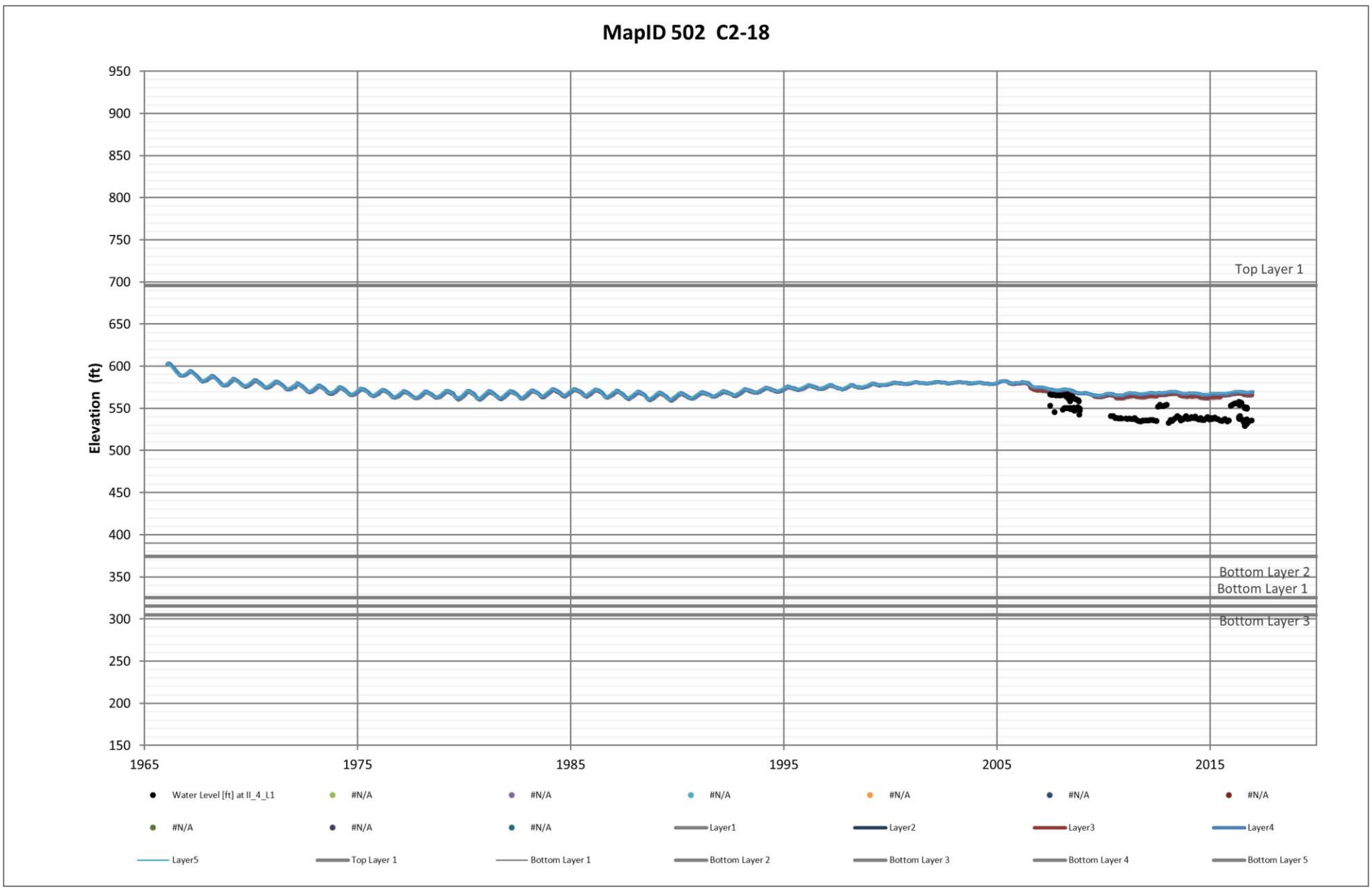


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Figure C2-17
Comparison of Measured and Simulated Groundwater Levels in CDA Well II-3

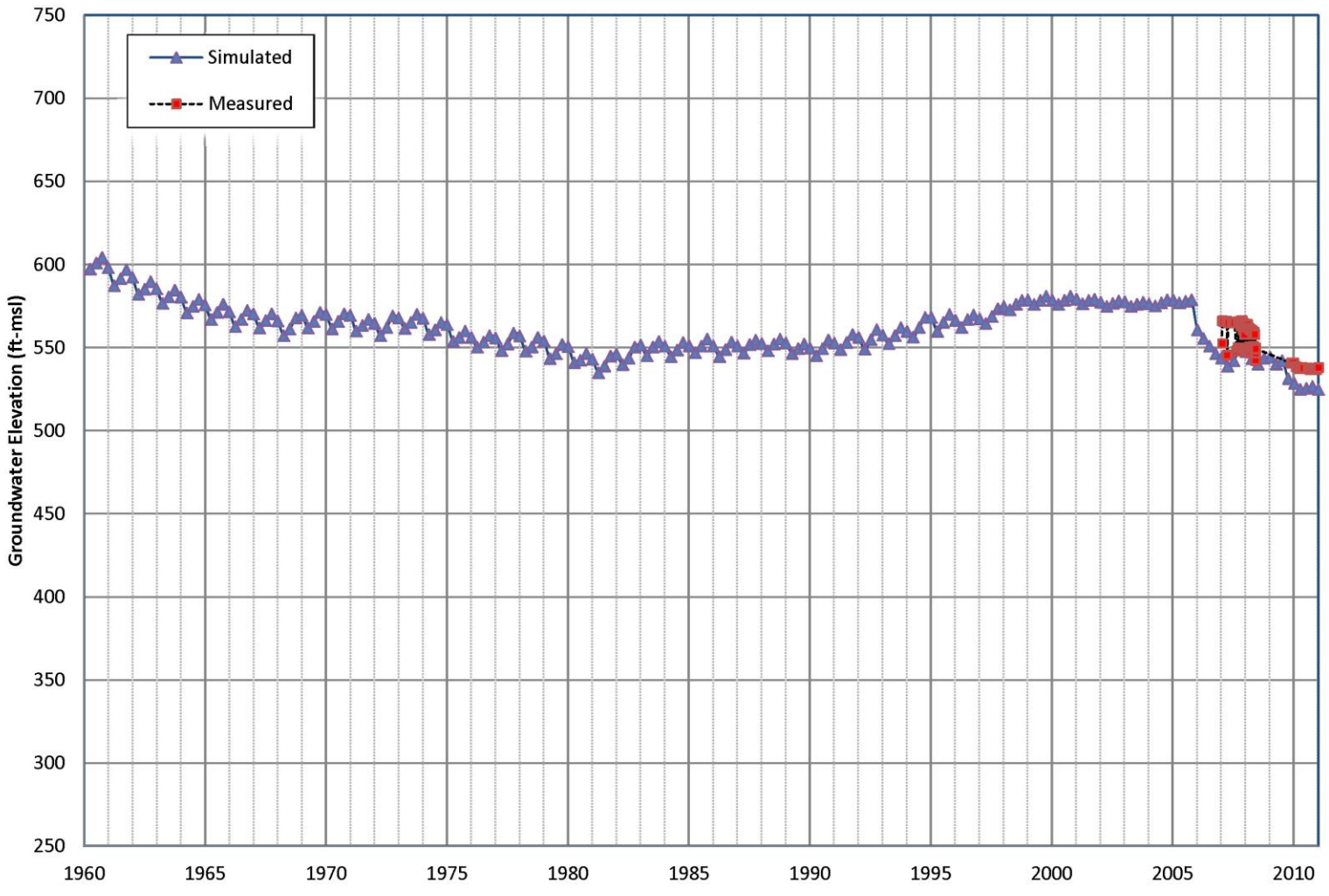


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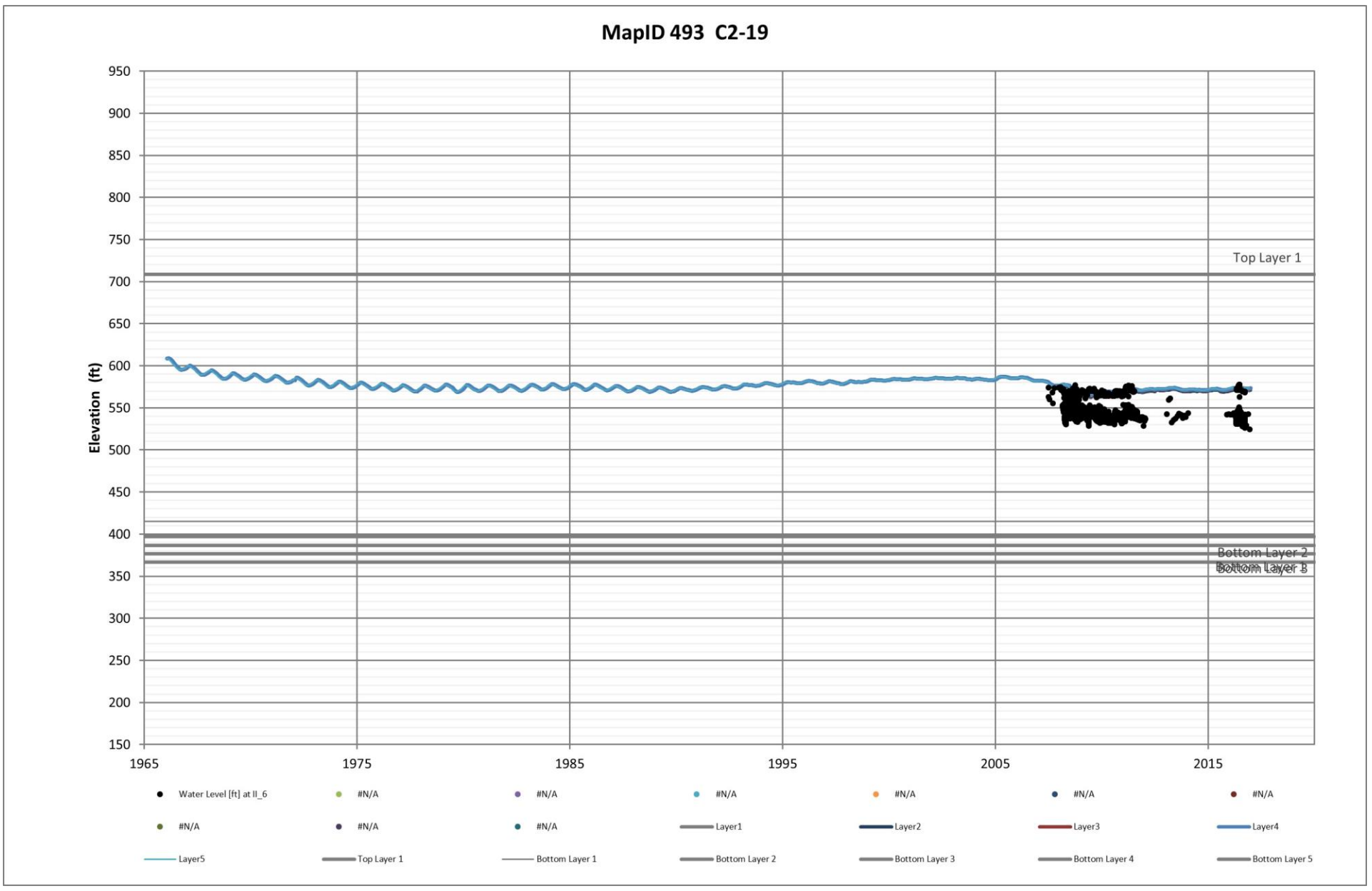


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Figure C2-18
Comparison of Measured and Simulated Groundwater Levels in CDA Well II-4

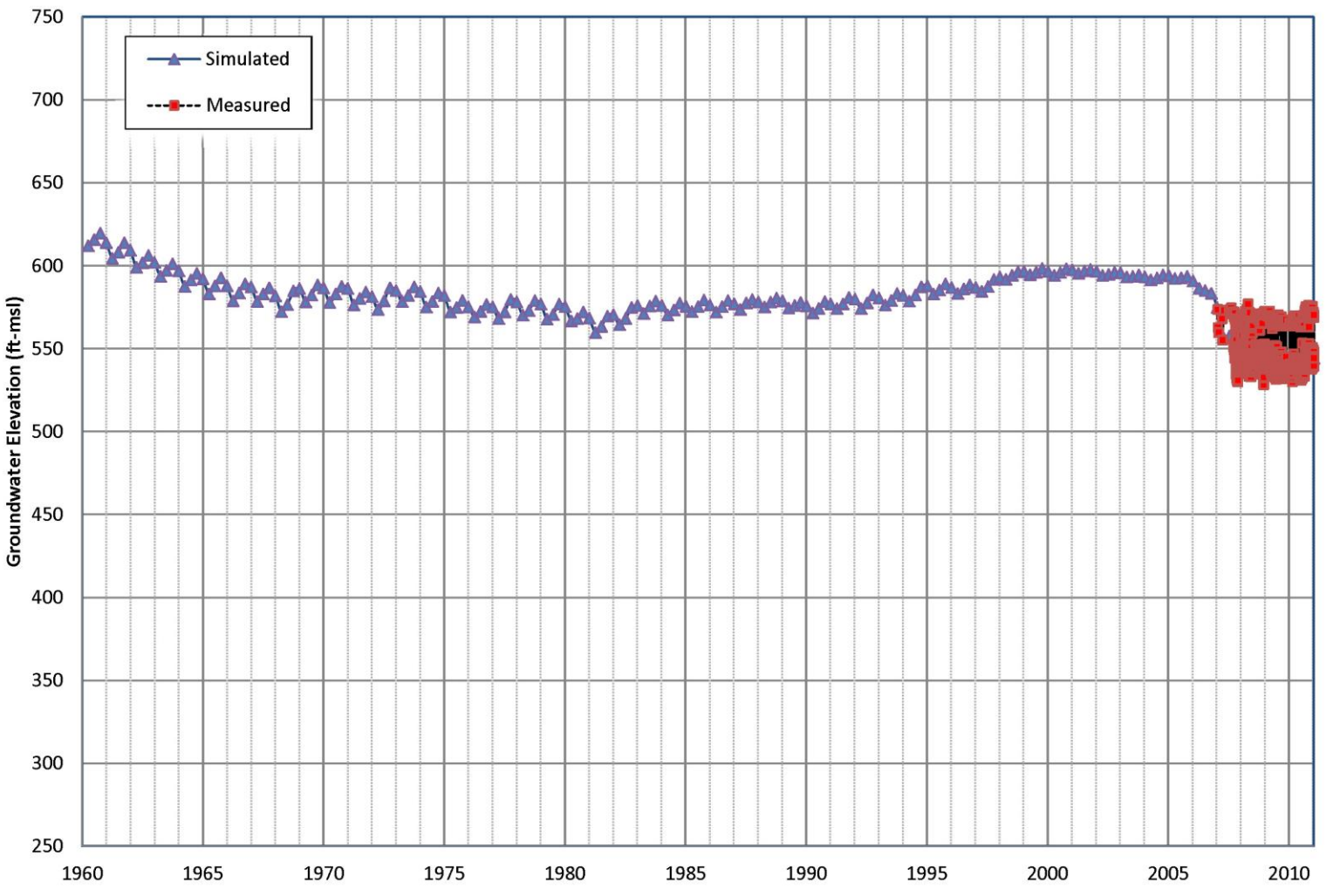


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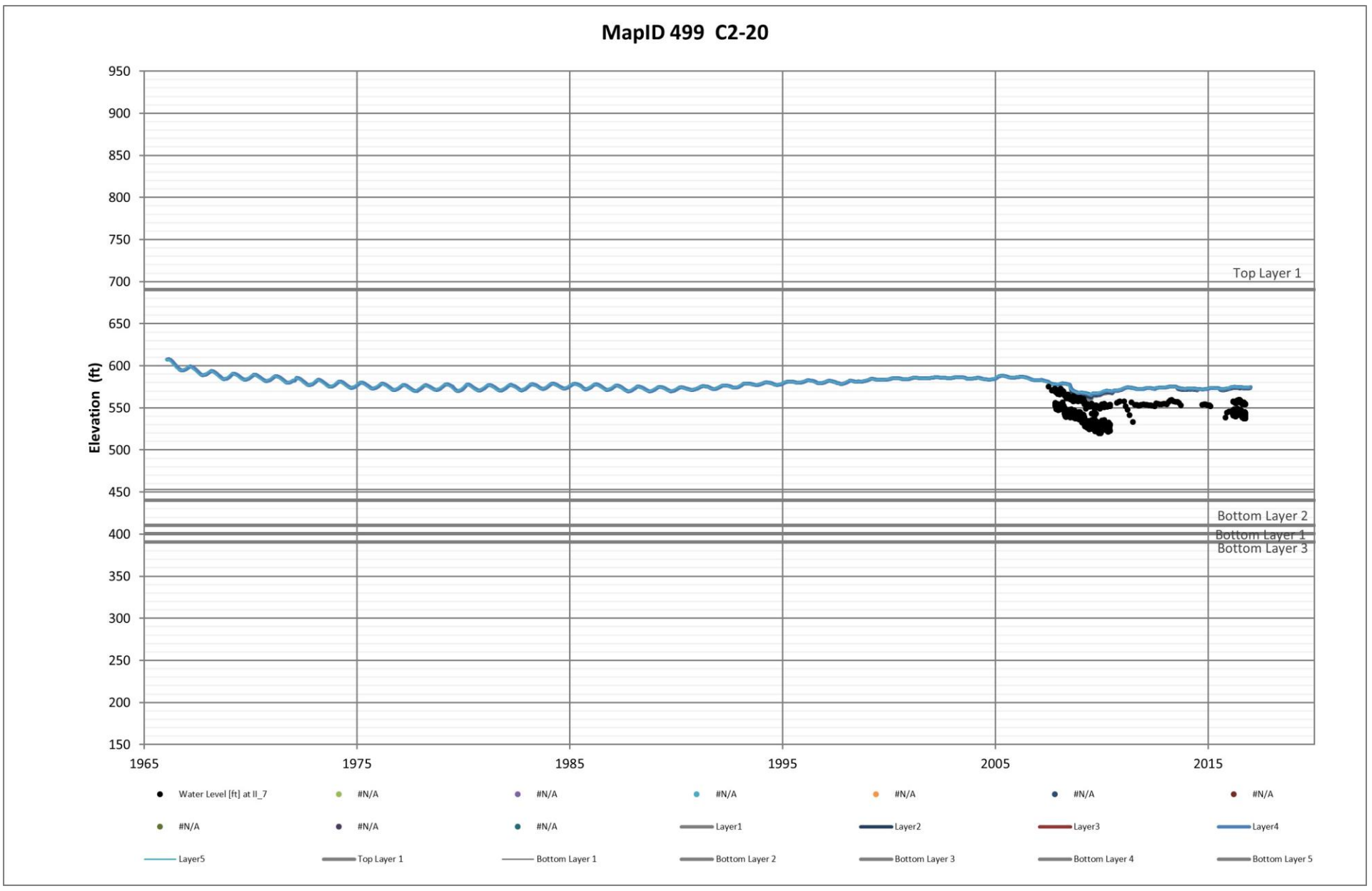


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Figure C2-19
Comparison of Measured and Simulated Groundwater Levels in CDA Well II-6

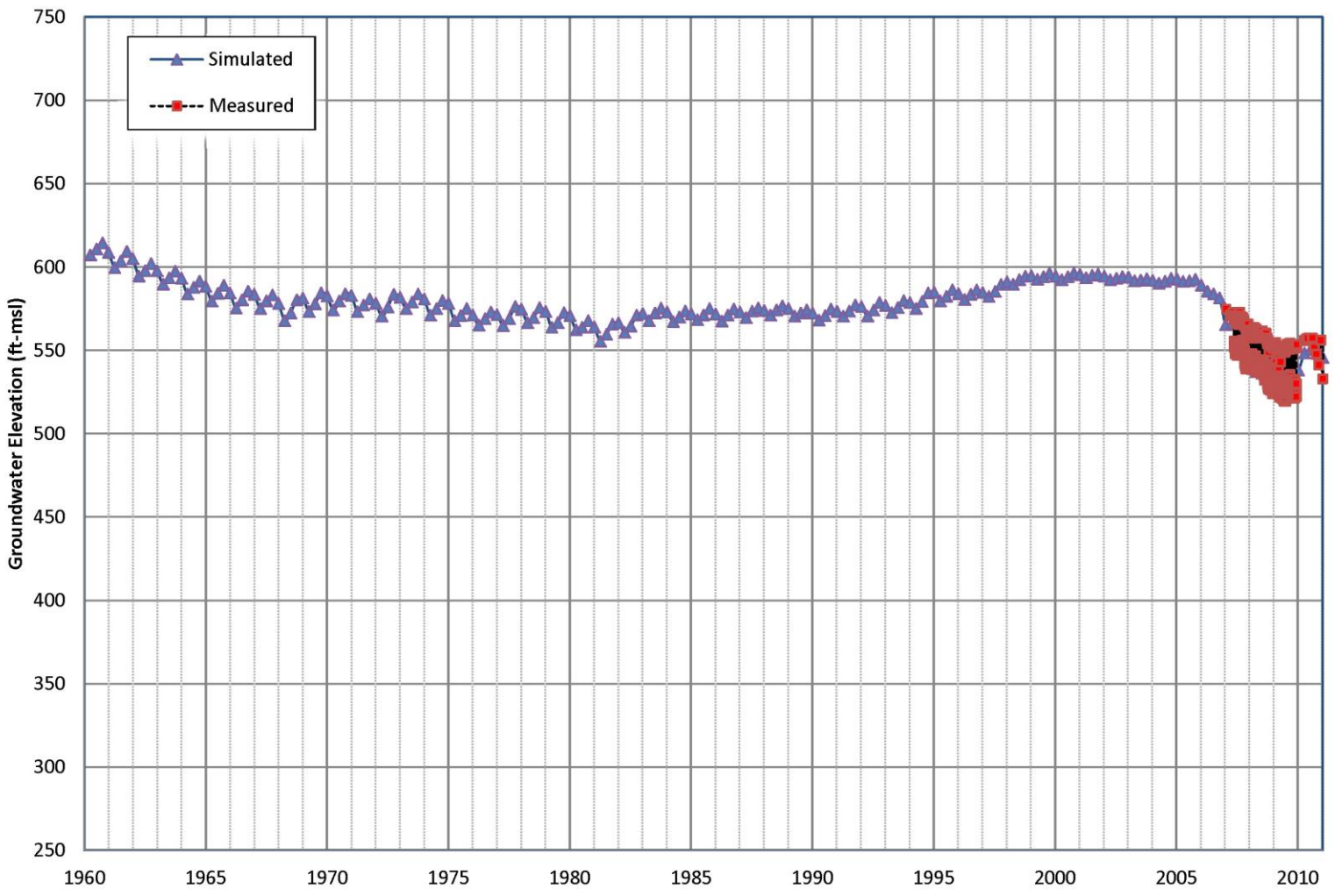


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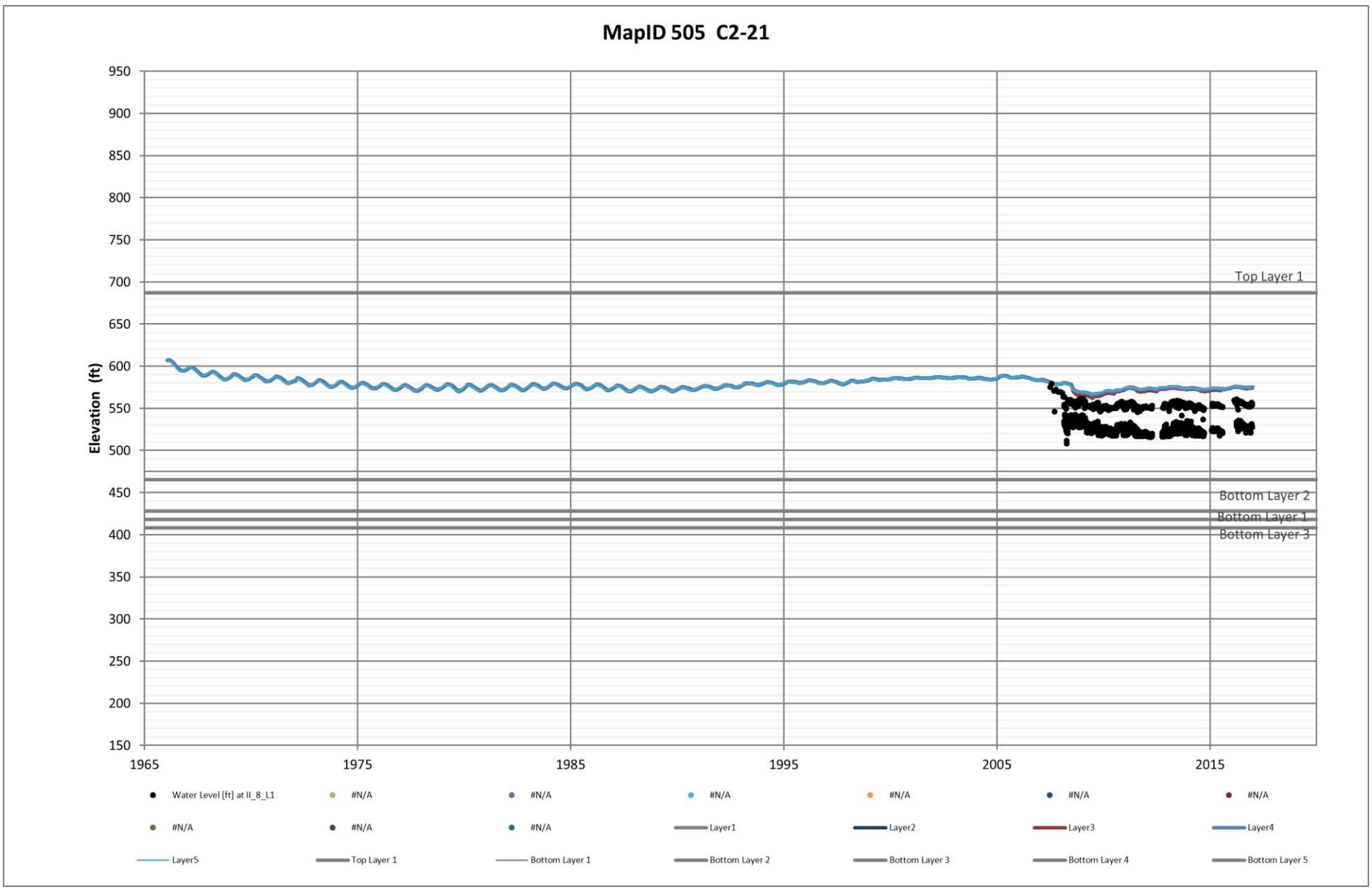


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Figure C2-20
Comparison of Measured and Simulated Groundwater Levels in CDA Well II-7

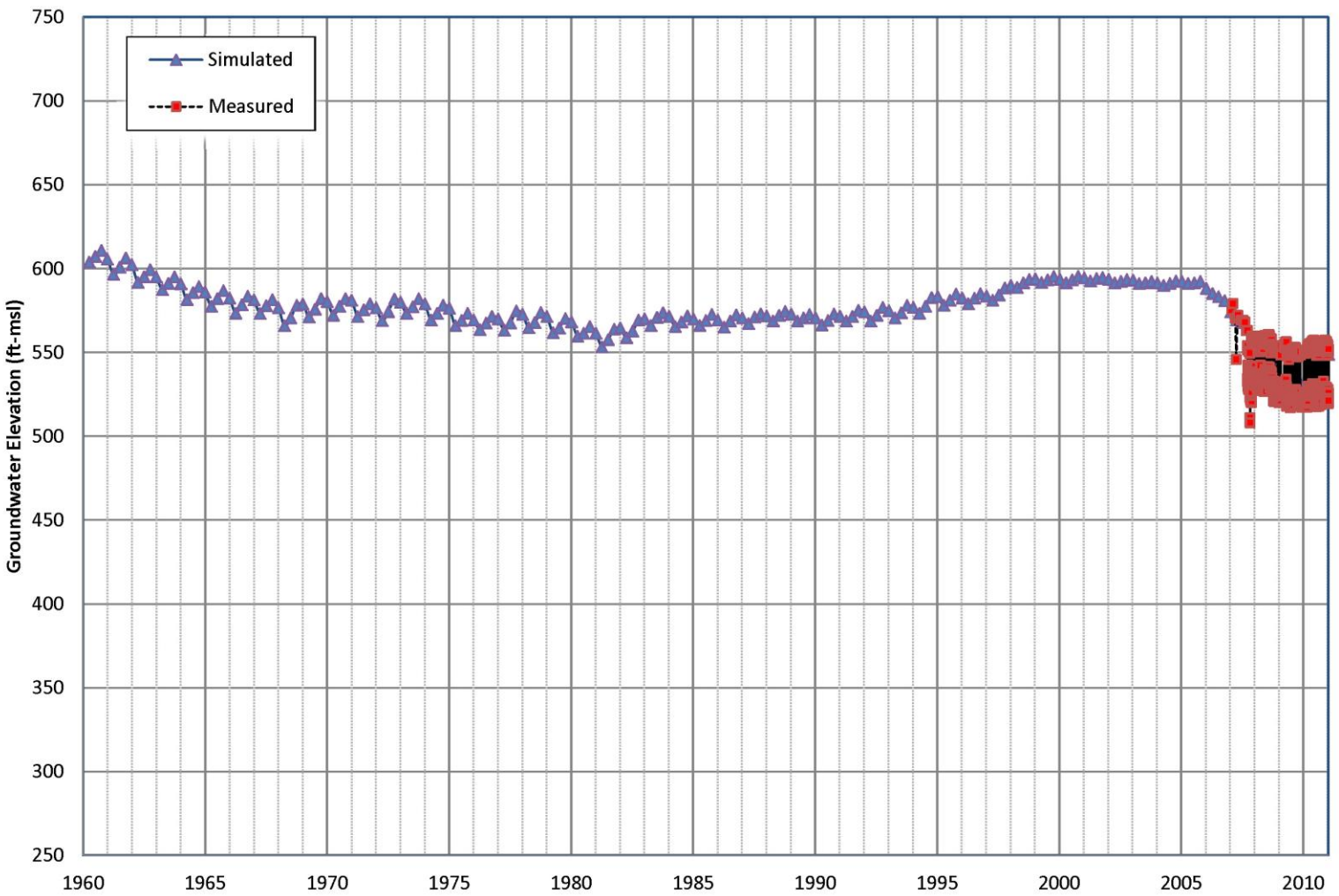


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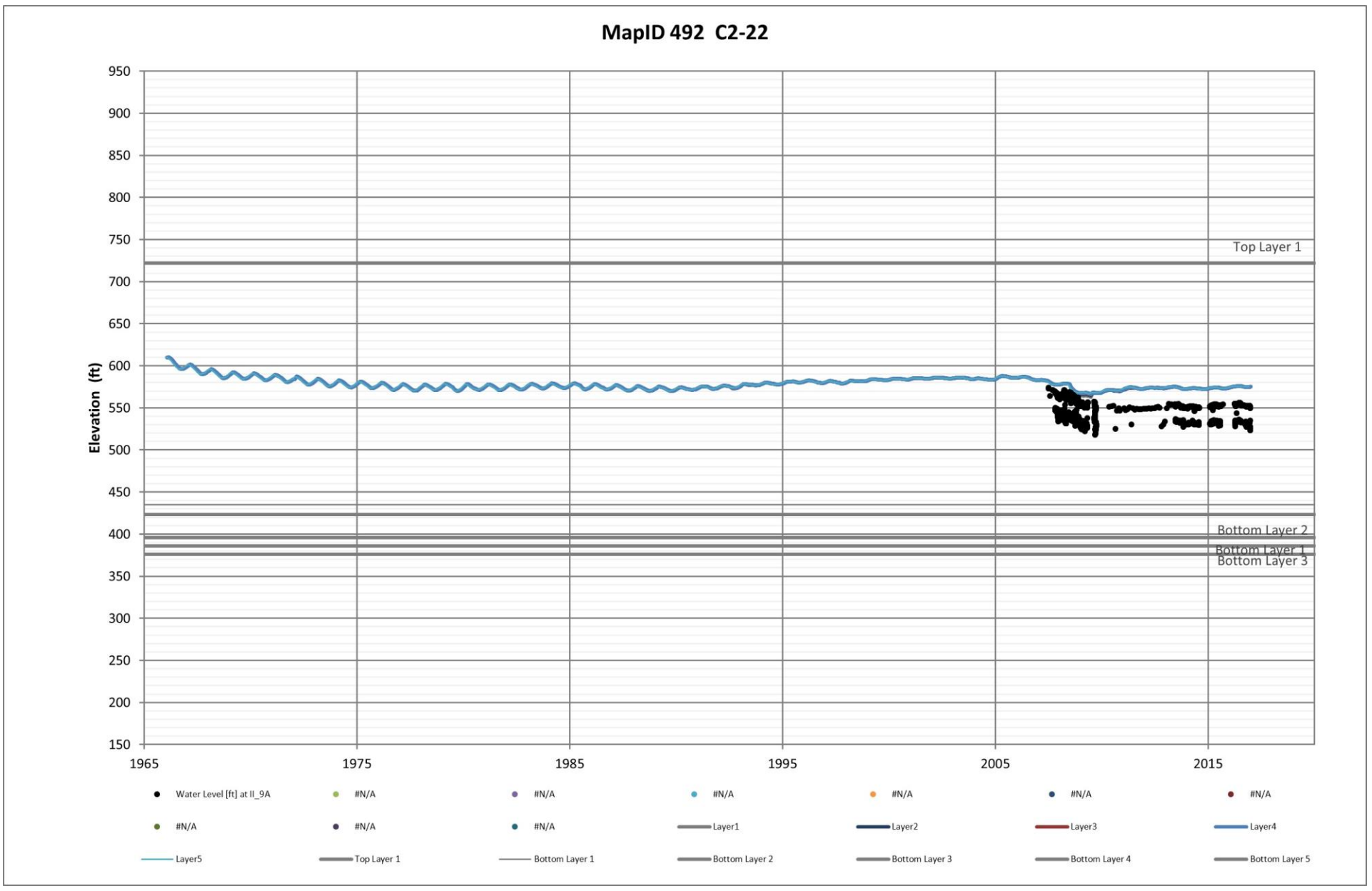


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Figure C2-21
Comparison of Measured and Simulated Groundwater Levels in CDA Well II-8

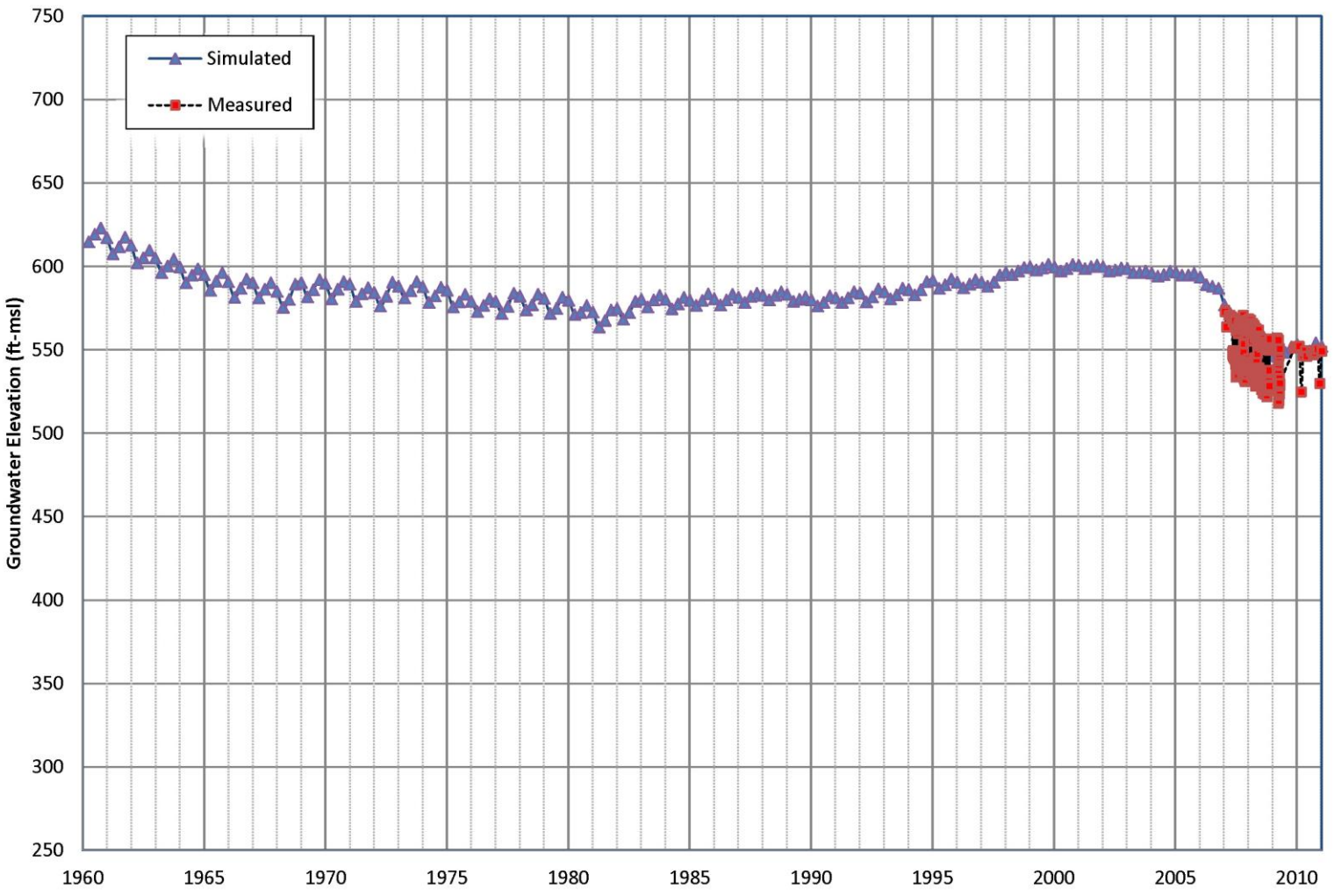


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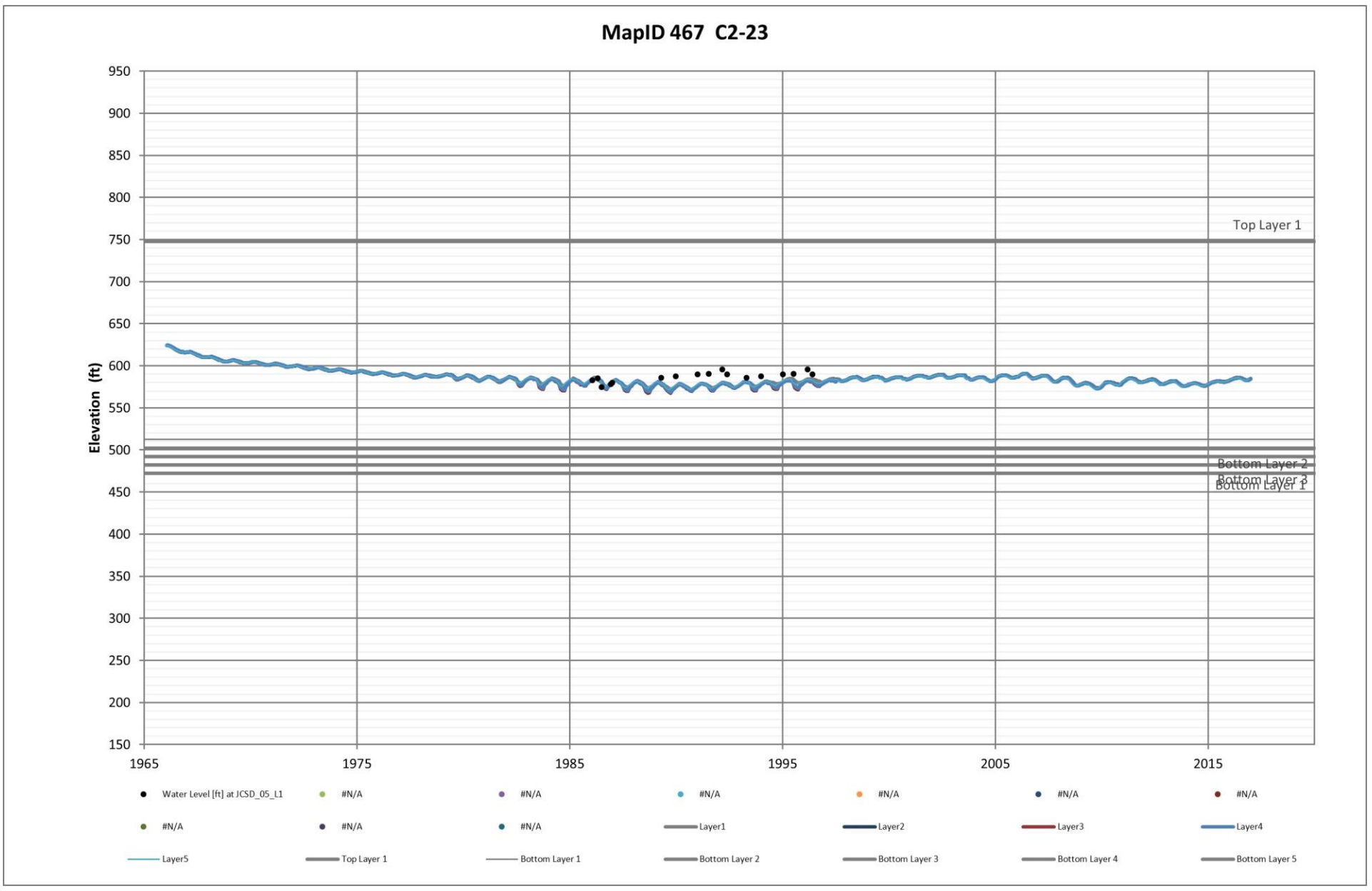


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Figure C2-22
Comparison of Measured and Simulated Groundwater Levels in CDA Well II-9A

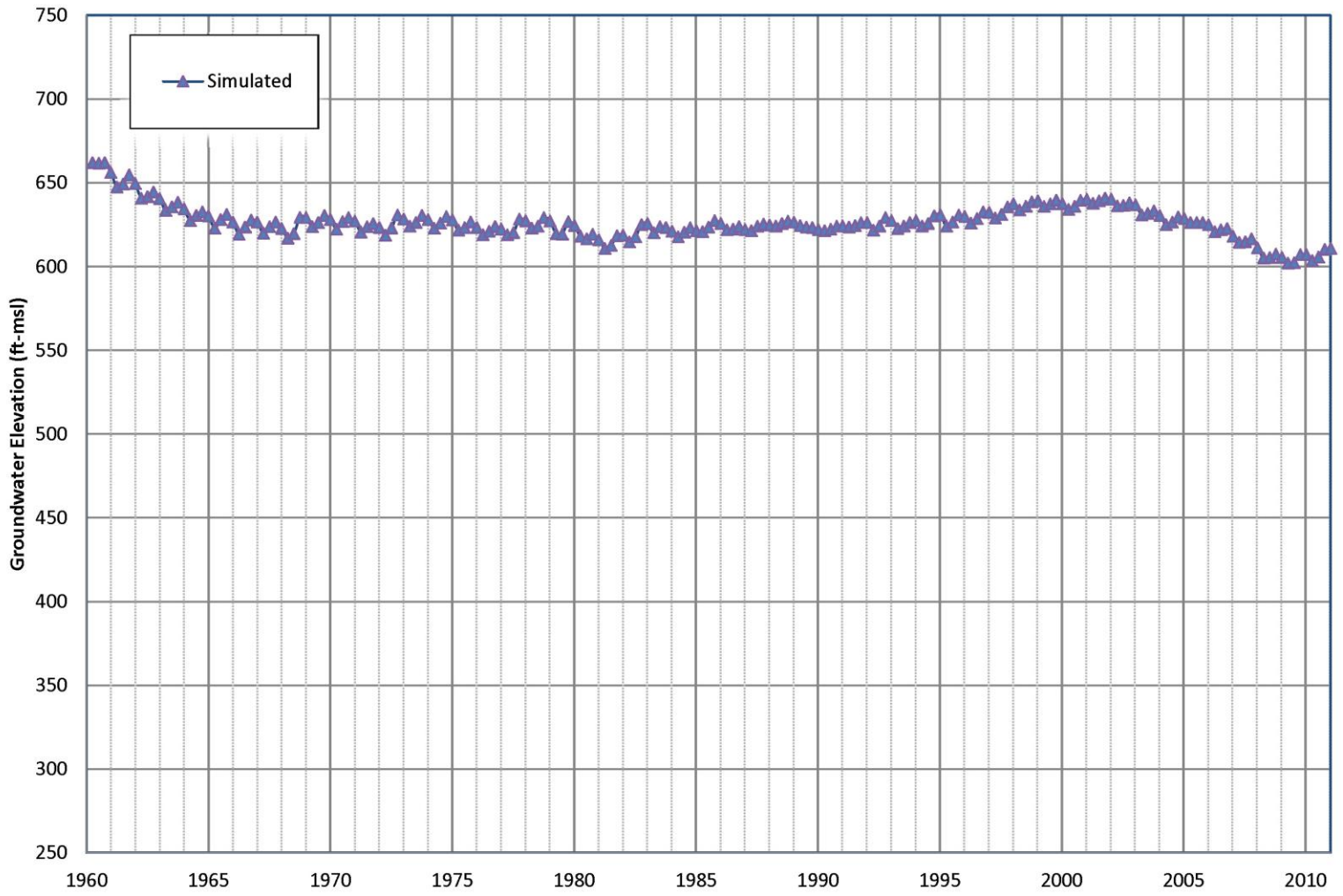


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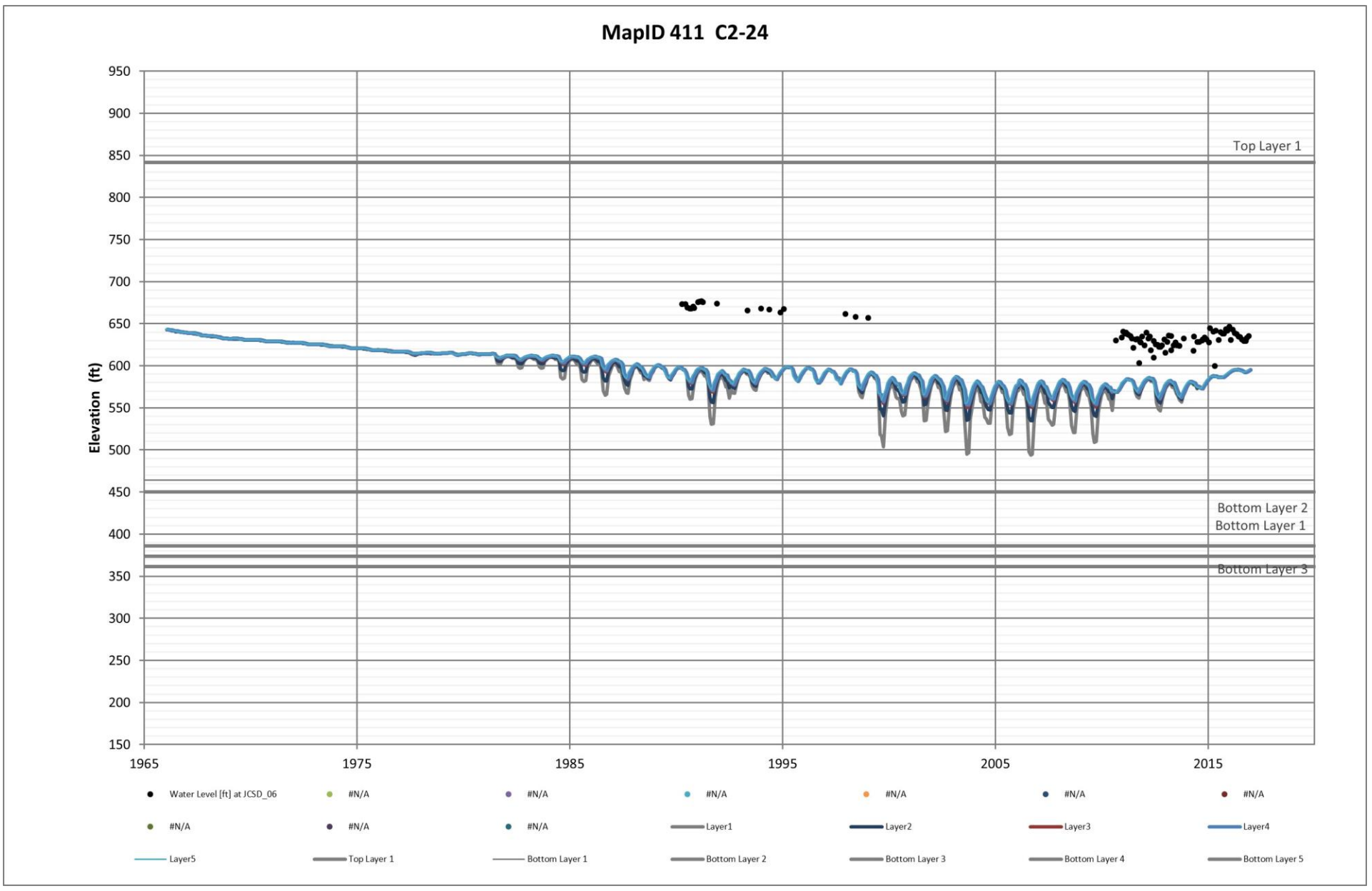


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Figure C2-23
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 5

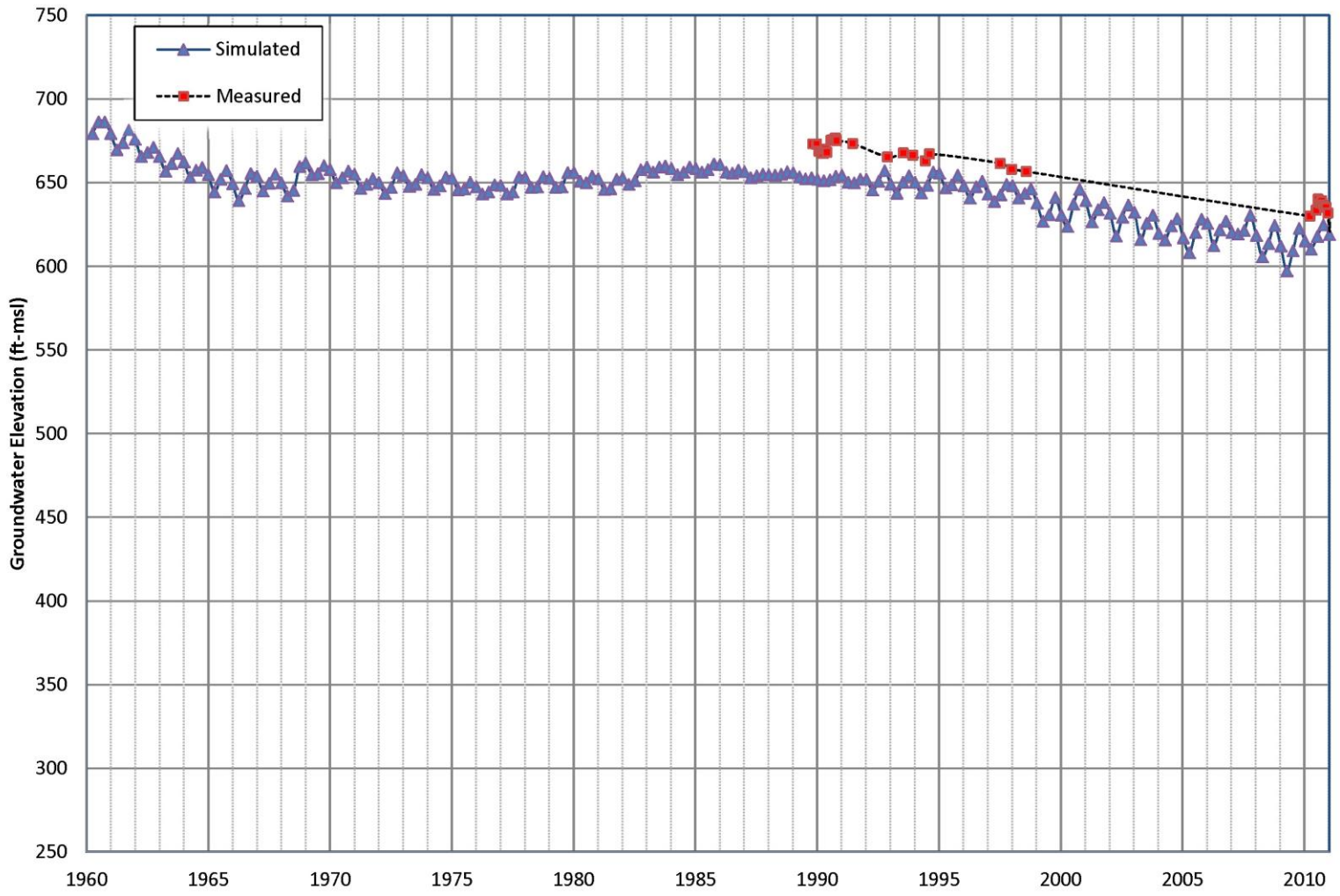


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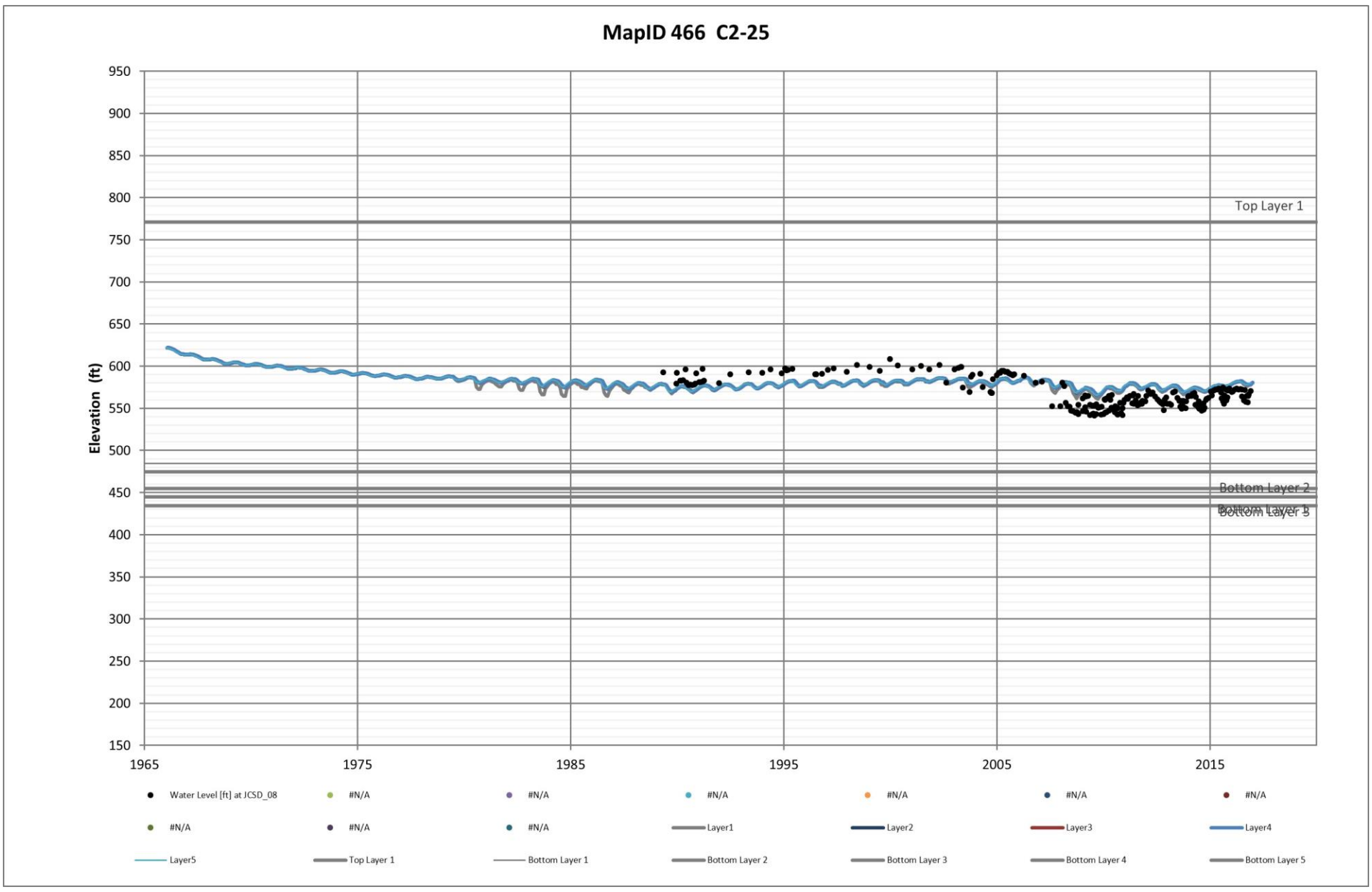


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Figure C2-24
Comparison of Measured and Simulated Groundwater Levels in JCSD Well MIRA LOMA #6

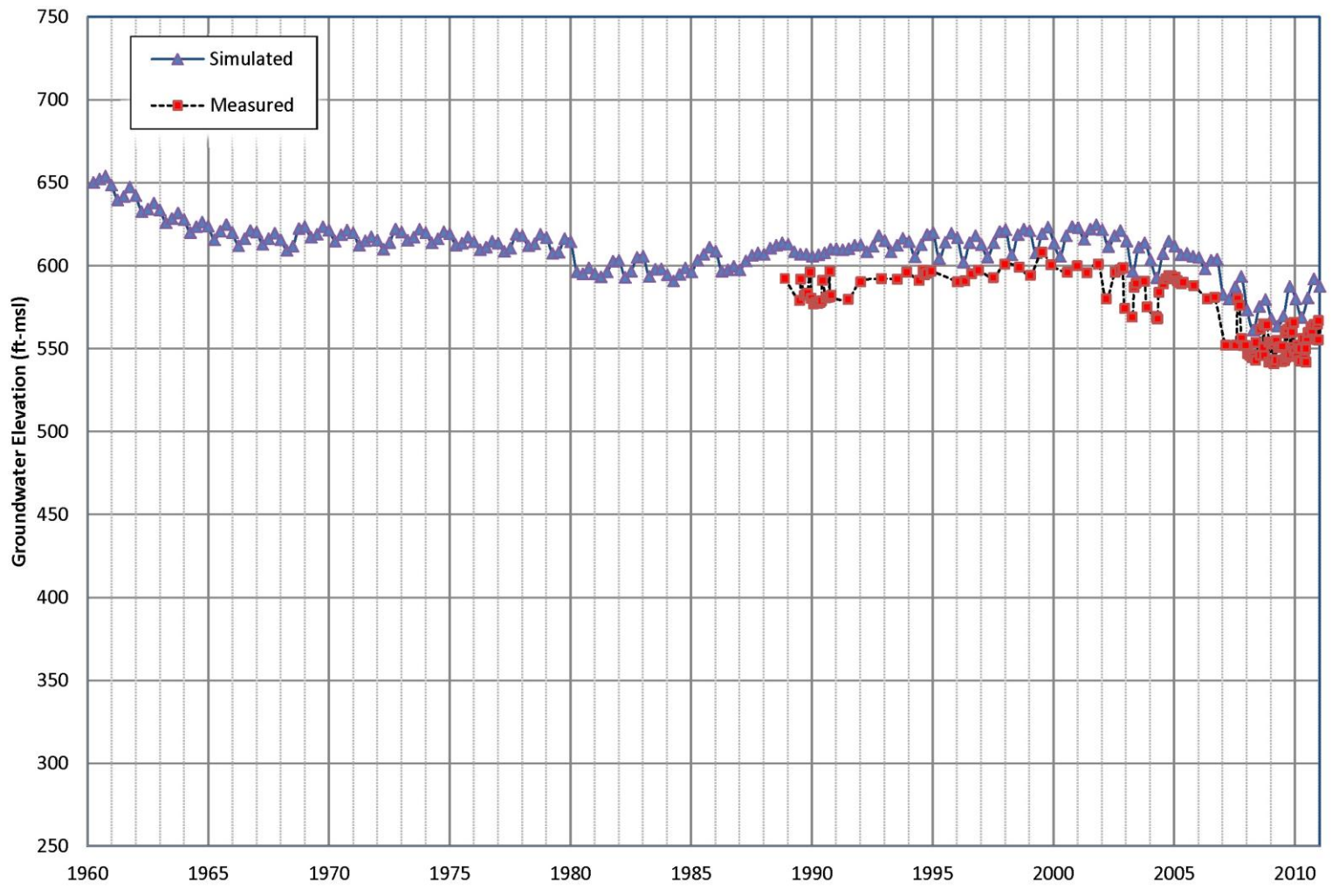


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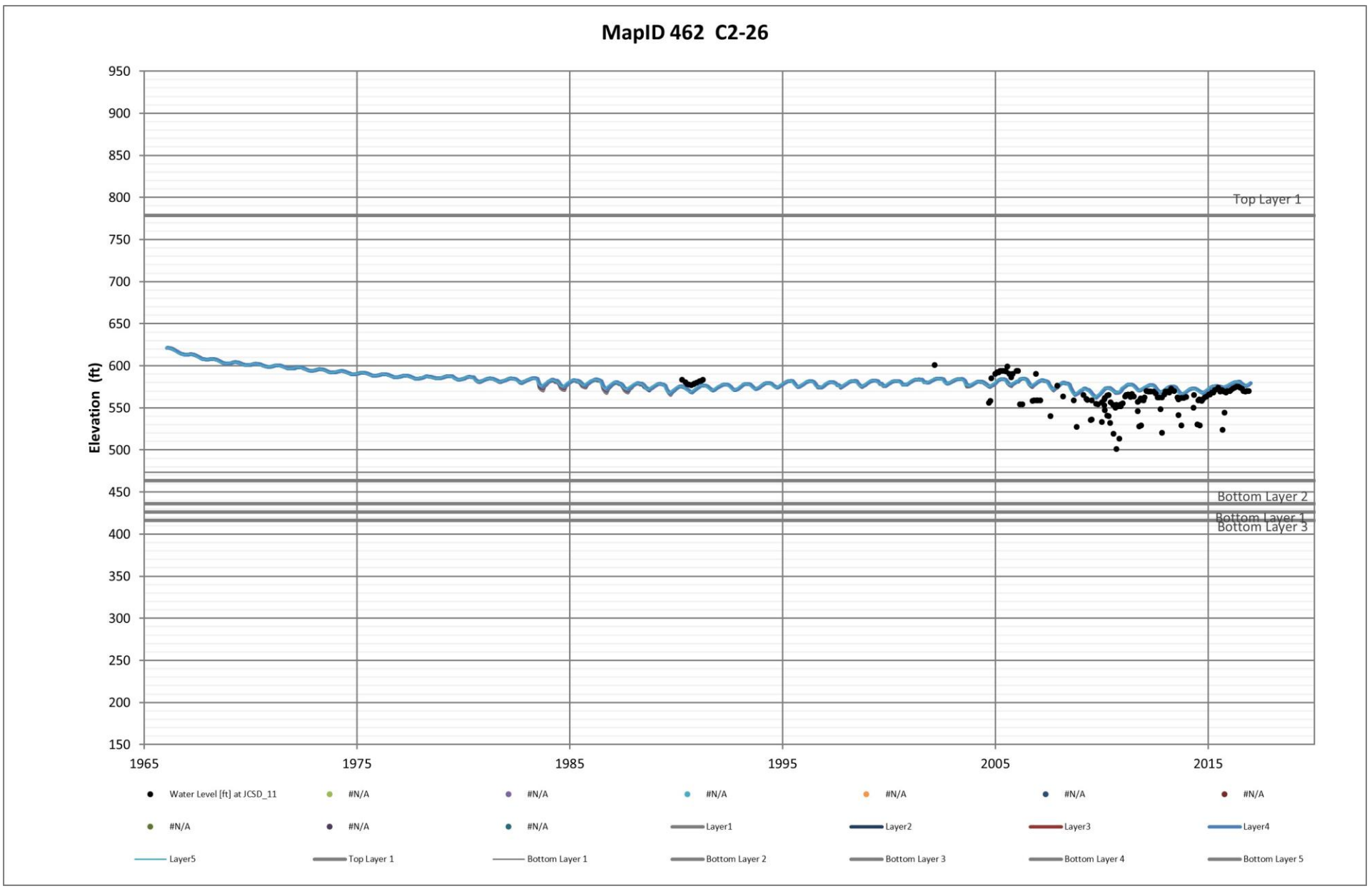


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Figure C2-25
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 8 (Russell Well)

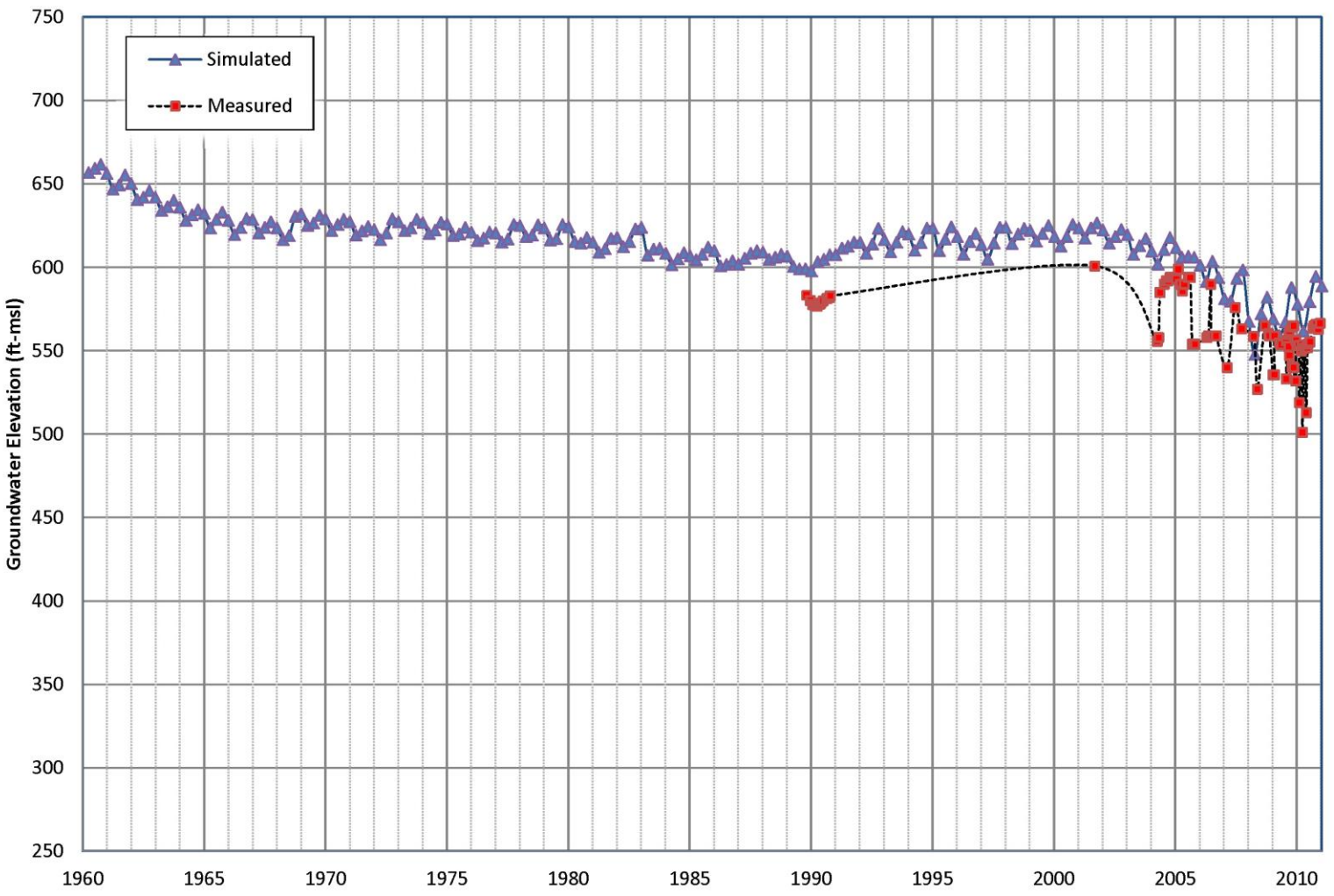


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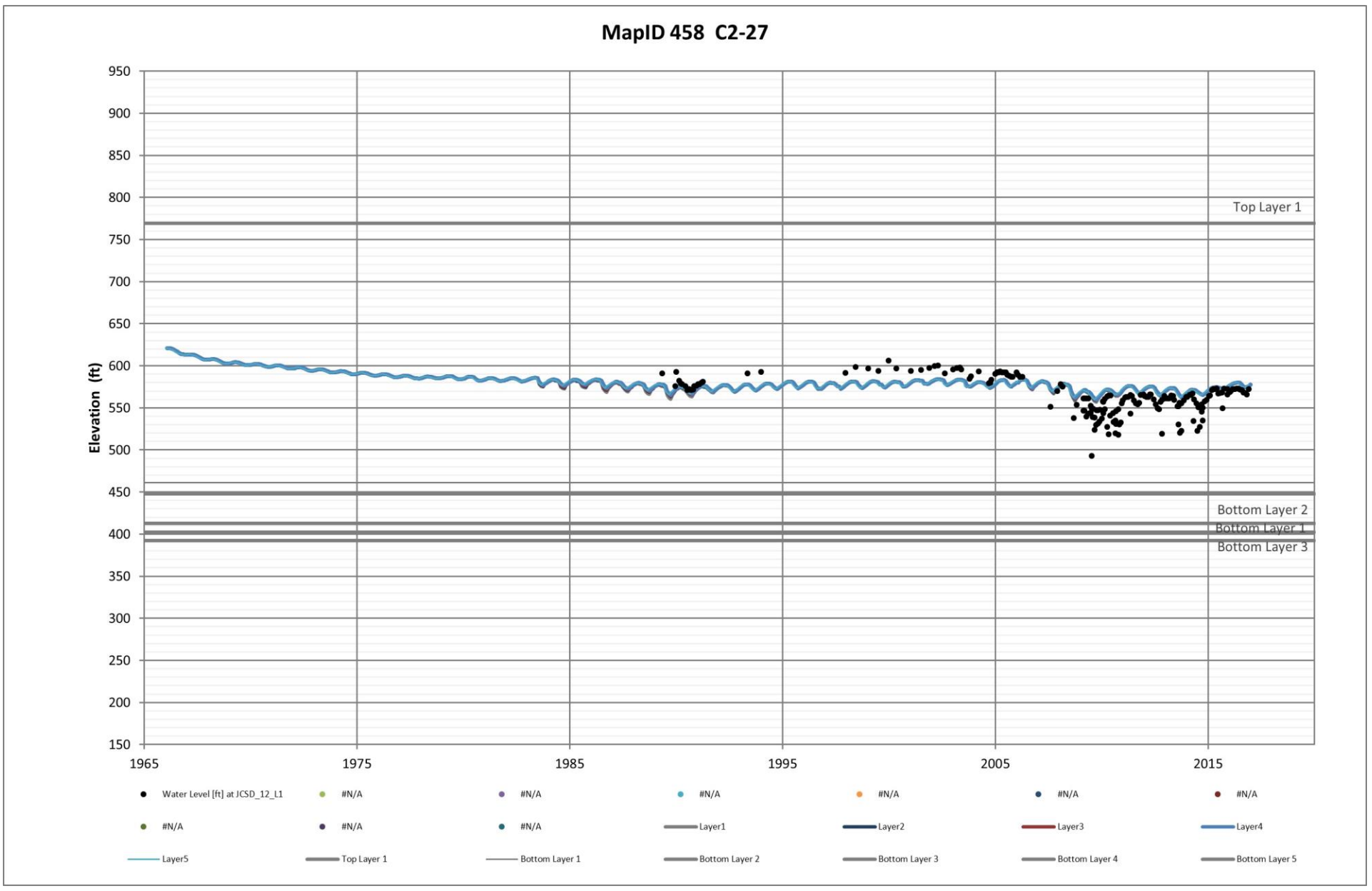


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Figure C2-26
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 11

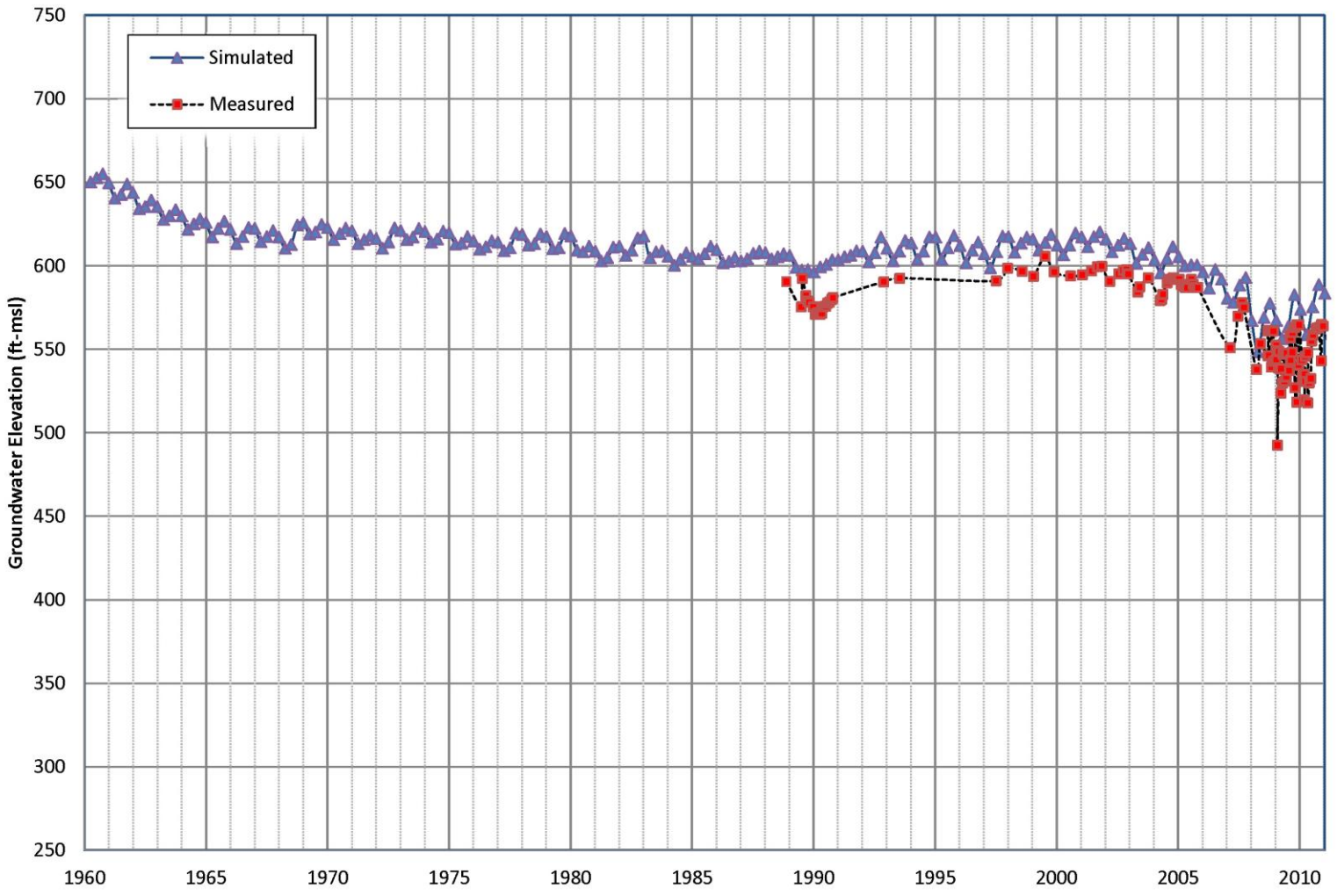


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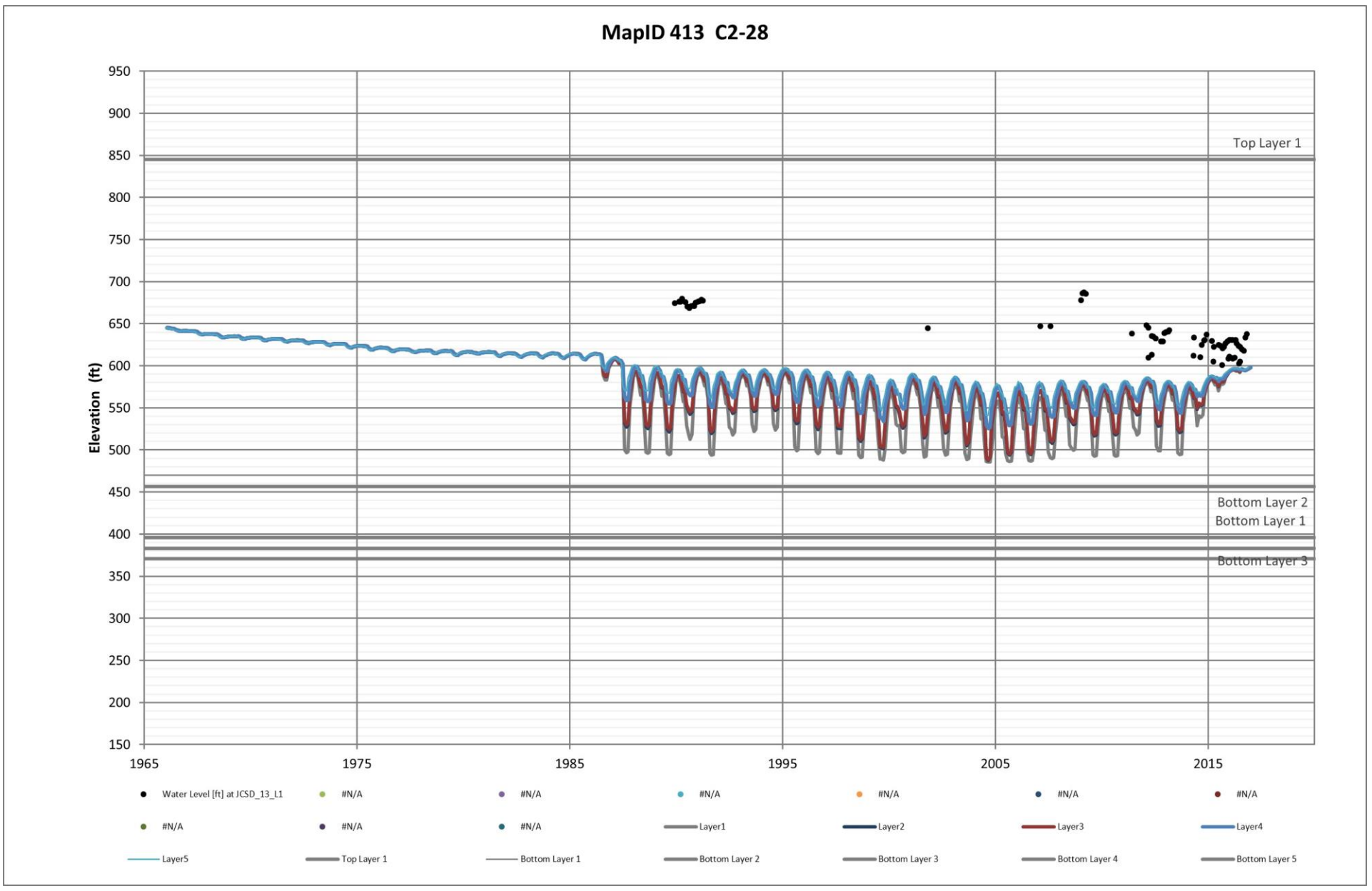


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Figure C2-27
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 12

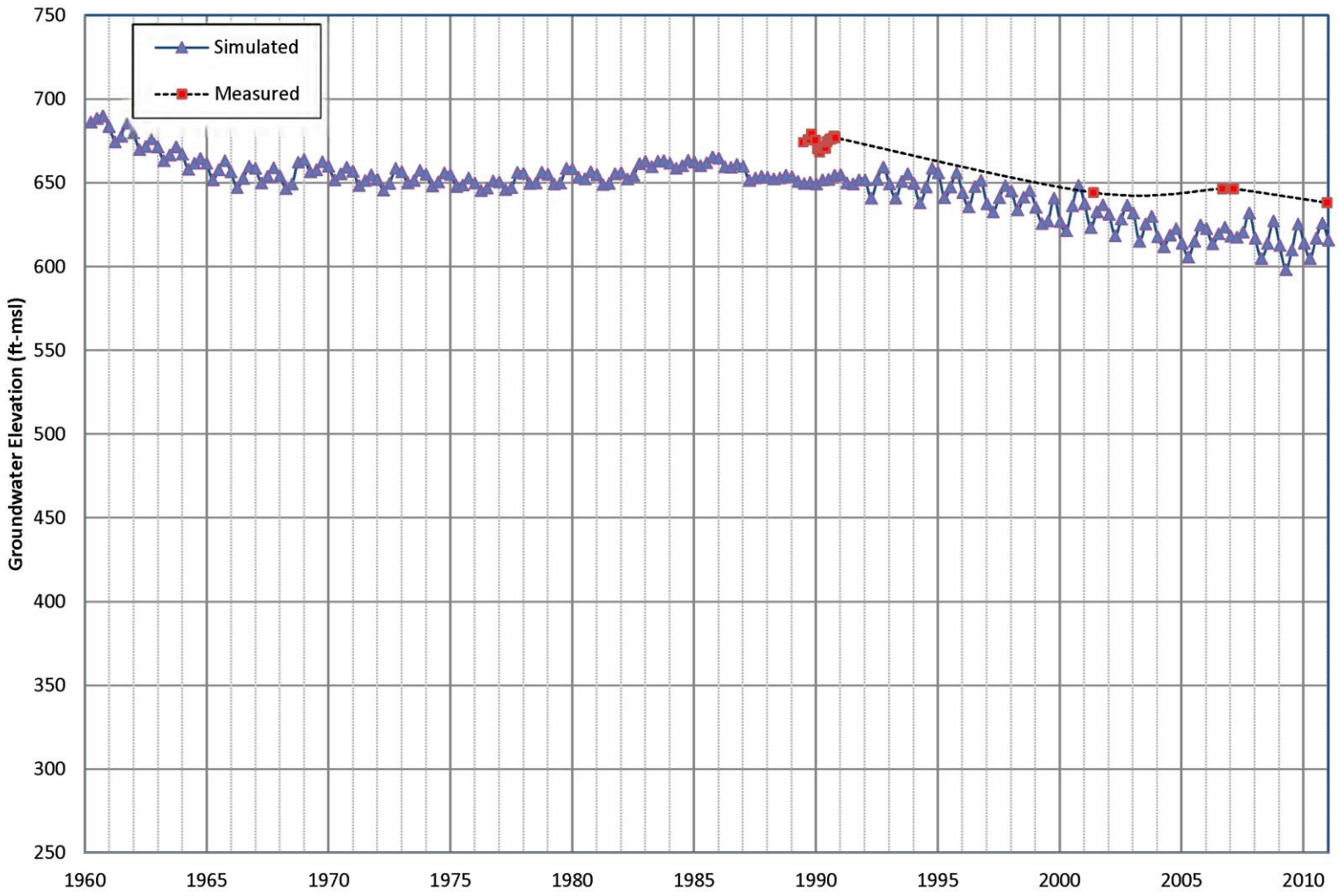


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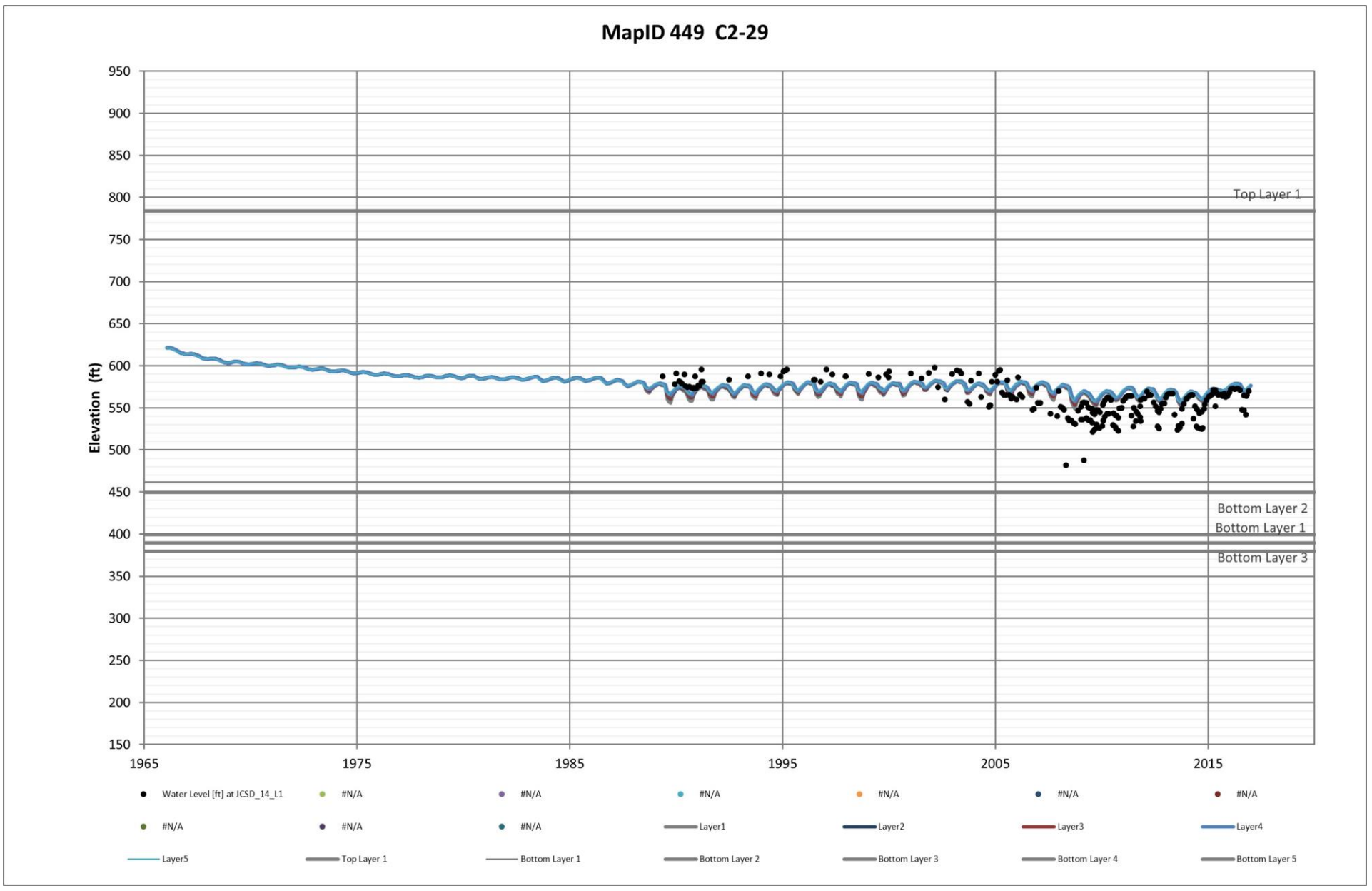


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Figure C2-28
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 13

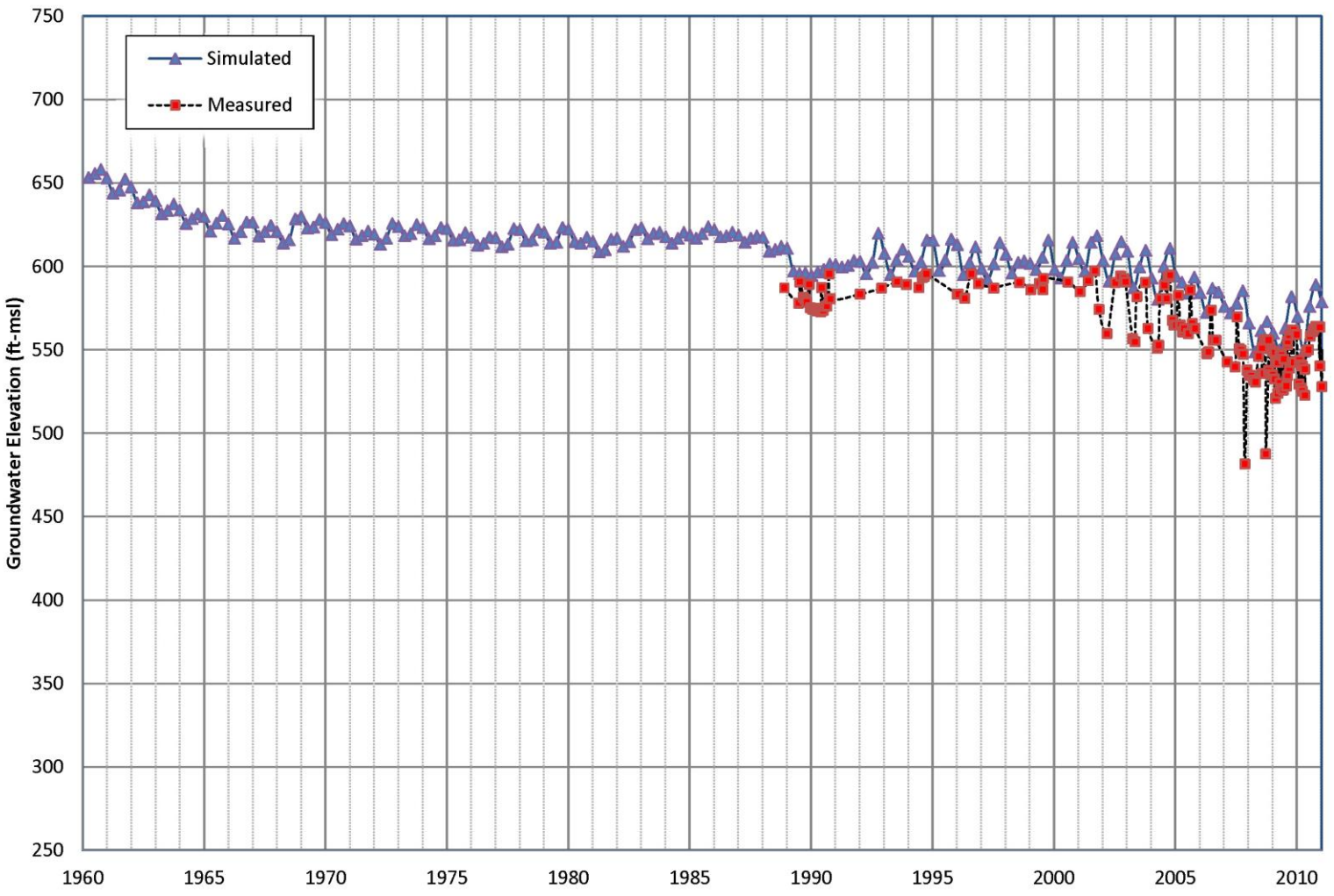


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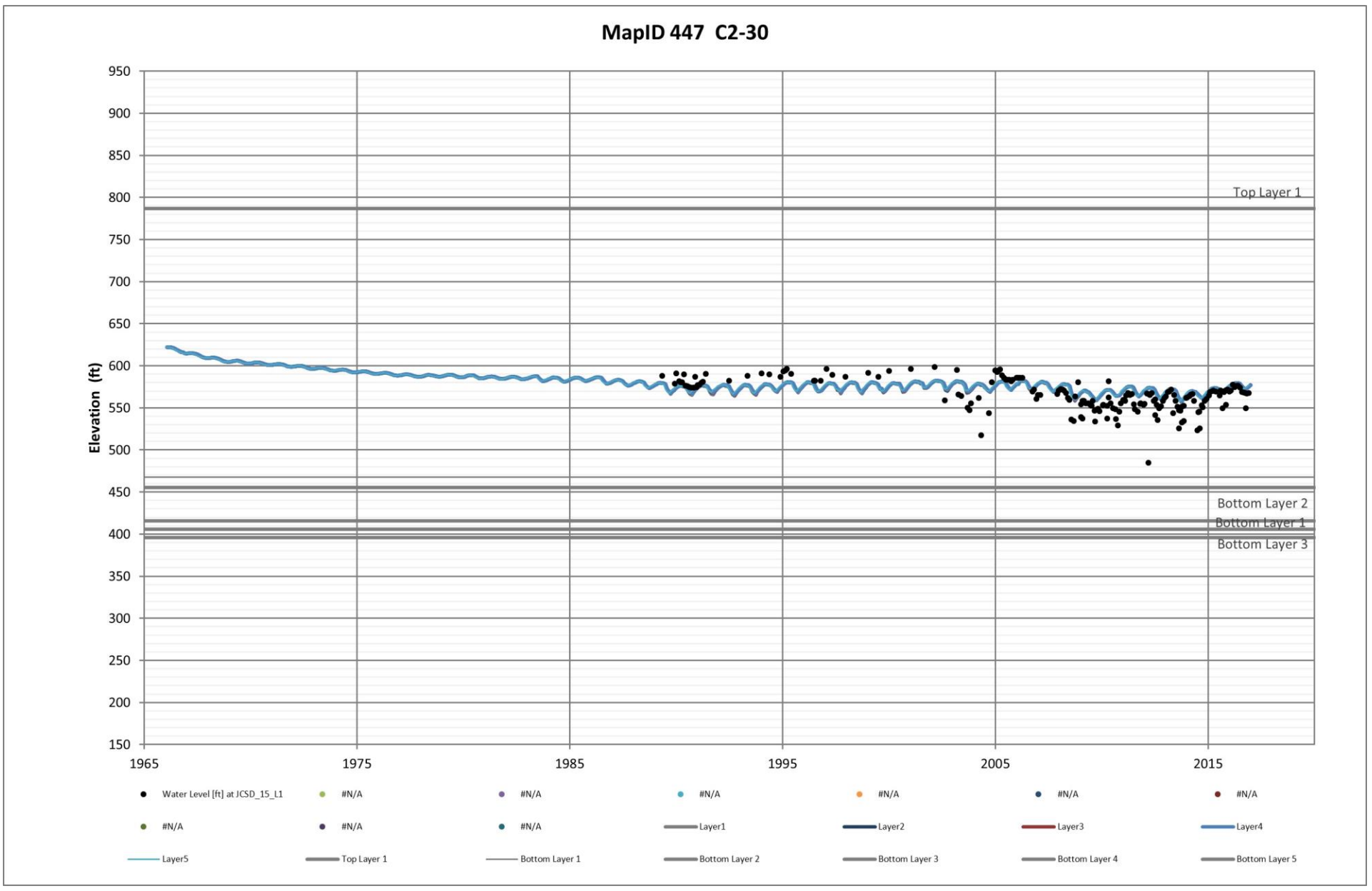


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Figure C2-29
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 14

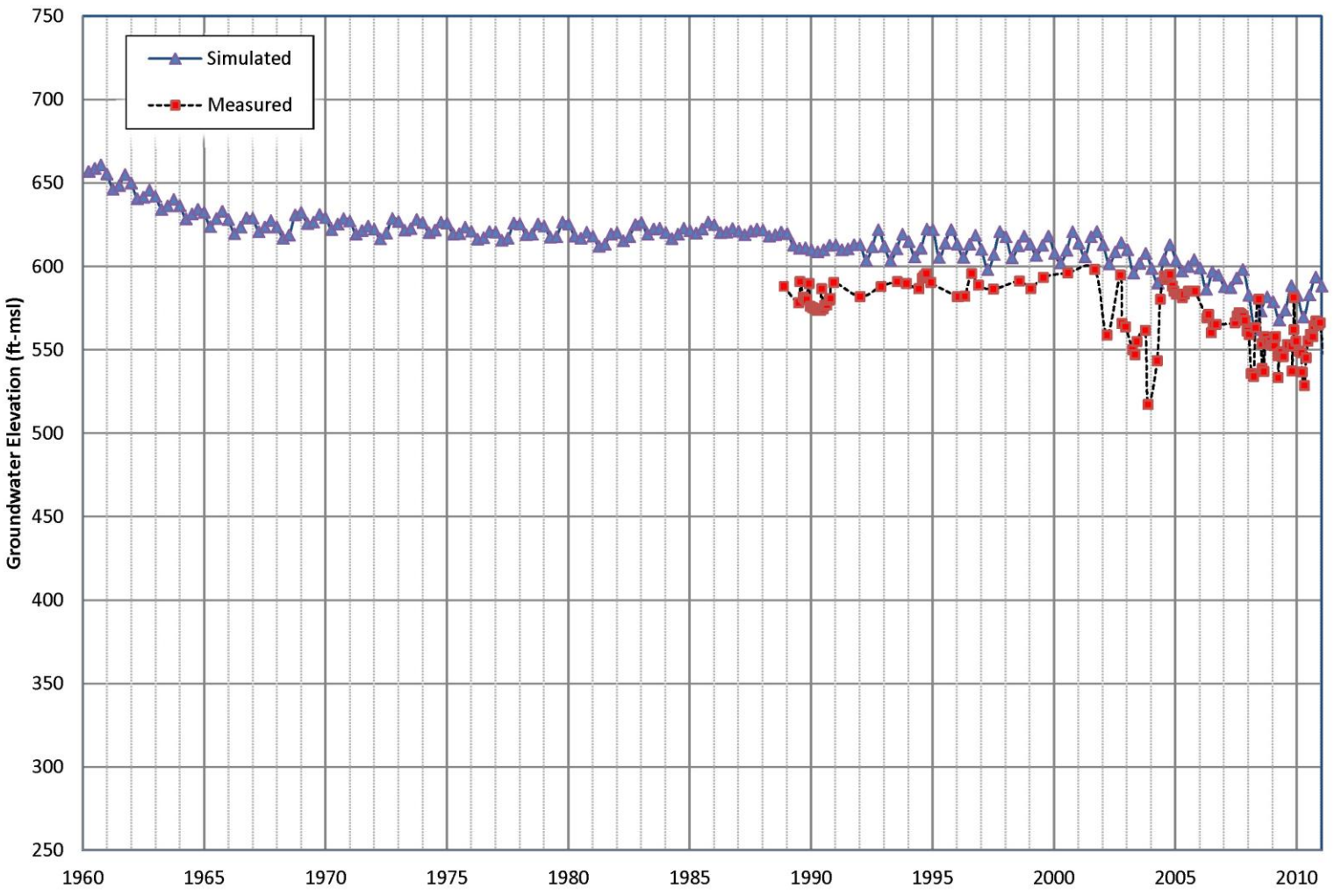


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

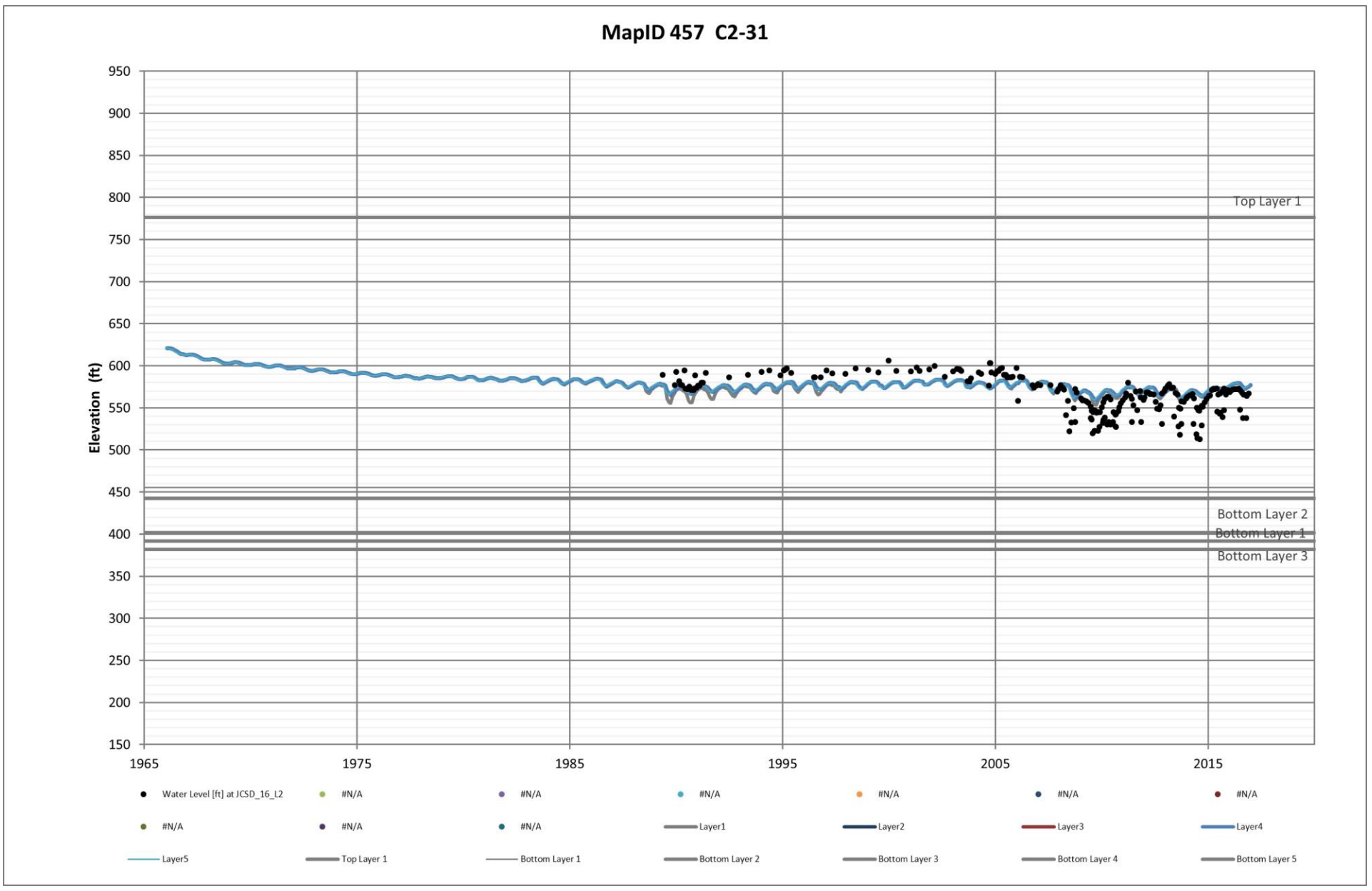


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Figure C2-30
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 15

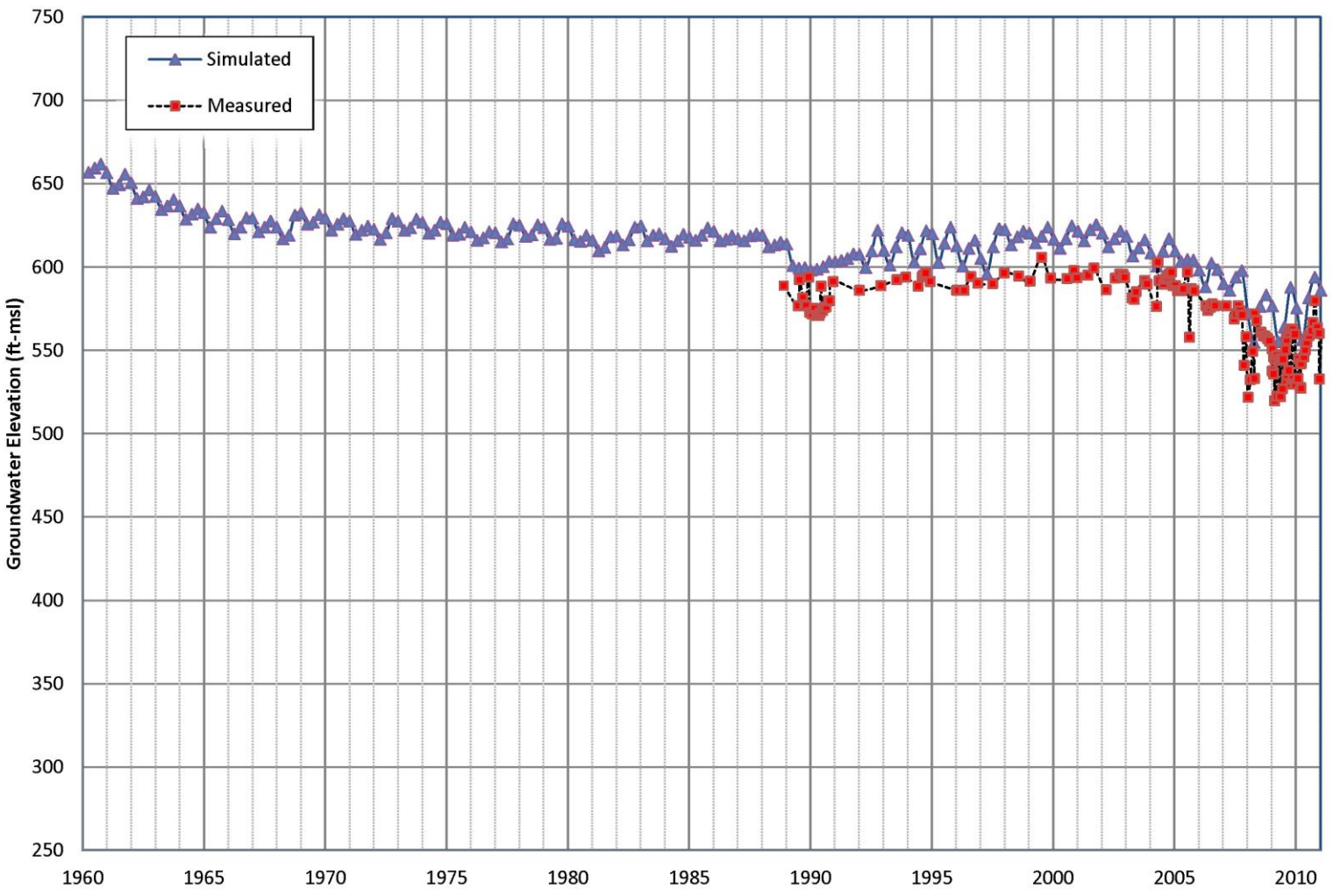


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

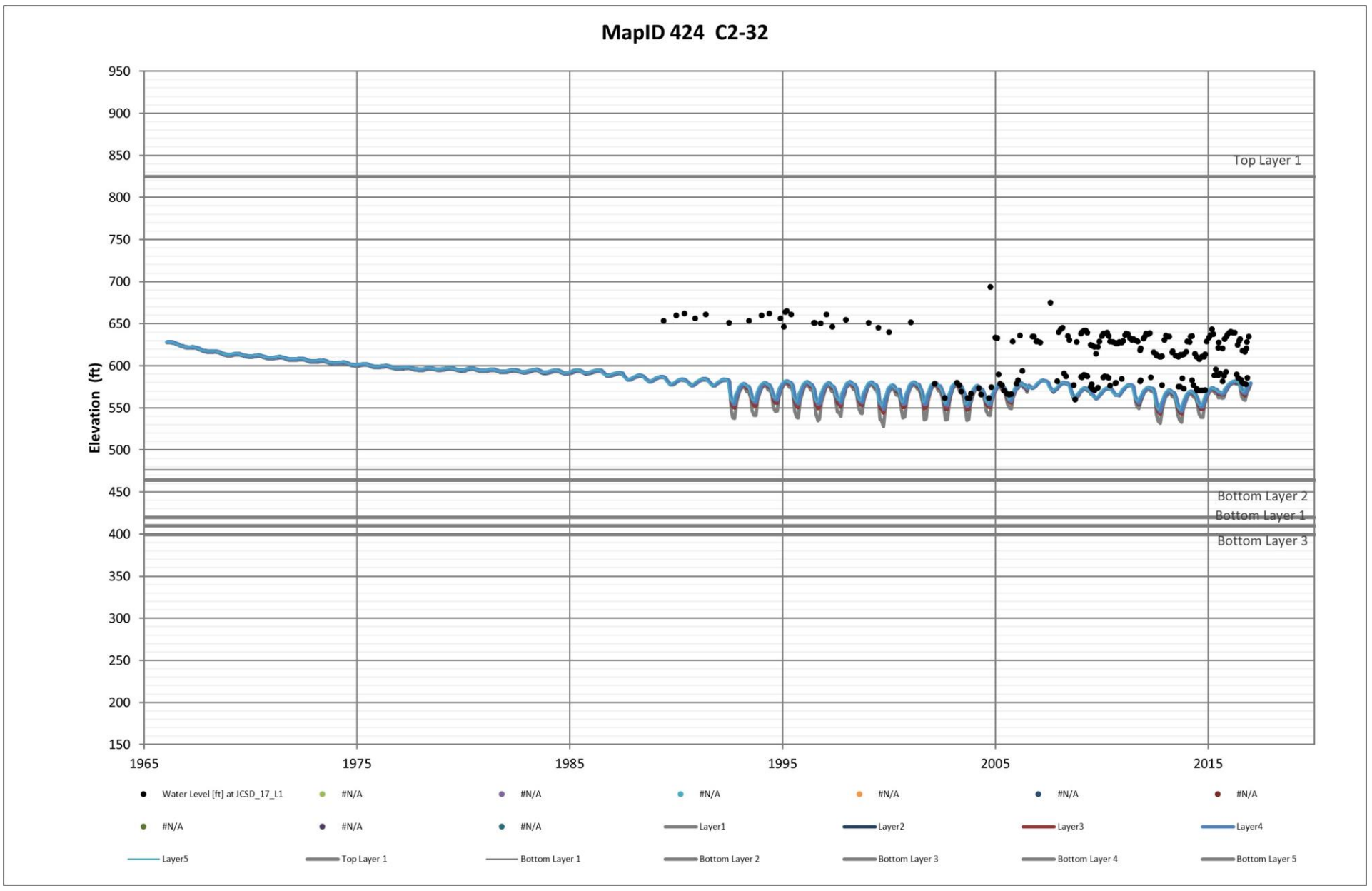


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Figure C2-31
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 16

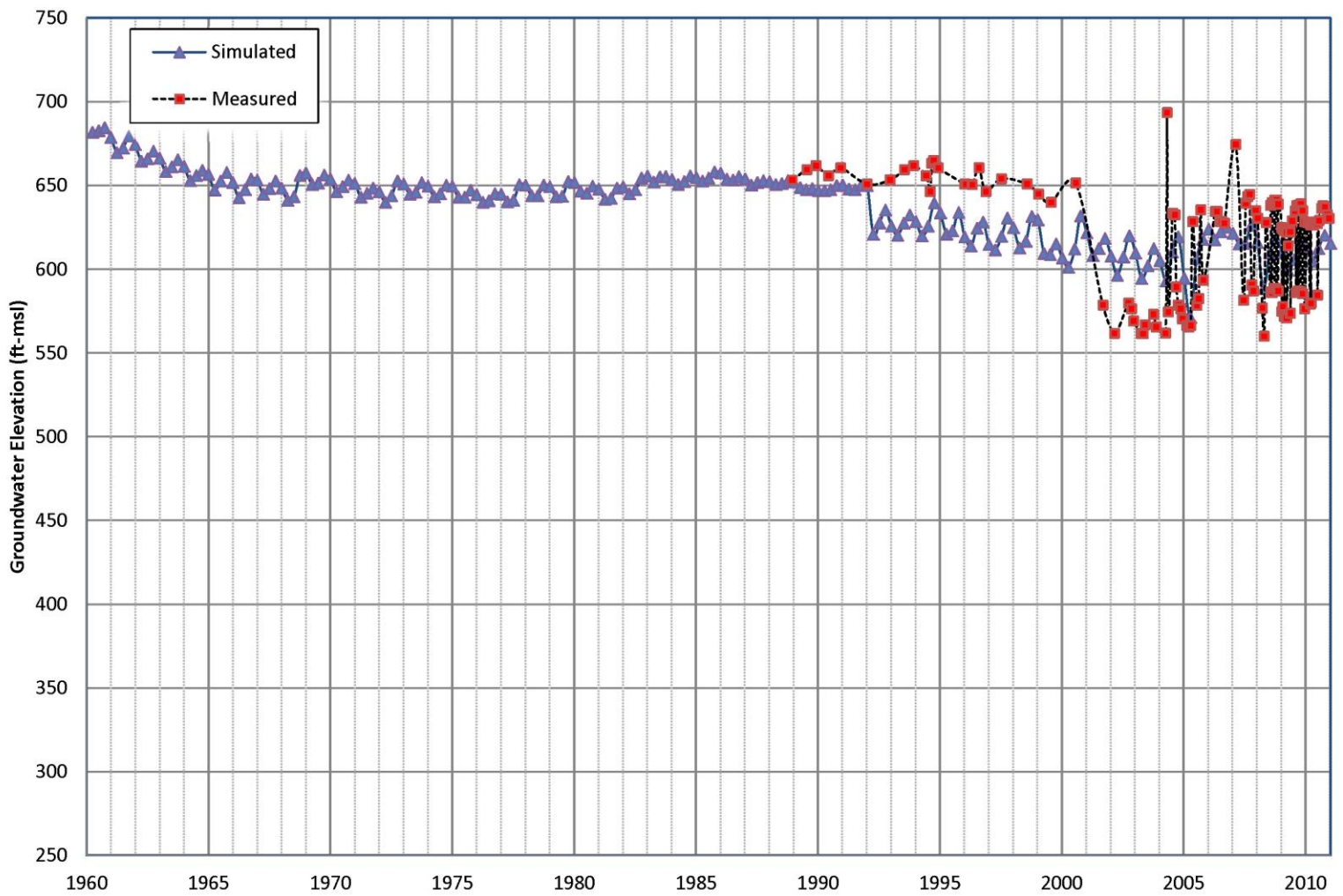


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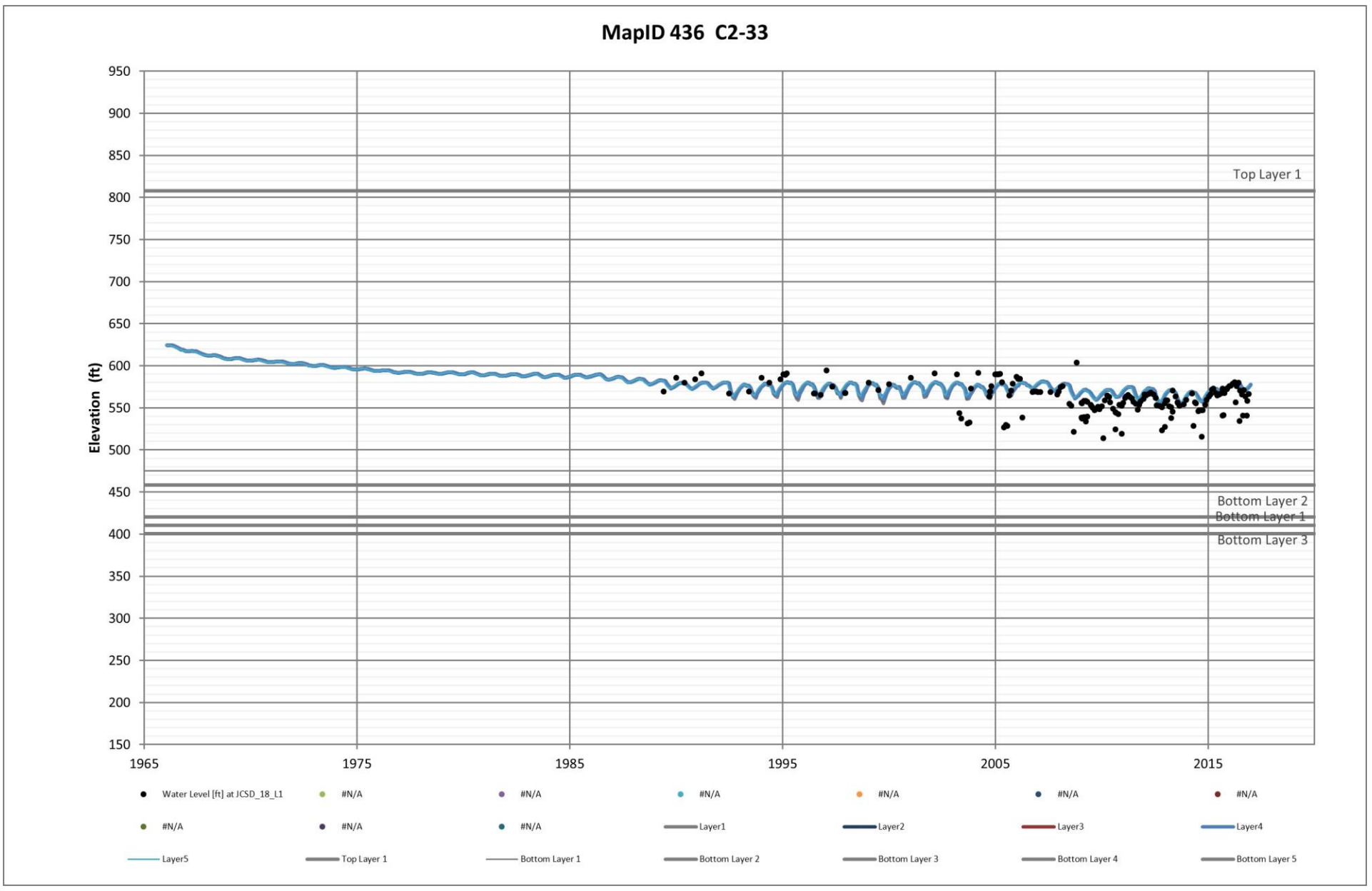


ISARM

Figure C2-32
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 17

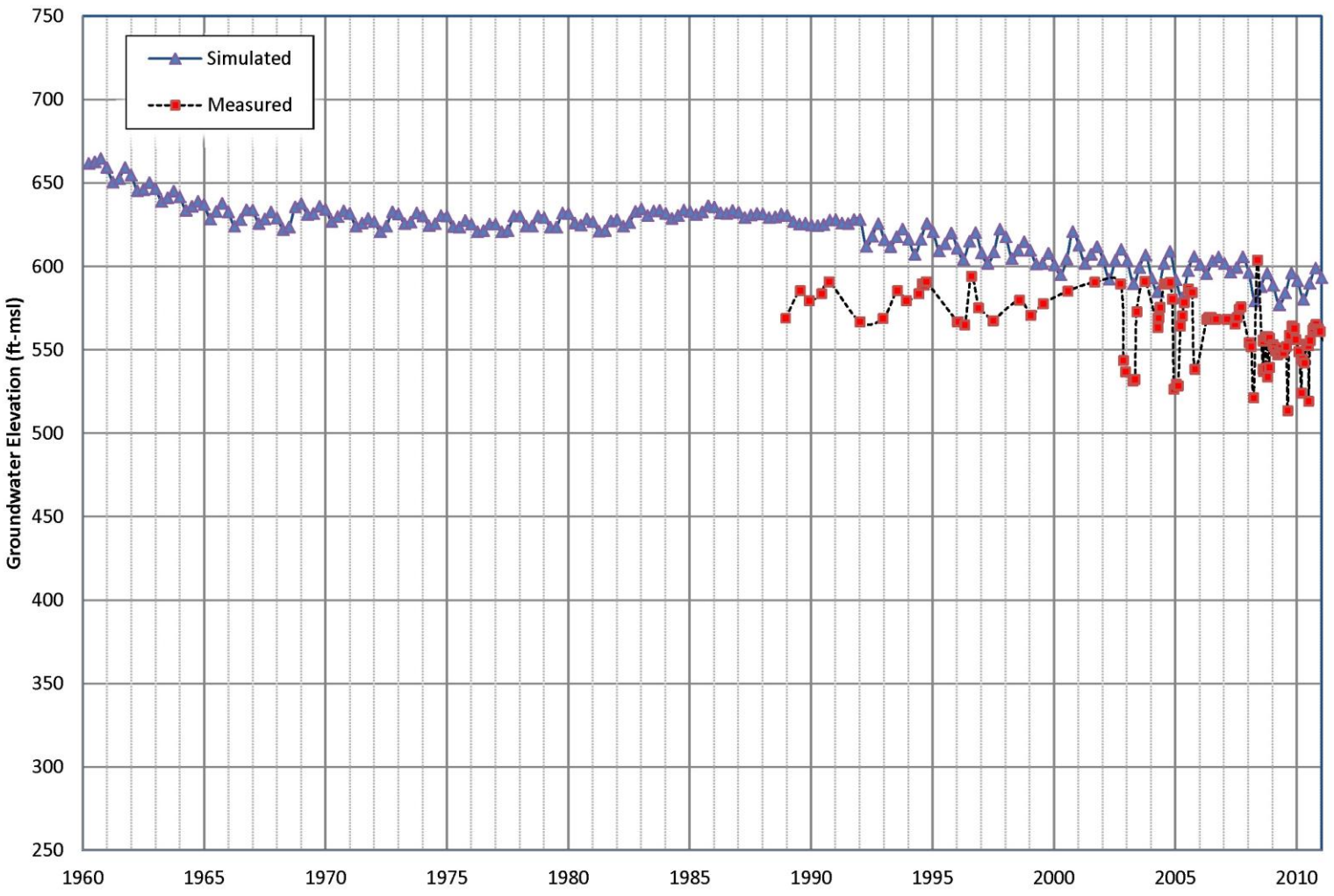


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

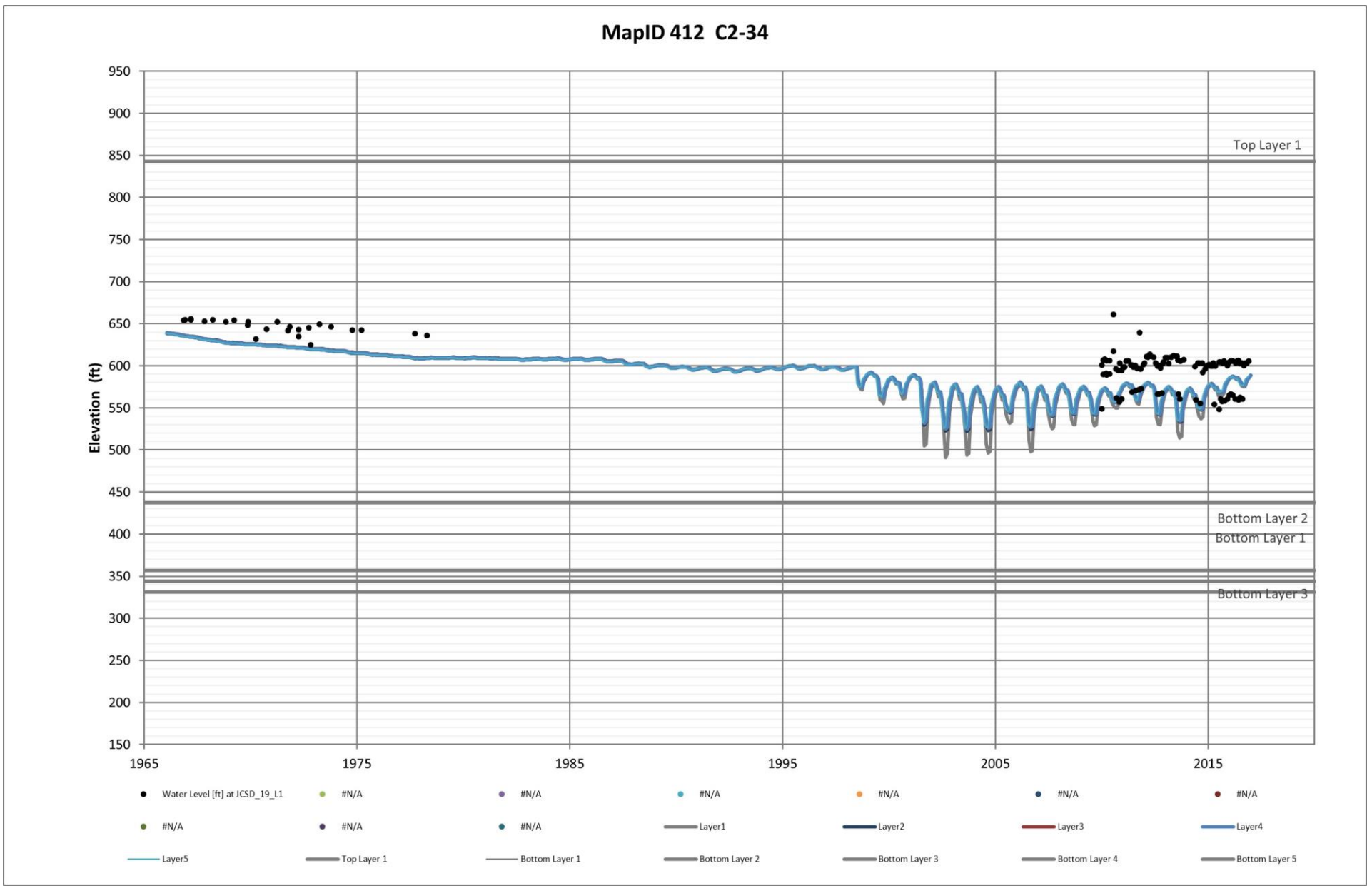


ISARM

Figure C2-33
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 18

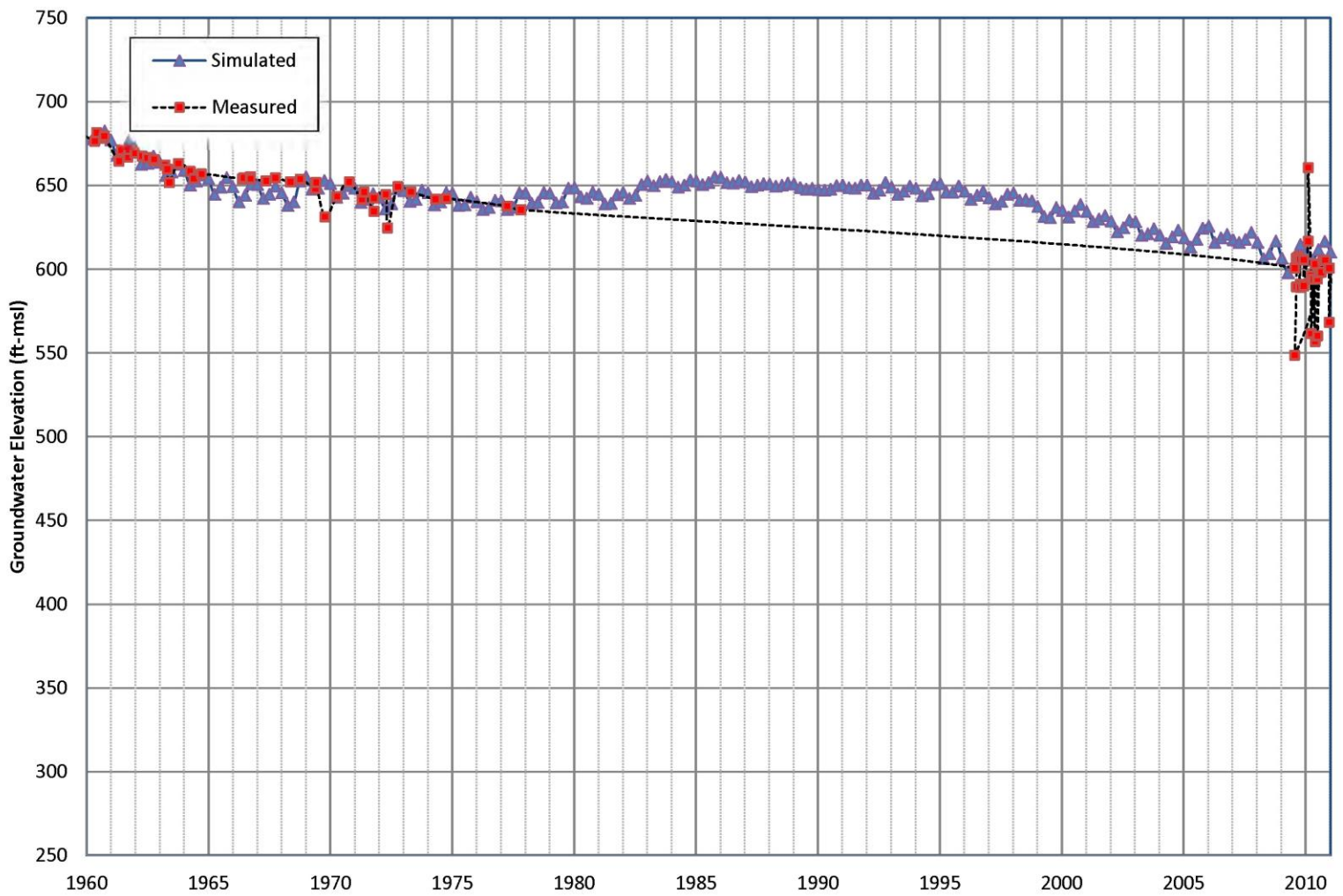


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

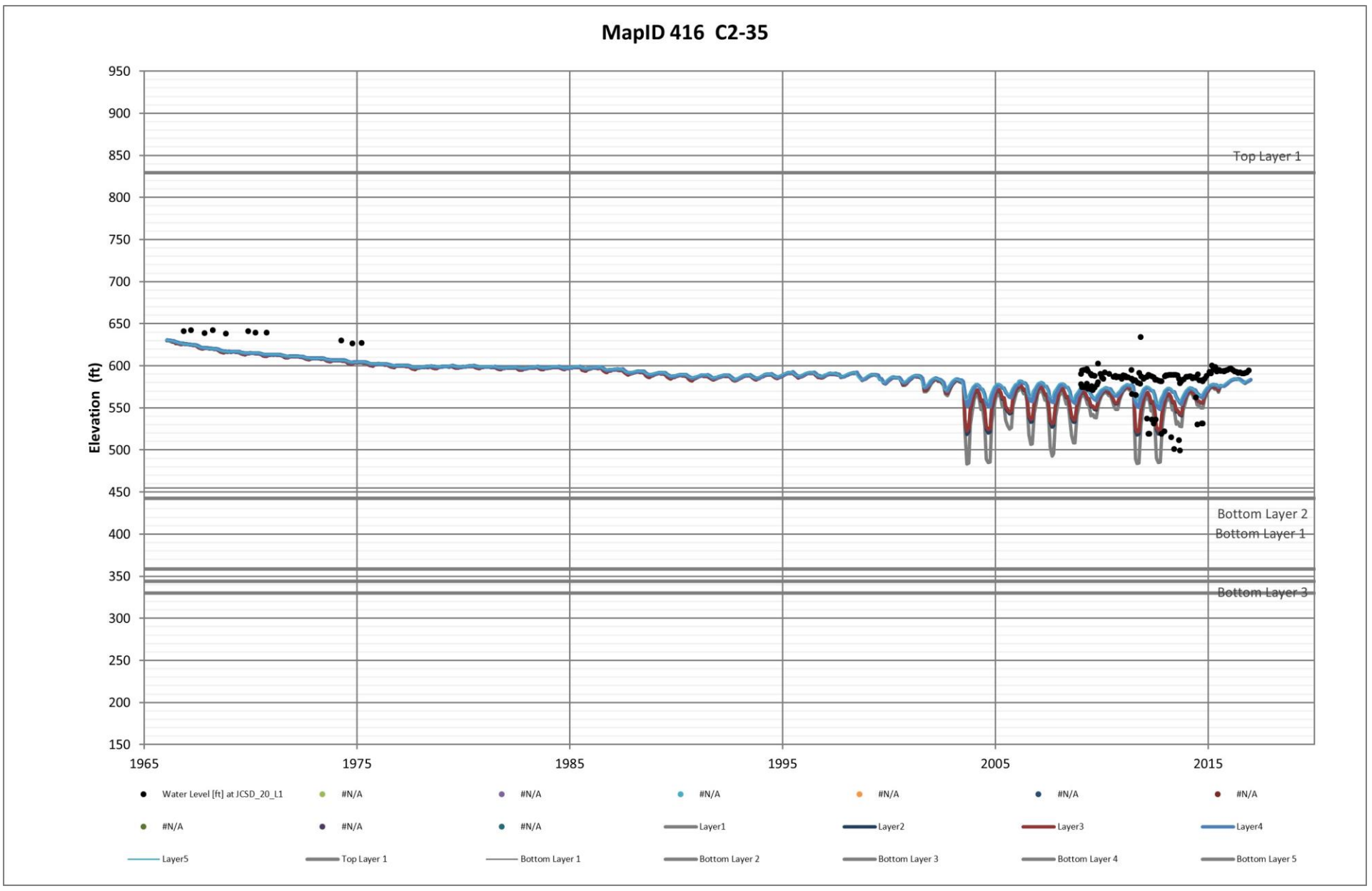


ISARM

Figure C2-34
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 19

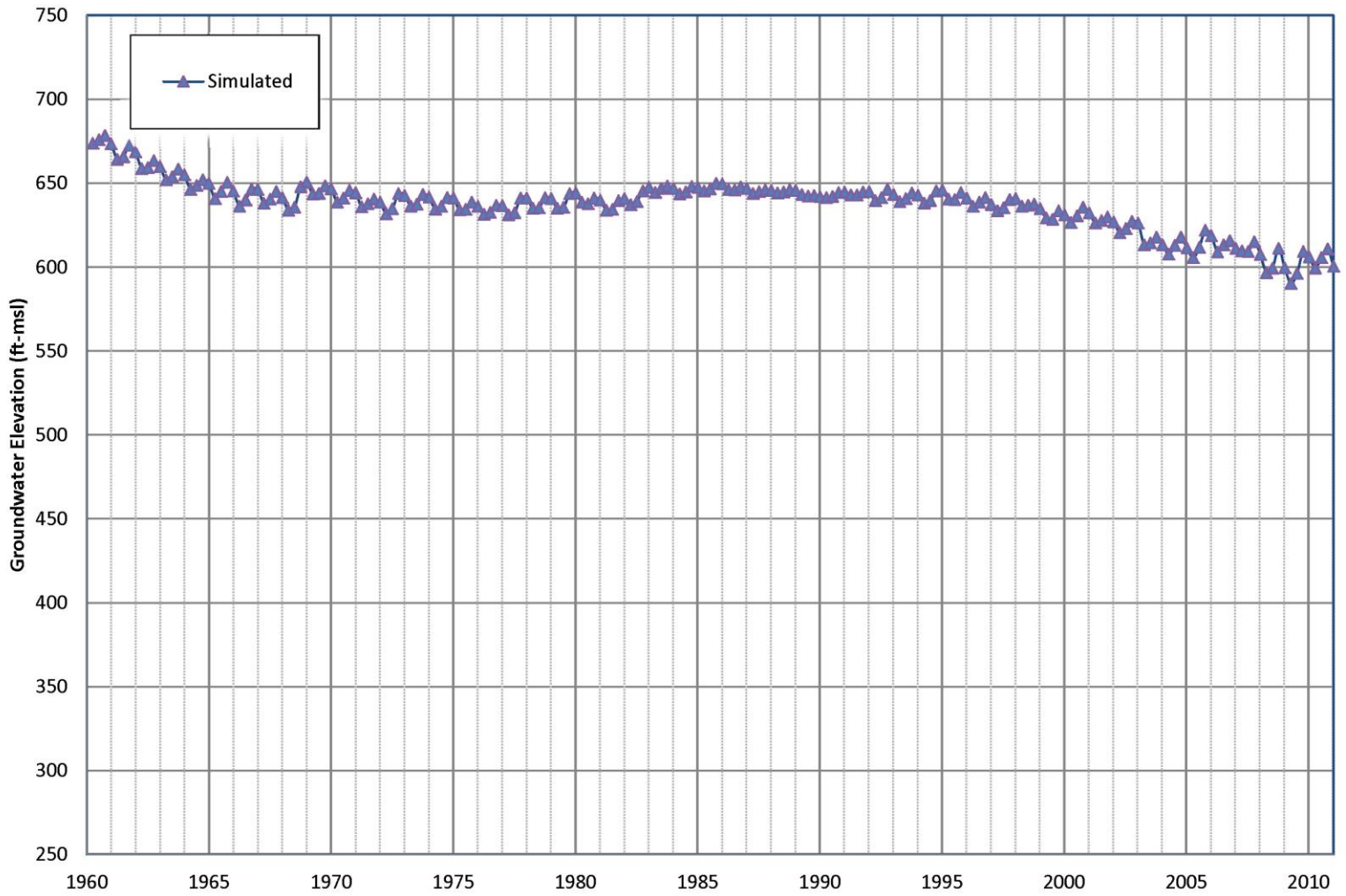


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

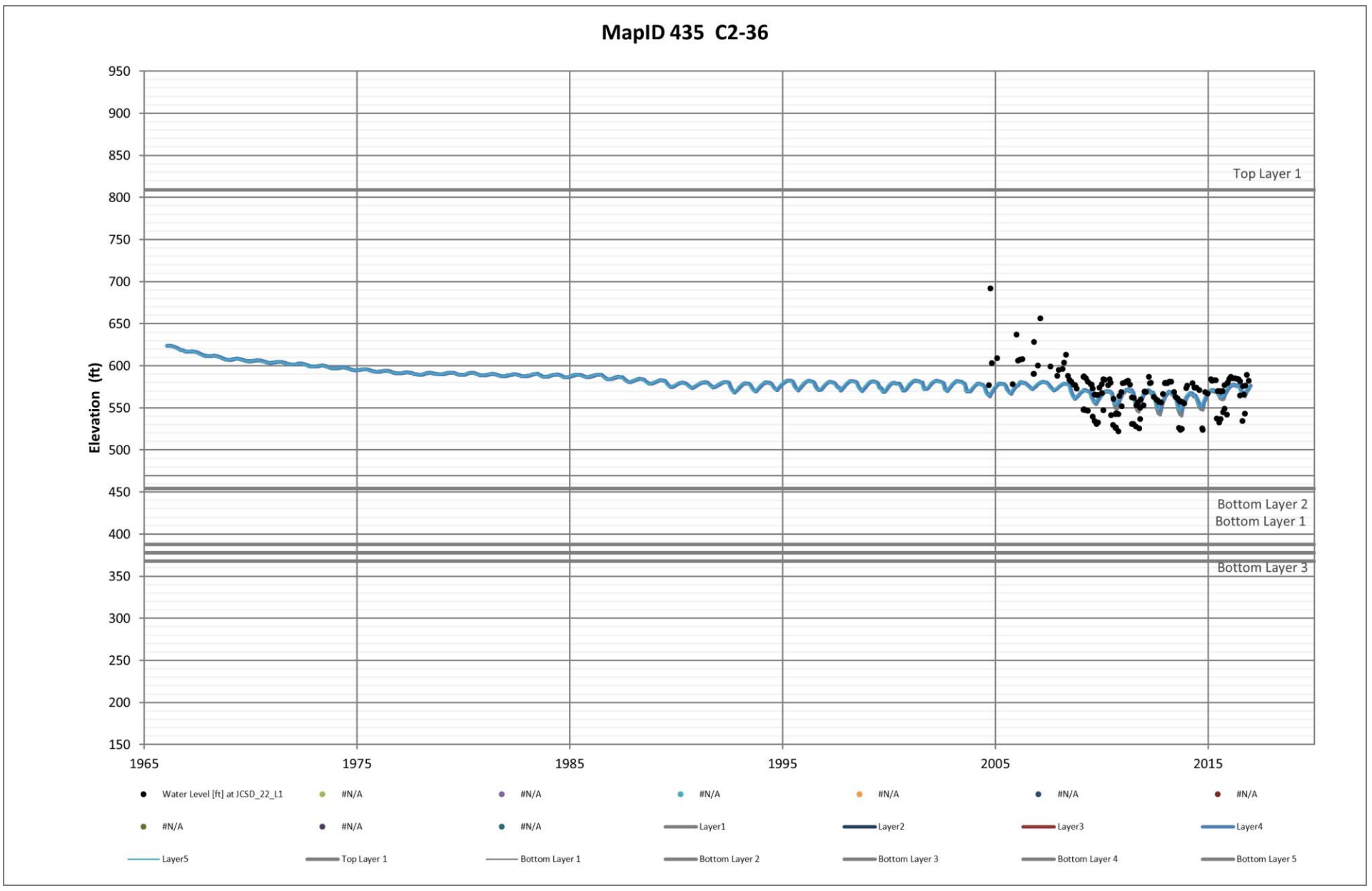


ISARM

Figure C2-35
Comparison of Measured and Simulated Groundwater Levels in JCSD Well MLSC2

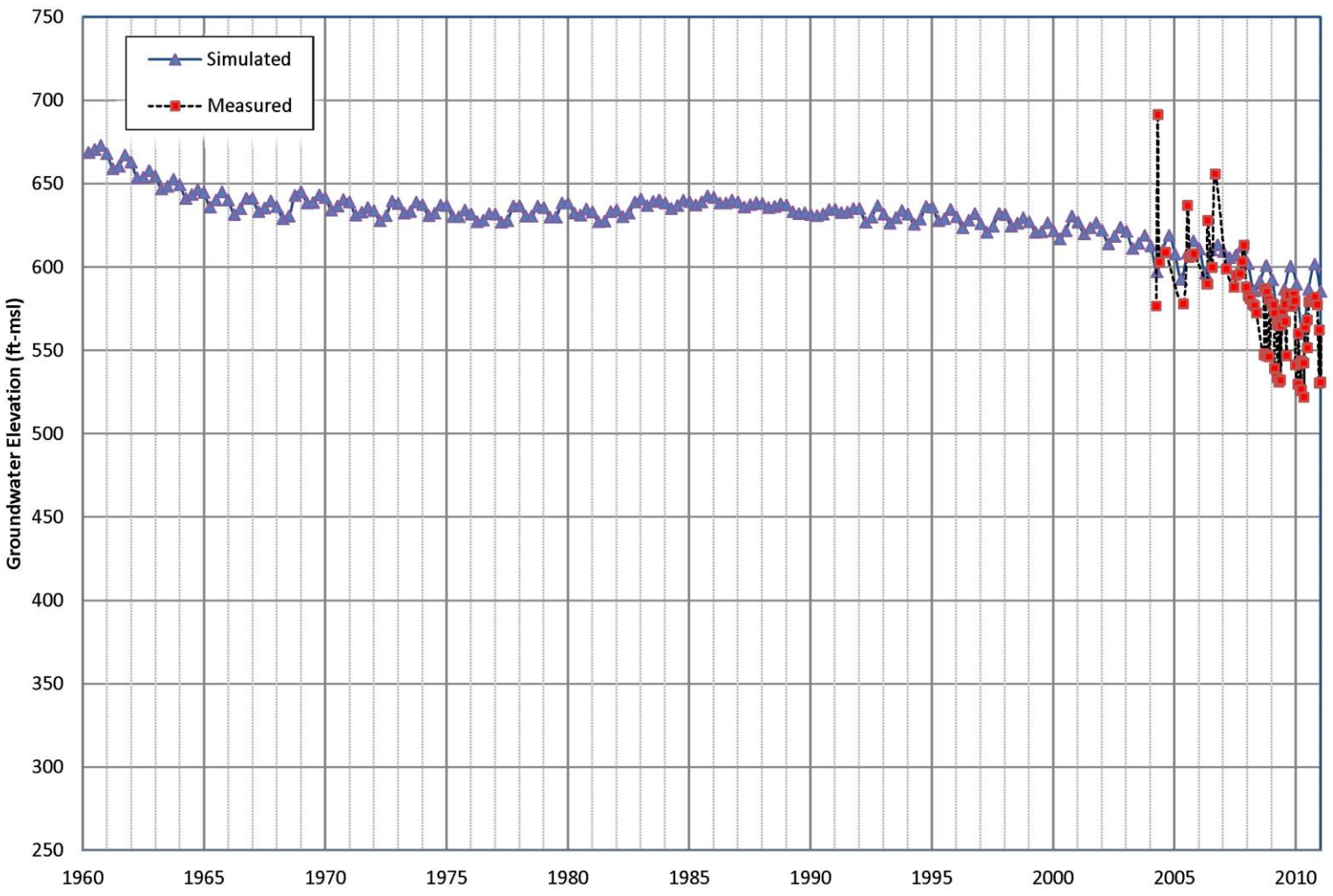


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

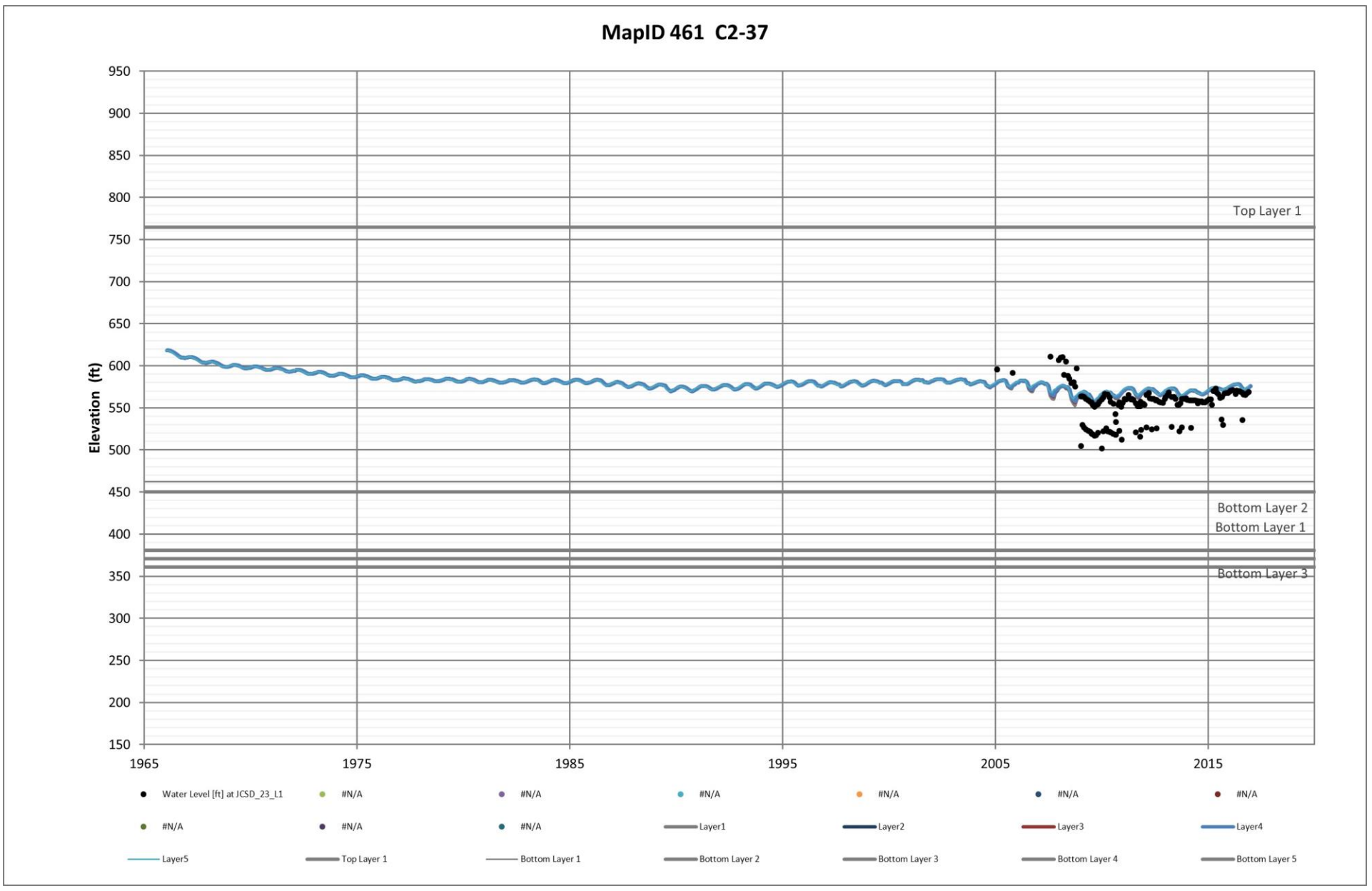


ISARM

Figure C2-36
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 22

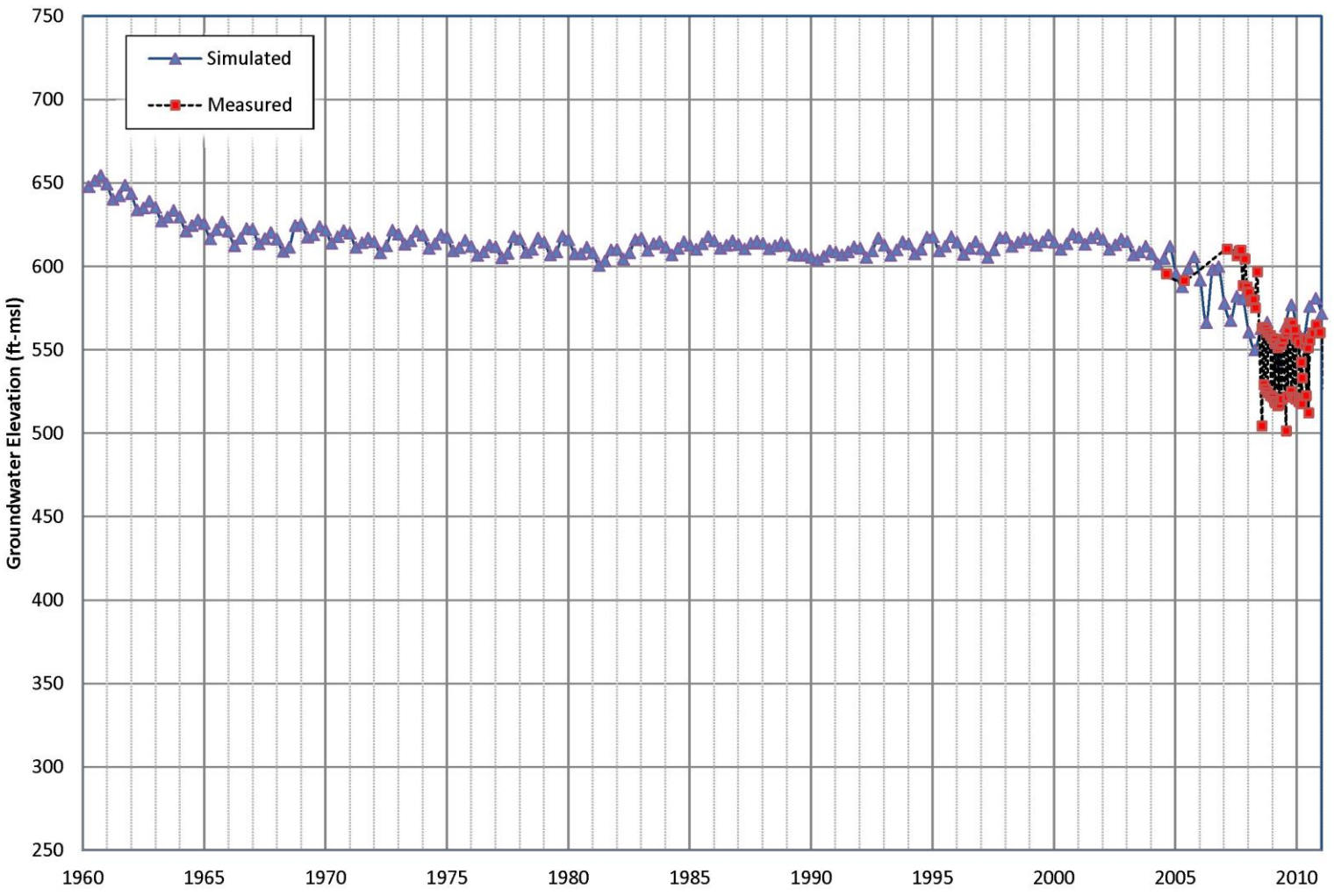


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

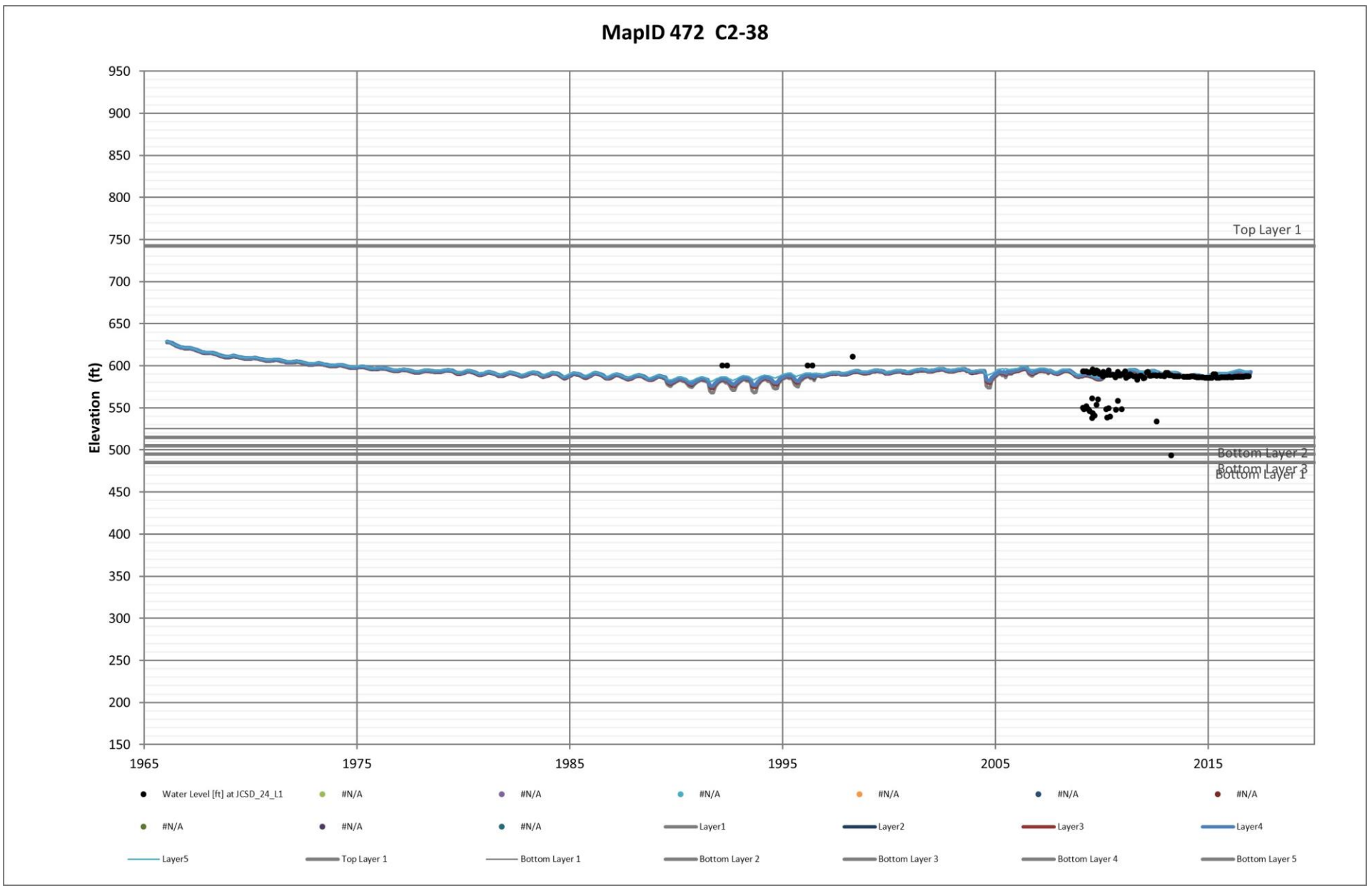


ISARM

Figure C2-37
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 23

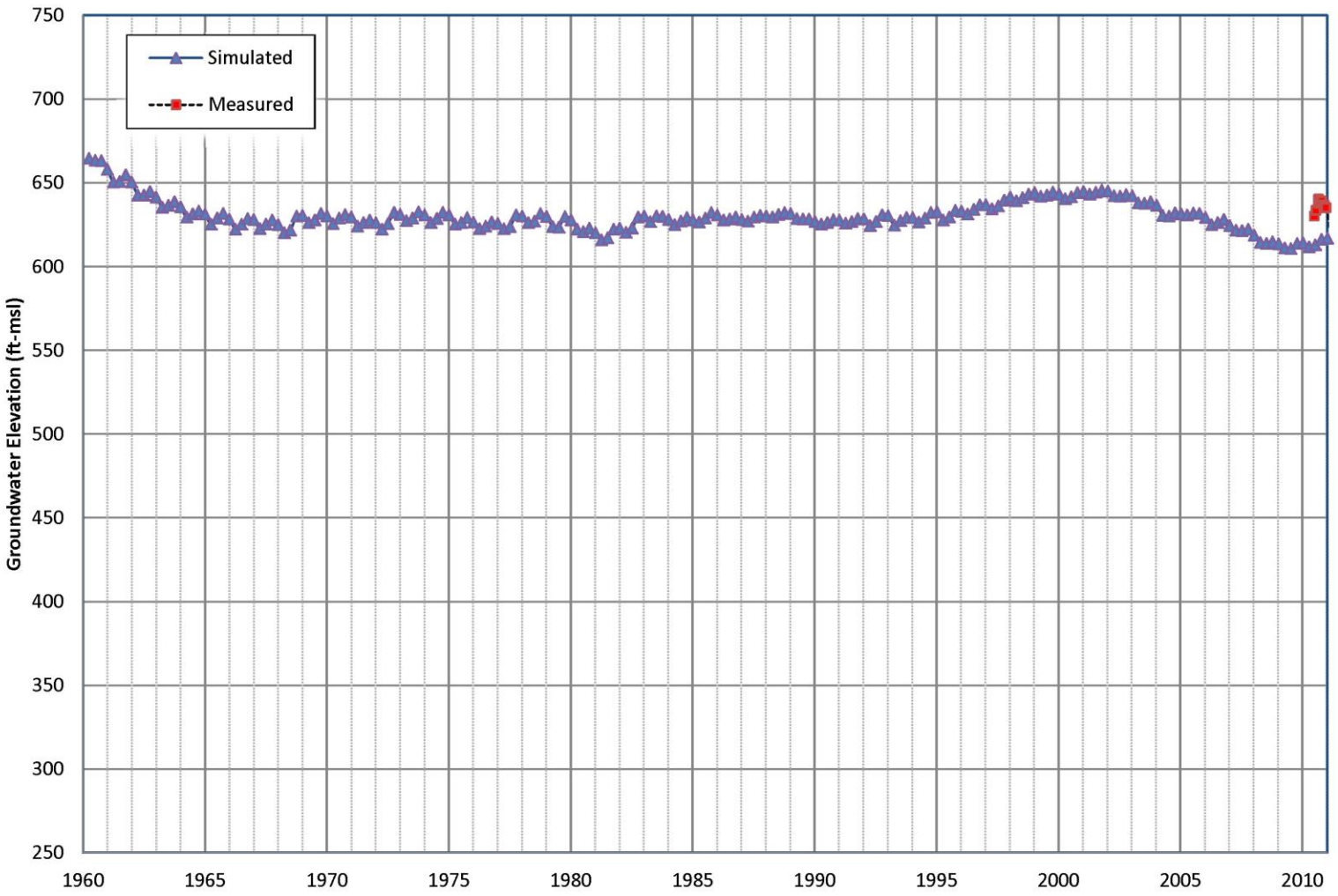


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

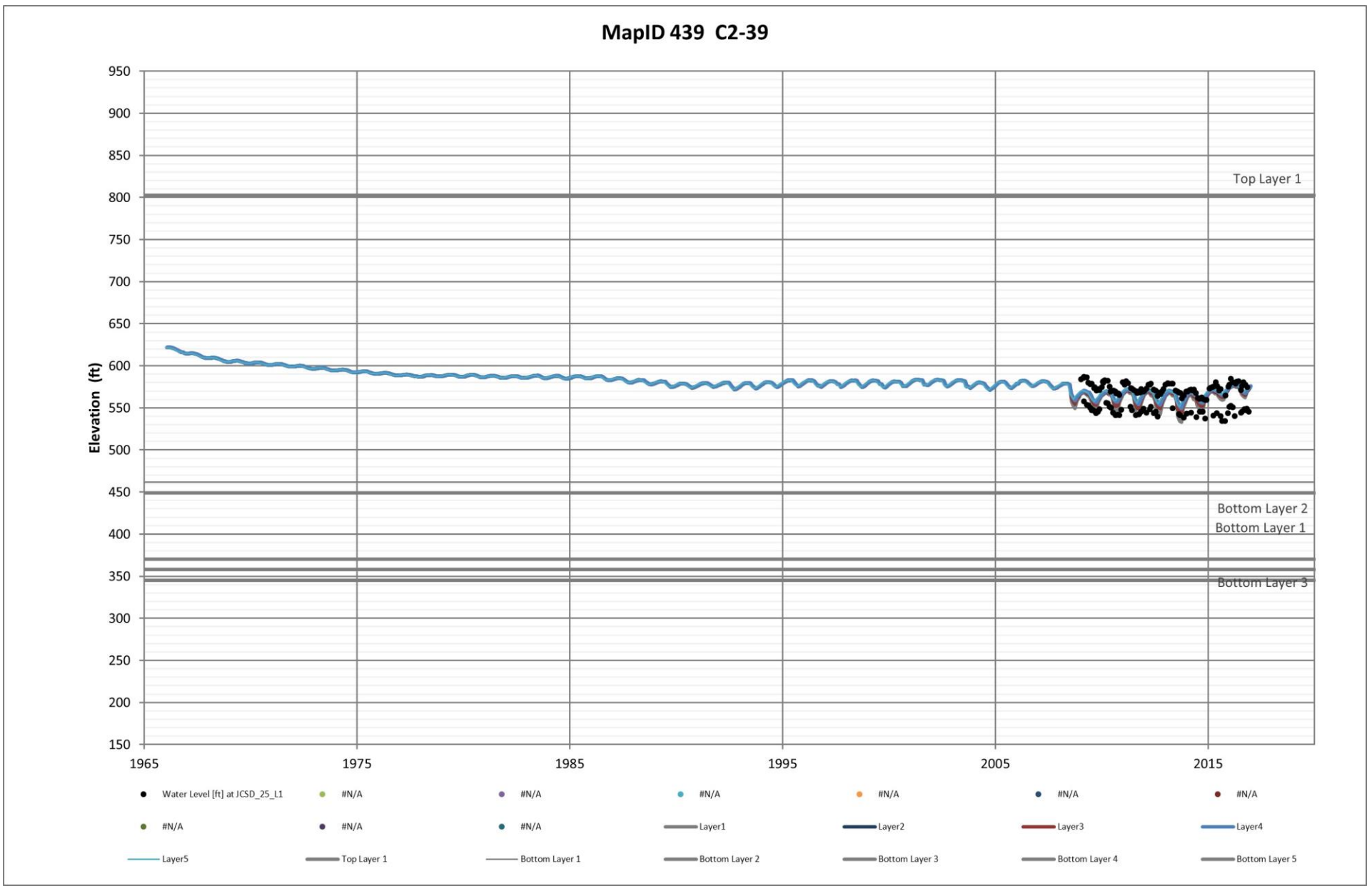


ISARM

Figure C2-38
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 6

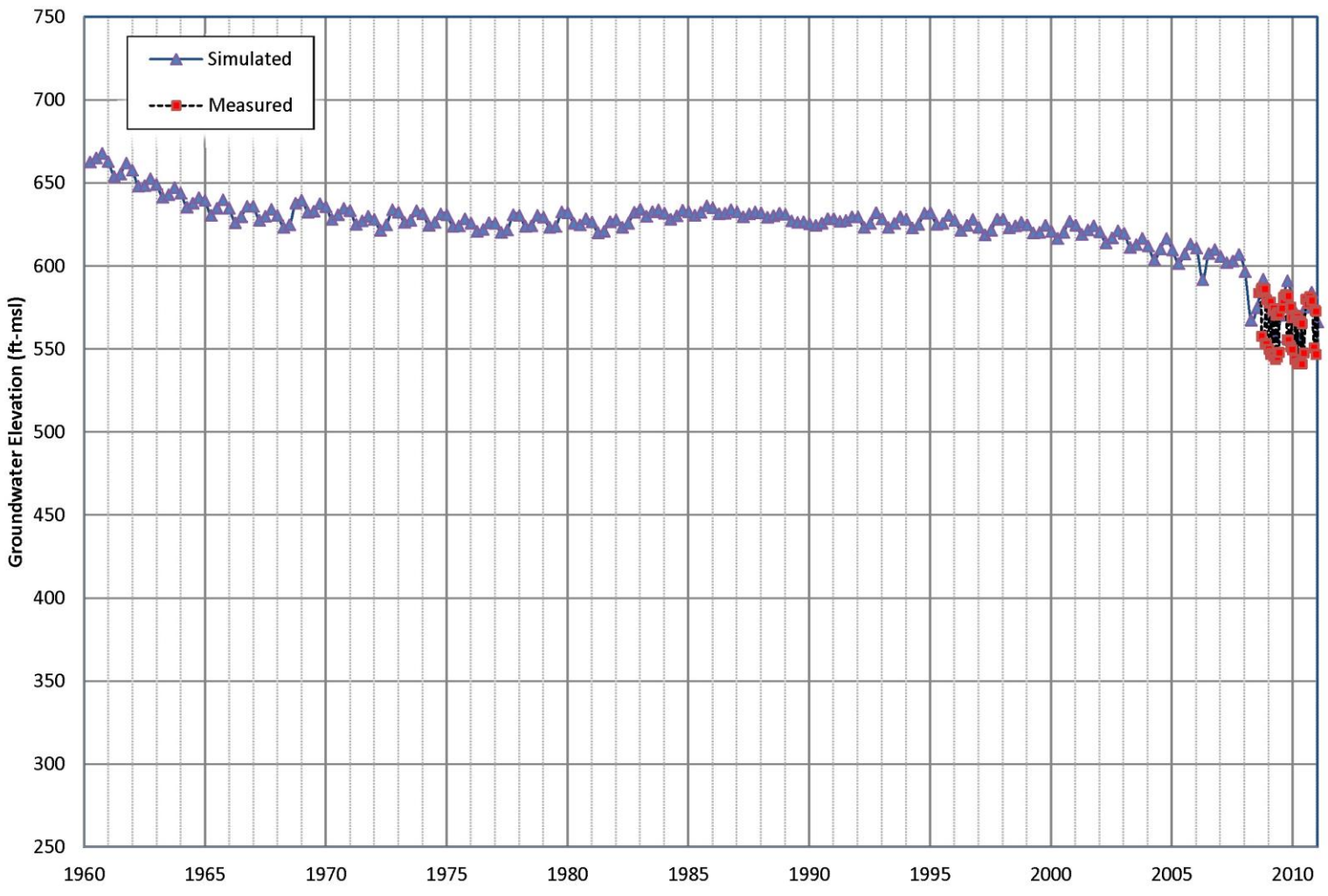


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

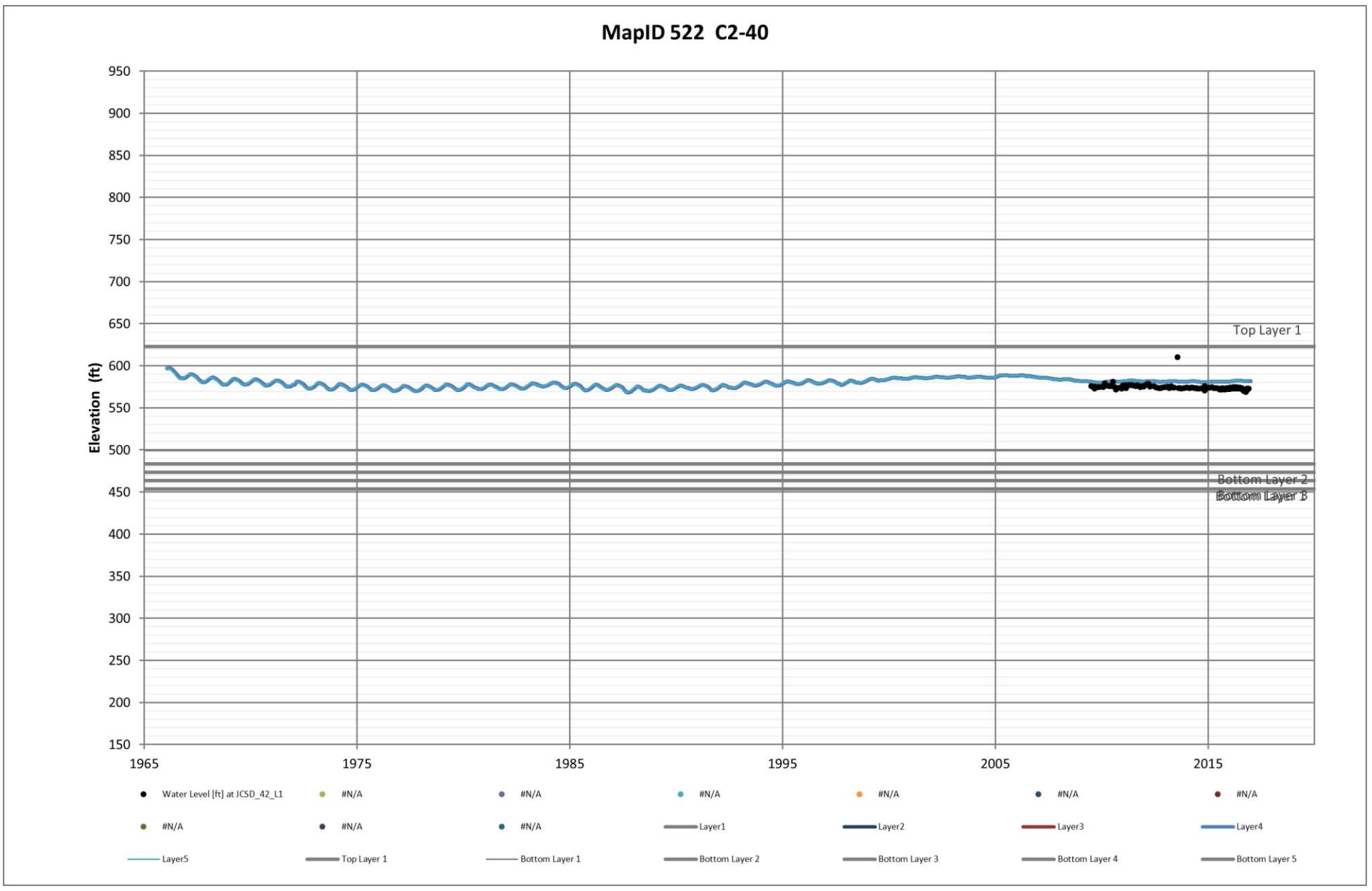


ISARM

Figure C2-39
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 25

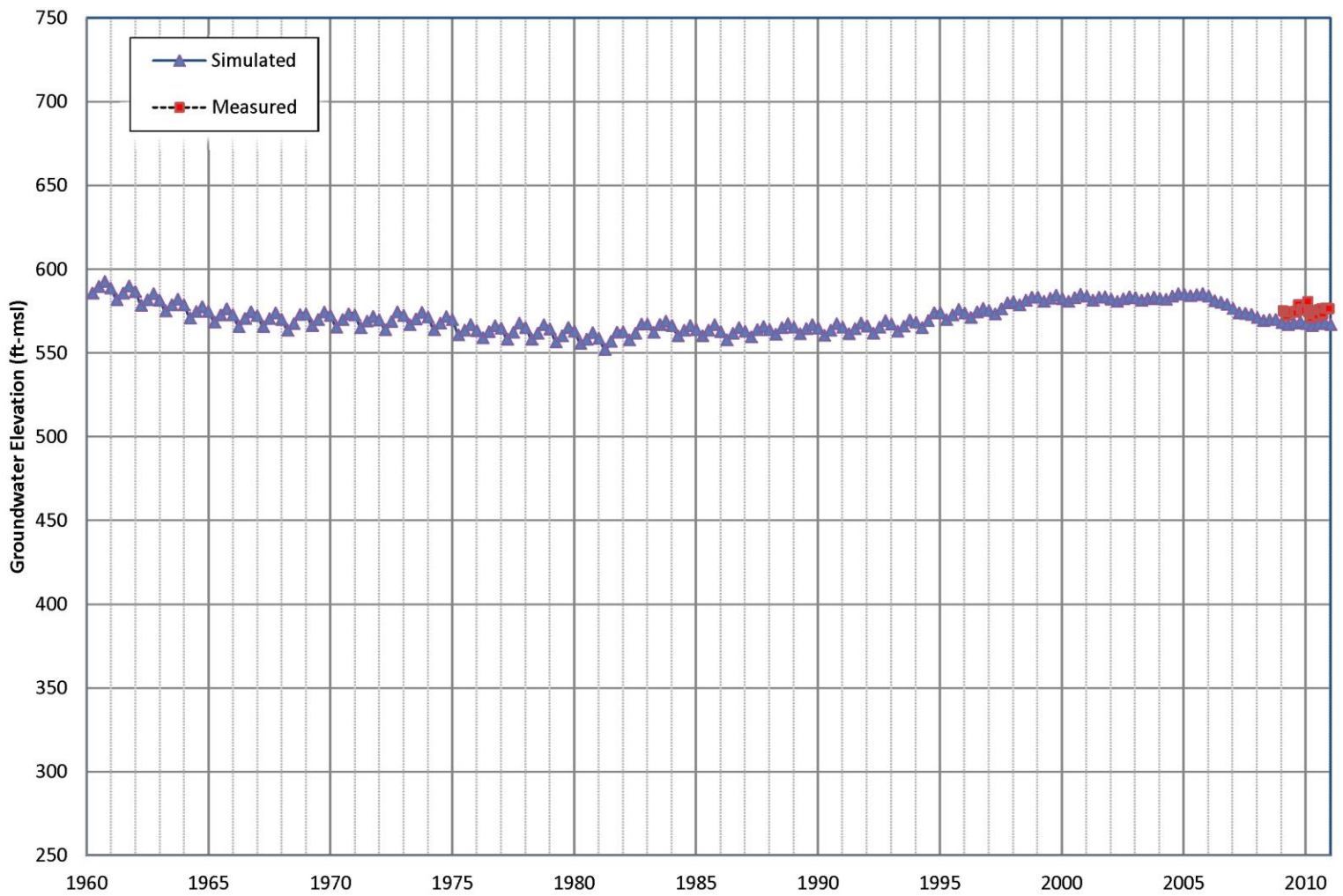


Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm



ISARM

Figure C2-40
Comparison of Measured and Simulated Groundwater Levels in JCSD Well 42



Appendix_C2_20151002_Validation_wells_Hydrographs.xlsm

From: "Mark Wildermuth, PE" <mwildermuth@weiwater.com>
Date: Wednesday, July 24, 2019 at 9:03 AM
To: Bob Tincher <bobt@sbvmwd.com>
Cc: Ron Craig <rcraig21@icloud.com>, "Elizabeth Hurst (ehurst@ieua.org)" <ehurst@ieua.org>, "Edgar Tellez-Foster (etellezfoster@cbwm.org)" <etellezfoster@cbwm.org>, "Wenbin Wang, PhD, PG" <wwang@weiwater.com>, Samantha Adams <sadams@weiwater.com>
Subject: July 10th meeting takeaways

Good Morning Bob:

This email is a follow up to our July 10th meeting at Valley District where we discussed the comments that the Chino Basin Watermaster (Watermaster) and Inland Empire Utilities Agency (IEUA) submitted to you regarding ISARM TM3. Thank you for hosting this very interesting meeting.

At the conclusion of the meeting, the group asked Wenbin Wang and me to summarize the things we could agree on. From my notes and recollection, I have three items.

First, the ISARM, as it is currently configured, requires too much computer time to use modern calibration parameter estimating techniques that utilize tools like PEST, and given the lateness of our comments and the need for timely completion of the HCP work, for the present application of the ISARM, the stakeholders will have settled with a manual trial-and-error calibration for the ISARM. Second, in our comments we asserted that the relative error statistic is an appropriate metric for groundwater model calibration, and the way it was applied artificially biased its value low (a low value suggesting a better calibration than a high value). We also asserted that the inclusion of over 9,000 groundwater level observations from one year at wells in the lower Chino Basin heavily skewed the calibration statistics. We did not reach agreement on these two issues. That said, Geoscience committed to eliminating most of these 9,000 observations, including only those observations that match up with model-estimated groundwater levels at those well (about 12 observation per well). Geoscience further agreed to publish the coefficient of determination (aka, R2 or R-square) values alongside their relative error values in an addendum to the TM3 report. The R2statistic should be included for all the basins and related scatter plots and tables. We respectfully request that you publish our estimates of the relative error for each basin (see our comments) or revised versions of them based on our comments alongside the prior Geoscience estimates. As to the Chino Basin, we ask that you provide us a file that contains the observed and model-computed groundwater levels such that we can audit Geoscience's updated calibration statistics.

Finally, Valley District committed to Ron, IEUA and the Watermaster that any water quality model built on the ISARM would be used only for groundwater basins upstream of Riverside Narrows.

Mark Wildermuth, PE

Principal Engineer
President
23692 Birtcher Drive
Lake Forest, CA 92630
Office 949.420.3030
Direct 949.600.7500

Cell 949.842.9430
Fax 949.420.4040

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EXTERNAL EMAIL

From: Sovich, Tim [mailto:tsovich@ocwd.com]
Sent: Wednesday, July 31, 2019 6:10 PM
To: Johnson Yeh
Cc: Woodside, Greg; Wes Danskin (wdanskin@gmail.com); Dave Romero (dromero@balleau.com) (dromero@balleau.com); Bob Tincher (bobt@sbvmwd.com)
Subject: RE: Upper SAR Integrated Model - Slides for 25-Jul-19 Conference Call and Summary of 10-Jul-19 Modeling Subcommittee Meeting

Johnson,

Since I was unable to attend the July 25 conference call as I was on vacation, I reviewed the slides today from the said meeting and have the following comments:

1. I agree with all of the USGS comments from Wes' summary of the July 10 modeling sub-committee meeting. I thought Wes did a great job of highlighting all of the major conclusions, path forward, and background discussion from the July 10 meeting. In my opinion, Wes' comments are consistent with the overall consensus of the modeling sub-committee.

2. Slide 39, bullet #1: the wording implies that manual trial-and-error calibration is less rigorous than automated techniques (i.e., PEST). I request revising this wording when discussing this in the final model report. The manual trial-and-error method may be less rigorous mathematically and/or statistically, but more thoroughly utilizes the expert's knowledge of the hydrogeology and hydrology of the system being modeled if done properly.

3. Slide 40, calibration vs. verification period: I wholeheartedly agree with Wes that if a model does not provide a sufficient match between simulated and observed heads (and flows) for some later verification period, then the model should be refined and that verification period should be included as an extension of the calibration period. I was very surprised how adamant Wenbin was about not doing this for the Chino Basin model so as to adhere to some modeling philosophy that I feel is out of context.

4. Slides 44 and 45, defining quality of the ISARM calibration: three bullet items are presented that accurately depict the primary methods preferred by Geoscience, WEI, and the USGS. With the modeling I have done at OCWD over the years, I most closely align with the semi-quantitative goodness of fit approach employed by the USGS as described on slide 45. However, I believe I commented at the July 10 meeting that in addition to qualitatively matching hydrographs and stream flow graphs, I have found it extremely valuable to qualitatively review simulated versus observed groundwater elevation contour maps for various snapshots over the model period. Preferably, the groundwater contours of observed heads should be constructed (or at least reviewed) by the same group of people running the model. The flow patterns and gradients should be similar between simulated and observed contours and can often inform the modeler or reviewer of potential problems areas, especially along boundaries where flow may be going the wrong direction due to improperly specified boundary heads or flows. Lastly, simulated vs. observed vertical gradients are very important to somehow show graphically wherever depth-specific monitoring wells have sufficient observations.

Best regards,
Tim

From: Sovich, Tim [mailto:tsovich@ocwd.com]
Sent: Wednesday, July 31, 2019 7:13 PM
To: Johnson Yeh
Cc: Woodside, Greg; Wes Danskin (wdanskin@gmail.com) (wdanskin@gmail.com); Dave Romero (dromero@balleau.com) (dromero@balleau.com); Bob Tincher (bobt@sbvmwd.com) (bobt@sbvmwd.com)
Subject: RE: Upper SAR Integrated Model - Slides for 25-Jul-19 Conference Call and Summary of 10-Jul-19 Modeling Subcommittee Meeting

One other thing I forgot to mention in my previous email regarding my comments on the July 25 conference call slides that summarized the July 10 model sub-committee meeting:

There is no mention of our discussion at the July 10 meeting regarding the differences in pumping between the Chino Basin model and the ISARM. Mark Wildermuth talked about the many wells (mostly agricultural I believe) that were not metered in the past and several of which are still not metered today. Mark described his logic that WEI used to estimate the seasonal agricultural pumping based on old land use maps and anecdotal information of crop types grown in various areas of Chino Basin. I don't think we reached a consensus on whether or not Mark would be willing to share their electronic pumping data file used for the Chino Basin model, or at a minimum, if Geoscience could or would be able to do a comparison of seasonal (monthly, quarterly, or annual?) historical pumping used in the two models. I am concerned that the ISARM may be missing a significant amount of pumping in the Chino Basin.

Regards,
Tim

From: Sovich, Tim [mailto:tsovich@ocwd.com]
Sent: Wednesday, July 31, 2019 7:54 PM
To: Johnson Yeh
Cc: Woodside, Greg; Wes Danskin (wdanskin@gmail.com) (wdanskin@gmail.com); Dave Romero (dromero@balleau.com) (dromero@balleau.com); Bob Tincher (bobt@sbvmwd.com) (bobt@sbvmwd.com)
Subject: RE: Upper SAR Integrated Model - Slides for 25-Jul-19 Conference Call and Summary of 10-Jul-19 Modeling Subcommittee Meeting

A couple last comments after reviewing the calibration hydrographs that BGW put together for the WEI Chino Basin model vs. the ISARM. These were shown very quickly at the July 10 meeting but I had a chance to review them more closely today.

1. Quite a few of the wells have a similar goodness of fit between the two models by visually comparing the hydrographs.

2. I was somewhat surprised that many of the wells have a better fit in the Chino Basin model than the ISARM, especially for wells that have significant temporal variations in the observed heads, and especially for the earlier years of the calibration period. Per my previous email, the reason for this better fit in the Chino Basin model may be because of the additional efforts by WEI to estimate unmetered pumping as compared to the ISARM that only used published CBWM pumping data.

3. For the ISARM calibration hydrographs, it is difficult to discern which layer the well is screened in and thus which layer of simulated heads is being calibrated since the results for all layers are shown on the hydrographs.

4. Lastly, some of the hydrographs appear to have different observed heads for the same well between the Chino Basin model and ISARM. For some wells the values appear the same but just more or less data points, but for other wells the observed data appears to have different values, possibly implying the wrong well was used on the hydrograph or maybe pumping water levels used instead of just static? Example: see page 44 of the calibration hydrograph PDF for the well with map ID 525 C1-54. The observed heads for this well in the ISARM are quite different and have much more seasonal variation than those shown in the Chino Basin model for this same well.

Regards,
Tim

Tim Sovich, P.E.
Principal Engineer

Orange County Water District
18700 Ward Street, Fountain Valley, CA 92708
tel: (714) 378-3226
fax:
email: tsovich@ocwd.com

APPENDIX B

Database Plan (GEOSCIENCE, March 21, 2018)

GEOSCIENCE

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Technical Memorandum

To:	Mr. Bob Tincher, PE Deputy General Manager - Resources San Bernardino Valley Municipal Water District 380 East Vanderbilt Way San Bernardino, CA 92408-3593	
From:	Dennis E. Williams, Ph.D., PG, CHG President GEOSCIENCE Support Services, Inc.	Johnson Yeh, Ph.D., PG, CHG Principal Geohydrologist GEOSCIENCE Support Services, Inc.
	Kapo Couibaly, Ph.D., PG Project Geohydrologist GEOSCIENCE Support Services, Inc.	
Date:	March 21, 2018	
Subject:	**Upper Santa Ana River Integrated Model - Database Plan**	

1.0 INTRODUCTION

San Bernardino Valley Municipal Water District (Valley District), in cooperation with Western Municipal Water District (Western), Inland Empire Utilities Agency (IEUA), Orange County Water District (OCWD), Riverside Public Utilities (RPU), the U.S. Geological Survey (USGS), the U.S. Fish and Wildlife Service (USFWS), and the California Department of Fish and Wildlife (CDFW), has tasked GEOSCIENCE Support Services, Inc. (GEOSCIENCE) with constructing a groundwater flow model for the Upper Santa Ana River (SAR) Watershed and Groundwater Basin (Figure 1) by integrating existing groundwater and surface water models. This model, known as the Integrated SAR Model, will be used as a management tool to determine what factors contribute to reduced streamflow in the SAR, and to evaluate potential effects from proposed projects on streamflow and groundwater levels across the basin.

This technical memorandum (TM) presents the approach used to develop a comprehensive database of all geohydrologic data collected for the Integrated SAR Model. A database documentation file will also be provided, which will include a detailed description of the database and its tables and fields. The draft

TM was issued on February 16, 2018. This revised TM incorporates responses to comments received on the draft TM (Appendix A).

2.0 LOCATIONS, DATES, AND TYPES OF DATA INCLUDED

The database will include all data collected from January 1966 through December 2016, which represents the model calibration period. The types of data include, but are not limited to:

- Well information (e.g., well name, well type, well status, well X and Y coordinates, ground surface elevation, distance from reference point to ground surface, reference point type, depth of well casing, depth intervals of well perforations, etc.);
- Groundwater pumping;
- Precipitation;
- Streamflow;
- Wastewater discharge;
- Surface water diversion;
- Groundwater recharge;
- Evaporation;
- Water level data (e.g., well name, measurement date/time, depth from reference point to water level, activity of well during measurement (static or pumping), measurement method, etc.);
- Various GIS (Geographical Information System) coverages and/or shapefiles (e.g., ground surface elevation (topography), water features (rivers, streams, recharge basins), geologic faults, land use maps, soil types, etc.).

3.0 DATA SOURCES

Data used to develop the database were obtained from multiple sources. The primary sources and types of data are summarized below:

- Various water agencies: well information, groundwater pumping, groundwater levels, groundwater recharge, and surface water diversions.
- Chino Basin Watermaster: well information, groundwater pumping, groundwater levels, groundwater recharge, surface water diversions, and wastewater discharge.

- SAR Watershed Watermaster: wastewater discharge.
- California Department of Water Resources (DWR): land use data.
- Southern California Association of Governments (SCAG): land use data.
- National Oceanic and Atmospheric Administration (NOAA): evaporation data.
- LA County: evaporation data.
- San Bernardino County and Riverside County: precipitation data.
- United States Army Corps of Engineers (USACE): streamflow.
- United States Geological Survey (USGS): groundwater levels, streamflow, and soil types.

4.0 DATABASE STRUCTURE

In order to provide an easy way to access and manage the database, data collected for the Integrated SAR Model will be organized into five databases, as summarized below:

1. Groundwater Database
2. Surface Water Database
3. Meteorological Database
4. GIS Database
5. Documents Database

Within each database (except for the GIS and documents databases), related data are grouped into database tables, which consist of rows and columns (fields). The following sections describe each database and the platform used.

4.1 Database Platforms

The groundwater, surface water, and meteorological databases will be developed using Microsoft Access. This choice is based on the wide availability of Microsoft Access and its relative simplicity. The GIS database will be developed with ESRI ArcGIS 10.2 and the ESRI file geodatabase format will be used. Similarly, this choice is based on the relative availability of ESRI ArcGIS and the fact that this format is a cross-platform that can be read by various programs outside of the ESRI products. The documents database will be developed using Adobe Acrobat.

4.2 Groundwater Database

The groundwater database will focus on data collected for groundwater. Four database tables are included in this database. Explanations for each database table are provided in Tables 1 through 4. These tables include:

- Well information (Table 1)
- Groundwater Pumping (Table 2)
- Groundwater Levels (Table 3)
- Subsurface Lithology (Table 4)

All tables will share a unique well name field which will be used to effectively link the individual tables.

4.3 Surface Water Database

The surface water database will focus on data collected for surface water. Five database tables are included in this database. Explanations for each database table are provided in Tables 5 through 9. These tables include:

- Surface Water Station Information (Table 5)
- Groundwater Recharge (Table 6)
- Streamflow (Table 7)
- Wastewater Discharge (Table 8)
- Surface Water Diversion (Table 9)

All tables will share a unique well name field which will be used to effectively link the individual tables.

4.4 Meteorological Database

The meteorological database will focus on data collected for meteorology. Three database tables are included in this database. Explanations for each database table are provided in Tables 10 through 12. These tables include:

- Meteorological Station Information (Table 10)
- Precipitation (Table 11)

- Evaporation (Table 12)

All tables will share a unique well name field which will be used to effectively link the individual tables.

4.5 GIS Database

The GIS database will be prepared in shapefile or raster format, and will include the following:

- Ground surface elevation (topography)
- Digital elevation model (DEM)
- Water features (rivers, streams, recharge basins)
- Geologic faults
- Land use maps
- Soil types
- Additional features for integrated SAR model

4.6 Documents Database

The documents database will be prepared in PDF format, and will include the following:

- DWR well logs
- E-logs
- Well construction reports for key wells
- Historical maps
- Aquifer test analyses
- Project files (meeting minutes, final TMs, etc.)

5.0 DATA ENTRY

After the database is approved by the Technical Advisory Committee (TAC), the data will be loaded into the database.

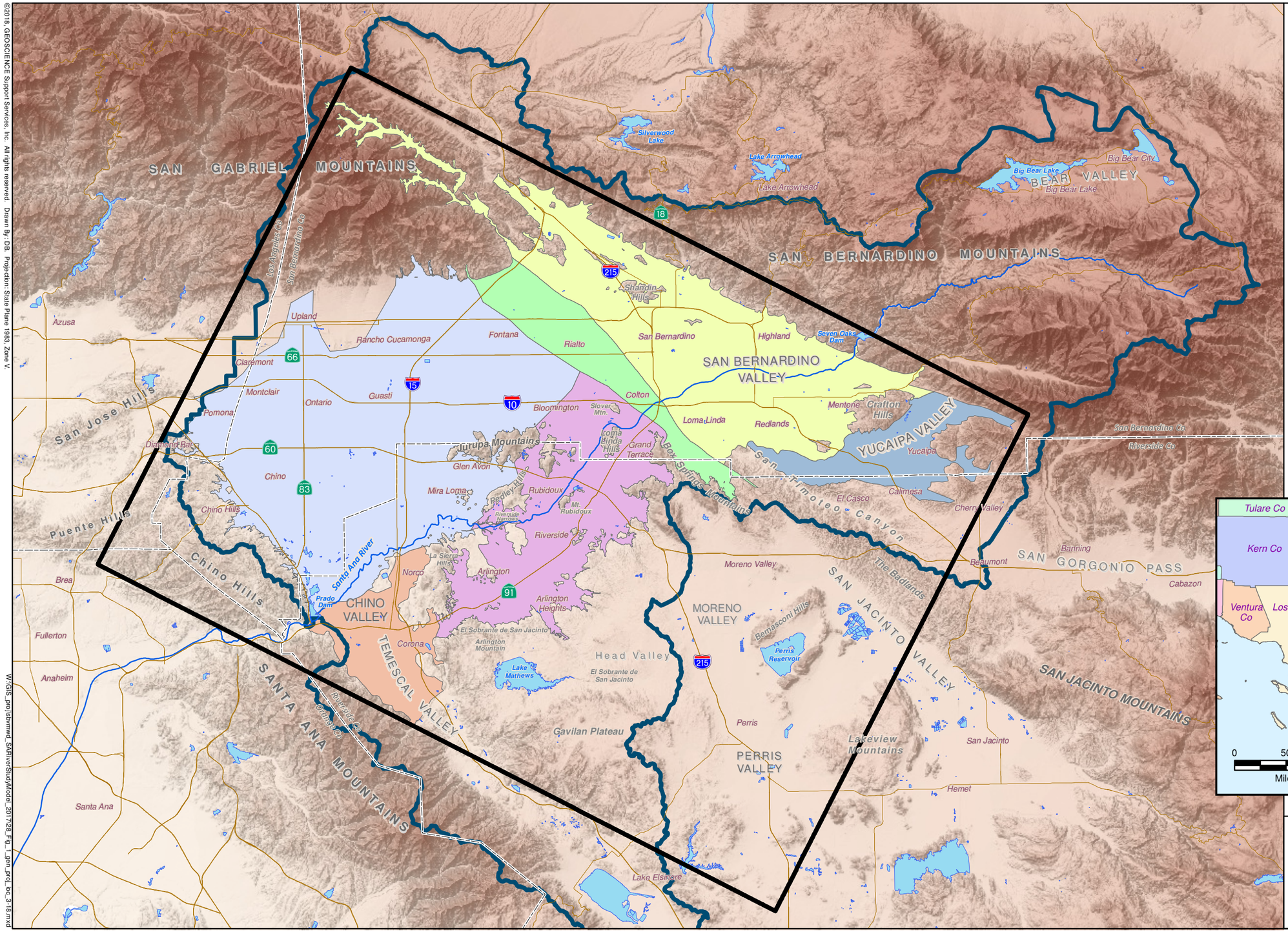
6.0 QUALITY ASSURANCE / QUALITY CONTROL

A systematic Quality Assurance/Quality Control (QA/QC) review will be performed on the collected data to identify potential errors and outliers in the flow and water quality data. The consolidated database will also be reviewed to identify and eliminate duplicate data.

FIGURE

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©2018, GEOSCIENCE Support Services, Inc. All rights reserved. Drawn By: DB. Projection: State Plane 1983, Zone V.


SAN GABRIEL MOUNTAINS
SAN BERNARDINO MOUNTAINS
BEAR VALLEY
SAN BERNARDINO VALLEY
YUCAIPA VALLEY
CHINO VALLEY
TEMESCAL VALLEY
MORENO VALLEY
PERRIS VALLEY
SAN JACINTO VALLEY
SAN JACINTO MOUNTAINS
SANTA ANA MOUNTAINS
SAN GORGONIO PASS
Puente Hills
San Jose Hills
Chino Hills
Jurupa Mountains
Box Springs Mountains
San Timoteo Canyon
Badlands
Lakeview Mountains
Gavilan Plateau
Head Valley
Silverwood Lake
Lake Arrowhead
Big Bear Lake
Big Bear City
Seven Oaks Dam
Prado Dam
Lake Mathews
Perris Reservoir
Lake Elsinore
Santa Ana River
Los Angeles Co
San Bernardino Co
Riverside Co
Orange Co
Azusa
Upland
Rancho Cucamonga
Fontana
Rialto
San Bernardino
Highland
Claremont
Montclair
Ontario
Guasti
Colton
Bloomington
Pomona
Diamond Bar
Chino
Mira Loma
Glen Avon
Rubidoux
Riverside
Norco
Corona
Arlington
Arlington Heights
Moreno Valley
Perris
Hemet
San Jacinto
Beaumont
Banning
Cabazon
Loma Linda
Redlands
Mentone
Crafton Hills
Yucaipa
Calimesa
El Casco
Cherry Valley
Brea
Fullerton
Anaheim
Santa Ana
Chino Hills
Sharidin Hills
Bernasconi Hills
Grand Terrace
Loma Linda Hills
Sleven Mtn.
Mt. Rubidoux
Riverside Narrows
La Sierra Hills
El Sobrante de San Jacinto
Arlington Mountain
El Sobrante de San Jacinto
Lake Arrowhead
Big Bear Lake
Riverside Co
San Bernardino Co
Riverside Co
Orange Co
Chino Hills
Santa Ana River
Prado Dam
Perris Reservoir
Lake Mathews
Lake Elsinore
Lakeview Mountains
Gavilan Plateau
Head Valley
Perris
San Jacinto
Hemet
Moreno Valley
Beaumont
Banning
Cabazon
Yucaipa
Calimesa
El Casco
Cherry Valley
Redlands
Loma Linda
Mentone
Crafton Hills
Colton
Bloomington
Rialto
Fontana
Rancho Cucamonga
Upland
Azusa
Claremont
Montclair
Ontario
Guasti
Pomona
Diamond Bar
Chino
Mira Loma
Glen Avon
Rubidoux
Riverside
Norco
Corona
Arlington
Arlington Heights
Brea
Fullerton
Anaheim
Santa Ana
Chino Hills
Sharidin Hills
Bernasconi Hills
Grand Terrace
Loma Linda Hills
Sleven Mtn.
Mt. Rubidoux
Riverside Narrows
La Sierra Hills
El Sobrante de San Jacinto
Arlington Mountain
Lake Arrowhead
Big Bear Lake
Big Bear City
Seven Oaks Dam

TABLES

GEOSCIENCE

Well Information Database Table

Column Name	Column Definition	Units	Explanation
SWN	State Well Number	-	Wells are identified according to their location in the rectangular system used for subdivision of public lands
Name	Well Name	-	Unique abbreviation for use in the database
Owner	Well Owner	-	Well owner
Long	Longitude	degrees	Geographic location in decimal degrees
Lat	Latitude	degrees	Geographic location in decimal degrees
Perfs_Top	Top of perforated interval	ft	Top of perforated interval
Perfs_Bot	Bottom of perforated interval	ft	Bottom of perforated interval
Top_1*	Top of first perforated interval	ft	Top of first perforated interval
Bot_1*	Bottom of first perforated interval	ft	Bottom of first perforated interval
Ref_pt	Reference Point	ft	Reference point for water level measurement
Ref_dat	Reference Point Datum	-	Elevation datum of the reference point (NAVD88, NGVD29, etc.)
W_stat	Well Status	-	Well status (destroyed, abandoned, active, etc.)
St_type	Well Type	-	Well type (pumping, monitoring, lithology, etc.)
Case_ft	Cased Depth	ft	Depth of well casing
Hole_ft	Borehole Depth	ft	Borehole depth from surface
Lithlog	Lithologic Log	-	Is a lithologic log on file for this well? (yes or no)
Elog	E-log	-	Is a e-log on file for this well? (yes or no)
Aquifer_test	Aquifer test results	-	Is an aquifer test on file for this well? (yes or no)
Notes	General Notes and Comments	-	General notes and comments (change in Ref_pts, etc.)

*Additional fields will be added to accommodate the screened intervals of wells in the database.

Table 1

Groundwater Pumping Database Table

Column Name	Column Definition	Units	Explanation
SWN	State Well Number	-	Wells are identified according to their location in the rectangular system used for subdivision of public lands
Name	Well Name	-	Unique abbreviation for use in the database
Date	Date	-	Date
Q_afm	Production	acre-ft/month	Groundwater volume produced by the well during the month
Source	Source	-	Source of production data

Table 2

Groundwater Levels Database Table

Column Name	Column Definition	Units	Explanation
SWN	State Well Number	-	Wells are identified according to their location in the rectangular system used for subdivision of public lands.
Name	Well Name	-	Unique abbreviation for use in the database
Date	Date	-	Date
DTW	Depth to Water	ft	Depth to water below reference point
WL_Status	Water Level Status	-	Water level status (static, pumping, or unknown)
WL_Method	Water Level Method	-	Water level method (electric sounder, steel tape, automated transducer, etc.)
GW_Elev	Groundwater Elevation	ft amsl	Elevation of groundwater
Source	Source	-	Source of groundwater levels

Table 3

Subsurface Lithology Database Table

Column Name	Column Definition	Units	Explanation
SWN	State Well Number	-	Wells are identified according to their location in the rectangular system used for subdivision of public lands
Name	Well Name	-	Unique abbreviation for use in the database
From	Beginning of Depth Interval	ft	Beginning of depth interval for a specific lithology
To	End of Depth Interval	ft	End of depth interval for a specific lithology
Lith	Lithology Type	-	Lithologic description
Source	Source	-	Source of lithologic description

Table 4

Surface Water Station Information Database Table

Column Name	Column Definition	Units	Explanation
StName	Station Name	-	Unique abbreviation of the station name database
Long	Longitude	degrees	Geographic location in decimal degrees
Lat	Latitude	degrees	Geographic location in decimal degrees
Sta_typ	Station Type	-	Describes the station type (recharge pond, stream gage, discharge, etc.)
Area	Station Area	acres	Station area for recharge basins
Notes	General Notes and Comments	-	General notes and comments

Table 5

Groundwater Recharge Database Table

Column Name	Column Definition	Units	Explanation
Name	Recharge Basin Name	-	Name of recharge basin
Date	Date	-	Date
Area	Area	acres	Area of recharge basin
Rch_afm	Recharge	acre-ft/month	Amount of groundwater recharge
Source	Source	-	Source of data

Table 6

Streamflow Database Table

Column Name	Column Definition	Units	Explanation
Name	Gaging Station Name	-	Name of gaging station
Date	Date	-	Date
SW_Q_cfs	Surface Water Discharge	cfs	Surface water discharge
Codes	Codes	-	Data-value qualification codes
Source	Source	-	Source of data

Table 7

Wastewater Discharge Database Table

Column Name	Column Definition	Units	Explanation
Name	Name	-	Name of discharge facility
Date	Date	-	Date of mesurement
Flow_cfs	Flow	cfs	Wastewater discharge
Source	Source	-	Source of data

Table 8

Surface Water Diversion Database Table

Column Name	Column Definition	Units	Explanation
Location	Location	-	Location of surface water diversion
Date	Date	-	Date
Flow_cfs	Flow	cfs	Surface water diversion
Source	Source	-	Source of data

Table 9

Meteorological Station Information Database Table

Column Name	Column Definition	Units	Explanation
StName	Station Name	-	Unique abbreviation of the station name
Long	Longitude	degrees	Geographic location in decimal degrees
Lat	Latitude	degrees	Geographic location in decimal degrees
Elev	Elevation	ft	Station elevation
Sta_typ	Station Type	-	Station type (ET, rainfall, etc.)
Notes	General Notes and Comments	-	General notes and comments

Table 10

Precipitation Database Table

Column Name	Column Definition	Units	Explanation
Station	Station	-	Name of precipitation station
Date	Date	-	Date
Precip	Precipitation	inches	Amount of precipitation
Source	Source	-	Source of data

Table 11

Evaporation Database Table

Column Name	Column Definition	Units	Explanation
Station	Station	-	Name of evaporation station
Date	Date	-	Date
Evap	Evaporation	inches	Amount of evaporation
Source	Source	-	Source of data

Table 12

APPENDIX A

Comments Received and GEOSCIENCE Responses for the Draft Database Plan

(16-Feb-2018)

GEOSCIENCE

Comments Received and GEOSCIENCE Responses for the Draft Database Plan

No.	Commenter	Section	Pg.	Comment	GEOSCIENCE Response
1	OCWD	Tables	Table 1	Will this structure be able to handle multi-depth nested monitoring wells? If so, I assume that each casing of a nested well will have a unique SWN number even though they are constructed within the same borehole?	Yes, each casing of a nested well will have a unique SWN. For example, multi-depth nested monitoring wells 01N/06W-26A01S, 01N/06W-26A02S, and 01N/06W-26A03S are constructed in the same location with depth of 870 ft, 660 ft, and 550 ft, respectively.
2	OCWD	Tables	Table 1	Add a field for Cased Depth	Table 1 was revised.
3	OCWD	Tables	Table 1	Split Perfs into two fields: Perfs_Top and Perfs_Bot (this way they can be queryable numerical fields rather than a text string)	Table 1 was revised.
4	OCWD	Tables	Table 1	What about production wells with multiple screened intervals within a single well casing? Retain all the detailed intervals or only store topmost and bottommost perf as in #3 above?	All detailed intervals will be provided. Table 1 shows new fields for Top_1 and Bot_1. Additional fields will be added to accommodate the screened intervals of all wells in the database.
5	OCWD	Tables	Table 1	Possibly could add yes/no fields for lithlog, elog, and aquifer test results (these fields have been helpful in our OCWD database)	Table 1 was revised.
6	OCWD	Tables	Tables 2 through 4	Change State Well Number field name to SWN to be consistent with Table 1.	Tables 2 through 4 were revised.
7	OCWD	Tables	Table 3	Add a field for WL Method (e.g., electric sounder, steel tape, automated transducer, etc.)	Table 3 was revised.
8	OCWD	Tables	Table 3	Add a field for WL Status (static, pumping, or unknown)	Table 3 was revised.
9	OCWD	Tables	Table 6	Change field name from Rch to Rch_afm to be consistent with monthly pumping field in Table 2.	Table 6 was revised.
10	OCWD	Tables	Tables 8 and 9	Change field names from Flow to Flow_cfs to be consistent with previous volumetric rate names above including the units.	Tables 8 and 9 were revised.
11	OCWD	-	-	In addition to the four Access databases proposed in the memo (groundwater, surface water, meteorological, and GIS), you might want to consider having a fifth "Documents Database," which would include PDF files of documents such as DWR well logs, elogs, well construction reports for key wells, historical maps, aquifer test analyses, and project files such as meeting minutes and final tech memos.	An additional documents database was added on Page 3, Section 4.0 and Page 5, Section 4.6.

APPENDIX C

Meeting Minutes

GEOSCIENCE

APPENDIX C:

MEETING MINUTES

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Minutes of the Upper Santa Ana River Integrated Model Kickoff Meeting

San Bernardino Valley Municipal Water District

May 10, 2017
1:00 pm
Valley District

Issued on June 2, 2017

Attendees:	Army Corps of Engineers (USACE): Chris Jones
	Aspen: Scott White
	CA Department of Fish and Wildlife: Joanna Gibson
	Chino Basin Watermaster: Edgar Tellez Foster
	GEOSCIENCE: Dennis Williams, Johnson Yeh, Kapo Coulibaly, Mark Williams, Brian Villalobos, and Lauren Wicks
	ICF: Brendan Belby (remotely)
	Inland Empire Utilities Agency (IEUA): Jason Pivovaroff
	Leidos: Joel Degner
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Tim Sovich
	Riverside: Farid Bowshaki and Michael Plinski
	San Bernardino Valley Municipal Water District (Valley District): Heather Dyer, Wen Huang, and Bob Tincher
	Santa Ana Watershed Project Authority (SAWPA): Ian Achimore
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	Western Municipal Water District (WMWD): Ryan Shaw and Mallory Gandara

ITEM 1: INTRODUCTIONS

Mr. Bob Tincher, Water Resources Manager with the San Bernardino Valley Municipal Water District (Valley District), commenced the kickoff meeting with introductions by all those in attendance.

ITEM 2: ADMINISTRATIVE GUIDELINES

Mr. Tincher explained that the purpose of this meeting was to review the scope of work for the Santa Ana River (SAR) Integrated Model and make sure any questions regarding the proposed process are answered.

ITEM 3: OVERVIEW OF PROJECT WORK PLAN AND DATA REQUEST

The GEOSCIENCE team delivered a presentation that summarized the work plan items, including:

- Project Goals,
- Project Approach and Scope of Work,
- Deliverables and Work Product,
- Project Meetings and Peer Review, and
- Project Schedule.

Dr. Dennis Williams started off by outlining the project goals, and Dr. Johnson Yeh then discussed the six (6) key issues that the modeling approach was based on.

Questions asked, along with follow-up responses, included:

1. Mr. Tincher asked for an explanation of the process for creating a lithologic model. Mr. White from Numeric Solutions replied that geologic data will be compiled along with the structural interpretation (i.e., base of aquifer from known data). Numerical values are assigned to lithology intervals from driller's logs and the lithology between known points is interpolated in 3-D space using a geostatistical method, such as kriging. Model layers are then defined from the resulting lithologic model. Mr. White confirmed that Numeric Solutions makes these types of models routinely, and have already completed 3 of the 5 lithologic models for the proposed Integrated SAR Model. The remaining 2 models will be developed from available information, including pre-existing cross-sections.
2. Regarding the 1963, 1984, 1993, and 2005 land use maps which will be used for the Integrated SAR Model, Ms. Gibson asked what the importance of those years were. Dr. Yeh replied that these are the available Department of Water Resources (DWR) land use maps which will be used by the model to calculate runoff generated during the calibration period from 1966 through 2016. Mr. Plinski asked what year was going to be used for the streambed topography, and Dr. Yeh replied that the most recent LIDAR data from 2015-2016 would be used.
3. Mr. Plinski asked what data would be used to compare model-calculated and actual riparian consumption. In particular, Mr. Plinski was interested in what shallow groundwater data was available. Dr. Yeh replied that Aspen would quantify the riparian consumption and the model will be used to verify the amount of surface water from observed measurements; there are very few shallow groundwater data available.
4. Mr. Bowshaki inquired how the diversity of riparian vegetation and varying root depth would affect the root zone package in MODFLOW. Mr. White from Aspen acknowledged that, while there is not a lot of data available for rooting depth of various species, rooting depth is dependent on the depth of water. Aerial photography will be used to trace the location, density, and type of vegetation with time, and modeled groundwater elevations will be used to come up with an estimate of root depth. Ms. Dyer commented that this will be an iterative process and, since no one has attempted this yet, much of the details will likely have to be figured out as we go. Dr. Yeh added that the new ET package in MODFLOW can handle variable depth.

5. It was asked what the importance is of historical data sets. Dr. Yeh replied that it is important to see how the model performs against known historical data in order to make sure that the model is defendable and that the Technical Advisory Committee (TAC) is comfortable moving forward to model simulations. Ms. Dyer mentioned that it is a way to calibrate the model, and Mr. Tincher added that we are hoping that by looking at historical data, the model can help identify why water level has declined in the river. Dr. Williams explained that the calibration technique is known as history matching. There are a lot of different inflows and outflows that must be quantified and adjusted so that the model reflects observed water levels.

6. Mr. Sovich asked for clarification on the model calibration period, which was listed as 1996 through 2016 in the proposal. Dr. Yeh clarified that the value listed must have been a typo; the calibration period is 1966 through 2016.

7. In regards to the basin underflow, Dr. Yeh explained that the Integrated SAR Model will maintain the underflow values from the Rialto-Colton Basin Model since it was peer-reviewed by the USGS and Balleau Groundwater, and calibrated to both water levels and perchlorate concentrations (including groundwater flow direction and seepage velocity).

8. Dr. Yeh presented an example of how the model will be run. Preliminary testing has indicated the model will take approximately 3 days to run with the proposed cell size. Clarification was requested regarding why 5 runs were being made each time, and Dr. Williams replied that the 5 runs represent runs with different variations made to the model parameters.

9. Mr. Tincher asked Dr. Yeh to explain what the TAC was. Dr. Yeh described the TAC as the Technical Advisory Committee, composed essentially of the assembled group, the US Geological Survey (USGS), and Balleau Groundwater. Ms. Dyer explained that they tried to recreate the procedure used for the Rialto-Colton Model since it was so successful. Valley District has approached the USGS and Balleau Groundwater to serve as advisors for the model construction and calibration process, and will send out their proposals to the group for review as soon as they are received.

10. Dr. Yeh described that the model calibration will be conducted using over 800 wells and 9 gaging stations. Mr. Sovich queried whether those wells are monitoring wells or production wells. Dr. Yeh replied that both types of wells will be used and that some of the monitoring wells are multi-depth USGS monitoring wells. Mr. Plinski commented that there did not appear to be very many wells in the Temescal Basin.

11. Dr. Williams asked Dr. Yeh to elaborate on the decoupling capability of the Integrated SAR Model. Dr. Yeh explained that each of the 5 individual models in the integrated model will be able to be used independently. The boundary conditions for each will come from the calibrated Integrated SAR Model. Mr. Sovich asked if the boundaries would be time specified and Dr. Yeh replied in the affirmative. Ms. Dyer added that this function could help with CEQA documentation for individual projects since the individual models, which have been updated with the best available data, can be used to conduct project-specific model scenarios.

12. Mr. Belby inquired whether the HCP covered activities mentioned in discussions about the predictive model scenarios will include all of the current activities in the Chino Basin and IEUA area. Ms. Dyer replied that a final list will be provided, which may come from ICF. She also explained that there are other activities which may not be classified as an HCP covered activity that can be evaluated in the planned predictive scenarios for “other projects not included in the HCP covered activities” (i.e., Scenario 3). Mr. Pivovaroff clarified that the HCP projects in the

IEUA area are those outlined in the Recharge Master Plan Update. Mr. Belby then asked whether the new model will incorporate the work that has already been done on some of the projects. Ms. Dyer explained that Mr. Belby is currently working on a surface flow analysis based on data from previous models of the Chino Basin and may be concerned if there is a significant difference in the results. Mr. Tellez Foster explained that Wildermuth Environmental Inc. (WEI) has been doing extra modeling for some of the recharge basins. This modeling will be included in the updated version of the Wasteload Allocation Model (WLAM).

13. Mr. Tincher posed the question of whether the flows from the new model would supersede previous estimates since it will take into account both groundwater and surface water. Ms. Dyer replied that she does not expect the results to be hugely different, but there might be some differences as you move downstream. Regardless, these estimates will be refined. Mr. Pivovaroff asked if there was a point in the process of development where you would reach out to WEI to address differences. Dr. Williams replied that GEOSCIENCE has developed a version of the Chino Basin Model but would like to get the model files from WEI to avoid unnecessary differences. Mr. Tincher added that if the model files are provided, a comparison can be made regarding any difference in the modeling results. This becomes significantly harder to do if the files are not provided. Dr. Yeh explained that, if the files are not provided, the Chino Basin section of the Integrated SAR Model will be based on the published report by WEI; however, some data may be missing.

14. Mr. Huang inquired whether the proposed project schedule, planned to be completed at the end of July 2018, included the possible creation of the Chino Basin Model. Dr. Yeh replied that it did account for the extra time required to build the model should the model files not be provided.

15. Dr. Coulibaly presented the data requests for the Integrated SAR Model. Mr. Tincher remarked that it would be helpful to set up a matrix regarding the data request items, agency responsible for providing the information, and status.

16. Regarding the data request for Prado Dam data, Mr. Sovich questioned whether it might be easier to use the inflow which has already been calculated. Mr. Degner replied that the inflow data is what information from the data request would be used to find, so it would be helpful to have the inflow data if it has already been calculated. He added that evapotranspiration data would still be needed. Mr. Sovich remarked that the evapotranspiration may already be included in the calculations. Mr. Tincher explained that the key information is surface water levels and surface flow because the evapotranspiration can be adjusted during the calibration process. Ms. Dyer pointed out that Mr. Jones from the Army Corps of Engineers (USACE) was in attendance and might possibly be of some help regarding the Prado Dam data request. Following the meeting, Mr. Sovich circulated Table 6 from the most recent 2015-2016 Santa Ana River Watermaster Report, which showed monthly inflow to Prado calculated based on daily measured outflow and change in storage.

17. Mr. Sovich inquired whether a water budget was planned as part of Task 1. Dr. Yeh replied that a water budget will be included as part of Technical Memorandum (TM) 1.

18. Mr. Sovich also questioned whether or not the 100-ft grid spacing was overkill, and whether a 200-ft grid might be sufficient. Dr. Williams explained that, while a 100-ft grid may be overkill, it will not have to be refined down. This prevents the need for competing models which may not be consistent with the results of the Integrated SAR Model.

19. Regarding the model calibration, Mr. Sovich asked whether GEOSCIENCE had thought about

calibrating the individual models before calibrating the Integrated SAR Model. Dr. Yeh confirmed that that approach would be used – each of the 5 models will be updated and calibrated, then the boundary conditions will be removed, and the Integrated SAR Model will be calibrated.

20. Mr. Sovich also questioned whether the hydrologic period from 1996 through 2016 would be sufficient, especially given that some of the older data going back to 1966 may be less reliable. Dr. Williams and Dr. Yeh explained that the calibration period was chosen to correspond to the HCP baseline (1966-1990), and Ms. Dyer added that the HCP baseline was established by Mr. Belby and represented the period of time that existing models had in common. Mr. Plinski mentioned that perhaps more importance should be placed on more recent data, given Mr. Sovich's comment on data accuracy.
21. Mr. Sovich questioned how changes in the river channel over time will be addressed by the model. Dr. Yeh acknowledged that that subject has not been thought about yet, but Mr. Degner pointed out that channelization has been taken into account in the existing models.
22. Mr. Bowshaki asked whether the whole dataset will be used, or whether part will be withheld to serve as a validation for the calibration. Dr. Yeh replied that the team would like to use the whole data set, but place more importance on model performance during the more recent time period.
23. Regarding groundwater levels, Mr. Sovich inquired whether pre-existing groundwater level contours will be looked at – particularly how each basin transitions to the next – or whether a new set of contours will be created from the data. Dr. Williams replied that both will probably be done.
24. Mr. Tincher commented on the peer-review discussed by Ms. Dyer earlier in the meeting. The review team, including the USGS and Balleau Groundwater, has been used for two previous basins. Mr. Tincher wanted to make sure the team agreed with the choice to use these two groups for this project. Mr. Plinski remarked that, as an observer during the Rialto-Colton Model process, he thought the exchange went well and the model is probably one of the better ones because of it. Mr. Achimore asked whether the review team would write up a TM at the end. Mr. Tincher replied in the affirmative and Mr. Plinski noted that Balleau provided comments on each of the modeling TMs for the Rialto-Colton Model. Ms. Dyer added that this review process would add weight to the modeling results. Ms. Gibson agreed that it would make the process more transparent. Mr. Shaw inquired about the cost and Mr. Tincher replied that the proposals should be coming in on Friday (May 12). These proposals will be sent around for comment along with cost-share letters.

ITEM 4: ACTION ITEM LIST AND DECISION LOG

Action Item List

Action Item Description	Responsible Agency	Status
1. Finalize the list of HCP covered activities	Valley District/ICF	In Progress
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	In Progress
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	In Progress

Decision Log

Item	Description
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.

ITEM 5: OTHER BUSINESS

No other business was discussed at this meeting.

ITEM 6: NEXT MEETING

The next meeting, which will be a conference call, is scheduled for Wednesday, May 31st, 2017 at 3:30pm. GEOSCIENCE will send around the call-in details.

ADJOURNMENT

The meeting adjourned on Wednesday, May 10th, 2017 at 2:30pm.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

San Bernardino Valley Municipal Water District

May 31, 2017
3:30 pm

Issued on June 23, 2017

Attendees:	Aspen: Scott White
	CA Department of Fish and Wildlife (CDFW): Joanna Gibson
	Chino Basin Watermaster: Edgar Tellez Foster
	City of Riverside Public Utilities (RPU): Farid Bowshaki and Michael Plinski
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, Kapo Coulibaly, Mark Williams, Brian Villalobos, and Lauren Wicks
	ICF: Brendan Belby
	Inland Empire Utilities Agency (IEUA): Liz Hurst and Sylvie Lee
	Leidos: Joel Degner
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Tim Sovich
	San Bernardino Valley Municipal Water District (Valley District): Heather Dyer, Wen Huang, and Bob Tincher
	Santa Ana Watershed Project Authority (SAWPA): Mark Norton
	US Army Corps of Engineers (USACE): Jen McAdoo and Erica Kemp Weitzman
	US Fish and Wildlife Service (USFWS): Kai Palenscar and Karin Cleary-Rose
	Western Municipal Water District (WMWD): Ryan Shaw

ITEM 1: APPROVAL OF 10-MAY-17 KICKOFF MEETING MINUTES

Mr. Yeh explained that, after sending the draft meeting minutes to the Technical Advisory Committee (TAC) on 18-May-17, Mr. Sovich sent a response to clarify the Prado Dam inflow calculation and availability of daily data. No additional comments were provided by the TAC during the conference call. Any remaining comments will be received until close of business, Friday, 2-Jun-17, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh reviewed the project schedule with the group and explained that Task 1 (Model Integration) is anticipated to take five and a half (5 ½) months and is expected to be completed at the end of October

2017. He also went over the other tasks, peer review processes, and scheduled workshops and conference calls.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the action item list from the project kickoff meeting, which was included in the previous meeting minutes. Ms. Dyer provided an update of the HCP covered activities. She explained that the ICF team presented the preliminary assessment analysis for hydrology on 15-May-17. An internal workshop will be held on 12-Jun-17 to come up with some ideas for achieving recommended minimum flows in the river, which will help determine the final covered activities package. It is expected that a finalized list will be available around the end of June after baseflow issues are resolved.

ITEM 4: REVIEW DECISION LOG

The decision log from the project kickoff meeting was also reviewed by Mr. Yeh. Mr. Bowshaki expressed his concern about placing importance on the last five or six years, which represent drought conditions. Mr. Yeh replied that a decision needs to be made on what time period will be given more importance, and it should include dry, wet, and average hydrologic conditions. Mr. Sovich added that, given the length of the model calibration, "more recent" can be the last 20 years or so.

ITEM 5: UPDATE ON PEER REVIEW

Ms. Dyer updated the group regarding the progress of the peer review. Proposals from Balleau Groundwater and the USGS have been received and will be taken to the Valley District Board for the 13-Jun-17 workshop. They will then go to the full Board meeting on 20-Jun-17 for approval. Ms. Dyer expects that the partners will take the proposals to their boards in July.

Mr. Dennis Williams was curious about which members from the USGS would be involved. Ms. Dyer replied that a team will be put together to work on each component based on their specialties, but she does not have an exact list.

Mr. Sovich asked if the peer review would be conducted as independent evaluations by Balleau and USGS, or as a collaborative effort. Mr. Yeh explained that in previous experiences the review was done individually. Mr. Tincher added that the Balleau proposal was more detailed than that submitted by USGS, therefore he anticipates that Balleau will be doing a more in-depth review of model files while USGS will provide their expertise during the modeling process. Mr. Huang agreed that Balleau will look closely at the actual model files and present their results and opinions to the TAC.

ITEM 6: UPDATE ON COST SHARING LETTER

Ms. Dyer explained that she is currently working on the cost sharing letter and anticipates having a draft ready to send to the partners by Friday, 2-Jun-17. After the partners review it and provide comments, it will be finalized and ready for Boards in July. Ms. Dyer added that it will also include a proposal from ICF for their participation in the project.

ITEM 7: STATUS OF TASK 1 – MODEL INTEGRATION

Mr. Yeh presented an update of Task 1.1 (Comprehensive Review of Existing Model Reports), Tasks 1.4 and 1.5 (Construct and Calibrate Chino Basin Model), and Task 1.6 (Update Five Existing Models). Task 1.1 is complete. Mr. Yeh explained that available hydrogeologic data have been collected and data requests are being made for the remaining required information.

Mr. Scott White from Aspen updated the group on Task 1.7 (Groundwater Consumption from Riparian Habitat). He suggested using USACE current vegetation mapping for Prado Basin and comparing vegetation categories with aerial photos to determine what can be distinguished visually. These distinguishable vegetation categories can then be mapped in other areas using aerial photos. Mr. White would like input on the approach. Ms. Dyer suggested creating a subcommittee to work on that issue and offered to circulate possible dates for the meeting.

Mr. Degner then updated the group on Tasks 1.7 (Groundwater Consumption from Riparian Habitat) and 1.11 (Update and Expand HSPF Watershed Model). In particular, he presented slides showing available streamflow to help calibrate the riparian consumption. Mr. Degner explained that the Santa Ana River Watermaster separates out baseflow from stormflow. This information (available in excel from 1990) shows strong seasonal variation. He described how it is important the model accurately simulate the baseflow, especially at Prado Dam and the Riverside Narrows, to look at how specific projects will affect baseflow requirements.

Mr. Villalobos and Mr. Eric White from Numeric Solutions provided an update on Task 1.8 (Develop Conceptual Integrated SAR Lithologic Model). Mr. Villalobos summarized GEOSCIENCE progress to-date as providing information to Numeric Solutions that it did not already have, including lithologic and geophysical information, cross-sections, and model files for the Yucaipa Basin. Mr. Eric White described Numeric Solution's progress to-date, which has included compiling data from existing models into a unified Petrel project and constructing the Yucaipa model using 15 lithology code descriptions. The next steps include comparing/creating flow layer elevations and refining the basement surface to make it conformable across the integrated model.

The following comments were provided by participants:

1. Mr. Sovich asked if groundwater pumping data are monthly values. Mr. Yeh replied that monthly data are available for the majority of the calibration period. However, prior to 1970, data are only available as annual pumping for some wells, especially in the Chino Basin. Monthly data was requested, but Mr. Yeh explained that if only annual data are available, the pumping will be redistributed monthly based on seasonal variations established from some current conditions. Mr. Sovich agreed with this approach.
2. Ms. Dyer asked if leaks from municipal water systems are normally included in groundwater models. Mr. Yeh explained that this recharge is handled differently, depending on the model. For example, the SBBA Model assumes 3% of total pumping is recharged in the form of leaks.
3. Mr. Dennis Williams asked Mr. Eric White what the current plans were for the Chino Basin. Mr. White replied that it depends on what data is provided; if the Chino Model is not able to be

received, the lithology model will need to be reconstructed. In response to this, Mr. Tellez Foster from Chino Basin Watermaster revealed that model input data (e.g., groundwater elevations, pumping data, and recharge data) will be provided, but lithologic data and model output will not be provided. Mr. Sovich inquired as to whether or not layer elevations will be provided. Mr. Dennis Williams replied that there are some published cross-sections which can be used to determine layer elevations.

4. Mr. Sovich questioned how Petrel handles the presence of faults. Mr. Dennis Williams stated that most of the effects caused by faults (or groundwater barriers) will be handled in the flow model calibration based on water level differences across the faults; a hydraulic characteristic value will be assigned to the faults during calibration. Mr. Sovich agreed that being able to simulate head differences across faults, rather than offsets caused by faulting, is what really matters.

ITEM 8: OTHER BUSINESS

No other business was discussed at this conference call.

ITEM 9: NEXT MEETING

The next meeting, which will be a conference call, is scheduled for Wednesday, June 21st, 2017 at 4:00 pm. GEOSCIENCE will send around the call-in details.

ADJOURNMENT

The meeting adjourned on Wednesday, May 31st, 2017 at 4:20 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	In Progress (End of June)
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide update)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	In Progress
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	In Progress
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

June 21, 2017
4:00 pm

Issued on July 17, 2017

Attendees:	Aspen: Scott White
	CA Department of Fish and Wildlife (CDFW): Joanna Gibson
	Chino Basin Watermaster: Edgar Tellez Foster
	City of Riverside Public Utilities (RPU): Farid Bowshaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, Mark Williams, Brian Villalobos, and Lauren Wicks
	ICF: Brendan Belby
	Inland Empire Utilities Agency (IEUA): Jason Pivovaroff
	Leidos: Joel Degner
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Greg Woodside
	San Bernardino Valley Municipal Water District (Valley District): Heather Dyer, Wen Huang, and Bob Tincher
	Santa Ana Watershed Project Authority (SAWPA): Mark Norton
	US Army Corps of Engineers (USACE): Chris Jones
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	Western Municipal Water District (WMWD): Ryan Shaw

ITEM 1: APPROVAL OF 31-MAY-17 KICKOFF MEETING MINUTES

No comments were provided by the TAC during the conference call. Any remaining comments will be received until close of business, Friday, 23-Jun-17, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh explained there were four months left for Task 1.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the action item list from the 31-May-17 conference call, which was included in the previous meeting minutes. Ms. Dyer provided an update of the HCP covered activities, which will likely be available at the end of July. She explained that a strategy meeting was held between all of the

partners. The options for maintaining flow requirements need to be reviewed before a final list is determined. Ms. Dyer also stated the subcommittee meeting to discuss the methodology for mapping vegetation is complete. Mr. Yeh explained that the changes in river channel over time and the time period for which extra emphasis will be placed on model performance will be included in the Draft Calibration Plan TM for the TAC to review.

ITEM 4: REVIEW DECISION LOG

The decision log from the 31-May-17 conference call was also reviewed by Mr. Yeh.

ITEM 5: UPDATE ON PEER REVIEW

Mr. Tincher updated the group regarding the progress of the peer review. The remaining contract for Balleau Groundwater and the contract for ICF (who will be part of the peer review process) were approved at the 20-Jun-17 Board meeting. Mr. Yeh will add the members of the peer review team to the distribution list.

ITEM 6: UPDATE ON COST SHARING LETTER

Ms. Dyer explained that a draft letter was sent to the partners for review. She has not received any responses yet, although Mr. Pivovaroff suggested possibly adding a contingency line item (e.g., 10%), which may eliminate the need to go back to individual Boards in the case of change orders. Mr. Tincher replied that, since the contracts were already approved by the Valley District Board, they will probably not include the additional line item. However, he suggested that this is something that individual agencies may do on their end, if they wish. Ms. Dyer suggested holding a separate conference call to discuss the available options.

ITEM 7: STATUS OF TASK 1 – MODEL INTEGRATION

Mr. Yeh presented an update of Task 1. Task 1.1 is complete. Mr. Yeh explained that Tasks 1.4 and 1.5 (Construct and Calibrate the Chino Basin Model) and Task 1.6 (Update Five Existing Models) are currently in progress. The data update is complete for 18 USGS streamflow gaging stations, 17 precipitation stations, and 3 evapotranspiration stations. Wastewater discharge, water level, artificial recharge, and groundwater pumping data are currently being collected and updated. Mr. Yeh reviewed the status of data requests and pointed out that since data request items 6-13 (pertaining to the Chino Basin Model) will not be provided, optional Task 1.5 will need to be implemented.

Mr. Villalobos provided an update on the construction of a lithologic model for the Chino Basin, which is part of Task 1.5. Driller's logs and e-logs from existing cross-sections will be used as control points, along with driller's logs from GEOSCIENCE's in-house database. The lithology from 5 of the 11 cross-sections has already been classified. These lithology classifications will then be provided to Numeric Solutions. Mr. Williams and Mr. Yeh explained that this is the same approach that was used for the Rialto-Colton, SBBA, and Riverside models.

Mr. Villalobos also provided an update on the work for Task 1.8 (Develop Conceptual Integrated SAR Lithologic Model). He explained that the boundaries between the basins are currently being evaluated. Correlation recommendations will be made at the next conference call.

Mr. White from Aspen provided an update for Task 1.7 (Groundwater Consumption from Riparian Habitat). He explained that a meeting was held at GEOSCIENCE discuss the approach. Ms. Dyer brought a USGS report[1] that described a modeling approach in which vegetation categories were described. It was decided to start with those categories, which should be recognizable from aerial photographs. The draft Annual Report of the Prado Basin Habitat Sustainability Committee[2], brought by Mr. Palenscar, took a similar approach. Mr. White also explained that a series of aerial photographs have been selected for identifying vegetation. He requested the existing vegetation map for the Prado Basin from Mr. Jones. Ms. Dyer also expressed her interest in contacting OCWD regarding pictures from photo stations within the Prado area.

Mr. Degner provided an update for Task 1.11 (Update and Expand HSPF Watershed Model). He explained that most of the requested data from the SAR Watermaster has been received. Data has also been requested from USACE. Mr. Degner also provided a list of hydrology modifications that need to be taken into account during modeling. These modifications include changes in reservoir/treatment facility operation, wetlands creation, notable discharges, and various water projects that affect flow into/out of the river.

ITEM 8: OTHER BUSINESS

No other business was discussed at this conference call.

ITEM 9: NEXT MEETING

The next meeting, which will be a conference call, is scheduled for Wednesday, July 12th, 2017 at 4:00 pm. GEOSCIENCE will send around the call-in details.

ADJOURNMENT

The meeting adjourned on Wednesday, June 21st, 2017 at 4:35 pm.

[1] Maddock, T. III, K.J. Baird, R.T. Hanson, W. Schmid, and H. Ajami. 2012. RIP-ET: A Riparian Evapotranspiration Package for MODFLOW-2005. Techniques and Methods 6-A39. Virginia: U.S. Geological Survey.

[2] Wildermuth Environmental, Inc. 2017. Annual Report of the Prado Basin Habitat Sustainability Committee – Water Year 2015/2016, Committee Draft. Prepared for Inland Empire Utilities Agency and Chino Basin Watermaster. Dated May 31, 2017.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	In Progress (End of July)
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Plan TM)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Plan TM)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	In Progress
8. Provide Prado area vegetation map to Aspen	USACE	In Progress
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

July 12, 2017
4:00 pm

Issued on August 18, 2017

Attendees:	Aspen: Scott White
	Balleau Groundwater: Dave Romero and Steve Silver
	CA Department of Fish and Wildlife (CDFW): Joanna Gibson
	Chino Basin Watermaster: Edgar Tellez Foster
	City of Riverside Public Utilities (RPU): Farid Boushaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, Kapo Coulibaly, Brian Villalobos, and Lauren Wicks
	Leidos: Joel Degner
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Tim Sovich
	San Bernardino Valley Municipal Water District (Valley District): Heather Dyer, Wen Huang, and Bob Tincher
	Santa Ana Watershed Project Authority (SAWPA): Ian Achimore
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Wes Danskin, Linda Woolfenden, and Claudia Faunt
	Western Municipal Water District (WMWD): Ryan Shaw

ITEM 1: INTRODUCTION OF PEER REVIEW TEAM

Ms. Faunt and Mr. Romero provided brief introductions for the USGS and Balleau Groundwater teams, respectively.

ITEM 2: APPROVAL OF 21-JUN-17 CONFERENCE CALL MINUTES

Per Mr. Tincher's comment, received 7-Jul-17, the minutes were changed to reflect that Optional Task 1.5 will need to be implemented. Decision Log Item No. 7 was clarified to reflect that the USGS and Wildermuth reports will be used as "reference documents", per Ms. Dyer's comment at the 12-July-17 conference call. No additional comments were provided by the TAC. Any remaining comments will be received until close of business, Friday, 14-Jul-17, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 3: REVIEW SCHEDULE

Mr. Yeh explained that the project is anticipated to be completed in July 2018 and that there are three and a half months left for Task 1.

ITEM 4: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the action item list from the 21-Jun-17 conference call, which was included in the previous meeting minutes. Mr. Tincher declared Action Item No. 7 (regarding cost sharing) to be complete. Mr. Scott White stated that Action Item No. 8 (regarding Prado area vegetation maps) is still in progress. Action Item No. 9 (review of list of historical hydrology modifications) will remain open for TAC members to provide comments as needed. These modifications include any operations/projects that have altered flow or groundwater levels.

ITEM 5: REVIEW DECISION LOG

The decision log from the 21-Jun-17 conference call was also reviewed by Mr. Yeh.

ITEM 6: UPDATE ON COST SHARING LETTER

This item is complete.

ITEM 7: STATUS OF TASK 1 – MODEL INTEGRATION

Mr. Yeh updated the group on the progress of Task 1. Work for Tasks 1.4, 1.5, and 1.6 has consisted of collecting data for the model updates. Wastewater discharge data is currently being collected. Groundwater pumping has been received for approximately 400 wells, and water level data has been received for approximately 340 wells.

Mr. Villalobos presented an update of the construction of the lithologic model for the Chino Basin (Task 1.5). Control points in data gap areas throughout the basin have been selected and USGS classification codes are being applied to the lithologic information for these control points. Mr. Villalobos mentioned that this work should be completed within a week, and the coded intervals will be sent to Numeric Solutions.

Mr. Villalobos also provided an update on Task 1.8 (Develop Conceptual Integrated SAR Lithologic Model). He explained that the team has been working on the database and are hoping to have results to present to the group at the next progress meeting.

Mr. Scott White presented an update on Task 1.7 (Groundwater Consumption from Riparian Habitat). He provided an example of some of the changes that can be seen with aerial photographs through time (e.g., change in river course and vegetation). The vegetation will be categorized (e.g., wetland/marshland, deep-rooted riparian, upland transition, etc.) mapped at roughly decade-long intervals.

An update of Task 1.11 (Update and Expand HSPF Watershed Model) was provided by Mr. Yeh and Mr. Degner. Mr. Yeh announced that land use data has been collected for 1963, 1984, 1993, 2005, and 2015. Mr. Degner, who is working on the surface water aspect of the modeling, presented a review of

information available for Prado Dam. He explained how the inflow, which is calculated by taking the outflow plus/minus change in storage, does not take evapotranspiration (ET) into account. While he thinks that ET will probably be low for the dam area, which is mainly used in winter months for flood control, Mr. Degner pointed out that ET will be much higher in the Prado Wetlands area, which is filled with water year-round. Mr. Degner also explained that Prado operations are a key variable that need to be understood to properly conduct predictive scenarios. In an effort to not recreate anything that has already been done, Mr. Degner is going to contact OCWD about their Prado operations model.

The following comments were provided by participants:

1. Mr. Huang inquired about the selection criteria for target wells. Mr. Yeh replied that the target wells largely reflect the targets currently being used for the individual models. These wells typically have long-term water levels and known completion intervals.
2. Mr. Sovich pointed out that a temporary variance for storage in Prado Dam was granted to OCWD for 2017. However, since the model calibration is only through 2016, it may not have an effect. Mr. Palenscar pointed out that variances have been granted for the past several years, but may not have been used since rainfall was below average.
3. Mr. Danskin pointed out that the model period covers a time frame encompassing significant groundwater level and anthropogenic changes. He cautioned that model results can often look correct but be fundamentally wrong. To help prevent this, Mr. Danskin suggested putting together a conceptual model of what is going on in relation to the geology, hydrology, and vegetation so that model results can be evaluated easier. Mr. Yeh and Mr. Williams agreed to put some conceptual slides together.
4. Mr. Sovich agreed with Mr. Danskin's suggestion to create conceptual slides for the main model elements. He also recommended conducting a preliminary water balance, even if only for the critical model areas. Mr. Williams asked if a particular time frame was recommended for which to conduct the water budget. Mr. Danskin suggested keeping it simple with two main time periods, such as 1966 through 1980 (representing the period where water levels might rise) and 1980 on.
5. Mr. Danskin also pointed out that the distribution of wells, particularly in the Bunker Hill Basin, is asymmetrical. If all of the wells are used, the model calibration could be skewed to selected areas.
6. Mr. Sovich asked if the target wells were already designated by model layer. Mr. Yeh replied that the majority of them have layer designations based on the existing models, but some wells will need to be reevaluated to reflect any modification made during the refinement of the lithologic model.
7. Mr. Sovich also inquired how wells with screened intervals in multiple layers will be handled. Mr. Yeh replied that the multi-node well package, which assigns pumping to model layers based on screened interval and aquifer properties, will be used for the Integrated SAR Model. Mr. Romero added that the multi-node approach will also account for average head and provide a representative water level for calibration.

ITEM 8: OTHER BUSINESS

No other business was discussed at this conference call.

ITEM 9: NEXT MEETING

The next meeting, which will be a face-to-face meeting at Valley District, is scheduled for Wednesday, July 19th, 2017 at 3:00 pm. This meeting is being held to get the TAC's approval of the proposed model domain, cell size, and computer code. GEOSCIENCE will also send around call-in details for people who cannot make the physical meeting.

ADJOURNMENT

The meeting adjourned on Wednesday, July 12th, 2017 at 5:10 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	In Progress (End of July)
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Plan TM)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Plan TM)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	In Progress

Action Item Description	Responsible Agency	Status
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	In Progress
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	In Progress
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.

Minutes for the Upper Santa Ana River Integrated Model Update Meeting

San Bernardino Valley
July 19, 2017
3:00 pm

Issued on August 18, 2017

Attendees:	Balleau Groundwater: Dave Romero and Steve Silver
	CA Department of Fish and Wildlife (CDFW): Joanna Gibson
	Chino Basin Watermaster: Edgar Tellez Foster
	City of Riverside Public Utilities (RPU): Farid Boushaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, Kapo Coulibaly, Lauren Wicks, and Leo Liu
	ICF: Brendan Belby
	Inland Empire Utilities Agency: Liz Hurst
	Leidos: Joel Degner
	Orange County Water District (OCWD): Tim Sovich
	San Bernardino Valley Municipal Water District (Valley District): Wen Huang
	Santa Ana Watershed Project Authority (SAWPA): Ian Achimore
	US Army Corps of Engineers (USACE): Chris Jones and Jen McAdoo
	US Geological Survey (USGS): Wes Danskin, Linda Woolfenden, Claudia Faunt, and Geoff Cromwell
	Western Municipal Water District (WMWD): Mallory Gandara

ITEM 1: INTRODUCTION

Mr. Yeh conducted introductions and explained that the main purpose of this meeting is to review and determine the computer code, model domain, and model cell size of the Integrated SAR Model.

ITEM 2: DISCUSSION OF TASK 1.2 – DETERMINE THE COMPUTER CODE, MODEL DOMAIN, AND MODEL CELL SIZE OF THE INTEGRATED SAR MODEL

Mr. Yeh reviewed the project goals and the five existing groundwater models. He explained that the Integrated SAR Model will use the Multi-Node Well (MNW) Package and streamflow routing package. Mr. Coulibaly presented the proposed model domain and cell size of 102.5 ft by 102.5 ft. The proposed model code is MODFLOW-NWT. Mr. Coulibaly also reviewed the step-by-step process that is proposed for the construction and calibration of the Integrated SAR Model.

Questions asked, along with follow-up responses, included:

1. Mr. Huang and Mr. Sovich asked about the boundary conditions between models. Mr. Yeh explained that the underflow was assigned for each existing model, but that the Integrated SAR Model will resolve discrepancies in the underflow between the existing models. Mr. Romero suggested making the existing model underflow boundaries specified head boundaries and evaluating model-generated water levels against observed water levels. The amount of flow needed to maintain those water levels can then be assessed. Mr. Danskin and Mr. Sovich agreed that this would be a good approach for the first step. Mr. Williams mentioned that, once integrated, the boundaries between the models should go away. Mr. Romero agreed.

2. Mr. Boushaki questioned the uniform cell size and whether or not it would include higher resolution in key areas. Mr. Yeh explained that, while the uniform model cell size has been proposed, sensitivity runs could be made for the MODFLOW-USG (unstructured grid).

3. Mr. Sovich inquired when the model layering would be discussed. Mr. Yeh replied that topic will be discussed at the next conference call, along with the approach from the lithologic modeling.

4. Mr. Sovich asked what the reason had been for rotating the Rialto-Colton Model. Mr. Williams replied that it had been rotated so that it was parallel to the main faults.

5. Mr. Boushaki expressed his concern at the amount of time needed to run over 3 million cells, and inquired if computational time could be saved by constructing a grid with larger cell sizes and higher resolution in key areas. Mr. Yeh replied that the goal of using a uniform cell size is to maintain the integrity of the existing models; using the MODFLOW-USG will sacrifice the resolution of the individual models, especially if different areas of interest are required for future runs. He reemphasized that GEOSCIENCE believes the model runs can be made fairly quickly by using parallel cloud computing.

   Mr. Danskin cautioned that time needs to be spent considering options before acting, although he observed that it seems like different options have been tested. He recommended focusing on setting up the model parameters and not worrying about the grid.

6. In response to Mr. Coulibaly's remark that the Rialto-Colton Model will be used as a guide for the Integrated SAR Model since it has undergone such a thorough peer-review process, Mr. Danskin cautioned that the SAR is the main controlling feature — not the Rialto-Colton Model. Therefore, he recommended focusing on the hydrogeologic structure, even if it means departing from the existing Rialto-Colton Model.

7. Mr. Sovich questioned the methodology presented for the model calibration runs. He and Mr. Boushaki were concerned that running additional runs before analyzing the results of the first runs may cause problems since the cumulative effect of parameter changes won't be able to be seen. Mr. Yeh replied that this methodology will only be used during the initial calibration period to "rough in" model parameters for the main calibration runs. Mr. Sovich agreed that this approach would be sufficient for sensitivity runs, but time needs to be taken between main calibration runs to digest the results.

   Mr. Danskin expressed that he would like to see the river do rational things and suggested thinking about the process in conceptual terms. He also cautioned jumping too quickly into multiple runs. He also recommended not messing with steady state runs because transient conditions will provide more information. Mr. Romero and Mr. Sovich agreed with looking at the big picture and then fine-tuning.

8. After Mr. Coulibaly presented pros and cons of the USG, Mr. Williams asked if the USGS has

experience with the MODFLOW-USG. Mr. Danskin explained that they are slowly getting away from fixed grids but are limited by budget constraints. Ms. Faunt offered that she has used it in the LA area, with mixed results. While MODFLOW-6 incorporates some of the MODFLOW-USG features, she explained that there are no pre- or post-processors available. She stated that while it is not simple, it could be done. Mr. Danskin cautioned that the project budget and time frame should be considered. Mr. Romero agreed and pointed out that it would be unfortunate to find a problem half-way through. Ms. Faunt added that they have run into bugs throughout their experience.

9. Mr. Yeh asked for suggestions regarding the MODFLOW-USG bench testing. Mr. Sovich questioned if it's even needed anymore. Mr. Yeh, Mr. Romero, and Ms. Faunt expressed their concurrence. Mr. Romero and Ms. Faunt added that if it's doable with the smaller size, there's no reason not to.
10. Mr. Huang asked if there was going to be a separate discussion for the construction of the Chino Basin Model. Mr. Yeh replied that the same model layers and parameters from the WEI report will be used for the model calibration. Flux terms, where not provided, will be determined following the same approach outlined in the WEI model report.

ITEM 3: OTHER BUSINESS

Mr. Danskin explained that he had memorialized comments from the last meeting for the record. Mr. Huang agreed that he would send those comments out to the rest of the group.

ITEM 4: NEXT MEETING

The next meeting, which will be a conference call, is scheduled for Thursday, August 10th, 2017 at 3:00 pm. GEOSCIENCE will send around the call-in details.

ADJOURNMENT

The meeting adjourned on Wednesday, July 19th, 2017 at 4:10 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	In Progress (End of July)
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)

Action Item Description	Responsible Agency	Status
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Plan TM)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Plan TM)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	In Progress
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	In Progress
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	In Progress
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	In Progress
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

August 10, 2017
3:00 pm

Issued on September 22, 2017

Attendees:	Aspen: Scott White
	Balleau Groundwater: Dave Romero and Steve Silver
	Chino Basin Watermaster: Edgar Tellez Foster
	City of Riverside Public Utilities (RPU): Farid Boushaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, Kapo Coulibaly, and Lauren Wicks
	Inland Empire Utilities Agency: Liz Hurst and Jason Pivovaroff
	Leidos: Joel Degner
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Tim Sovich
	Santa Ana Watershed Project Authority (SAWPA): Ian Achimore and Mark Norton
	US Army Corps of Engineers (USACE): Jen McAdoo
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Wes Danskin, Linda Woolfenden, and Claudia Faunt
	Western Municipal Water District (WMWD): Ryan Shaw

ITEM 1: APPROVAL OF 12-JUL-17 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 14-Aug-17, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: APPROVAL OF 19-JUL-17 MEETING/CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 14-Aug-17, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 3: REVIEW SCHEDULE

Mr. Yeh explained that the project is anticipated to be completed in July 2018 and that there are two and a half months left for Task 1.

ITEM 4: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the action item list from the 12-Jul-17 conference call and 19-Jul-17 meeting, which were included in the previous meeting minutes. Mr. Scott White declared Action Item No. 8 (regarding Prado area vegetation maps) to be complete. Action Item No. 9 (review of list of historical hydrology modifications) will remain open for TAC members to provide comments as needed for one more week, and then will be considered complete. Action Items 10 (FTP access), 11 (OCWD contact information), 13 (model files for Balleau review), and 14 (distribution of USGS comments) are also complete. Regarding Balleau's review of the model files, Mr. Romero indicated that he would like to have a discussion with GEOSCIENCE. Mr. Yeh replied that he will schedule a call.

ITEM 5: REVIEW DECISION LOG

The decision log from the 12-Jul-17 conference call and 19-Jul-17 meeting was also reviewed by Mr. Yeh.

ITEM 6: STATUS OF TASK 1 – MODEL INTEGRATION

Mr. Yeh explained that Task 1.1 (Comprehensive Review of Existing Model Reports) and Task 1.2 (Establish Domain and Cell Size of Integrated SAR Model) are complete.

Mr. Coulibaly reviewed the model boundary and grid and explained that for Task 1.3 (Run Models in SAR Domain to Ensure Consistency with Original Model), the existing models will each be brought into the new model grid and run to verify consistency.

Mr. Eric White updated the group on Tasks 1.4 & 1.5 (Construct and Calibrate the Chino Basin Model) as well as Task 1.8 (Develop Conceptual Integrated SAR Lithologic Model). He explained that a preliminary lithologic model has been constructed for the Chino Basin. He also described how the individual lithologic models will be incorporated into a single project model. The lithologic models will continue to be modified so that the base layer is conformable throughout the model area and flow layers are unified.

Mr. Yeh reviewed the data collection effort for Task 1.6 (Update Five Existing Models).

Mr. Scott White updated the group on progress for Task 1.7 (Groundwater Consumption from Riparian Habitat). Mr. White showed some example vegetation maps and explained that riparian and wetland vegetation classifications were established. Similar maps will now be developed for various years (e.g., every decade or so) throughout the model calibration period.

Mr. Degner updated the group on progress for Task 1.11 (Update and Expand HSPF Watershed Model). Mr. Degner reviewed the effects of evapotranspiration on baseflow and described the three unknowns that will be calculated using outflow data (ungaged tributary inflow, evapotranspiration, and groundwater recharge/discharge).

Questions asked, along with follow-up responses, included:

1. Regarding running the individual models in the Integrated SAR Model grid, Dr. Williams added that GEOSCIENCE intends to honor the comment made previously that the individual model results need to make sense. Mr. Danskin expressed his appreciation for this approach and believes that it is prudent to move forward progressively.

2. During presentation of the Chino Basin lithologic model, Mr. Danskin asked about what vertical structure was used and whether the Petrel model assumes an implicit horizontal connection. Mr. Eric White replied that this model was top-conformable – it follows the surface structure. However, he explained that structure can be added, such as creating a steeper dip near alluvial fans. Mr. Danskin questioned why known fault and geologic structures shouldn't be added. At the very least, Mr. Danskin recommends including this as a limitation. Ms. Woolfenden agreed. Mr. Williams explained that creating the top-conformable lithologic model is typically the first step. The TAC group may then collectively decide where to add more detail (e.g., faults, anticlinal structure, etc.). Mr. White added that Numeric Solutions has built some models that have included very complicated geologic structures and it can certainly be done for this model, but would require additional time and effort. In reply, Mr. Danskin stated that we may just want to show that we're aware of the basin structure and limitations. Ms. Woolfenden mentioned that she has some references that could be used for structural features in the Chino Basin.

3. Since effects from riparian vegetation was a major driving force for the creation of the Integrated SAR Model, Mr. Danskin suggested finding a way to incorporate the vegetation mapping in the model calibration, such as how water levels affect vegetation. Mr. Scott White replied that information on rooting depth is mostly unavailable except for shallow-rooted species (i.e., around 1-ft deep), which are probably using surface water or water in the unsaturated zone rather than the aquifer. Mr. Palenscar explained that part of the impetus for the project was to understand changes in groundwater-surface water interactions in the future. He agreed that river buffering is an important consideration. Mr. White stated that they would like to know how changes in groundwater may change the location of deep/shallow-rooted vegetation.

   Mr. Romero inquired into the method that might be used to determine consumptive use by riparian vegetation. Mr. Scott White replied that they're currently conducting literature searches for evapotranspiration rates and mentioned that Mr. Degner also has a good start on this process. Mr. White explained that there are two key areas to consider: vegetation intercepting rainfall (leading to less groundwater input) and deeper-rooted vegetation accessing water below the water table (leading to more groundwater output).

   Mr. Sovich mentioned that OCWD had a monitoring well very near the river that showed very constant water levels – nearly the same as the river elevation. Therefore, he offered that anything deeper than annual vegetation (e.g., grasses) may be accessing groundwater near the river. Mr. Danskin mentioned that in some previous studies he has been involved in, many plants are willing to use water from precipitation and have very shallow roots but are adaptable and can grow deeper. This adaptability made it difficult to figure out the mass balance. He reiterated that, if the vegetation along the river is a driving force for integrating the models, he would want to know how to make the models useful for that topic. Mr. Romero

added that nearby groundwater pumping may be capturing surface water without creating a change in groundwater levels. Mr. White agreed and added that in that case, the groundwater flow direction may be changing. Mr. Sovich asked if there was a way to come up with a function where the evapotranspiration is a function of the depth of the groundwater level. Mr. Yeh replied that the model's ET Package allows for four different categories with variable depth/ET rates. Mr. Boushaki added that the process of mapping the depth zones and assigning ET rates for them is the answer to the question.

4. Mr. Degner pointed out that there wasn't an apparent effect from the removal of Arundo. Mr. Palenscar replied that while the Arundo was removed, it was replaced by layered native vegetation with similar water requirements. Therefore, it would be hard to discern a difference.
5. Regarding seasonal decreases in baseflow, Mr. Sovich commented that he doesn't believe that all of the decrease is due to evapotranspiration. He explained that lower groundwater levels in the summer may lead to losing stream conditions while higher water levels in winter may cause the SAR to gain flow. Mr. Degner agreed that the seasonal dip should be "ET loss/ change in groundwater recharge" rather than just ET loss.
6. Mr. Danskin mentioned that contributions from Lytle Creek should be included on the SAR Hydrology Schematic. Mr. Degner replied that it's listed on there as "Warm/Lytle Creek". Mr. Danskin stated that he believes Lytle Creek should be considered a separate inflow due to fundamental differences between Warm Creek and Lytle Creek.
7. Mr. Danskin also mentioned that it would be very difficult to have an algorithm for baseflow because there is multi-year carryover (water stored in alluvial fans during wet years and released slowly) that may not even show up in water levels. This represents a limitation of most groundwater flow models.

ITEM 7: OTHER BUSINESS

No other business was discussed at this conference call.

ITEM 8: NEXT MEETING

The next meeting, which will be a conference call, is scheduled for Wednesday, August 30th, 2017 at 3:00 pm. GEOSCIENCE will send around the call-in details.

ADJOURNMENT

The meeting adjourned on Thursday, August 10th, 2017 at 4:20 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	In Progress (End of July)
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Plan TM)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Plan TM)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	In Progress
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		

Action Item Description	Responsible Agency	Status
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	In Progress
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

August 30, 2017
3:00 pm

Issued on September 29, 2017

Attendees:	Balleau Groundwater: Dave Romero and Steve Silver
	Chino Basin Watermaster: Edgar Tellez Foster
	City of Riverside Public Utilities (RPU): Farid Boushaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, Kapo Coulibaly, and Lauren Wicks
	Leidos: Joel Degner
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Tim Sovich
	US Army Corps of Engineers (USACE): Chris Jones
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Wes Danskin and Linda Woolfenden
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher
	Western Municipal Water District (WMWD): Mallory Gandara

ITEM 1: APPROVAL OF 10-AUG-17 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Friday, 1-Sep-17, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh explained that the project is anticipated to be completed in July 2018 and that there are two months left for Task 1.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the action item list from the 10-Aug-17 conference call, which were included in the previous meeting minutes. Since there were no additional comments for Action Item No. 9 (review of list of historical hydrology modifications), Mr. Yeh declared it complete. Action Items 12 (conceptual geology, hydrology, and vegetation), 16 (limitations of not having a structural model), and 17 (lithologic model assumptions) will be discussed at the model workshop on 27-Sep-17. Action Item 15 (call between GEOSCIENCE and Balleau) is complete, although Mr. Romero clarified that Balleau is

interested in reviewing the individual models when they are up and running in the new Integrated SAR Model domain.

ITEM 4: REVIEW DECISION LOG

There were no new items for the decision log from the 10-Aug-17 conference call.

ITEM 5: STATUS OF TASK 1 – MODEL INTEGRATION

Mr. Yeh explained that Task 1.1 (Comprehensive Review of Existing Model Reports) and Task 1.2 (Establish Domain and Cell Size of Integrated SAR Model) are complete.

For Task 1.3 (Run Models in SAR Domain to Ensure Consistency with Original Model), Mr. Yeh explained that the individual models are being put in the Integrated SAR Model grid and rerun to verify the results are the same as those from the existing models. The Yucaipa, SBBA, and Rialto-Colton Models have already been converted and run in the new model domain. The water budgets and water levels from these models are identical to the original model output, indicating a successful integration.

Mr. Yeh also updated the group on the progress of Tasks 1.4 and 1.5 (Construct and Calibrate the Chino Basin Model). He explained that the model is currently being constructed so that the grid, rotation, and stress periods are consistent with the Integrated SAR Model.

For Task 1.6 (Update Five Existing Models), Mr. Yeh explained that the data collection is complete except for some groundwater pumping and water levels. Water levels for calibration targets are approximately 98% complete.

Mr. Degner updated the group on Task 1.7 (Groundwater Consumption from Riparian Habitat). He explained that a conference call was held with USFWS to discuss riparian mapping and evapotranspiration. Aspen is continuing to work on the mapping for 10-year intervals and is developing consumptive use curves. Mr. Yeh added that the results will be provided at the next model workshop.

Mr. Yeh stated that the unified model layers for Task 1.8 (Develop Conceptual Integrated SAR Lithologic Model) will also be discussed at the model workshop.

Mr. Yeh also updated the group on Task 1.11 (Update and Expand the HSPF Watershed Model). He explained that GEOSCIENCE developed a Hydrological Simulation Program – FORTRAN (HSPF) watershed model for the upper SAR watershed for the Santa Ana Watershed Project Authority (SAWPA). Model calibration is complete for 2007 through 2016 using 2012 land use. GEOSCIENCE is currently working on the remaining model calibration periods. Mr. Yeh stated that the different land uses to be used for model calibration (e.g., 1963 and 1984) have been digitized and the model is currently being calibrated.

Questions asked, along with follow-up responses, included:

1. Mr. Romero enquired as to whether there is a stand-alone form of the SBBA model that would be available for review. Mr. Yeh replied that GEOSCIENCE is currently working with Stantech to

refine the return flow, but the files will be available soon. Mr. Yeh agreed to provide these files after the model is updated.

2. Mr. Boushaki asked for clarification between the two model runs (original vs. in Integrated SAR Model domain). Mr. Yeh replied that the individual models are run in the new model grid to make sure that the model results can be duplicated. This helps reduce error when assembling the larger model. In addition, Mr. Yeh mentioned that there is an approximately 10% increase in calculation time. Mr. Boushaki also inquired about the Riverside-Arlington Model and Mr. Coulibaly replied that they are in the process of rotating the model grid to correspond to the Integrated SAR Model grid.
3. Mr. Romero asked if the consumptive use curves were being constructed to show consumptive use with depth. Mr. Degner replied that they are seasonal curves.
4. Mr. Danskin asked how the model handles water in the upper (hard rock) portions of the watershed model area. Mr. Yeh replied that the current model assumes there is no groundwater flow from these areas and that streamflow gaging stations are used to determine the amount of surface inflow into the groundwater model area. Mr. Danskin cautioned that, while this is a common practice, the underflow from this area is most likely not zero. He suggested adding these assumptions to the model limitations. Mr. Yeh agreed.
5. Mr. Danskin mentioned that an estimate of bedrock flow into the alluvial basin from BCM models in Sacramento. He also explained that it became clear from his work in the Bunker Hill Basin that the mountain blocks are slowly being dewatered, so it should be acknowledged in some fashion during this project. Mr. Sovich offered that OCWD has monitoring well data near the mountain front areas. He explained that the deeper ports on the multi-depth monitoring wells show greater response to storms than the shallower ports, especially so in wet years. Mr. Danskin questioned if there were any isotope data on those wells and Mr. Sovich responded in the negative. Mr. Danskin explained that isotope data could be used to determine if the water originated from higher elevation. Mr. Danskin feels the work would be viewed more favorably for a longer time if underflow from mountain areas were acknowledged. He predicts it might be on the order of 10,000 acre-ft. Mr. Danskin agreed to look for a reference that could be used to estimate the potential magnitude of mountain front underflow.
6. Mr. Danskin suggested thinking about a weighting function for streamflow gages vs. water levels for model calibration, since weighting everything equally is probably incorrect. Mr. Yeh replied that GEOSCIENCE will propose a weighting method for the group to discuss.
7. Mr. Romero commented that Balleau would also want to look at the HSPF model when it is up and running. Mr. Yeh agreed.
8. Mr. Williams asked how the USGS treated flow from fractured basalt in Owen's Valley (i.e., flow from Eastern Sierras). Mr. Danskin replied that they excluded the hard rock, although he added that he would not do that again now.

ITEM 6: OTHER BUSINESS

No other business was discussed at this conference call.

ITEM 7: NEXT MEETING

The next meeting, which will be a face-to-face model workshop at Valley District, is scheduled for Wednesday, September 27th, 2017 at 1:00 pm. GEOSCIENCE will send around call-in details for those unable to attend in person.

ADJOURNMENT

The meeting adjourned on Wednesday, August 30th, 2017 at 4:00 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	In Progress (End of July)
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Plan TM)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Plan TM)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	In Progress
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	In Progress
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	In Progress
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	In Progress
19. Propose method of weighting data for model calibration	GEOSCIENCE	In Progress
20. Look for reference regarding flow from hard rock	USGS	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.

Minutes for the Upper Santa Ana River Integrated Model Update Workshop

San Bernardino Valley Municipal Water District

September 27, 2017
1:00 pm

Issued on November 3, 2017

Attendees:	Aspen: Scott White
	Balleau Groundwater: Dave Romero and Steve Silver
	Chino Basin Watermaster: Edgar Tellez Foster
	City of Riverside Public Utilities (RPU): Farid Boushaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams*, Johnson Yeh, Kapo Coulibaly, Leo Liu*, and Lauren Wicks*
	ICF: Brendan Belby
	Inland Empire Utilities Agency (IEUA): Jason Pivovaroff and Sylvie Lee
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Tim Sovich, Greg Woodside, and Richard Zembal*
	US Army Corps of Engineers (USACE): Jen McAdoo*
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Wes Danskin, Claudia Faunt, and Geoff Cromwell
	RMC: Kathy Macklin*
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher, and Heather Dyer
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Ryan Shaw
	(*Participated remotely)

ITEM 1: APPROVAL OF 30-AUG-17 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Friday, 29-Sep-17, at which time the minutes shall be considered “approved” and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh explained that the project is anticipated to be completed in July 2018 and that there is one month remaining for Task 1. He also mentioned that Task 1 is slightly behind schedule, especially for the Chino and SBBA models. Pumping for Chino was received that day, and they are still waiting for data from the City of Redlands for the SBBA. However, Mr. Yeh thinks this time can be made up later.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the action item list from the 30-Aug-17 conference call, which were included in the previous meeting minutes. Ms. Dyer provided an update on Action Item 1 (finalize list of HCP covered activities) and said the list should be finalized within a week or so.

Action Items 3 (river changes through time), 4 (time period for which data reliability/model performance should be emphasized), 12 (conceptual geology, hydrology, and vegetation), 16 (limitations of not having a structural model), and 19 (method of weighting data for calibration) will be included in the model calibration workplan. Mr. Danskin asked if the group would have a chance to review the workplan before model calibration begins. Mr. Yeh replied that the draft workplan is anticipated to be completed in four weeks. The group will have 2 to 3 weeks to review and submit comments/recommendations. Mr. Danskin added that he would be interested in how the model calibration will be appropriate in terms of the future use of the model (e.g., be able to simulate wet or dry periods, etc.). He advised addressing this issue before too much effort is spent calibrating to something that may not be important. He also suggested making the workplan a jointly authored effort, and offered to contribute as needed. Mr. Sovich asked if the workplan would also include a conceptual model and Mr. Yeh replied in the affirmative.

Mr. Yeh explained that Action Item 17 (lithologic model assumptions) will be included in the model integration technical memorandum (TM-1). Action Item 18 (provide SBBA files for Balleau review) is still in progress because they are waiting on the updated return flow.

Mr. Danskin stated that for Action Item 20 (reference regarding flow from hard rock), the USGS could provide comparable flow values, not just a reference. Ms. Faunt also mentioned that the Basin Characterization Model, which estimates recharge and runoff for the State of California, may be of use for providing those values.

ITEM 4: REVIEW DECISION LOG

The decision log from the 30-Aug-17 conference call was also reviewed by Mr. Yeh.

ITEM 5: STATUS UPDATE OF TASK 1.6 – UPDATE THE FIVE EXISTING MODELS

Mr. Yeh described the updated Riverside-Arlington Basin Model, which included refining the cell size and changing the rotation, as well as the results from rerunning the model in the Integrated Model domain. He also provided the results of integrating the Rialto-Colton Basin Model. Mr. Coulibaly presented the results of integrating the Yucaipa Basin Model. While the SBBA Model is still waiting on return flow values, Mr. Yeh presented the preliminary change in groundwater storage. He also

presented the progress for the construction of the Chino Basin Model and showed the change in groundwater storage calculated by the existing model (from WEI 2015 model report).

Questions asked, along with follow-up responses, included:

1. Mr. Tincher asked if the Riverside-Arlington Model will be cut back to the Rialto-Colton boundary in the final model to avoid overlap with the Rialto-Colton Model area. Mr. Yeh replied in the affirmative, and explained that running the Riverside-Arlington Model as-is was just an initial step to confirm that it was integrated successfully.
2. Mr. Sovich asked if the Riverside-Arlington model was calibrated to any gaged SAR streamflow. Mr. Yeh replied that the current Riverside-Arlington model uses the River Package in MODFLOW and cannot be calibrated to streamflow. This will be changed for the Integrated SAR Model.
3. Mr. Sovich also asked if there are monitoring wells to provide boundary conditions in the northern part of the Riverside-Arlington Model and Mr. Yeh replied that there are several wells. In particular, the WVWD 16 Well is an Index Well for the 1961 Decree and has a very good record. Mr. Sovich inquired if the wells were screened at multiple depths and Mr. Yeh replied that there is only one model layer in the northern model area.
4. Mr. Sovich commented that the hydrographs had a very large vertical scale. Mr. Yeh replied that these hydrographs were prepared to show general trends for the presentation, but additional calibration figures can be made with a smaller vertical scale. Mr. Danskin added that it is nice to have water levels and fluxes on the same scale so that relative differences in magnitude can easily be seen. He suggested to perhaps “blow-up” the figures as needed.
5. Mr. Danskin mentioned that it can be difficult to simulate initial model conditions because of the lag associated with the movement of water as the system responds to hydrologic conditions. He advised trying to remove these starting conditions from the model calibration (i.e., ignore first 10 years or so) to help remove bias.
6. Mr. Sovich observed that the Riverside-Arlington Model appears to underestimate water levels in downgradient areas. Mr. Yeh replied that the modeling team will look into these areas.
7. Mr. Boushaki questioned if the departure from mean annual precipitation was the primary cause for changes in cumulative departure from groundwater storage. Mr. Yeh replied that groundwater pumping was also an important factor.
8. Regarding the cumulative departure from average annual precipitation shown on the cumulative change in groundwater storage for the Yucaipa Basin, Mr. Tincher remarked that the precipitation gage (from the San Bernardino Valley Hospital) could have a different climate than conditions experienced in the Yucaipa Valley. Mr. Sovich observed that the hydrographs do not seem to respond very much to the wet and dry periods and that it might be because the recharge does not have enough annual variation. Mr. Danskin agreed and recommended focusing on why the model is not able to simulate the low water levels observed in 2006. Mr. Williams commented that it may be a storativity problem. Mr. Danskin thought this was possible, but that it might also be related to the basin volume, boundary conditions (cataclastic hard rock that is highly fractured and might be part of the flow system), and/or flow barriers.

9. Mr. Sovich also observed that the Yucaipa model is underestimating water levels in the upgradient portion of the model area, which may be because not enough water is being transmitted from the north.
10. Mr. Danskin asked about the storage in Chino Basin. Mr. Tellez-Foster explained that the basin was adjudicated in 1978. Several sets of measures to control overdraft have been authorized since then. Mr. Danskin observed that the magnitude of change shown from the existing model will affect everything that's close to it. He also stated that if the change is real, the data will support it. It was also acknowledged that the Chino Basin has a desalter program that may be affecting the observed declines in groundwater storage.

ITEM 6: STATUS UPDATE OF TASK 1.7 – GROUNDWATER CONSUMPTION FROM RIPARIAN HABITAT

Mr. Scott White provided an update on the vegetation classification and mapping, which is being conducted over approximately 10-year periods for Prado Basin and the Riverside Narrows. He explained that they also attempted to account for agricultural impacts. Mr. White mentioned that maps are also being prepared from Prado Basin to Riverside Narrows for selective years, including a recent year, following significant scouring from an El Niño year, and after the eradication of Arundo. Mr. White presented current estimates for consumptive water use which were assembled from literature sources. He explained that many of the estimates were adapted from agricultural research.

Questions asked, along with follow-up responses, included:

11. Mr. White was asked why old areal photographs were being used from the 1960s and he explained that the task was to characterize vegetation throughout the 50-year period. Mr. Zembal offered that he thought an appropriate task would be to establish baseline conditions. Ms. Dyer explained that the goal of mapping the vegetation through time is to have an additional tool with which to assess flow impacts from the model. Mr. Zembal cautioned that the effects of agriculture in early time periods may make it hard to correlate the amount of flow in the river and available groundwater with the distribution of riparian vegetation.
12. Regarding the different evapotranspiration values available for Arundo, Mr. Palenscar commented that the location of the vegetation in the studies (e.g., close to the river, farther away, etc.) might account for some of the differences. Mr. White mentioned that it may turn out that the model is not sensitive to the differences in evapotranspiration for Arundo.
13. Mr. White was asked if the model would be able to be used to fine-tune evapotranspiration estimates and he replied that he didn't think so, but he hopes the model may be able to back into where vegetation types may be found in the future.
14. Mr. White explained that it is hard to extrapolate areas from areal photos because they were taken on a specific day; some in spring, some in summer, etc. This causes apparent differences in the amount of open water or dirt. He also mentioned that open water in March would become shallow rooted riparian in summer.

15. Mr. Zembal questioned the total acre estimates and added that recent measurements have been around 4,000 to 5,000 acres for the Prado Basin. Mr. White ventured that there may be differences between delineated study areas used for previous measurements and the current study, which was arbitrarily drawn. Mr. Zembal suggested revisiting the study area for existing conditions. Mr. Palenscar offered that a Chino Basin study for the Prado Basin may be a good reference to look into. The group agreed to work out study area discrepancies at another time and Ms. Dyer suggested another subcommittee meeting.
16. Mr. Danskin shared his experience with Owen's Valley and that they had found the riparian vegetation uses less water than originally thought. He stated that he likes the current approach so far.

ITEM 7: STATUS UPDATE OF TASK 1.8 – DEVELOPMENT OF CONCEPTUAL INTEGRATED SAR LITHOLOGIC MODEL

Mr. Degner updated the group on the development of the lithologic model for the Integrated SAR Model area, including information used and basement definitions. Mr. Villalobos also discussed some of the considerations for basement modification. He explained that they would like to have a subcommittee workshop in about one month to bring all of the data together and make some decisions regarding the model basements. The end goal is to have a crystalline basement defined all the way across the model area.

Questions asked, along with follow-up responses, included:

17. Mr. Danskin cautioned that driller's logs are often inaccurate. He explained that in the past, he and his colleagues have looked primarily at available gravity data and then determined how important the different geology is to the flow system. He also ventured that, while the bedrock may be located at depth, the geological materials become very dense after approximately 800 ft deep, and may not contribute much flow. He recommended honoring known data and creating dashed lines for estimated areas. Ms. Faunt added that deeper areas could always be included as model layers, especially if pumping wells are not completed in them.

ITEM 8: STATUS UPDATE OF TASK 1.11 – UPDATE AND EXPAND HSPF WATERSHED MODEL

Mr. Yeh described the status of the HSPF watershed model for the Integrated SAR Model area, including construction, integration of the watershed model and groundwater model, and land use changes through time.

Questions asked, along with follow-up responses, included:

18. Mr. Belby asked about the model in the Chino Basin area and Mr. Yeh replied that the same assumptions for the existing model were followed, except for flux terms simulated by the previous R4 watershed model and model layers. The new HSPF model will be used to determine flux terms such as mountain front runoff and deep percolation from precipitation and the model layers will be determined from the updated lithologic model. At the end, he

explained, the model will be calibrated.

19. Regarding a question raised about how water travels between subareas, Mr. Yeh replied that the HSPF computer code routes water between the watershed subareas.

ITEM 9: OTHER BUSINESS

No other business was discussed at this workshop.

ITEM 10: NEXT MEETING

The next meeting, which will be a conference call, is scheduled for Monday, October 23th, 2017 at 3:30 pm. GEOSCIENCE will send around call-in details.

ADJOURNMENT

The meeting adjourned on Wednesday, September 27th, 2017 at 4:00 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	In Progress (Mid October)
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete

Action Item Description	Responsible Agency	Status
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	In Progress (Will be included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	In Progress (Will be included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	In Progress (Will be included in TM-1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	In Progress
19. Propose method of weighting data for model calibration	GEOSCIENCE	In Progress (Will be included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	In Progress
Items from 27-Sep-17 Workshop		

Action Item Description	Responsible Agency	Status
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	In Progress
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	In Progress
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.

Item	Description
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call (Draft)

October 23, 2017
3:30 pm

Issued on December 11, 2017

Attendees:	Aspen: Scott White
	Balleau Groundwater: Dave Romero and Steve Silver
	CA Department of Fish and Wildlife: Joanna Gibson
	Chino Basin Watermaster: Edgar Tellez Foster
	City of Riverside Public Utilities (RPU): Farid Boushaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, David Barnes, and Lauren Wicks
	ICF: Brendan Belby
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Greg Woodside and Richard Zembal
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Claudia Faunt, Geoff Cromwell, and Linda Woolfenden
	RMC: Cathy Macklin
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher, Heather Dyer, and Wen Huang
	Santa Ana Regional Water Quality Control Board (SARWQCB): Eric Lindberg
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Ryan Shaw and Mallory Gandara

ITEM 1: APPROVAL OF 27-SEP-17 MODEL WORKSHOP MINUTES

Mr. Wang (WEI) was not included in the list of attendees for the draft meeting minutes and will be added to the final meeting minutes. No additional comments were provided by the TAC. Any remaining comments will be received until close of business, Friday, 27-Oct-17, at which time the minutes shall be considered “approved” and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh explained that the project is still anticipated to be completed in July 2018, even though Task 1 is approximately six weeks behind schedule. He explained some tasks (such as Task 3) will be started earlier to make up the lost time.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the action item list from the 27-Sep-17 workshop, which was included in the previous meeting minutes. Ms. Dyer provided an update on Action Item 1 (finalize list of HCP covered activities) and said this task is complete. The memo is being reviewed by ICF and Ms. Dyer should be able to get the numbers to GEOSCIENCE by the end of the week.

Action Items 3 (river changes through time), 4 (time period for which data reliability/model performance should be emphasized), 12 (conceptual geology, hydrology, and vegetation), 16 (limitations of not having a structural model), and 19 (method of weighting data for calibration) will be included in the model calibration workplan. Action Item 17 (lithologic model assumptions) will be included in the model integration technical memorandum (TM-1). Action Item 18 (provide SBBA files for Balleau review) is still in progress because they are waiting on the updated return flow.

Action Item 20 (reference regarding flow from hard rock), is still in progress. Ms. Faunt commented that the USGS could pull flow values from the Basin Characterization Model (BCM), but need a shapefile of the model domain so they can identify the area. Mr. Yeh replied that GEOSCIENCE will send the file. Mr. Yeh also described that Action Item 21 (revisit areas in existing models where model over/under estimates observed water levels) is in progress.

Mr. Scott White provided a summary of Action Item 22 (subcommittee meeting to resolve remaining riparian concerns), for which a phone call was held the week of 16-Oct-17. Attendees included Mr. Palenscar, Mr. Zembal, Mr. Lowe from Aspen, and Mr. Koulibaly from GEOSCIENCE. The two main questions that were discussed were the purpose of the current mapping effort in terms of the overall Habitat Conservation Plan and applicability of literature sources. The vegetation mapping is intended to support the groundwater model and not provide baseline conditions. It was also decided that a technical memorandum will be issued summarizing the sources and reasons for selection. Ms. Dyer added that the vegetation mapping is meant to help with model calibration and develop numbers needed for evaluating effects of the HCPs. Mr. Woodside would like to discuss these items further offline, because OCWD still has concerns about the acreage used in the Prado area and the effects of underestimating the vegetation area. Mr. White suggested holding another meeting. Ms. Dyer mentioned that a face-to-face meeting might be helpful, and suggested it would be helpful if OCWD could provide the proposed boundary prior to the meeting so the mapping areas can be compared. Mr. Yeh said he would schedule the meeting, and Mr. Romero added that Balleau would be interested in participating remotely.

For Action Item 23 (subcommittee meeting to resolve remaining lithologic model concerns), Mr. Yeh explained that he sent a poll around to develop a time and will send the meeting date out shortly.

ITEM 4: REVIEW DECISION LOG

The decision log from the 27-Sep-17 model workshop was also reviewed by Mr. Yeh.

ITEM 5: STATUS UPDATE OF TASK 1 – MODEL INTEGRATION

Mr. Yeh explained that Tasks 1.1 (Review Existing Model Reports), 1.2 (Establish Domain and Cell Size of Integrated SAR Model), and 1.3 (Run Models in SAR Domain to Ensure Consistency with Original Model) are complete. Work is still progressing on Tasks 1.4&1.5 (Construct and Calibrate Chino Basin Model) and 1.6 (Update Five Existing Models). Mr. Yeh described the approach being used to estimate hydraulic conductivity, which is similar to that outlined by Ms. Faunt in her USGS paper. He also explained how the boundary conditions for the Chino Basin Model were being developed, although he mentioned that some of these conditions will be removed once the model is integrated into the Integrated SAR Model. Model inflows and outflows were also discussed.

Questions asked, along with follow-up responses, included:

1. Mr. Boushaki asked what the assumptions and boundary conditions are for the updated models. Mr. Yeh replied that existing assumptions are being used for the integration process. Boundary conditions will be revised during model calibration. He also explained that after calibration, the five individual models will use boundary conditions from the Integrated SAR Model.
2. Mr. Williams asked Mr. Yeh to describe if subsurface outflow was occurring at Prado. Mr. Yeh replied that underflow from this location is very minimal. Mr. Woodside confirmed this and said that he thinks it is less than 500 acre-ft/yr.
3. Mr. Yeh was asked when some of the missing terms for the Chino Basin Model will be determined and he replied that they are currently in the process of loading the numbers into the model. Rather than wait for the final evapotranspiration, Mr. Yeh said they will get the model up and running with a temporary value and revise based on the results of the riparian vegetation mapping.
4. Mr. Romero requested a copy of the riparian vegetation coverage shown on the presentation slide as well as a map from OCWD and Mr. Yeh replied that he would send them over.
5. Mr. Boushaki mentioned that he had some questions about the HSPF model and Mr. Yeh said that he would call after the meeting to discuss these.
6. Mr. Boushaki also asked who would be reviewing the watershed model and Mr. Yeh replied that Balleau Groundwater would be reviewing that as well. Mr. Romero agreed that Balleau was interested in examining the model files when they are ready.
7. Ms. Dyer suggested sending any additional questions/comments to Mr. Yeh in advance of the next meeting so that he could be prepared to answer any concerns.

ITEM 6: OTHER BUSINESS

The lithologic model subcommittee meeting will be scheduled for some time between November 6th and 9th. GEOSCIENCE will send around the final details. No other business was discussed at this workshop.

ITEM 7: NEXT MEETING

The next meeting, which will be a conference call, is scheduled for Monday, November 27th, 2017 at 3:30 pm. GEOSCIENCE will send around call-in details.

ADJOURNMENT

The meeting adjourned on Monday, October 23rd, 2017 at 4:30 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete

Action Item Description	Responsible Agency	Status
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	In Progress (Will be included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	In Progress (Will be included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	In Progress (Will be included in TM-1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	In Progress
19. Propose method of weighting data for model calibration	GEOSCIENCE	In Progress (Will be included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	In Progress
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	In Progress
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete

Action Item Description	Responsible Agency	Status
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	In Progress
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.

Item	Description
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

November 27, 2017
3:30 pm

Issued on January 9, 2018

Attendees:	Aspen: Scott White
	Balleau Groundwater: Dave Romero and Steve Silver
	City of Riverside Public Utilities (RPU): Farid Boushaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, and Lauren Wicks
	ICF: Brendan Belby
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Tim Sovich and Richard Zembal
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Geoff Cromwell and Linda Woolfenden
	San Bernardino Valley Municipal Water District (Valley District): Wen Huang
	Santa Ana Regional Water Quality Control Board (SARWQCB): Cindy Li
	Wildermuth Environmental, Inc. (WEI): Mark Wildermuth
	Western Municipal Water District (WMWD): Mallory Gandara

ITEM 1: APPROVAL OF 23-OCT-17 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Wednesday, 29-Nov-17, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh explained that the project is still anticipated to be completed in July 2018, even though Task 1 is approximately ten weeks behind schedule. The revised return flow for the SBBA model was received that day and Task 1 is expected to be completed in mid-January.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the action item list from the 23-Oct-17 conference call, which was included in the previous meeting minutes. Many of the action items will be addressed in the Model Calibration Workplan and TM No. 1. Mr. Yeh described the subcommittee meeting held for Action Item 23

(subcommittee meeting to resolve remaining lithologic model concerns) was held on November 9th. The action items and decisions from this meeting were emailed to the TAC on November 10th. Action Items 24 (shapefile for USGS), 25 (additional subcommittee meeting to resolve riparian mapping concerns), 26 (provide proposed boundary for vegetation mapping), and 27 (provide current riparian map to Balleau) are complete.

ITEM 4: REVIEW DECISION LOG

The decision log from the 23-Oct-17 conference call was also reviewed by Mr. Yeh. Mr. Yeh explained that the watershed model files for Balleau review should be ready in approximately 2-3 weeks.

ITEM 5: STATUS UPDATE OF TASK 1 – MODEL INTEGRATION

Mr. Scott White from Aspen provided an update of Task 1.7 (Groundwater Consumption from Riparian Habitat). He described the results from the subcommittee meeting held at the CA. Department of Fish and Wildlife Office on November 8th. The main topics discussed were the acreages of mapped riparian vegetation and the evapotranspiration estimates used for the analysis. Mr. White explained that no conclusions on what values to be used for evapotranspiration have been reached yet, and some additional literature sources will be consulted. One of the issues left to address is how to account for differences in evapotranspiration between wet and dry years. Mr. White also described how during the subcommittee meeting, Balleau Groundwater suggested looking at shallow groundwater zones (i.e., with water levels less than 20 ft bgs) to define the study area and look at thermal imaging to determine where evapotranspiration is occurring (reduced temperatures correspond to areas of ET).

Mr. Eric White of Numeric Solutions updated the group on the status of Task 1.8 (Develop Conceptual Integrated SAR Lithologic Model). A 7-layer scenario will be used to develop unified model layers for the Integrated SAR Model, which includes layer divisions for both “consolidated sediments” and “crystalline bedrock”. Mr. White also presented contour maps of preliminary layer elevations and thicknesses. Mr. Yeh said cross-sections will be developed so the unification of the model layers can be reviewed by the group.

For Task 1.12 (Build Integrated SAR Model using Streamflow Routing Package), Mr. Yeh presented a map of the stream segments. The Streamflow Routing Package has been compiled. He also explained that once the model layers are finalized, the Integrated SAR Model can be run. Mr. Yeh also explained the step-by-step approach being used for Tasks 1.9, 1.10, 1.12, and 1.13 (Make 4 Initial Model Runs of Integrated SAR Model).

Questions asked, along with follow-up responses, included:

1. Mr. Zembal added that there was general agreement during the subcommittee meeting on mapping riparian vegetation to add in areas affected by upstream activities along Chino and Mill Creeks. Mr. Yeh explained that information provided by IEUA and Chino Basin Watermaster from their Annual Report will be incorporated in the vegetation mapping efforts, which will cover the Chino and Mill Creek areas.
2. Mr. Cromwell said he would follow up on the gravity data to see if basement elevations for the data set have already been calculated.

ITEM 6: OTHER BUSINESS

No other business was discussed by the group during this conference call.

ITEM 7: NEXT MEETING

The next meeting, which will be a conference call, is scheduled for Monday, December 18th, 2017 at 3:30 pm. GEOSCIENCE will send around call-in details.

ADJOURNMENT

The meeting adjourned on Monday, November 27th, 2017 at 4:15 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete

Action Item Description	Responsible Agency	Status
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	In Progress (Will be included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	In Progress (Will be included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	In Progress (Will be included in TM-1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	In Progress
19. Propose method of weighting data for model calibration	GEOSCIENCE	In Progress (Will be included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	In Progress
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	In Progress
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete

Action Item Description	Responsible Agency	Status
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This

Item	Description
	conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

December 18, 2017
3:30 pm

Issued on February 2, 2018

Attendees:	Aspen: Scott White
	Balleau Groundwater: Dave Romero and Steve Silver
	City of Riverside Public Utilities (RPU): Farid Boushaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, David Barnes, and Lauren Wicks
	ICF: Brendan Belby
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Tim Sovich
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Geoff Cromwell and Linda Woolfenden
	San Bernardino Valley Municipal Water District (Valley District): Heather Dyer and Bob Tincher
	Santa Ana Regional Water Quality Control Board (SARWQCB): Eric Lindberg and Cindy Li
	Santa Ana Watershed Project Authority (SAWPA): Ian Achimore
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Ryan Shaw

ITEM 1: APPROVAL OF 27-NOV-17 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Wednesday, 20-Dec-17, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh explained that the project is still anticipated to be completed in July 2018. Task 1 is expected to be completed in mid-January.

ITEM 3: REVIEW PROJECT BUDGET

Mr. Yeh showed the project budget and currently billed amounts for each task. He explained that

Task 1 is expected to be over budget by approximately $40,000, largely because of unanticipated work on Tasks 1.4 and 1.6 (Construct and Calibrate Chino Basin Model, Update the Five Existing Models) and Task 1.11 (Update and Expand HSPF Watershed Model). For the Chino Basin Model, well locations were provided as a map from Chino Basin Watermaster and had to be hand digitized. In addition, Mr. Yeh described how raw pumping data from the Chino Basin Watermaster was found to be inconsistent with data reported in the WEI Chino Basin Model Report. Some additional analysis was necessary to determine that the increased pumping used in the WEI Chino Basin Model were developed to account for unmetered agricultural pumping. In order to create a comprehensive land use representation for the construction and calibration of the watershed model, older land use maps from DWR had to be hand digitized.

Mr. Yeh also mentioned that it appears Task 5 (Project Management, Peer Review and Meetings) may also go over budget because of the additional subcommittee meetings that have been held to resolve issues (e.g., riparian vegetation consumptive use mapping and lithologic modeling).

Mr. Tincher asked if GEOSCIENCE was anticipating issuing a change order and Mr. Yeh replied that he would like to put together a budget amendment that explains the overages and plans to submit it the first week of January. Mr. Tincher also asked the group for input and suggested contacting him after the meeting if anyone had questions or concerns.

ITEM 4: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the action item list from the 27-Nov-17 conference call, which was included in the previous meeting minutes. Many of the action items will be addressed in the Model Calibration Workplan and TM No. 1. Action Item 28 (follow up on basement elevations from Lengenheim et al., 2006 gravity data) is complete.

ITEM 5: REVIEW DECISION LOG

The decision log from the 27-Nov-17 conference call was also reviewed by Mr. Yeh.

ITEM 6: STATUS UPDATE OF TASK 1 – MODEL INTEGRATION

Mr. Barnes presented an update of the Chino Basin Model including fluxes and preliminary calibration results. He mentioned that wells near the evapotranspiration boundary are key for determining if extinction depths are being modeled correctly. He pointed out how the model currently tends to overestimate water levels, so further calibration will be conducted. Despite this, the magnitude and timing of water level variations seem to compare well with observed water levels and the initial water balance terms agree well with previous modeling efforts by WEI. Mr. Yeh stated that they hope to complete the model calibration and incorporate the Chino Basin Model into the Integrated SAR Model by the next model workshop.

Mr. Scott White provided an update of the estimates of riparian consumption. He explained that a memorandum summarizing the approach and literature sources used had been circulated to the group and that he is interested in receiving comments so that it may be finalized.

Mr. Eric White provided an update on the unification of model layers across the Integrated SAR Model boundary. He mentioned that they received depth-converted data from the Lengenheim et al. (2006) gravity survey, which will be helpful for defining the basement and adding model layer 7 to the Chino and Rialto-Colton Models.

Questions asked, along with follow-up responses, included:

1. Mr. Wang asked how many calibration wells are being used for the Chino Basin Model. Mr. Yeh replied that there are two sets of calibration targets: 100 wells used by the WEI Chino Basin Model, and 9 additional wells near the evapotranspiration area which were obtained from the annual report. Overall, there is a large database with over 70,000 water level measurements which are being considered for the Chino Basin Model calibration. Mr. Yeh also mentioned that additional calibration will be performed in Task 2 following review of the calibration workplan by the TAC.
2. Mr. Tincher questioned whether GEOSCIENCE has noticed any significant differences between water balance terms from the Chino Basin Model to be used for the Integrated SAR Model and those from the WEI Chino Basin Model. Mr. Yeh answered that some of the differences seen between flux terms on the water budget slide are due to differences in time frame. He added that GEOSCIENCE is especially focusing on developing evapotranspiration and streambed percolation estimates that the group feels comfortable about.
3. Mr. Tincher asked if GEOSCIENCE is trying to calibrate to the WEI model. Mr. Yeh and Mr. Williams replied that the WEI values were provided for comparison only, but that GEOSCIENCE is not trying to match WEI water balance values. Mr. Yeh explained that they want the model calibration to match observed data and the evapotranspiration calculated by Aspen's investigation.
4. Mr. Sovich asked if the model layers in the new Chino Basin Model were the same as those from WEI's Chino Basin Model or if they have been modified to reflect the updated lithologic model. Mr. Yeh replied that for this first step, the model layers are approximately the same as the WEI model (recreated by using published cross-sections). Mr. Sovich also asked why underflow from Temescal Basin isn't available yet and Mr. Barnes replied that he just needs to post-process the model output data.
5. Mr. Boushaki observed that there appears to be a systematic error between observed and simulated water levels for some of the calibration targets shown in the presentation and believes that, if the problem were with the initial water levels, the observed and simulated should still converge after a while. Mr. Sovich suggested that the overestimation might be caused by the hydraulic conductivity and Mr. Yeh agreed that the hydraulic conductivity probably needs to be adjusted in further calibration.
6. Mr. Sovich questioned if the hydraulic conductivity values were the same for both the WEI and GEOSCIENCE Chino Basin Models. Mr. Yeh replied that since the WEI model files were not provided, the initial calibration presented at this meeting relied on hydraulic conductivity values from GEOSCIENCE's previous version of the Chino Basin Model that was developed for SAWPA in 2000 and updated several times since then. This hydraulic conductivity was based on lithologic data, cross-sections from the WEI model report, and pumping test data in the area.

Mr. Lindberg asked why the model files were not made available and Mr. Williams replied that he was not sure.

7. Mr. Romero inquired about the differences between pumping provided by Chino Basin Watermaster and those values reported in the WEI Chino Basin Model report. Mr. Yeh replied that the pumping used by WEI in their Chino Basin Model was higher than those provided by the Chino Basin Watermaster prior to 1998. He explained that agricultural pumping was unmetered prior to 1998, so the WEI pumping included estimates of agricultural pumping for that time period based on land use and crop types.

8. Mr. Romero commented that Balleau Groundwater is still reviewing the memorandum on riparian consumption, but expect to send some comments in. He added that they are conducting an independent assessment of consumptive use using an energy balance technique and that the results are comparable so far. Mr. Romero explained that the purpose of conducting an independent assessment is to make sure the different approaches come up with something similar, although he expects the model to come up with a lower value since the riparian consumption analyses include soil moisture above the vadose zone. Mr. Silver added that the results of the riparian consumption analyses should also be in line with results from the watershed model. Mr. Scott White asked how Balleau Groundwater thinks the difference between groundwater and soil moisture consumption should be determined. Mr. Romero suggested relying on the model calibration, especially since vadose zone studies are different everywhere. He explained that once the model is calibrated to a total evapotranspiration that everyone feels comfortable with, model scenarios can be run to determine differences in evapotranspiration and impacts on riparian areas.

9. Mr. Palenscar asked if the Balleau Groundwater energy balance approach is a snapshot in time and Mr. Romero replied that the values are weighted over the seasons. Mr. Palenscar mentioned that he is interested in the comparison and in what numbers the energy approach uses for arundo. Mr. Romero replied that they intend to tabulate their results in a similar memorandum to the one issued by Aspen.

10. Mr. Sovich inquired whether there is a vadose zone in the Prado area during the flood season and Mr. Scott White replied that he was interested in that as well. Mr. Romero agreed that the groundwater levels near ponded water should be at or close to ground surface and that the groundwater flow model will calculate the evapotranspiration for shallow groundwater based on model-calculated head. Mr. Sovich also wondered how the drop in water levels during summer would be handled and whether rooting depths would need modified. Mr. Barnes replied that the ET Package in MODFLOW is capable of incorporating various extinction depths.

11. Mr. Palenscar suggested an outside review of the riparian consumption approach and recommended having Dr. Santiago from UC Riverside vet the assumptions. Mr. Palenscar plans on discussing this option at the January workshop.

12. Mr. Romero asked if model layer 1 shown in the northeast area of the model domain continues to the southwest. Mr. Yeh replied that it stops at the Riverside Narrows. Mr. Sovich questioned why layers 1 and 2 are not just combined since the system is unconfined. Mr. Yeh replied that the USGS defined the area covered by model layer 1 as having high hydraulic conductivity in the Rialto-Colton and Riverside model area. GEOSCIENCE and Numeric Solutions want to maintain these areas as a distinct model layer because they would be hard to simulate as one layer if combined with model layer 2. Mr. Sovich agreed after noting the thickness of model layer 2.

13. Mr. Wang asked if model layers 4 and 5 were complete and Mr. Eric White answered that the correlations are done but the maps have not been completed yet.
14. Mr. Wang asked if the PowerPoint slides from the conference call would be available and Mr. Yeh replied that he would circulate them after the meeting.

ITEM 6: OTHER BUSINESS

No other business was discussed by the group during this conference call.

ITEM 7: NEXT MEETING

The next meeting, which will be a model workshop at Valley District, will be based on the results of the scheduling poll. Following this conference call, the workshop date was determined to be Tuesday, January 30th, 2018 at 10:00 am. GEOSCIENCE sent around the meeting details.

ADJOURNMENT

The meeting adjourned on Monday, December 18th, 2017 at 4:50 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	In Progress (Approach will be included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		

Action Item Description	Responsible Agency	Status
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	In Progress (Will be included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	In Progress (Will be included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	In Progress (Will be included in TM-1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	In Progress
19. Propose method of weighting data for model calibration	GEOSCIENCE	In Progress (Will be included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	In Progress

Action Item Description	Responsible Agency	Status
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	In Progress
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.

Item	Description
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	

Minutes for the Upper Santa Ana River Integrated Model Update Workshop

January 30, 2018
10:00 am

Issued on March 15, 2018

Attendees:	Aspen: Scott White
	Balleau Groundwater: Dave Romero and Steve Silver
	Chino Basin Watermaster: Edgar Tellez Foster
	City of Riverside Public Utilities (RPU): Farid Boushaki and Greg Herzog
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, Brian Villalobos, David Barnes, and Lauren Wicks
	ICF: Brendan Belby
	Inland Empire Utilities Agency (IEUA): Liz Hurst and Jason Pivovaroff (phone)
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Tim Sovich
	U.C. Riverside: Hoori Ajami
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Wes Danskin and Geoff Cromwell
	San Bernardino Valley Municipal Water District (Valley District): Heather Dyer, Bob Tincher, and Wen Huang
	Santa Ana Regional Water Quality Control Board (SARWQCB): Eric Lindberg
	Santa Ana Watershed Project Authority (SAWPA): Mark Norton
	Wildermuth Environmental, Inc. (WEI): Mark Wildermuth (phone) and Wenbin Wang (phone)
	Western Municipal Water District (WMWD): Ryan Shaw and Mallory Gandara

ITEM 1: INTRODUCTION

ITEM 2: APPROVAL OF 18-DEC-17 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Friday, 2-Feb-18, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 3: REVIEW SCHEDULE

Mr. Yeh showed a revised project schedule and explained that the project is still anticipated to be completed in July 2018. Task 1 is expected to be completed in mid-February.

ITEM 4: REVIEW PROJECT BUDGET

Mr. Yeh showed the project budget and currently billed amounts for each task. He explained that Task 1 is over budget by approximately $40,000, largely because of unanticipated work on Tasks 1.4 and 1.6 (Construct and Calibrate Chino Basin Model, Update the Five Existing Models) and Task 1.11 (Update and Expand HSPF Watershed Model). Task 5 (Project Management, Peer Review and Meetings) may also go over budget because of the additional subcommittee meetings that have been held to resolve issues (e.g., riparian vegetation consumptive use mapping and lithologic modeling).

Mr. Yeh explained that a budget amendment was issued on 9-Jan-18. Mr. Tincher informed the group that the budget amendment will be taken to the Board in February. He also asked the group to contact him if they had any questions or concerns. Mr. Danskin asked whether the status of the change order would affect the schedule and Mr. Yeh replied that it would not; GEOSCIENCE is moving on to Task 2 in the meantime.

ITEM 5: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the action item list from the 18-Dec-17 conference call, which was included in the previous meeting minutes. Many of the action items were addressed in the Model Calibration Workplan (TM No. 2). Action Items 18 (provide stand-alone SBBA Model files to Balleau for review), 20 (reference regarding flow from hard rock), and 21 (revisit areas in existing models where model over/under estimates observed water levels) are still in progress. Mr. Scott White gave an update on Action Item 29 (submittal of comments on draft "Evaporation Estimates" memo). He explained he received a few comments and the methodology described in the memo will also be discussed at the riparian subcommittee meeting.

ITEM 6: REVIEW DECISION LOG

No decisions were made at the 18-Dec-17 conference call.

ITEM 7: STATUS UPDATE OF TASK 1 – MODEL INTEGRATION

Mr. Villalobos presented the unified Integrated SAR Model layers, including the geologic and structural conceptual model. He explained that the groundwater flow barriers simulated in the model include recent mapping. He also described how faulting and folding as well as the presence of older paleosols may affect the movement of water and this is simulated in the model by controlling flow coefficients (e.g., hydraulic conductivity). In this way, the structure is accounted for in the model. Mr. Eric White also presented the updated model layer elevations.

Questions asked, along with follow-up responses, included:

1. Mr. Danskin questioned whether there was a fault between the Santa Ana Mountain Block and Perris Block. Mr. Villalobos replied that it's just the designated boundary, but is sometimes

mapped as a fault. He explained that the bedrock and Miocene rock comes up east of this location due to the Chino Fault.

2. Mr. Danskin expressed his appreciation at going through the geology and suggested identifying areas where the model might perform well (e.g., middle of model area) and where it might not perform as well (e.g., model edges, San Timoteo Formation, areas where paleosols may be present, etc.). He explained this is a normal limitation of groundwater flow models but should be acknowledged to serve as a "road map" for future work. The effect of geology and structure in these areas should also be explained.
3. Mr. Tincher asked if lithologic data from the WEI Chino Basin Model was used for the update. Mr. Villalobos replied that they started with the cross-sections from the WEI model report and used additional data to create a contact for the consolidated sedimentary rock and bedrock (new model layer).
4. Mr. Danskin suggested using "less-permeable" rather than "non-permeable" when describing bedrock or the basement.
5. Mr. Danskin also suggested coming up with names or designations for the model layers to aid understanding and help archive the model layer decision process. However, he cautioned that the names/designations need to be considered thoroughly because they will stick.
6. Mr. Cromwell asked why certain formations are broken out in the northeastern portion of the basin but not in the southwestern portion (Chino Basin). Mr. Villalobos replied that the divisions in the northeastern portion of the model were simply maintained from previous work. The Chino Basin could also be subdivided if needed.
7. Mr. Sovich observed that the faults appear to be offsetting the younger alluvium and asked if the model will account for that and whether or not there are observed water levels to support this. Mr. Yeh replied that from Rialto-Colton to Chino Basin, water levels are offset approximately 200 to 400 ft. Mr. Sovich also questioned the terminology for confining units in the Rialto-Colton area, and Mr. Yeh replied that the terminology comes from Dutcher and Garrett (1963).
8. Mr. Danskin suggested that the top saturated surface should be either connected or overtly not be, but an explanation needs to be provided because the layers will dictate where the water flows. He explained that it's difficult to route water downwards in MODFLOW.

Mr. Scott White provided an update on the estimates of groundwater consumption by riparian habitat and Mr. Romero presented the results of Balleau Groundwater's approach to checking riparian consumption estimates. Mr. Romero pointed out that shallow groundwater areas (<20 ft) are generally coincident with young wash deposits and the presence of riparian vegetation. Balleau's estimated evapotranspiration is fairly consistent with Aspen's estimates. Mr. Romero showed that the numbers from the literature review fall within the range of evapotranspiration calculated using the thermal based energy balance.

Questions asked, along with follow-up responses, included:

9. Mr. Norton asked about the creation of the vegetation categories and Mr. White replied that they decided to go with coarse categories for the purposes of the water balance. While more categories are typically used for habitat assessments, it becomes difficult to map larger areas with that detail and through time. Mr. Norton also mentioned that SAWPA has some additional coverage for the SAR Watershed if the group is interested in incorporating it.
10. Mr. Tincher explained that the scope was originally primarily limited to Prado and Mr. White explained that mapping focused on Prado, Riverside Narrows, and the length of the river, but not very far laterally from the river.
11. Mr. Norton asked why there were two values for arundo. Mr. White replied that the water use depends on the location. However, he explained that the value used for arundo does not have a big effect on the water balance because of the low acreage. Mr. Romero added that it is typical to have ranges of evapotranspiration because of the variability of precipitation. Ms. Dyer added that this will be discussed further at the subcommittee meeting.
12. Mr. Danskin inquired if there were any studies or modeling that could be done or exists to support the estimates. Ms. Dyer mentioned there was some verification in the Chino Basin area and. Mr. Tellez Foster added that there is an extensive monitoring network that were also used to calibrate the Chino Basin Model.
13. Ms. Ajami asked if any unsaturated zone modeling was being done and Mr. Yeh replied in the negative. Ms. Ajami explained that the groundwater consumptive use would then be overestimated and that remote sensing might provide another source of information to help constrain numbers. Mr. Romero agreed and added that the groundwater model should come up with a value that is less than the initial estimates because of the use of soil moisture.
14. Ms. Dyer stated that the effect of reduced effluent on shallow groundwater is an important factor that will need to be explained.
15. Mr. Romero suggested creating a single layer for the river and shallow groundwater system. Mr. Danskin added that the SAR has incised older material and deposited very recent material and agreed that this hydrologic unit should be very well connected. Mr. Yeh replied that right now, Model Layer 1 is only located above the Riverside Narrows; this will need to be modified.
16. Mr. Sovich asked if there were any monitoring points by the river that might show hydraulic separation. Mr. Yeh replied there are some USGS multi-depth monitoring wells that show similar water levels at different depths in the Rialto-Colton area. Mr. Tellez Foster added that all of the monitoring points in Prado have a shallow and deep zone and Mr. Lindberg suggested that Kleinfelder might have additional information northeast of Prado.
17. Ms. Dyer asked about the rooting depth. Mr. Romero replied that 20 ft is just a best estimate and seems to bound the location of riparian vegetation. Mr. Scott White replied that actual numbers might not be available for rooting depths, which vary by species, but that 20 ft is a reasonable estimate. Ms. Dyer explained that she was concerned about what conditions would affect riparian vegetation health because of decreased groundwater levels and asked if the differences in the extent of shallow groundwater can be assessed. Mr. Romero and Mr. Yeh replied that maps can be generated to show the change.

18. Mr. Scott White pointed out that the extent of the young alluvium might prove to be a very important consideration, especially if water moves laterally easier than it can move downwards through older material.

19. Ms. Dyer suggested it would be helpful to identify areas that would be more likely to be affected by reduced effluent. This might allow the HCP activities to be tweaked in a way to become conservation measures instead (managed offset). While he agrees with the approach, Mr. Shaw warned against committing on a particular range based on modeling. Ms. Dyer agreed that there are many factors that contribute to riparian health and that multiple tools can be developed to potentially reduce effects.

20. Mr. Tincher expressed that the biggest factor affecting riparian health is likely the drought. Ms. Dyer suggested doing an analysis on the extent of riparian vegetation over time to see how it responds to changes in hydrology. Mr. Tincher added that water levels could be used in place of riparian coverage as well. Mr. Tellez Foster and Ms. Hurst explained that riparian coverage is available for Prado back to 1965. Mr. Yeh verified that this study is included in the modeling. Mr. White added that more effects might be seen in Riverside Narrows since Prado has historically had more management.

21. Mr. Danskin pointed out that the Commerce Center Well along the Santa Ana River shows the same trend in water level as the trend in Balleau's estimated evapotranspiration, with a significant decline around 2005. Mr. Lindberg asked when the Chino Basin Desalter came online and Mr. Tellez Foster replied 2001 with an expansion in 2005. Mr. Tincher added that all of the system responses (precipitation, streamflow, water levels, evapotranspiration) seem to be following the same trend.

22. Ms. Dyer asked how the difference between groundwater consumption and evapotranspiration estimates will be determined. Mr. Romero replied that that will be calculated by the model. The model should be able to reproduce the observed changes in baseflow and the model-calculated evapotranspiration should be less than the estimates. He explained however, that there are many factors affecting the decrease in baseflow. The model will be able to identify these factors.

23. Mr. Tincher observed that the fairly consistent extent of riparian vegetation with decreasing evapotranspiration may be an indication of system resiliency.

Mr. Yeh provided an update of the watershed model that will be used to estimate the runoff for the streamflow routing package, areal recharge, and mountain front recharge. Model calibration results were also presented. Mr. Barnes presented an update of the Chino Basin Model including hydraulic conductivity, fluxes, and preliminary calibration results. Mr. Yeh also briefly described the next steps for running the Integrated SAR Model.

Questions asked, along with follow-up responses, included:

24. Mr. Lindberg asked how the hydraulic conductivity was determined between grid cells and Mr. Eric White replied that the values were interpolated between lithologic logs. Mr. Lindberg mentioned that he would be interested in seeing those slides from the previous presentation.

25. Mr. Sovich asked what initial value was used based on the range of hydraulic conductivity estimates. Mr. Barnes replied that they started with an average and adjusted this number based on pumping tests. Mr. Sovich mentioned that it would be good to see the actual hydraulic conductivity value being used and Mr. Yeh replied that a column will be added to the table.
26. Mr. Danskin observed that he could not see the streams or geology reflected in the hydraulic conductivity zones for Model Layer 1 in the Chino Basin Model. Mr. Eric White explained that the detail can get lost when using an average of the material below the surface. Mr. Danskin suggested revisiting this area. Mr. Yeh agreed and said that it will be modified to include the results from Mr. Romero's presentation.
27. Mr. Silver asked how the calibration zones were delineated. Mr. Yeh replied they were based on pump test data and the specific capacity of wells. He mentioned that additional zones may need to be added during the calibration process.
28. Mr. Sovich asked about the high hydraulic conductivity zone in Model Layer 2 and whether it was an old drainage area. Mr. Silver replied that a report by French from the 1960s notes patterns like that.
29. Mr. Tincher asked why underflow inflow for the Chino Basin Model was the same at the end of the calibration period. Mr. Barnes replied that it was estimated from the WEI model (assumed to be the same as 2011), but will be updated during the Integrated SAR Model calibration. Mr. Boushaki asked if the inflow by basin was available and Mr. Barnes replied that it was not provided in this presentation but that it could be broken apart.
30. Mr. Sovich asked if there was a graph showing the quantity of areal recharge the precipitation represents. Mr. Barnes replied the recharge is approximately 12% of the precipitation, and Mr. Sovich thought that sounded reasonable.
31. Mr. Sovich asked if municipal pumping was generally from a deeper zone and Mr. Barnes replied that agricultural pumping generally tends to be shallower.
32. Mr. Boushaki suggested creating estimates of riparian consumption (e.g., Aspen, Balleau, GEOSCIENCE) with consistent areas so the estimates can be compared.
33. Mr. Danskin noted that the ET Package in MODFLOW can make groundwater levels look really good, but doesn't always make fluxes of ET look good because of changes in vegetation. Ms. Ajami mentioned that the new ET Package can account for vegetation fractionation.
34. Mr. Sovich suggested it would be helpful to see screened intervals on hydrographs as well as the model layer.
35. Mr. Huang questioned if some of the observed water levels included pumping measurements and Mr. Barnes replied that the target set still needs to be cleaned up a bit.
36. Ms. Dyer asked if the updated model from WEI included HCP activities which should not be included in the baseline simulation. Mr. Yeh replied that this is just the historical condition for now and they will make sure the assumptions for the future scenarios are consistent.
37. Mr. Sovich observed that it appears the gradient is too flat from upstream to downstream. Mr. Yeh agreed.

38. Ms. Dyer asked if the individual models are complete. Mr. Yeh replied there is still some work to do on Chino Basin and SBBA models, but this can be done in parallel with work on the Integrated SAR Model.
39. Mr. Boushaki noted instances of high R^2 in streamflow for the watershed model and asked if further calibration would be conducted. Mr. Yeh replied the surface water model calibration was complete. Mr. Boushaki suggested considering other metrics for model performance. Mr. Yeh agreed.
40. Mr. Danskin suggested that model performance in 1966 shouldn't be given as much importance as over the last 10 years. If the model is forced to match everything, it's going to be wrong. He also suggested unweighting the weighting function for your R^2 or coefficient of variation and weight the data points in a scaled fashion. However, 1:1 is probably wrong because not all data points are equal. Mr. Yeh pointed out that the model calibration does improve during the last 25 years.

ITEM 8: OVERVIEW OF FLOW MODEL CALIBRATION PLAN TECHNICAL MEMORANDUM (TASK 2.1)

Mr. Yeh quickly reviewed the Calibration Plan which was issued 29-Jan-18. He explained that MODFLOW-2005 and MODFLOW-NWT will be used to run the model. MOFLOW-2005 is faster, so it will help speed up the modeling process.

Questions asked, along with follow-up responses, included:

41. Mr. Norton inquired as to the hydrologic period that will be used for the model scenarios. Mr. Yeh replied that it might be the historic conditions (at least 25 years), but it depends on the decision of the group. Ms. Dyer asked if 50 years could be used and Mr. Yeh replied in the affirmative. Mr. Sovich asked what land use will be used and Mr. Yeh replied that also depends on the group decision. They could use current or 2040 land use.
42. Mr. Norton asked if the Waste Load Allocation Model (WLAM) would be modified based on the Integrated SAR Model results. Mr. Yeh replied that this work would help the WLAM, especially in regard to rising water.

ITEM 9: OTHER BUSINESS

No other business was discussed by the group during this conference call.

ITEM 10: NEXT MEETING

A subcommittee meeting for riparian vegetation will be held on February 7th, 2018 at Valley District at 1:00 pm. The next Integrated SAR Model meeting, which will be a conference call, will be Thursday, February 22nd, 2018 at 3:00 pm. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Tuesday, January 30th, 2018 at 3:15 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		

Action Item Description	Responsible Agency	Status
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	In Progress (Will be included in TM-1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	In Progress
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	In Progress
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	In Progress
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		

Action Item Description	Responsible Agency	Status
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	In Progress
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	In Progress
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	In Progress
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	In Progress
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	In Progress
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This

Item	Description
	conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

February 22, 2018
3:00 pm

Issued on March 28, 2018

Attendees:	Aspen: Scott White
	Balleau Groundwater: Dave Romero and Steve Silver
	City of Riverside Public Utilities (RPU): Farid Boushaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, Kapo Coulibaly, David Barnes, and Lauren Wicks
	ICF: Brendan Belby
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Tim Sovich
	US Geological Survey (USGS): Wes Danskin and Geoff Cromwell
	San Bernardino Valley Municipal Water District (Valley District): Heather Dyer
	Santa Ana Regional Water Quality Control Board (SARWQCB): Eric Lindberg
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Mallory Gandara

ITEM 1: APPROVAL OF 30-JAN-18 MODEL WORKSHOP MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 26-Feb-18, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed a revised project schedule and explained that that GEOSCIENCE had planned to issue the draft Technical Memorandum (TM) No. 1: Model Integration on February 21, 2018, but received some comments from the USGS on TM No. 2 that also apply to TM No. 1. Therefore, these comments will be incorporated into TM No. 1. Comments on TM No. 2: Flow Model Calibration Plan will be discussed during this conference call, along with key points from the riparian subcommittee meeting held on February 7, 2018.

ITEM 3: STATUS OF CHANGE ORDER

Ms. Dyer provided an update on the change order and informed the group that the Board approved the change order on February 21, 2018.

ITEM 4: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the action item list from the 30-Jan-18 model workshop, which was included in the previous meeting minutes. GEOSCIENCE is currently working with Aspen and Numeric Solutions to complete the new action items. Ms. Dyer added that she followed up with Mr. Mark Norton from SAWPA regarding Action Item 32 (additional mapping data in SAR tributaries) and said that he could not find the original images, but did send some additional files that Ms. Dyer will send along to the project team.

ITEM 5: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the 30-Jan-18 model workshop. Mr. Sovich suggested putting the model layer number on the hydrographs in addition to the screened interval (Decision Log item 20). Mr. Danskin added that a land surface datum would also be helpful to show on the hydrographs. Mr. Yeh agreed.

ITEM 6: REVIEW OF 7-FEB-18 RIPARIAN CONSUMPTIVE USE SUBCOMMITTEE MEETING

Ms. Wicks provided an overview of the riparian consumptive use subcommittee meeting, which was well attended. She explained that Aspen and Balleau Groundwater went over the methods they used to estimate riparian consumptive use. Additional suggestions arose from discussion of these techniques, and are included in the Action Item list following these minutes. One of these action items was to provide the TAC with a short summary of the two estimation methods, which was submitted on February 23, 2018. The group was asked to provide any comments within a week.

ITEM 7: DISCUSSION OF FLOW MODEL CALIBRATION PLAN (TASK 2.1)

Mr. Danskin and Mr. Cromwell from the USGS as well as Mr. Romero from Balleau Groundwater presented their comments for the draft TM No. 2: Flow Model Calibration Plan.

Questions and comments included:

1. Mr. Danskin and Ms. Dyer reminded the group that the modeling task is challenging. Mr. Danskin explained that future model revisions may be required, but that getting close and documenting the process and concerns might be a practical goal.
2. Mr. Danskin suggested separating the geology and hydrology. Mr. Sovich agreed and added that Table 2-1 is hard to follow basin-to-basin. Mr. Sovich also suggested that the cross-sections might be more useful if the layers are shaded rather than just having a colored line for the layer elevation.
3. Mr. Danskin explained that the dipping beds of the San Timoteo Formation will probably be difficult to model.
4. Mr. Sovich suggested revisiting the idea to have a model layer 1 that incorporates the river channel and shallow alluvium as one layer with higher hydraulic conductivity along the river. Mr. Danskin agreed that it would help the model numerically and conceptually. Mr. Romero also suggested having a model layer 1 that extends throughout the model area. Mr. Danskin added that the model results would make more sense if all of the inflows and outflows from the surface were contained in one model layer. Mr. White asked if that would have any effect

on the simulation of riparian evapotranspiration and Mr. Romero replied that he didn't believe that it would have a significant effect. To minimize effects, Mr. Sovich suggested having the bottom of model layer 1 represent the bottom of the river channel deposits and extrapolating it out horizontally. Mr. Yeh assured the group that these options would be considered and Mr. Danskin offered to help.

5. Mr. Sovich explained that the US Army Corps of Engineers (USACE) has measured outflow from Prado and daily change in storage when water is impounded behind the dam with which they calculate the inflow. In the summer when there is no water behind the dam, they assume inflow is equal to outflow and do not account for evapotranspiration. Mr. Danskin suggested using this estimated flow to evaluate modeled flow into Prado.
6. Mr. Sovich suggested having a table for the last 10-20 years showing estimated flux components and explaining how they were estimated (even if they just come from the existing models).
7. Mr. Sovich also suggested plotting the different zones for the multi-depth wells on the same hydrograph to see if the model is producing the correct vertical gradient.
8. Mr. Yeh expressed that the feedback on TM No. 2 provides very good comments that the GEOSCIENCE team plans to incorporate.

ITEM 8: OVERVIEW OF DATABASE PLAN

Due to time constraints, this subject will be discussed at the next project update meeting. Mr. Yeh invited anyone who has comments to submit them via email.

ITEM 9: OTHER BUSINESS

No other business was discussed by the group during this conference call.

ITEM 10: NEXT MEETING

The next Integrated SAR Model meeting, which will be a conference call, will be Thursday, March 22nd, 2018 at 3:00 pm. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Thursday, February 22nd, 2018 at 4:15 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		

Action Item Description	Responsible Agency	Status
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	In Progress (Will be included in Lithologic TM)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	In Progress
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	In Progress
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		

Action Item Description	Responsible Agency	Status
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	In Progress
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	In Progress
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	In Progress
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.

Item	Description
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.

Item	Description
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

March 22, 2018
3:00 pm

Issued on April 25, 2018

Attendees:	Aspen: Scott White
	Balleau Groundwater: Dave Romero and Steve Silver
	City of Riverside Public Utilities (RPU): Farid Boushaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, Kapo Coulibaly, David Barnes, and Lauren Wicks
	ICF: Brendan Belby
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Tim Sovich
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Wes Danskin and Geoff Cromwell
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Mallory Gandara

ITEM 1: APPROVAL OF 22-FEB-18 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 26-Mar-18, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed a revised project schedule and explained that GEOSCIENCE plans to have a model workshop in mid-May to review the model calibration results. GEOSCIENCE will start Draft TM No. 4 to describe the major assumptions of the predictive model scenarios. Model files were sent to Balleau Groundwater on January 9th and March 5th for each of the individual groundwater models as well as the HSPF watershed model for peer review. Comments on the Draft Riparian Consumptive Use TM and Draft Flow Model Calibration Plan will be discussed during this conference call, along with an overview of Draft TM No. 1 - Model Integration.

ITEM 3: REVIEW ACTION ITEM LIST

Item 3 was skipped due to the volume of content to cover at the conference call.

ITEM 4: REVIEW DECISION LOG

Item 4 was skipped due to the volume of content to cover at the conference call.

ITEM 5: REVIEW COMMENTS ON DRAFT RIPARIAN CONSUMPTIVE USE TM (TASK 1.7)

Mr. White from Aspen and Mr. Romero from Balleau Groundwater presented their responses to comments received from the CA Department of Fish and Wildlife and OCWD. Mr. Yeh will send out the powerpoint after the call to allow further examination of these comments.

Questions and comments included:

1. Mr. White explained a written summary to describe the mapping and evapotranspiration estimates is being worked on, which will account for the expanded riparian vegetation area.
2. Mr. White suggested talking about the estimated ET for Giant Reed in the report because the model does not have a precise answer for this area. Mr. Sovich suggested running a sensitivity analysis with double 63.4 in/yr.
3. Mr. Romero explained recent reduction in ET can be explained by more than one factor and it would be good to have a baseline with and without drought conditions so careful calibration could result in estimating how much each component contributes to reduced ET. Mr. Sovich added that it would be nice to have the last wet year added to see how it changes the ET.
4. Mr. Romero suggested the technical committee discuss if the approach for partitioning ET is adequate or if some increased sophistication is needed. Mr. Sovich suggested a ground-truthing approach independent of the model as another option.
5. Mr. Yeh described the evapotranspiration areas of the model and stated the model ET areas were shown on Figures 23 through 28 of Draft TM No. 1.

ITEM 6: OVERVIEW OF DRAFT TM NO. 1 - MODEL INTEGRATION (TASK 1.14)

Mr. Yeh provided an overview of Draft TM No. 1 – Model Integration. Mr. Yeh briefly explained the development of the geologic conceptual model, estimation of riparian consumptive use, update to the existing model, construction and calibration of the Chino Basin model, and the development of a watershed model to simulate runoff generated within the Upper Santa Ana River Watershed.

Comments on the draft TM No. 1 are due on April 6th.

ITEM 7: REVIEW COMMENTS ON DRAFT FLOW MODEL CALIBRATION PLAN (TASK 2.1)

Ms. Wicks from GEOSCIENCE presented the response to comments on the Draft Flow Model Calibration Plan.

ITEM 8: REVIEW COMMENTS ON DRAFT DATABASE PLAN (TASK 6.1)

Mr. Coulibaly from GEOSCIENCE presented the response to comments on the Draft Database Plan.

ITEM 9: OTHER BUSINESS

No other business was discussed by the group during this conference call.

ITEM 10: NEXT MEETING

The next Integrated SAR Model meeting, which will be a conference call, will be Thursday, April 19th, 2018 at 10:00 am. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Thursday, March 22nd, 2018 at 4:00 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete

Action Item Description	Responsible Agency	Status
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	In Progress
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	In Progress
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete

Action Item Description	Responsible Agency	Status
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	In Progress
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	In Progress
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.

Item	Description
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

April 19, 2018
10:00 am

Issued on June 13, 2018

Attendees:	Balleau Groundwater: Dave Romero and Steve Silver
	City of Riverside Public Utilities (RPU): Greg Herzog
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, David Barnes, and Lauren Wicks
	Inland Empire Utilities Agency (IEUA): Josh Aguilar
	Numeric Solutions: Eric White
	Orange County Water District (OCWD): Tim Sovich, Richard Zembal, and Greg Woodside
	US Geological Survey (USGS): Wes Danskin and Geoff Cromwell
	San Bernardino Valley Municipal Water District (Valley District): Heather Dyer and Wen Huang
	Santa Ana Regional Water Quality Control Board: Eric Lindberg
	State Water Resources Control Board: Jan Stepek
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Mallory Gandara
	Other: Bonnie Johnson and Cathy Macklin

ITEM 1: APPROVAL OF 22-FEB-18 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 23-Apr-18, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed a revised project schedule and explained that the anticipated project completion date has been moved back one month due to additional work needed to address comments from the TAC, including the modification of model layers. He also explained that the model workshop in June will include a review of the model calibration and the predictive scenario assumptions. Ms. Dyer added that they were awarded the Section 6 grant, which would likely allow for some extra scenario runs. She asked TAC members to start thinking about what additional scenarios everyone would like to see run. Mr. Zembal suggested looking at what happened to the habitat in Temescal. Mr. Romero added that

Balleau Groundwater will need to look at general model performance along the river to see that the model is reasonably characterizing recharge and discharge. He brought up the possibility that some of the extra funds may be needed to refine the model calibration.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the uncompleted items in the Action Item list, which was included in the 22-Mar-18 meeting minutes. This includes Items 20 (reference regarding flow from hard rock), 21 (revisit areas where model over/under estimates water levels), 30 (figure showing areas where model has trouble), 31 (model layer names), and 40 (provide comments on Draft TM No. 1).

Mr. Yeh mentioned that GEOSCIENCE is currently waiting for additional comments on Draft TM No. 1: Model Integration. Per the request of IEUA, Mr. Yeh also reviewed the process of receiving and addressing the comments. While a date is typically set for the submittal of comments on a draft TM, Mr. Yeh explained that it is not really enforced. Mr. Aguilar stated that IEUA was working with consultants to provide comments on the draft TM No. 1 but, due to the technical nature of the review, needed some extra time to make sure they are able to provide productive comments; he anticipates being able to provide the comments the following week. Mr. Yeh indicated that he would check with the TAC to see who is still planning on submitting comments and the anticipated timeframe for those comments so that the schedule can be updated.

ITEM 4: REVIEW DECISION LOG

Mr. Yeh explained that there were no new decisions from the last conference call.

ITEM 5: REVIEW COMMENTS ON DRAFT TM NO. 1 – MODEL INTEGRATION (TASK 1.14)

Mr. Barnes presented responses to comments on TM No. 1 received from OCWD, which are the only comments to be received so far.

Questions and comments included:

1. Mr. Woodside asked how extinction depth for ET was determined. Mr. Barnes replied that it was generally based on rooting depths for the vegetation types.
2. Based on OCWD's comment requesting that the WEI calibration statistics be shown as a comparison for the Chino Basin Model calibration statistics in TM No. 1, Mr. Yeh asked Mr. Wang if WEI could supply the calibration results. This would allow GEOSCIENCE to provide statistics in response to this comment. Mr. Wang replied in the affirmative. Mr. Sovich added that he often does not look at the relative percent errors because it may not be very meaningful if the range of observations is too high.
3. Mr. Sovich asked if there were deep water levels that required model layer 1 to be so thick. Mr. Barnes replied that the depth to water levels is particularly high in the foothill areas. The thickness of model layer 1 was designed to avoid dry cell issues. Mr. Sovich agreed on this approach.

4. Mr. Romero suggested that using the model-calculated inflow and outflow from the integrated model might help individual model calibration. If that doesn't help, he recommends performing a sensitivity analysis on flow to model areas. Mr. Danskin and Mr. Williams agreed with this recommendation.
5. Mr. Williams asked Mr. Yeh how long the Integrated SAR Model currently takes to run and Mr. Yeh replied that the model currently takes about two days to run.

ITEM 6: STATUS UPDATE OF TASK 2 – FLOW MODEL CALIBRATION

Mr. Yeh provided an overview of the progress on the flow model calibration. He explained that 16 model runs have been made so far, including four used for initial testing.

Questions and comments included:

6. Mr. Sovich asked if the conceptual model for the Rialto-Colton area has the groundwater flow barriers restricting flow or completely impeding flow. Mr. Yeh replied that the San Jacinto Fault and Barrier E have no-flow boundary conditions along portions of the groundwater flow barriers. Mr. Sovich suggested that opening up the faults a bit might improve groundwater levels in the Chino Basin area. Mr. Yeh replied that GEOSCIENCE is looking into the difference in groundwater levels, but he thinks the model underestimation in the Chino Basin may be caused by the hydraulic conductivity and extension of Barrier J. Mr. Romero pointed out that some of the wells in the area have multiple completions; some of the completions have model-simulated water levels that match closer with observed levels.
7. Mr. Sovich and Mr. Danskin indicated that they liked the groundwater level contour figure showing groundwater flow directions and Mr. Sovich suggested that it might also be helpful to see how contours of observed head compare. Mr. Danskin agreed. Mr. Yeh replied that these will be created. Mr. Danskin also suggested providing a cross-section that's approximately parallel to the SAR above the figure to illustrate where fluxes are occurring.
8. Mr. Sovich inquired about the 500-ft depression seen just north of Prado Dam. Mr. Yeh replied that this was largely caused by ET and rising water.

ITEM 7: OTHER BUSINESS

Mr. Stepek from the State Water Board indicated that he has some questions on the Integrated SAR Model. For example, he asked why the model uses the well package for recharge terms rather than the recharge package. Mr. Yeh replied that the well package is used to help track water but there is no difference between using the well package and the recharge package to assign recharge. Mr. Yeh suggested that Mr. Stepek send any questions he has by email and Mr. Stepek agreed.

Mr. Romero also mentioned that Balleau Groundwater has some preliminary thoughts on the individual model files and would like to coordinate with Mr. Yeh on, plus some material to present to the group in the near future.

No other business was discussed by the group during this conference call.

ITEM 8: NEXT MEETING

The next Integrated SAR Model meeting, which will be a conference call, will be Thursday, May 17th, 2018 at 10:00 am. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Thursday, April 19th, 2018 at 11:40 am.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		

Action Item Description	Responsible Agency	Status
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	In Progress
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	In Progress
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	In Progress
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	In Progress
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	In Progress

Action Item Description	Responsible Agency	Status
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	In Progress
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.

Item	Description
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

May 17, 2018
10:00 am

Issued on July 11, 2018

Attendees:	Balleau Groundwater: Dave Romero and Steve Silver
	City of Riverside Public Utilities (RPU): Farid Boushaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, David Barnes, and Lauren Wicks
	ICF: Brendan Belby
	Orange County Water District (OCWD): Tim Sovich
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher
	Santa Ana Regional Water Quality Control Board: Eric Lindberg
	State Water Resources Control Board: Jan Stepek
	Santa Ana Watershed Project Authority (SAWPA): Ian Achimore
	US Geological Survey (USGS): Geoff Cromwell
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Mallory Gandara

ITEM 1: APPROVAL OF 19-APR-18 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 21-May-18, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed a revised project schedule and explained that Task 2 is in progress. The model calibration results will be discussed at the June workshop, along with predictive model scenario assumptions. Mr. Yeh also reviewed the technical memoranda submitted and comments received to date.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the uncompleted items in the Action Item list, which was included in the 17-May-18 meeting agenda and 19-Apr-18 meeting minutes. This includes Items 20 (reference regarding flow from hard rock), 21 (revisit areas where model over/under estimates water levels), 30 (figure showing areas

where model has trouble), 31 (model layer names), 40 (provide comments on Draft TM No. 1), and 41 (propose additional scenarios). Action Item 41 will also be discussed at the model workshop, and Mr. Yeh requested that TAC members provide ideas for additional model runs or suggestions prior to the meeting. Mr. Yeh also inquired about Action Item 42 (provide the electronic data for Chino Basin calibration hydrographs) and Mr. Wang replied that WEI sent out the data yesterday for review prior to providing the data to GEOSCIENCE. Mr. Tincher asked how not having the data from WEI would impact the schedule and Mr. Yeh replied that it would not impact the schedule; while it would provide additional data to evaluate the model calibration, the model calibration is not dependent on it.

ITEM 4: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes.

ITEM 5: STATUS UPDATE OF TASK 2 – FLOW MODEL CALIBRATION

Mr. Barnes provided an overview of the progress on the flow model calibration, including flux terms and initial results from the steady state calibrations, while Mr. Yeh provided the preliminary results of the transient calibration. Mr. Yeh described that there are still some large residuals that the modeling team is working on addressing, and explained that while the model layers were updated, the hydraulic conductivity values have not yet been changed from the original models. He expects the model performance to improve once the hydraulic conductivity is calibrated. Mr. Yeh also explained that removing the underflow boundaries in the Rialto-Colton Basin area caused a lowering of the groundwater levels. The modeling team is still working on the barrier effects to correct this underestimation.

Questions and comments included:

1. Mr. Romero asked if this status update was devoted only to the Integrated SAR Model terms. Mr. Yeh replied in the affirmative and explained that previous comments from the individual model calibration will be incorporated in the models and TM No. 1 will be updated accordingly.
2. Mr. Boushaki inquired when TM No. 2 might be available for review, and if it would be ready before the model workshop. Mr. Yeh replied that TM No. 2 will not be finalized prior to the meeting, but the slides presented at the meeting will include the most up-to-date model calibration results.
3. Mr. Romero was curious how the Integrated SAR Model ran (e.g., did it merge easily, especially in regards to the underflow inflow and mountain front recharge quantities). Mr. Barnes replied that it is coming together, but there were some surprises. They are currently working on some sensitivity analysis with the groundwater flow barriers in the Rialto-Colton area. Mr. Romero was not surprised that there would be some trouble with that interface. He also asked if the underflow values were currently the same as the individual boundaries. Mr. Barnes replied that the external inflow terms are the same as the individual models, but the interflow between basins are different since those boundaries have been removed. Mr. Romero also asked if the specified flux boundaries will change and Mr. Yeh replied that they will. He explained that this is especially true for the Red Hill Fault since the model-calculated water levels in the Chino

Basin are largely underestimated; additional flow might be needed across the fault. Mr. Romero agreed with this approach.

4. Mr. Sovich asked what the underflow inflow/specified flux boundaries were based on. Mr. Barnes replied that it depended on the individual model, since each model had a different approach. Mr. Sovich also asked if mountain front runoff was applied to layer 1 and Mr. Yeh replied that that also depends on the model. For example, mountain front recharge in the Rialto-Colton area is applied to layers 2 and 5; no changes have been made to the original models yet.
5. Mr. Sovich inquired why observed water levels were not used for the initial water levels. Mr. Barnes replied that the steady state model run was made to reach a numerical solution that is stable. Mr. Yeh added that since there are only about 100 water level measurements across the model area, the model is run to avoid errors associated with hand-contouring the data.
6. Mr. Sovich questioned what layers the residuals shown in the figures were from. Mr. Yeh suggested color-coding the residuals for future presentations so the model layers could be distinguished.
7. Mr. Boushaki asked how the low flows might affect the overall calibration and asked if the number of occurrences of high vs. low flows in range of observed. Mr. Yeh replied that they looked at the overall residuals. He also explained that the statistics are only one indication of the model performance – the distribution of the residuals on the scatter plot and graphical representation of observed vs. model-simulated flow provide qualitative assessments of the model performance. He added that a frequency analysis could be conducted.
8. Mr. Sovich asked how the modeling team planned to address the low flow events after 1996. Mr. Yeh replied that they will adjust the vertical hydraulic conductivity of the streambed. Mr. Sovich questioned if this adjustment would affect the results in previous years and Mr. Yeh explained that he did not think it would because it's such a small amount of water.
9. Mr. Romero asked if the river stage was variable and Mr. Yeh replied that it was constant.
10. Mr. Sovich inquired if the model accounts for changes in stream channels. Mr. Yeh replied that the model incorporates variable hydraulic conductivity and width for the stream segments. For example, he explained that in the SBBA, the streambed conductance needs to be increased in wet years (similar to what was done with the original USGS model).
11. Mr. Sovich asked if the underestimation of rising groundwater to streamflow might be caused by low groundwater levels. Mr. Yeh explained that the water levels near the stream match fairly well, so there might be too much recharge and too much flow from Riverside to Chino Basins. The streambed percolation likely needs to be adjusted.
12. Mr. Boushaki noted that the model seems to have a problem capturing very low flows.
13. Mr. Sovich suggested that the storage coefficient may be too high in areas because there is not enough amplitude in simulated water levels, as compared to observed levels. Mr. Yeh replied that he thought it was more of a flux terms issue. He explained that they are going to adjust the streambed conductance values.
14. Mr. Romero observed that the area of historic high groundwater seems to be underestimated – water is mounding in the wrong areas. He explained that after looking at the model files in the

Bunker Hill Basin, the lithologic model does not conceptually capture the idea of a river running through that area. He suggested increasing the permeability along the river to allow some of the areas of high groundwater to drain to areas that are underestimated. Mr. Yeh agreed.

15. In regards to how Lytle Creek Basin interacts with the fault, Mr. Romero suggested that some of this information might help delineate where the fault is at depth.
16. Mr. Sovich requested that the observed water level be added to the profiles showing model-simulated water levels. Mr. Yeh agreed.
17. Mr. Romero commented that Balleau Groundwater will coordinate with Mr. Yeh to receive copies of the Integrated Model. He also mentioned that they are putting together observations and ideas from the individual models.

ITEM 6: OTHER BUSINESS

No other business was discussed by the group during this conference call.

ITEM 7: NEXT MEETING

The next Integrated SAR Model meeting, which will be a model workshop at Valley District, will be Wednesday, June 20th, 2018 from 9:00 am to 12:00pm. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Thursday, May 17th, 2018 at 11:45 am.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)

Action Item Description	Responsible Agency	Status
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	In Progress
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	In Progress
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	In Progress
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	In Progress
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		

Action Item Description	Responsible Agency	Status
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	In Progress
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	In Progress
Items from 17-May-18 Conference Call (none)		

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.

Item	Description
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model,

Item	Description
	actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.
Items from 17-May-18 Conference Call	
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.

Minutes for the Upper Santa Ana River Integrated Model Update Workshop
San Bernardino Valley Municipal Water District

June 20, 2018
9:00 am

Issued on July 25, 2018

Attendees:	Balleau Groundwater: Dave Romero and Steve Silver
	City of Riverside Public Utilities (RPU): Farid Boushaki
	Flow Science: John List
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, David Barnes, and Lauren Wicks
	ICF: Brendan Belby
	Inland Empire Utilities Agency (IEUA): Liz Hurst
	Orange County Water District (OCWD): Tim Sovich and Greg Woodside
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher and Heather Dyer
	Santa Ana Regional Water Quality Control Board: Cindy Li
	State Water Resources Control Board: Jan Stepek (remotely)
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Claudia Faunt
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang (remotely)
	Western Municipal Water District (WMWD): Mallory Gandara

ITEM 1: INTRODUCTION

ITEM 2: APPROVAL OF 17-MAY-18 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 25-Jun-18, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 3: REVIEW SCHEDULE

Mr. Yeh showed the current project schedule and explained that the expected project ending date is the end of August. He also discussed upcoming events: comments on TM No. 4 are due by July 6, TM No. 3 (Model Calibration) is expected to be issued on June 29 and comments from the TAC will be due by July 20. GEOSCIENCE plans on having weekly discussions with Balleau Groundwater through the end of July, and expect to present Balleau's review of the model at the July 18th conference call. Predictive scenario assumptions will also be finalized at that conference call.

ITEM 4: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the uncompleted items in the Action Item list, which was included in the 20-Jun-18 workshop agenda and 17-May-18 meeting minutes. This includes Items 20 (reference regarding flow from hard rock), 21 (revisit areas where model over/under estimates water levels), 30 (figure showing areas where model has trouble), 31 (model layer names), 41 (propose additional scenarios), and 42 (provide the electronic data for Chino Basin calibration hydrographs). Action Items 20, 21, and 30, will also be included in TM No. 3. Mr. Yeh also pointed out that since the data from Action Item 42 has not been provided yet, comparisons between Integrated SAR Model and WEI's Chino Basin Model performance are general.

ITEM 5: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes. Decisions 25 through 27, which pertain to model figures, will be included in TM No. 3.

ITEM 6: RESULTS OF FLOW MODEL CALIBRATION (TASK 2)

Mr. Barnes provided an overview of the flux terms used in the Integrated Model, results of the pseudo steady state simulation run, and results of the Integrated SAR Model calibration in the Yucaipa Basin. Mr. Yeh provided the results of the Integrated SAR Model transient calibration in the SBBA, Rialto-Colton, Riverside-Arlington, and Chino Basins. Mr. Yeh explained that these results represent the draft calibration, and additional work will be conducted to refine model performance in certain locations.

Questions and comments included:

1. Mr. Williams asked what percentage of the total precipitation the recharge from precipitation represents. Mr. Yeh replied that it varies, but is generally somewhere between 1-5%.
2. Mr. Boushaki observed that the snapshot periods used for the estimation of maximum ET did not include the most recent drought period. He inquired if this was accounted for in the model. Mr. Barnes explained that the snapshots are used to apply ET parameters in the model, which are varied through the model calibration period, but that the actual ET is calculated by the model. Since ET is largely dependent on groundwater elevation, the effects of drought conditions are captured through lowering water levels (corresponding to less ET).
3. Mr. Palenscar asked if the model is able to account for conditions following flood events (e.g., loss of vegetation from scour). Mr. Barnes replied that the vegetation coverage comes from the vegetation mapping and Ms. Dyer pointed out that the mapping from 2004 through 2006 would have captured flood effects. Mr. Romero added that if the scour was significant, the model could be adjusted for a specific condition. However, he explained that the scenarios will be used to assess a change in conditions, like recharge. He also suggested that a sensitivity analysis could be performed to address any concerns.
4. Mr. Sovich asked if there had been any observable changes in pumping. Mr. Barnes replied in the affirmative and explained that, in Chino Basin, there has been a large shift from mainly agricultural pumping in the earlier model years to municipal pumping in recent years. Mr. Sovich asked if there was also a change in depth associated with this shift in pumping. Mr. Yeh

explained that, in general, municipal pumping is deeper than agricultural pumping. Mr. Sovich also asked if it was possible to put maximum pumping (adjudicated pumping) on the figures and Mr. Boushaki and Mr. Yeh explained that that would be difficult since the regulations take into account 5-year averages, replenishment, and water levels in index wells.

5. In regards to the steady state run, Mr. Woodside inquired how much the conditions really represented steady state. Mr. Barnes explained that it was a pseudo steady state used to develop initial water levels for the transient model calibration and Mr. Romero added that there is never going to be a perfect place to start. He explained that fluxes should stabilize within 10-15 years – even in places where the initial water levels may be off. However, a numerical steady state is necessary to move forward. Mr. Sovich asked if any parameters were changed during the steady state run and Mr. Barnes replied that while parameters were not altered, they were updated based on results of the transient calibration. Mr. Sovich suggested changing the name of the "steady state calibration" to reflect the actual process and conditions used. The modeling team agreed to change the terminology to reflect a pseudo steady state simulation run.
6. Mr. Sovich asked if the initial water levels could be changed manually where there were observed outliers. Mr. Barnes explained that, while this would fix the problem initially, the aquifer parameters and fluxes used in the model would remove this effect. Mr. Yeh added that some of the outliers may reflect perched water that the model is unable to simulate.
7. Mr. Romero mentioned that during wet years, streambed infiltration would increase. Mr. Yeh agreed and explained that that is accounted for in the model.
8. Mr. Sovich suggested adding the initial calibration to the hydrographs for comparison.
9. Mr. List pointed out that the model doesn't capture the peaks in Well #1 in the SBBA. Mr. Palenscar explained that this well is located near the confluence of the Cajon and Lytle creeks. Several TAC members suggested it might be a storativity problem, but Mr. Yeh is afraid that changing the storativity could cause other overestimation elsewhere. Mr. Silver suggested looking at the wetted area and Mr. Palenscar described that this part of the creek is probably wetted about one-third of the year and that the porosities of the two creeks are different. He also pointed out that there are old mining basins in the area that may contribute to recharge. Mr. Williams asked if the nearby fault was leaky and Mr. Yeh replied it was pretty tight. Mr. Romero brought up Ms. Wolfenden's idea that the faults may be more permeable at shallow depths, allowing water to spill over the fault. Mr. Williams agreed. Mr. Sovich added that in Orange County, they attributed huge spikes in wet years to contributions from fracture systems, and Mr. List agreed this could be a factor. Mr. Yeh replied that they will use the group's suggestions to try to improve calibration at this location.
10. Mr. Boushaki commented on the calibration statistics and requested adding the root mean-squared error. Mr. Yeh replied that this will be added to TM No. 3.
11. Mr. Woodside asked for additional clarification on what data are outstanding for the WEI Chino Basin model. Mr. Yeh explained that they had requested the water level residual data from WEI in response to a comment from a previous model update conference call. Mr. Sovich had requested earlier that the Integrated SAR Model results be compared to WEI's model performance in a similar manner as the other models.

12. Mr. Palenscar asked how the amount of rising water was gaged and Mr. Yeh explained that rising water is a model-calculated value, calibrated to water level and streamflow. Mr. Romero added that the model becomes the way to determine the amount of rising water since there is no other way to measure that. Ms. Dyer mentioned that the USGS has some measured data and Mr. Yeh explained that this data was incorporated in the initial model assumptions and adjusted during model calibration.
13. Ms. Hurst mentioned that the underflow value from Riverside-Arlington Basin to Chino Basin looks a little high and she would like to look into that. Mr. Romero observed that this model is presenting new information, since this is the first time all of the models have been looked at cohesively.
14. Mr. Boushaki suggested that there may be a trade-off between using a local, highly calibrated model and a large model that provides a big view of the area. Mr. Tincher asked if there was a trade-off since the large model is providing refined estimates of underflow volumes for the individual models. He also mentioned that all models have error, but that error has to be looked at in terms of the purpose of the investigation. Mr. Sovich observed that the hydrographs can sometimes offer more information about model performance than the residual statistics, and that the hydrographs of the model calibration show improvement.
15. Mr. Sovich asked why ET seems to top out around the late 1990s and was wondering if there was some maximum threshold. Mr. Tincher proposed that it may have to do with the available area for vegetation and observed that Aspen's numbers from the vegetation mapping also seem to show the same relationship.
16. Mr. Palenscar asked if the model could show if RIX infiltration eventually becomes rising water downstream. Mr. Yeh replied that the model could be used to track RIX water, if the group wishes to make that run. Ms. Dyer added that this is actually one of the questions that needs answered for the Habitat Conservation Plan. Mr. Yeh suggested that this could be determined through different model runs. Mr. Romero added that there is a difference between actual RIX discharge becoming rising water, or the RIX recharge causing rising water. The group agreed that the effect was what was important – not whether the rising water was actually RIX recharge.
17. Ms. Li asked how the surface water calibration was linked to the groundwater model. Mr. Yeh explained that there are 2 different models used for the Integrated SAR Model: the watershed model and the groundwater flow model. He added that the final Integrated SAR Model results are being compared to the calibrated watershed model results in response to a previous comment from Mr. Boushaki.

ITEM 7: DISCUSSION OF MAJOR ASSUMPTIONS OF PREDICTIVE SCENARIOS (TASK 3.1)

Ms. Wicks reviewed some of the major assumptions for the predictive scenario runs. Additional information is needed from the TAC regarding the reduction in pumping for Scenario 1a, selection of HCP projects for Scenarios 2c, 2d, 2e, and any additional Scenario 2 runs, and scenario assumptions for Scenarios 3, 4, and 5.

Questions and comments included:

1. Mr. Tincher suggested using one of the Scenario 2 model runs to evaluate stormwater recharge projects upstream separately to determine downstream effects. Mr. Yeh proposed evaluating these effects with Scenario 2c. Ms. Dyer added that she anticipates the possibility of having many runs for Scenario 2, given the number of projects that may need individual analyses. Mr. Yeh asked how this would affect the project schedule and Ms. Dyer replied that the priority would be looking at the big picture (i.e., baseline vs. all HCP activities). She added that they were able to get the grant, so a large amount of that money will be available for additional scenarios – even after the completion of this phase of work (going forward several years). For the immediate needs, Ms. Dyer mentioned that she and Mr. Belby would sit down and figure out which projects need to be analyzed first.

2. Regarding the HCP base period from 1966 through 1990, Mr. Sovich suggested using a different base period for the predictive scenarios that incorporates more recent hydrology. He explained that his concern was that this period represents the time with the least confidence in model calibration. Mr. Belby explained that this period represents a time period of overlap between different models that incorporated dry, wet, and average hydrology. Ms. Faunt asked if this hydrology would be added on to the end of the calibration run. Mr. Yeh explained that the predictive scenarios would be tacked on to the end and the model runs would use 2012 land use. Ms. Faunt felt comfortable with this approach. In response to questions about future land use, Mr. Yeh added that scenario runs could also be made with different land use at the TAC's discretion.

3. Mr. Boushaki mentioned that some of the numbers for RPU.5 and RPU.8 look bigger than what they were expecting and asked where the numbers came from. Ms. Dyer explained that the old assumptions for RPU.6 need to be rerun through the Integrated SAR Model and then the revised assumptions will need to be run as well. She clarified that these activities represent possible activities over the next 50 years for permitting purposes. Mr. Tincher asked if the model will help determine what projects have the greatest impacts on fish habitat and Ms. Dyer replied that she's hoping that these predictive scenarios will provide that information. Mr. Sovich asked if there was a ranking for the projects and Ms. Dyer explained that they have some idea of potential phases based on need and cost, but that nothing is definite.

4. Ms. Hurst wanted to make sure that the HCP values came from the new modeling and Ms. Dyer replied in the affirmative.

5. Ms. Dyer clarified that some of the projects have already been independently permitted, but they were kept on the list just in case.

6. Mr. Belby asked if the Chino Basin projects have already been built into the model and Ms. Wicks replied that they are still developing the assumptions. Mr. Belby explained that he wanted to make sure they were modeled in the same way that ICF is using to analyze them for the HCP. Ms. Dyer suggested having Mr. Yeh and his modeling team coordinate with Mr. Belby and Ms. Hurst suggested also including the WEI modeling team.

7. Mr. Palenscar asked if climate change was being considered in the predictive scenarios and Mr. Yeh replied that this could be built into a scenario run if the group wishes. Ms. Dyer explained this would probably be necessary for at least one run. Mr. Tincher suggested creating a book end since there is such a range of estimates.

ITEM 8: OTHER BUSINESS

No other business was discussed by the group during this conference call.

ITEM 9: NEXT MEETING

The next Integrated SAR Model meeting, which will be a conference call, will be Wednesday, July 18th, 2018 from 8:30 am to 10:00 am. GEOSCIENCE will send around the meeting details. Mr. List requested a tentative date for the August meeting and Mr. Yeh said he would send around a poll for the best available time for the group.

ADJOURNMENT

The meeting adjourned on Wednesday, June 20th, 2018 at 12:00 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete

Action Item Description	Responsible Agency	Status
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete

Action Item Description	Responsible Agency	Status
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	In Progress
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	In Progress
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.

Item	Description
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.

Item	Description
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.
Items from 17-May-18 Conference Call	
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
Items from 20-Jun-18 Model Workshop	
28	Terminology for the steady state run will be modified to reflect pseudo steady state conditions.
29	The initial calibration results (Draft TM No. 1) will be added onto calibration hydrographs in Draft TM No. 3 for comparison.
30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

July 18, 2018
8:30 am

Issued on September 20, 2018

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	Chino Basin Watermaster: Anna Truong
	City of Riverside Public Utilities (RPU): Farid Boushaki
	Flow Science: John List
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, David Barnes, and Lauren Wicks
	ICF: Brendan Belby
	Inland Empire Utilities Agency (IEUA): Liz Hurst
	Orange County Water District (OCWD): Tim Sovich and Greg Woodside
	RMC: Cathy Macklin
	San Bernardino Valley Municipal Water District (Valley District): Heather Dyer and Wen Huang
	Santa Ana Watershed Project Authority (SAWPA): Ian Achimore
	State Water Resources Control Board: Jan Stepek
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Claudia Faunt and Geoff Cromwell
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Mallory Gandara
	Yucaipa Valley Water District (YVWD): Jennifer Ares

ITEM 1: APPROVAL OF 20-JUN-18 WORKSHOP MINUTES

In a previous email, Mr. Boushaki informed the TAC that he intended to provide some comments on the workshop meeting minutes. No other comments were provided by the TAC. The 20-Jun-18 workshop minutes will be finalized after receiving and incorporating Mr. Boushaki's comments and any other comments which may be submitted.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed the current project schedule and discussed upcoming events: no comments have been received on TM No. 4 yet, comments on TM No. 3 (Model Calibration) are due by July 27, and the September workshop will present a review of the comments and scenario results.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the uncompleted items in the Action Item list, which was included in the 18-Jul-18 conference call agenda and 20-Jun-18 workshop minutes. Mr. Yeh suggested withdrawing Item 42 (provide the electronic data for Chino Basin calibration hydrographs), since it appears the information will not be provided. Mr. Woodside agreed, but added that the lack of information should be documented. Mr. Yeh also explained that a tentative meeting date for Item 43 (meeting to coordinate HCP assumptions in Chino Basin) was scheduled for July 30. Since the meeting, a conflict was discovered and the meeting will need to be rescheduled.

ITEM 4: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes.

ITEM 5: BGW'S PEER REVIEW OF THE INTEGRATED SAR MODEL

Mr. Romero provided an overview of BGW's peer review of the model, including a summary of the review process and objectives. BGW found some areas in the model with higher than normal specific storage, which was the only parameter with any concern. The simulated model transmissivity was also generally a little lower than values obtained from pumping tests (i.e., specific capacity). Mr. Romero observed that a general increase in transmissivity my benefit the model. He also mentioned that GEOSCIENCE is working on refining the foot print area of where ET occurs, but that the modeled ET is generally in line with typical expected behavior. In terms of the hydrographs, Mr. Romero explained that BGW is still working on ways to classify the model performance; some are good, some need improvement, and some may appear worse than they are because of the frequency/range of observed water levels. Things BGW is still looking at include rising groundwater in Prado Basin, flow data in the area of the RIX plant, fault effects, Hole Lake behavior, cross-checking model parameters with the lithologic model, and developing recommendations. Mr. Romero also offered that BGW would be happy to talk with any of the TAC members if they have any questions.

Mr. Yeh explained that GEOSCIENCE has been having weekly conference calls with BGW so that the model calibration can be refined as quickly as possible, and have already made good progress. Mr. Barnes described the work done so far, which has included refining the ET footprint, and addressing areas of high storativity.

Questions and comments included:

1. Mr. Romero explained that there were some areas with high specific storage and that BGW has been working with GEOSCIENCE to correct these areas. Mr. Yeh replied that corrections have been made and explained that the model uses storativity, which is the specific storage multiplied by the aquifer thickness. Ms. Hurst asked for an explanation on the importance of

specific storage and Mr. Romero replied that it represents the amount of water released by an aquifer and relates to the amount of storage in an aquifer. Changes in specific storage affect the way water is stored in the aquifer and how far hydraulic effects can extend (e.g., cones of depression).

2. Regarding the distribution of recharge, Mr. Romero said the model results look conceptually sound, but BGW is still in the process of observing general behavior of modeled specified flow. Mr. Boushaki asked if the recharge range shown on the slides was per cell, and Mr. Romero replied in the affirmative.

3. Mr. Palenscar asked if the data for the rising water were empirical or if actual data were available. Mr. Romero replied that the colors shown on the slides represent modeled data, but they also compared model-calculated streamflow to observed.

4. Mr. Palenscar asked if the model takes into account the placement of the Seven-Oaks Dam, and Mr. Yeh answered in the affirmative. He also explained that the shift of San Bernardino discharge to RIX is also accounted for in the model. Mr. Romero added that discharge from water treatment plants are also taken into account and are reflected in the observed and simulated values.

5. Regarding the streamflow at Warm Creek, Mr. Palenscar asked if the gage took into account both flow from Warm Creek and Lytle Creek. Mr. Yeh replied that it's only Warm Creek. Mr. Boushaki explained there are three gages in the area: E Street, Warm Creek, and Lytle Creek. He went on to state that the advantage to using Warm Creek over Lytle is that Lytle Creek has retention basins upstream which could interfere with the comparison of model-calculated and observed. If a comparison wanted to be made between model-calculated and observed flow in Lytle, Mr. Boushaki recommended using the HSPF output rather than the groundwater model output because of channel lining.

6. Mr. Sovich observed that, in general, the model-calculated flows are a bit too low downstream and a bit high upstream. He asked if that means the model might be losing too much water. Mr. Romero replied that might be something to look into. Mr. Yeh added that at Prado, the model-simulated data also has a drain component to simulate rising water which should be added to the flow. After the meeting, BGW confirmed that the drain package was not included in the meeting presentation slides. Those slides were updated before being sent to the group.

7. Mr. Palenscar explained that the ET area modified near Sunnyflow Creek is subject to scour and changes regularly. He cautioned making a permanent change to a dynamic area. Mr. Barnes replied that he considered the land use in the area and the area removed coincided with developed land north of the flood plain and will double-check to make sure no flood areas were removed.

8. Mr. Sovich asked if the changes presented at this meeting were done after the issuance of TM No. 3: Model Calibration. Mr. Yeh replied in the affirmative and Mr. Sovich asked if it would be worthwhile to reissue the report. Mr. Yeh explained that the refinements will be minor and will likely not affect the results by a significant degree. He would still like to receive comments from the TAC on the current issue of the TM so that GEOSCIENCE can review and respond to comments/concerns at the September workshop.

9. Ms. Dyer mentioned that she would like to set up a call with the CA Department of Fish and Wildlife, USFWS, and BGW to review riparian modeling results.

10. Mr. Sovich inquired what avenue would be used for letting the rest of the group know the answers to any substantive questions on the modeling results. Mr. Yeh replied that he would coordinate and send out any important comments/changes. He also mentioned that these will be reviewed at the next workshop as well.

ITEM 6: STATUS OF PREDICTIVE MODEL SCENARIOS – TASK 3

Ms. Wicks reviewed the status of the predictive scenarios, and explained that the first scenarios to be run will be in support of the HCP DEIR.

Questions and comments included:

1. Mr. Sovich asked about the difference between Scenario 1 and 2. Mr. Yeh replied that Scenario 1 will use the calibrated model (past conditions) while Scenario 2a will represent future conditions using the HCP base hydrology.

ITEM 7: OTHER BUSINESS

No other business was discussed by the group during this conference call.

ITEM 8: NEXT MEETING

After circulating a poll, it was determined that the next Integrated SAR Model meeting, which will be a workshop at Valley District, will be September 14th, 2018. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Wednesday, July 18th, 2018 at 10:05 am.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
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9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
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15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)

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25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
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Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete

Action Item Description	Responsible Agency	Status
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	In Progress
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	In Progress
Items from 18-Jul-18 Conference Call		
44. Meeting with Valley District, USFWS, CDFS, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
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9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
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Items from 23-Oct-17 Conference Call	

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18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
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Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.
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30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.

Minutes for the Upper Santa Ana River Integrated Model Update Workshop

San Bernardino Valley Municipal Water District

September 14, 2018
1:00 pm

Issued on December 13, 2018

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	City of Riverside Public Utilities (RPU): Farid Boushaki
	Flow Science: John List (remotely)
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, David Barnes, Lauren Wicks, and Leo Liu (remotely)
	ICF: Brendan Belby
	Inland Empire Utilities Agency (IEUA): Chris Berch
	Orange County Water District (OCWD): Tim Sovich and Greg Woodside
	San Bernardino Valley Municipal Water District (Valley District): Heather Dyer, Bob Tincher, and Wen Huang
	Santa Ana Watershed Project Authority (SAWPA): Mark Norton and Ian Achimore (remotely)
	State Water Resources Control Board: Jan Stepek (remotely)
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Wes Danskin and Geoff Cromwell (remotely)
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang (remotely)
	Western Municipal Water District (WMWD): Mallory Gandara, Ryan Shaw, and Jason Pivovaroff

ITEM 1: INTRODUCTION

ITEM 2: APPROVAL OF 18-JUL-18 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Wednesday, 19-Sep-18, at which time the minutes shall be considered “approved” and will be finalized.

ITEM 3: REVIEW SCHEDULE

Mr. Yeh showed the current project schedule and discussed upcoming events. He explained that GEOSCIENCE plans on issuing TM-5 in two parts: TM-5a will provide scenario results for an initial set of predictive scenario runs, while TM-5b will summarize the remaining scenario runs.

ITEM 4: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the uncompleted items in the Action Item list, which was included in the 14-Sep-18 workshop agenda and 18-Jul-18 conference call minutes. These include Items 41 (TAC to provide additional scenario run suggestions), 43 (meeting to coordinate HCP assumptions in Chino Basin). The current list of predictive model scenario runs will be emailed to the TAC for review and comment.

ITEM 5: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes.

ITEM 6: USGS'S PEER REVIEW OF THE INTEGRATED SAR MODEL

Mr. Danskin reviewed the comments he had submitted previously. While he does not currently get this impression from the TAC, Mr. Danskin cautioned against unbridled optimism. He also expressed that he felt the group has made significant progress and was pleased that the model integration was accomplished without too much difficulty.

Questions and comments included:

1. In response to Mr. Danskin's suggestion that further development of subarea models would be useful, Mr. Yeh commented that they are still planning on creating 5 individual models for the area with improved boundary conditions from the Integrated SAR Model. Even though these models have the same or better grid size as the original individual models, Mr. Danskin reminded the group that smoothing assumptions were made to develop a unified geology. However, he pointed out that much of the uncertainty in the individual models comes from boundary condition assumptions.
2. Mr. Danskin also pointed out that the USGS has provided other comments face-to-face with GEOSCIENCE, along with detailed geologic comments.

ITEM 7: BGW'S PEER REVIEW OF THE INTEGRATED SAR MODEL

Mr. Romero provided an overview of BGW's peer review of the model, which was made using the June 28th model files. He pointed out that progress and change has been made since then. Mr. Romero also stressed that, while guidelines exist, there is no "cook book" for model construction and calibration. He showed an animation of changing groundwater level contours and monthly recharge/discharge terms, and observed that the model seems to reproducing trends that are expected based on the conceptual model of the area. In addition, the groundwater model is showing shallow groundwater in areas where shallow groundwater has been known to exist.

Mr. Romero also presented an analysis of capture mapping performed using the Integrated SAR Model, following the approach used in USGS Scientific Investigations Report 2008-5207. The capture analysis shows how groundwater pumping induces change, or how pumping captures flow. He explained this is one way to use the model to develop an understanding of how the system responds to pumping. Mr. Silver pointed out that this analysis also shows the value of integrating the individual models, since a similar analysis with a stand-alone model would end up capturing water from the general head boundaries.

Questions and comments included:

3. Mr. Sovich asked why heads appeared to be stacking up in the north corner of the Chino Basin. Mr. Yeh replied that those simulated water levels were in response to water level data at a shallow USGS well. The area was assigned a lower hydraulic conductivity to produce water levels that reflect observed levels in response to comments from the TAC, but that the high water levels are likely caused by perched conditions. Mr. Silver observed that similar conditions are also seen in the Rialto-Colton Basin.
4. Mr. Romero suggested considering recharge contribution from mountain blocks in future model work. He observed that, generally, the model is not performing as well in the northern part of the basin (i.e., Yucaipa Basin and SBBA). In particular, simulated streamflow in Warm Creek is biased high. Mr. Yeh mentioned that GEOSCIENCE has since adjusted the streambed percolation and brought the streamflow down so that it matches the observed flow well. However, he noted that the flow here is typically low relative to other streams.
5. Mr. Romero suggested possibly looking at other gages. However, Mr. Boushaki commented that the gages currently used are probably the correct ones since there are problems associated with some of the other gages that affect the quality of the data, especially in San Timoteo. Mr. Danskin said he wasn't surprised there was an issue with observed data in San Timoteo Creek, but mentioned that simulated flow in Warm Creek is more important given the occurrence of rising water. Mr. Silver added that the model showed Warm Creek start flowing again in the '80s, as expected.
6. Mr. Sovich asked how the model-calculated ET (from both the surface water model and groundwater model) compares with the numbers developed by Aspen. Mr. Romero replied that the ET values are within the same range as Aspen's and reasonably match those from the energy balance, with the exception of wet years. He observed that the independent approaches have provided a variability of results. He suggested including a sensitivity analysis with the predictive scenarios (by scaling up/down the ET) to determine what effect it might have.
7. Mr. Danskin observed that ET is so highly buffered by other things in the model that it is typically artificially flat. However, he agreed with Mr. Sovich that the simulated ET trend doesn't feel right. The overall water budget could look right, but it's hard to tell what is really happening in the real world because there usually isn't data to corroborate it. Mr. Romero suggested that installing piezometers might provide insight on simulation of ET rates and trends. Mr. Danskin expressed some concern moving forward with scenario runs given what appears to be a highly buffered ET – the scenario runs may not show the correct ET response/effects.

8. Mr. Wang observed that the simulated ET looked high, and that the Chino Basin is a major contributor to ET.

9. Mr. Sovich suggested looking at the 5-year running average of ET to see how it compares to the energy balance.

10. Mr. Pivovaroff mentioned that LIDAR studies conducted as part of the Chino Adaptive Management Plan show a long-term increase in plant health in the southern portion of Prado Basin since the early 2000s. Mr. Tincher mentioned that it would be interesting to plot the average flow of the River at this location to see how flows compared. Mr. Romero commented that baseflow and precipitation do drop off at the end of the calibration period, indicating drought conditions.

11. Mr. Boushaki explained that ET is one of the hardest things to calculate. The two approaches used have different assumptions (i.e., energy balance and flux approach). The assumptions associated with each approach may account for some of the discrepancy. Mr. Yeh replied that the model-calculated ET is largely driven by riparian area and depth to water. The riparian area was based on the results from Aspen, which is pretty constant after 2000. He added that the calculated ET does show a decline towards the end of the calibration period, just not as steep as that shown by the energy method. Mr. Sovich observed that the groundwater levels must be fairly constant in the riparian area to cause such a shallow slope in ET and asked if there were any riparian target wells that would support that. Mr. Yeh replied that there are shallow groundwater hydrographs in the riparian areas that match up well with observed levels. Mr. Barnes added that they typically don't expect much fluctuation along the river.

12. Ms. Dyer commented that for HCP purposes, the goal is to estimate the impact to vegetation. They want to understand what is going to happen and are committing to a long-term monitoring program. They just want to make sure the approach is defensible, but that it sounds like the group is on the right path. She suggested running a few HCP scenarios and see if the results make sense. The results will also help define where additional monitoring may be needed. Mr. Romero agreed and Mr. Danskin pointed out that a few good piezometers will go a long way.

13. Mr. Sovich asked if GEOSCIENCE has tried adjusting streambed conductance to improve model simulated results. Mr. Yeh replied that they have already made some changes and will show updated results.

14. Mr. Romero suggested that refining recharge might help improve calibration in the upper area of the basin, but Mr. Danskin cautioned changing recharge to match water levels when transmissivity has already been iteratively adjusted. However, he added that the facies in the area could be mapped and transmissivity values developed as a follow-up work element. Then it would be more appropriate to revisit recharge estimates.

15. In response to the capture mapping shown by BGW, Mr. Danskin observed that the maps could be used to illustrate how pumping captures water from the river. He explained that pumping does not take from recharge; it takes from discharge (e.g., streamflow, ET, rising groundwater, underflow to another groundwater basin, etc.).

ITEM 8: REVIEW COMMENTS ON DRAFT TM NO. 3 – MODEL CALIBRATION

Mr. Barnes reviewed the comments received for draft TM No. 3 and the initial responses, including updated calibration results. Due to time constraints, not all of the comments were able to be covered. However, Mr. Yeh pointed out that all responses were provided in the handouts. If anyone has any questions about specific comments/responses, he encouraged them to send an email.

Questions and comments included:

1. Mr. Danskin expressed his appreciation for the incorporation of comments, especially in terms of figure edits. He acknowledged that these changes can be difficult and expensive, but that they will add significant value to the end product.
2. Mr. List explained that previously published contours in the Chino Basin area just to the west of the Rialto-Colton Fault indicate flow across the boundary. Mr. Williams pointed out that the leakage appears to occur in the southern portion of the fault. Mr. List agreed but feels there is also groundwater flow occurring higher up and recommended that possibility be considered and perhaps tested through sensitivity runs.
3. Mr. Boushaki requested more information on the model calibration approach. Mr. Yeh replied that additional (step-by-step) detail will be provided in the final TM No. 3. Mr. Danskin suggested leading with what parameters were changed the most, and then discuss how the decisions were grouped (e.g., cell-by-cell, zones, by river segment, etc.).
4. Mr. Sovich asked if the calibration was complete. Mr. Yeh replied in the affirmative, but mentioned that additional changes outside of the current scope of work (e.g., contribution of mountain front recharge/underflow and timing) could help improve model performance in the future.

ITEM 9: OTHER BUSINESS

No other business was discussed by the group during this conference call.

ITEM 10: NEXT MEETING

The next Integrated SAR Model conference call will be October 10th, 2018, at 10:00 am. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Friday, September 14th, 2018 at 4:00 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		

Action Item Description	Responsible Agency	Status
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		

Action Item Description	Responsible Agency	Status
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
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37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
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Items from 14-Sep-18 Conference Call		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete

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31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.
Items from 14-Sep-18 Workshop	
33	Additional detail regarding calibration (decisions, steps, methodology, etc.) will be included in the final TM-3.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

October 10, 2018
10:00 am

Issued on December 14, 2018

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	California Department of Fish and Wildlife (CDFW): Joanna Gibson
	Chino Basin Watermaster (CBWM): Edgar Tellez-Foster
	City of Riverside Public Utilities (RPU): Farid Boushaki
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, David Barnes, and Lauren Wicks
	Inland Empire Utilities Agency (IEUA): Liz Hurst
	Orange County Water District (OCWD): Greg Woodside
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher
	State Water Resources Control Board: Jan Stepek
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Wes Danskin
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Jason Pivovaroff

ITEM 1: APPROVAL OF 14-SEP-18 WORKSHOP MINUTES

Mr. Romero indicated that BGW had a minor comment on the draft minutes. In a follow-up email, it was requested to add "simulation of" before "ET rates and trends" in comment #7 of the meeting minutes. This change has been made in the finalized version. No other comments were provided by the TAC.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed the current project schedule and discussed upcoming events. He explained that they are waiting for comments from IEUA/CBWM/WEI before finalizing TM No. 3 (Model Calibration). Currently, work is underway on Task 3: Develop and Run Predictive Model Scenarios. To support this task, CBWM and WEI provided pumping and recharge data for Chino Basin, which were submitted at the end of October.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the Action Item list, which was included in the 10-Oct-18 conference call agenda and 14-Sep-18 workshop minutes. The only uncompleted item currently on the list is Item 41: Propose additional scenarios in the event that the budget allows for extra model runs.

ITEM 4: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes.

ITEM 5: STATUS OF PREDICTIVE MODEL SCENARIOS

Ms. Wicks discussed the list of currently proposed model scenarios, including the model run priority. Four different groups are currently envisioned, with completion dates as follows: 1) end of December, 2018; 2) end of March, 2019; 3) end of June, 2019; and 4) end of September, 2019. In regards to the scenario run simulating all HCP covered activities (shown as Scenario 2 on the presentation slides), Ms. Wicks explained that additional runs could be added. For example, Chino Basin Watermaster suggested a possible run where projects come online based on their expected implementation date. Ms. Wicks will also follow-up on any projects that were not assigned a priority during the meeting and recirculate the revised list to the group. Ms. Wicks also reviewed where the monthly recharge and discharge assumptions for the HCP Activities are coming from.

Mr. Barnes discussed the proposed future monthly groundwater pumping based on a review of Urban Water Management Plans (UWMPs).

Questions and comments included:

1. Mr. Tincher suggested renumbering the scenario list to reflect the original numbering in the proposal document. Ms. Wicks and Mr. Yeh replied that the numbering will be modified and the list will be updated to include a comprehensive list of scenario runs. The list will also indicate which scenario runs were included in the original proposal.
2. Mr. Pivovaroff indicated that the Western HCP activities may be included with the third or fourth group of model runs. However, the Riverside-Arlington Basin for SGMA/GSP runs may need to be pushed forward.
3. Mr. Tincher indicated that the Enhanced Recharge Project (VD.3) and Active Recharge Activities (VD.2.01-2.13) should be given high priority. They will be included in the first set of model runs.
4. Mr. Boushaki asked for an explanation of the numbers included in the "HCP Activity" column. Ms. Wicks explained that these correspond to the activities listed in the Table 2-2 which was developed by ICF.
5. Ms. Hurst explained that IEUA are finalizing the list of activities and priority.
6. Mr. Boushaki reminded the group that the UWMPs were submitted in 2016 and that new legislation will require agencies to reduce their water use. He questioned whether the scenario assumptions will take the conservation measures into consideration. Mr. Tincher observed that the degree of conservation is speculative at this point, but he does not expect that the

incremental effects will create a huge change in the modeling results. As such, he recommended sticking to published estimates.

7. Mr. Danskin explained that the USGS requires all modeling investigations to include a sensitivity analysis, which helps determine whether the model is well structured. He suggested adding a run in which all of the pumping is turned off. After running for many years (i.e., about 100), the water level contours should look similar to the Mendenhall Maps from 1905. If the model is unable to produce similar patterns, he explained that something is not structurally correct in the model. Mr. Danskin also explained that this will be important for interpreting the scenario results. He also cautioned that it is not a given that the scenario runs will go smoothly, and additional time may be required.
8. Mr. Woodside suggested conducting a model run with other operations in the groundwater basins, which may not be reflected in the UWMPs and Baseline run.
9. Mr. Woodside asked if the scenario runs would include a simple water budget to evaluate whether the input/output values are reasonable. Mr. Yeh explained that each run will include this analysis.
10. Mr. Romero asked for clarification on how project effects will be evaluated. As he understands it, the scenario run will be subtracted from the baseline scenario to isolate the project effects. Mr. Yeh verified that this is the approach that will be used.

ITEM 6: OTHER BUSINESS

No other business was discussed by the group during this conference call.

ITEM 7: NEXT MEETING

The next Integrated SAR Model meeting, which will be a conference call, will be November 15th, 2018, from 10:00 am to 11:30 am. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Wednesday, October 10th, 2018 at 11:05 am.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		

Action Item Description	Responsible Agency	Status
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		

Action Item Description	Responsible Agency	Status
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	In Progress
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		

Action Item Description	Responsible Agency	Status
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	Complete
Items from 18-Jul-18 Conference Call		
44. Meeting with Valley District, USFWS, CDFW, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete
Items from 14-Sep-18 Workshop		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete
Items from 10-Oct-18 Conference Call		
46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This

Item	Description
	conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-

Item	Description
	simulated groundwater elevation contours.
Items from 17-May-18 Conference Call	
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
Items from 20-Jun-18 Model Workshop	
28	Terminology for the steady state run will be modified to reflect pseudo steady state conditions.
29	The initial calibration results (Draft TM No. 1) will be added onto calibration hydrographs in Draft TM No. 3 for comparison.
30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.
Items from 14-Sep-18 Workshop	
33	Additional detail regarding calibration (decisions, steps, methodology, etc.) will be included in the final TM-3.
Items from 10-Oct-18 Conference Call	
34	The numbering for the proposed scenario runs will reflect that originally used in the proposal.
35	A “sensitivity run” will be made with no pumping to evaluate whether the model can reproduce water level patterns seen in the 1905 Mendenhall maps of the area.
36	A model scenario will be added to evaluate groundwater basin management activities that differ from the baseline.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

November 15, 2018
10:00 am

Issued on December 24, 2018

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	City of Riverside Public Utilities (RPU): Farid Boushaki
	Flow Science: John List
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, David Barnes, and Lauren Wicks
	Inland Empire Utilities Agency (IEUA): Liz Hurst
	Orange County Water District (OCWD): Tim Sovich
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Geoff Cromwell
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Mallory Gandara

ITEM 1: APPROVAL OF 10-OCT-18 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 19-Nov-18, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed the current project schedule and discussed upcoming events. He announced that they hope to have preliminary scenario results to present at the December conference call, and will present the first set of scenario runs at the January model workshop and Valley District. A Doodle poll will be sent to TAC members to determine when the model workshop will be held.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the Action Item list, which was included in the 15-Nov-18 conference call agenda and 10-Oct-18 workshop minutes. The only uncompleted item currently on the list is Item 41: Propose additional scenarios in the event that the budget allows for extra model runs. For Item 46, an updated list of the proposed scenarios with revised numbering and prioritization was circulated to the TAC before the meeting.

ITEM 4: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes. In response to Item 35 (conduct sensitivity run with no pumping to evaluate whether the model can reproduce water level patterns seen in the 1905 Mendenhall maps of the area), Mr. List asked how the modeling team proposes to reproduce the hydrology that led to the measured water levels from 1905. Mr. Yeh replied that the calibration period hydrology from 1966 through 2016 will be used, but all pumping will be turned off. Mr. Boushaki suggested that the San Bernardino gage has data back to the 1880s, and it may be useful to compare the hydrology and see if it is similar. Mr. Romero clarified that the purpose of the model run is to see what happens when the pumping is turned off and see if the model-calculated water levels at the end of the model run are reasonably representative of the water level patterns that were observed in 1905 (e.g., areas of historical high groundwater, etc.); it is not the purpose of the model run to match water levels from 1905 exactly. Mr. Sovich suggested also turning off managed (artificial) recharge.

ITEM 5: STATUS OF PREDICTIVE MODEL SCENARIOS

Ms. Wicks discussed the updated list of proposed model scenarios, including the revised model run priority. Ms. Wicks also updated the TAC on the development of monthly recharge and discharge assumptions for the individual HCP Activities.

Mr. Barnes reviewed the proposed future monthly groundwater pumping assumptions for the scenario runs.

Questions and comments included:

1. Mr. List requested more detail be provided for some of the model scenarios, such specific activities to be included in Scenario 4 (Evaluate Groundwater Management Activities and Changes in Groundwater Pumping). Mr. Yeh explained that the assumptions for this group of runs will be reexamined after the initial modeling results for baseline conditions are available. Specific assumptions will be presented as they are developed.
2. Mr. Boushaki observed that the ID numbers in ICF's Table 2-2 do not match what was submitted in 2016. For example, Riverside does not have an RPU.5. These project IDs will be verified for the HCP covered activities in the predictive scenario runs.
3. Mr. Sovich asked if the production is going to be applied to existing wells, or if it is also being applied to new/proposed wells. Mr. Barnes explained that the projected pumping is generally being applied to existing wells in the absence of information of proposed wells, but new wells are included where they are known (e.g., Chino Basin and Rialto-Colton).
4. Mr. Tincher observed that the Plaintiff pumping should be capped at 66,998 afy, although there were additional extraction agreements during the period of high groundwater levels. Unless the model predicts high levels, the maximum Plaintiff pumping should not exceed this value.
5. Mr. Sovich asked what pumping is used as a "base" to ramp up pumping. Mr. Barnes explained that the Urban Water Management Plans use 2015 as a base year. However, future pumping distribution is typically based on the average of the last 5 years, except where additional data is provided (i.e., Chino Basin).

6. Ms. Hurst asked whether the pumping projections shown for Chino Basin were based on the Urban Water Management Plan or whether they came from WEI. Mr. Barnes replied that the values shown in the presentation were from WEI.
7. Mr. Sovich asked what the boundary condition assumptions will be for the model scenarios. Mr. Yeh replied that the model has two main types of boundary conditions: mountain front runoff where the groundwater basin meets the mountains and underflow into Chino Basin. The mountain front runoff will be based on the hydrology while estimates of underflow into Chino Basin were provided by Chino Basin Watermaster/WEI. Mr. Sovich asked if there were any specified head boundaries and Mr. Yeh replied that those boundary conditions are only found in a small area representing Hole Lake, which will remain constant.

ITEM 6: OTHER BUSINESS

No other business was discussed by the group during this conference call.

ITEM 7: NEXT MEETING

The next Integrated SAR Model meeting, which will be a conference call, will be December 20th, 2018, from 10:00 am to 11:30 am. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Thursday, November 15th, 2018 at 11:00 am.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		

Action Item Description	Responsible Agency	Status
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		

Action Item Description	Responsible Agency	Status
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	Complete
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		

Action Item Description	Responsible Agency	Status
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	Complete
Items from 18-Jul-18 Conference Call		
44. Meeting with Valley District, USFWS, CDFW, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete
Items from 14-Sep-18 Workshop		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete
Items from 10-Oct-18 Conference Call		
46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	Complete
Items from 15-Nov-18 Conference Call		
47. Verify project IDs for the HCP covered activities in the predictive scenario runs	GEOSCIENCE/ICF	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.

Item	Description
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.

Item	Description
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.
Items from 17-May-18 Conference Call	
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
Items from 20-Jun-18 Model Workshop	
28	Terminology for the steady state run will be modified to reflect pseudo steady state conditions.
29	The initial calibration results (Draft TM No. 1) will be added onto calibration hydrographs in Draft TM No. 3 for comparison.
30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.
Items from 14-Sep-18 Workshop	
33	Additional detail regarding calibration (decisions, steps, methodology, etc.) will be included in the final TM-3.
Items from 10-Oct-18 Conference Call	
34	The numbering for the proposed scenario runs will reflect that originally used in the proposal.
35	A "sensitivity run" will be made with no pumping to evaluate whether the model can reproduce water level patterns seen in the 1905 Mendenhall maps of the area.
36	A model scenario will be added to evaluate groundwater basin management activities that differ from the baseline.
Items from 15-Nov-18 Conference Call	
37	For Scenario 1d (sensitivity run with no pumping), artificial recharge and other pre-development activities will also be removed.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

December 20, 2018
10:00 am

Issued on February 22, 2019

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	Flow Science: John List
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, David Barnes, Leo Liu, and Lauren Wicks
	Inland Empire Utilities Agency (IEUA): Liz Hurst
	Orange County Water District (OCWD): Tim Sovich
	Riverside Public Utilities (RPU): Farid Boushaki
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher, Heather Dyer, and Wen Huang
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Wes Danskin
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Ryan Shaw, Mallory Gandara, and Jason Pivovaroff

ITEM 1: APPROVAL OF 15-NOV-18 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 24-Dec-18, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed the current project schedule and discussed upcoming events. He explained they are still waiting on comments from WEI on Technical Memorandum 3 (TM-3): Model Calibration. TM-3 will be finalized after these comments are received. He also announced that the first set of scenario runs will be presented at the January model workshop at Valley District. Three batches of scenario runs are currently planned, to be completed at the end of July.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the Action Item list, which was included in the 20-Dec-18 conference call agenda and 15-Nov-18 conference call minutes. The only uncompleted item currently on the list is Item 47: Verify HCP Activity IDs, which is in progress.

ITEM 4: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes.

ITEM 5: STATUS OF PREDICTIVE MODEL SCENARIOS

Ms. Wicks discussed the updated list of proposed model scenarios.

Mr. Barnes reviewed the preliminary results from the Baseline scenario run, as well as updated projected monthly groundwater pumping assumptions, the Streamflow Routing Package, and ET areas.

Questions and comments included:

1. Mr. Danskin asked the group if there were any lingering concerns regarding the Scenario 1 run with no pumping. He explained that his goal for this scenario was to see the effects of pumping and recharge. He has found it useful in the past to remove the pumping, see what happens, and then remove the recharge to see how the model behaves with no pumping. He explained this includes large picture items, like whether the model can converge or if a lake is created in Bunker Hill.
2. Mr. Sovich asked what the assumptions are for artificial recharge in the baseline scenario run. Mr. Barnes replied that it depends on the basin and whether they are associated with an HCP project. As an example, Mr. Yeh explained that in the SBBA, they projected State Water availability and assumed that it goes to meet direct delivery first. The remaining is available for artificial recharge. He also explained that artificial recharge in the Chino Basin was provided by Chino Basin Watermaster and WEI while spreading from RIX was provided by the City of San Bernardino.
3. Mr. Tincher questioned why, if the scenarios reuse past hydrology, why the peak in predicted water levels for YVWD Well 43 is higher than what is seen in the past. Mr. Barnes explained that while the hydrology is reused for precipitation, many of the other fluxes rely on projections. For example, increases in artificial recharge can have a positive effect on water levels. Mr. Danskin added that the large peaks are reflective of El Niño events.
4. Mr. Danskin asked why the Cajon well seems to respond well early and later but not for much of the calibration period. He mentioned that the well is near the boundary, so he would expect the model to overestimate water levels, but the data shows that the observed levels are high. Mr. Yeh replied that the streambed percolation after 1990 was modified to match observed water levels elsewhere. The model was allowed to underestimate water levels at this location in order to provide a better match in other parts of the basin. Mr. Danskin mentioned that this is an important limitation to mention. He explained that the model is teaching us that there is something going on in this area that we don't quite understand.

5. Mr. Romero asked if the effect of the HCP activities would be shown as the difference between the baseline and the HCP scenario run. Mr. Yeh answered in the affirmative and added that for streamflow comparison, additional charts will be prepared, including exceedance flow with statistical analysis.

6. Mr. Tincher questioned whether the baseline period may be wetter and whether a drier period should be considered. Mr. Danskin explained that future hydrology is difficult to predict but acknowledged that the present climate signatures are not well represented by historical conditions. He mentioned this is another footnote to consider. Mr. Yeh added that one of the climate change scenarios should consider the worst case – dry years without any El Niño events. Mr. Tincher agreed that a scenario like this would be helpful.

ITEM 6: OTHER BUSINESS

No other business was discussed by the group during this conference call.

ITEM 7: NEXT MEETING

The next Integrated SAR Model meeting, which will be a workshop at Valley District, will be January 29th, 2019, from 1:30 pm to 4:30 pm. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Thursday, December 20th, 2018 at 10:55 am.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete

Action Item Description	Responsible Agency	Status
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)

Action Item Description	Responsible Agency	Status
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		

Action Item Description	Responsible Agency	Status
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	Complete
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	Complete
Items from 18-Jul-18 Conference Call		
44. Meeting with Valley District, USFWS, CDFW, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete
Items from 14-Sep-18 Workshop		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete
Items from 10-Oct-18 Conference Call		
46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	Complete
Items from 15-Nov-18 Conference Call		
47. Verify project IDs for the HCP covered activities in the predictive scenario runs	GEOSCIENCE/ICF	In Progress

Action Item Description	Responsible Agency	Status
Items from 20-Dec-18 Conference Call (none)		

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	

Item	Description
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.
Items from 17-May-18 Conference Call	
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
Items from 20-Jun-18 Model Workshop	
28	Terminology for the steady state run will be modified to reflect pseudo steady state conditions.
29	The initial calibration results (Draft TM No. 1) will be added onto calibration hydrographs in

Item	Description
	Draft TM No. 3 for comparison.
30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.
Items from 14-Sep-18 Workshop	
33	Additional detail regarding calibration (decisions, steps, methodology, etc.) will be included in the final TM-3.
Items from 10-Oct-18 Conference Call	
34	The numbering for the proposed scenario runs will reflect that originally used in the proposal.
35	A "sensitivity run" will be made with no pumping to evaluate whether the model can reproduce water level patterns seen in the 1905 Mendenhall maps of the area.
36	A model scenario will be added to evaluate groundwater basin management activities that differ from the baseline.
Items from 15-Nov-18 Conference Call	
37	For Scenario 1d (sensitivity run with no pumping), artificial recharge and other pre-development activities will also be removed.
Items from 20-Dec-18 Conference Call	
38	A simulation with no El Niño events will be included as one of the climate change alternatives.

Minutes for the Upper Santa Ana River Integrated Model Update Workshop

San Bernardino Valley Municipal Water District

January 29, 2019
1:30 pm

Issued on March 22, 2019

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	CA Department of Fish and Wildlife (CDFW): Joanna Gibson (remote)
	CA State Water Resources Control Board (State Board): Jan Stepek (remote)
	Flow Science: John List (remote)
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, David Barnes, Leo Liu (remote), and Lauren Wicks
	ICF: Brendan Belby
	Orange County Water District (OCWD): Tim Sovich
	RBC Resources: Ron Craig
	Riverside Public Utilities (RPU): Farid Boushaki
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher, Heather Dyer, Wen Huang, and Tim Kellett
	Santa Ana Regional Water Quality Control Board (Regional Board): Cindy Li
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Wes Danskin (remote) and Geoff Cromwell (remote)
	Wildermuth Environmental, Inc. (WEI): Mark Wildermuth and Wenbin Wang
	Western Municipal Water District (WMWD): Ryan Shaw, Mallory Gandara, and Jason Pivovaroff (remote)

ITEM 1: INTRODUCTIONS

ITEM 2: APPROVAL OF 20-DEC-18 CONFERENCE CALL MINUTES

One comment on the 20-Dec-18 conference call meeting minutes was received from Mr. Boushaki at RPU, indicating that he had called into the meeting but was not on the attendee list. His name will be added in the final meeting minutes. No additional comments were provided by the TAC. Any remaining

comments will be received until close of business, Friday, 1-Feb-19, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 3: REVIEW SCHEDULE

Mr. Yeh showed the current project schedule and discussed upcoming events. He explained they are currently working on Task 3: Develop and Run Predictive Scenarios. He also stated that they are working with IEUA to finalize Draft TM-4 and announced that TM-5a, describing the results of the first set of scenario runs, will be sent to the group by the end of the week (Friday 1-Feb-19). Another TM, TM-5b, is already planned to describe the next batch of scenario runs.

ITEM 4: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the Action Item list, which was included in the 29-Jan-19 conference call agenda and 20-Dec-18 conference call minutes. The only uncompleted item currently on the list is Item 47: Verify HCP Activity IDs, which is in progress.

ITEM 5: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes.

ITEM 6: OVERVIEW OF DRAFT TM-5A: PREDICTIVE SCENARIO RUNS

Mr. Barnes reviewed the HCP Covered Activities, scenario assumptions, and preliminary model results from Scenarios 2a (Baseline Run), 2b.1 (All HCP Covered Activities), Scenario 2c.1 (SNRC + San Bernardino Baseflow Reduction + Rialto Baseflow Reduction), Scenario 2c.2 (SNRC + San Bernardino Baseflow Reduction), Scenario 2c.3 (Rialto Baseflow Reduction), Scenario 2h (Enhanced Recharge), and Scenario 2j (Evaluation of Valley District Stormwater Capture Program at Prado Dam).

Questions and comments included:

1. Mr. Boushaki asked if the recharge basins had a specified capacity. Mr. Yeh replied that they have the basin area and percolation rate for each. Mr. Huang asked if this percolation rate takes basin clogging and the decay rate into account. Mr. Yeh and Ms. Dyer replied that the percolation rates used included updated information from Mr. Nate Scheevel of Scheevel Engineering, which accounts for the decay curve.
2. Ms. Dyer observed that many of the recharge values were slightly lower than what was originally anticipated and inquired whether the stormflow capture projects were cumulative (i.e., whether the model took into account stormflow diversions higher up in the watershed). Mr. Yeh replied in the affirmative.
3. Ms. Dyer asked whether the recharge was "new water" and Mr. Yeh explained that additional analysis is needed to determine new water.
4. Mr. Craig asked whether imported water recharge is tracked separately. Ms. Dyer replied that imported water is only anticipated to be used in few projects, namely Cactus Basins. Mr. Yeh

added that imported water recharge occurs in the model, but these activities are not classified as HCP Covered Activities.

5. Mr. Sovich asked if the available flows in the model are connected to the surface water model and Mr. Silver asked if the HSPF model is being rerun for the scenario runs. Mr. Yeh replied that it depends on the project and location – some of the individual models rely on HSPF input while some use the curve number method, etc.

6. Mr. Wildermuth inquired whether or not project associated pumping was being modified to take advantage of the additional recharge. Mr. Yeh explained that the Scenario 2 runs use the projected pumping from the baseline scenario run. This allows the project effects to be isolated. Scenario 4 runs, which consider different management strategies, can be developed to evaluate recovery options. Mr. Wildermuth asked which scenario should be used for regulatory purposes and Mr. Tincher replied that that question is hard to answer at this point. Mr. Tincher agreed that the Scenario 4 runs can be used to evaluate additional pumping to take advantage of pumping, and Ms. Dyer added that they are still trying to understand how much water they can get into the ground before they work on how they're going to get it out.

7. Ms. Dyer asked about flow to the Santa Ana River from the Sterling Natural Resource Center (SNRC) project. Mr. Yeh explained that this scenario run includes updated flow rates and discharge location (which was moved downstream). Ms. Dyer replied that they will have to talk to East Valley and make sure additional modeling work is done to evaluate the effect of recycled water in the Santa Ana River.

8. Mr. Huang asked if the recharge for Cactus Basins was based on the recharge capacity and Mr. Yeh replied in the affirmative.

9. Mr. Boushaki inquired what the assumptions were for off-channel recharge in the North Riverside Aquifer Storage and Recovery Project. Mr. Yeh replied that the off-channel recharge values came from modeling conducted by Scheevel Engineering based on scenario hydrology. Mr. Boushaki also asked if this project was going to remain being called "RPU.5". Ms. Dyer explained that they are going to keep referring to the rubber dam project as RPU.5 for the sake of continuity, since there have already been so many previous documents using that designation, but the project is in Valley District's pile. She added that at the beginning of the chapter, she plans on including a description of which agencies are cost sharing which projects.

10. Mr. Boushaki suggested modifying the scale on some of the plots to allow better resolution and Mr. Craig suggested it would be clearer to show reductions as a negative. Mr. Barnes replied that the plots will be modified.

11. Mr. Huang asked where the WD.1 (San Bernardino Baseflow Reduction) reduced effluent discharge is going. Ms. Dyer replied that there is not a lot of direction yet on what to do with the water that is taken out of RIX. Ms. Wicks explained that when she talked to San Bernardino, the current assumption is that that water would be going towards purple pipe use and Mr. Yeh clarified that the water is not currently in the model. Mr. Danskin observed that the Scenario 2 runs seem to be operating more as response functions instead of scenarios that take into account a complete water balance. Mr. Tincher recommended that the reduced discharge should be applied somewhere, but suggested that this may something that is done in Scenario 4. Ms. Dyer added that the scenarios will have to be refined after speaking to the City some more. Mr.

Danskin suggested summarizing each project in a simplistic water balance table indicating diversion, baseflow reduction, and recharge.

12. Mr. Belby asked if the model includes stormwater channels to track where the stormwater is going and how much flow is in the channels. Mr. Yeh replied that they will have to double-check the Streamflow Routing Package network.
13. Mr. Wildermuth questioned if there's going to be a seasonal distribution to the storage for the Santa Ana River Sustainable Parks and Tributaries Water Reuse Project (RPU.10). Ms. Dyer replied that there would be a diurnal fluctuation, but they have not discussed seasonal trends.
14. Mr. Shaw observed that the recharge values for the Arlington Basin Water Quality Improvement Project (West.6) may need to be modified.
15. Mr. Wildermuth explained that increased capture from Wineville Basin (IEUA.1.01), Jurupa Basin (IEUA.1.06), and RP3 Basins (IEUA.1.10) goes from Wineville to Jurupa and Jurupa to RP3.
16. Mr. Wildermuth also asked whether the dry weather capture volumes shown matched those values that IEUA included in their package. Mr. Barnes replied in the affirmative. Mr. Wildermuth questioned where the apparent seasonal fluctuation came from and explained that dry weather flows shouldn't vary much during the year. Mr. Barnes replied that they would look into it.
17. Mr. Sovich asked if pumping projections guided the development of the recharge projects so they would help balance out the demand. Ms. Dyer explained that they are planning for a 30 to 50-year permits and the goal is to be able to fully offset project impacts so all of them can be built if needed. However, she said that just because environmental clearance is obtained, it doesn't mean that all of these projects will be built. Mr. Sovich also asked whether the additional recharge would offset imported water and Mr. Tincher replied that it won't necessarily offset it, but could.
18. Mr. Wildermuth reiterated the need for a recovery plan. Without one, he explained, the project effects will be underestimated. He also added that there may be a lag associated with recharge higher in the basin, such that it does not show up downstream within the 25-year model simulation period. Mr. Sovich asked if these concerns can be answered with the model. Mr. Barnes replied that the water budgets and streamflow routing package can provide that information, especially since much of the recharge occurs in the vicinity of the streams. For example, he explained that groundwater elevations in the vicinity of the recharge basins will rise and there will be reduced streambed percolation near the recharge activity and downstream. Mr. Sovich added that you should be able to see some effect at Prado.
19. Mr. Romero observed that the Scenario 2 runs were more like response functions to see how the system responded to each activity while Scenario 4 would factor in management strategies. He asked how recharge and pumping will be combined in Scenario 4. Mr. Yeh replied that there are different management options and the modeling assumptions for these scenarios will need to be discussed with and decided by the group. Ms. Dyer added that an in-depth management plan will be needed going forward long-term, which has different tools or options of mitigating impacts, but we need to understand the effects before we start adding in the management flexibility.

20. Mr. Shaw asked if the wastewater discharge shown on Slide 105 includes discharge from the projects and Mr. Barnes replied that this figure shows wastewater discharge under baseline conditions (no HCP activities).
21. Mr. Sovich suggested adding historical averages from 1966 through 1990 to the charts showing flux terms for scenario runs.
22. The group discussed the appropriateness of showing wastewater discharge for SNRC in the Annual Change in Wastewater Discharge Compared to Baseline graphs. Ms. Dyer explained that while water is being discharged to City Creek, the water is not actually going to contribute to fish habitat because it will recharge before reaching streamflow. Even though modeling shows approximately 4,000 acre-ft per year of discharge reaching the Santa Ana River, Mr. Palenscar explained that it's a dry area so it won't contribute to streamflow. Mr. Tincher observed that the subtraction of discharge from the Riverside-Arlington Basin and addition of discharge to the SBBA makes sense in terms of a water balance, but it doesn't serve the purpose of the modeling to demonstrate effects to aquatic habitat.
23. Mr. Huang asked about phasing for the Clean Water Factory. Ms. Dyer explained that the 5 mgd scenario is counting on future growth. The numbers are based on current numbers and how much can be taken out to still make discharge/flow obligations.
24. Mr. Tincher observed that the enhanced recharge volume seems low. Mr. Barnes explained that the values shown represent the change in recharge from baseline conditions. Mr. Yeh said they will double check the values.
25. Mr. Tincher suggested adding a brief scenario description on figures illustrating scenario results.
26. Mr. Palenscar observed that it seems the projects are unable to capture really high flows. Mr. Barnes agreed and explained that many of the projects have diversion capacities associated with them.
27. For the flow exceedance charts, Mr. Wildermuth explained that it's more helpful to look horizontally between lines rather than vertically, since it is plotted on a logarithmic scale. Mr. Palenscar asked if there was another way to present the data, but Mr. Barnes replied that they looked at the hydrographs and the changes were too difficult to distinguish. Mr. Romero added that the exceedance charts were useful for answering low flow questions and checking thresholds.
28. Mr. Tincher asked if there was a way to show the seasonality of flow differences. Mr. Sovich added that he would like to see volumes, including annual and monthly averages. Mr. Tincher observed that there should also be a way to show what water could be captured – just because the water is there, doesn't mean you'll be able to catch it if there's too much flow or volume behind Prado. Mr. Wildermuth agreed that using a rating curve and stage at Prado would be difficult. Ms. Dyer suggested breaking out the averages seasonally as well, including wet, dry, and average conditions. Brendan added that it might be helpful to see the exceedance average for August, September, and October (driest period).
29. Mr. Romero suggested it would be nice to be able to see the change in ET between the baseline and the scenario runs.
30. Mr. Palenscar observed that ET typically decreases after flood events due to scour, but that the model-simulated ET doesn't seem to reflect this. Mr. Barnes explained that some of the stepping

seen in the simulated ET is due to changes in land use and vegetation mapping, which is assumed to be constant between land use map years.

ITEM 7: OTHER BUSINESS

No other business was discussed by the group during this workshop.

ITEM 8: NEXT MEETING

The next Integrated SAR Model meeting, which will be a conference call, will be February 28th, 2019, from 10:30 am to 11:30 am. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Tuesday, January 29th, 2019 at 4:40 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete

Action Item Description	Responsible Agency	Status
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)

Action Item Description	Responsible Agency	Status
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	Complete
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	Complete
Items from 18-Jul-18 Conference Call		
44. Meeting with Valley District, USFWS, CDFW, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete
Items from 14-Sep-18 Workshop		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete
Items from 10-Oct-18 Conference Call		
46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	Complete
Items from 15-Nov-18 Conference Call		
47. Verify project IDs for the HCP covered activities in the predictive scenario runs	GEOSCIENCE/ICF	Complete
Items from 20-Dec-18 Conference Call (none)		
Items from 29-Jan-19 Workshop		
48. Modify TM 5a figures based on suggestions from the TAC	GEOSCIENCE	In Progress
49. Add a simple table to TM 5a showing recharge/discharge for each HCP Covered Activity	GEOSCIENCE	Complete
50. Modify recharge values for West.6	GEOSCIENCE / Western	Complete

Action Item Description	Responsible Agency	Status
51. Develop assumptions for management runs (Scenario 4)	TAC	In Progress
52. Break out flow statistics seasonally and monthly in TM 5a	GEOSCIENCE	In Progress
53. Create new figure(s) in TM 5a showing difference in ET	GEOSCIENCE	Complete

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	

Item	Description
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.
Items from 17-May-18 Conference Call	
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
Items from 20-Jun-18 Model Workshop	
28	Terminology for the steady state run will be modified to reflect pseudo steady state conditions.

Item	Description
29	The initial calibration results (Draft TM No. 1) will be added onto calibration hydrographs in Draft TM No. 3 for comparison.
30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.
Items from 14-Sep-18 Workshop	
33	Additional detail regarding calibration (decisions, steps, methodology, etc.) will be included in the final TM-3.
Items from 10-Oct-18 Conference Call	
34	The numbering for the proposed scenario runs will reflect that originally used in the proposal.
35	A "sensitivity run" will be made with no pumping to evaluate whether the model can reproduce water level patterns seen in the 1905 Mendenhall maps of the area.
36	A model scenario will be added to evaluate groundwater basin management activities that differ from the baseline.
Items from 15-Nov-18 Conference Call	
37	For Scenario 1d (sensitivity run with no pumping), artificial recharge and other pre-development activities will also be removed.
Items from 20-Dec-18 Conference Call	
38	A simulation with no El Niño events will be included as one of the climate change alternatives.
Items from 29-Jan-19 Workshop	
39	Scenario 2 runs will be used to determine project impacts without additional modification of pumping and non-HCP recharge while the Scenario 4 runs will incorporate management and recovery plans in response to the additional recharge from the HCP Covered Activities.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

February 28, 2019
10:30 am

Issued on April 1, 2019

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	CA State Water Resources Control Board (State Board): Jan Stepek
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, David Barnes, and Lauren Wicks
	Orange County Water District (OCWD): Tim Sovich
	RBC Resources: Ron Craig
	San Bernardino Valley Municipal Water District (Valley District): Heather Dyer and Chris Jones
	Santa Ana Regional Water Quality Control Board (Regional Board): Cindy Li
	US Geological Survey (USGS): Geoff Cromwell
	Wildermuth Environmental, Inc. (WEI): Mark Wildermuth and Wenbin Wang
	Western Municipal Water District (WMWD): Mallory Gandara

ITEM 1: APPROVAL OF 29-JAN-18 MODEL WORKSHOP MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 4-Mar-19, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed the current project schedule and discussed upcoming events. He explained they are currently revisiting assumptions and scenario runs for Task 3: Develop and Run Predictive Scenarios.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the Action Item list, which was included in the 28-Feb-19 conference call agenda and 29-Jan-18 workshop minutes. Regarding Action Item 51 (develop assumptions for management runs (Scenario 4)), Mr. Romero questioned whether these runs were going to be more complex and look at a combined effect or whether they will be more of a response function. Mr. Yeh replied that these runs can be structured however the TAC decides, but he thought it would be helpful to include the combined effect to optimize recharge and recovery. Mr. Craig asked how instantaneous the reroute and reapplication of beneficial use would be and whether or not there is a lag associated with it. Mr. Yeh replied that the assumptions for Scenario 4 will be based on the results from Scenario 2. There may

be some lag associated with the different processes, depending on the assumptions, but the stresses (e.g., pumping, recharge, etc.) can be varied monthly.

ITEM 4: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes.

ITEM 5: STATUS OF TASK 3 – DEVELOP AND RUN PREDICTIVE SCENARIOS

Mr. Barnes updated the group on the update of Technical Memorandum (TM) No. 4: Major Assumptions of Predictive Scenarios. Scenario 1 will take a water balance approach as opposed to a sensitivity approach. Therefore, as Mr. Barnes explained, changes in contribution of various sources of flow to the river, changes in the river footprint (riparian are and shallow groundwater), and losing and gaining stream reaches will be analyzed in the calibrated model. He also discussed climate change assumptions for the future scenario runs and reviewed comments and responses to TM No. 5a: Predictive Scenario Results – Part 1. Comments for this TM were received from OCWD and the Water Board. Mr. Yeh declared they are still expecting additional comments.

Questions and comments included:

1. Mr. Sovich suggested showing monthly ET for the last five years or an average monthly bar for ET.
2. Mr. Sovich asked if the non-HCP projects were all planned. Mr. Barnes explained that many of the facilities are already operating but will have different operation (e.g., increased recycled water and imported water recharge due to increased water use).
3. Mr. Sovich observed that the pumping assumptions for the predictive scenarios look artificial. Mr. Barnes explained that the pumping used for the predictive scenarios is a product of the future pumping projections used. However, he explained that the pumping is the same for the baseline and project runs, so the impact will have little impact. Mr. Sovich agreed.
4. Mr. Wildermuth offered to collaborate on a description of the Chino Basin pumping projections for the scenario runs. Mr. Sovich also requested an explanation on why pumping is less than the historical pumping.
5. Mr. Romero asked if the climate change scenarios would be compared to the baseline scenario to determine how climate change will affect everything. Mr. Barnes explained that the all project condition will be used (climate change with all projects will be compared to the run with all projects and no climate change). Mr. Sovich asked how climate change will affect each project (re: amount of recharge, timing, etc.). Mr. Yeh replied that this is a good question which needs to be discussed with the whole group, since it would represent a significant effort. Mr. Sovich recommended keeping things the same so it's more of an apples-to-apples comparison. Mr. Romero agreed. Ms. Dyer added that the worst case scenario for climate change would be extended drought and asked if a scenario with these conditions could be run. Mr. Yeh said these could be discussed. Mr. Sovich further explained that some projections he's seen for climate change have involved similar amounts of rainfall over a shorter period. Mr. Barnes replied that he would look at the monthly change factors and the distribution. Mr. Sovich

suggested generating a figure showing the average monthly precipitation change factor for the 12-month period (above 1.0 or below).

ITEM 6: OTHER BUSINESS

No other business was discussed by the group during this workshop.

ITEM 7: NEXT MEETING

The next Integrated SAR Model meeting, which will be a conference call, will be March 28th, 2019, from 10:30 am to 11:30 am. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Thursday, February 28th, 2019 at 11:50 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete

Action Item Description	Responsible Agency	Status
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		

Action Item Description	Responsible Agency	Status
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	Complete
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	Complete
Items from 18-Jul-18 Conference Call		
44. Meeting with Valley District, USFWS, CDFW, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete
Items from 14-Sep-18 Workshop		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete
Items from 10-Oct-18 Conference Call		
46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	Complete
Items from 15-Nov-18 Conference Call		
47. Verify project IDs for the HCP covered activities in the predictive scenario runs	GEOSCIENCE/ICF	Complete
Items from 20-Dec-18 Conference Call (none)		
Items from 29-Jan-19 Workshop		
48. Modify TM 5a figures based on suggestions from the TAC	GEOSCIENCE	In Progress
49. Add a simple table to TM 5a showing recharge/discharge for each HCP Covered Activity	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
50. Modify recharge values for West.6	GEOSCIENCE / Western	Complete
51. Develop assumptions for management runs (Scenario 4)	TAC	In Progress
52. Break out flow statistics seasonally and monthly in TM 5a	GEOSCIENCE	In Progress
53. Create new figure(s) in TM 5a showing difference in ET	GEOSCIENCE	Complete
Items from 28-Feb-19 Conference Call		
54. Create a figure showing the distribution of average precipitation change factors over a 12-month period.	GEOSCIENCE	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.

Item	Description
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.

Item	Description
Items from 17-May-18 Conference Call	
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
Items from 20-Jun-18 Model Workshop	
28	Terminology for the steady state run will be modified to reflect pseudo steady state conditions.
29	The initial calibration results (Draft TM No. 1) will be added onto calibration hydrographs in Draft TM No. 3 for comparison.
30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.
Items from 14-Sep-18 Workshop	
33	Additional detail regarding calibration (decisions, steps, methodology, etc.) will be included in the final TM-3.
Items from 10-Oct-18 Conference Call	
34	The numbering for the proposed scenario runs will reflect that originally used in the proposal.
35	A "sensitivity run" will be made with no pumping to evaluate whether the model can reproduce water level patterns seen in the 1905 Mendenhall maps of the area.
36	A model scenario will be added to evaluate groundwater basin management activities that differ from the baseline.
Items from 15-Nov-18 Conference Call	
37	For Scenario 1d (sensitivity run with no pumping), artificial recharge and other pre-development activities will also be removed.
Items from 20-Dec-18 Conference Call	
38	A simulation with no El Niño events will be included as one of the climate change alternatives.
Items from 29-Jan-19 Workshop	
39	Scenario 2 runs will be used to determine project impacts without additional modification of pumping and non-HCP recharge while the Scenario 4 runs will incorporate management and recovery plans in response to the additional recharge from the HCP Covered Activities.
Items from 28-Feb-19 Conference Call	
40	Geoscience will work with WEI to add additional discussion on the projected pumping in Chino Basin.
41	Recharge and timing of HCP projects under climate change conditions will be kept the same as those used without climate change to simplify the comparison of the results.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

March 28, 2019
11:00 am

Issued on June 3, 2019

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	CA State Water Resources Control Board (State Board): Jan Stepek
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, David Barnes, and Lauren Wicks
	Orange County Water District (OCWD): Tim Sovich
	Riverside Public Utilities (RPU): Farid Boushaki
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher
	US Geological Survey (USGS): Geoff Cromwell
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Mallory Gandara
	Dazhi Warren

ITEM 1: APPROVAL OF 28-FEB-18 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 1-Apr-19, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed the current project schedule and discussed upcoming events. He explained that the results of the second batch of scenario runs will be presented at the May Model Workshop.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the Action Item list, which was included in the 28-Mar-19 conference call agenda and 28-Feb-18 conference call minutes. He explained that Action Item 51 (develop assumptions for management runs (Scenario 4)) will be an agenda item for the next model workshop.

ITEM 4: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes.

ITEM 5: STATUS OF TASK 3 – DEVELOP AND RUN PREDICTIVE SCENARIOS

Mr. Barnes briefed the group on assumptions for the next set of scenario runs, which will be included in TM 5b. These scenarios include Scenarios 1, 2c.4, 2c.5, 2c.7, 2d.1, 2d.2, 2d.3, 2d.4, 2d.6, 2e.1, and 2e.2. Climate change assumptions for the Scenario 2b climate alternative scenarios were also discussed.

Questions and comments included:

1. Mr. Tincher asked if all of the upstream discharge from the Riverside Regional Water Quality Control Plant (RWQCP) percolates. He explained that it is important to show the net change, since the reduced discharge from RWQCP makes it look like too much is taken out (when it is really moved upstream for habitat conservation). In addition, Mr. Tincher suggested showing total discharge to streamflow from the SNRC project (moved from RIX to City Creek). Mr. Barnes replied that these changes will be incorporated in TM 5b.
2. Mr. Tincher, Mr. Sovich, and Mr. Boushaki asked for clarification on the change factor figures. Mr. Barnes explained that there is some overlap between basins and the figure will be clarified.
3. Mr. Boushaki questioned why climate change conditions are being run for the entire simulation period, given that climate change would occur slowly. Mr. Yeh replied that this model run helps bookend simulations and indicates the overall impact that climate change might have on project operations.
4. Mr. Sovich observed that the precipitation values look different than what might be expected given the change factors. Mr. Barnes explained some of the reasons between how the data is shown and what areas they correspond to (model area vs. southern California).
5. Mr. Sovich asked if ET change factors were based on temperature. Mr. Barnes replied in the affirmative and explained that model-calculated ET is still dependent on groundwater levels.
6. Mr. Sovich and Mr. Boushaki asked for additional clarification on the application of change factors for historical hydrology. Mr. Barnes explained that the annual and month change factors were provided by the State in their climate change guidance document. Based on a request from Mr. Boushaki, Mr. Yeh told the group he would circulate the guidance document.
7. Mr. Sovich suggested that it would be interesting to see the cumulative departure with the projected precipitation under climate change conditions and the actual precipitation. In addition, he observed it would be good to see a comparison of river flows at the main gaging station locations with and without climate change. Mr. Barnes and Mr. Yeh agreed that these comparisons would be made.

ITEM 6: OTHER BUSINESS

Mr. Tincher asked when the integration of Prado into the modeling effort would be discussed. Mr. Yeh explained that the additional work will look at the change in Prado inflow under various project scenarios. These results will then be run through OCWD's recharge facility model to determine the amount of water flowing to Orange County. Mr. Tincher added that the goal is to determine if any of the projects recharge water that would have been recharged by OCWD. Mr. Yeh stated that he is planning on discussing this scope of work further at the next model workshop.

ITEM 7: NEXT MEETING

The next Integrated SAR Model meeting, which will be a model workshop, will be held in early May at Valley District. After sending around a Doodle poll, it was decided that the workshop should be held on Thursday, May 30th, 2019, from 1:30 pm to 4:30 pm. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Thursday, March 28th, 2019 at 12:15 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		

Action Item Description	Responsible Agency	Status
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete

Action Item Description	Responsible Agency	Status
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	Complete
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	Complete
Items from 18-Jul-18 Conference Call		
44. Meeting with Valley District, USFWS, CDFW, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete
Items from 14-Sep-18 Workshop		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete
Items from 10-Oct-18 Conference Call		
46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	Complete
Items from 15-Nov-18 Conference Call		
47. Verify project IDs for the HCP covered activities in the predictive scenario runs	GEOSCIENCE/ICF	Complete
Items from 20-Dec-18 Conference Call (none)		
Items from 29-Jan-19 Workshop		
48. Modify TM 5a figures based on suggestions from the TAC	GEOSCIENCE	In Progress
49. Add a simple table to TM 5a showing recharge/discharge for each HCP Covered Activity	GEOSCIENCE	Complete
50. Modify recharge values for West.6	GEOSCIENCE / Western	Complete
51. Develop assumptions for management runs (Scenario 4)	TAC	In Progress
52. Break out flow statistics seasonally and monthly in TM 5a	GEOSCIENCE	In Progress
53. Create new figure(s) in TM 5a showing difference in ET	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
Items from 28-Feb-19 Conference Call		
54. Create a figure showing the distribution of average precipitation change factors over a 12-month period.	GEOSCIENCE	In Progress
Items from 28-Mar-19 Conference Call		
55. Add figures for context re: redistribution of flows to the SAR (e.g., SNRC, SAR Sustainable Parks and Tributaries Water Reuse Project)	GEOSCIENCE	In Progress
56. Revise/clarify figures for climate change factors.	GEOSCIENCE	In Progress
57. Circulate the climate change guidance document to the TAC	GEOSCIENCE	Complete
58. Create cumulative departure chart with projected precipitation under climate change conditions and actual precipitation	GEOSCIENCE	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
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6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
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8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This

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	conceptual model will then be used to help evaluate the model results.
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Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-

Item	Description
	simulated groundwater elevation contours.
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26	A frequency analysis of observed streamflow will be conducted.
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Items from 28-Feb-19 Conference Call	
40	Geoscience will work with WEI to add additional discussion on the projected pumping in Chino Basin.
41	Recharge and timing of HCP projects under climate change conditions will be kept the same as those used without climate change to simplify the comparison of the results.
Items from 28-Mar-19 Conference Call	
42	Comparisons between streamflow in the SAR under baseline and climate change conditions

Item	Description
	will be made at the main streamflow gaging locations.

Minutes for the Upper Santa Ana River Integrated Model Update Workshop
San Bernardino Valley Municipal Water District

May 30, 2019
1:30 pm

Issued on June 28, 2019

Attendees:	Balleau Groundwater (BGW): Dave Romero* and Steve Silver*
	California Department of Fish and Wildlife (CDFW): Joanna Gibson and Kim Romich
	Flow Science: John List*
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, David Barnes, Lauren Wicks*, and Leo Liu*
	ICF: Brendan Belby* and Scott Fleury*
	Orange County Water District (OCWD): Tim Sovich and Richard Zembal*
	RBC Resources: Ron Craig
	Riverside Public Utilities (RPU): Greg Herzog
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher, Heather Dyer, Tim Kellett, and Wen Huang
	US Fish and Wildlife Service (USFWS): Kai Palenscar
	US Geological Survey (USGS): Wes Danskin*
	Wildermuth Environmental, Inc. (WEI): Mark Wildermuth*
	Western Municipal Water District (WMWD): Mallory Gandara and Jason Pivovaroff
	** = Participated remotely*

ITEM 1: INTRODUCTIONS

ITEM 2: APPROVAL OF 28-MAR-19 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 3-Jun-19, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 3: REVIEW SCHEDULE

Mr. Yeh showed the current project schedule and discussed upcoming events. He explained that they expect to finish the scenarios by the end of July and hope to issue the final report by the end of September. However, he explained that comments received from IEUA (discussed briefly at this workshop) may delay the schedule by approximately 3 months.

ITEM 4: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the Action Item list, which was included in the 30-May-19 conference call agenda and 28-Mar-19 conference call minutes. He explained that Action Items involving edits to TM 5a (Action Items 55, 56, and 58) are in progress. He also explained that the preliminary assumptions for Scenario 4 (relating to Action Item 51) will be presented during the workshop. However, due to time constraints, this discussion was postponed until the next conference call.

ITEM 5: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes.

ITEM 6: CONSIDER IEUA/CBWM REQUEST FOR A SEPARATE MEETING TO REVIEW THEIR COMMENTS ON DRAFT TM NO. 3: MODEL CALIBRATION AND DRAFT TM NO. 5A: PREDICTIVE SCENARIO RESULTS – PART 1 WITH GEOSCIENCE AND MODELING TEAM

Mr. Tincher explained that comments on the model calibration by WEI on behalf of IEUA and Chino Basin Watermaster were submitted by Mr. Ron Craig to Valley District (who are serving as project managers). Given potential cost implications and in an effort to keep the decision making process transparent, Mr. Tincher wanted to bring these comments back to the TAC along with the initial GEOSCIENCE response, prepared at the request of Valley District. A discussion was held amongst the TAC regarding these comments and the decision was made to hold a separate subcommittee meeting with the modeling experts (including GEOSCIENCE, BGW, USGS, WEI, OCWD, and Valley District) to determine the best path forward. This meeting will be held on July 10th, 2019 at Valley District.

Questions and comments included:

1. Mr. Craig acknowledged that the comments were not very timely due to resource issues, but explained that IEUA and Chino Basin Watermaster want to ensure that the final Integrated SAR Model is a model that everyone can be comfortable with. Given that some of the comments were substantive and fundamental, Mr. Craig believed that it was best to make them known to the group and believes that it would be best to get the experts together in the same room to discuss concerns and solutions.
2. Ms. Dyer clarified that the 25-year HCP base period was identified through the process of using the GEOSCIENCE and WEI models to predict riparian impacts – it represents the period of overlap between the two models. In addition, she explained that one of the main purposes of the modeling for the HCP Covered Activities was to determine the take coverage and that this preliminary modeling will be followed up with a very comprehensive monitoring program. She and Ms. Gibson have already submitted a grant proposal for the monitoring program and Ms. Dyer feels confident that they have a good shot at being awarded a grant for it.
3. In response to concerns about the Integrated SAR Model potentially being used for a solute transport model in the future, Ms. Dyer explained that ideas were being developed on how to use the Integrated SAR Model now that the time and resources had been used to develop it. Mr. Craig cautioned that the foundation of the model may not meet the goals of other uses,

such as solute transport. Mr. Tincher clarified that funding is available to turn the Integrated SAR Model into a solute transport model in a separate project, and suggested that a discussion be held on how the model can be specifically improved for future uses. Mr. Tincher also questioned if the comments about the model would be the same if the water quality concerns were absent.

4. Mr. Sovich suggested acknowledging the intended purpose(s) of the Integrated SAR Model in the limitations section of the final model report. Mr. Craig supported this suggestion.
5. Mr. Danskin summarized the comments as falling under three main categories:
    - The first is a put and take issue: where will recovery pumping be located and what is reasonable? Mr. Danskin explained this is likely an iterative solution process and the assumptions are something the individual water agencies will need to work on. Mr. Tincher recognized that there is an upper end to recharge. He added that they are already planning management scenarios and suggested postponing a discussion of those assumptions until later in the meeting, since this topic was on the agenda. Mr. Danskin agreed.
    - The second issue, which covers the majority of the comments, deals with disagreements in style. Mr. Danskin explained that the model is calibrated to fluxes, but the project's interest on changes in fluxes, which are very difficult to measure (aside from streamflow and pumping). Therefore, he explained that the monitoring aspect will be important. He went on to explain that there are two ways to calibrate a flow model: trial and error or automated calibration procedure. Mr. Danskin observed that in his experience, the trial and error approach tends to be used by people with backgrounds in geology, hydrology, and groundwater modeling while the automated approach tends to be used by people with a background in engineering. Mr. Danskin believes that the trial and error approach is always best to use on an initial model. Once the model is more robust, PEST (an automated approach) can be good because it indicates correlation and confidence levels. Based on this and prior experience, he suggested that the trial and error approach being used for the Integrated SAR Model is appropriate. He added that PEST can be used once the model is ready for refinement at a later date, but he is not convinced it is necessary yet. However, he cautioned that PEST is costly in terms of computational time. He also reminded the group that the topic of what kind of calibration to use was discussed at the beginning of the model development process (over 18 months ago).
    - The third issue is intended purpose. Mr. Danskin explained that the Integrated SAR Model is designed to handle the SAR and nearby areas and to simulate approximate flow and timing along the SAR. Mr. Danskin agrees that the final report should contain a Uses and Limitations section that clearly states what the model is/isn't designed to be used for. For example, is the near-surface stratigraphy captured well enough that you are able to see the accumulation of salts in the upper 25 ft? In addition, he explained that the Chino Basin Model was structured to do a variety of different things that are separate from the purposes of this investigation. He suggested that the Integrated SAR Model could be improved if the Chino Basin Model was provided.
6. Ms. Dyer asked for Mr. Yeh's general opinion regarding the appropriateness of the model for the intended use. Mr. Yeh explained that the scope of work for the Integrated SAR Model was to rely on previously developed models for the Yucaipa, SBBA, Rialto-Colton, Riverside-Arlington, and Chino Basins. The main work consisted of integrating the models, removing the

boundaries between models, creating a streamflow routing package, and developing unified model layers. He added that many of the existing models had used PEST during the initial calibration. He suggested that it would be more efficient to go back and use PEST in the individual models if a problem area were to be identified, rather than running PEST on the entire integrated model.

7. Mr. Tincher questioned what particular problem areas there may be with model calibration. Mr. Craig explained that there were some important habitat locations that have limited data and therefore may have high uncertainty. Ms. Dyer explained that this is a good example of where we need to focus future monitoring and that the modeling results are the first step of a very long process. She went on to explain that the flow assumptions for the HCP Covered Activities were developed by the individual agencies and the development of these flows were aimed at estimating how much water may be needed 50 years out, but that these projections are difficult to make.
8. Mr. Wildermuth explained that since the Integrated SAR Model was making use of 5 previously developed and calibrated models, he believed it was appropriate to use PEST. He added that this process would be important if the model will be used for water quality. Furthermore, he suggested that computational time could be minimized by limiting PEST to a reasonable number of parameters. Mr. Danskin agreed this would be appropriate if the geology and the layer from one model to another were very similar. However, the subsurface geology and layering was changed significantly in order to integrate the existing models.
9. Mr. Wildermuth explained that the Chino Basin Model was calibrated by using wells geographically distributed across the basin. In the Integrated SAR Model, there are thousands of observations in 2 areas. He believes this gives a false impression of calibration. Mr. Barnes replied that the calibration target selection in Chino Basin overlap with those used by WEI. He went on to explain that GEOSCIENCE looked at the calibration results with and without the shallow wells in Prado and they were very similar (mean residual within a few tenths of a foot). Mr. Barnes stressed the importance of including these measurements since this is one of the key areas of interest. Measurements from these wells were added in response to comments by OCWD. Mr. Sovich explained that he believes it's useful to have some data there, even if the model is only used to match water levels in the last year of simulation. Mr. Wildermuth agreed with including the data but not the amount.
10. Mr. Barnes described that the calibration metrics for the Chino Basin area in the Integrated SAR Model were very similar to those presented in WEI's 2015 report. However, Mr. Danskin explained that the model-simulated hydrographs and water balance may provide a better picture of model calibration since calibration statistics are inherently affected by the location of wells (the distribution of which is highly dependent on where people need wells and rarely ideal for statistical studies). Mr. Yeh reminded the group that GEOSCIENCE was asked by OCWD to compare the Integrated SAR Model statistics to the WEI Chino Basin Model. This resulted in the creation of Action Item 42 which was later withdrawn since nothing was provided. Mr. Tincher asked if there was any way these data could be provided and Mr. Craig responded that he would look into it.
11. The TAC decided that an in-person subcommittee meeting would be the most efficient way to resolve outstanding concerns about the model. Mr. Danskin agreed that an in-depth discussion would allow all of the modelers to get on the same page. He suggested a letter be sent to the group after the meeting to document points of agreement/disagreement and main

conclusions. Mr. Tincher requested that Mr. Danskin be involved with that process. Mr. Pivovaroff also requested that comments be discussed in terms of which may benefit the initial intent of the modeling and which would help take it to the next level. As an end user of the modeling results, Mr. Fleury reminded the group that they really need to be confident in the model's ability to identify changes in groundwater levels in areas of riparian vegetation.

12. Mr. Tincher asked if the group would need to hit the "pause button" in the meantime and Mr. Yeh replied that the GEOSCIENCE modeling team would just finish up TM 5b (summarizing model runs already completed) until after the subcommittee meeting. Ms. Dyer expressed some concern regarding changes to the model at this stage and whether or not changes will cause drastic differences in the results. Mr. Danskin explained that it would be really difficult to change the model at this point and anticipated that much of the discussion would be geared towards what kind of fine tuning could be done and how to present the approach/results. He went on to explain that these type of changes wouldn't make much impact to the model results but would allow everyone to understand limitations better.

STATUS OF TASK 7 – OVERVIEW OF DRAFT TM NO. 5B: PREDICTIVE SCENARIO RESULTS – PART 2

Mr. Barnes reviewed scenario assumptions with the group for the second set of model runs and presented part of the results. Due to time constraints, only the results of Scenario 1 (Evaluate Flow in the SAR and Identify Factors that May Be Contributing to Reduced Flows) were covered at this workshop.

Questions and comments included:

13. Ms. Dyer explained to the TAC that she sat down with GEOSCIENCE and ICF to discuss different ways to present the results. She added that she is interested in questions or suggestions from the group to help determine what kind of figures/tables would be helpful. Mr. Barnes added that some of the figures developed for Scenario 1 may be helpful for other runs as well.
14. Mr. Sovich asked what the impact of non-HCP projects (already planned and approved) would be and added that it would be nice to know the incremental effect. He inquired if there was a separate run for that. Ms. Dyer explained that a run could be made and the group might want to think about adding it to the list of scenario runs.
15. Ms. Dyer requested that changes in flow be described in terms of cubic feet per second (cfs), especially in key habitat areas, since flow in acre-feet per year (AFY) can be hard to visualize. Mr. Barnes agreed that flows can be shown as AFY and cfs.
16. Ms. Gibson asked if the model will take into consideration wetted area. Ms. Dyer explained that the model results will be provided to Mr. Belby at ICF, who will use the flow results in a separate model to determine changes in wetted area.
17. Mr. Tincher asked if the model takes into consideration changes due to ongoing discharges (specifically the redistribution of discharge for RPU.10 purple pipe project) and Mr. Barnes replied that the model takes changes in groundwater/surface water interaction into account due to groundwater mounding from recharge or a change in discharge location.
18. Ms. Dyer stated that she needs to know how much water would reach Santa Ana Sucker habitat with and without the Rubber Dam Project (RPU.5).

19. Ms. Dyer asked how runoff was accounted for in the model scenarios and how potential changes are accounted for. Mr. Barnes replied that the most recent land use (2012) is used with historical hydrology (precipitation from 1966 to 1990). He added that there's a slight increase in runoff compared to the calibration period because of increased impermeable area.
20. Mr. Sovich asked what the term "surface water discharge" represented in the annual water budgeted for the Integrated SAR Model area and Mr. Barnes explained that was primarily recycled water discharge, although there are some other sources (e.g., dewatering discharge, OC-59 turnout water, etc.). This will be clarified. Mr. Sovich also requested another figure showing the net budget for each year (representing total recharge or discharge).
21. In response to figures of the sources of inflow to the SAR, Mr. Palenscar observed that there doesn't seem to be an obvious change from the establishment of the Seven Oaks Dam in 1997-2003. Mr. Tincher explained that the dam doesn't take water, only slows it down, and they're trying to recharge outflow from Seven Oaks Dam downstream.
22. The TAC requested that the animation of the depth to water be distributed to the group and Mr. Barnes replied that they will send it out. Ms. Dyer also requested that some geographic reference points be added. She added that the figures of shallow water can be useful to identify potential monitoring well locations.
23. Mr. Tincher briefly explained that Slide 253 involves preliminary assumptions for Scenario 4, which will be summarized in a TM in the near future. Part of the goal of the management scenarios is to determine what projects may be implemented realistically (e.g., want to avoid high groundwater in the SBBA). Mr. Sovich asked if the scenarios should look at wet periods and Mr. Tincher explained that most of these projects are designed to help water supply in dry years. Mr. Yeh added that wet periods would be covered as part of the average hydrologic conditions.

ITEM 6: OTHER BUSINESS

No other business was discussed.

ITEM 7: NEXT MEETING

The next Integrated SAR Model meeting, which will be a conference call, will be Wednesday, June 26th, 2019, from 8:30 pm to 10:00 am. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Thursday, May 30th, 2019 at 5:00 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		

Action Item Description	Responsible Agency	Status
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		

Action Item Description	Responsible Agency	Status
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	Complete
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		

Action Item Description	Responsible Agency	Status
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	Complete
Items from 18-Jul-18 Conference Call		
44. Meeting with Valley District, USFWS, CDFW, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete
Items from 14-Sep-18 Workshop		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete
Items from 10-Oct-18 Conference Call		
46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	Complete
Items from 15-Nov-18 Conference Call		
47. Verify project IDs for the HCP covered activities in the predictive scenario runs	GEOSCIENCE/ICF	Complete
Items from 20-Dec-18 Conference Call (none)		
Items from 29-Jan-19 Workshop		
48. Modify TM 5a figures based on suggestions from the TAC	GEOSCIENCE	In Progress
49. Add a simple table to TM 5a showing recharge/discharge for each HCP Covered Activity	GEOSCIENCE	Complete
50. Modify recharge values for West.6	GEOSCIENCE / Western	Complete
51. Develop assumptions for management runs (Scenario 4)	TAC	In Progress
52. Break out flow statistics seasonally and monthly in TM 5a	GEOSCIENCE	In Progress
53. Create new figure(s) in TM 5a showing difference in ET	GEOSCIENCE	Complete
Items from 28-Feb-19 Conference Call		
54. Create a figure showing the distribution of average precipitation change factors over a 12-month period.	GEOSCIENCE	Complete
Items from 28-Mar-19 Conference Call		
55. Add figures for context re: redistribution of flows to the SAR (e.g., SNRC, SAR Sustainable Parks and Tributaries Water Reuse Project)	GEOSCIENCE	Complete
56. Revise/clarify figures for climate change factors.	GEOSCIENCE	Complete
57. Circulate the climate change guidance document to the TAC	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
58. Create cumulative departure chart with projected precipitation under climate change conditions and actual precipitation	GEOSCIENCE	In Progress
Items from 30-May-19 Workshop		
59. Schedule a modeling subcommittee meeting to discuss IEUA/CBWM comments on the Integrated SAR Model	GEOSCIENCE	Complete
60. Document results of modeling subcommittee meeting to present to the TAC	GEOSCIENCE / USGS	In Progress
61. Check to see if the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) are available so that model results in Chino Basin can be compared directly	Ron Craig	In Progress
62. Provide changes to streamflow from HCP Activities in both AFY and cfs, particularly in areas where habitat is a concern	GEOSCIENCE	In Progress
63. Distribute animation of river footprint to TAC and add geographic reference points	GEOSCIENCE	In Progress
64. Decide if another scenario run should be made to determine the incremental effect of non-HCP projects that are already planned and approved	TAC	In Progress
65. Summarize project assumptions in terms of a water balance (where water is going and how much)	GEOSCIENCE	Complete

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian

Item	Description
	vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.
Items from 17-May-18 Conference Call	
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
Items from 20-Jun-18 Model Workshop	
28	Terminology for the steady state run will be modified to reflect pseudo steady state conditions.
29	The initial calibration results (Draft TM No. 1) will be added onto calibration hydrographs in Draft TM No. 3 for comparison.
30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.
Items from 14-Sep-18 Workshop	
33	Additional detail regarding calibration (decisions, steps, methodology, etc.) will be included in the final TM-3.

Item	Description
Items from 10-Oct-18 Conference Call	
34	The numbering for the proposed scenario runs will reflect that originally used in the proposal.
35	A "sensitivity run" will be made with no pumping to evaluate whether the model can reproduce water level patterns seen in the 1905 Mendenhall maps of the area.
36	A model scenario will be added to evaluate groundwater basin management activities that differ from the baseline.
Items from 15-Nov-18 Conference Call	
37	For Scenario 1d (sensitivity run with no pumping), artificial recharge and other pre-development activities will also be removed.
Items from 20-Dec-18 Conference Call	
38	A simulation with no El Niño events will be included as one of the climate change alternatives.
Items from 29-Jan-19 Workshop	
39	Scenario 2 runs will be used to determine project impacts without additional modification of pumping and non-HCP recharge while the Scenario 4 runs will incorporate management and recovery plans in response to the additional recharge from the HCP Covered Activities.
Items from 28-Feb-19 Conference Call	
40	Geoscience will work with WEI to add additional discussion on the projected pumping in Chino Basin.
41	Recharge and timing of HCP projects under climate change conditions will be kept the same as those used without climate change to simplify the comparison of the results.
Items from 28-Mar-19 Conference Call	
42	Comparisons between streamflow in the SAR under baseline and climate change conditions will be made at the main streamflow gaging locations.
Items from 30-May-19 Workshop	
43	Intended purposes of the model will be acknowledged in the Limitations section of the final report.
44	Additional text will be added to the final report describing changes made during model calibration (e.g., change in underflow volumes).
45	The amount of water reaching Santa Ana Sucker habitat will be calculated with and without the Riverside North Aquifer Storage and Recovery Project (Rubber Dam Project; RPU.5).
46	"Surface Water Discharge" components will be clarified (e.g., recycled water discharge, dewatering discharge, OC-59 turnout water, etc.).

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

June 26, 2019
8:30 am - 10:00 am

Issued on July 29, 2019

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	CA State Water Resources Control Board (State Board): Jan Stepek
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, David Barnes, Lauren Wicks, and Leo Liu
	Orange County Water District (OCWD): Tim Sovich and Greg Woodside
	RBC Resources: Ron Craig
	Riverside Public Utilities (RPU): Greg Herzog and Farid Boushaki
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher, Heather Dyer, and Wen Huang
	US Geological Survey (USGS): Wes Danskin
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Ryan Shaw

ITEM 1: APPROVAL OF 30-MAY-19 WORKSHOP MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Friday, 28-Jun-19, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed the current project schedule and discussed upcoming events. He explained that TM-5b, summarizing the results of the second batch of scenario runs, will be issued on 28-Jun-19. In addition, a subcommittee meeting to discuss IEUA/WEI comments on the Integrated SAR Model will be held on 10-Jul-19 at Valley District.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the Action Item list, which was included in the 26-Jun-19 conference call agenda and 30-May-19 workshop minutes. He explained that Action Items involving edits to TM-5 (Action Items 48, 52, 54-56, and 58) are in progress, along with Action Item 51 (develop assumptions for management scenarios) and 64 (determine if another scenario run is needed to determine incremental effect of non-HCP projects). Mr. Craig announced that Action Item 61 (check if electronic data for WEI Chino Basin calibration residuals are available) is also still in progress. Action Item 60 (document results of subcommittee meeting) will be conducted following the subcommittee meeting on 10-Jul-19.

ITEM 4: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes.

ITEM 5: OVERVIEW OF DRAFT TM NO. 5B: PREDICTIVE SCENARIO RESULTS – PART 2

Mr. Barnes continued with his review of the results from the second set of scenario runs. This included a review of the results of Scenario 1 (Factors that May be Causing Reduced Flows in the SAR), which he reviewed at the 30-May-19 model workshop, and Scenarios 2c.4 (SNRC), 2c.5 (SAR Sustainable Parks and Tributaries Water Reuse Project), 2c.6 (Western Riverside County Regional Wastewater Treatment Plant Enhancement and Expansion), 2c.7 (IEUA Baseflow Reduction Activities), 2d.1 (Phase I Active Recharge Activities), 2d.2 (Phase II Active Recharge Activities along Lytle Creek), 2d.3 (Phase II Active Recharge Activities along Cajon and Cable Creeks), 2d.4 (Phase II Active Recharge Activities along City Creek, Plunge Creek, and Mill Creek), 2d.6 (Riverside North Aquifer Storage and Recovery Project), 2d.7 (recap of Evaluation of Valley District Stormwater Capture Program at Prado Dam), 2e.1 (IEUA Stormflow Activities) and 2e.2 (All IEUA Activities). Mr. Yeh explained that additional results will be presented in Draft TM-5b.

Questions and comments included:

1. Mr. Tincher observed that the tributary runoff, which is driven by rainfall, indicates that the area is still experiencing effects from drought. Mr. Yeh agreed and clarified that the drought conditions started in 1999.
2. Mr. Danskin observed that the rising water seems to be remarkably flat. In Bunker Hill Basin, he recalled that observed rising water was very low in earlier periods. He questioned whether the water levels might be a little high and/or static. Mr. Barnes explained that the rising water shown in the figure was the total of all rising water in the model area, including Prado and Riverside Narrows. Mr. Danskin replied that the static nature of the total rising water, despite a downtrend in precipitation, may be good news for vegetation along the SAR. Ms. Dyer responded that vegetation would likely respond at a localized level (transition based on groundwater), depending on changes in rising water and flow throughout the model. Mr. Tincher requested that rising water be presented as a stacked bar chart so the various contributions to rising water (and where it's coming from) can be discerned. Mr. Danskin added that it is very easy for the model to tell you where water is coming up, but it can still be fairly difficult to understand what the river is doing.
3. In response to the animation presented of changes in the shallow groundwater footprint along the SAR, Mr. Tincher observed that the footprint pinches out periodically prior to Prado and asked why that might be. Mr. Barnes replied that the seasonal changes in shallow depth to water in the Prado area become more stable as the simulation continues, likely due to increased surface water discharges of recycled water. Mr. Danskin agreed that this makes sense. Mr. Tincher requested that the animation be labeled by year rather than stress period. Mr. Danskin remarked that this is an important dynamic figure that represents a synthesis of what the model is doing. He suggested possibly adding a bar along the bottom of the animation showing the date and adding a couple of hydrographs in the left corner with characteristic water level trends. Mr. Romero added that, even though the overall rising water percentage is static, the animation

highlights changes. In addition, he mentioned that BGW looked at rising water during their model review and felt that the model-calculated values made sense based on known rising water.

4. Mr. Romero suggested looking at different shallow groundwater footprints, perhaps 12-15 ft, because the area may expand quite a bit. Mr. Barnes replied that he can generate these maps, depending on what threshold the group would like to see. Ms. Dyer replied that she and ICF would contact GEOSCIENCE later to discuss what footprints would be helpful for their analysis.
5. Mr. Danskin observed that Scenario 2d.1, while there is 19,000 acre-ft/yr of recharge, only produces a change in ET of about 300 acre-ft/yr. Mr. Yeh replied that it's not net recharge, but that this net change will be presented in the water balance. Mr. Danskin asked Ms. Dyer how all of these complicated factors will be put together and she replied that they are working on that. Mr. Barnes added that the ET results are sometimes influenced by where the projects are located. Mr. Sovich asked what the extinction depth was in the model and Mr. Barnes replied that it depended on the type of vegetation – ranging from 1 to 17 ft.

ITEM 6: OTHER BUSINESS

No other business was discussed.

ITEM 7: NEXT MEETING

The next Integrated SAR Model meeting, which will be a conference call, will be Thursday, July 25th, 2019, from 10:30 am to 12:00 pm. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Wednesday, June 26th, 2019 at 9:55 am.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		

Action Item Description	Responsible Agency	Status
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)

Action Item Description	Responsible Agency	Status
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete

Action Item Description	Responsible Agency	Status
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	Complete
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	Complete
Items from 18-Jul-18 Conference Call		
44. Meeting with Valley District, USFWS, CDFW, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete
Items from 14-Sep-18 Workshop		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete
Items from 10-Oct-18 Conference Call		

Action Item Description	Responsible Agency	Status
46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	Complete
Items from 15-Nov-18 Conference Call		
47. Verify project IDs for the HCP covered activities in the predictive scenario runs	GEOSCIENCE/ICF	Complete
Items from 20-Dec-18 Conference Call (none)		
Items from 29-Jan-19 Workshop		
48. Modify TM 5a figures based on suggestions from the TAC	GEOSCIENCE	In Progress
49. Add a simple table to TM 5a showing recharge/discharge for each HCP Covered Activity	GEOSCIENCE	Complete
50. Modify recharge values for West.6	GEOSCIENCE / Western	Complete
51. Develop assumptions for management runs (Scenario 4)	TAC	In Progress
52. Break out flow statistics seasonally and monthly in TM 5a	GEOSCIENCE	In Progress
53. Create new figure(s) in TM 5a showing difference in ET	GEOSCIENCE	Complete
Items from 28-Feb-19 Conference Call		
54. Create a figure showing the distribution of average precipitation change factors over a 12-month period.	GEOSCIENCE	Complete
Items from 28-Mar-19 Conference Call		
55. Add figures for context re: redistribution of flows to the SAR (e.g., SNRC, SAR Sustainable Parks and Tributaries Water Reuse Project)	GEOSCIENCE	Complete
56. Revise/clarify figures for climate change factors.	GEOSCIENCE	Complete
57. Circulate the climate change guidance document to the TAC	GEOSCIENCE	Complete
58. Create cumulative departure chart with projected precipitation under climate change conditions and actual precipitation	GEOSCIENCE	In Progress
Items from 30-May-19 Workshop		
59. Schedule a modeling subcommittee meeting to discuss IEUA/CBWM comments on the Integrated SAR Model	GEOSCIENCE	Complete
60. Document results of modeling subcommittee meeting to present to the TAC	GEOSCIENCE / USGS	In Progress

Action Item Description	Responsible Agency	Status
61. Check to see if the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) are available so that model results in Chino Basin can be compared directly	Ron Craig	In Progress
62. Provide changes to streamflow from HCP Activities in both AFY and cfs, particularly in areas where habitat is a concern	GEOSCIENCE	Complete
63. Distribute animation of river footprint to TAC and add geographic reference points	GEOSCIENCE	In Progress
64. Decide if another scenario run should be made to determine the incremental effect of non-HCP projects that are already planned and approved	TAC	In Progress
65. Summarize project assumptions in terms of a water balance (where water is going and how much)	GEOSCIENCE	Complete
Items from 26-Jun-19 Conference Call		
66. Further annotations to animation of river footprint through time, including replacing stress period with year	GEOSCIENCE	In Progress
67. Create stacked bar chart for rising water	GEOSCIENCE	In Progress
68. Look at different shallow groundwater footprints (e.g., 12-15 ft)	GEOSCIENCE	Complete

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	

Item	Description
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.

Item	Description
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.
Items from 17-May-18 Conference Call	
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
Items from 20-Jun-18 Model Workshop	
28	Terminology for the steady state run will be modified to reflect pseudo steady state conditions.
29	The initial calibration results (Draft TM No. 1) will be added onto calibration hydrographs in Draft TM No. 3 for comparison.
30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.
Items from 14-Sep-18 Workshop	
33	Additional detail regarding calibration (decisions, steps, methodology, etc.) will be included in the final TM-3.
Items from 10-Oct-18 Conference Call	
34	The numbering for the proposed scenario runs will reflect that originally used in the proposal.
35	A "sensitivity run" will be made with no pumping to evaluate whether the model can reproduce water level patterns seen in the 1905 Mendenhall maps of the area.
36	A model scenario will be added to evaluate groundwater basin management activities that differ from the baseline.
Items from 15-Nov-18 Conference Call	
37	For Scenario 1d (sensitivity run with no pumping), artificial recharge and other pre-development activities will also be removed.
Items from 20-Dec-18 Conference Call	
38	A simulation with no El Niño events will be included as one of the climate change alternatives.
Items from 29-Jan-19 Workshop	

Item	Description
39	Scenario 2 runs will be used to determine project impacts without additional modification of pumping and non-HCP recharge while the Scenario 4 runs will incorporate management and recovery plans in response to the additional recharge from the HCP Covered Activities.
Items from 28-Feb-19 Conference Call	
40	Geoscience will work with WEI to add additional discussion on the projected pumping in Chino Basin.
41	Recharge and timing of HCP projects under climate change conditions will be kept the same as those used without climate change to simplify the comparison of the results.
Items from 28-Mar-19 Conference Call	
42	Comparisons between streamflow in the SAR under baseline and climate change conditions will be made at the main streamflow gaging locations.
Items from 30-May-19 Workshop	
43	Intended purposes of the model will be acknowledged in the Limitations section of the final report.
44	Additional text will be added to the final report describing changes made during model calibration (e.g., change in underflow volumes).
45	The amount of water reaching Santa Ana Sucker habitat will be calculated with and without the Riverside North Aquifer Storage and Recovery Project (Rubber Dam Project; RPU.5).
46	"Surface Water Discharge" components will be clarified (e.g., recycled water discharge, dewatering discharge, OC-59 turnout water, etc.).
Items from 26-Jun-19 Conference Call (none)	

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

July 25, 2019
10:30 am - 12:00 pm

Issued on September 19, 2019

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	CA State Water Resources Control Board (State Board): Jan Stepek
	Flow Science: John List
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Dennis Williams, Johnson Yeh, David Barnes, Lauren Wicks, and Leo Liu
	Orange County Water District (OCWD): Greg Woodside
	RBC Resources: Ron Craig
	Riverside Public Utilities (RPU): Farid Boushaki
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher
	US Geological Survey (USGS): Wes Danskin
	Wildermuth Environmental, Inc. (WEI): Wenbin Wang
	Western Municipal Water District (WMWD): Ryan Shaw and Mallory Gandara

ITEM 1: APPROVAL OF 26-JUN-19 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 29-Jul-19, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed the updated project schedule, which includes additional time needed to address comments on the Integrated SAR Model. He explained that action items to address comments were developed during a modeling subcommittee meeting, which was held at Valley District on July 10, 2019. Upcoming milestones include a finalized version of TM-3 (Model Calibration) by the end of August, comments on TM-5b (Scenarios, part two) due back from the TAC by August 9th, issuance of draft TM-4b (Management Scenario Assumptions) by August 1st, and draft TM-5c (Scenarios, part three) by the end of November. The project is expected to be completed by the end of January 2020.

ITEM 3: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the Action Item list, which was included in the 25-Jul-19 conference call agenda and 26-Jun-19 conference call minutes. He explained that Action Items involving edits to TM-5 (Action Items 48, 52, and 58) are still in progress, along with Action Items 51 (develop assumptions for management scenarios), 61 (check if electronic data for WEI Chino Basin calibration residuals are available), 63 and 66

(edits to animation), 64 (determine if another scenario run is needed to determine incremental effect of non-HCP projects), and 67 (create stacked bar chart for rising water). Action Item 60 (document results of subcommittee meeting) was completed by the USGS and WEI. These summaries were discussed in Agenda Item 5.

ITEM 4: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes.

ITEM 5: SUMMARY AND REVIEW OF ACTION ITEMS FROM MODELING SUBCOMMITTEE MEETING

Mr. Yeh informed the group that the modeling subcommittee meeting was held on July 10, 2019, at Valley District. Attendees included representatives of Valley District, OCWD, USGS, BGW, Geoscience, RBC Resources, and WEI. In addition to discussing key areas of concern expressed through comments from IEUA/Chino Basin Watermaster, BGW presented an evaluation of model performance in the Chino Basin area, for both the WEI model and the Integrated SAR Model. The meeting lasted approximately 6 hours. Mr. Danskin further summarized the subcommittee meeting by presenting the main conclusions, path forward, and background from the USGS summary letter, which was distributed to the group. At the request of Mr. Tincher, Mr. Romero also briefly summarized BGW's review of model performance in Chino Basin for the TAC, which included a comparison of water level residuals, hydrographs, water budget, and transmissivity.

Questions and comments included:

1. In response to the different calibration techniques, Mr. Tincher questioned if the trial and error model calibration approach should be referred to as being "less rigorous" than an automated regression technique (e.g., PEST). Mr. Danskin explained that the automated technique is very quantitative and defines a best fit for selected parameters. He acknowledged that using "less rigorous" could be misinterpreted and offered to write an additional explanation about this. However, while he believes the trial and error approach is best to use for initial calibration and that he is comfortable with the model in its current state, he explained that automated techniques can polish calibration and provide additional insight.
2. Mr. Danskin advised that use of the Integrated SAR Model would require some background work to determine if the model was structured appropriately to do different kinds of water quality management (e.g., salt loading). He further advised that if this model were to be used for water quality management in the future, a separate TAC should be developed to go through the structure of the model, appropriate modifications, and political and technical issues.
3. Mr. Wang suggested to compare model hydraulic conductivities rather than the transmissivity shown in BGW's review of the Chino Basin models. Mr. Silver explained that they did look at hydraulic conductivity as well as other model parameters such as specific yield, but that they decided to compute the transmissivity to summarize the model parameters simply, especially since the two models have different model layer assumptions. Mr. Romero went on to explain that, even though hydraulic conductivities are input into the model, the model converts it to transmissivity based on the saturated thickness, so he thought it was a valid comparison. Mr. Yeh

agreed. Mr. Danskin further explained that the hydraulic conductivity can give insight into the conceptual model of the geologic facies, but that the model actually uses the transmissivity. He suggested that looking at both, which BGW did during their review, is necessary to avoid misinterpretations. Mr. Williams agreed. A distribution map of hydraulic conductivity values used in the Integrated SAR Model is provided in TM-3.

4. Mr. Yeh explained to the group that the Geoscience modeling team will complete the additional work recommended by the modeling subcommittee meeting and summarized in the USGS and WEI summaries. TM-3 will also be updated to include additional information in response to comments.

ITEM 6: DISCUSSION OF ASSUMPTIONS FOR "MANAGEMENT RUNS" THAT WILL TAKE INTO CONSIDERATION PHASING OF UPSTREAM WATER SUPPLY PROJECTS (SCENARIO 4)

Mr. Barnes briefly reviewed some of the major assumptions to be considered in each basin and the general approach for the management scenarios. These will also be summarized in TM-4b.

ITEM 7: OTHER BUSINESS

No other business was discussed.

ITEM 8: NEXT MEETING

The next Integrated SAR Model meeting, which will be a conference call, will be Thursday, August 29th, 2019, from 10:30 am to 12:00 pm. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Thursday, July 25th, 2019 at 12:00 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		

Action Item Description	Responsible Agency	Status
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)

Action Item Description	Responsible Agency	Status
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete

Action Item Description	Responsible Agency	Status
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	Complete
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	Complete
Items from 18-Jul-18 Conference Call		
44. Meeting with Valley District, USFWS, CDFW, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete
Items from 14-Sep-18 Workshop		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete
Items from 10-Oct-18 Conference Call		

Action Item Description	Responsible Agency	Status
46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	Complete
Items from 15-Nov-18 Conference Call		
47. Verify project IDs for the HCP covered activities in the predictive scenario runs	GEOSCIENCE/ICF	Complete
Items from 20-Dec-18 Conference Call (none)		
Items from 29-Jan-19 Workshop		
48. Modify TM 5a figures based on suggestions from the TAC	GEOSCIENCE	In Progress
49. Add a simple table to TM 5a showing recharge/discharge for each HCP Covered Activity	GEOSCIENCE	Complete
50. Modify recharge values for West.6	GEOSCIENCE / Western	Complete
51. Develop assumptions for management runs (Scenario 4)	TAC	In Progress
52. Break out flow statistics seasonally and monthly in TM 5a	GEOSCIENCE	In Progress
53. Create new figure(s) in TM 5a showing difference in ET	GEOSCIENCE	Complete
Items from 28-Feb-19 Conference Call		
54. Create a figure showing the distribution of average precipitation change factors over a 12-month period.	GEOSCIENCE	Complete
Items from 28-Mar-19 Conference Call		
55. Add figures for context re: redistribution of flows to the SAR (e.g., SNRC, SAR Sustainable Parks and Tributaries Water Reuse Project)	GEOSCIENCE	Complete
56. Revise/clarify figures for climate change factors.	GEOSCIENCE	Complete
57. Circulate the climate change guidance document to the TAC	GEOSCIENCE	Complete
58. Create cumulative departure chart with projected precipitation under climate change conditions and actual precipitation	GEOSCIENCE	In Progress
Items from 30-May-19 Workshop		
59. Schedule a modeling subcommittee meeting to discuss IEUA/CBWM comments on the Integrated SAR Model	GEOSCIENCE	Complete
60. Document results of modeling subcommittee meeting to present to the TAC	GEOSCIENCE / USGS	Complete

Action Item Description	Responsible Agency	Status
61. Check to see if the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) are available so that model results in Chino Basin can be compared directly	Ron Craig	In Progress
62. Provide changes to streamflow from HCP Activities in both AFY and cfs, particularly in areas where habitat is a concern	GEOSCIENCE	Complete
63. Distribute animation of river footprint to TAC and add geographic reference points	GEOSCIENCE	In Progress
64. Decide if another scenario run should be made to determine the incremental effect of non-HCP projects that are already planned and approved	TAC	In Progress
65. Summarize project assumptions in terms of a water balance (where water is going and how much)	GEOSCIENCE	Complete
Items from 26-Jun-19 Conference Call		
66. Further annotations to animation of river footprint through time, including replacing stress period with year	GEOSCIENCE	In Progress
67. Create stacked bar chart for rising water	GEOSCIENCE	In Progress
68. Look at different shallow groundwater footprints (e.g., 12-15 ft)	GEOSCIENCE	Complete
Items from 25-Jul-19 Conference Call (none)		

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.

Item	Description
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
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8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
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9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
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15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
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17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.

Item	Description
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.
Items from 17-May-18 Conference Call	
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
Items from 20-Jun-18 Model Workshop	
28	Terminology for the steady state run will be modified to reflect pseudo steady state conditions.
29	The initial calibration results (Draft TM No. 1) will be added onto calibration hydrographs in Draft TM No. 3 for comparison.
30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.
Items from 14-Sep-18 Workshop	
33	Additional detail regarding calibration (decisions, steps, methodology, etc.) will be included in the final TM-3.
Items from 10-Oct-18 Conference Call	
34	The numbering for the proposed scenario runs will reflect that originally used in the proposal.
35	A "sensitivity run" will be made with no pumping to evaluate whether the model can reproduce water level patterns seen in the 1905 Mendenhall maps of the area.
36	A model scenario will be added to evaluate groundwater basin management activities that differ from the baseline.
Items from 15-Nov-18 Conference Call	
37	For Scenario 1d (sensitivity run with no pumping), artificial recharge and other pre-development activities will also be removed.
Items from 20-Dec-18 Conference Call	
38	A simulation with no El Niño events will be included as one of the climate change alternatives.
Items from 29-Jan-19 Workshop	

Item	Description
39	Scenario 2 runs will be used to determine project impacts without additional modification of pumping and non-HCP recharge while the Scenario 4 runs will incorporate management and recovery plans in response to the additional recharge from the HCP Covered Activities.
Items from 28-Feb-19 Conference Call	
40	Geoscience will work with WEI to add additional discussion on the projected pumping in Chino Basin.
41	Recharge and timing of HCP projects under climate change conditions will be kept the same as those used without climate change to simplify the comparison of the results.
Items from 28-Mar-19 Conference Call	
42	Comparisons between streamflow in the SAR under baseline and climate change conditions will be made at the main streamflow gaging locations.
Items from 30-May-19 Workshop	
43	Intended purposes of the model will be acknowledged in the Limitations section of the final report.
44	Additional text will be added to the final report describing changes made during model calibration (e.g., change in underflow volumes).
45	The amount of water reaching Santa Ana Sucker habitat will be calculated with and without the Riverside North Aquifer Storage and Recovery Project (Rubber Dam Project; RPU.5).
46	"Surface Water Discharge" components will be clarified (e.g., recycled water discharge, dewatering discharge, OC-59 turnout water, etc.).
Items from 26-Jun-19 Conference Call (none)	
Items from 25-Jul-19 Conference Call	
47	Additional work will be completed according to the conclusions from the modeling subcommittee meeting (as summarized in the documents prepared by USGS, WEI, and OCWD). TM-3 will also be updated to include additional information in response to comments.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

September 17, 2019
9:00 am – 10:30 am

Issued on December 6, 2019

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	CA State Water Resources Control Board (State Board): Jan Stepek
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, David Barnes, and Lauren Wicks
	Orange County Water District (OCWD): Greg Woodside and Tim Sovich
	RBC Resources: Ron Craig
	Riverside Public Utilities (RPU): Farid Boushaki
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher, Kai Palenscar, Heather Dyer, and Matt Howard
	US Geological Survey (USGS): Wes Danskin
	Wildermuth Environmental, Inc. (WEI): Mark Wildermuth
	Western Municipal Water District (WMWD): Jason Pivovaroff and Mallory Gandara

ITEM 1: APPROVAL OF 25-JUL-19 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Thursday, 19-Sep-19, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed the updated project schedule, which includes additional time needed to address comments on the Integrated SAR Model. He explained that action items to address comments were developed during the 10-Jul-19 modeling subcommittee meeting. Upcoming milestones include a finalized version of TM-3 (Model Calibration) which will include the action items identified in the modeling subcommittee meeting, and draft TM-5c (Scenarios, part three). The project is expected to be completed by the end of January 2020.

ITEM 3: REVIEW PROJECT BUDGET

Mr. Yeh reviewed the requested change order and briefly described the work that the tasks would cover. He explained that these tasks were added due to delay or out of scope work. Mr. Tincher added that CBWM and IEUA are still reviewing the change order and that Mr. Tincher would email the funders to discuss how the change order would be covered. Mr. Pivovaroff asked if any of the work was eligible for grant funding and Ms. Dyer replied that all of the grant money will be used.

ITEM 4: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the Action Item list, which was included in the 17-Sep-19 conference call agenda and 25-Jul-19 conference call minutes. He explained that Action Items involving edits to TM-5 (Action Items 48, 52, and 58) are still in progress and will be addressed through the finalization of TM-5. Action Item 61 (check if electronic data for WEI Chino Basin calibration residuals are available) was initiated by resending the request to CBWM, but no data have been received yet.

ITEM 5: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes.

ITEM 6: DISCUSSION OF ASSUMPTIONS FOR "MANAGEMENT RUNS" THAT WILL TAKE INTO CONSIDERATION REJECTED RECHARGE AND POSSIBLE PHASING OF UPSTREAM WATER SUPPLY PROJECTS (SCENARIO 4)

TM-4b, describing the main assumptions of the management scenarios, was submitted on 1-Aug-19. Comments were received from OCWD. Mr. Barnes reviewed the response to comments and discussed the main assumptions for the management runs by basin.

Questions and comments included:

1. Mr. Danskin recommended having a cumulative departure of runoff since precipitation and runoff may not correlate directly. He explained that this is important because the basin runs on runoff, not direct precipitation. He further suggested that Lytle/Santa Ana be used as an indicator of runoff.
2. Mr. Danskin asked for clarification on how the constraints would be met and Mr. Barnes explained that an iterative process would be used, similar to the approach used to determine baseline pumping in Rialto-Colton. Mr. Danskin suggested developing a couple of response-type functions of the scenario results (e.g., water levels vs. recharge) as a way to summarize the process of iterations to the group. Mr. Romero added that the process and reasoning behind the approach should also be included.
3. Mr. Tincher added that he hopes the management scenarios will provide an indication of the amount of recharge the upper basin area can take.
4. Mr. Sovich asked whether pumping adjustments would be made spatially or by adding new wells based on communications with the various water districts. Mr. Yeh replied that a combination approach would be used. For example, scenario pumping in Rialto-Colton and Riverside-Arlington will rely on existing wells plus any new wells. In Chino Basin, IEUA and CBWM will be consulted as to where new wells will be located.

ITEM 7: REVIEW CHANGE IN SHALLOW DEPTH TO GROUNDWATER AND IMPACT ON RIPARIAN HABITAT

Mr. Barnes briefly reviewed some of the work being done by ICF and Geoscience to assess how changes in shallow depth to groundwater may impact riparian habitat. Differences in model-calculated depth to groundwater between the baseline and all HCP Activities runs were identified to try to determine where transition zones may occur.

Questions and comments included:

5. Mr. Sovich suggested that it might be helpful to show a map with change in water levels. Ms. Dyer replied that the figure will be part of the ICF HCP document and that they're trying to determine where more monitoring may be required. Mr. Danskin suggested using "stoplight" colors to illustrate the changes. Ms. Dyer suggested that a corresponding table might be helpful to summarize water level change and area. Mr. Danskin liked this idea and added that areas where change is occurring might be highlighted, as these may be hydrologically more sensitive. Mr. Romero added that timing should also be considered to fully characterize what's happening (change in acreages through time), or clarify intention of looking at the worst case scenario.
6. Mr. Tincher asked if the analysis will include determining why areas are rising/falling. Mr. Yeh replied that there is a water budget for each area which can be used to see what's changing.
7. Ms. Dyer clarified that this analysis shows only one side of things: the impact side. They also plan to evaluate the wetlands and habitat being built upstream. Ultimately, Ms. Dyer explained that they want to make sure they have enough mitigation set aside.

ITEM 8: OTHER BUSINESS

No other business was discussed.

ITEM 9: NEXT MEETING

The next Integrated SAR Model meeting will be a model workshop at Valley District to review the next batch of model runs. Based on the results of a poll, the workshop was scheduled for Wednesday, December 4th at 1:30 pm. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Tuesday, September 17th, 2019 at 10:30 am.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete

Action Item Description	Responsible Agency	Status
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	Complete
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
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46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	Complete
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47. Verify project IDs for the HCP covered activities in the predictive scenario runs	GEOSCIENCE/ICF	Complete
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Action Item Description	Responsible Agency	Status
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58. Create cumulative departure chart with projected precipitation under climate change conditions and actual precipitation	GEOSCIENCE	In Progress
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68. Look at different shallow groundwater footprints (e.g., 12-15 ft)	GEOSCIENCE	Complete
Items from 25-Jul-19 Conference Call (none)		
Items from 17-Sep-19 Conference Call		
69. Create cumulative departure of runoff figure	GEOSCIENCE	In Progress
70. Create figures for management runs illustrating response	GEOSCIENCE	In Progress
71. Edit figures/tables showing possible areas impacted by change in shallow depth to groundwater based on comments and suggestions from TAC	GEOSCIENCE/ICF	In Progress

Decision Log

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26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
Items from 20-Jun-18 Model Workshop	
28	Terminology for the steady state run will be modified to reflect pseudo steady state conditions.
29	The initial calibration results (Draft TM No. 1) will be added onto calibration hydrographs in Draft TM No. 3 for comparison.
30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.

Item	Description
Items from 14-Sep-18 Workshop	
33	Additional detail regarding calibration (decisions, steps, methodology, etc.) will be included in the final TM-3.
Items from 10-Oct-18 Conference Call	
34	The numbering for the proposed scenario runs will reflect that originally used in the proposal.
35	A "sensitivity run" will be made with no pumping to evaluate whether the model can reproduce water level patterns seen in the 1905 Mendenhall maps of the area.
36	A model scenario will be added to evaluate groundwater basin management activities that differ from the baseline.
Items from 15-Nov-18 Conference Call	
37	For Scenario 1d (sensitivity run with no pumping), artificial recharge and other pre-development activities will also be removed.
Items from 20-Dec-18 Conference Call	
38	A simulation with no El Niño events will be included as one of the climate change alternatives.
Items from 29-Jan-19 Workshop	
39	Scenario 2 runs will be used to determine project impacts without additional modification of pumping and non-HCP recharge while the Scenario 4 runs will incorporate management and recovery plans in response to the additional recharge from the HCP Covered Activities.
Items from 28-Feb-19 Conference Call	
40	Geoscience will work with WEI to add additional discussion on the projected pumping in Chino Basin.
41	Recharge and timing of HCP projects under climate change conditions will be kept the same as those used without climate change to simplify the comparison of the results.
Items from 28-Mar-19 Conference Call	
42	Comparisons between streamflow in the SAR under baseline and climate change conditions will be made at the main streamflow gaging locations.
Items from 30-May-19 Workshop	
43	Intended purposes of the model will be acknowledged in the Limitations section of the final report.
44	Additional text will be added to the final report describing changes made during model calibration (e.g., change in underflow volumes).
45	The amount of water reaching Santa Ana Sucker habitat will be calculated with and without the Riverside North Aquifer Storage and Recovery Project (Rubber Dam Project; RPU.5).
46	"Surface Water Discharge" components will be clarified (e.g., recycled water discharge, dewatering discharge, OC-59 turnout water, etc.).
Items from 26-Jun-19 Conference Call (none)	
Items from 25-Jul-19 Conference Call	
47	Additional work will be completed according to the conclusions from the modeling subcommittee meeting (as summarized in the documents prepared by USGS, WEI, and OCWD). TM-3 will also be updated to include additional information in response to

Item	Description
	comments.
Items from 17-Sep-19 Conference Call (none)	

Minutes for the Upper Santa Ana River Integrated Model Update Workshop

San Bernardino Valley Municipal Water District

December 4, 2019
1:30 pm – 4:30 pm

Issued on February 14, 2020

Attendees:	Balleau Groundwater (BGW): Dave Romero* and Steve Silver*
	Elsinore Valley Municipal Water District (EVMWD): Jesus Gastellum
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, David Barnes, Lauren Wicks, and Leo Liu*
	Orange County Water District (OCWD): Tim Sovich
	RBC Resources: Ron Craig*
	Riverside Public Utilities (RPU): Farid Boushaki
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher, Kai Palenscar, Heather Dyer, and Matt Howard
	Santa Ana Regional Water Quality Control Board (Regional Board): Cindy Li
	Santa Ana Watershed Project Authority (SAWPA): Mark Norton
	US Geological Survey (USGS): Wes Danskin*
	Western Municipal Water District (WMWD): Ryan Shaw and Mallory Gandara

ITEM 1: APPROVAL OF 17-SEP-19 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Friday, 6-Dec-19, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed the updated project schedule. Upcoming milestones include a finalized version of TM-3 (Model Calibration), and draft TM-5c (Scenarios, part three). The project is expected to be completed by the end of March 2020.

ITEM 3: REVIEW PROJECT BUDGET

Mr. Tincher updated the group on the budget status. He explained that the funding agencies have agreed to cover the most recent budget amendment, which will be taken to the December Valley District Board meeting and should be finalized by the end of the year.

ITEM 4: REVIEW ACTION ITEM LIST

Mr. Yeh reviewed the Action Item list, which was included in the 4-Dec-19 workshop agenda and 17-Sep-19 conference call minutes. He explained that Action Items involving edits to TM-5 (Action Items 48, 52, and 58) are still in progress and will be addressed through the finalization of TM-5.

ITEM 5: REVIEW DECISION LOG

Mr. Yeh reviewed the decision log from the last meeting, which was also included in the previous meeting minutes. No decisions were made at the last conference call.

ITEM 6: OVERVIEW OF DRAFT TM NO. 5C: PREDICTIVE SCENARIO RESULTS – PART 1

Mr. Barnes briefly reviewed assumptions and preliminary results for the next set of scenario runs, which includes the climate change scenarios (Scenarios 2b.2 and 2b.3), IEUA reduced flow from wastewater treatment plants (Scenario 2c.8), Clean Water Factory (Scenario 2g), Western's Victoria Basin Recharge Project (Scenario 2f), RIX operational scenarios (Scenario 2h), and management scenarios to reduce, or eliminate, rejected recharge upstream ad optimize storage and recovery (Scenarios 4.1 through 4.6).

Questions and comments included:

1. Mr. Shaw asked about the difference between 2030 and 2070 climate change projections. Mr. Barnes replied that the 2030 estimates assumed projected 2030 climate with variability around the 2030 mean. The 2070 projections show a slightly larger departure. All of the climate change values were obtained from the DWR Climate Change Guidance Document, which was circulated to the TAC during a previous action item but can be resent.
2. Mr. Gastellum asked what impact the climate change has on recharge and Mr. Sovich wondered about impacts on ET. Mr. Barnes replied that the DWR change factors were applied to runoff based on a linear relationship between runoff and precipitation. The change factors were applied throughout the model domain based on DWR cell designation from the guidance document. As for ET, Mr. Barnes throught that ET may increase under climate change conditions, but that model ET change is still being evaluated.
3. Mr. Danskin commented that there are many different climate models available, but that there are also different kinds of errors associated with each model depending on the assumptions made. He went on to explain that the DWR climate model is based on two populations of data: pre 1970 and post 1970. Given the uncertainties imbedded in the scenarios, he would not be surprised if the error bars were the same magnitude as the climate differences.
4. Mr. Norton asked how the SNRC assumptions used for the Integrated SAR Model scenario runs compare to those used in the SAWPA Wasteload Allocation Model runs. Mr. Yeh replied that they would need to compare the assumptions. Ms. Wicks addressed this comment at the December SAWPA meeting, stating that the discharge assumptions for the Integrated SAR Model runs were based on the 2020 Average Expected discharge from the SAWPA model runs.

5. Mr. Tincher was confused by Slide 53 and suggested making changes to indicate that, while discharge is being removed from RIX (in Riverside-Arlington Basin), it was being relocated to the SBBA. Mr. Yeh replied that the figure will be modified.

6. Mr. Huang stated that the CWF will likely slowly ramp up in production. Mr. Barnes explained that no ramp-up is currently assumed. Mr. Sovich observed that the current assumptions provide a worst case scenario.

7. Ms. Li asked what the source of water is for Victoria recharge. Mr. Shaw responded that it will be a mix of recycled and non-potable water.

8. Mr. Boushaki asked how SWP water will be "maximized" in SBBA and whether delivery probabilities are being factored in. Mr. Yeh replied that the amount of available SWP water is based on State projections. Mr. Tincher added that, in reality, Valley District would probably want to utilize SWP water first. The main questions are then 1) can SWP water alone satisfy Valley District needs? 2) Can all of the proposed HCP projects be completed without producing rejected recharge? and 3) How should projects be phased to maximize cost and effect? These questions are reflected in the SBBA assumptions for the management scenarios. In addition, Mr. Tincher does not foresee Valley District needing to install additional extraction wells. From a management perspective, they would rather constrain recharge rather than put more water in the ground than needed or safe relative to liquifaction thresholds. Mr. Sovich asked if future SWP use will be more than current use and Mr. Tincher replied that SWP use will likely go up with demand, depending on supply. Mr. Sovich asked if 2040 pumping is enough to offset increased demand in the SBBA. Mr. Barnes replied that it depends on the hydrology. Geoscience has run the bookend model runs, but has not finished the phasing assumptions. Ms. Dyer said she will take a look at the proposed phasing she provided to ICF.

9. Mr. Gastellum asked how 2040 pumping was established for the management scenarios. Mr. Barnes replied that the approach varied depending on the model area. Urban water management plans were used for Rialto-Colton Basin, and Geoscience worked with water agencies or constrained pumping to water levels from Index Wells for the other model areas.

10. Mr. Shaw asked if they were able to get SWP water to Rialto-Colton Basin. Mr. Huang replied that they are working on constructing conveyance to Cactus Basins. He also suggested mentioning the 2018 Settlement in the constraints.

11. Mr. Tincher observed a discrepancy between the initial water level for the Western Judgement Index Wells used for the scenario runs and the current water level shown on slides 75 and 77. The initial water level is about 50 ft higher than observed 2019 measurements, which would affect the pumping assumptions for the predictive scenario runs; the index wells will be below the judgment minimum threshold of 822 ft for the majority of the predictive period (2020-2044). Mr. Barnes replied that the initial condition was taken as the water level elevation at the end of the calibration period (i.e., 2016) but that he would investigate the differences. Mr. Gastellum suggested that water level differences also be evaluated in terms of model calibration at those wells.

12. In response to the water budget comparisons provided on Slide 78, Mr. Danskin observed that it is often helpful to have a "Cliff Notes" version of the modeling results, which can be helpful for interpreting big picture changes. For example, where did the water come from? Where did it go to? Furthermore, he suggested that it's even more helpful if the explanation could be

provided succinctly (~10 words or less). Mr. Yeh replied that Geoscience will work on these simple explanations.

13. Mr. Palenscar stated that he assumed the drop in ET was due to a change in vegetation. He enquired where these changes might be happening. Mr. Barnes replied that he would have to look at the water budgets a little closer, but offered that it may be related to changes in groundwater pumping in some areas. Mr. Sovich also observed that high groundwater disappeared between Scenario 4.1 and Scenario 4.2. Mr. Yeh explained that this was due to the relocation of recharge to upgradient areas.
14. In response to the table summarizing average rising water between scenario runs, as shown on Slide 79, Mr. Tincher asked what change is significant. Ms. Dyer replied that the biologists will take the data and translate it as part of the EIR analysis. Mr. Boushaki suggested adding deltas to the table to make the differences easy to discern.
15. Mr. Palenscar asked whether the model was able to estimate streamflow at different places. Mr. Barnes replied in the affirmative and explained that the model has both groundwater and surface water budgets. Mr. Boushaki asked what the spatial resolution of the Streamflow Routing Package was and Mr. Barnes replied 100 ft.

ITEM 7: OTHER BUSINESS

No other business was discussed.

ITEM 8: NEXT MEETING

The next Integrated SAR Model meeting will be a conference call on Thursday, January 23rd from 10:00 – 11:30 am. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Wednesday, December 4th, 2019 at 4:30 pm.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)

Action Item Description	Responsible Agency	Status
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)

Action Item Description	Responsible Agency	Status
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	Complete
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	Complete
Items from 18-Jul-18 Conference Call		

Action Item Description	Responsible Agency	Status
44. Meeting with Valley District, USFWS, CDFW, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete
Items from 14-Sep-18 Workshop		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete
Items from 10-Oct-18 Conference Call		
46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	Complete
Items from 15-Nov-18 Conference Call		
47. Verify project IDs for the HCP covered activities in the predictive scenario runs	GEOSCIENCE/ICF	Complete
Items from 20-Dec-18 Conference Call (none)		
Items from 29-Jan-19 Workshop		
48. Modify TM 5a figures based on suggestions from the TAC	GEOSCIENCE	In Progress
49. Add a simple table to TM 5a showing recharge/discharge for each HCP Covered Activity	GEOSCIENCE	Complete
50. Modify recharge values for West.6	GEOSCIENCE / Western	Complete
51. Develop assumptions for management runs (Scenario 4)	TAC	Complete
52. Break out flow statistics seasonally and monthly in TM 5a	GEOSCIENCE	In Progress
53. Create new figure(s) in TM 5a showing difference in ET	GEOSCIENCE	Complete
Items from 28-Feb-19 Conference Call		
54. Create a figure showing the distribution of average precipitation change factors over a 12-month period.	GEOSCIENCE	Complete
Items from 28-Mar-19 Conference Call		
55. Add figures for context re: redistribution of flows to the SAR (e.g., SNRC, SAR Sustainable Parks and Tributaries Water Reuse Project)	GEOSCIENCE	Complete
56. Revise/clarify figures for climate change factors.	GEOSCIENCE	Complete
57. Circulate the climate change guidance document to the TAC	GEOSCIENCE	Complete
58. Create cumulative departure chart with projected precipitation under climate change conditions and actual precipitation	GEOSCIENCE	In Progress
Items from 30-May-19 Workshop		

Action Item Description	Responsible Agency	Status
59. Schedule a modeling subcommittee meeting to discuss IEUA/CBWM comments on the Integrated SAR Model	GEOSCIENCE	Complete
60. Document results of modeling subcommittee meeting to present to the TAC	GEOSCIENCE / USGS	Complete
61. Check to see if the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) are available so that model results in Chino Basin can be compared directly	Ron Craig	In Progress
62. Provide changes to streamflow from HCP Activities in both AFY and cfs, particularly in areas where habitat is a concern	GEOSCIENCE	Complete
63. Distribute animation of river footprint to TAC and add geographic reference points	GEOSCIENCE	In Progress
64. Decide if another scenario run should be made to determine the incremental effect of non-HCP projects that are already planned and approved	TAC	In Progress
65. Summarize project assumptions in terms of a water balance (where water is going and how much)	GEOSCIENCE	Complete
Items from 26-Jun-19 Conference Call		
66. Further annotations to animation of river footprint through time, including replacing stress period with year	GEOSCIENCE	In Progress
67. Create stacked bar chart for rising water	GEOSCIENCE	In Progress
68. Look at different shallow groundwater footprints (e.g., 12-15 ft)	GEOSCIENCE	Complete
Items from 25-Jul-19 Conference Call (none)		
Items from 17-Sep-19 Conference Call		
69. Create cumulative departure of runoff figure	GEOSCIENCE	In Progress
70. Create figures for management runs illustrating response	GEOSCIENCE	In Progress
71. Edit figures/tables showing possible areas impacted by change in shallow depth to groundwater based on comments and suggestions from TAC	GEOSCIENCE/ICF	In Progress
Items from 4-Dec-19 Workshop		
72. Resend DWR Climate Change Guidance Document to TAC	GEOSCIENCE	Completed
73. Compare Integrated SAR Model SNRC assumptions to SAWPA Wasteload Allocation Model SNRC assumptions	GEOSCIENCE	Completed

Action Item Description	Responsible Agency	Status
74. Modify figure showing change in discharge for Scenario 2g (CWF)	GEOSCIENCE	In Progress
75. Provide HCP Project phasing	Valley District	In Progress
76. Add 2018 Settlement Agreement to constraints for Rialto-Colton management runs	GEOSCIENCE	In Progress
77. Investigate differences between initial modeled water level in Index Wells for scenario runs and current observed water levels	GEOSCIENCE	In Progress
78. Discuss areas where ET is dropping and what may be causing the change (e.g., change in vegetation due to pumping, groundwater levels, etc.)	GEOSCIENCE	In Progress
79. Add deltas to table comparing rising groundwater for all scenario runs	GEOSCIENCE	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	

Item	Description
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.
Items from 17-May-18 Conference Call	

Item	Description
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
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46	"Surface Water Discharge" components will be clarified (e.g., recycled water discharge, dewatering discharge, OC-59 turnout water, etc.).
Items from 26-Jun-19 Conference Call (none)	
Items from 25-Jul-19 Conference Call	
47	Additional work will be completed according to the conclusions from the modeling subcommittee meeting (as summarized in the documents prepared by USGS, WEI, and OCWD). TM-3 will also be updated to include additional information in response to comments.
Items from 17-Sep-19 Conference Call (none)	
Items from 4-Dec-19 Workshop	
48	Short, concise summaries will be added for each project describing modeling results.

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

January 23, 2020
10:00 am – 11:30 am

Issued on February 21, 2020

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	CA State Water Resources Control Board (State Board): Jan Stepek
	Elsinore Valley Municipal Water District (EVMWD): Jesus Gastellum
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, David Barnes, and Lauren Wicks
	Orange County Water District (OCWD): Tim Sovich
	RBC Resources: Ron Craig
	Riverside Public Utilities (RPU): Farid Boushaki, Mike Plinski, and Greg Herzog
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher, Kai Palenscar, and Kirsten
	Western Municipal Water District (WMWD): Mallory Gandara

ITEM 1: APPROVAL OF 4-DEC-19 WORKSHOP MINUTES

Mr. Boushaki provided a comment via email regarding number 11 of the draft workshop minutes. This comment was incorporated into the finalized meeting minutes. No other comments were provided by the TAC. Any remaining comments will be received until close of business, Monday, 27-Jan-20, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed the updated project schedule. Upcoming milestones include a finalized version of TM-3 (Model Calibration), draft TM-5c (Scenarios, part three), draft Final Report, and Final Report. The project is expected to be completed by the end of April 2020.

ITEM 3: REVIEW ACTION ITEM LIST

There were no questions from the group on the Action Item list from the last meeting, which was also included in the agenda and previous meeting minutes.

ITEM 4: REVIEW DECISION LOG

There were no questions from the group on the decision log from the last meeting, which was also included in the agenda and previous meeting minutes.

ITEM 5: FOLLOW-UP: WESTERN JUDGMENT INDEX WELLS WATER LEVELS

Mr. Barnes reviewed the water levels used for the Western Judgment Index Wells and explained that the current water level used for the model scenarios is approximately 50 ft higher than 2019 observed levels. This is due to a combination of two factors. 1) Observed water levels after model calibration (2016) continue to drop through 2019. This accounts for approximately 25 ft of the difference. 2) Model calibration tends to overestimate water levels in the vicinity of the index wells (approximately 25 ft). Seven additional model calibration runs were conducted since the last meeting, but water levels at the end of model calibration were unable to be significantly improved in these areas. Geoscience recommends addressing the bias by shifting the initial water levels down to observed levels. Additional calibration can be performed at a later time to improve water levels in this area. A note will be made in the final report.

Questions and comments included:

1. Mr. Tincher asked how the model accounts for data points influenced by pumping, and observed that some of the data points after 2011 may not be static. Mr. Yeh replied that pumping water levels are typically removed prior to calibration. Mr. Barnes added that he will go back and check those points to see if they were static or not.
2. Mr. Plinsky asked what might be causing the model to overestimate water levels in the key well areas and Mr. Yeh replied that it might be due to the screened interval of the well(s) and lithology. Something seems to happen when water levels drop, and additional work is needed to investigate this area. Mr. Romero agrees and noted that calibration at Flume 2 and 5 seems to miss during dry periods and wondered if it was related to the river potentially going dry. Mr. Barnes replied that they can look into this. Mr. Romero also explained that these types of issues frequently arise when looking at specific areas in models – he agreed that progress should keep moving forward but that the issue should be addressed through future work.
3. Mr. Plinsky commented that the treatment plant for some of the Flume wells was turned on in 2007-2008 and wondered if this might be related. Mr. Yeh replied that Geoscience needs to look at water levels at different depths but that they confirmed with Riverside that the pumping volumes used in the model were correct.
4. Mr. Boushaki questioned whether the correction would be a systematic bias removal across the model or at a specific point and asked what effects this would have elsewhere. Mr. Barnes replied that they are looking at removing the bias for the initial condition in the predictive scenarios and have not looked at bias removal for other periods.

ITEM 6: UPDATES TO TM3 BASED ON SUBGROUP ACTION ITEMS

Mr. Barnes briefly reviewed changes that will be incorporated into the finalized version of Technical Memorandum (TM) No. 3 in response to action items from the July 2019 modeling subcommittee workshop. He also addressed a question that was made about what portion of return flow imported water makes up. He explained that return flow methodologies used for the Integrated SAR Model are different depending on the methodologies used for the individual models. He also showed a hypothetical slide showing the potential fate of imported water recharge in the basin.

Questions and comments included:

5. Mr. Tincher and Mr. Gastellum asked about the return flow percentage on Slide 48 (28.2%). Mr. Barnes replied that Slide 48 is just a hypothetical example.
6. Mr. Yeh explained that when imported water recharges in spreading grounds or through direct use, it will mix with local groundwater. When this water is pumped and applied for various subsequent uses (e.g., landscape irrigation), the contribution of imported water to the return flows cannot be quantified without making a solute transport model run to determine the amount of mixing.
7. Mr. Plinsky urged caution and explained that we need to understand how the fate of return flows manifest in the real world (e.g., how losses to ET and underflow going to be handled?). Mr. Yeh agreed and clarified that the return flow calculation currently considered by the Integrated SAR Model is only for the first year (i.e., application of water and initial return flow). He explained that the solute transport model would also track losses year by year.
8. Mr. Plinsky also mentioned that we also need to understand where water gets applied and how that is handled in the model. Mr. Yeh replied that the imported water would be distributed based on use by agency. Mr. Plinsky asked how the model handles the confining layer in the pressure zone and Mr. Yeh replied that it depends on the vertical and horizontal hydraulic conductivity of each layer.

ITEM 7: OVERVIEW OF DRAFT TM NO. 5C: PREDICTIVE SCENARIO RESULTS – PART 2

Mr. Barnes also briefly reviewed some additional results from TM No. 5c that were not able to be covered during the last model workshop due to time constraints.

Questions and comments included:

9. Mr. Herzog suggested that Geoscience may want to reconsider using Thorne 10 as a key well to show hydrographs for the predictive scenarios since it has been destroyed. Mr. Barnes asked if he could recommend a good replacement well in the area and Mr. Herzog and Mr. Plinsky said they would look into some options and circle back.

ITEM 8: OTHER BUSINESS

No other business was discussed.

ITEM 9: NEXT MEETING

The next Integrated SAR Model meeting will be a conference call on Tuesday, February 18th from 9:00 – 10:00 am. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Thursday, January 23rd, 2020 at 11:30 am.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		

Action Item Description	Responsible Agency	Status
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
18. Provide stand-alone SBBA Model files to Balleau for review after return flow has been updated	GEOSCIENCE	Complete
19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
Items from 27-Sep-17 Workshop		
21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		

Action Item Description	Responsible Agency	Status
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	Complete
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		

Action Item Description	Responsible Agency	Status
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	Complete
Items from 18-Jul-18 Conference Call		
44. Meeting with Valley District, USFWS, CDFW, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete
Items from 14-Sep-18 Workshop		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete
Items from 10-Oct-18 Conference Call		
46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	Complete
Items from 15-Nov-18 Conference Call		
47. Verify project IDs for the HCP covered activities in the predictive scenario runs	GEOSCIENCE/ICF	Complete
Items from 20-Dec-18 Conference Call (none)		
Items from 29-Jan-19 Workshop		
48. Modify TM 5a figures based on suggestions from the TAC	GEOSCIENCE	In Progress
49. Add a simple table to TM 5a showing recharge/discharge for each HCP Covered Activity	GEOSCIENCE	Complete
50. Modify recharge values for West.6	GEOSCIENCE / Western	Complete
51. Develop assumptions for management runs (Scenario 4)	TAC	Complete
52. Break out flow statistics seasonally and monthly in TM 5a	GEOSCIENCE	In Progress
53. Create new figure(s) in TM 5a showing difference in ET	GEOSCIENCE	Complete
Items from 28-Feb-19 Conference Call		
54. Create a figure showing the distribution of average precipitation change factors over a 12-month period.	GEOSCIENCE	Complete
Items from 28-Mar-19 Conference Call		
55. Add figures for context re: redistribution of flows to the SAR (e.g., SNRC, SAR Sustainable Parks and Tributaries Water Reuse Project)	GEOSCIENCE	Complete
56. Revise/clarify figures for climate change factors.	GEOSCIENCE	Complete
57. Circulate the climate change guidance document to the TAC	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
58. Create cumulative departure chart with projected precipitation under climate change conditions and actual precipitation	GEOSCIENCE	In Progress
Items from 30-May-19 Workshop		
59. Schedule a modeling subcommittee meeting to discuss IEUA/CBWM comments on the Integrated SAR Model	GEOSCIENCE	Complete
60. Document results of modeling subcommittee meeting to present to the TAC	GEOSCIENCE / USGS	Complete
61. Check to see if the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) are available so that model results in Chino Basin can be compared directly	Ron Craig	In Progress
62. Provide changes to streamflow from HCP Activities in both AFY and cfs, particularly in areas where habitat is a concern	GEOSCIENCE	Complete
63. Distribute animation of river footprint to TAC and add geographic reference points	GEOSCIENCE	In Progress
64. Decide if another scenario run should be made to determine the incremental effect of non-HCP projects that are already planned and approved	TAC	In Progress
65. Summarize project assumptions in terms of a water balance (where water is going and how much)	GEOSCIENCE	Complete
Items from 26-Jun-19 Conference Call		
66. Further annotations to animation of river footprint through time, including replacing stress period with year	GEOSCIENCE	In Progress
67. Create stacked bar chart for rising water	GEOSCIENCE	In Progress
68. Look at different shallow groundwater footprints (e.g., 12-15 ft)	GEOSCIENCE	Complete
Items from 25-Jul-19 Conference Call (none)		
Items from 17-Sep-19 Conference Call		
69. Create cumulative departure of runoff figure	GEOSCIENCE	In Progress
70. Create figures for management runs illustrating response	GEOSCIENCE	In Progress
71. Edit figures/tables showing possible areas impacted by change in shallow depth to groundwater based on comments and suggestions from TAC	GEOSCIENCE/ICF	In Progress
Items from 4-Dec-19 Workshop		

Action Item Description	Responsible Agency	Status
72. Resend DWR Climate Change Guidance Document to TAC	GEOSCIENCE	Completed
73. Compare Integrated SAR Model SNRC assumptions to SAWPA Wasteload Allocation Model SNRC assumptions	GEOSCIENCE	Completed
74. Modify figure showing change in discharge for Scenario 2g (CWF)	GEOSCIENCE	In Progress
75. Provide HCP Project phasing	Valley District	In Progress
76. Add 2018 Settlement Agreement to constraints for Rialto-Colton management runs	GEOSCIENCE	In Progress
77. Investigate differences between initial modeled water level in Index Wells for scenario runs and current observed water levels	GEOSCIENCE	In Progress
78. Discuss areas where ET is dropping and what may be causing the change (e.g., change in vegetation due to pumping, groundwater levels, etc.)	GEOSCIENCE	In Progress
79. Add deltas to table comparing rising groundwater for all scenario runs	GEOSCIENCE	In Progress
Items from 23-Jan-23 Conference Call		
80. Check that water level measurements used for Judgment wells are static	GEOSCIENCE	In Progress
81. Provide suggestion for replacement of Thorne 10 hydrograph for predictive scenarios	RPU	In Progress

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.
Items from 21-Jun-17 Conference Call	

Item	Description
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model, actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.

Item	Description
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.
Items from 17-May-18 Conference Call	
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
Items from 20-Jun-18 Model Workshop	
28	Terminology for the steady state run will be modified to reflect pseudo steady state conditions.
29	The initial calibration results (Draft TM No. 1) will be added onto calibration hydrographs in Draft TM No. 3 for comparison.
30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.
Items from 14-Sep-18 Workshop	
33	Additional detail regarding calibration (decisions, steps, methodology, etc.) will be included in the final TM-3.
Items from 10-Oct-18 Conference Call	
34	The numbering for the proposed scenario runs will reflect that originally used in the proposal.
35	A "sensitivity run" will be made with no pumping to evaluate whether the model can reproduce water level patterns seen in the 1905 Mendenhall maps of the area.
36	A model scenario will be added to evaluate groundwater basin management activities that differ from the baseline.
Items from 15-Nov-18 Conference Call	
37	For Scenario 1d (sensitivity run with no pumping), artificial recharge and other pre-development activities will also be removed.
Items from 20-Dec-18 Conference Call	
38	A simulation with no El Niño events will be included as one of the climate change alternatives.
Items from 29-Jan-19 Workshop	
39	Scenario 2 runs will be used to determine project impacts without additional modification of

Item	Description
	pumping and non-HCP recharge while the Scenario 4 runs will incorporate management and recovery plans in response to the additional recharge from the HCP Covered Activities.
Items from 28-Feb-19 Conference Call	
40	Geoscience will work with WEI to add additional discussion on the projected pumping in Chino Basin.
41	Recharge and timing of HCP projects under climate change conditions will be kept the same as those used without climate change to simplify the comparison of the results.
Items from 28-Mar-19 Conference Call	
42	Comparisons between streamflow in the SAR under baseline and climate change conditions will be made at the main streamflow gaging locations.
Items from 30-May-19 Workshop	
43	Intended purposes of the model will be acknowledged in the Limitations section of the final report.
44	Additional text will be added to the final report describing changes made during model calibration (e.g., change in underflow volumes).
45	The amount of water reaching Santa Ana Sucker habitat will be calculated with and without the Riverside North Aquifer Storage and Recovery Project (Rubber Dam Project; RPU.5).
46	"Surface Water Discharge" components will be clarified (e.g., recycled water discharge, dewatering discharge, OC-59 turnout water, etc.).
Items from 26-Jun-19 Conference Call (none)	
Items from 25-Jul-19 Conference Call	
47	Additional work will be completed according to the conclusions from the modeling subcommittee meeting (as summarized in the documents prepared by USGS, WEI, and OCWD). TM-3 will also be updated to include additional information in response to comments.
Items from 17-Sep-19 Conference Call (none)	
Items from 4-Dec-19 Workshop	
48	Short, concise summaries will be added for each project describing modeling results.
Items from 23-Jan-20 Conference Call (none)	

Minutes for the Upper Santa Ana River Integrated Model Update Conference Call

February 18, 2020
9:00 am – 10:00 am

Issued on April 10, 2020

Attendees:	Balleau Groundwater (BGW): Dave Romero and Steve Silver
	CA State Water Resources Control Board (State Board): Jan Stepek
	Elsinore Valley Municipal Water District (EVMWD): Jesus Gastellum
	GEOSCIENCE Support Services, Inc. (GEOSCIENCE): Johnson Yeh, David Barnes, and Lauren Wicks
	Orange County Water District (OCWD): Tim Sovich and Greg Woodside
	RBC Resources: Ron Craig
	Riverside Public Utilities (RPU): Farid Boushaki
	San Bernardino Valley Municipal Water District (Valley District): Bob Tincher, and Chris Jones
	Western Municipal Water District (WMWD): Jason Pivovaroff
	Wildermuth Environmental, Inc. (WEI): Mark Wildermuth

ITEM 1: APPROVAL OF 23-JAN-19 CONFERENCE CALL MINUTES

No comments were provided by the TAC. Any remaining comments will be received until close of business, Friday, 21-Feb-20, at which time the minutes shall be considered "approved" and will be finalized.

ITEM 2: REVIEW SCHEDULE

Mr. Yeh showed the updated project schedule. A finalized version of TM-3 (Model Calibration) was submitted on February 14. Upcoming deliverables include draft TM-5c (Scenarios, part three), draft Final Report, and Final Report. The project is expected to be completed by the end of April 2020.

ITEM 3: REVIEW ACTION ITEM LIST

There were no questions from the group on the Action Item list from the last meeting, which was also included in the agenda and previous meeting minutes.

ITEM 4: REVIEW DECISION LOG

There were no questions from the group on the decision log from the last meeting, which was also included in the agenda and previous meeting minutes.

ITEM 5: UPDATES TO TM NO. 3: MODEL CALIBRATION

Mr. Barnes reviewed updates to TM No. 3, which included updated calibration results, reducing the water level measurements of wells in Prado Basin to monthly intervals, including R^2 residual statistics, model-calculated water level contours vs. observed water level contours, water level profiles along the SAR, qualifying the relative contribution of inflow/outflow terms, maps showing the vertical movement of water by model layer, and maps illustrating areas of uncertainty.

Questions and comments included:

1. Mr. Boushaki asked why the observed water levels were different for the two plots along the SAR and Mr. Barnes explained that the plots are for wet and dry hydrology. Therefore, the observed measurements correspond to those periods as well.
2. Regarding geologic uncertainty, Mr. Romero commented that Note 3 (referring to generally higher water level residuals in the Yucaipa Basin) could also apply to the SBBA – particularly in the northwest area away from the SAR. Mr. Barnes agreed and explained that they struggled with how to illustrate some of the general uncertainties. He also expressed his appreciation for any suggestions on how to better represent these uncertainties on the figures. Mr. Romero concurred that uncertainty is not an easy thing to characterize and thought that the figures were a good first cut at doing so.

ITEM 6: STATUS UPDATE: TM NO. 5C PREDICTIVE SCENARIO RESULTS

Mr. Barnes briefly reviewed the progress of upcoming TM No. 5c. Iterative management runs are currently being conducted and several more scenarios are being put together. TM No. 5c is anticipated to be completed in about one month.

ITEM 7: OTHER BUSINESS

No other business was discussed.

ITEM 8: NEXT MEETING

After sending out a Doodle survey to the TAC, it was decided that the next Integrated SAR Model meeting, which will be a conference call, will be held on Tuesday, April 7th from 10:00 am – 12:00 pm. GEOSCIENCE will send around the meeting details.

ADJOURNMENT

The meeting adjourned on Tuesday, February 18th, 2020 at 10:00 am.

Action Item List

Action Item Description	Responsible Agency	Status
Items from 10-May-17 Kickoff Meeting		
1. Finalize the list of HCP covered activities	Valley District/ICF	Complete
2. Set up a matrix regarding data request items, agency responsible for providing information, and status	GEOSCIENCE	Complete (Table will be used to provide status updates)
3. Look into how changes in river channel over time will be addressed in model	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
Items from 31-May-17 Conference Call		
4. Suggest time period for which data reliability/ model performance should be emphasized (should include wet, dry, and average hydrology)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
5. Circulate suggested dates for subcommittee meeting to discuss methodology for mapping vegetation	Valley District	Complete
Items from 21-Jun-17 Conference Call		
6. Add peer review team to distribution list	GEOSCIENCE (Valley District to provide contacts)	Complete
7. Cost share members to evaluate possible inclusion of contingency line item and schedule separate meeting, if needed	Various/ Valley District	Complete
8. Provide Prado area vegetation map to Aspen	USACE	Complete
9. TAC members to review list of historical hydrology modifications and provide Leidos with any other items deemed relevant	Various	Complete
Items from 12-Jul-17 Conference Call		
10. Access to the FTP site will be made available to the members of the peer review team.	GEOSCIENCE	Complete
11. Send Adam Hutchinson's (OCWD) contact information to Mr. Degner and Mr. White	Valley District	Complete
12. Put together conceptual slides for geology, hydrology, and vegetation (*see USGS Review Comments No. 1 for details*)	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
13. Make model files available to Balleau Groundwater for review	GEOSCIENCE	Complete
Items from 19-Jul-17 Meeting		

Action Item Description	Responsible Agency	Status
14. Send USGS review comments on the Integrated SAR Model to the TAC	Valley District	Complete
Items from 10-Aug-17 Conference Call		
15. Schedule a call between GEOSCIENCE and Balleau to review model files	GEOSCIENCE	Complete
16. List limitations of not having a structural model (*see USGS Review Comments No. 2 for details*)	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft Calibration Workplan)
17. List lithologic model assumptions	GEOSCIENCE / Numeric Solutions	Complete (Included in Draft TM No. 1)
Items from 30-Aug-17 Conference Call		
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19. Propose method of weighting data for model calibration	GEOSCIENCE	Complete (Included in Draft Calibration Workplan)
20. Look for reference regarding flow from hard rock	USGS	Complete (Included in TM No. 3)
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21. Revisit areas in existing models where model over/under estimates observed water levels (e.g., Riverside-Arlington and Yucaipa Models)	GEOSCIENCE	Complete (Included in TM No. 3)
22. Schedule subcommittee meeting to resolve remaining riparian mapping concerns	Aspen/Various	Complete
23. Schedule subcommittee meeting to resolve remaining lithologic model concerns	GEOSCIENCE / Numeric Solutions	Complete
Items from 23-Oct-17 Conference Call		
24. Provide shapefile of model boundary to USGS	GEOSCIENCE	Complete
25. Schedule a face-to-face subcommittee meeting to resolve additional riparian mapping concerns	Aspen/Various	Complete
26. Provide proposed boundary for vegetation mapping prior to meeting	OCWD	Complete
27. Provide current riparian map to Balleau to review, along with any OCWD maps	GEOSCIENCE	Complete
Items from 27-Nov-17 Conference Call		
28. Follow up on basement elevations from Lengenheim et al. (2006) gravity data	USGS	Complete
Items from 18-Dec-17 Conference Call		

Action Item Description	Responsible Agency	Status
29. Submit any comments on the draft memorandum "Evaporation Estimates" to Aspen	Various	Complete
Items from 30-Jan-18 Workshop		
30. Create a figure indicating where the model might have or has trouble	GEOSCIENCE	Complete (Included in TM No. 3)
31. Come up with model layer names or designations	GEOSCIENCE / Numeric Solutions	Complete (Included in TM No. 3)
32. Look into SAWPA mapping data in tributaries	GEOSCIENCE / Aspen	Complete
33. Modify Model Layer 1 to include recent alluvium below Riverside Narrows	GEOSCIENCE / Numeric Solutions	Complete
34. Analyze how the extent of riparian vegetation changes over time (historically)	Aspen	Complete
35. Revisit top layer in Chino area and the distribution of hydraulic conductivity – should mimic geology	GEOSCIENCE	Complete
Items from 22-Feb-18 Conference Call		
36. Look at how the extent of various riparian types as well as the total riparian acreage has changed over the model calibration period (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE/ Aspen	Complete
37. Incorporate Balleau Groundwater's ET estimates in the model, along with work by Aspen and WEI (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
38. Put together a short summary of the 2 estimation methods for TAC members to submit comments on (from 7-Feb-18 Riparian Subcommittee Meeting)	GEOSCIENCE	Complete
39. Send information to group regarding revised model layers	GEOSCIENCE	Complete
Items from 22-Mar-18 Conference Call		
40. Provide comments on the Draft TM No. 1 – Model Integration	TAC Members	Complete
Items from 19-Apr-18 Conference Call		
41. Propose additional scenarios in the event that the budget allows for extra model runs.	TAC Members	Complete
42. Provide the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) in response to OCWD's comment on Draft TM No. 1.	WEI	Withdrawn – No Information Provided
Items from 17-May-18 Conference Call (none)		
Items from 20-Jun-18 Model Workshop		

Action Item Description	Responsible Agency	Status
43. Meet with HCP modeling team to coordinate modeling assumptions in the Chino Basin for predictive Scenarios.	IEUA, ICF, GEOSCIENCE, Valley District, and WEI	Complete
Items from 18-Jul-18 Conference Call		
44. Meeting with Valley District, USFWS, CDFW, and BGW to discuss riparian modeling results	Valley District, USFWS, CDFS, and BGW	Complete
Items from 14-Sep-18 Workshop		
45. Circulate list of proposed scenarios to TAC	GEOSCIENCE	Complete
Items from 10-Oct-18 Conference Call		
46. Recirculate updated list of proposed scenarios with revised numbering and prioritization to TAC	GEOSCIENCE	Complete
Items from 15-Nov-18 Conference Call		
47. Verify project IDs for the HCP covered activities in the predictive scenario runs	GEOSCIENCE/ICF	Complete
Items from 20-Dec-18 Conference Call (none)		
Items from 29-Jan-19 Workshop		
48. Modify TM 5a figures based on suggestions from the TAC	GEOSCIENCE	In Progress
49. Add a simple table to TM 5a showing recharge/discharge for each HCP Covered Activity	GEOSCIENCE	Complete
50. Modify recharge values for West.6	GEOSCIENCE / Western	Complete
51. Develop assumptions for management runs (Scenario 4)	TAC	Complete
52. Break out flow statistics seasonally and monthly in TM 5a	GEOSCIENCE	In Progress
53. Create new figure(s) in TM 5a showing difference in ET	GEOSCIENCE	Complete
Items from 28-Feb-19 Conference Call		
54. Create a figure showing the distribution of average precipitation change factors over a 12-month period.	GEOSCIENCE	Complete
Items from 28-Mar-19 Conference Call		
55. Add figures for context re: redistribution of flows to the SAR (e.g., SNRC, SAR Sustainable Parks and Tributaries Water Reuse Project)	GEOSCIENCE	Complete
56. Revise/clarify figures for climate change factors.	GEOSCIENCE	Complete
57. Circulate the climate change guidance document to the TAC	GEOSCIENCE	Complete

Action Item Description	Responsible Agency	Status
58. Create cumulative departure chart with projected precipitation under climate change conditions and actual precipitation	GEOSCIENCE	In Progress
Items from 30-May-19 Workshop		
59. Schedule a modeling subcommittee meeting to discuss IEUA/CBWM comments on the Integrated SAR Model	GEOSCIENCE	Complete
60. Document results of modeling subcommittee meeting to present to the TAC	GEOSCIENCE / USGS	Complete
61. Check to see if the electronic data used to generate Table 6-4 and the hydrographs shown in Appendices C1 and C2 of the 2013 Chino Basin Model Report (WEI, 2015) are available so that model results in Chino Basin can be compared directly	Ron Craig	In Progress
62. Provide changes to streamflow from HCP Activities in both AFY and cfs, particularly in areas where habitat is a concern	GEOSCIENCE	Complete
63. Distribute animation of river footprint to TAC and add geographic reference points	GEOSCIENCE	In Progress
64. Decide if another scenario run should be made to determine the incremental effect of non-HCP projects that are already planned and approved	TAC	In Progress
65. Summarize project assumptions in terms of a water balance (where water is going and how much)	GEOSCIENCE	Complete
Items from 26-Jun-19 Conference Call		
66. Further annotations to animation of river footprint through time, including replacing stress period with year	GEOSCIENCE	In Progress
67. Create stacked bar chart for rising water	GEOSCIENCE	In Progress
68. Look at different shallow groundwater footprints (e.g., 12-15 ft)	GEOSCIENCE	Complete
Items from 25-Jul-19 Conference Call (none)		
Items from 17-Sep-19 Conference Call		
69. Create cumulative departure of runoff figure	GEOSCIENCE	In Progress
70. Create figures for management runs illustrating response	GEOSCIENCE	In Progress
71. Edit figures/tables showing possible areas impacted by change in shallow depth to groundwater based on comments and suggestions from TAC	GEOSCIENCE/ICF	In Progress
Items from 4-Dec-19 Workshop		

Action Item Description	Responsible Agency	Status
72. Resend DWR Climate Change Guidance Document to TAC	GEOSCIENCE	Completed
73. Compare Integrated SAR Model SNRC assumptions to SAWPA Wasteload Allocation Model SNRC assumptions	GEOSCIENCE	Completed
74. Modify figure showing change in discharge for Scenario 2g (CWF)	GEOSCIENCE	In Progress
75. Provide HCP Project phasing	Valley District	In Progress
76. Add 2018 Settlement Agreement to constraints for Rialto-Colton management runs	GEOSCIENCE	In Progress
77. Investigate differences between initial modeled water level in Index Wells for scenario runs and current observed water levels	GEOSCIENCE	In Progress
78. Discuss areas where ET is dropping and what may be causing the change (e.g., change in vegetation due to pumping, groundwater levels, etc.)	GEOSCIENCE	In Progress
79. Add deltas to table comparing rising groundwater for all scenario runs	GEOSCIENCE	In Progress
Items from 23-Jan-20 Conference Call		
80. Check that water level measurements used for Judgment wells are static	GEOSCIENCE	In Progress
81. Provide suggestion for replacement of Thorne 10 hydrograph for predictive scenarios	RPU	In Progress
Items from 18-Feb-20 Conference Call (none)		

Decision Log

Item	Description
Items from 10-May-17 Kickoff Meeting	
1	To account for the length of the calibration period (1966-2016) and differences in data accuracy, additional importance will be placed on more recent data as well as model performance over the more recent time period.
2	The TAC agreed to use the USGS and Balleau Groundwater as a peer-review group, pending review of their proposals.
3	An attempt will be made to compare the Integrated SAR Model results in the Chino Basin area to WEI's Chino Basin Model to address potential differences.
Items from 31-May-17 Conference Call	
4	If monthly pumping data is not available, annual pumping will be redistributed monthly based on seasonal variations established from current conditions.
5	Published cross-sections will be used to help determine layer elevations in the reconstructed lithologic model of the Chino Basin.

Item	Description
Items from 21-Jun-17 Conference Call	
6	Optional Task 1.5 will need to be implemented in lieu of receiving Chino Basin data request items 6-13.
7	The USGS Techniques and Methods 6-A39 report (Maddock et al. 2012) and the Prado Basin Habitat Sustainability Committee Annual Report (Wildermuth Environmental, Inc. 2017) will be used as reference documents for vegetation mapping.
Items from 12-Jul-17 Conference Call	
8	Conceptual slides will be developed so that the group can come to an agreement on basic behavior/characteristics regarding geology, hydrology, and vegetation in the model area. This conceptual model will then be used to help evaluate the model results.
Items from 19-Jul-17 Meeting	
9	The Integrated SAR Model will use the MODFLOW-NWT model code with the Multi-Node Well (MNW) and Streamflow Routing Packages. A uniform cell size of 102.5 ft by 102.5 ft will be used.
10	After discussion, a bench test of the MODFLOW-USG was no longer deemed necessary.
Items from 10-Aug-17 Conference Call (none)	
Items from 30-Aug-17 Conference Call	
11	Potential flow contribution from surrounding hard rock will be acknowledged and assumptions will be stated.
Items from 27-Sep-17 Workshop	
12	The vertical scale on hydrographs will be appropriate for the purpose (e.g., a fixed vertical scale will be used to demonstrate magnitude differences between different basins while a variable vertical scale of equal distance will be used to show local variation).
13	An attempt will be made to remove bias/uncertainty caused by modeling discrepancies from transient conditions at the beginning of the model calibration period.
Items from 23-Oct-17 Conference Call	
14	A technical memorandum will be issued summarizing the sources used for the riparian vegetation mapping and reasons for their selection.
15	Balleau Groundwater will review the watershed model files when they are ready.
16	Evapotranspiration for the Chino Basin Groundwater Model will be finalized after the group is satisfied with the results of the riparian mapping.
Items from 27-Nov-17 Conference Call	
17	Areas affected by upstream activities along Chino and Mill Creeks will be included in the riparian vegetation mapping by incorporating information from IEUA and Chino Basin Watermaster Annual Reports.
Items from 18-Dec-17 Conference Call (none)	
Items from 30-Jan-18 Workshop	
18	When describing the basement or bedrock, terms such as “less-permeable” will be used instead of “non-permeable”.
19	On slides describing the method of assigning hydraulic conductivity to the Chino Basin Model,

Item	Description
	actual hydraulic conductivity will be tabulated along with initial hydraulic conductivity.
20	The screened interval(s) of each well will be identified on hydrographs.
21	Additional metrics for model performance (other than R^2) will also be considered.
Items from 22-Feb-18 Conference Call	
22	The model layer will also be identified on each hydrograph.
23	USACE-estimated inflow into Prado will also be used to evaluate modeled flow.
Items from 22-Mar-18 Conference Call (none)	
Items from 19-Apr-18 Conference Call	
24	Groundwater level contours of observed head will be created for comparison with model-simulated groundwater elevation contours.
Items from 17-May-18 Conference Call	
25	Water Level Residuals will be color coded by model layer.
26	A frequency analysis of observed streamflow will be conducted.
27	Observed water levels will be added to profiles of model-simulated water levels.
Items from 20-Jun-18 Model Workshop	
28	Terminology for the steady state run will be modified to reflect pseudo steady state conditions.
29	The initial calibration results (Draft TM No. 1) will be added onto calibration hydrographs in Draft TM No. 3 for comparison.
30	Root mean squared error (RMSE) will be added to the calibration statistics in TM No. 3.
31	One Scenario 2 predictive model run will incorporate all stormwater capture projects.
Items from 18-Jul-18 Conference Call	
32	Important issues raised during subcommittee or peer review meetings will be communicated to the TAC through email or in project update conference calls/workshops.
Items from 14-Sep-18 Workshop	
33	Additional detail regarding calibration (decisions, steps, methodology, etc.) will be included in the final TM-3.
Items from 10-Oct-18 Conference Call	
34	The numbering for the proposed scenario runs will reflect that originally used in the proposal.
35	A "sensitivity run" will be made with no pumping to evaluate whether the model can reproduce water level patterns seen in the 1905 Mendenhall maps of the area.
36	A model scenario will be added to evaluate groundwater basin management activities that differ from the baseline.
Items from 15-Nov-18 Conference Call	
37	For Scenario 1d (sensitivity run with no pumping), artificial recharge and other pre-development activities will also be removed.
Items from 20-Dec-18 Conference Call	
38	A simulation with no El Niño events will be included as one of the climate change alternatives.
Items from 29-Jan-19 Workshop	

Item	Description
39	Scenario 2 runs will be used to determine project impacts without additional modification of pumping and non-HCP recharge while the Scenario 4 runs will incorporate management and recovery plans in response to the additional recharge from the HCP Covered Activities.
Items from 28-Feb-19 Conference Call	
40	Geoscience will work with WEI to add additional discussion on the projected pumping in Chino Basin.
41	Recharge and timing of HCP projects under climate change conditions will be kept the same as those used without climate change to simplify the comparison of the results.
Items from 28-Mar-19 Conference Call	
42	Comparisons between streamflow in the SAR under baseline and climate change conditions will be made at the main streamflow gaging locations.
Items from 30-May-19 Workshop	
43	Intended purposes of the model will be acknowledged in the Limitations section of the final report.
44	Additional text will be added to the final report describing changes made during model calibration (e.g., change in underflow volumes).
45	The amount of water reaching Santa Ana Sucker habitat will be calculated with and without the Riverside North Aquifer Storage and Recovery Project (Rubber Dam Project; RPU.5).
46	"Surface Water Discharge" components will be clarified (e.g., recycled water discharge, dewatering discharge, OC-59 turnout water, etc.).
Items from 26-Jun-19 Conference Call (none)	
Items from 25-Jul-19 Conference Call	
47	Additional work will be completed according to the conclusions from the modeling subcommittee meeting (as summarized in the documents prepared by USGS, WEI, and OCWD). TM-3 will also be updated to include additional information in response to comments.
Items from 17-Sep-19 Conference Call (none)	
Items from 4-Dec-19 Workshop	
48	Short, concise summaries will be added for each project describing modeling results.
Items from 23-Jan-20 Conference Call (none)	
Items from 18-Feb-20 Conference Call (none)	

APPENDIX D

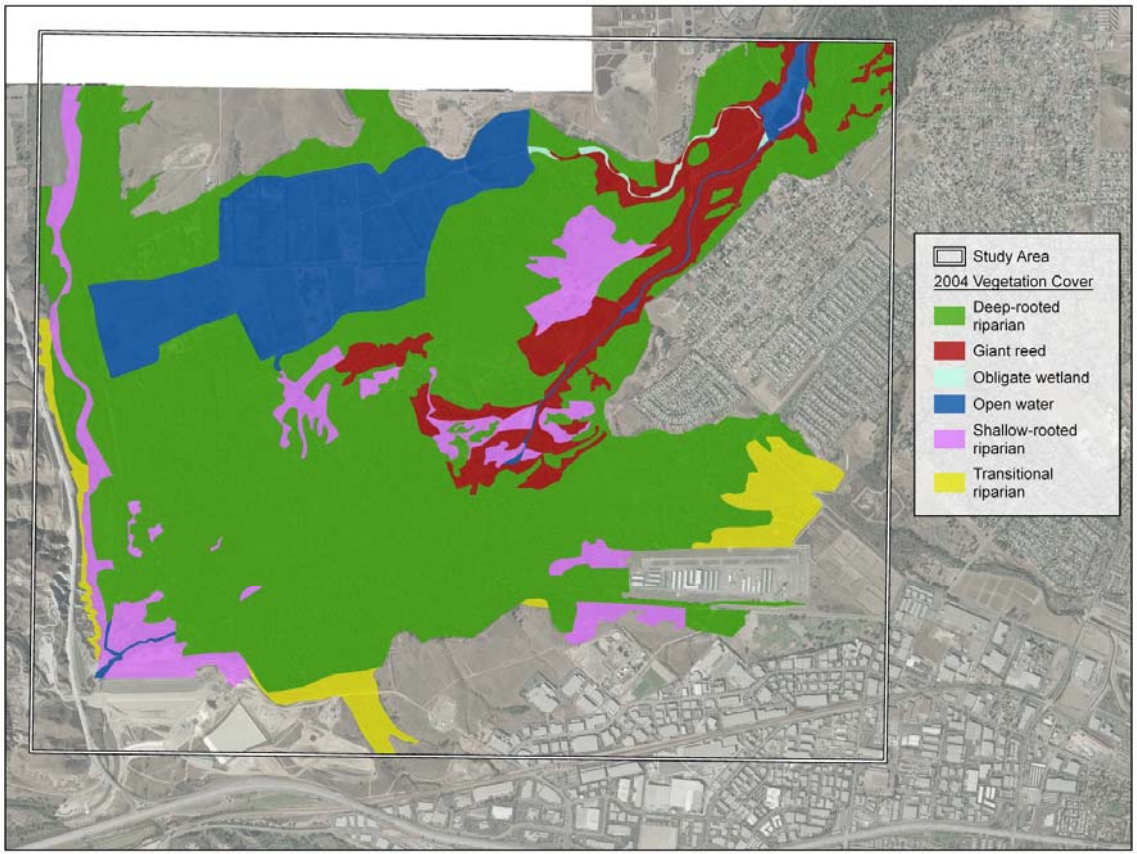
Riparian Vegetation Mapping and Consumptive Water Use

Riparian Subcommittee Meeting Presentation Slides by Aspen Environmental Group

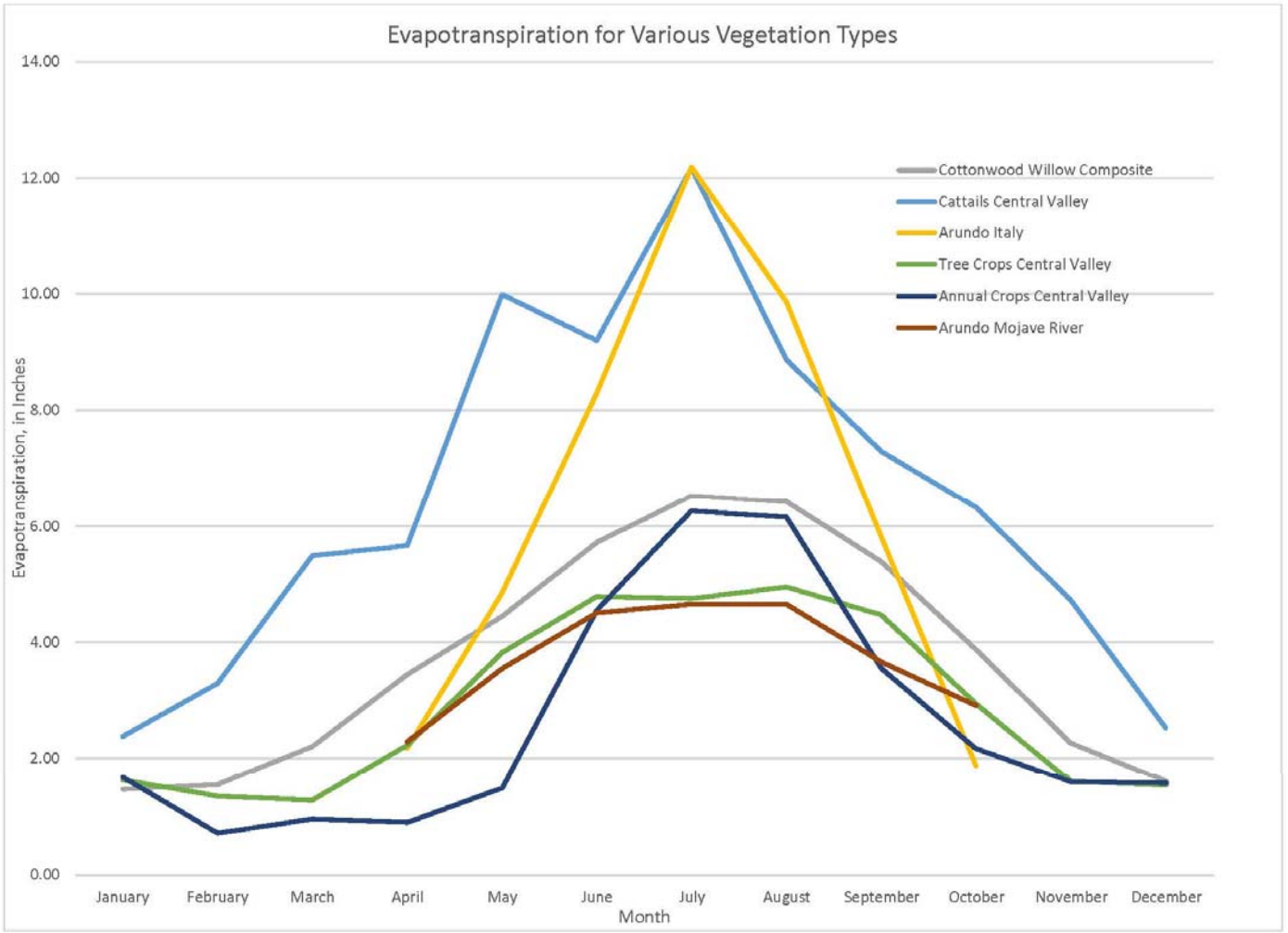
(February 7, 2018)

GEOSCIENCE

USAR Integrated Model
Riparian Subcommittee Meeting – February 7, 2018
Riparian Vegetation Mapping and Consumptive Water Use



Aspen Environmental Group


Evapotranspiration for Various Vegetation Types
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Evapotranspiration, in Inches
January
February
March
April
May
June
July
August
September
October
November
December
Month
Cottonwood Willow Composite
Cattails Central Valley
Arundo Italy
Tree Crops Central Valley
Annual Crops Central Valley
Arundo Mojave River

USAR Integrated Model
Riparian Subcommittee Meeting – February 7, 2018
Riparian Vegetation Mapping and Consumptive Water Use

Estimated annual riparian consumptive use: Prado Basin 1965-2015

Vegetation Type & ET (inches)		1965	1976	1988	1996	2004	2015
		Acre-feet / year					
Deep-rooted riparian	acres	368.9	1,813.6	2,251.7	2,395.2	2,330.3	2,296.7
57.7	annual consumption	1,773.8	8,720.4	10,827.0	11,516.9	11,204.9	11,043.2
Giant reed	acres	0.0	6.3	62.8	121.3	279.2	154.5
63.4	annual consumption	0.0	33.3	331.9	640.7	1,475.3	816.3
Obligate wetland	acres	78.7	0.0	1.6	17.9	9.0	3.7
60	annual consumption	393.5	0.0	8.2	89.5	44.9	18.4
Managed wetland	acres	0.0	0.0	536.6	493.3	478.9	477.2
50	annual consumption	0.0	0.0	2,235.8	2,055.4	1,995.6	1,988.3
Open water	acres	50.2	49.0	76.7	170.1	37.0	392.7
54	annual consumption	225.9	220.5	344.9	765.5	166.4	1,767.2
Shallow-rooted riparian	acres	62.3	664.4	60.2	274.7	307.7	151.2
31.6	annual consumption	164.1	1,749.6	158.4	723.3	810.3	398.1
Transitional riparian	acres	433.2	106.4	531.2	138.7	194.9	99.5
35.5	annual consumption	1,281.6	314.8	1,571.4	410.2	576.6	294.3
Unvegetated sandy wash	acres	433.2	106.4	531.2	3.3	0.0	0.0
1	annual consumption	36.1	8.9	44.3	0.3	0.0	0.0
Total	acres	1,426.5	2,746.1	4,051.9	3,614.4	3,637.1	3,575.4
	annual consumption	3,874.9	11,047.4	15,521.9	16,201.8	16,273.9	16,325.7

Prado Basin Estimated annual consumptive use

Σ (acres x annual ET)

(Feb 2018)

Placeholder values

Aspen Environmental Group

USAR Integrated Model
Riparian Subcommittee Meeting – February 7, 2018
Riparian Vegetation Mapping and Consumptive Water Use

Estimated annual riparian consumptive use: Riverside Narrows 1965-2015

Vegetation Type		1969	1974	1983	1996	2004	2015
Deep-rooted riparian	acres	70.3	135.5	113.3	102.2	93.3	103.4
57.7	annual consumption	338.0	651.5	544.8	491.4	448.5	497.3
Giant reed	acres	0.0	0.0	7.3	20.5	5.3	2.7
63.4	annual consumption	0.0	0.0	38.6	108.3	27.8	14.0
Obligate wetland	acres	0.0	0.0	1.5	0.0	0.0	4.2
60	annual consumption	0.0	0.0	7.5	0.0	0.0	21.0
Open water	acres	25.1	17.8	36.6	28.0	25.5	10.8
54	annual consumption	113.0	80.1	164.7	126.0	114.6	48.5
Transitional riparian	acres	6.3	8.4	17.7	25.0	37.5	56.9
35.5	annual consumption	18.6	24.9	52.4	74.0	110.8	168.4
Unvegetated sandy wash	acres	88.9	20.1	20.3	15.1	24.6	0.0
1	annual consumption	7.4	1.7	1.7	1.3	2.1	0.0
Total	acres	190.6	181.8	196.7	190.8	186.1	178.0
	annual consumption	477.0	758.2	809.6	800.9	703.8	749.2

Riverside Narrows

Estimated annual consumptive use

Σ (acres x annual ET)

(Feb 2018)

Placeholder values

USAR Integrated Model
Riparian Subcommittee Meeting – February 7, 2018
Riparian Vegetation Mapping and Consumptive Water Use

Estimated annual riparian consumptive use: Riparian corridor (excluding Prado and Riv. Narrows)

Vegetation Type		1988	1996	2010	2015
Deep-rooted riparian	acres	2,203.7	1,570.2	2,028.0	2,173.2
57.7	annual consumption	10,596.0	7,550.0	9,751.1	10,449.5
Giant reed	acres	457.8	860.7	204.4	331.2
63.4	annual consumption	2,418.7	4,547.5	1,079.9	1,749.8
Obligate wetland	acres	0.0	22.8	107.5	23.8
60	annual consumption	0.0	114.0	537.5	119.0
Open water	acres	194.5	253.2	410.2	153.3
54	annual consumption	875.3	1,139.4	1,845.8	689.8
Shallow-rooted riparian	acres	0.0	0.3	0.0	16.2
31.6	annual consumption	0.0	0.8	0.0	42.8
Transitional riparian	acres	393.1	512.0	0.0	962.1
35.5	annual consumption	1,163.0	1,514.8	0.0	2,846.3
Unvegetated sandy wash	acres	255.9	338.7	394.2	92.9
1	annual consumption	21.3	28.2	32.9	7.7
Total	acres	3,505.0	3,558.0	3,144.3	3,752.7
	annual consumption	15,074.3	14,894.7	13,247.1	15,904.9

Riparian corridor

Estimated annual consumptive use

Σ (acres x annual ET)

(Feb 2018)

Placeholder values

USAR Integrated Model
Riparian Subcommittee Meeting – February 7, 2018
Riparian Vegetation Mapping and Consumptive Water Use

Estimated annual riparian consumptive use: Upper SAR				
Location	**1983/1988**	**1996**	**2004/2010**	**2015**
Prado Basin	15,521.9	16,201.8	16,273.9	16,325.7
Riverside Narrows	809.6	800.9	703.8	749.2
SAR corridor	15,074.3	14,894.7	13,247.1	15,904.9
Total	31,405.8	31,897.4	30,224.8	32,979.8

Total

Estimated annual consumptive use

(Feb 2018)

APPENDIX E

Shallow Groundwater and Evapotranspiration Assessment

Riparian Subcommittee Meeting Presentation Slides by Balleau Groundwater, Inc.

(February 7, 2018)

GEOSCIENCE

Upper Santa Ana River Integrated Model

Shallow Groundwater and Evapotranspiration Assessment

SETTING

Interest in conceptual understanding of shallow groundwater and Evapotranspiration (ET) in the Upper Santa Ana River (SAR) area

Information provides basis for peer review of the hydrologic budget and representation of the Upper SAR in the groundwater model

Assessment based on information related to:

1. Regional Geology
2. Depth to water
3. Riparian Vegetation
4. Estimate of ET

SETTING

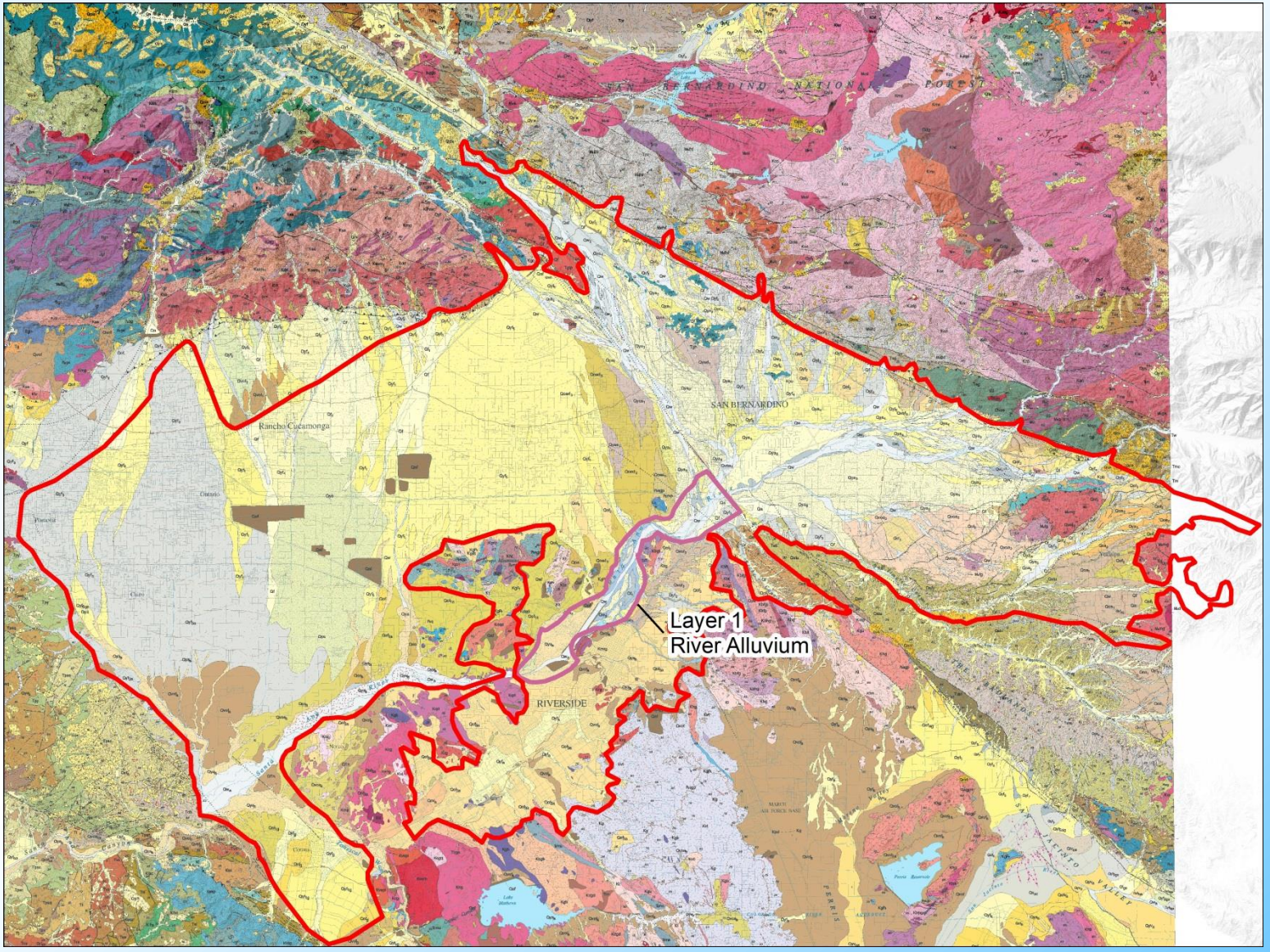
Interest in conceptual understanding of shallow groundwater and Evapotranspiration (ET) in the Upper Santa Ana River (SAR) area

Information provides basis for peer review of the hydrologic budget and representation of the Upper SAR in the groundwater model

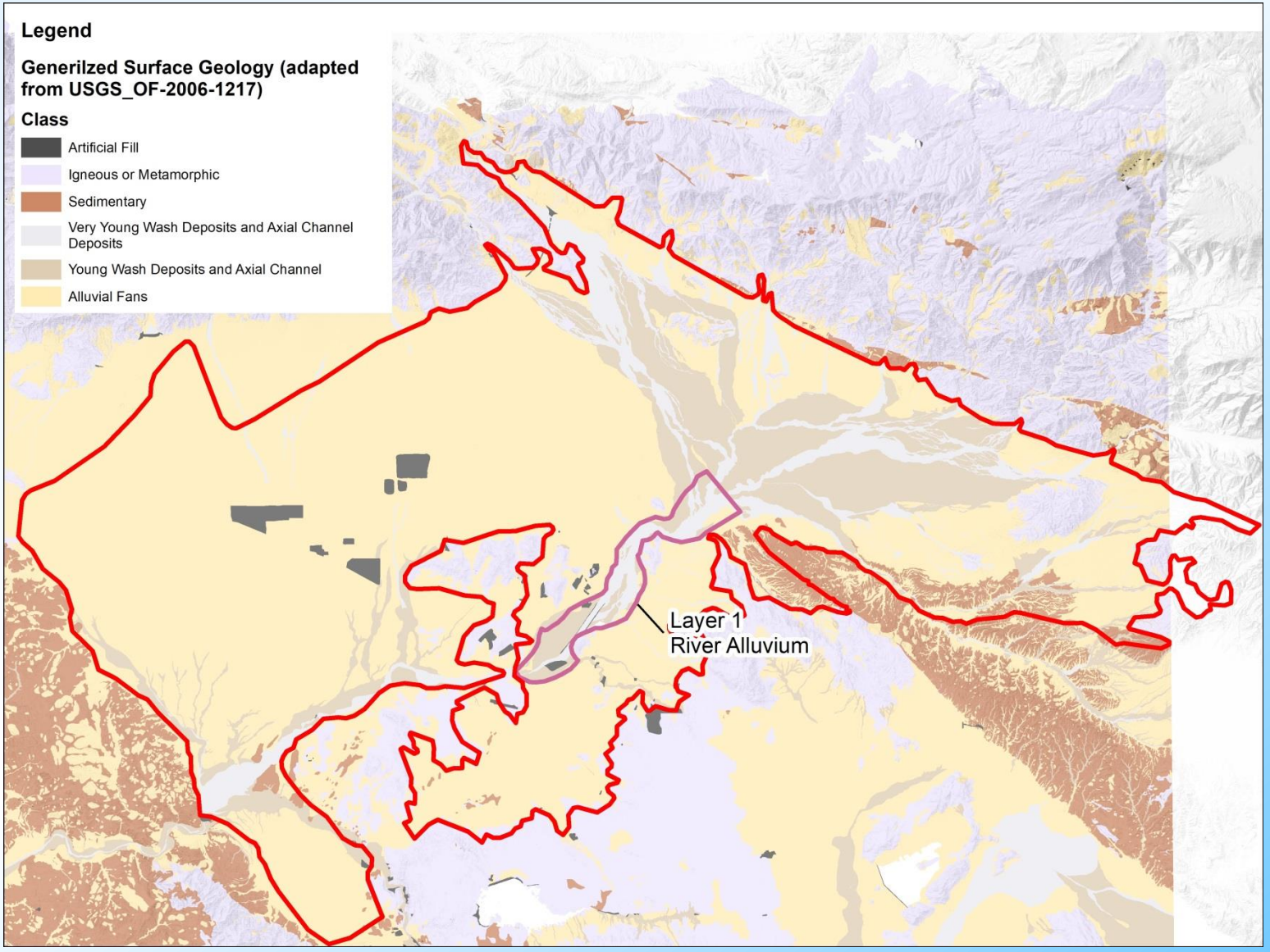
Assessment based on information related to:

1. Regional Geology
2. Depth to water
3. Riparian Vegetation
4. Estimate of ET

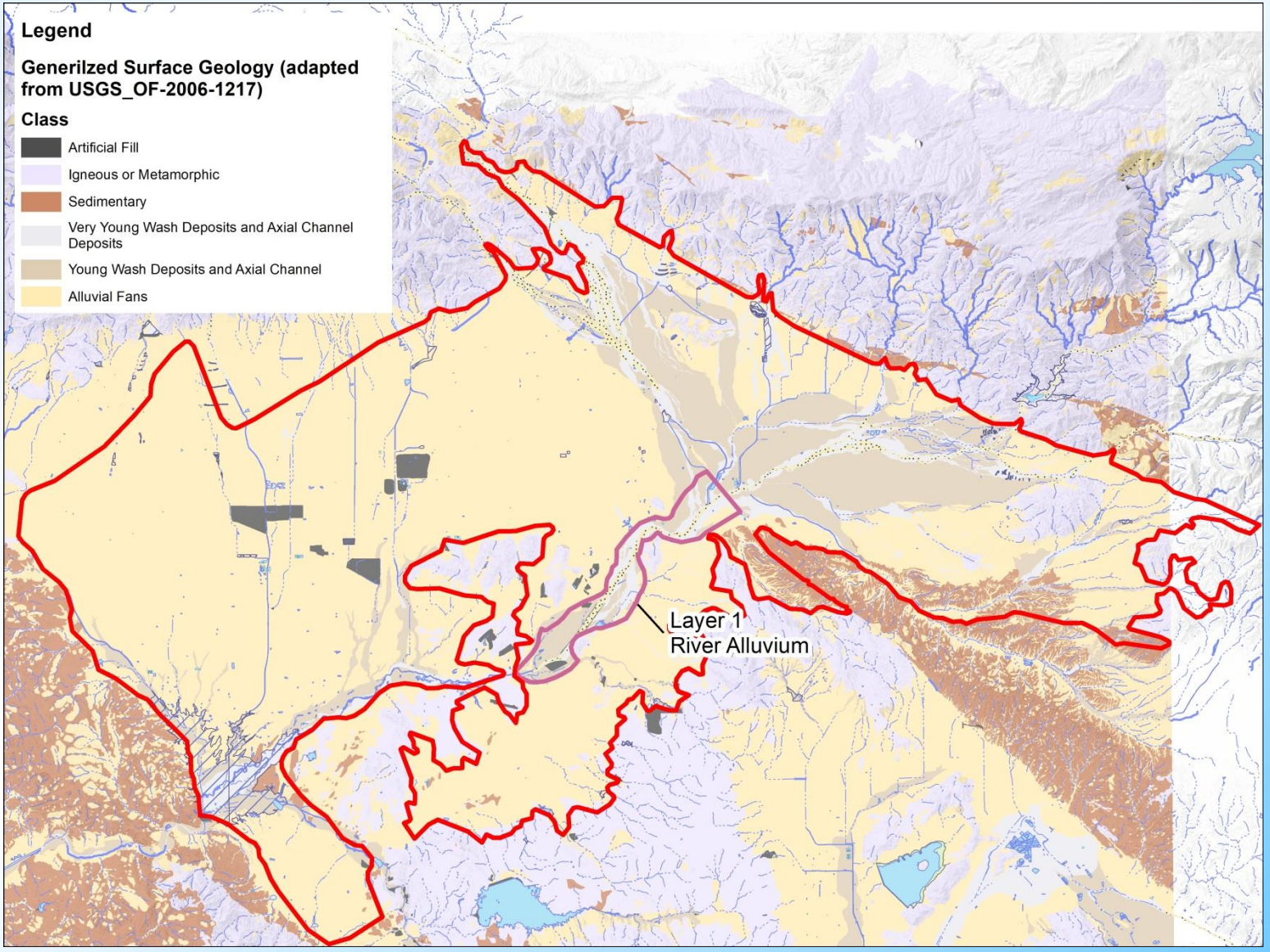
Surface Geology (adapted from USGS OFR 2006-1217)



Generalized Surface Geology (adapted from USGS OFR 2006-1217)



Streams (National Hydrography Dataset)



SETTING

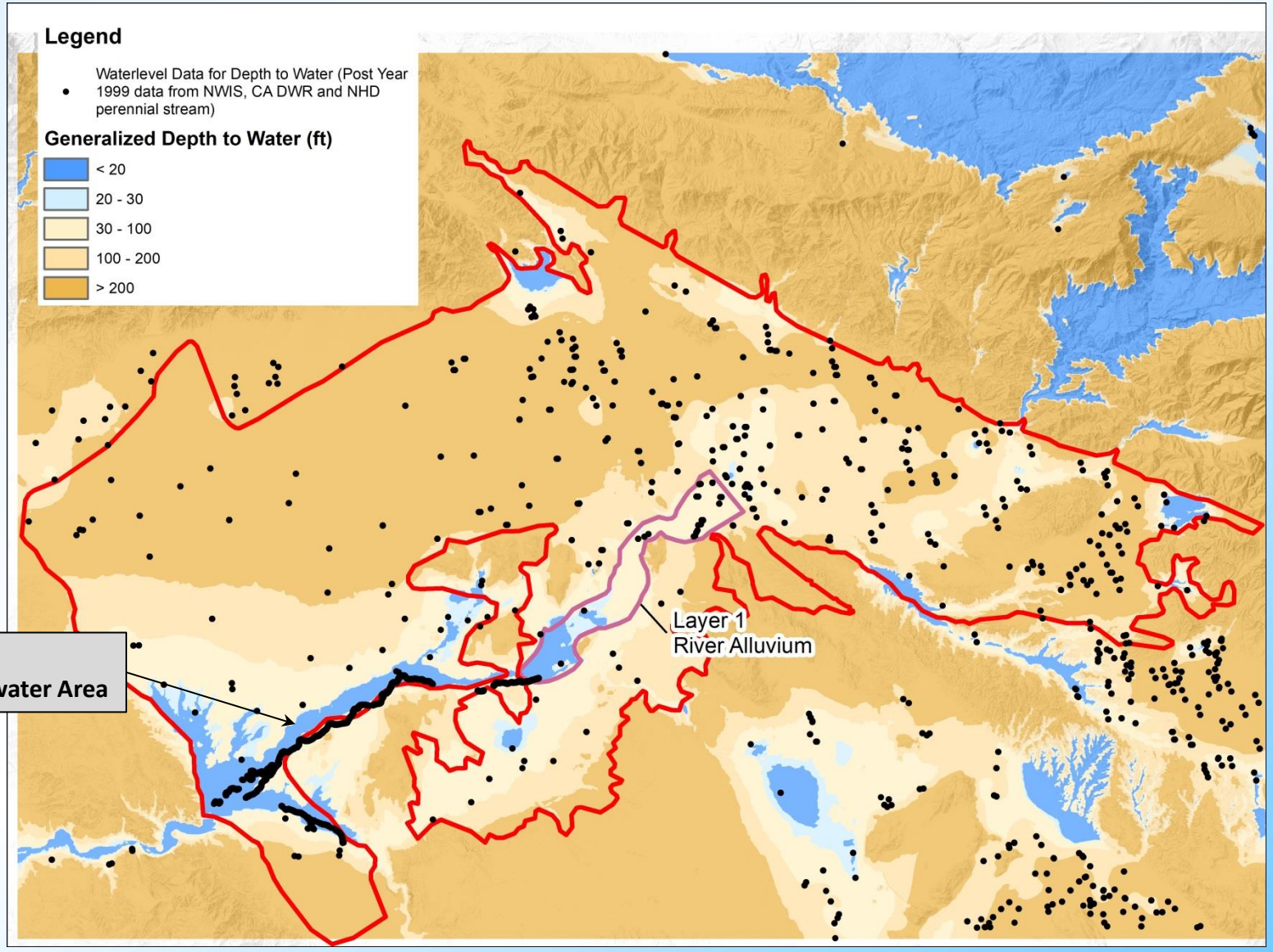
Interest in conceptual understanding of shallow groundwater and Evapotranspiration (ET) in the Upper Santa Ana River (SAR) area

Information provides basis for peer review of the hydrologic budget and representation of the Upper SAR in the groundwater model

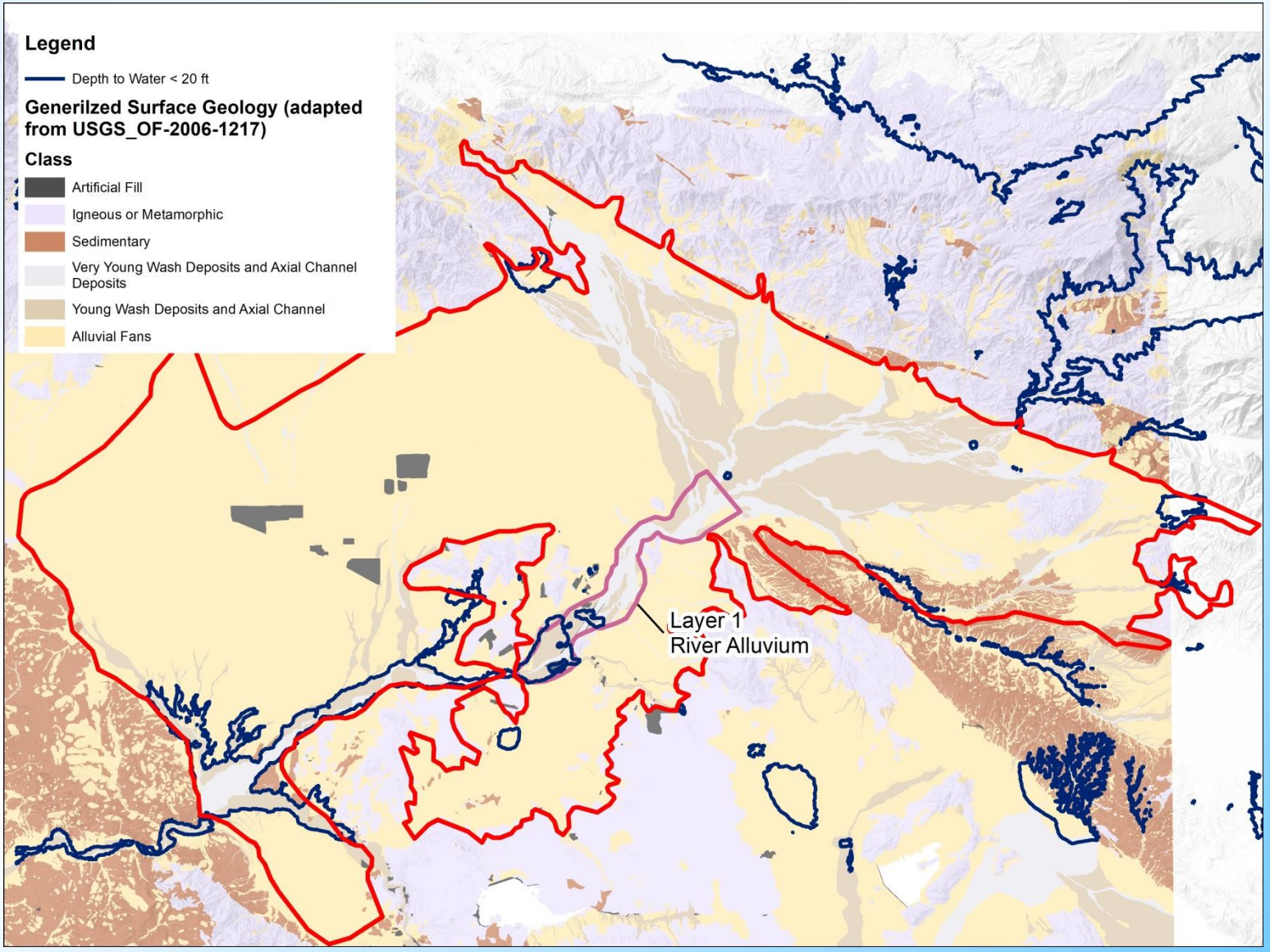
Assessment based on information related to:

1. Regional Geology
2. Depth to water
3. Riparian Vegetation
4. Estimate of ET

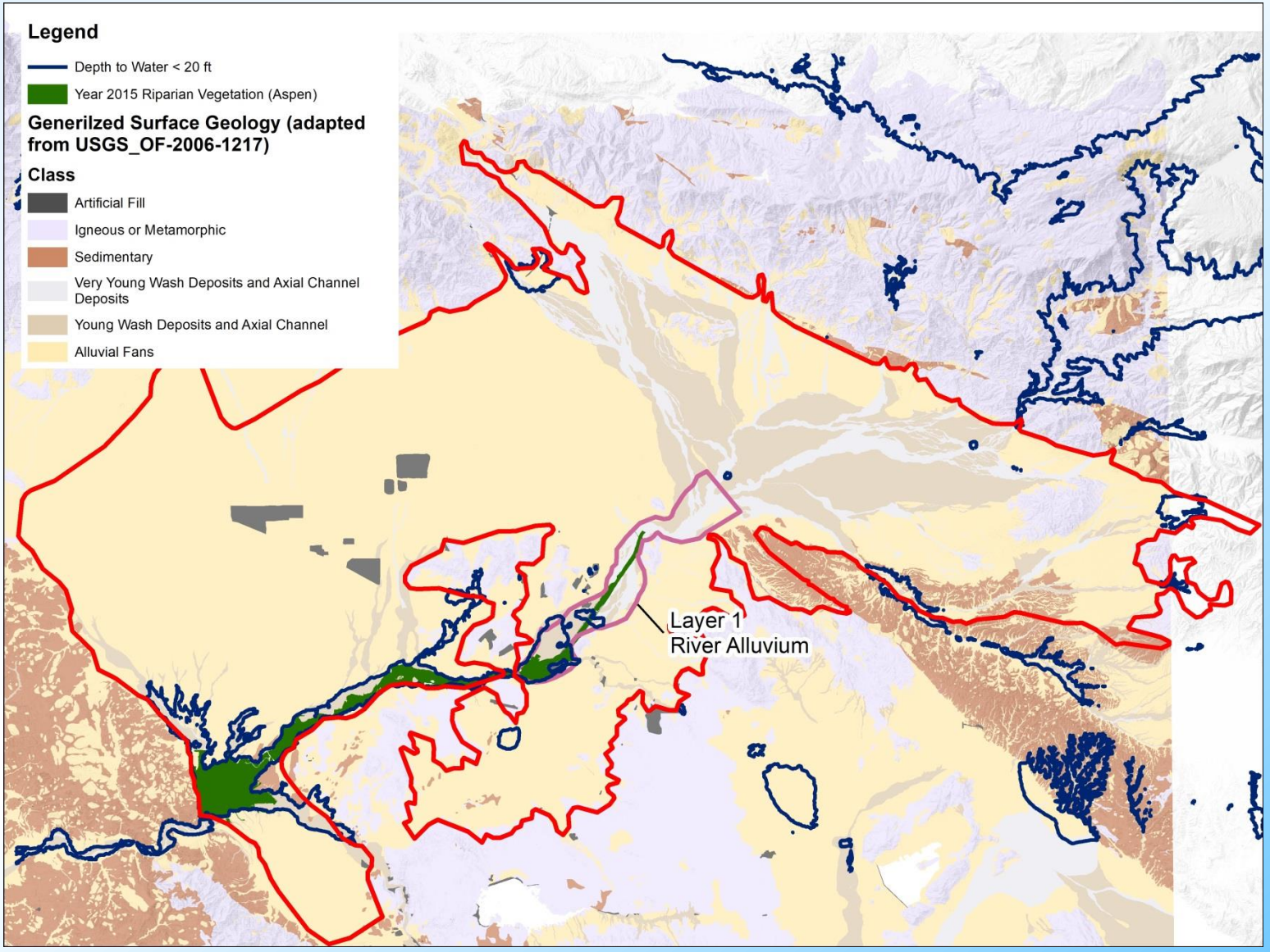
Generalized DTW (average of post 1999 water-level data)



Shallow DTW (less than 20 ft) and Geology



Shallow DTW (less than 20 ft), Geology and Riparian Vegetation



OBSERVATION

Shallow groundwater and riparian vegetation are spatially coincident with Upper Santa Ana River wash deposits along specific reaches of the river.

This suggests the groundwater model layer representing the Upper Santa Ana River should incorporate the width of river wash deposits to account for shallow groundwater interaction with the river and with ET.

A single model layer representing the river and shallow groundwater processes throughout the integrated model domain may have utility in this setting. It also would facilitate moving shallow groundwater through multiple basins.

Model development (integration) work is anticipated to guide this process and decision.

SETTING

Interest in conceptual understanding of shallow groundwater and Evapotranspiration (ET) in the Upper Santa Ana River (SAR) area

Information provides basis for peer review of the hydrologic budget and representation of the Upper SAR in the groundwater model

Assessment based on information related to:

1. Regional Geology
2. Depth to water
3. Riparian Vegetation
4. Estimate of ET

ET ESTIMATE

What is it?

We estimated ET with application of an operational Simplified Surface Energy Balance (SSEBop) to the Upper Santa Ana River Integrated Model riparian zone.

SSEBop is a thermal based approach to estimating ET (Senay et al., 2013; Savoca et al., 2013).

The method is adapted to the model area using parameters developed in a study of the Colorado River Basin (Senay et al. 2016) with LANDSAT 5 and LANDSAT 8 thermal data having 3.5 and 2.5-acre pixels respectively.

ET ESTIMATE

How does it work?

ET is estimated by applying the temperature relationship between ”Wet” areas (cool, high latent heat flux, high ET) and “Dry” areas (hot, high sensible heat flux, low ET) to remotely-sensed surface-temperature data.

Fractional ET (ET divided by reference ET) from different times can be used to obtain seasonal and yearly ET amounts.

ET ESTIMATE

Data used

Remotely sensed Thermal and Vegetation index data:
Data obtained from USGS ESPA system (https://espa.cr.usgs.gov/) includes 272 LANDSAT 5 datasets for years 1986 to 2011 and 43 LANDSAT 8 datasets for years 2013 to 2017. Averaged 10 datasets per year (LANDSAT visits every 16 days, datasets are eliminated due to cloud cover or poor quality).

Meteorological data including Reference ET, air temperature and solar radiation:
Daily data was obtained for UC Riverside station from CIMIS system (http://www.cimis.water.ca.gov/).

ET ESTIMATE

References

Senay, G.B., Bohms, S., Ramesh, K., Singh, R.K , Gowda, P.H., and Velpuri, N.M., 2013, Operational Evapotranspiration Mapping Using Remote Sensing and Weather Datasets: A New Parameterization for the SSEB Approach: Paper No. JAWRA-12-0097-P of the Journal of the American Water Resources Association (JAWRA).

Savoca, M.E., Senay, G.B., Maupin, M.A., Kenny, J.F., and Perry, C.A., 2013, Actual evapotranspiration modeling using the operational Simplified Surface Energy Balance (SSEBop): USGS Survey Scientific Investigations Report 2013-5126.

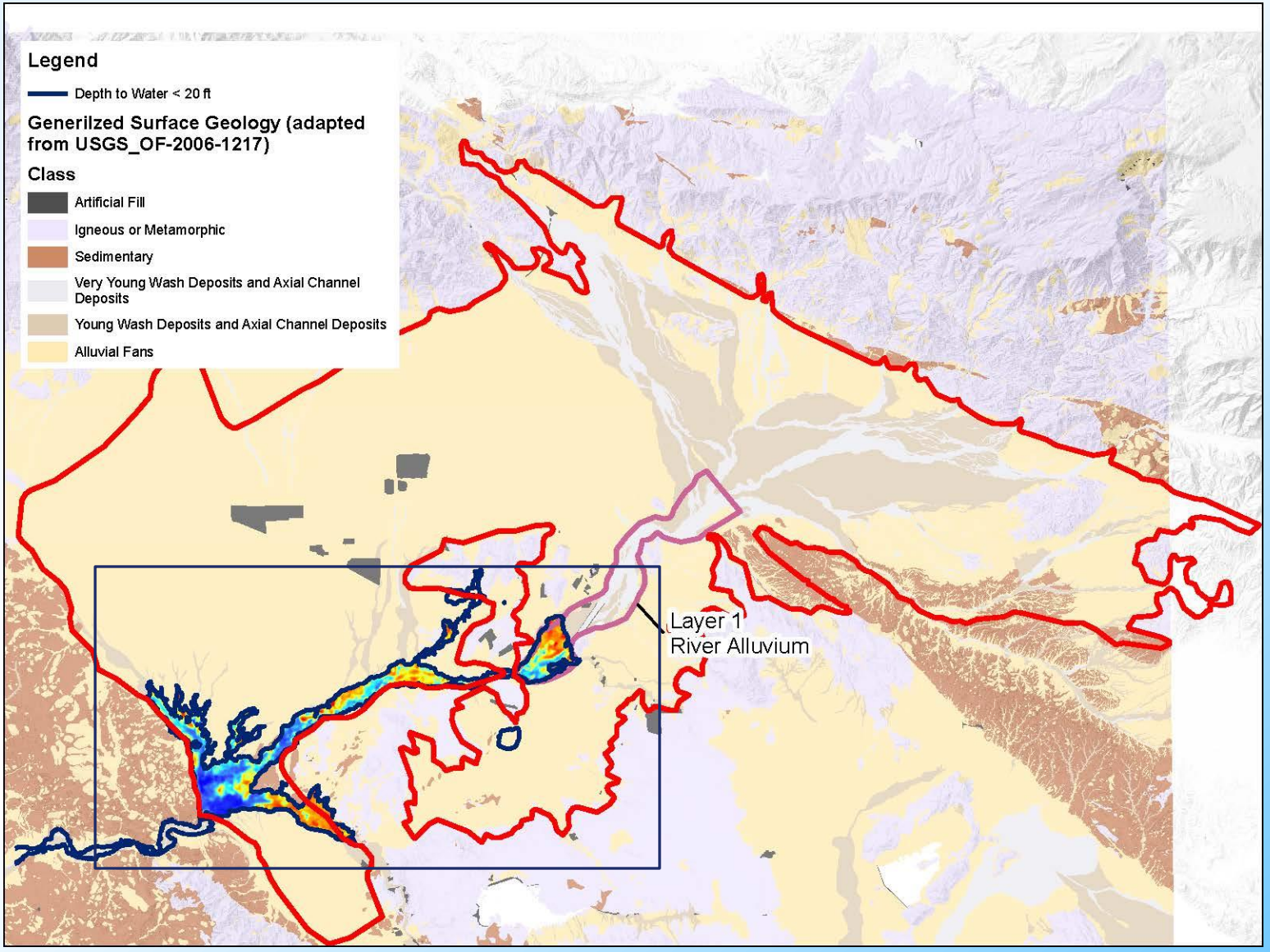
Senay, G.B., Friedrichs, M., Singh, R.K., Velpuri, N.M., 2016, Evaluating Landsat 8 evapotranspiration for water use mapping in the Colorado River Basin: Remote Sens. Environ., 185 (2016), pp. 171-185

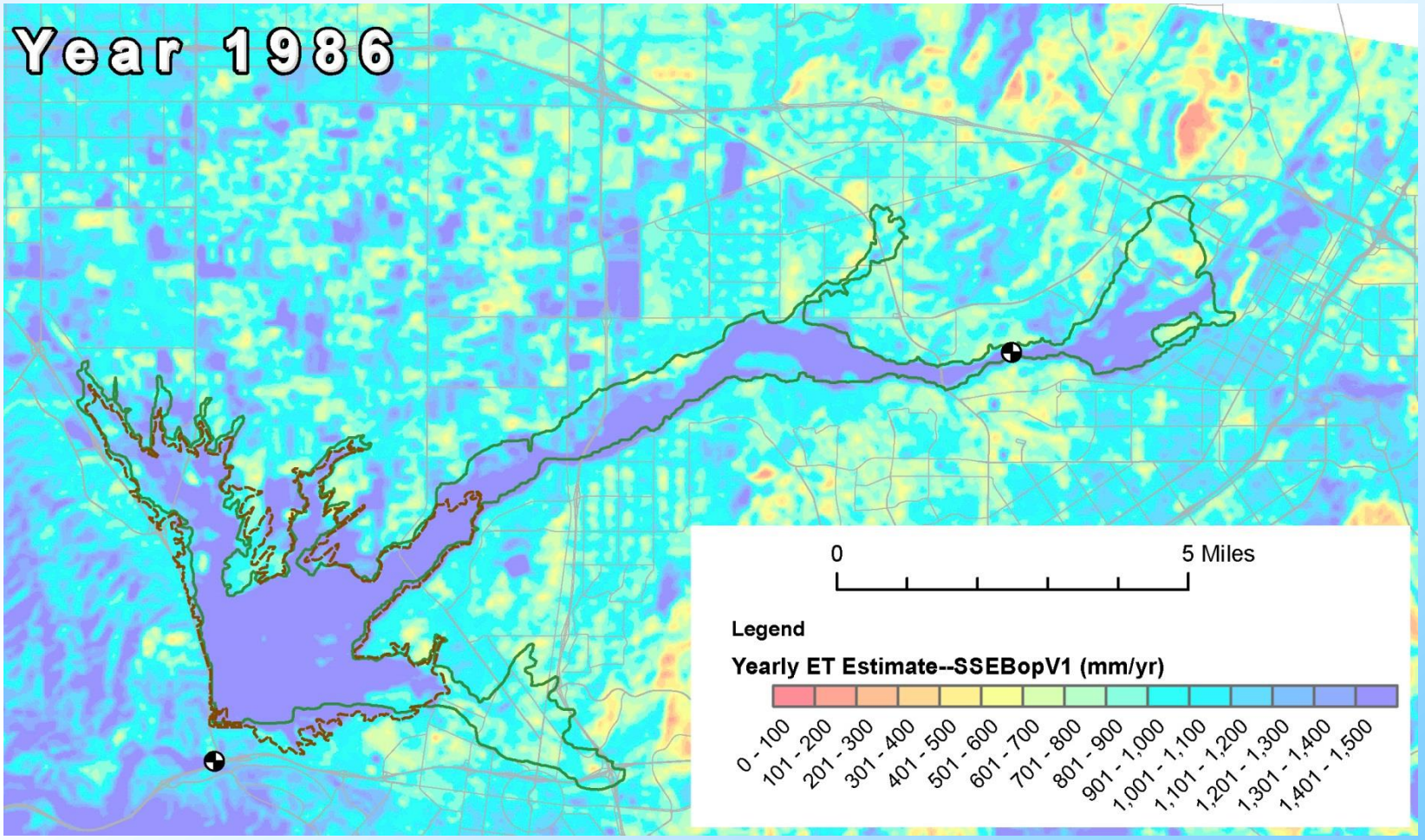
APPLICATION OF SSEBop

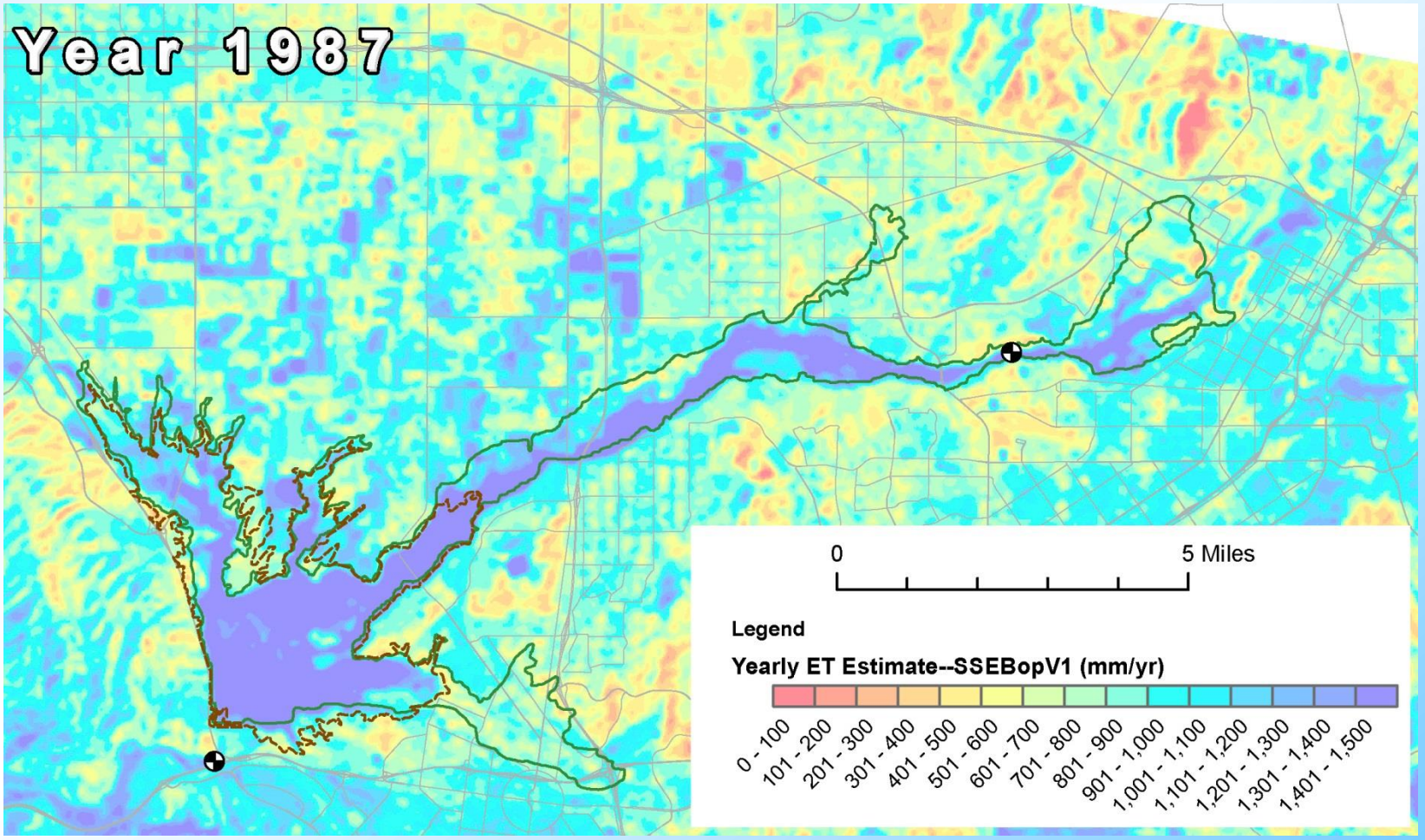
1986 through 2016

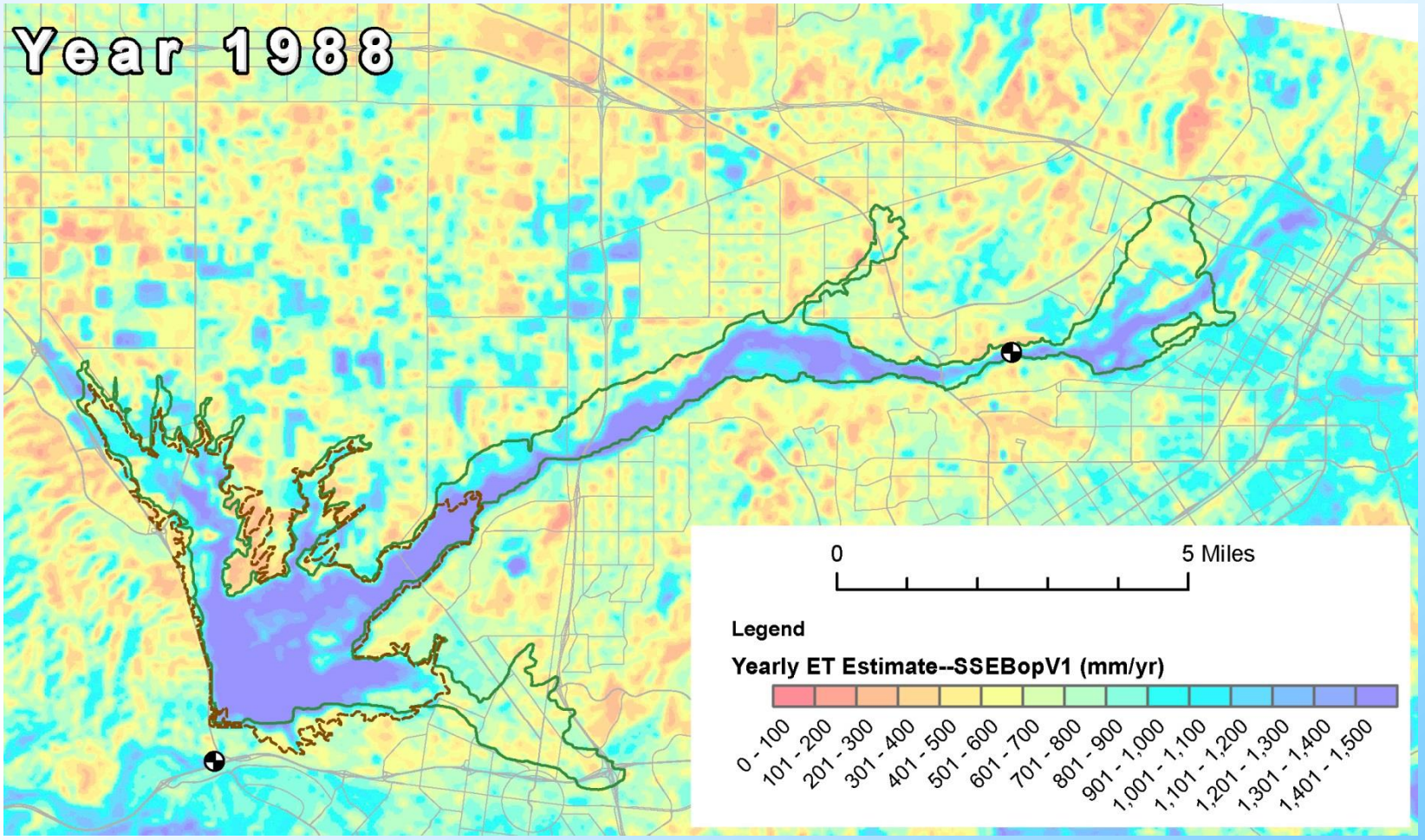
(No data in 2012)

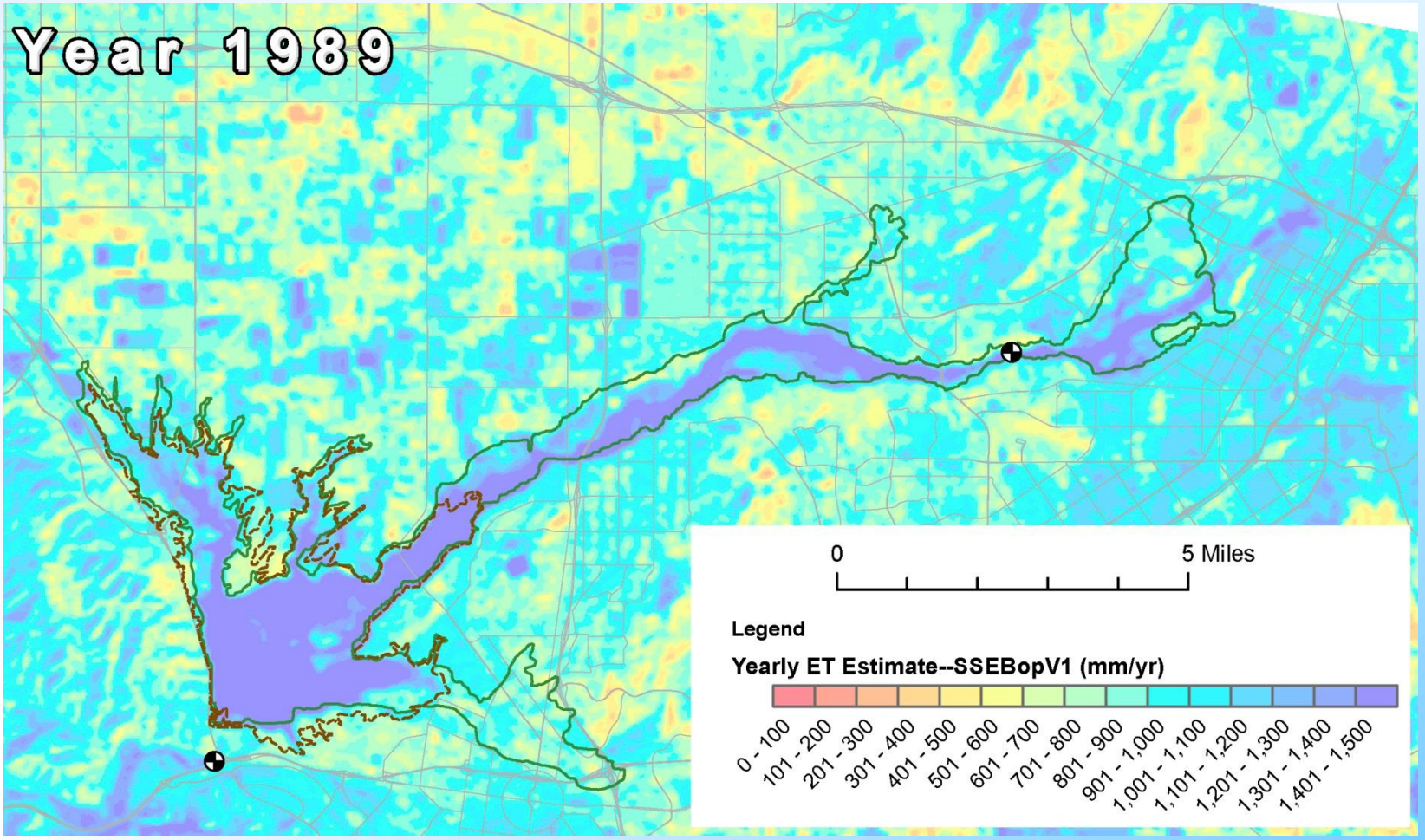
ET ESTIMATE ALONG SHALLOW GROUNDWATER AREA

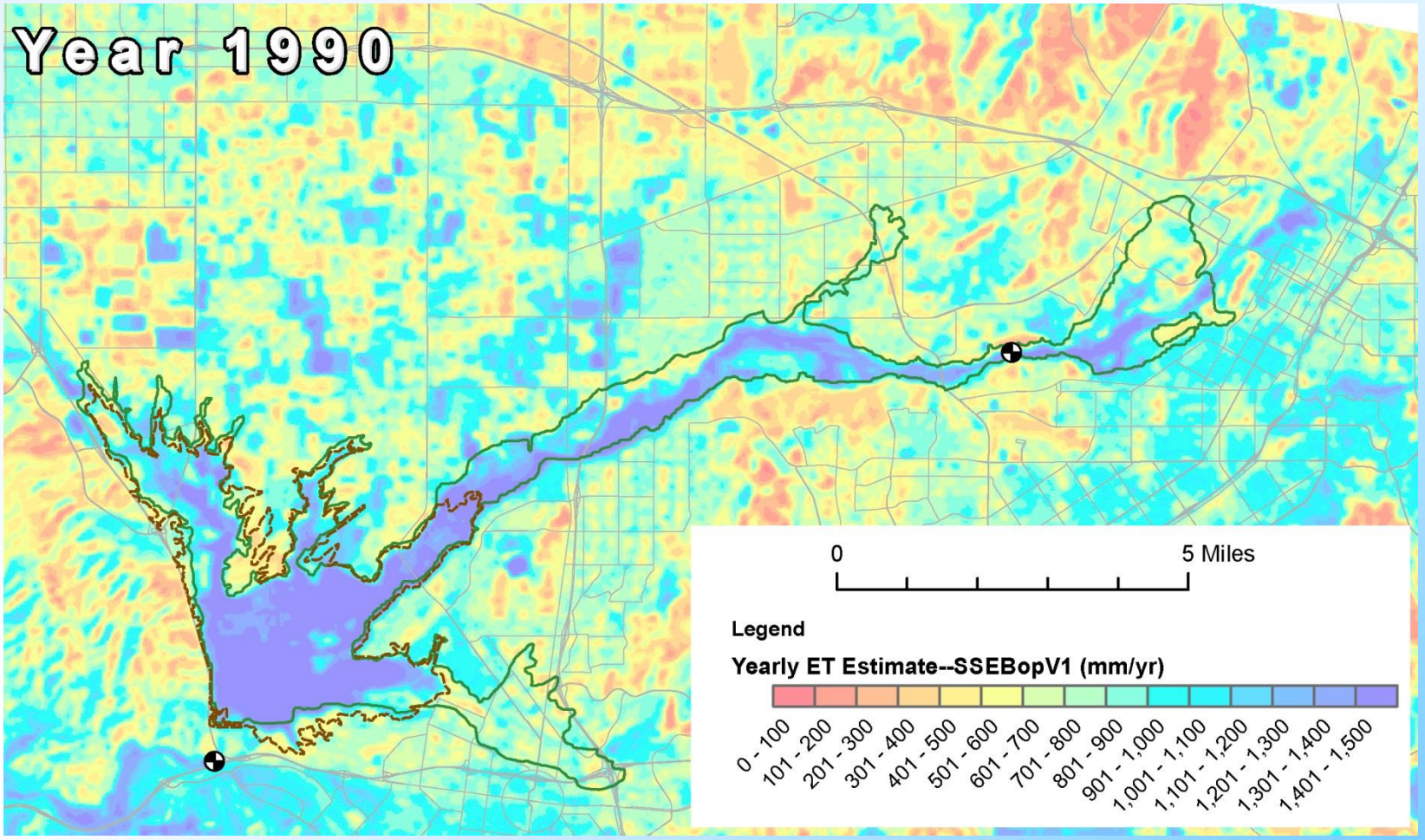


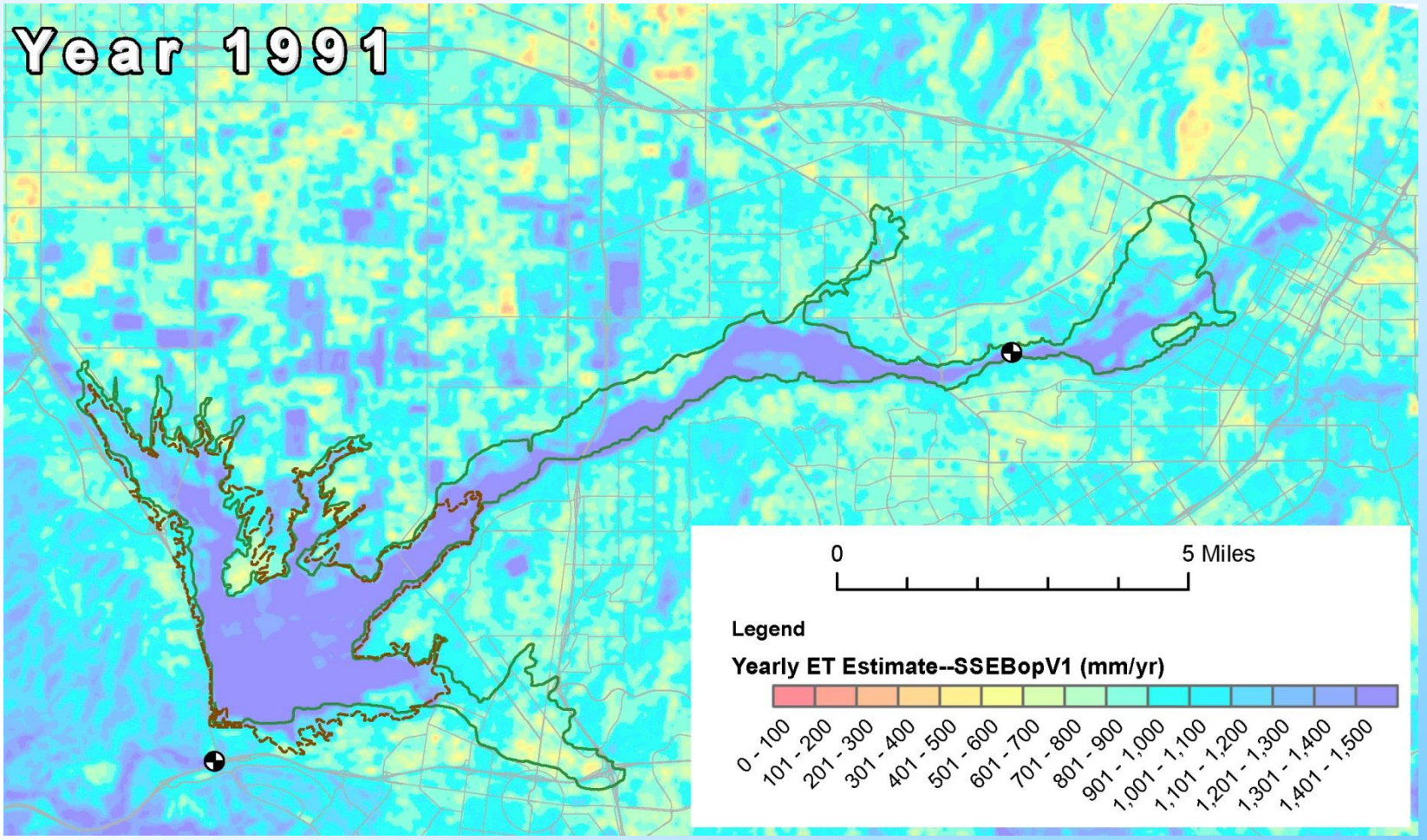

Year 1986
0
5 Miles
Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
0 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
901 - 1,000
1,001 - 1,100
1,101 - 1,200
1,201 - 1,300
1,301 - 1,400
1,401 - 1,500

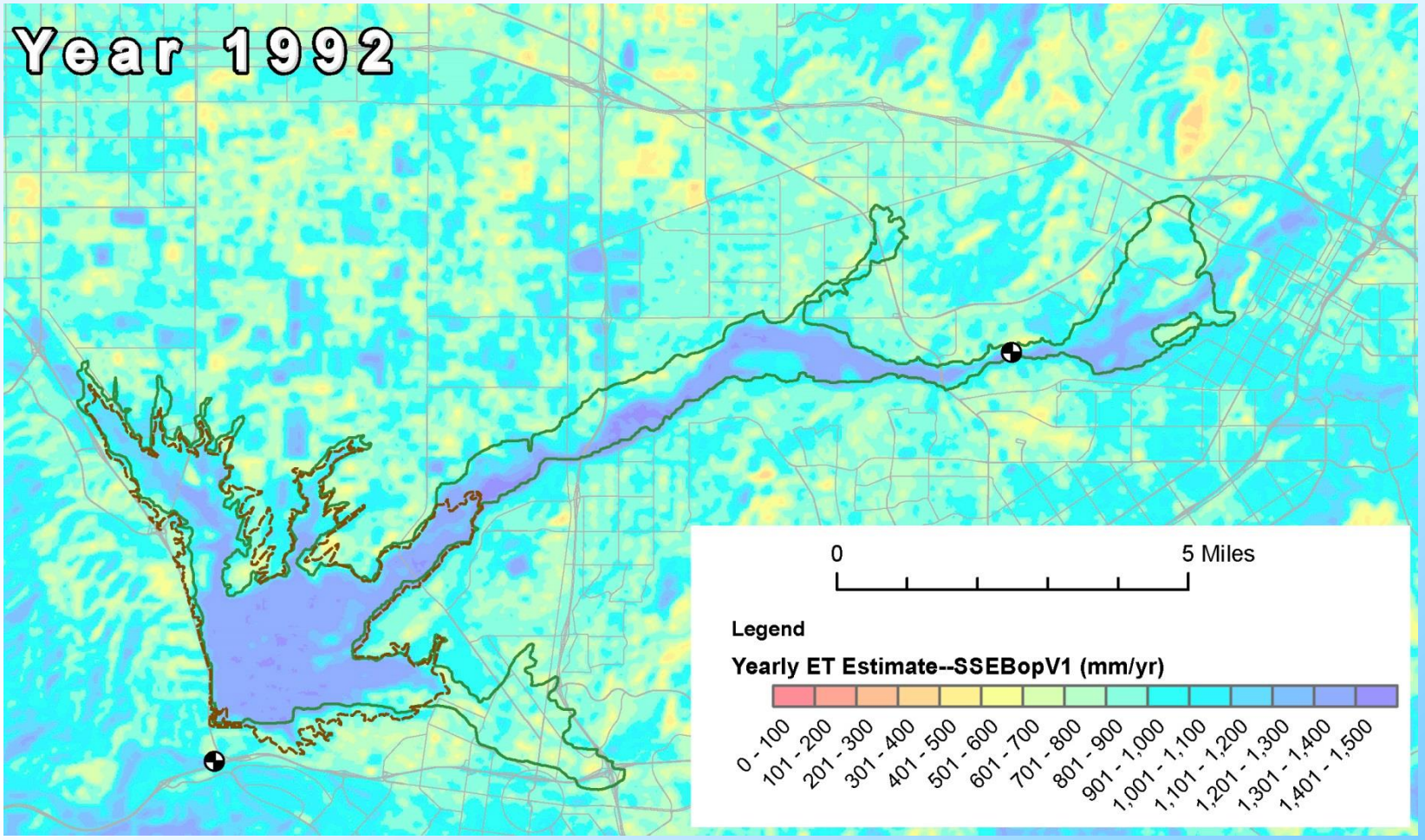

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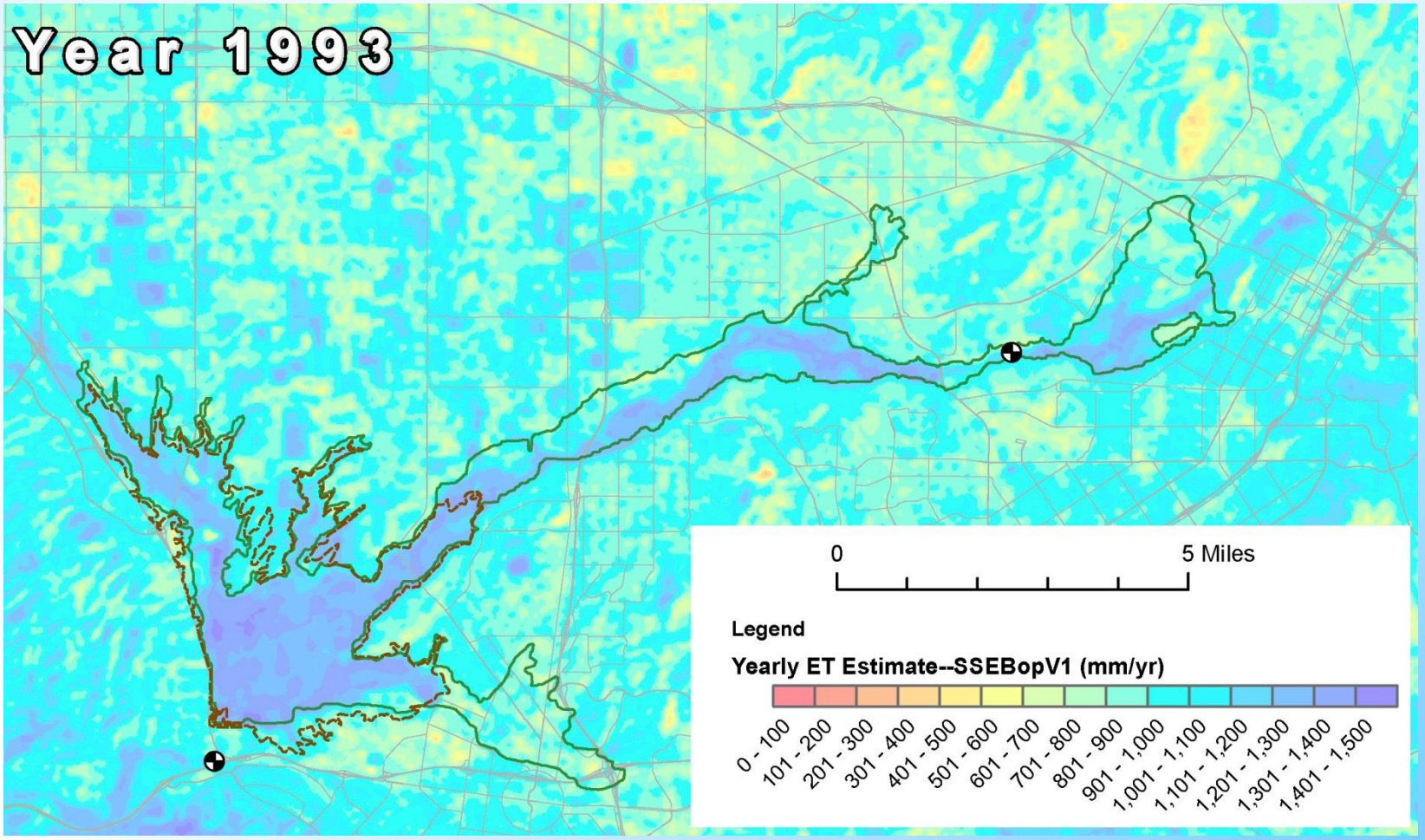

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Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
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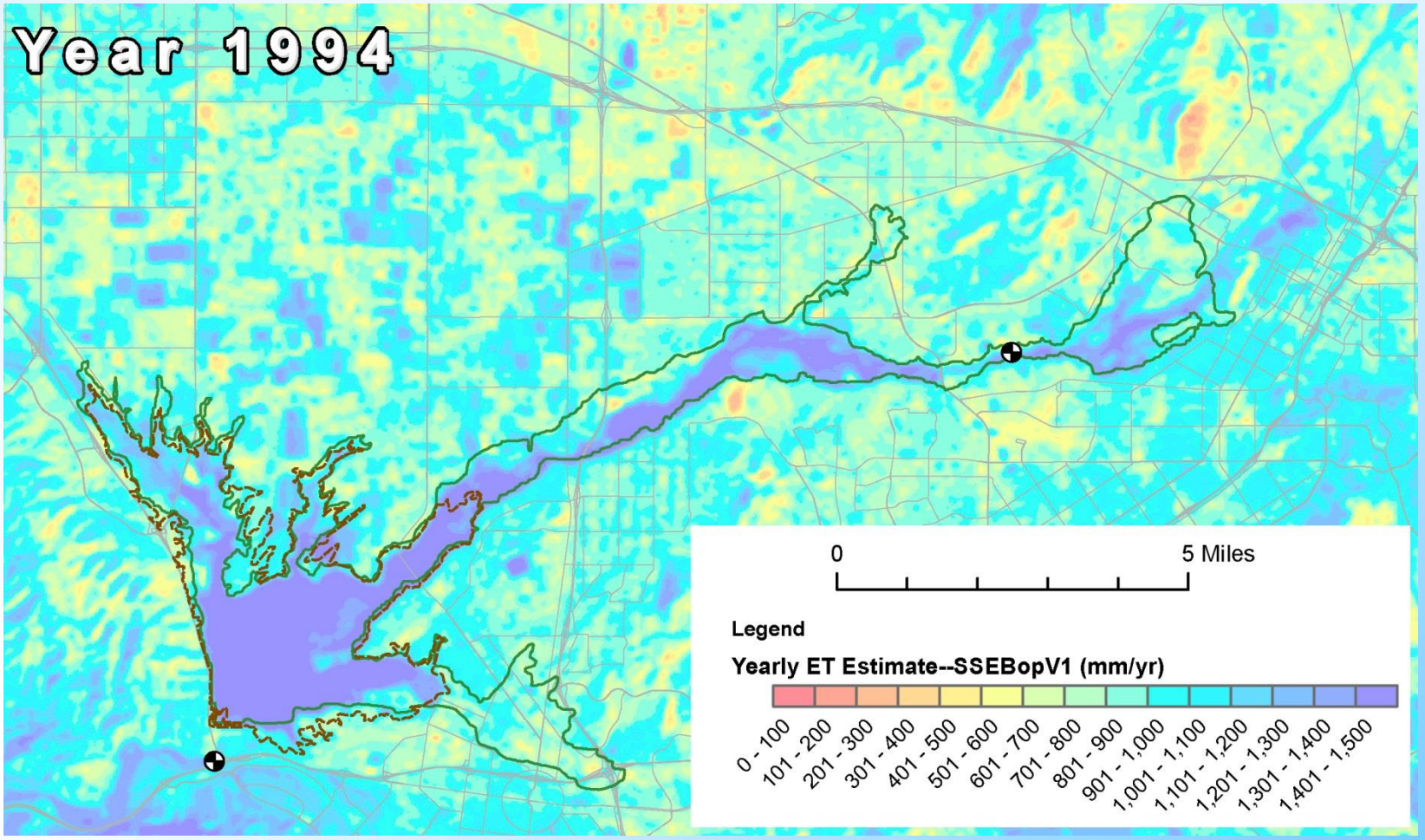

Year 1989
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5 Miles
Legend
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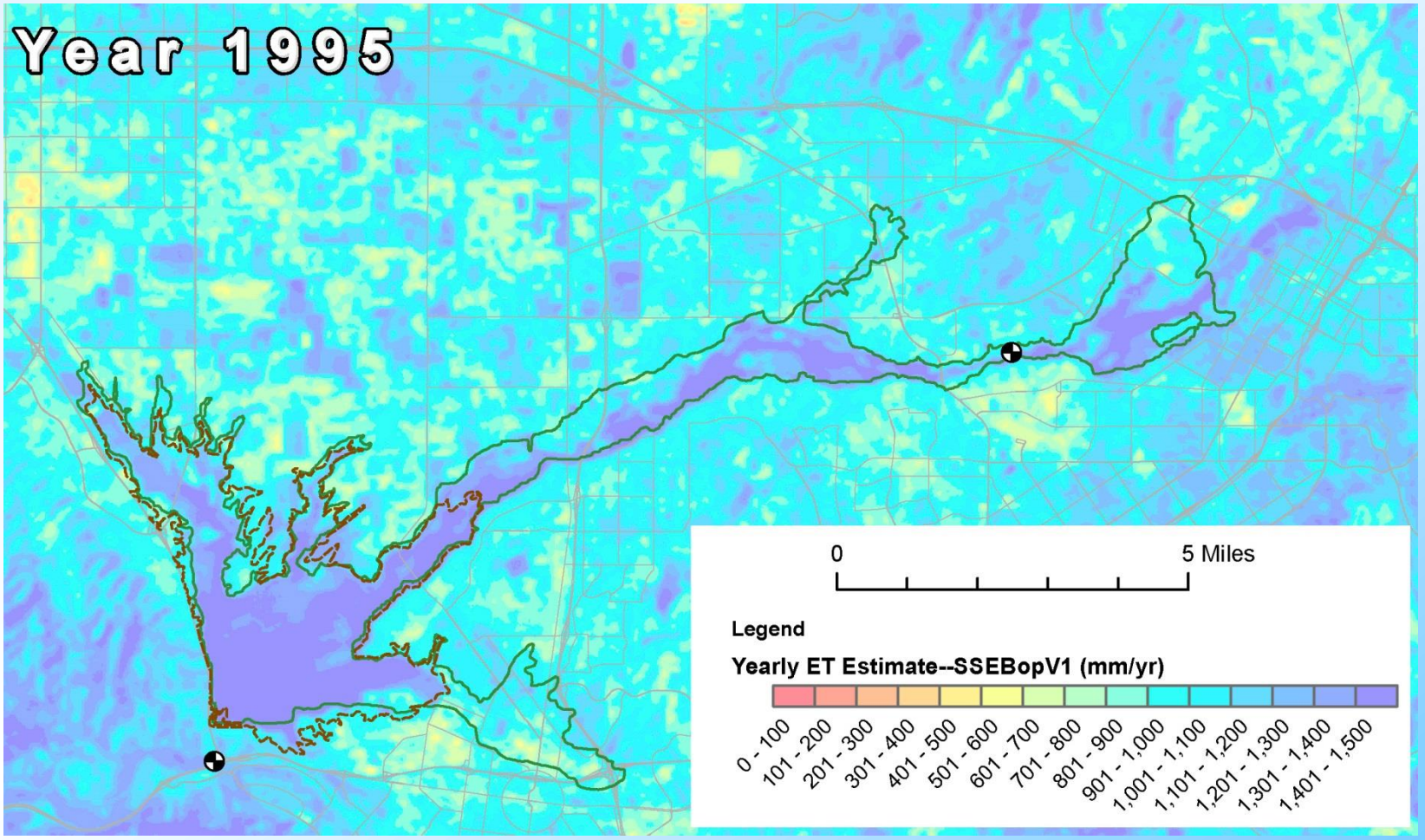

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5 Miles
Legend
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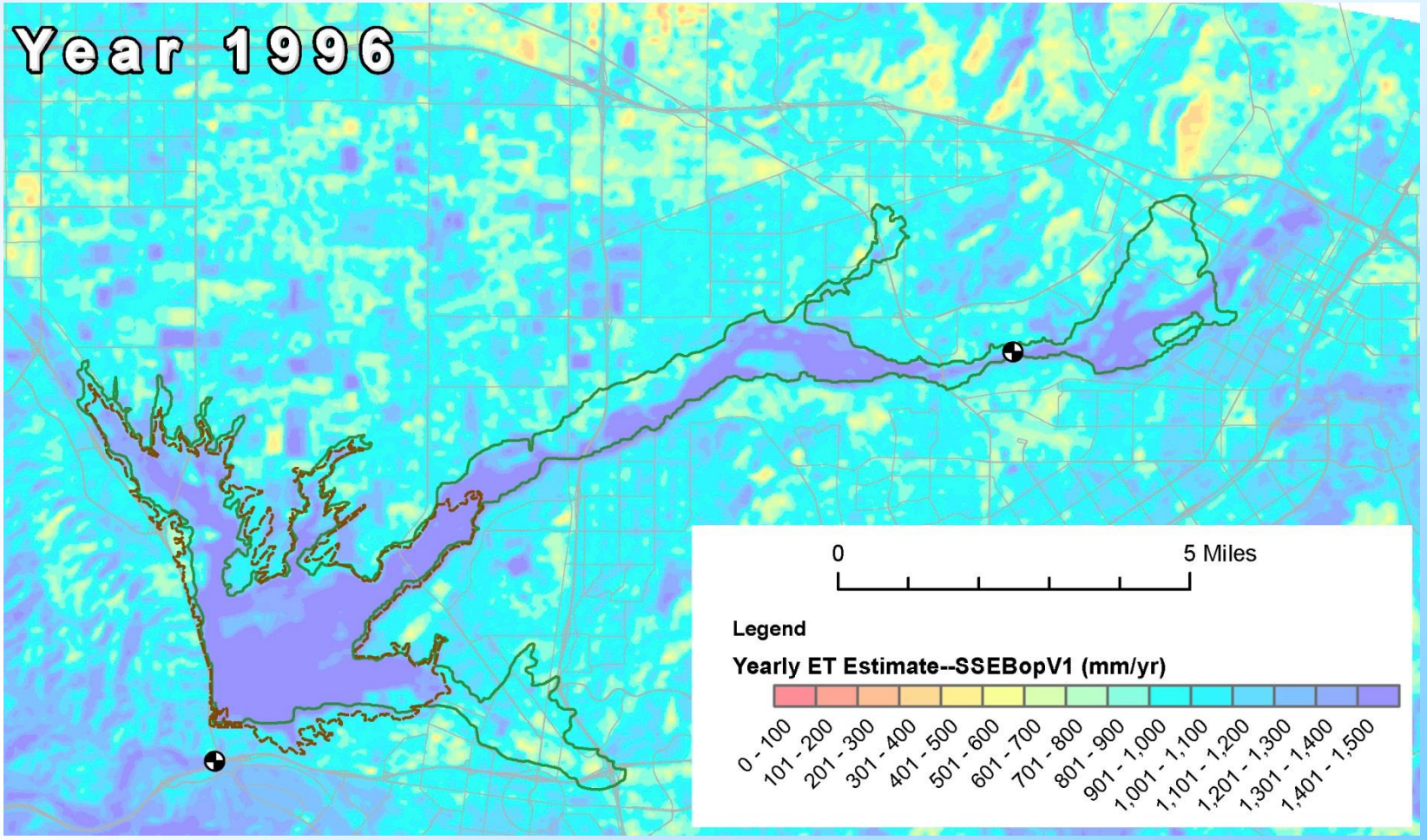

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Legend
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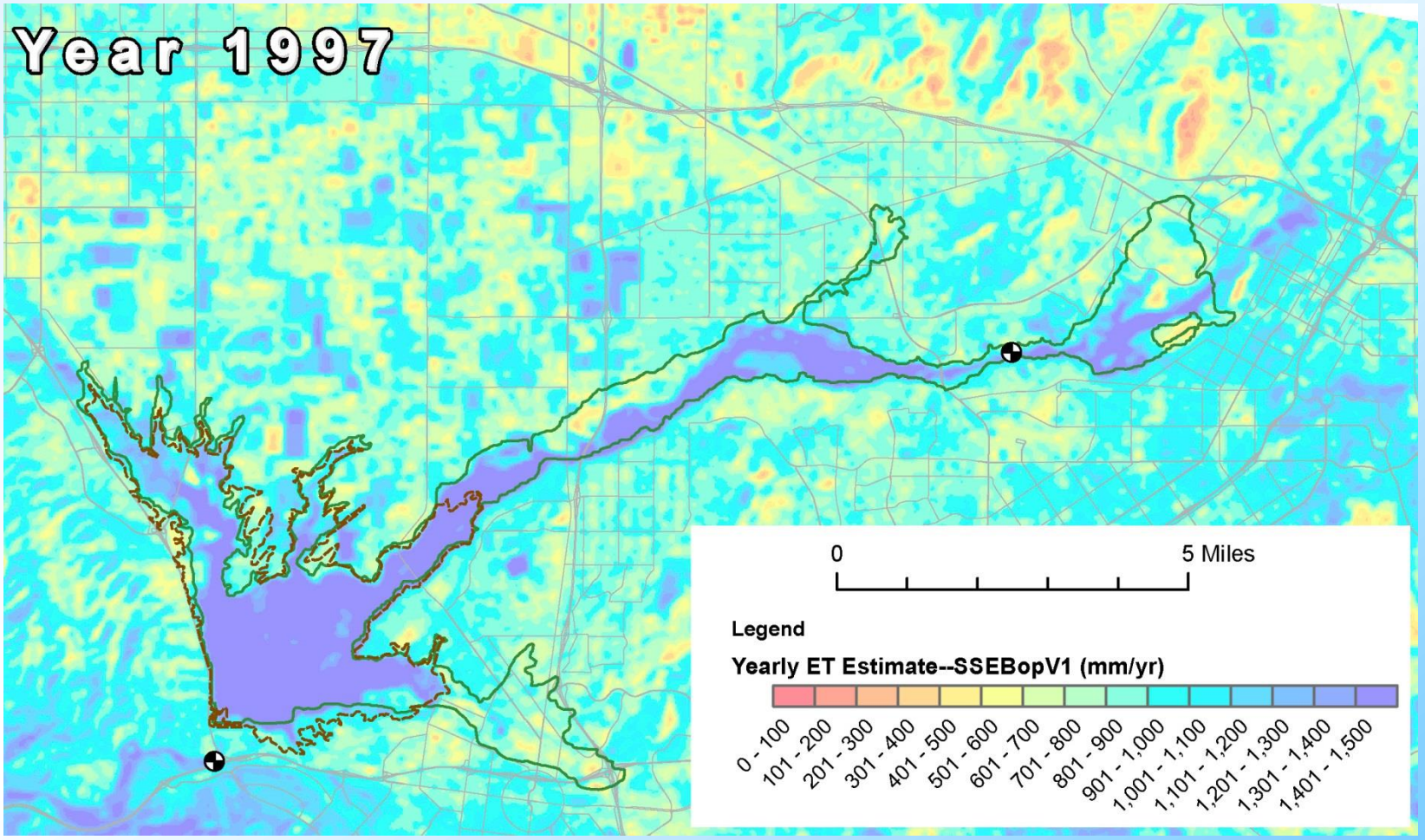

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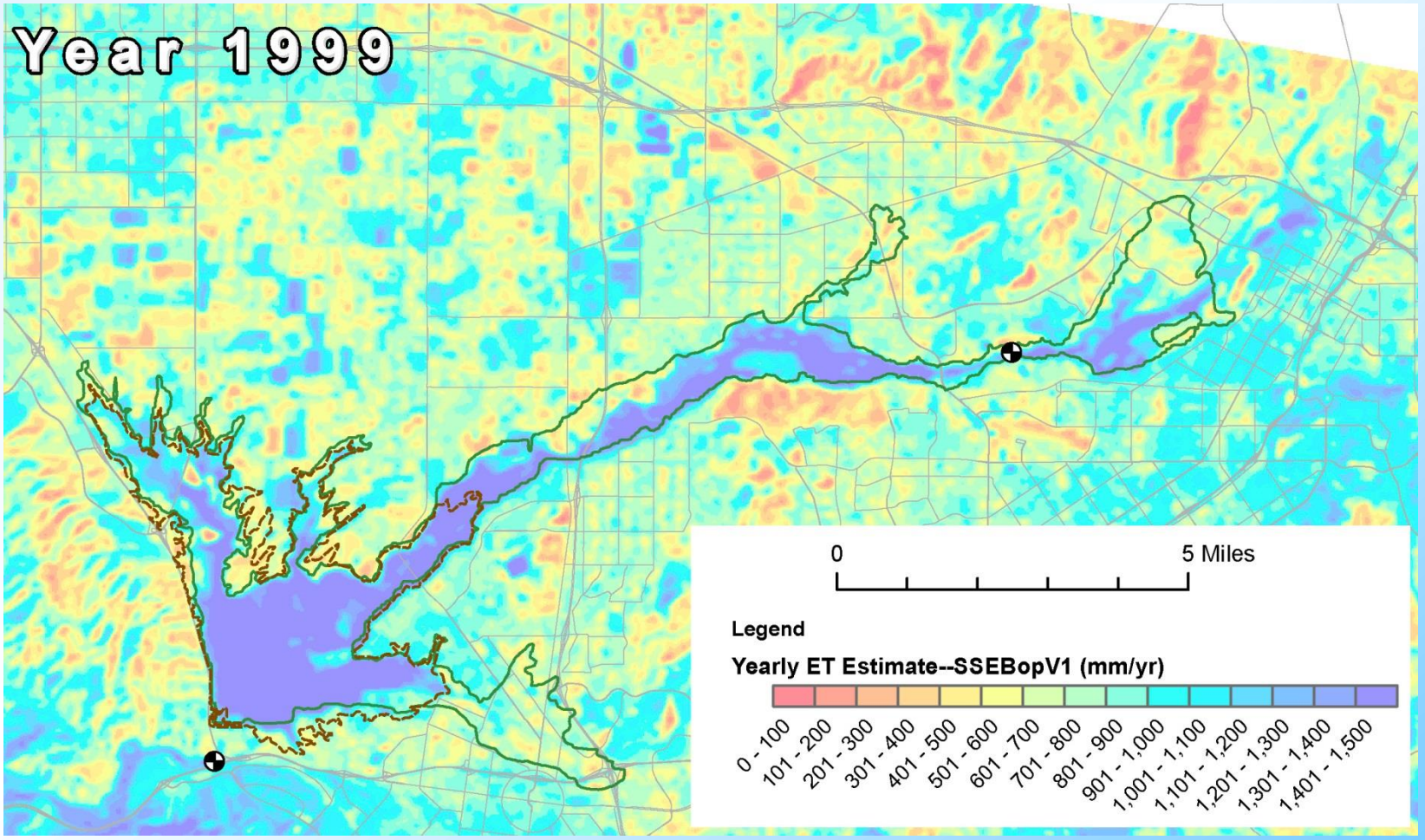

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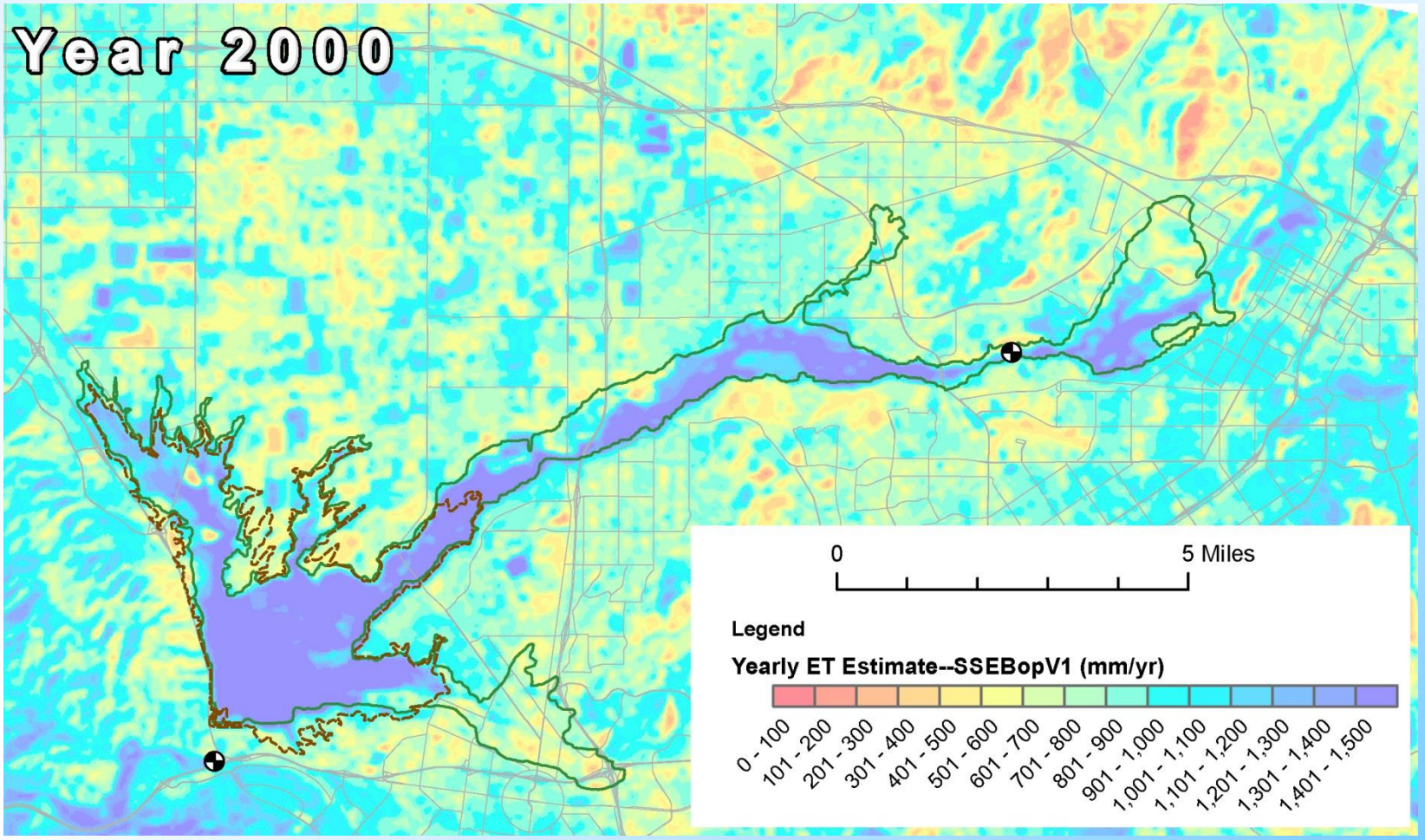

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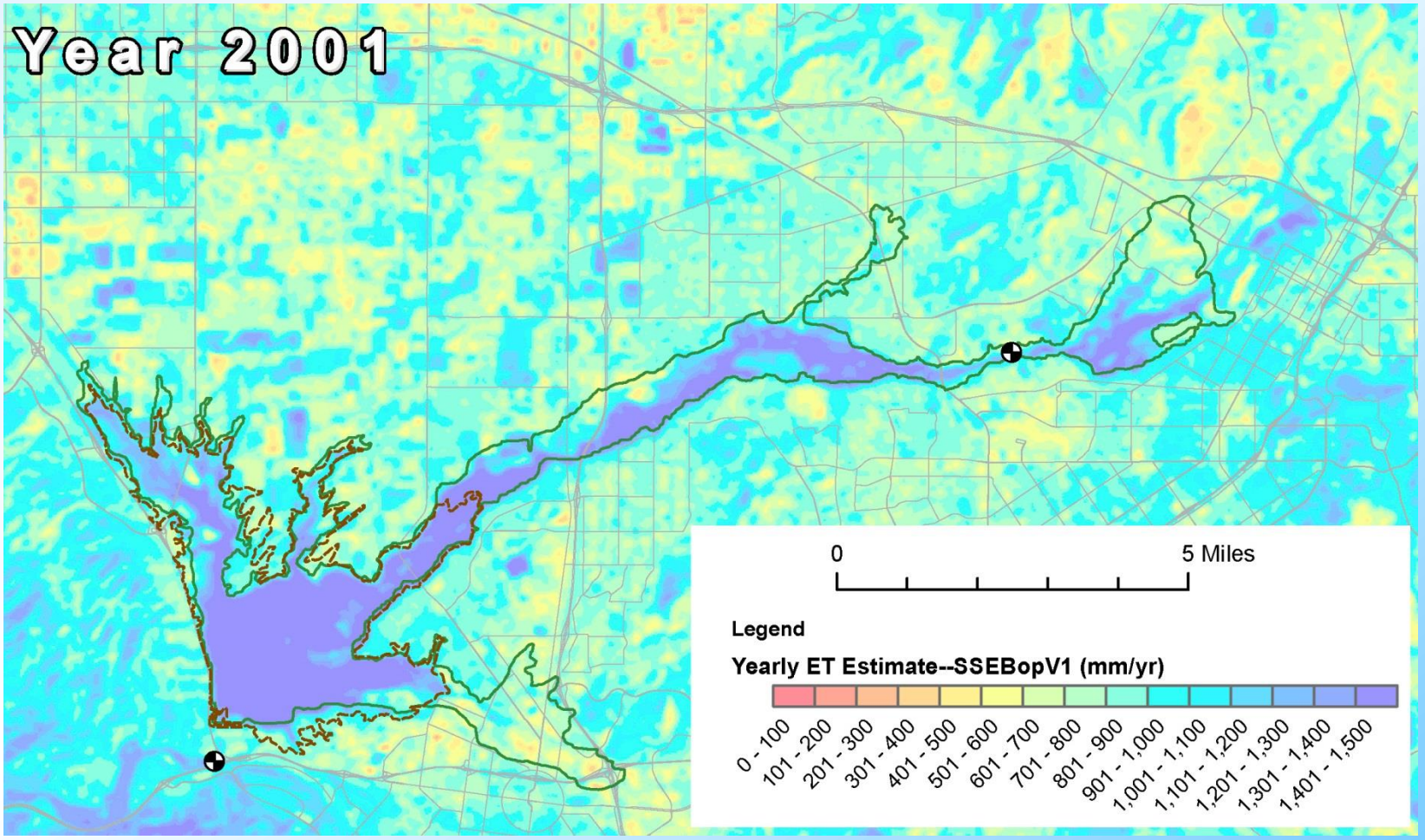

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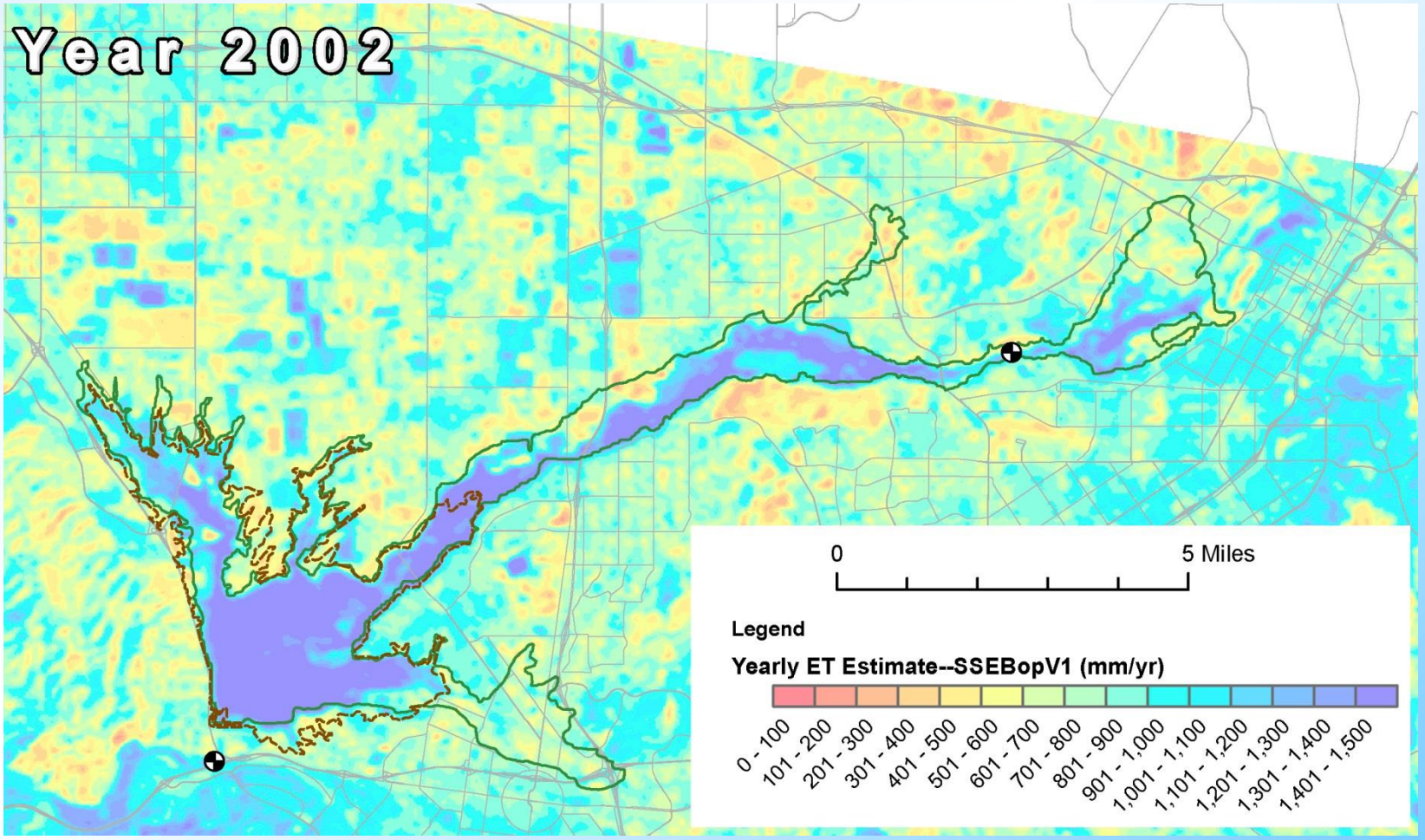

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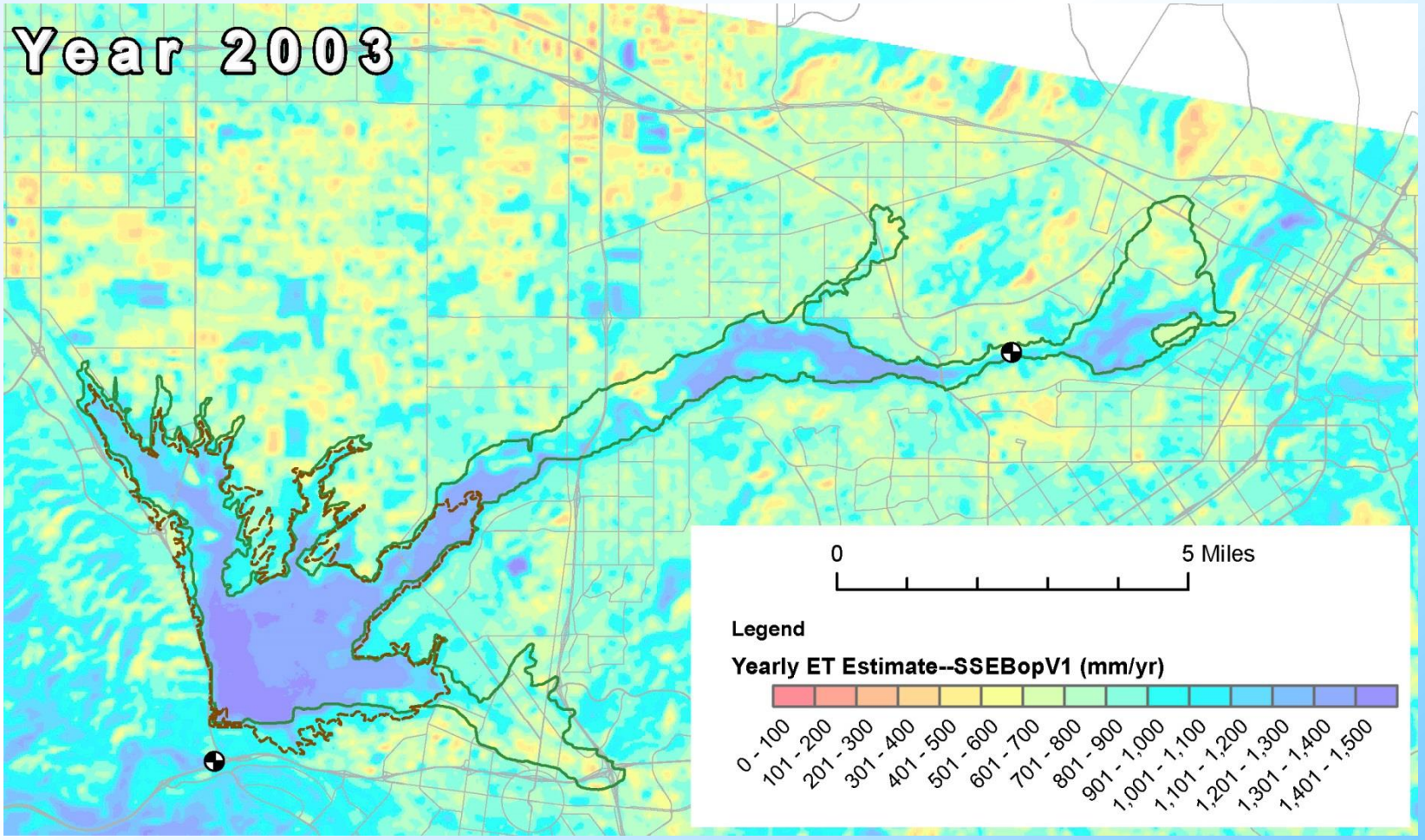

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Legend
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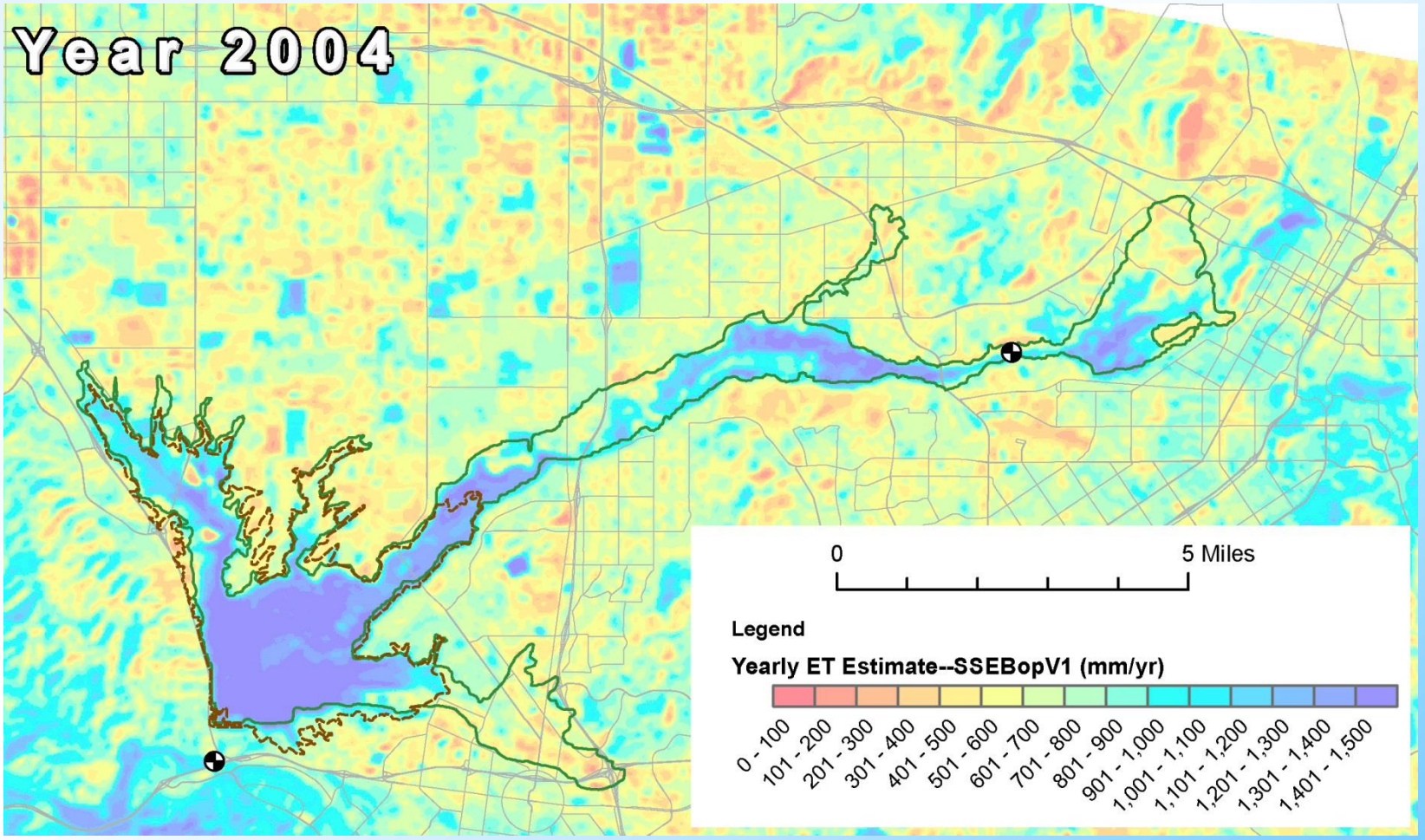

Year 1999
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5 Miles
Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
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201 - 300
301 - 400
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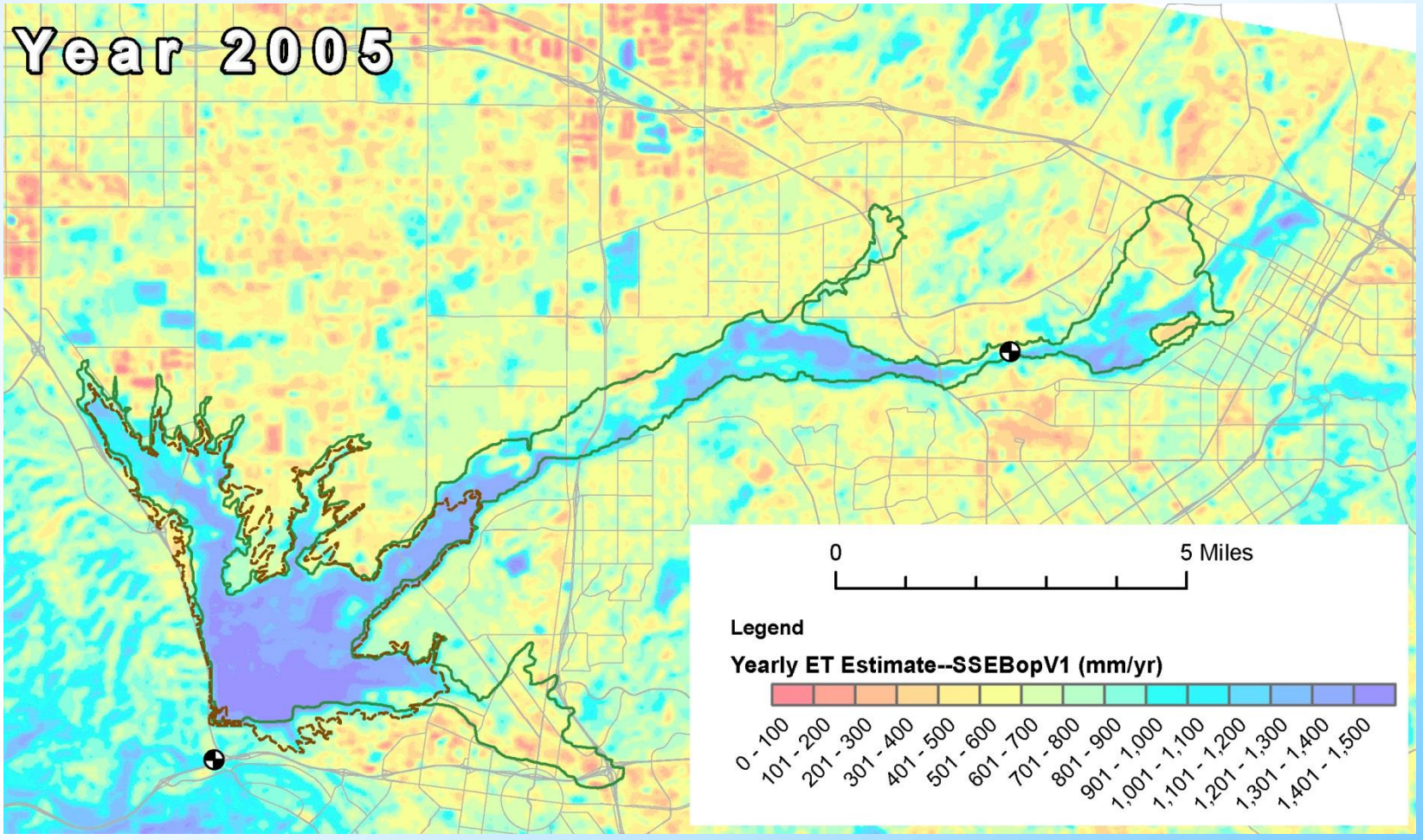

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5 Miles
Legend
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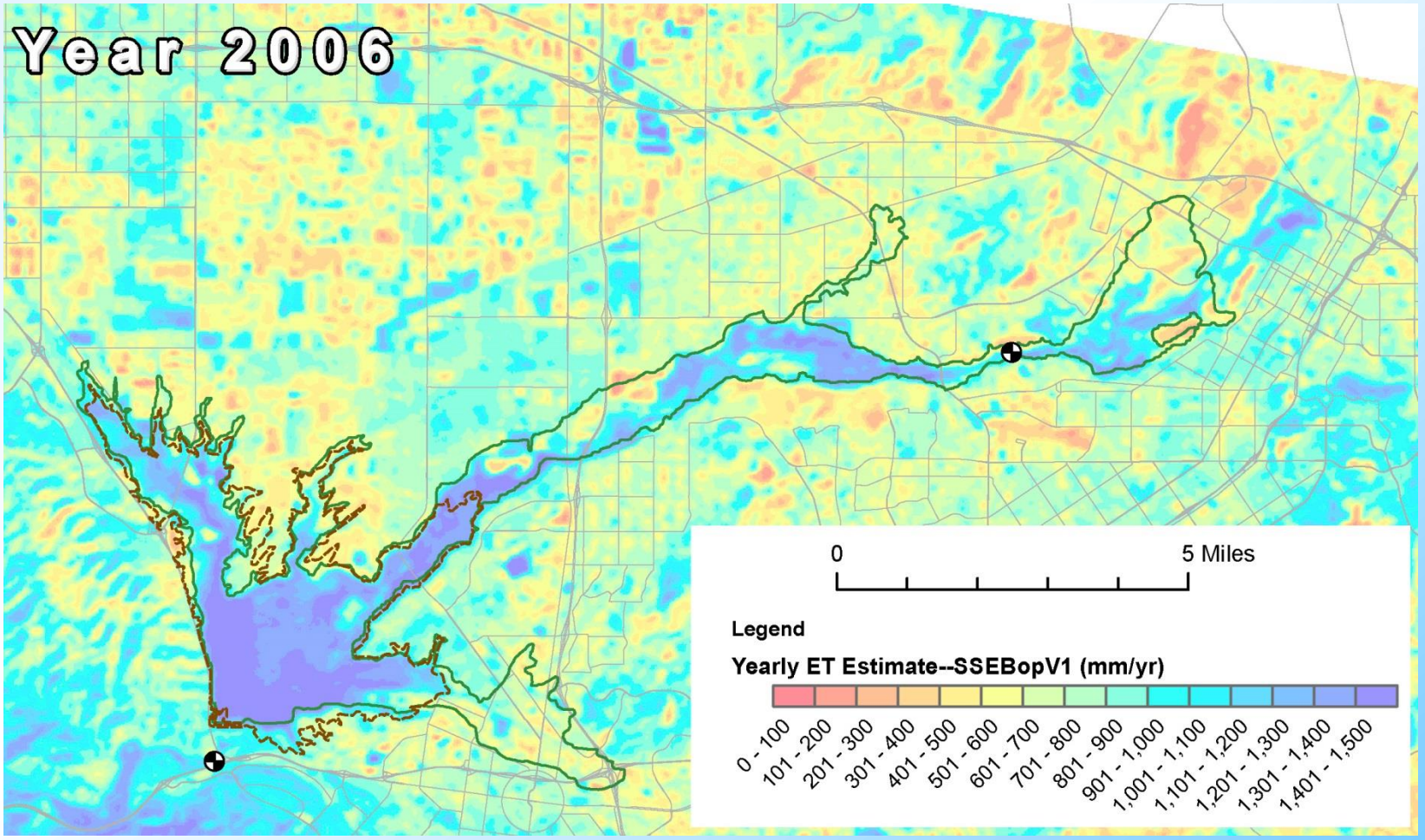

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Yearly ET Estimate--SSEBopV1 (mm/yr)
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301 - 400
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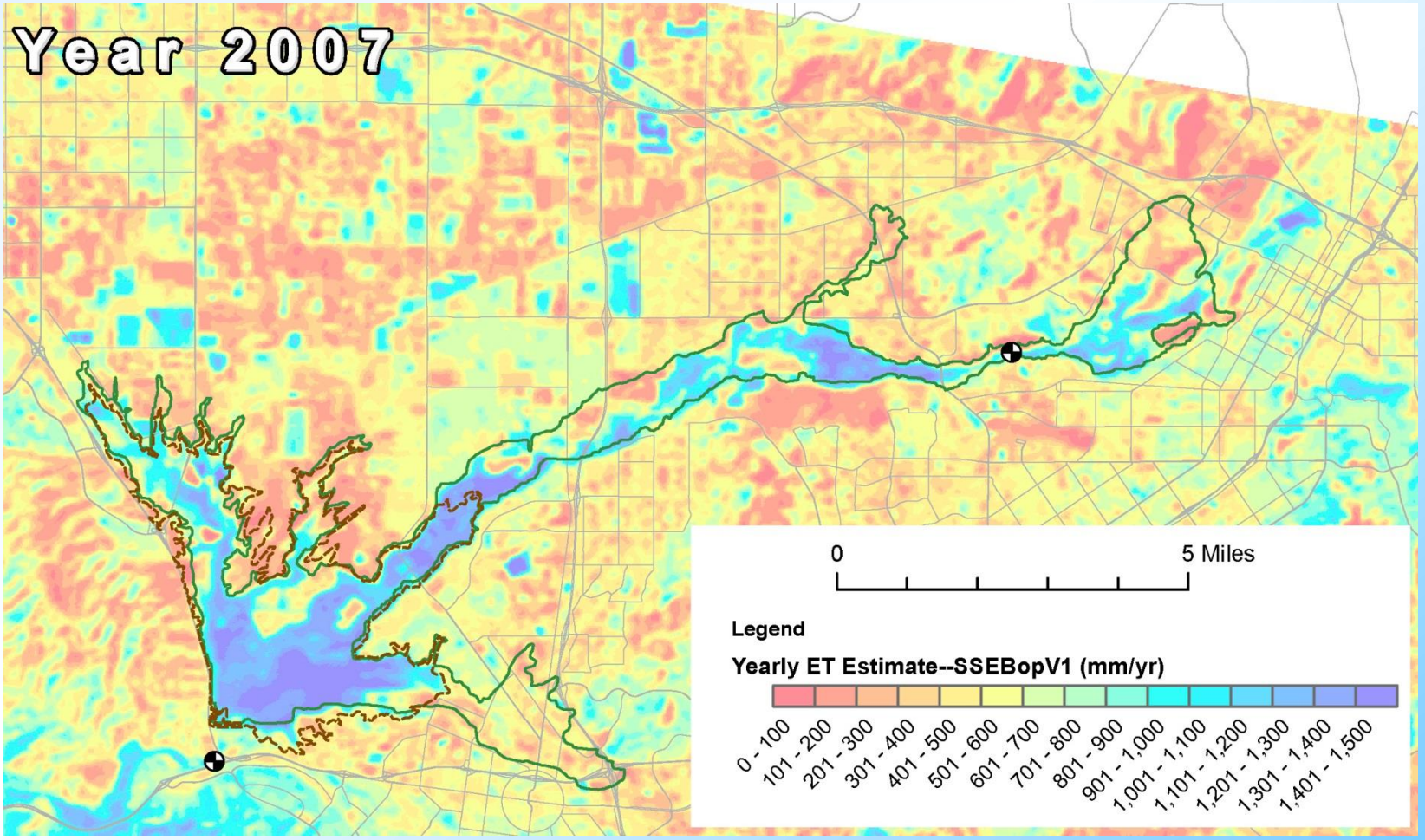

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Legend
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201 - 300
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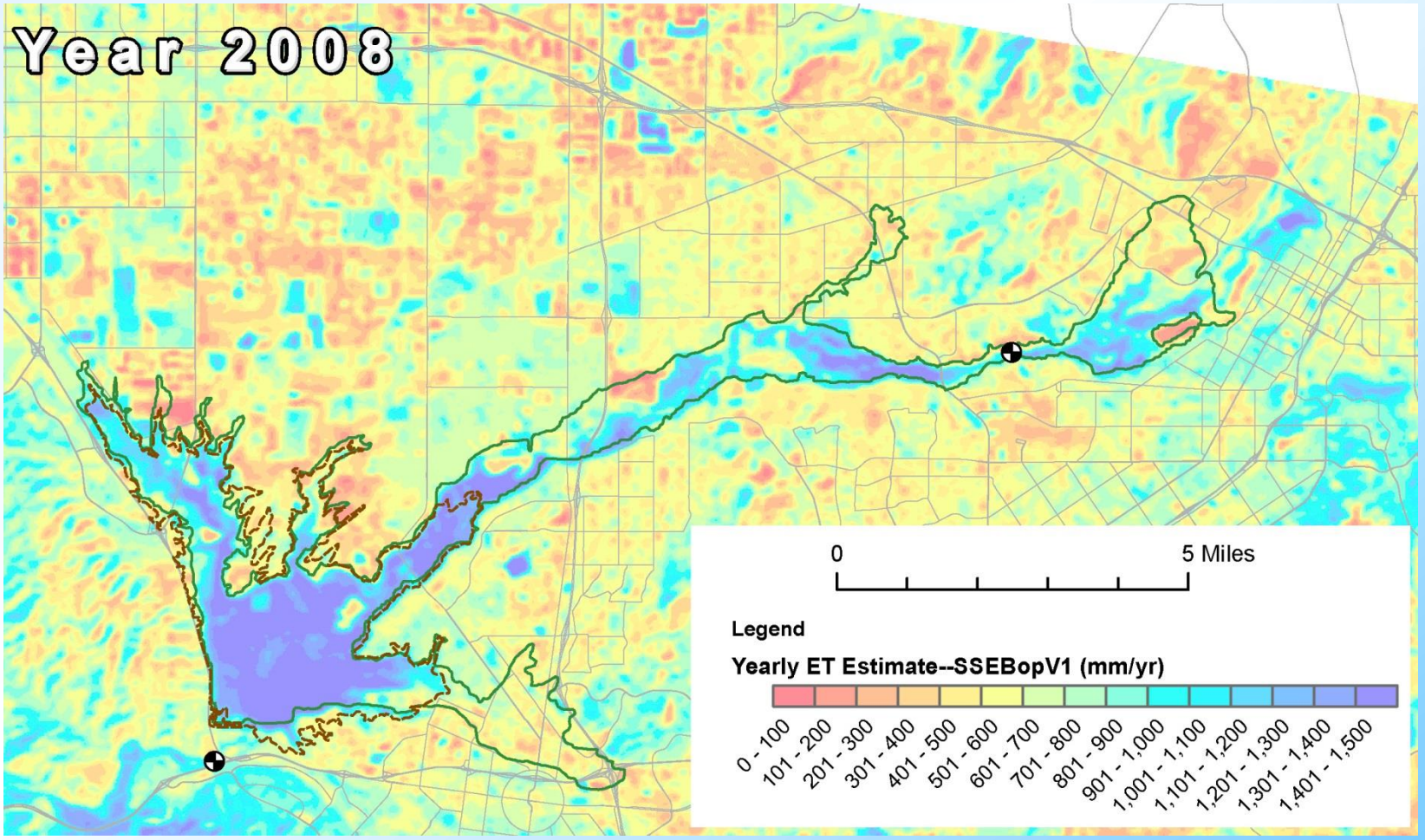

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Yearly ET Estimate--SSEBopV1 (mm/yr)
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201 - 300
301 - 400
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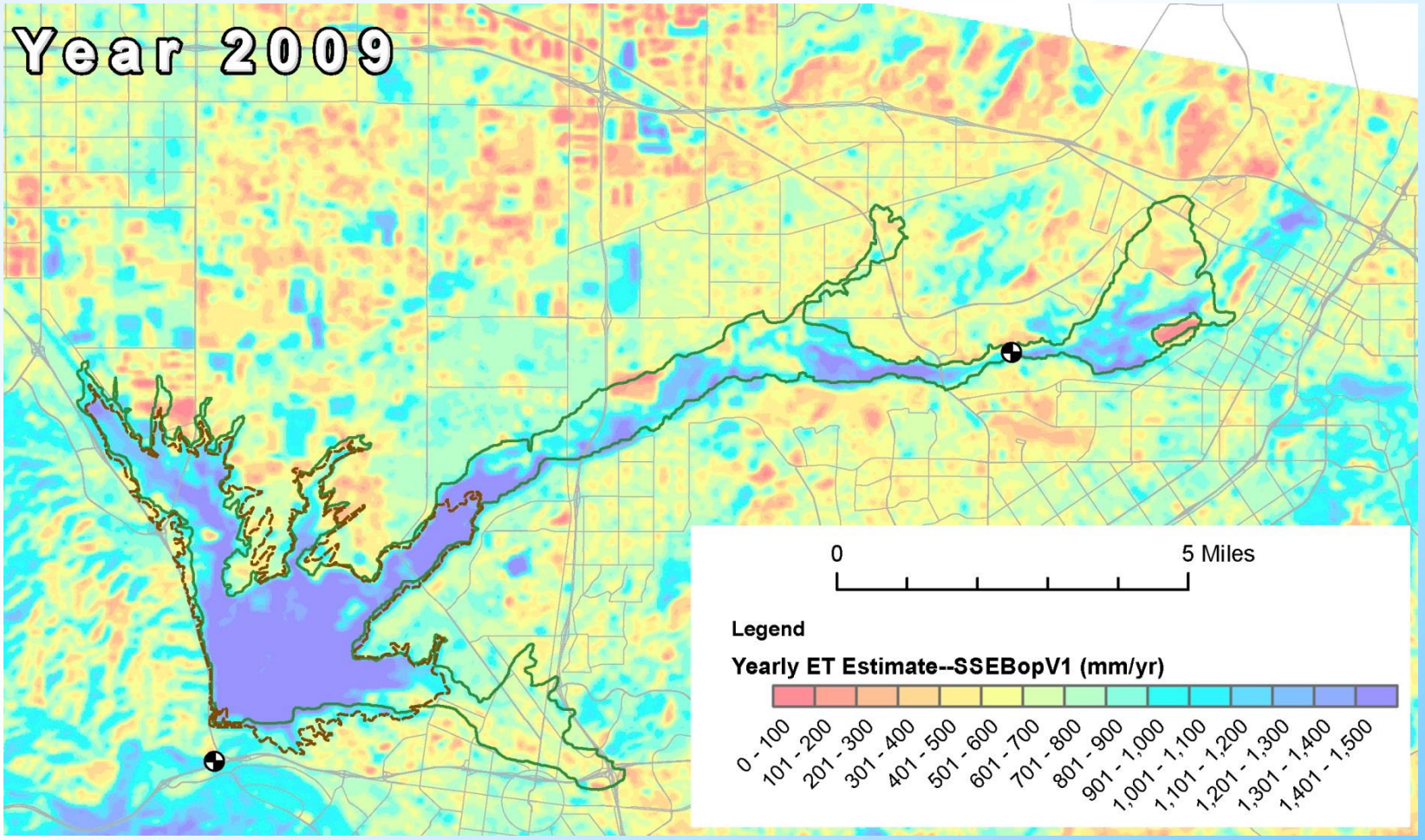

Year 2004
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5 Miles
Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
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201 - 300
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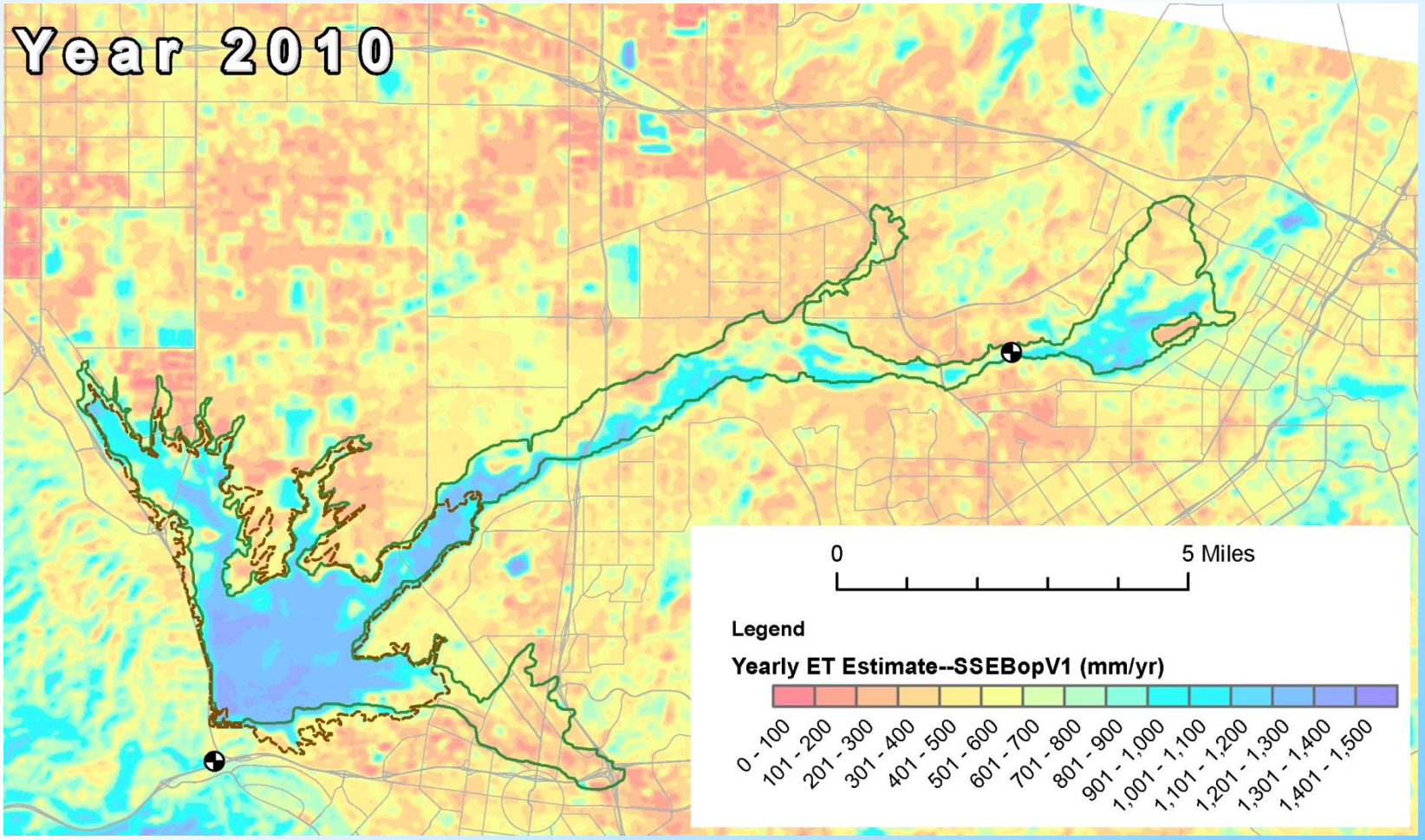

Year 2005
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Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
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201 - 300
301 - 400
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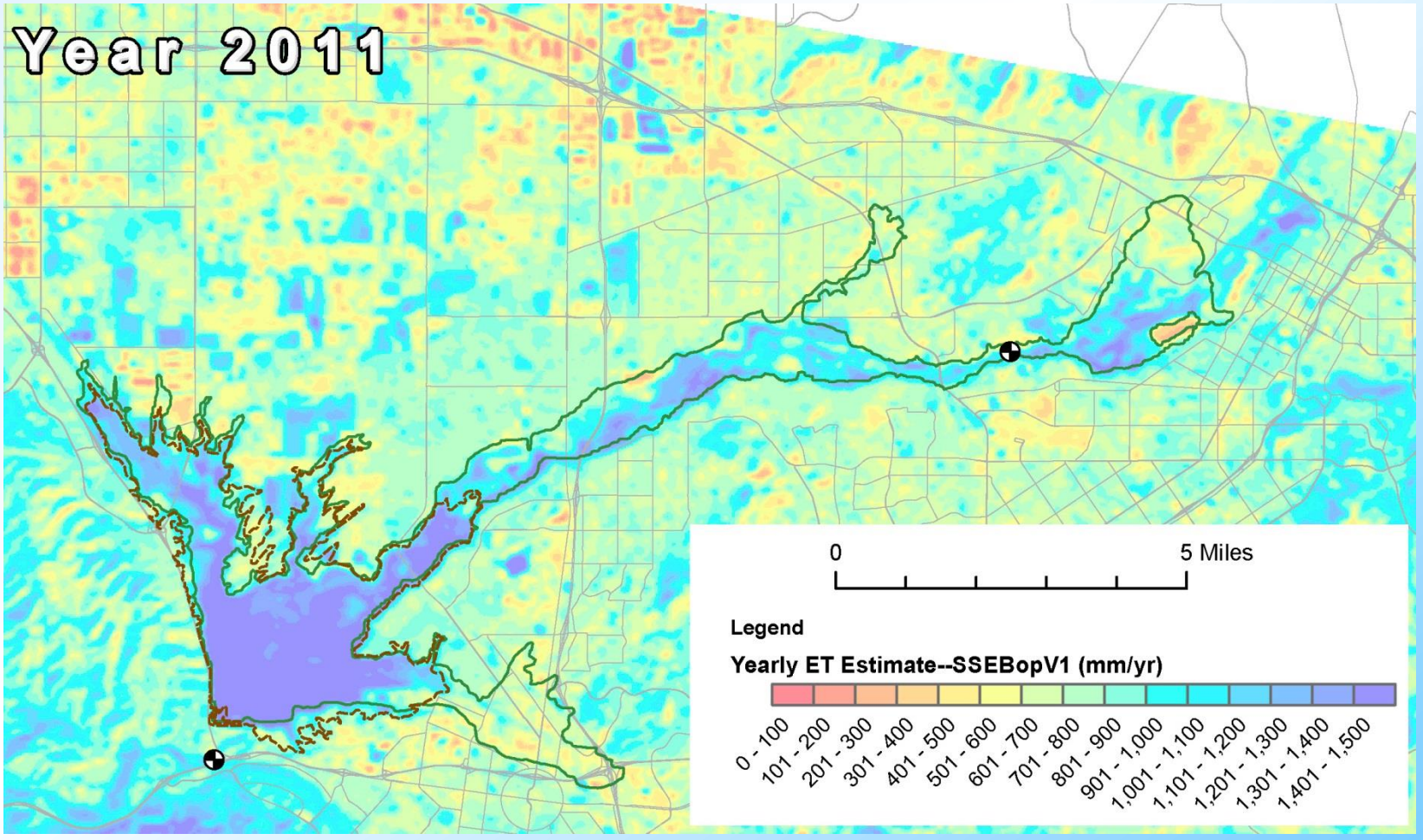

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Yearly ET Estimate--SSEBopV1 (mm/yr)
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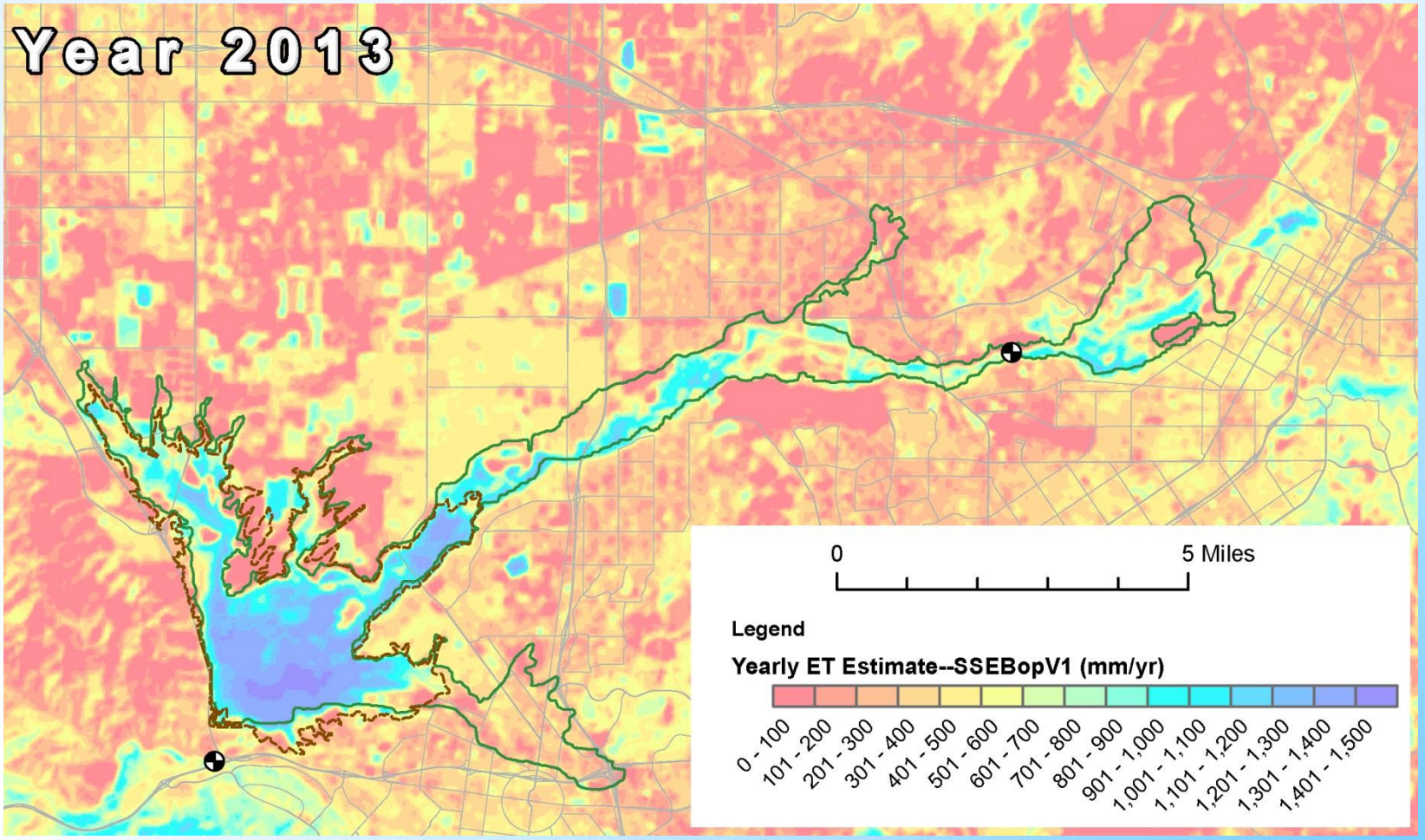

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Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
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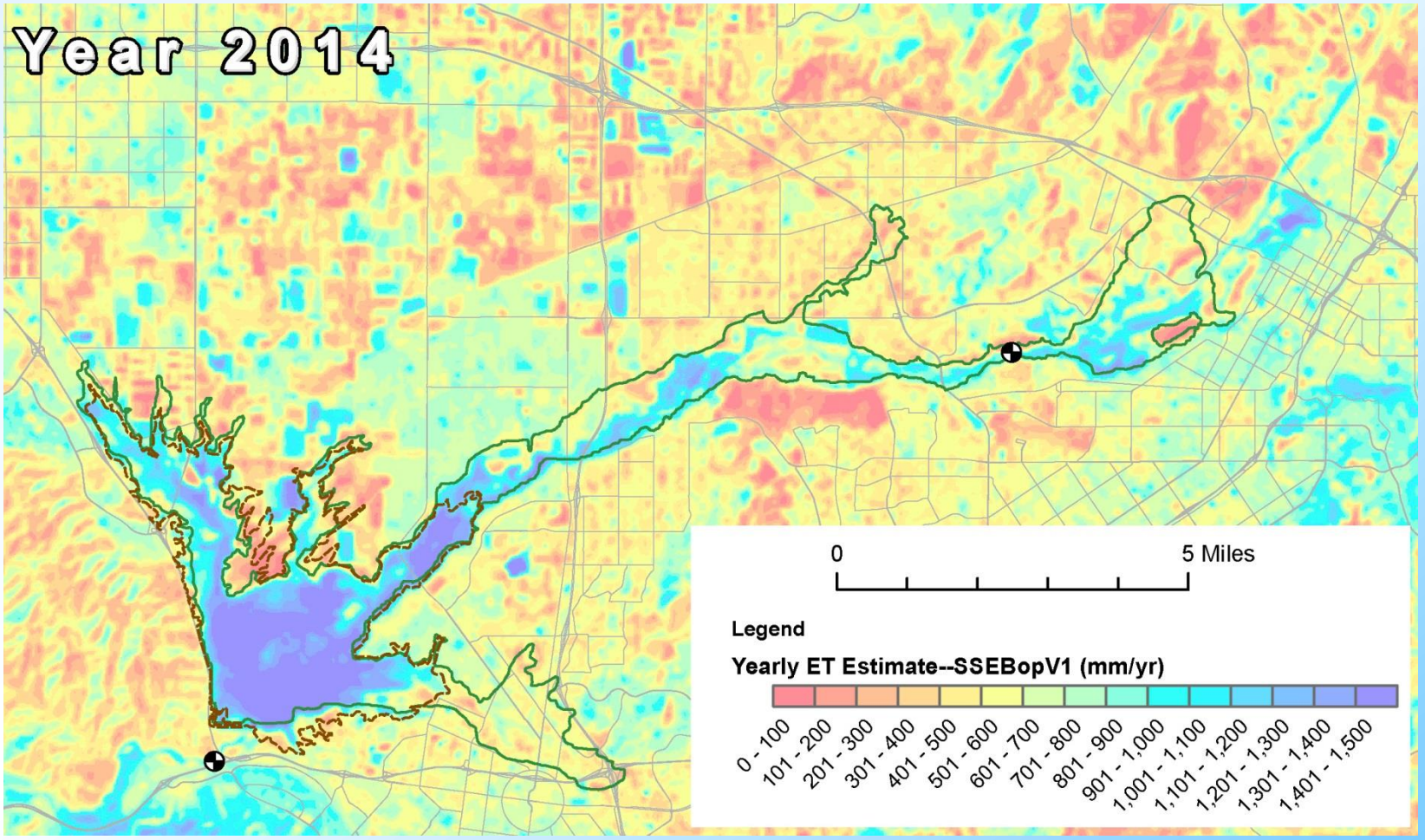

Year 2008
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5 Miles
Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
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301 - 400
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501 - 600
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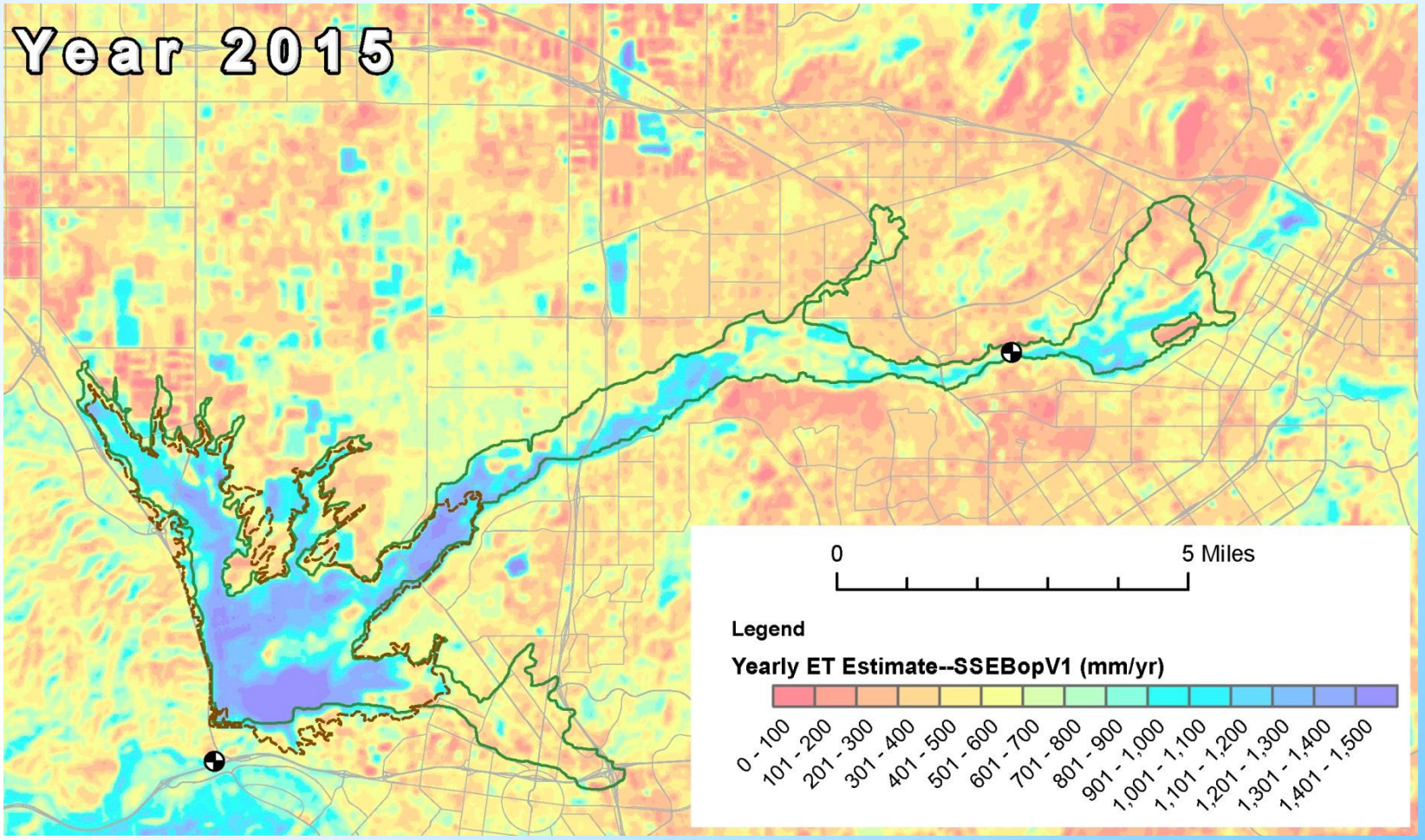

Year 2009
0
5 Miles
Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
0 - 100
101 - 200
201 - 300
301 - 400
401 - 500
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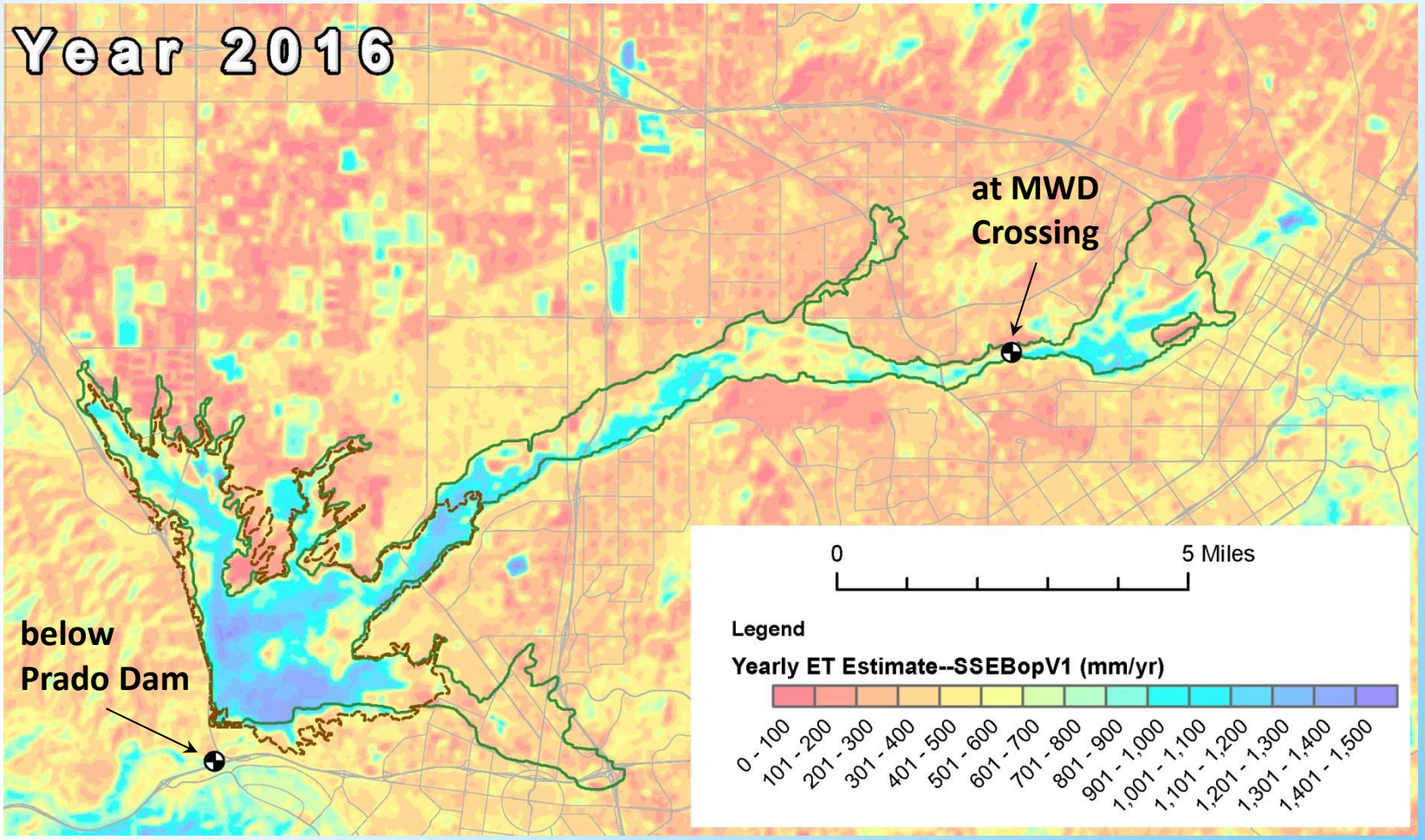

Year 2010
0
5 Miles
Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
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701 - 800
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1,401 - 1,500


Year 2011
0
5 Miles
Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
0 - 100
101 - 200
201 - 300
301 - 400
401 - 500
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701 - 800
801 - 900
901 - 1,000
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1,301 - 1,400
1,401 - 1,500

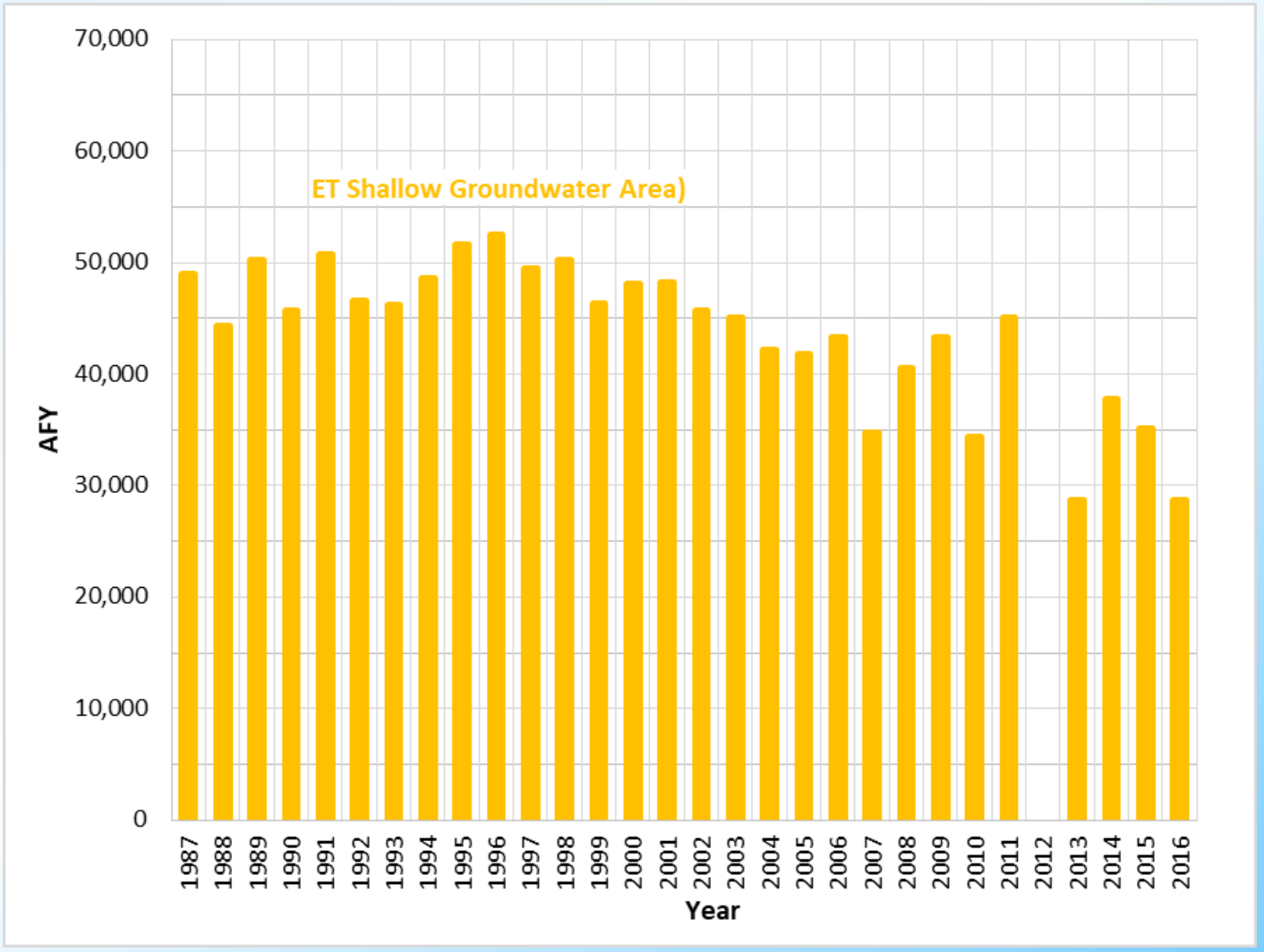

Year 2013
0
5 Miles
Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
0 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
901 - 1,000
1,001 - 1,100
1,101 - 1,200
1,201 - 1,300
1,301 - 1,400
1,401 - 1,500


Year 2014
0
5 Miles
Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
0 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
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1,301 - 1,400
1,401 - 1,500

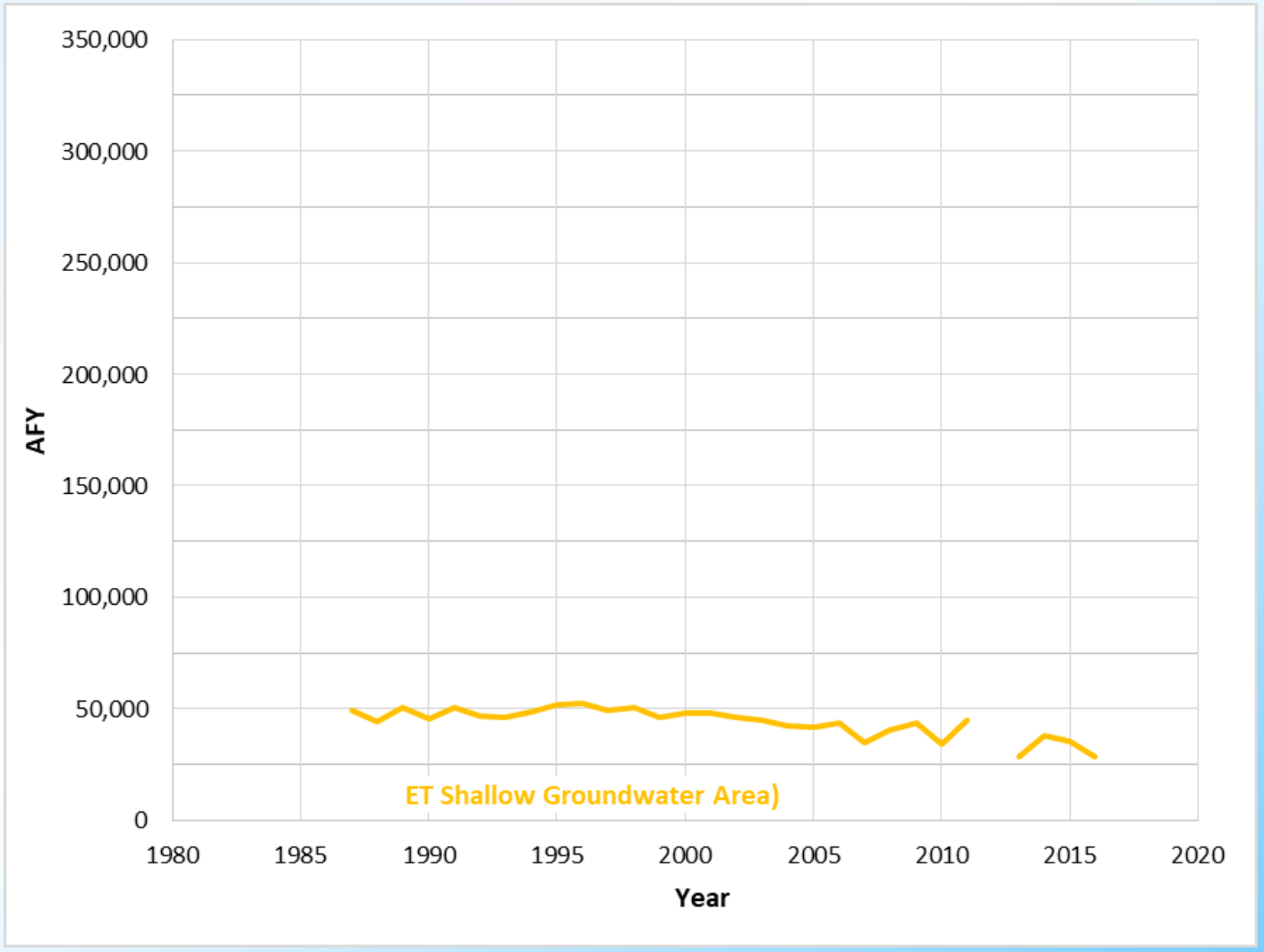

Year 2015
0
5 Miles
Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
0 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
901 - 1,000
1,001 - 1,100
1,101 - 1,200
1,201 - 1,300
1,301 - 1,400
1,401 - 1,500


Year 2016
at MWD Crossing
below Prado Dam
0
5 Miles
Legend
Yearly ET Estimate--SSEBopV1 (mm/yr)
0 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
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1,401 - 1,500

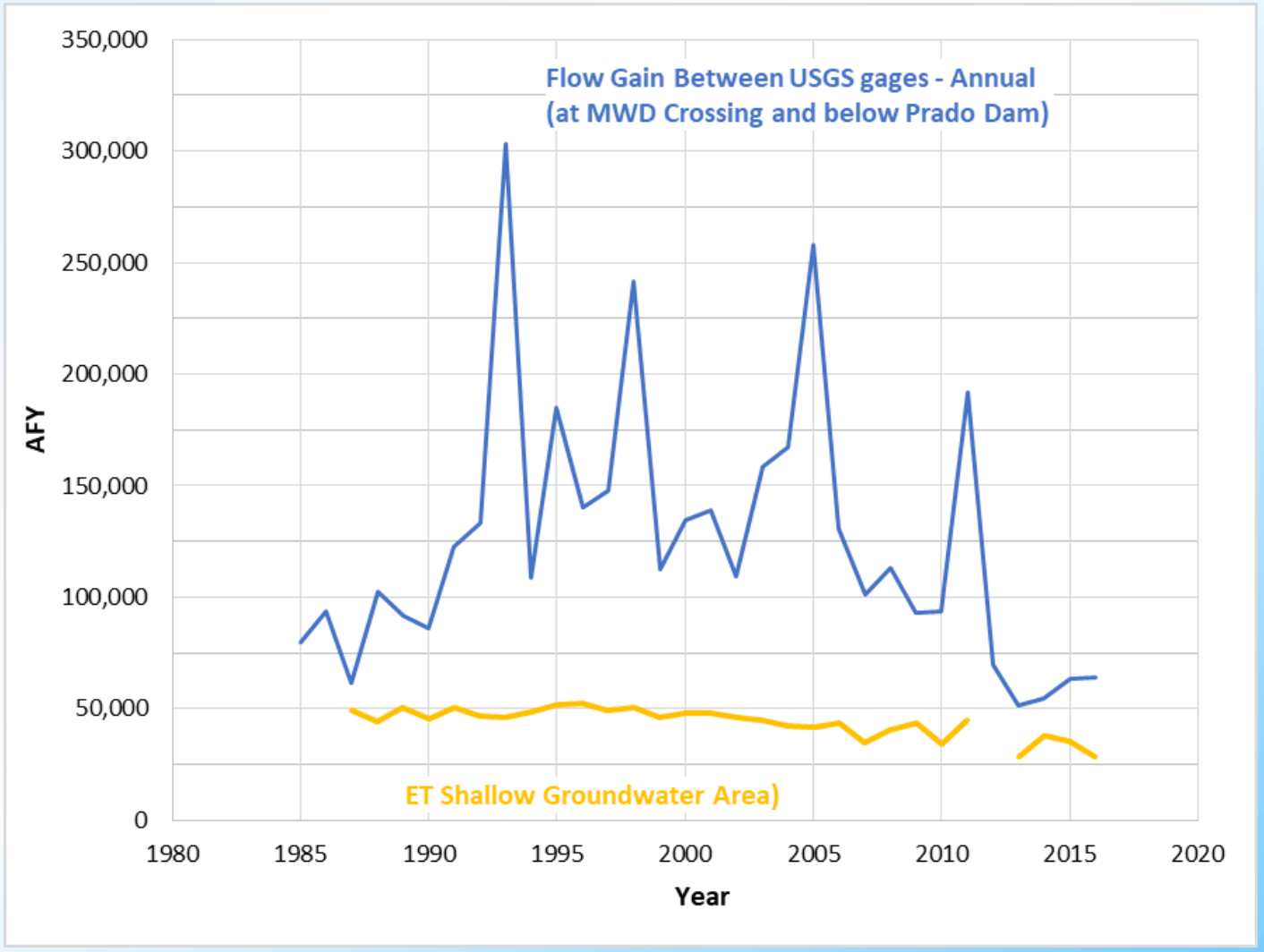
SUMMARY OF AVERAGE ANNUAL ET



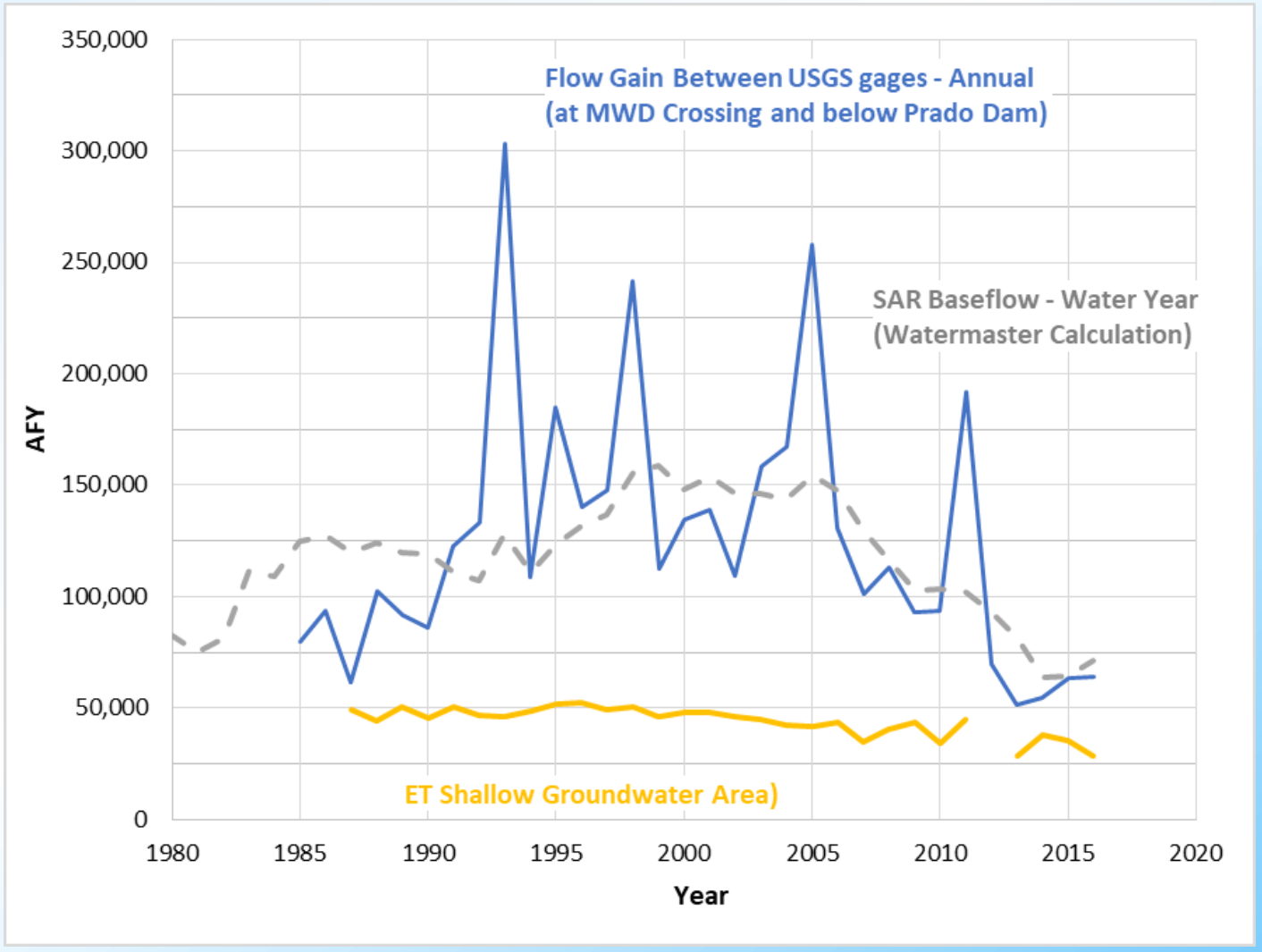
AVERAGE ANNUAL ET



AVERAGE ANNUAL ET AND RIVER FLOW

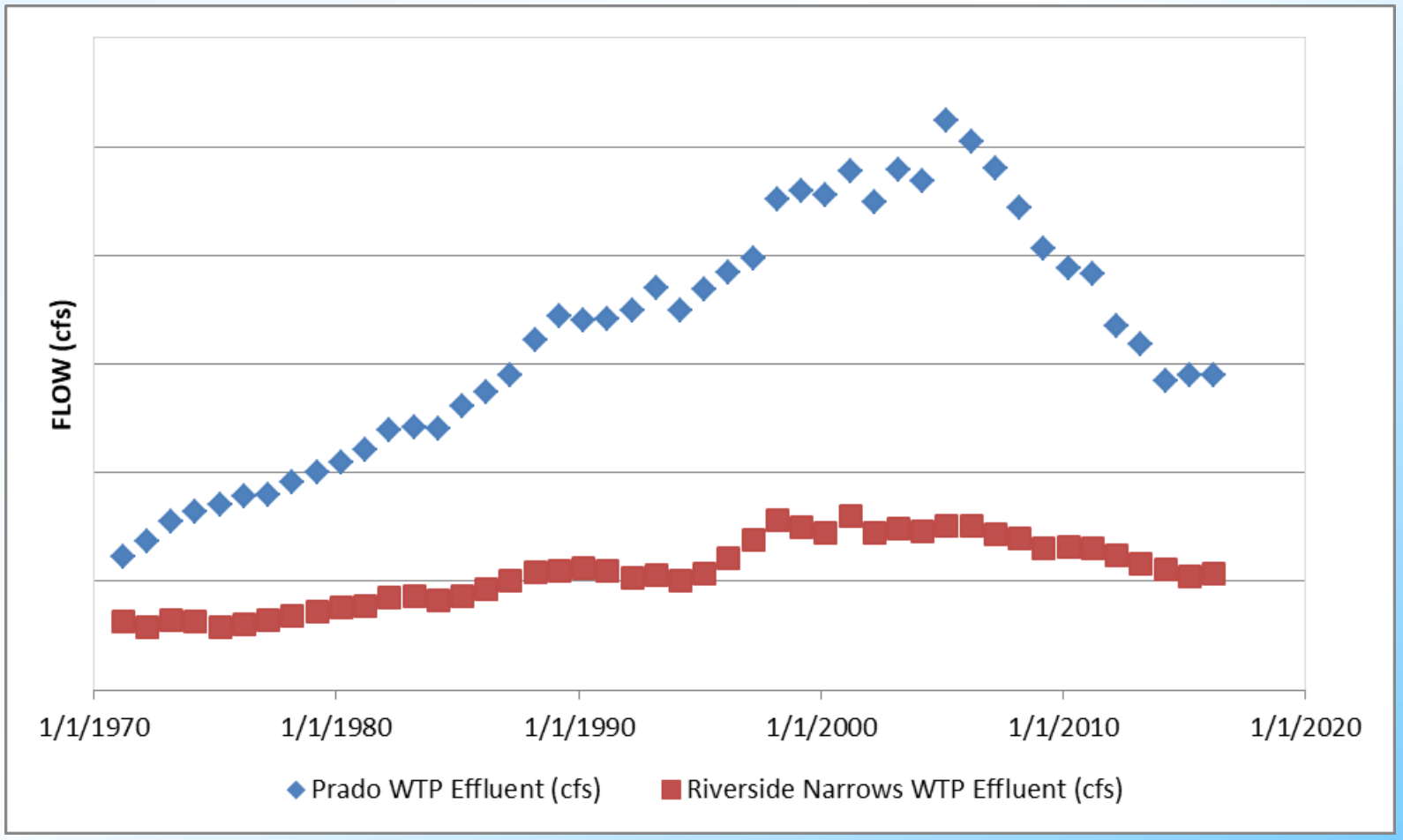


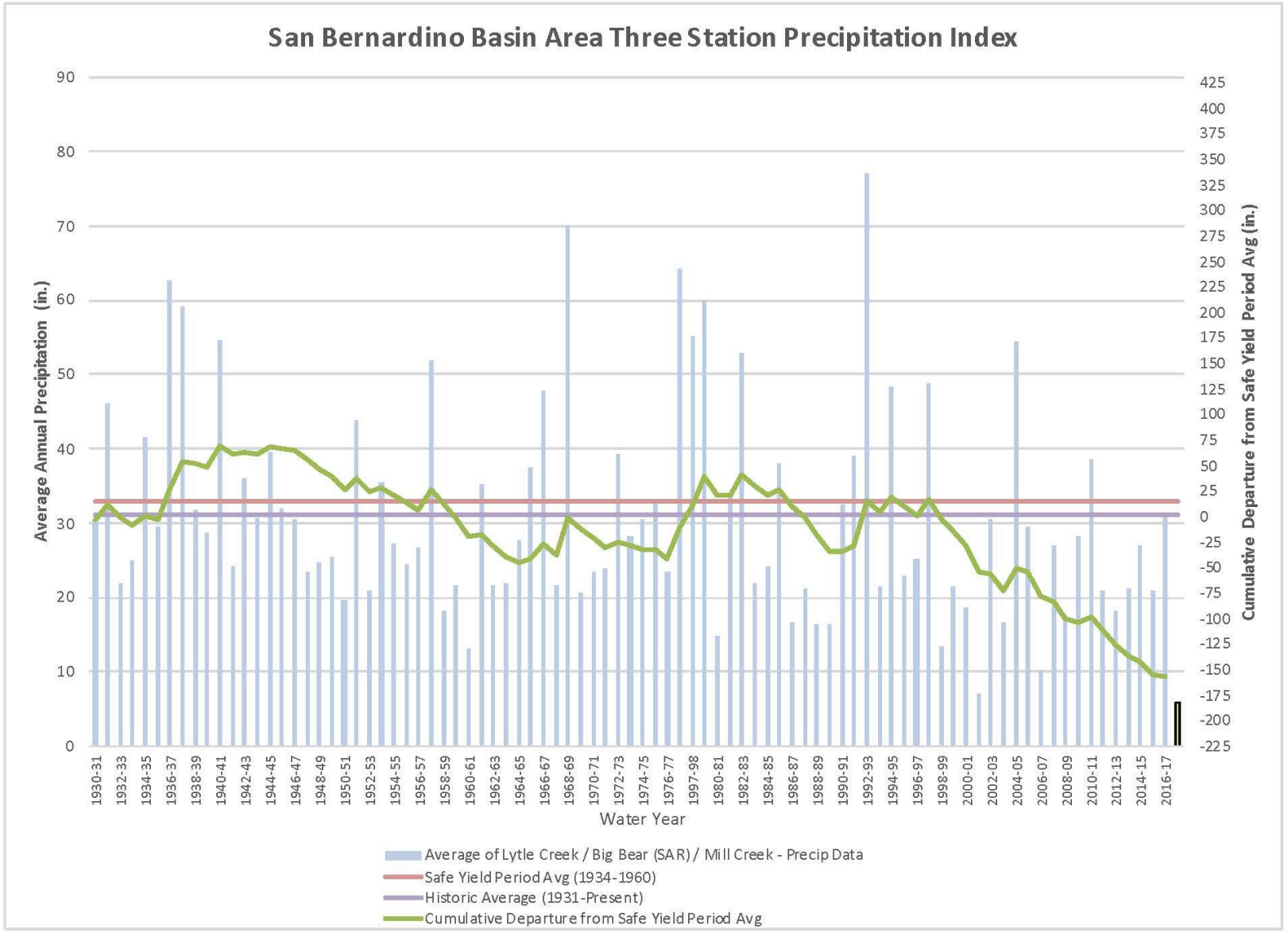
AVERAGE ANNUAL ET AND RIVER FLOW



Water Treatment Plant (WTP) Flows and Precipitation

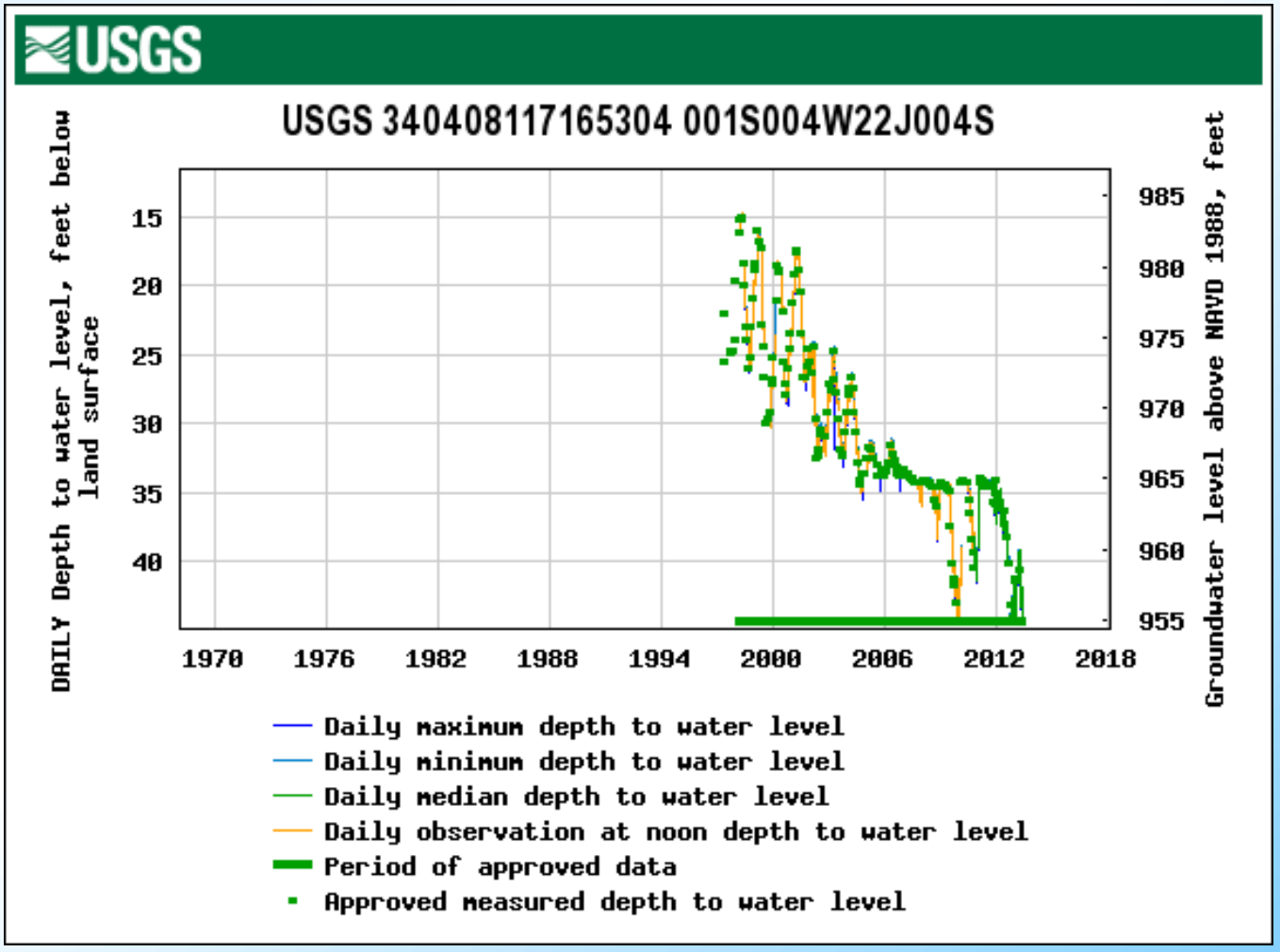
WTP DECREASE IN FLOW OVER LAST DECADE




San Bernardino Basin Area Three Station Precipitation Index
Average Annual Precipitation (in.)
Cumulative Departure from Safe Yield Period Avg (in.)
Water Year
Average of Lytle Creek / Big Bear (SAR) / Mill Creek - Precip Data
Safe Yield Period Avg (1934-1960)
Historic Average (1931-Present)
Cumulative Departure from Safe Yield Period Avg

Shallow Water Level
(San Bernardino Commerce Center)

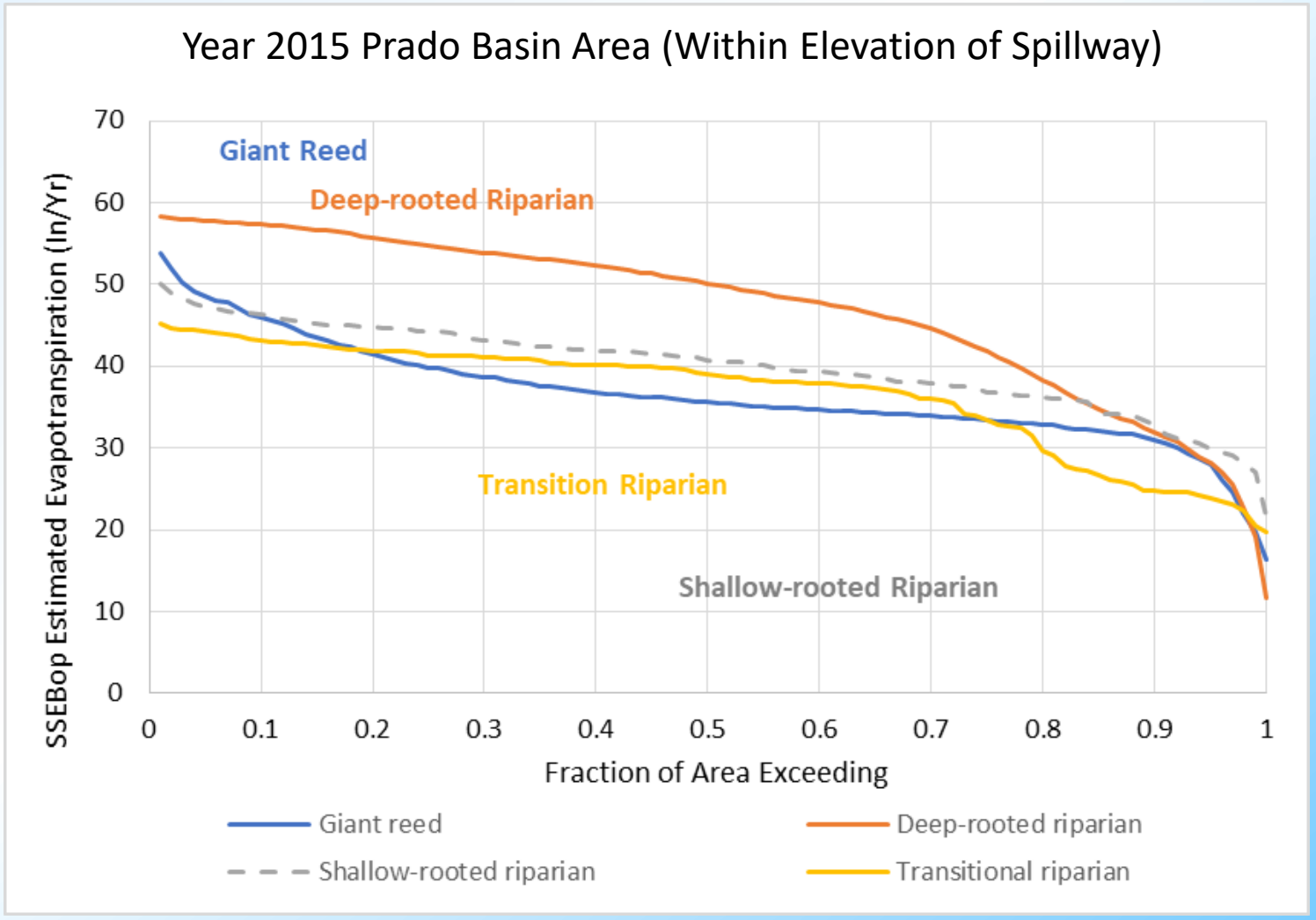
Upper-most Piezometer - Water Table



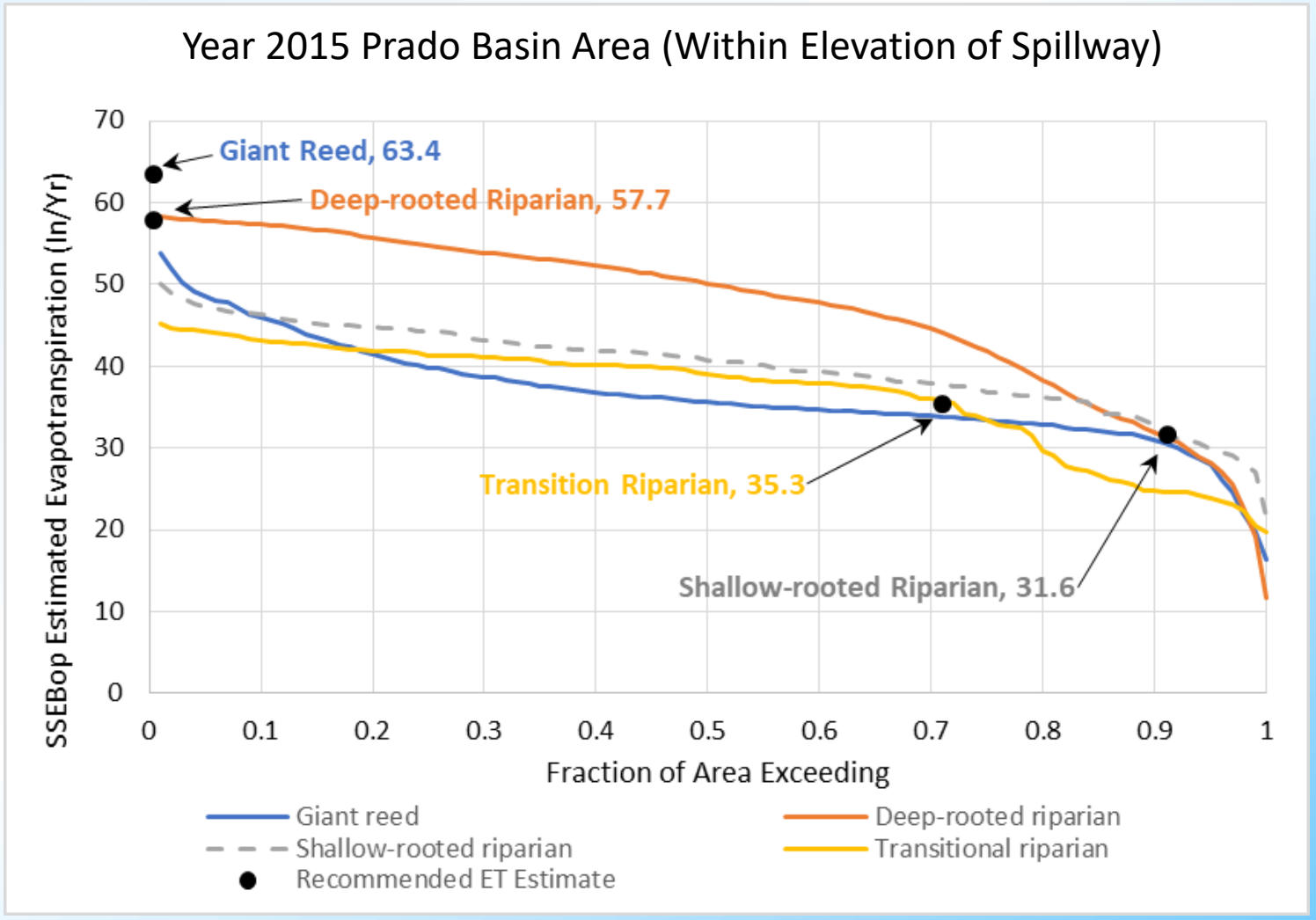
San Bernardino Commerce Center

ET Estimates - Aspen Environmental Group

ESTIMATED ET - Aspen *Environmental Group*, 12/7/17 Memorandum



ESTIMATED ET - Aspen *Environmental Group*, 12/7/17 Memorandum



OBSERVATION

The SSEBop ET estimate is a systematic analysis regionally applied to the Upper Santa Ana River area over multiple years.

The ET estimate by Aspen Environmental Group is within the range of the historical variability derived from the SSEBop estimate.

The ET estimate provides insight to evaluating the shallow groundwater budget represented in the SAR integrated model.

ET simulated in the groundwater model should be generally less than the values derived from SSEBop because the energy balance approach Includes ET from soil moisture in the vadose zone (above the water table).

That is, calibration of the groundwater model is a basis for estimating ET in a range that is bounded by the SSEBop estimate.


SAN BERNARDINO
Valley
MUNICIPAL
WATER DISTRICT

APPENDIX F

Evapotranspiration Estimates by Aspen Environmental

(Draft, December 7, 2017)

GEOSCIENCE



Aspen Environmental Group

615 North Benson Ave., Suite E, Upland, CA 91786
Tel. 909-480-4124, www.aspeneg.com

PROJECT MEMORANDUM: Upper Santa Ana River Integrated Model

Date: December 7, 2017
To: Johnson Yeh, Geoscience Support Services
From: Scott D. White and Philip Lowe
Subject: **Evapotranspiration estimates**

This memorandum describes the methods and results of Aspen's literature review regarding evapotranspiration rates of predominant riparian vegetation types in the Upper Santa Ana River area, developed for purposes of estimating the effects of riparian evapotranspiration (i.e., consumptive use) on groundwater.

Evapotranspiration (ET) estimates were derived from a literature search of available published evapotranspiration rates for the habitats identified along the Santa Ana River for use in the groundwater integrated model. Riparian habitat types are based on categories recommended by Maddock et al. (2012) with one additional category for giant reed, due to its high abundance in the study area. The categories are listed in Table 1. Wherever available, research data on locally dominant riparian species were used for each category. However, in the cases of shallow-rooted riparian and transition riparian, agricultural data were used as surrogates for locally dominant riparian species. The literature search revealed a wide range of information regarding evapotranspiration for deep-rooted riparian, giant reed, obligate wetland and open water habitats. Little or no information was found that was applicable to the shallow-rooted riparian and deep-rooted riparian habitats. Consequently, proxy ET rates were used for these from published ET rates for irrigated crops that were considered, in consultation with biologists, representative of these types of vegetation.

Table 1. Riparian Habitats along the Santa Ana River.

VEGETATION TYPE	RELEVANT REPRESENTATIVE HABITATS FROM THE LITERATURE REVIEW
Deep-rooted riparian	Cottonwood, Willow
Giant reed	Arundo
Obligate wetland	Cattails, Tules, Bulrush
Open water	Open Water
Shallow-rooted riparian	Late season irrigated crops: corn and grain sorghum, potatoes, sugar beets and turnips.
Transition riparian	Irrigated tree crops: walnut, citrus, deciduous.

The literature search revealed a wide range of ET estimates for the deep-rooted riparian, giant reed, obligate wetland and open water habitats from various studies mostly in California and other western U.S. states. Table 2 gives representative published ET estimates, the sources, and the location of the source studies.

Table 2. Representative Published Evapotranspiration Estimates and Sources.			
GIANT REED (ARUNDO)			
Annual ET, in Inches	**Location**	**Source (See reference section for complete references)**	**Notes**
63.4	Italy	Triana, et al., 2015,	ET adjusted by Leidos based on Kv values derived from the source publication and recorded ETo values from Riverside.*
23 – 33	Mojave River, California	USBR, et al., 2010.	
240 - 480	California	California Invasive Plant Council, 2011.	
18 - 102	Italy	Triana, et al., 2015.	As cited in: Bren School of Environmental Science & Management, 2016.
11 - 389	Italy and Texas	Tuttolomondo et al., 2015, and Watts & Moore, 2011.	As cited in: Bren School of Environmental Science & Management, 2016.
73 - 147	California	Bren School of Environmental Science & Management, 2016.	

Table 2. Representative Published Evapotranspiration Estimates and Sources.			
DEEP-ROOTED RIPARIAN (COTTONWOOD/WILLOW)			
Annual ET, in Inches	**Location**	**Source (See reference section for complete references)**	**Notes**
57.7	Various western U.S. locations	Howes, et al., 2015.	ET adjusted by Leidos based on Kv values derived from the source publication and recorded ETo values from the California Irrigation Management Information System (CIMIS) station #44 at UC Riverside (CIMIS, 2017).
42 - 51	Various western U.S. locations	Howes, et al. 2015.	ET estimated by Aspen based on Kv values derived from the source publication and reference ETo values published by the California Irrigation Management Information System (CIMIS, 1999). CIMIS Reference ET (ETo) Zone 6.
29 - 37	Mojave River, California	USBR, et al., 2010.	
19 - 38	San Pedro River, Arizona	USGS, 2006.	
16 - 38	San Pedro River, Arizona	Southwest Watershed Research, 2009.	
20 - >37	San Pedro River, Arizona	Scott, et al. 2008.	
41 - 47	Texas	Cleverly, et al., 2006.	
50 - 72	Arizona	As referenced by Goodrich, et al., 2000.	
45 - 53	Santa Ana California	DWR, 1942.	

Table 2. Representative Published Evapotranspiration Estimates and Sources.			
OBLIGATE WETLAND (CATTAILS AND RUSHES)			
Annual ET, in Inches	**Location**	**Source (See reference section for complete references)**	**Notes**
60	Various western U.S. locations and Florida	Howes, et al. 2015.	ET adjusted by Leidos based on Kv values derived from the source publication and recorded ETo values from the California Irrigation Management Information System (CIMIS) station #44 at UC Riverside (CIMIS, 2017).
34 - 78	Various western U.S. locations and Florida	Howes, et al. 2015.	ET estimated by Aspen based on Kv values derived from the source publication and reference ETo values published by the California Irrigation Management Information System (CIMIS, 1999). CIMIS Reference ET (ETo) Zone 6.
53 - 134	Colorado River	USGS, 1968.	ET estimated in tanks.
51 - 63	Idaho	USGS, 1957.	
110 - 184	Southern California	DWR, 1942.	Estimated in tanks. Field estimate was 63 – 78 inches. Various other similar estimates reported.
SHALLOW-ROOTED RIPARIAN			
Annual ET, in Inches	**Location**	**Source (See reference section for complete references)**	**Notes**
31.6	Southern California	California Irrigation Training and Research Center, 2003.	Represented by late season crops: corn and grain sorghum, potatoes, sugar beets, turnips average. CIMIS Reference ET (ETo) Zone 6.
TRANSITION RIPARIAN			
Annual ET, in Inches	**Location**	**Source (See reference section for complete references)**	**Notes**
35.3	Southern California	California Irrigation Training and Research Center. 2003.	Represented by tree crops: walnuts, citrus, deciduous crops. CIMIS Reference ET (ETo) Zone 6.

Table 2. Representative Published Evapotranspiration Estimates and Sources.			
OPEN WATER			
54	Southern California	Howes, et al. 2015	ET adjusted by Leidos based on Kv values derived from the source publication and recorded ETo values from the California Irrigation Management Information System (CIMIS) station #44 at UC Riverside (CIMIS, 2017).
49 – 50	Delta Region and Lake Elsinore, CA	Howes, et al. 2015	ET estimated by Aspen based on Kv values derived from the source publication and reference ETo values published by the California Irrigation Management Information System (CIMIS, 1999). CIMIS Reference ET (ETo) Zone 6.
45.5	San Pedro River, AZ	USGS, 2006.	
*ET rates are estimated by reference ET rate (ETo) multiplied by an adjustment factor (Kv) specific to the type of vegetation.			

The literature research revealed a wide range of ET estimates, particularly for giant reed, which estimates ranged from 11 inches per year to 480. Table 3 provides the ET estimates recommended for this study, followed by an explanation of the choice of these estimates.

Table 3. Recommended Evapotranspiration Estimates and Sources.			
GIANT REED (ARUNDO)			
Annual ET, in Inches	**Location**	**Source (See reference section for complete references)**	**Notes**
63.4	Italy	Triana, et al., 2015,	ET adjusted by Leidos based on Kv values derived from the source publication and recorded ETo values from Riverside.
DEEP-ROOTED RIPARIAN (COTTONWOOD/WILLOW)			
57.7	Various western U.S. locations	Howes, et al., 2015.	ET adjusted by Leidos based on Kv values derived from the source publication and recorded ETo values from the California Irrigation Management Information System (CIMIS) station #44 at UC Riverside (CIMIS, 2017).
OBLIGATE WETLAND (CATTAILS AND RUSHES)			
60	Various western U.S. locations and Florida	Howes, et al. 2015.	ET adjusted by Leidos based on Kv values derived from the source publication and recorded ETo values from the California Irrigation Management Information System (CIMIS) station #44 at UC Riverside (CIMIS, 2017).
SHALLOW-ROOTED RIPARIAN			
31.6	Southern California	California Irrigation Training and Research Center, 2003.	Represented by late season crops: corn and grain sorghum, potatoes, sugar beets, turnips average. CIMIS Reference ET (ETo) Zone 6.

Table 3. Recommended Evapotranspiration Estimates and Sources.			
TRANSITION RIPARIAN			
35.3	Southern California	California Irrigation Training and Research Center. 2003.	Represented by tree crops: walnuts, citrus, deciduous crops. CIMIS Reference ET (ETo) Zone 6.
OPEN WATER			
54	Southern California	Howes, et al. 2015	ET adjusted by Leidos based on Kv values derived from the source publication and recorded ETo values from the California Irrigation Management Information System (CIMIS) station #44 at UC Riverside (CIMIS, 2017).

The Triana study for Arundo was selected for the reason that it was done in a part of Italy that has a similar climate, particularly in terms of rainfall, as Corona, California, and the results, when adjusted for the reference ET for Riverside California, was in the mid-range of the other estimates (See Table 2).

The deep-rooted riparian (cottonwood/willow) ET estimates cited in the Howes study were from various locations, including Santa Ana California, New Mexico. The range of ET for cottonwood/willow vegetation in the literature were more consistent than those for arundo, and are therefore considered more reliable. The recommended ET is on the high end but within the literature range, and have been adjusted using the reference ET for Riverside California.

The cattail ET estimate was also from the Howes study and adjusted for the reference ET for Riverside California. The Howes study referenced cattail and bulrush ET from studies mainly in California but also in Florida and Utah, and were also relatively consistent in the literature. The recommended ET value is about in the middle of the published range.

As no ET estimates for natural vegetation were found that directly related to the shallow-rooted riparian and transition riparian vegetation, published crop ET rates were used as a proxy. These ET rates were estimated from published relative reference ET rates for those crops applied to the published grass reference ET rates for CIMIS Reference ET (ETo) Zone 6, which includes the project area. The ET rate for these vegetation types is a little less than the ET for deep-rooted riparian vegetation and obligate wetland, which may be expected for the transition riparian due to the location of this vegetation type in comparison to the others. The shallow-rooted riparian vegetation can have very high monthly rates during the growing season, but due to the seasonality of this vegetation type, the annual rate is less than for cottonwood/willow.

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APPENDIX G

Technical Memorandum Summarizing the Development of a Unified Upper Santa Ana River Basin Conceptual and Lithologic Model via Integration of Existing Sub-Basin Models

(Numeric Solutions, Draft dated March 16, 2018)

GEOSCIENCE

Technical Memorandum Summarizing the Development of a Unified Upper Santa Ana River Basin Conceptual and Lithologic Model via Integration of Existing Sub-Basin Models

DRAFT

Prepared For:

Geoscience Services Incorporated
La Verne, California

Prepared By:

Numeric Solutions LLC
996 Seaward Avenue
Ventura, California 93001

March 16, 2018

Prepared By:

Eric White
Geoscientist / Modeler

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1.0 INTRODUCTION

1.1 Background and Purpose

This technical memorandum summarizes the development of a geologic model that has been developed, through aggregation of existing sub-basin models, to evaluate subsurface conditions within the Upper Santa Ana River (SAR) Groundwater Basin, Los Angeles, San Bernardino, and Riverside Counties, California. Numeric Solutions, LLC, in collaboration with GEOSCIENCE Support Services Incorporated (GEOSCIENCE) was tasked with developing an integrated geologic model (Task 1) for use in a unified groundwater model for the Upper SAR Basin. The original geologic basin models, three of which were previously developed by Numeric Solutions, were utilized in their entirety or in part for the development of the SAR Model.

The role of the geologic model is to integrate the available lithologic, geophysical, and structural data into a model framework that describes the nature, thickness, and extent of the unconsolidated, and water bearing consolidated sediments in the project area. Once these parameters are established, the model interpolates these conditions between data points to establish a three-dimensional grid through which geologic data can be modeled. The output of the is model is then used as input in the flow model to estimate hydraulic conductivities and layer elevations/thickness through the model domain. This model differs from the existing models in several ways. First, the number of model layers within the existing sub-basin models (Chino, Rialto-Colton, Riverside-Arlington, San Bernardino, and Yucaipa) do not contain a constant number of flow layers. Furthermore, in some cases the geologic definition of the model base was not consistent (consolidated sediments vs crystalline bedrock). Thus, the first step in integrating the models was to develop a uniform basement definition and a constant number of model layers across the model domain. Second, only three (Rialto-Colton, San Bernardino, and Riverside-Arlington) of the five-existing model previously had a lithologic model developed using Numeric Solutions' and Geoscience's methodology which uses geostatistical interpolation methods to approximate subsurface conditions in areas where no data exists. As a result, new lithologic models were developed for the Chino and Yucaipa Basins.

1.2 Scope of Work

The scope of work for this project involved the development of a unified three dimensional lithologic and hydrostratigraphic model from the existing models as well as various additional data sources including:

- 1,120 borehole logs prepared by geologists, engineers, or drillers. Lithologic descriptions on the original logs where interpreted and converted to a numeric "lithology value" ranging from 1 to 15 generally based on presumed hydraulic conductivity. In general, lithologic materials with presumed high hydraulic conductivity values have greater lithology values. Table XX provides a summary of the "lithology values" and the corresponding lithologic descriptions;
- 42 wells with downhole geophysical logs (typically long-and short-normal resistivity logs, natural gamma or gamma-ray logs, SP logs);
- Electronic files provided by the USGS for layer elevations and faults for the Yucaipa Basin;
- Geophysical gravity data provided by the USGS
- Oil and gas well log data from The Department of Oil, Gas and Geothermal Resources (DOGGR).

After compiling the selected data, Numeric Solutions performed a series of interpretations based on the data and integrated interpretations of geologic conditions by previous authors. These interpretations were presented to the project stakeholders for evaluation, input, and where necessary, modification at a series of in-person meetings and conference calls. Subsequently, a lithologic property model was developed using the process described in Section 2. The property model will be incorporated into a quantitative groundwater flow model by GEOSCIENCE.

1.3 Sub-Basin Model Updates or Development

1.3.1 Rialto-Colton Basin

A previous geologic model developed in 2014 by GEOSCIENCE and Numeric Solutions was used in for this project. The only changes made were (1) the combining of the existing model's Layer 1 (river deposits) and Layer 2 (upper aquifer) into a single model layer, and (2) adding an additional layer 6 to the model to include saturated consolidated sedimentary material. 202 wells with lithology data were used in model development.

1.3.2 San Bernardino Basin

A geologic model developed in 2013 by GEOSCIENCE, Stantec, and Numeric Solutions, was used for this project. The previous model consisted of five model layers. A sixth layer was added by subdividing the previous model's Layer 5. 304 wells with lithology data were used in model development.

1.3.3 Riverside-Arlington Basin

Numeric Solutions previously developed a geologic model for the Riverside-Arlington Basin for Wester Municipal Water District in 2008. For the unified SAR model, this model was updated with revised model layers. The previous model consisted of three model layers. This was updated to four model layers (Layer 5 are 6 are not present in the sub-basin). Layer 1 from the previous model (river deposits) was combined with Layer 2. Layer 2 was subdivided into two model layers and the previous model Layer 3 (now layer 4) was left unchanged. 321 wells with lithology data were used in model development.

1.3.4 Yucaipa Basin

For Yucaipa Basin, much of the framework (faults and model layer elevations) and borehole lithologic data had previously been compiled in an existing model develop by GEOSCIENCE and the USGS. By developing a set of cross sections though the basin, some adjustments to these layers were made, particularly in the northern most part of the basin. These data where then used to develop an updated model with 6 model layers. 10 faults, provided by the USGS, were also used in model development. Following finalizing the model framework, 66 wellbores with lithologic data were used to geostatistically estimate lithology throughout the Yucaipa Basin model area.

1.3.5 Chino Basin

The Chino Basin model (which includes the Temescal Basin) was based on work for the Chino Basin Water Master (CBWM) by Wildermuth Environmental Inc. in 2015. While no raw data was provided to GEOSCIENCE or Numeric Solutions, the data in Wildermuth's report provided the foundation for the development of a new "in-house" model for the Chino and Temescal Basins.

Model layer elevations for the three layers used by Wildermuth were taken from layer elevation maps provided in their report. This was done by georeferencing the maps and digitizing the contours. These contours were then loaded into Petrel™ and used to construct gridded surfaces which were used as the starting point for model layer generation. The CBWM model consists of 3 model layers and defined basement as the top of consolidated sediments. For consistency throughout the Upper SAR model, basement was defined as top of crystalline bedrock. To add a model layer to account for consolidated sediments, data from water wells, oil and gas exploratory wells, and geophysical data was used. Well logs from 12 oil and gas exploratory wells that penetrated crystalline basement were examined. These wells were also used to update the elevation for the base of unconsolidated sediments (base Layer 5) where appropriate. In addition, depth converted gravity data (Lengenheim et al., 2006) provide by the USGS was used to locally to define the top of crystalline bedrock in the southern portion of the basin where data was present. Finally, cross sections where developed though the oil and gas exploratory wells and water wells to further reinterpret top crystalline basement and the base of consolidated sediments in areas between data points.

CBMW's model layers for their base Layer 1 and base Layer 2 were used largely unchanged. Base Layer 3 was adjusted substantially, primarily in in the west end of the basin, using the data described above. Three layers were added to CBMW's model for consistency across the SAR model. The first of these is the additional consolidated sediments layer (Layer 6). Second, an additional layer was added by equally subdividing CBMW's Layer 3 into two layers (now Layers 4 and 5). Lastly, a new Layer 1 was added by dividing CBMW's Layer 1. This was done to include Santa Ana river deposits and the shallow aquifer. The base of the layers is defined by base shallow aquifer data points provided by GEOSCIENCE around the SAR and was set to have maximum thickness of 600'. CBMW's Layer 2 (now Layer 3) was not changed.

Lithology logs were provided to Numeric Solutions for 147 wells in the Chino Basin. These logs were used to develop the unified and independent lithologic models for the Chino Basin. Details on the methodology used to construct the lithology model will be described in more detail below.

Table - Count of lithology log in each sub-basin.

Sub-Basin	Lithology Logs
Chino	147
Rialto-Colton	202
Riverside-Arlington	321
San Bernardino	384
Yucaipa	66
TOTAL:	**1,120**

2.0 SAR LITHOLOGICAL MODELING WORKFLOW

Petrel™ (Schlumberger, 2014) is software for 3D visualization, 3D reservoir modeling and 3D mapping of the geological subsurface elements and is produced by petroleum service company Schlumberger. Petrel™ enables use of different modeling techniques (stochastic and deterministic) including facies modeling and various simulation algorithms as well as geostatistical tools and data

transformations. By using various forms of geophysical and borehole data a geological subsurface volume of interest can be modeled and interpreted. Drilling and other ways of data gathering is often expensive and limited. Geophysicists, geologists and engineers thus rely on software such as Petrel and the geostatistical algorithms implemented to model an area in question when data is scarce – which is the case in the Upper Santa Ana River Groundwater Basin.

2.1 Well Logs

Information on subsurface geologic properties such as lithologic values are stored with the wells in a vertical sequence and are called well logs. Well logs, also called borehole logs, are records of the geological subsurface penetrated by drilling. Information from the borehole can be inferred either by analyzing a sample from the borehole or by lowering instruments down into the borehole and making various measurements. Two kinds of well logs will be mentioned in this memorandum: lithologic and geophysical, though the main modeling effort has been to generate a geologic model of the subsurface material from the drillers' logs describing the "facies" or "lithologies" encountered along the borehole.

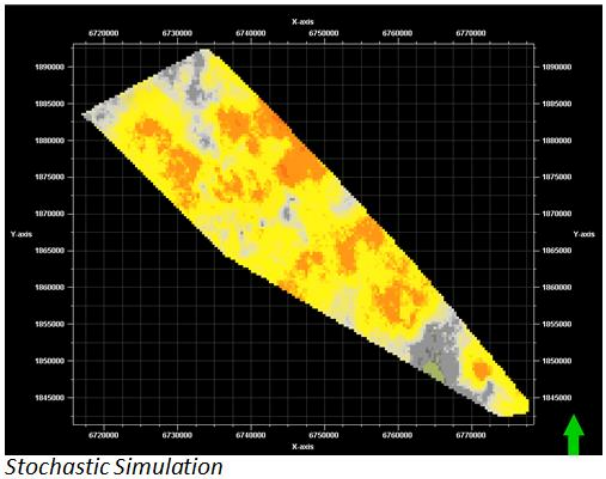
2.2 Modeling and Simulation

A simulation is a system of models having a definite resemblance of a geologic system whereas a model is an estimate, or an image, used to represent the spatial distribution of variables. Two different modeling methods are available in Petrel, deterministic and stochastic modeling.

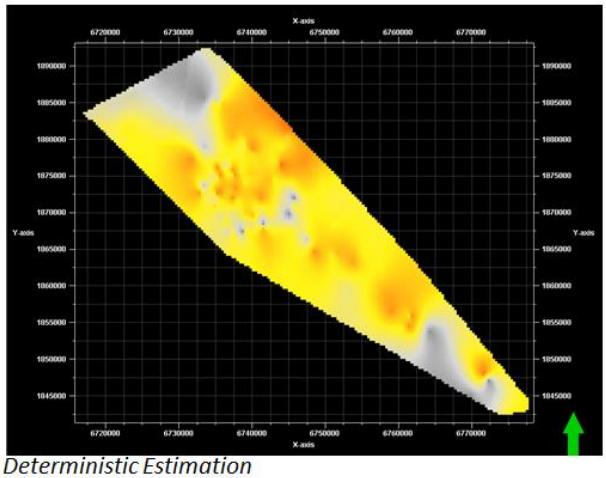
A *deterministic* model is a model where no randomness is involved in the modeling process, thus the same result will be generated for every modeling run with the same input data. A deterministic modeling algorithm will produce the same realization every time, which is "the best estimate." The deterministic approach requires great knowledge on the behavior of the variable being modeled. However very few earth science processes are understood in such detail. A stochastic approach is therefore more common and was thus used for this model.

A *stochastic* simulation model is based on a series of realizations representing a range of possibilities. The range of these possibilities depend on the distributions of the input data and the spatial variance of the input data and other elements used to constrain the geology. These realizations will have similar outputs (with the same input data) but with varying details. Stochastic modeling algorithms are more complex than deterministic algorithms implementing randomness. The distribution of a stochastically modeled property will have a distribution more typical of the real case. The specific variations and locations however are unlikely to match.

The same input data was used generating the images below:



Stochastic Simulation

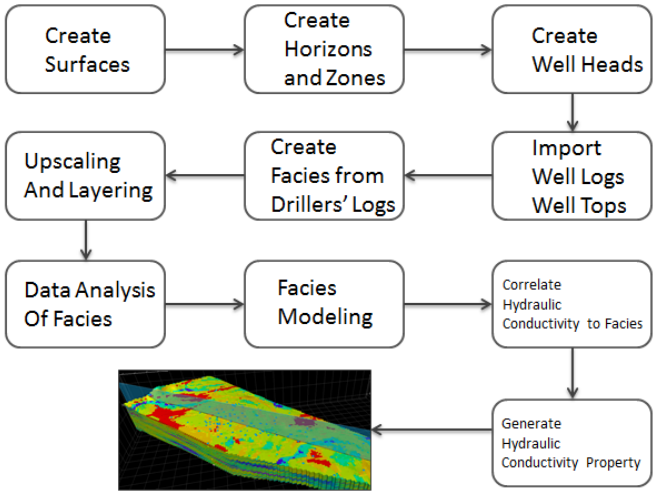


Deterministic Estimation

These figures show the spatial distribution of lithology in the model domain using lithology data from a sample of the well logs in the modeling area using a deterministic and a stochastic modeling algorithm.

2.2.1 Workflow

Constructing a 3D model in Petrel™ consists of many steps depending on what data is given. An overview of the process related to this study is given below:



For the integrated model first six steps were carried out using data from existing sub-basin models or new data provided by GEOSCIENCE or the USGS. The remaining four steps were carried out using the lithologic log data and geophysical log data. The geophysical logs were brought into the geological model as LAS formatted data. For this model, the logs have been used in a qualitative sense only for display with the lithological well log data on the cross sections. These geophysical logs can be used to interpret both lithological and fluid saturation conditions in the aquifer. Historically the geophysical logs have been used to pick flow unit contacts.

2.2.2 Data

The data used to create the 3D geologic model of the Upper Santa Ana River Groundwater Basin were received from GEOSCIENCE and the USGS and consisted of well logs consisting of lithological values, resistivity, gamma ray and stratigraphic surface data files with coordinates in XYZ format. All additional data and modeling elements required for the 3D geologic model were either obtained or generated by Numeric Solutions.

When working with wells in Petrel™ the existence of a well head is needed. A well head is simply information on the well such as its location, name and total depth. Well heads can be created interactively in Petrel as well as being imported. Well head data ether used from the existing models or provided by GEOSCIENCE and were loaded directly in spreadsheet form.

2.2.3 Creation of Stratigraphic Surfaces and Faults

The first step in construction of the 3D model is to generate surface from input data. Generally, the Petrel™ convergent interpolation algorithm is used, though this varies depending on the type of input data. The convergent interpolation algorithm is an iterative algorithm which converges on the solution (a final surface) by each iteration. Every iteration in the convergent interpolation algorithm consisted of three steps:

1. Refine - Increase of grid resolution
2. Adjust - Re gridding of the data
3. Smoothing - Minimizing curvature of the grid

No offset data for the faulting was received so the model was generated in two ways: 1] with no throw along the faults and 2] allowing the software to estimate the fault offsets based on the curvature of the surfaces and a fixed value input by the user to tell the algorithm how far from the fault to discount data. The final geocellular property model contains faults as internal pillar-gridded faults. The faults mapped in the area were brought into the model as vertical faults. Due to the lack of well-defined fault throw data, we did not specify displacements in the model.

The grid boundary was set using the outermost active cell boundary for any model layer provided by GEOSCIENCE. The cell size, or lateral grid dimensions, was set to Xinc=250 ft and Yinc=250 ft with a rotation of 27 degrees.

2.2.4 Creation of Horizons and Zones

For the surfaces to be incorporated into the 3D grid they needed to be transformed into horizons. With the creation of the seven horizons, six zones were created automatically in between the horizons. The zones, in turn, were divided into layers at a later stage in the modeling process.

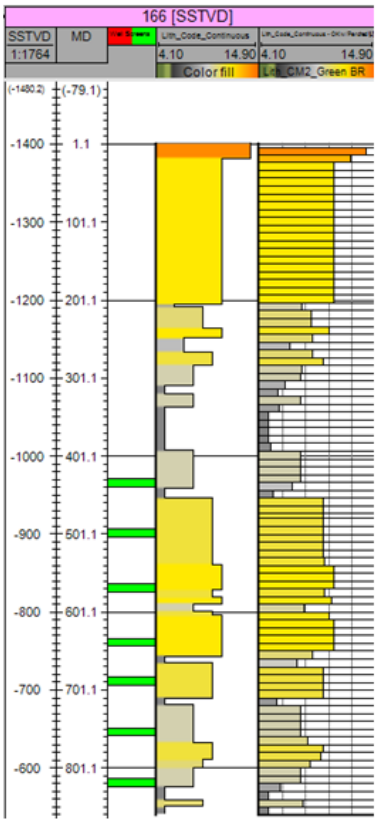
2.2.5 Creation of Facies Logs

In Petrel facies is regarded as a discrete property and is represented by an integer value. Facies modeling was done for the model volume where fourteen different types of facies existed. The lithologic facies indices were loaded from the lithologic facies data provided by GEOSCIENCE. Very few of the input data were adjusted in the model. There were some wells in the model that had anomalous values compared to neighboring wells and had to be reviewed. Less than 5% of the data were omitted and/or changed and such modification was reviewed with GEOSCIENCE.

2.2.6 Layering and Upscaling

Layering is the process when a zone is subdivided into internal layers. Layer can be carried out using a variety of methodologies and generally a method is chosen that will best match bedding. For zones 1-5, layering was set to follow a smoothed ground surface. This was chosen due to the young nature of these sediments and based of the assumption that, in most areas, the sediments were not highly deformed since the time of were deposited. In areas where there is more topographic relief it is assumed the that underlaying sediments would also show some degree of structural alteration. For Layer 6, a top conformable layering method was selected. This was based on the assumption that these consolidated sediments are older and more likely to have been deformed during basin expansion. Layer thickness was set at 20 feet for model layers 1-5 and 30 feet for model layer 6.

Upscaling was done to add the log data to the cells being penetrated by wells which have lithologic data associated. Each cell penetrated by the well needs to be given a single value of the lithology property. After determining the cells being penetrated by a well, the log data falling into the middle of each cell was used, this method is known as “mid-point pick.” For discrete data, this method is often preferable to taking an average or using the most abundant value as it better preserves the distribution because it prevents thin beds from being averaged out. An example of log upscaling is shown below:



Well logs generated in Petrel using data provided by GSSI. Well 166 well section with: completions (left/green), lithology data (middle) and upscaled model (right)

2.2.7 Property Model Development:

Once the I,J,K cell spacing is defined, the geocellular model framework is constructed, layers are generated, and the lithologic values at the wells are upscaled onto the cells, the model is ready to have properties distributed. The lithologic model properties at the cells are used to estimate the lithologic values for all the other cells in the model. This estimation process can vary widely depending on the data being used and the nature of the geological structures and settings within the modeling environment. For the Unified Santa Ana River Basin Model Numeric Solutions chose to use a stochastic (Gaussian Random Function Simulation [GRS]) approach for distributing the lithologic properties. The stochastic approach employs a system that accurately honors the input data distribution for each zone. Both methods honor the data at the wells and can be controlled through the use of horizontal and or vertical trends.

For this model, well data was honored precisely (Nugget = 0), and a spherical variogram was used with an anisotropy range of 15,000' in the major direction, 7,500' in the minor direction and 9.7' vertical. The major direction of orientation used is 59 degrees. This is the approximate average orientation of the Santa Ana River and was used to estimate the general direction of deposition of sediments in the model. This allows the model to trend features further in the major NE to SW direction than in the NW-SW direction, as is expected based on the depositional history of the basin.

2.2.7.1 Summary of Gaussian Random Function Simulation (GRS)

The Gaussian Random Function Simulation (GRS) is based on the Sequential Gaussian Simulation (SGS) function originally implemented in GSLIB (a Geostatistics program generated at Stanford University in the early 1990's). The GRS process was developed for Petrel to improve the performance and precision of the SGS function. The underlying algorithm of Sequential Gaussian Simulation (SGS) is simple kriging. Kriging gives an estimate of both the mean of the property value and its standard deviation at each grid node, so the variable at each grid node is represented as a random variable following a normal (Gaussian) distribution. Rather than choosing the weighted mean as the estimate at each node, SGS chooses a random deviate from this normal distribution, selected according to a uniform random number representing the probability level.

There are five basic steps in the SGS process:

1. Generate a random path though the grid nodes.
2. Visit the first node in that path and use kriging to estimate a mean and standard deviation at that node based on surrounding data (i.e., local conditional probability distribution, or lcpd).
3. Select at random a value from the lcpd and set the node value to that number.
4. Include the newly simulated value as part of the conditioning data.
5. Repeat steps 1 to 4 until all grid nodes have a simulated value.

A random path is used to avoid the artifacts induced by visiting grid nodes in a regular fashion. Sequential methods also use previously simulated values as "data" in the lcpd in order to preserve the proper covariance structure (spatial continuity) between simulated values.

For SGS it is important that the data actually follow a Gaussian distribution, so when SGS is used, the data are first transformed using the normal score transform.

In addition to the conditioning data that need to be honored, the input to a sequential simulation depends on the procedure used to estimate the cumulative density function (CDF). SGS requires one to describe the spatial continuity in terms of a variogram. These methods are very flexible and can also accommodate secondary data, but require a variogram of the secondary data and its relationship to the primary data and the strength of the relationship is controlled by the correlation coefficient between the primary and secondary data.

The Gaussian Random Function simulation (GRS) does differ from the Sequential Gaussian simulation (SGS) from GSLIB. GRS more accurately reproduces distributions. It is typically faster than SGS, with additional efficiencies due to its parallel architecture. GRS also has an option to run a fast collocated cosimulation.

Gaussian Random Function Simulation does a better job of modeling the expected variability in distributions. The speed gains of GRS can be impressive, in part due to its parallel methodology. In addition, the effects of varying the correlation coefficient when cosimulating properties can be seen practically real-time.

Recently geomodelers are encouraged to use the new GRS in workflows where SGS is usually applied. In large grids and/or in an uncertainty study context a great time-savings will be gained, as well as a visible improvement in achieving the desired distribution statistics.

3.0 RESULTS

The results of the modeling effort are provided in five cross-sections (Figures I-1 to I-5) and average maps for each layer (Figures I-6 to I-12).

Below is a histogram showing the relative abundance of each lithology type. This shows that lithology 11 (clean sand) is the most abundant. Also, the close relationship between the distributions of the upscaled cells (green) and the well logs (red) shows the robustness of the upscaling method (Mid-Point Pick). Secondly, the close match between the distribution of lithology seen throughout the distributed model cells (blue) and the upscaled cells and the wells logs indicates that the GRS algorithm is working property and accurately honoring the input data.

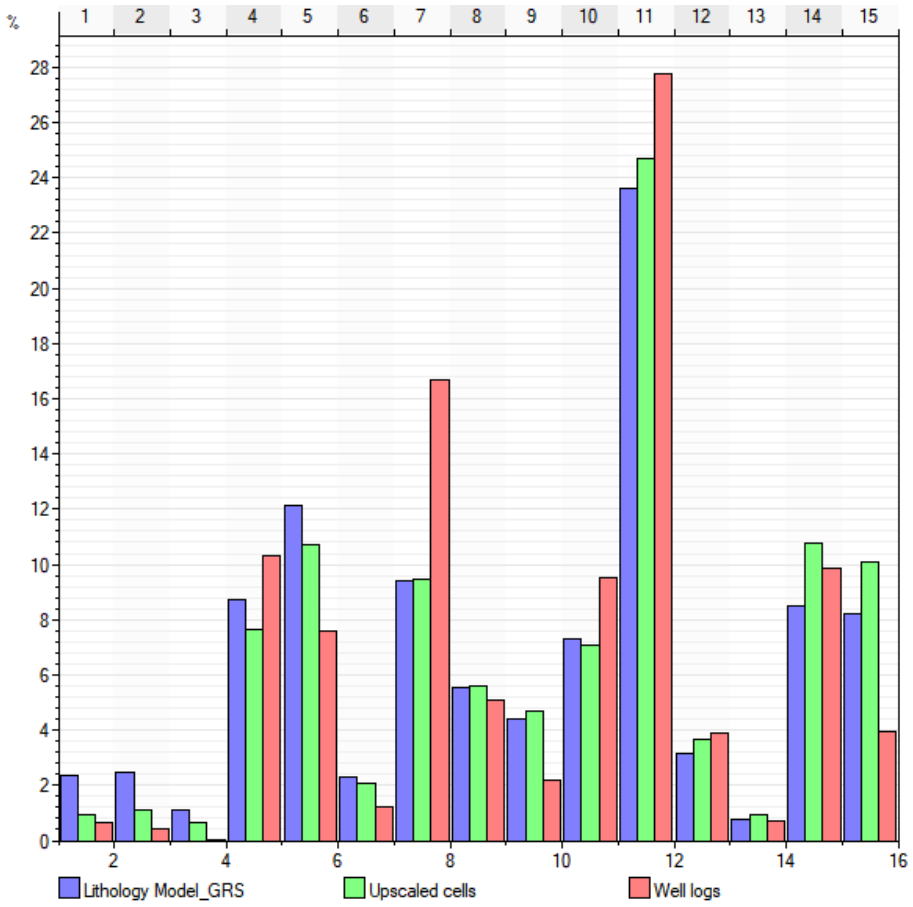


Figure - Histogram showing the relative abundance of each lithology in the well logs, upscaled cells, and in all of the cell in the Lithology Model.

4.0 REFERENCES

Langenheim, V.E. Tien-Chang Lee, Shawn Biehler, R.C. Jachens, and D.M. Morton (2006). Isostatic Gravity Map with Geology of the Santa Ana 30' x 60' Quadrangle, Southern California. USGS

A (NW)

A' (SE)

Lithology

- Bedrock
- Unweathered Bedrock
- Weathered Bedrock
- Organic Fines
- High Plasticity Clays
- Clay
- Silt
- Sandy Silt
- Clayey Sand
- Silty Sand
- Sand (Minor Silt/Clay)
- Clean Sand
- Gravel w/ Clay
- Gravel w/ Silt
- Gravel w/ Sand
- Clean Gravel

0 8000 16000 24000 32000 40000 48000 56000 64000 72000 80000 88000 96000 104000 112000 120000 128000 136000 144000

5600 4800 4000 3200 2400 1600 800 0 -800 -1600 -2400

Cajon_3/State_Well01N05W03A02S

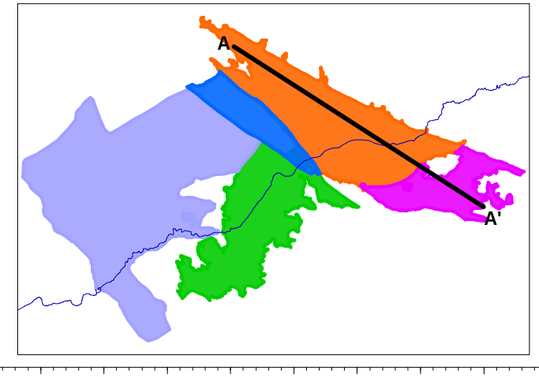
NewmarkMW7AB

EPA#06

EPA#09

Kendall01N04W21B02S

Unknown01N03W31M02S



Z-Scale: 1:10

Well projection limit: 500'

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Figure I-1

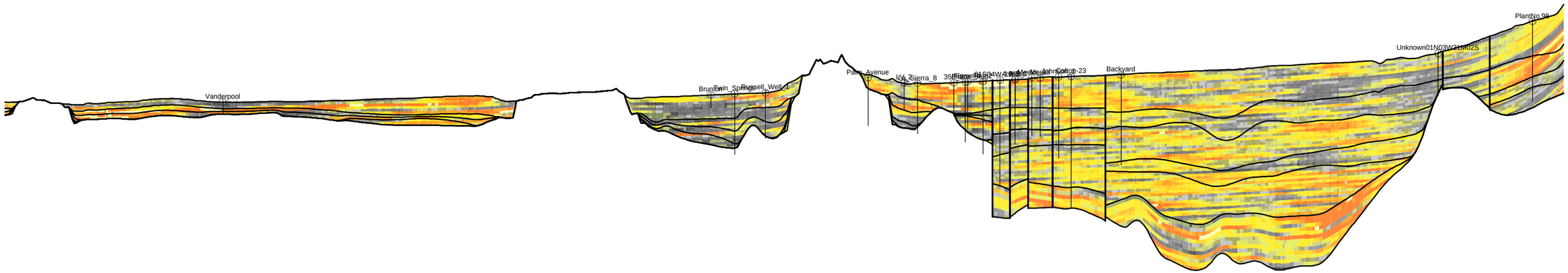
Numeric Solutions LLC
Geoinformation Management

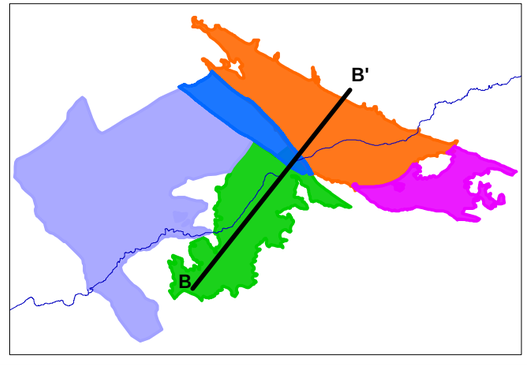
B (SW)

B' (NE)

Lithology

- Bedrock
- Unweathered Bedrock
- Weathered Bedrock
- Organic Fines
- High Plasticity Clays
- Clay
- Silt
- Sandy Silt
- Clayey Sand
- Silty Sand
- Sand (Minor Silt/Clay)
- Clean Sand
- Gravel w/ Clay
- Gravel w/ Silt
- Gravel w/ Sand
- Clean Gravel





Z-Scale: 1:10
Well projection limit: 500'

DRAFT

Figure I-2

Numeric Solutions LLC
Geoinformation Management

C (SW)

C' (NE)

Lithology

- Bedrock
- Unweathered Bedrock
- Weathered Bedrock
- Organic Fines
- High Plasticity Clays
- Clay
- Silt
- Sandy Silt
- Clayey Sand
- Silty Sand
- Sand (Minor Silt/Clay)
- Clean Sand
- Gravel w/ Clay
- Gravel w/ Silt
- Gravel w/ Sand
- Clean Gravel



Z-Scale: 1:10
Well projection limit: 500'

DRAFT

Figure I-3

Numeric Solutions LLC
Geoinformation Management

D (SW)

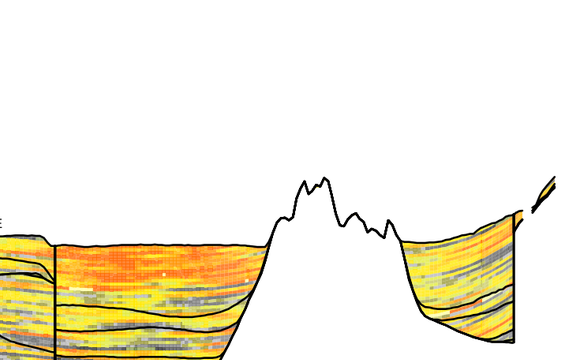
D' (NE)

Lithology

- Bedrock
- Unweathered Bedrock
- Weathered Bedrock
- Organic Fines
- High Plasticity Clays
- Clay
- Silt
- Sandy Silt
- Clayey Sand
- Silty Sand
- Sand (Minor Silt/Clay)
- Clean Sand
- Gravel w/ Clay
- Gravel w/ Silt
- Gravel w/ Sand
- Clean Gravel

8000 16000 24000 32000 40000 48000 56000 64000 72000 80000 88000 96000 104000 112000 120000 128000 136000 144000 152000

4000 3200 2400 1600 800 0 -800 -1600 -2400 -3200 -4000 -4800



Z-Scale: 1:10
Well projection limit: 500'

DRAFT

Figure I-4

Numeric Solutions LLC
Geoinformation Management

E (NW)

E' (SE)

Lithology

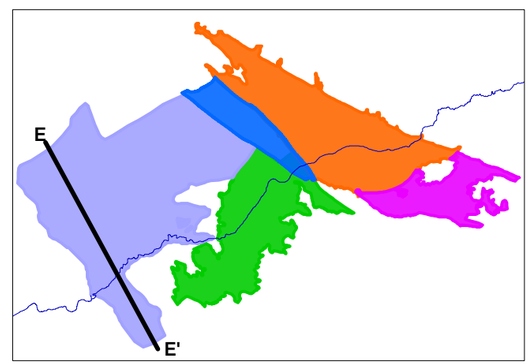
- Bedrock
- Unweathered Bedrock
- Weathered Bedrock
- Organic Fines
- High Plasticity Clays
- Clay
- Silt
- Sandy Silt
- Clayey Sand
- Silty Sand
- Sand (Minor Silt/Clay)
- Clean Sand
- Gravel w/ Clay
- Gravel w/ Silt
- Gravel w/ Sand
- Clean Gravel

Unknown49

1S8W23N1S

2S7W18C4S

Eureka_Ruben_1_29



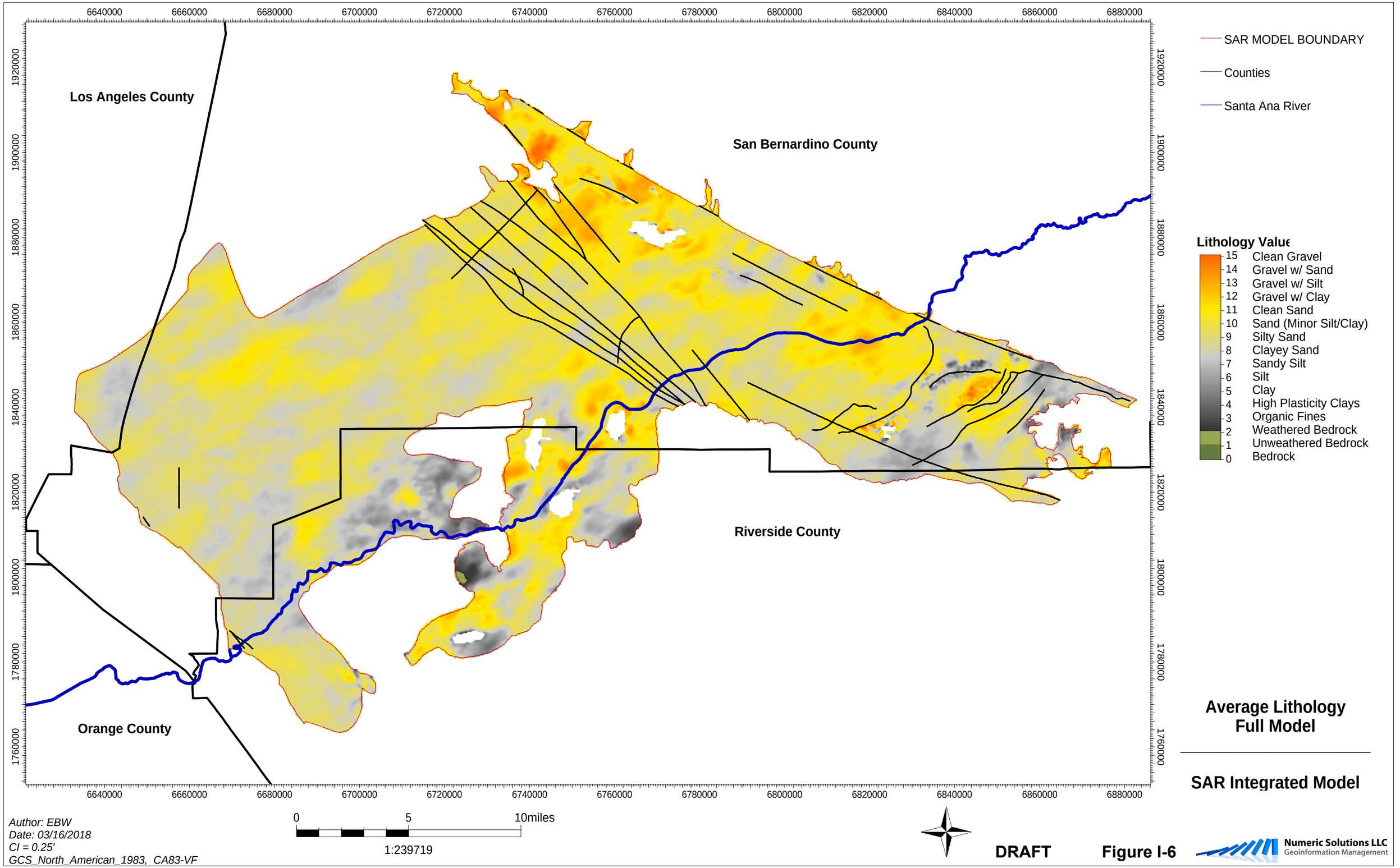
Z-Scale: 1:10

Well projection limit: 500'

DRAFT

Figure I-5

Numeric Solutions LLC
Geoinformation Management



Average Lithology
Full Model

SAR Integrated Model

Author: EBW
Date: 03/16/2018
CI = 0.25'
GCS_North_American_1983, CA83-VF

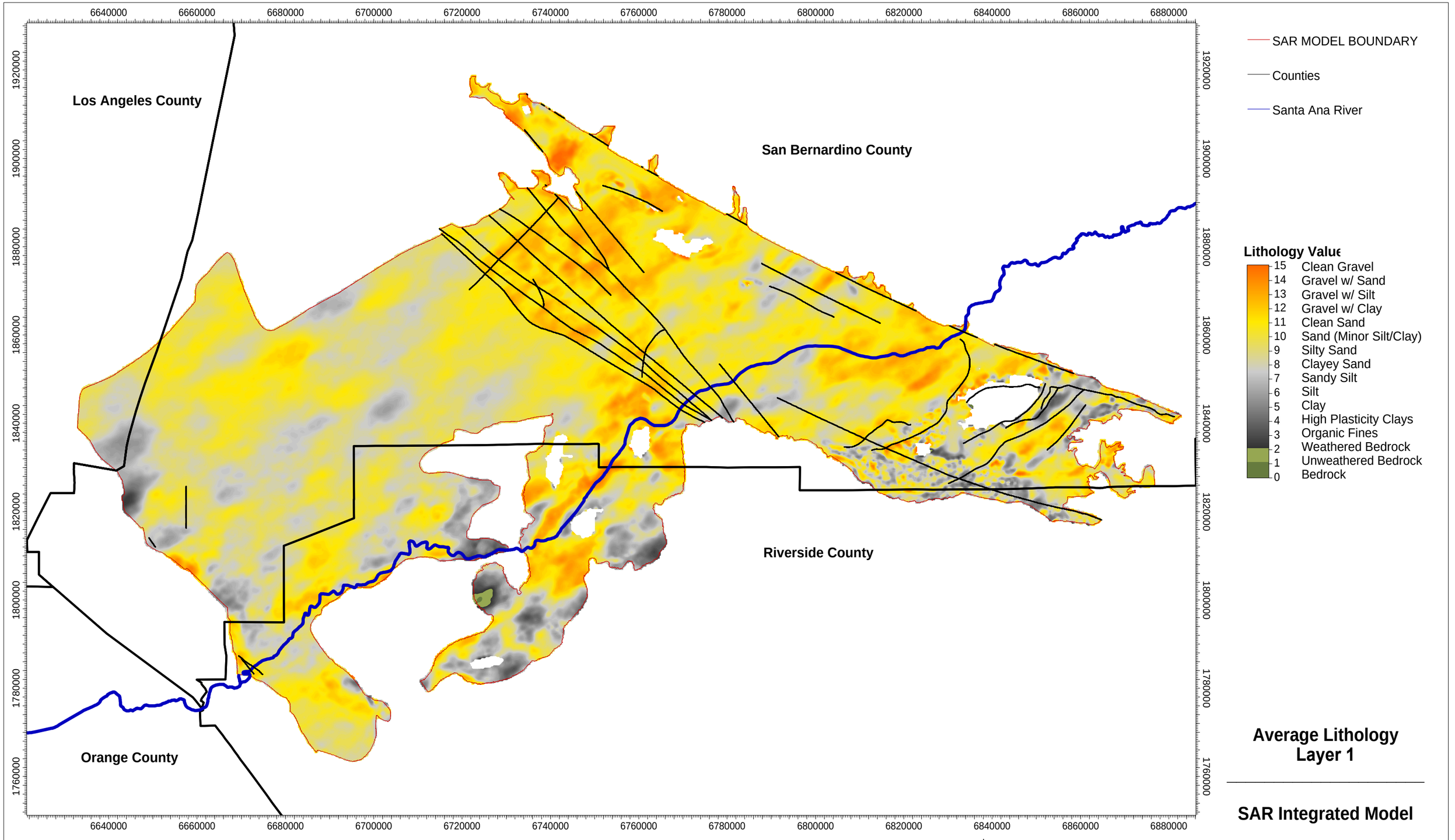
0 5 10miles

1:239719

DRAFT

Figure I-6

Numeric Solutions LLC
Geoinformation Management



Average Lithology Layer 1

SAR Integrated Model

Author: EBW
Date: 03/16/2018
CI = 0.25'
GCS_North_American_1983, CA83-VF

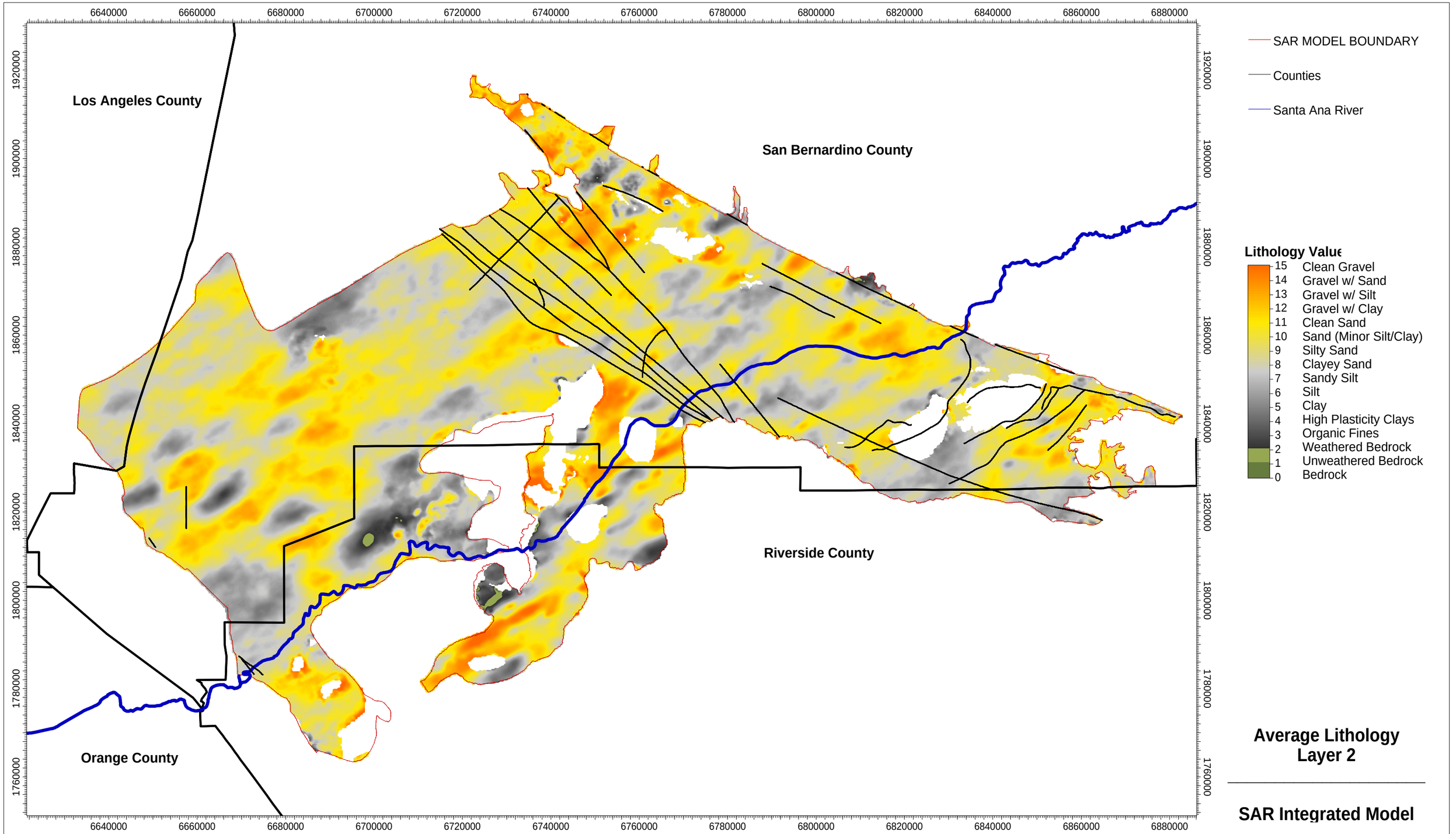
0 5 10miles

1:239719

DRAFT

Figure I-7

Numeric Solutions LLC
Geoinformation Management



Average Lithology Layer 2

SAR Integrated Model

Author: EBW
Date: 03/16/2018
CI = 0.25'
GCS_North_American_1983, CA83-VF

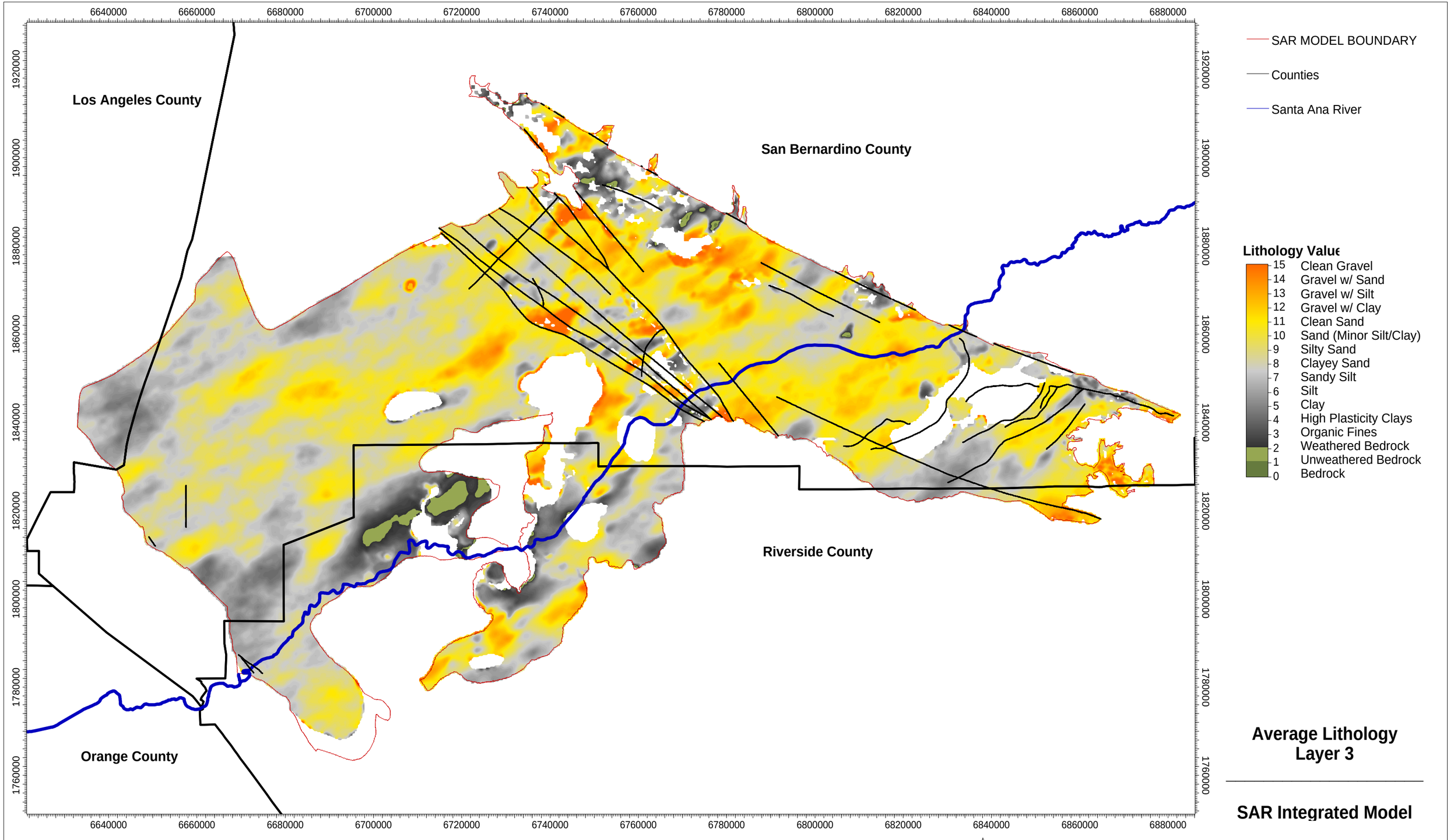
0 5 10miles

1:239719

DRAFT

Figure I-8

Numeric Solutions LLC
Geoinformation Management



Average Lithology Layer 3

SAR Integrated Model

Author: EBW
Date: 03/16/2018
CI = 0.25'
GCS_North_American_1983, CA83-VF

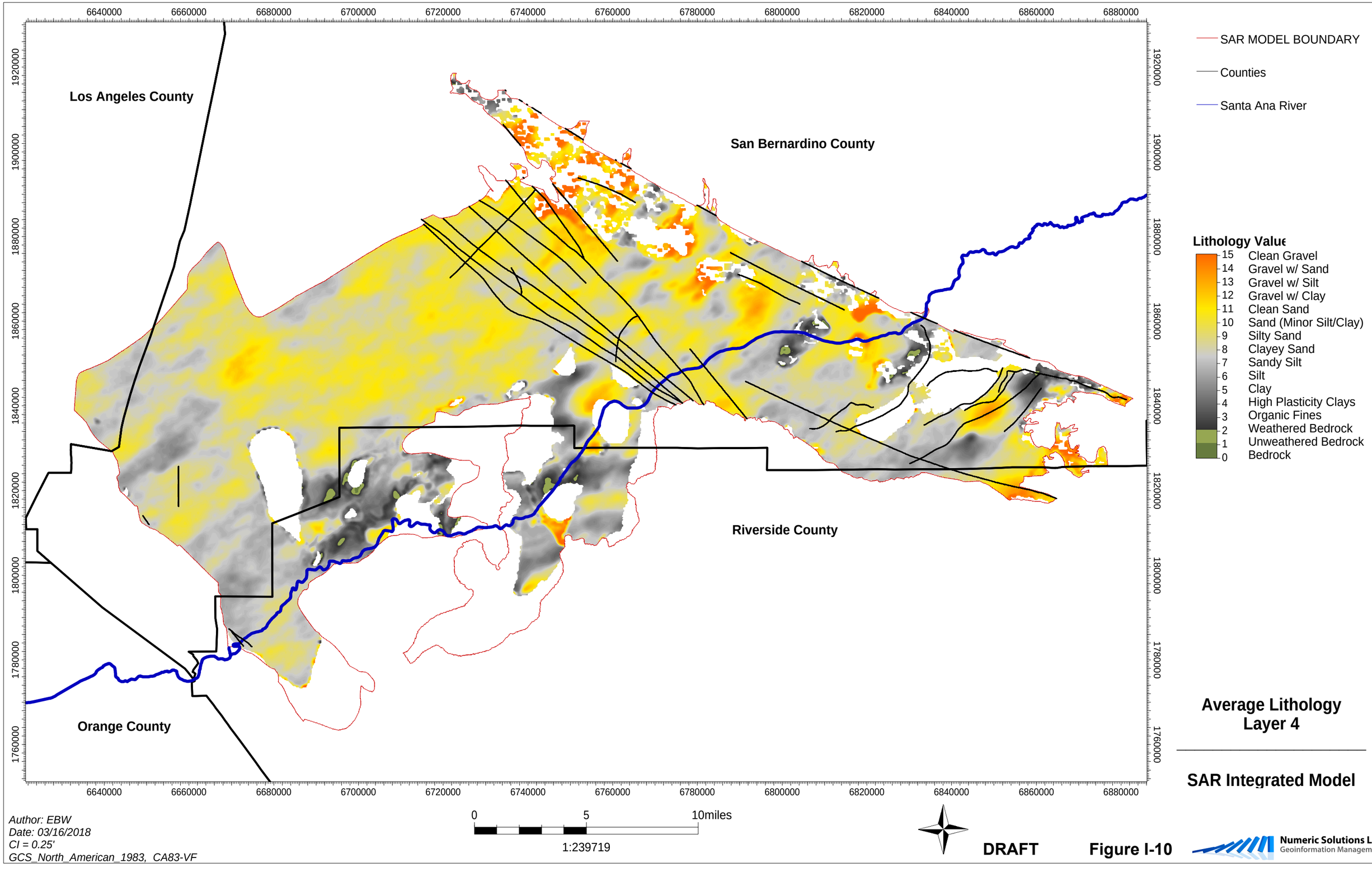
0 5 10miles

1:239719

DRAFT

Figure I-9

Numeric Solutions LLC
Geoinformation Management



Average Lithology Layer 4

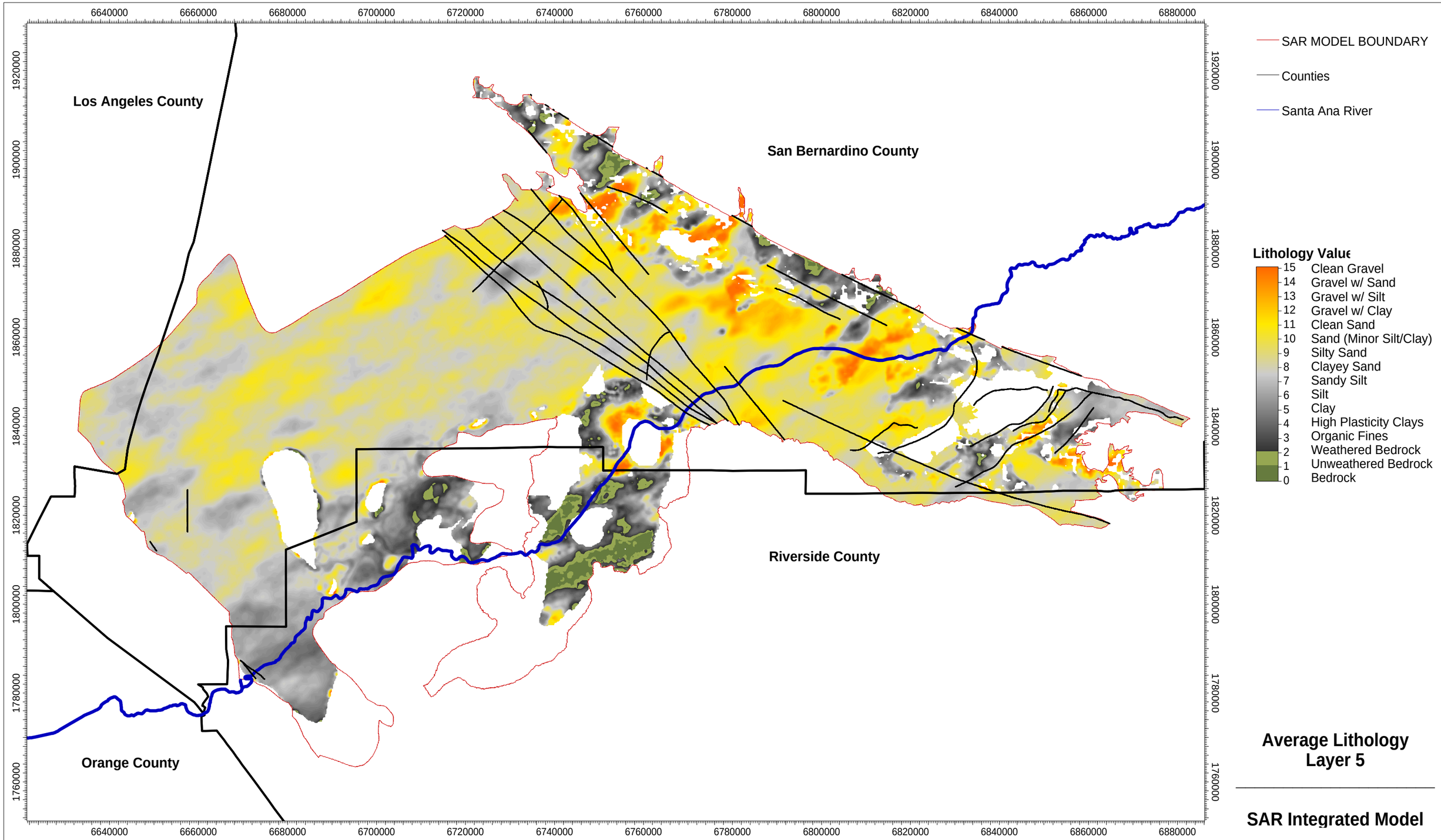
SAR Integrated Model

Author: EBW
Date: 03/16/2018
CI = 0.25'
GCS_North_American_1983, CA83-VF

DRAFT

Figure I-10

Numeric Solutions LLC
Geoinformation Management



Average Lithology Layer 5

SAR Integrated Model

Author: EBW
Date: 03/16/2018
CI = 0.25'
GCS_North_American_1983, CA83-VF

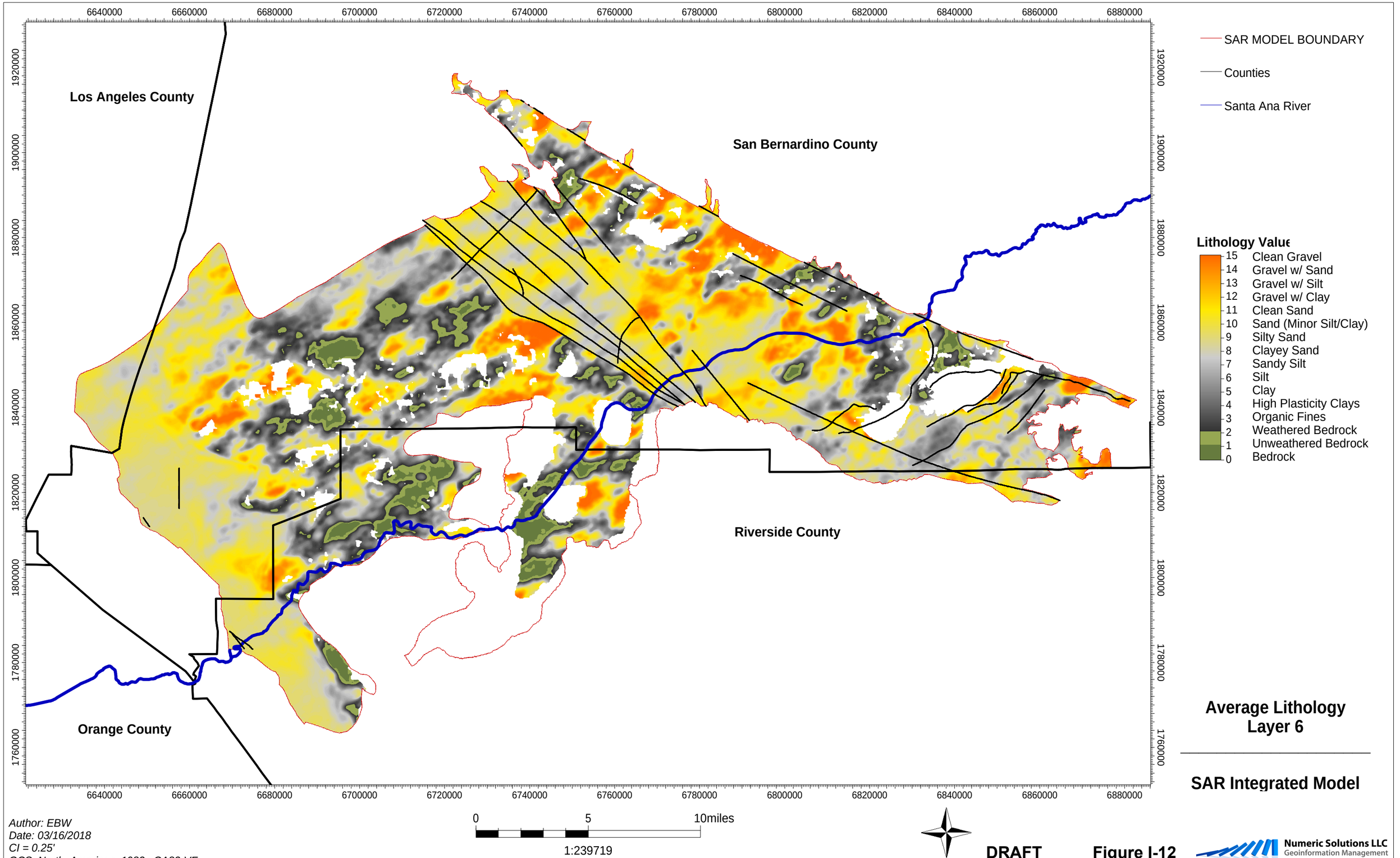
0 5 10miles

1:239719

DRAFT

Figure I-11

Numeric Solutions LLC
Geoinformation Management



Average Lithology
Layer 6

SAR Integrated Model

Author: EBW
Date: 03/16/2018
CI = 0.25'
GCS_North_American_1983, CA83-VF

DRAFT

Figure I-12

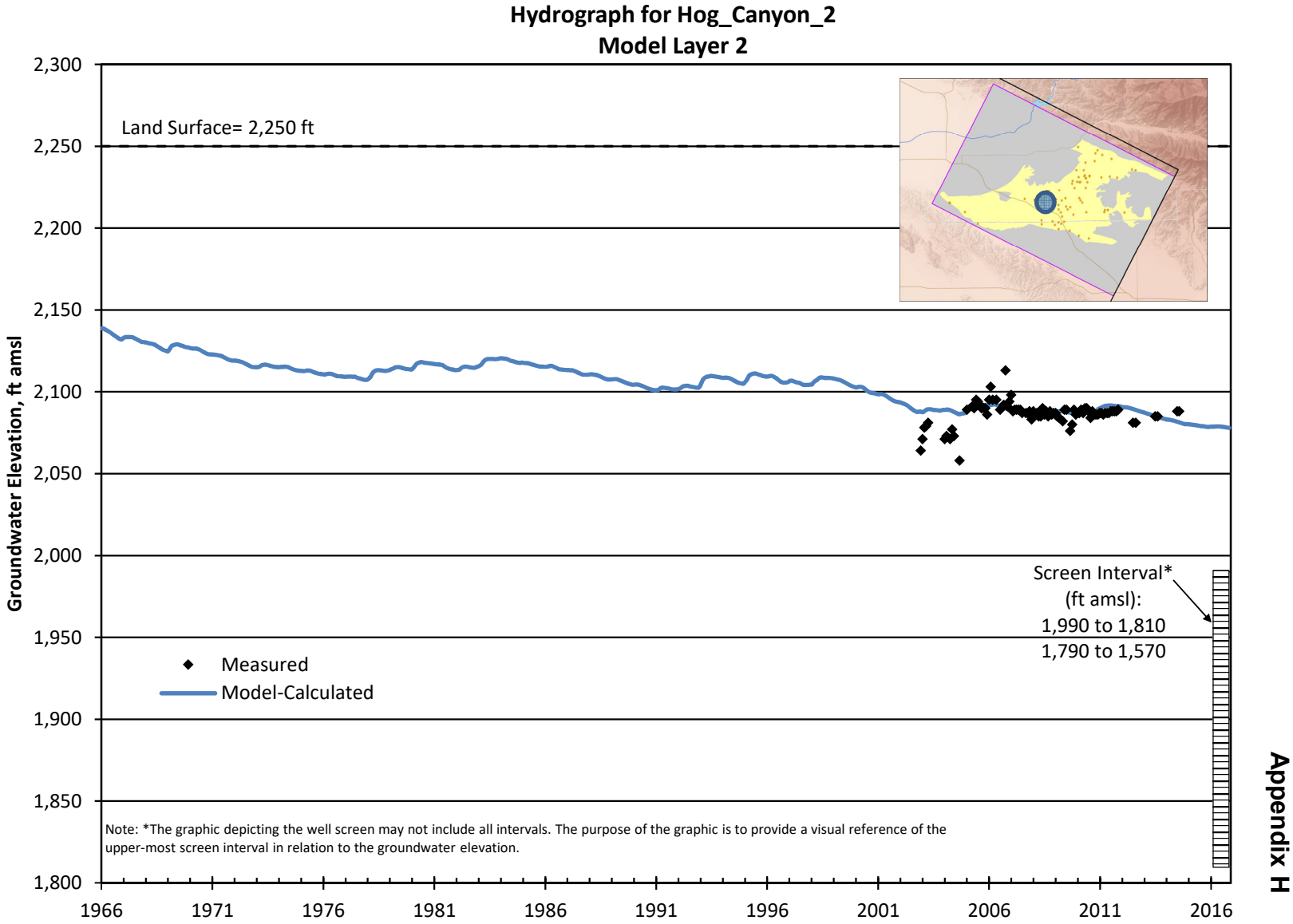
Numeric Solutions LLC
Geoinformation Management

APPENDIX H

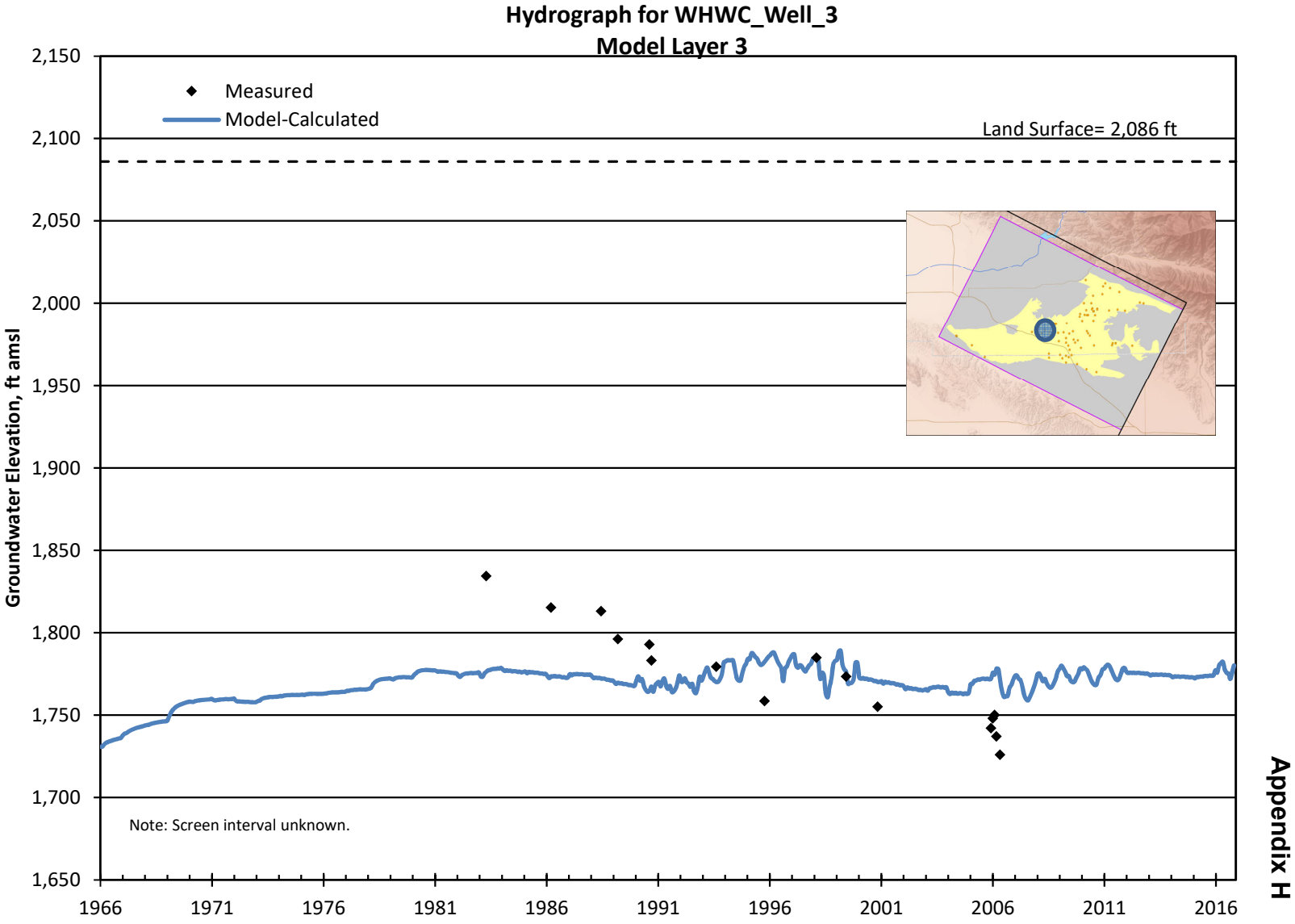
Individual Model Update: Selected Hydrographs for the Yucaipa Basin

Model Calibration Target Wells – 1966 to 2016

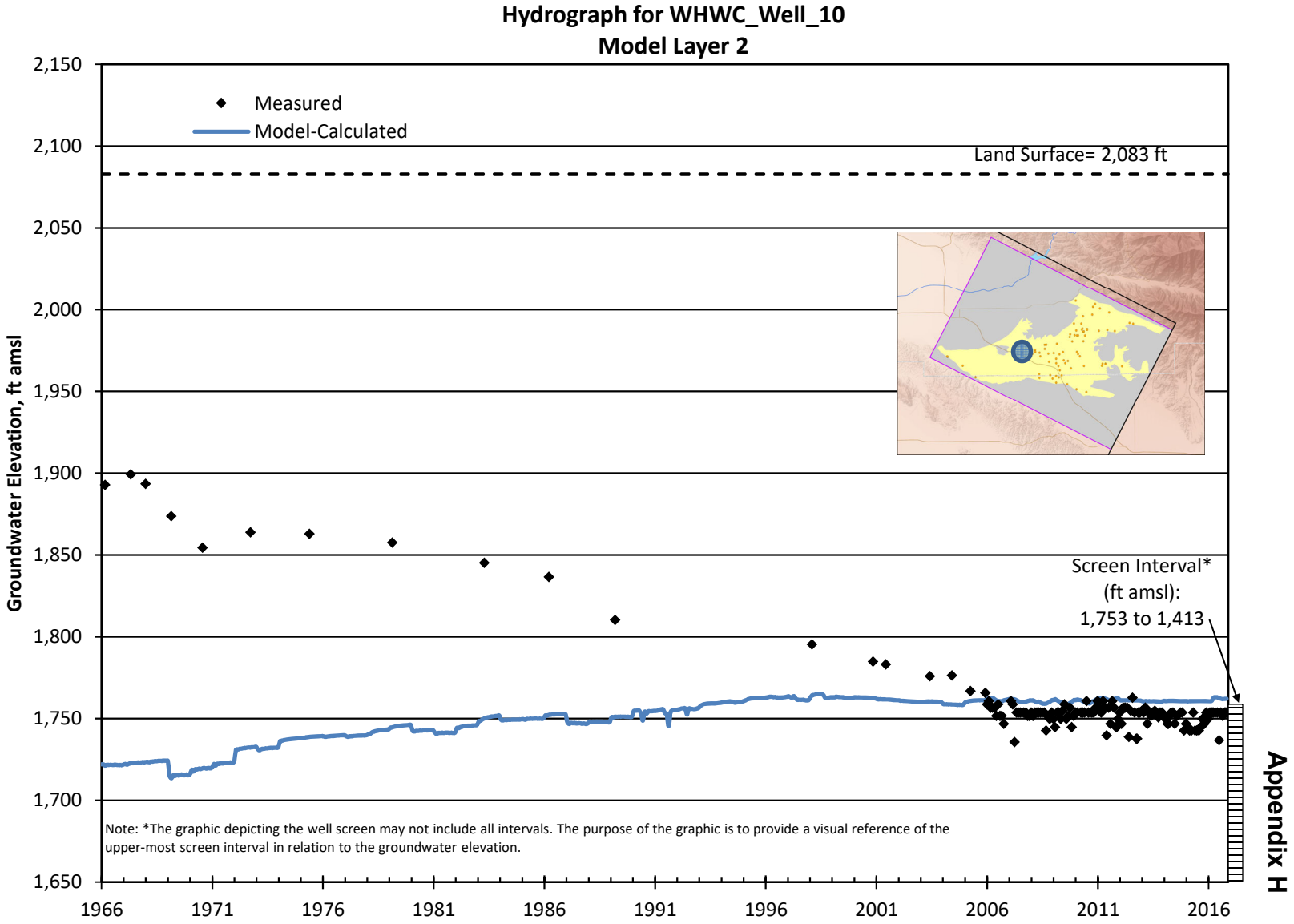
GEOSCIENCE

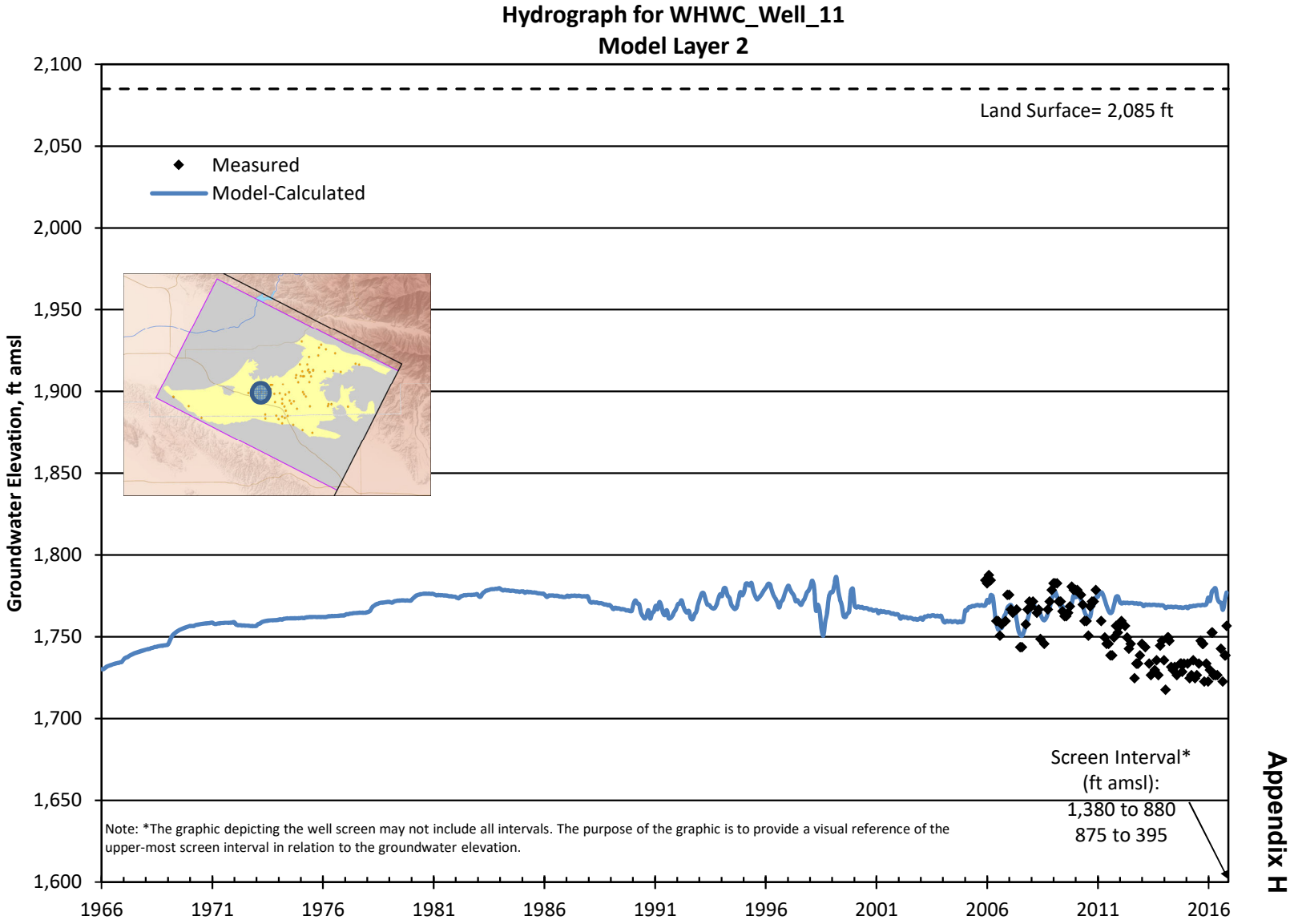

Hydrograph for Hog_Canyon_2
Model Layer 2
Land Surface= 2,250 ft
Groundwater Elevation, ft amsl
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1,900
1,850
1,800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,990 to 1,810
1,790 to 1,570
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix H

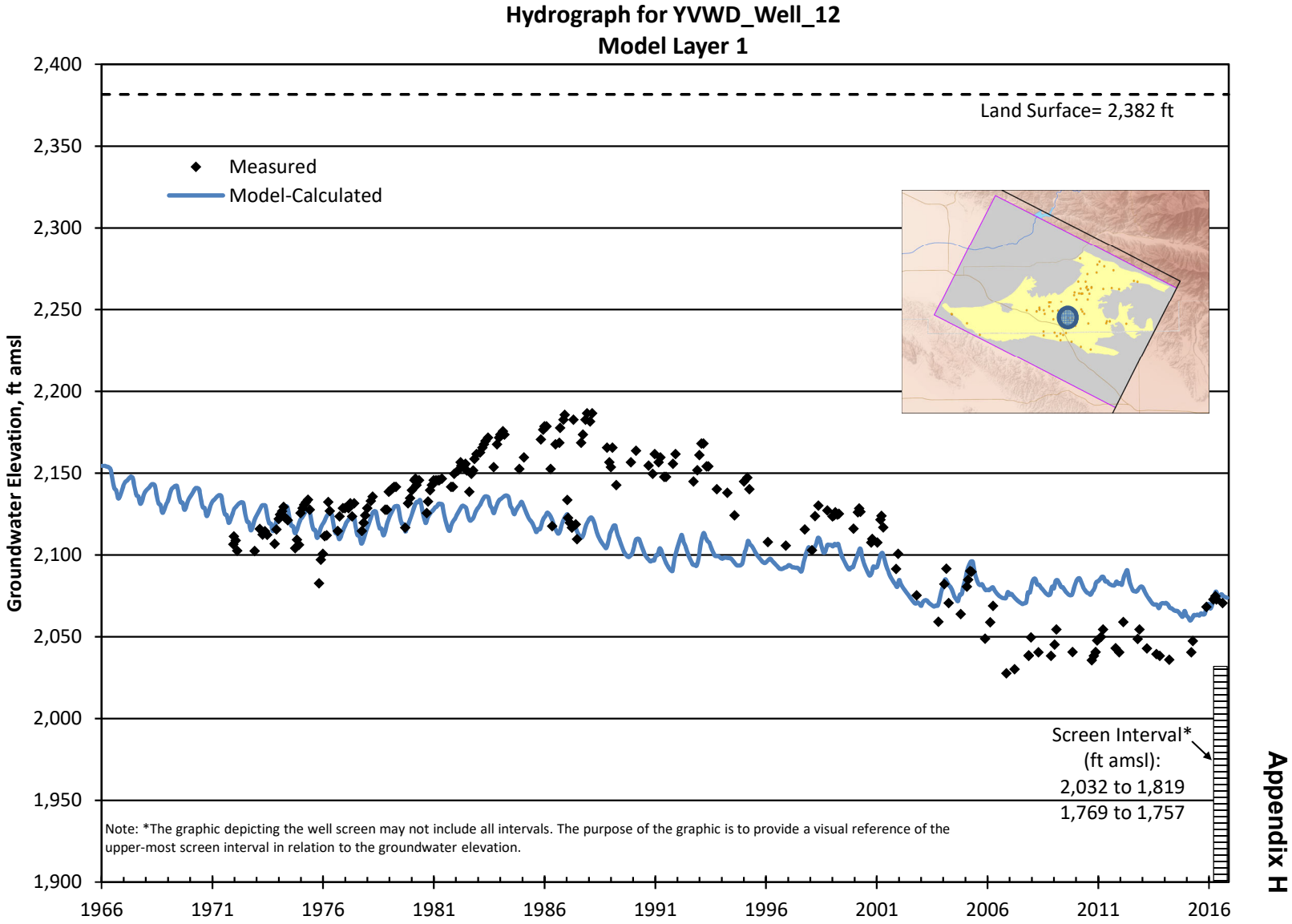

Hydrograph for WHWC_Well_3
Model Layer 3
Measured
Model-Calculated
Land Surface= 2,086 ft
Groundwater Elevation, ft amsl
2,150
2,100
2,050
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

Appendix H

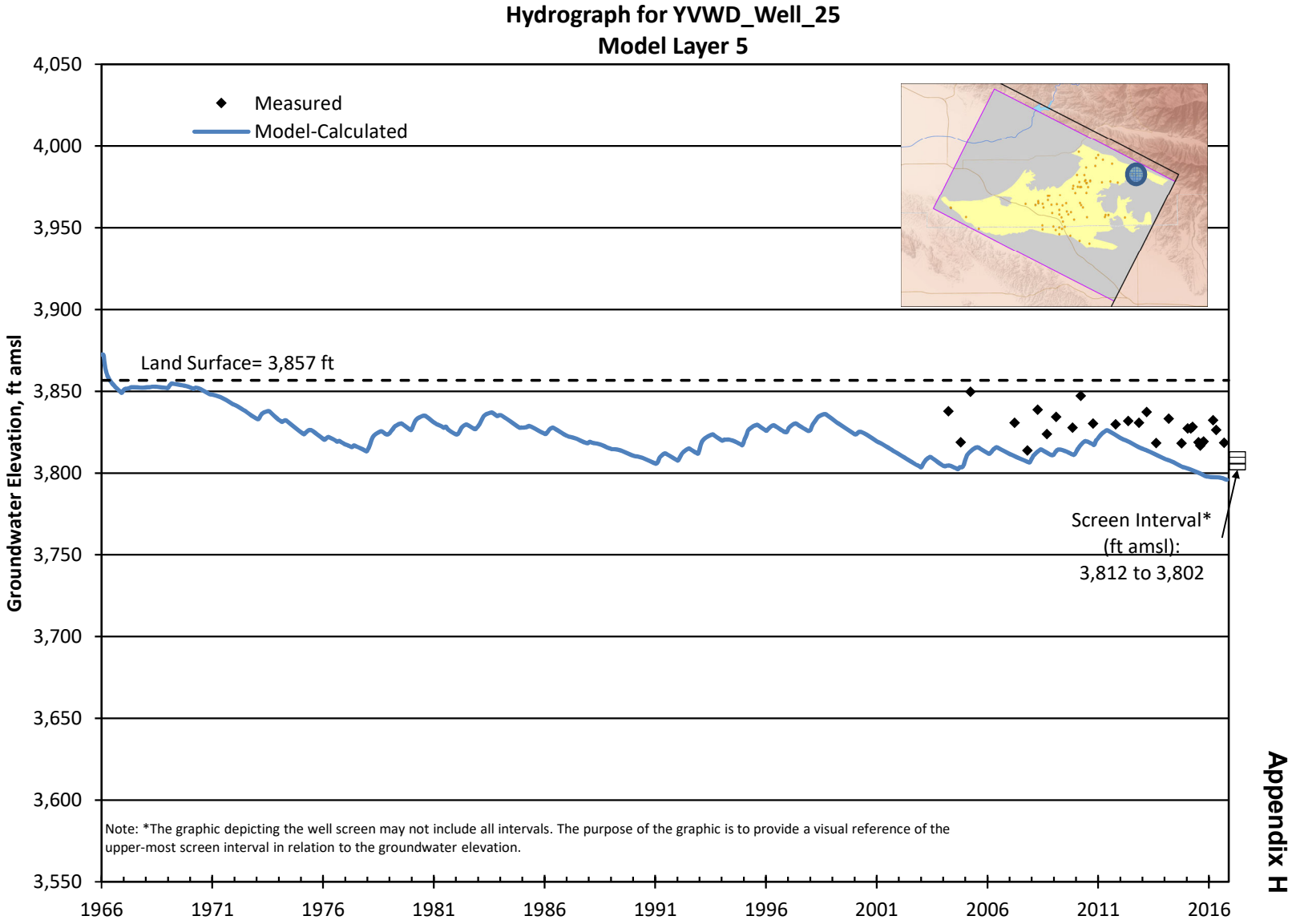

Hydrograph for WHWC_Well_10
Model Layer 2
Measured
Model-Calculated
Land Surface= 2,083 ft
Screen Interval*
(ft amsl):
1,753 to 1,413
Groundwater Elevation, ft amsl
2,150
2,100
2,050
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Appendix H


Hydrograph for WHWC_Well_11
Model Layer 2
Groundwater Elevation, ft amsl
2,100
2,050
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 2,085 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,380 to 880
875 to 395
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

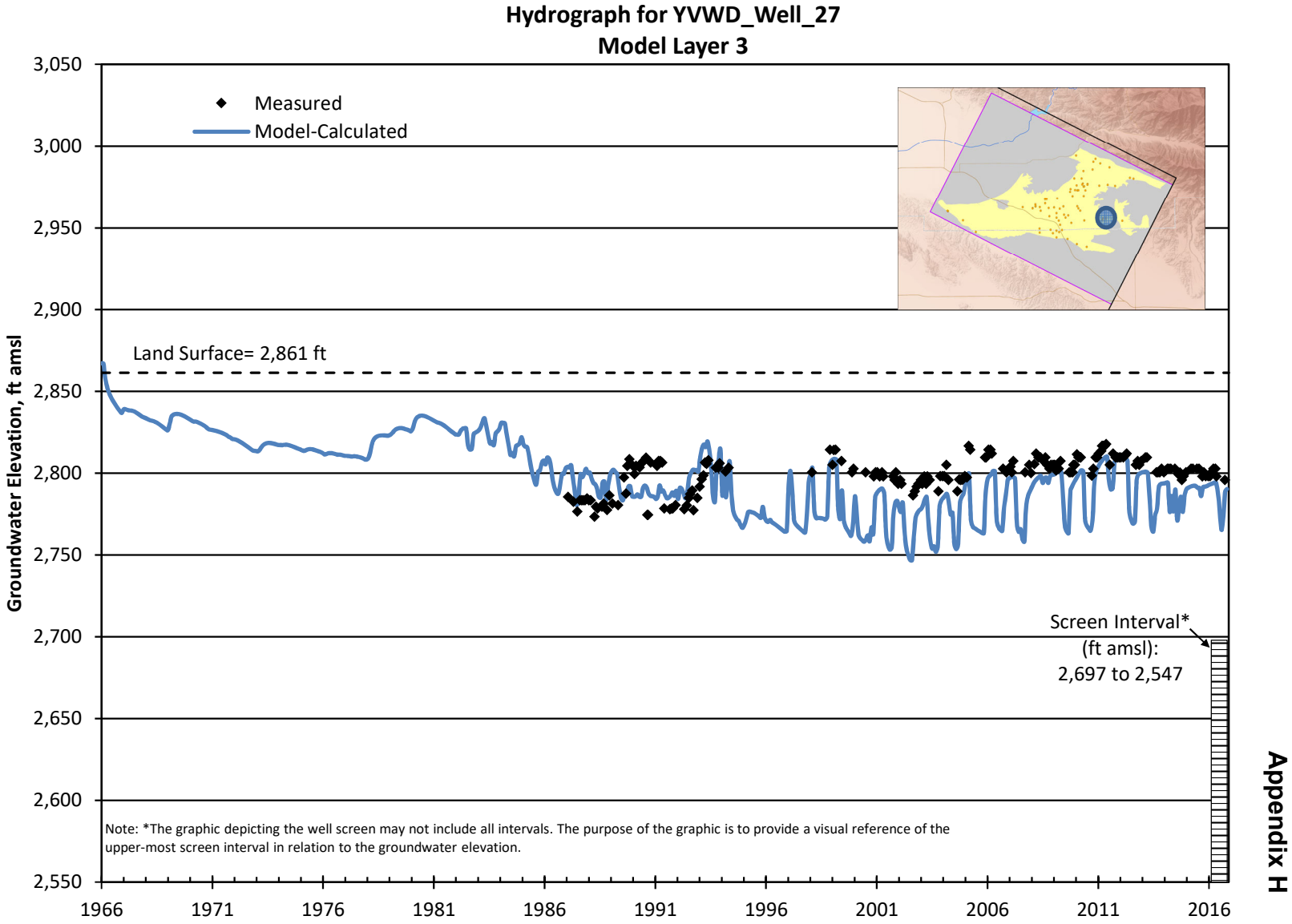
Appendix H


Hydrograph for YVWD_Well_12
Model Layer 1
Groundwater Elevation, ft amsl
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1,900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 2,382 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
2,032 to 1,819
1,769 to 1,757
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

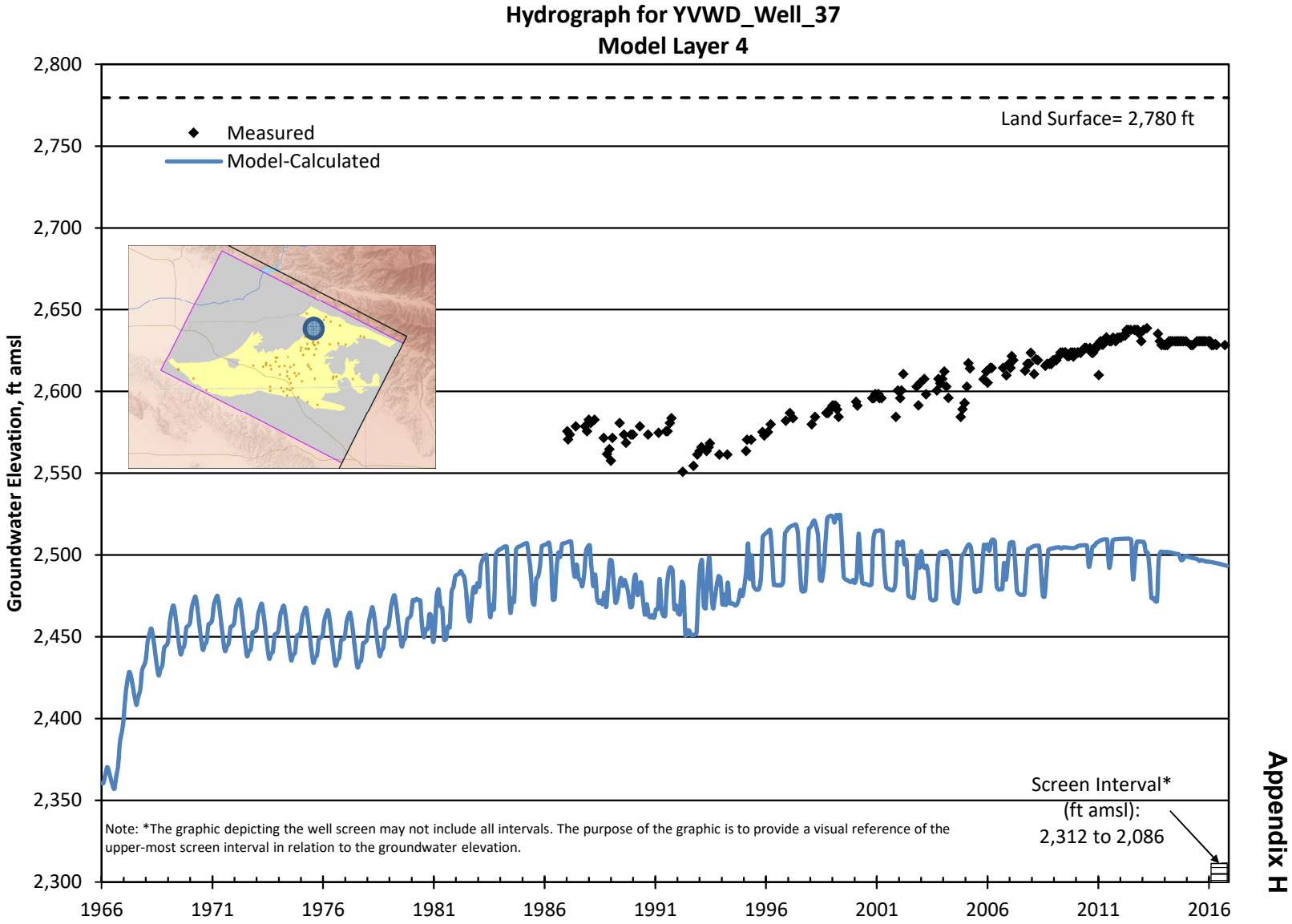
Appendix H


Hydrograph for YVWD_Well_25
Model Layer 5
Measured
Model-Calculated
Land Surface= 3,857 ft
Groundwater Elevation, ft amsl
4,050
4,000
3,950
3,900
3,850
3,800
3,750
3,700
3,650
3,600
3,550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
3,812 to 3,802
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

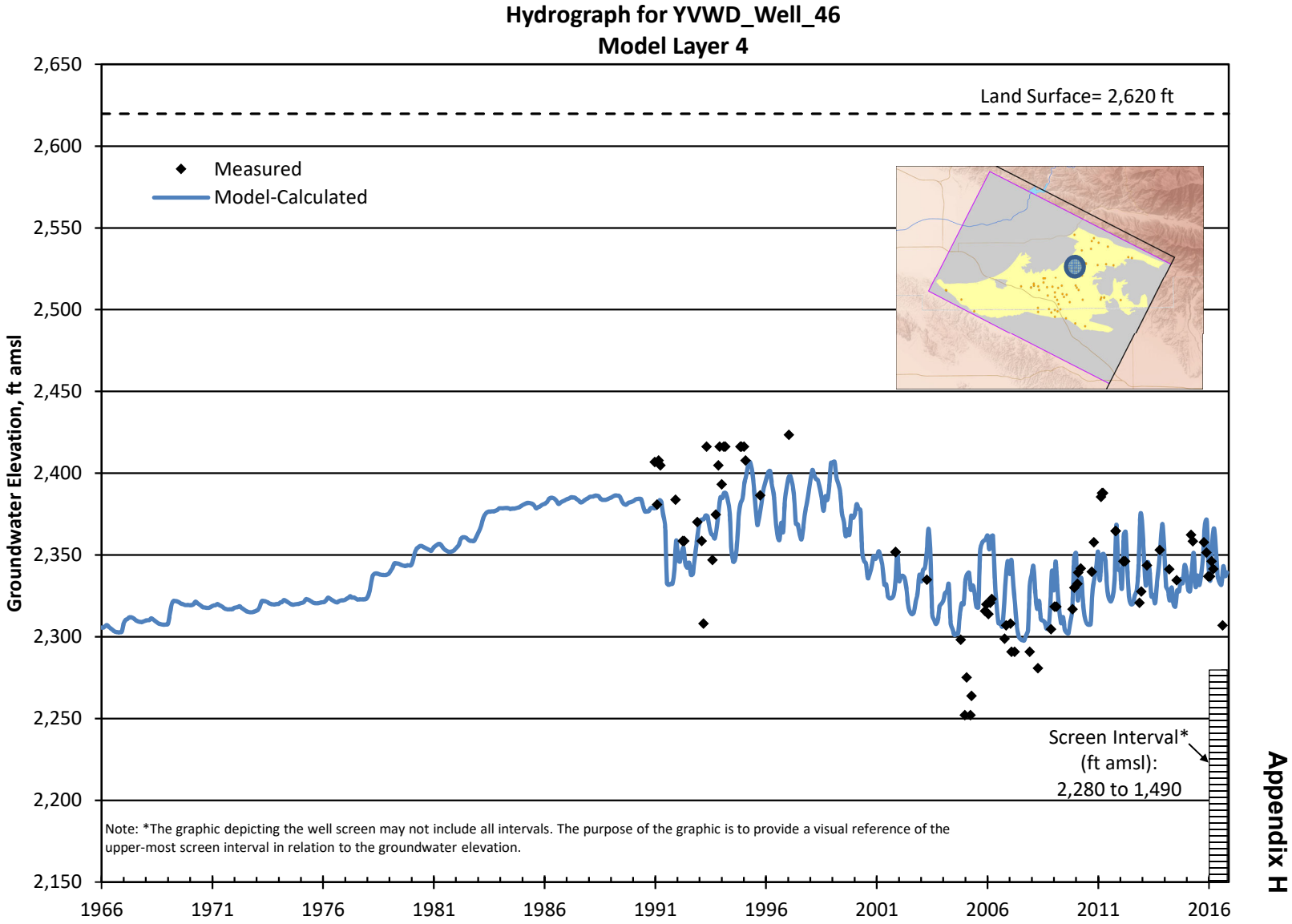
Appendix H


Hydrograph for YVWD_Well_27
Model Layer 3
Measured
Model-Calculated
Land Surface= 2,861 ft
Groundwater Elevation, ft amsl
3,050
3,000
2,950
2,900
2,850
2,800
2,750
2,700
2,650
2,600
2,550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,697 to 2,547
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

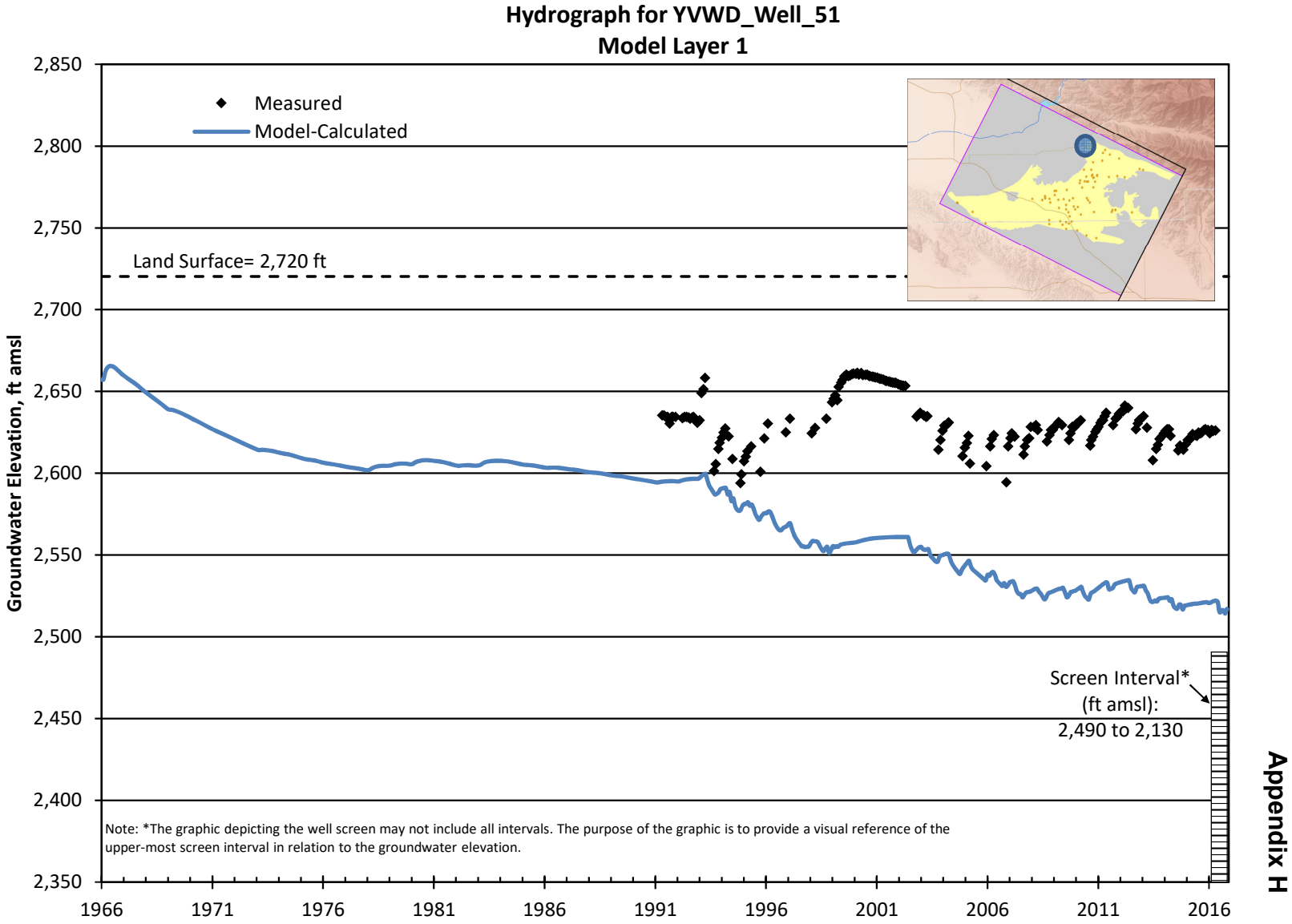
Appendix H


Hydrograph for YVWD_Well_37
Model Layer 4
Groundwater Elevation, ft amsl
2,800
2,750
2,700
2,650
2,600
2,550
2,500
2,450
2,400
2,350
2,300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 2,780 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
2,312 to 2,086
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

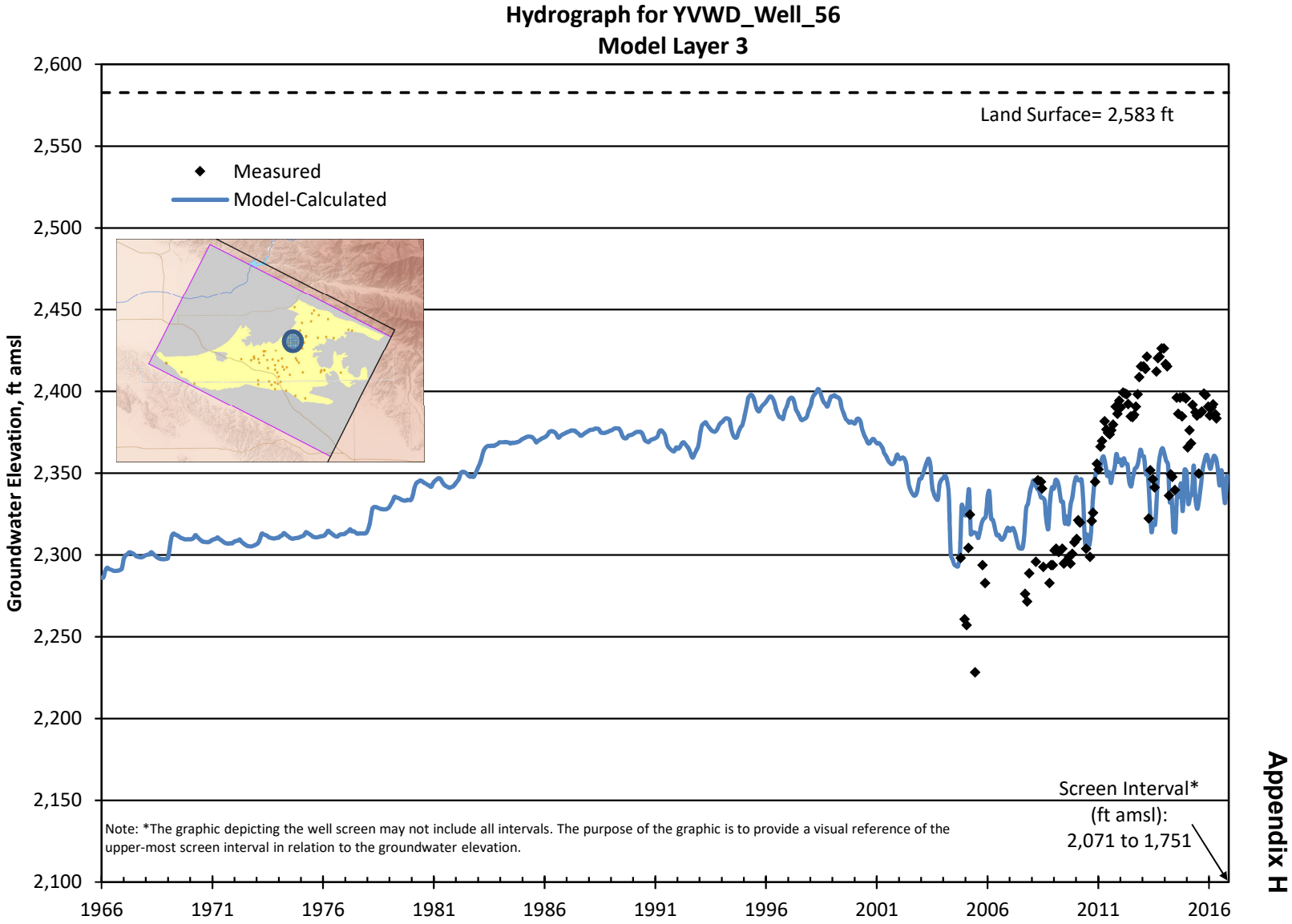
Appendix H


Hydrograph for YVWD_Well_46
Model Layer 4
Land Surface= 2,620 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,650
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,280 to 1,490
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

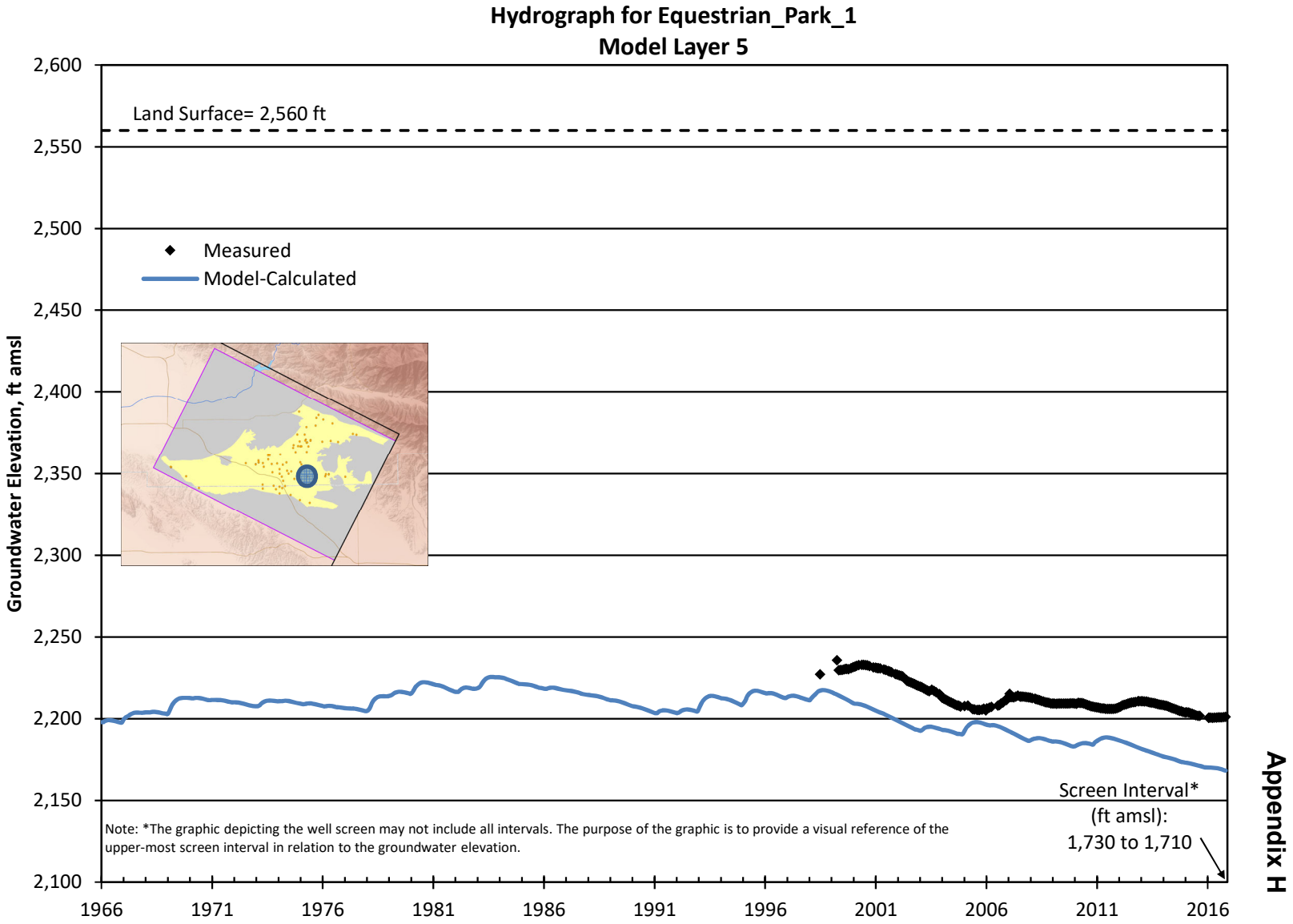
Appendix H


Hydrograph for YVWD_Well_51
Model Layer 1
Measured
Model-Calculated
Land Surface= 2,720 ft
Groundwater Elevation, ft amsl
2,850
2,800
2,750
2,700
2,650
2,600
2,550
2,500
2,450
2,400
2,350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,490 to 2,130
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

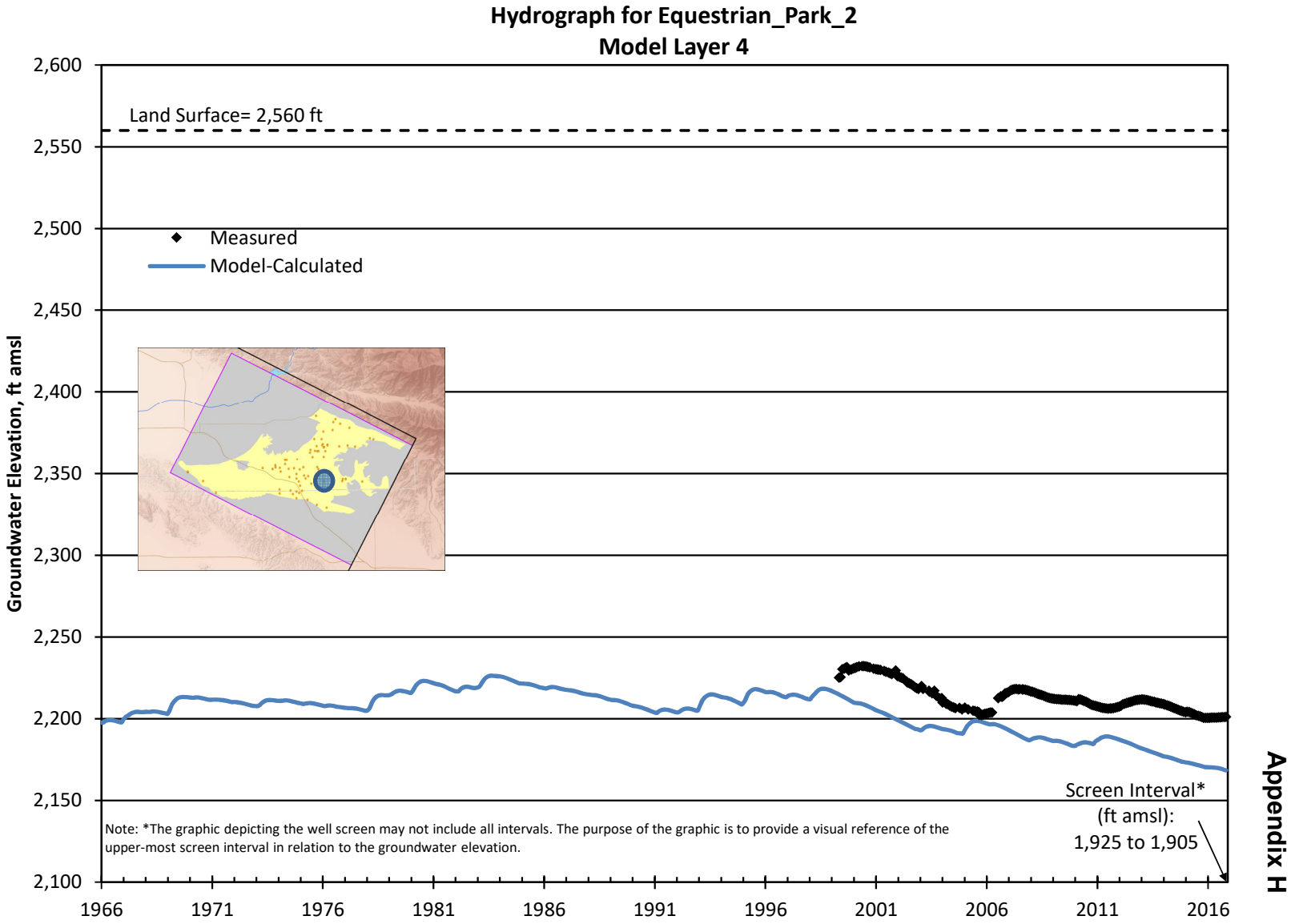
Appendix H


Hydrograph for YVWD_Well_56
Model Layer 3
Land Surface= 2,583 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,071 to 1,751
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

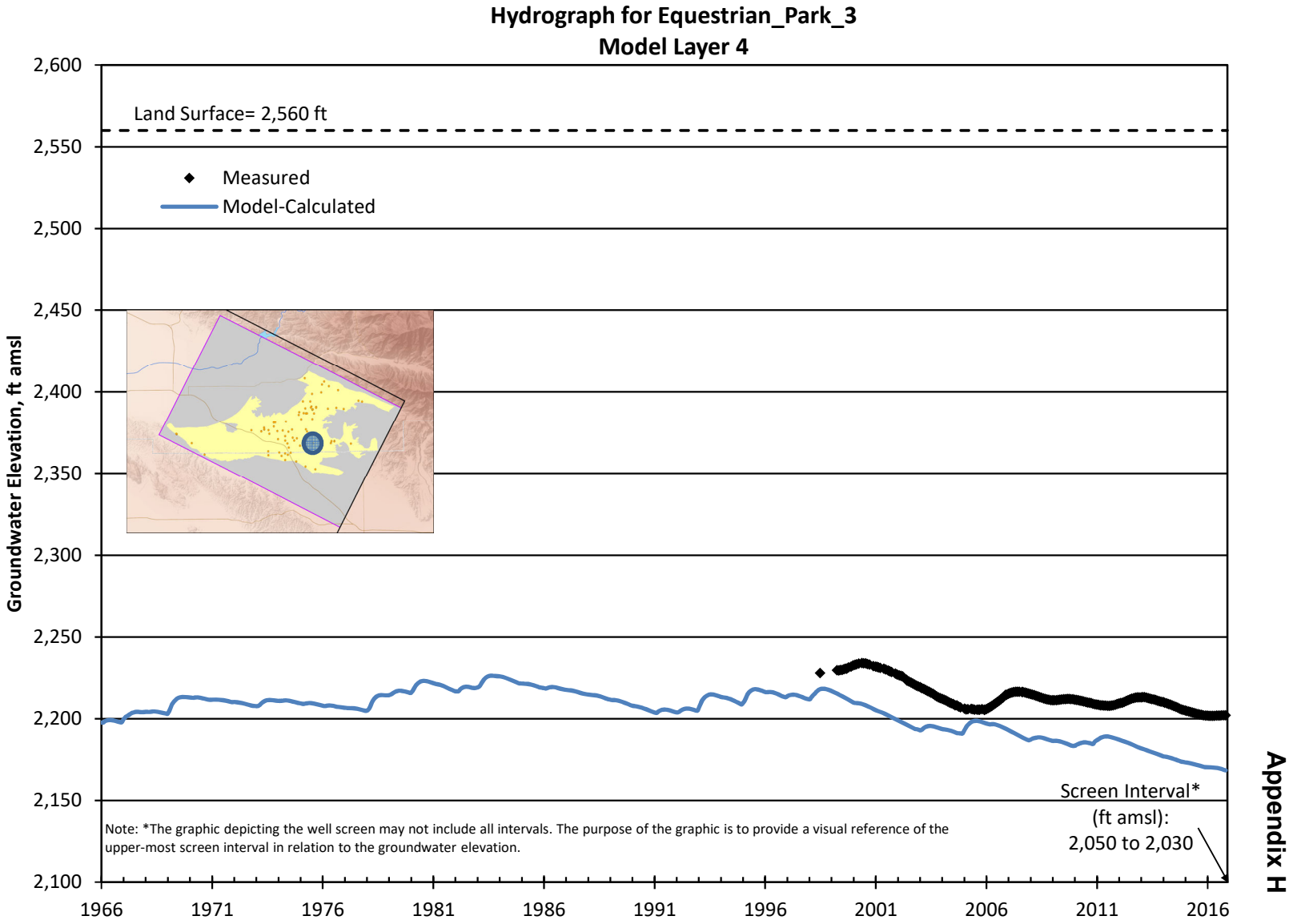
Appendix H


Hydrograph for Equestrian_Park_1
Model Layer 5
Land Surface= 2,560 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,730 to 1,710
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

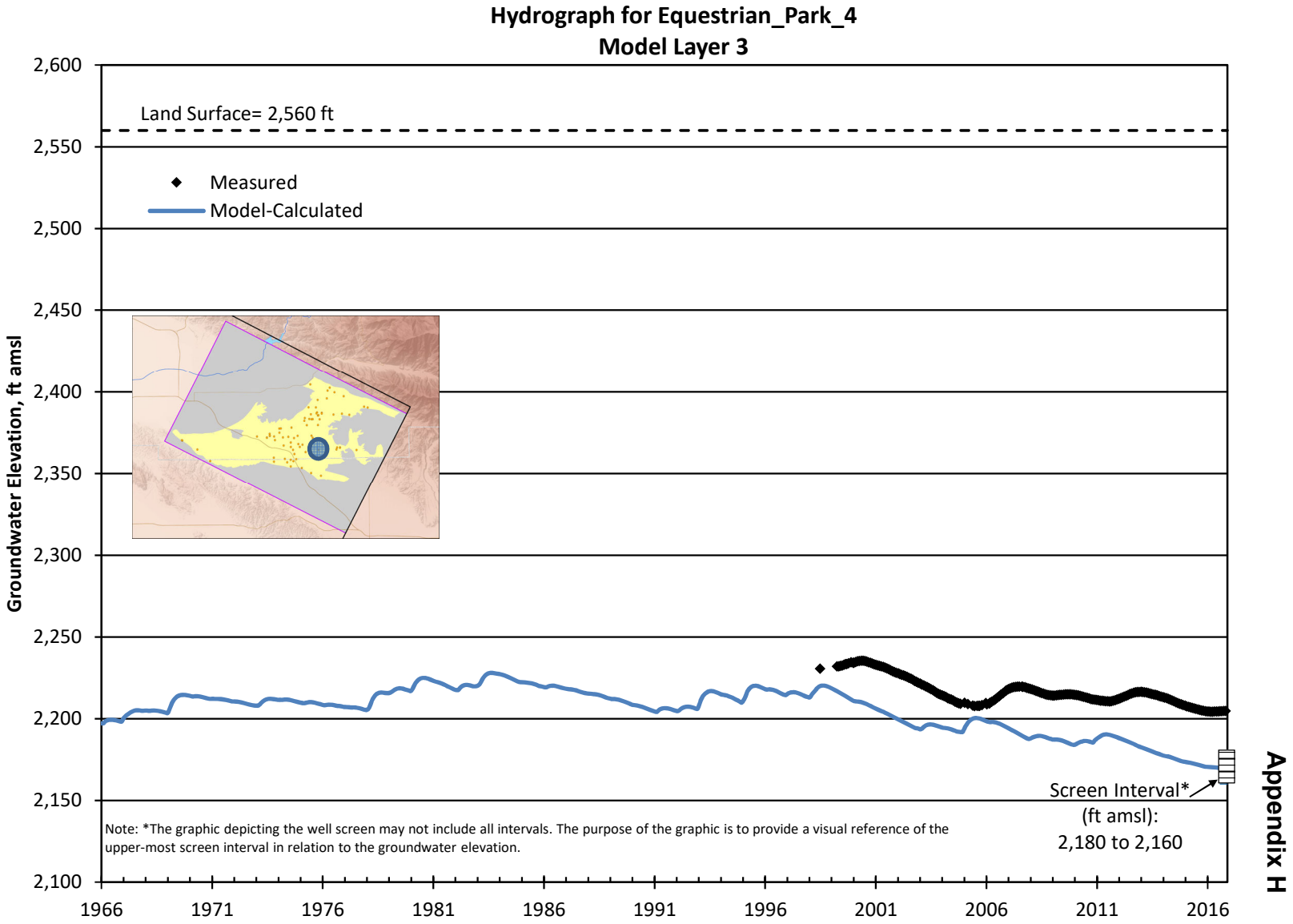
Appendix H

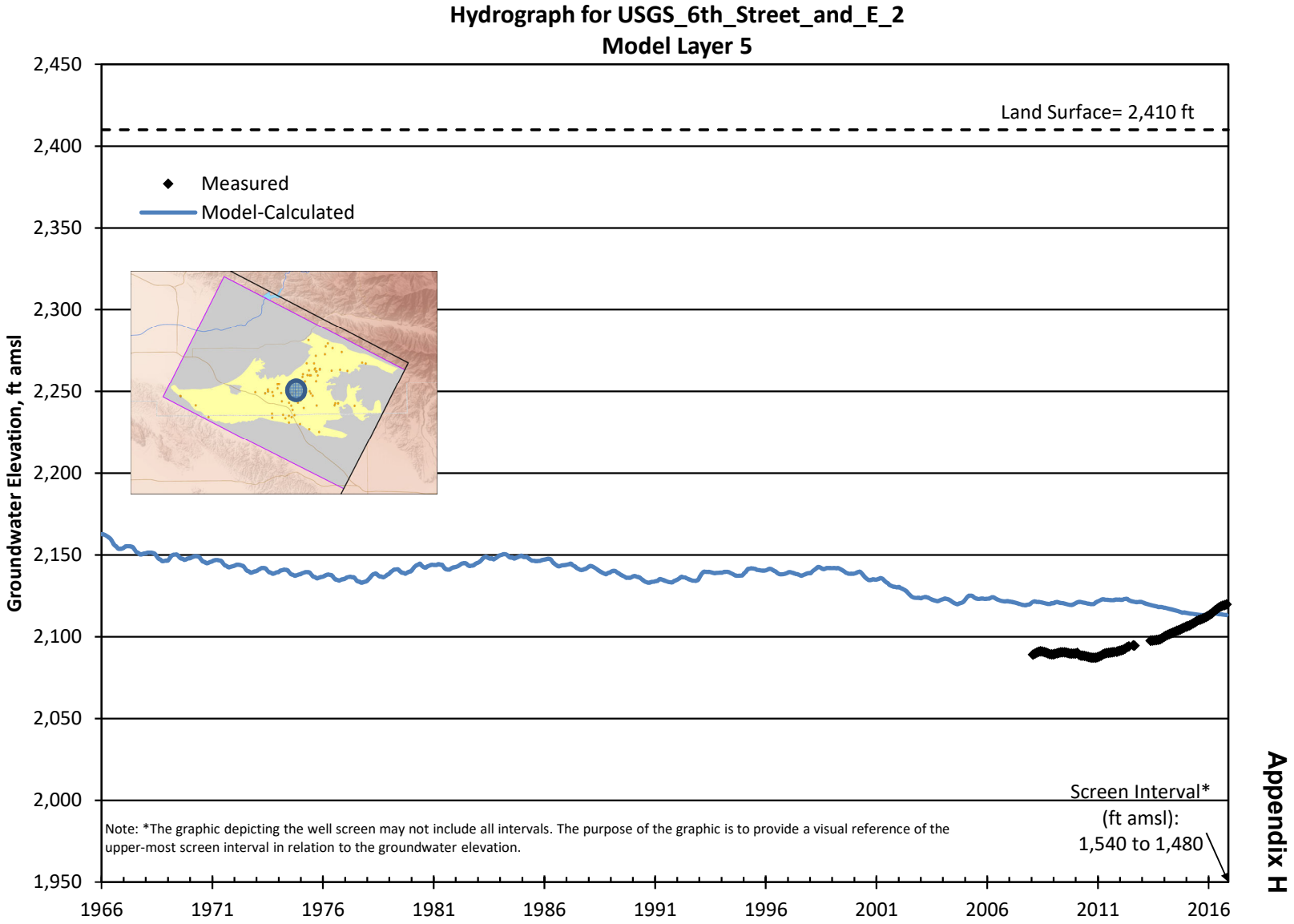

Hydrograph for Equestrian_Park_2
Model Layer 4
Land Surface= 2,560 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,925 to 1,905
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix H

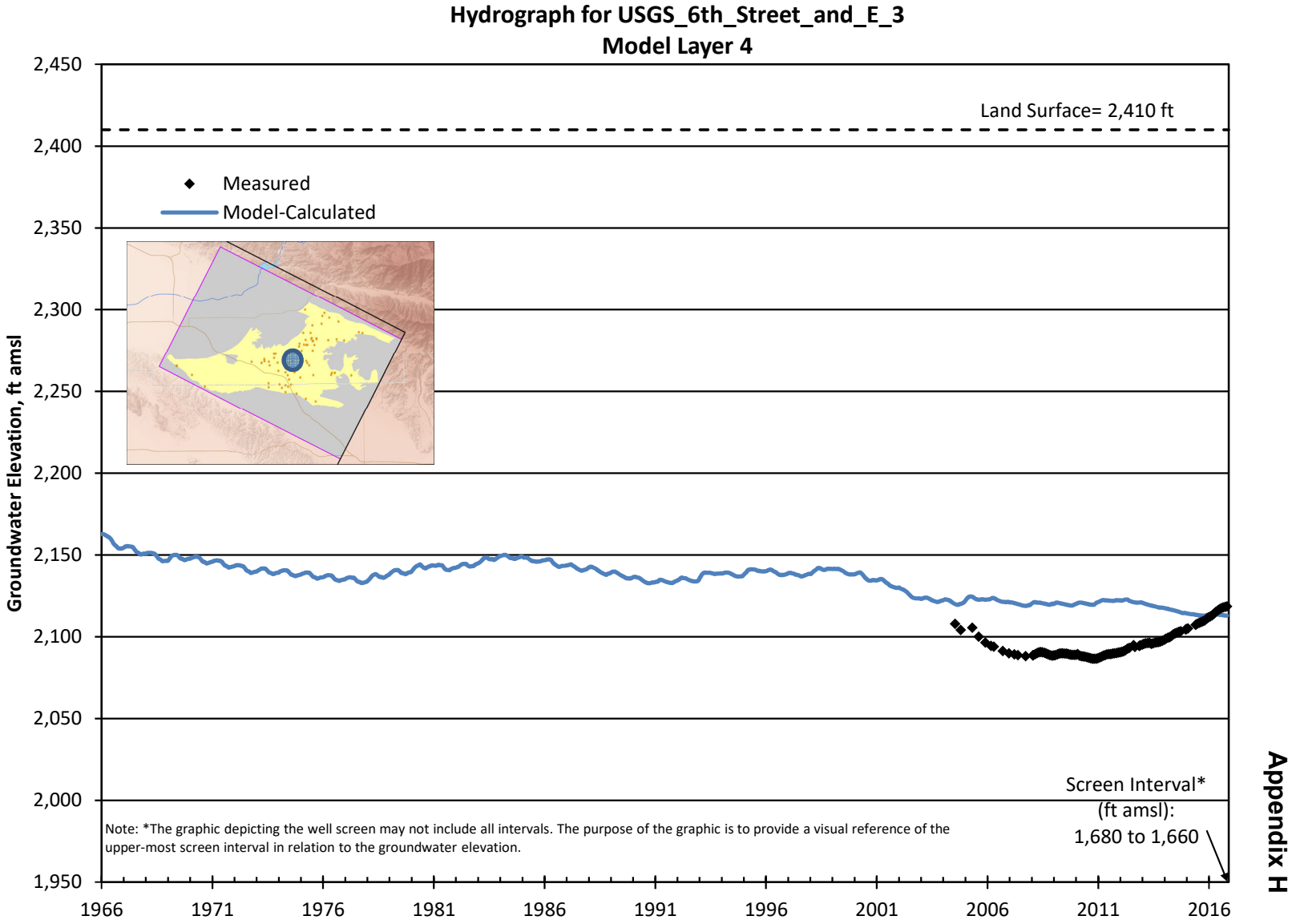

Hydrograph for Equestrian_Park_3
Model Layer 4
Land Surface= 2,560 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,050 to 2,030
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix H

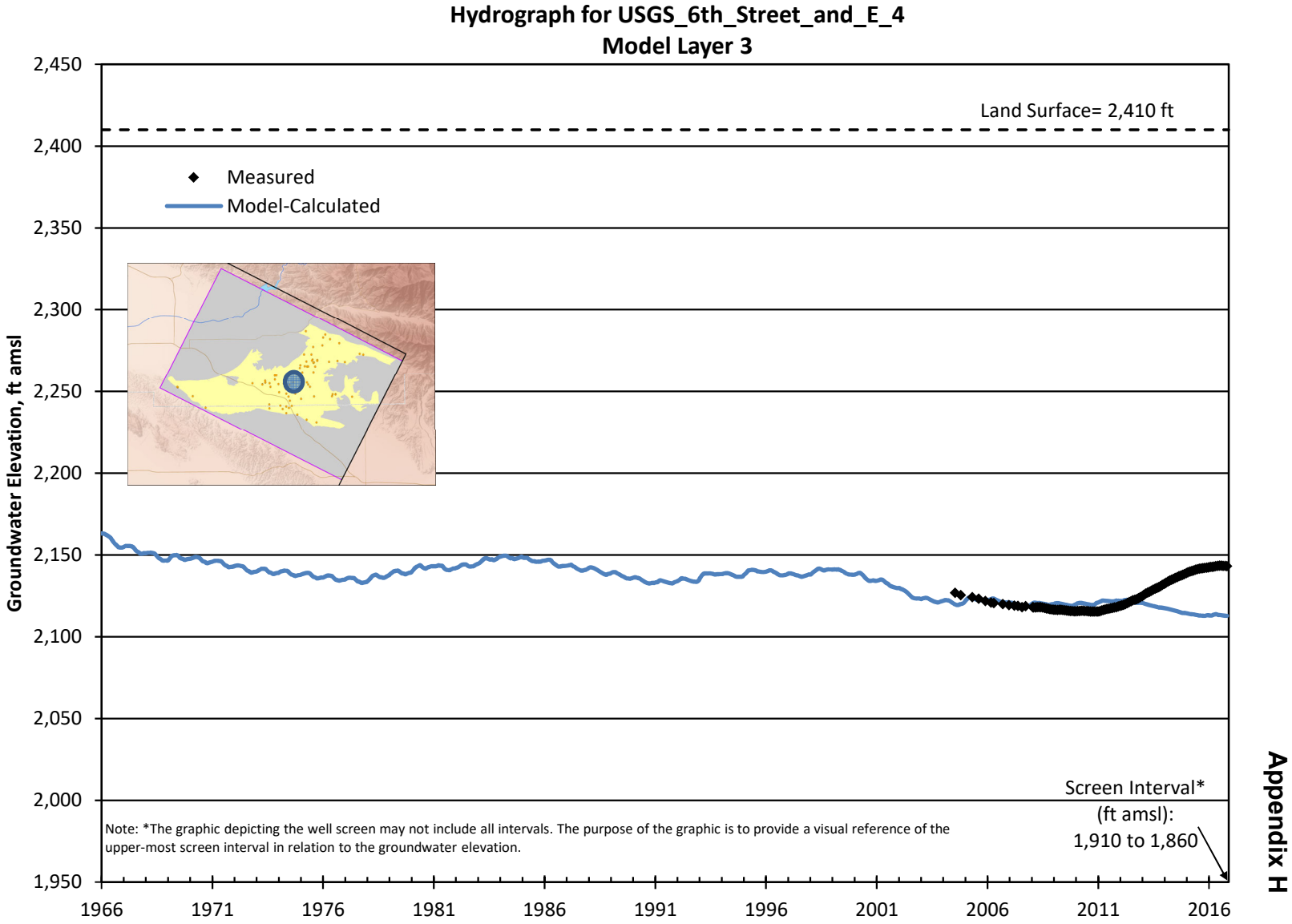

Hydrograph for Equestrian_Park_4
Model Layer 3
Land Surface= 2,560 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,180 to 2,160
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Appendix H


Hydrograph for USGS_6th_Street_and_E_2
Model Layer 5
Land Surface= 2,410 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,540 to 1,480
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

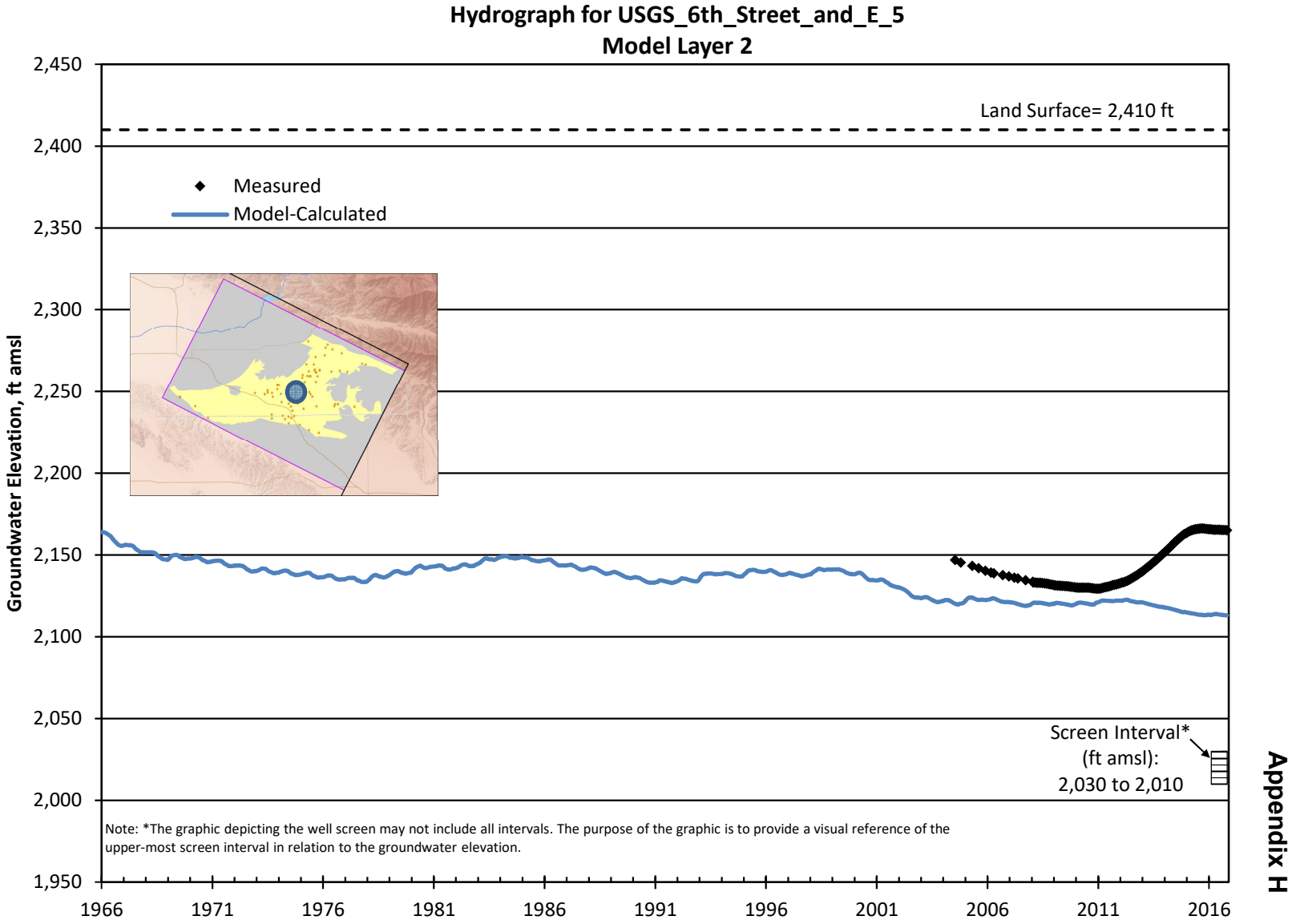
Appendix H


Hydrograph for USGS_6th_Street_and_E_3
Model Layer 4
Land Surface= 2,410 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,680 to 1,660
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix H

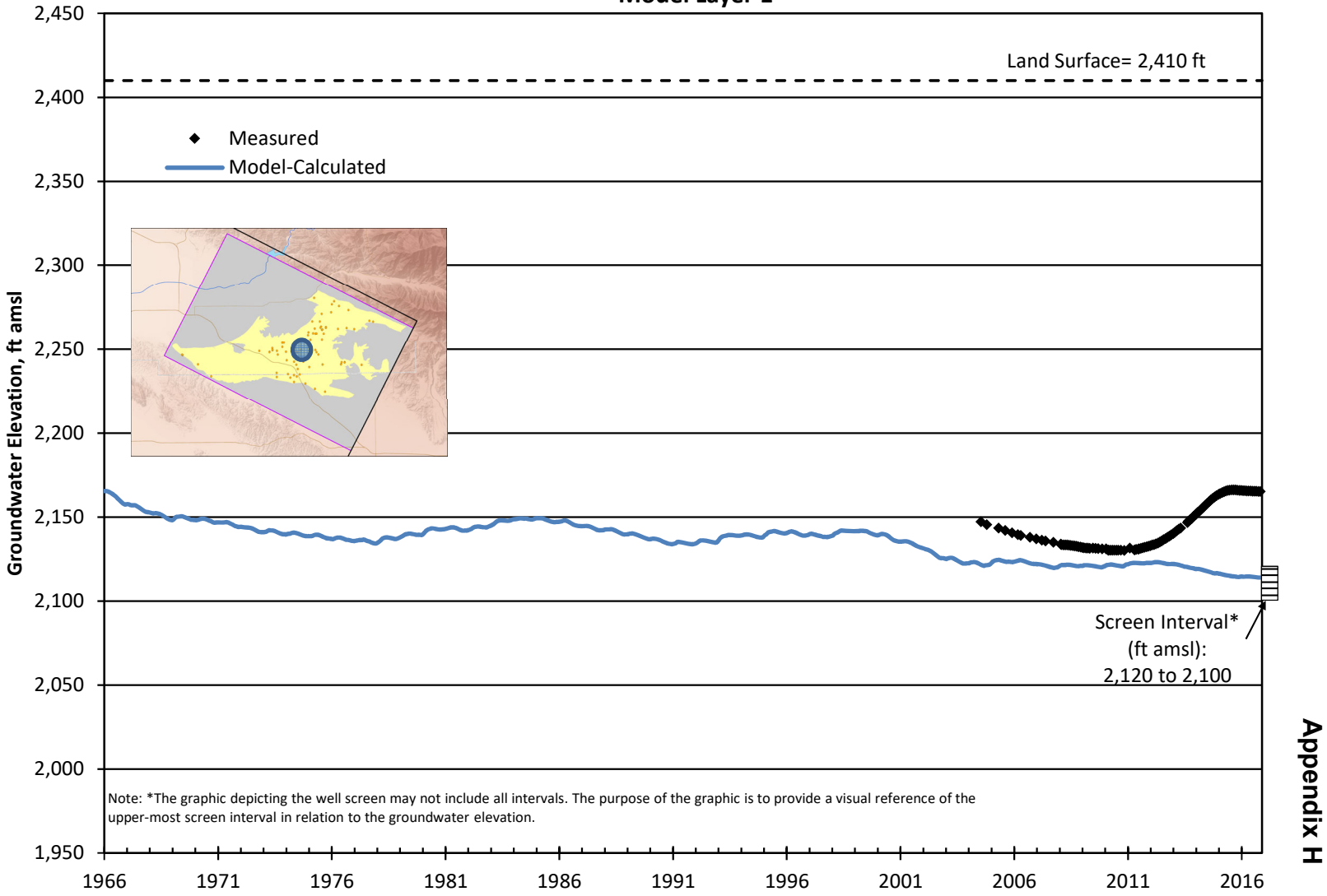

Hydrograph for USGS_6th_Street_and_E_4
Model Layer 3
Land Surface= 2,410 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,910 to 1,860
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix H

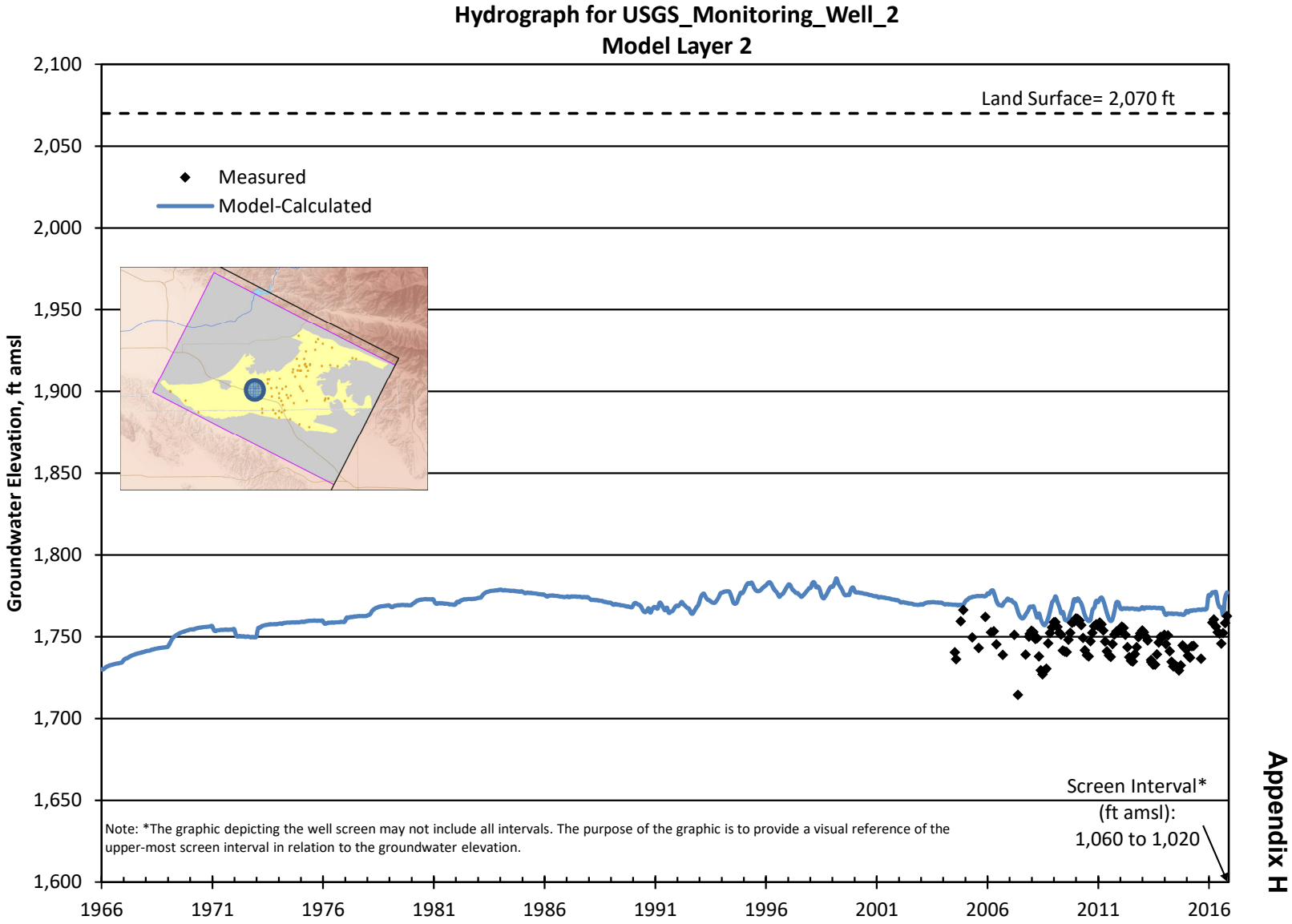

Hydrograph for USGS_6th_Street_and_E_5
Model Layer 2
Groundwater Elevation, ft amsl
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 2,410 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
2,030 to 2,010
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix H

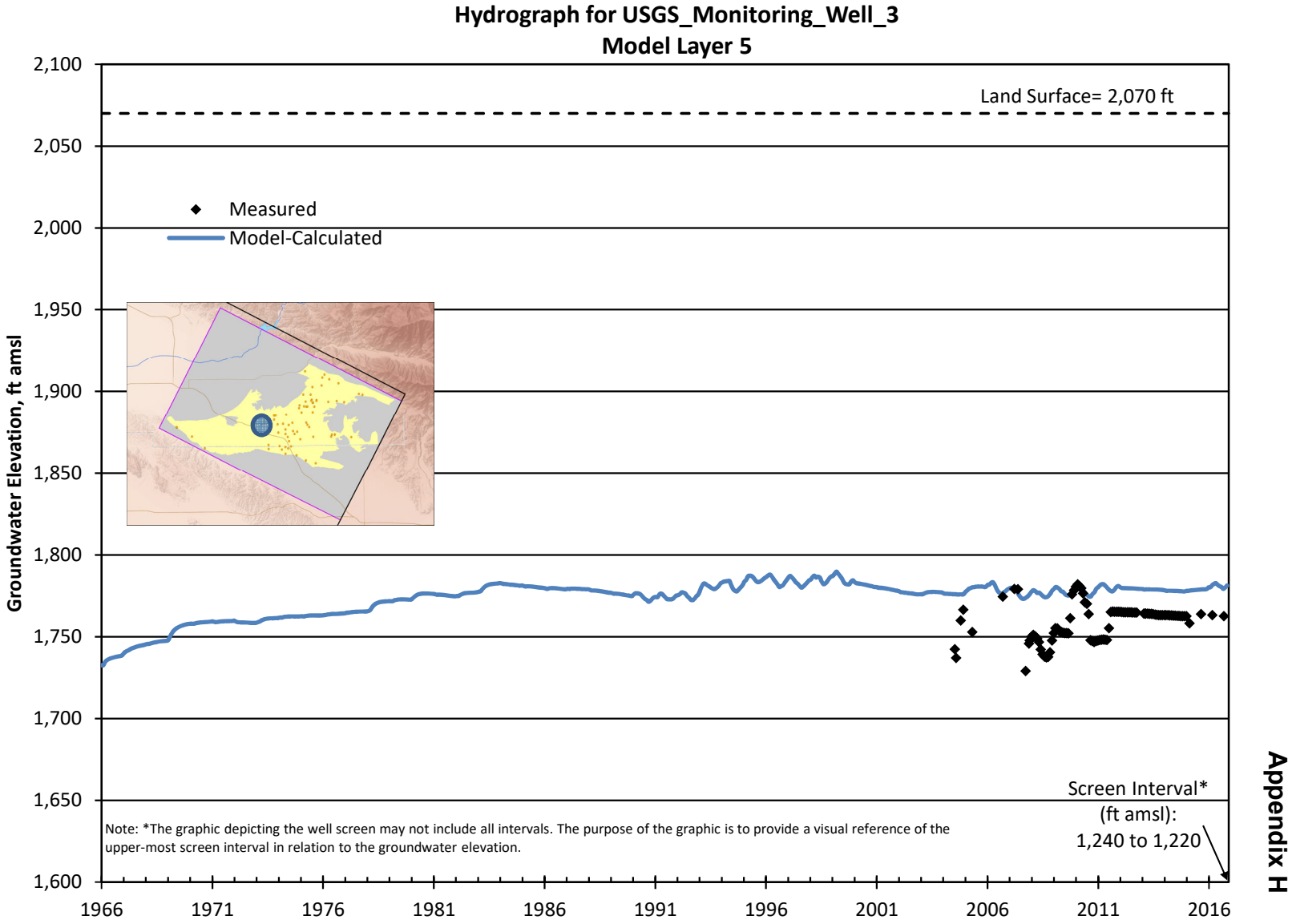
Hydrograph for USGS_6th_Street_and_E_6
Model Layer 1



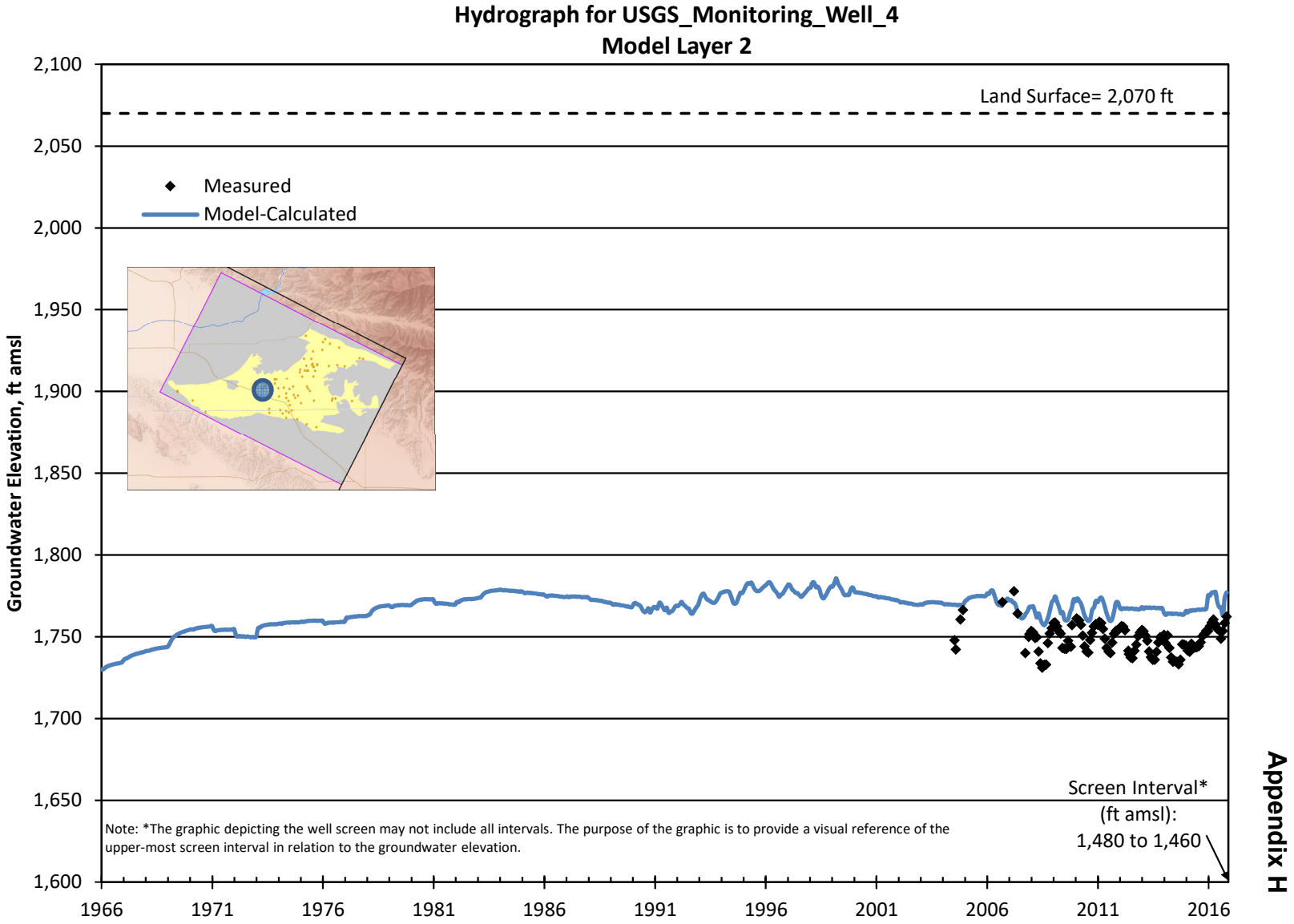
Appendix H


Hydrograph for USGS_Monitoring_Well_2
Model Layer 2
Land Surface= 2,070 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,100
2,050
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,060 to 1,020
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

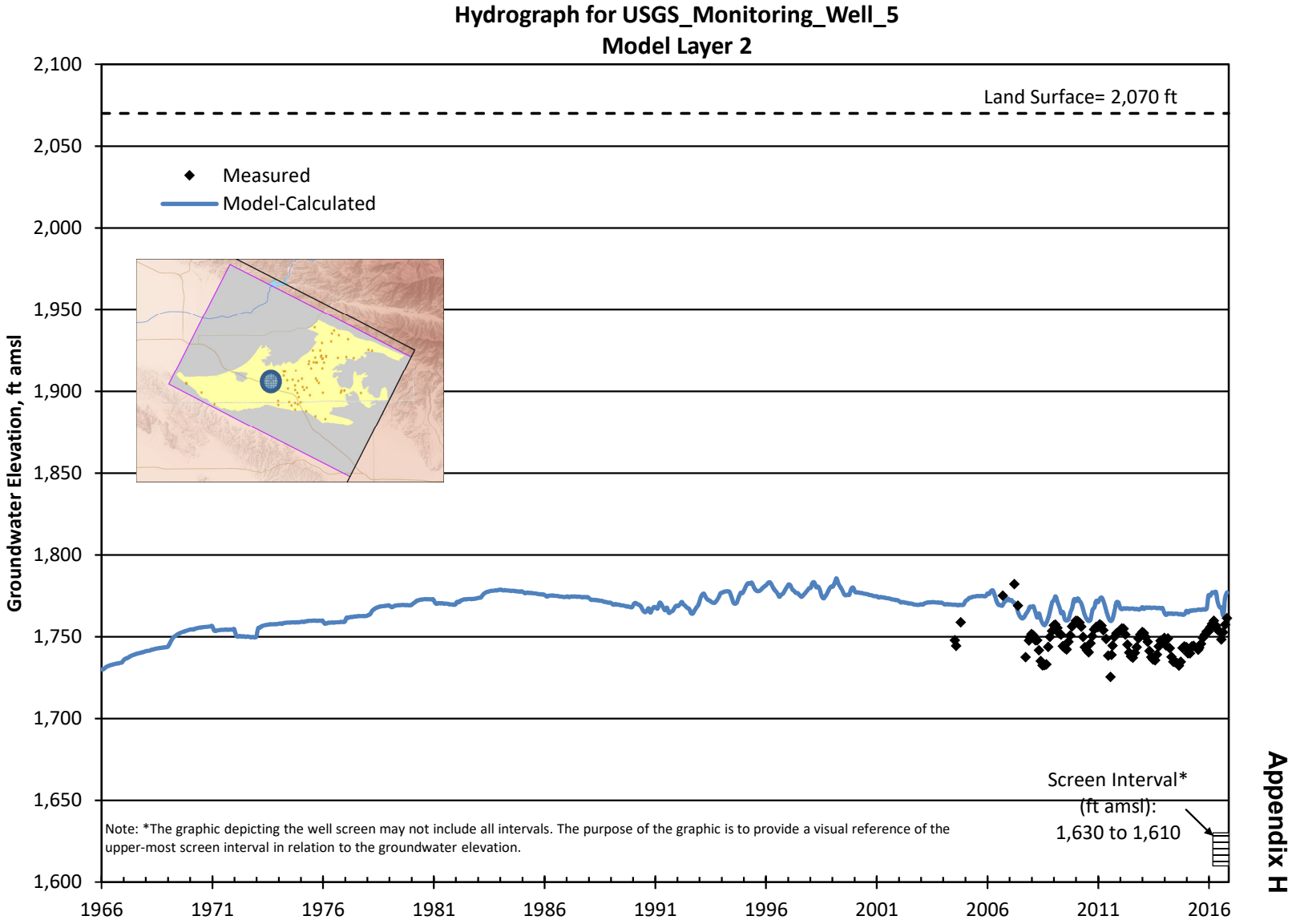
Appendix H


Hydrograph for USGS_Monitoring_Well_3
Model Layer 5
Land Surface= 2,070 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,100
2,050
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,240 to 1,220
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

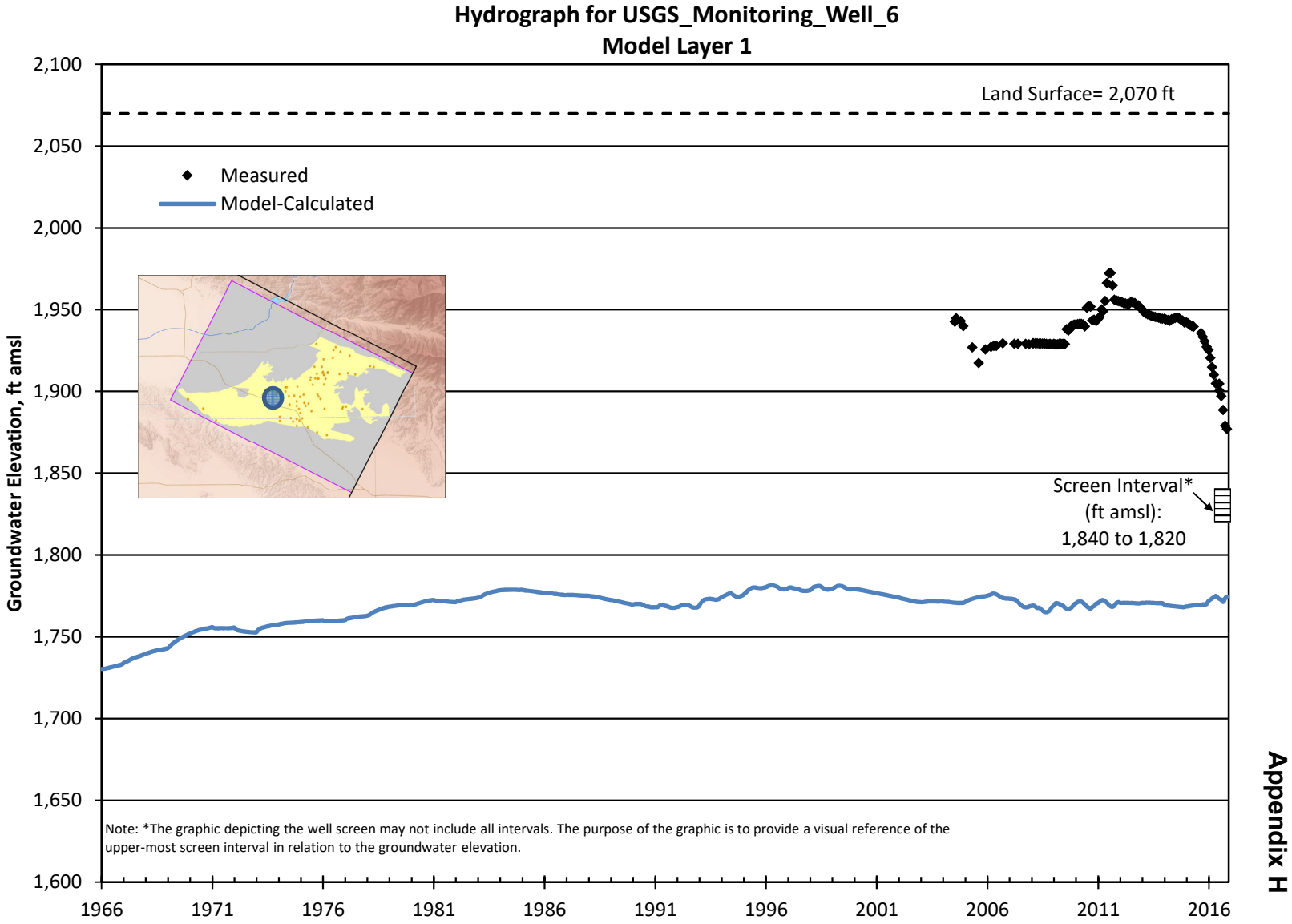
Appendix H


Hydrograph for USGS_Monitoring_Well_4
Model Layer 2
Land Surface= 2,070 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,100
2,050
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,480 to 1,460
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

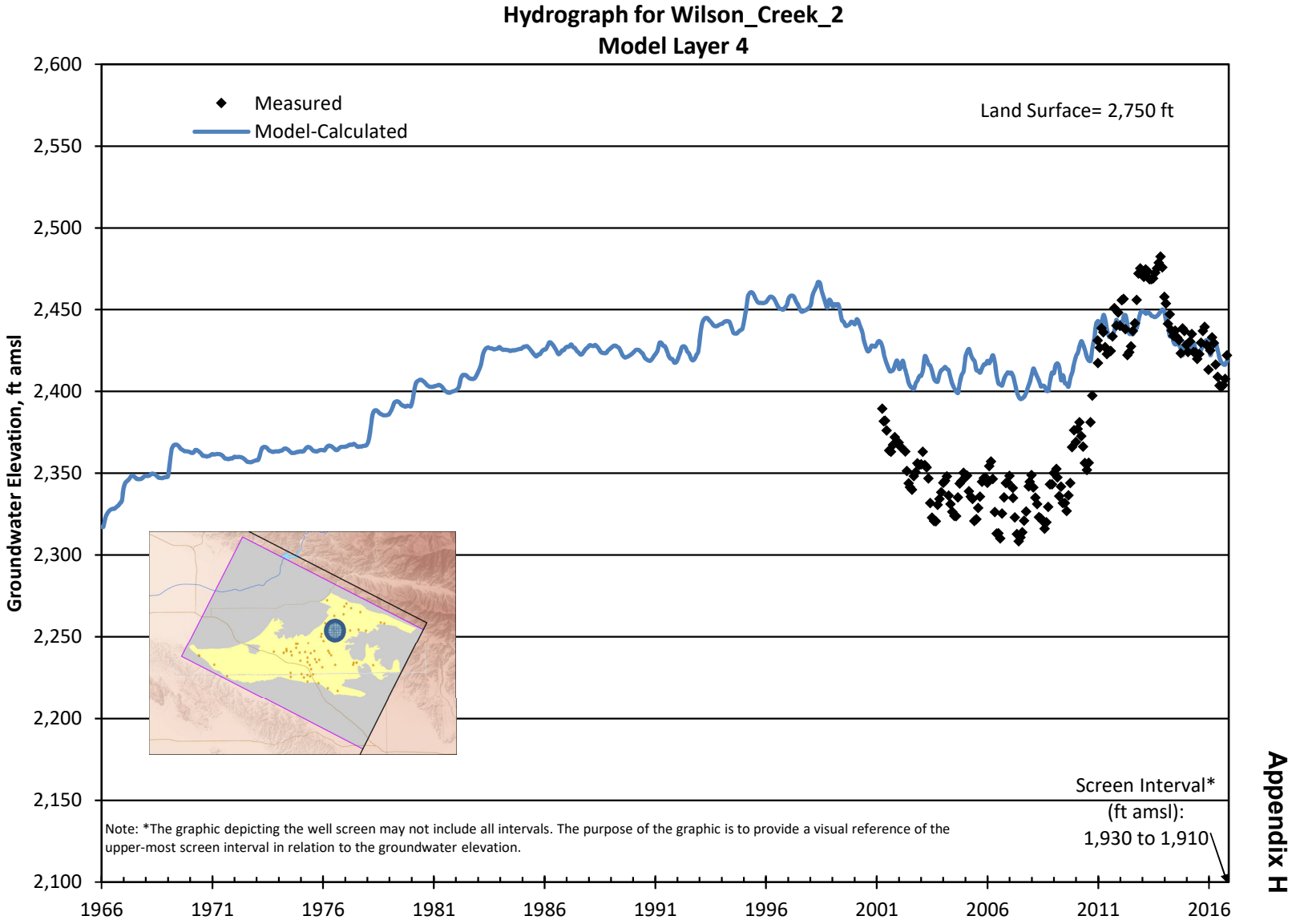
Appendix H


Hydrograph for USGS_Monitoring_Well_5
Model Layer 2
Land Surface= 2,070 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
2,100
2,050
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,630 to 1,610
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

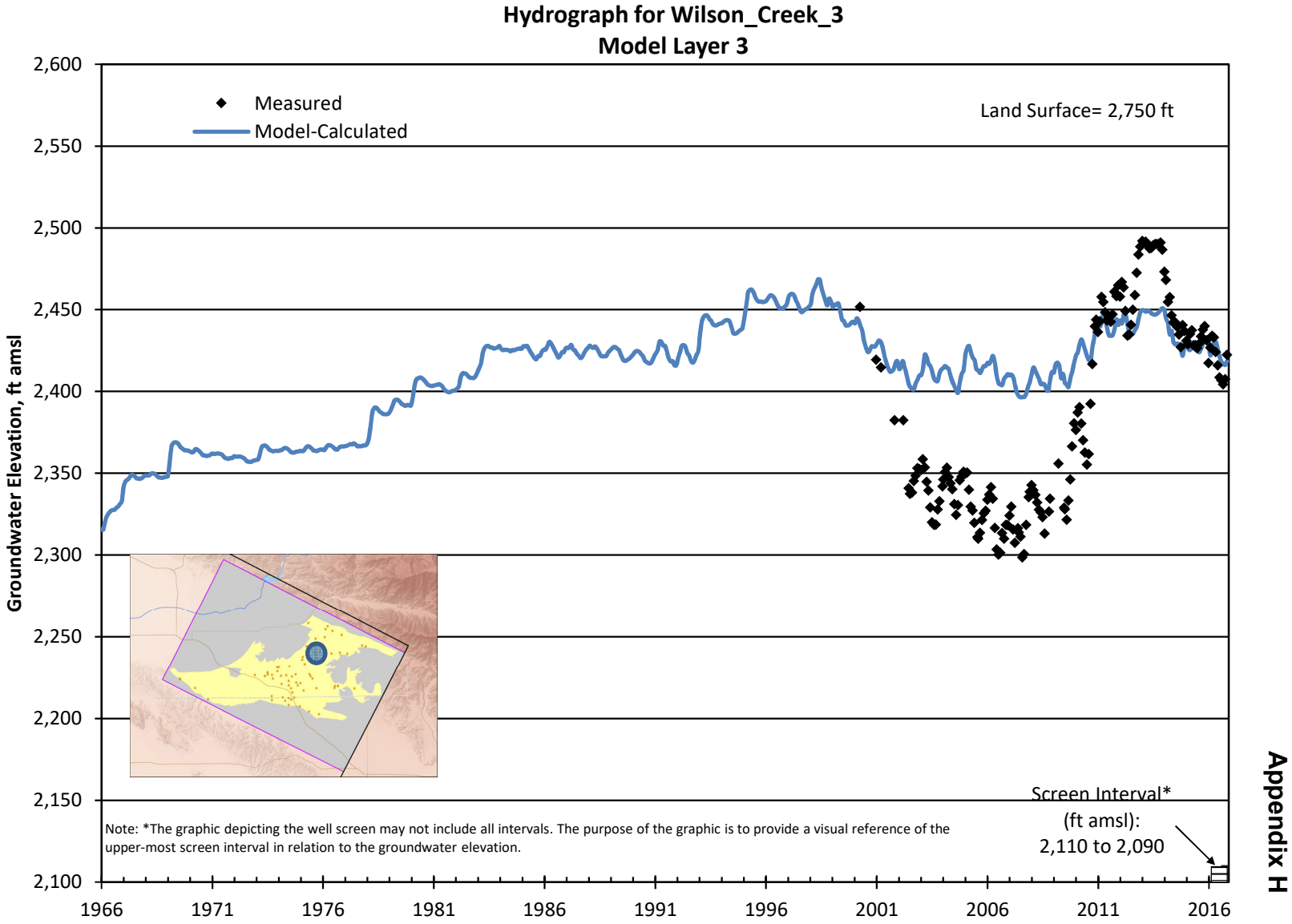
Appendix H


Hydrograph for USGS_Monitoring_Well_6
Model Layer 1
Land Surface= 2,070 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,840 to 1,820
Groundwater Elevation, ft amsl
2,100
2,050
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

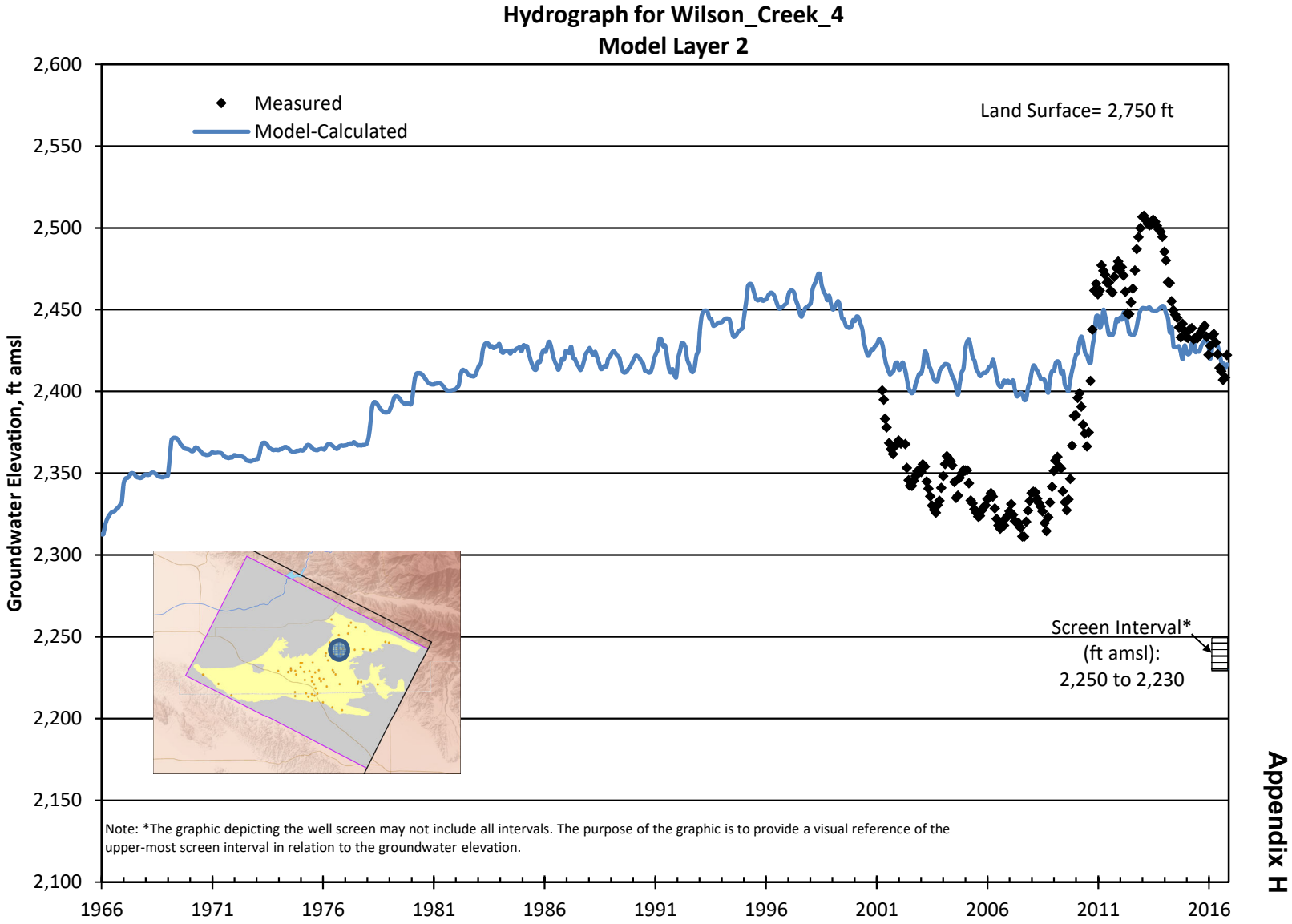
Appendix H


Hydrograph for Wilson_Creek_2
Model Layer 4
Measured
Model-Calculated
Land Surface= 2,750 ft
Groundwater Elevation, ft amsl
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,930 to 1,910
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

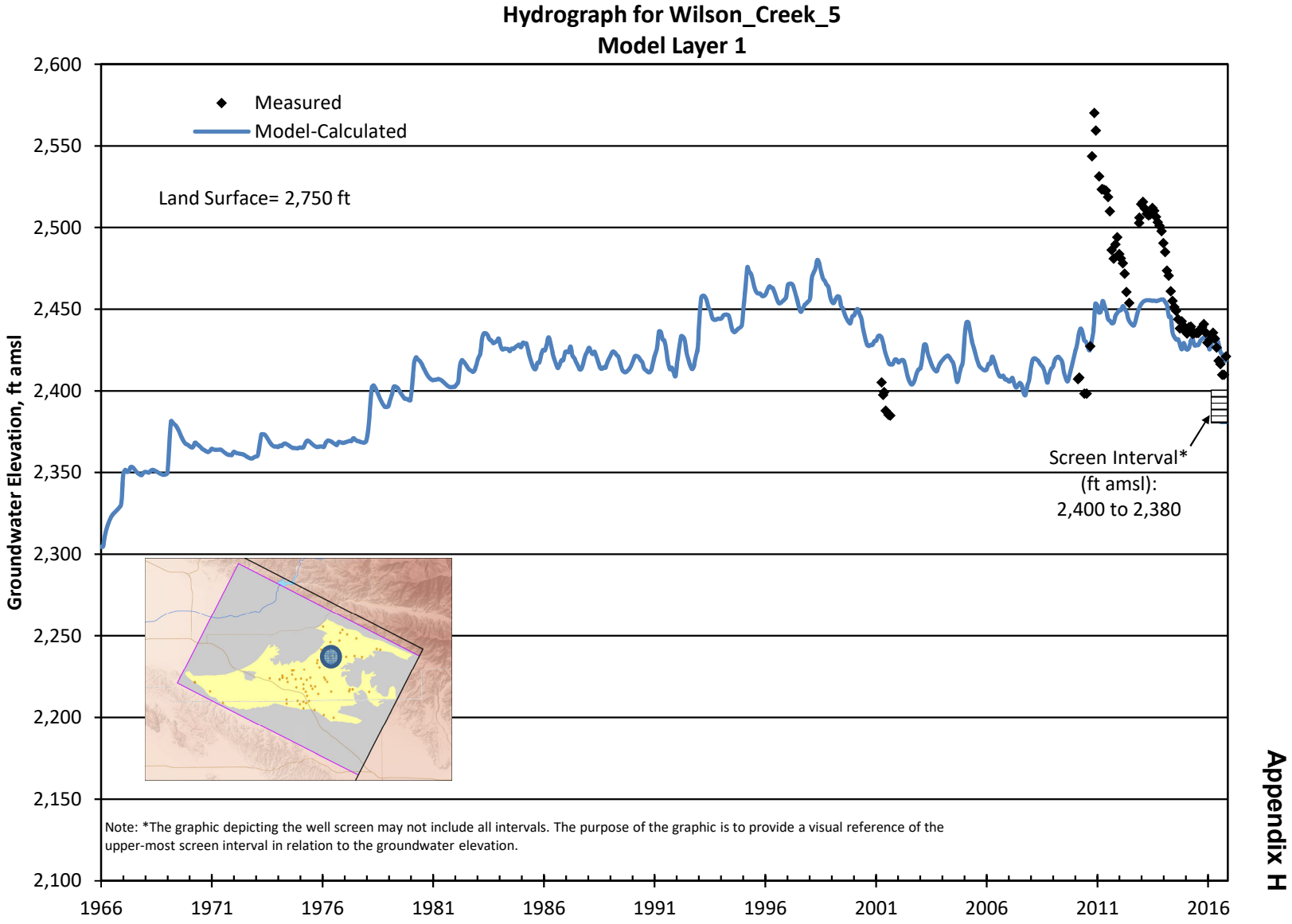
Appendix H


Hydrograph for Wilson_Creek_3
Model Layer 3
Measured
Model-Calculated
Land Surface= 2,750 ft
Groundwater Elevation, ft amsl
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,110 to 2,090
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix H


Hydrograph for Wilson_Creek_4
Model Layer 2
Measured
Model-Calculated
Land Surface= 2,750 ft
Groundwater Elevation, ft amsl
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,250 to 2,230
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix H

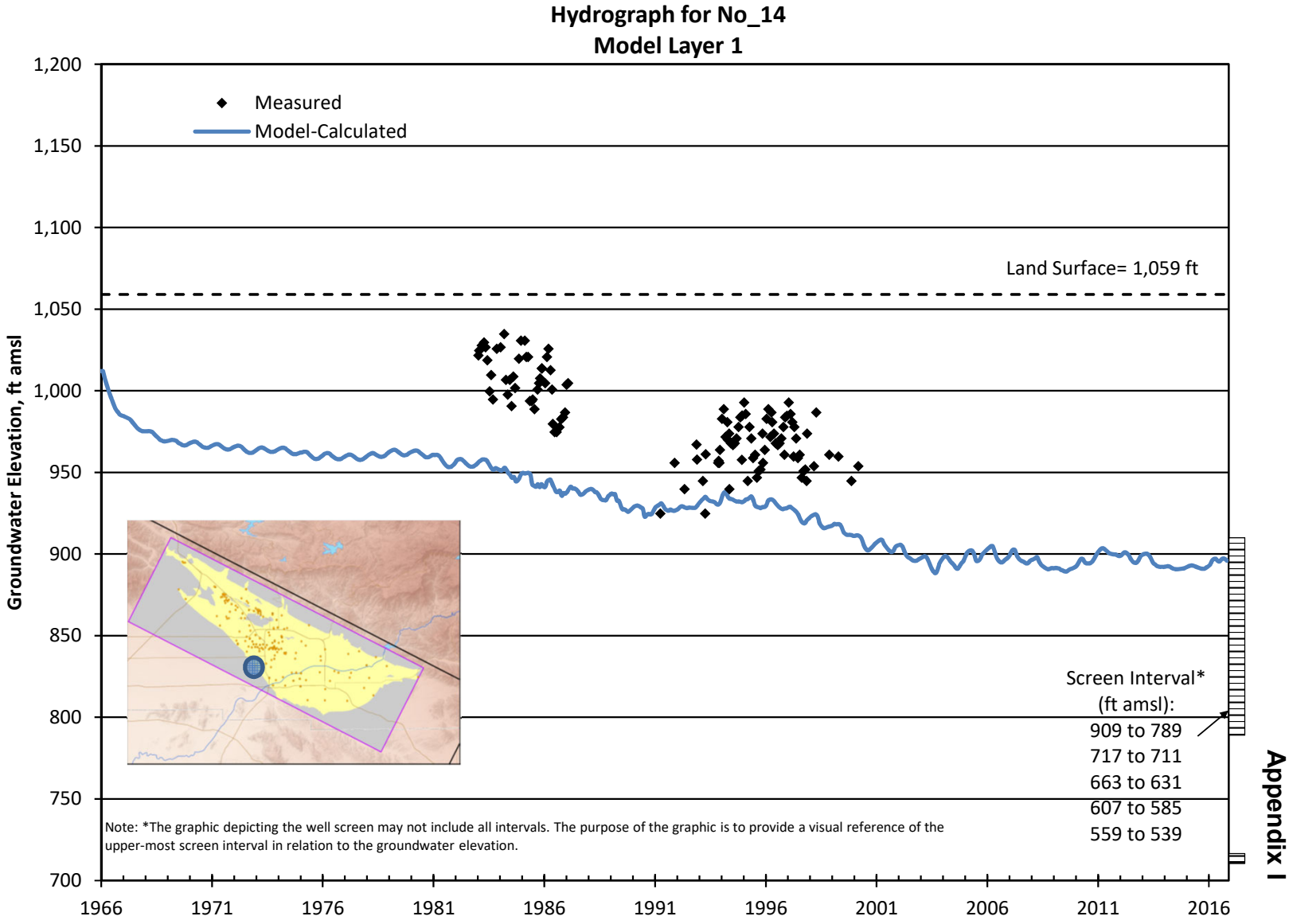

Hydrograph for Wilson_Creek_5
Model Layer 1
Measured
Model-Calculated
Land Surface= 2,750 ft
Screen Interval*
(ft amsl):
2,400 to 2,380
Groundwater Elevation, ft amsl
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix H

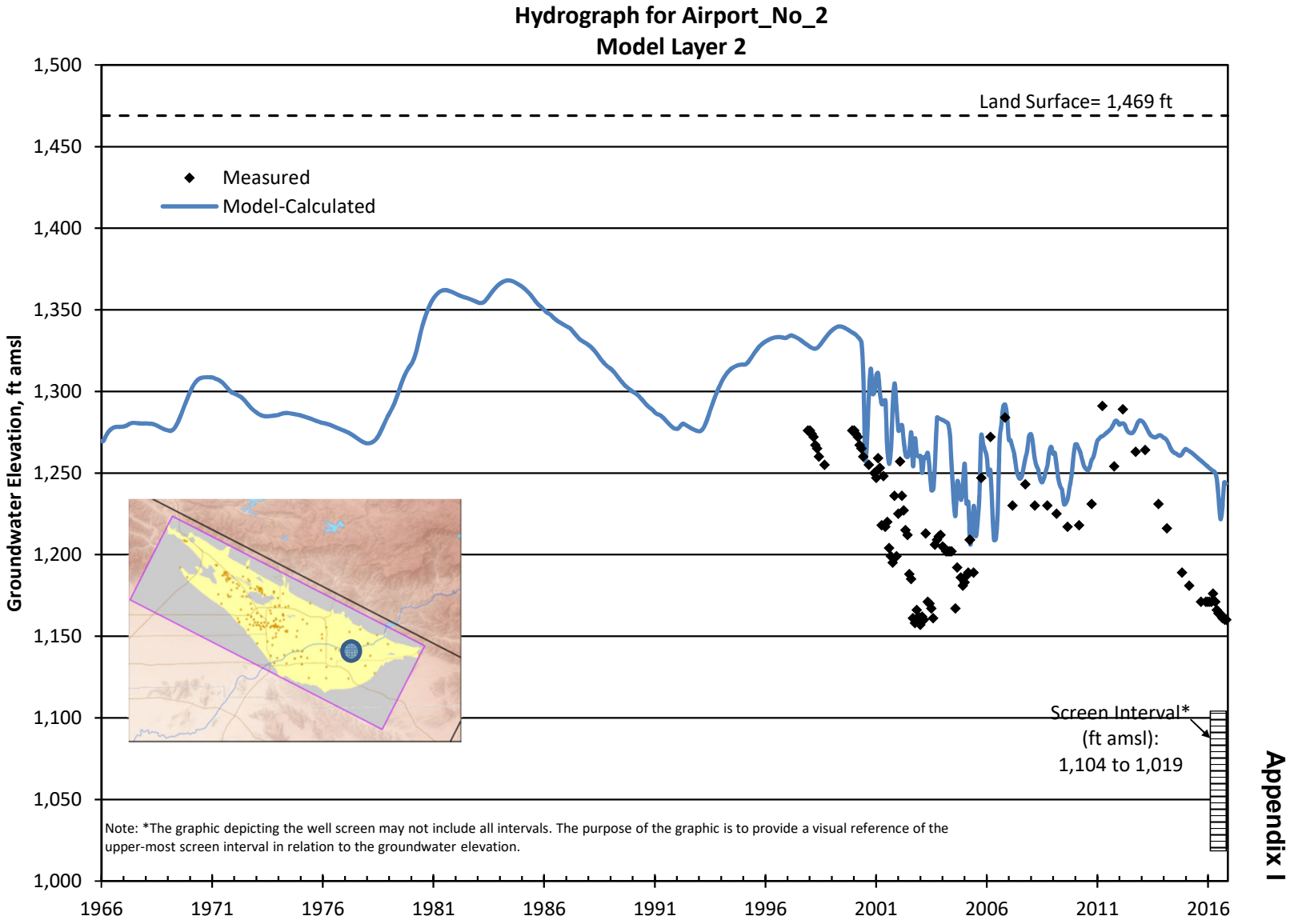
APPENDIX I

Individual Model Update: Selected Hydrographs for the San Bernardino Basin Area Model Calibration Target Wells – 1966 to 2016

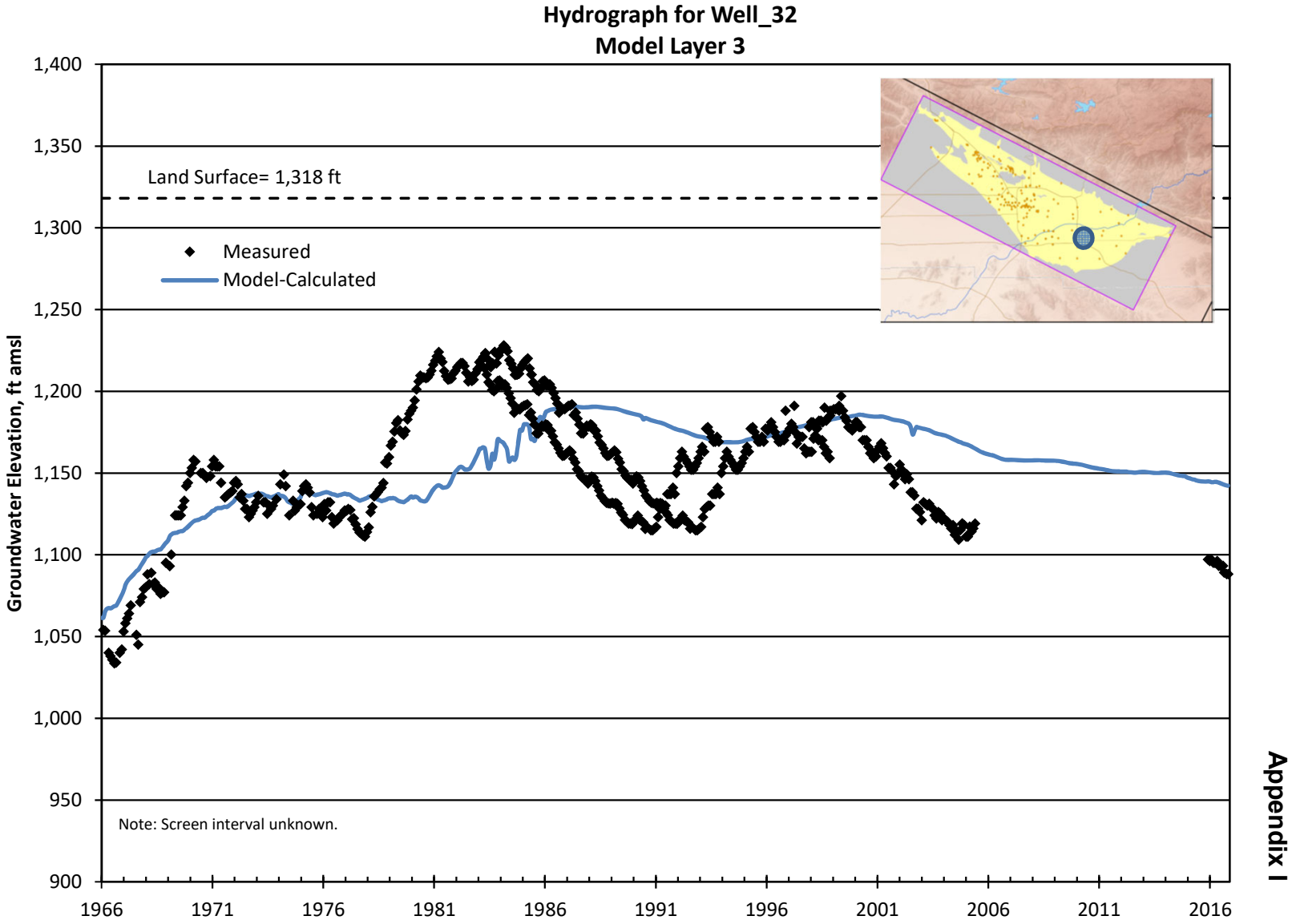
GEOSCIENCE


Hydrograph for No_14
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,059 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
909 to 789
717 to 711
663 to 631
607 to 585
559 to 539
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

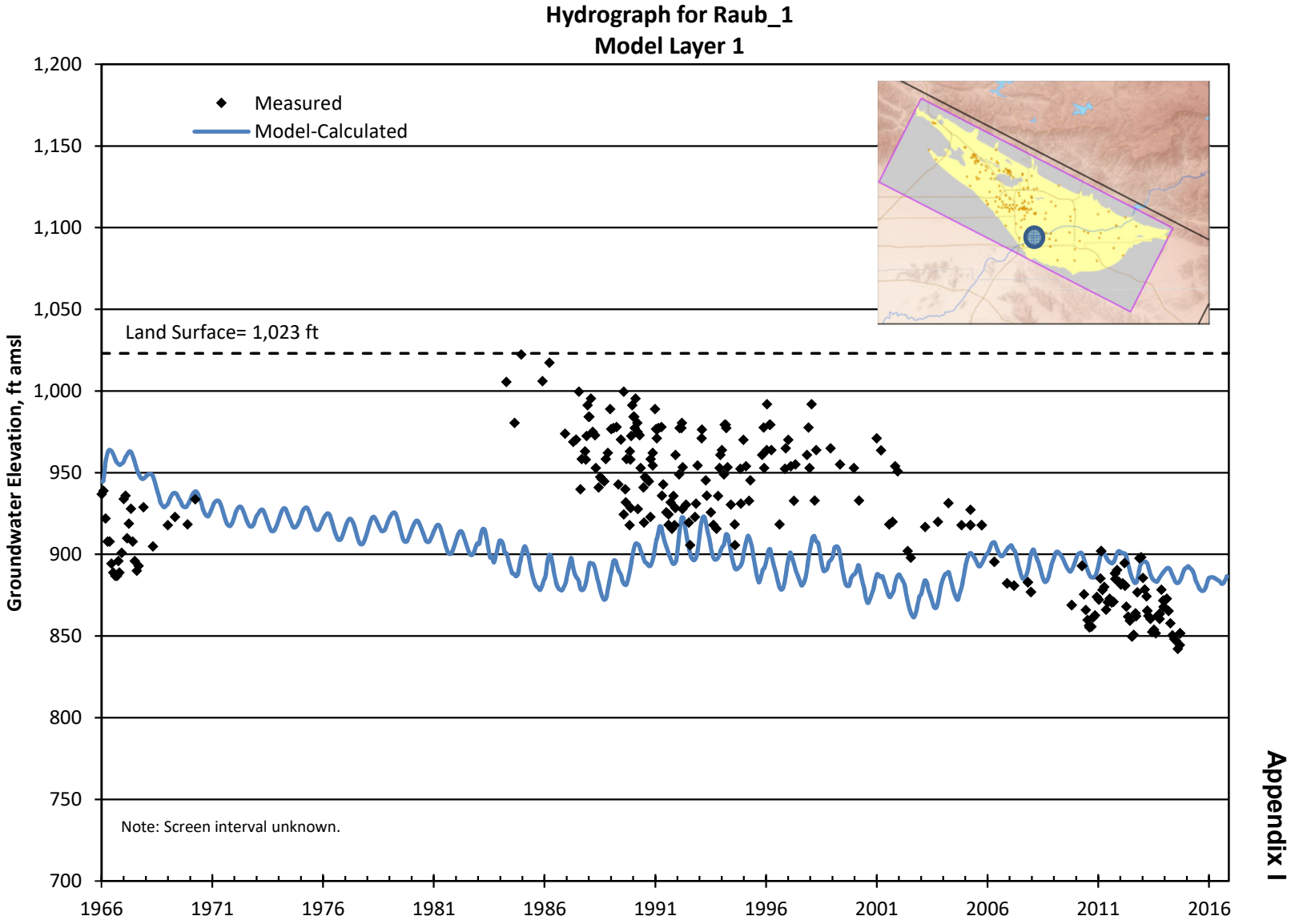
Appendix I


Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

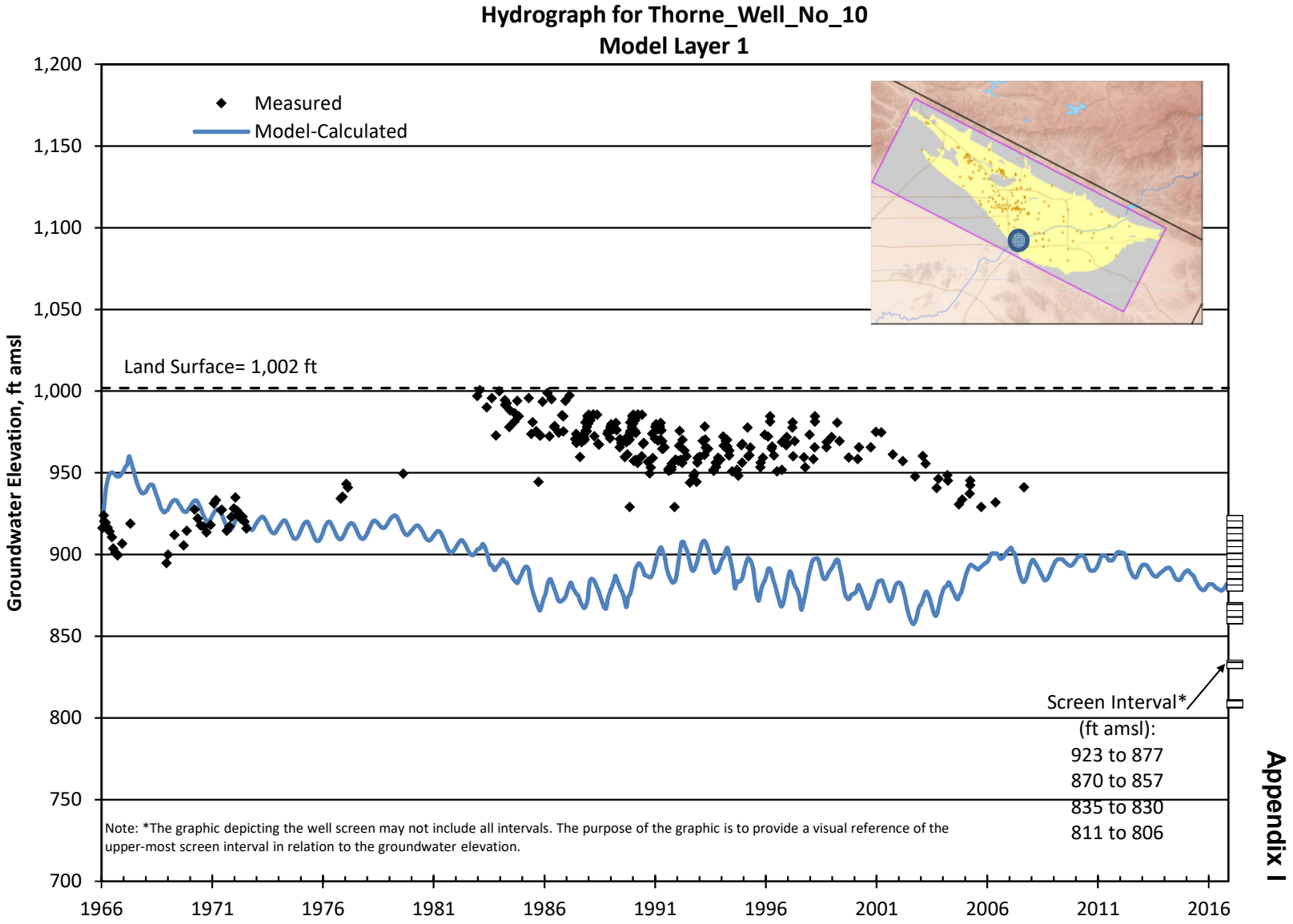
Appendix I


Hydrograph for Well_32
Model Layer 3
Land Surface= 1,318 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

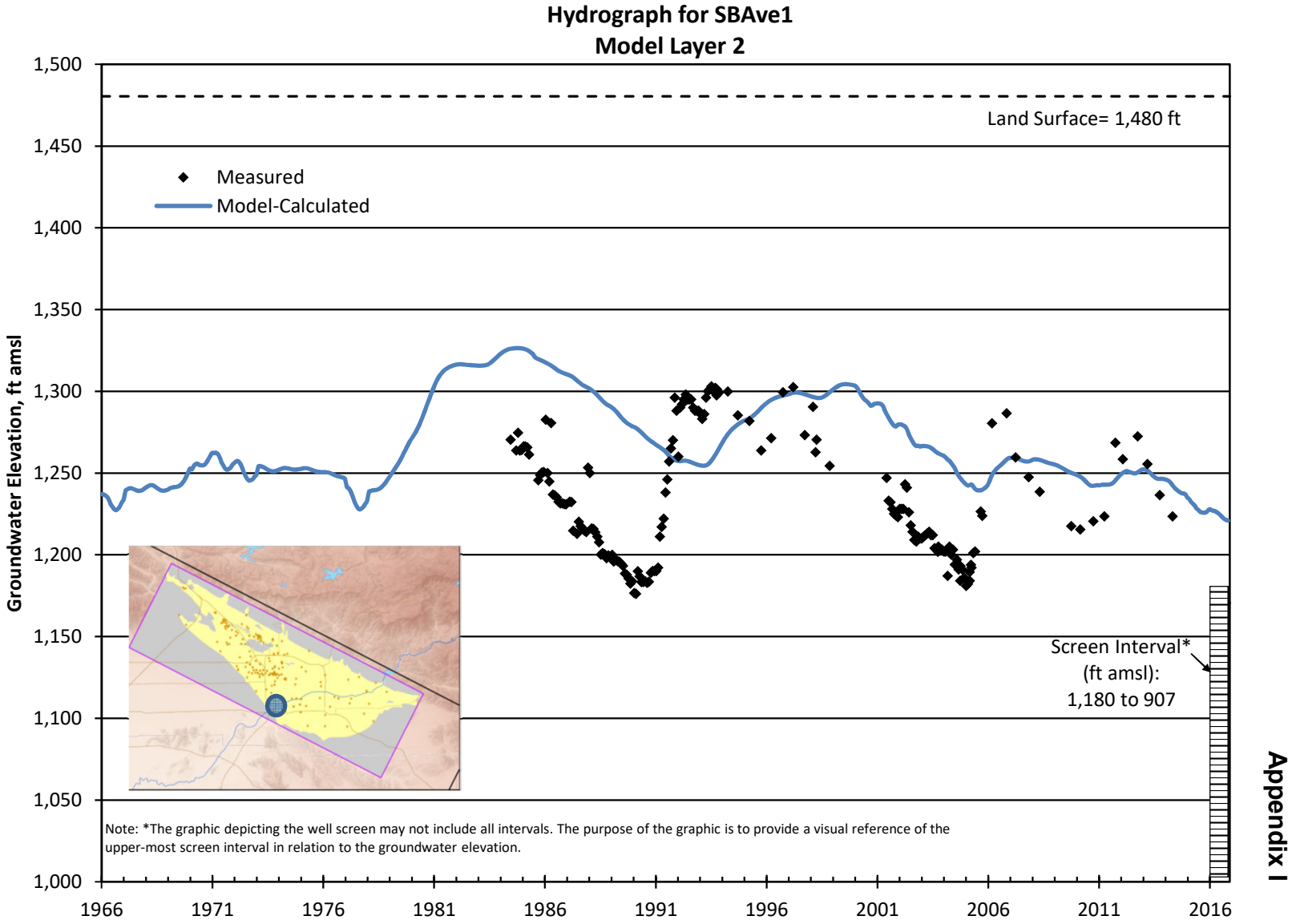
Appendix I


Hydrograph for Raub_1
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,023 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

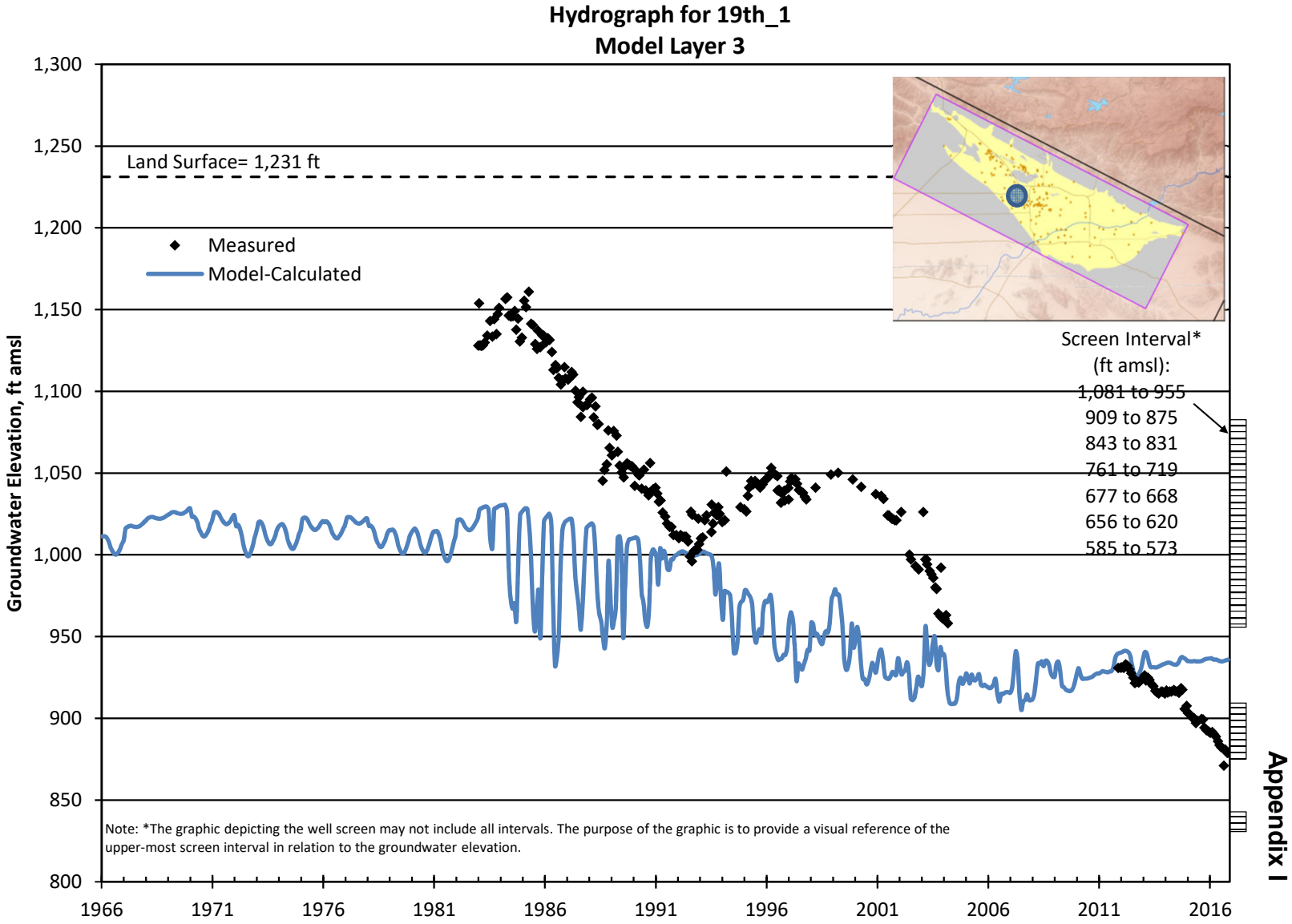
Appendix I


Hydrograph for Thorne_Well_No_10
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,002 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
923 to 877
870 to 857
835 to 830
811 to 806
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

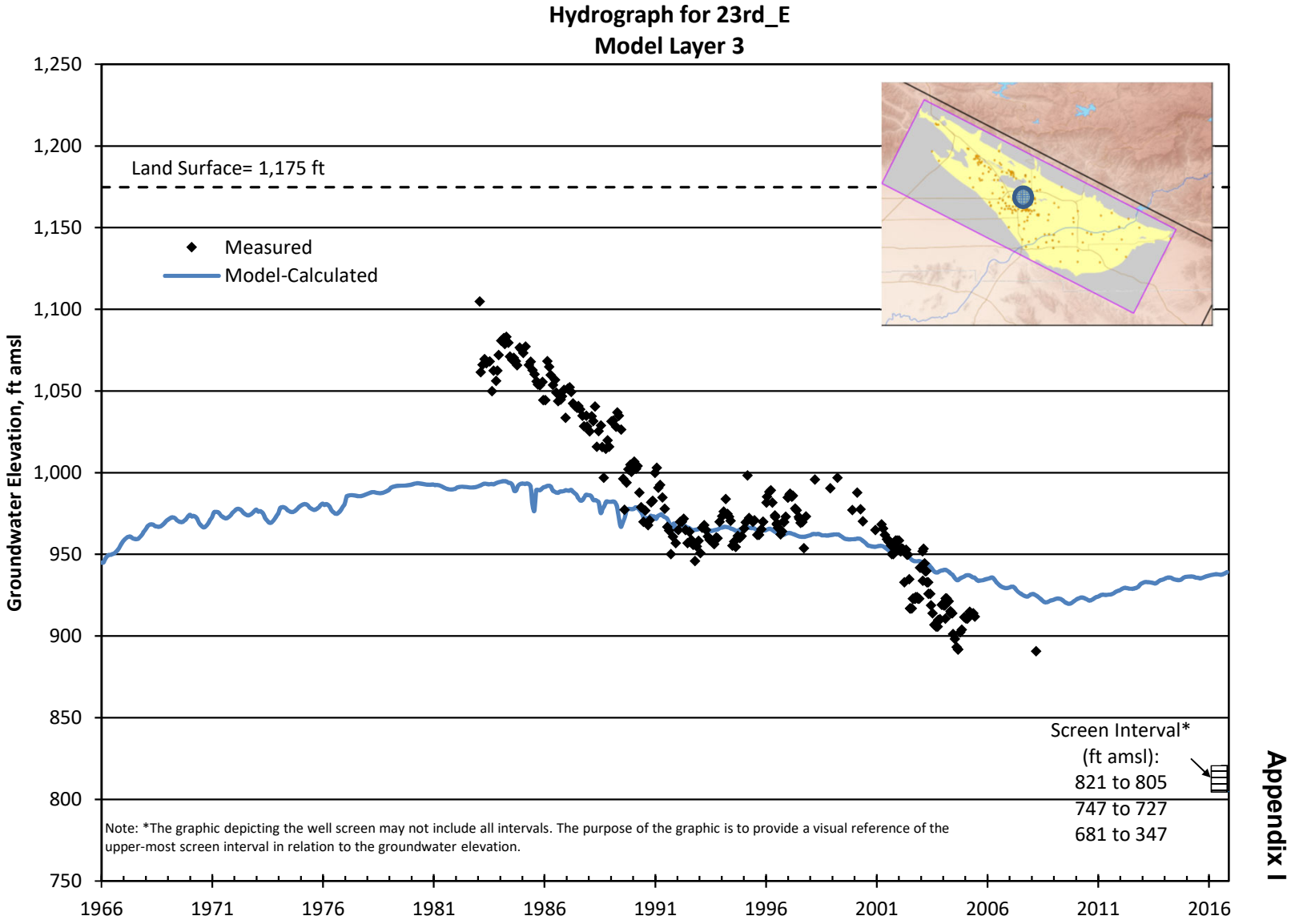
Appendix I


Hydrograph for SBAve1
Model Layer 2
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,480 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,180 to 907
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

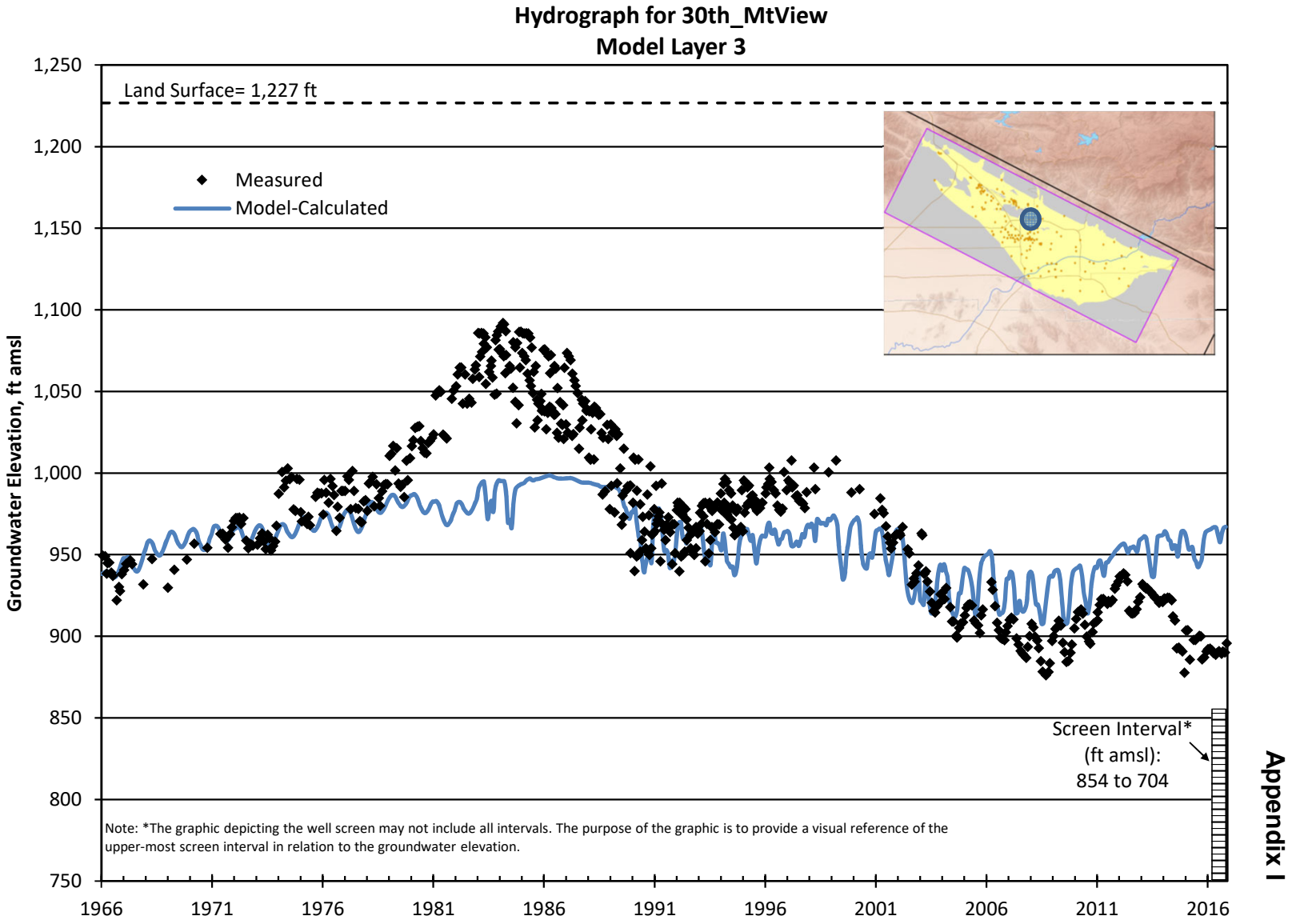
Appendix I


Hydrograph for 19th_1
Model Layer 3
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,231 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,081 to 955
909 to 875
843 to 831
761 to 719
677 to 668
656 to 620
585 to 573
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

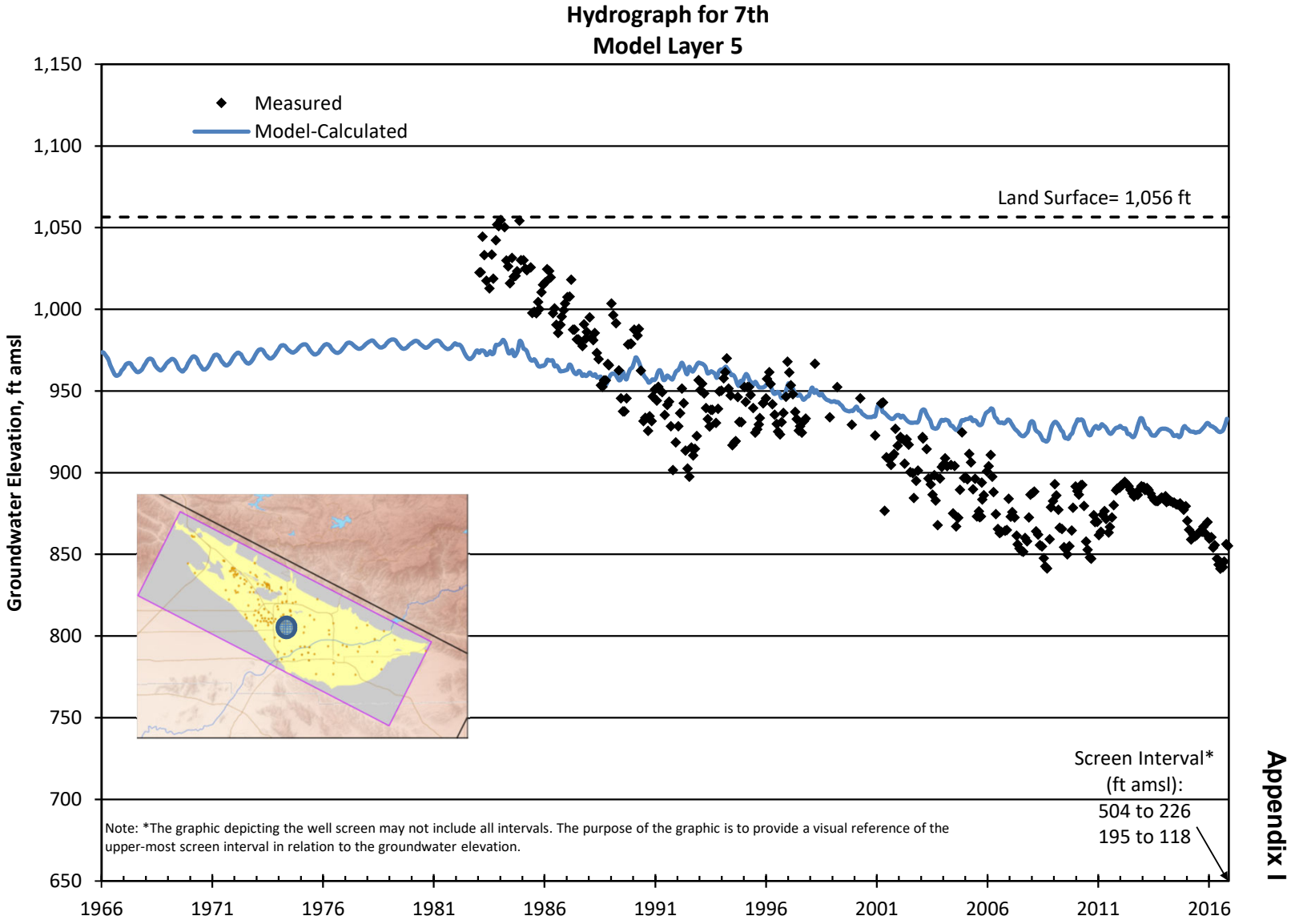
Appendix I


Hydrograph for 23rd_E
Model Layer 3
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,175 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
821 to 805
747 to 727
681 to 347
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

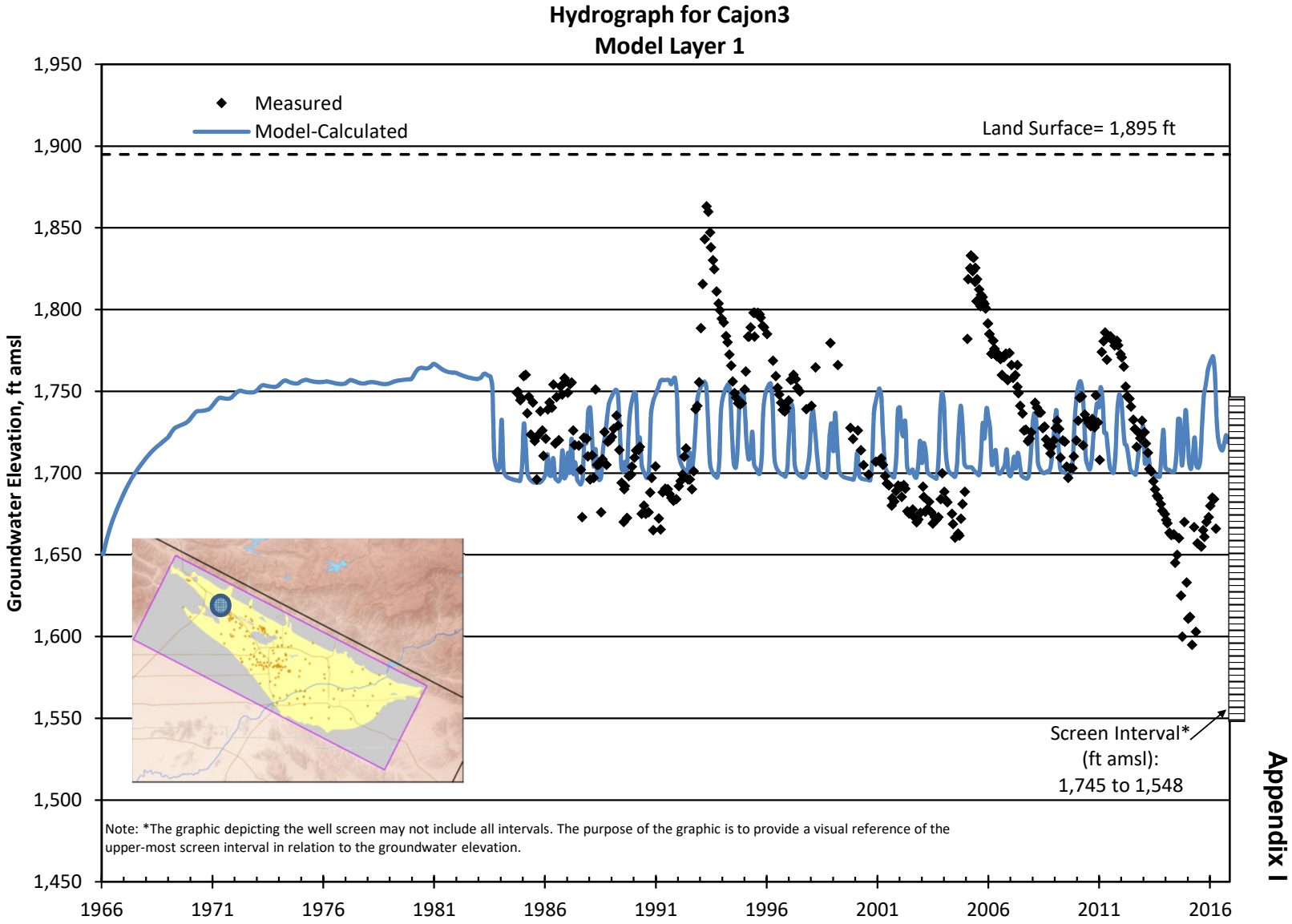
Appendix I


Hydrograph for 30th_MtView
Model Layer 3
Land Surface= 1,227 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
854 to 704
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

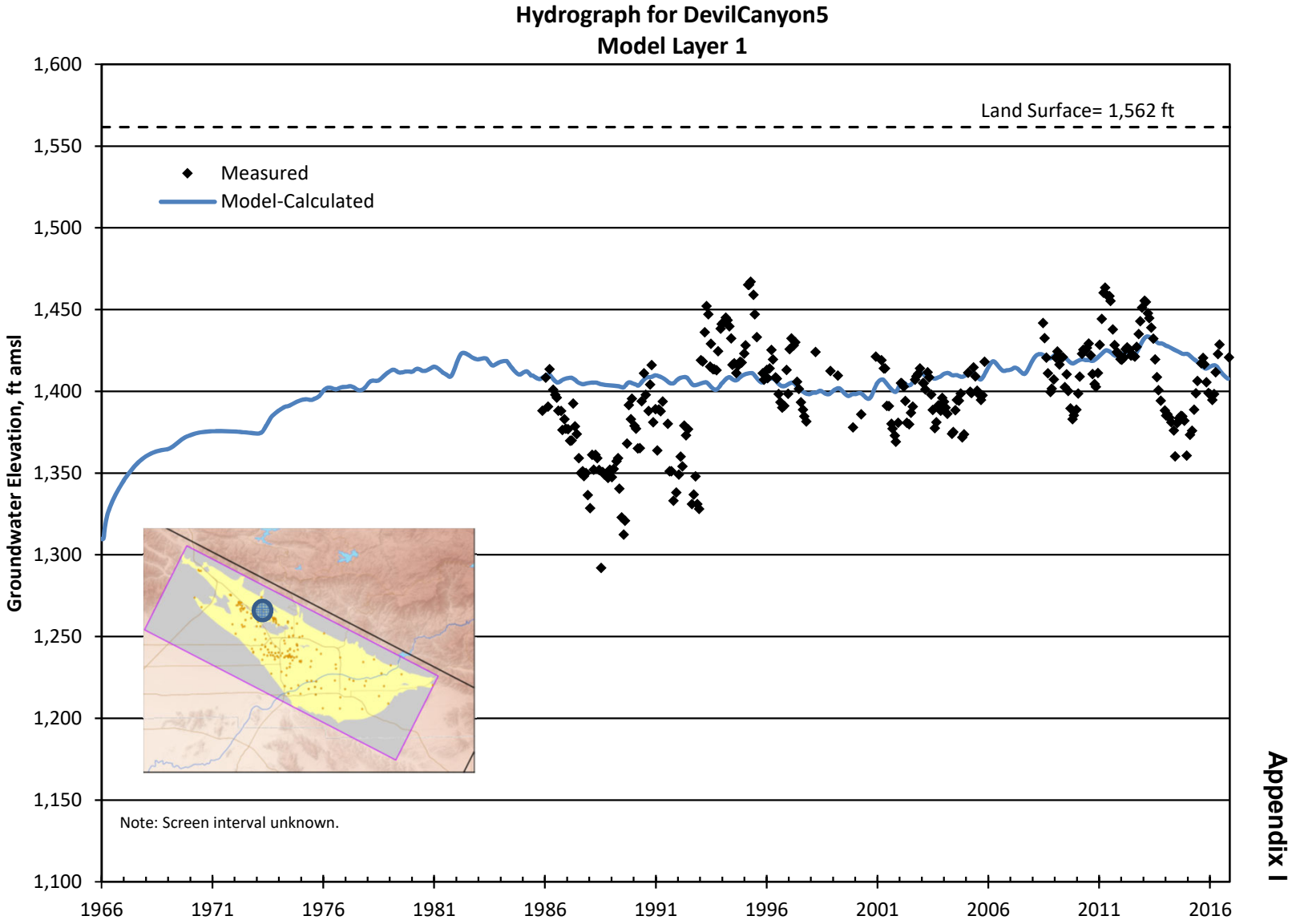
Appendix I


Hydrograph for 7th
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,056 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
504 to 226
195 to 118
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

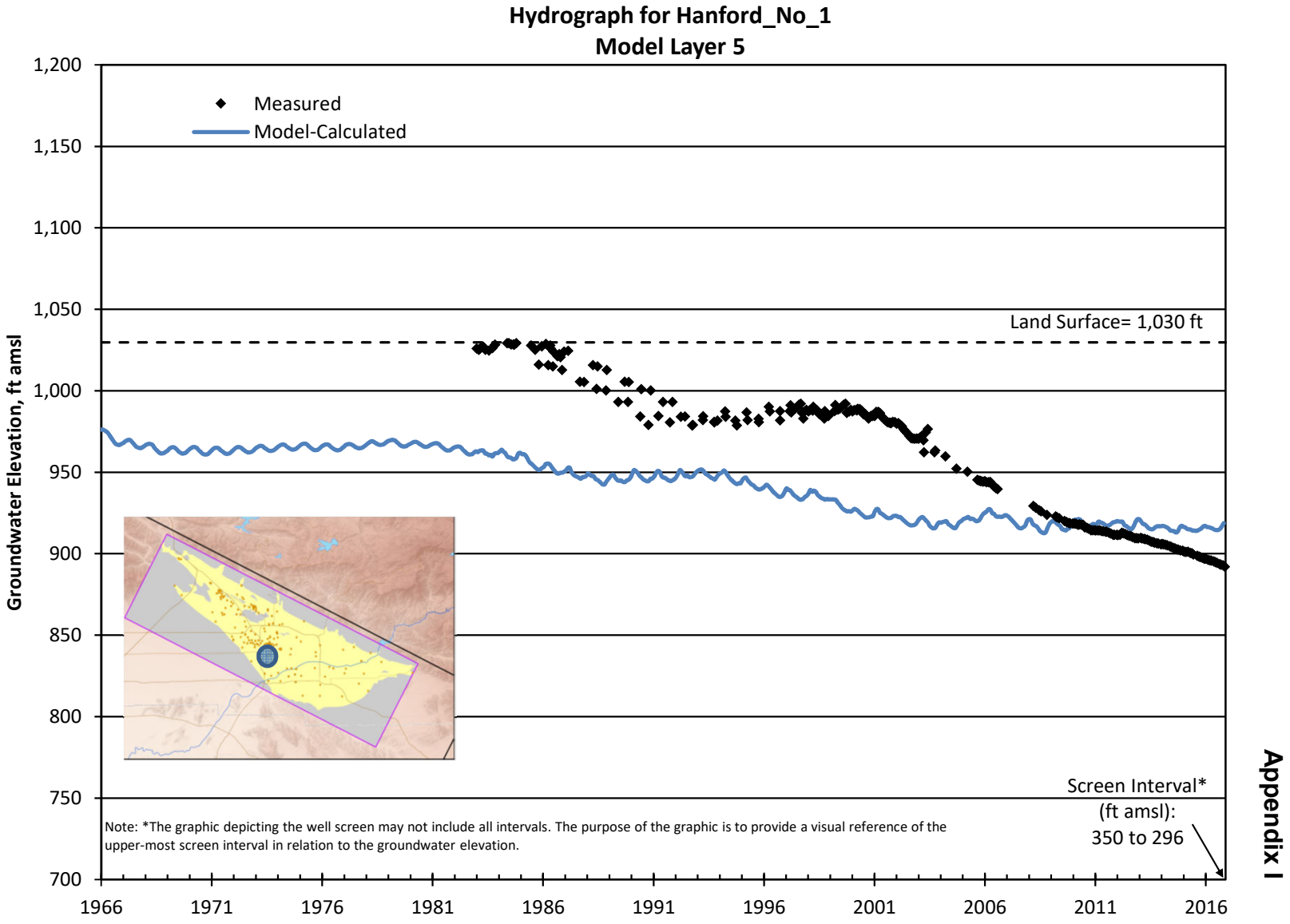
Appendix I


Hydrograph for Cajon3
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,895 ft
Groundwater Elevation, ft amsl
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,745 to 1,548
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

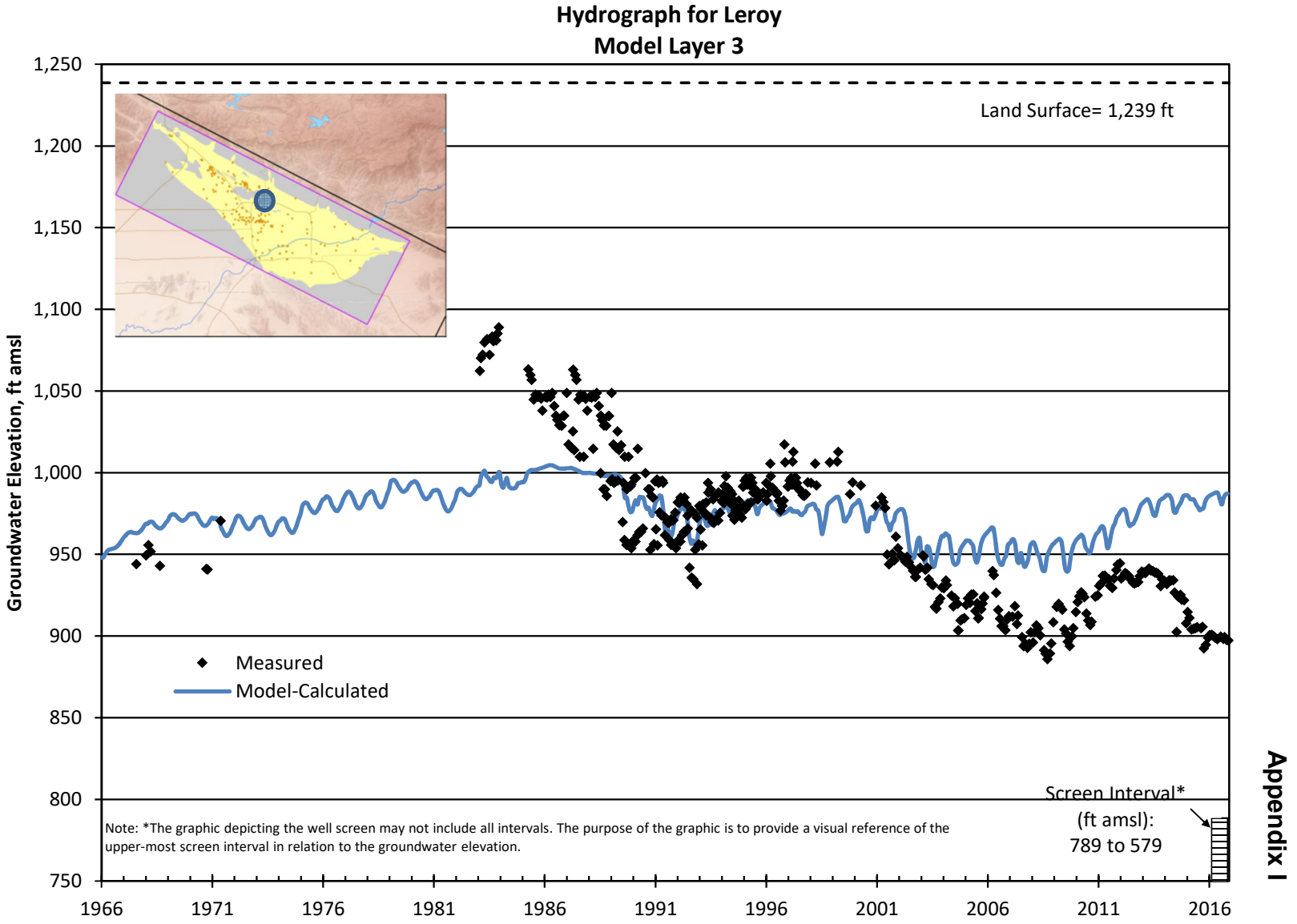
Appendix I


Hydrograph for DevilCanyon5
Model Layer 1
Land Surface= 1,562 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

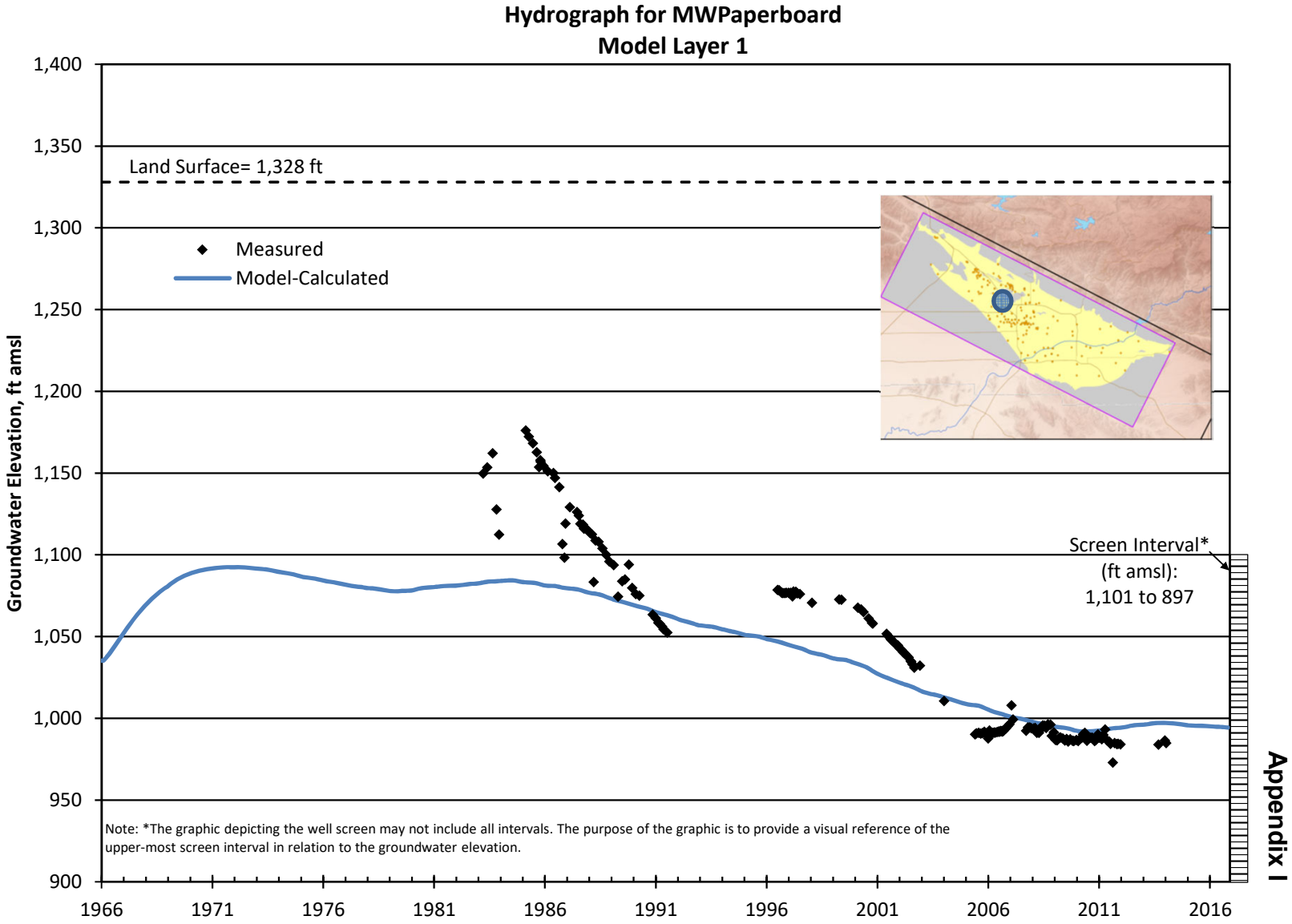
Appendix I


Hydrograph for Hanford_No_1
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,030 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
350 to 296
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

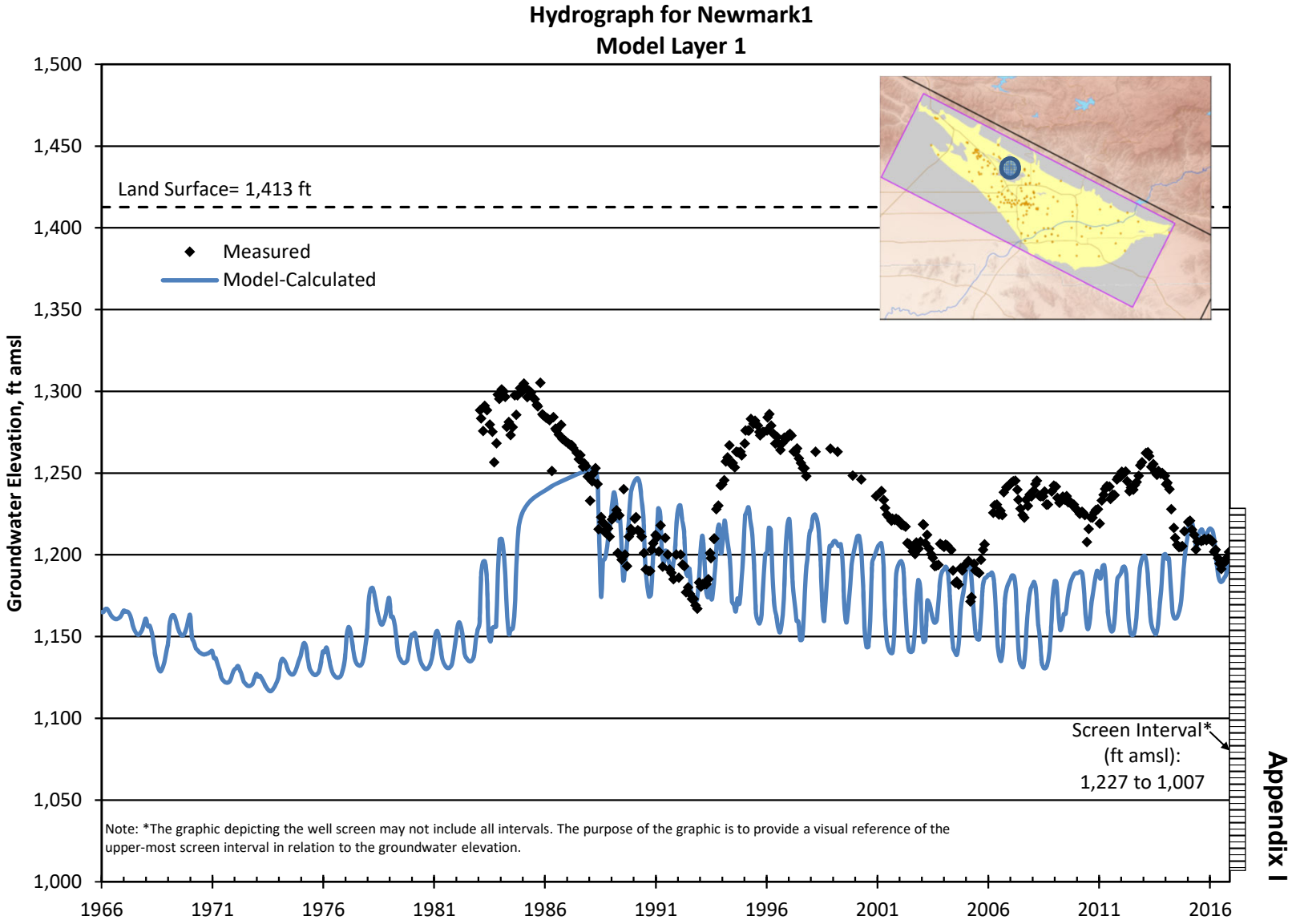
Appendix I


Hydrograph for Leroy
Model Layer 3
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,239 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
789 to 579
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

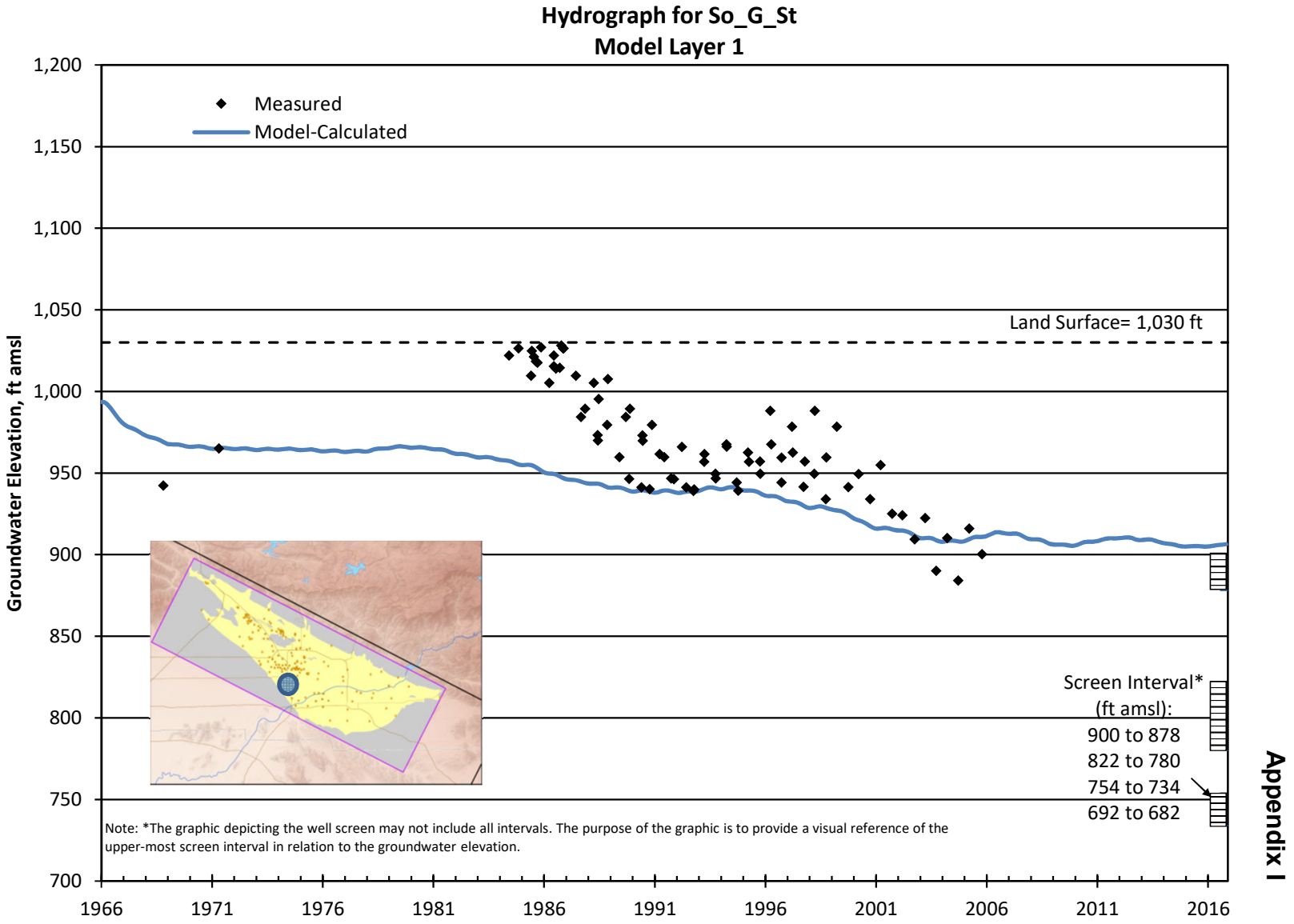
Appendix I


Hydrograph for MWPaperboard
Model Layer 1
Groundwater Elevation, ft amsl
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,328 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,101 to 897
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

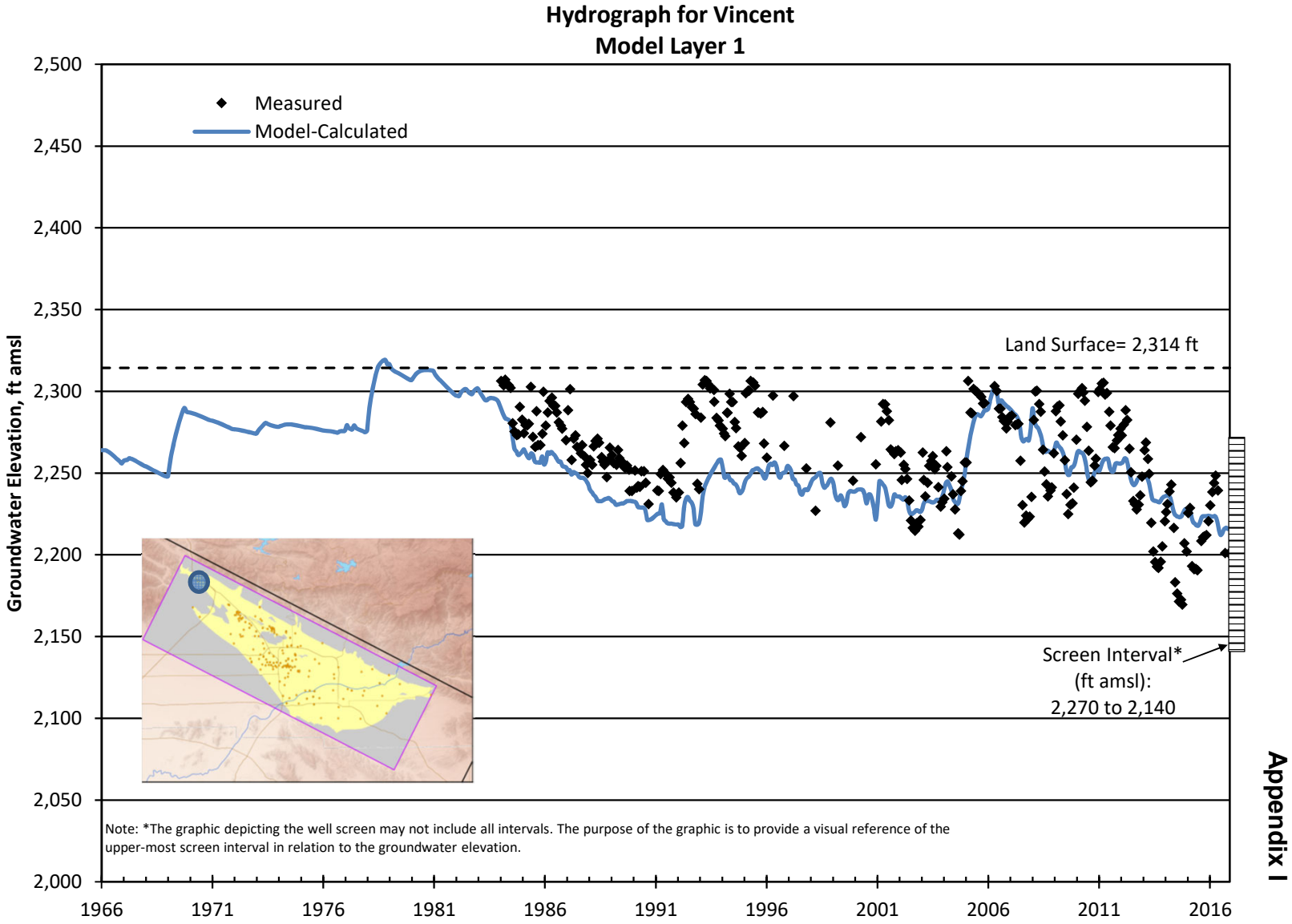
Appendix I


Hydrograph for Newmark1
Model Layer 1
Land Surface= 1,413 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,227 to 1,007
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

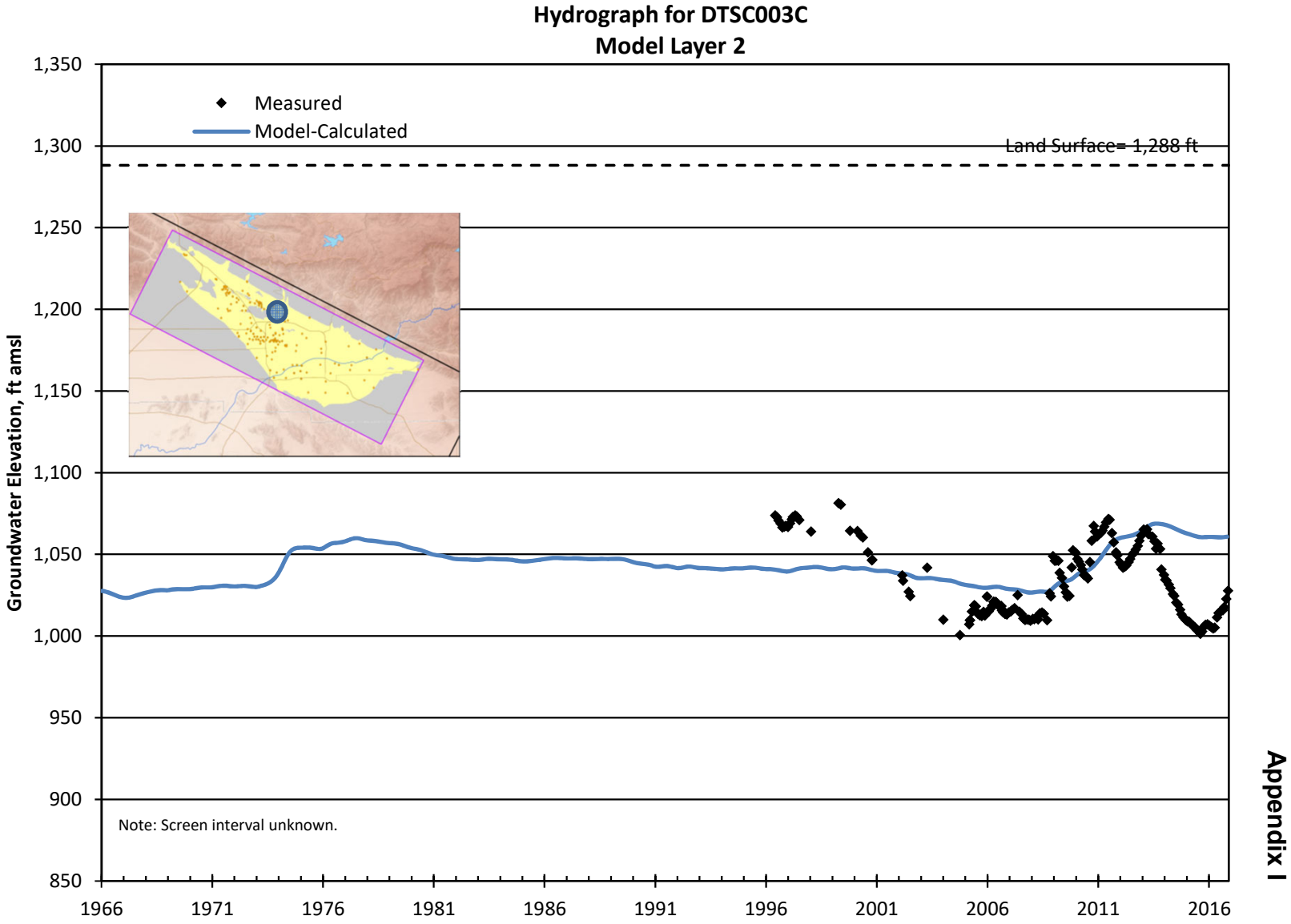
Appendix I


Hydrograph for So_G_St
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,030 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
900 to 878
822 to 780
754 to 734
692 to 682
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

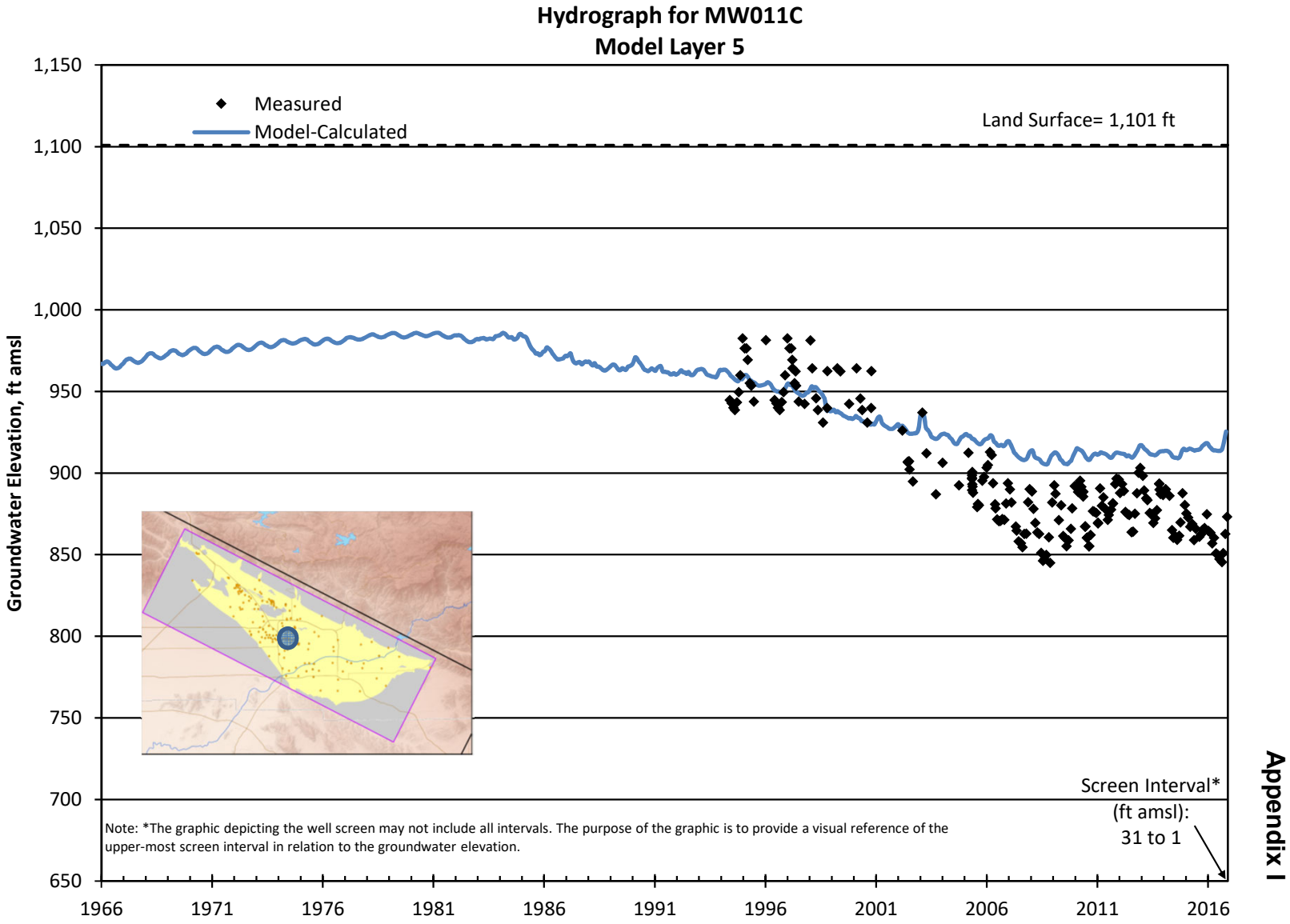
Appendix I


Hydrograph for Vincent
Model Layer 1
Measured
Model-Calculated
Land Surface= 2,314 ft
Screen Interval*
(ft amsl):
2,270 to 2,140
Groundwater Elevation, ft amsl
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

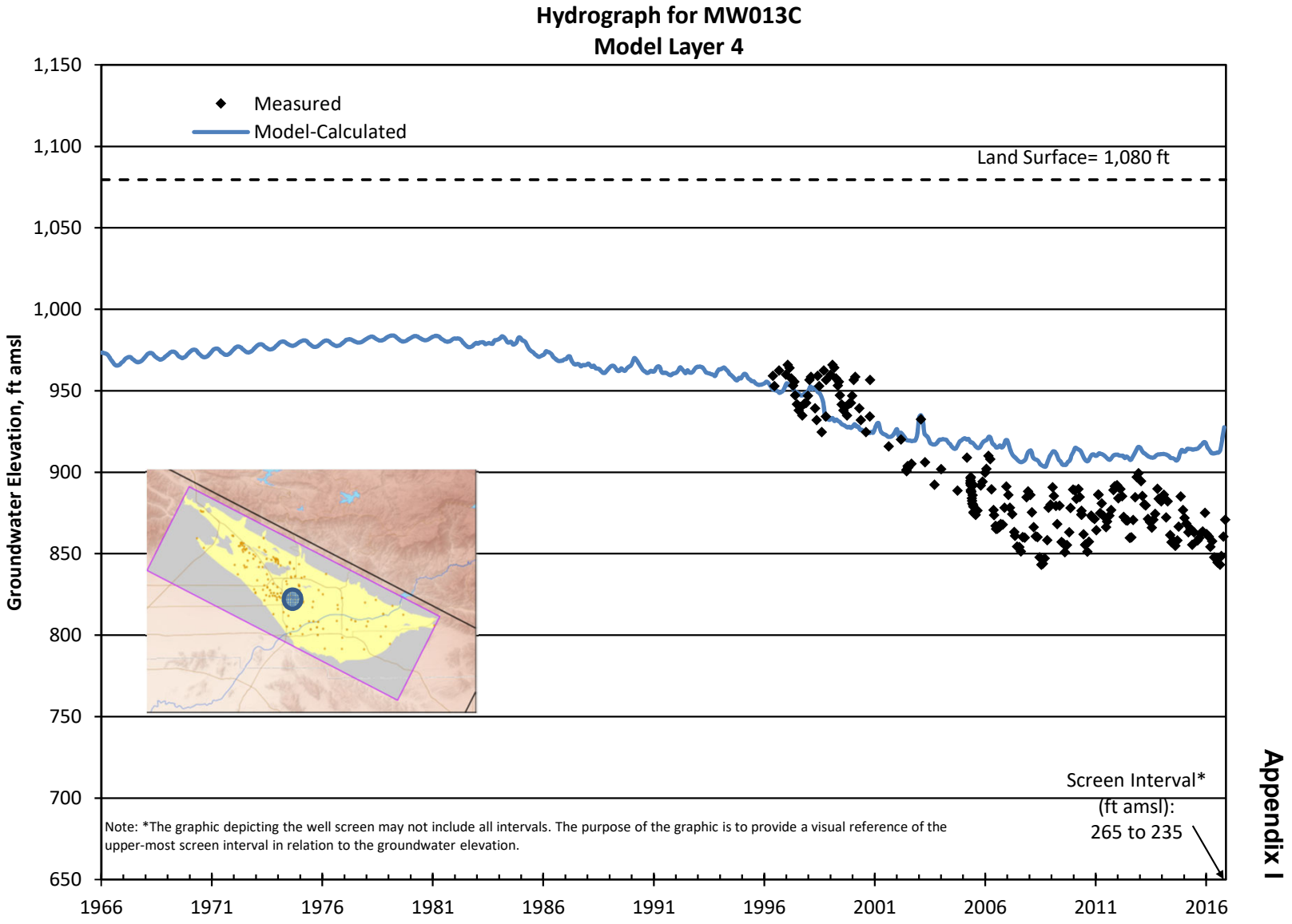
Appendix I


Hydrograph for DTSC003C
Model Layer 2
Measured
Model-Calculated
Land Surface= 1,288 ft
Groundwater Elevation, ft amsl
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

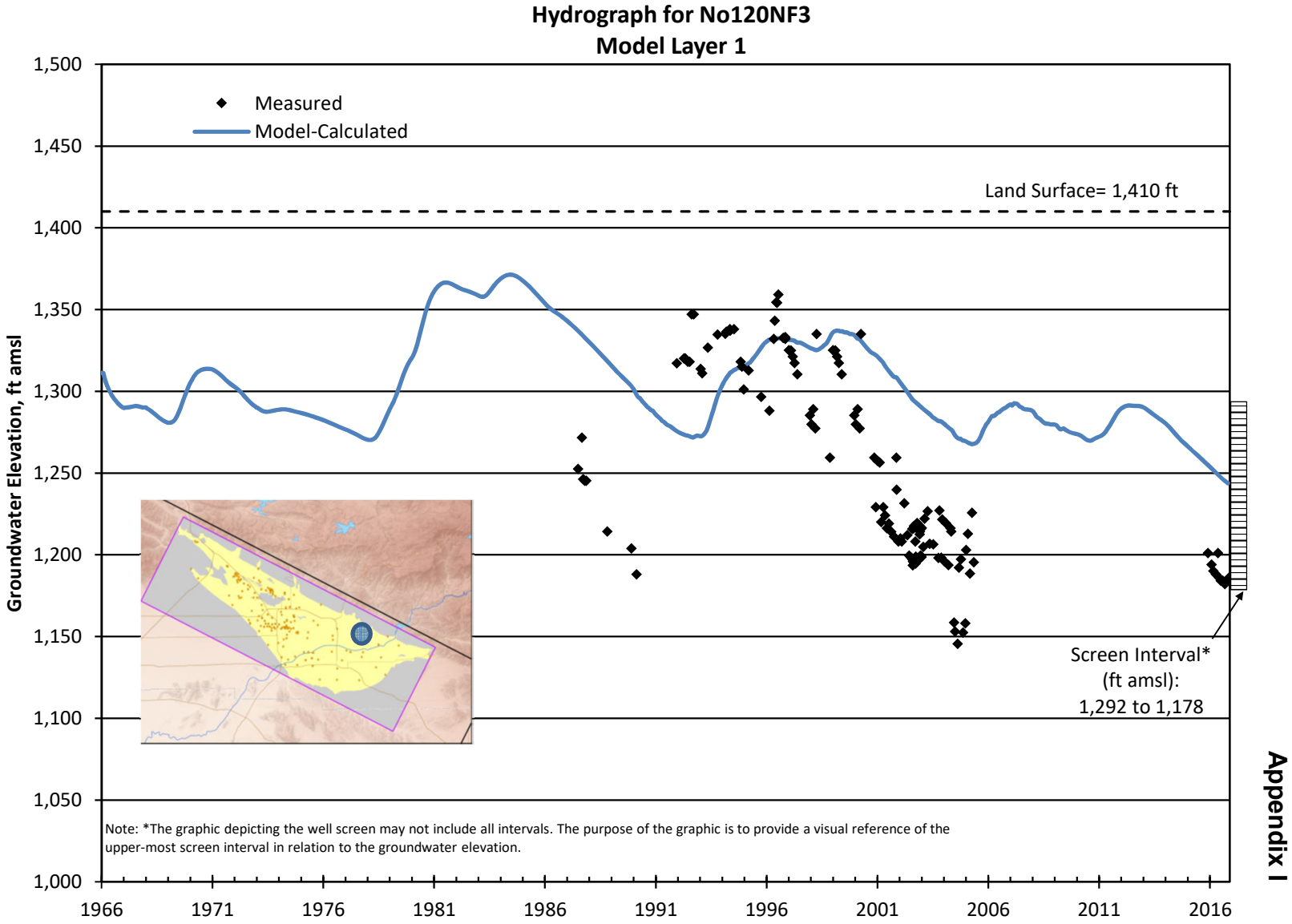
Appendix I


Hydrograph for MW011C
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,101 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
31 to 1
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

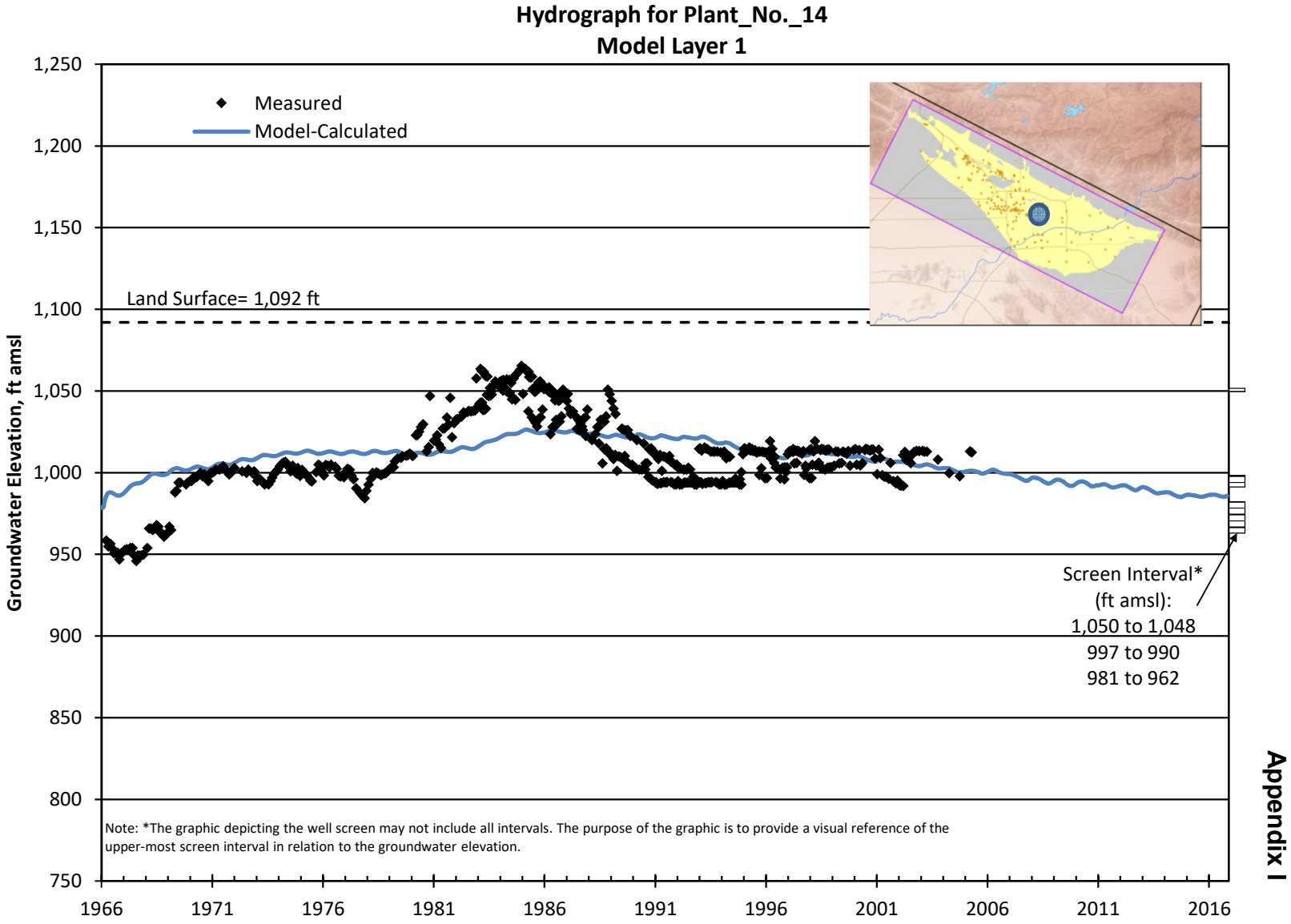
Appendix I


Hydrograph for MW013C
Model Layer 4
Measured
Model-Calculated
Land Surface= 1,080 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
265 to 235
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

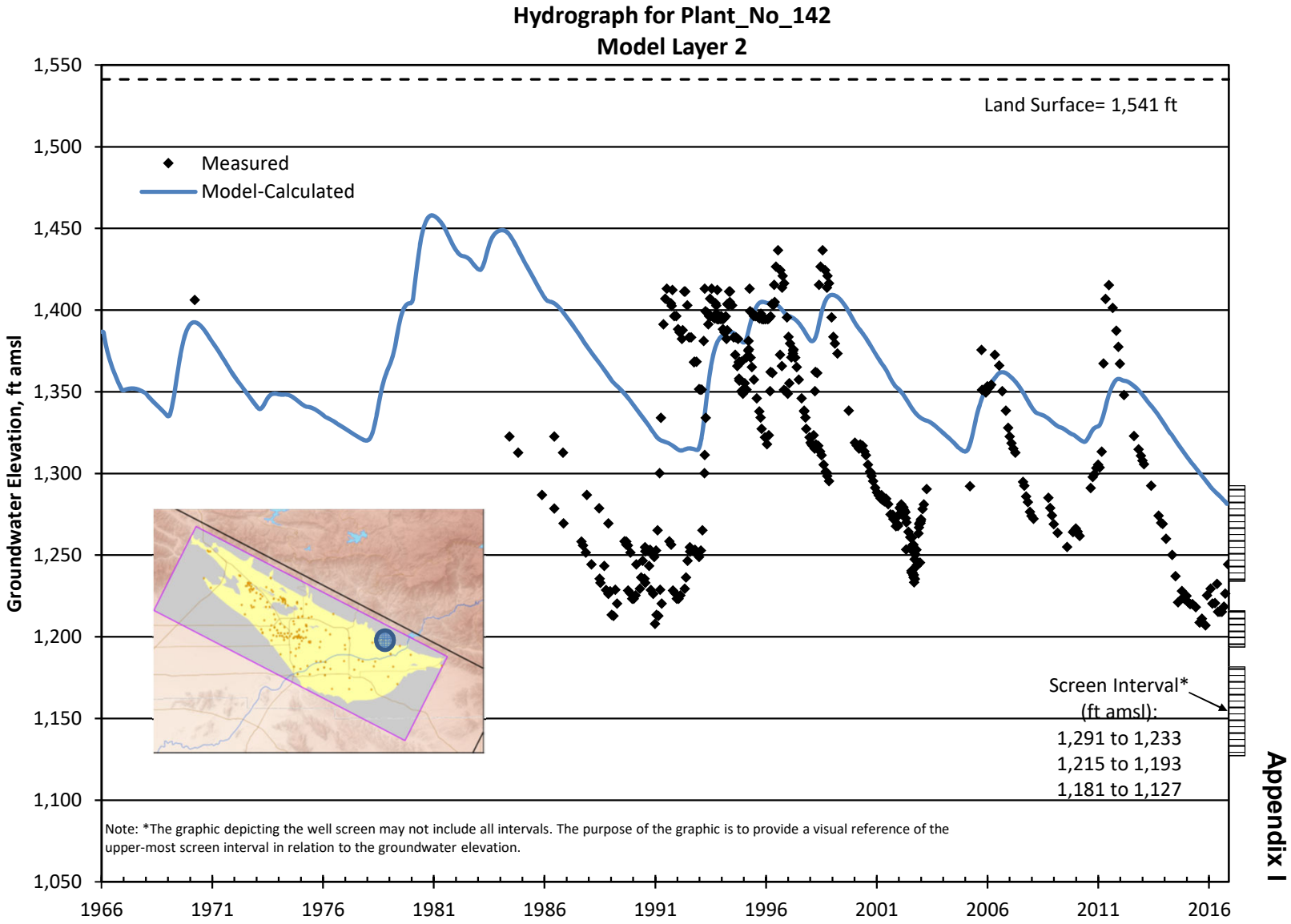
Appendix I


Hydrograph for No120NF3
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,410 ft
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,292 to 1,178
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

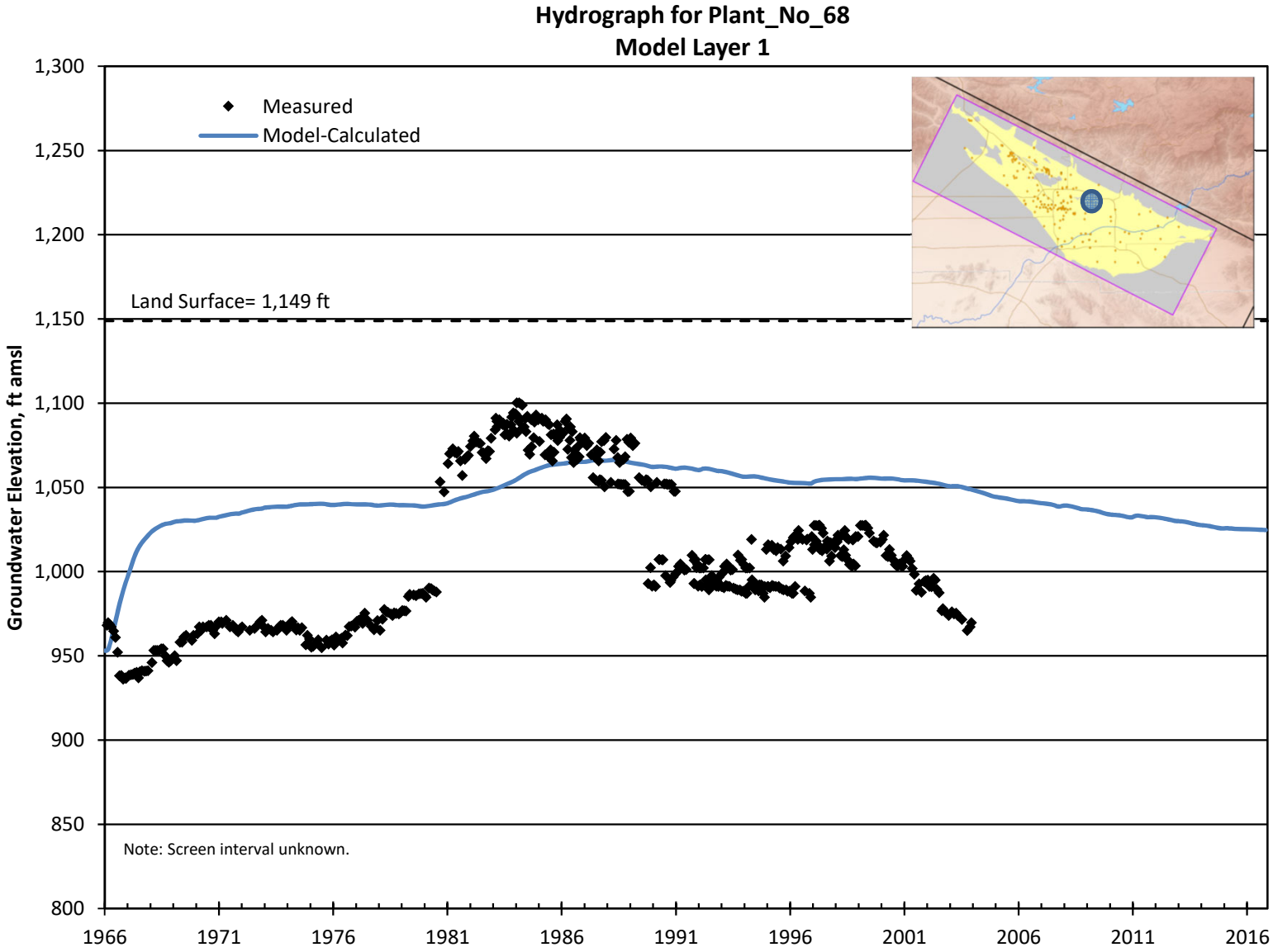
Appendix I


Hydrograph for Plant_No._14
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,092 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,050 to 1,048
997 to 990
981 to 962
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

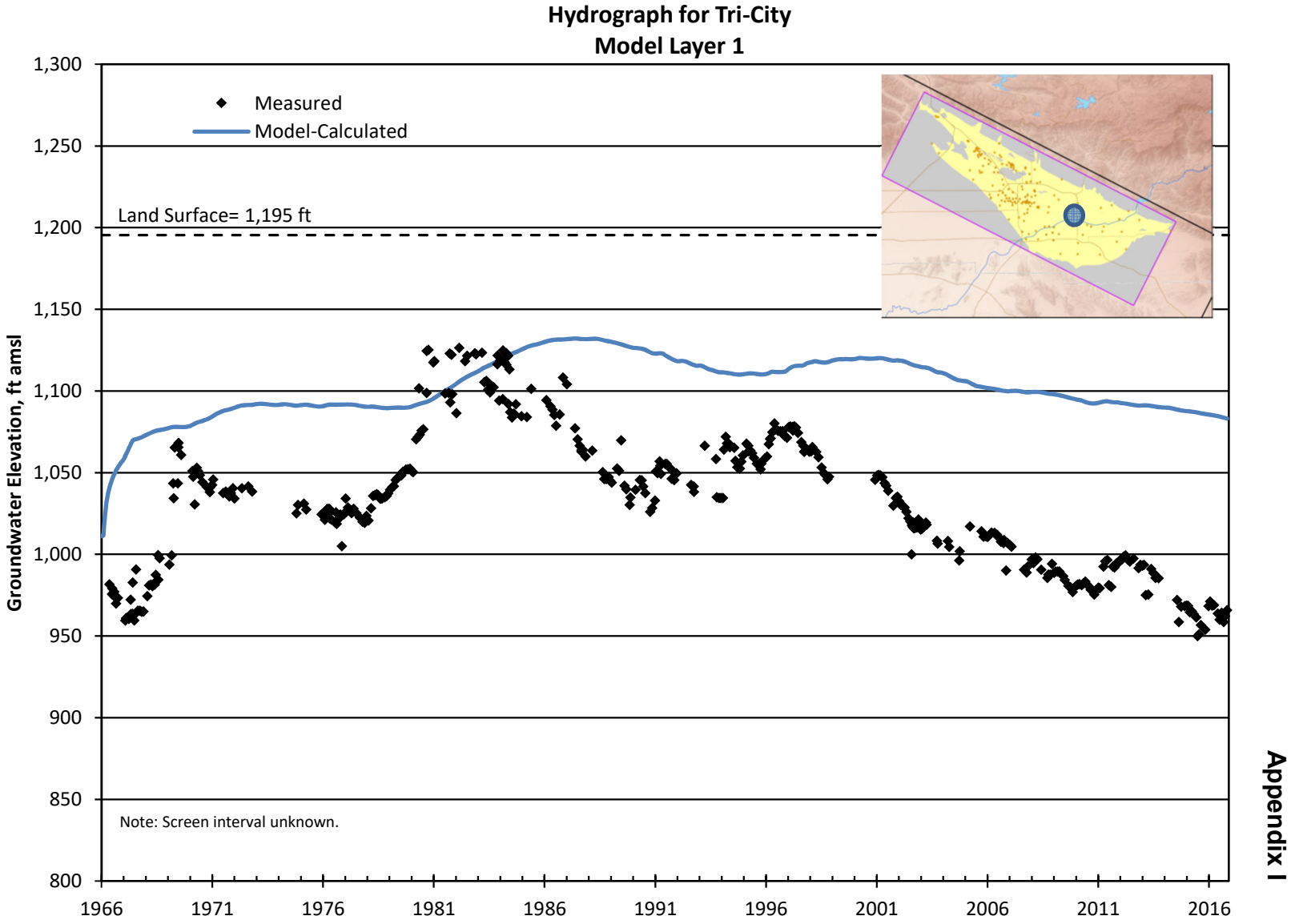
Appendix I


Hydrograph for Plant_No_142
Model Layer 2
Groundwater Elevation, ft amsl
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,541 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,291 to 1,233
1,215 to 1,193
1,181 to 1,127
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

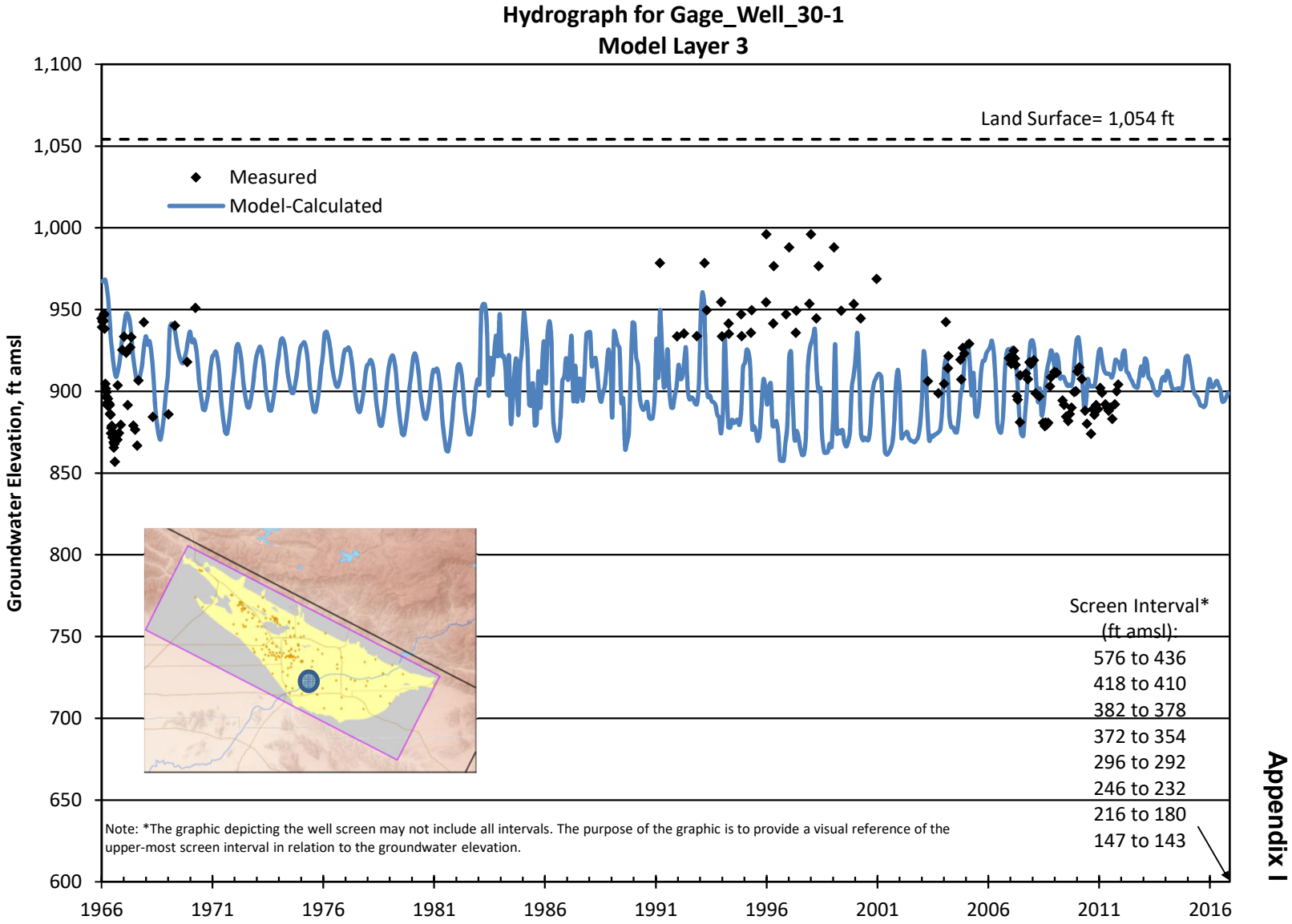
Appendix I


Hydrograph for Plant_No_68
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,149 ft
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

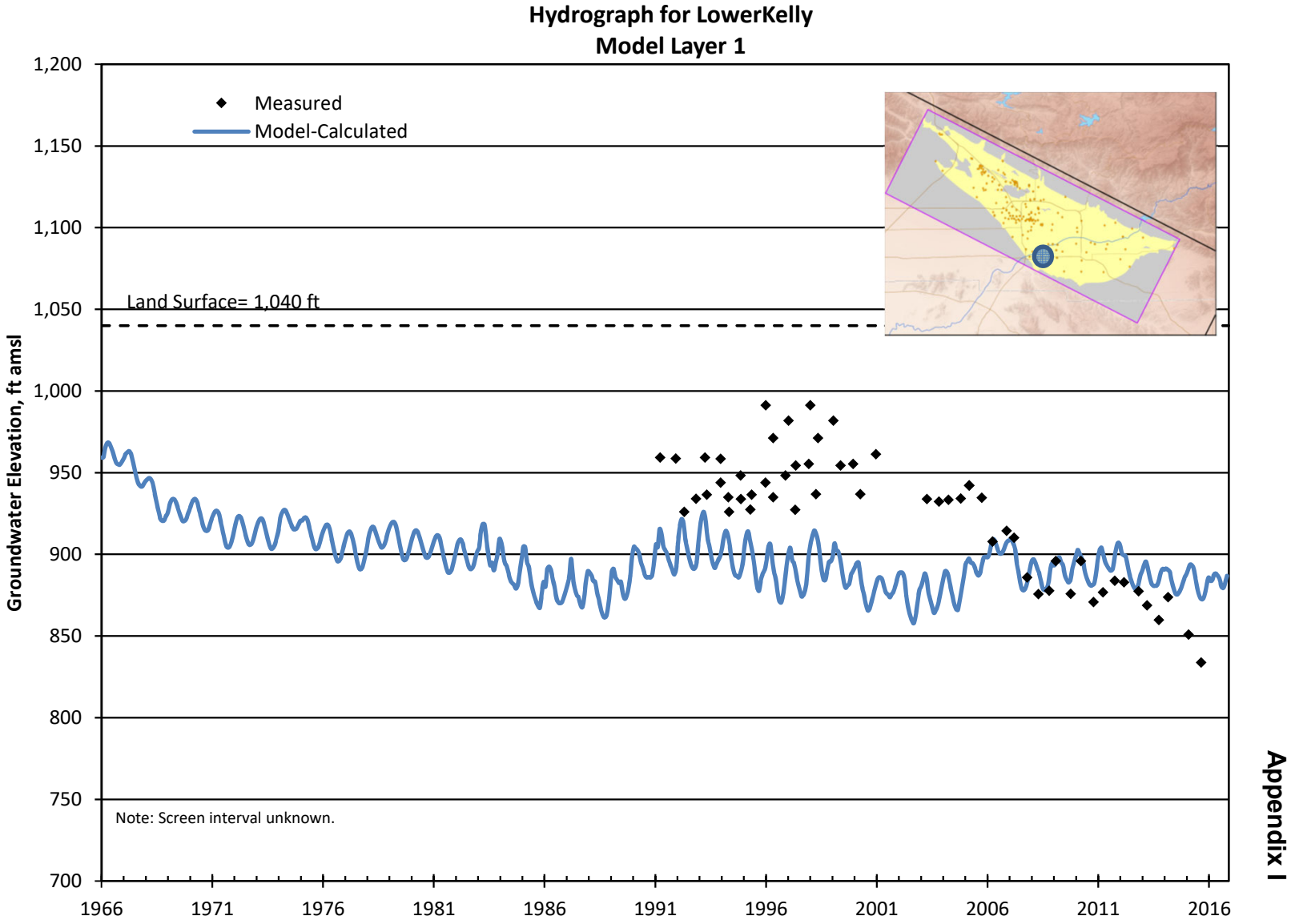
Appendix I


Hydrograph for Tri-City
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,195 ft
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

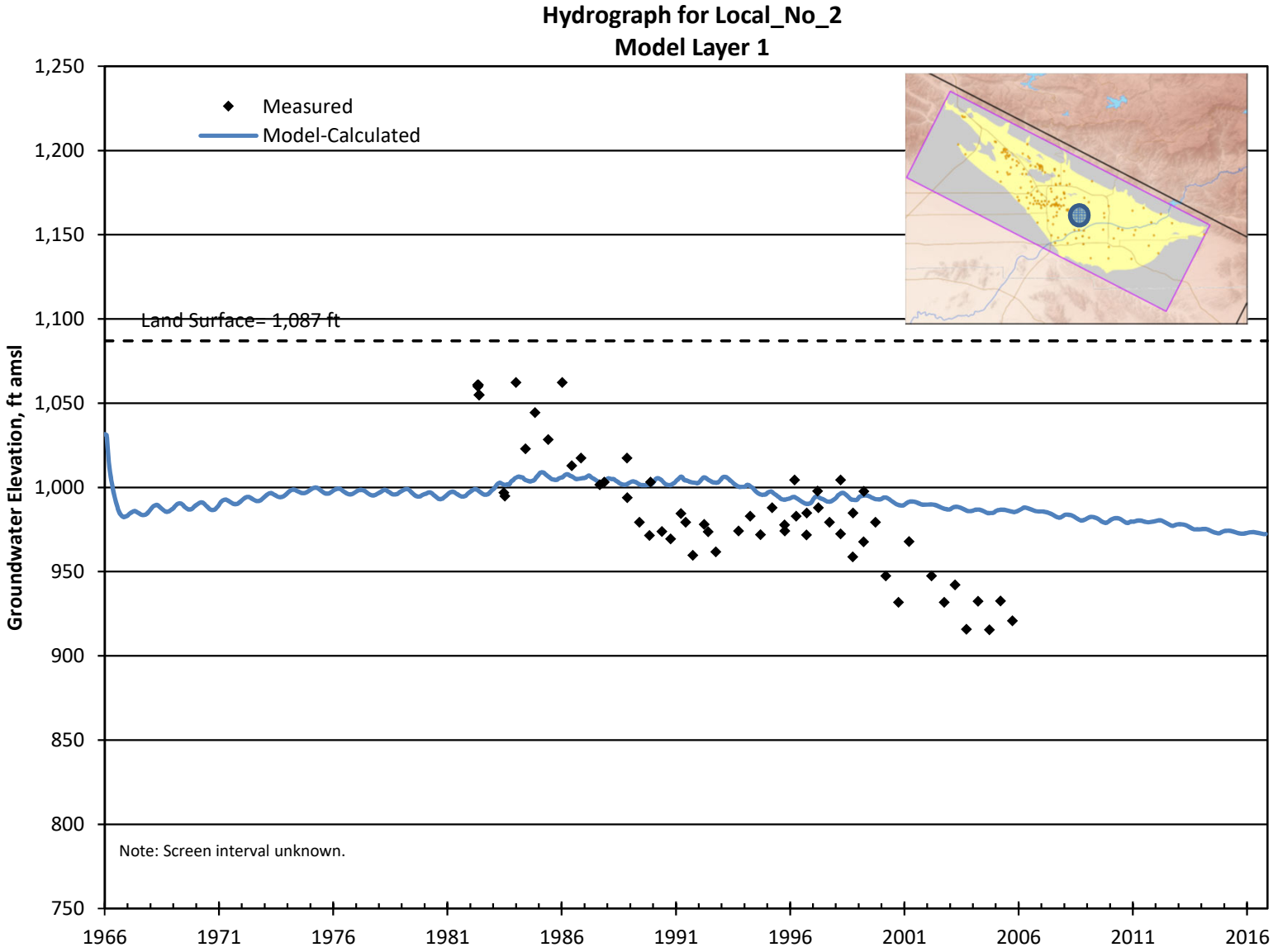
Appendix I


Hydrograph for Gage_Well_30-1
Model Layer 3
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,054 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
576 to 436
418 to 410
382 to 378
372 to 354
296 to 292
246 to 232
216 to 180
147 to 143
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

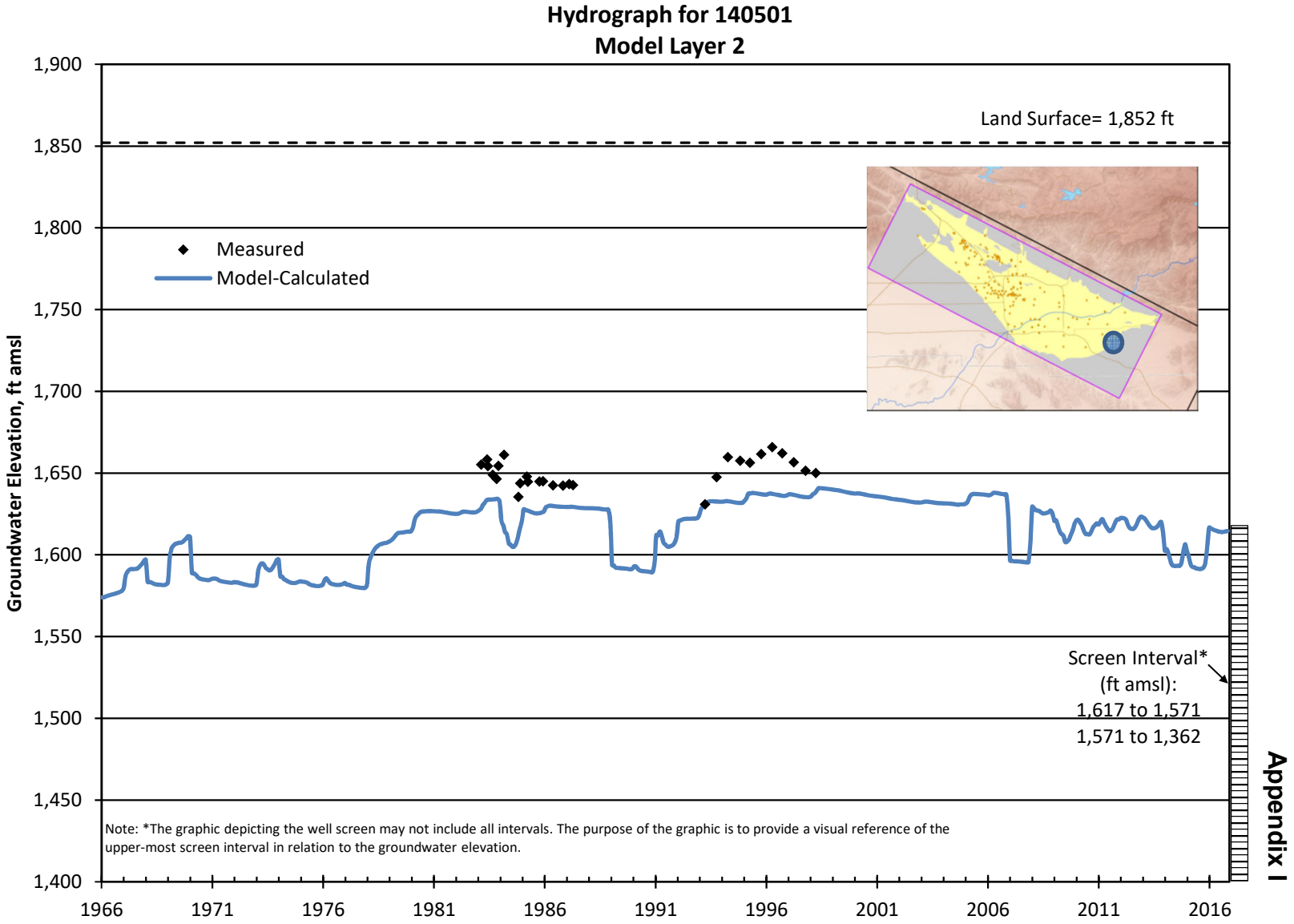
Appendix I


Hydrograph for LowerKelly
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,040 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

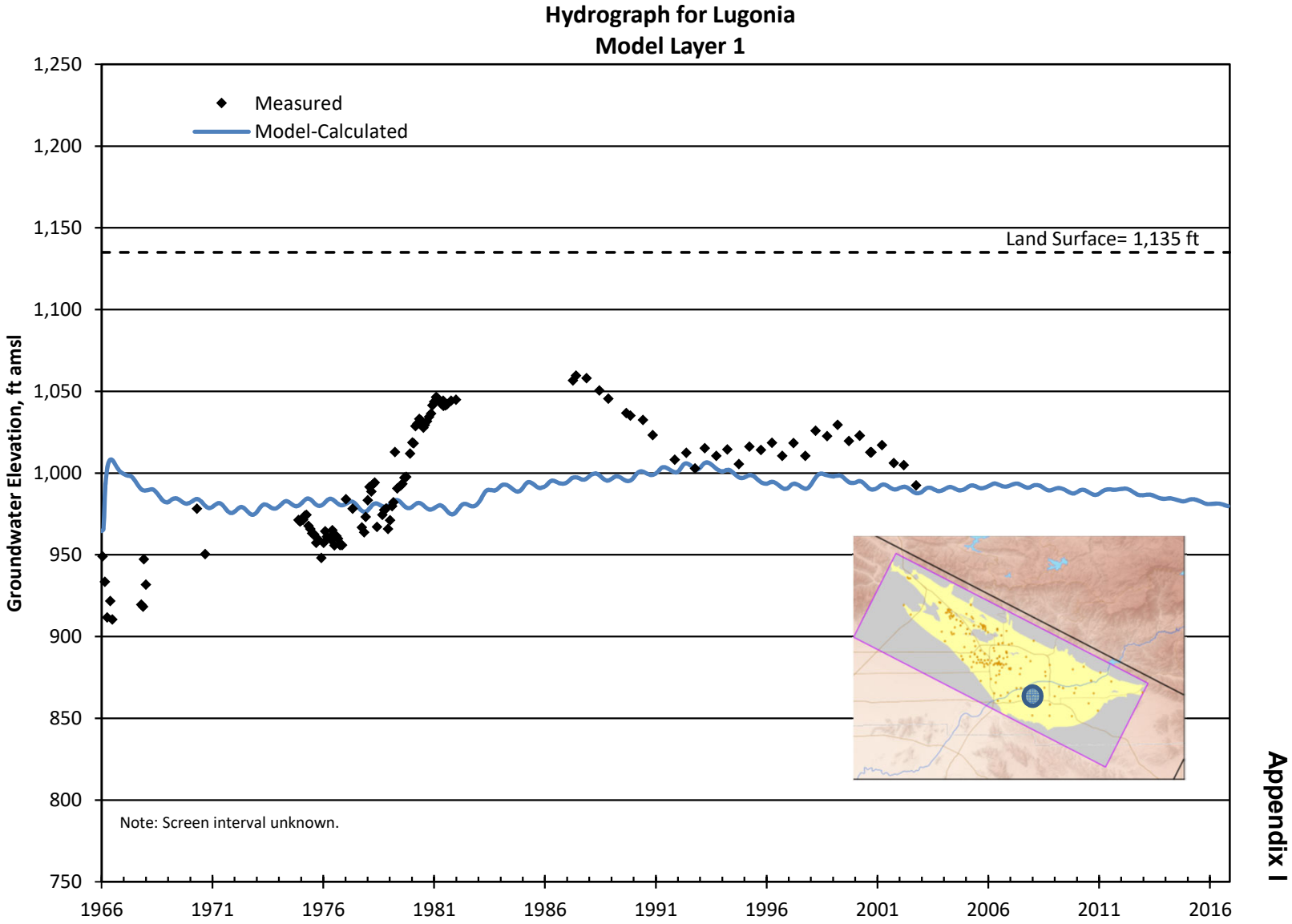
Appendix I


Hydrograph for Local_No_2
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,087 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

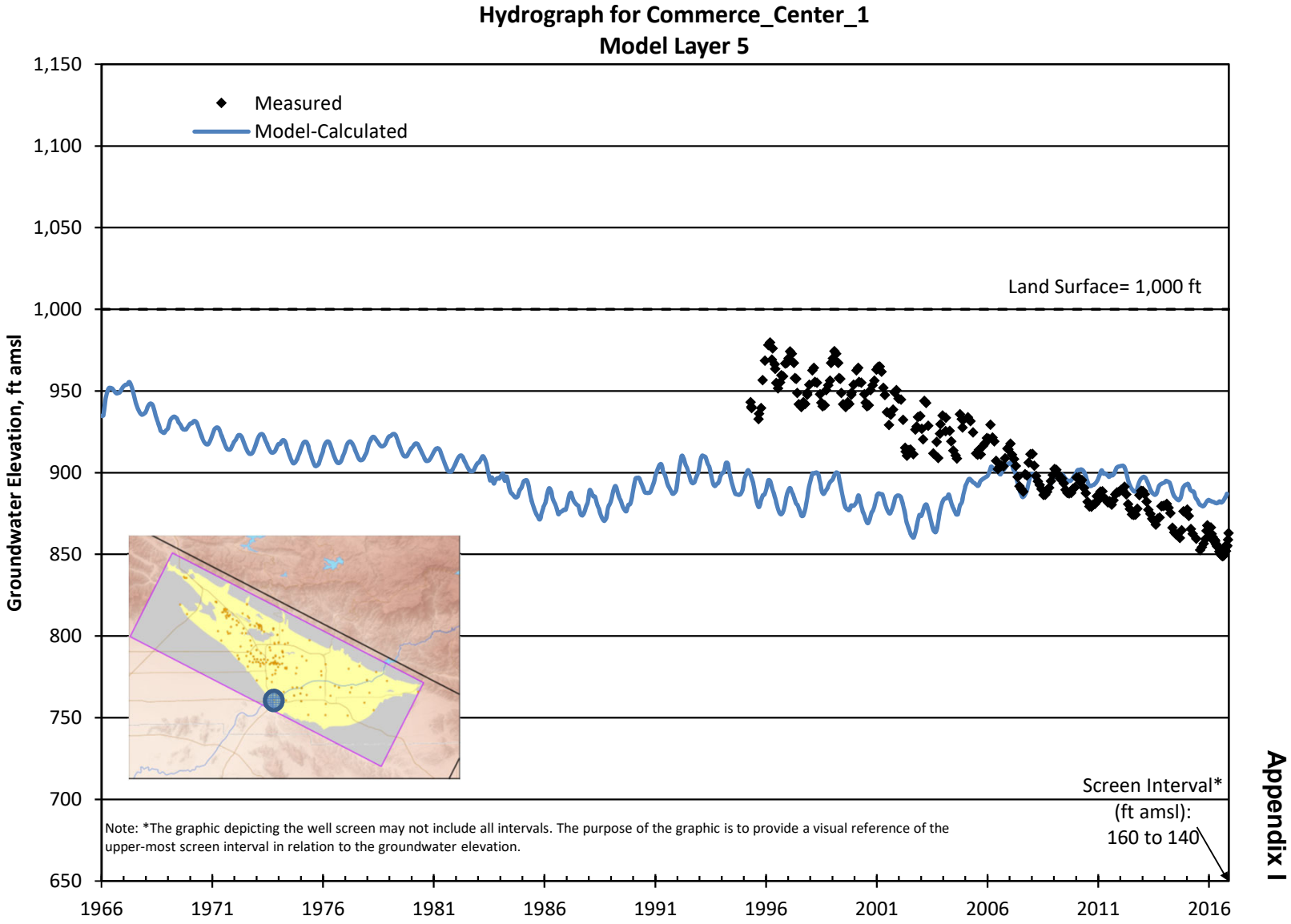
Appendix I


Hydrograph for 140501
Model Layer 2
Land Surface= 1,852 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,617 to 1,571
1,571 to 1,362
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

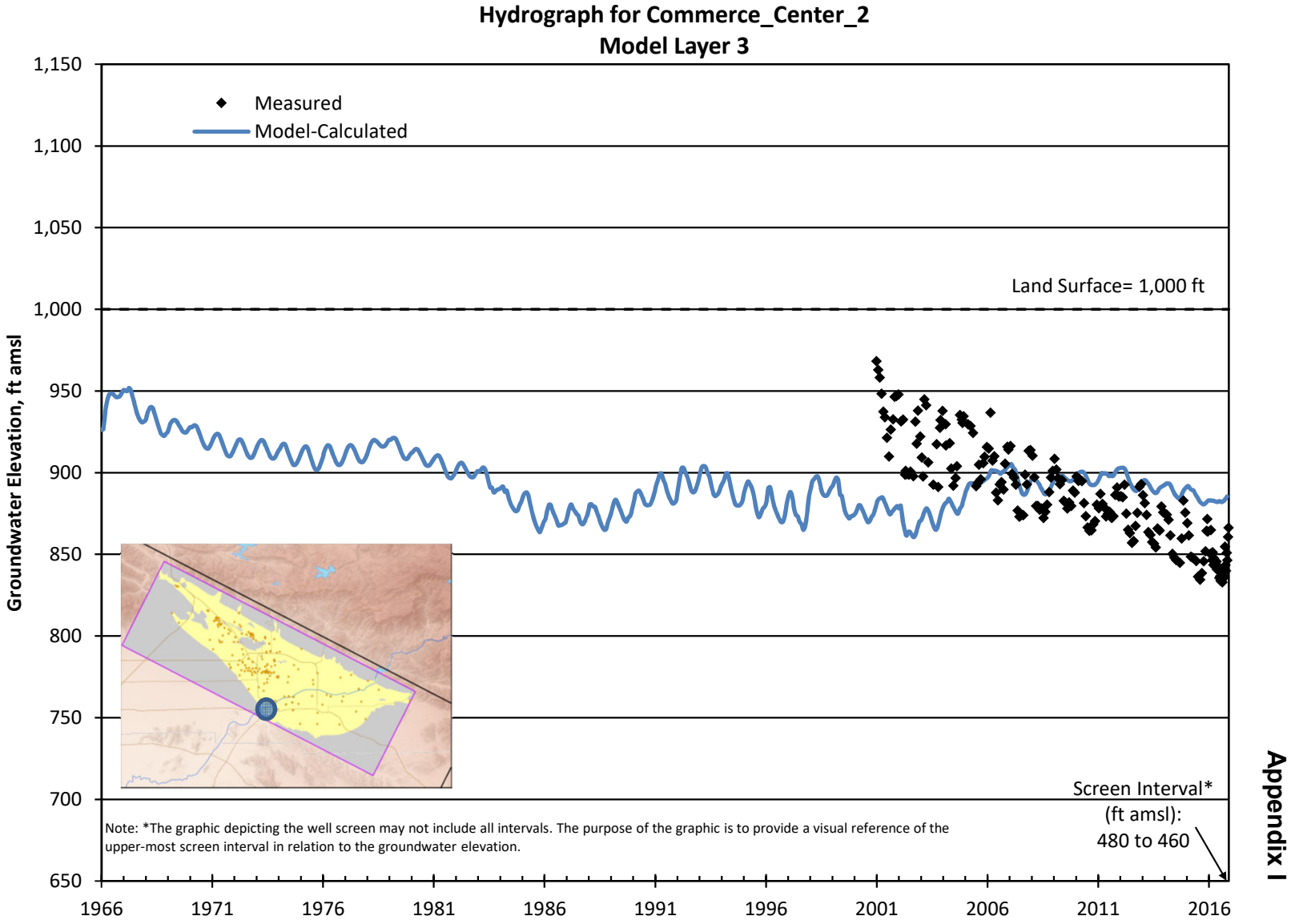
Appendix I


Hydrograph for Lugonia
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,135 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

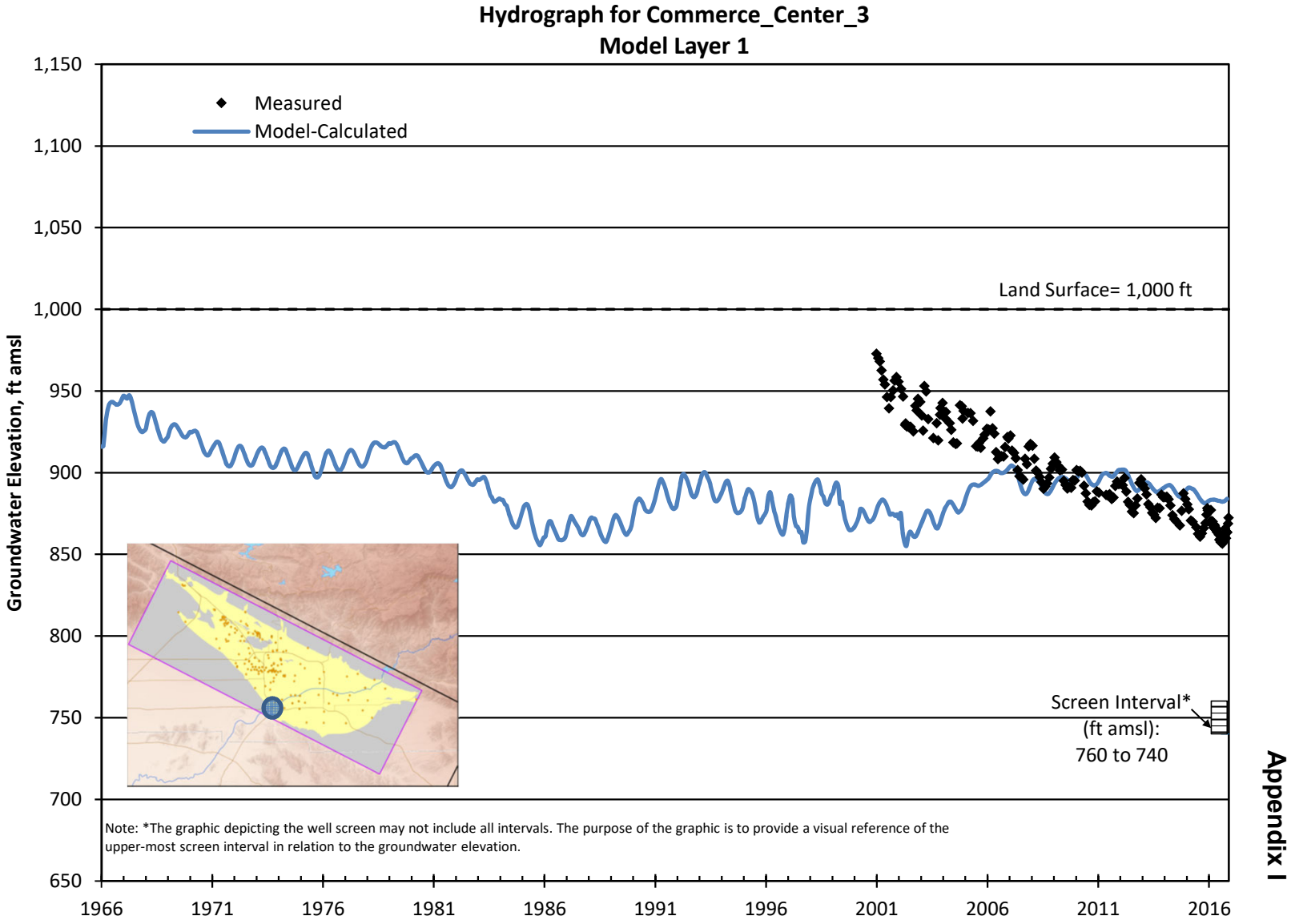
Appendix I


Hydrograph for Commerce_Center_1
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,000 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
160 to 140
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

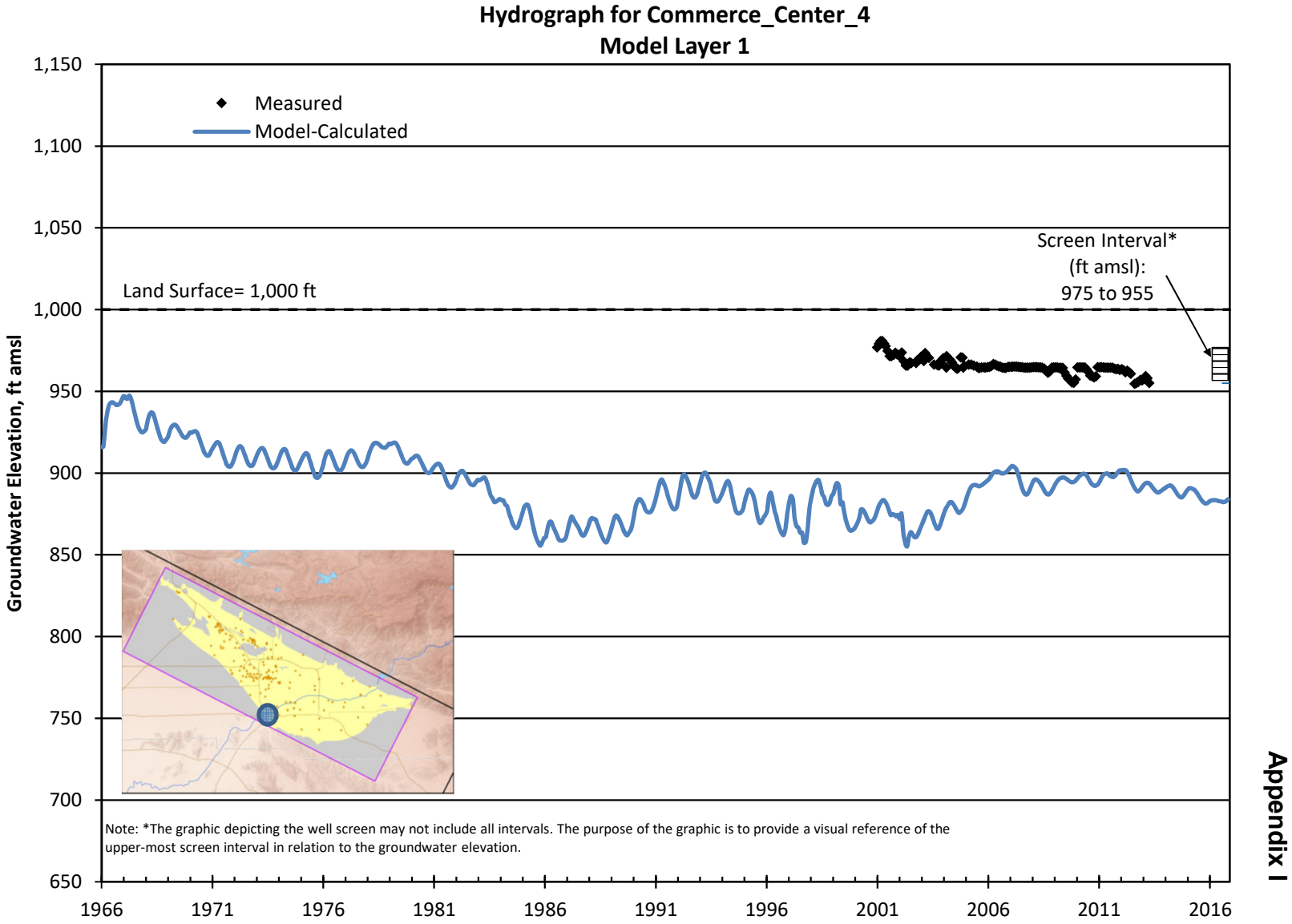
Appendix I


Hydrograph for Commerce_Center_2
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,000 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
480 to 460
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

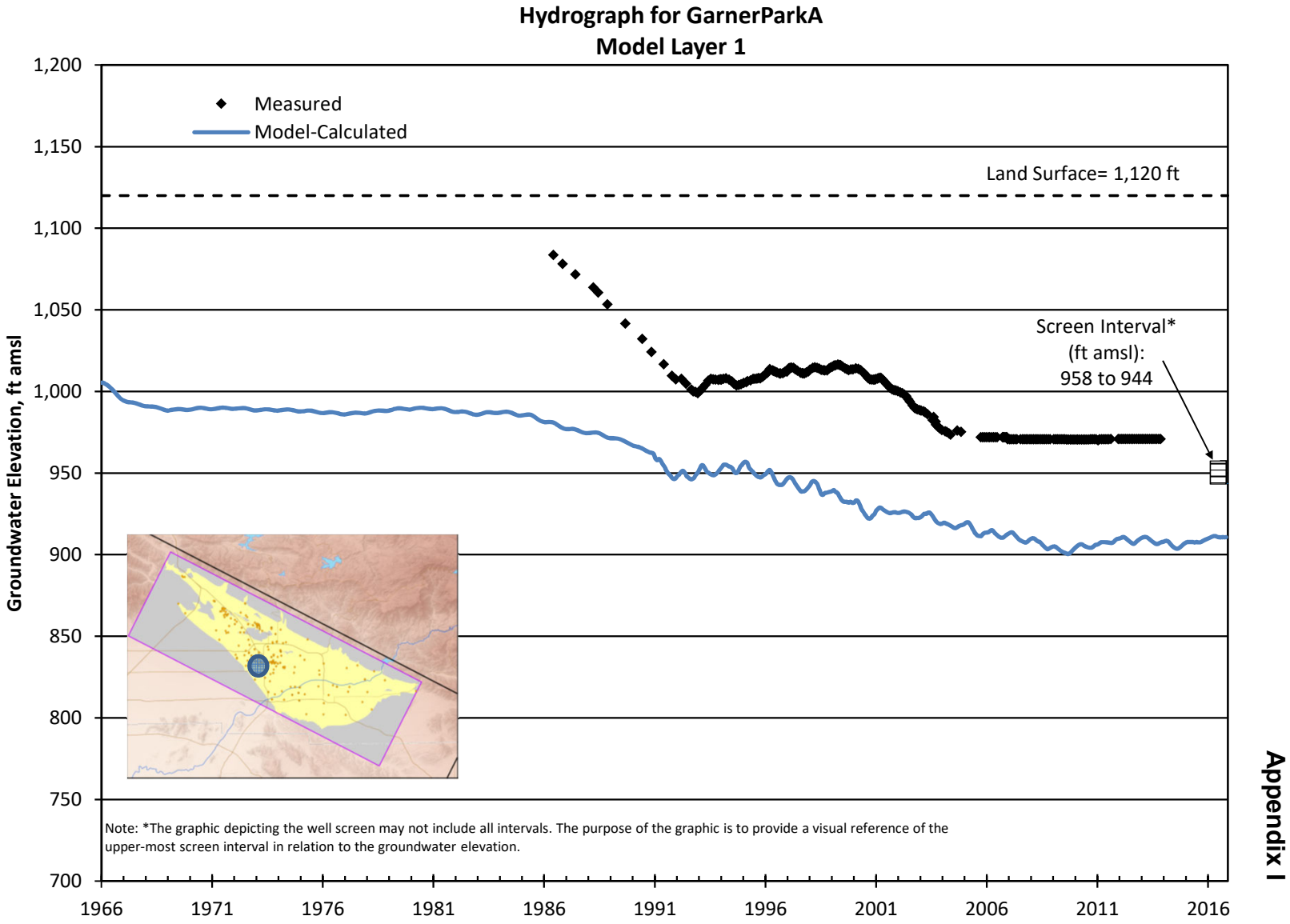
Appendix I


Hydrograph for Commerce_Center_3
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,000 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
760 to 740
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

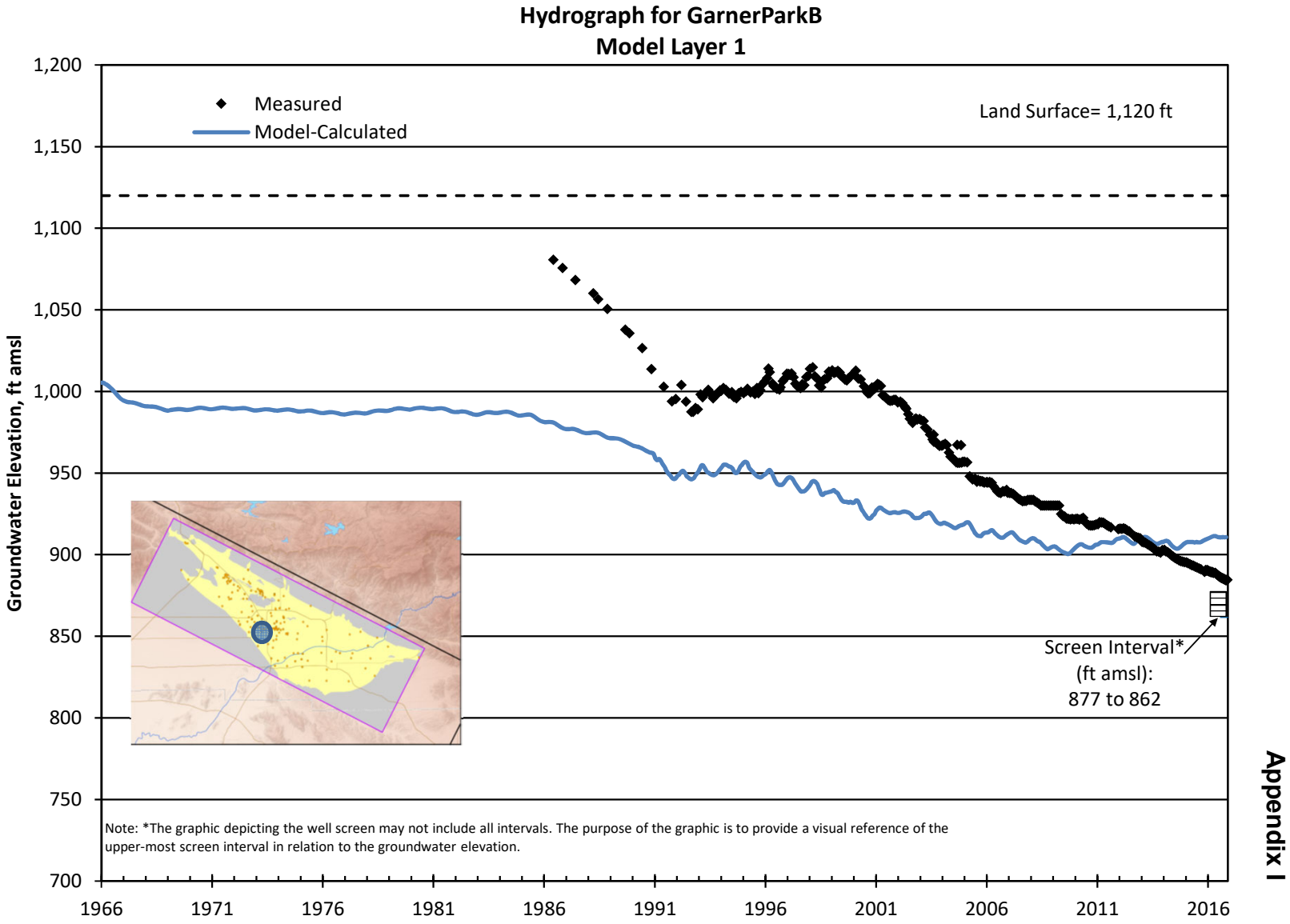
Appendix I


Hydrograph for Commerce_Center_4
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,000 ft
Screen Interval*
(ft amsl):
975 to 955
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

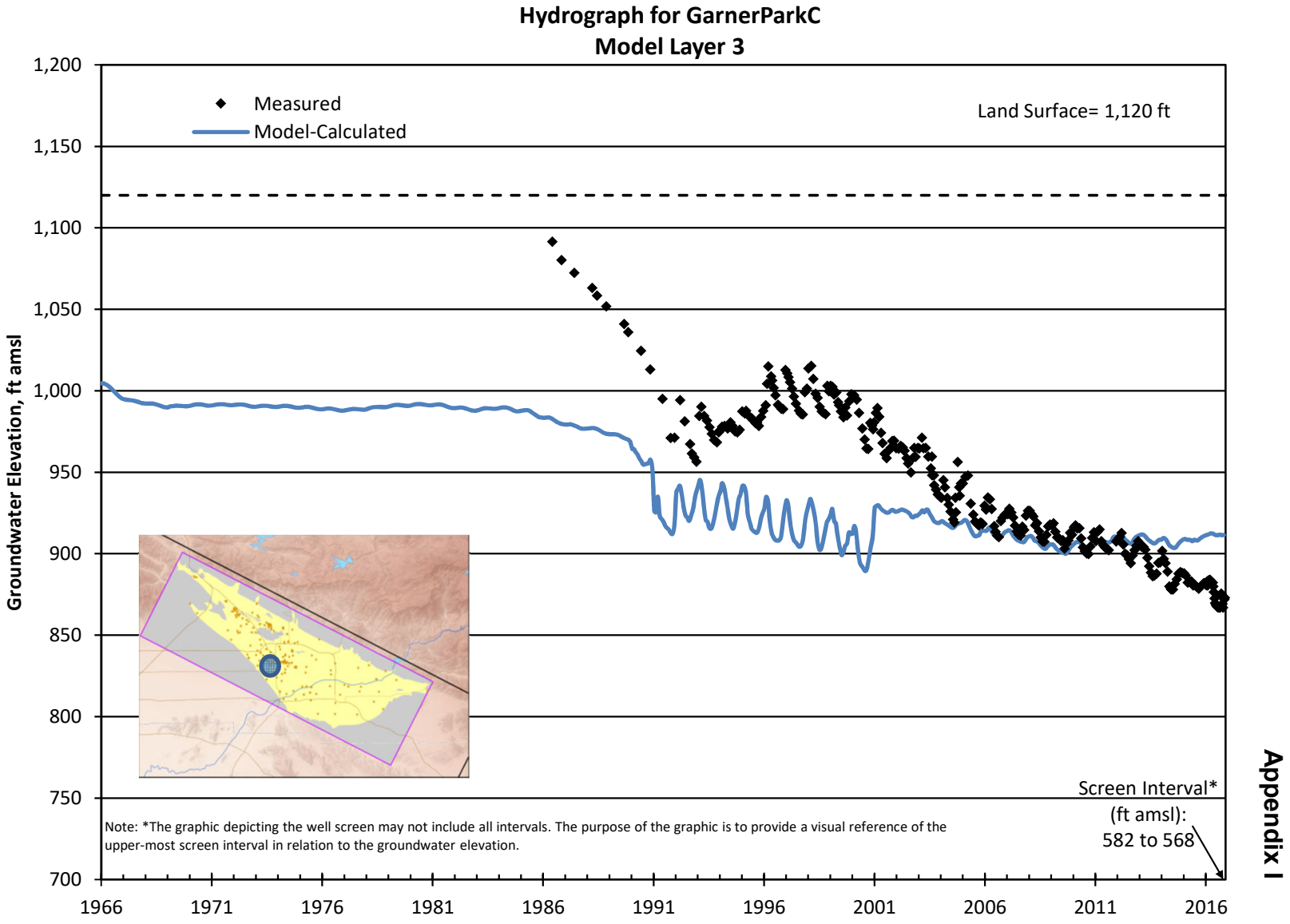
Appendix I


Hydrograph for GarnerParkA
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,120 ft
Screen Interval*
(ft amsl):
958 to 944
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

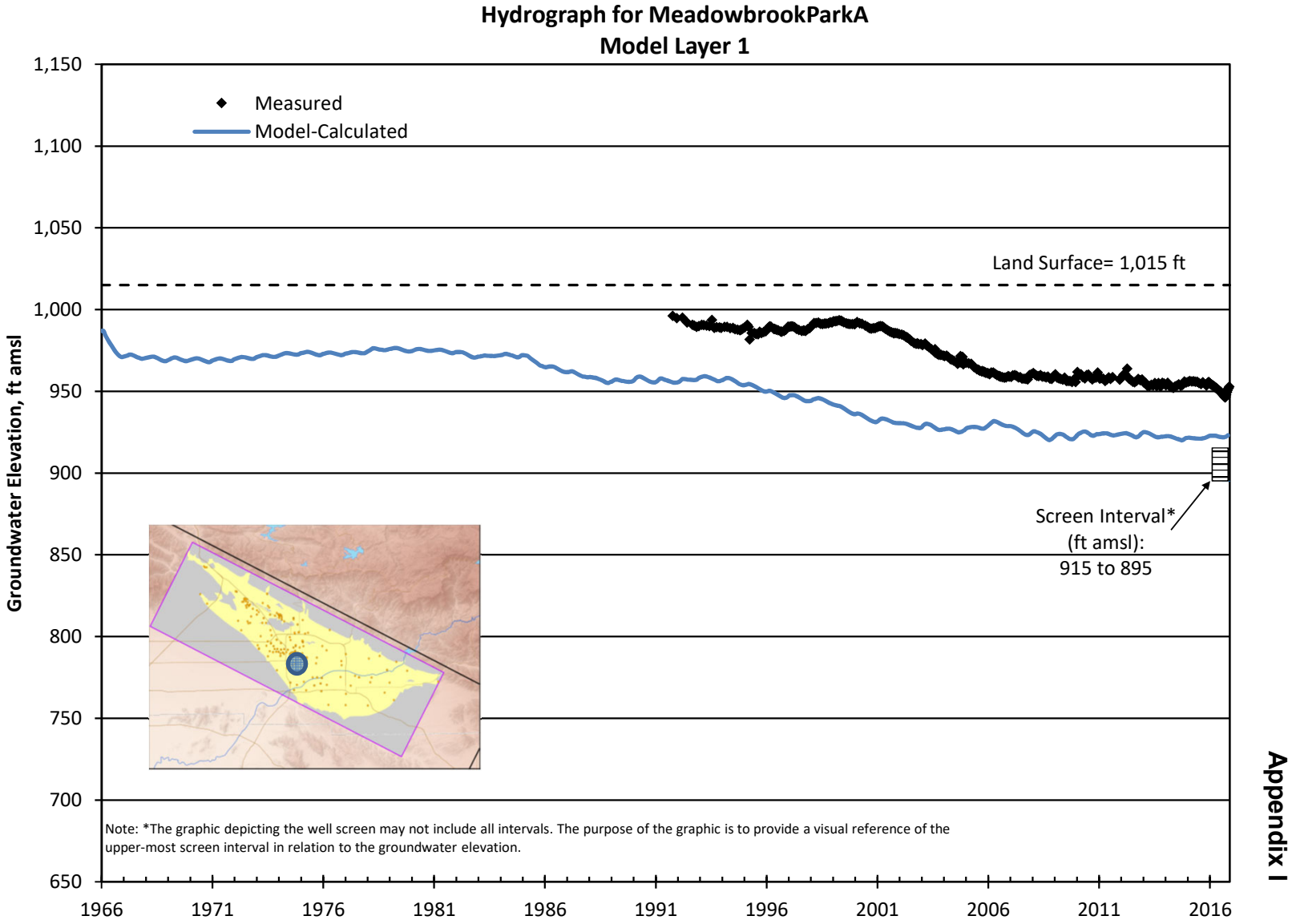
Appendix I


Hydrograph for GarnerParkB
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,120 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
877 to 862
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

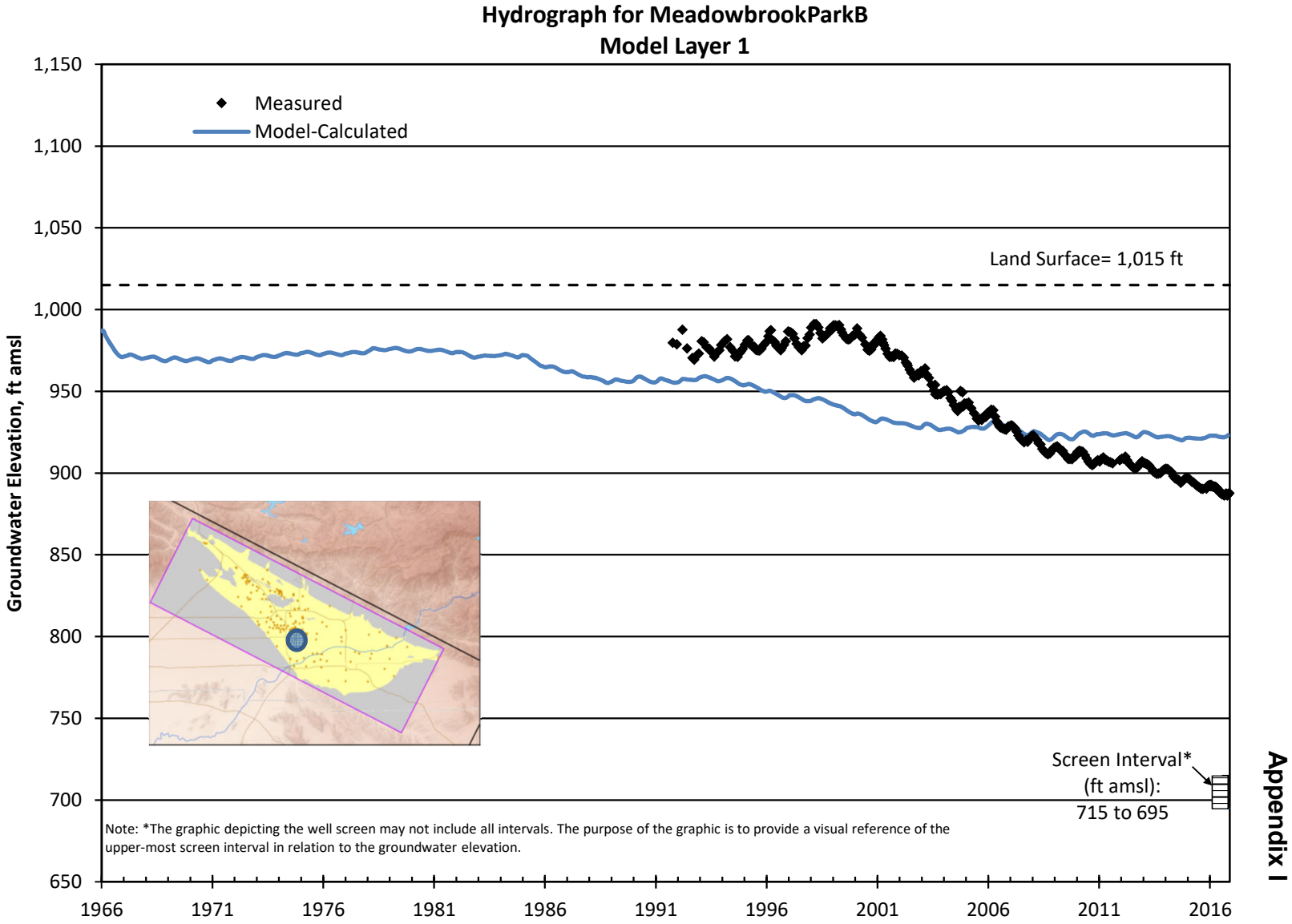
Appendix I


Hydrograph for GarnerParkC
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,120 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
582 to 568
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

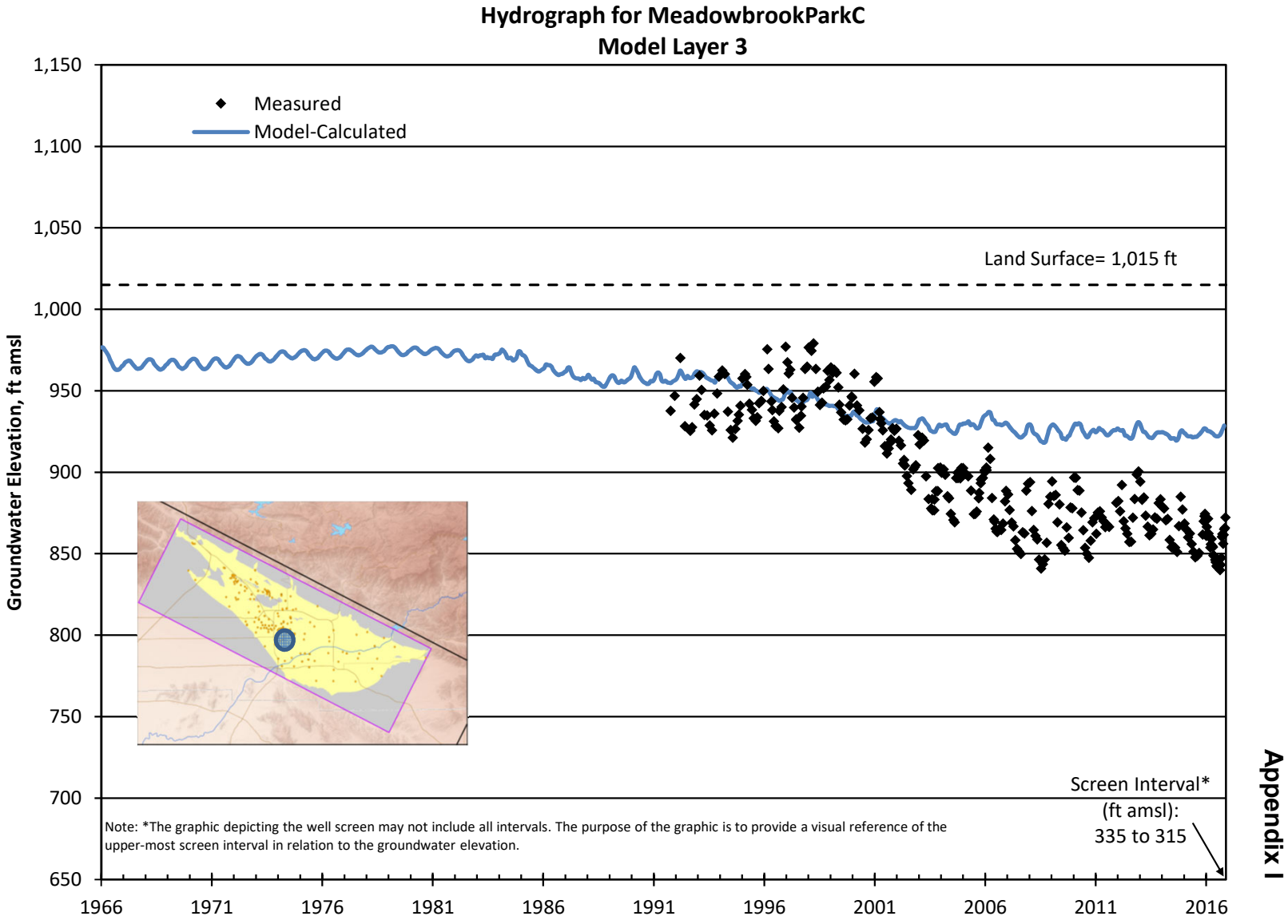
Appendix I


Hydrograph for MeadowbrookParkA
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,015 ft
Screen Interval*
(ft amsl):
915 to 895
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

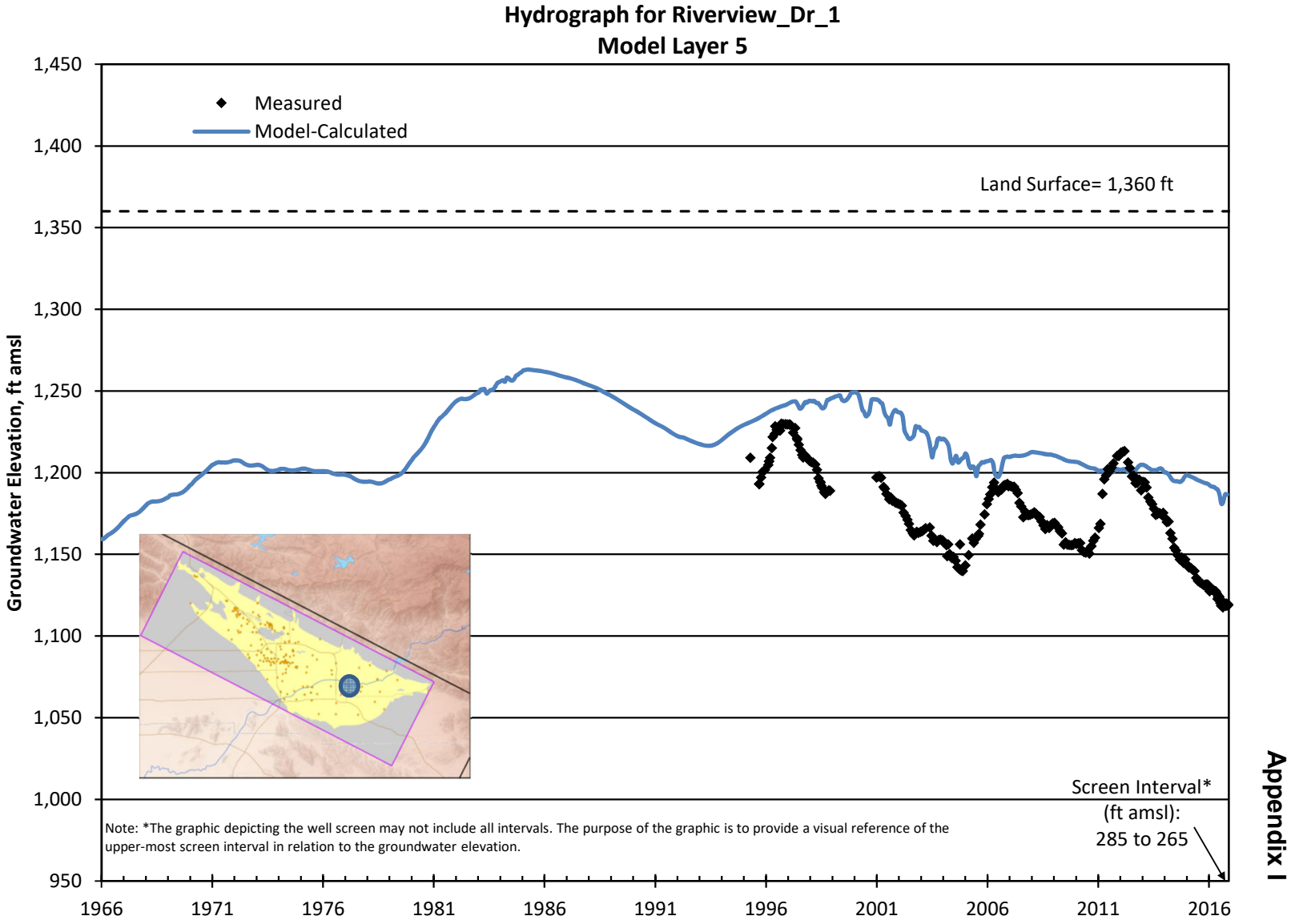
Appendix I


Hydrograph for MeadowbrookParkB
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,015 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
715 to 695
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

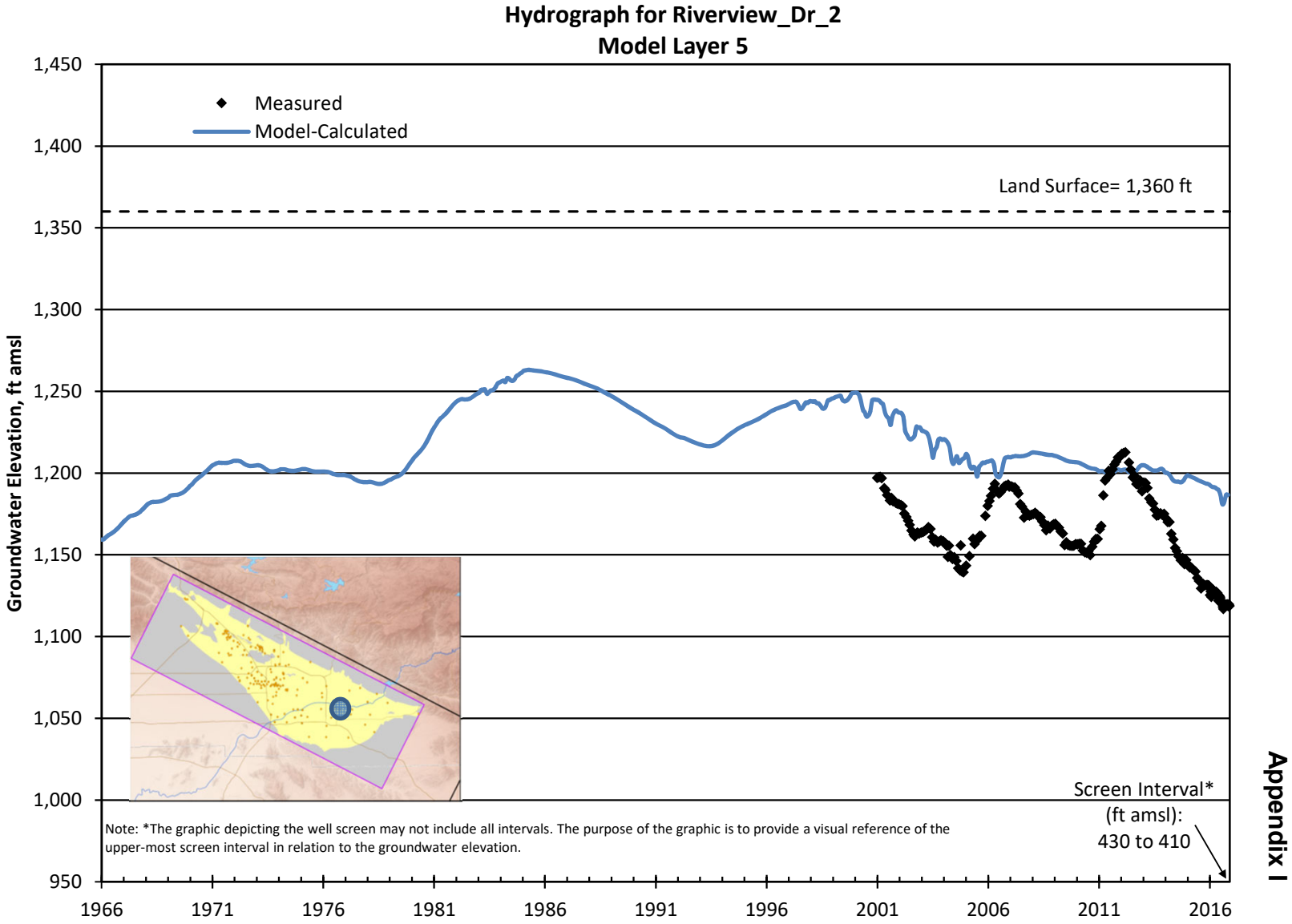
Appendix I


Hydrograph for MeadowbrookParkC
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,015 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
335 to 315
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

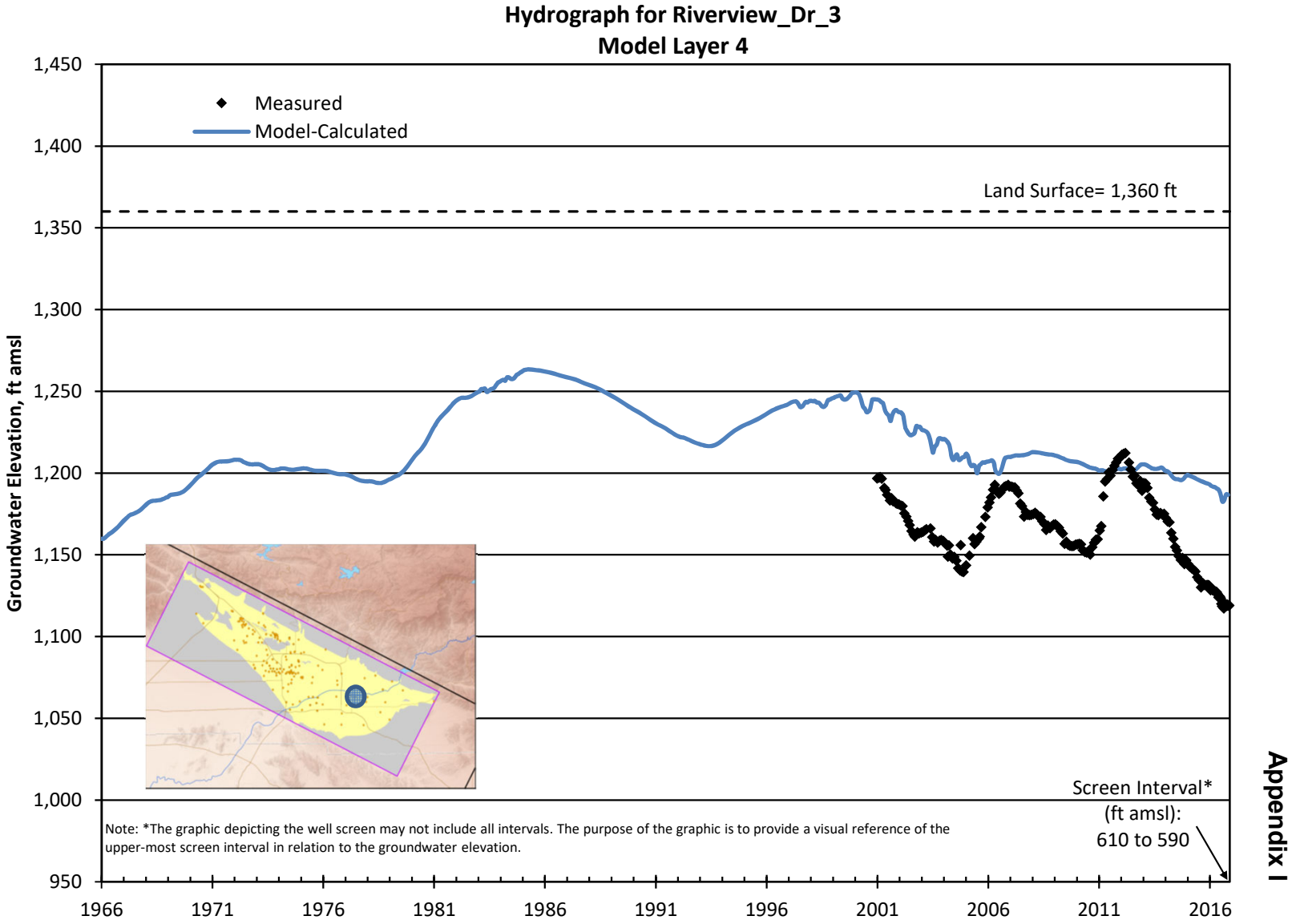
Appendix I


Hydrograph for Riverview_Dr_1
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,360 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
285 to 265
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

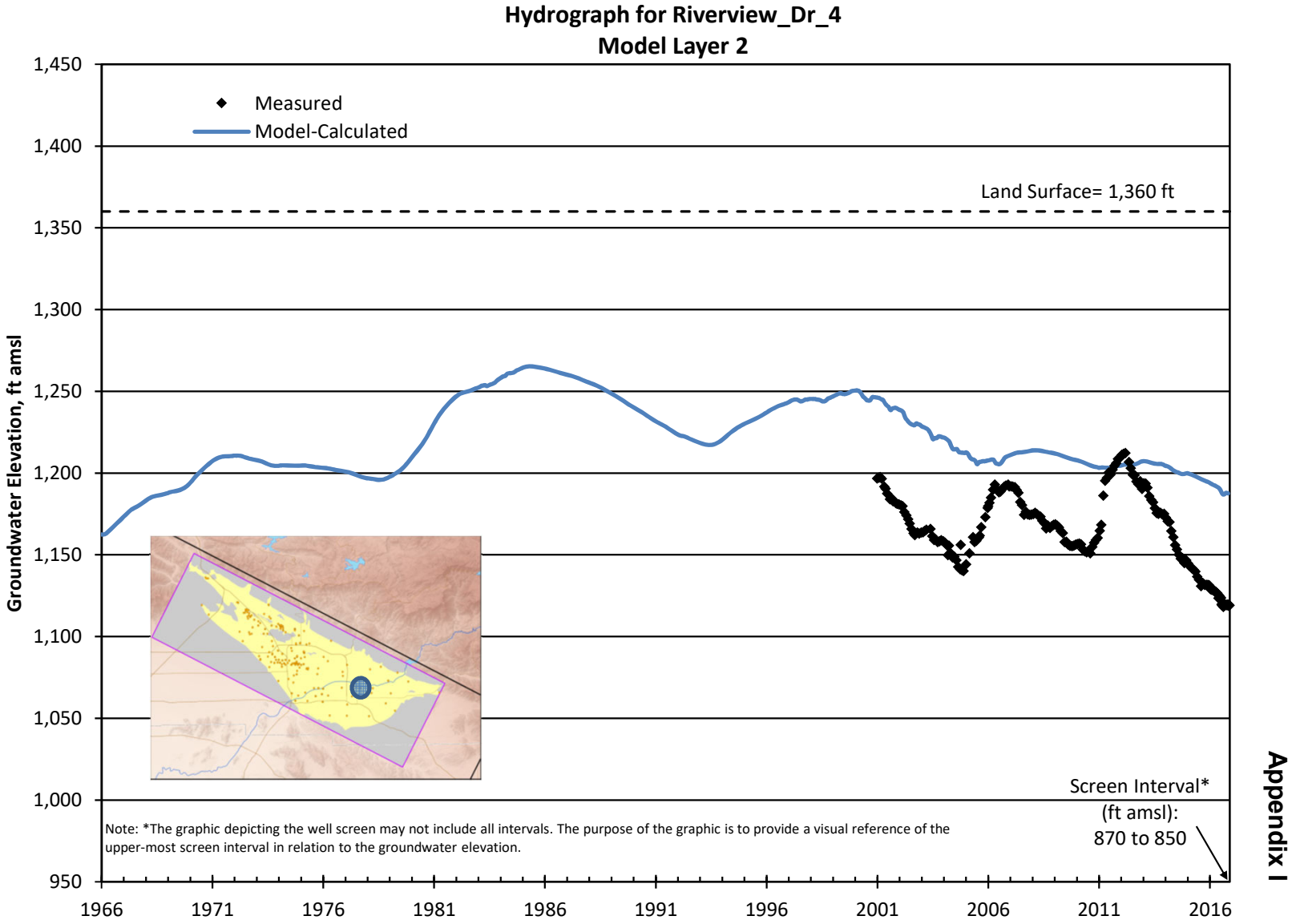
Appendix I


Hydrograph for Riverview_Dr_2
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,360 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Screen Interval*
(ft amsl):
430 to 410

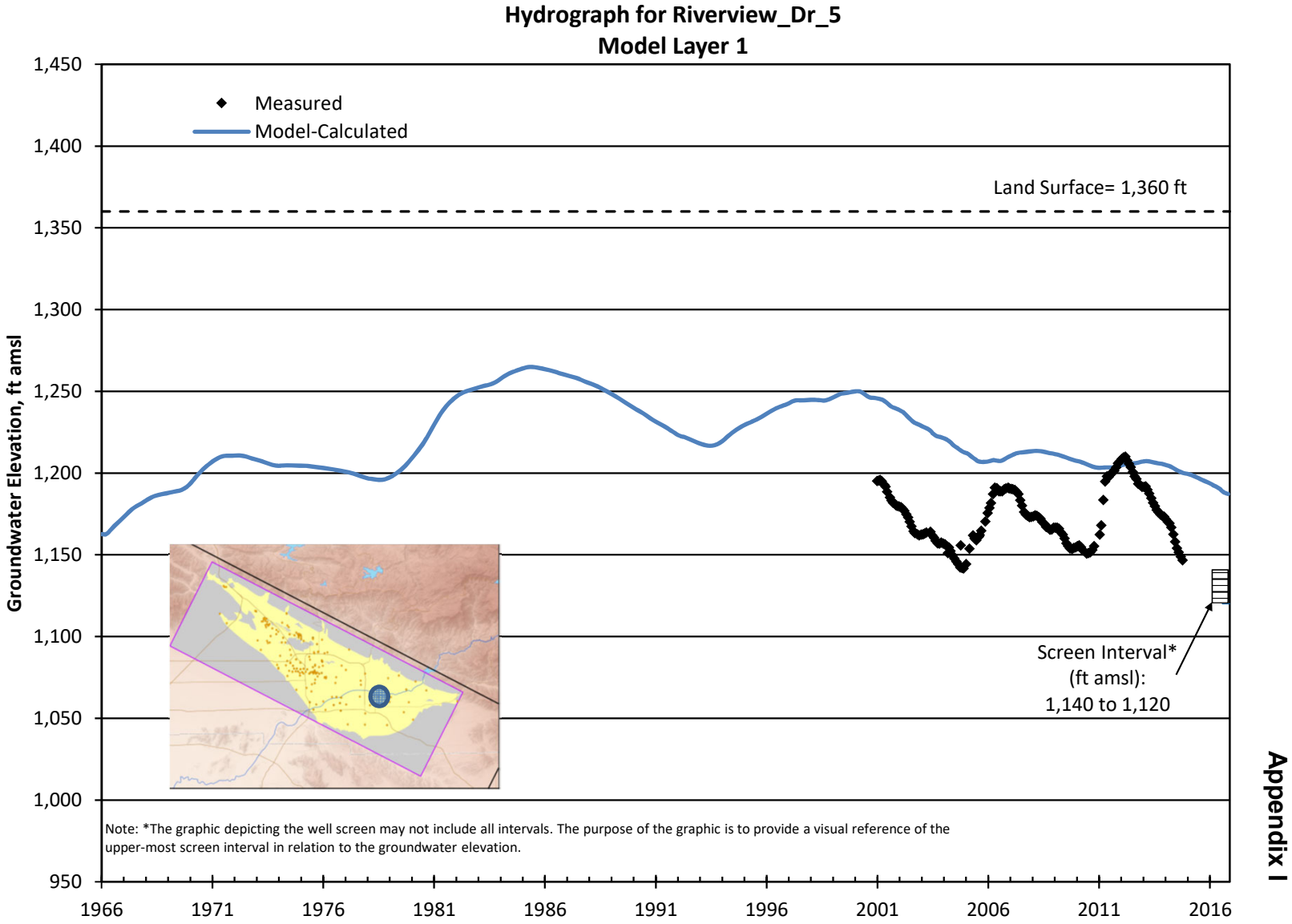
Appendix I


Hydrograph for Riverview_Dr_3
Model Layer 4
Measured
Model-Calculated
Land Surface= 1,360 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
610 to 590
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

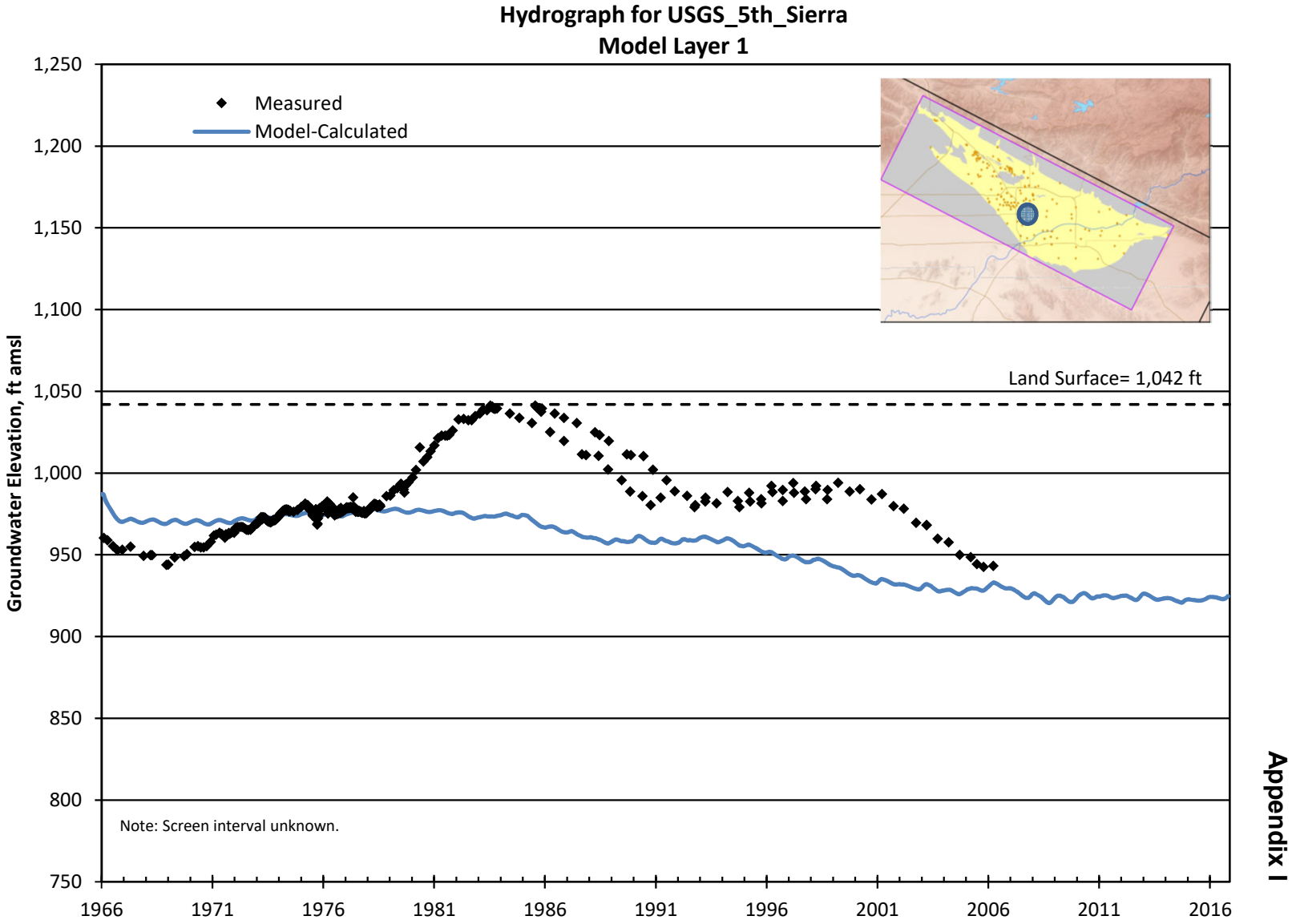
Appendix I


Hydrograph for Riverview_Dr_4
Model Layer 2
Measured
Model-Calculated
Land Surface= 1,360 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
870 to 850
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

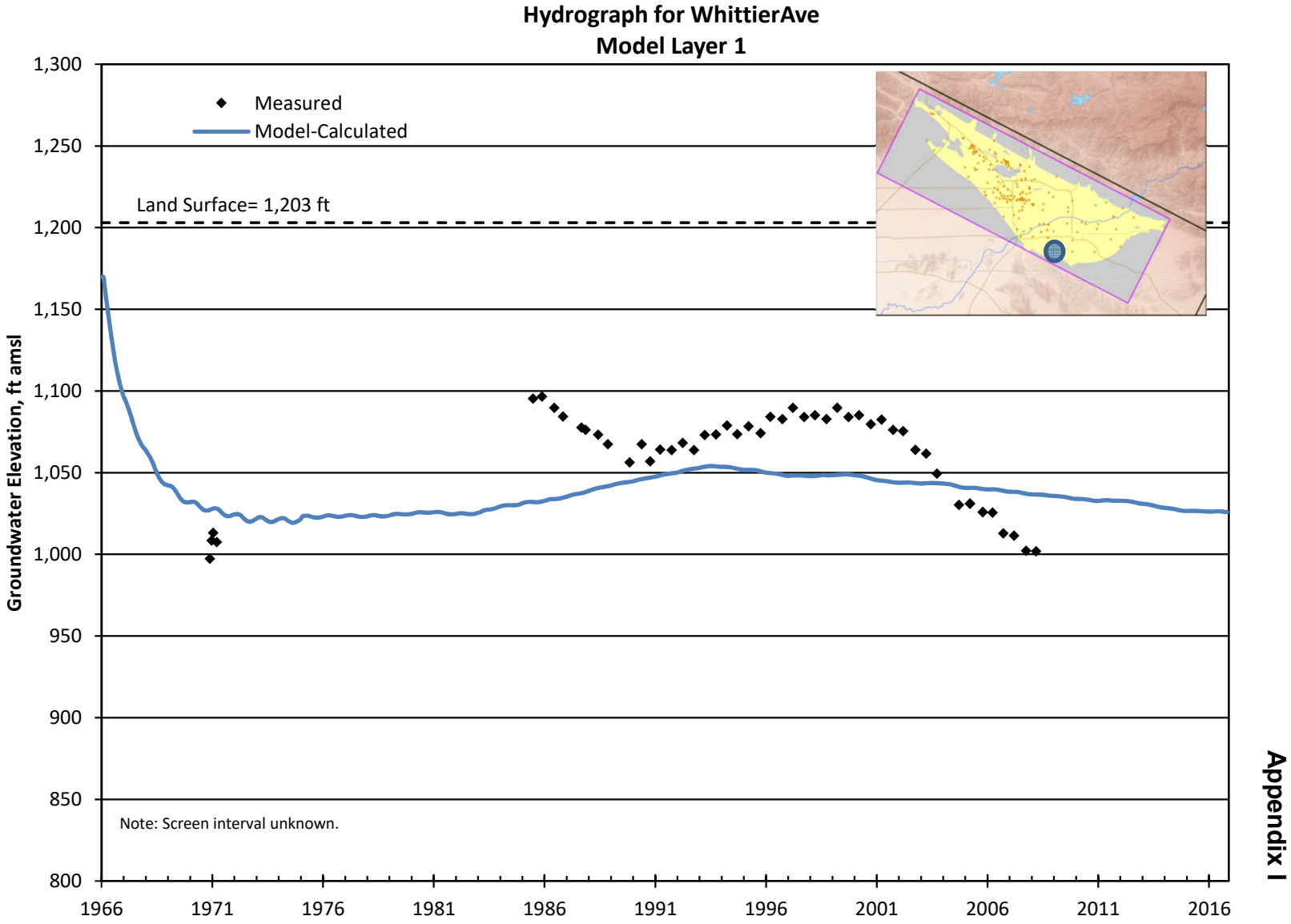
Appendix I


Hydrograph for Riverview_Dr_5
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,360 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,140 to 1,120
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

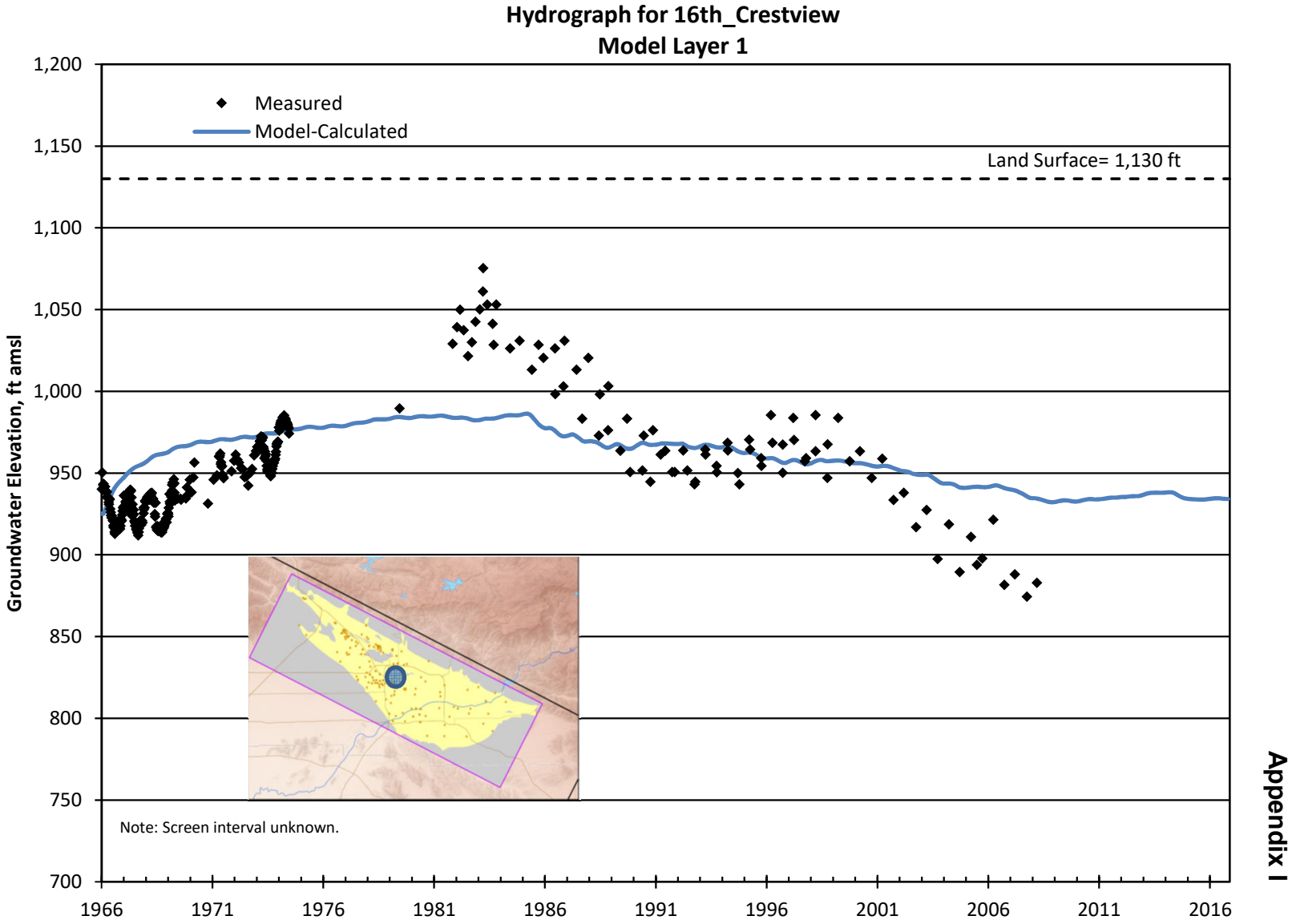
Appendix I


Hydrograph for USGS_5th_Sierra
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,042 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

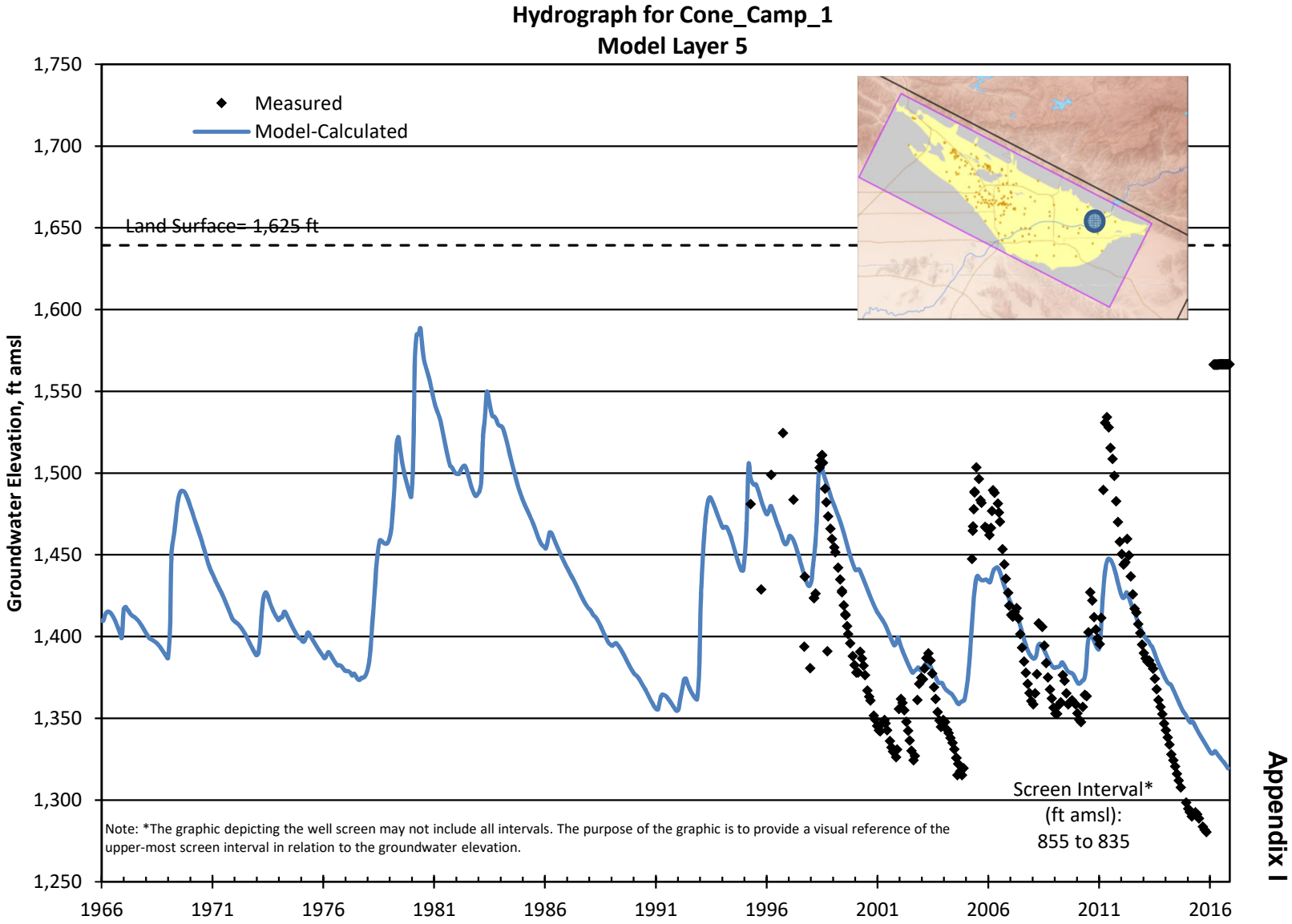
Appendix I


Hydrograph for WhittierAve
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,203 ft
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

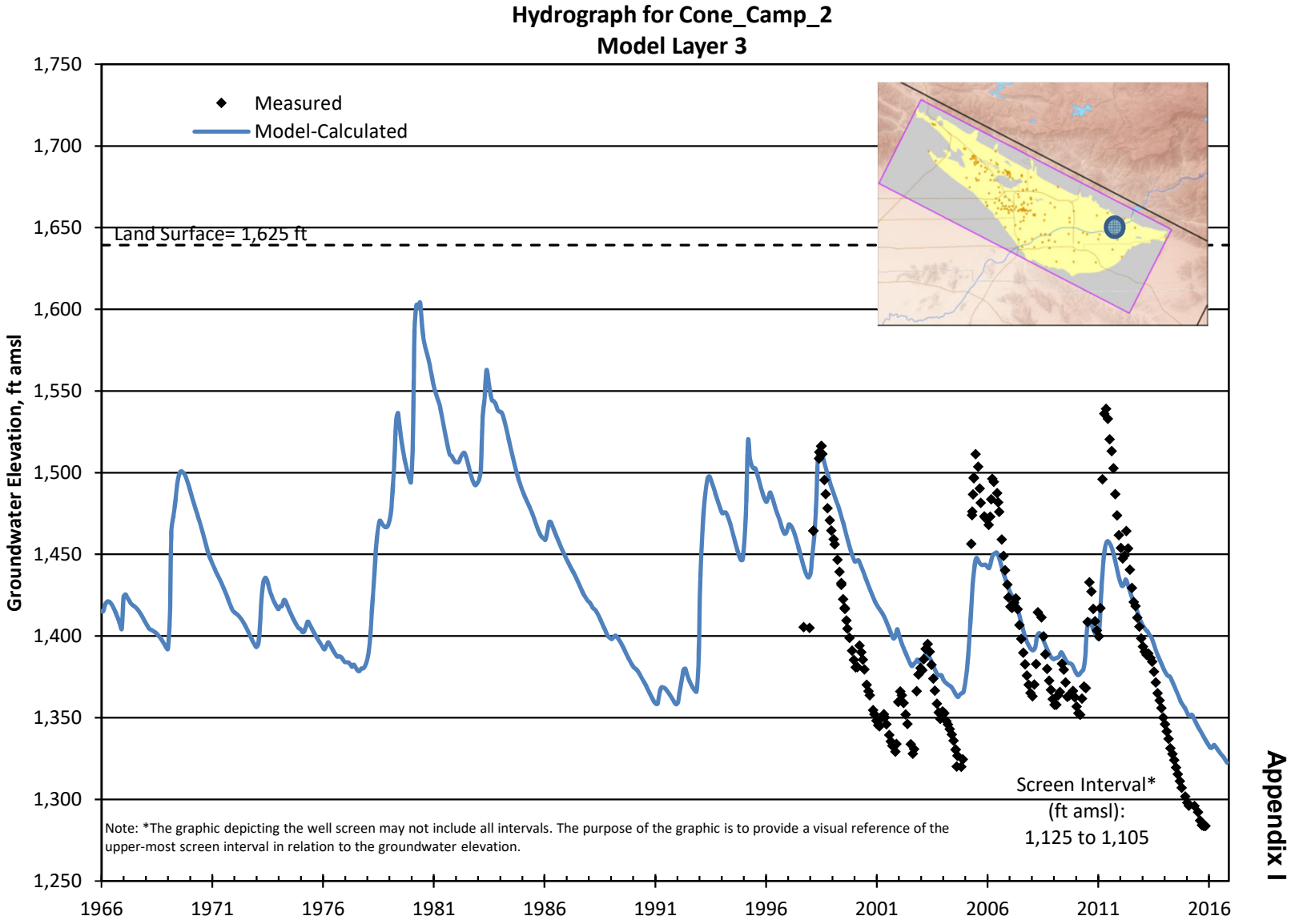
Appendix I


Hydrograph for 16th_Crestview
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,130 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

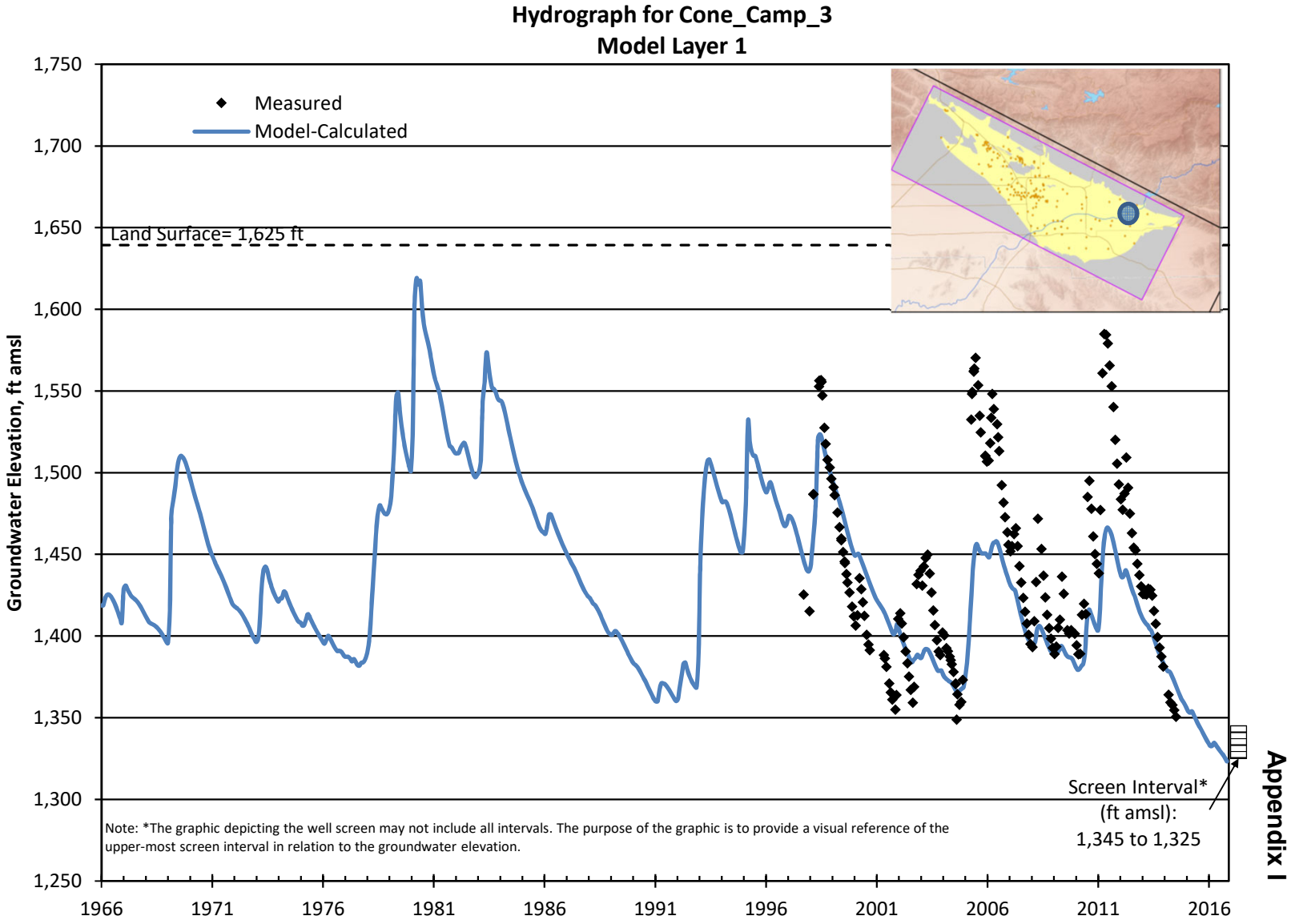
Appendix I


Hydrograph for Cone_Camp_1
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,625 ft
Groundwater Elevation, ft amsl
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
855 to 835
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

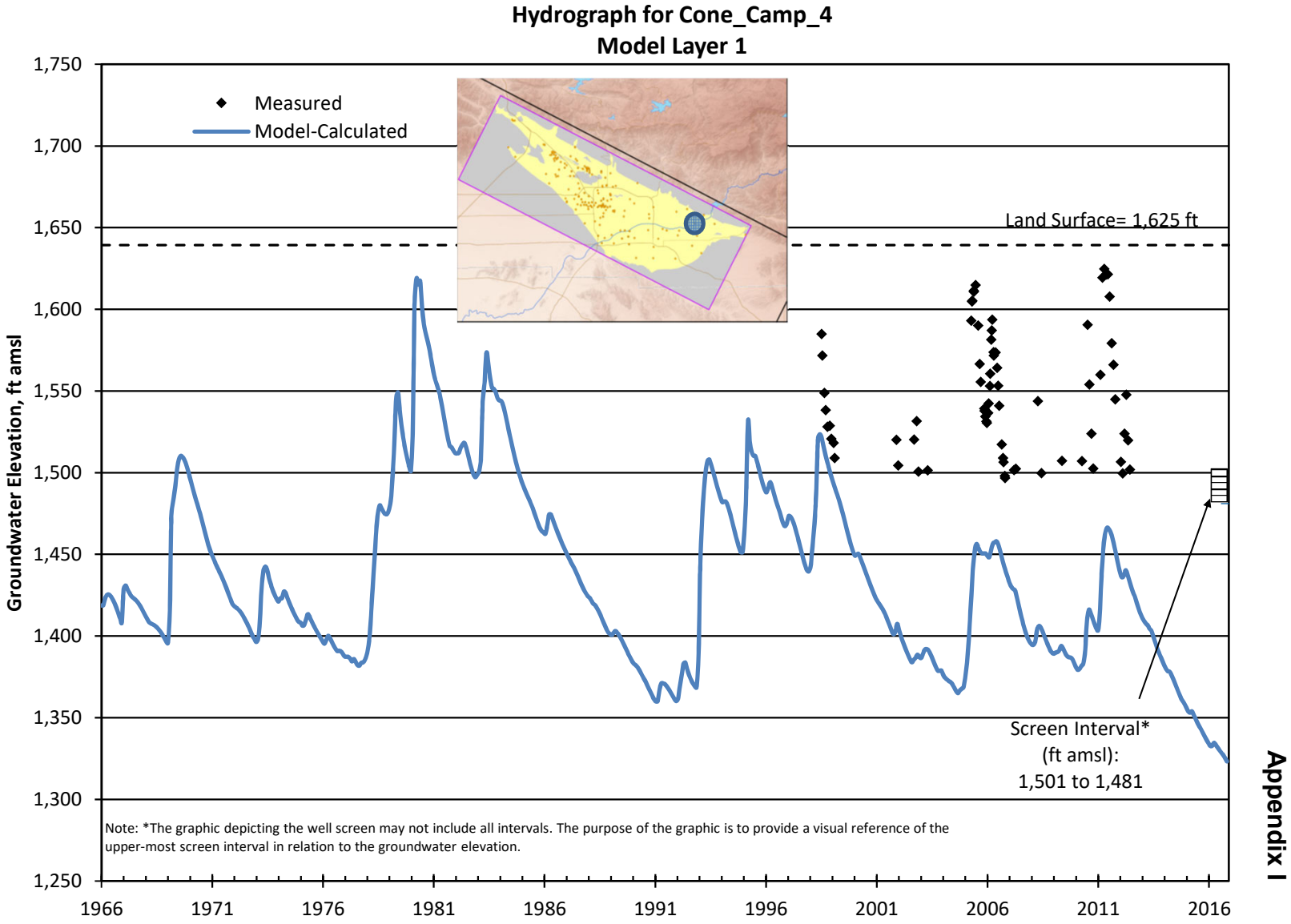
Appendix I


Hydrograph for Cone_Camp_2
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,625 ft
Groundwater Elevation, ft amsl
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,125 to 1,105
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

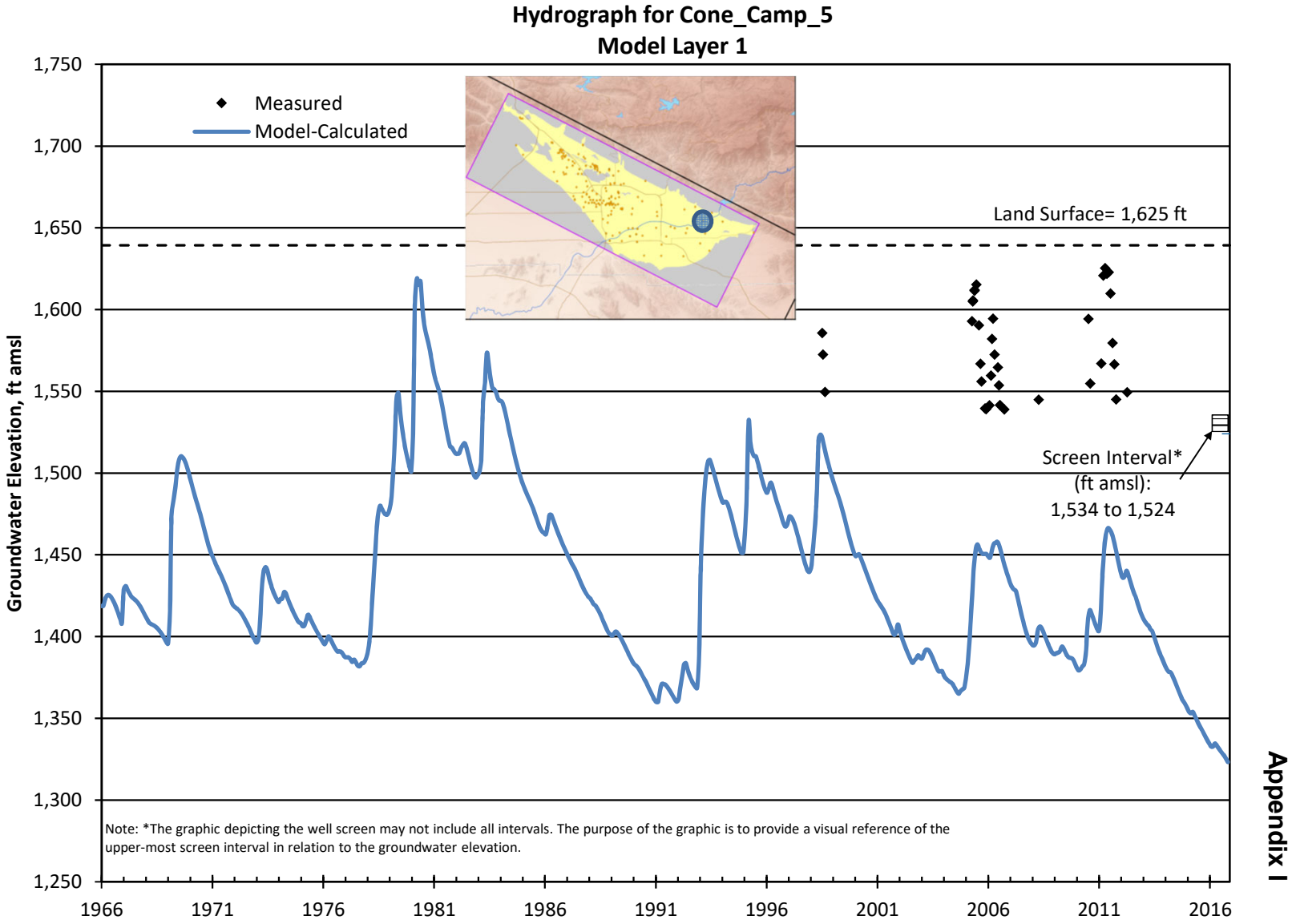
Appendix I


Hydrograph for Cone_Camp_3
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,625 ft
Groundwater Elevation, ft amsl
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,345 to 1,325
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

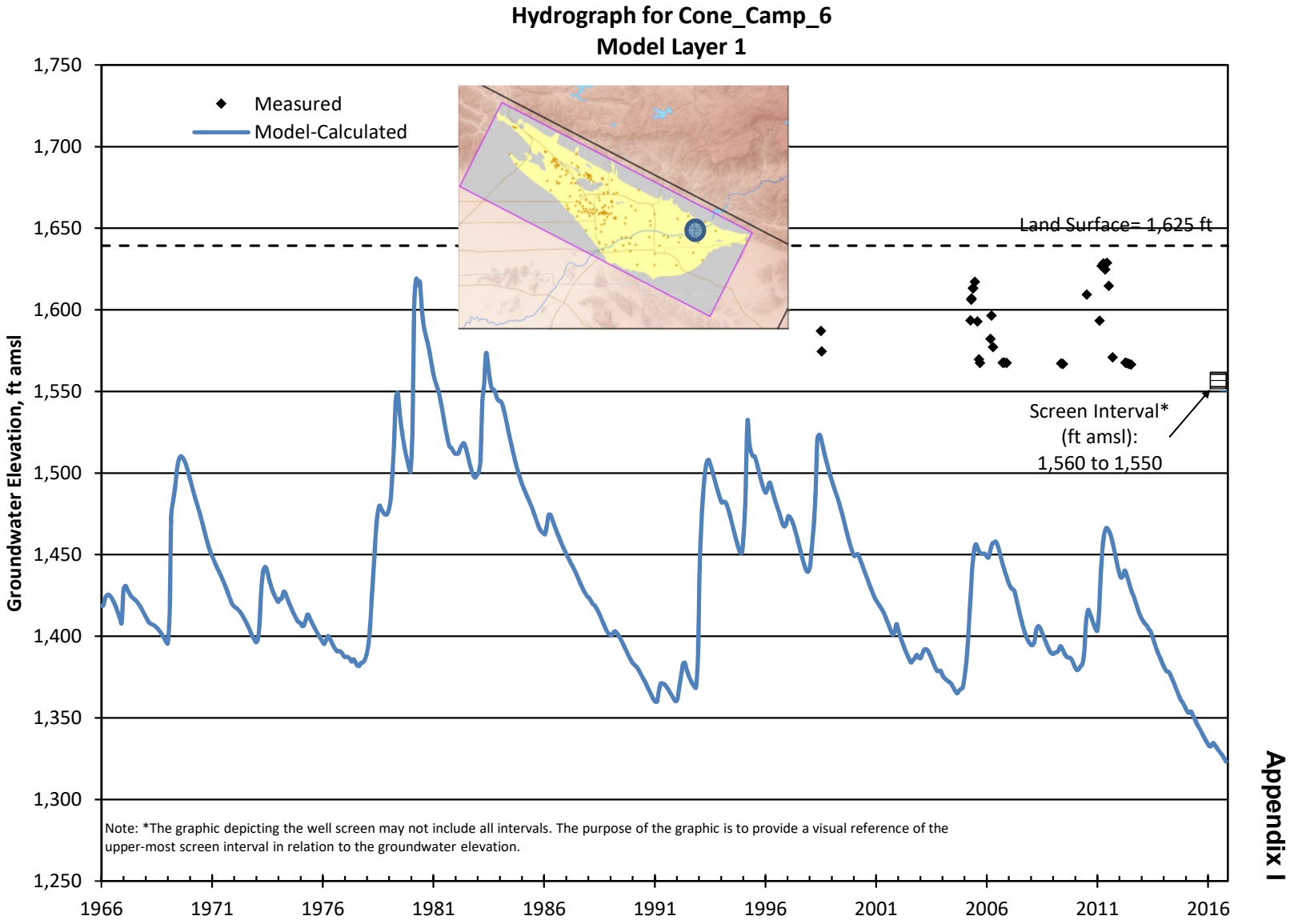
Appendix I


Hydrograph for Cone_Camp_4
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,625 ft
Groundwater Elevation, ft amsl
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,501 to 1,481
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

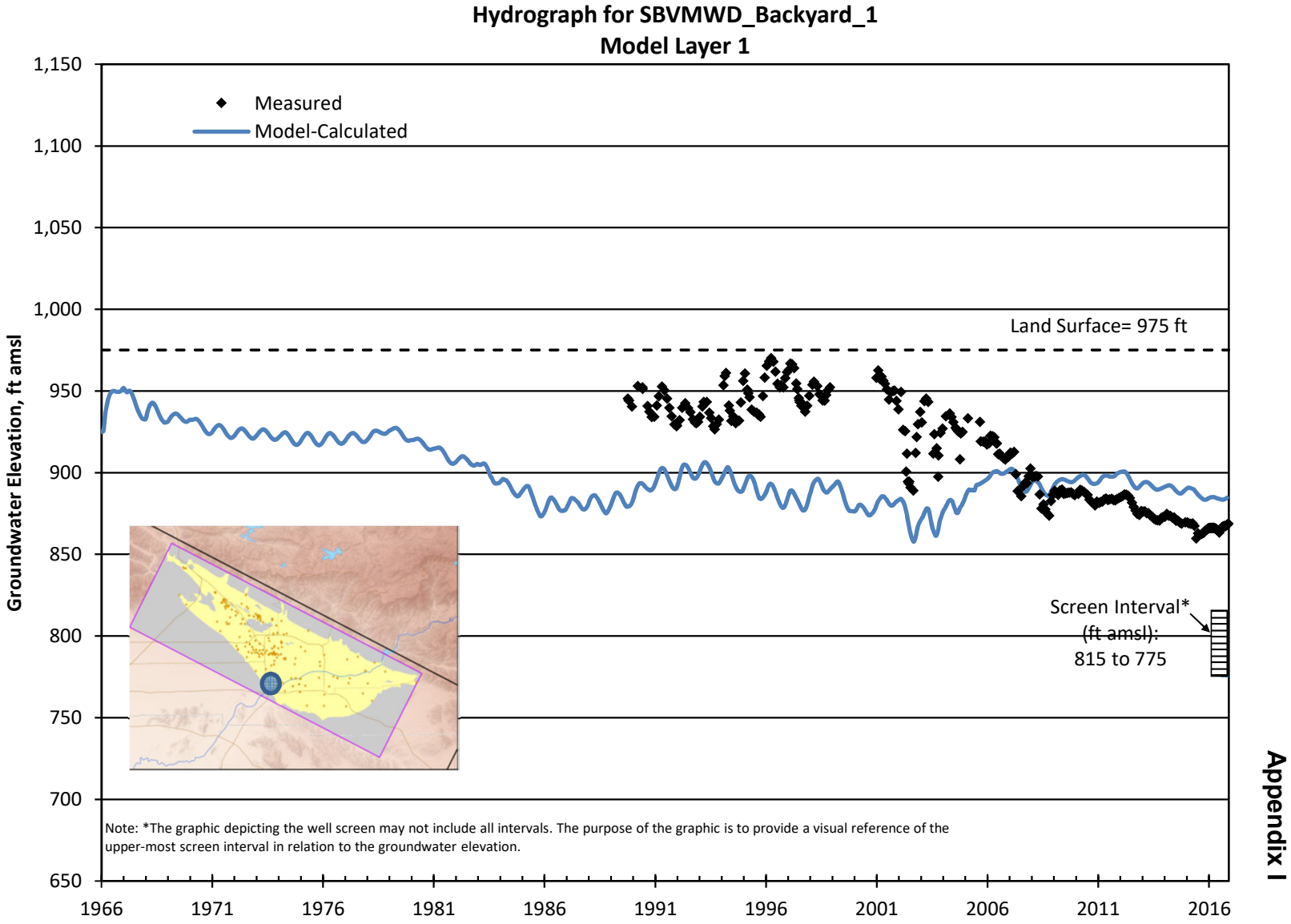
Appendix I


Hydrograph for Cone_Camp_5
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,625 ft
Screen Interval*
(ft amsl):
1,534 to 1,524
Groundwater Elevation, ft amsl
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

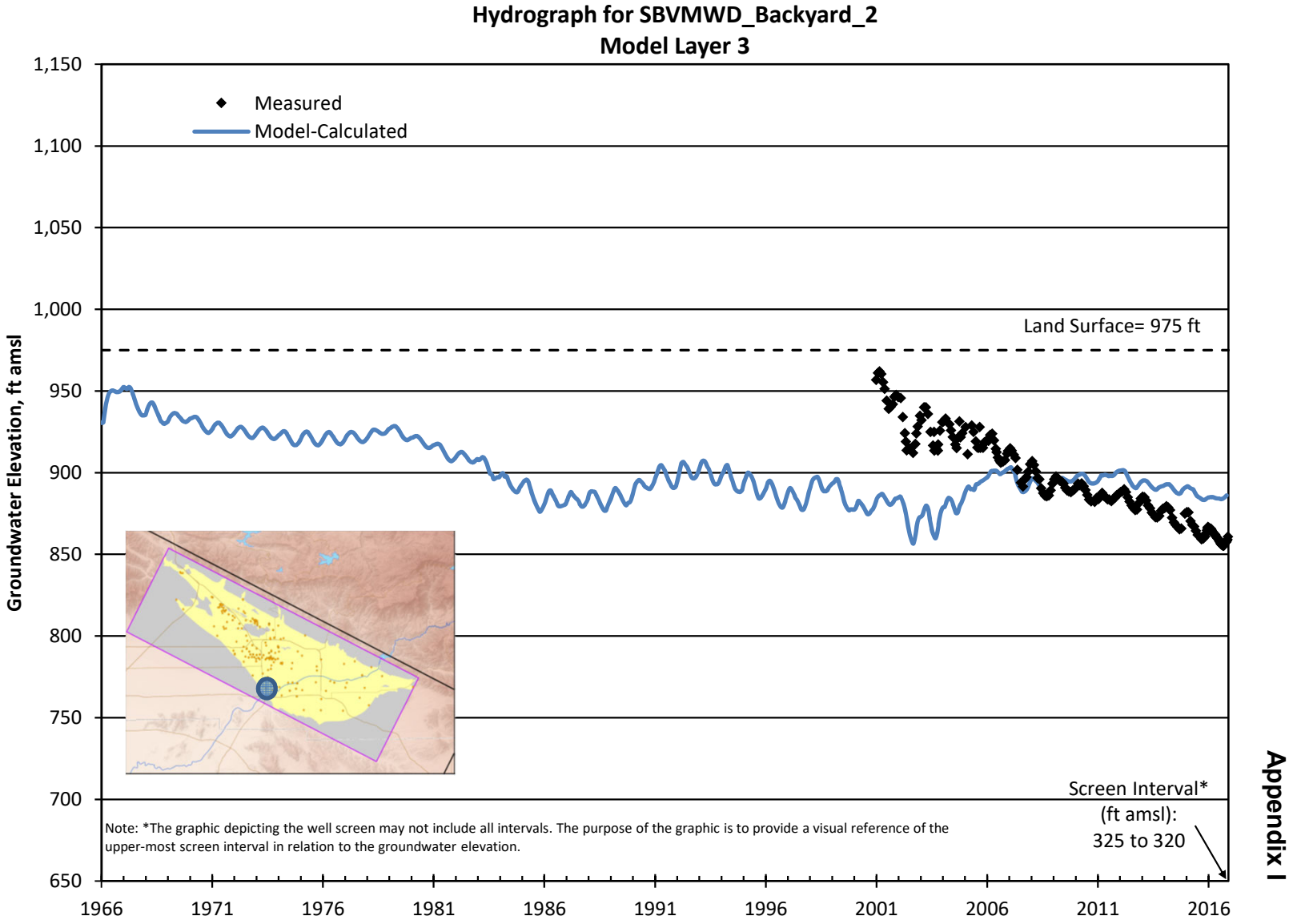
Appendix I


Hydrograph for Cone_Camp_6
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,625 ft
Screen Interval*
(ft amsl):
1,560 to 1,550
Groundwater Elevation, ft amsl
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

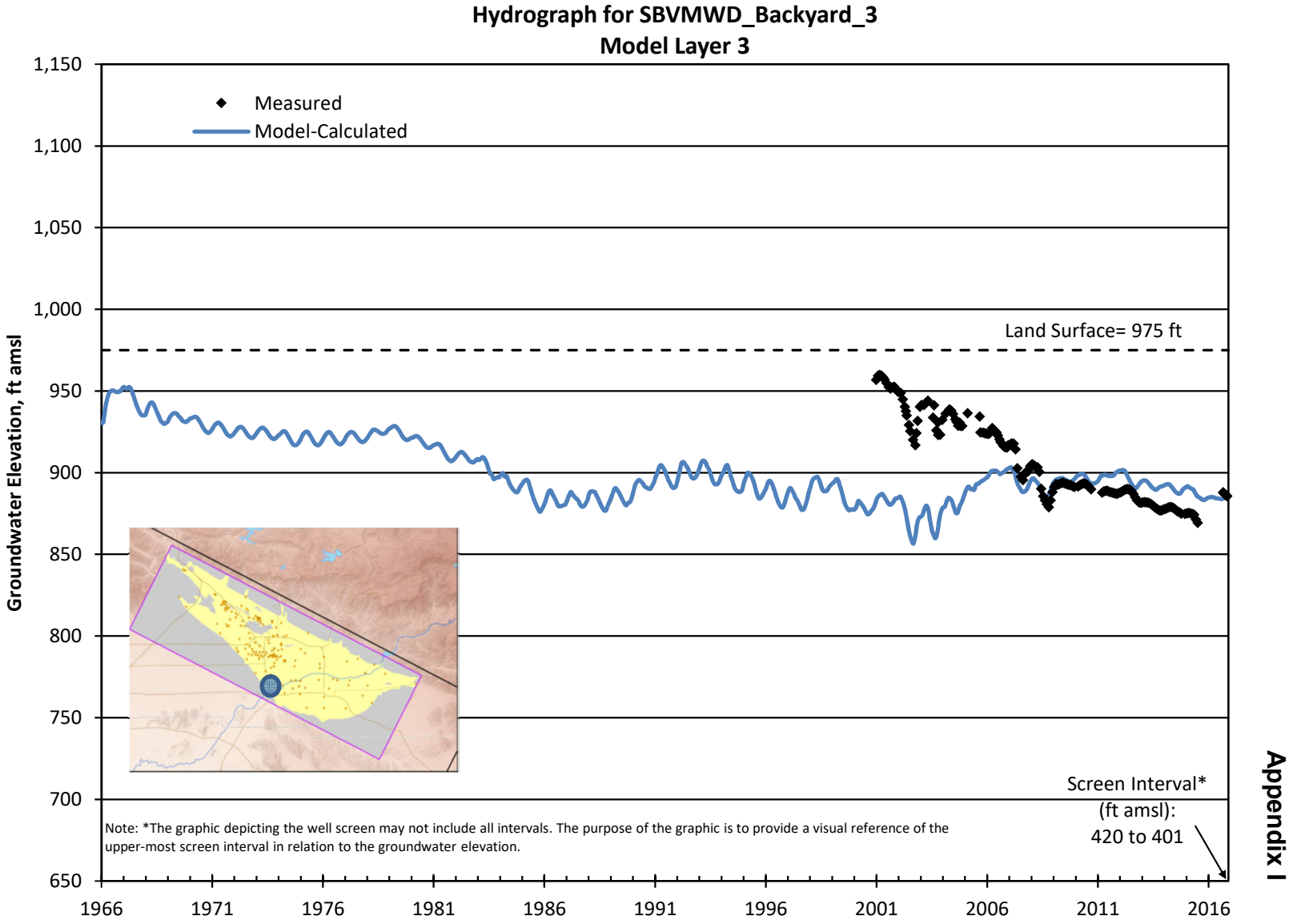
Appendix I


Hydrograph for SBVMWD_Backyard_1
Model Layer 1
Measured
Model-Calculated
Land Surface= 975 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
815 to 775
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

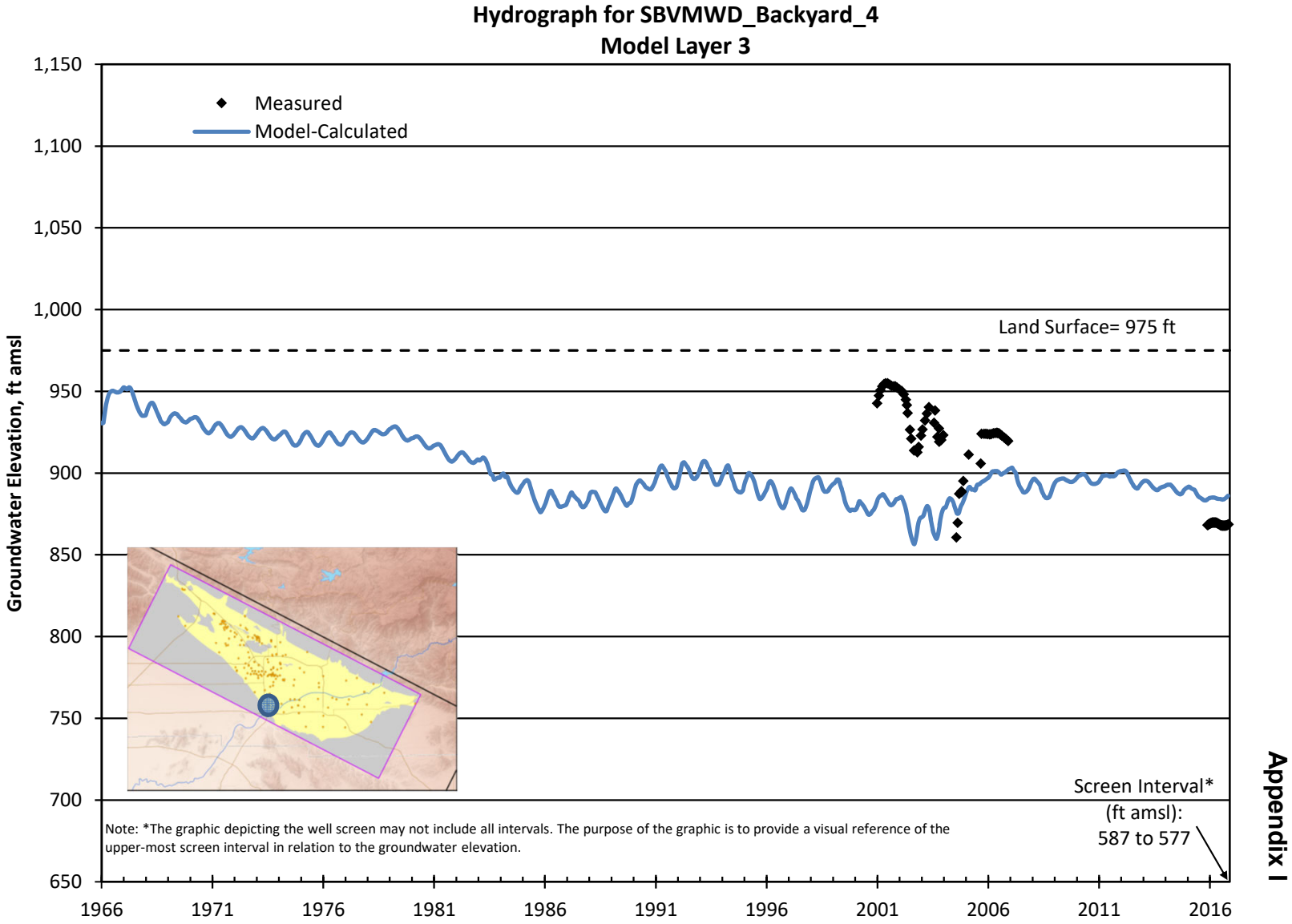
Appendix I


Hydrograph for SBVMWD_Backyard_2
Model Layer 3
Measured
Model-Calculated
Land Surface= 975 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
325 to 320
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

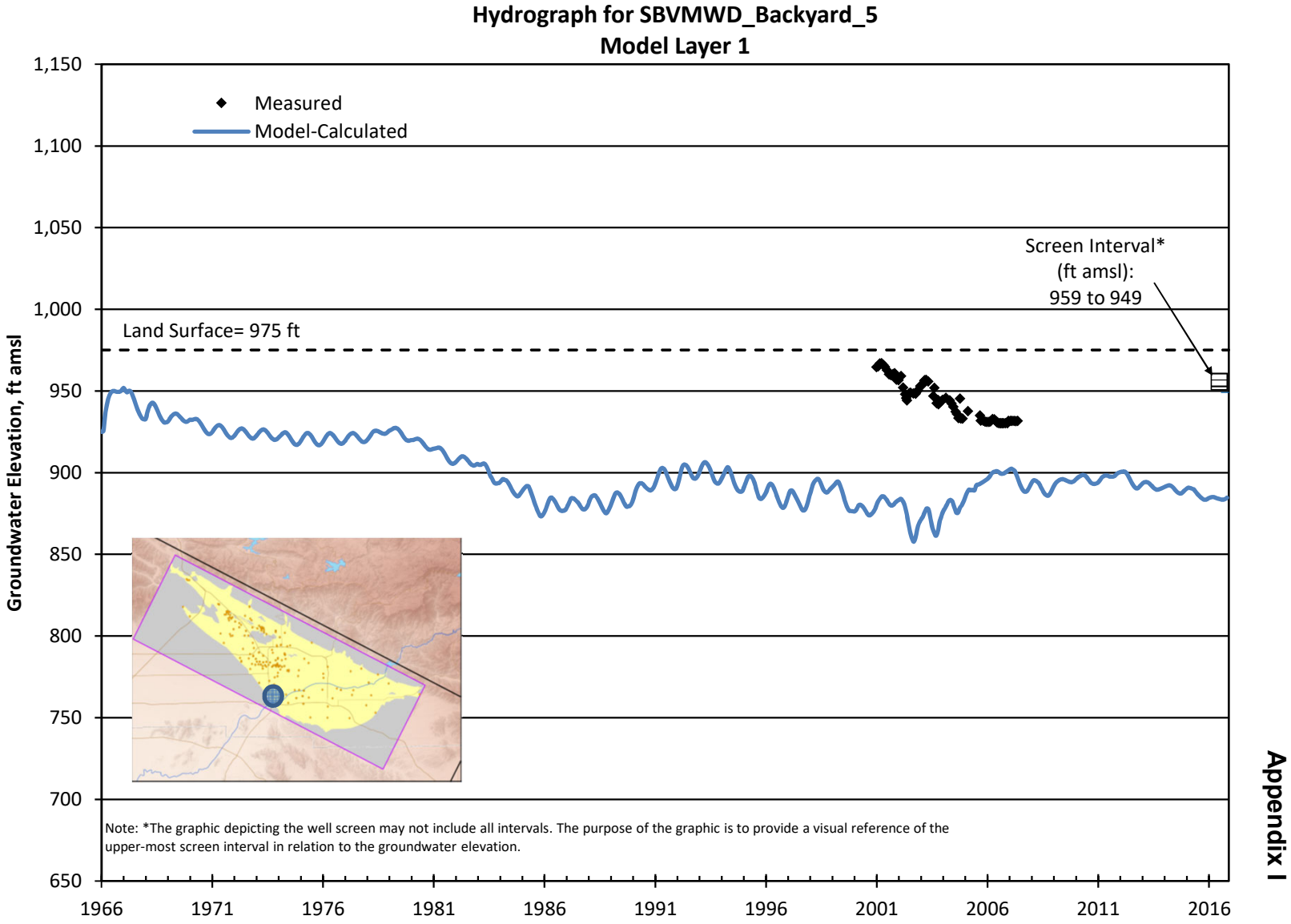
Appendix I


Hydrograph for SBVMWD_Backyard_3
Model Layer 3
Measured
Model-Calculated
Land Surface= 975 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
420 to 401
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

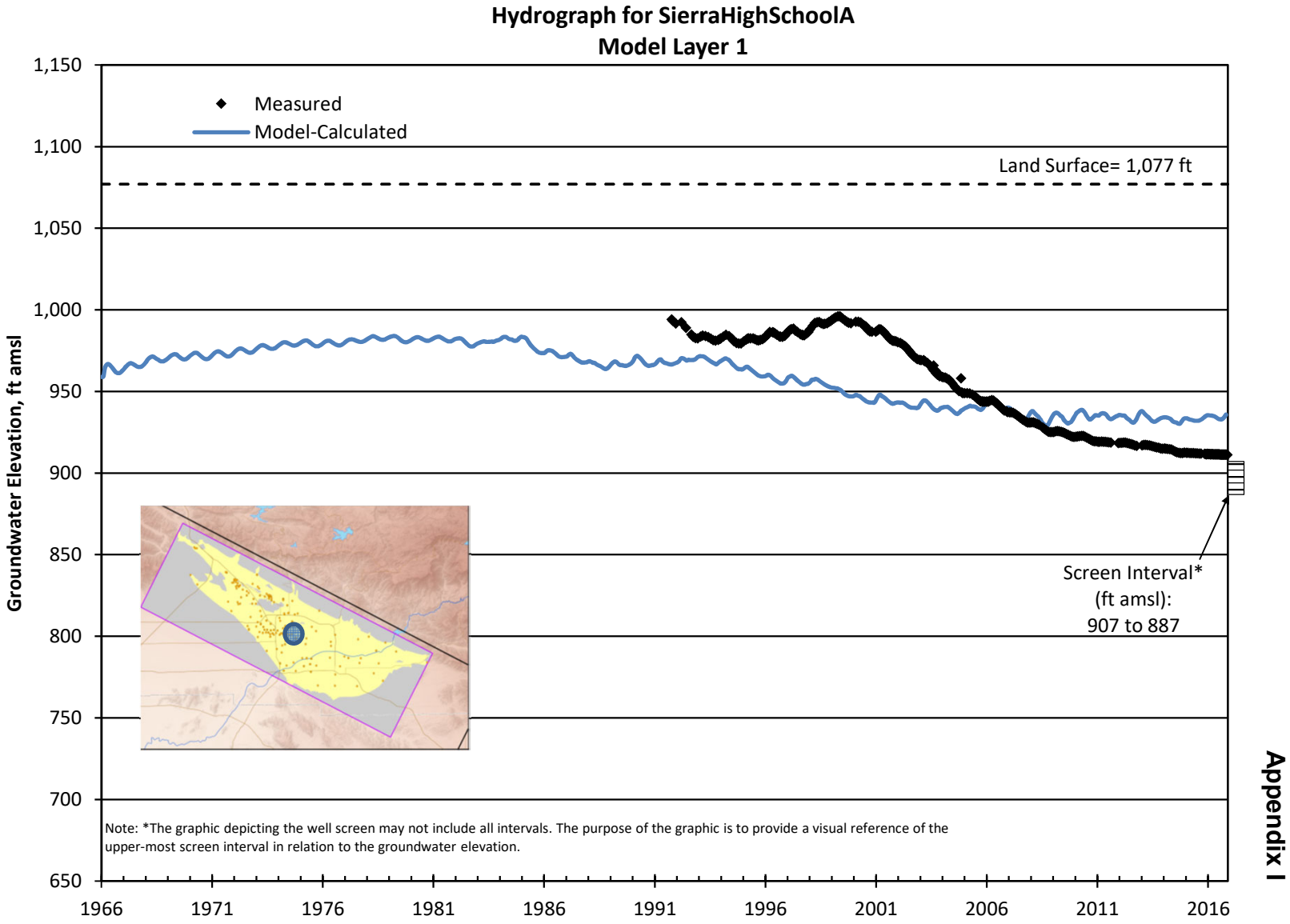
Appendix I


Hydrograph for SBVMWD_Backyard_4
Model Layer 3
Measured
Model-Calculated
Land Surface= 975 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
587 to 577
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

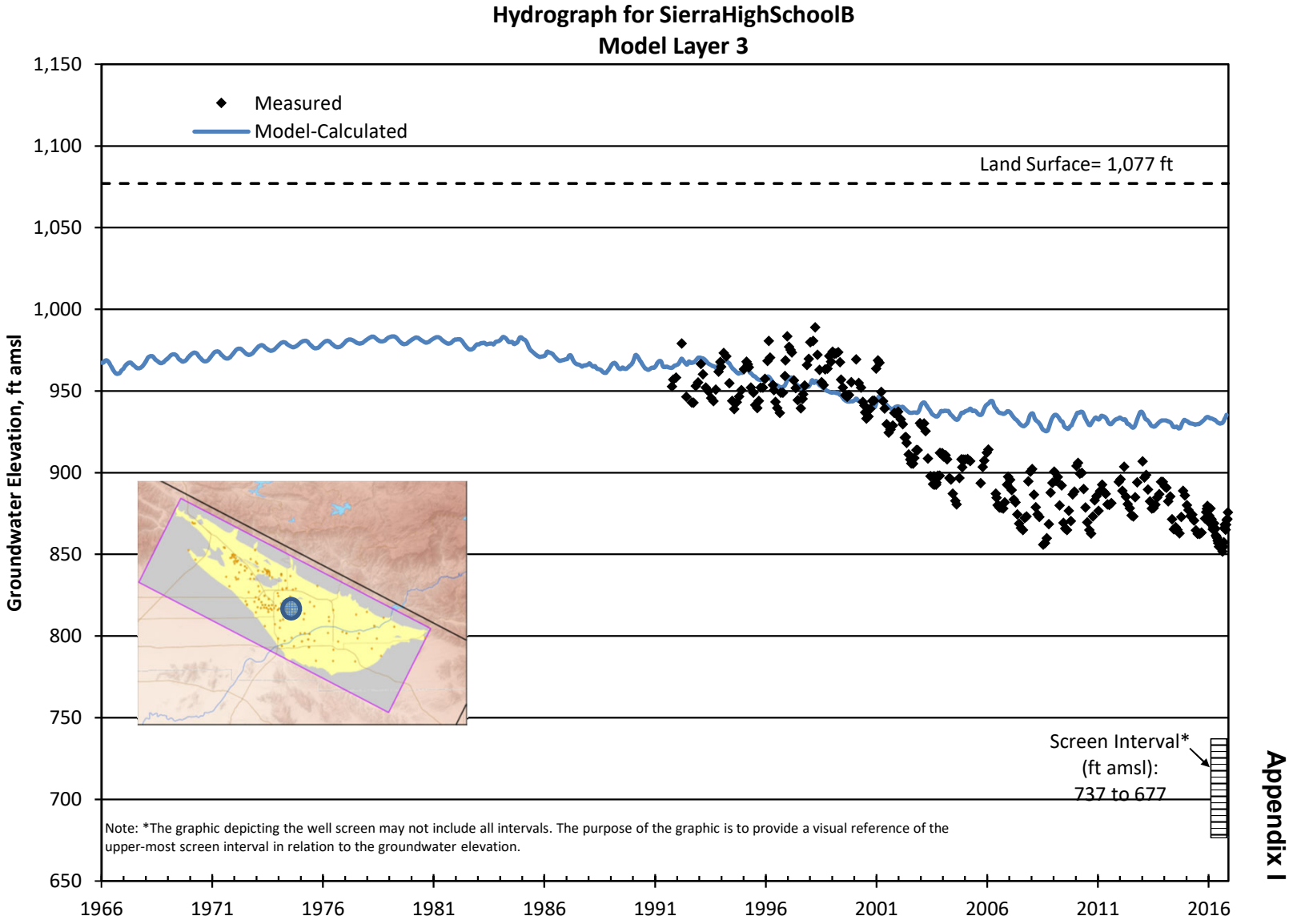
Appendix I


Hydrograph for SBVMWD_Backyard_5
Model Layer 1
Measured
Model-Calculated
Screen Interval*
(ft amsl):
959 to 949
Land Surface= 975 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

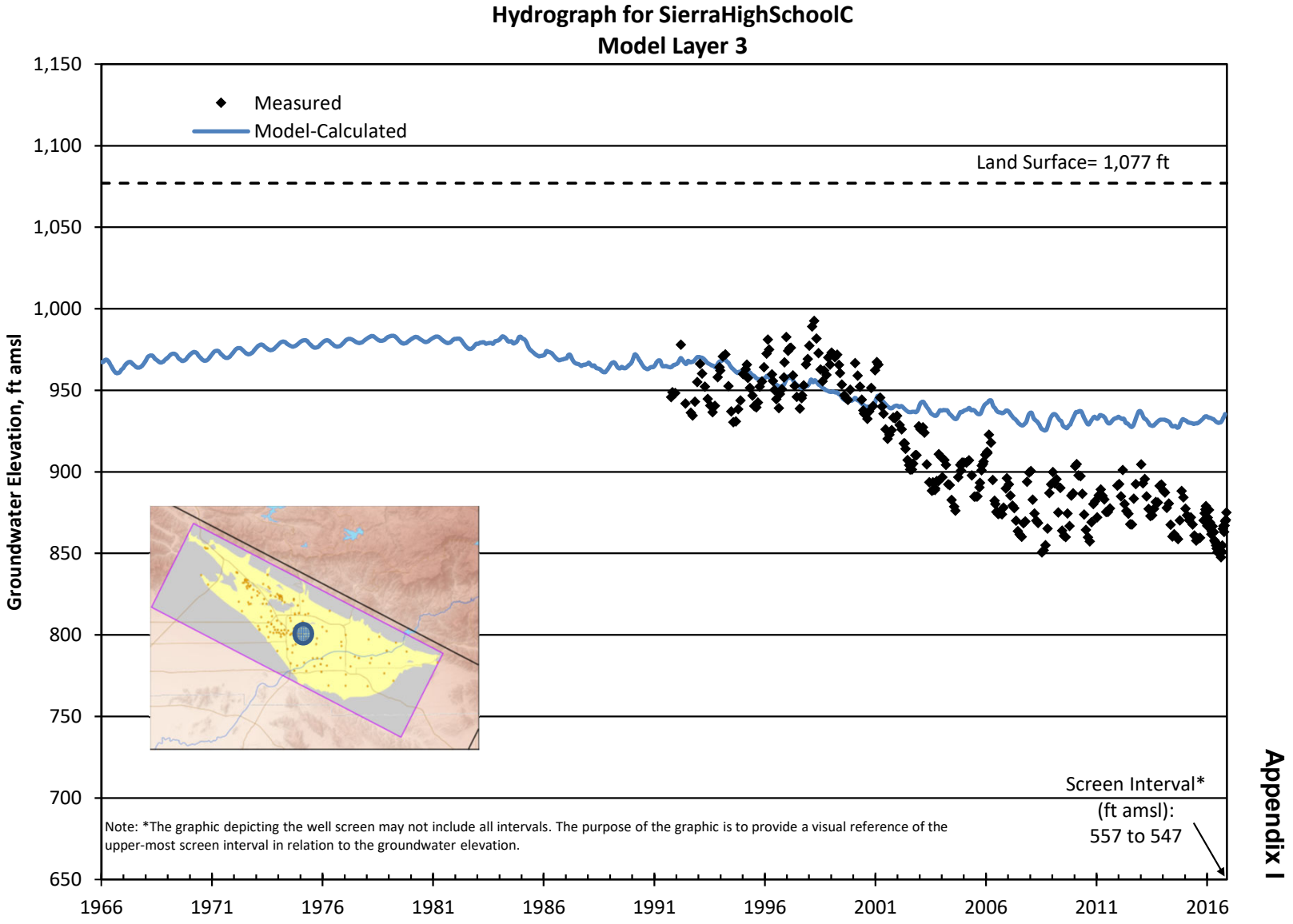
Appendix I


Hydrograph for SierraHighSchoolA
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,077 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
907 to 887
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

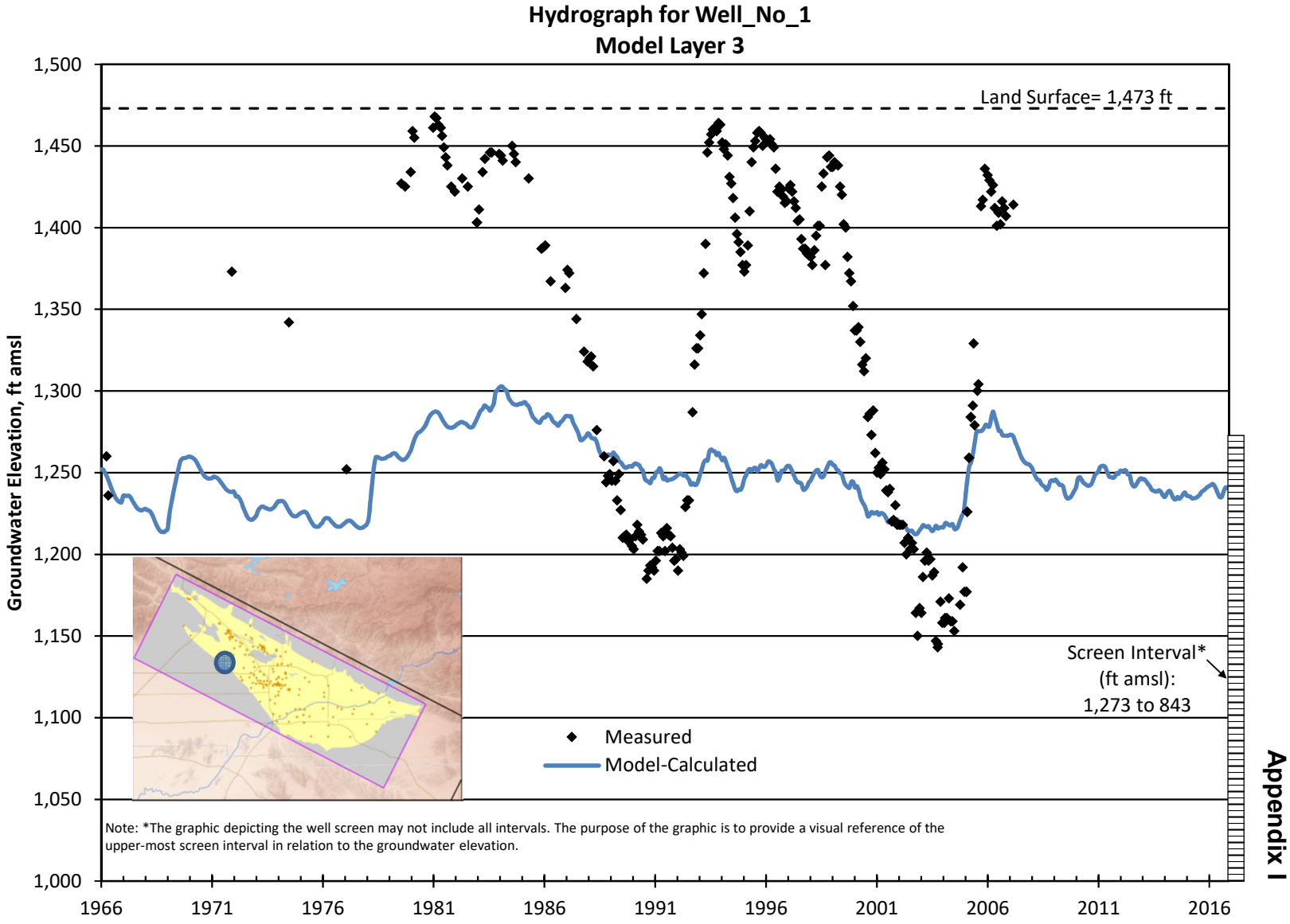
Appendix I


Hydrograph for SierraHighSchoolB
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,077 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
737 to 677
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

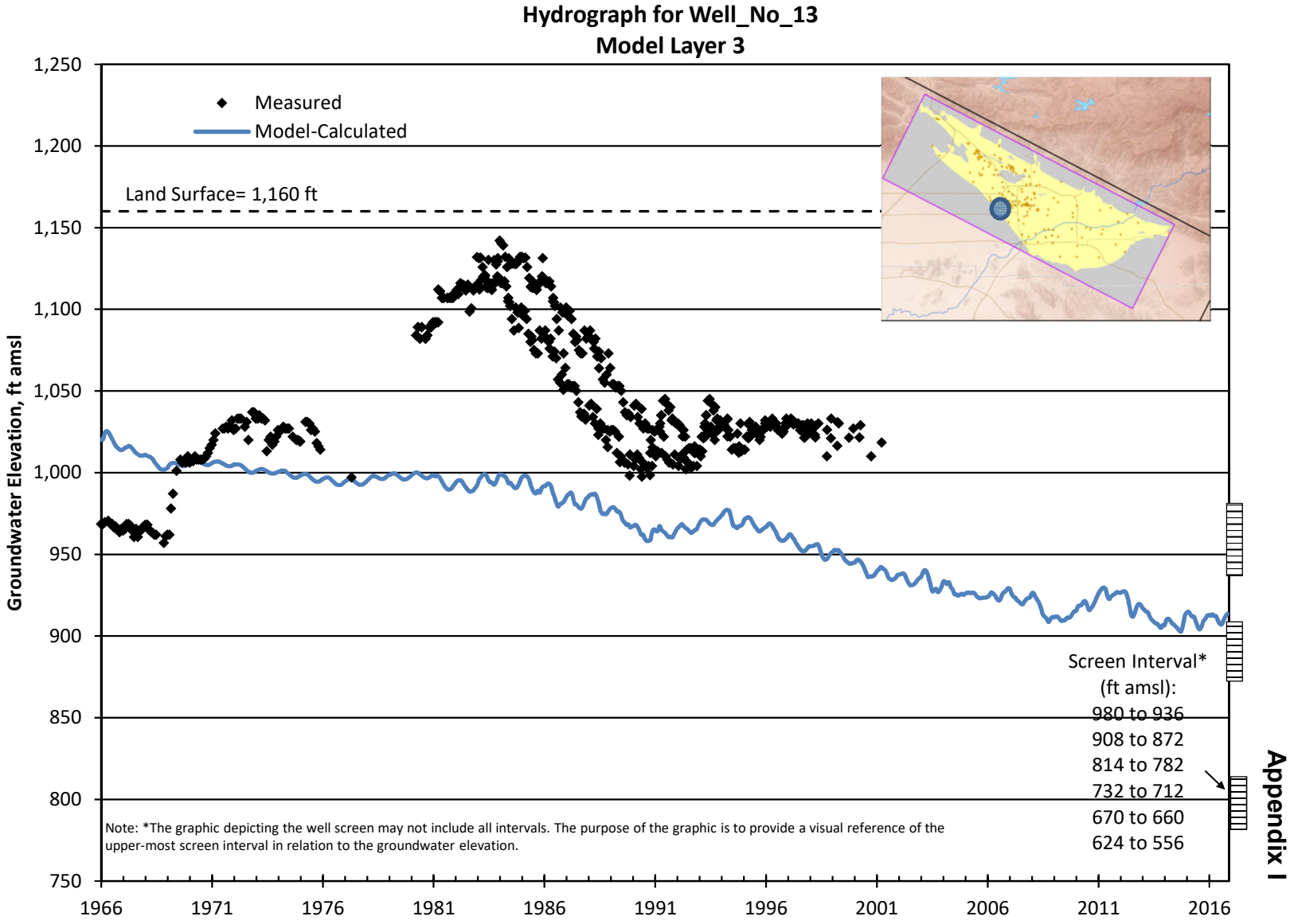
Appendix I


Hydrograph for SierraHighSchoolC
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,077 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
557 to 547
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix I


Hydrograph for Well_No_1
Model Layer 3
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,473 ft
Screen Interval*
(ft amsl):
1,273 to 843
Measured
Model-Calculated
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix I


Hydrograph for Well_No_13
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,160 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
980 to 936
908 to 872
814 to 782
732 to 712
670 to 660
624 to 556
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix I

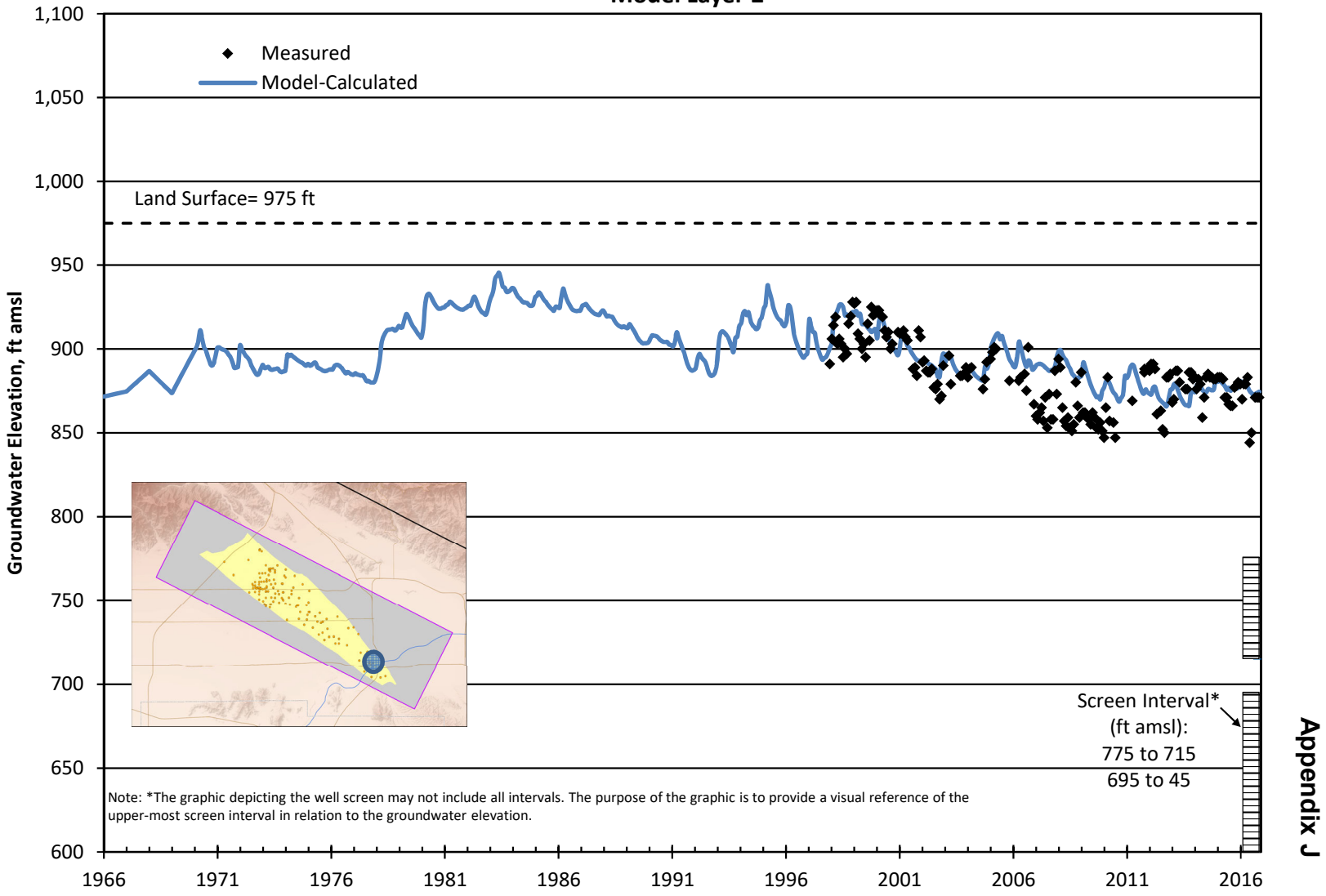
APPENDIX J

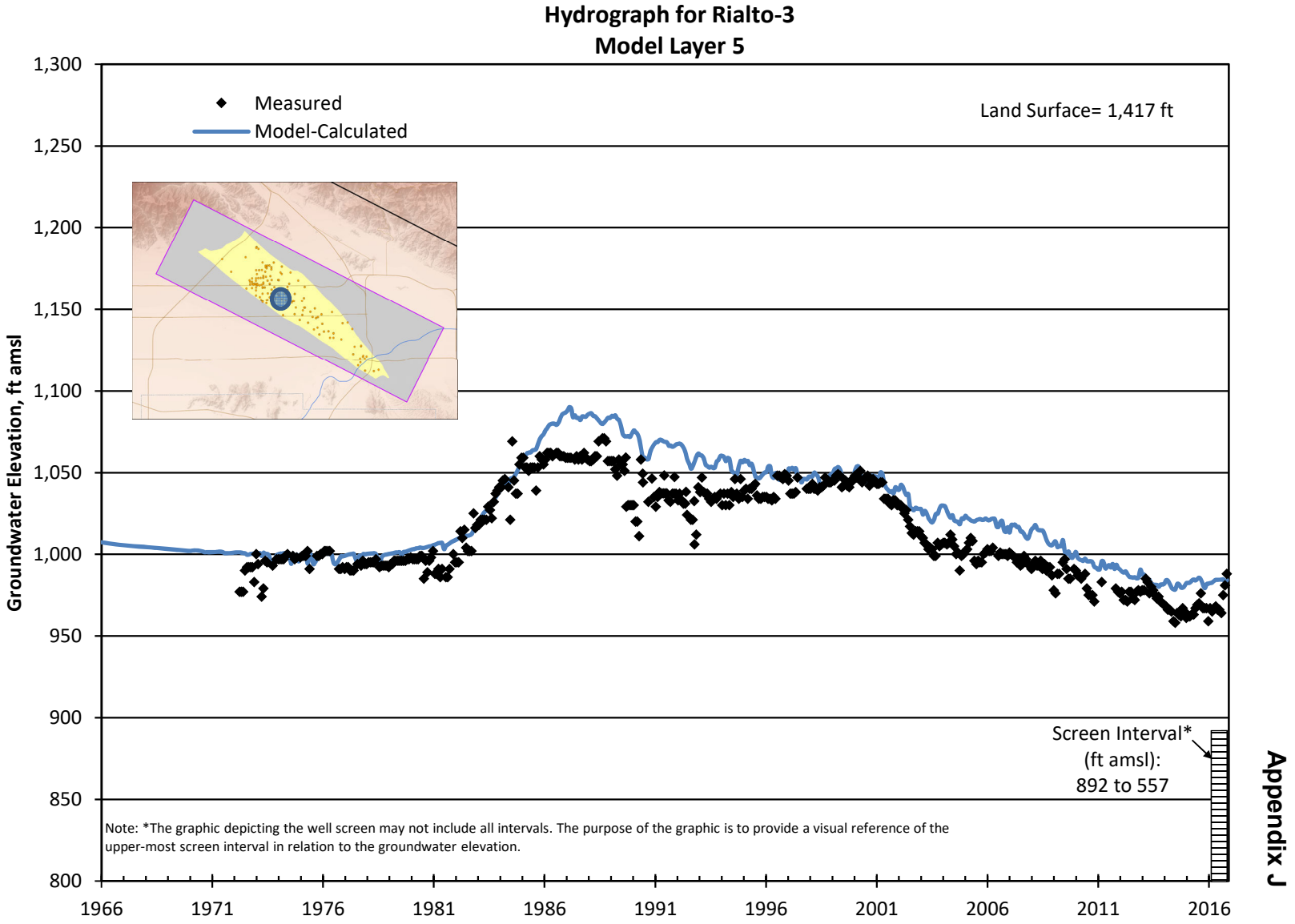
Individual Model Update: Selected Hydrographs for the Rialto-Colton Basin

Model Calibration Target Wells – 1966 to 2016

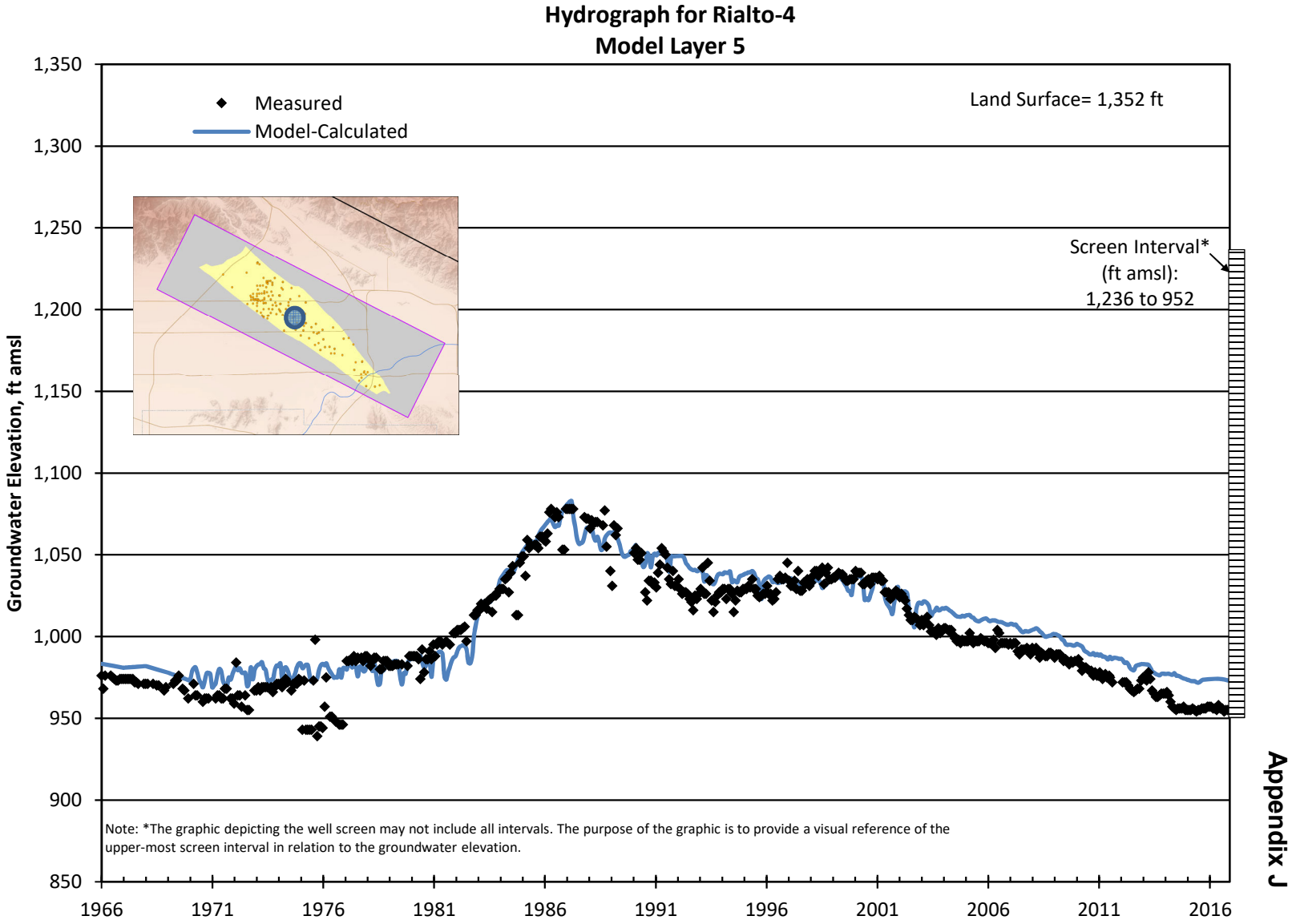
GEOSCIENCE

Hydrograph for Colton-23
Model Layer 2

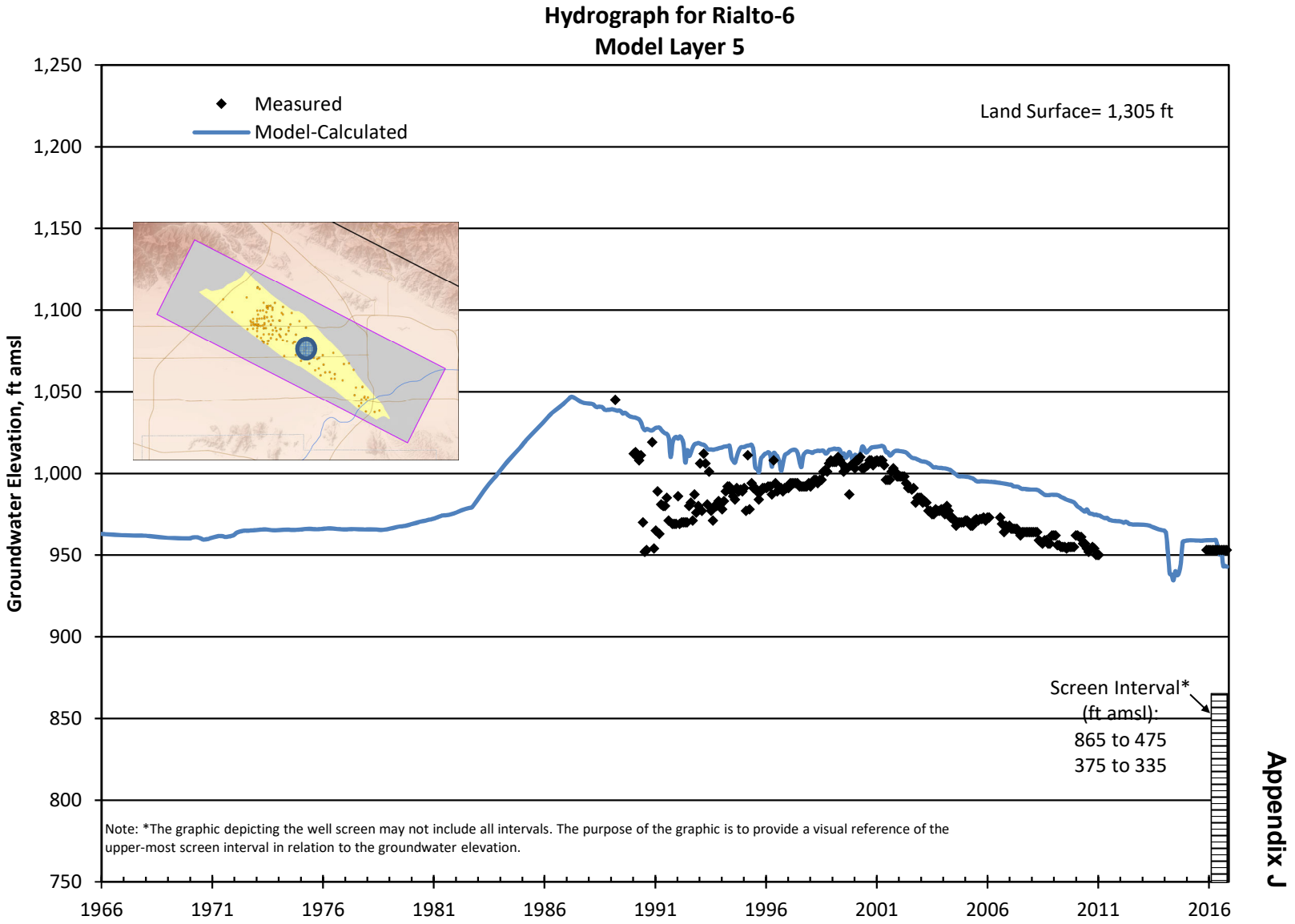



Hydrograph for Rialto-3
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,417 ft
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
892 to 557
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

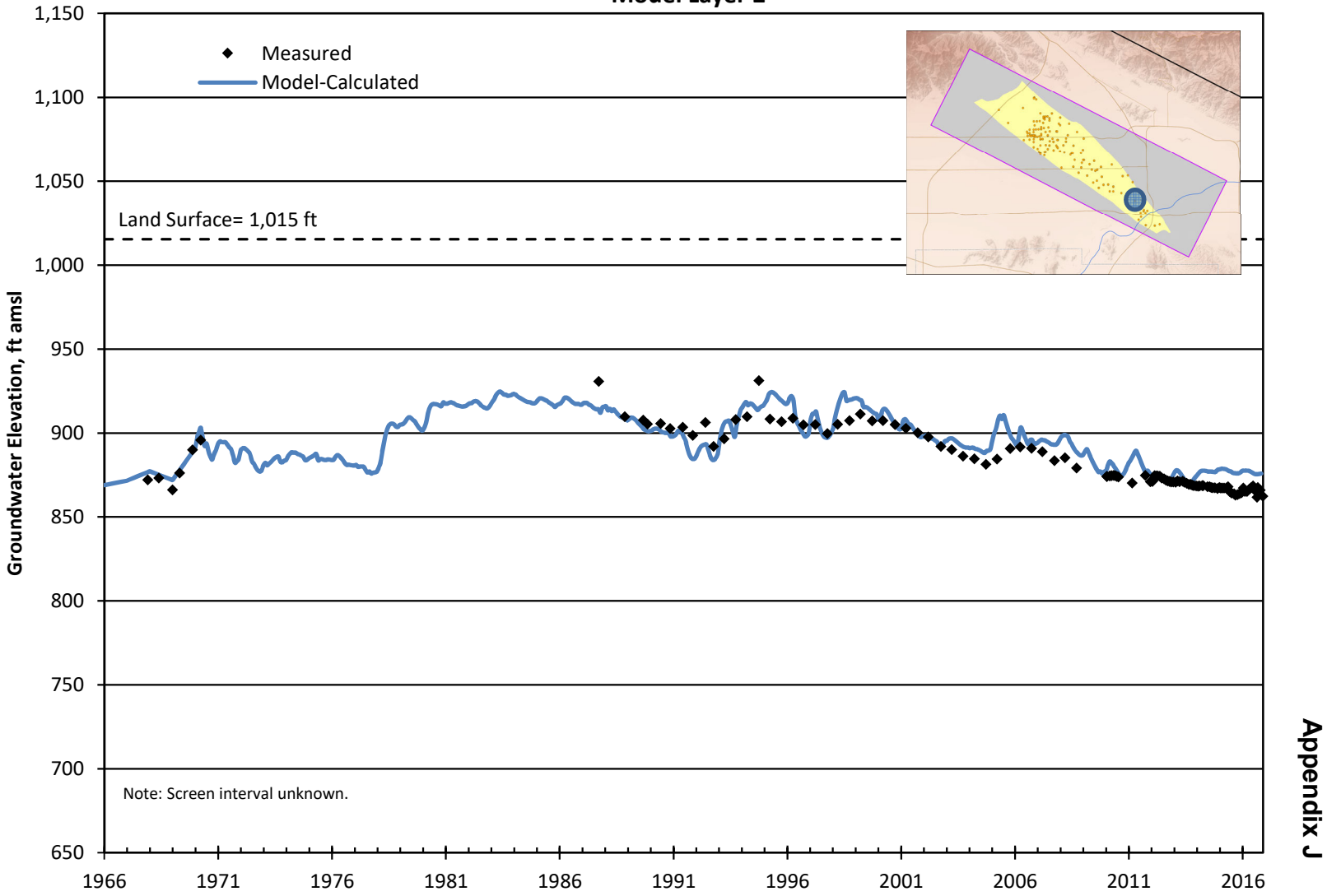

Hydrograph for Rialto-4
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,352 ft
Screen Interval*
(ft amsl):
1,236 to 952
Groundwater Elevation, ft amsl
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

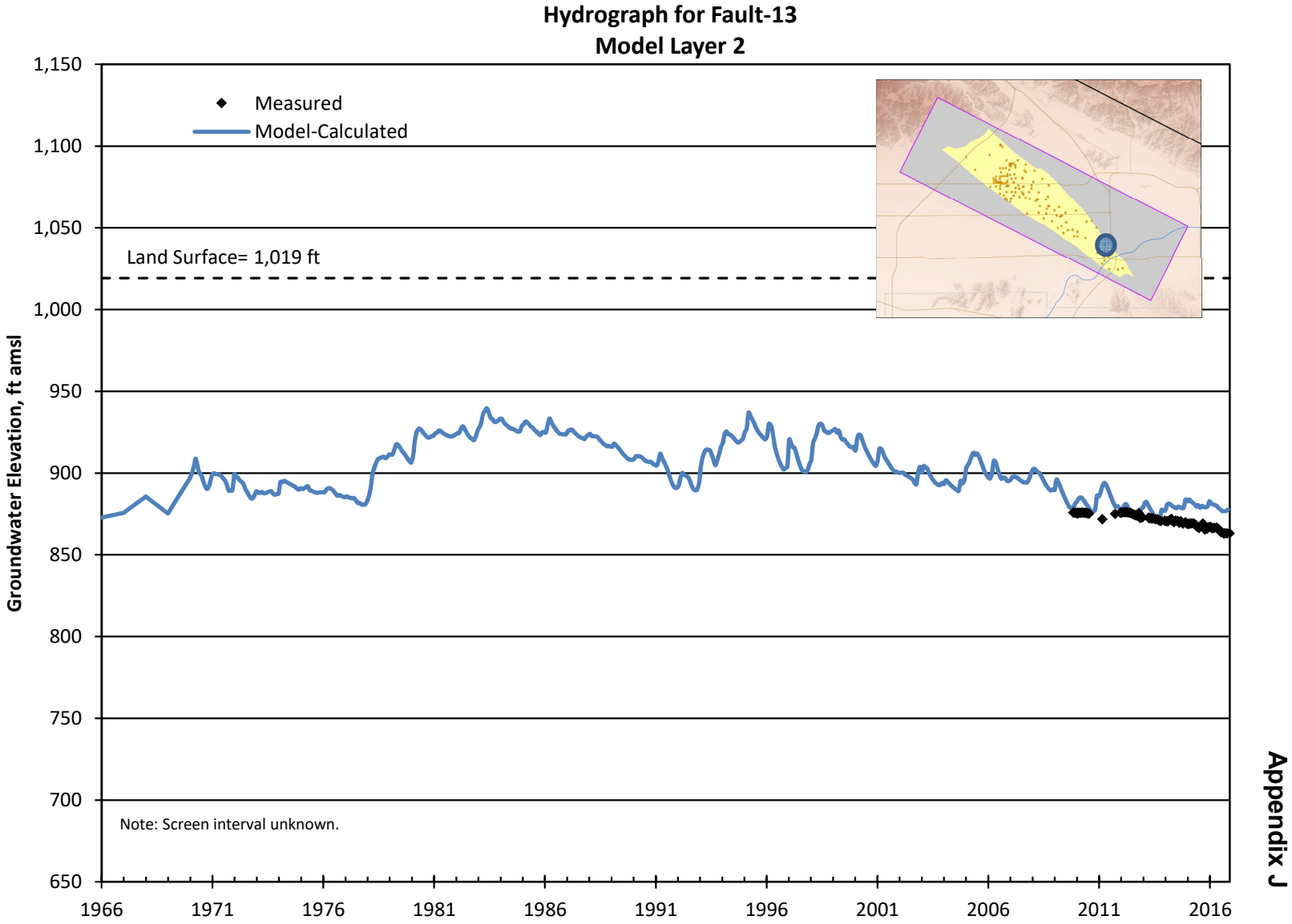

Hydrograph for Rialto-6
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,305 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
865 to 475
375 to 335
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

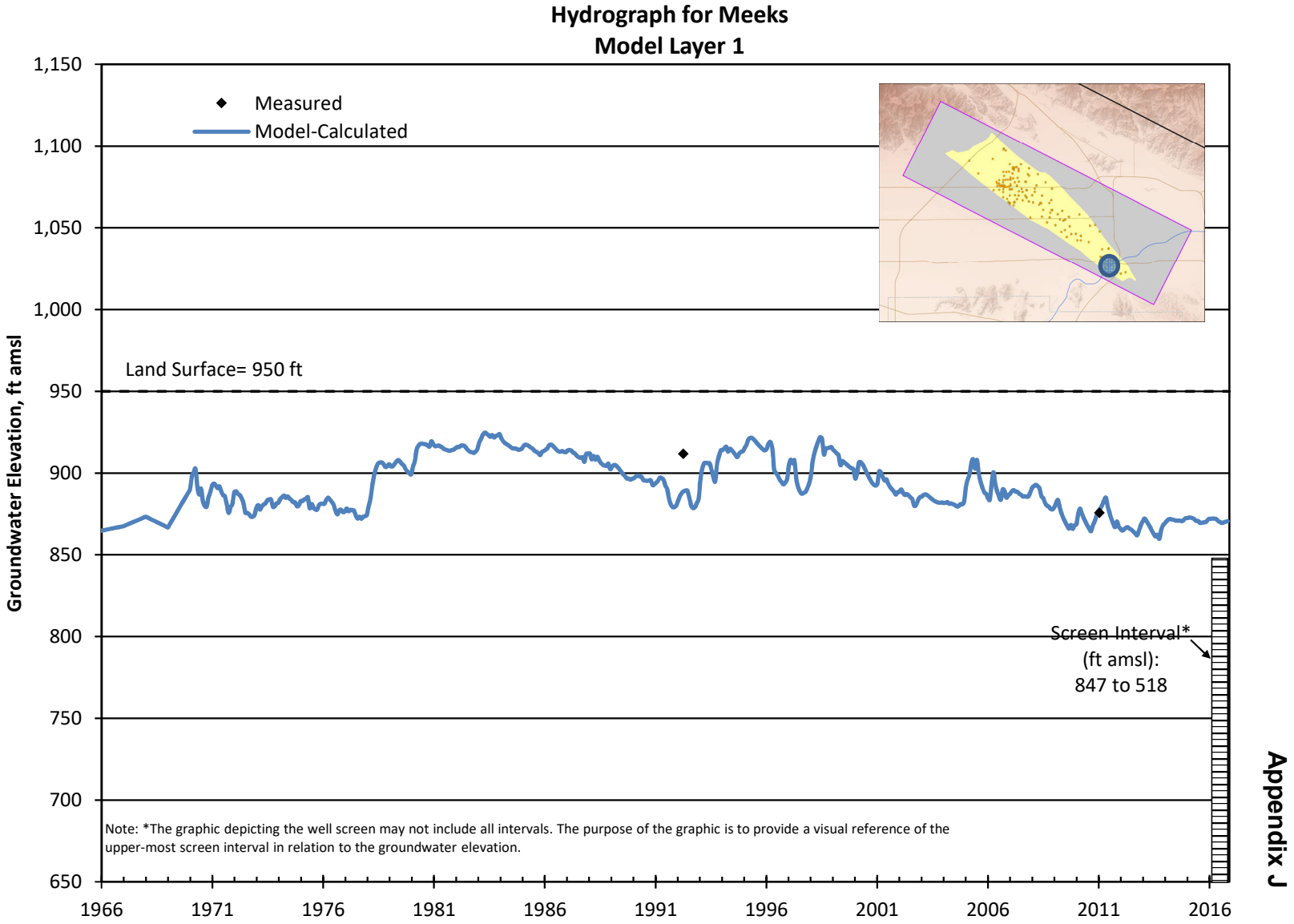
Hydrograph for Fault-11
Model Layer 2



Appendix J

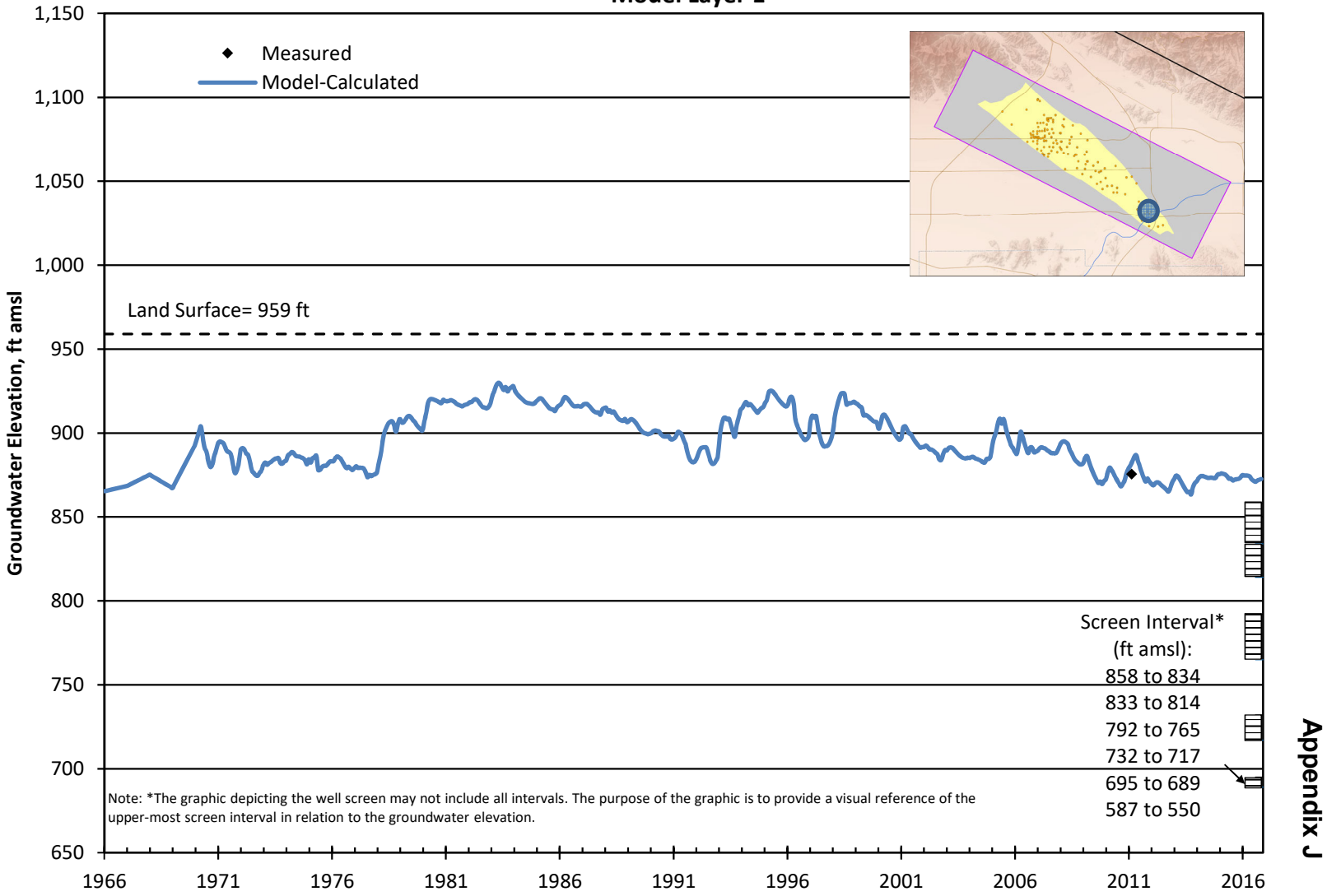

Hydrograph for Fault-13
Model Layer 2
Measured
Model-Calculated
Land Surface= 1,019 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

Appendix J

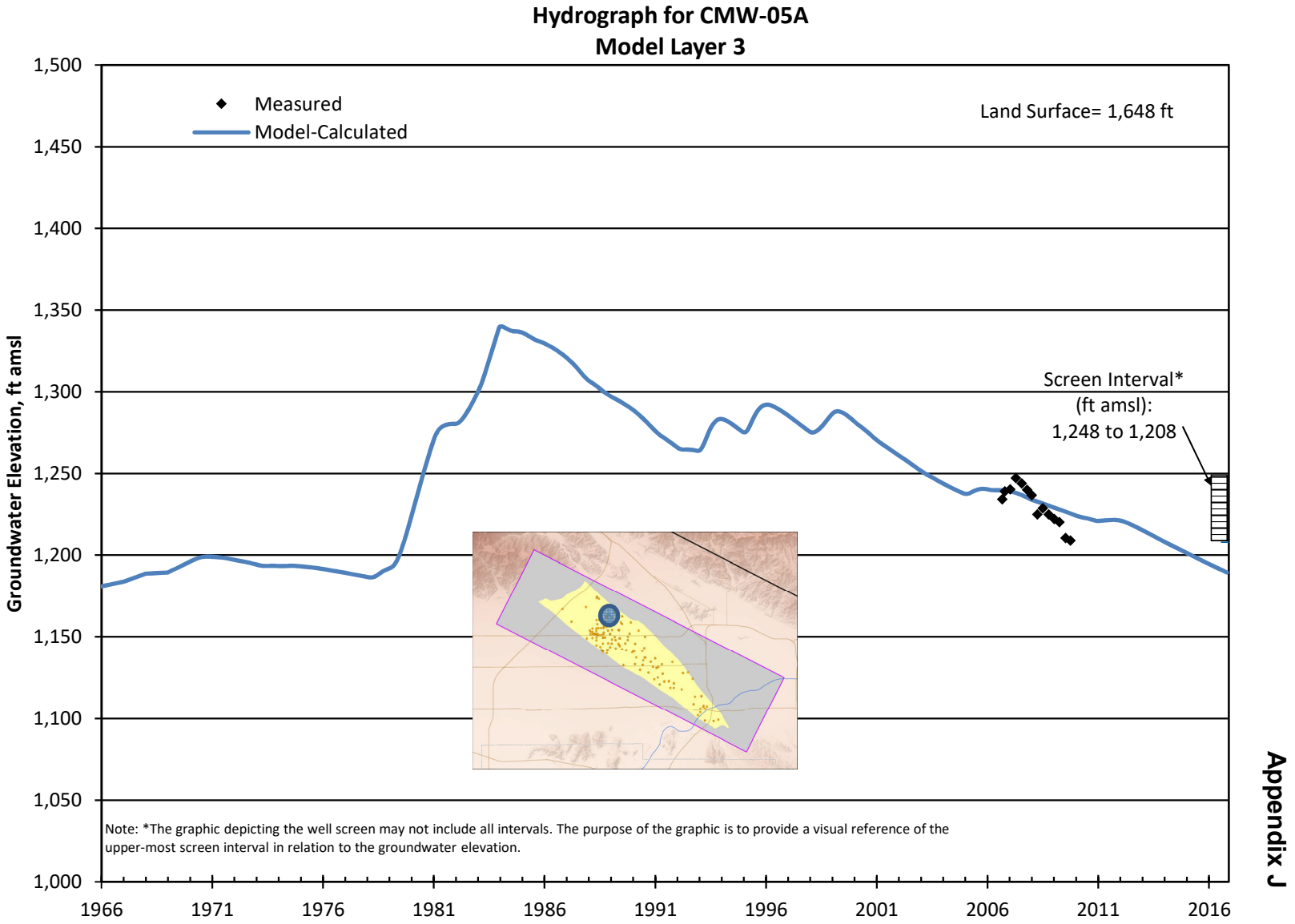

Hydrograph for Meeks
Model Layer 1
Measured
Model-Calculated
Land Surface= 950 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
847 to 518
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

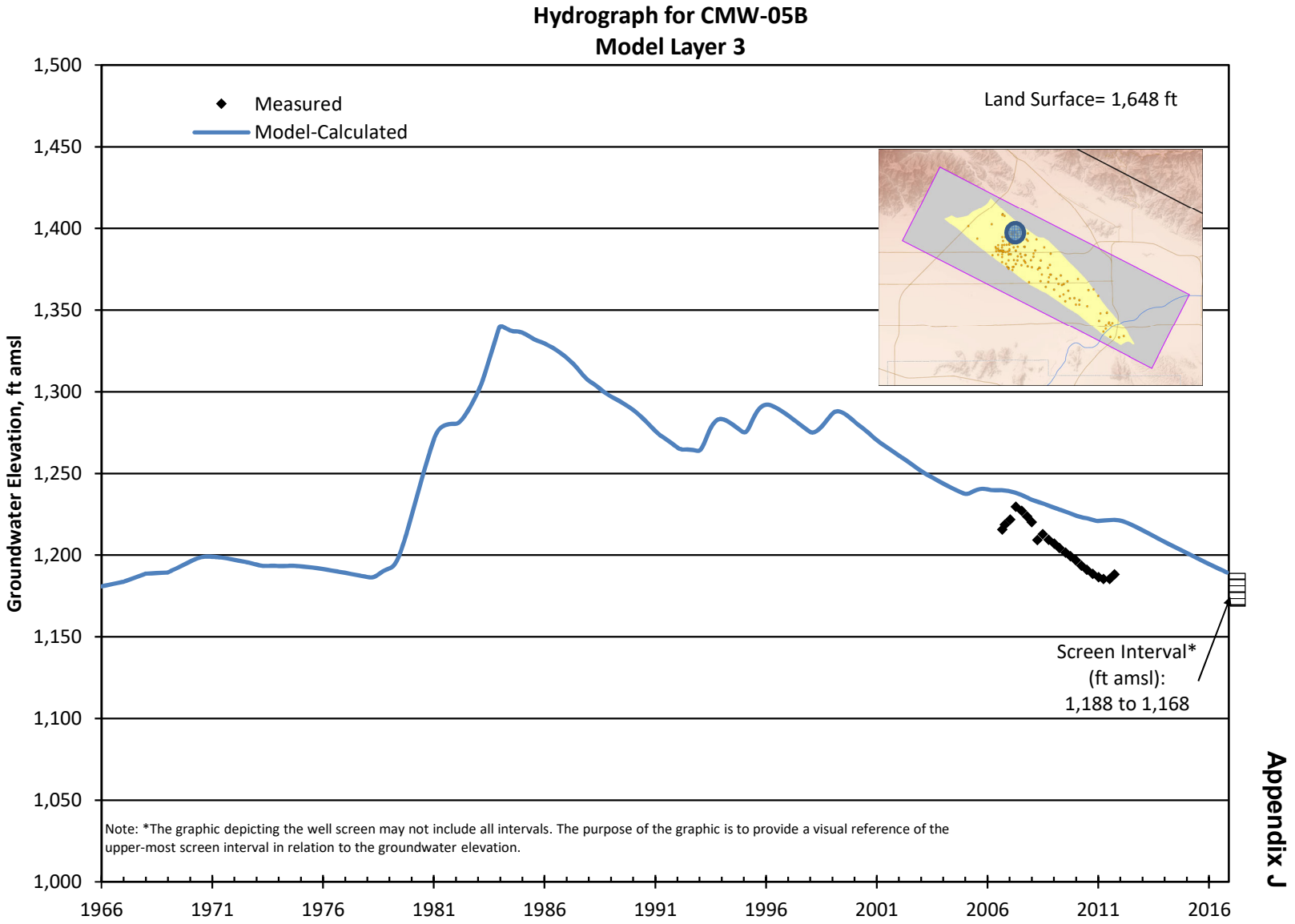
Hydrograph for Vaughn
Model Layer 1



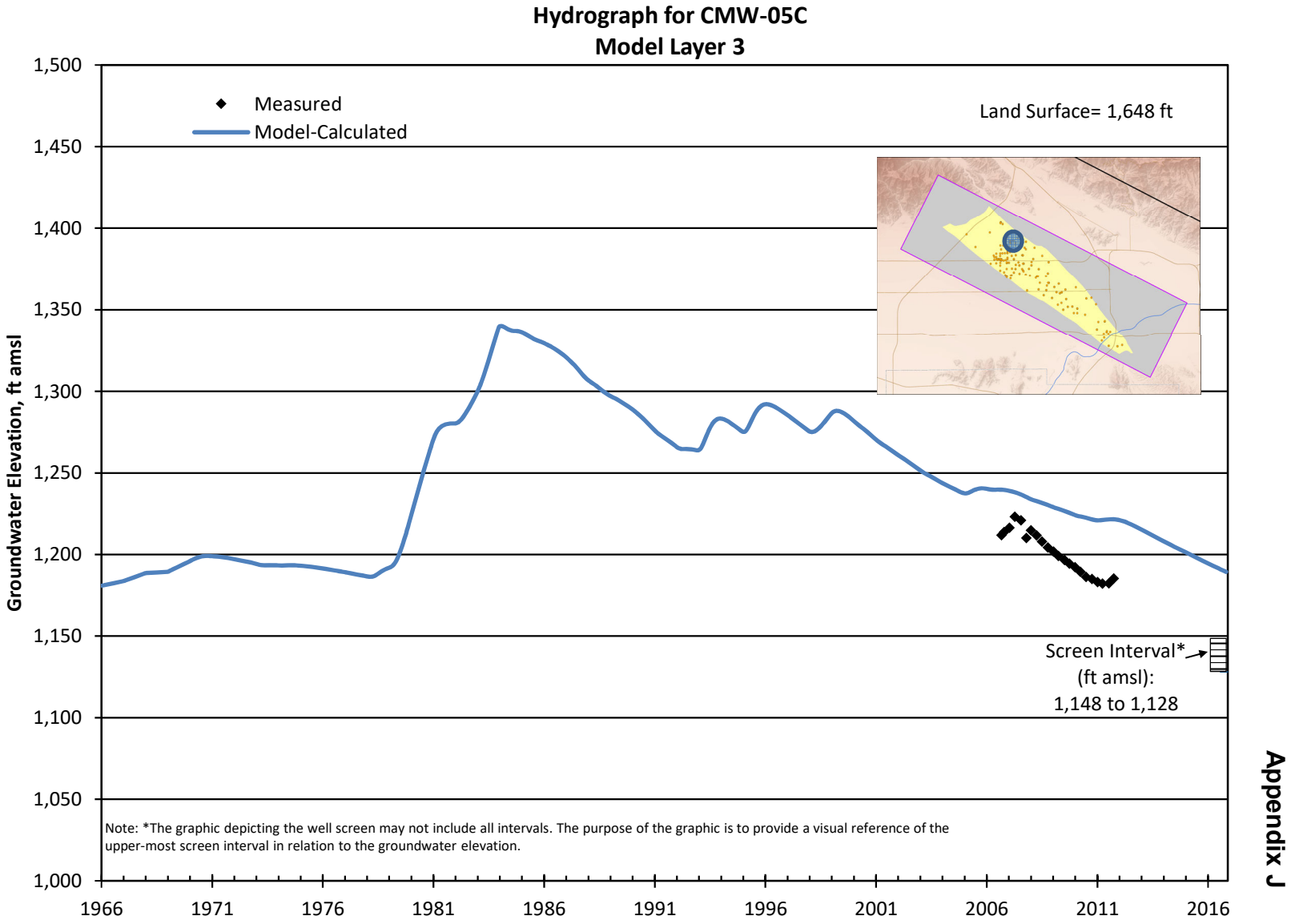
Appendix J


Hydrograph for CMW-05A
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,648 ft
Screen Interval*
(ft amsl):
1,248 to 1,208
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

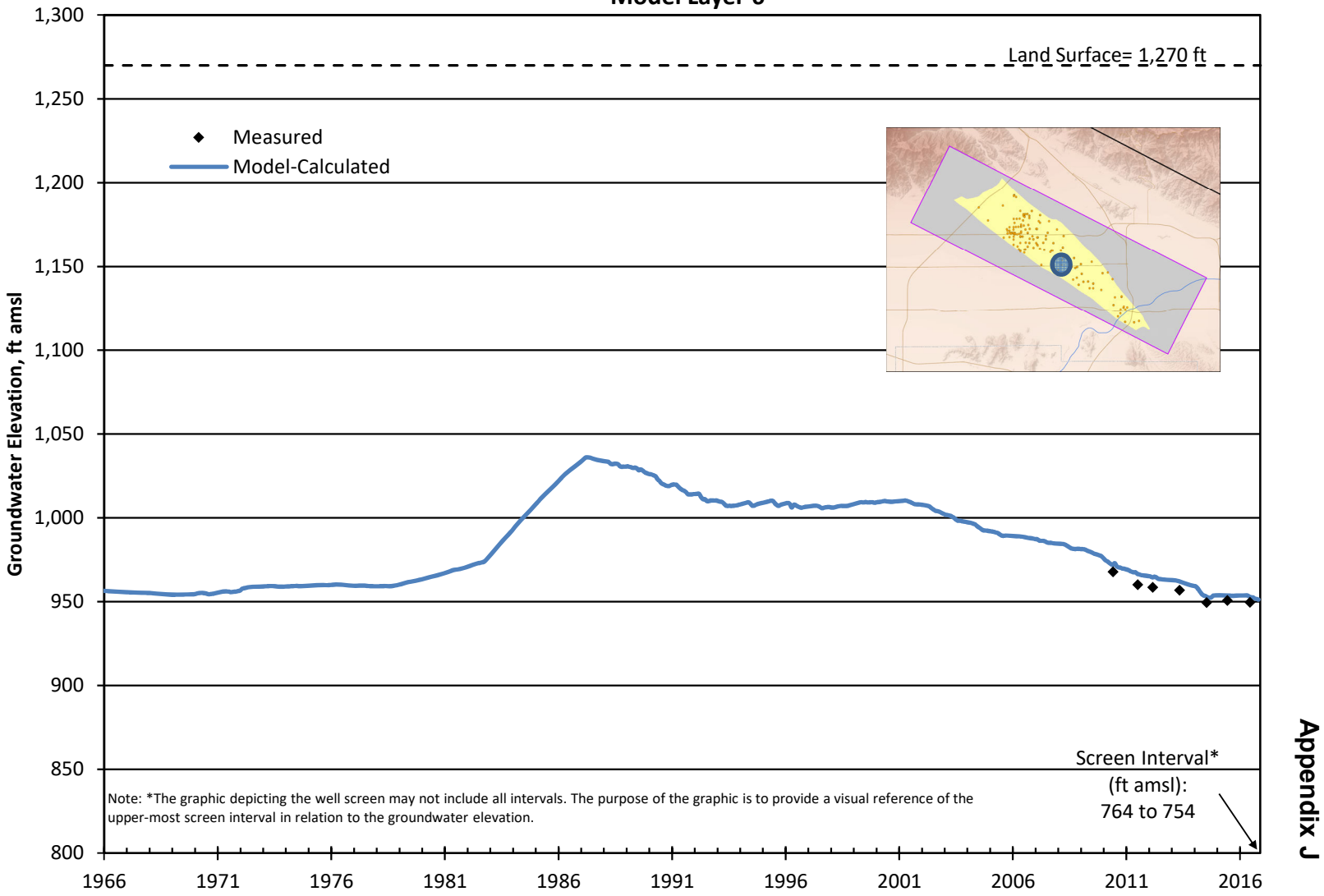

Hydrograph for CMW-05B
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,648 ft
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,188 to 1,168
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

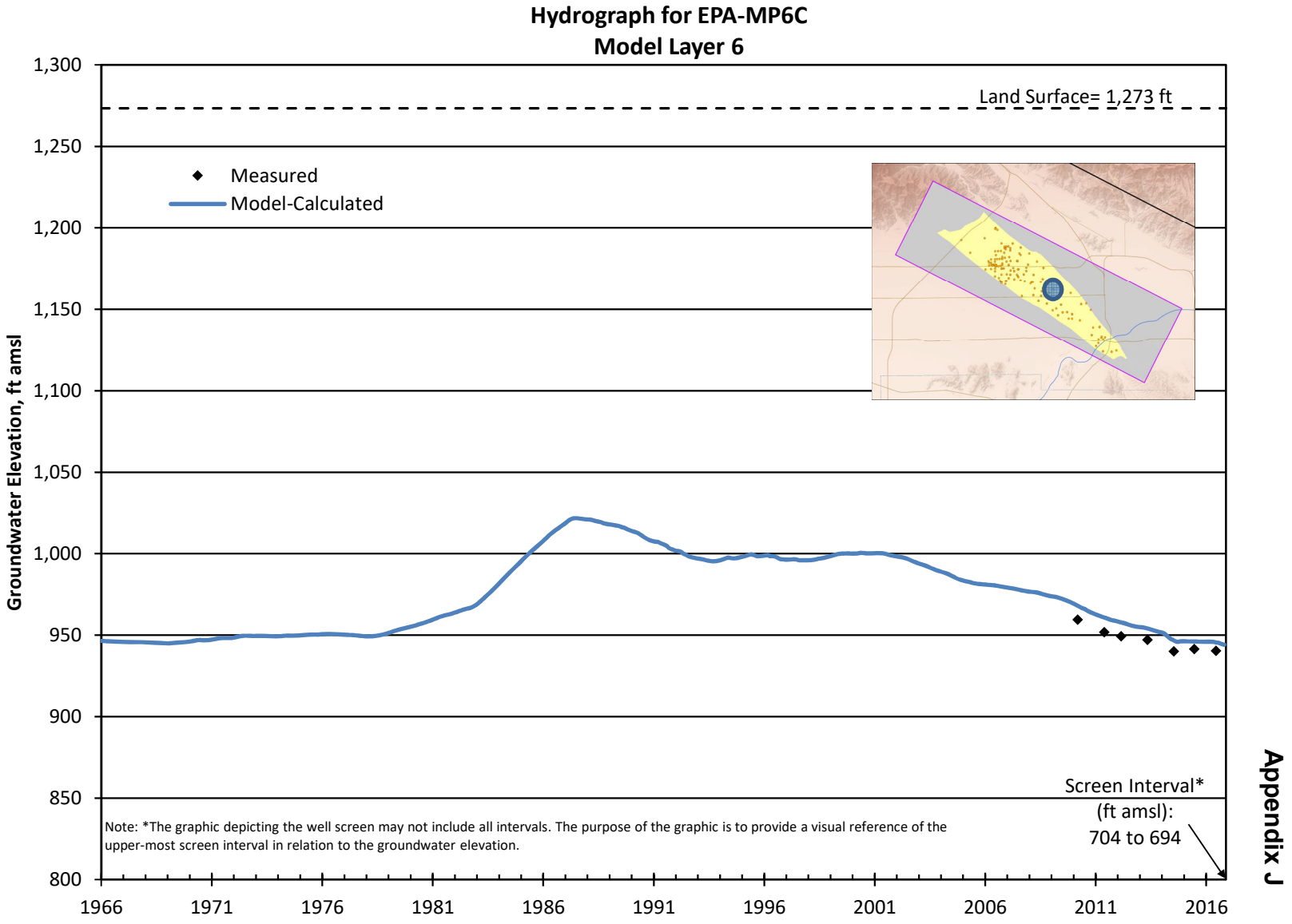

Hydrograph for CMW-05C
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,648 ft
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,148 to 1,128
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

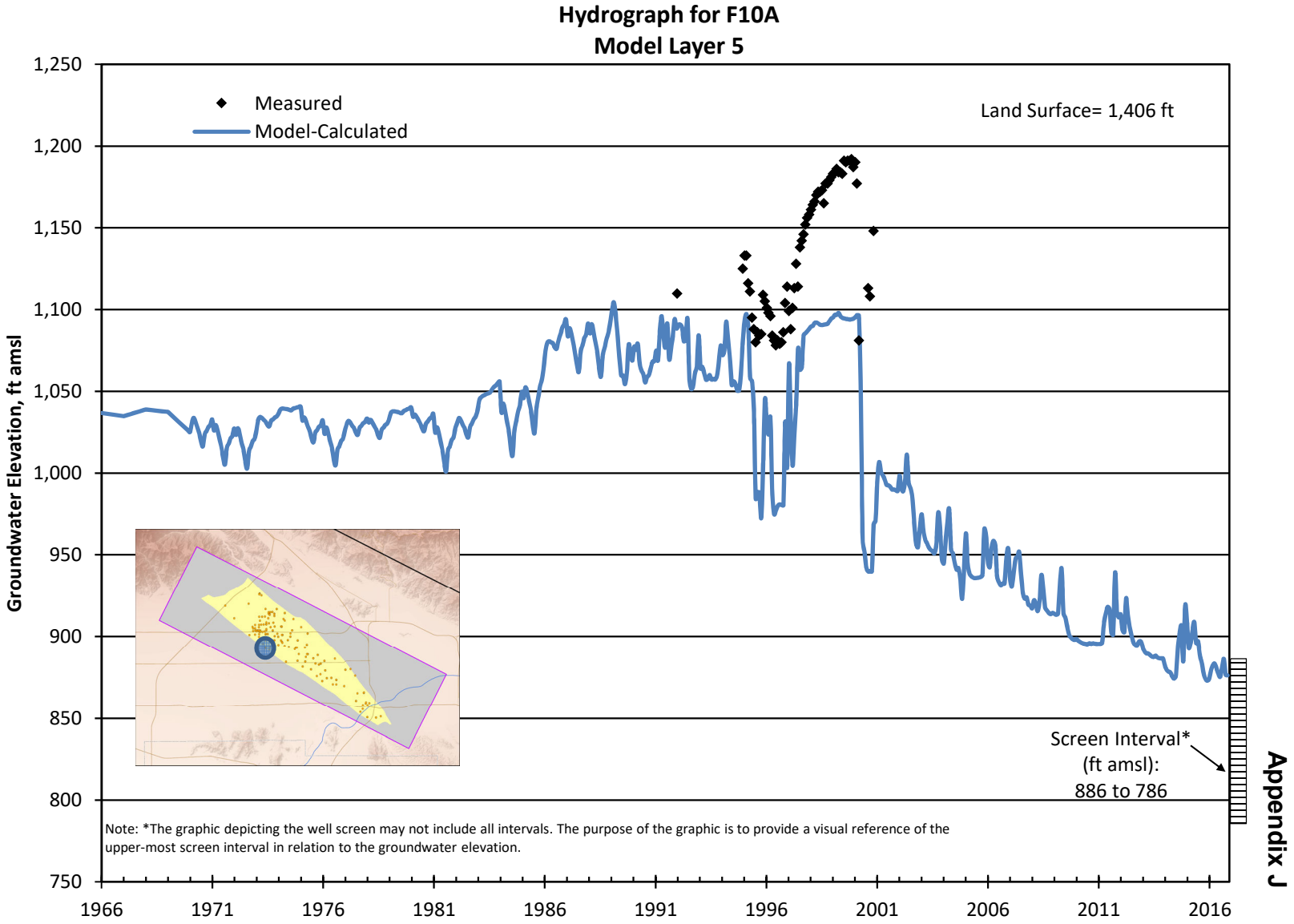
Hydrograph for EPA-MP2C
Model Layer 6

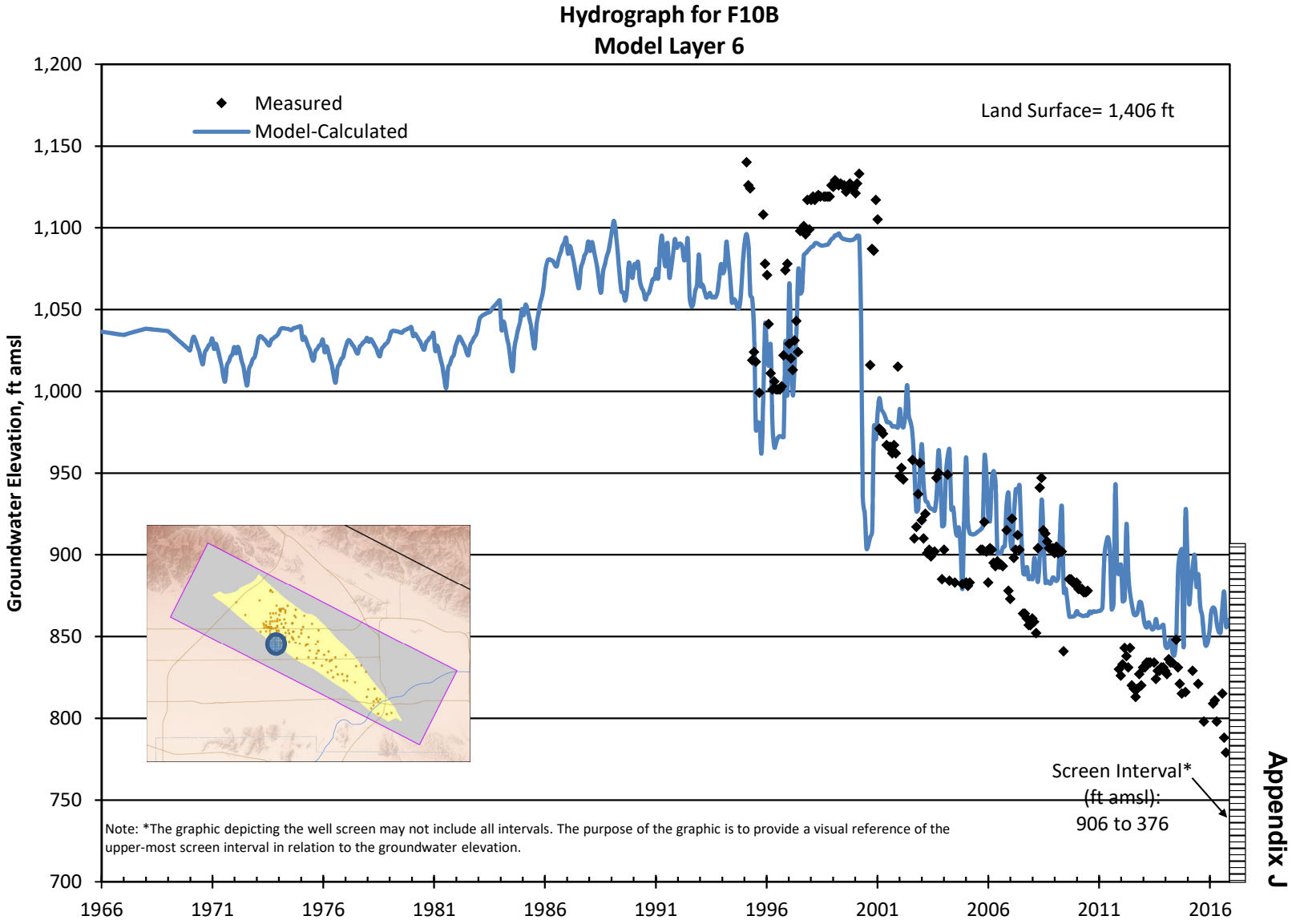


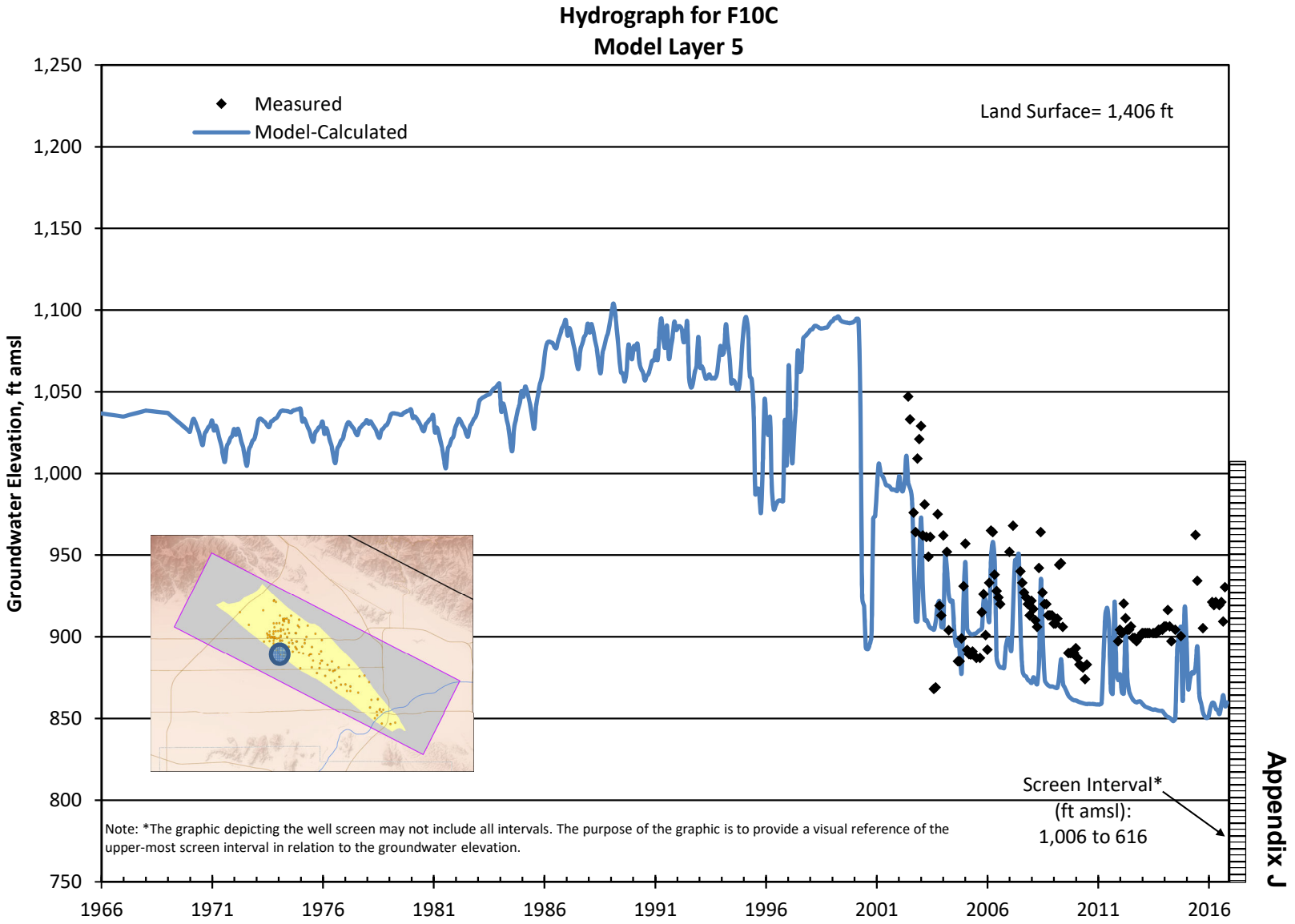
Appendix J

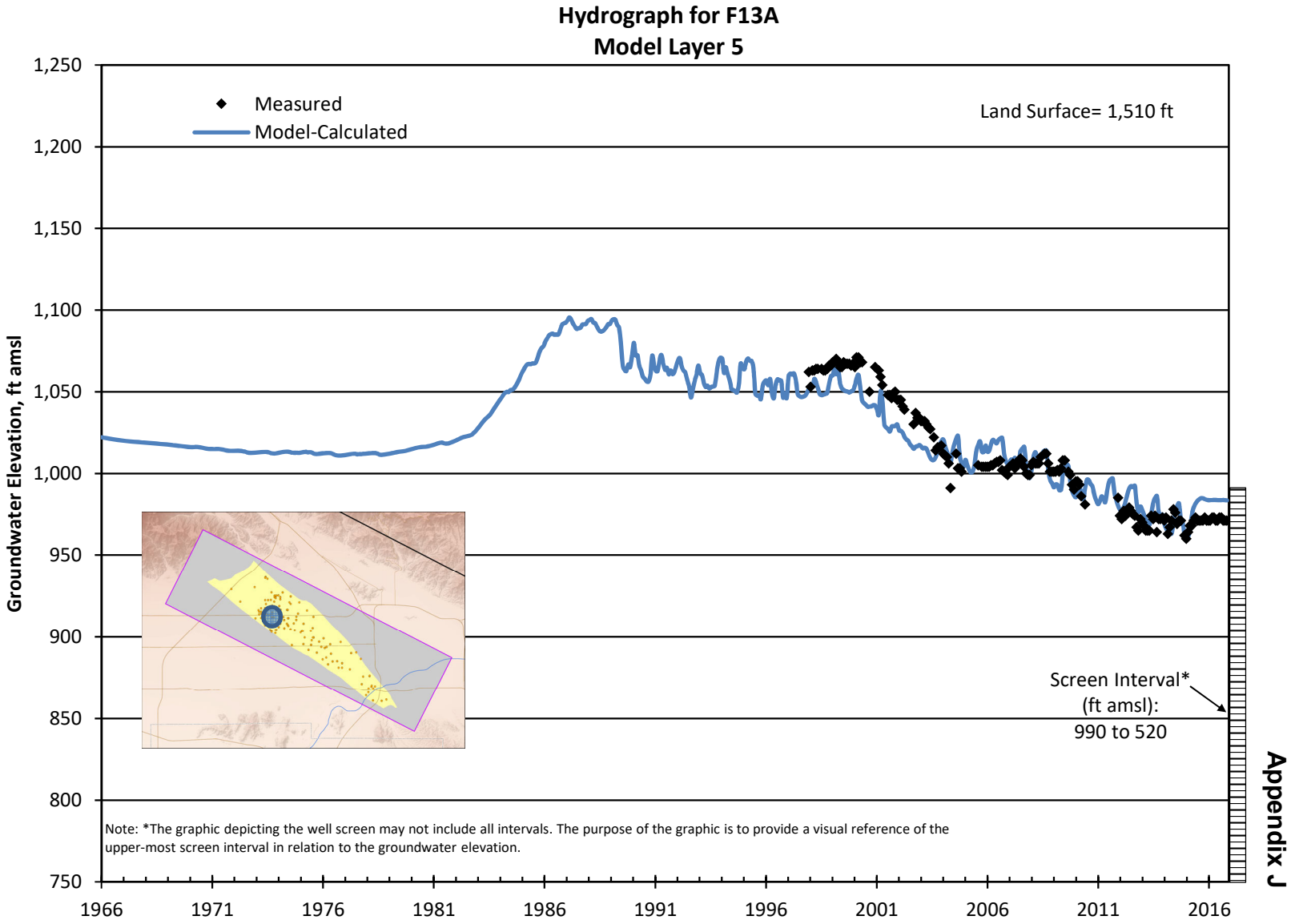

Hydrograph for EPA-MP6C
Model Layer 6
Land Surface= 1,273 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
704 to 694
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

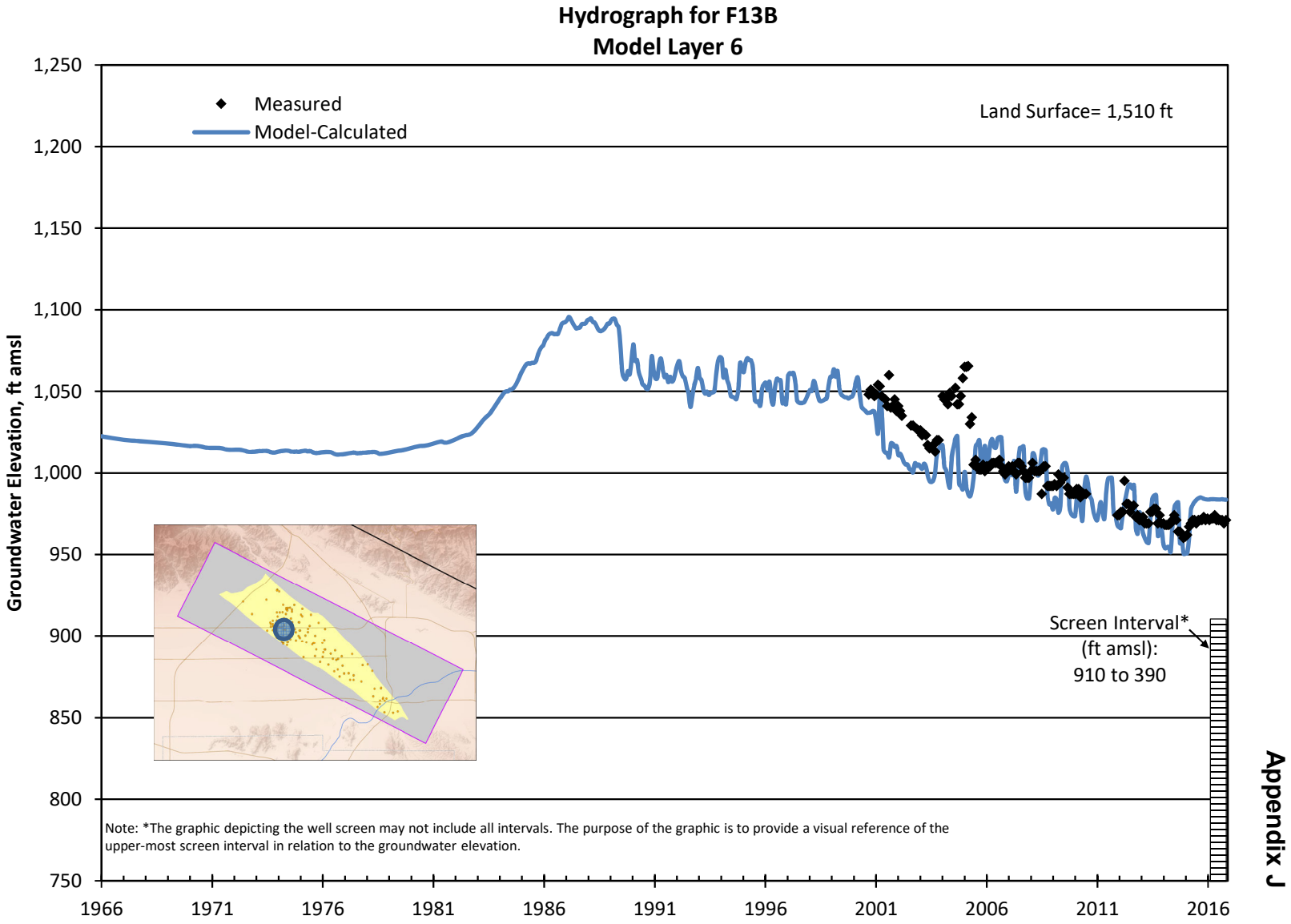
Appendix J


Hydrograph for F10A
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,406 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
886 to 786
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Appendix J

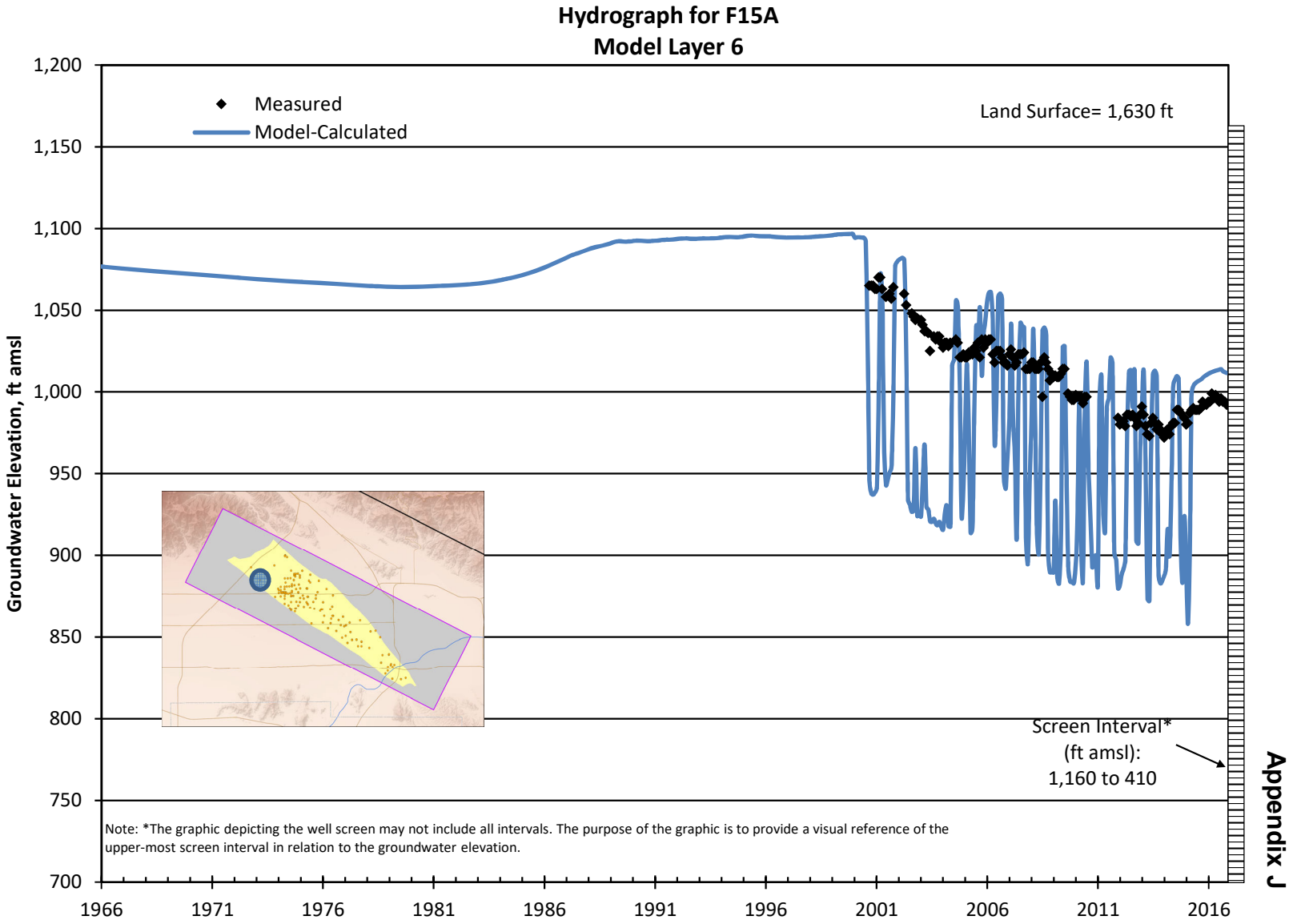

Hydrograph for F10B
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,406 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
906 to 376
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Appendix J

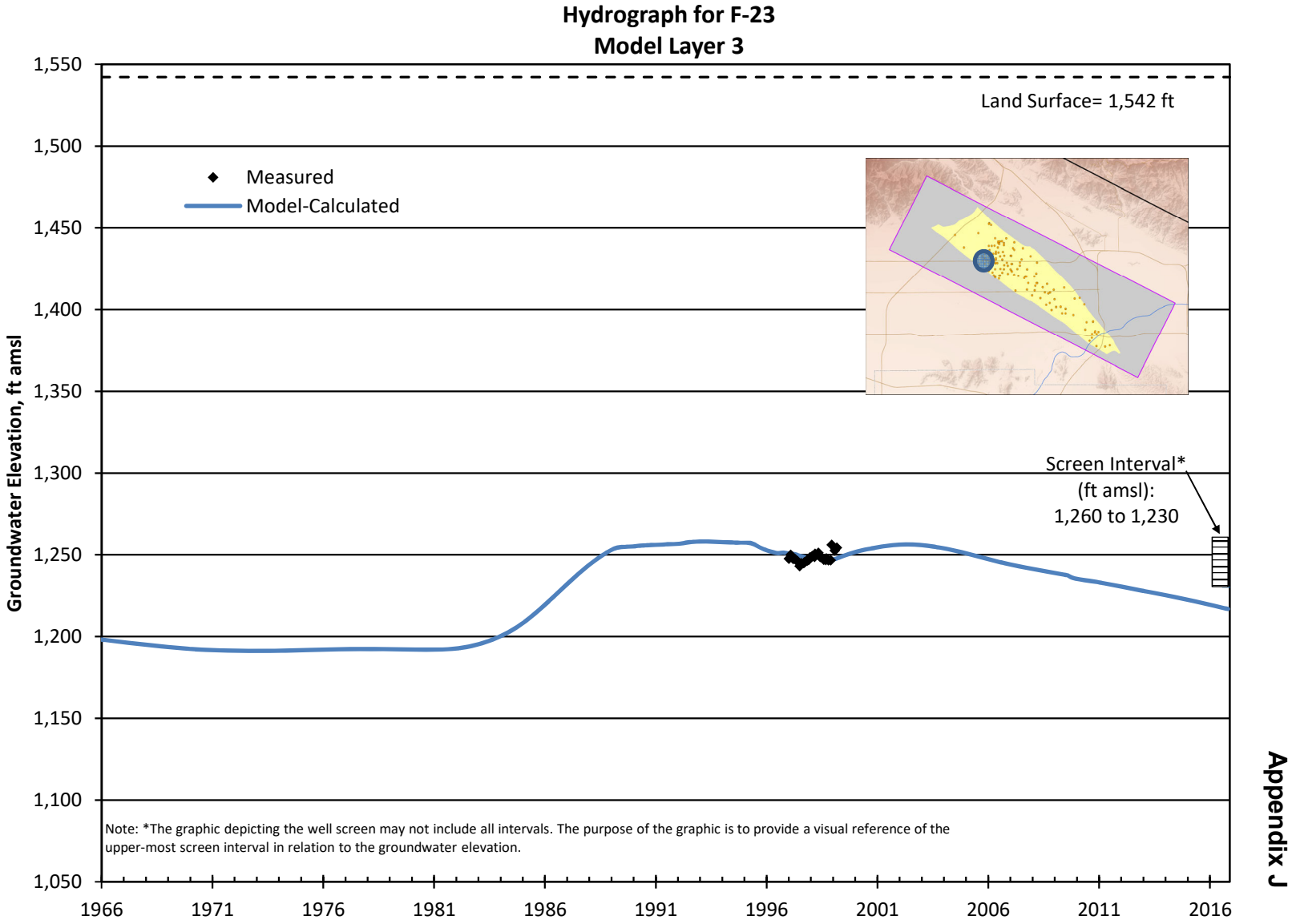

Hydrograph for F10C
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,406 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,006 to 616
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Appendix J


Hydrograph for F13A
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,510 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
990 to 520
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Appendix J

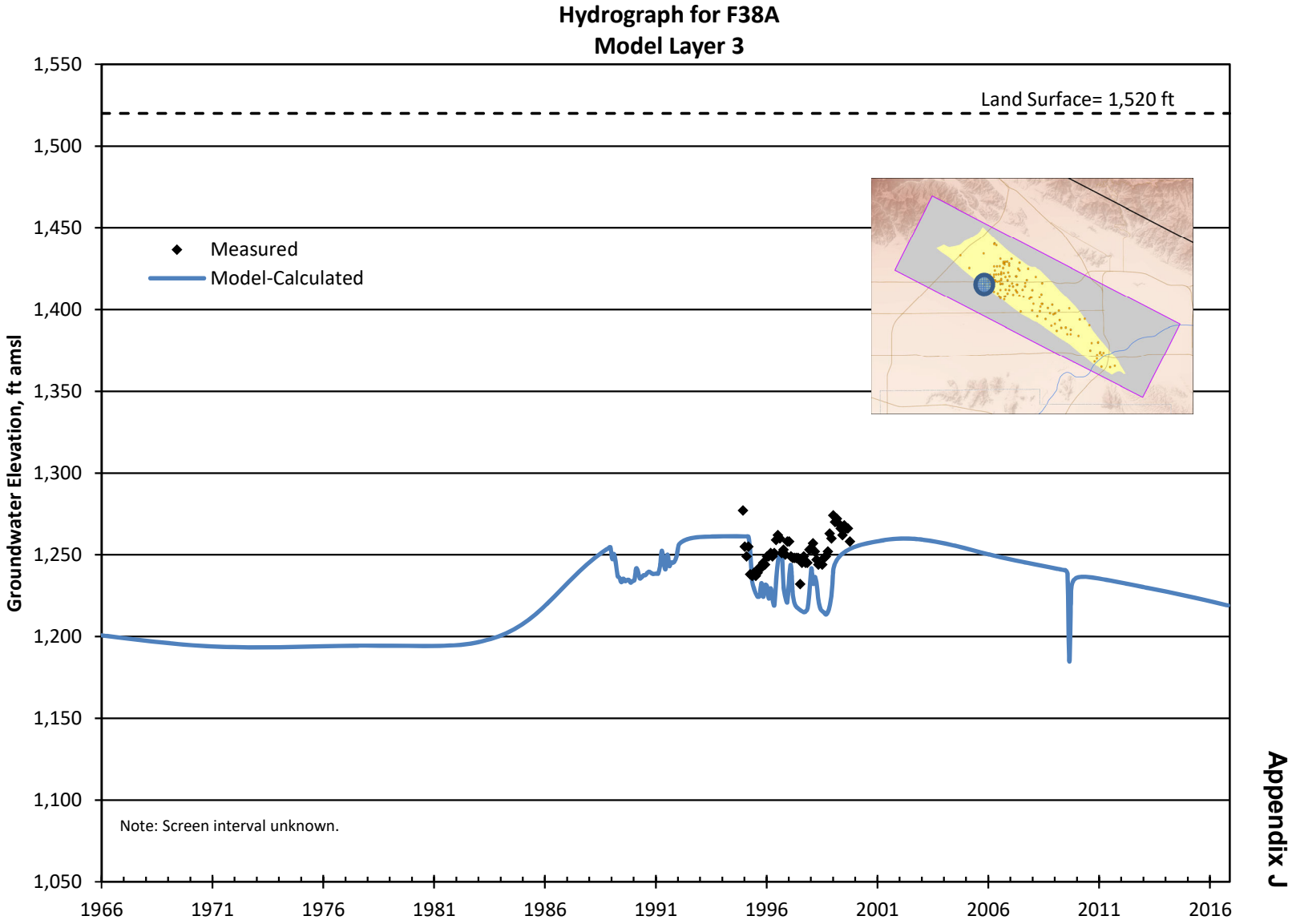

Hydrograph for F13B
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,510 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
910 to 390
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

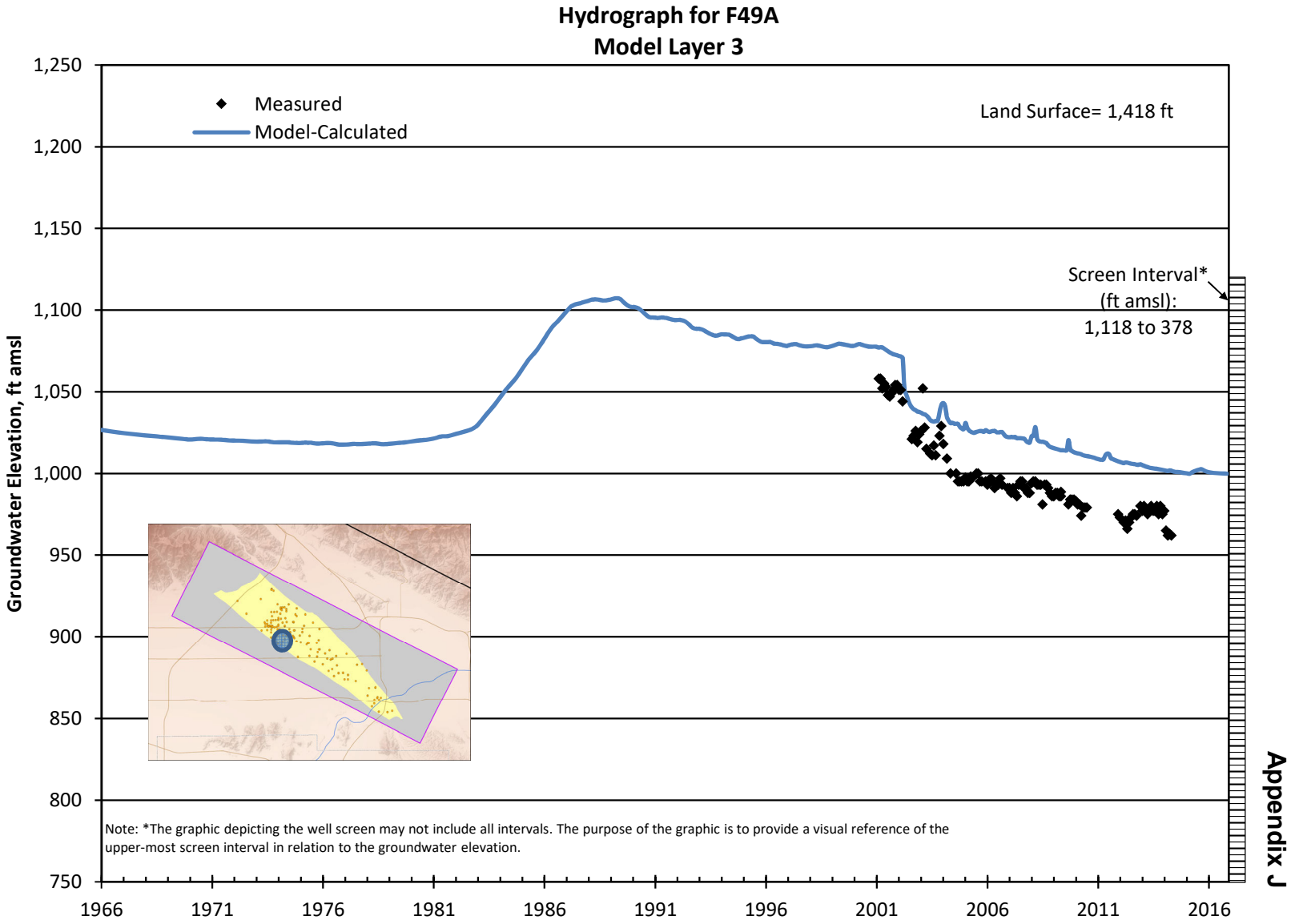

Hydrograph for F15A
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,630 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,160 to 410
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Appendix J


Hydrograph for F-23
Model Layer 3
Groundwater Elevation, ft amsl
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,542 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,260 to 1,230
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

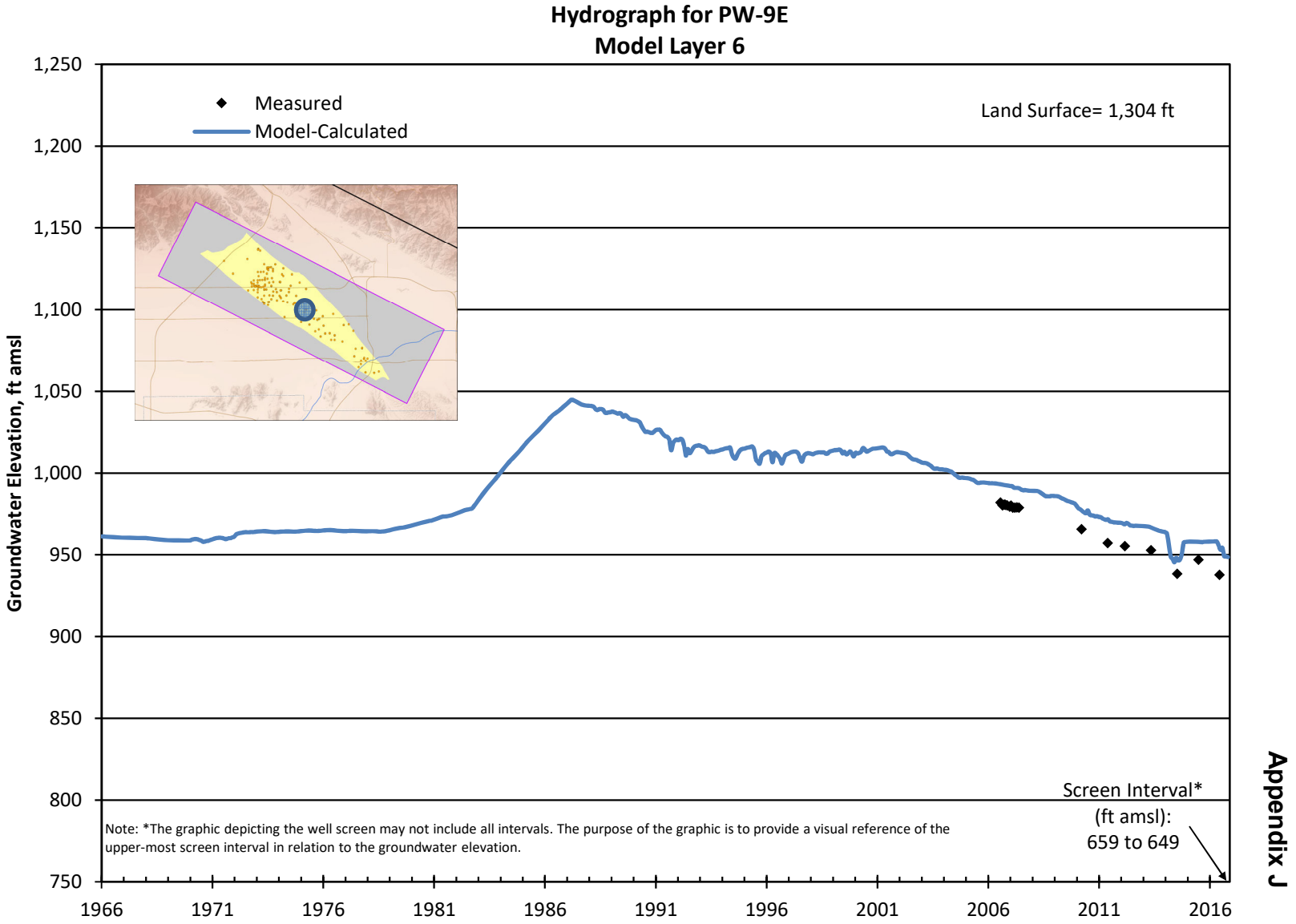
Appendix J


Hydrograph for F38A
Model Layer 3
Land Surface= 1,520 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

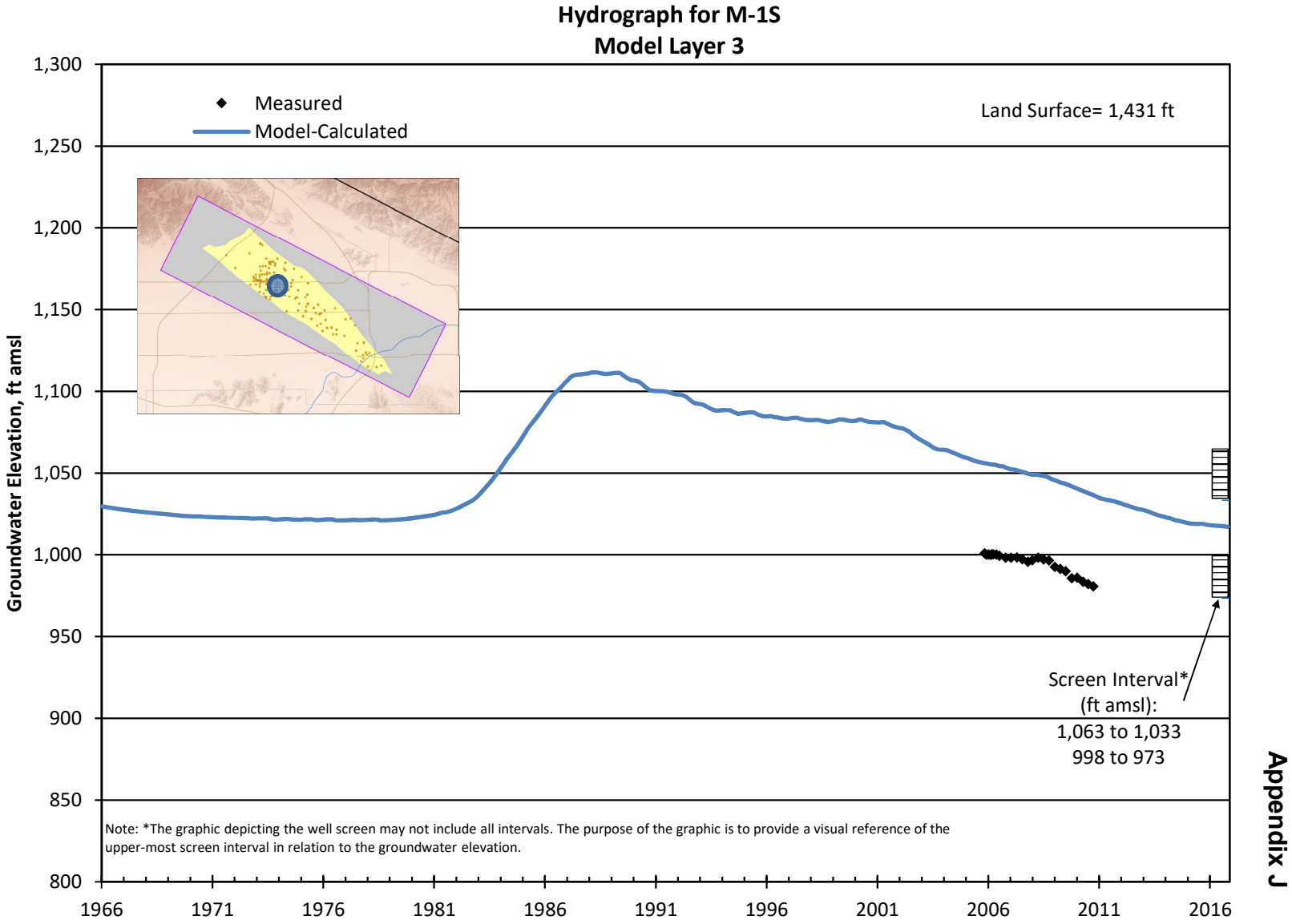
Appendix J


Hydrograph for F49A
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,418 ft
Screen Interval*
(ft amsl):
1,118 to 378
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

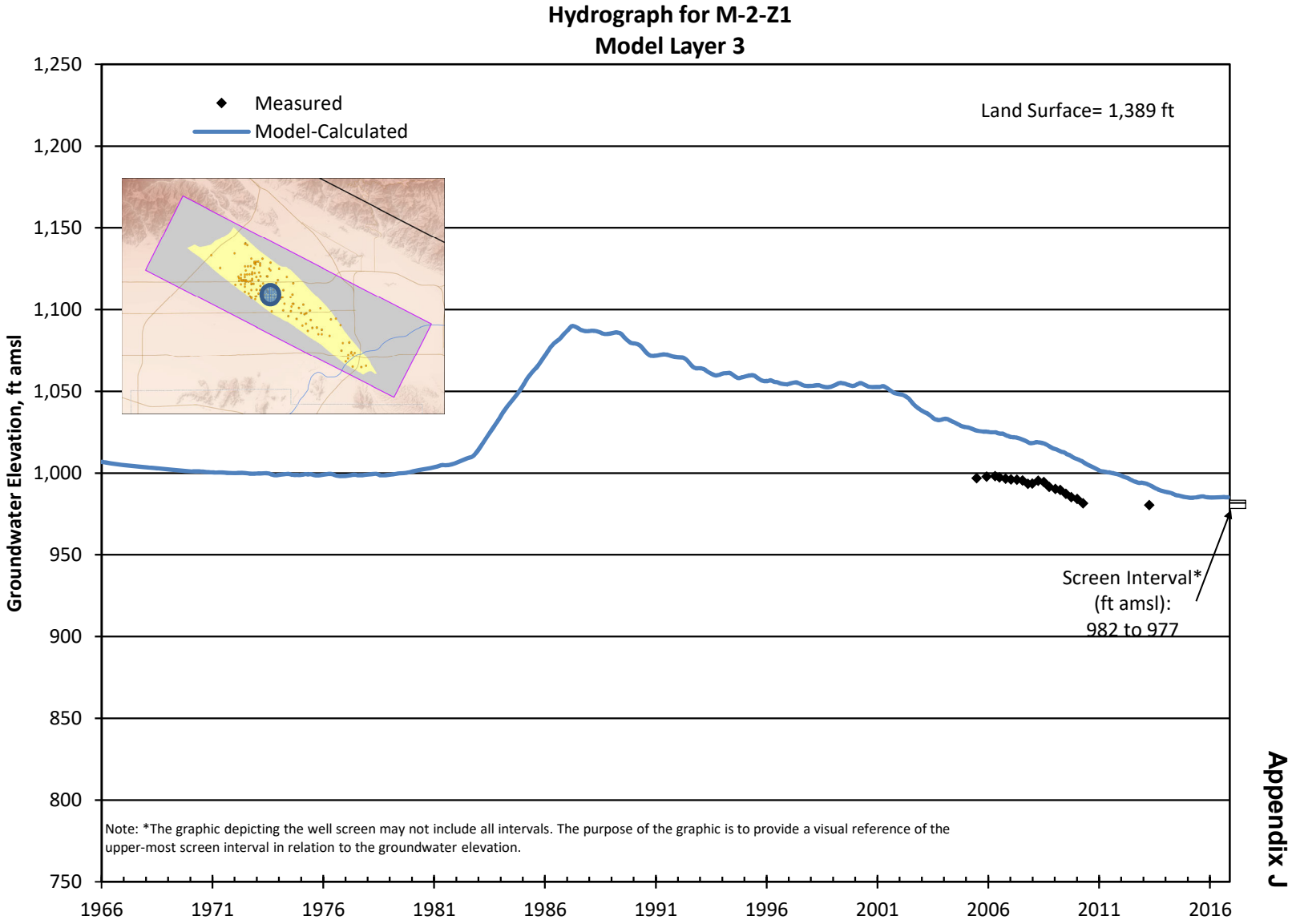
Appendix J


Hydrograph for PW-9E
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,304 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
659 to 649
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

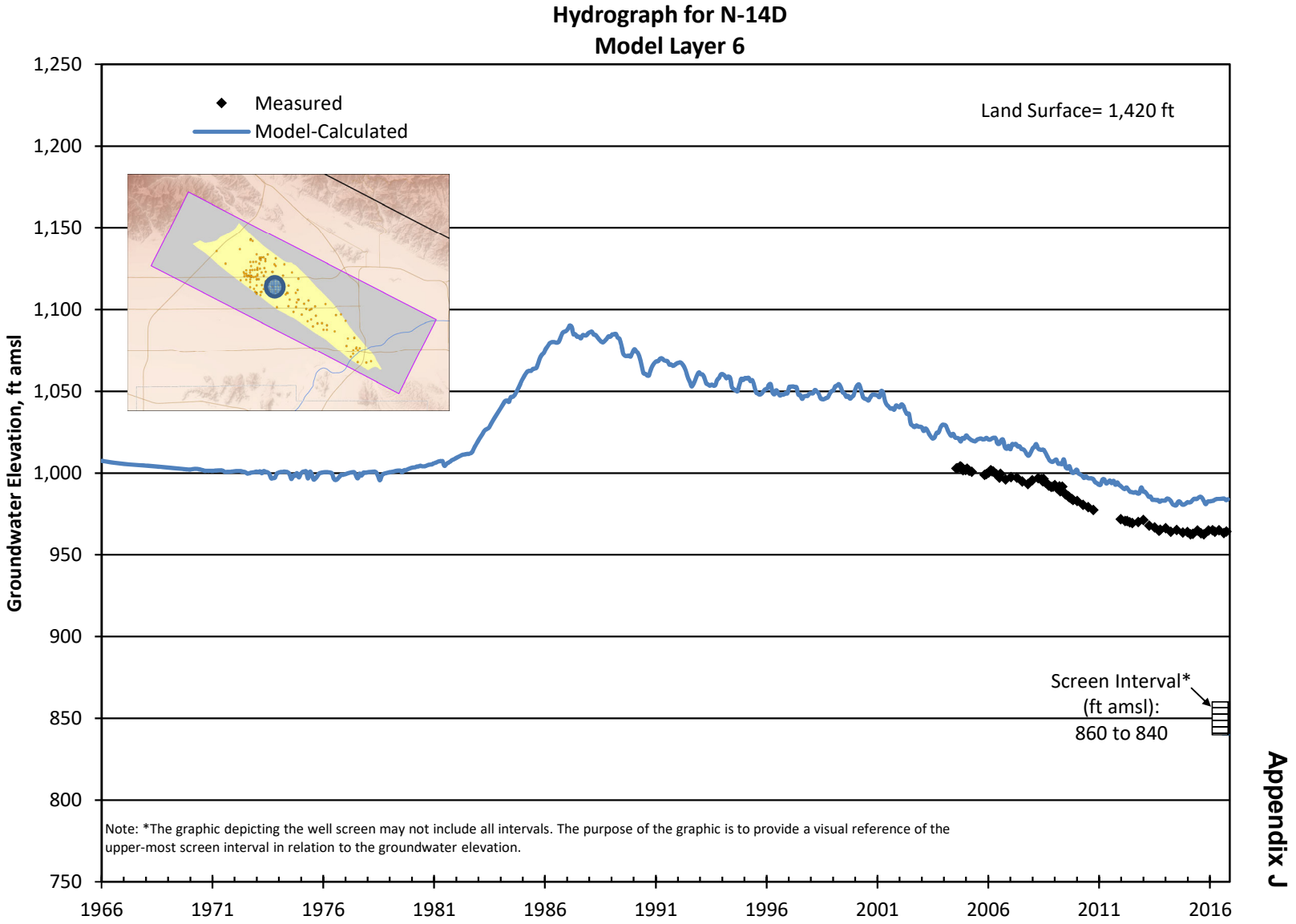
Appendix J


Hydrograph for M-1S
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,431 ft
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,063 to 1,033
998 to 973
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

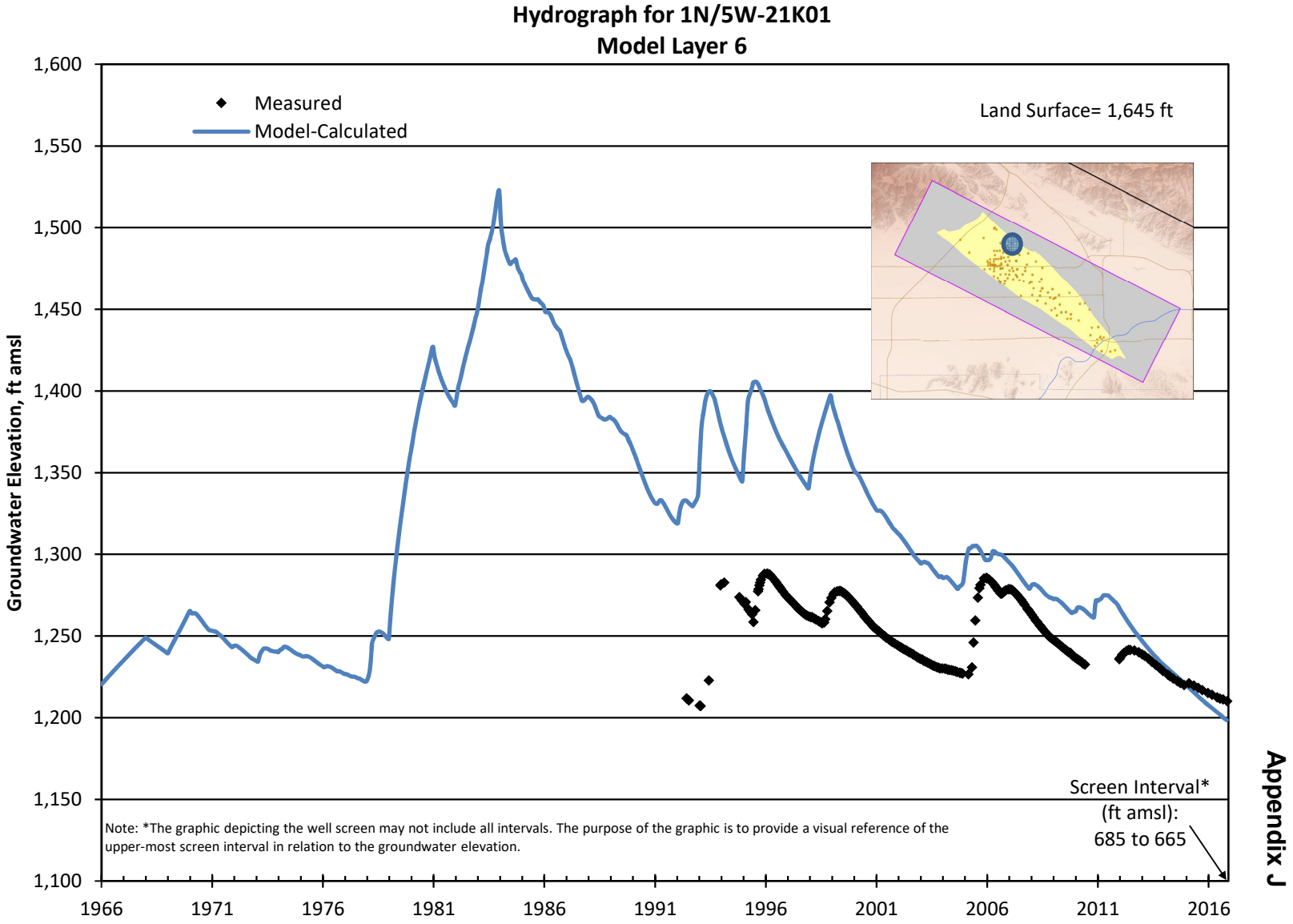
Appendix J


Hydrograph for M-2-Z1
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,389 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
982 to 977
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

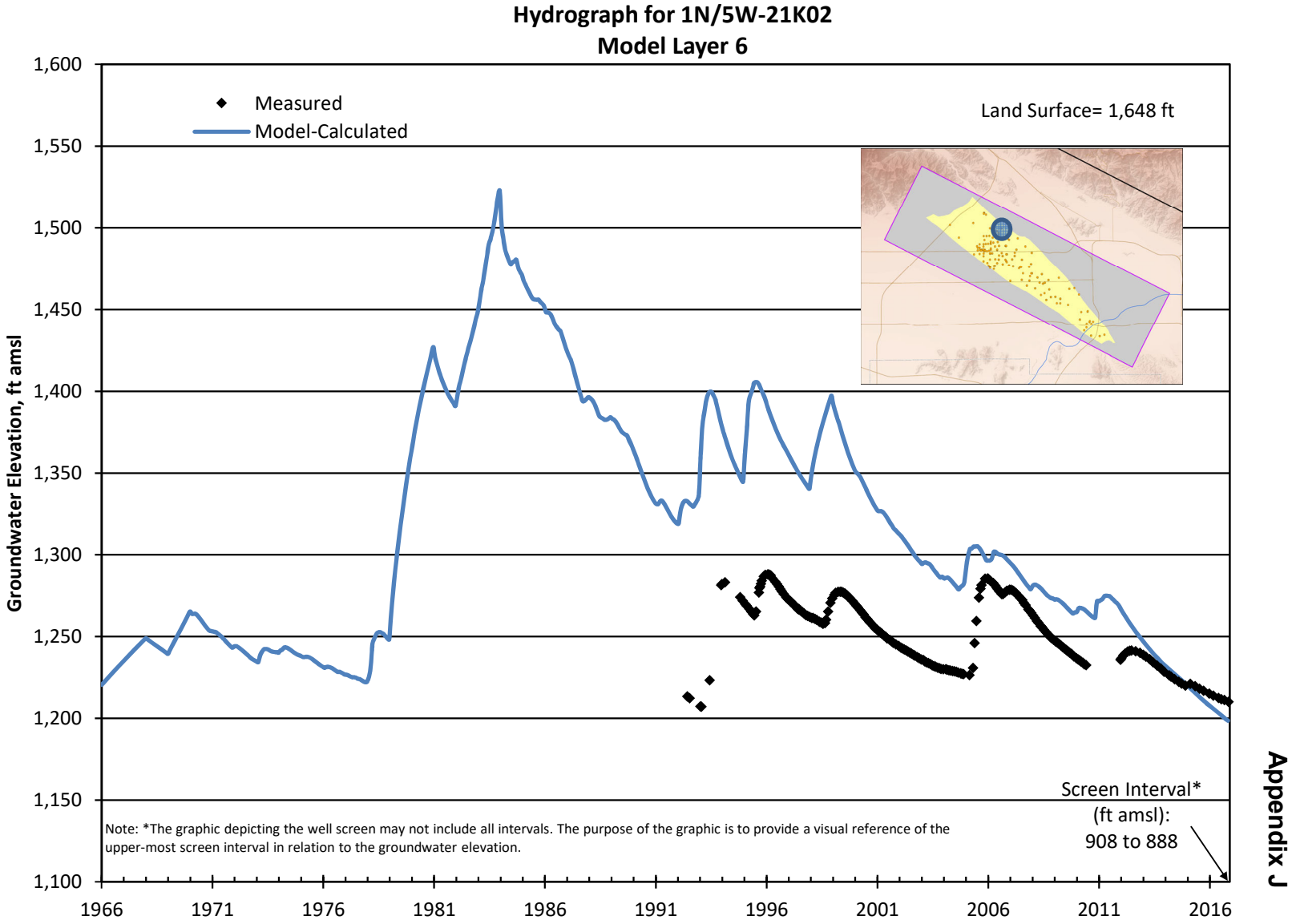
Appendix J


Hydrograph for N-14D
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,420 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
860 to 840
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

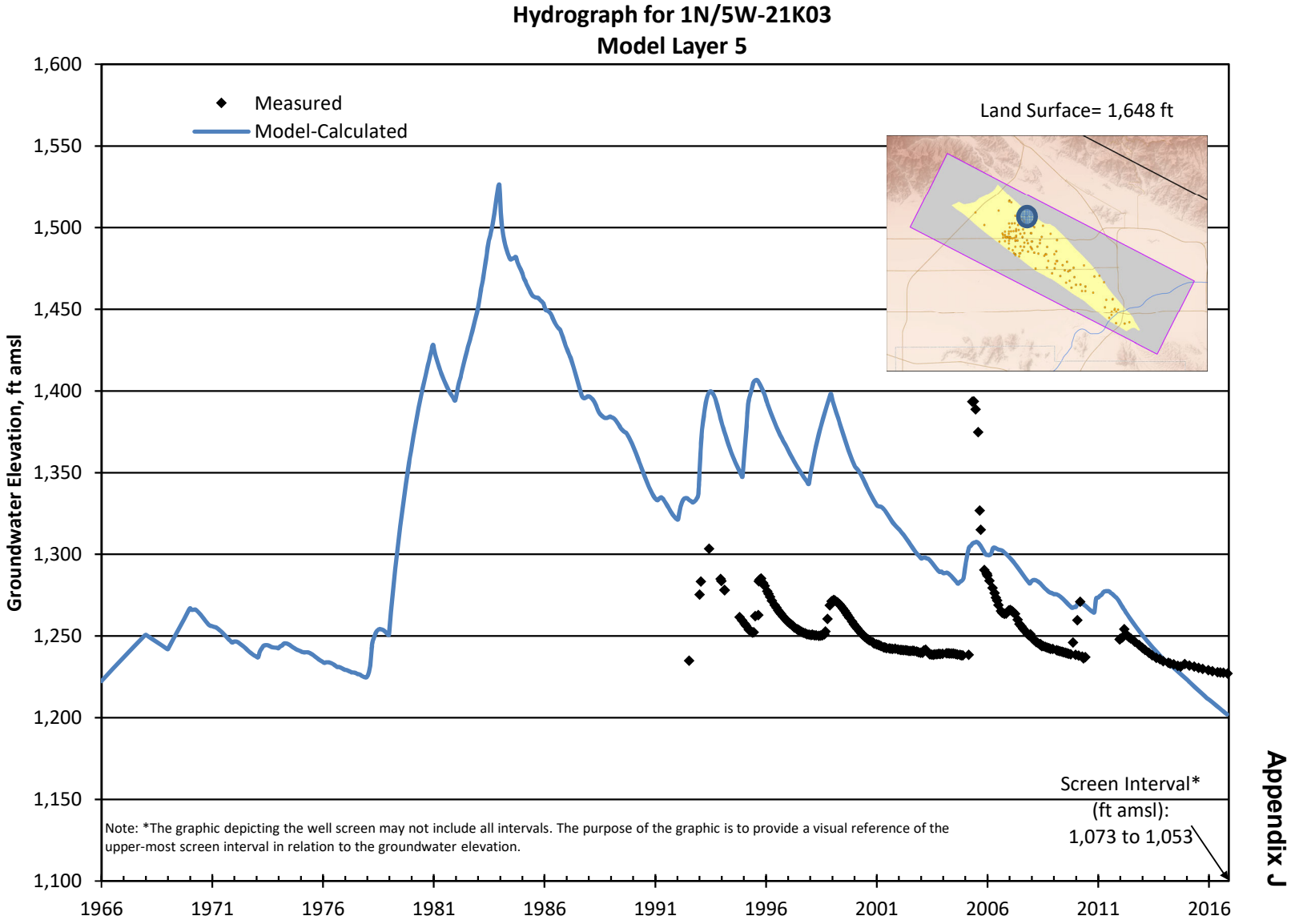
Appendix J


Hydrograph for 1N/5W-21K01
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,645 ft
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
685 to 665
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

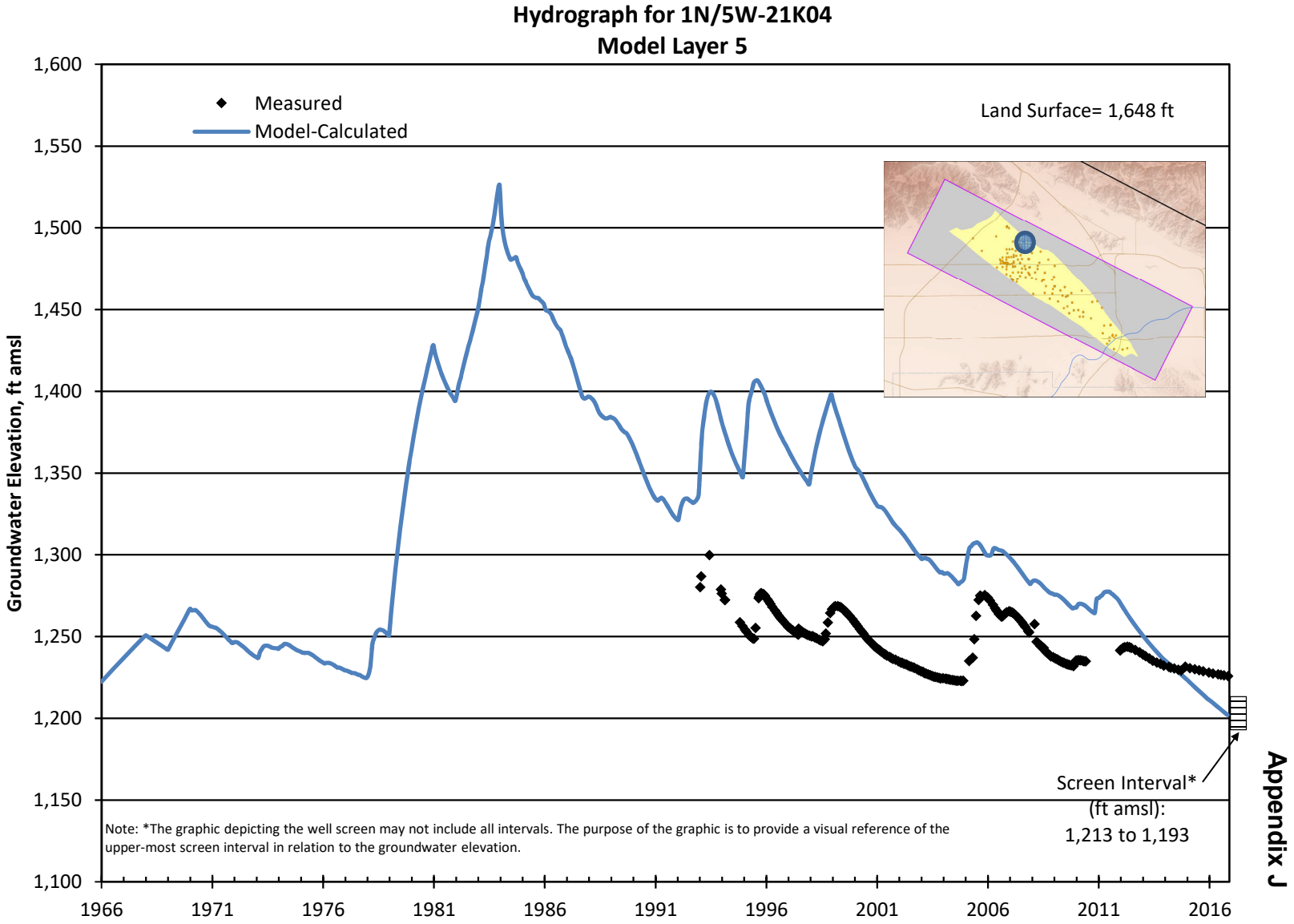
Appendix J


Hydrograph for 1N/5W-21K02
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,648 ft
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
908 to 888
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

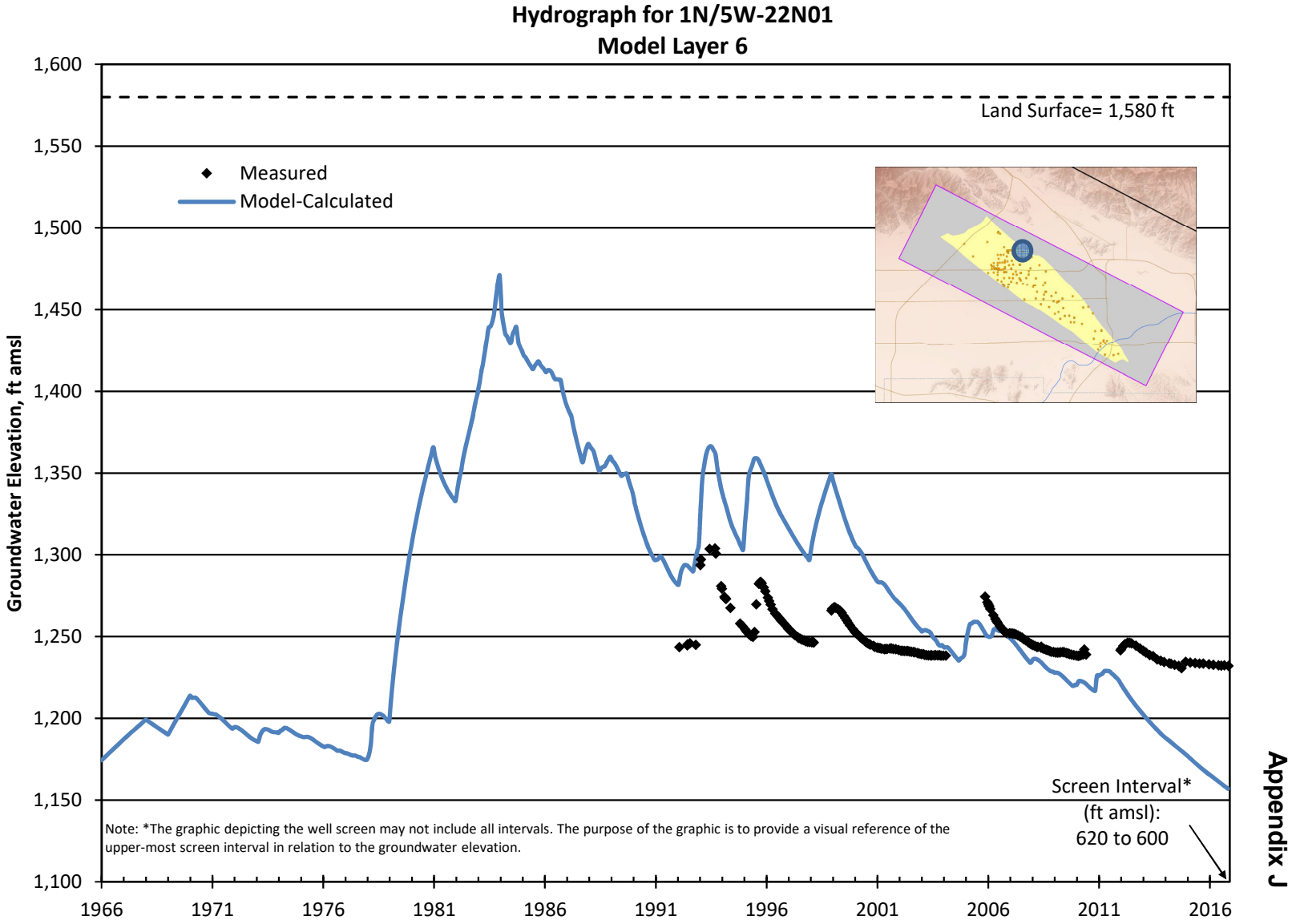
Appendix J


Hydrograph for 1N/5W-21K03
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,648 ft
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,073 to 1,053
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

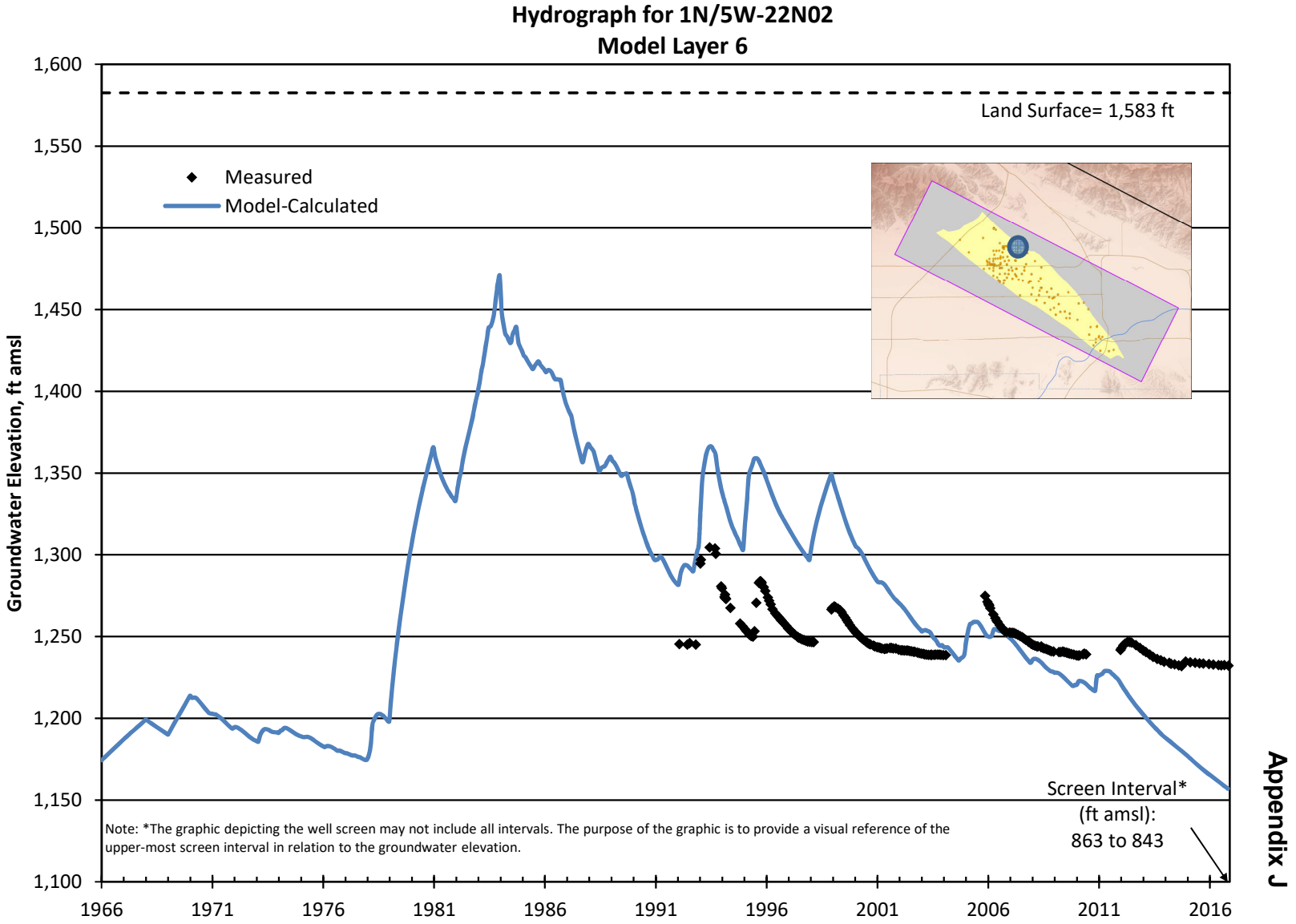
Appendix J


Hydrograph for 1N/5W-21K04
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,648 ft
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,213 to 1,193
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

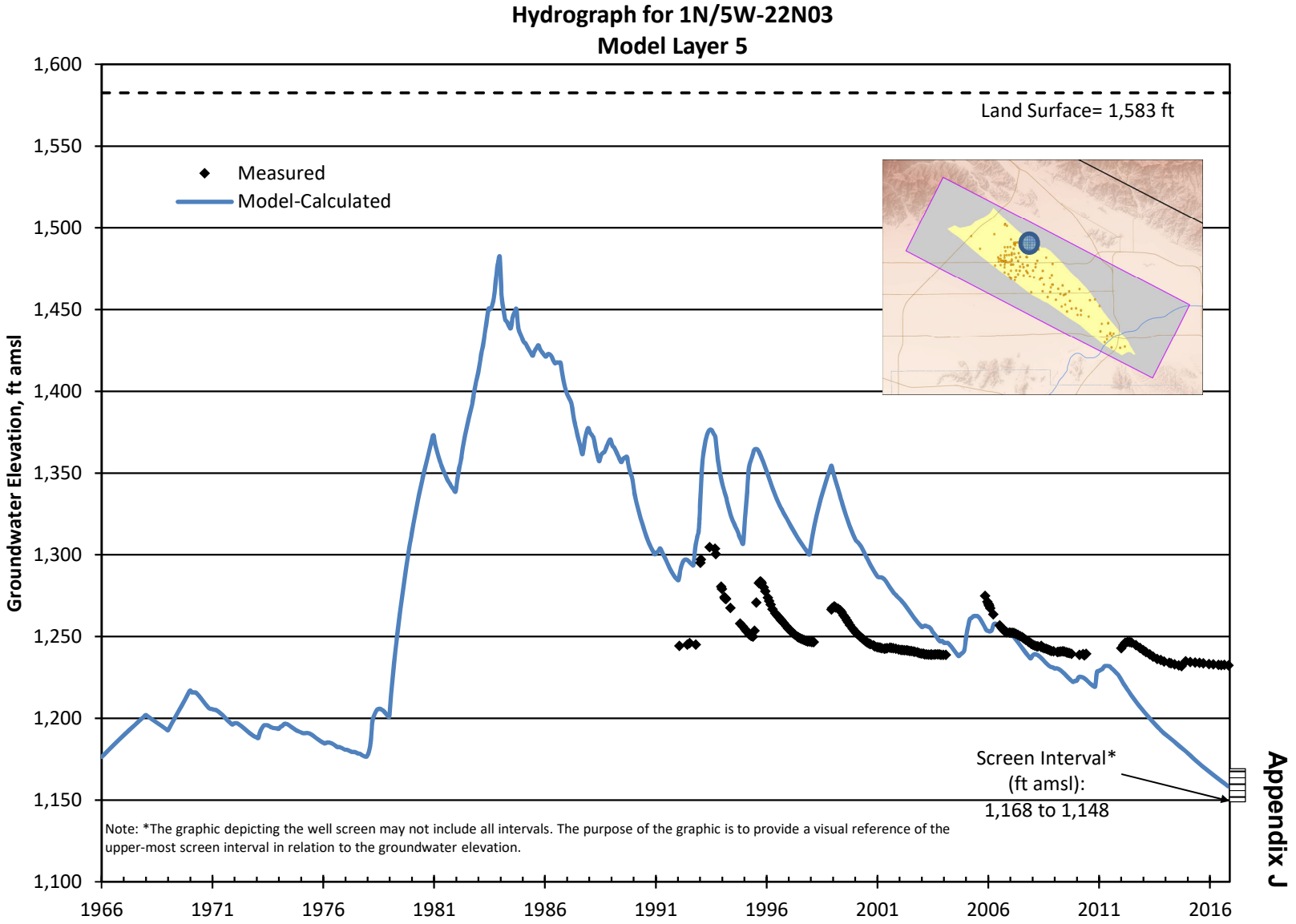
Appendix J


Hydrograph for 1N/5W-22N01
Model Layer 6
Land Surface= 1,580 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
620 to 600
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

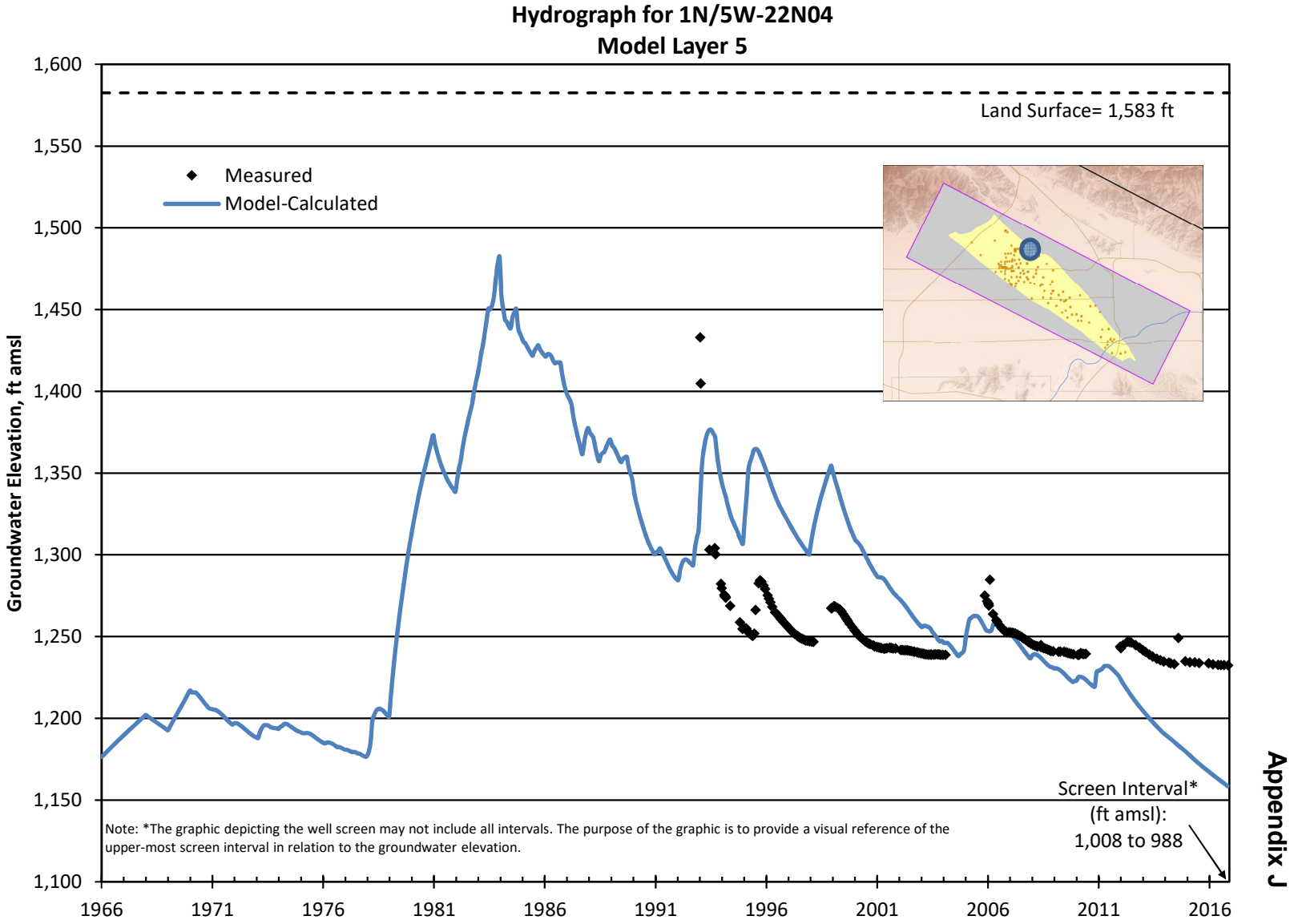
Appendix J


Hydrograph for 1N/5W-22N02
Model Layer 6
Land Surface= 1,583 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
863 to 843
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

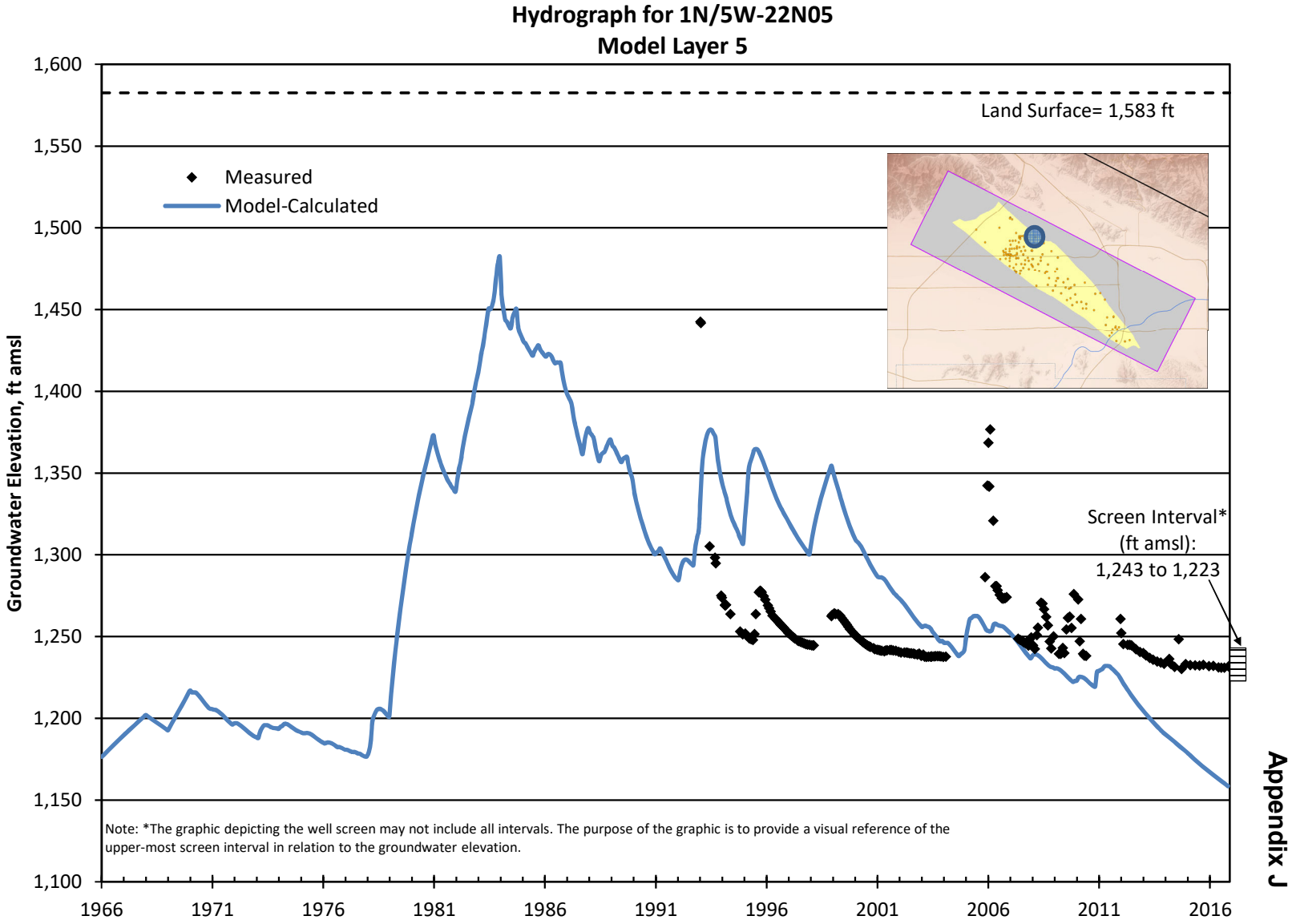
Appendix J


Hydrograph for 1N/5W-22N03
Model Layer 5
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,583 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,168 to 1,148
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

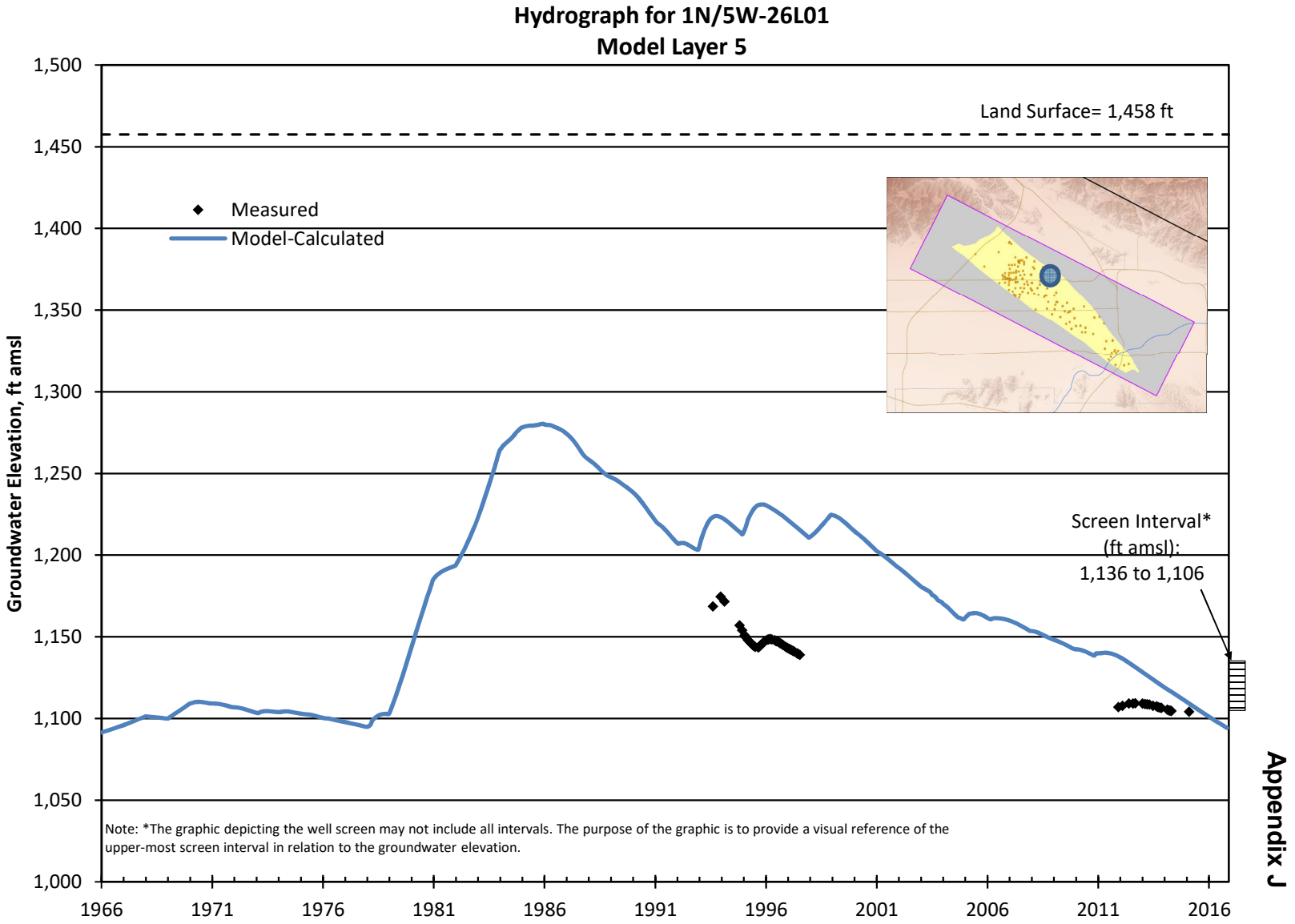
Appendix J


Hydrograph for 1N/5W-22N04
Model Layer 5
Land Surface= 1,583 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,008 to 988
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

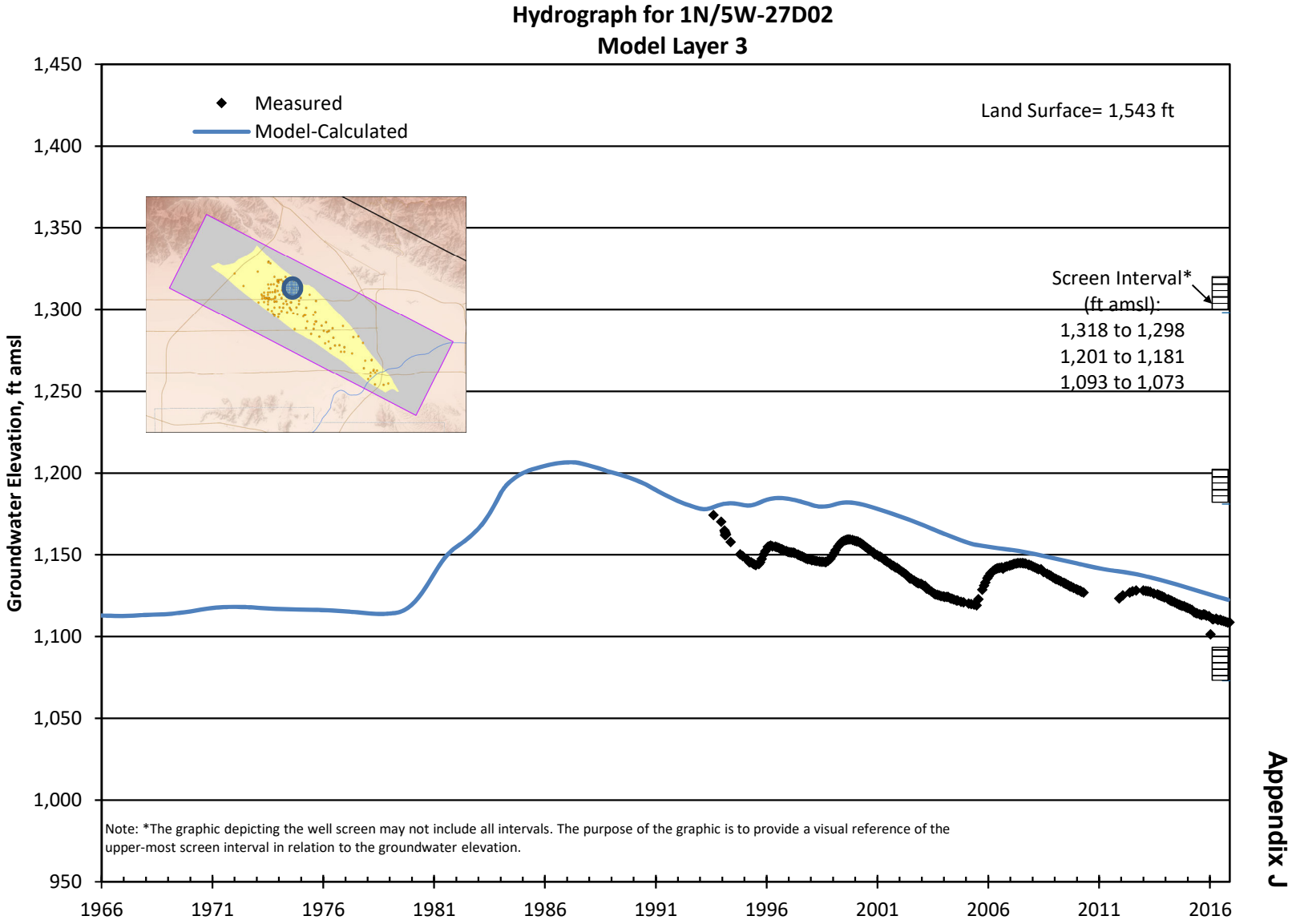
Appendix J


Hydrograph for 1N/5W-22N05
Model Layer 5
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,583 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,243 to 1,223
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

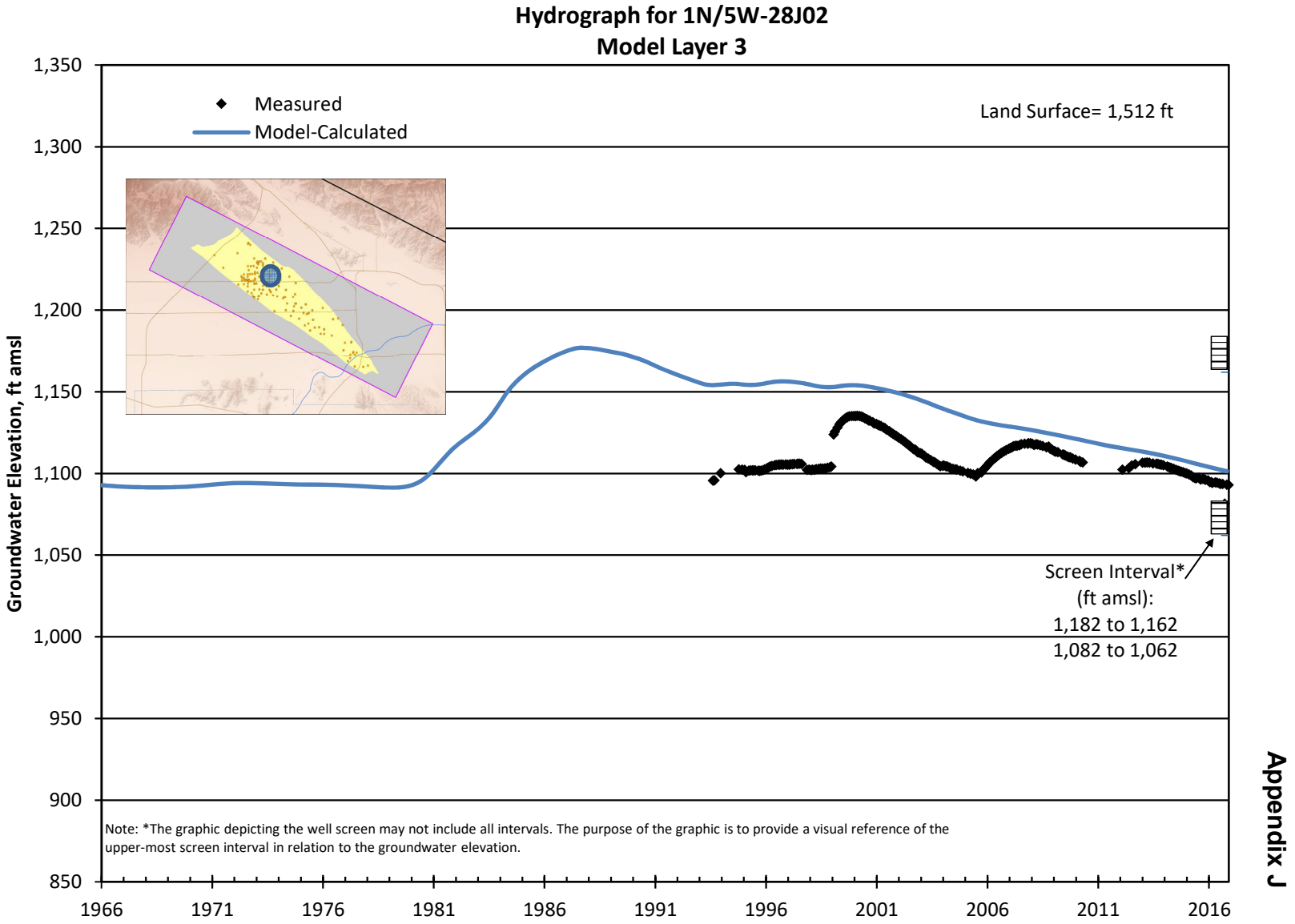
Appendix J


Hydrograph for 1N/5W-26L01
Model Layer 5
Land Surface= 1,458 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,136 to 1,106
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

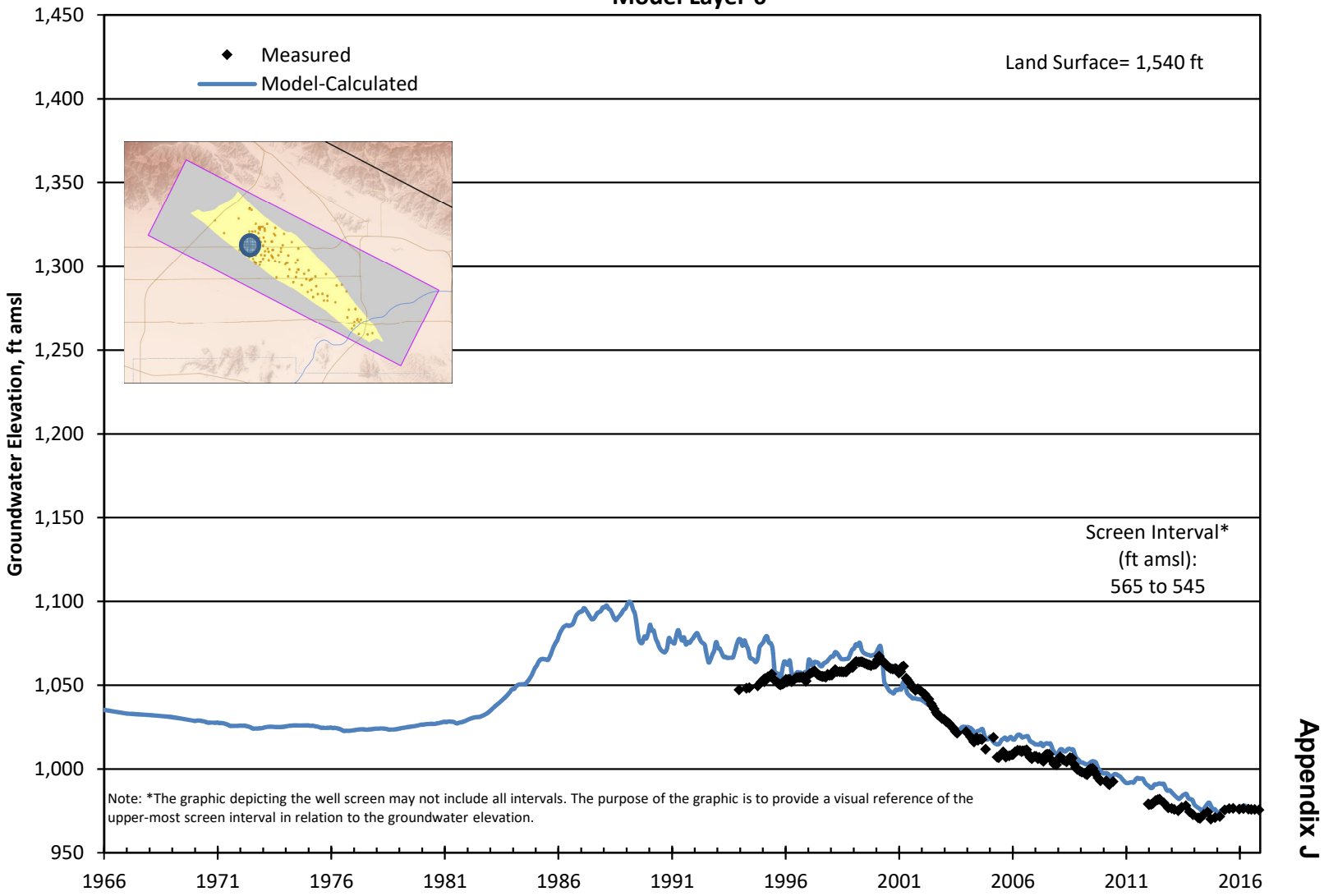

Hydrograph for 1N/5W-27D02
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,543 ft
Screen Interval*
(ft amsl):
1,318 to 1,298
1,201 to 1,181
1,093 to 1,073
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

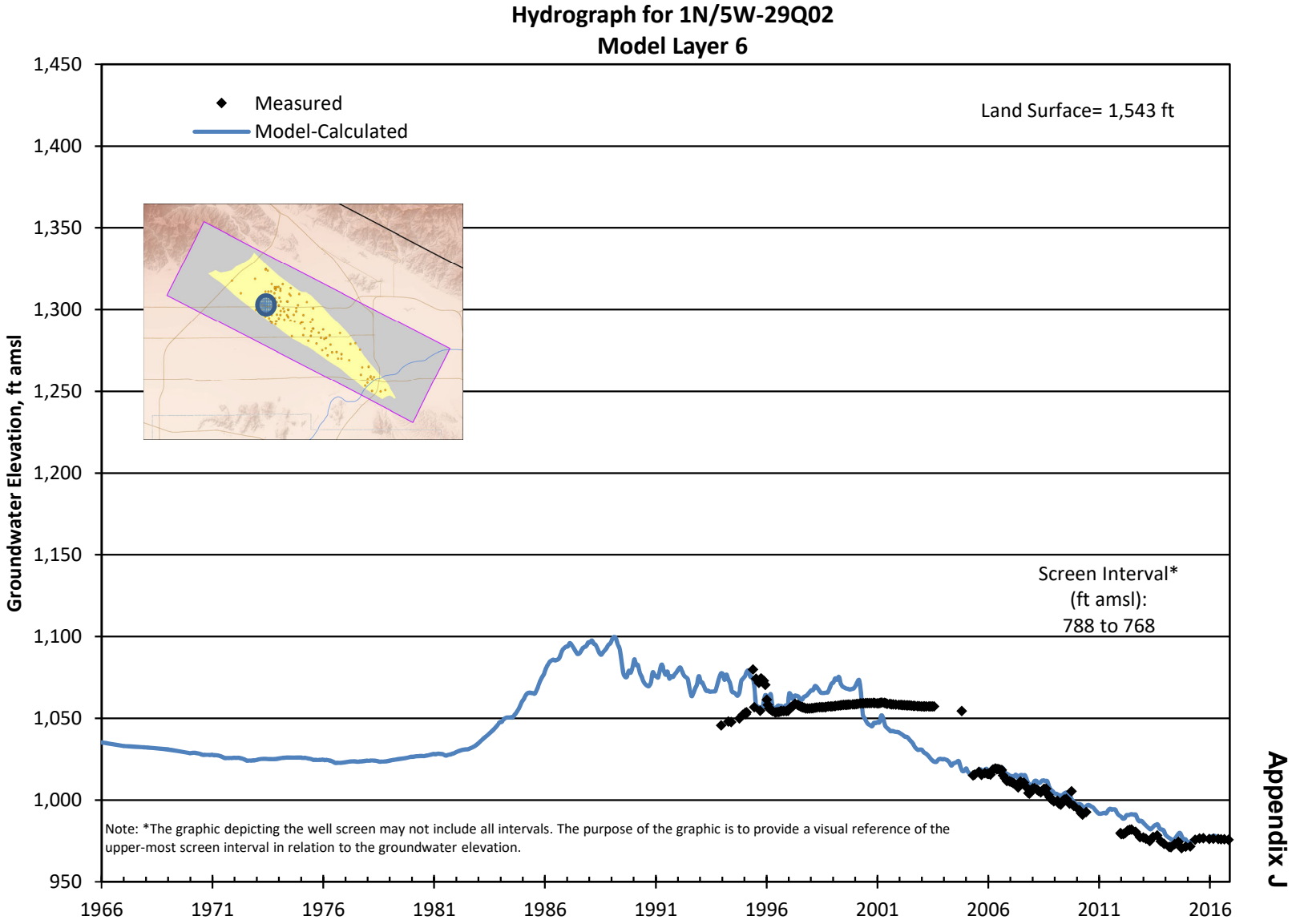

Hydrograph for 1N/5W-28J02
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,512 ft
Groundwater Elevation, ft amsl
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,182 to 1,162
1,082 to 1,062
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

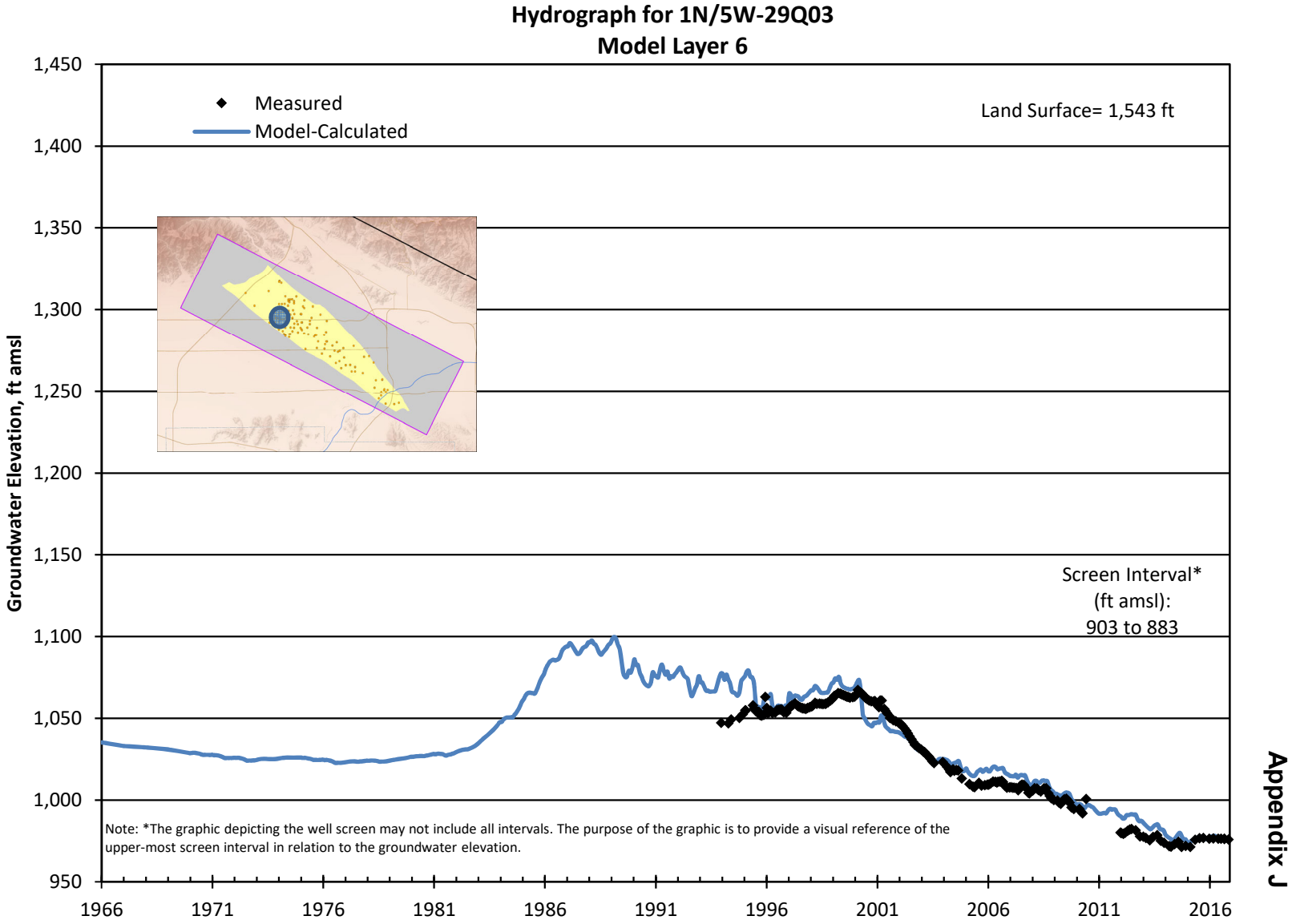
Hydrograph for 1N/5W-29Q01
Model Layer 6



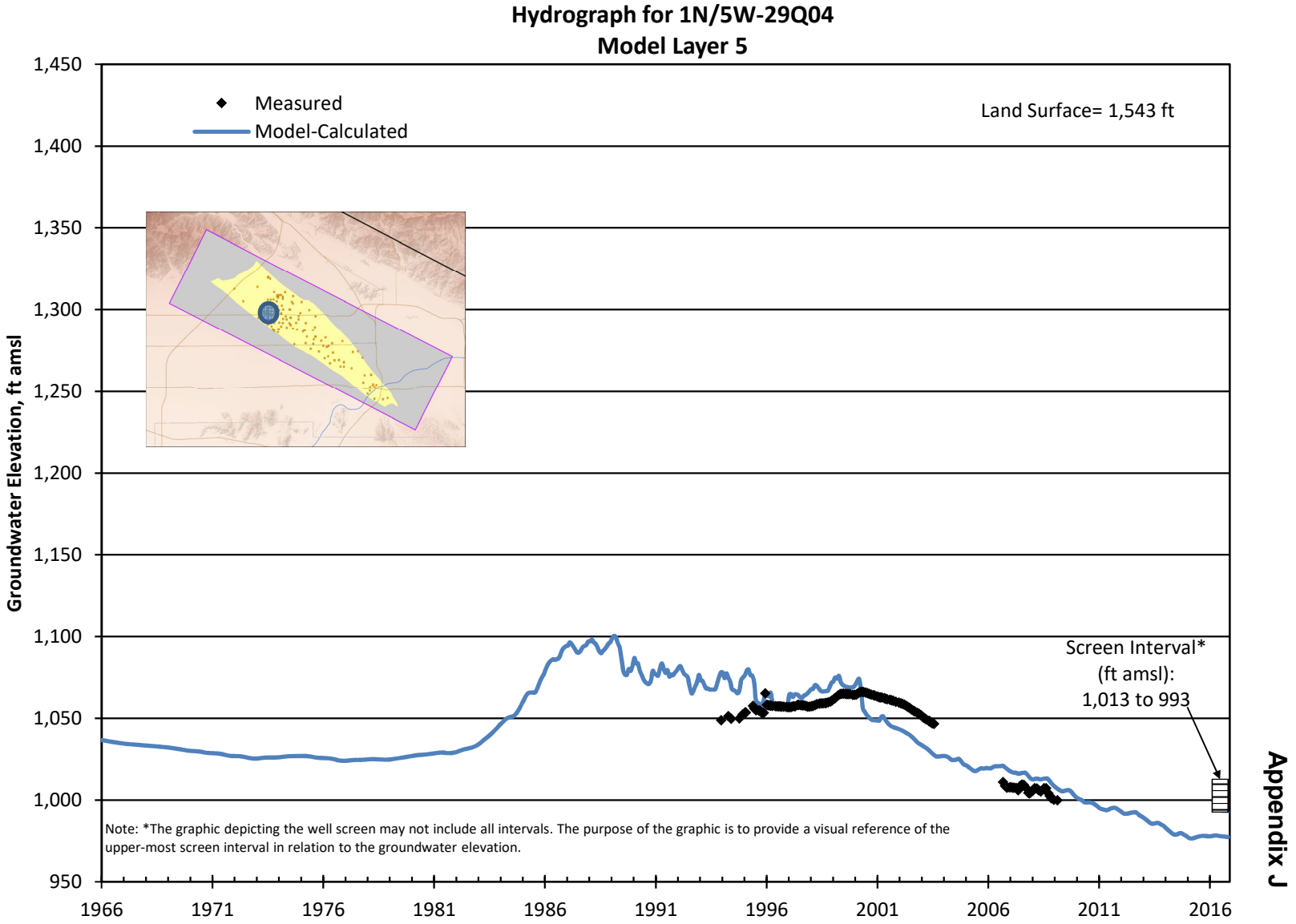
Appendix J


Hydrograph for 1N/5W-29Q02
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,543 ft
Screen Interval*
(ft amsl):
788 to 768
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

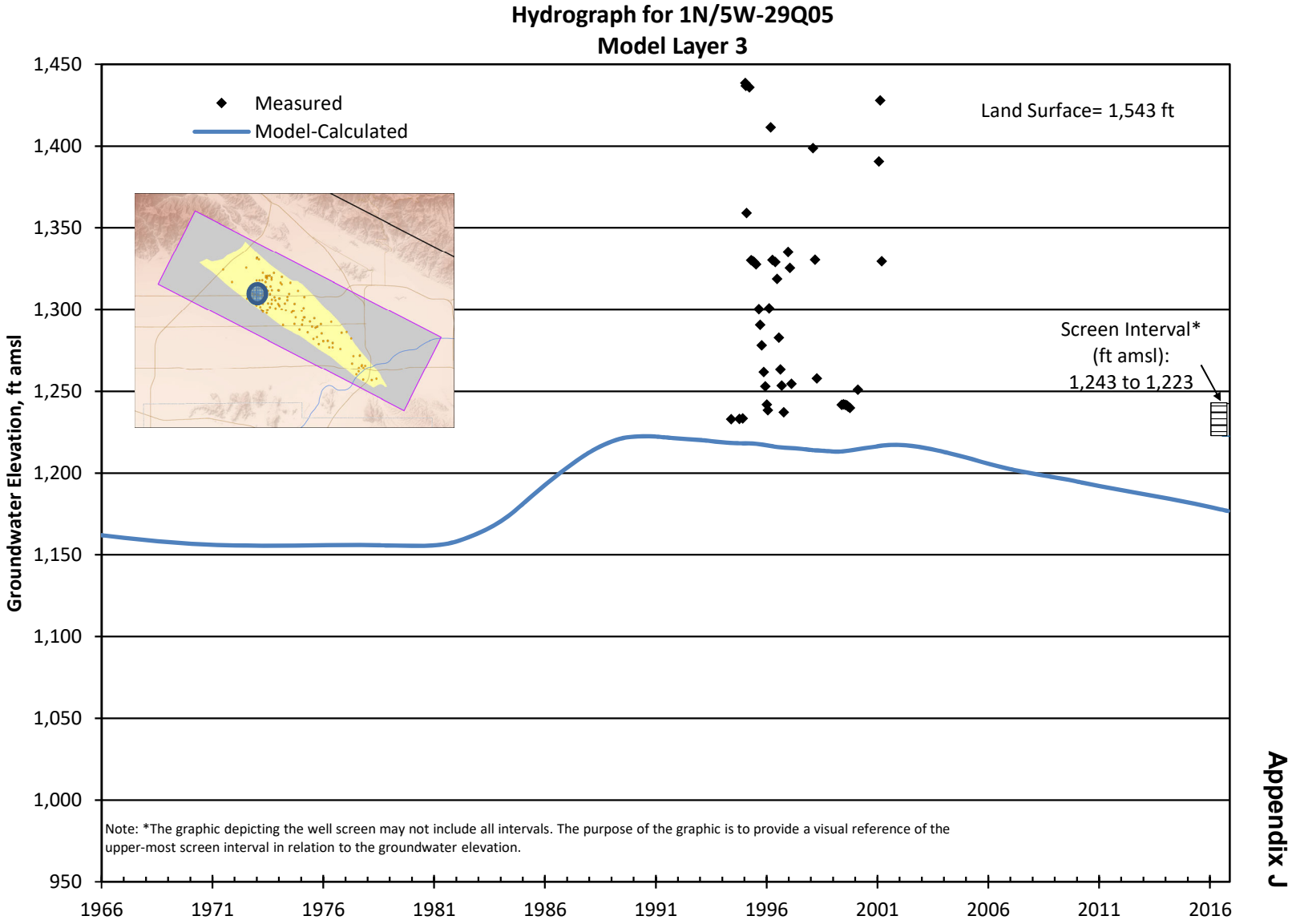
Appendix J


Hydrograph for 1N/5W-29Q03
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,543 ft
Screen Interval*
(ft amsl):
903 to 883
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

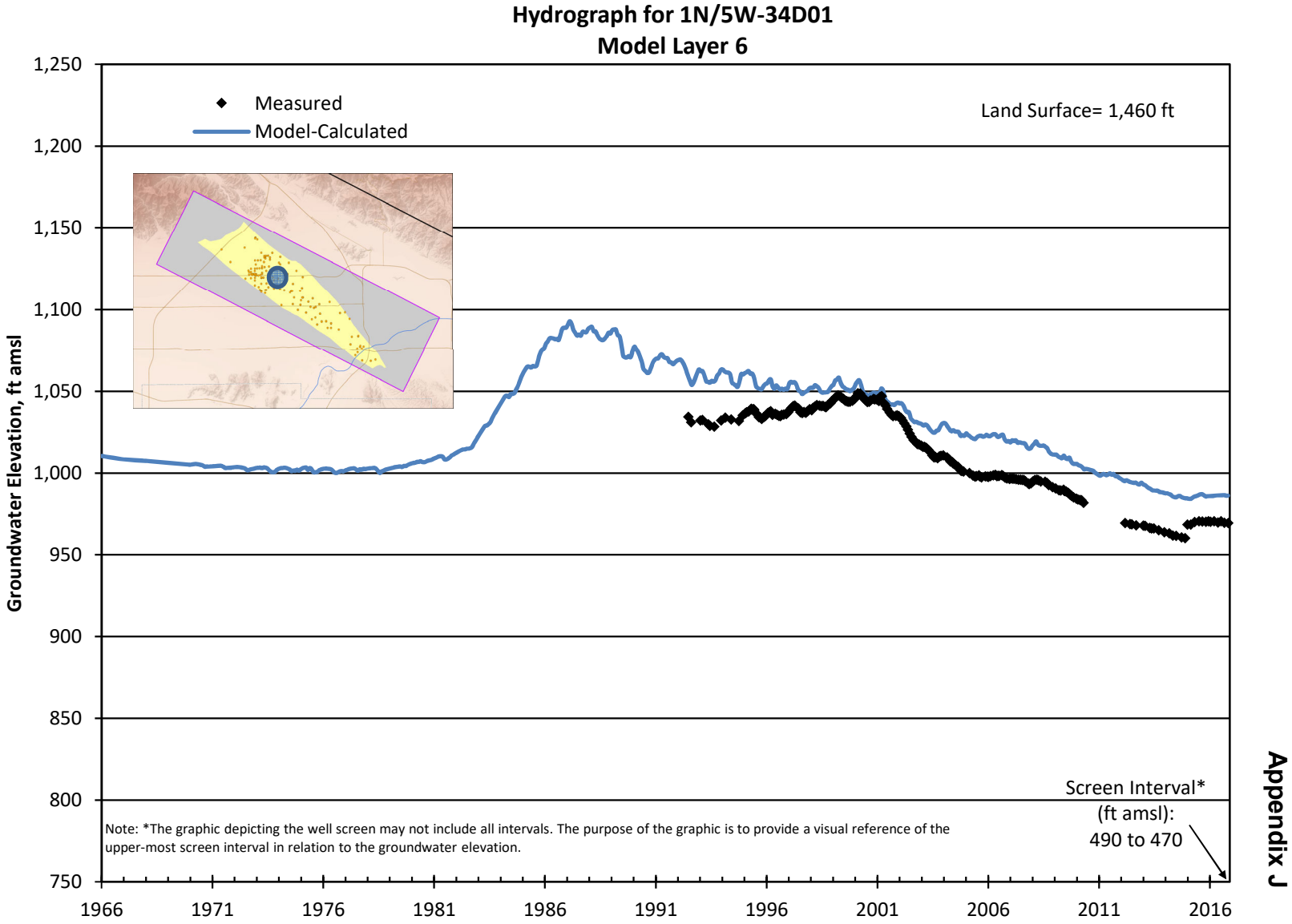
Appendix J


Hydrograph for 1N/5W-29Q04
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,543 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,013 to 993
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

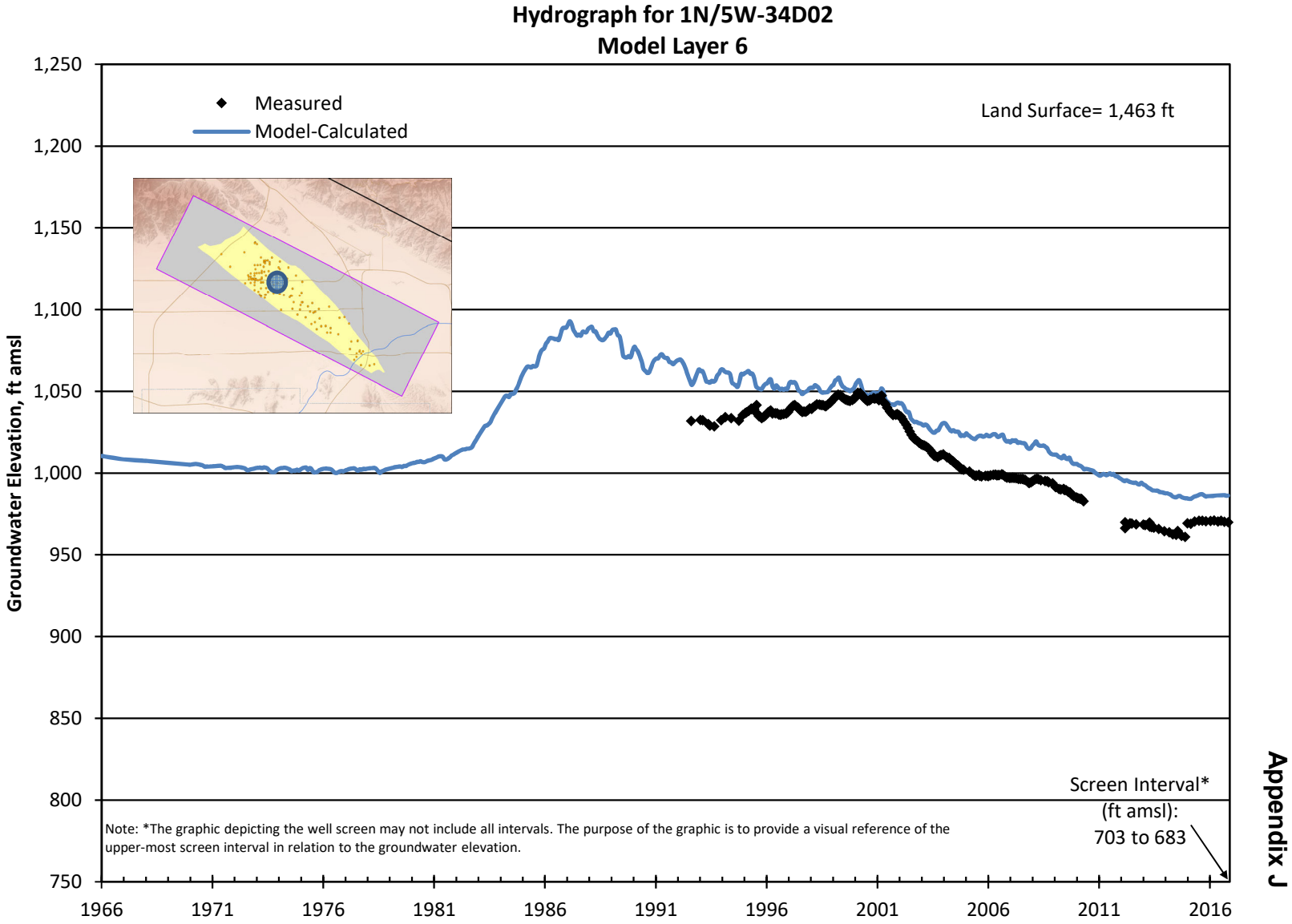
Appendix J


Hydrograph for 1N/5W-29Q05
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,543 ft
Screen Interval*
(ft amsl):
1,243 to 1,223
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

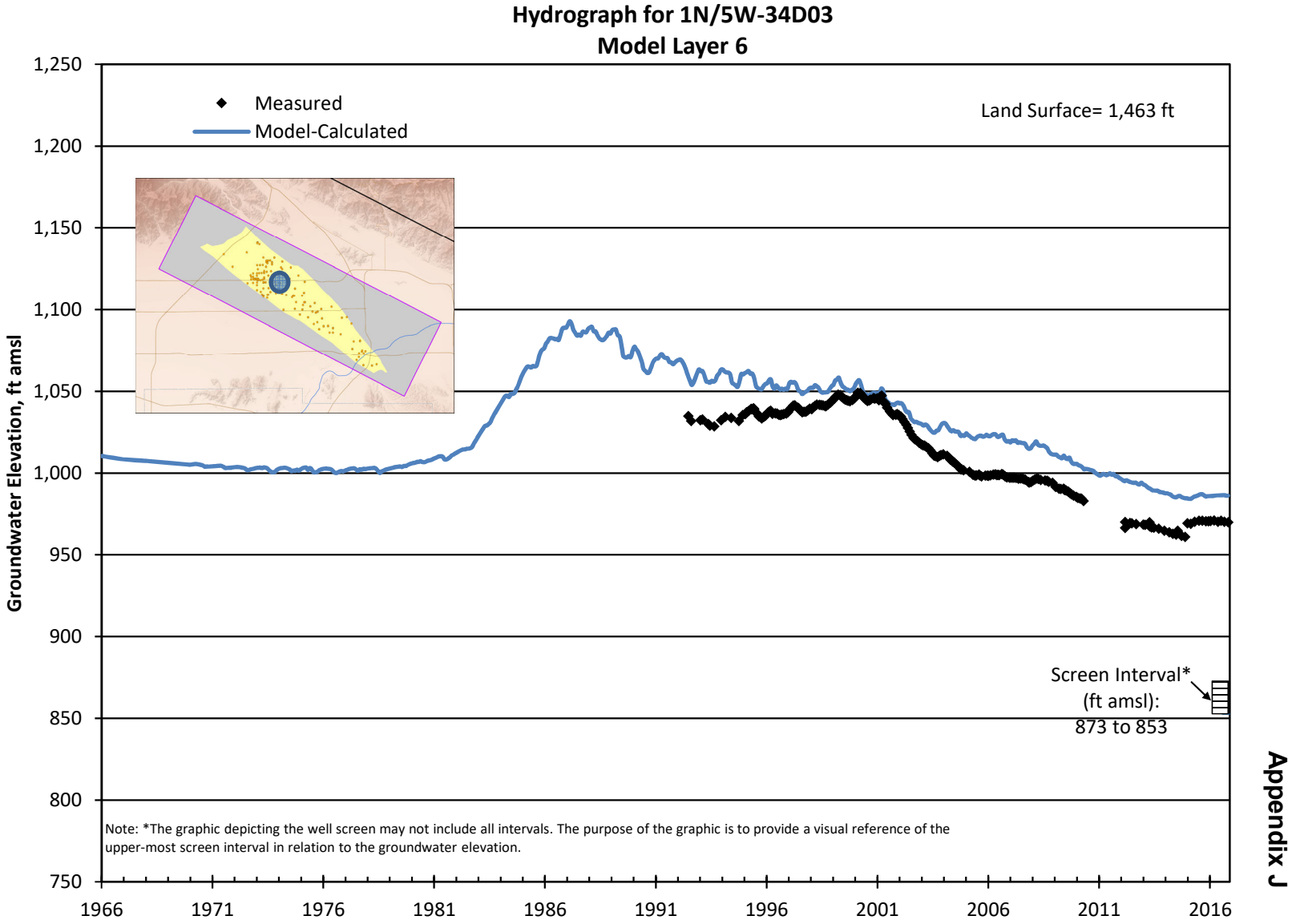
Appendix J


Hydrograph for 1N/5W-34D01
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,460 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
490 to 470
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

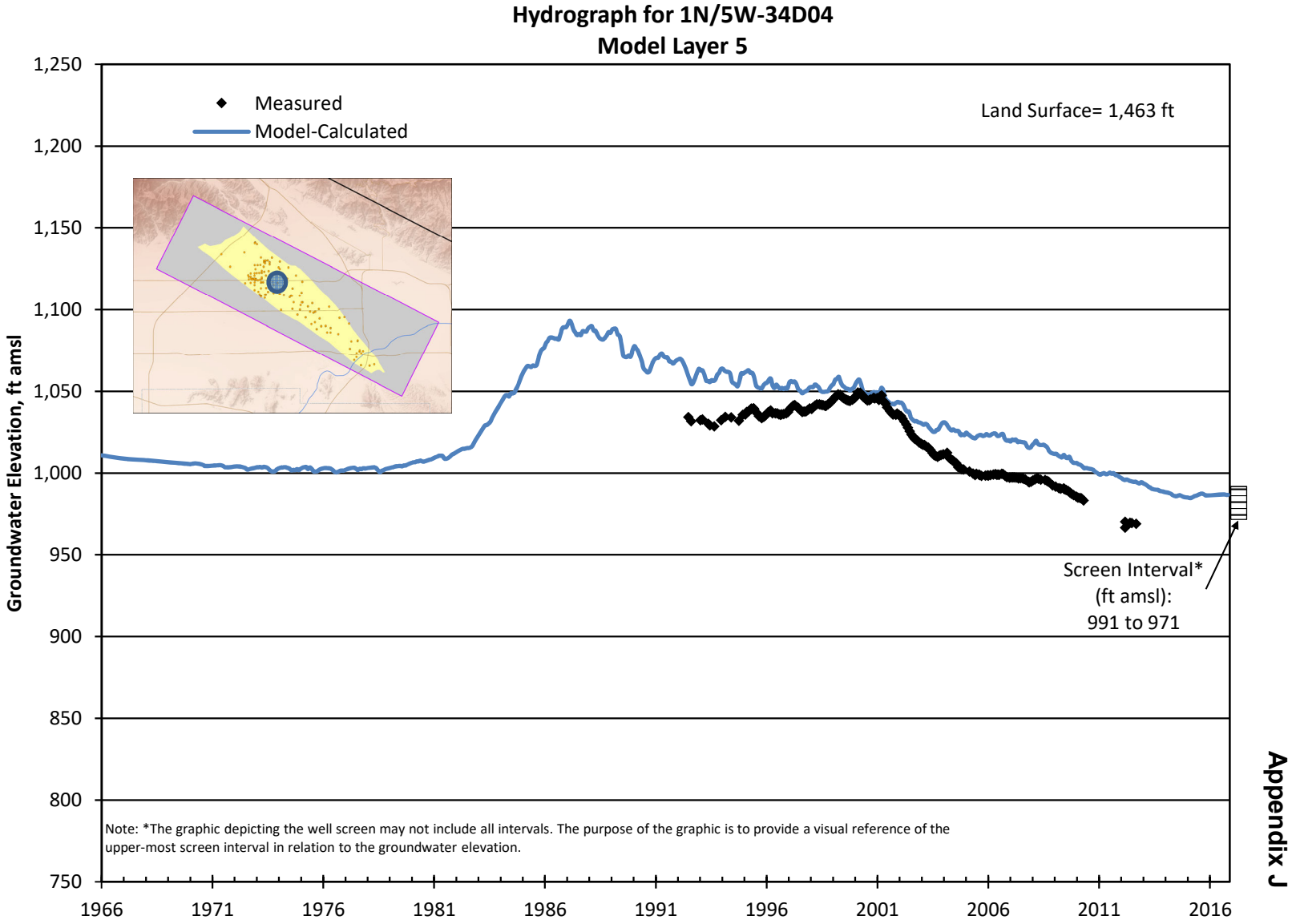
Appendix J


Hydrograph for 1N/5W-34D02
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,463 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
703 to 683
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

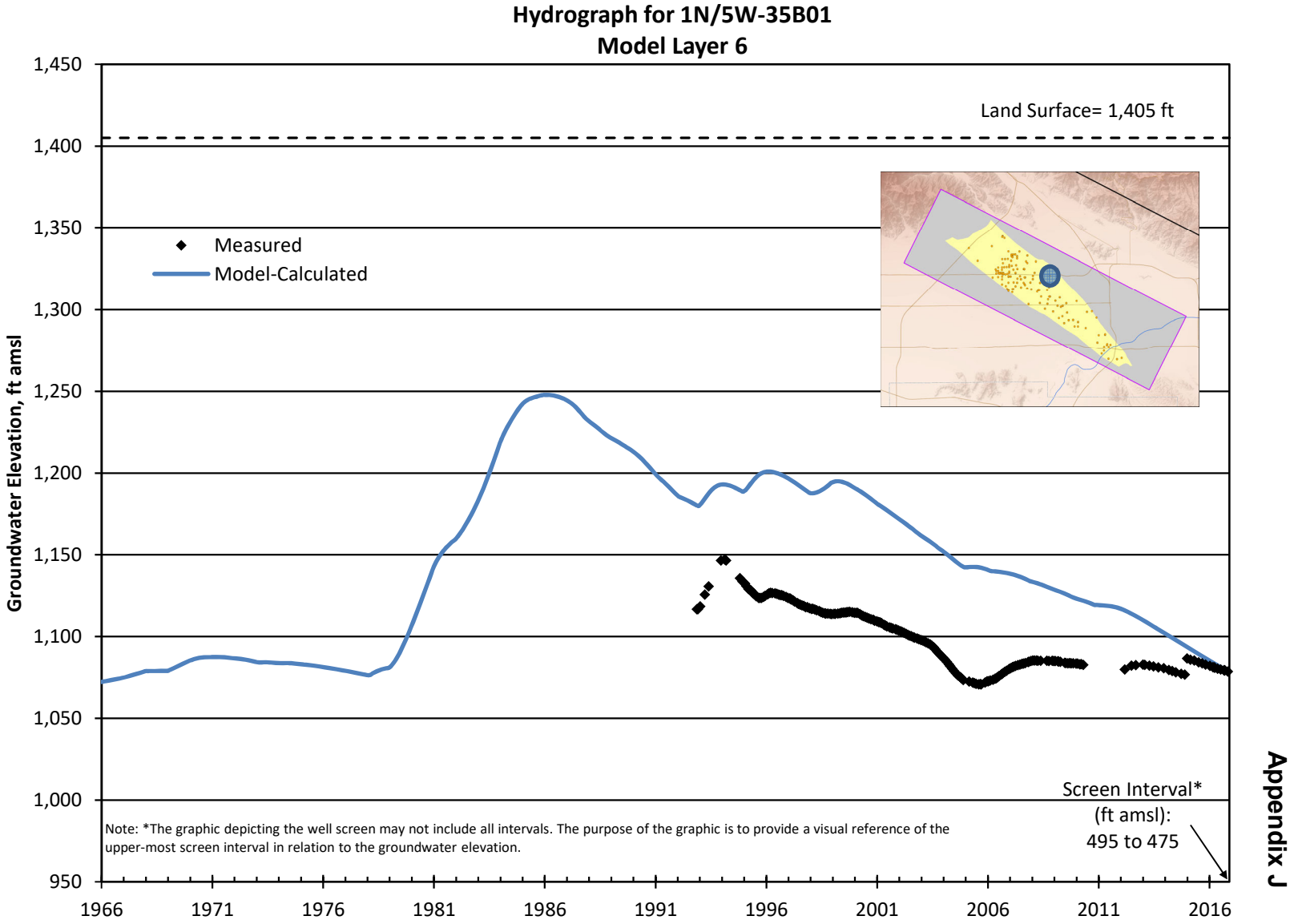
Appendix J


Hydrograph for 1N/5W-34D03
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,463 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
873 to 853
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

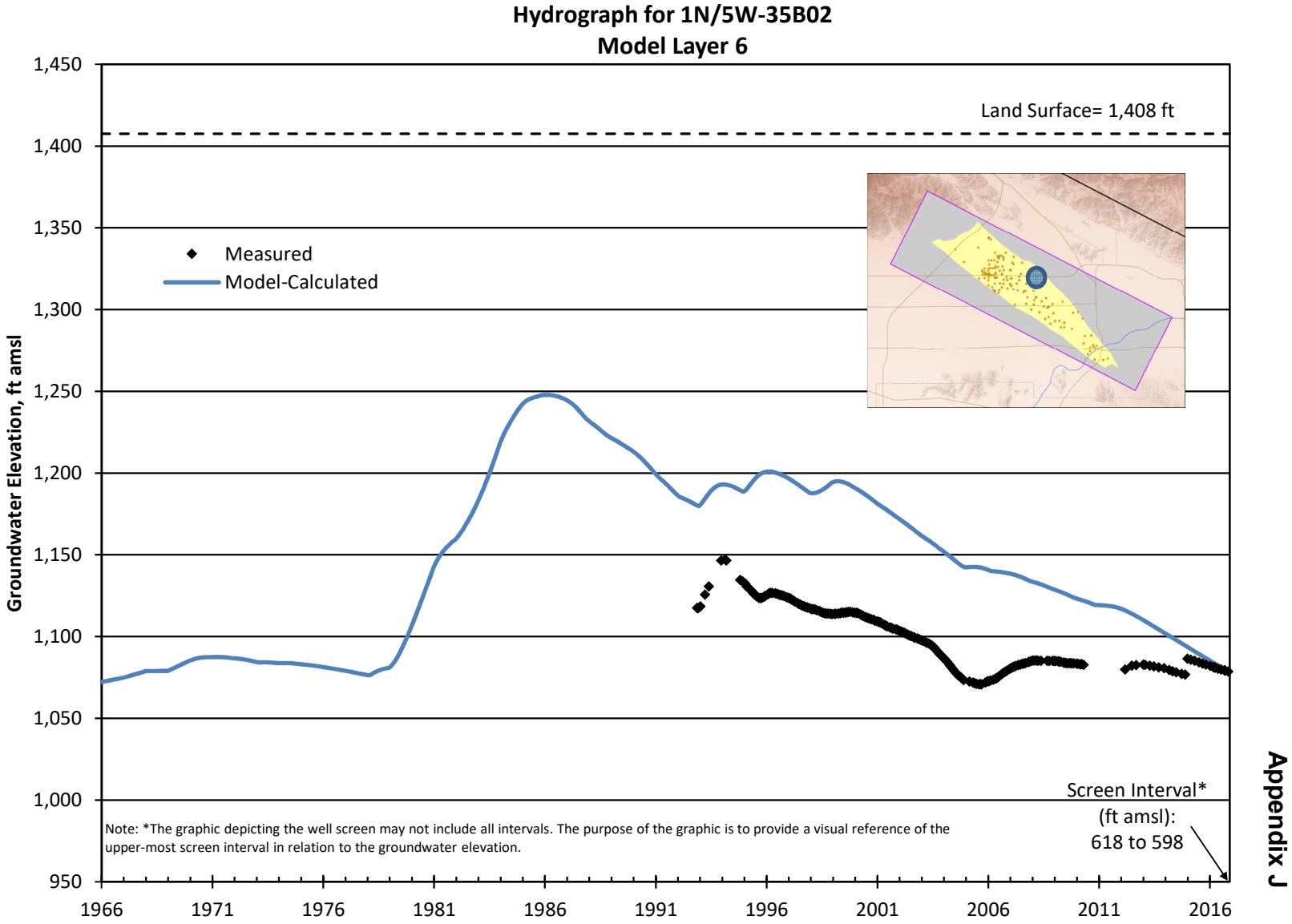
Appendix J


Hydrograph for 1N/5W-34D04
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,463 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
991 to 971
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

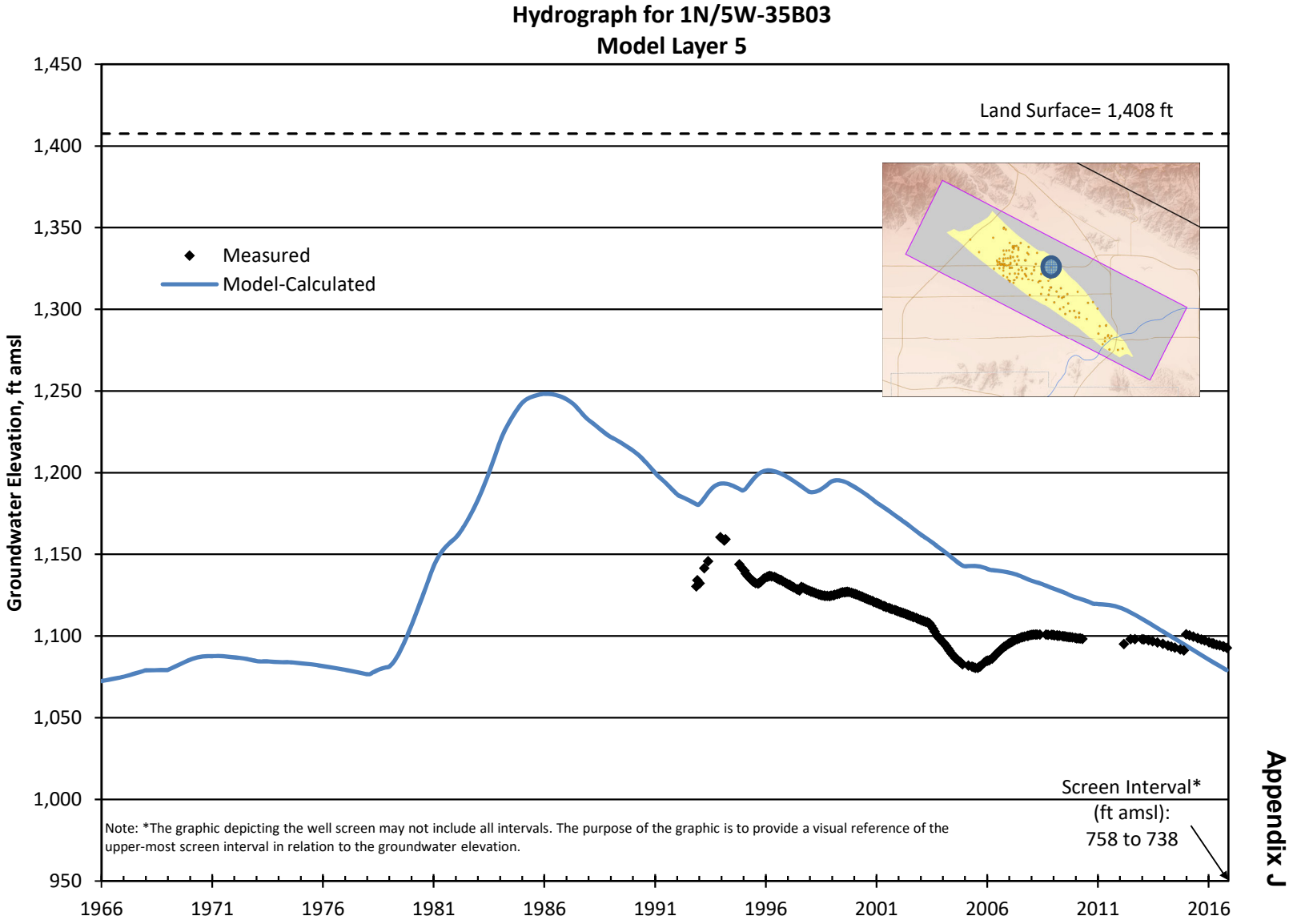
Appendix J


Hydrograph for 1N/5W-35B01
Model Layer 6
Land Surface= 1,405 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
495 to 475
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

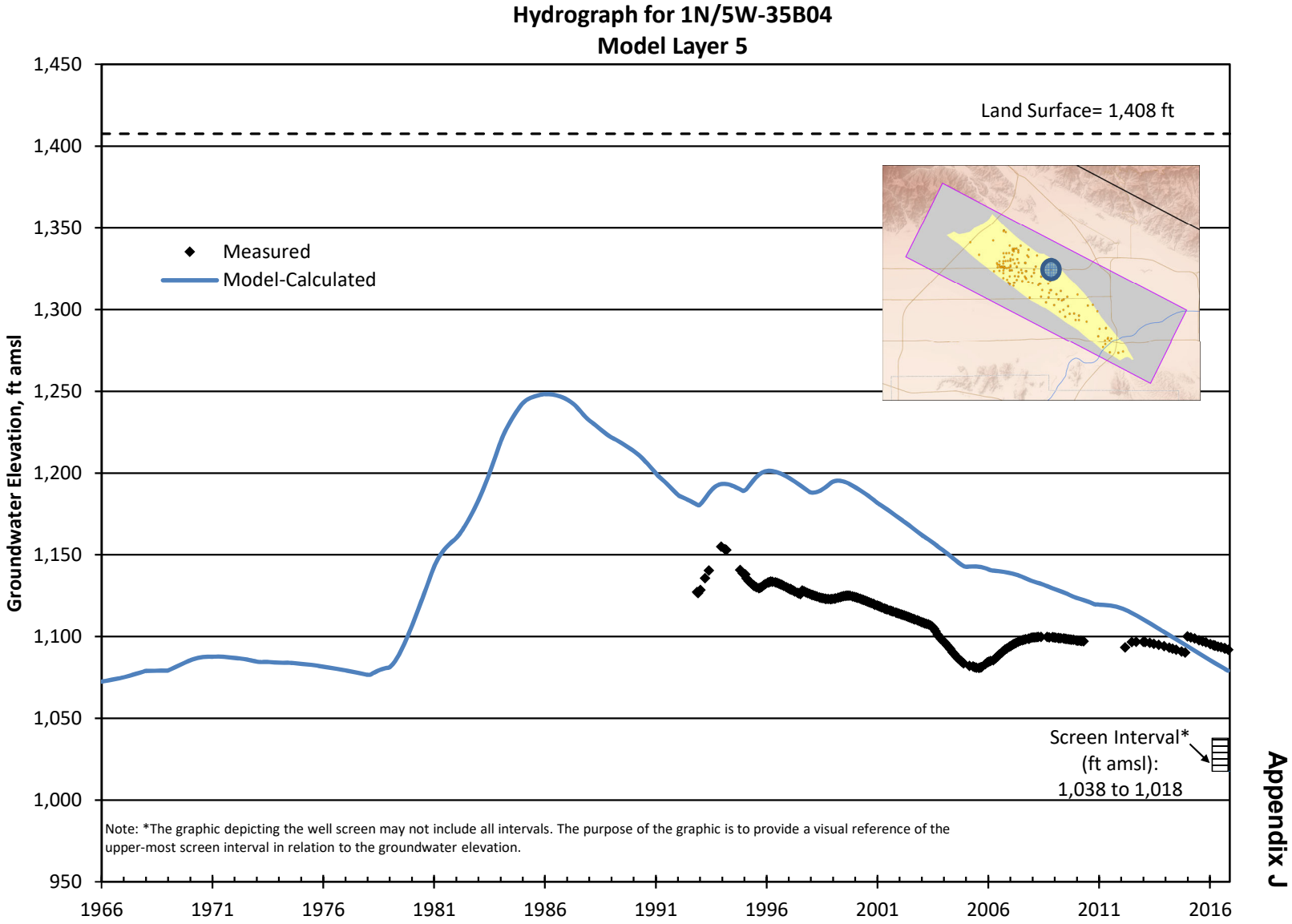
Appendix J


Hydrograph for 1N/5W-35B02
Model Layer 6
Land Surface= 1,408 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
618 to 598
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

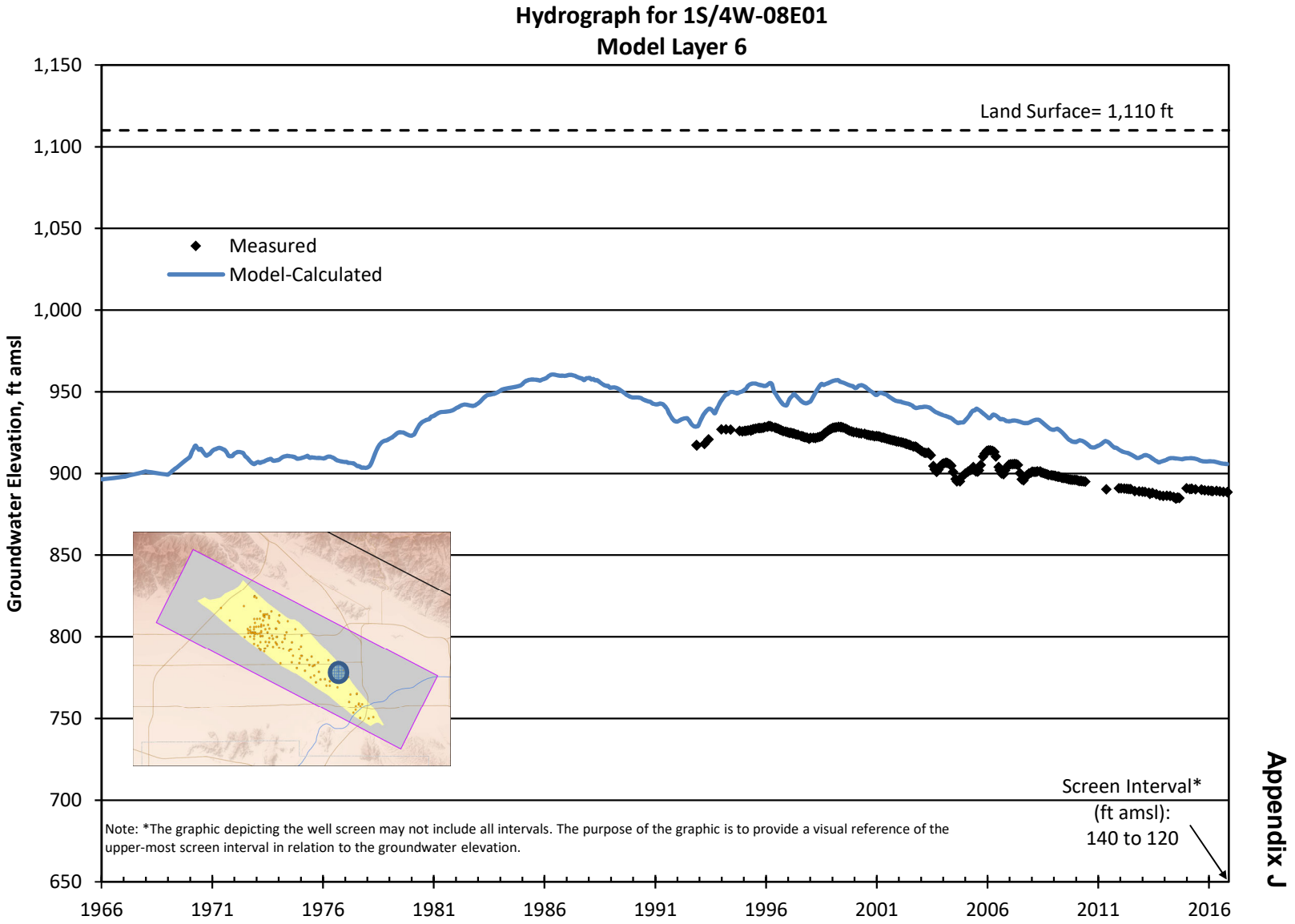
Appendix J


Hydrograph for 1N/5W-35B03
Model Layer 5
Land Surface= 1,408 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
758 to 738
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

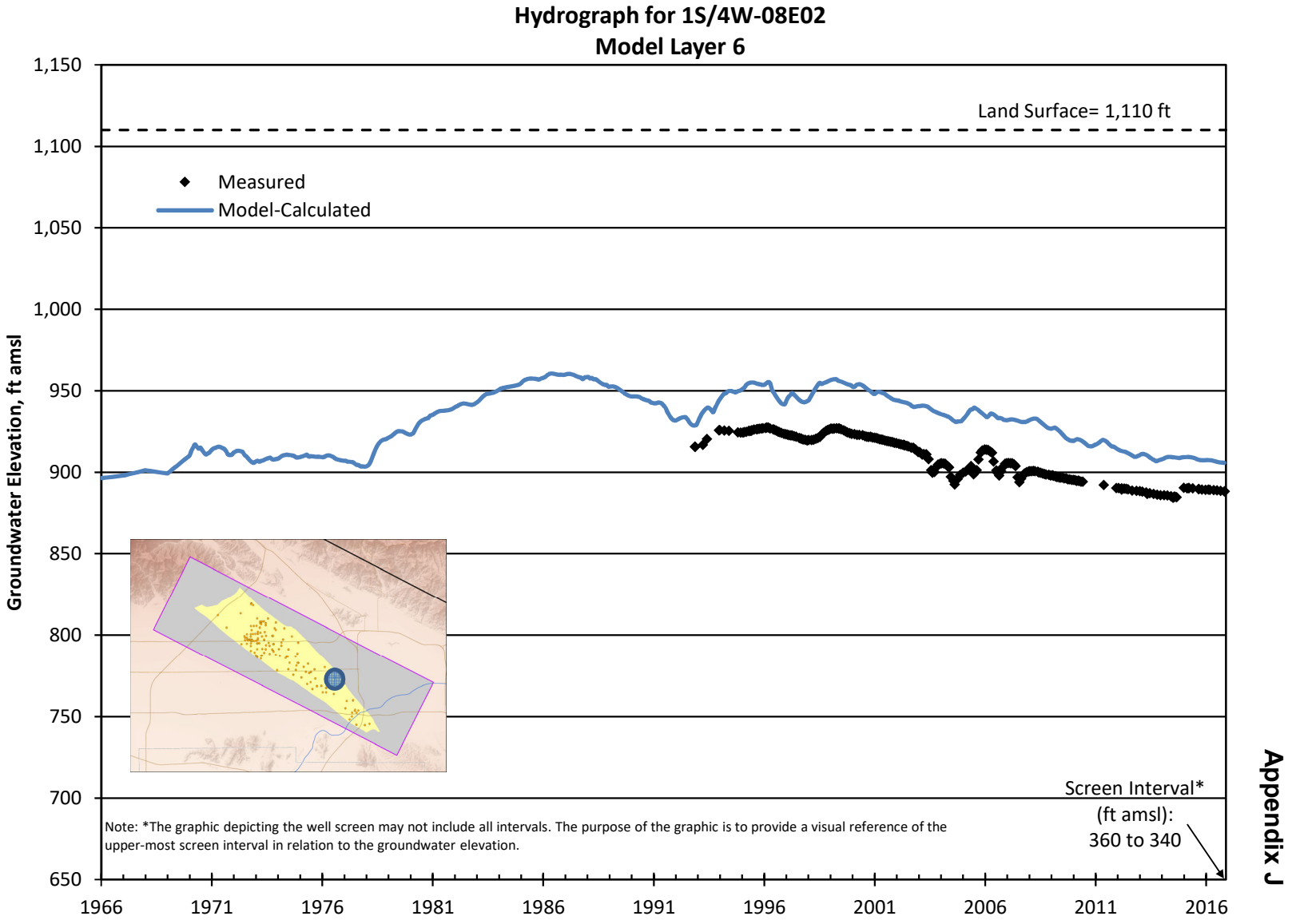
Appendix J


Hydrograph for 1N/5W-35B04
Model Layer 5
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,408 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,038 to 1,018
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

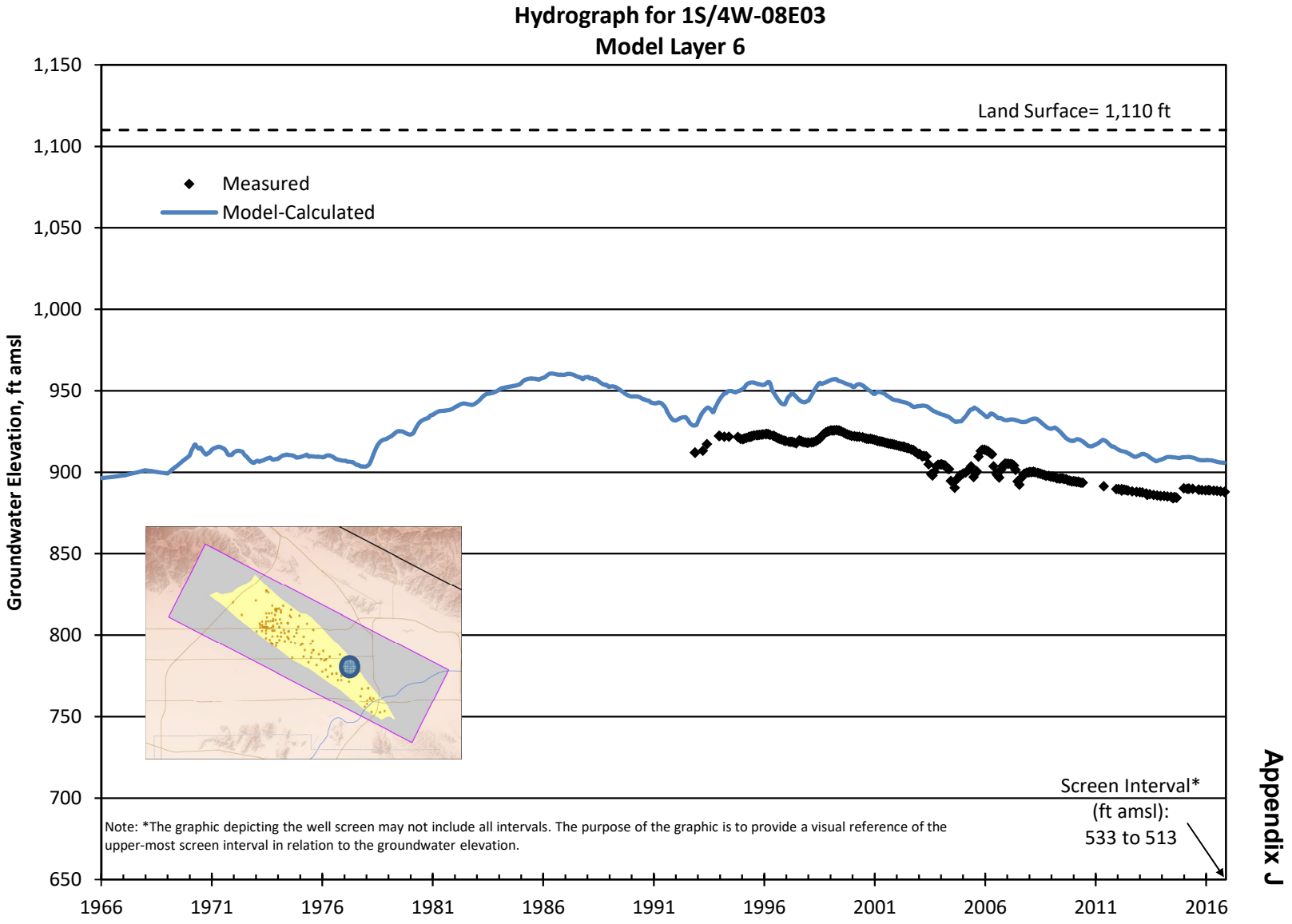
Appendix J


Hydrograph for 1S/4W-08E01
Model Layer 6
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,110 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
140 to 120
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

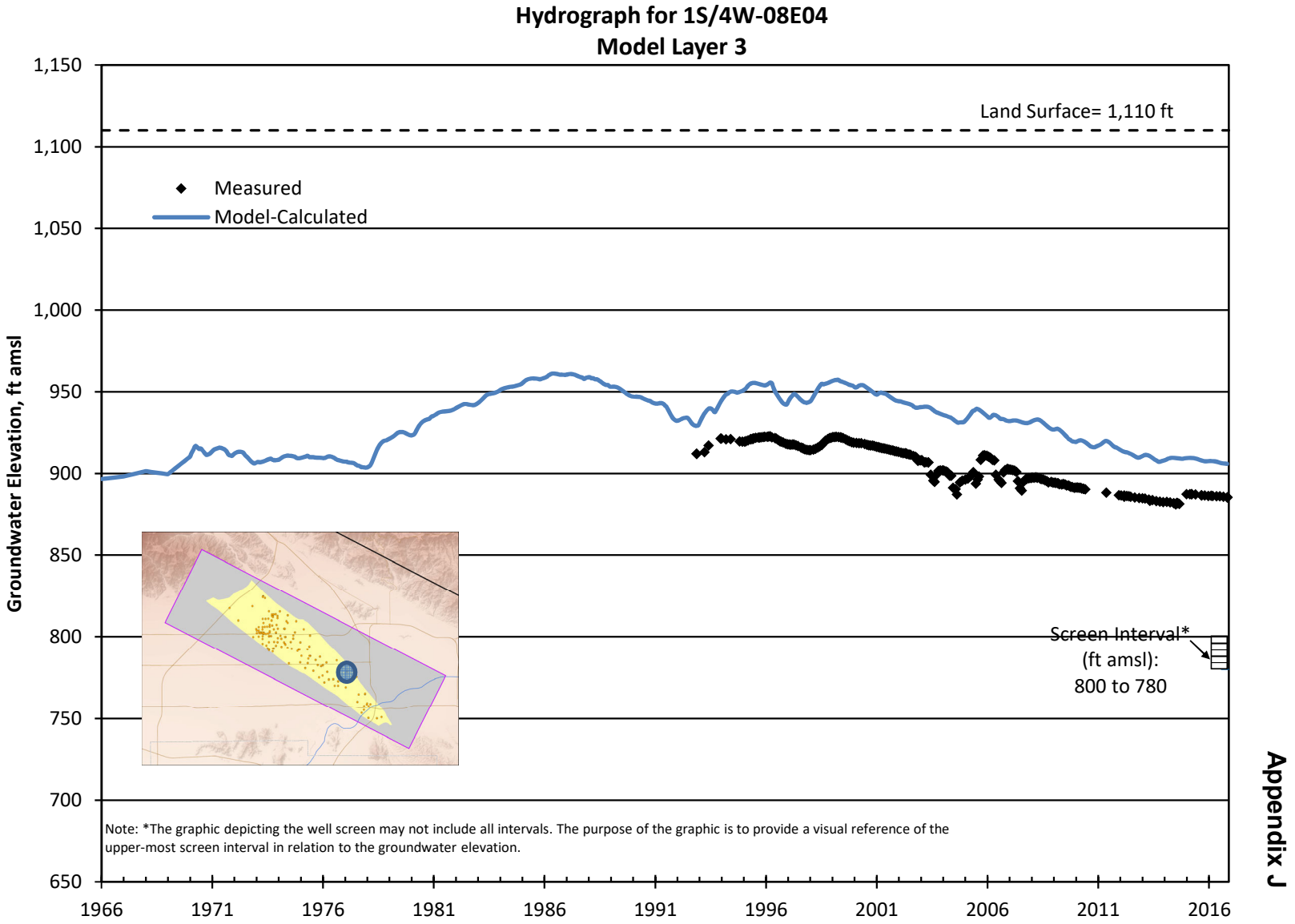
Appendix J


Hydrograph for 1S/4W-08E02
Model Layer 6
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,110 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
360 to 340
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

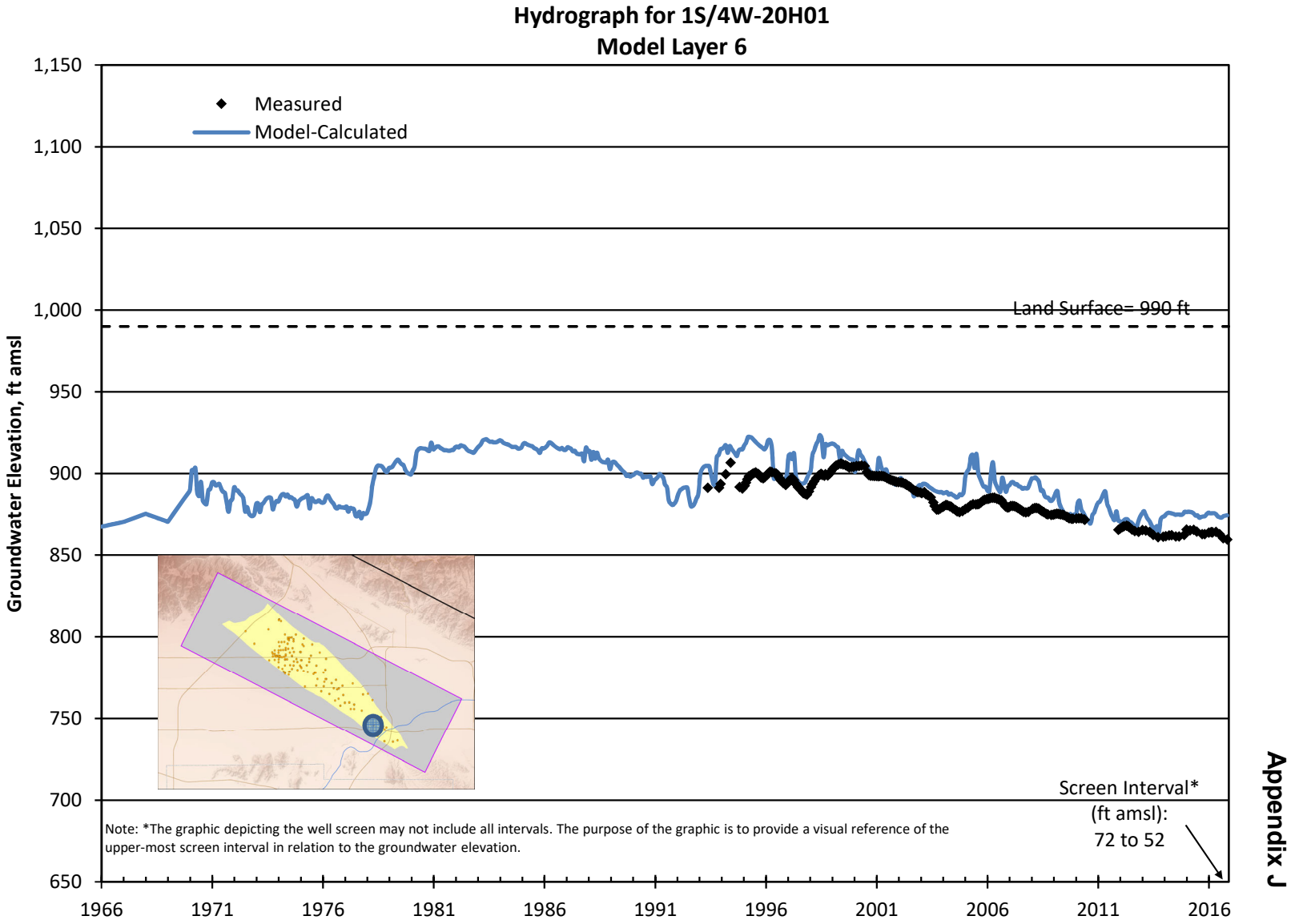
Appendix J


Hydrograph for 1S/4W-08E03
Model Layer 6
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,110 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
533 to 513
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

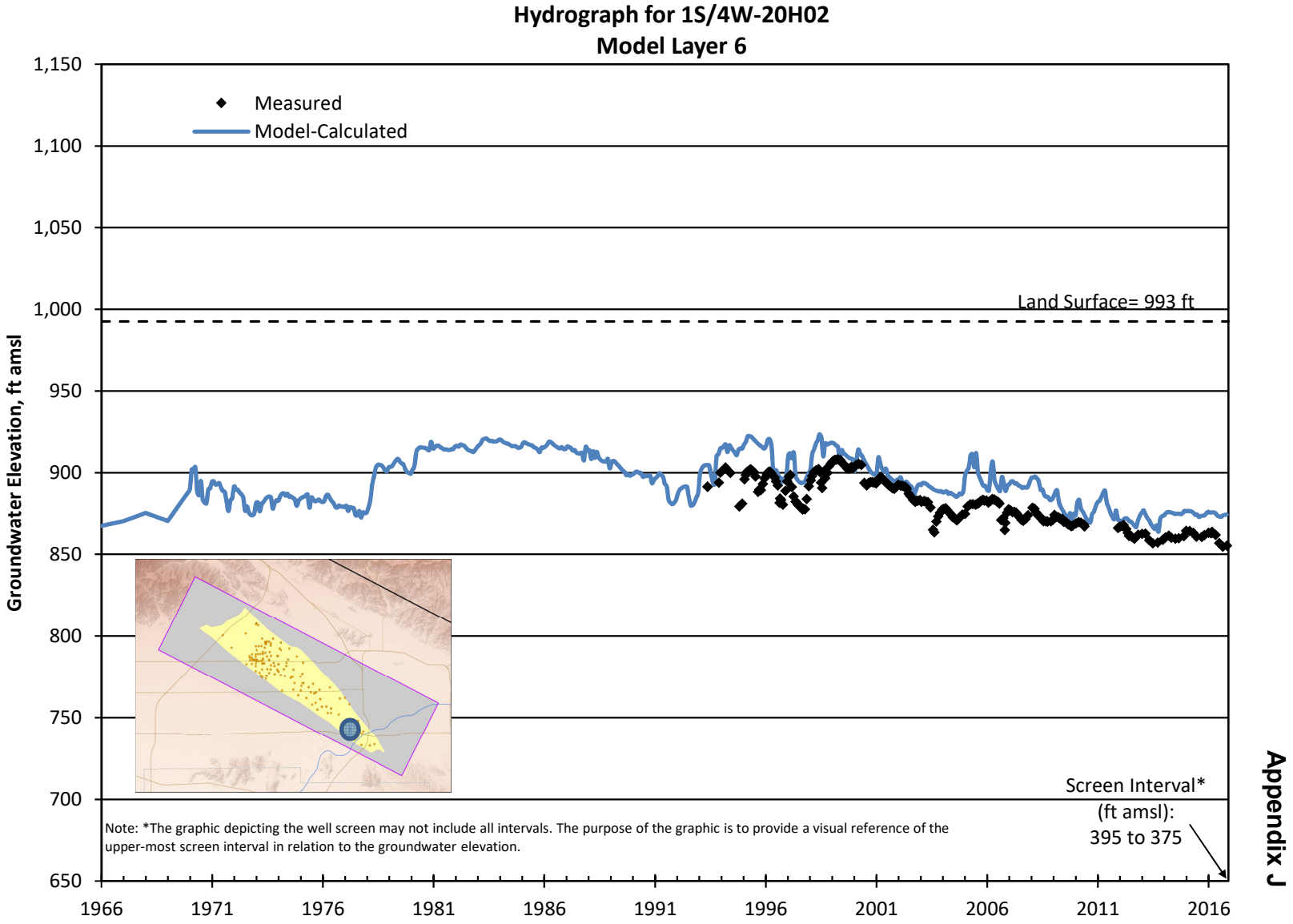
Appendix J


Hydrograph for 1S/4W-08E04
Model Layer 3
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,110 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
800 to 780
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

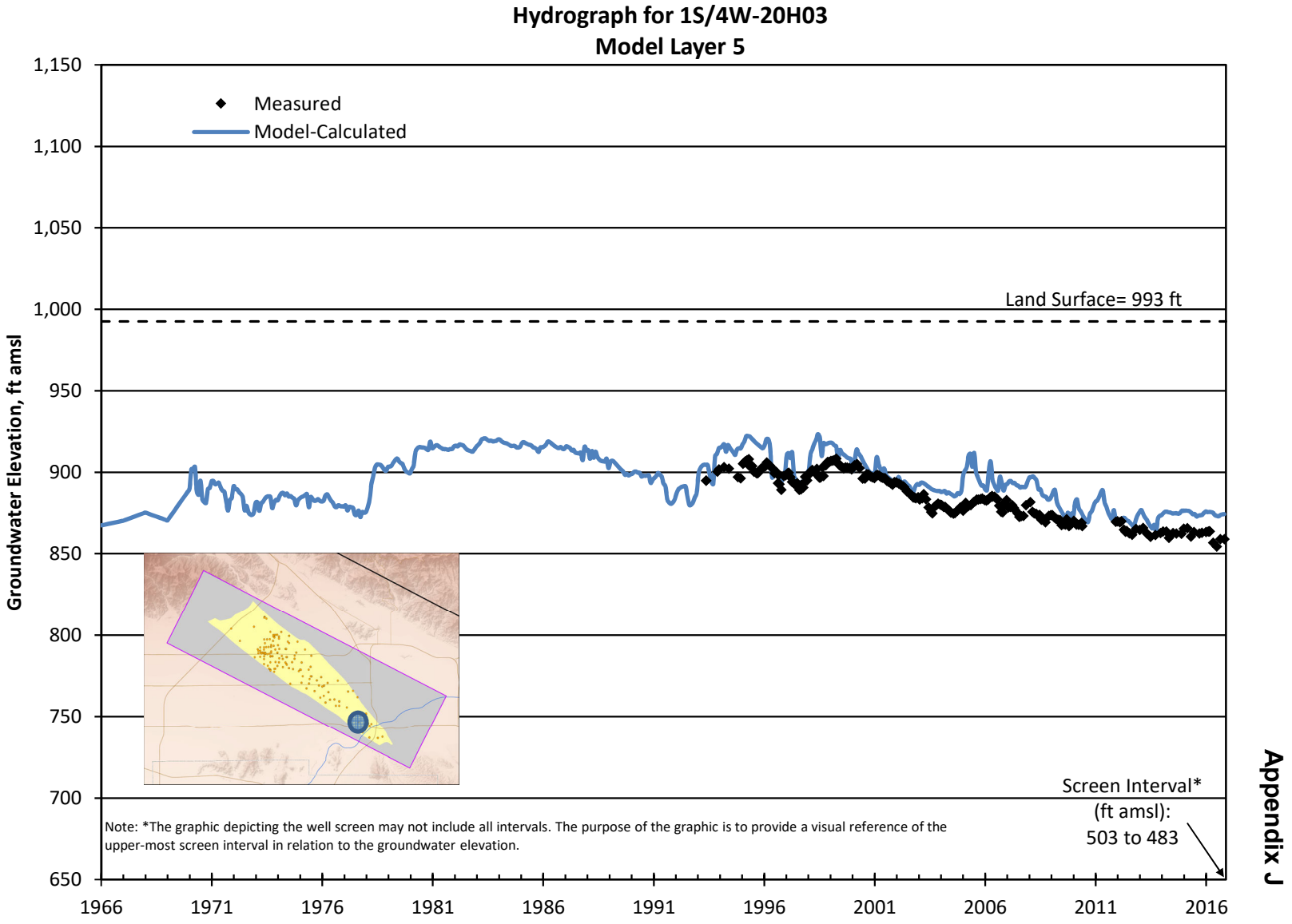
Appendix J


Hydrograph for 1S/4W-20H01
Model Layer 6
Measured
Model-Calculated
Land Surface= 990 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
72 to 52
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

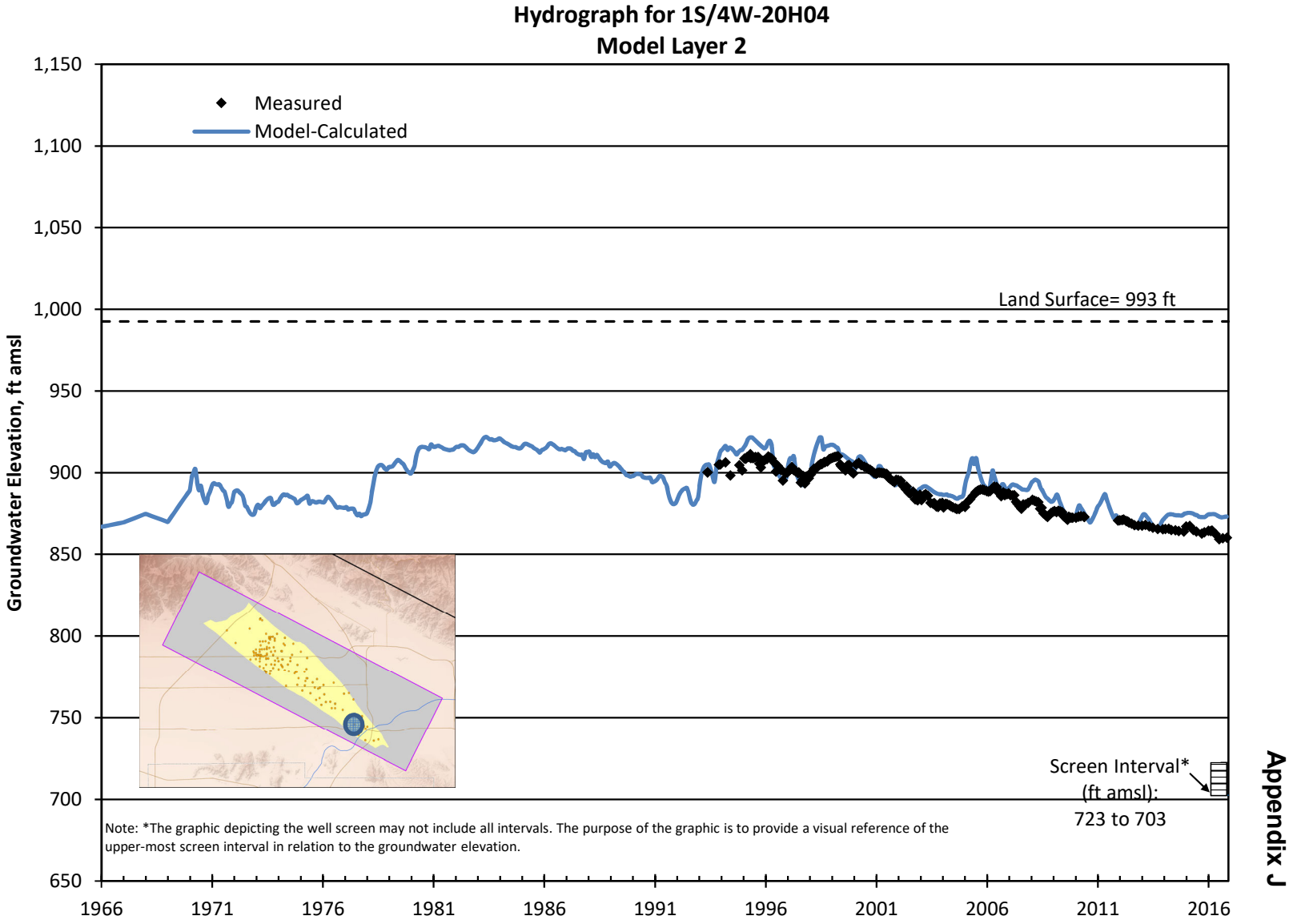
Appendix J


Hydrograph for 1S/4W-20H02
Model Layer 6
Measured
Model-Calculated
Land Surface= 993 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
395 to 375
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

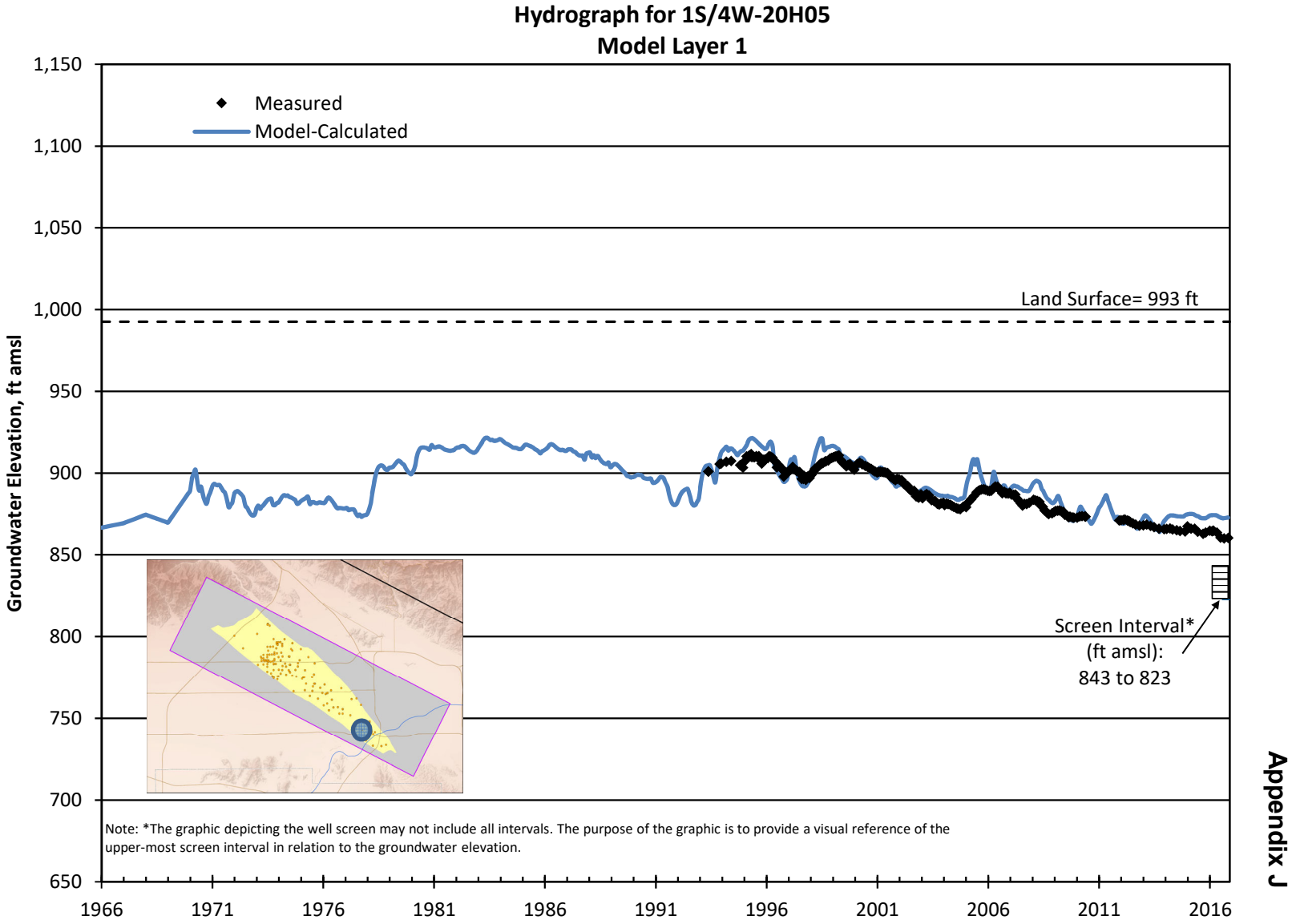
Appendix J


Hydrograph for 1S/4W-20H03
Model Layer 5
Measured
Model-Calculated
Land Surface= 993 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

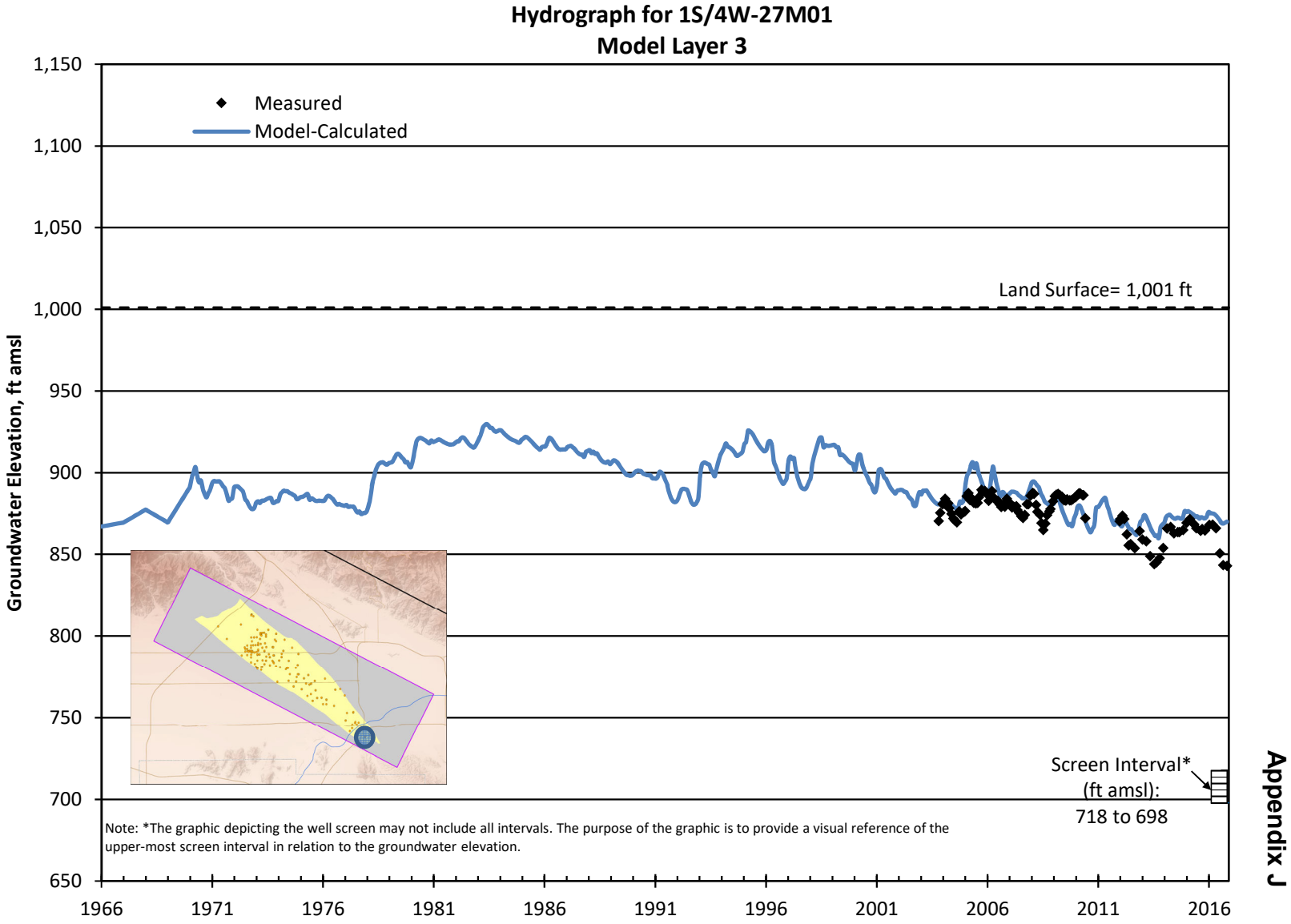
Appendix J


Hydrograph for 1S/4W-20H04
Model Layer 2
Measured
Model-Calculated
Land Surface= 993 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
723 to 703
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

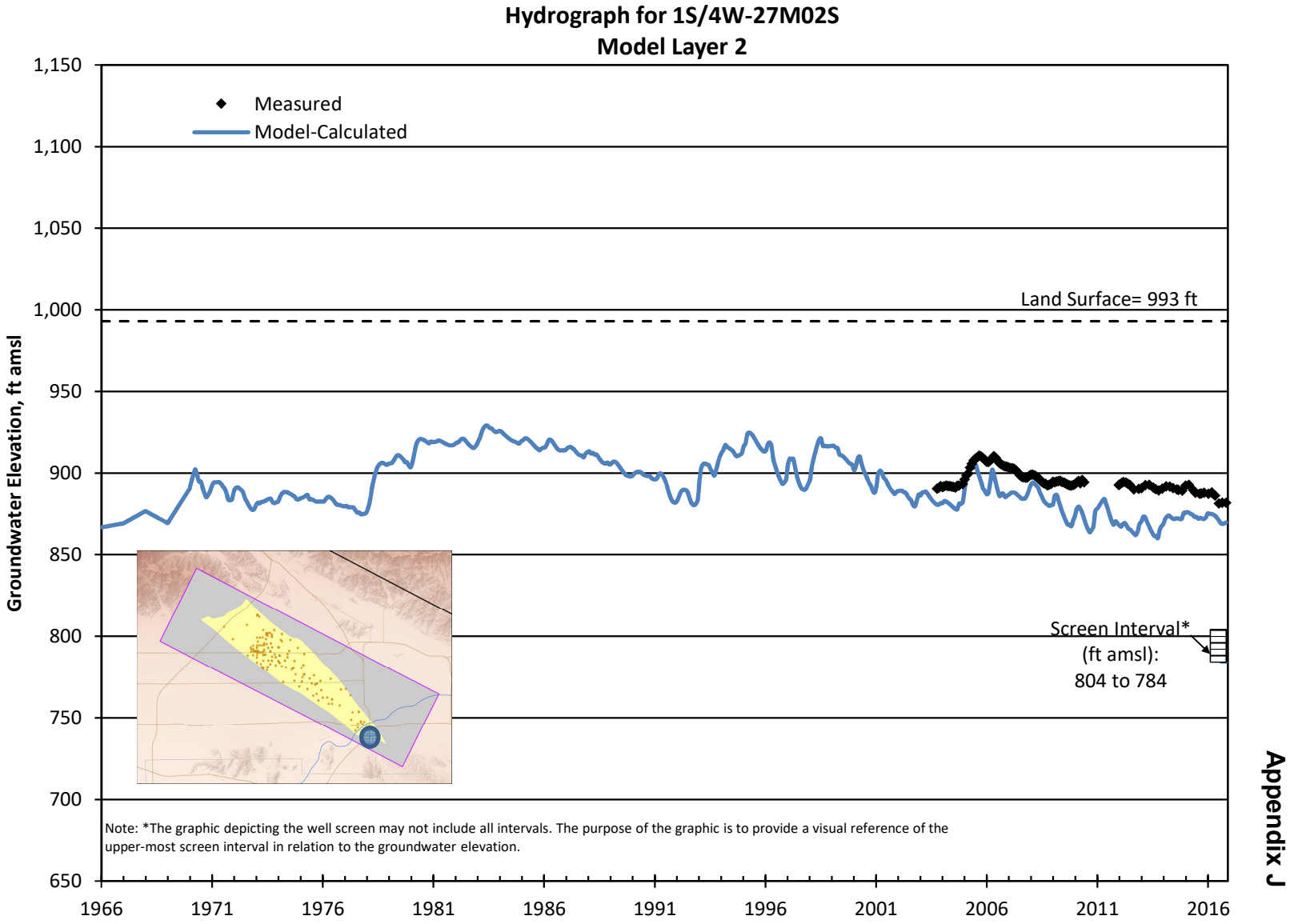
Appendix J


Hydrograph for 1S/4W-20H05
Model Layer 1
Measured
Model-Calculated
Land Surface= 993 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
843 to 823
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

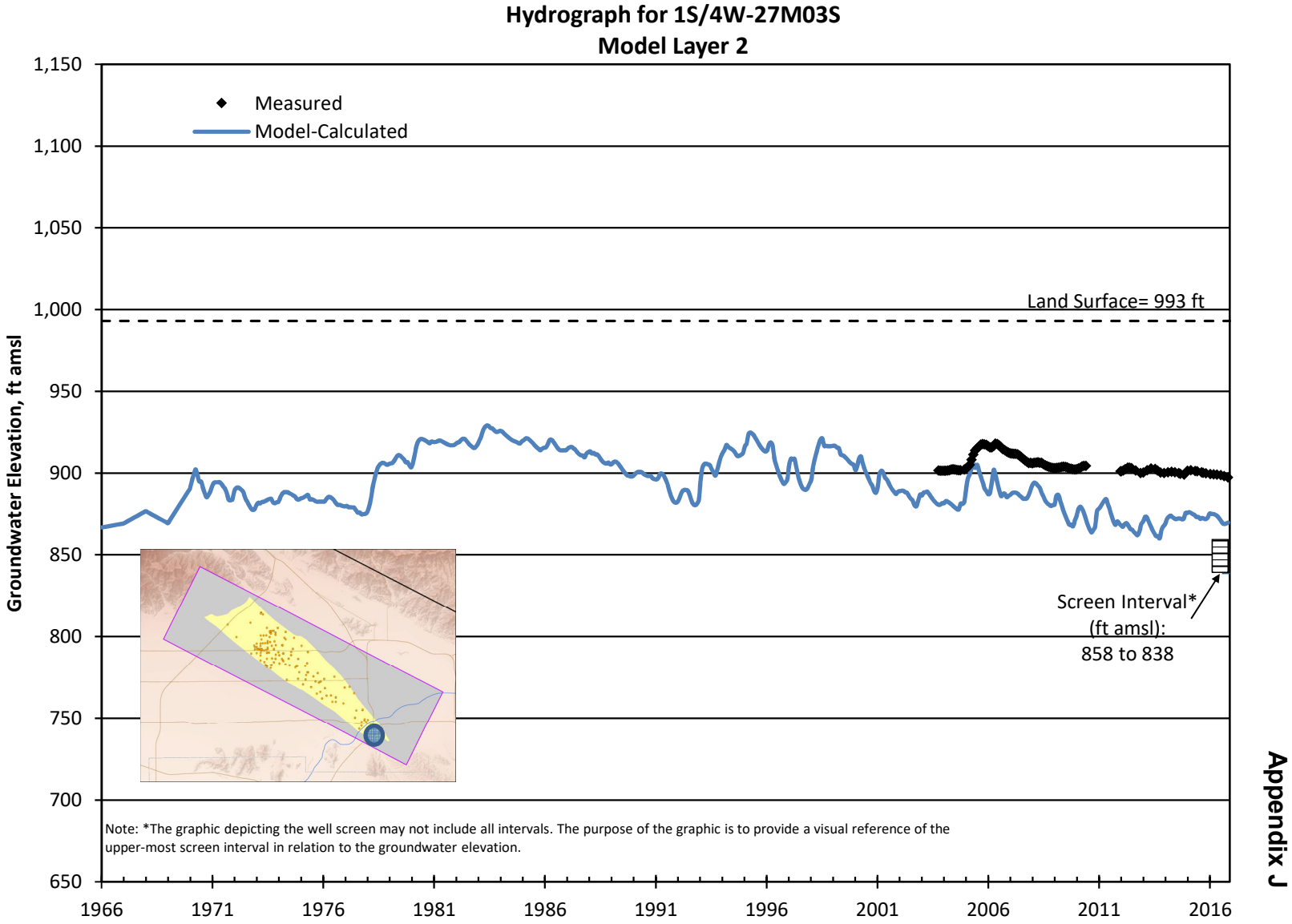
Appendix J


Hydrograph for 1S/4W-27M01
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,001 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
718 to 698
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

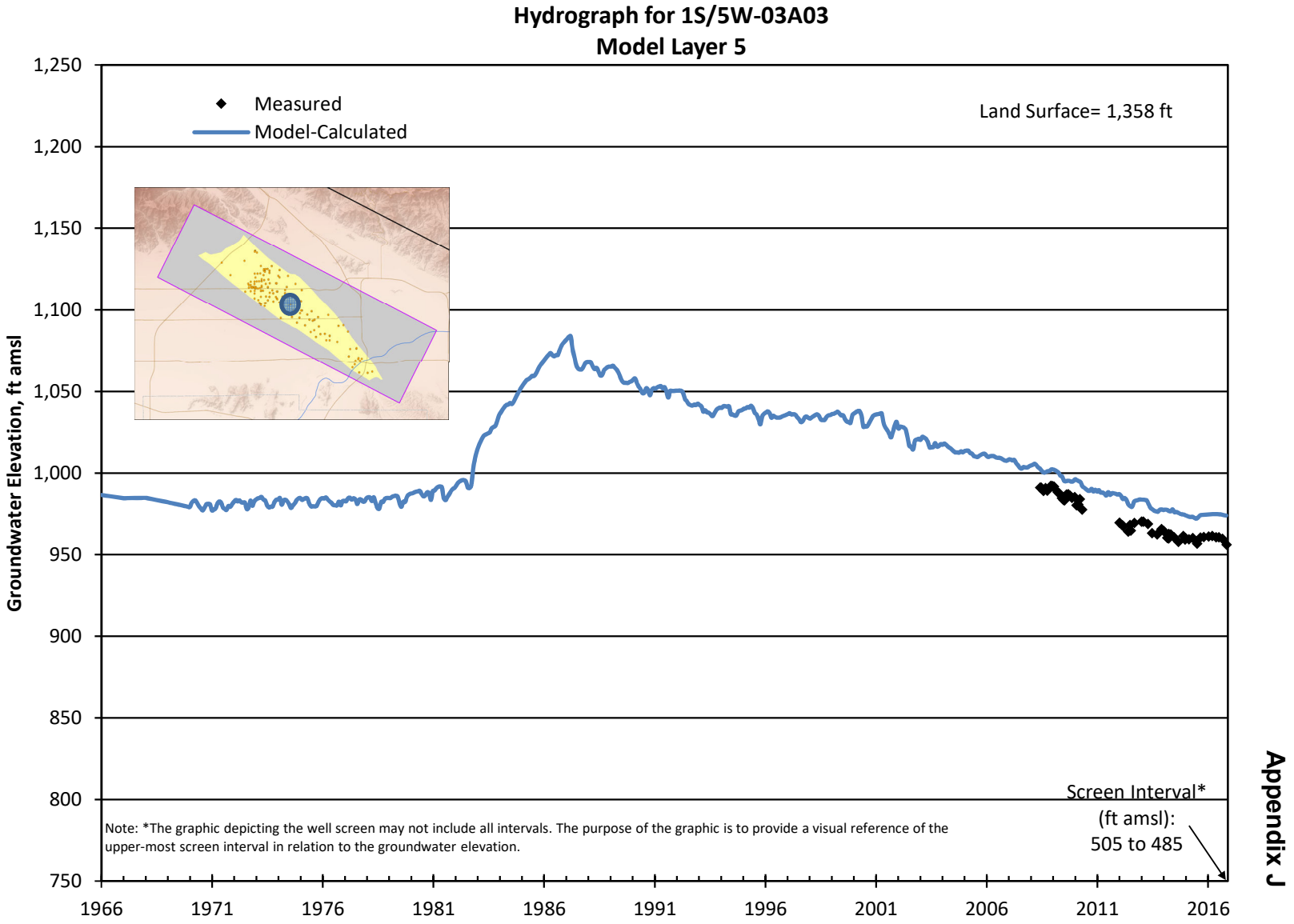
Appendix J


Hydrograph for 1S/4W-27M02S
Model Layer 2
Measured
Model-Calculated
Land Surface= 993 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
804 to 784
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

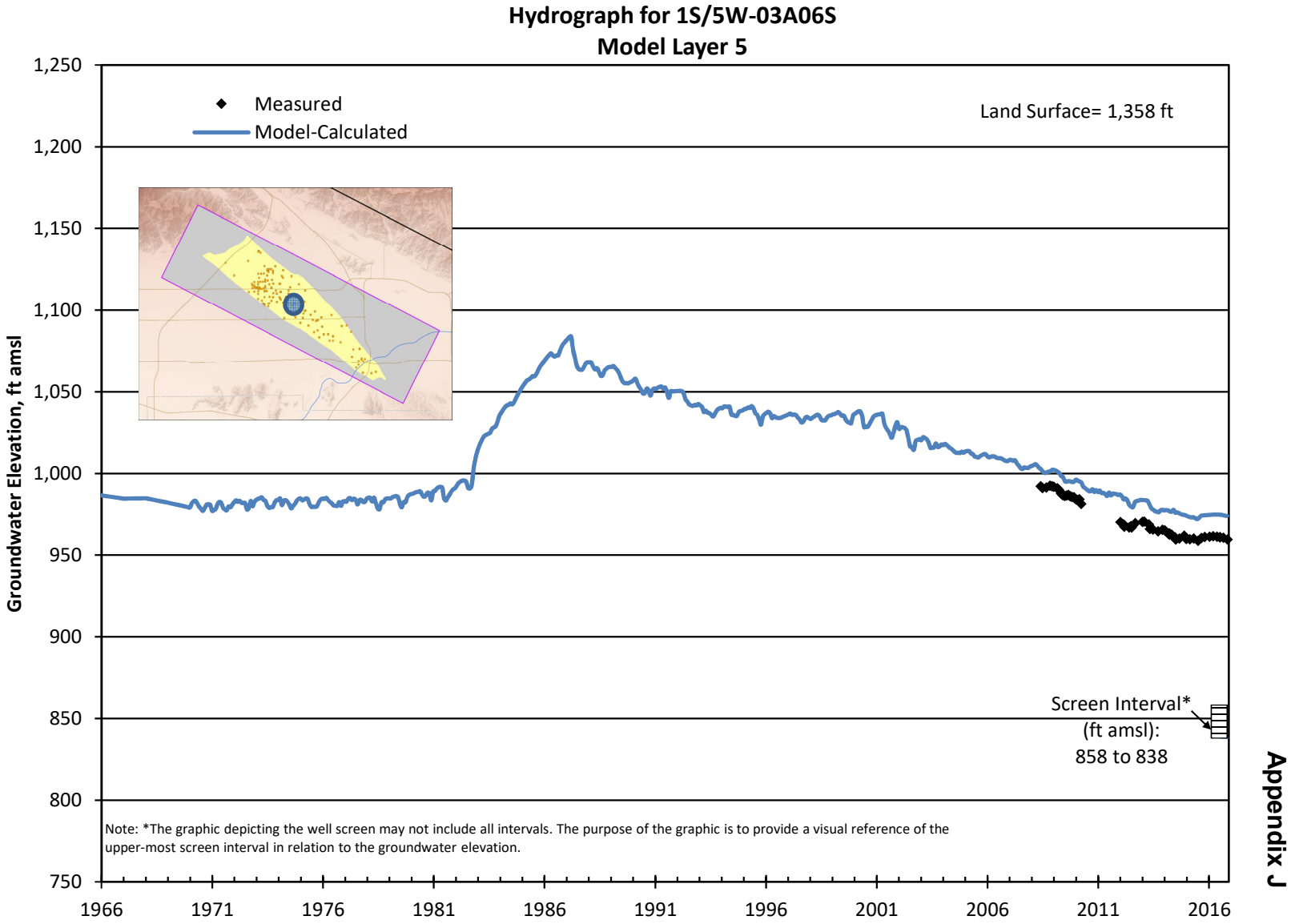
Appendix J


Hydrograph for 1S/4W-27M03S
Model Layer 2
Measured
Model-Calculated
Land Surface= 993 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
858 to 838
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

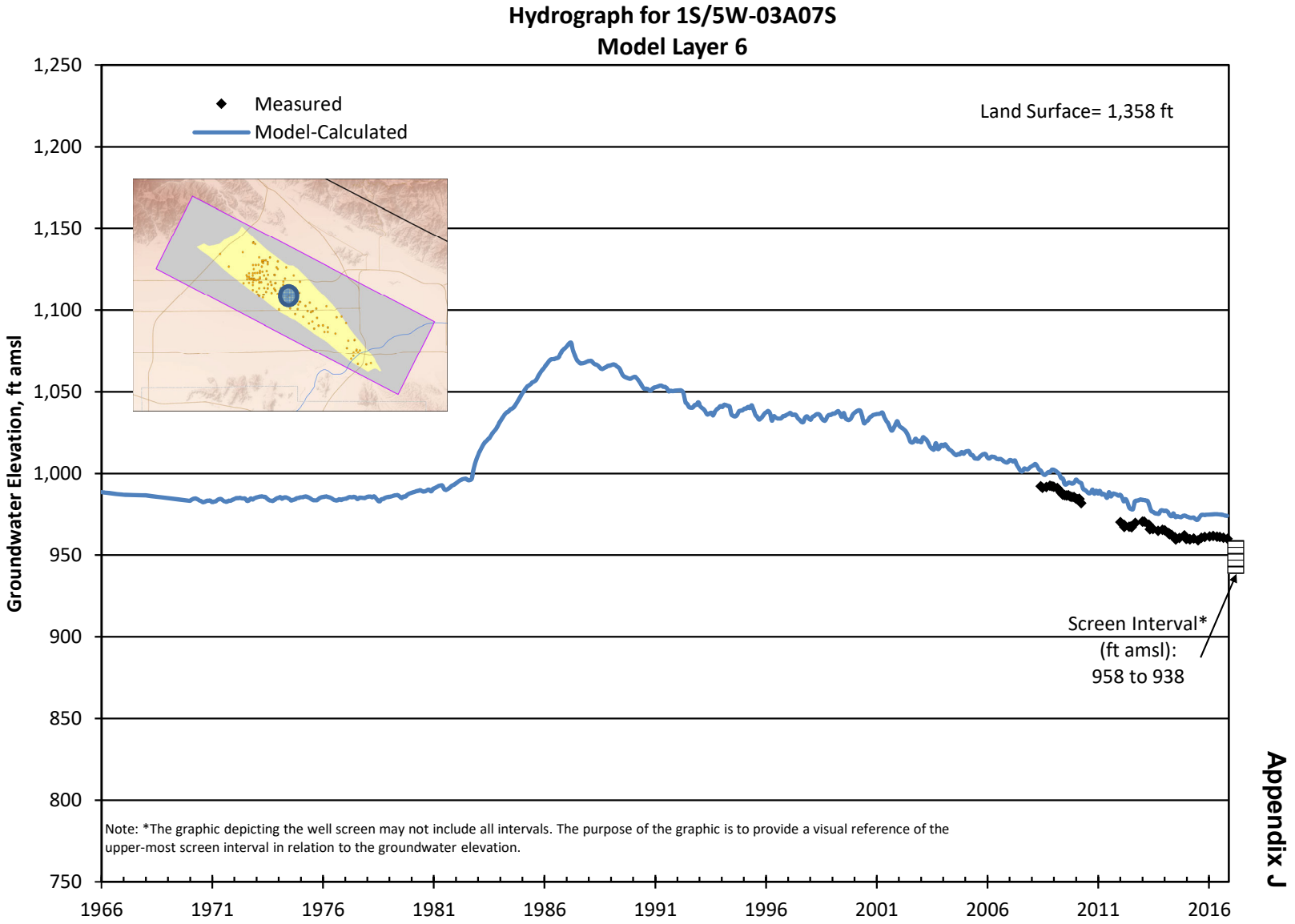
Appendix J


Hydrograph for 1S/5W-03A03
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,358 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Screen Interval*
(ft amsl):
505 to 485

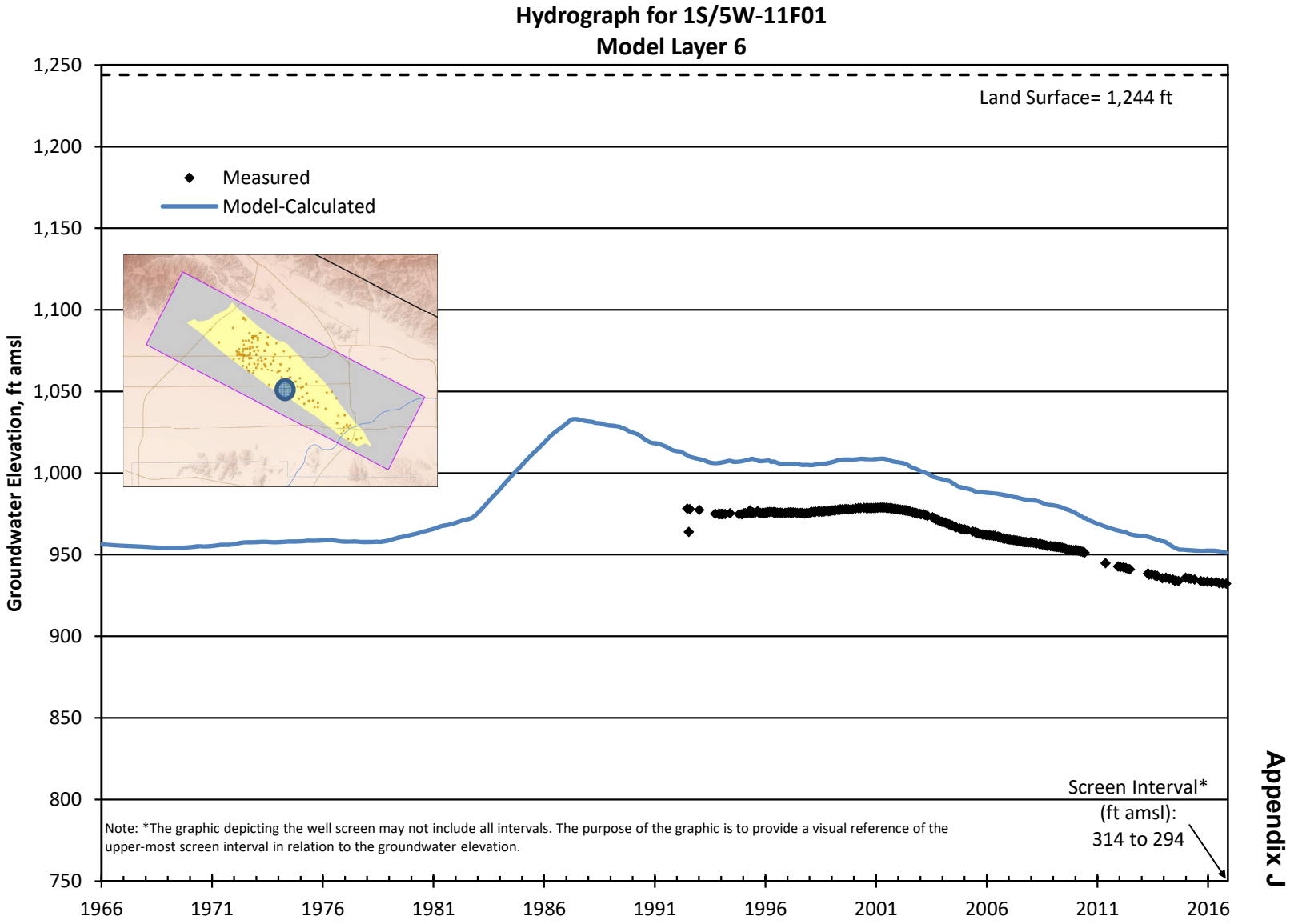
Appendix J


Hydrograph for 1S/5W-03A06S
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,358 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
858 to 838
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

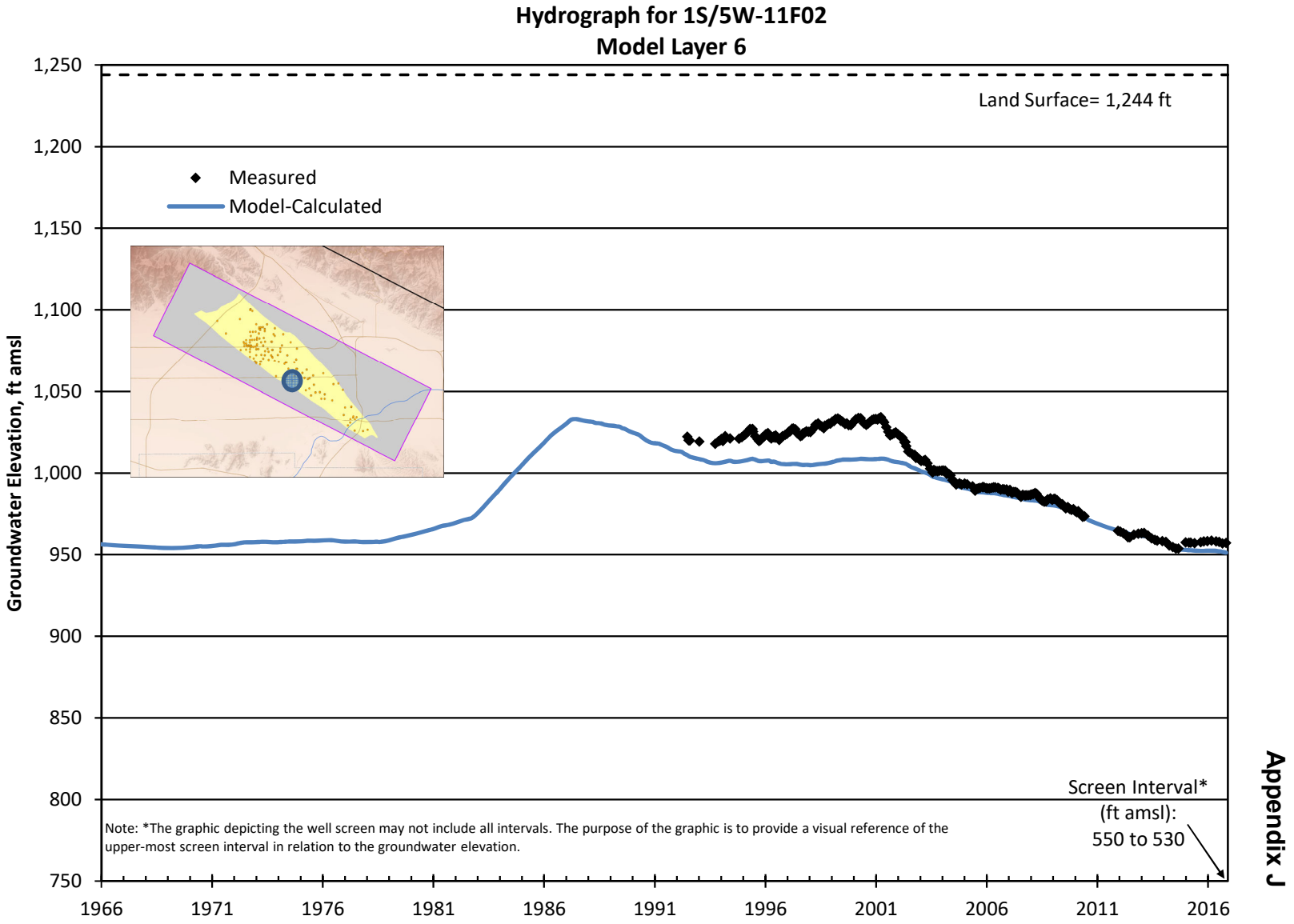
Appendix J


Hydrograph for 1S/5W-03A07S
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,358 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
958 to 938
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

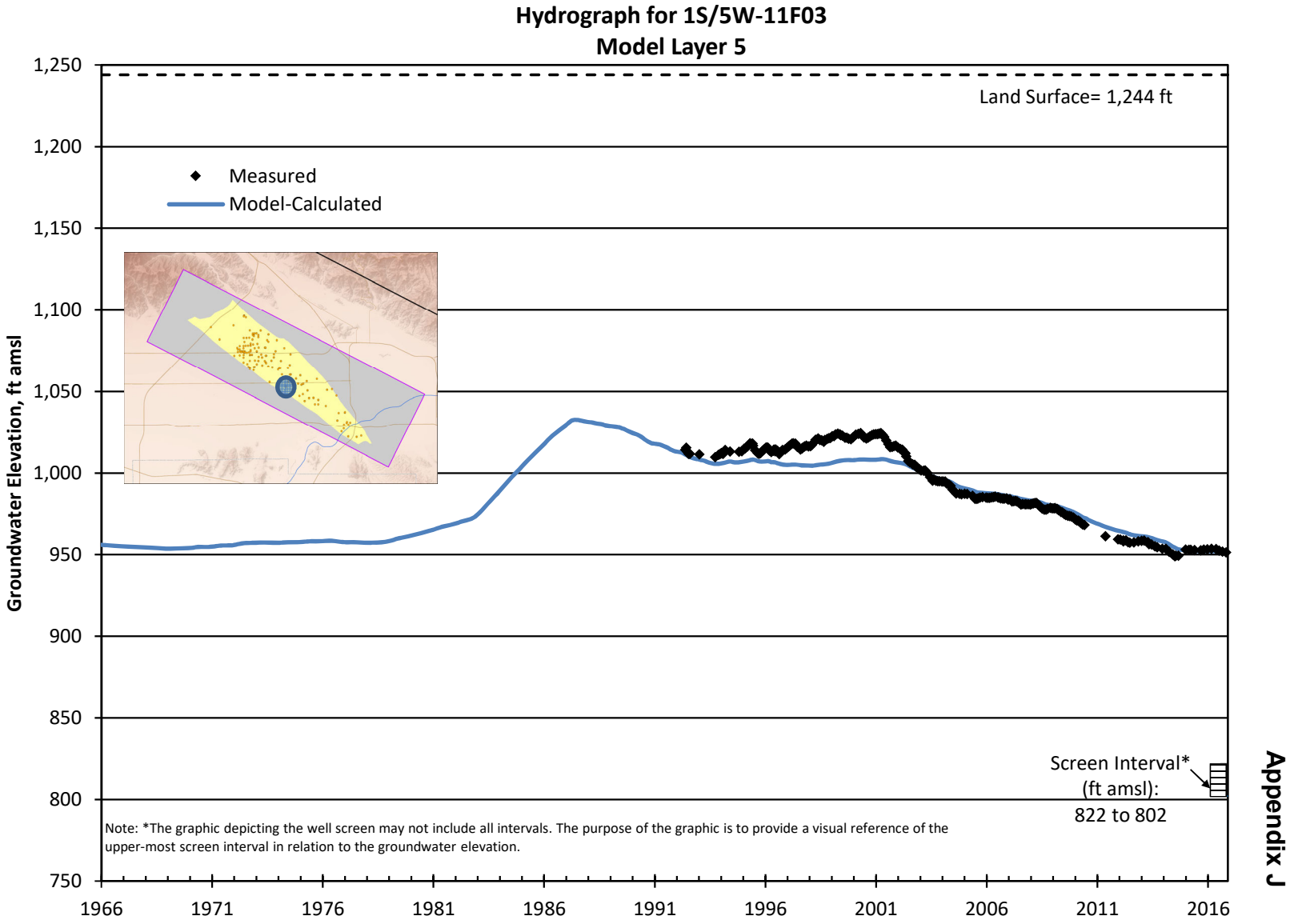
Appendix J


Hydrograph for 1S/5W-11F01
Model Layer 6
Land Surface= 1,244 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
314 to 294
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

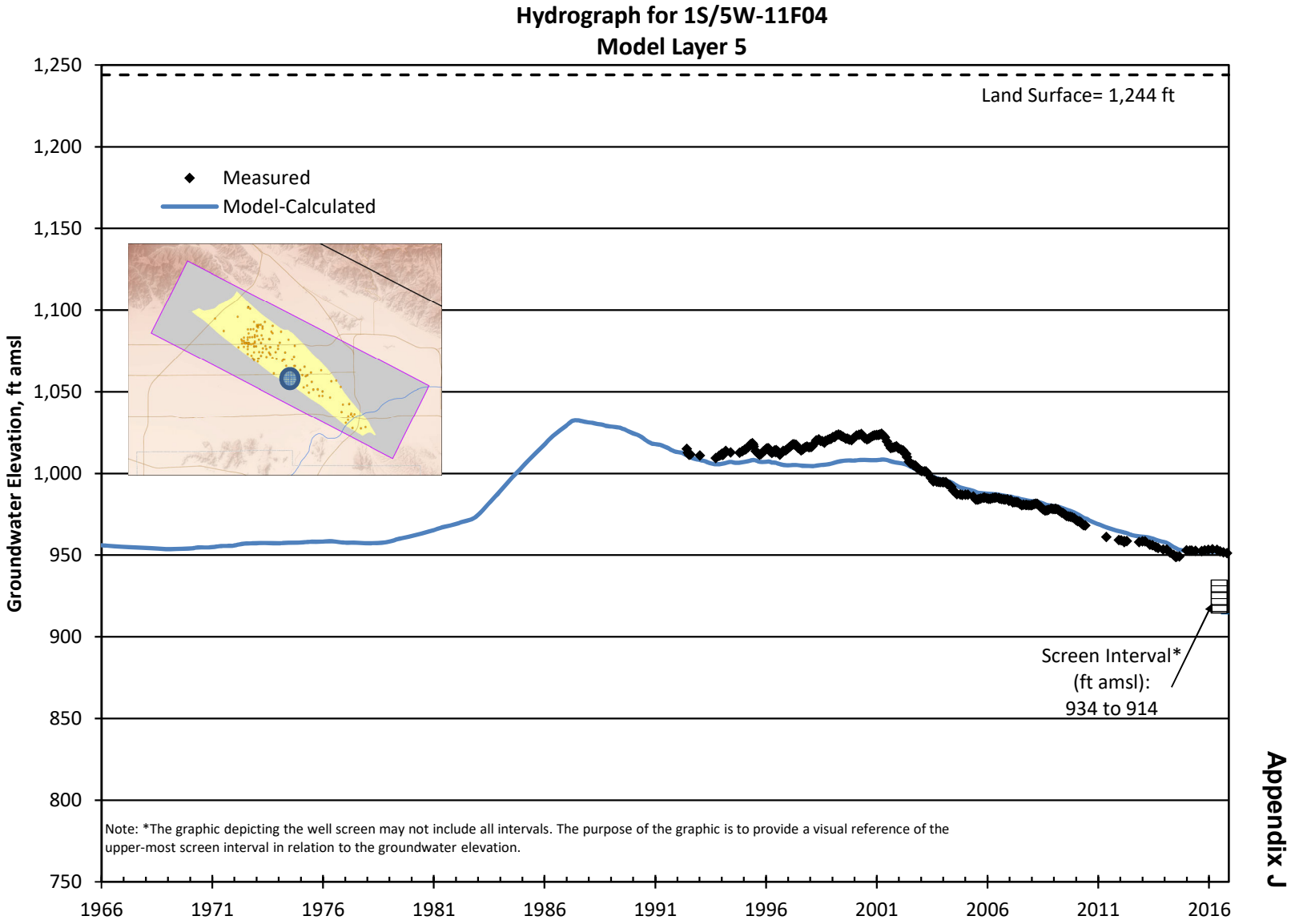
Appendix J


Hydrograph for 1S/5W-11F02
Model Layer 6
Land Surface= 1,244 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
550 to 530
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

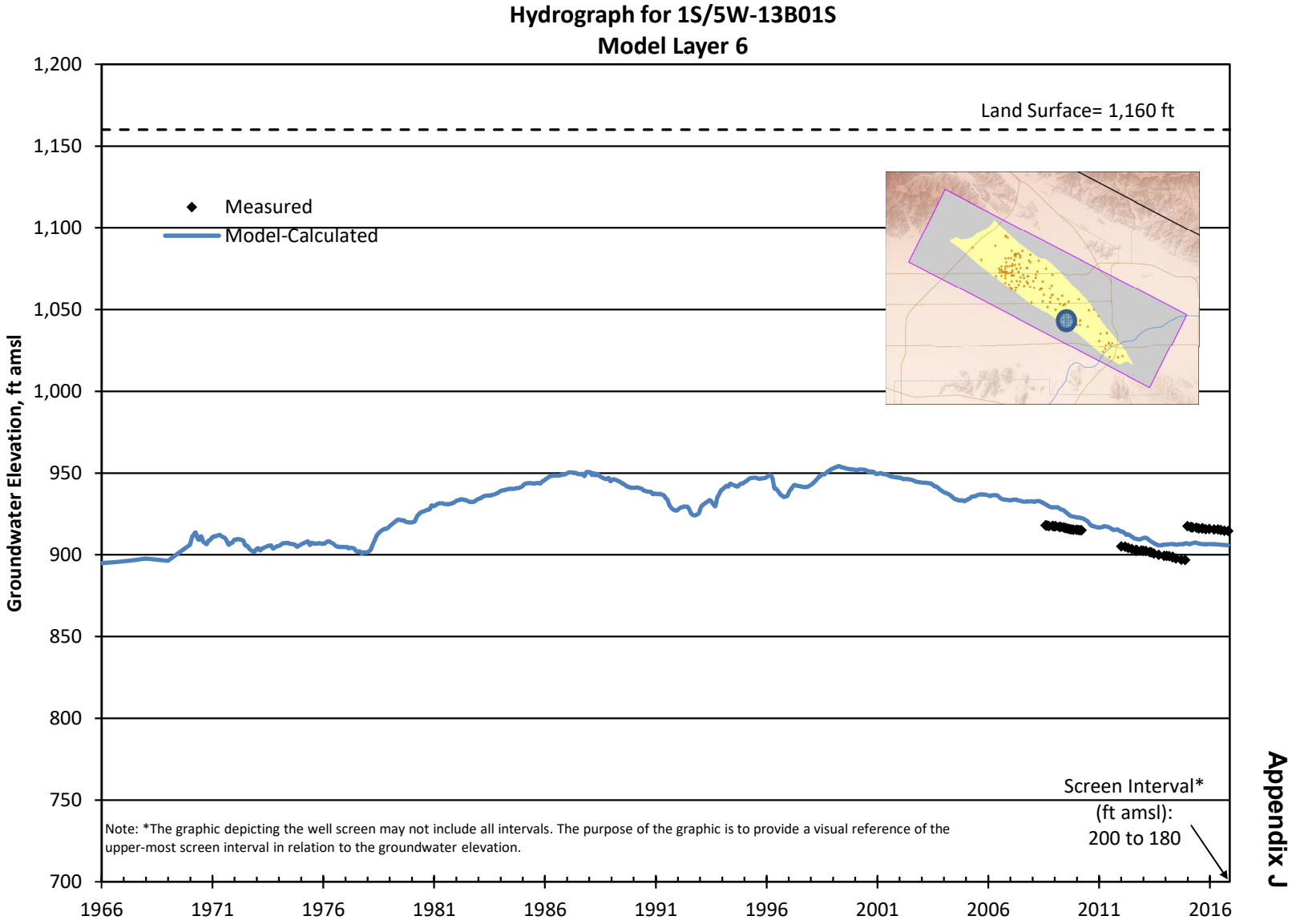
Appendix J


Hydrograph for 1S/5W-11F03
Model Layer 5
Land Surface= 1,244 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
822 to 802
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

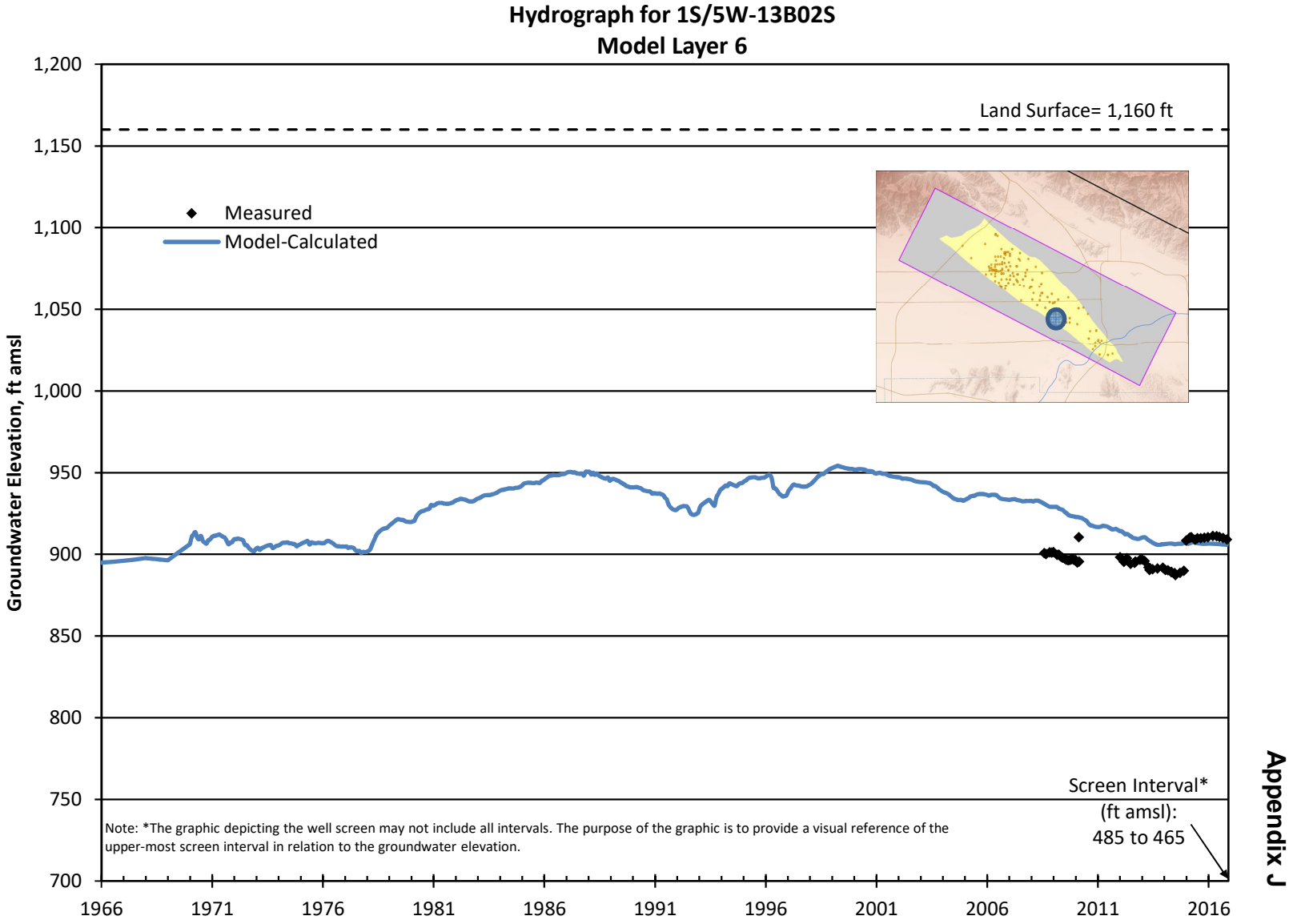
Appendix J


Hydrograph for 1S/5W-11F04
Model Layer 5
Land Surface= 1,244 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
934 to 914
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

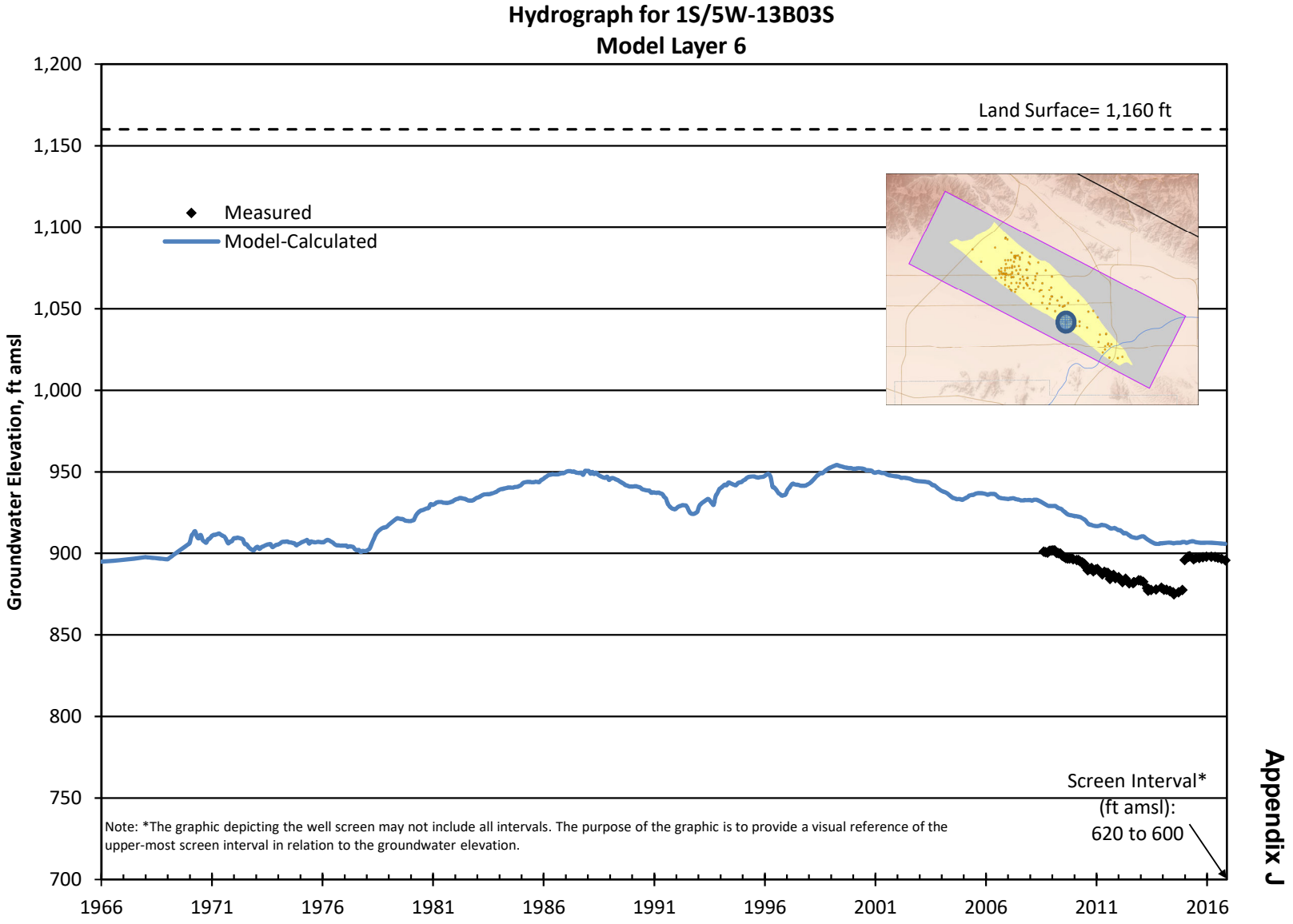
Appendix J


Hydrograph for 1S/5W-13B01S
Model Layer 6
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,160 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
200 to 180
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

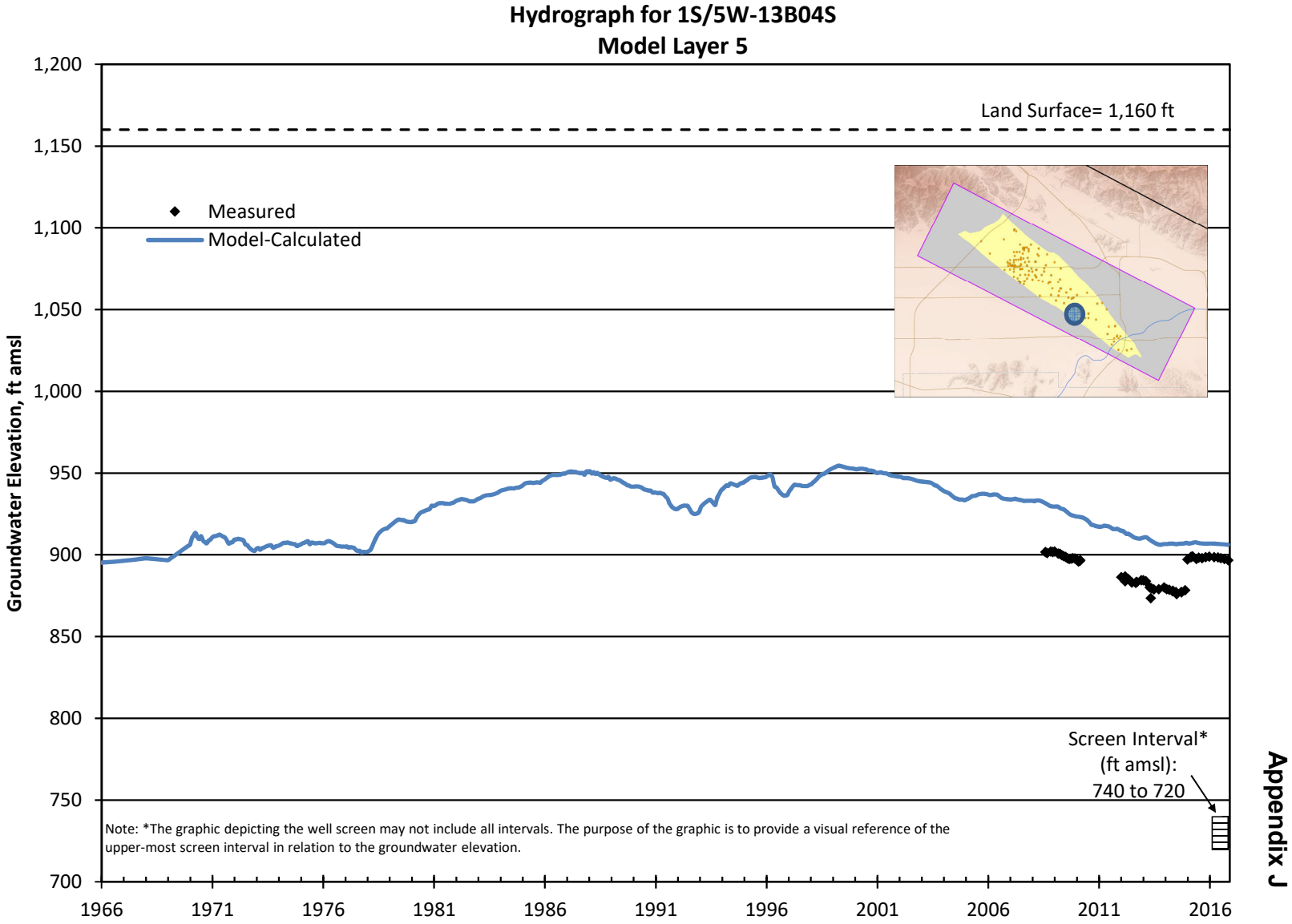
Appendix J


Hydrograph for 1S/5W-13B02S
Model Layer 6
Land Surface= 1,160 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
485 to 465
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

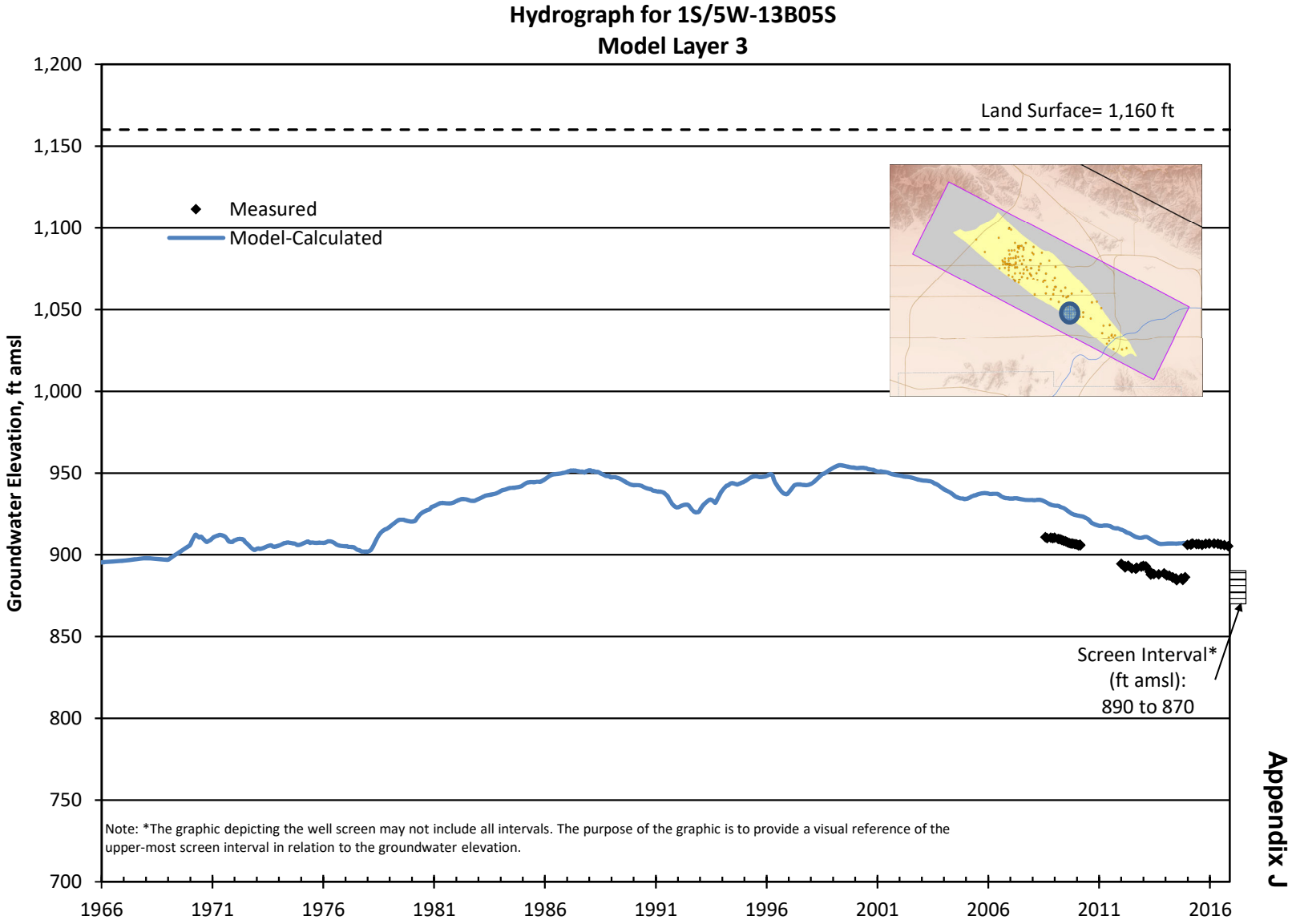
Appendix J


Hydrograph for 1S/5W-13B03S
Model Layer 6
Land Surface= 1,160 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
620 to 600
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

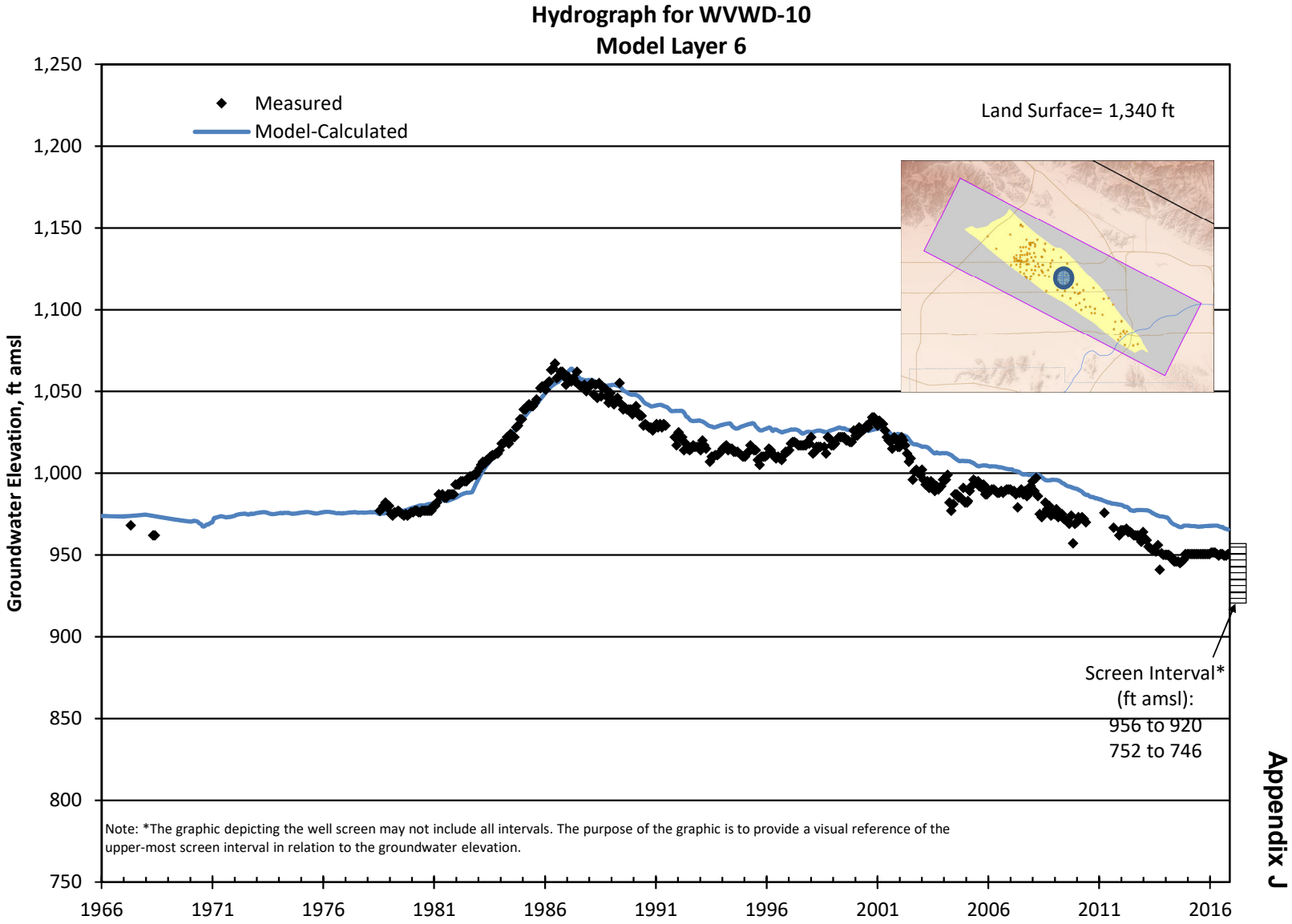
Appendix J


Hydrograph for 1S/5W-13B04S
Model Layer 5
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,160 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
740 to 720
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

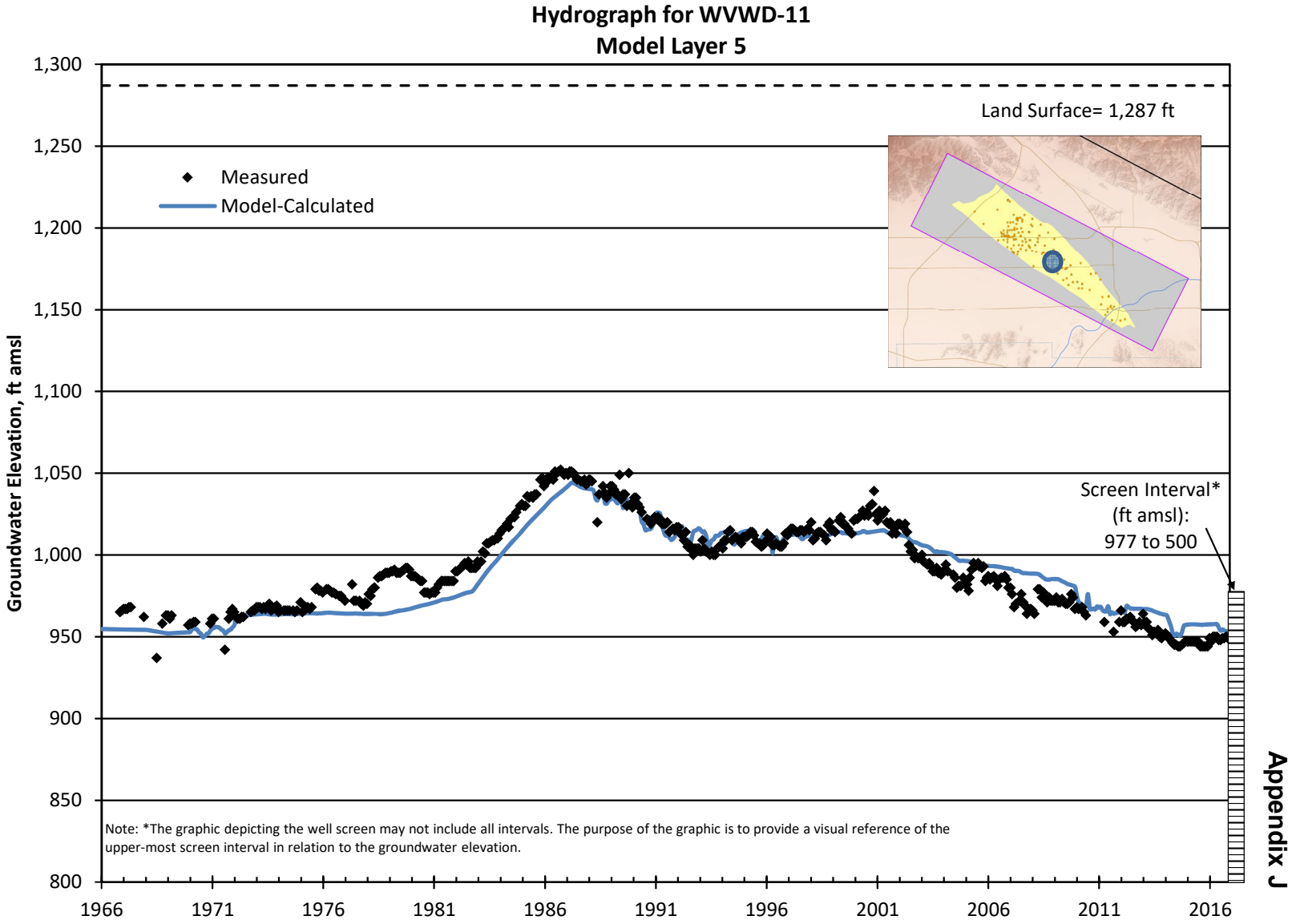
Appendix J


Hydrograph for 1S/5W-13B05S
Model Layer 3
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,160 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
890 to 870
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

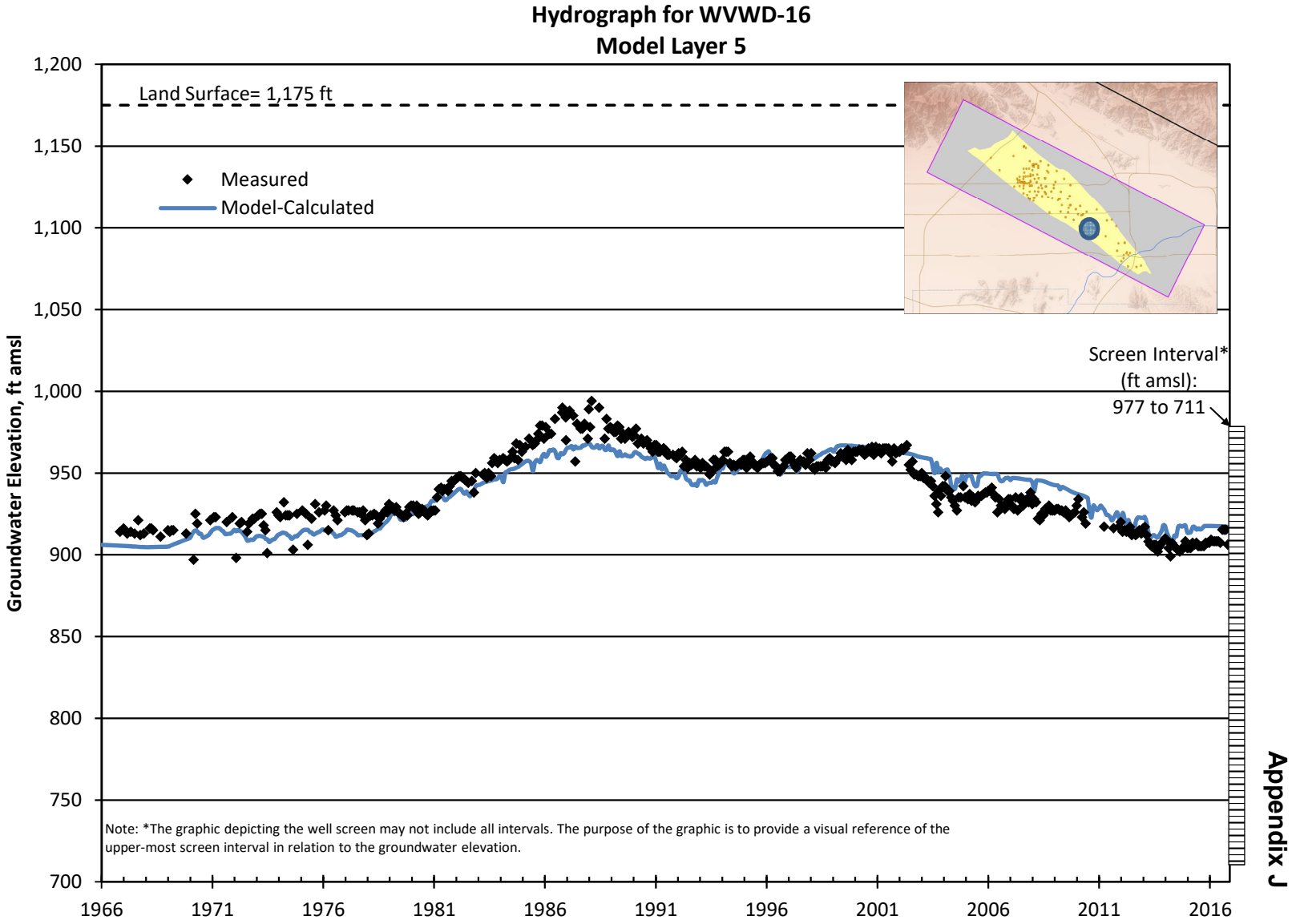
Appendix J


Hydrograph for WVWD-10
Model Layer 6
Measured
Model-Calculated
Land Surface= 1,340 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
956 to 920
752 to 746
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

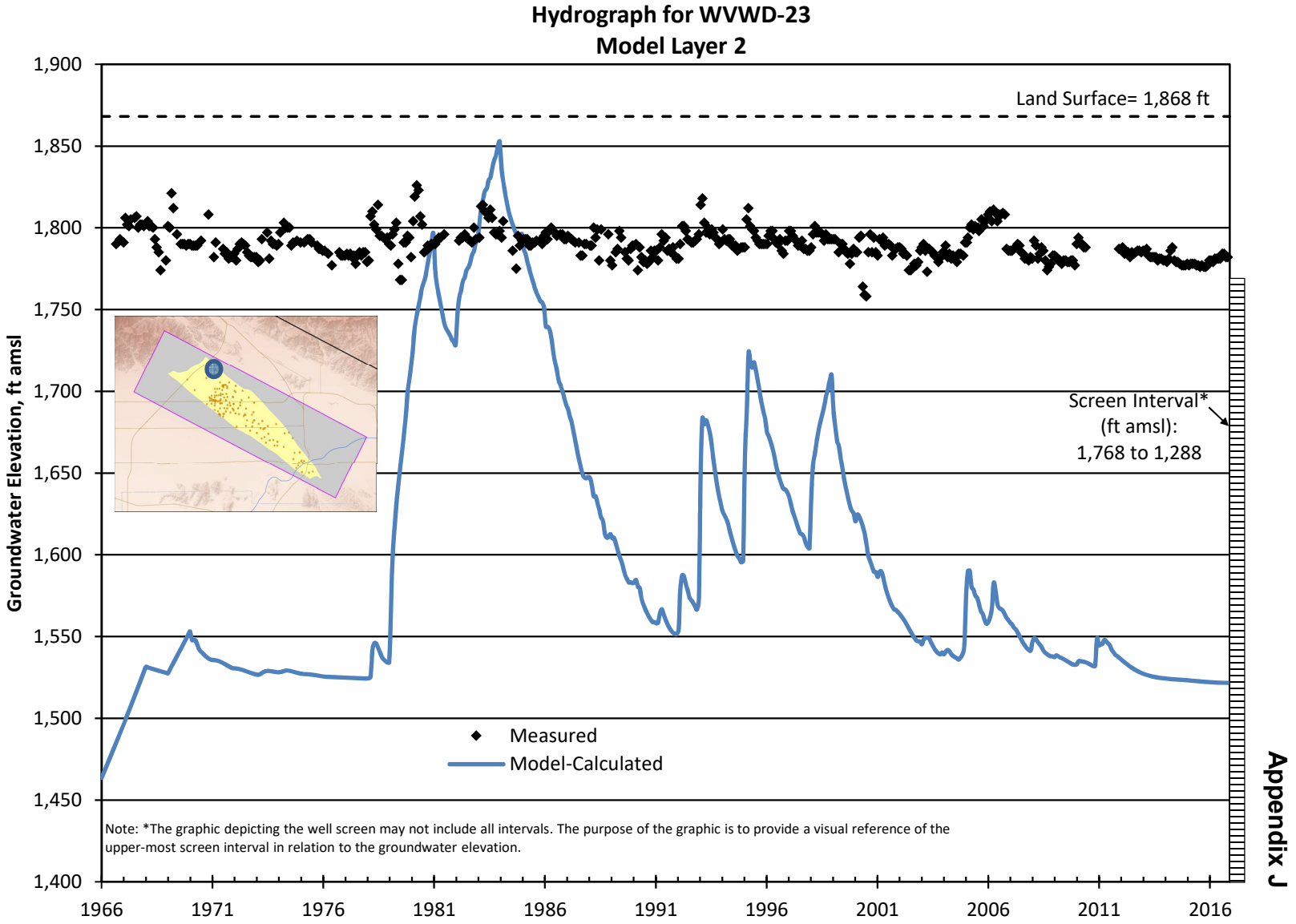
Appendix J


Hydrograph for WVWD-11
Model Layer 5
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Measured
Model-Calculated
Land Surface= 1,287 ft
Screen Interval*
(ft amsl):
977 to 500
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

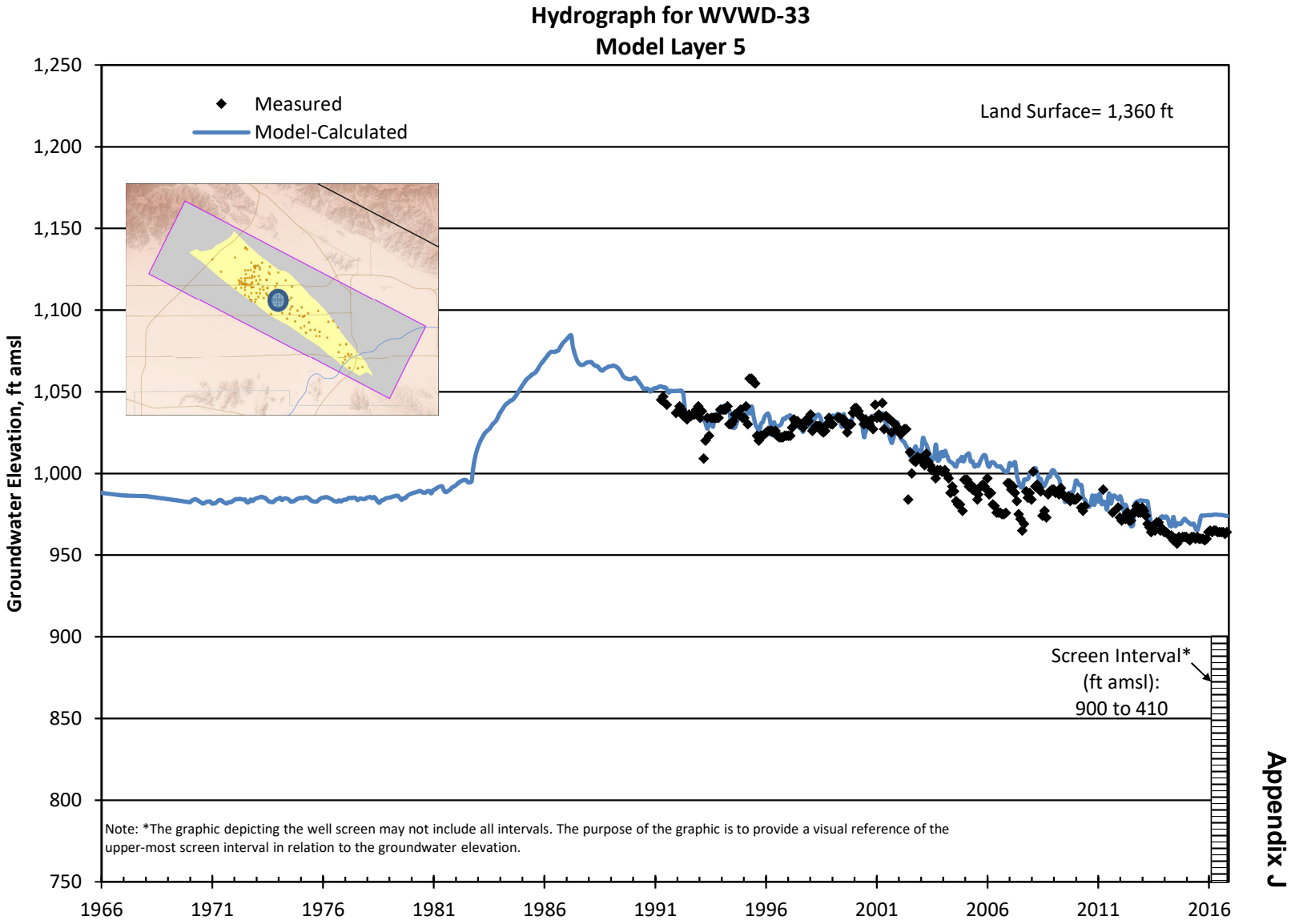
Appendix J


Hydrograph for WVWD-16
Model Layer 5
Land Surface= 1,175 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
977 to 711
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J


Hydrograph for WVWD-23
Model Layer 2
Groundwater Elevation, ft amsl
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,868 ft
Screen Interval*
(ft amsl):
1,768 to 1,288
Measured
Model-Calculated
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

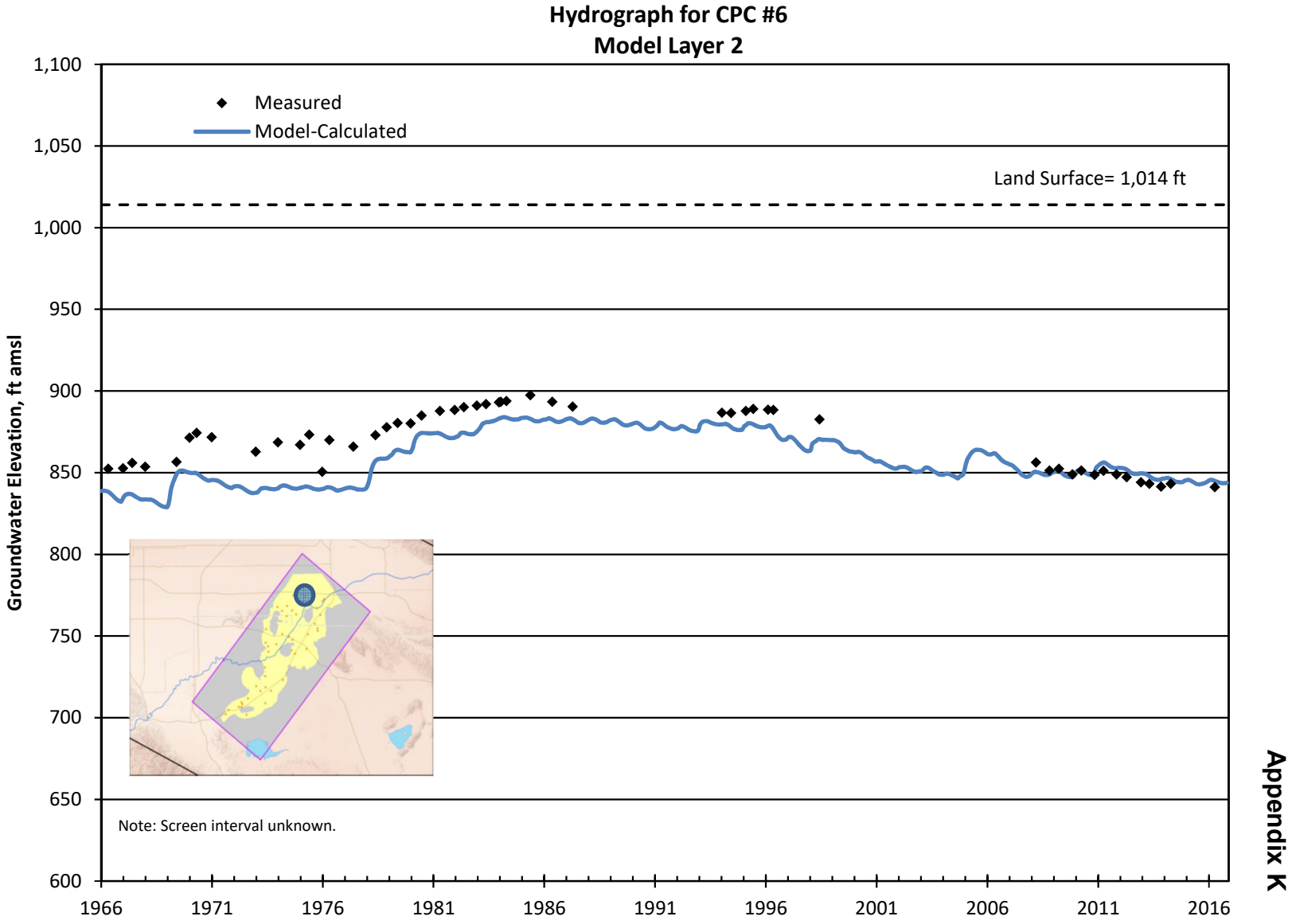

Hydrograph for WVWD-33
Model Layer 5
Measured
Model-Calculated
Land Surface= 1,360 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
900 to 410
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix J

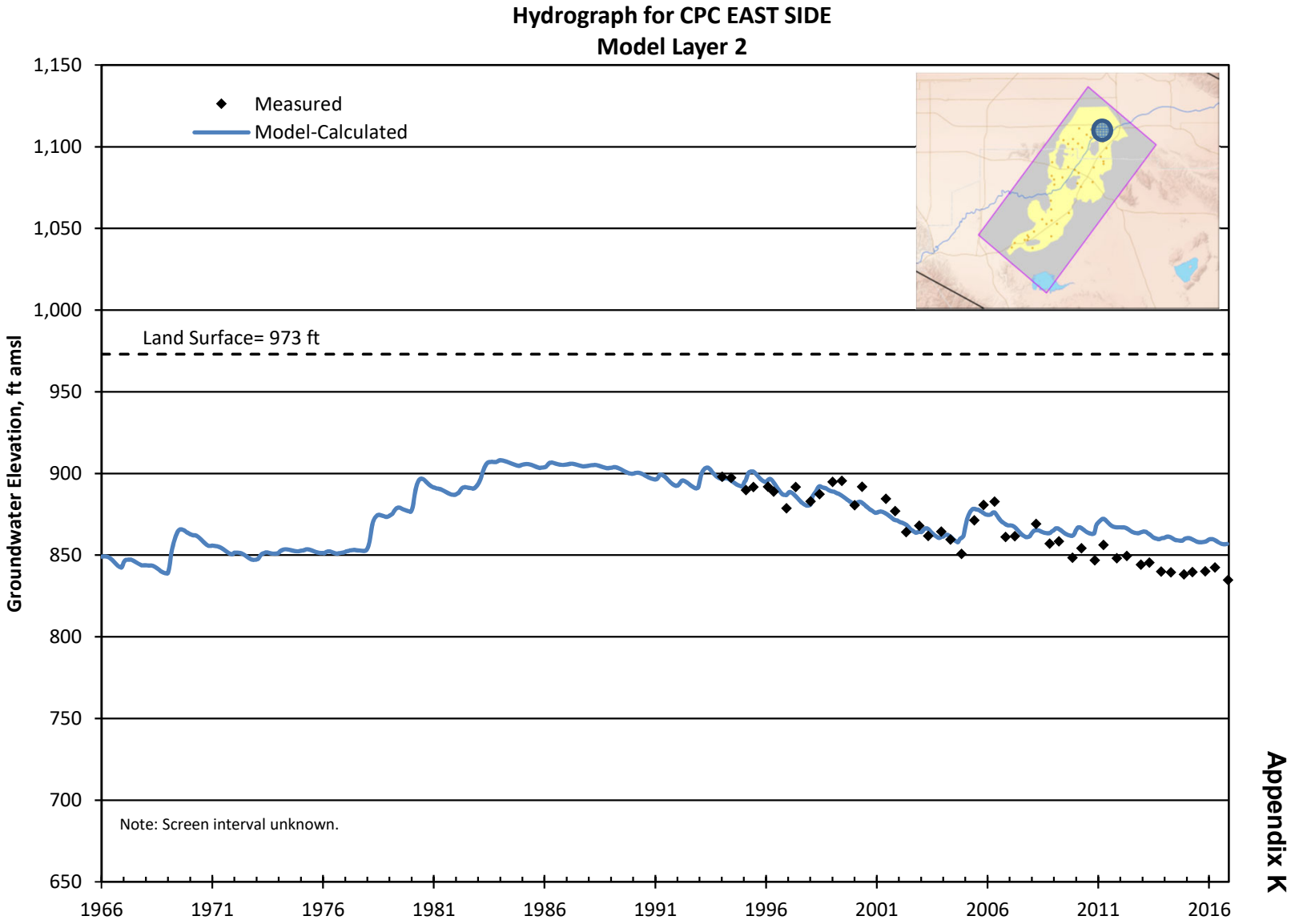
APPENDIX K

Individual Model Update: Selected Hydrographs for the Riverside-Arlington Basin Model Calibration Target Wells – 1966 to 2016

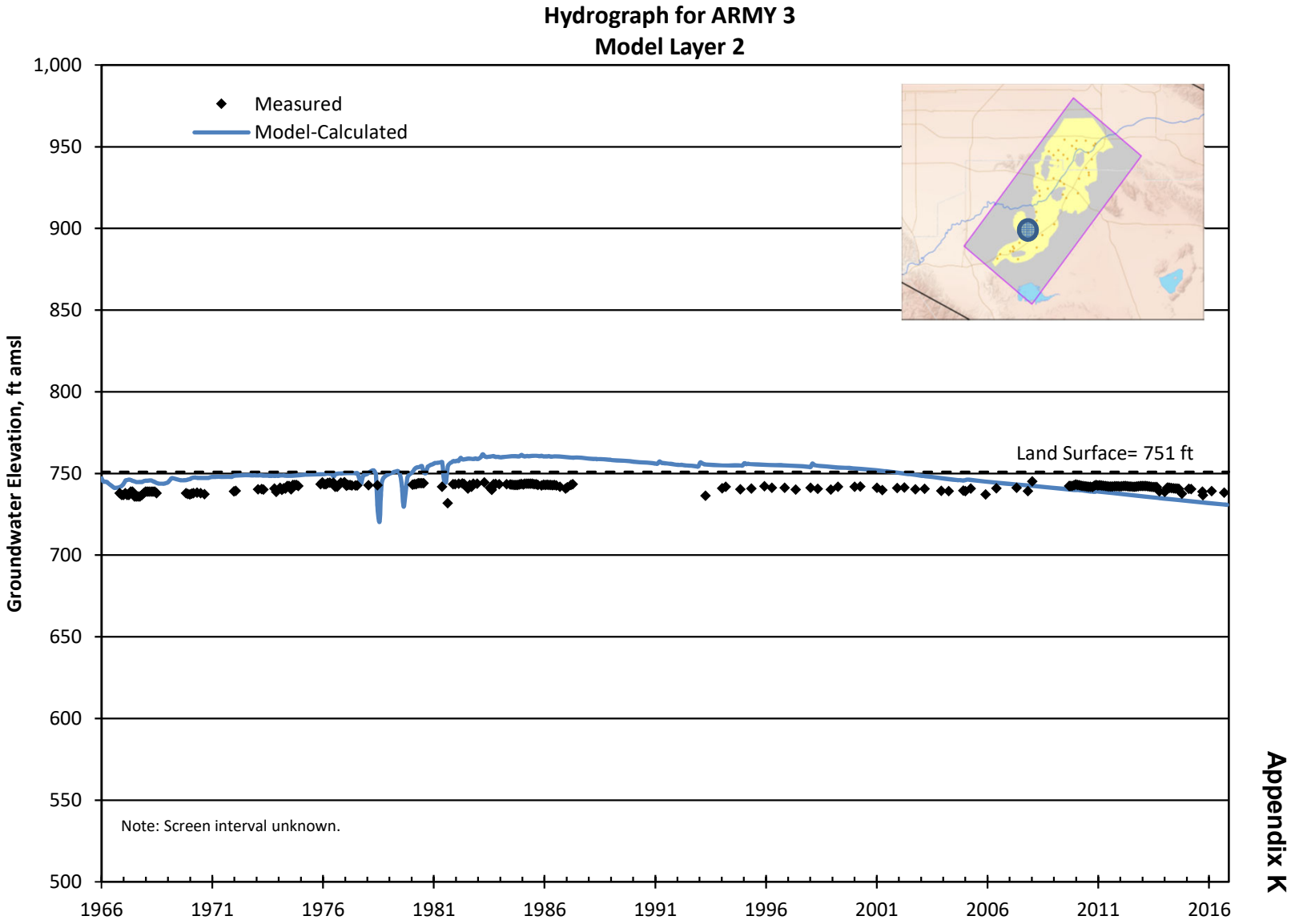
GEOSCIENCE


Hydrograph for CPC #6
Model Layer 2
Measured
Model-Calculated
Land Surface= 1,014 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

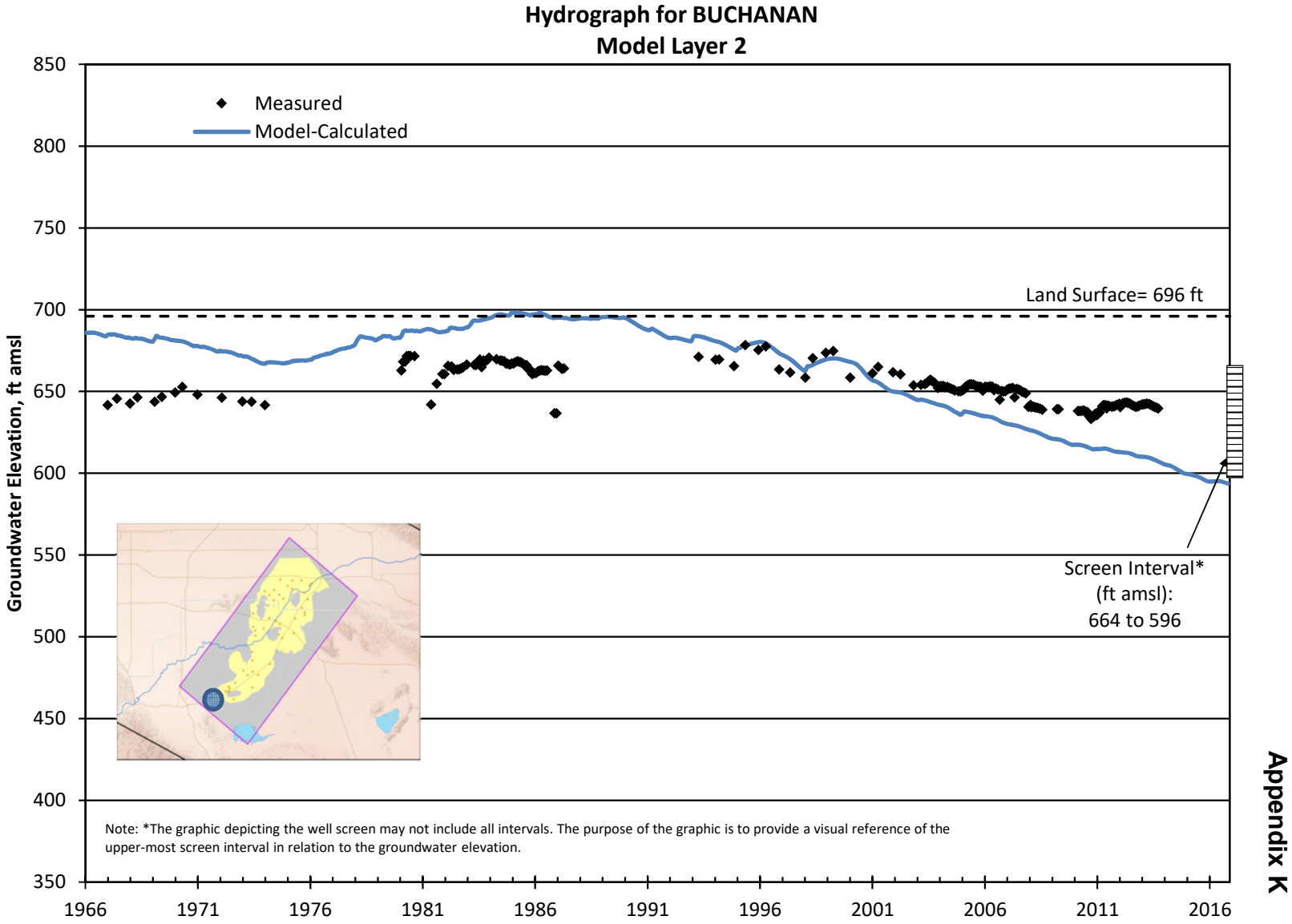
Appendix K


Hydrograph for CPC EAST SIDE
Model Layer 2
Measured
Model-Calculated
Land Surface= 973 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

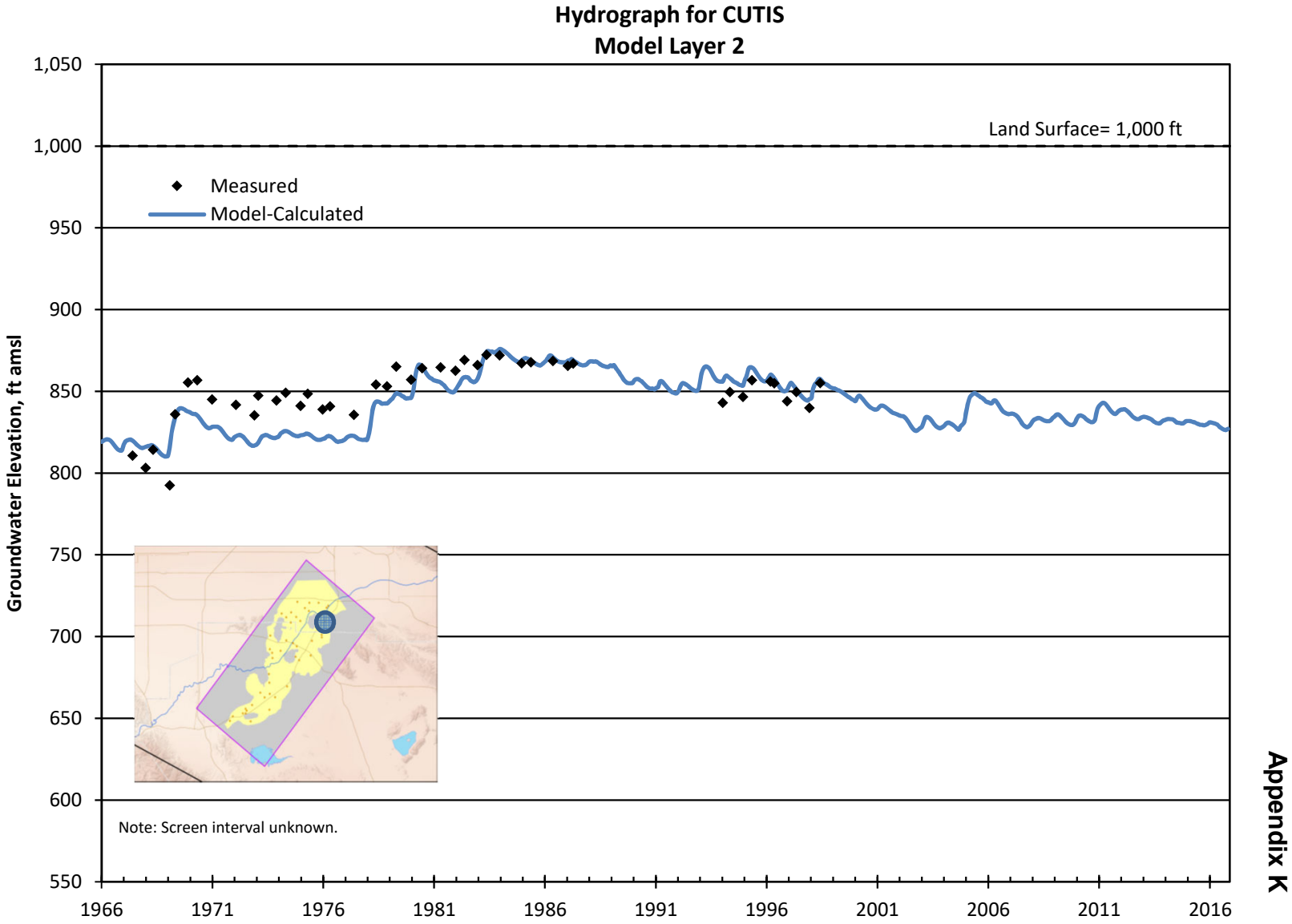
Appendix K


Hydrograph for ARMY 3
Model Layer 2
Measured
Model-Calculated
Land Surface= 751 ft
Note: Screen interval unknown.
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

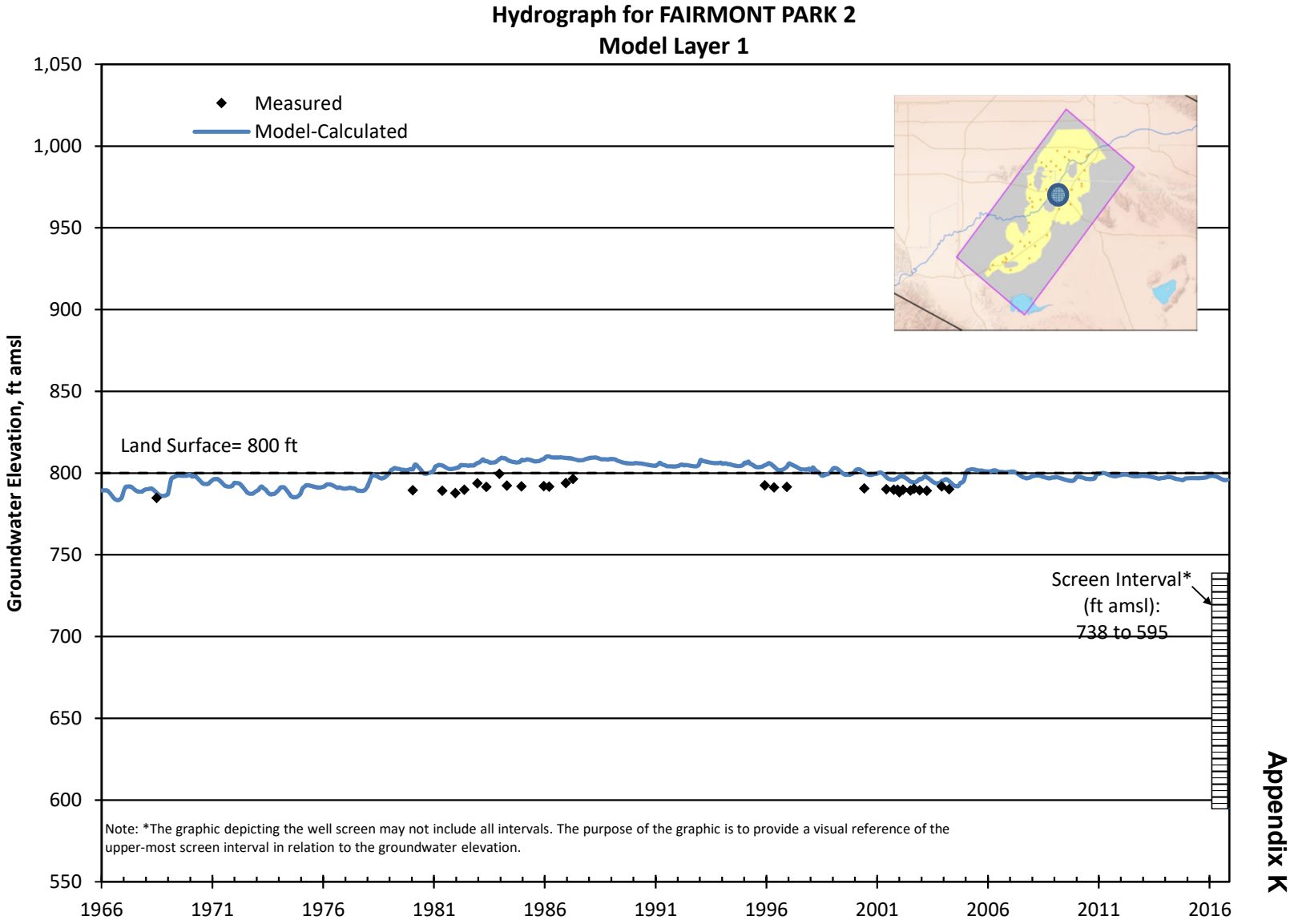
Appendix K


Hydrograph for BUCHANAN
Model Layer 2
Measured
Model-Calculated
Land Surface= 696 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
664 to 596
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

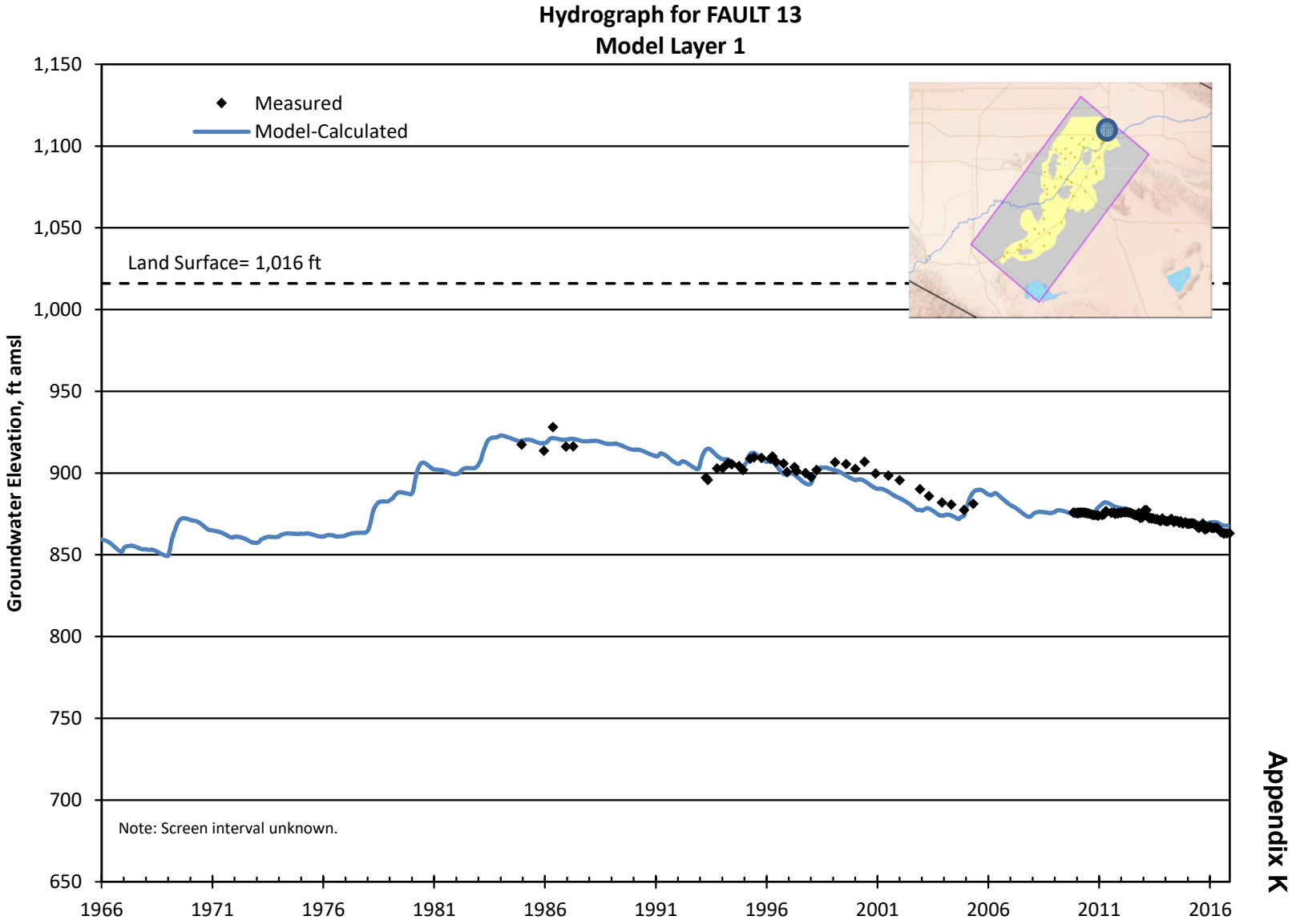
Appendix K


Hydrograph for CUTIS
Model Layer 2
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,000 ft
Measured
Model-Calculated
Note: Screen interval unknown.

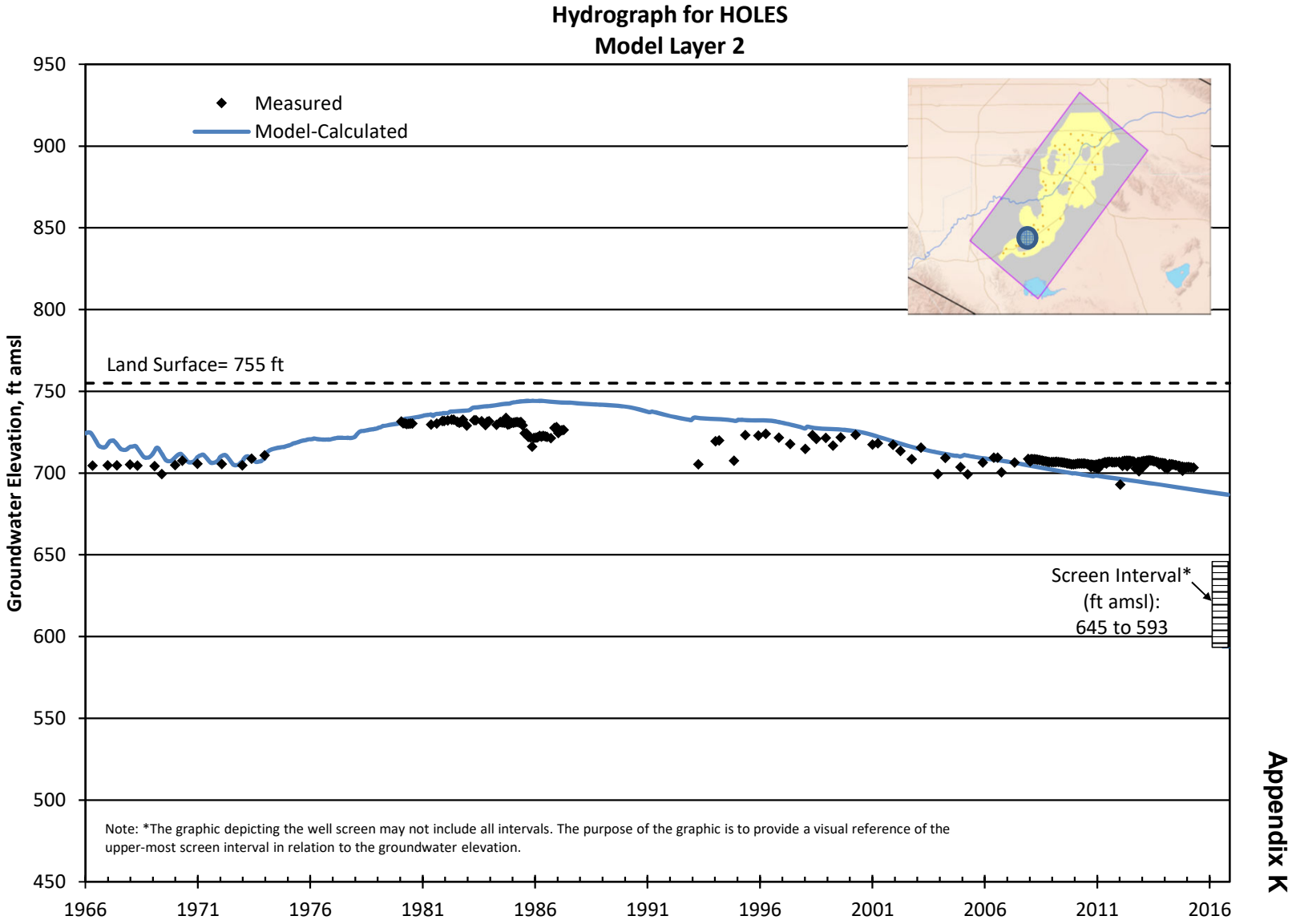
Appendix K


Hydrograph for FAIRMONT PARK 2
Model Layer 1
Measured
Model-Calculated
Land Surface= 800 ft
Screen Interval*
(ft amsl):
738 to 595
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

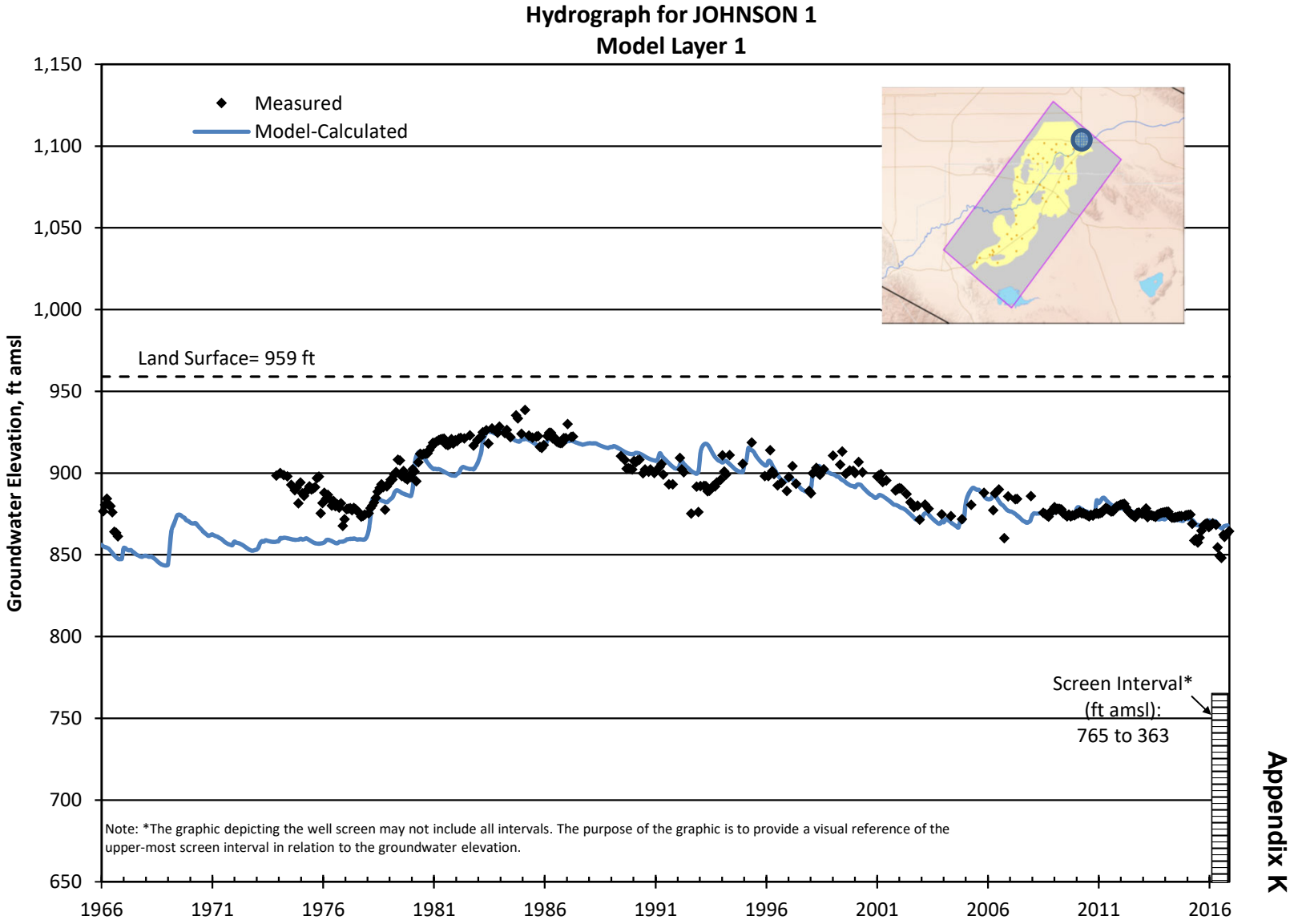
Appendix K


Hydrograph for FAULT 13
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,016 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

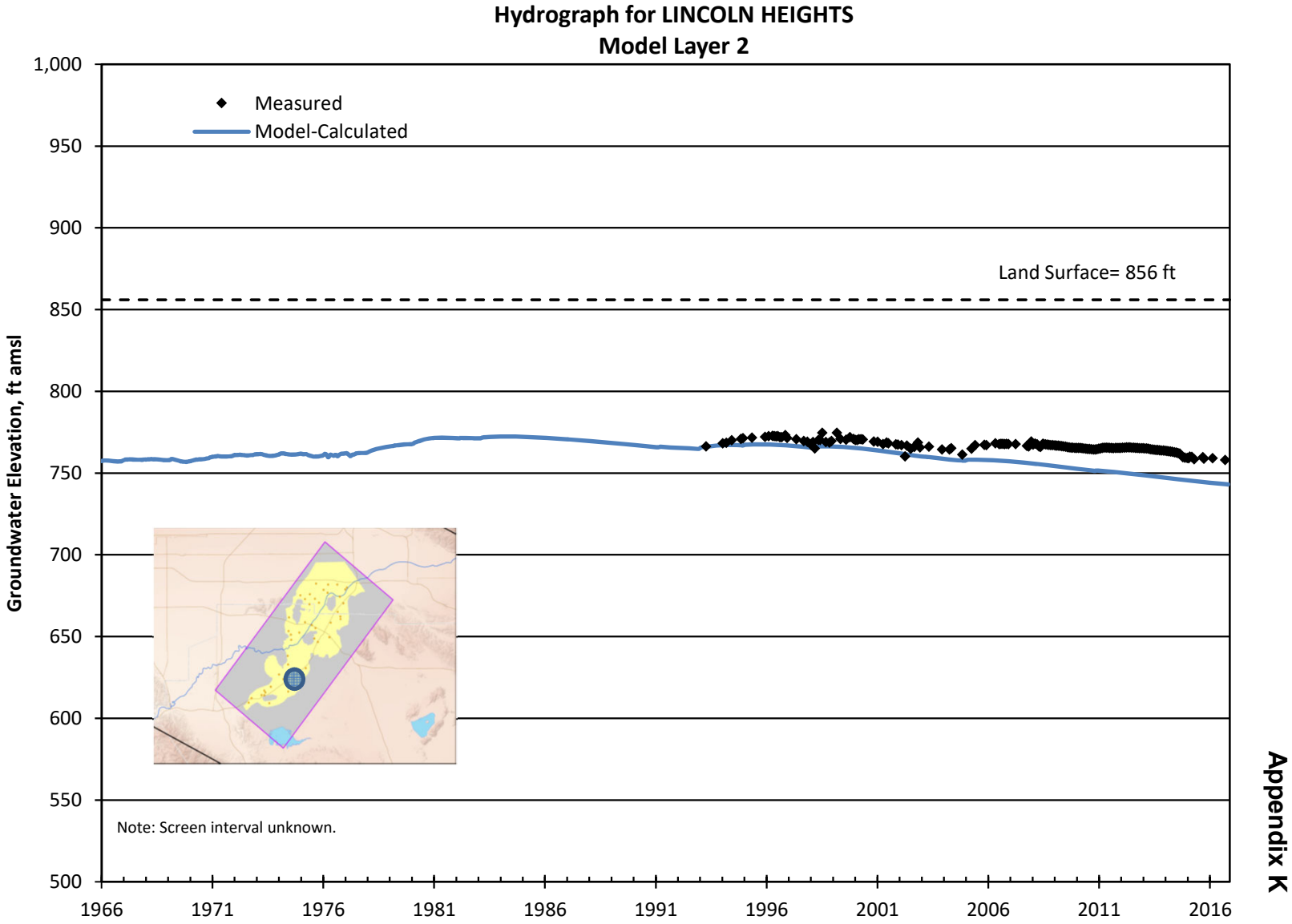
Appendix K


Hydrograph for HOLES
Model Layer 2
Measured
Model-Calculated
Land Surface= 755 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
645 to 593
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix K

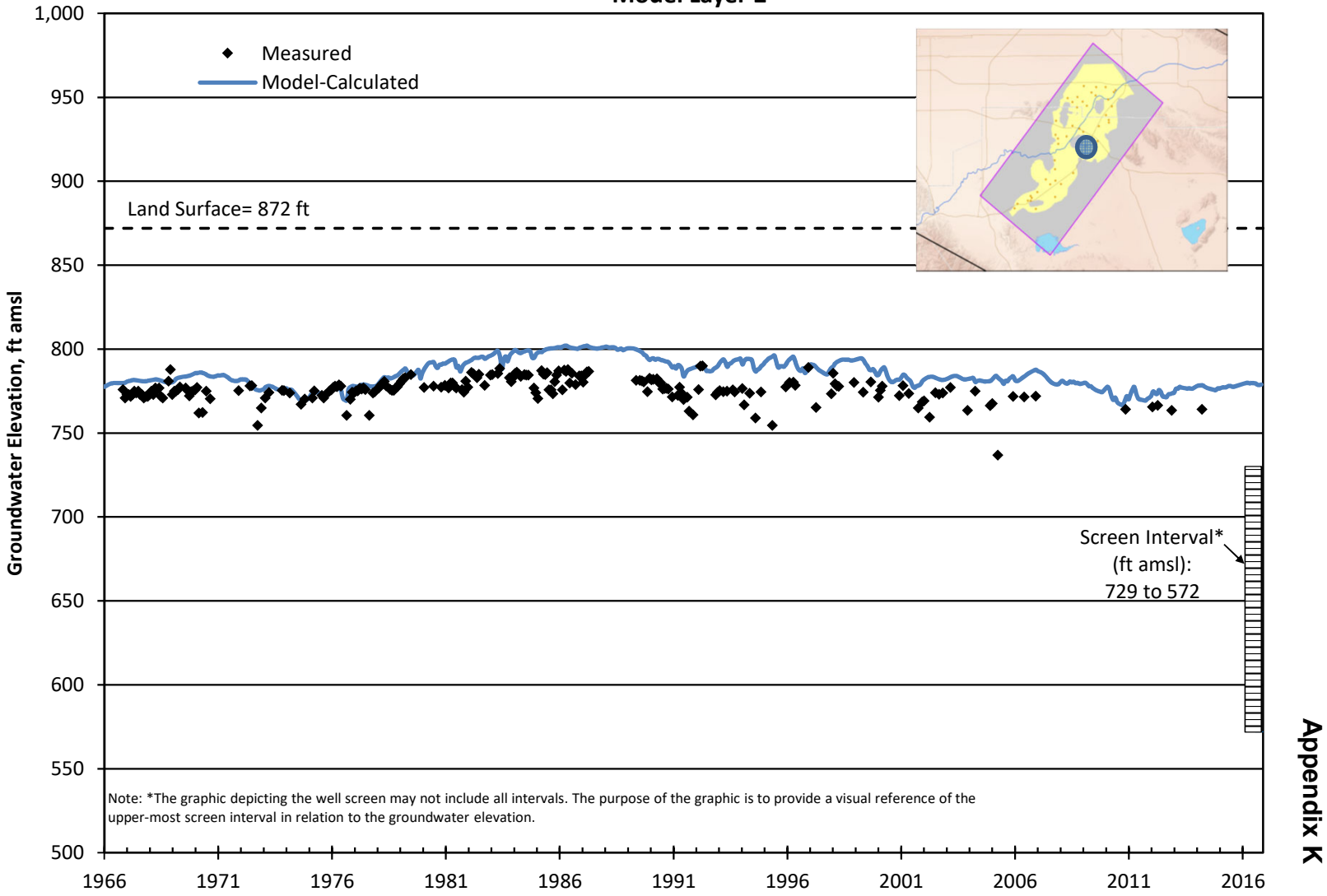

Hydrograph for JOHNSON 1
Model Layer 1
Measured
Model-Calculated
Land Surface= 959 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
765 to 363
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix K

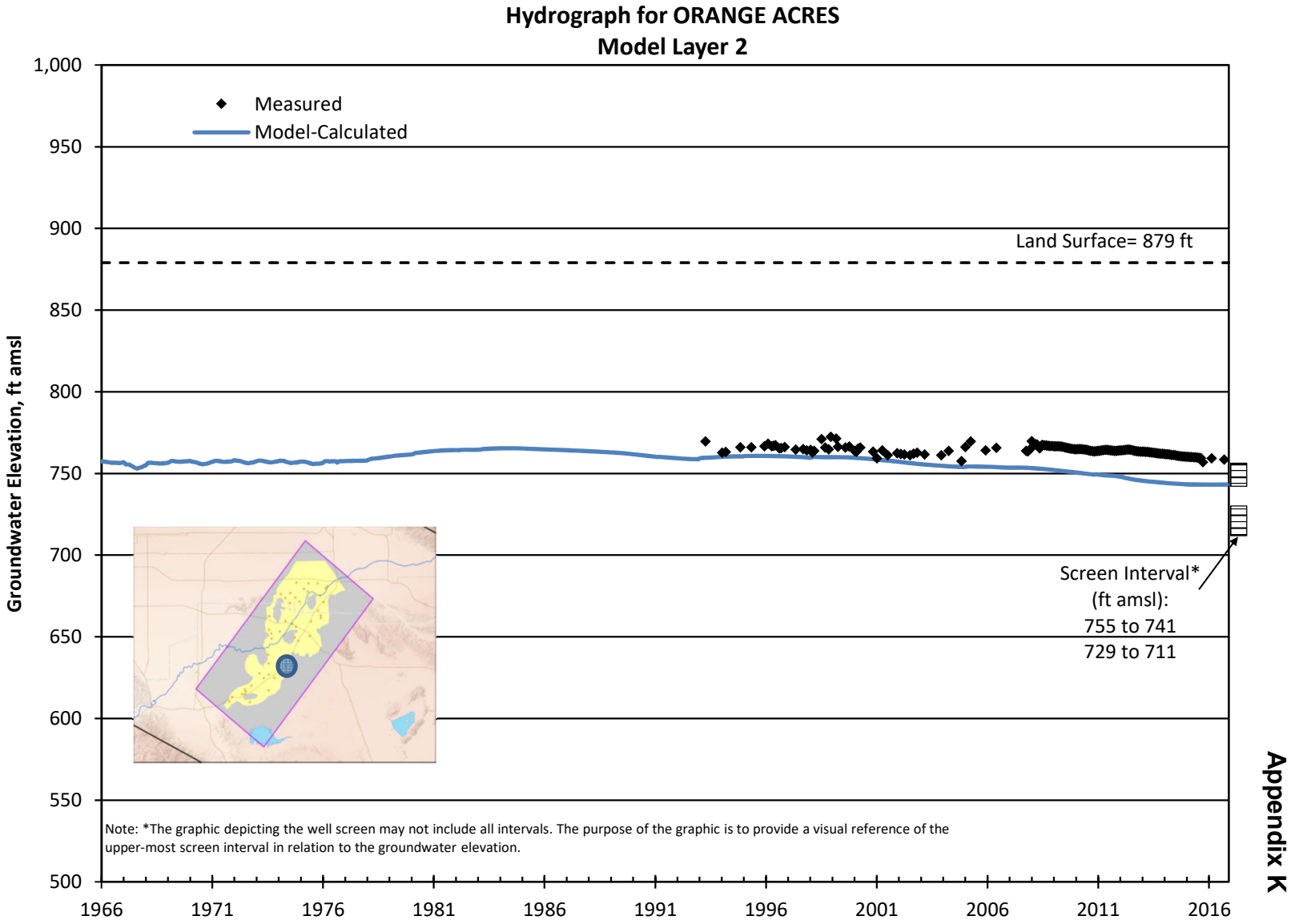

Hydrograph for LINCOLN HEIGHTS
Model Layer 2
Measured
Model-Calculated
Land Surface= 856 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

Appendix K

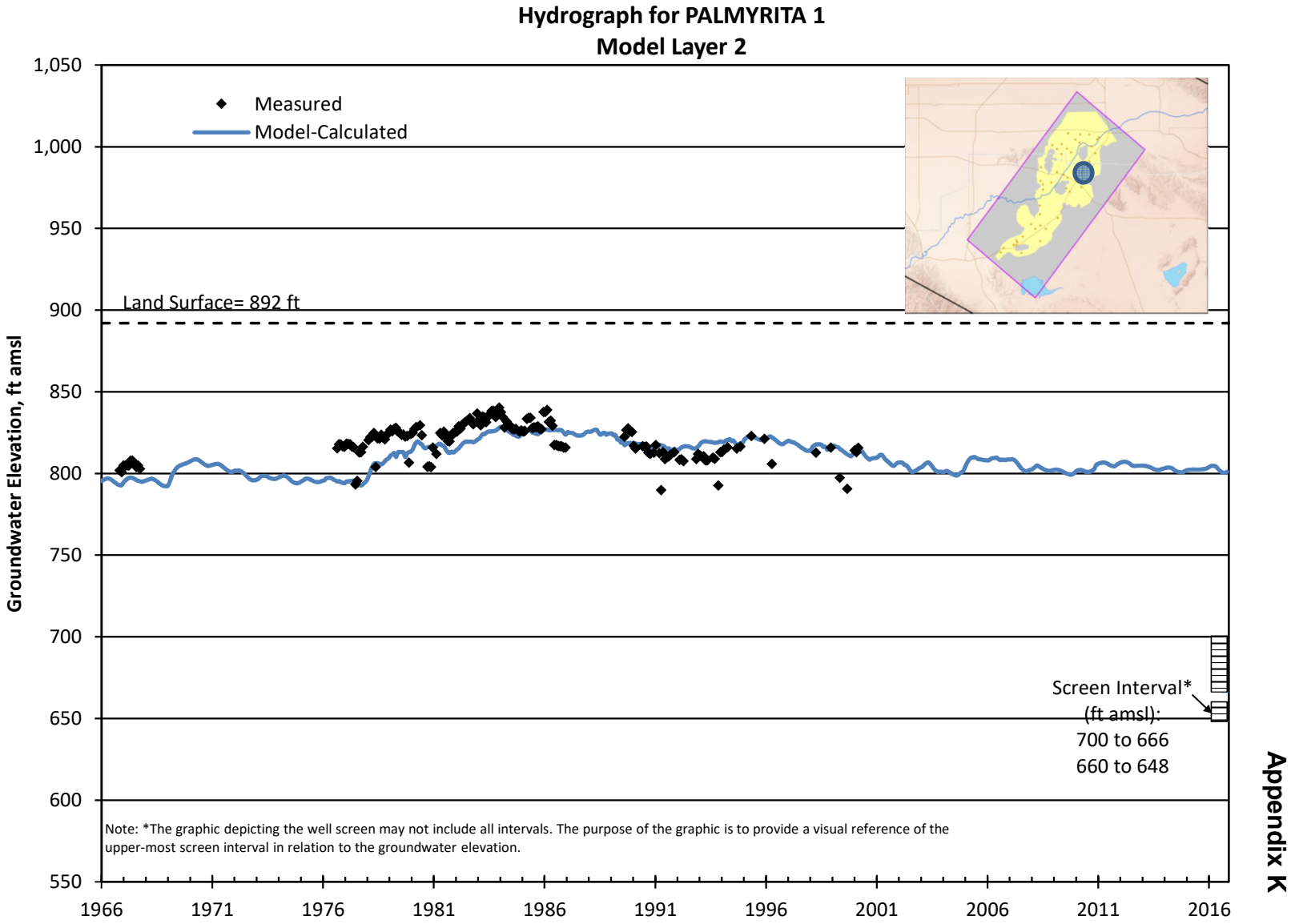
Hydrograph for MULBERRY
Model Layer 2



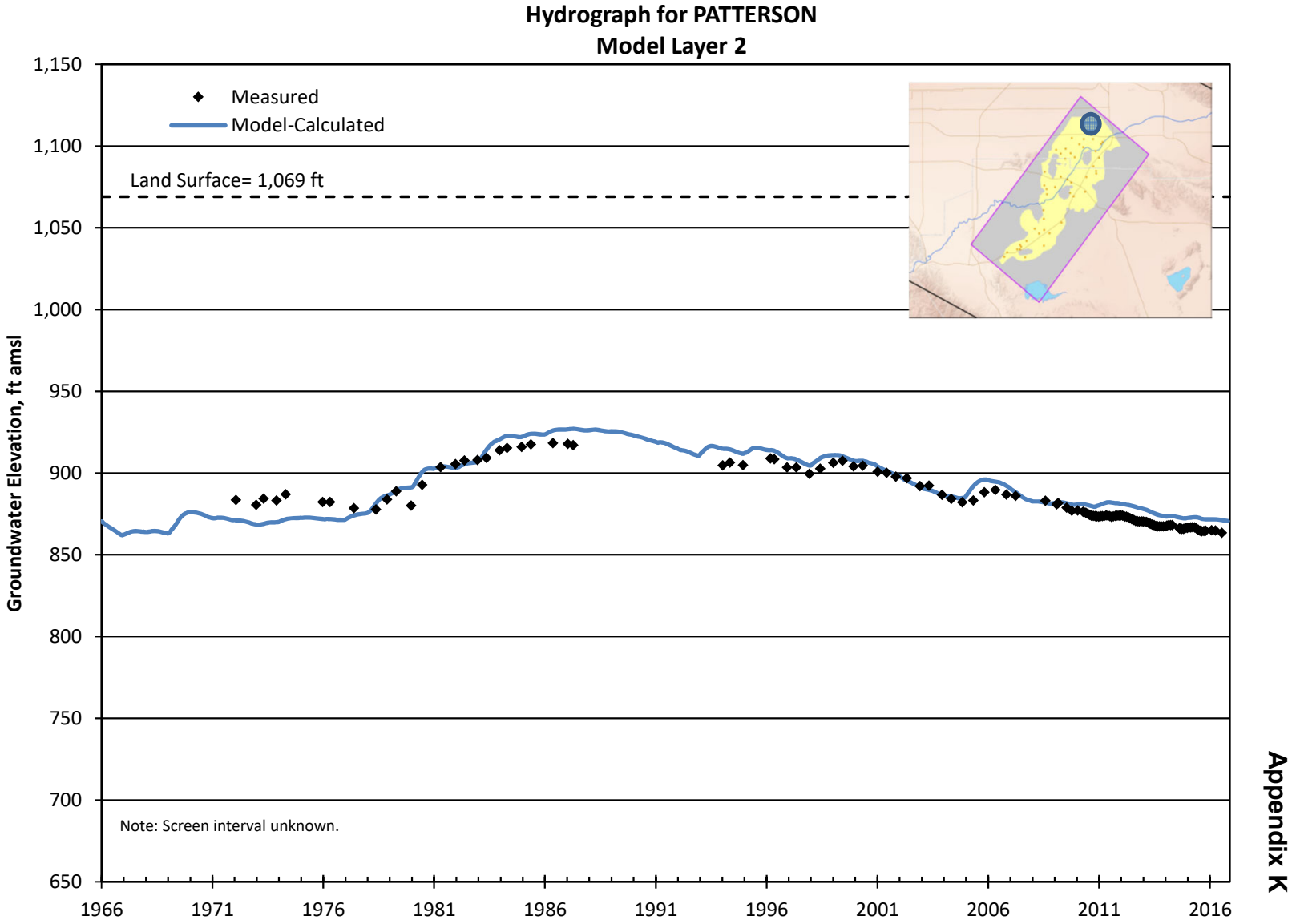
Appendix K


Hydrograph for ORANGE ACRES
Model Layer 2
Measured
Model-Calculated
Land Surface= 879 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
755 to 741
729 to 711
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

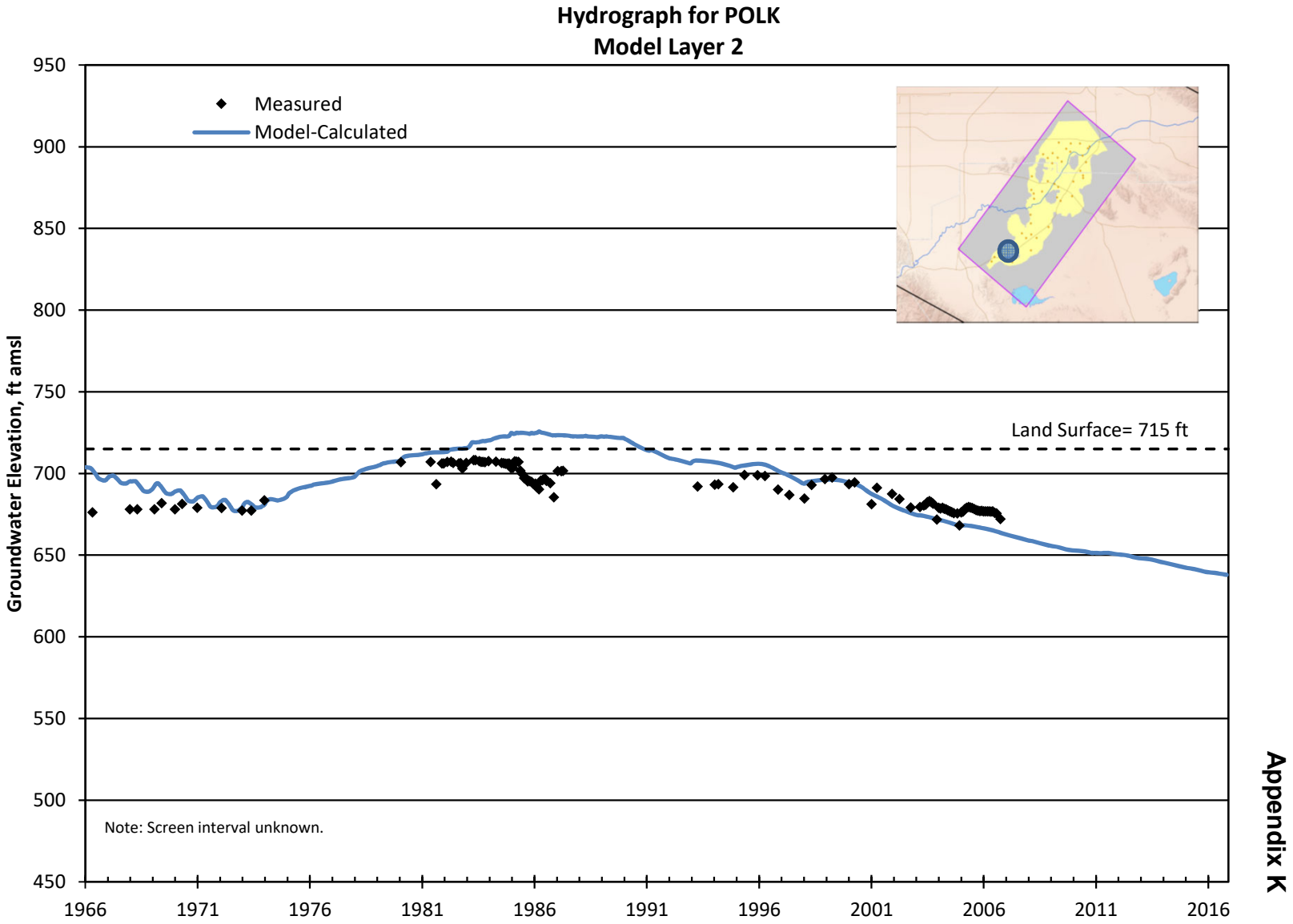
Appendix K


Hydrograph for PALMYRITA 1
Model Layer 2
Measured
Model-Calculated
Land Surface= 892 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
700 to 666
660 to 648
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

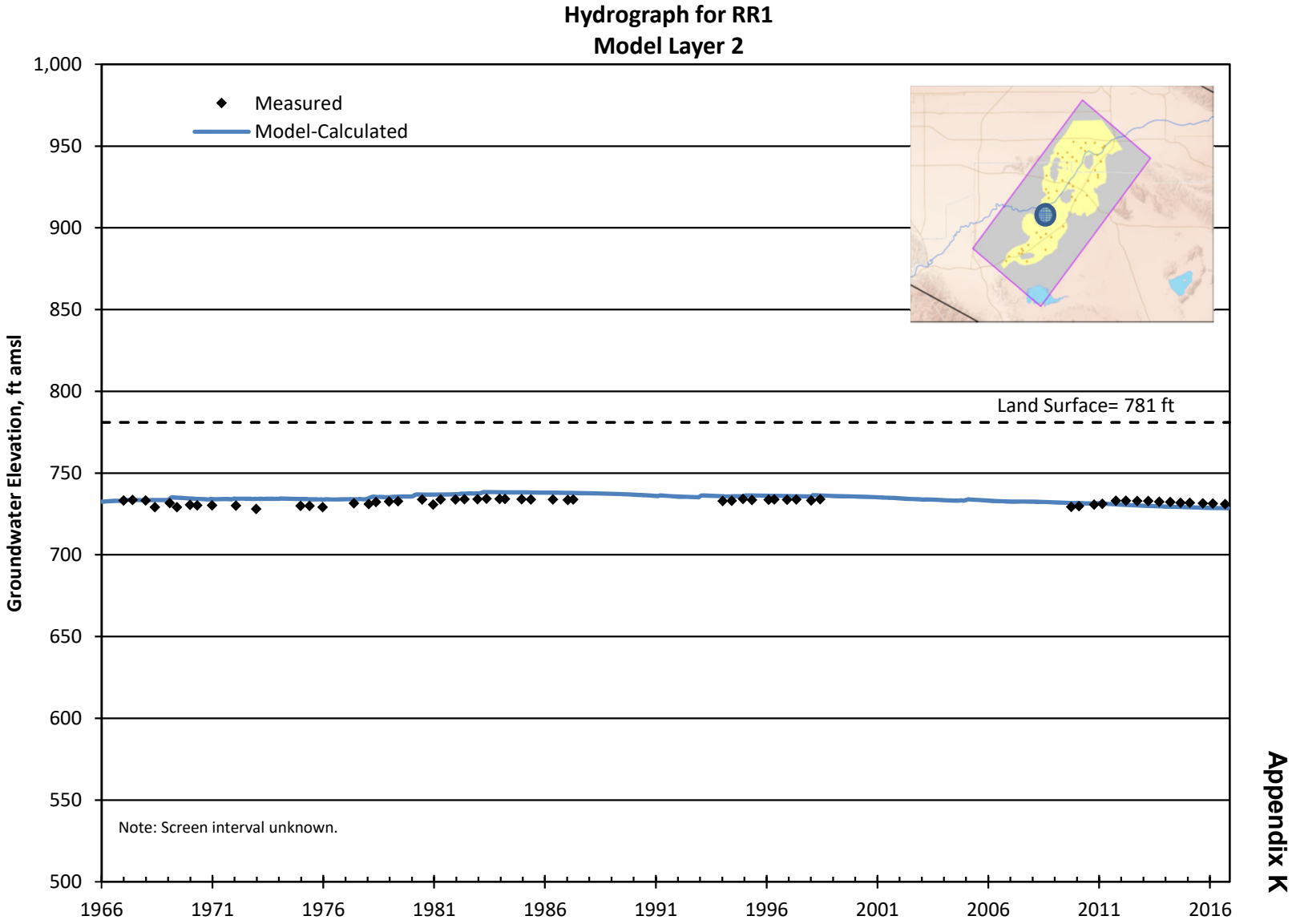
Appendix K


Hydrograph for PATTERSON
Model Layer 2
Measured
Model-Calculated
Land Surface= 1,069 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

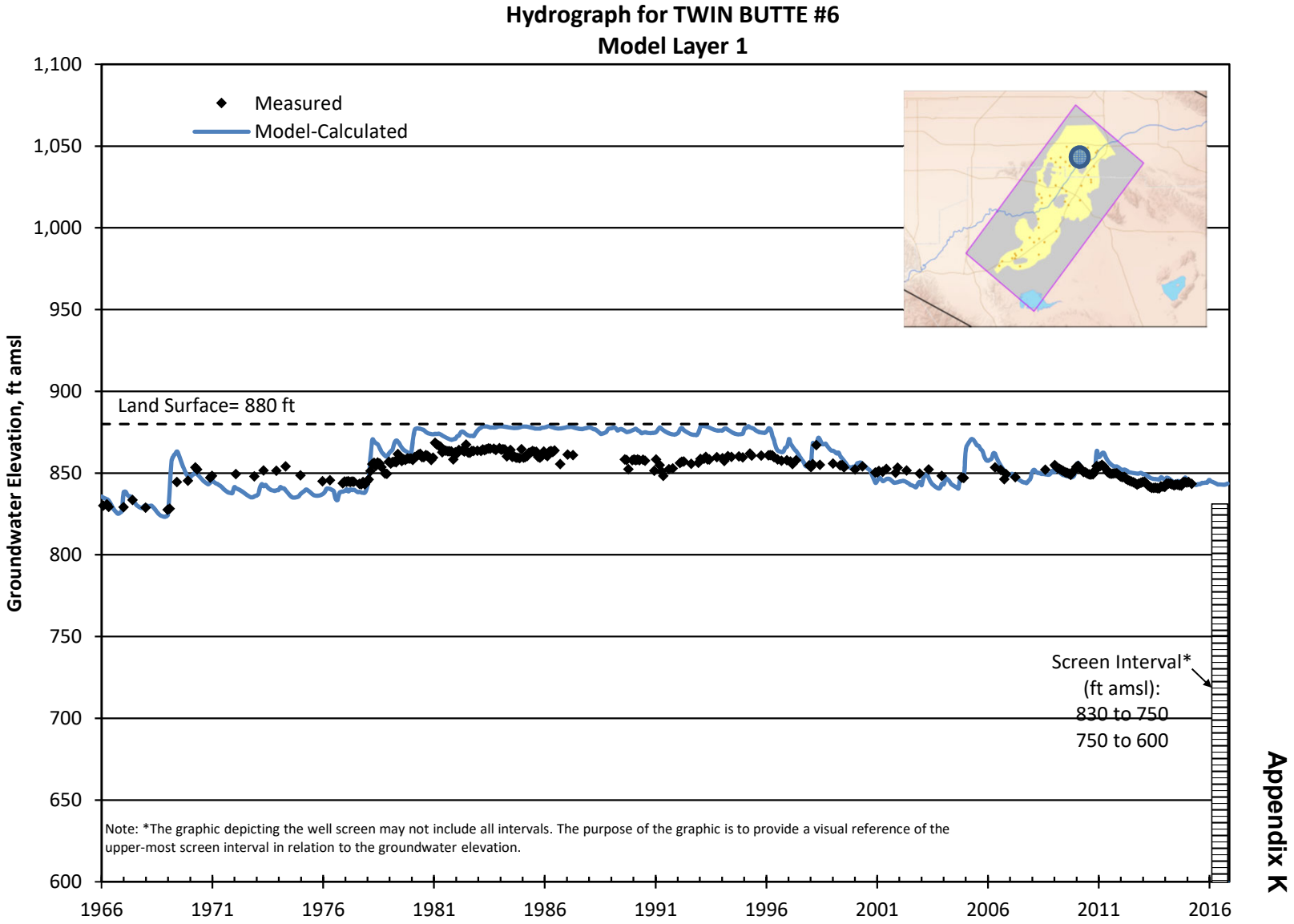
Appendix K


Hydrograph for POLK
Model Layer 2
Measured
Model-Calculated
Land Surface= 715 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

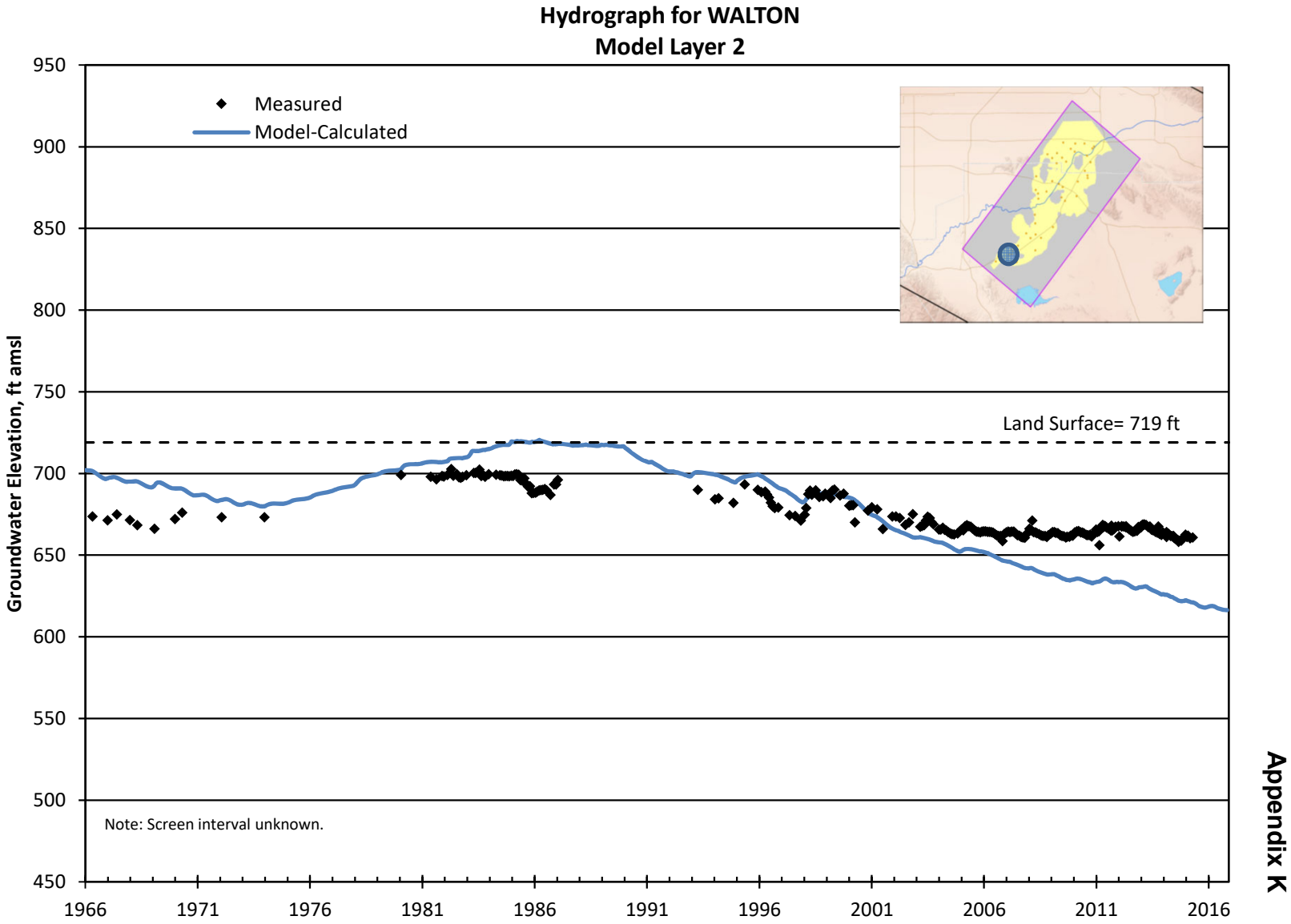
Appendix K


Hydrograph for RR1
Model Layer 2
Measured
Model-Calculated
Land Surface= 781 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

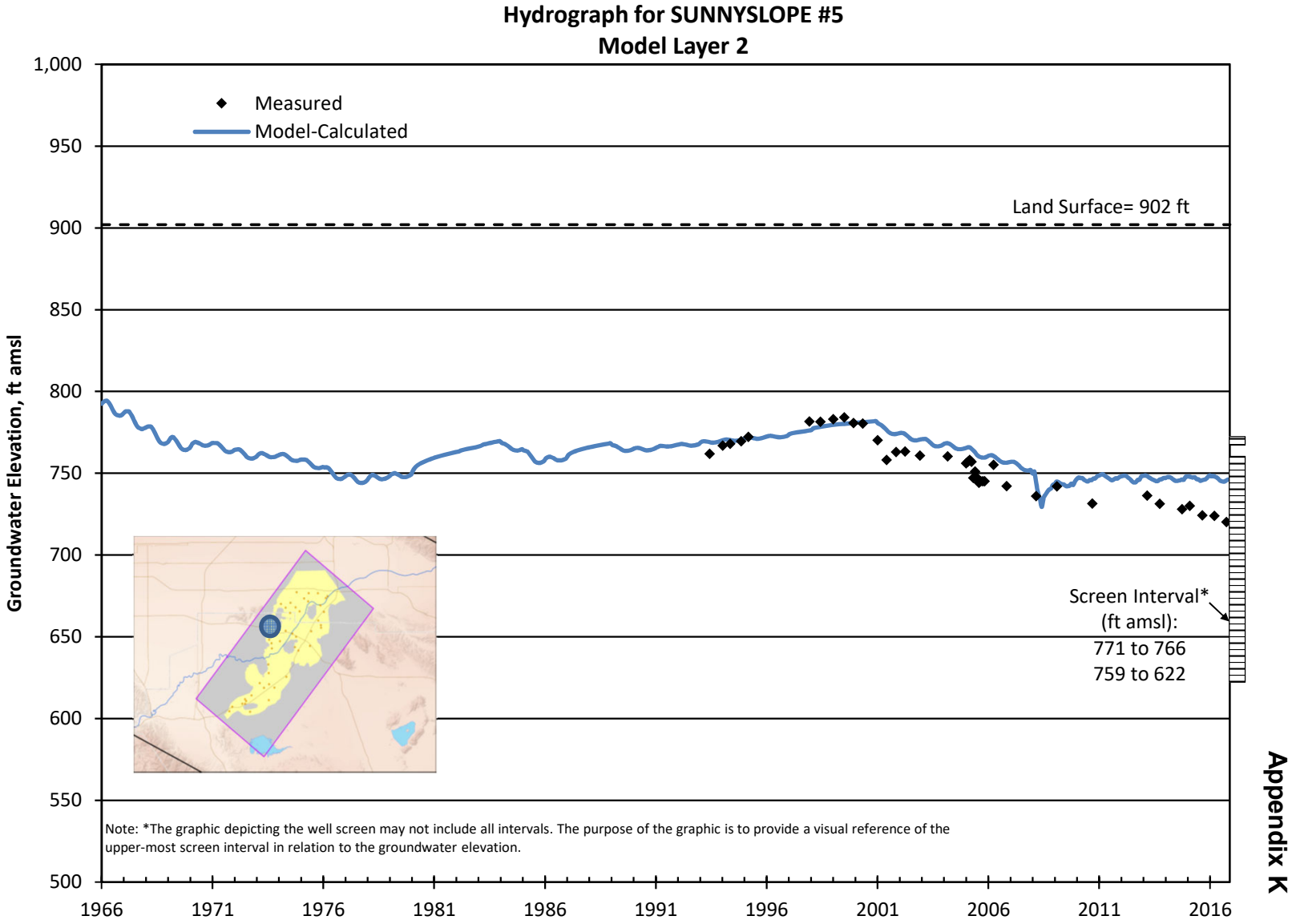
Appendix K


Hydrograph for TWIN BUTTE #6
Model Layer 1
Measured
Model-Calculated
Land Surface= 880 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
830 to 750
750 to 600
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

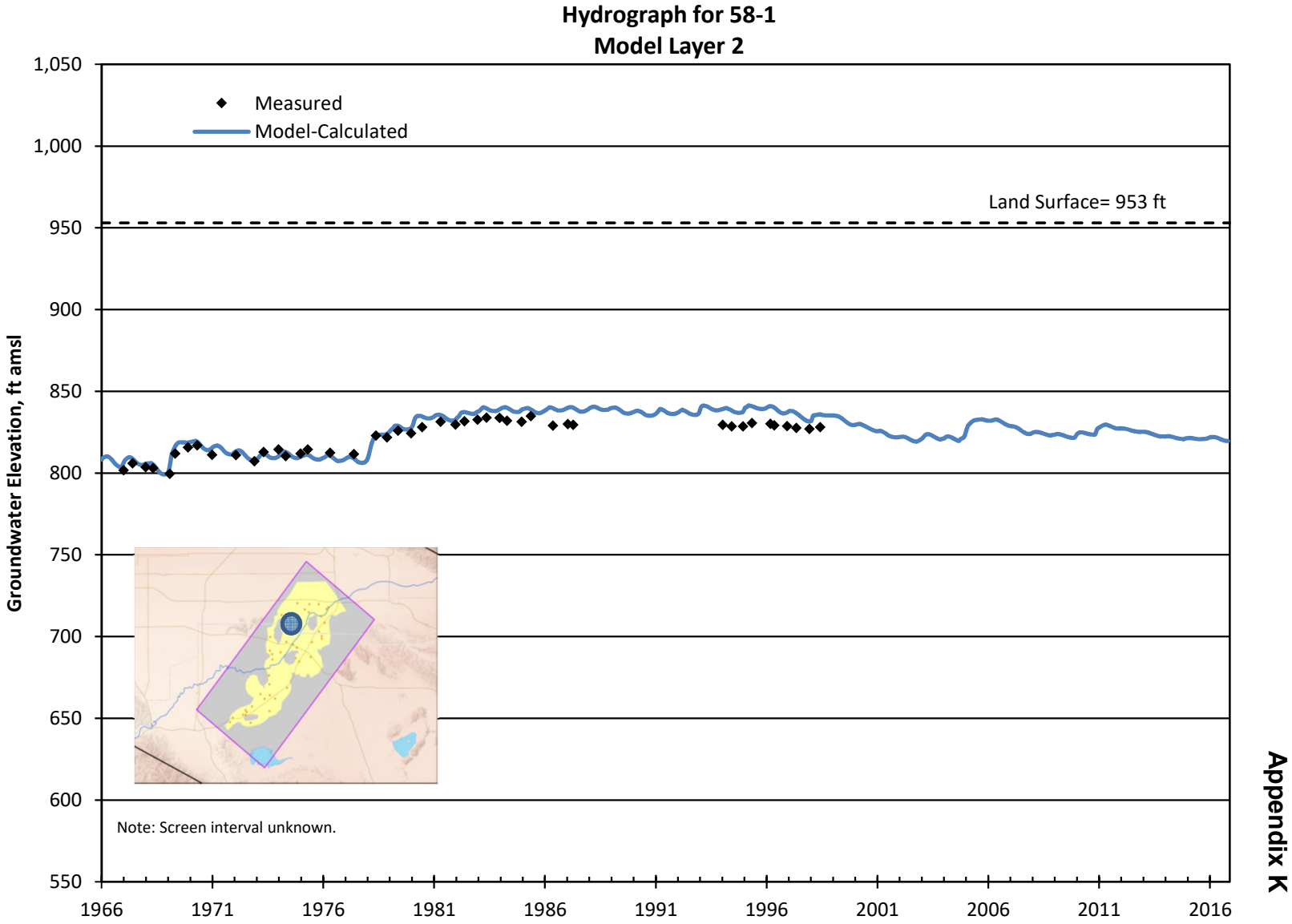
Appendix K


Hydrograph for WALTON
Model Layer 2
Measured
Model-Calculated
Land Surface= 719 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

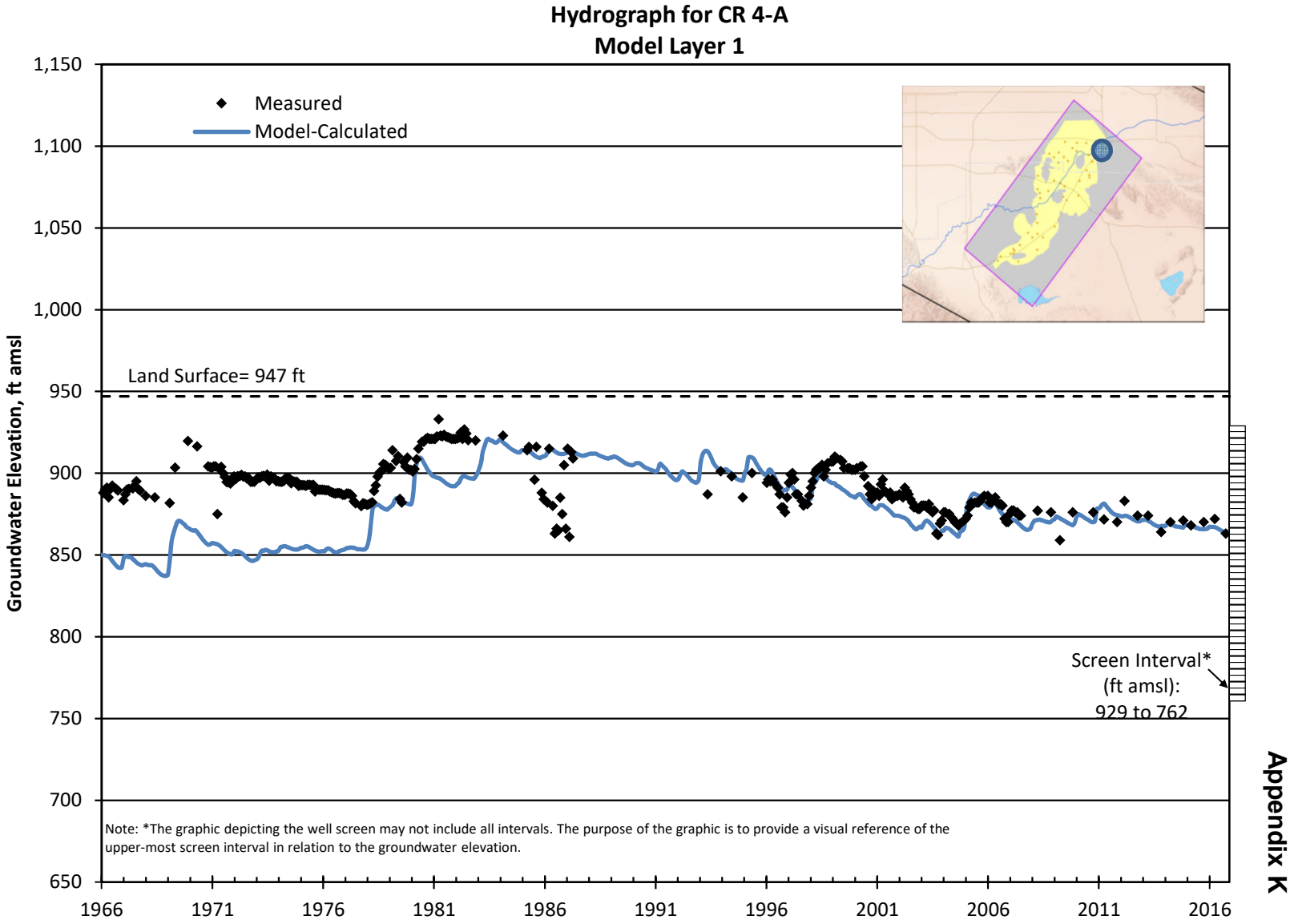
Appendix K


Hydrograph for SUNNYSLOPE #5
Model Layer 2
Measured
Model-Calculated
Land Surface= 902 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
771 to 766
759 to 622
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

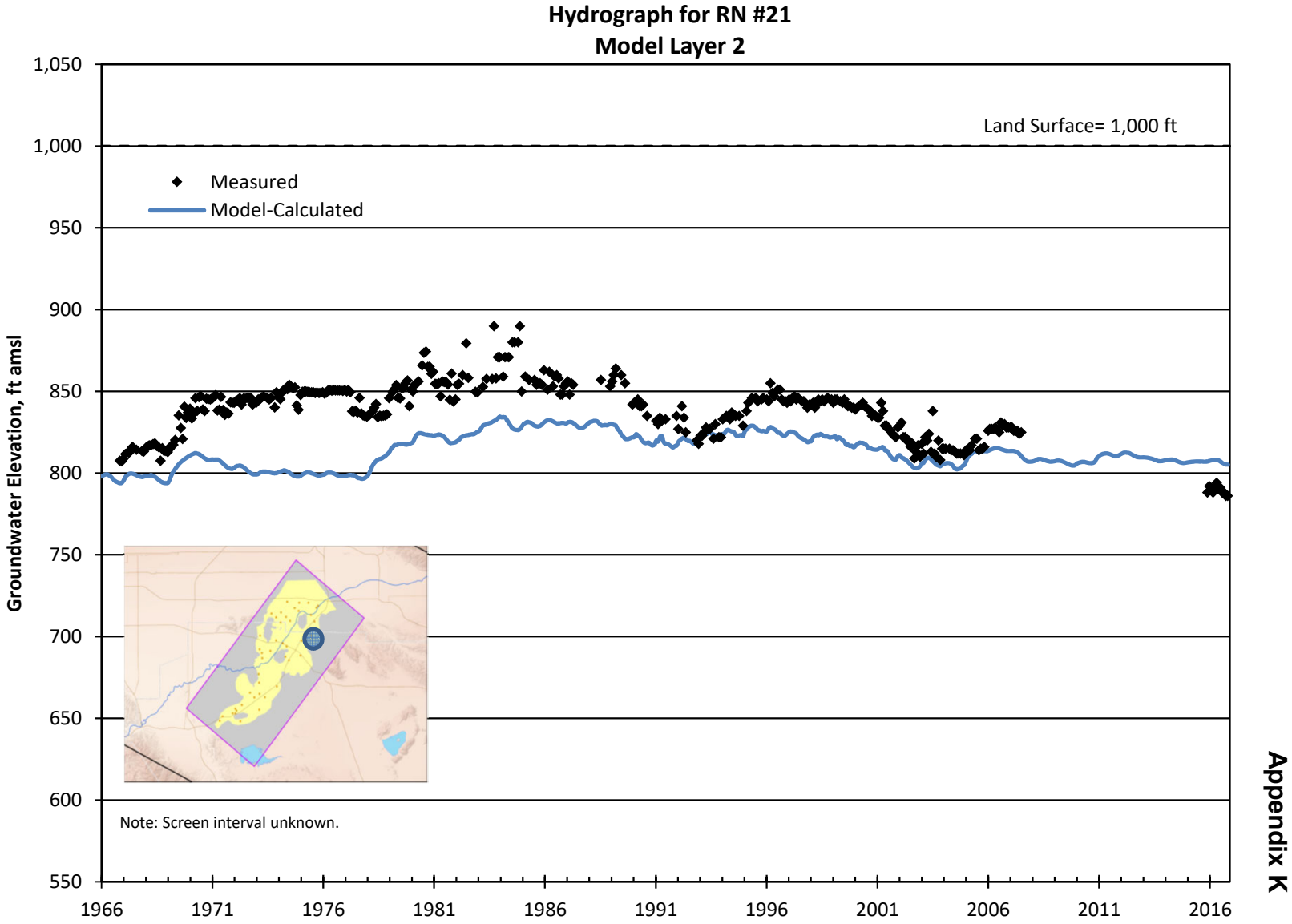
Appendix K


Hydrograph for 58-1
Model Layer 2
Measured
Model-Calculated
Land Surface= 953 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

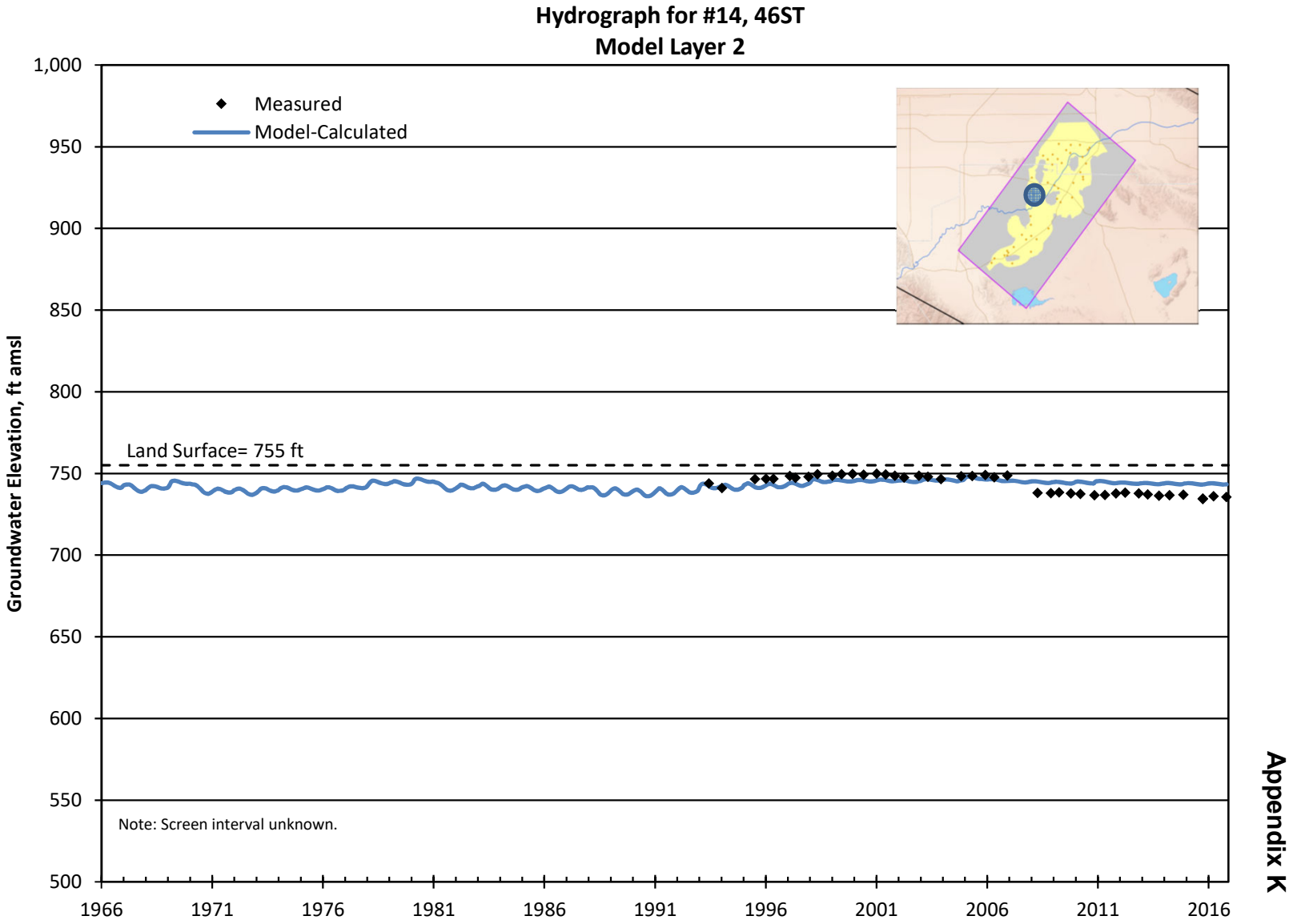
Appendix K


Hydrograph for CR 4-A
Model Layer 1
Measured
Model-Calculated
Land Surface= 947 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
929 to 762
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix K

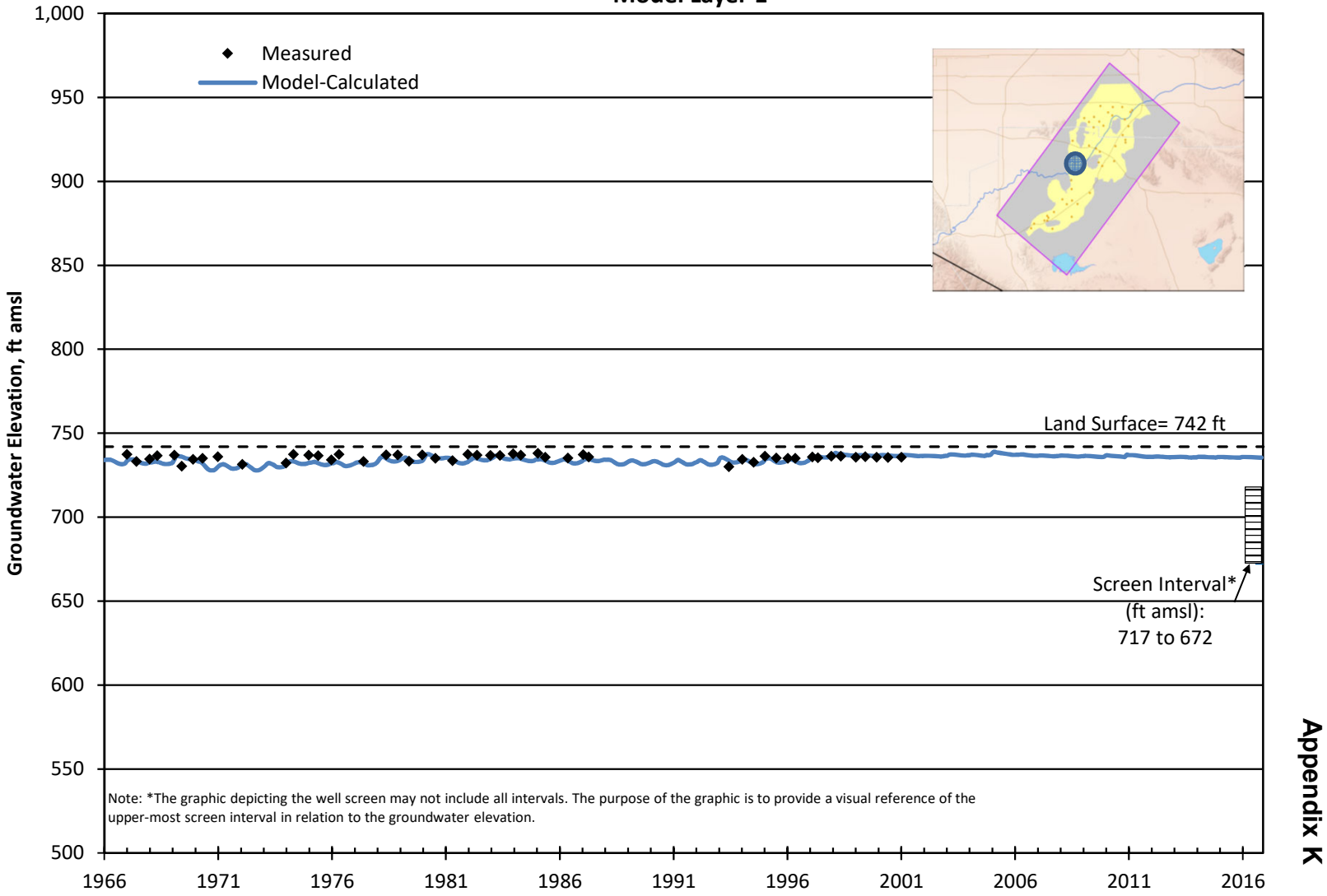

Hydrograph for RN #21
Model Layer 2
Land Surface= 1,000 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

Appendix K

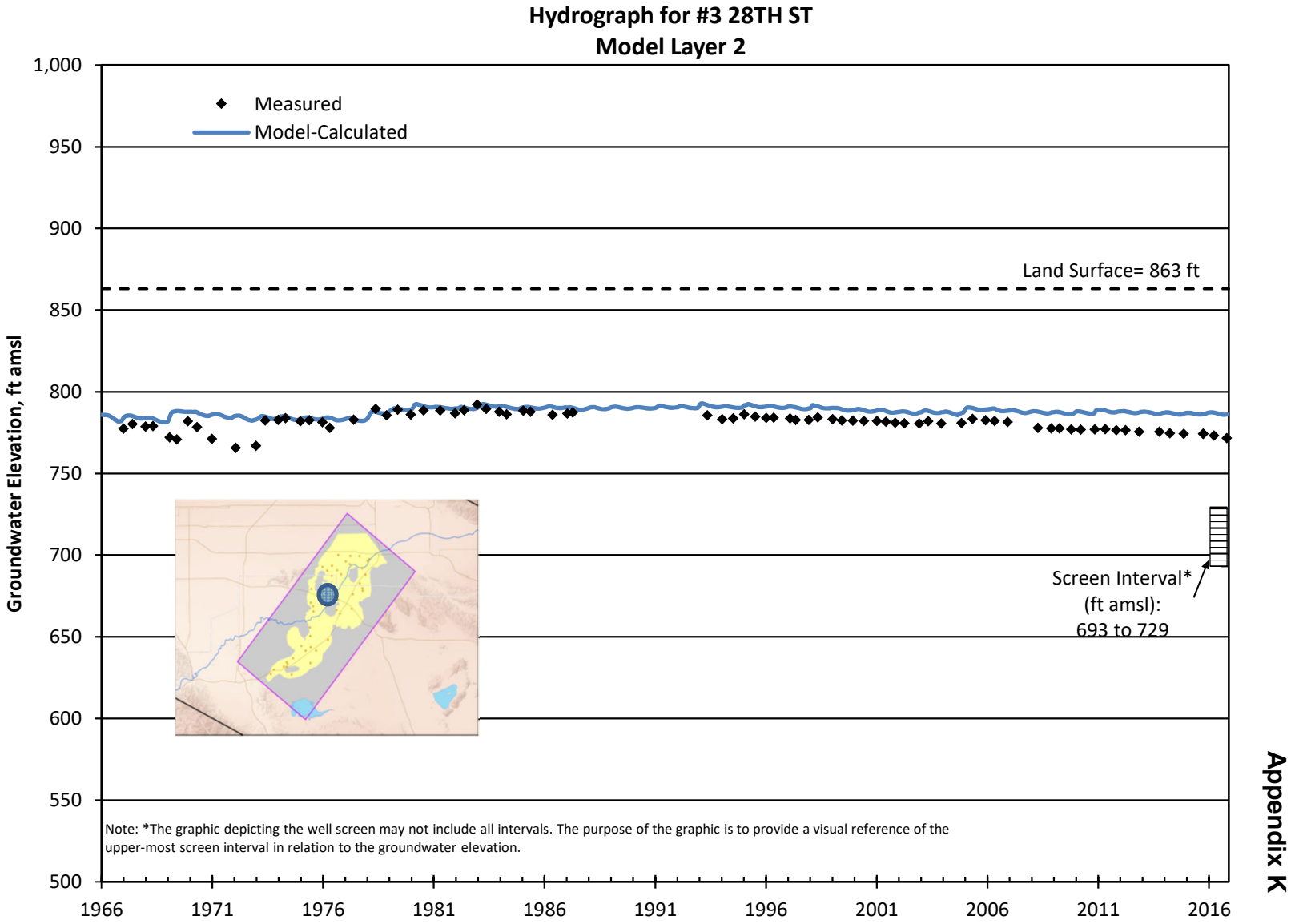

Hydrograph for #14, 46ST
Model Layer 2
Measured
Model-Calculated
Land Surface= 755 ft
Note: Screen interval unknown.
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

Appendix K

Hydrograph for #16 HUNTER
Model Layer 1

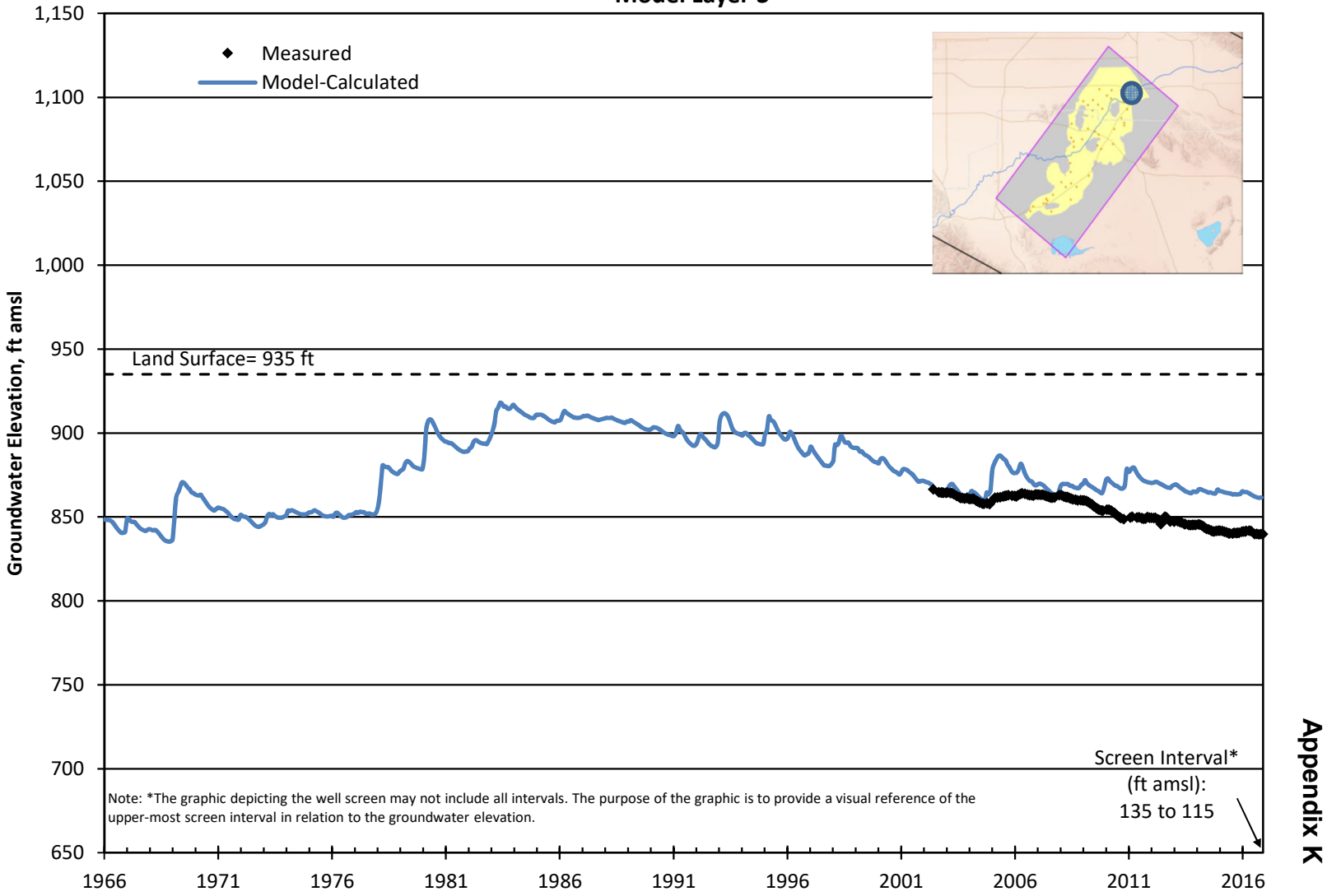


Appendix K


Hydrograph for #3 28TH ST
Model Layer 2
Measured
Model-Calculated
Land Surface= 863 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
693 to 729
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

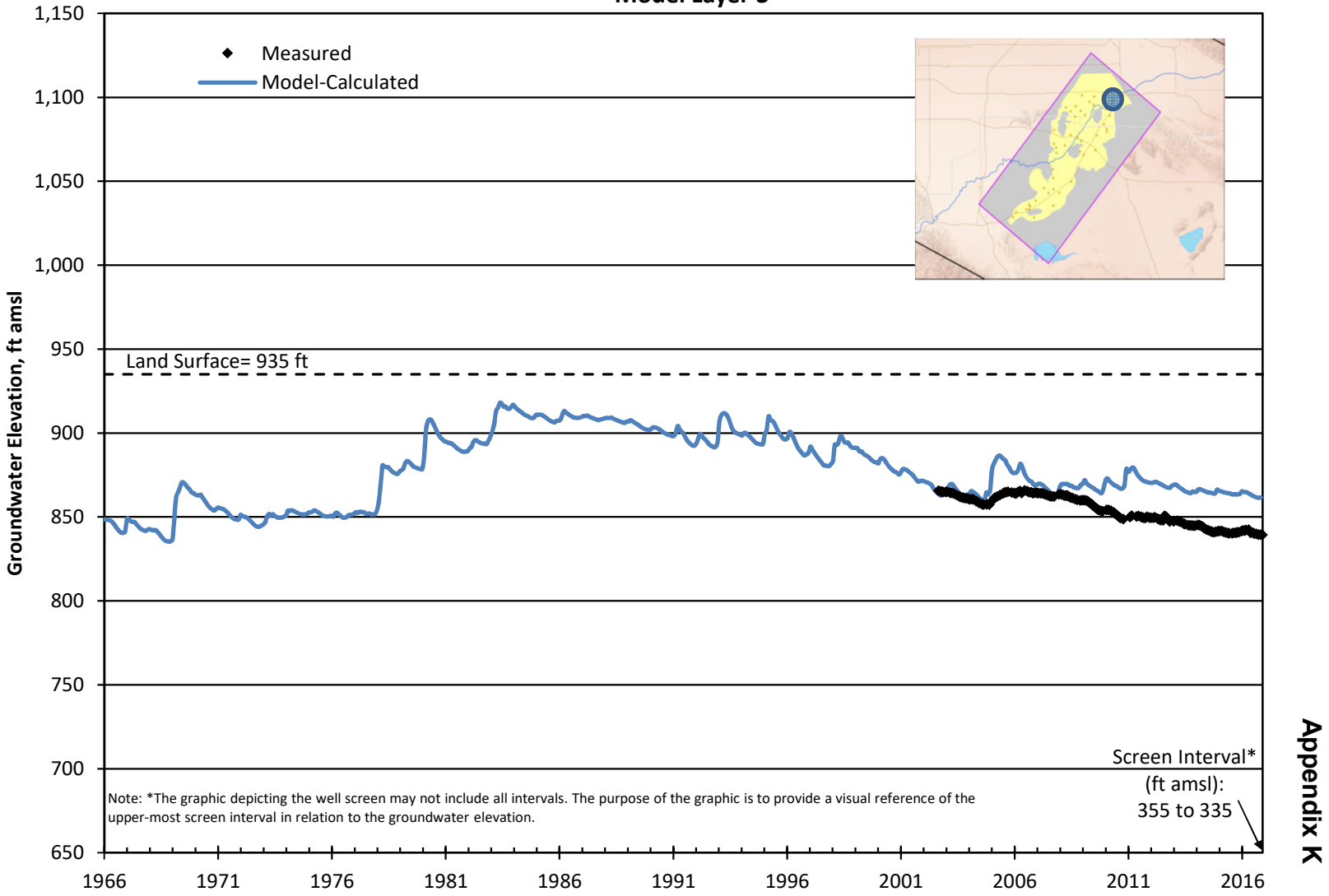
Appendix K

Hydrograph for 01S/04W-29H04S
Model Layer 3



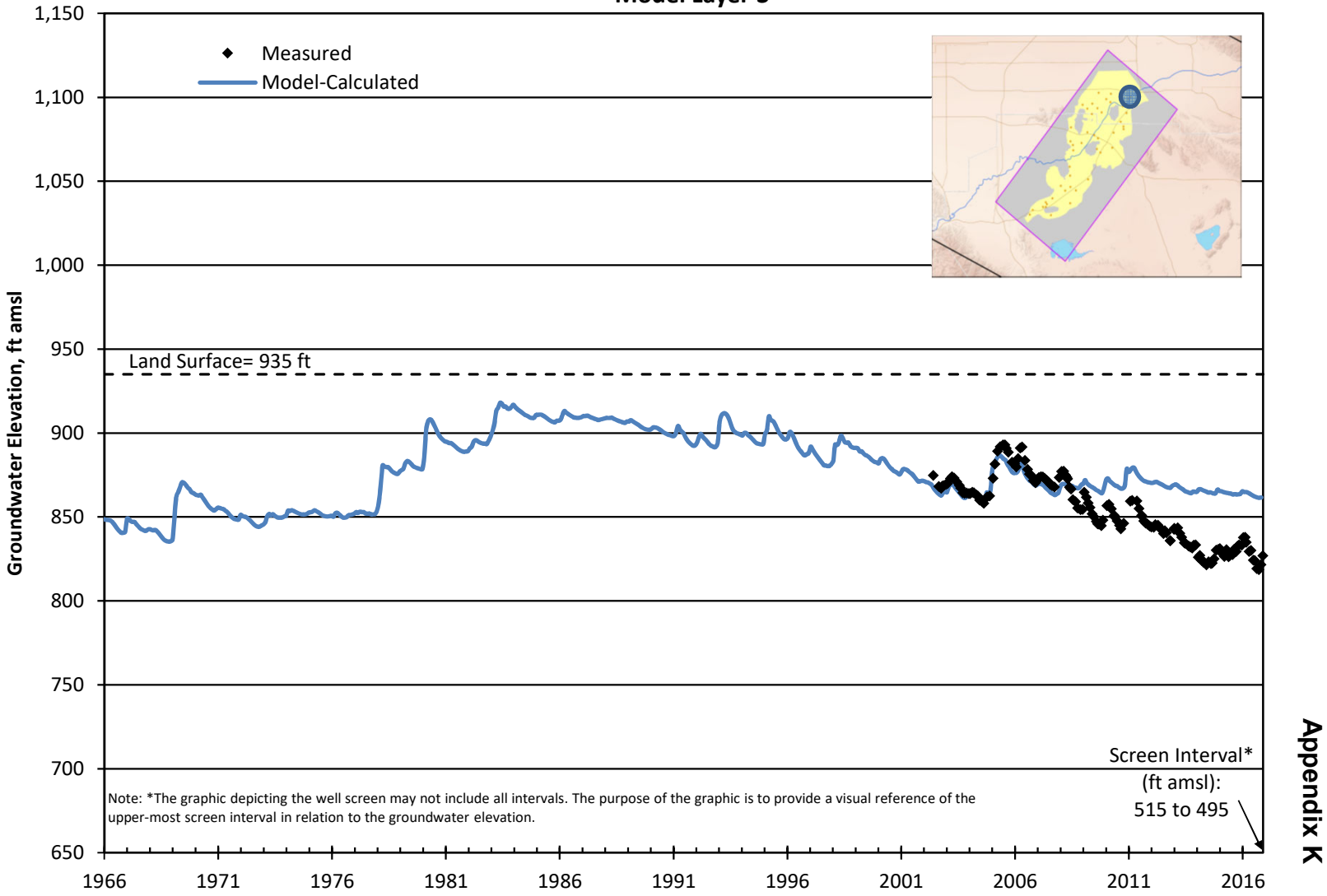
Appendix K

Hydrograph for 01S/04W-29H05S
Model Layer 3

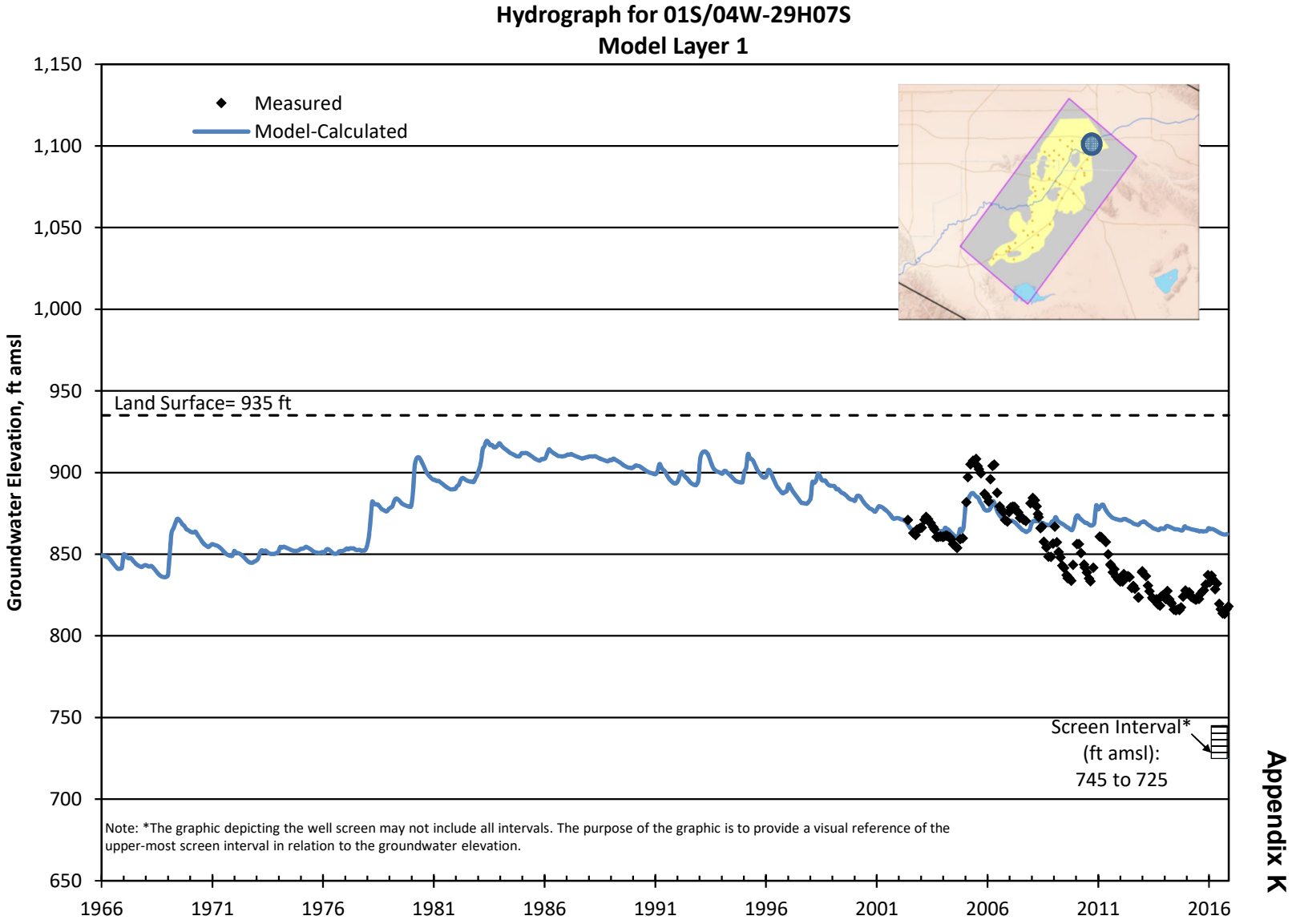


Appendix K

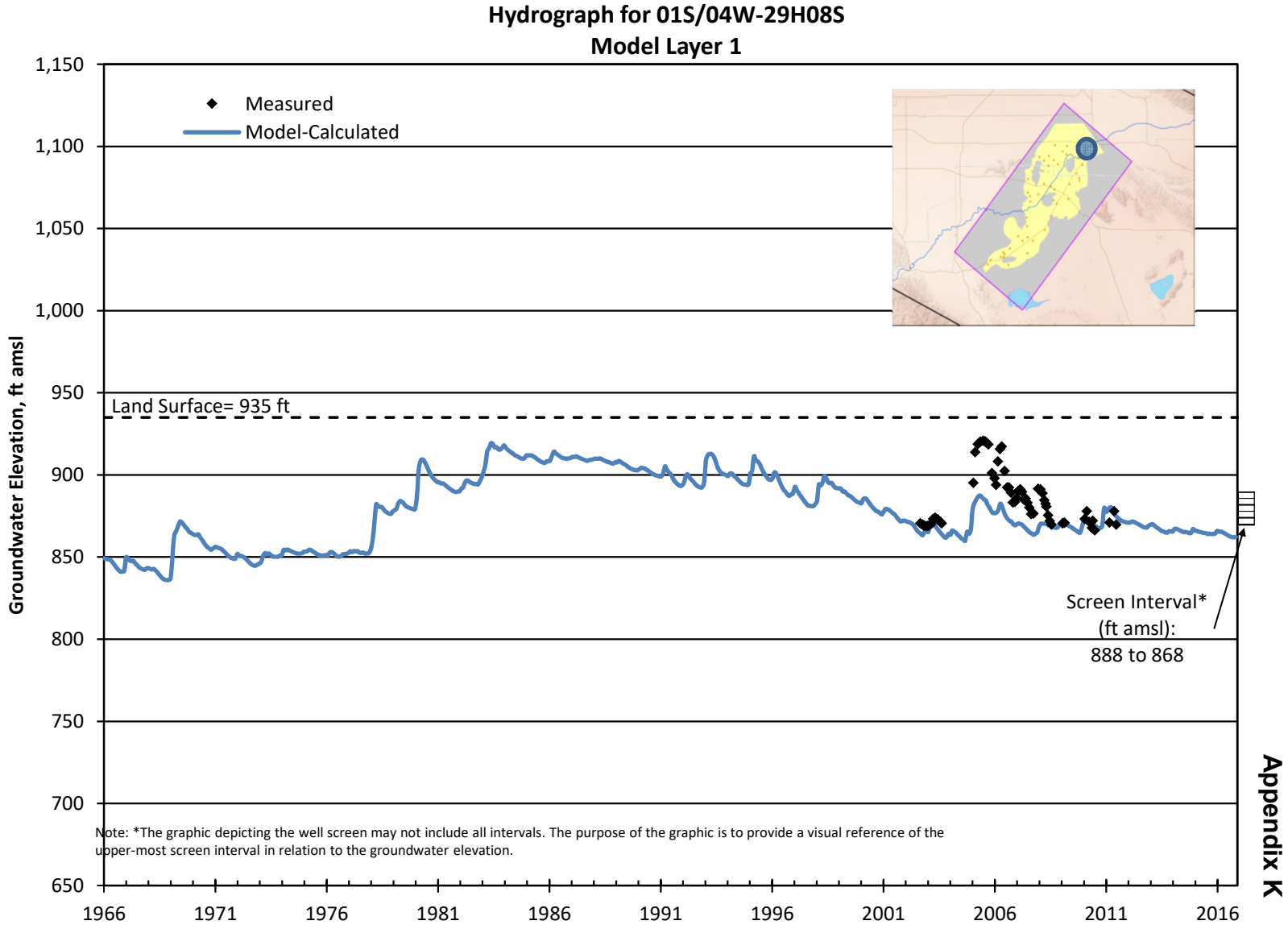
Hydrograph for 01S/04W-29H06S
Model Layer 3



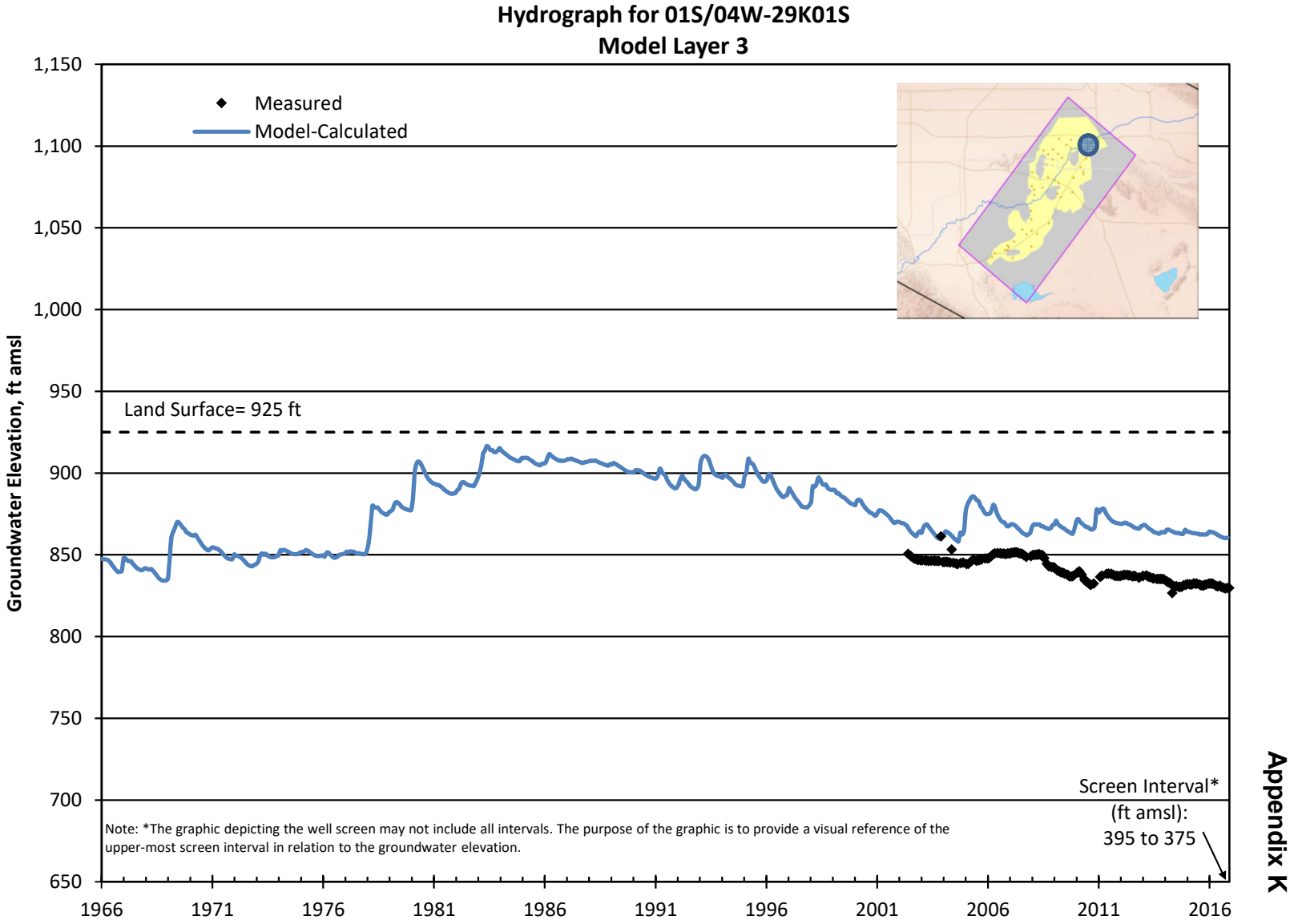
Appendix K


Hydrograph for 01S/04W-29H07S
Model Layer 1
Measured
Model-Calculated
Land Surface= 935 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
745 to 725
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

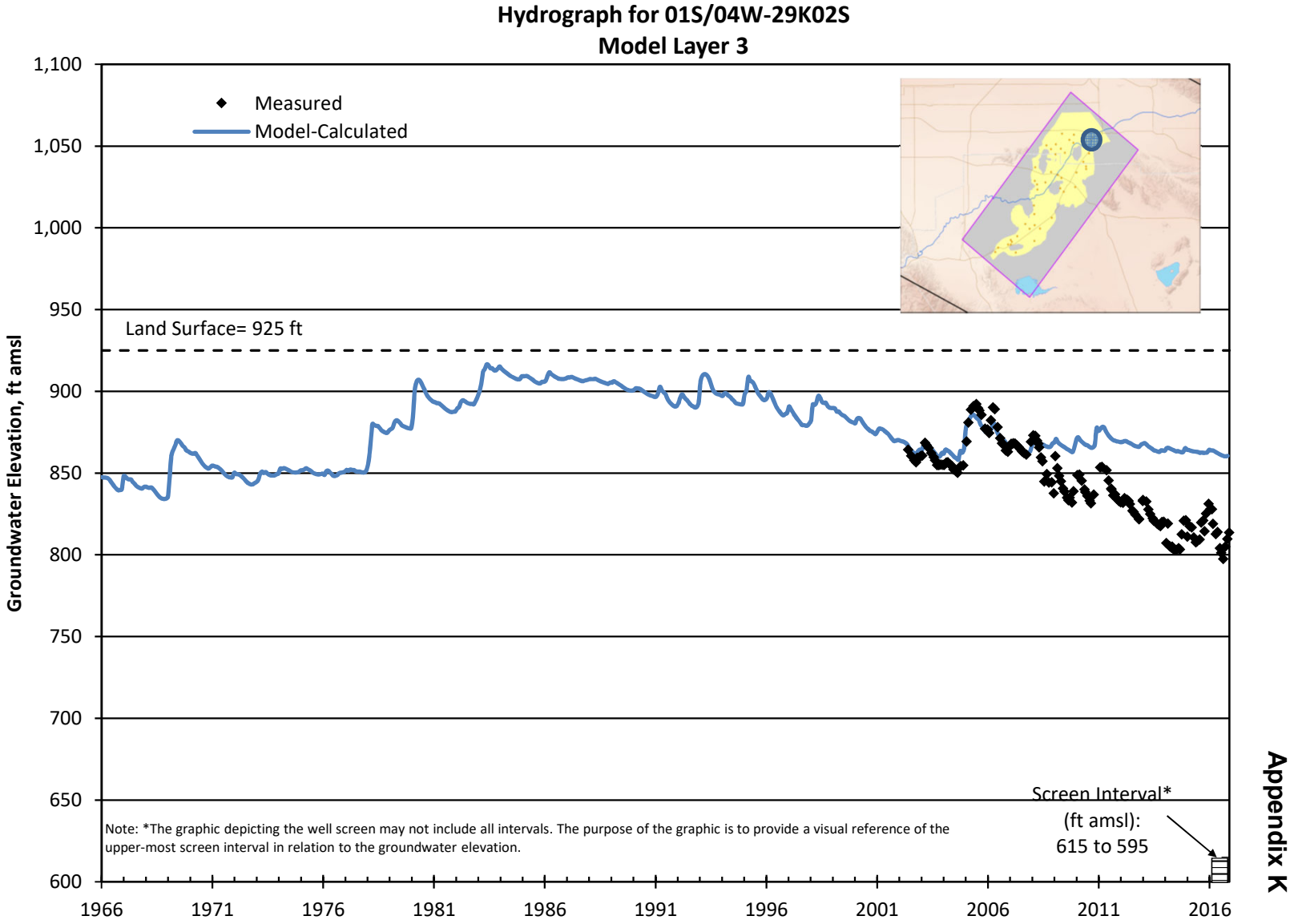
Appendix K


Hydrograph for 01S/04W-29H08S
Model Layer 1
Measured
Model-Calculated
Land Surface= 935 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
888 to 868
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix K

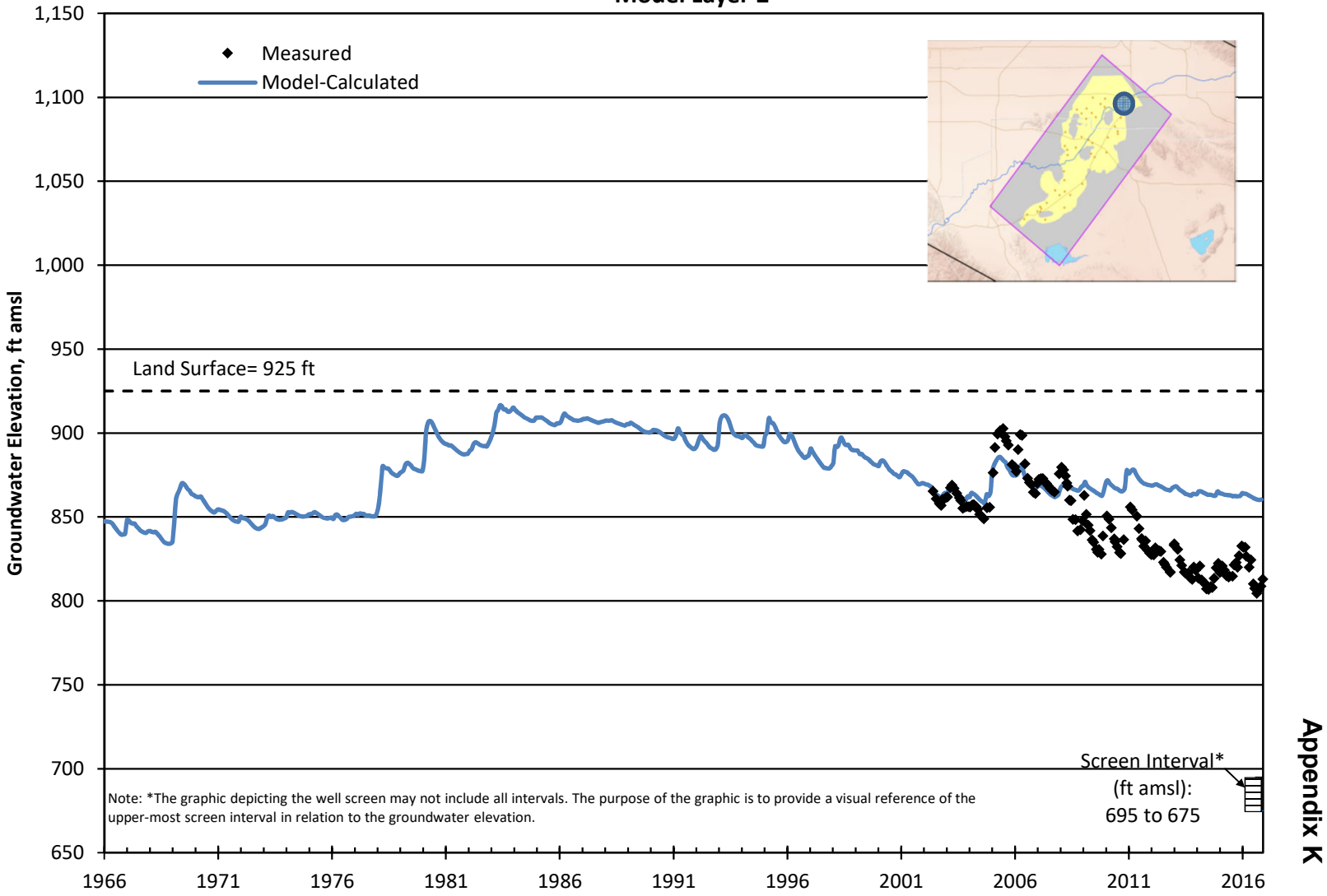

Hydrograph for 01S/04W-29K01S
Model Layer 3
Measured
Model-Calculated
Land Surface= 925 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
395 to 375
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix K

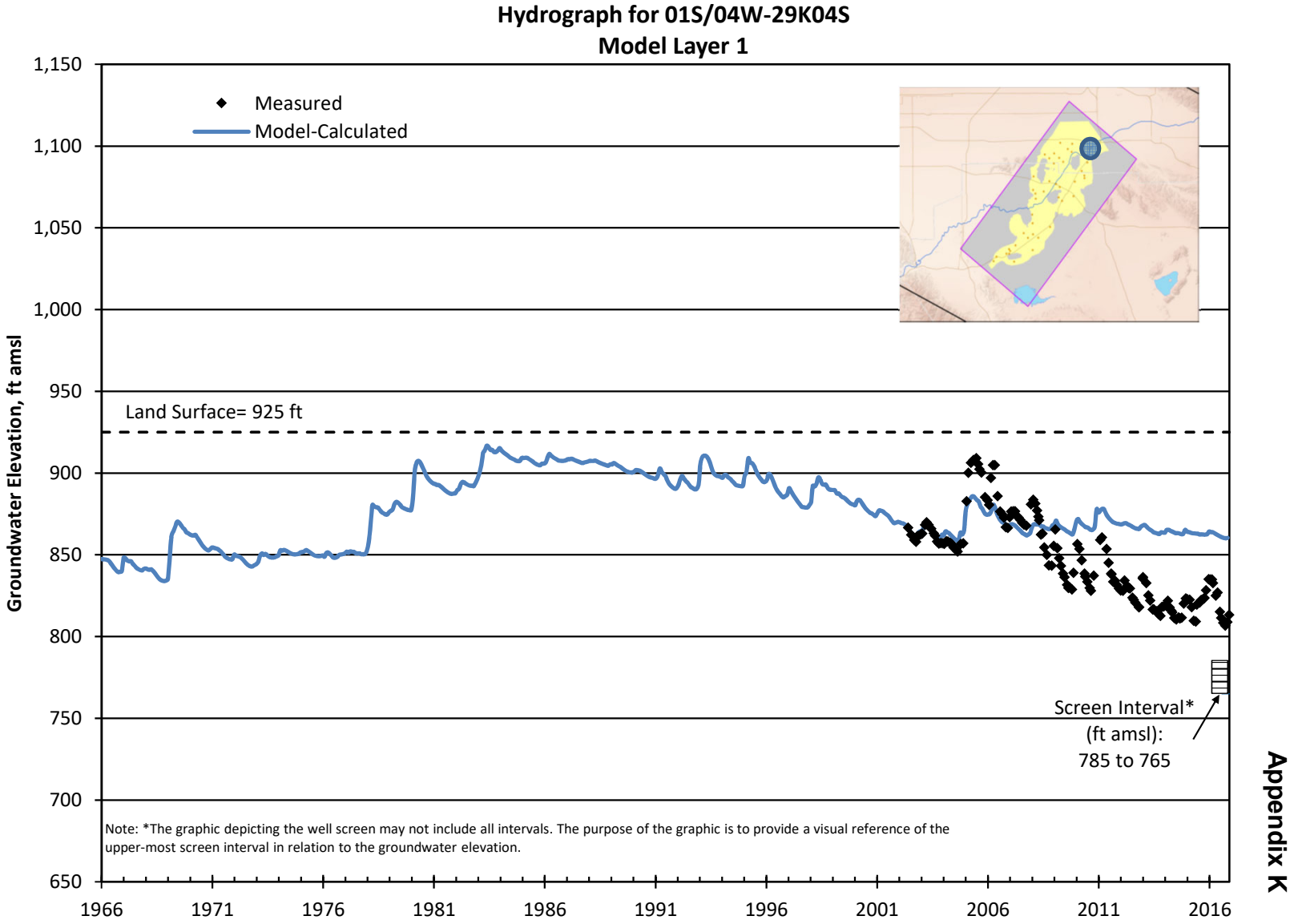

Hydrograph for 01S/04W-29K02S
Model Layer 3
Measured
Model-Calculated
Land Surface= 925 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
615 to 595
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix K

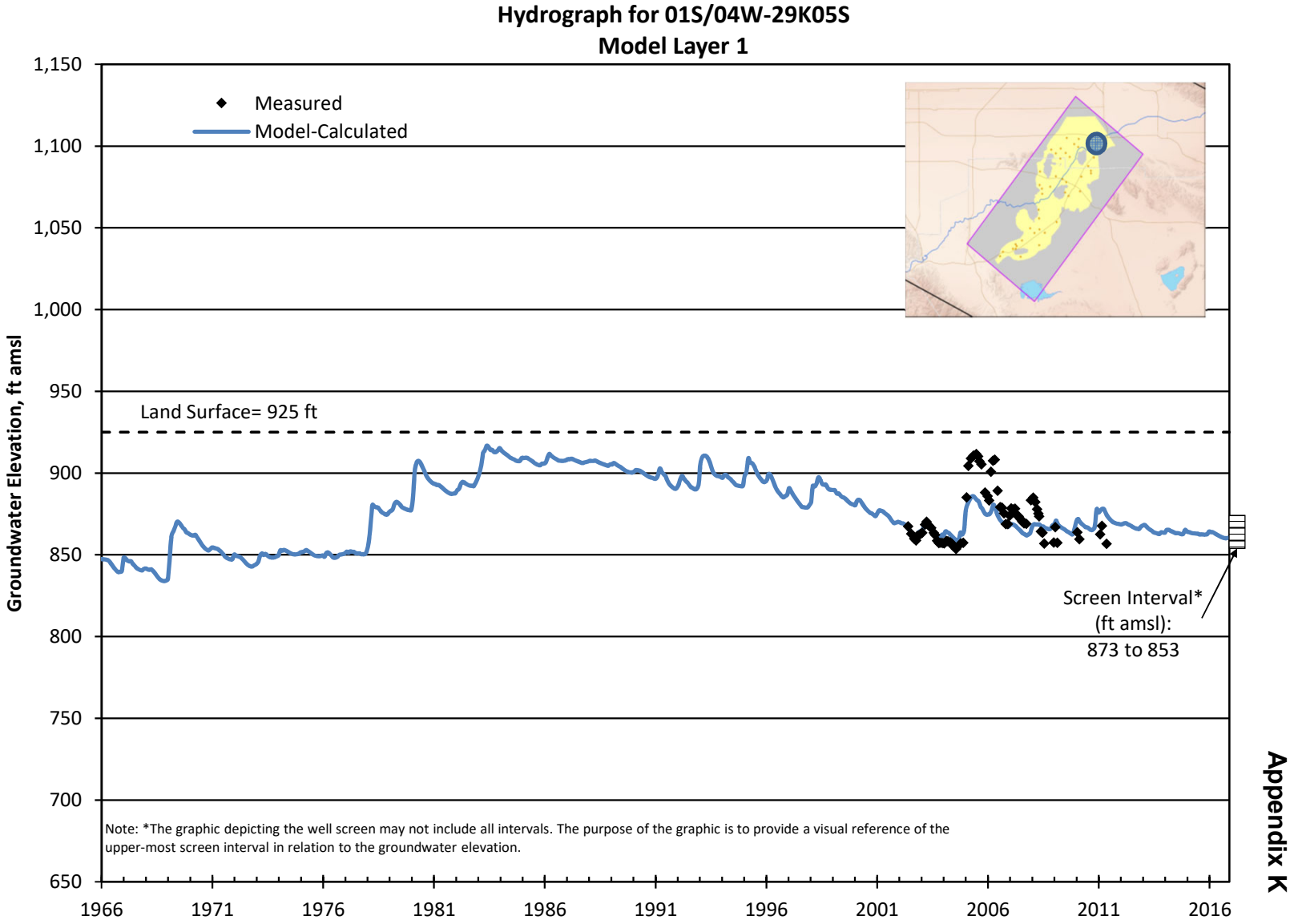
Hydrograph for 01S/04W-29K03S
Model Layer 2



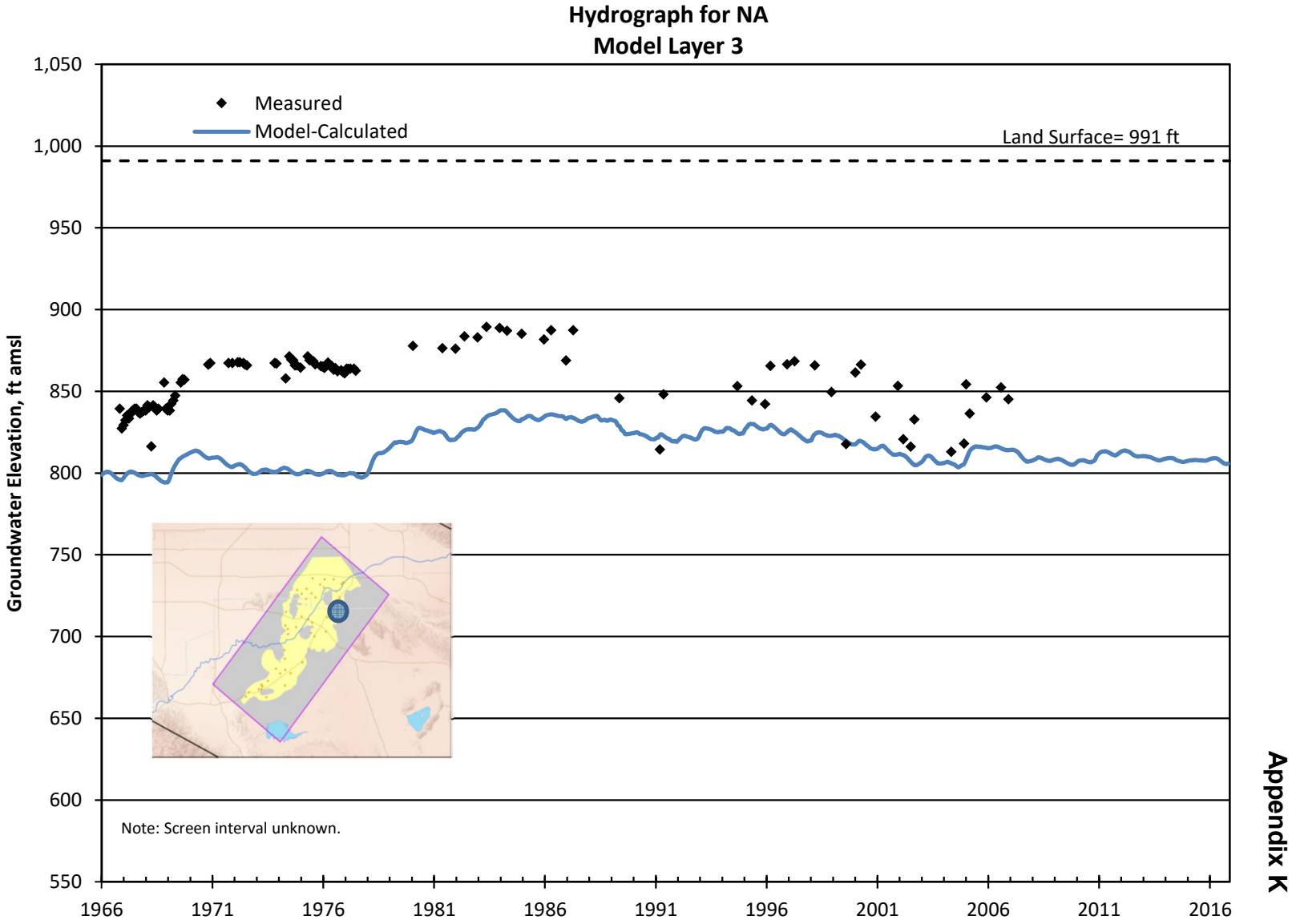
Appendix K


Hydrograph for 01S/04W-29K04S
Model Layer 1
Measured
Model-Calculated
Land Surface= 925 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
785 to 765
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

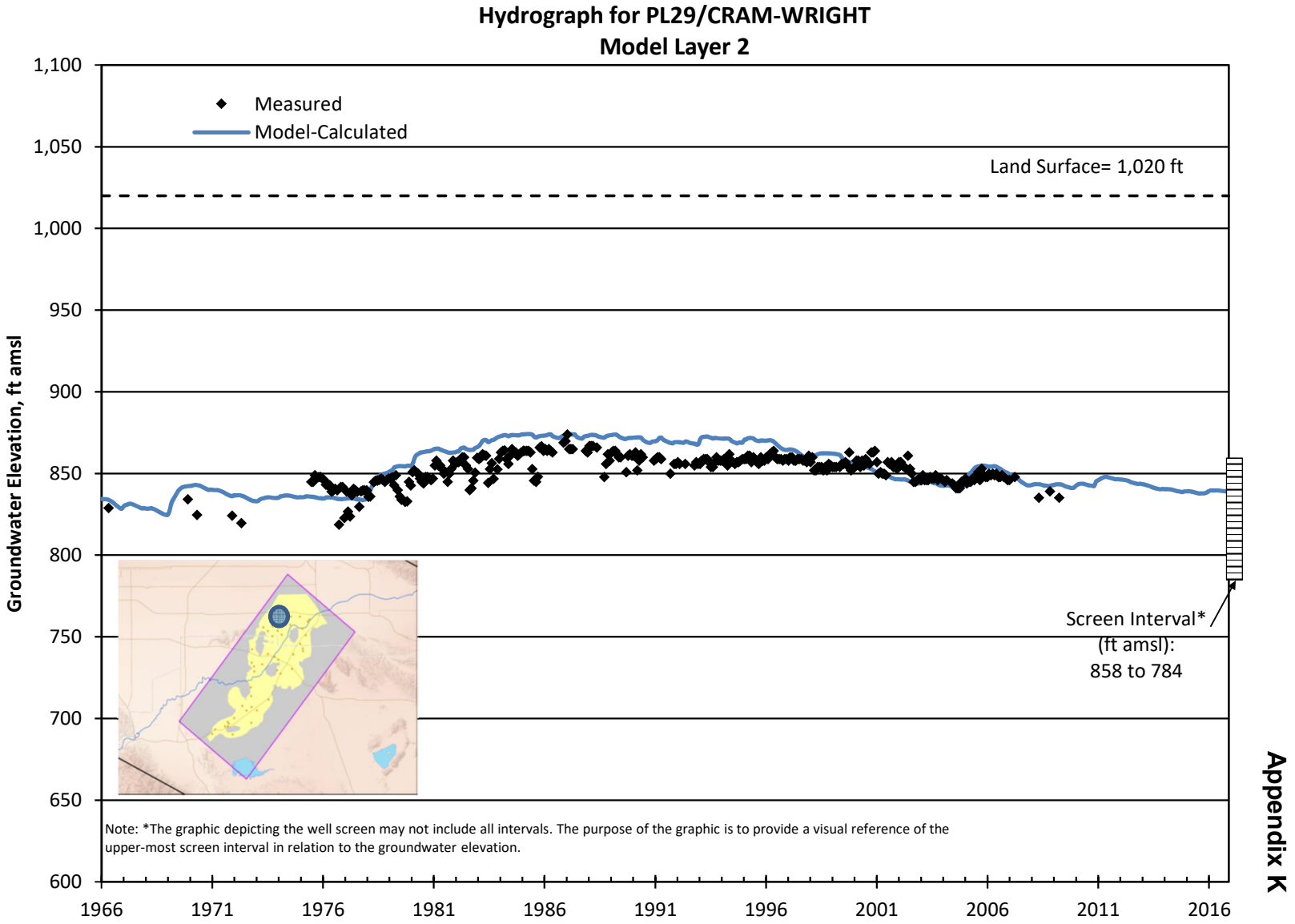
Appendix K


Hydrograph for 01S/04W-29K05S
Model Layer 1
Measured
Model-Calculated
Land Surface= 925 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
873 to 853
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

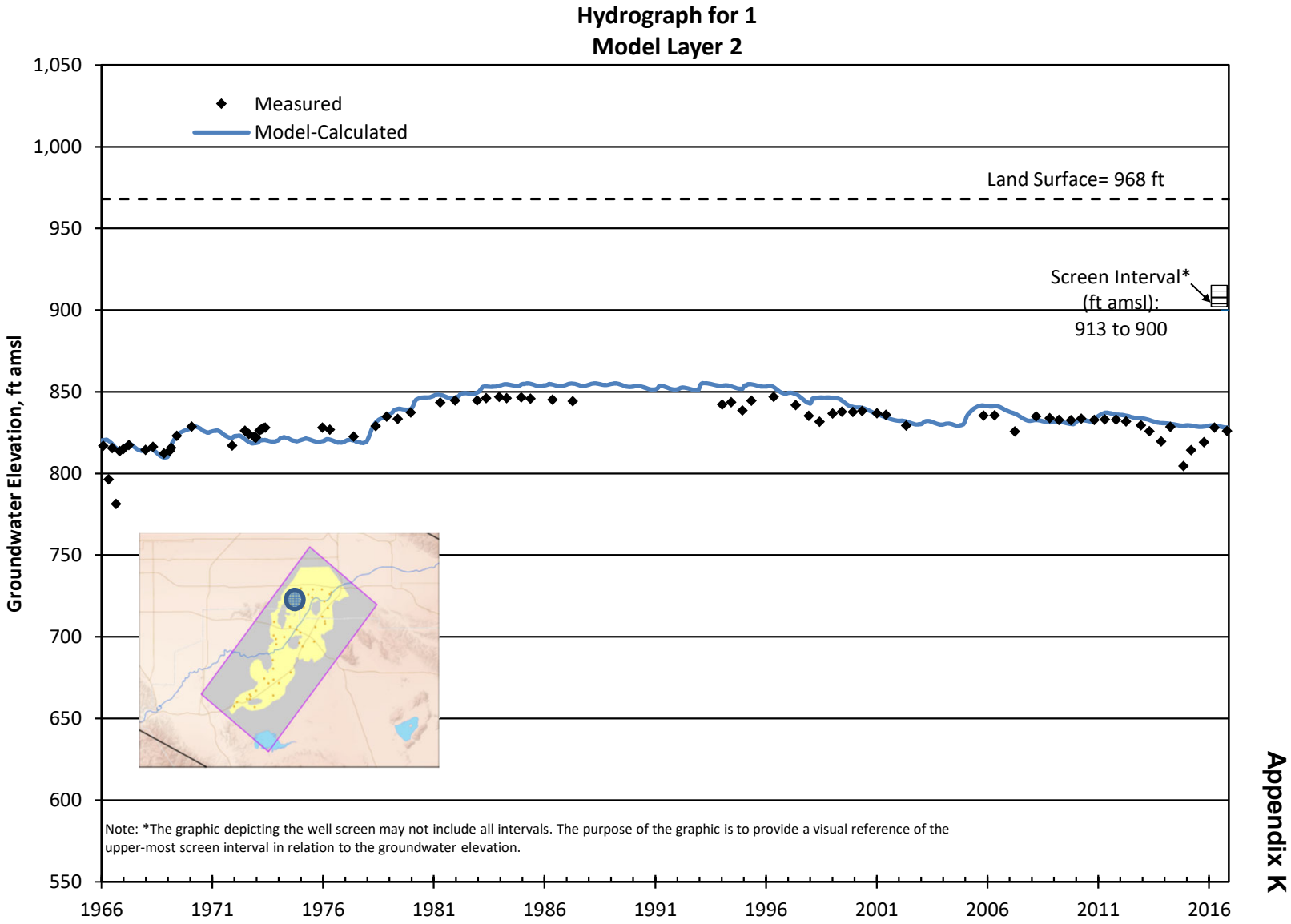
Appendix K


Hydrograph for NA
Model Layer 3
Measured
Model-Calculated
Land Surface= 991 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

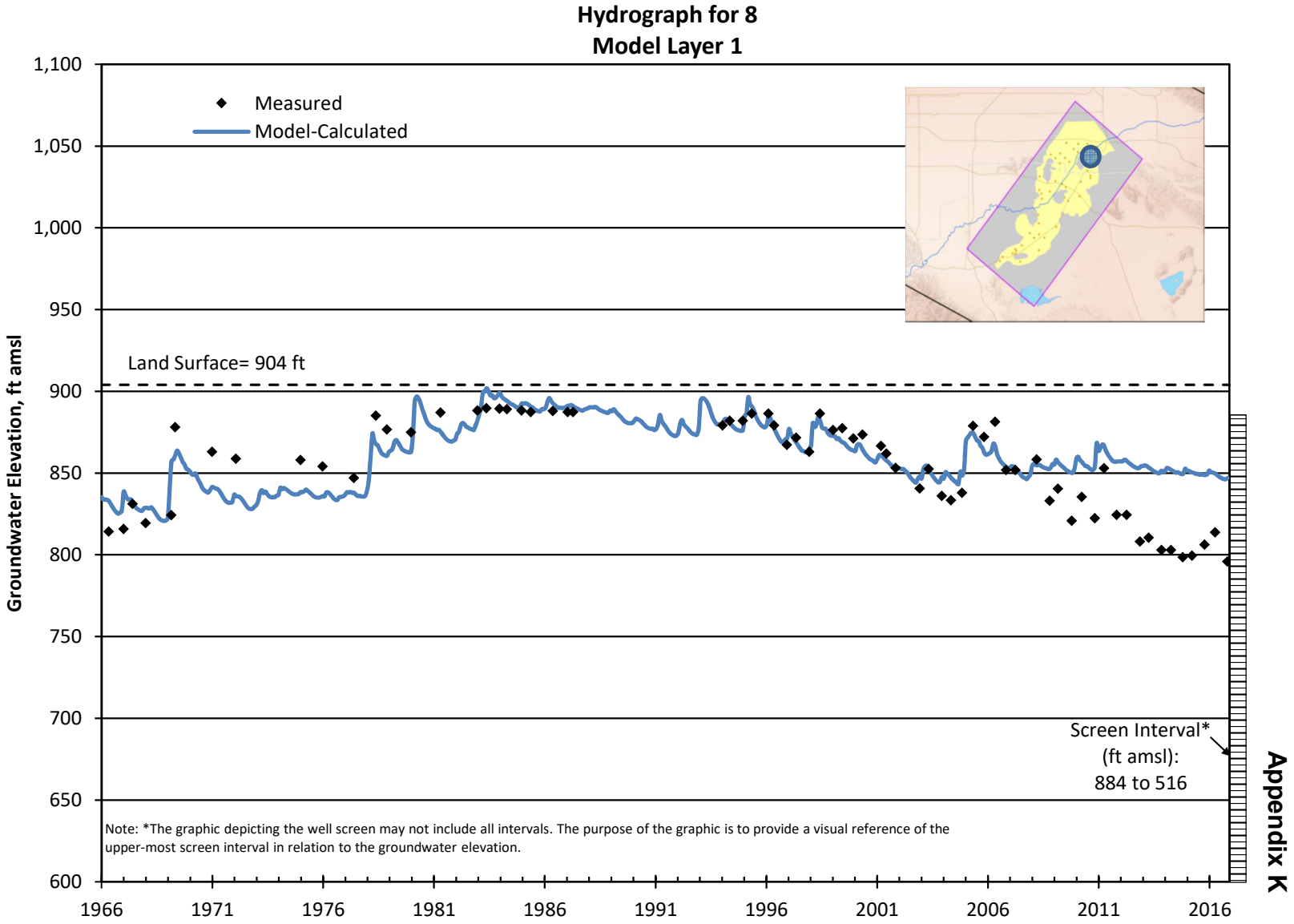
Appendix K


Hydrograph for PL29/CRAM-WRIGHT
Model Layer 2
Measured
Model-Calculated
Land Surface= 1,020 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
858 to 784
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

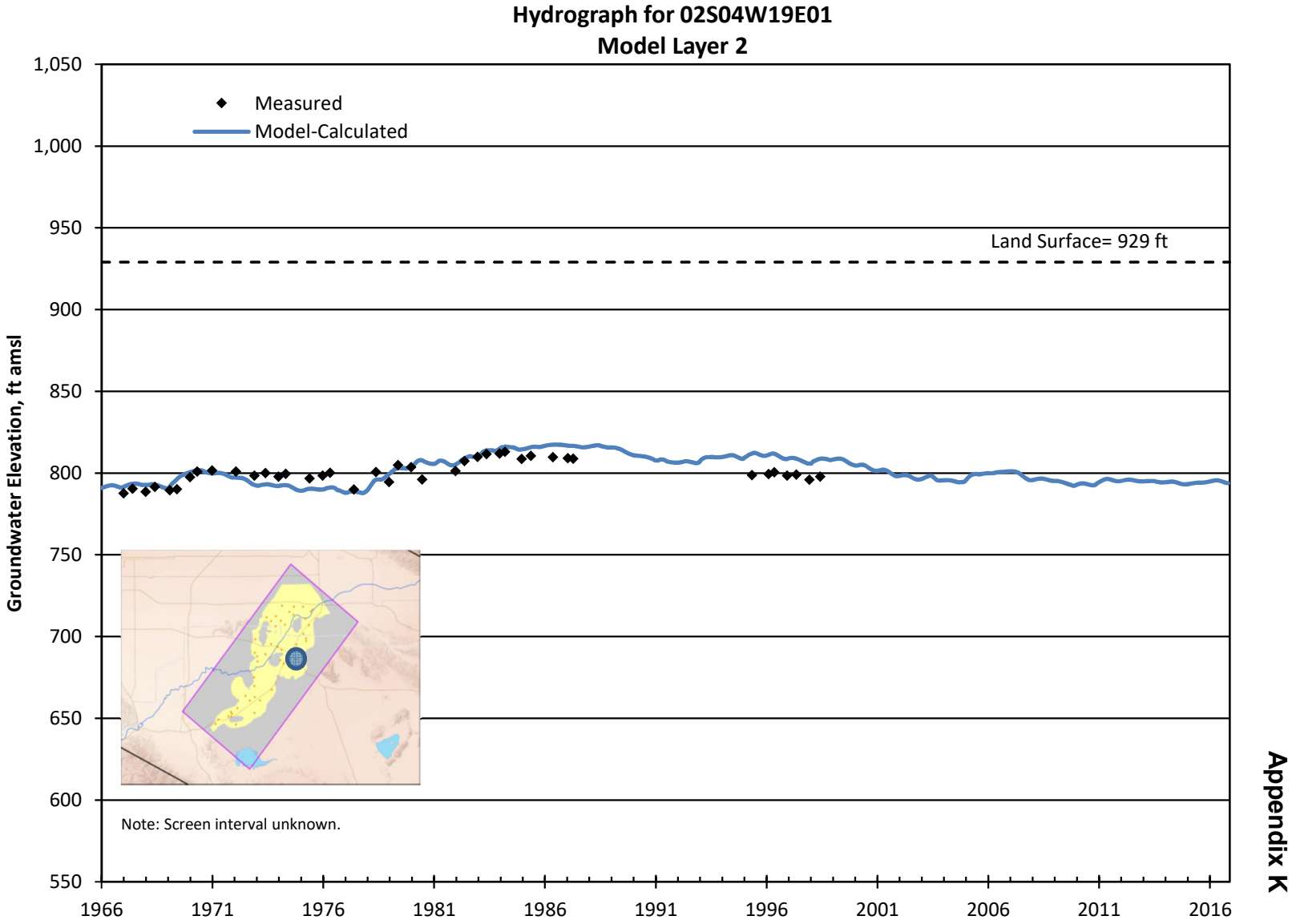
Appendix K


Hydrograph for 1
Model Layer 2
Measured
Model-Calculated
Land Surface= 968 ft
Screen Interval*
(ft amsl):
913 to 900
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

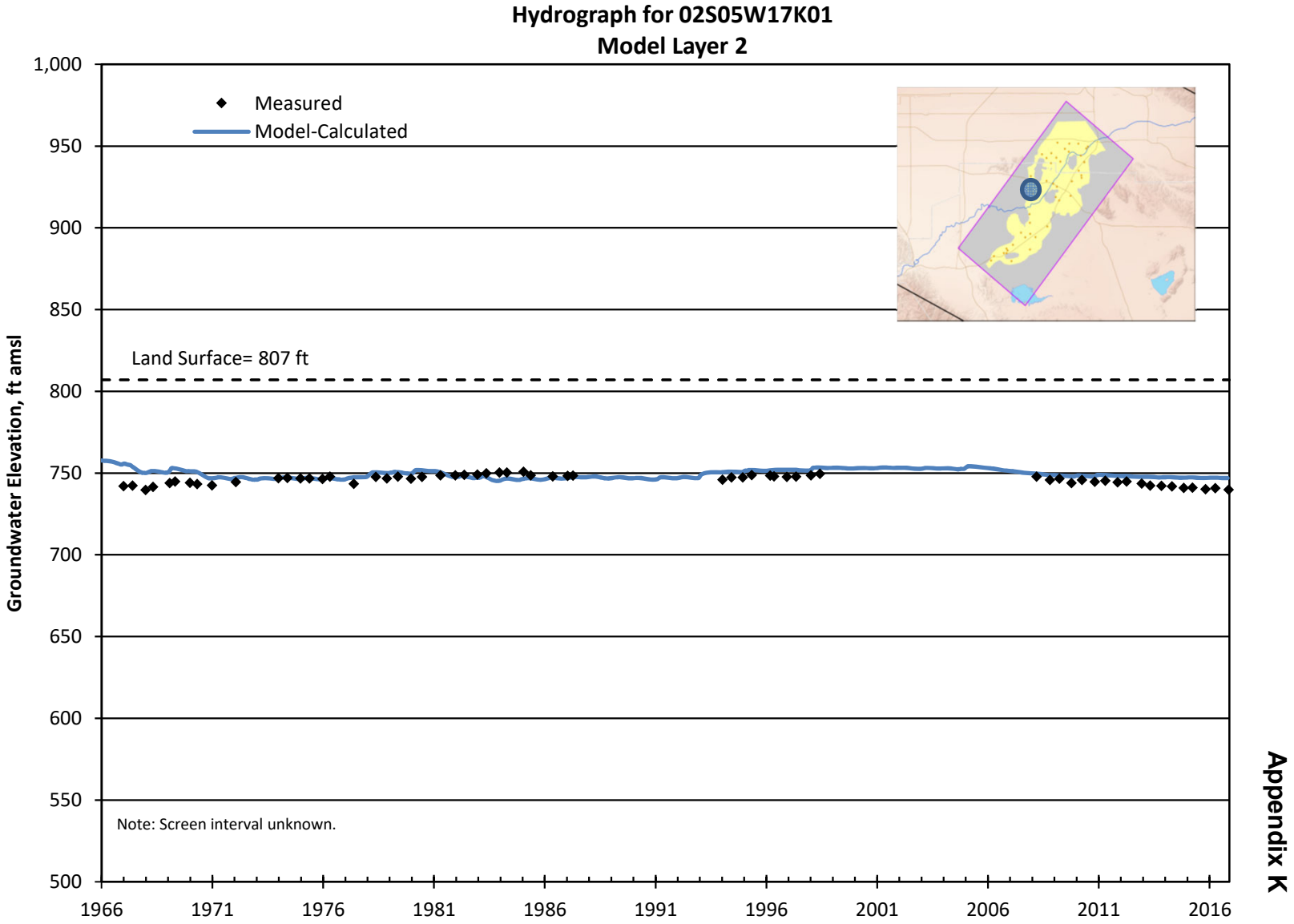
Appendix K


Hydrograph for 8
Model Layer 1
Measured
Model-Calculated
Land Surface= 904 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
884 to 516
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

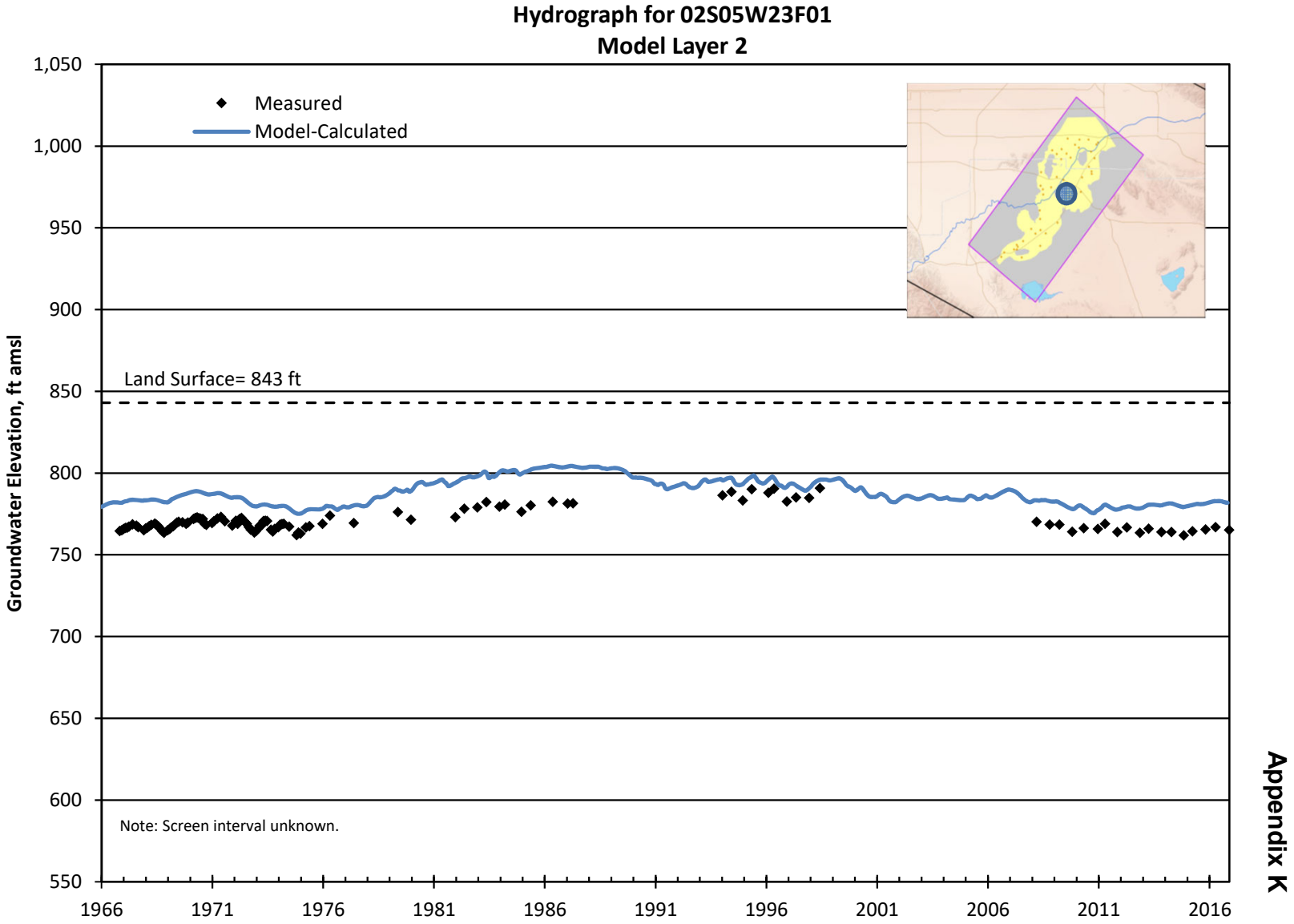
Appendix K


Hydrograph for 02S04W19E01
Model Layer 2
Measured
Model-Calculated
Land Surface= 929 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

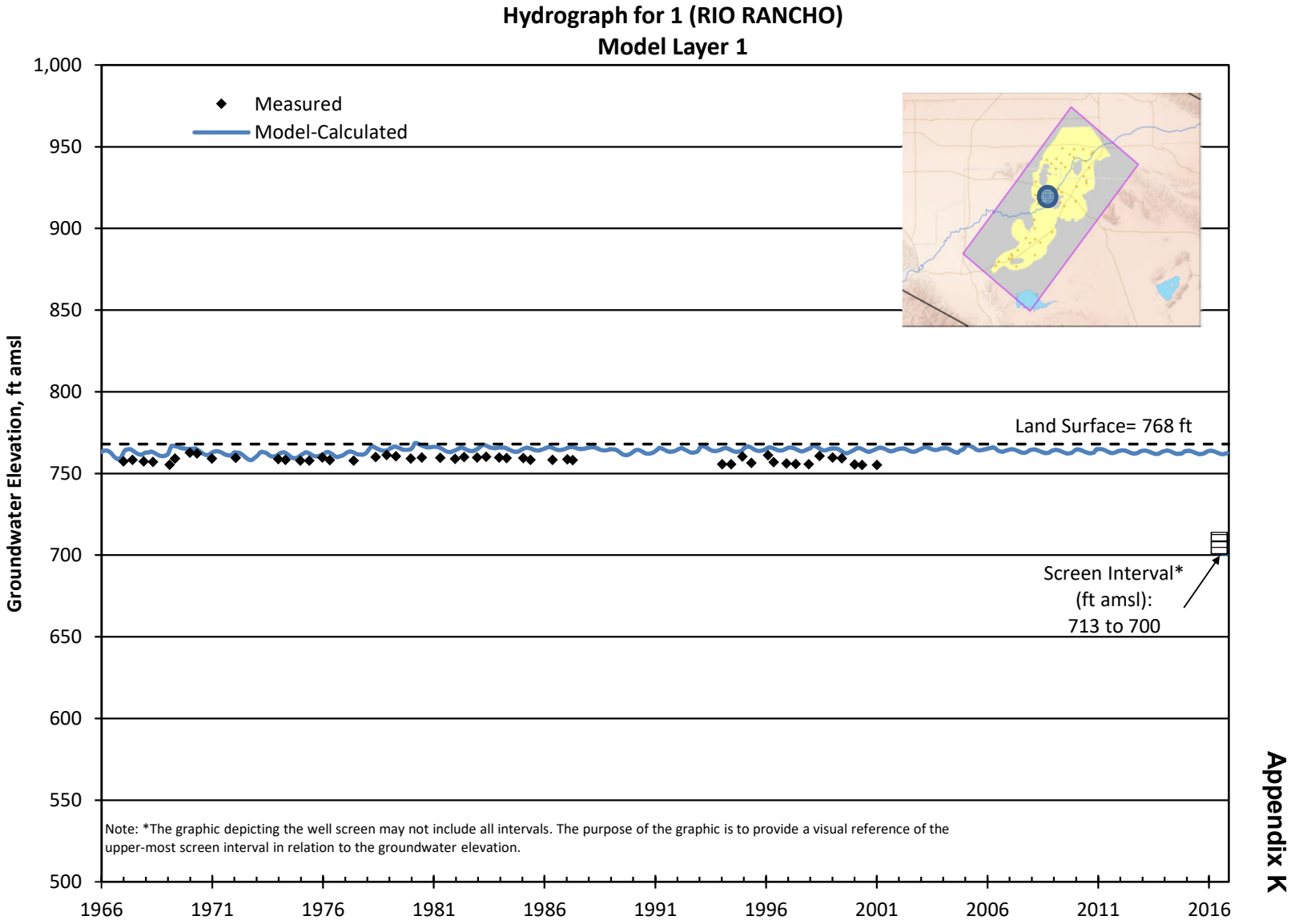
Appendix K


Hydrograph for 02S05W17K01
Model Layer 2
Measured
Model-Calculated
Land Surface= 807 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

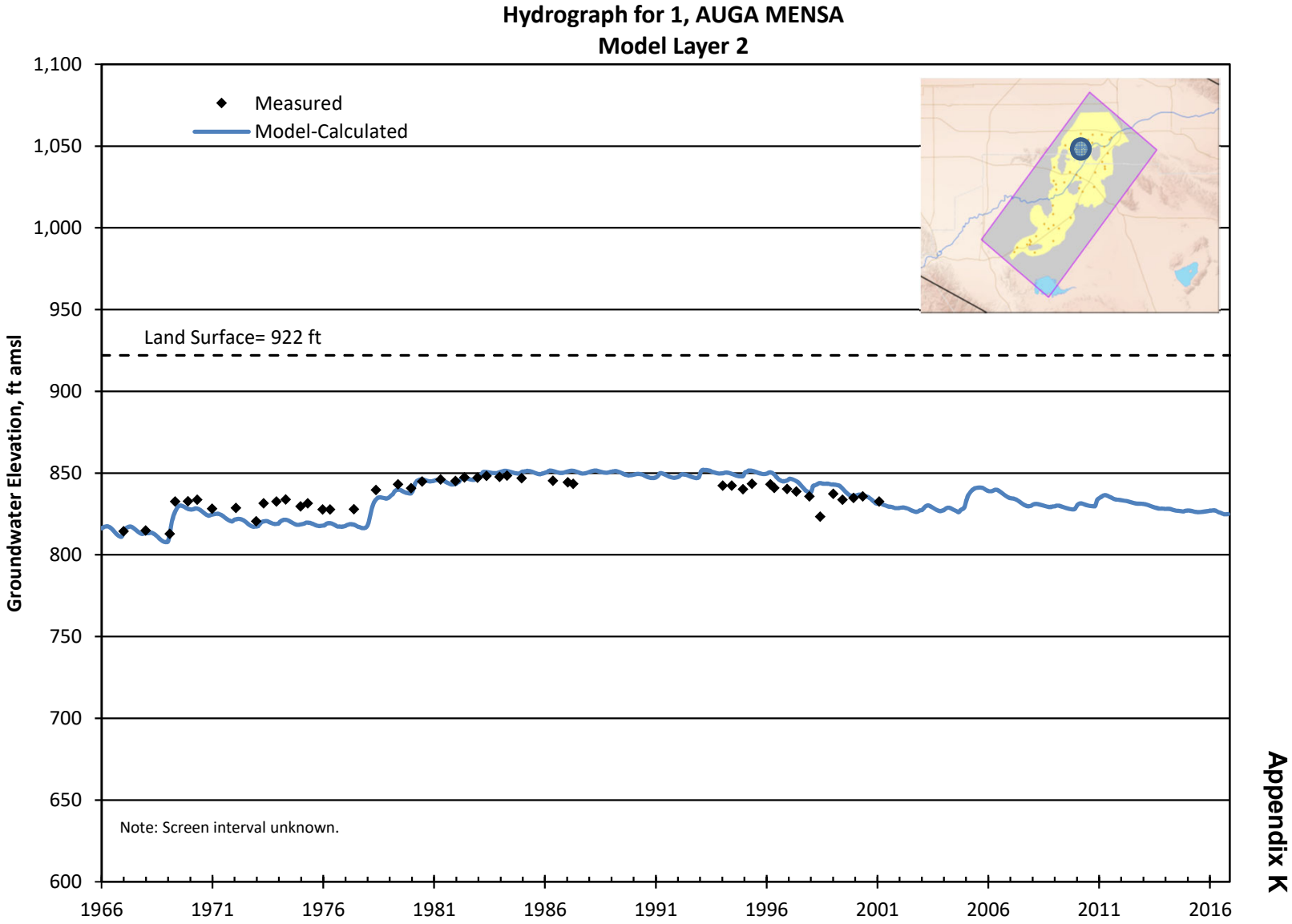
Appendix K


Hydrograph for 02S05W23F01
Model Layer 2
Measured
Model-Calculated
Land Surface= 843 ft
Note: Screen interval unknown.
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

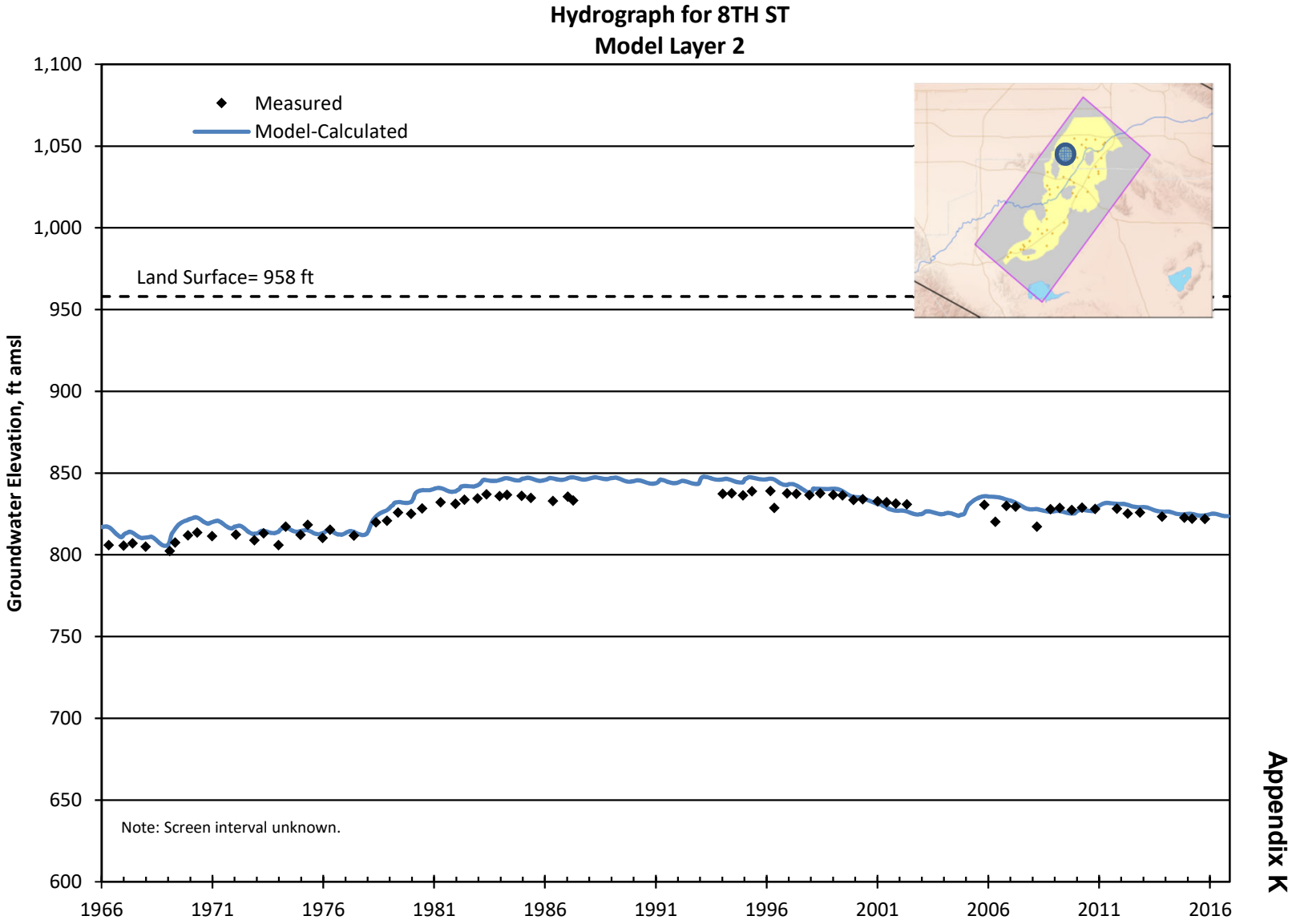
Appendix K


Hydrograph for 1 (RIO RANCHO)
Model Layer 1
Measured
Model-Calculated
Land Surface= 768 ft
Screen Interval*
(ft amsl):
713 to 700
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

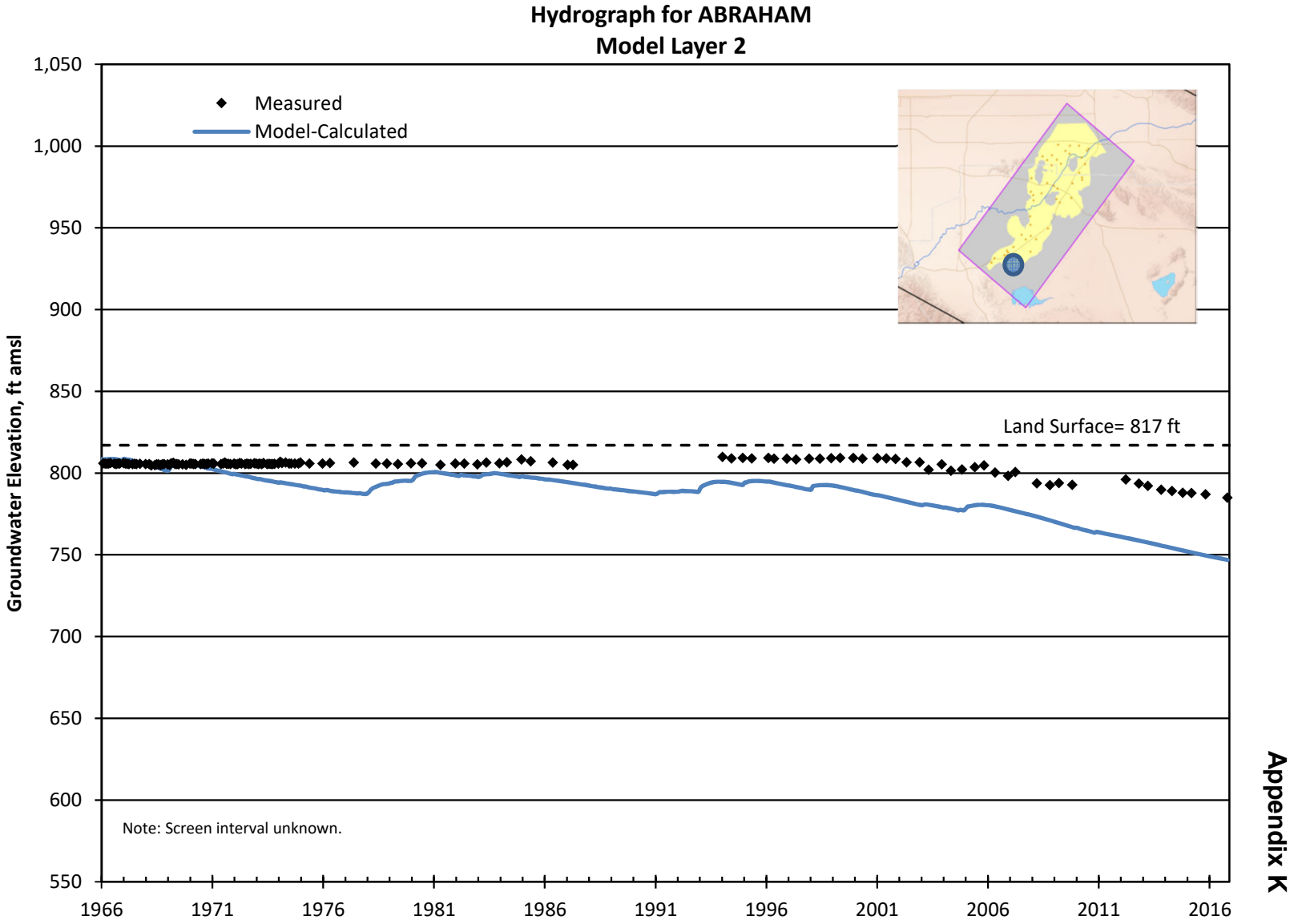
Appendix K


Hydrograph for 1, AUGA MENSA
Model Layer 2
Measured
Model-Calculated
Land Surface= 922 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

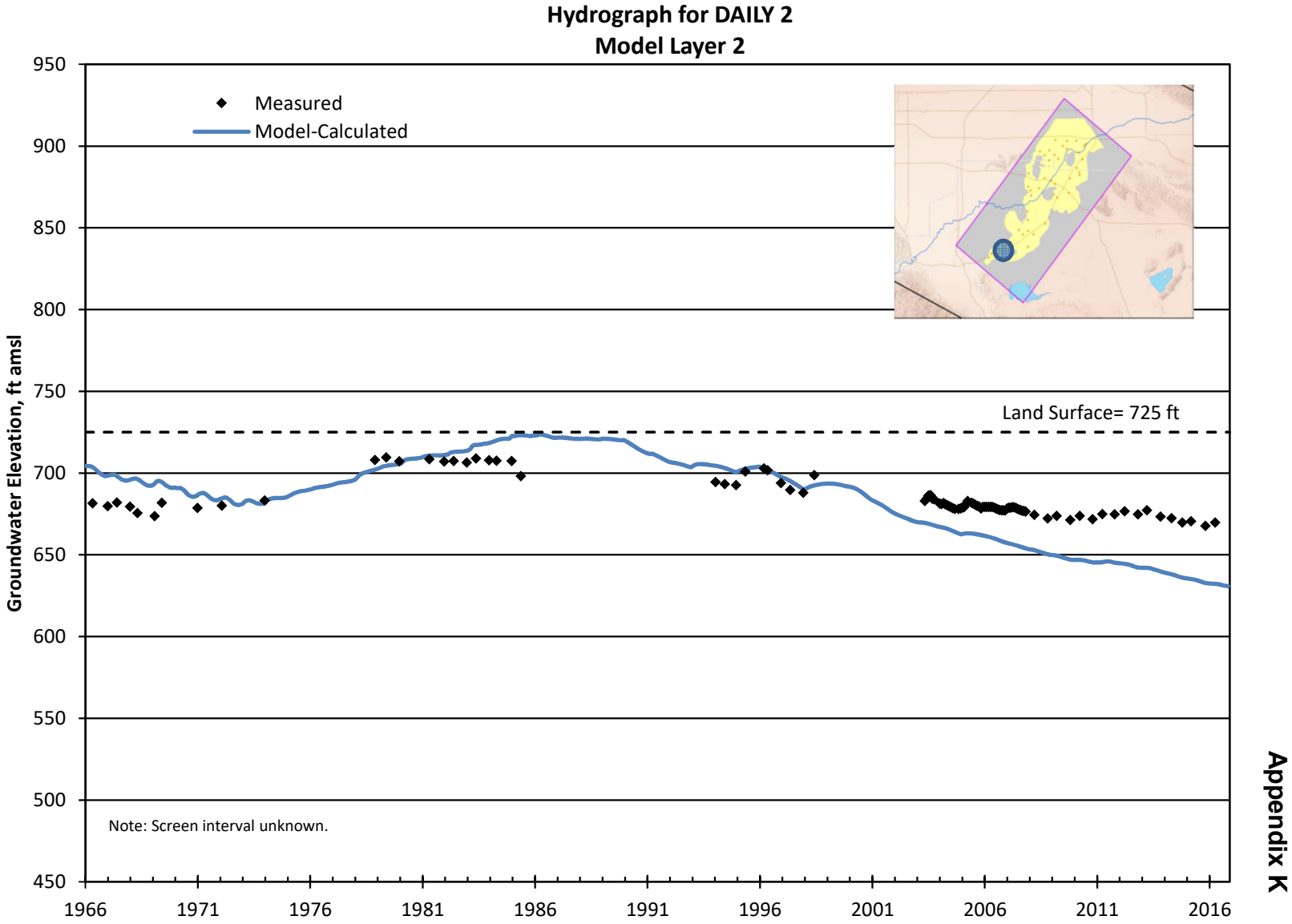
Appendix K


Hydrograph for 8TH ST
Model Layer 2
Measured
Model-Calculated
Land Surface= 958 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

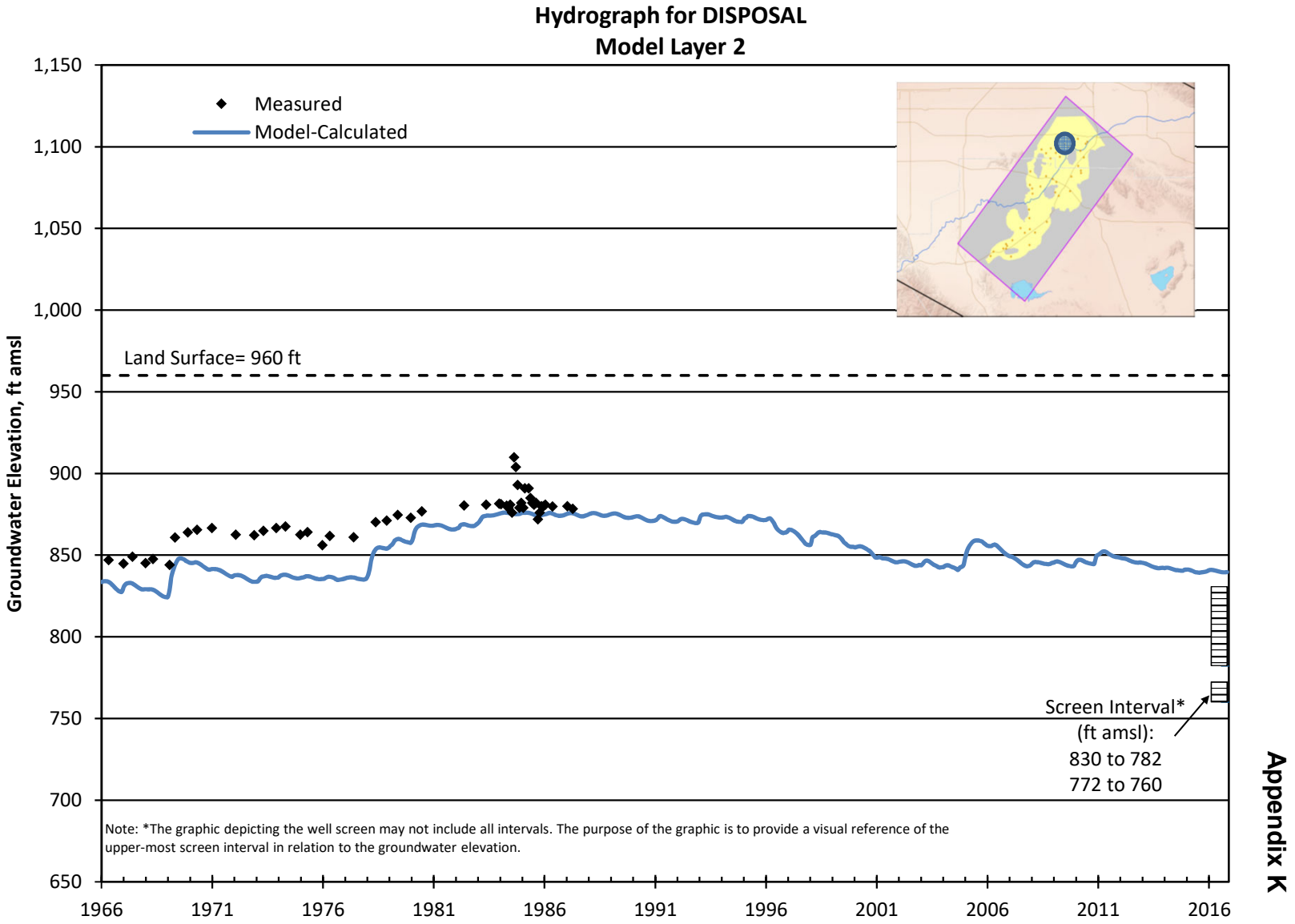
Appendix K


Hydrograph for ABRAHAM
Model Layer 2
Measured
Model-Calculated
Land Surface= 817 ft
Note: Screen interval unknown.
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

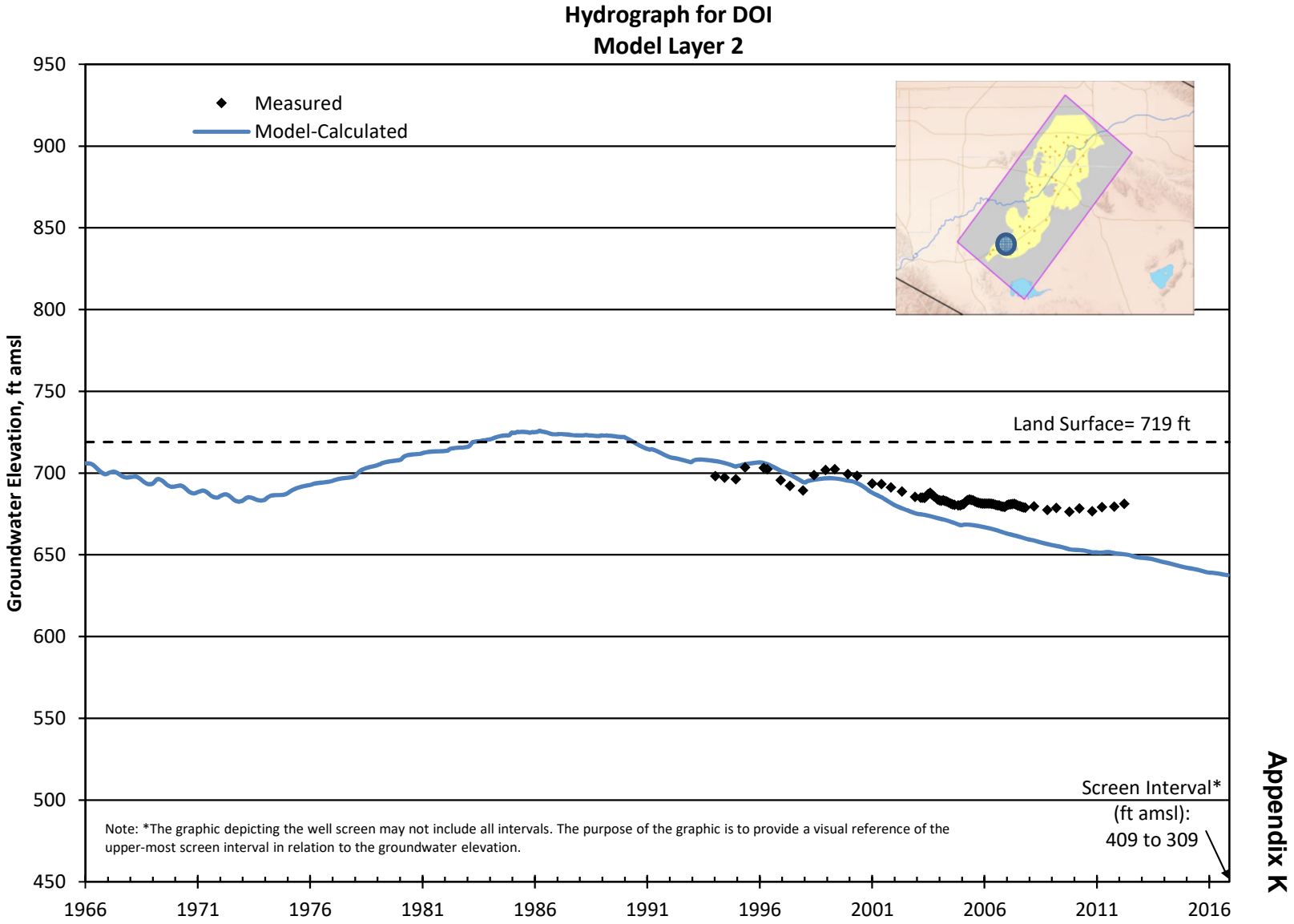
Appendix K

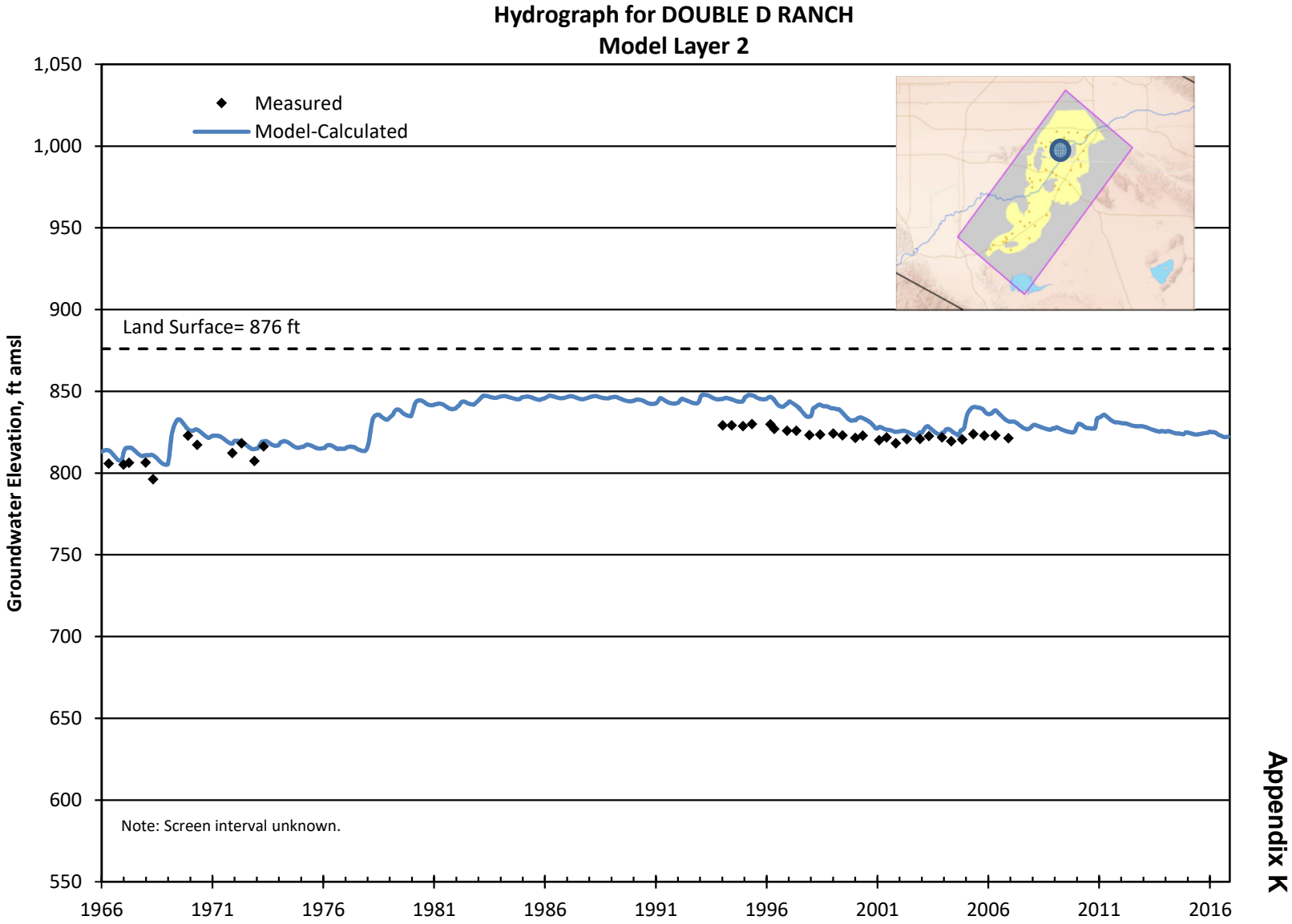

Hydrograph for DAILY 2
Model Layer 2
Measured
Model-Calculated
Land Surface= 725 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

Appendix K

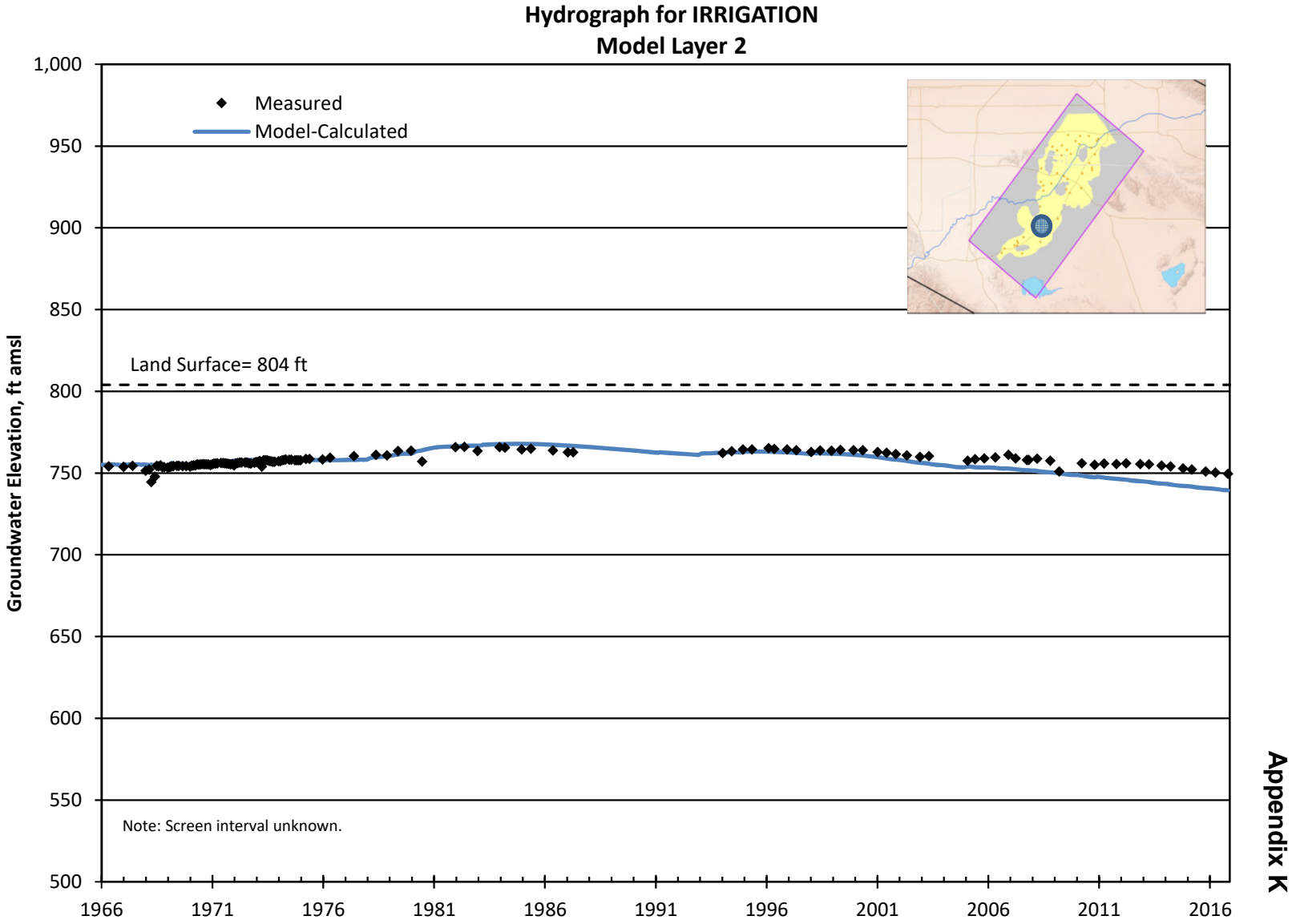

Hydrograph for DISPOSAL
Model Layer 2
Measured
Model-Calculated
Land Surface= 960 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
830 to 782
772 to 760
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix K

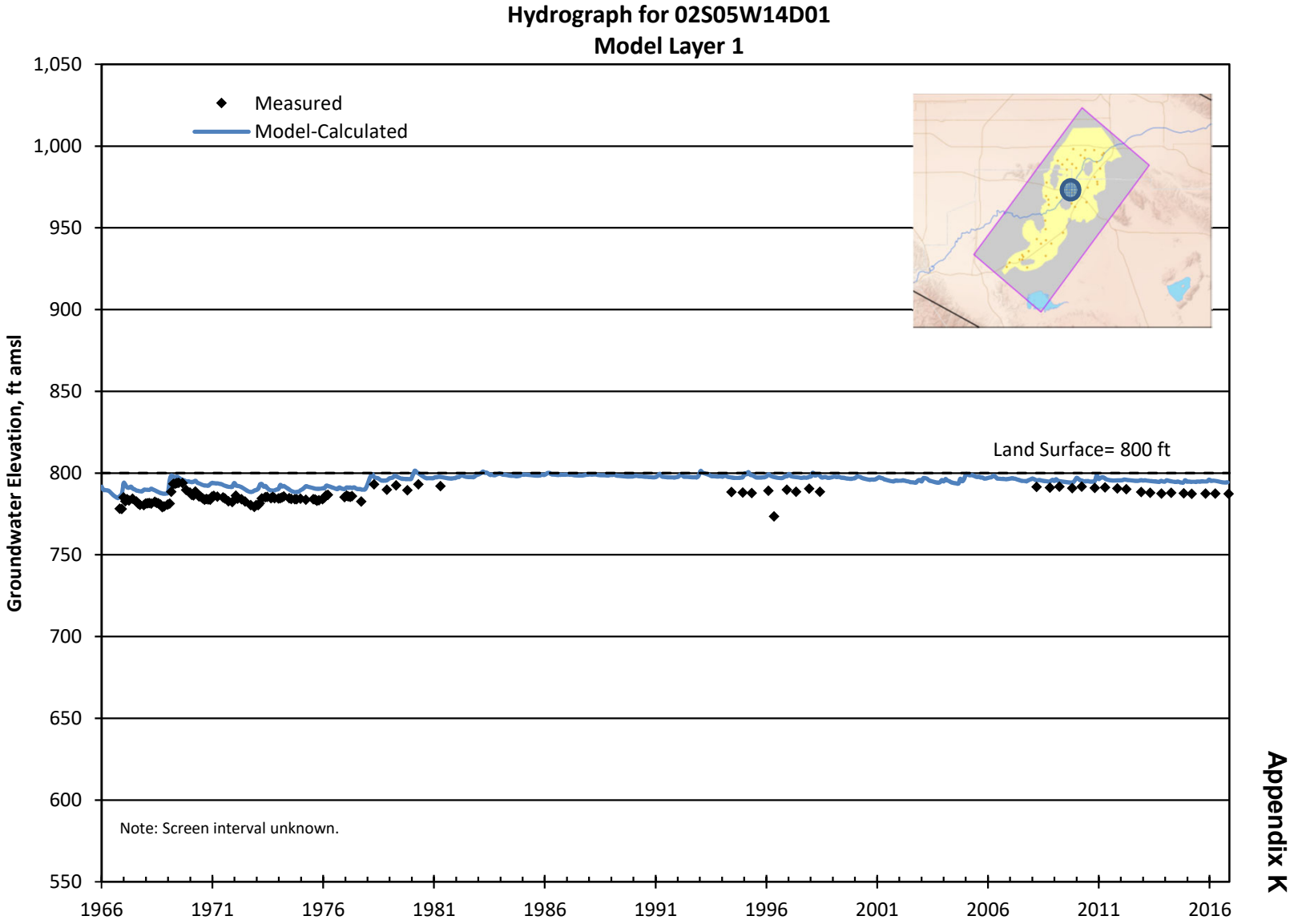

Hydrograph for DOI
Model Layer 2
Measured
Model-Calculated
Land Surface= 719 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Screen Interval*
(ft amsl):
409 to 309
Appendix K


Hydrograph for DOUBLE D RANCH
Model Layer 2
Measured
Model-Calculated
Land Surface= 876 ft
Note: Screen interval unknown.
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

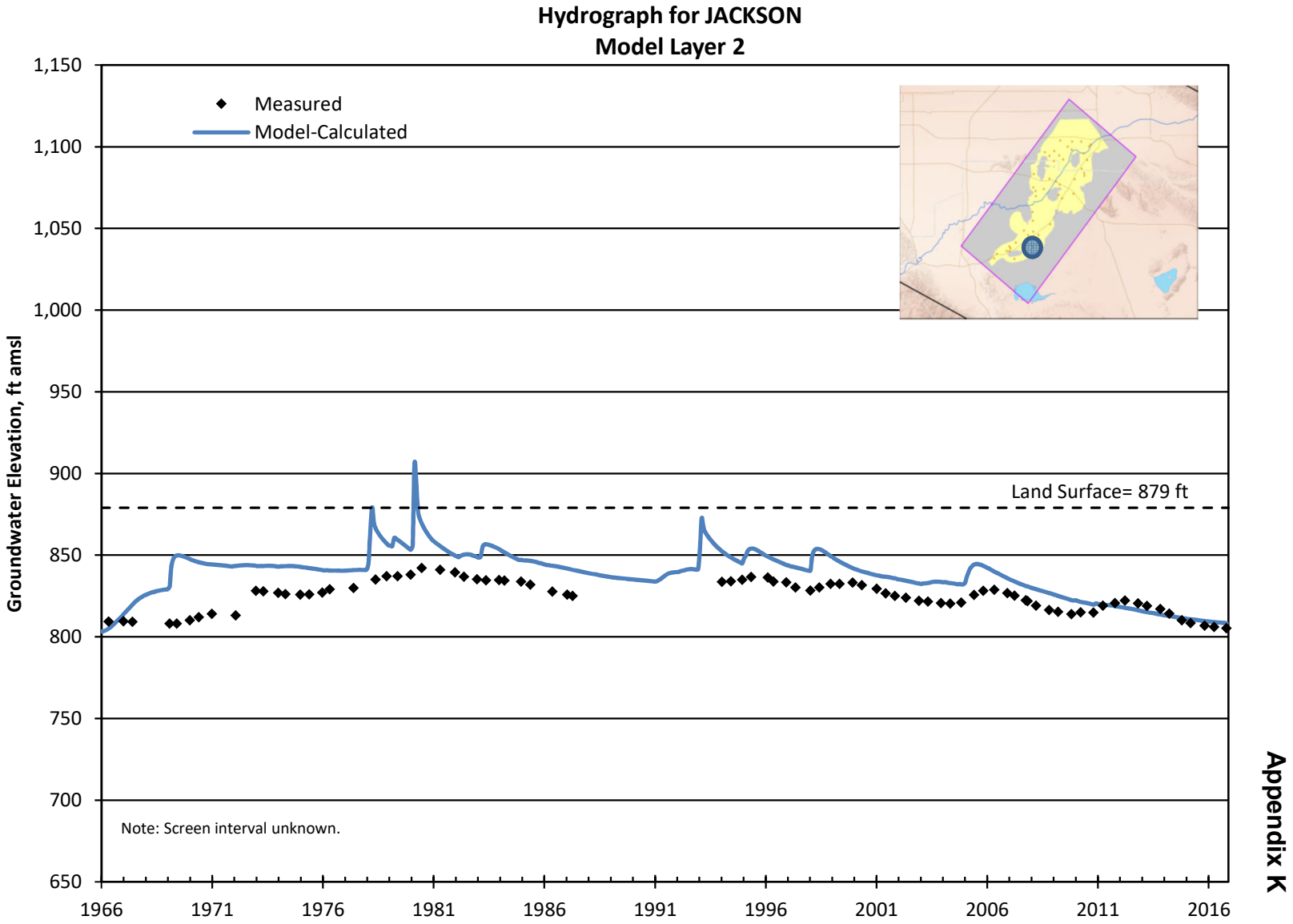
Appendix K


Hydrograph for IRRIGATION
Model Layer 2
Measured
Model-Calculated
Land Surface= 804 ft
Note: Screen interval unknown.
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

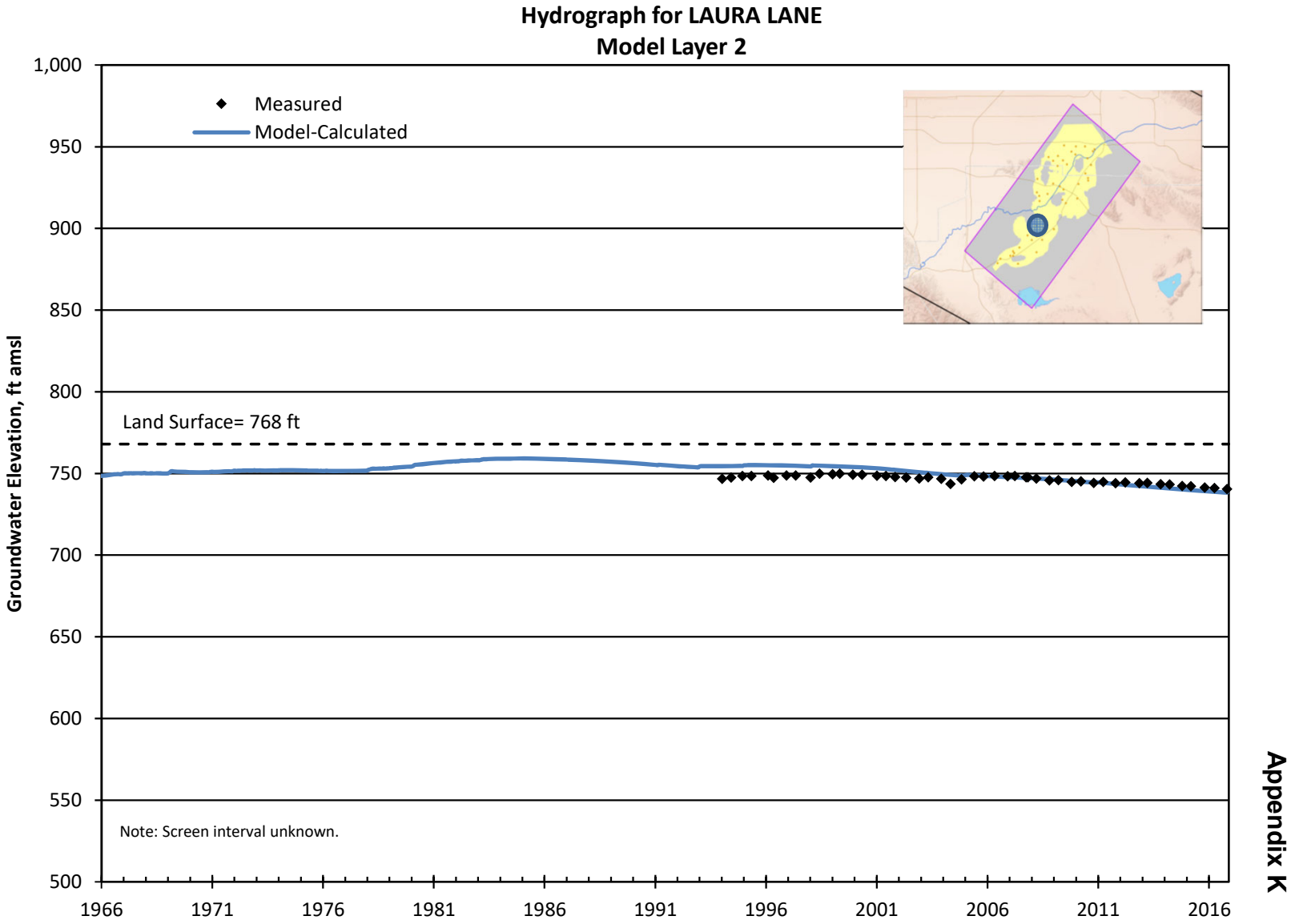
Appendix K


Hydrograph for 02S05W14D01
Model Layer 1
Measured
Model-Calculated
Land Surface= 800 ft
Note: Screen interval unknown.
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

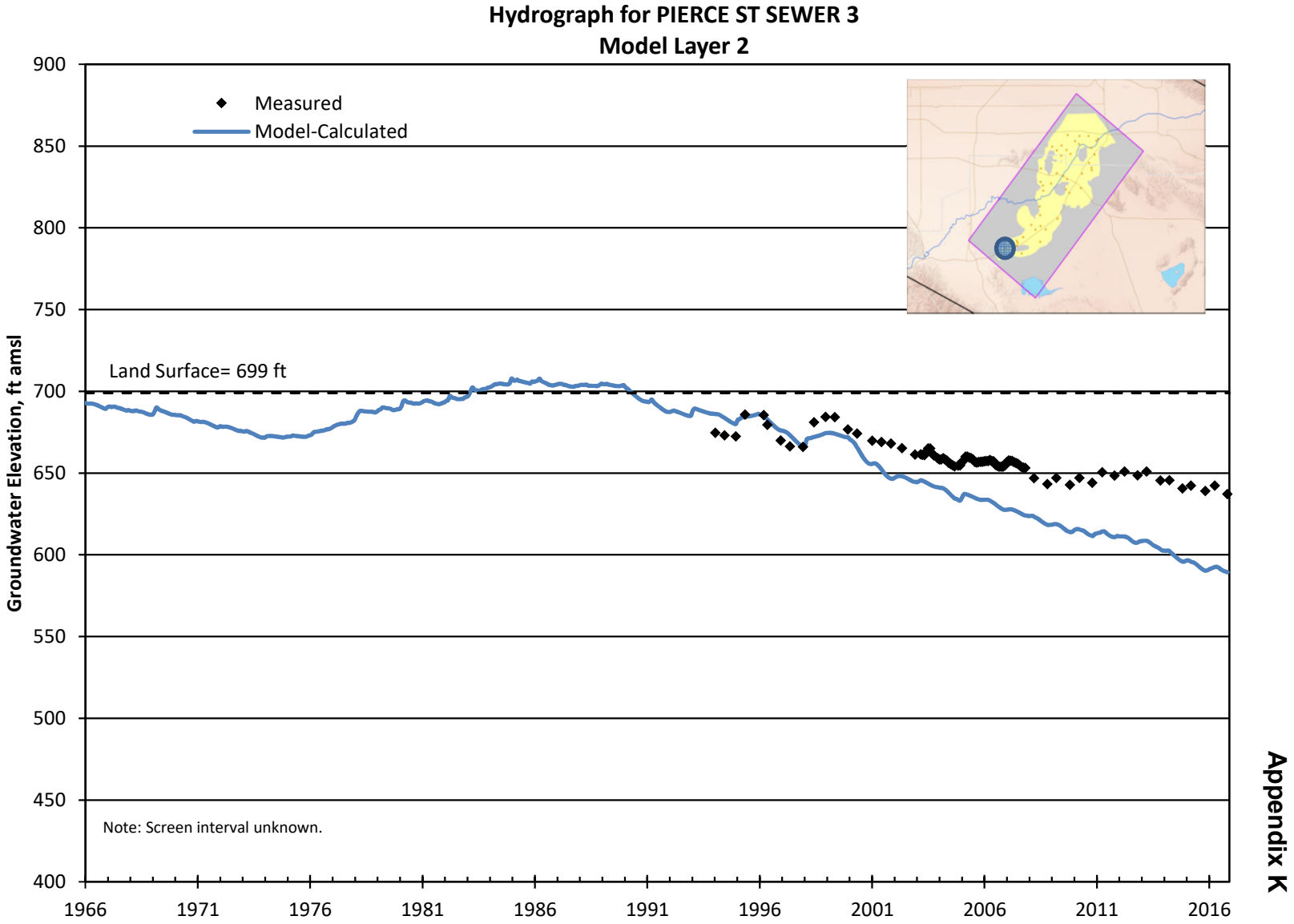
Appendix K


Hydrograph for JACKSON
Model Layer 2
Measured
Model-Calculated
Land Surface= 879 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

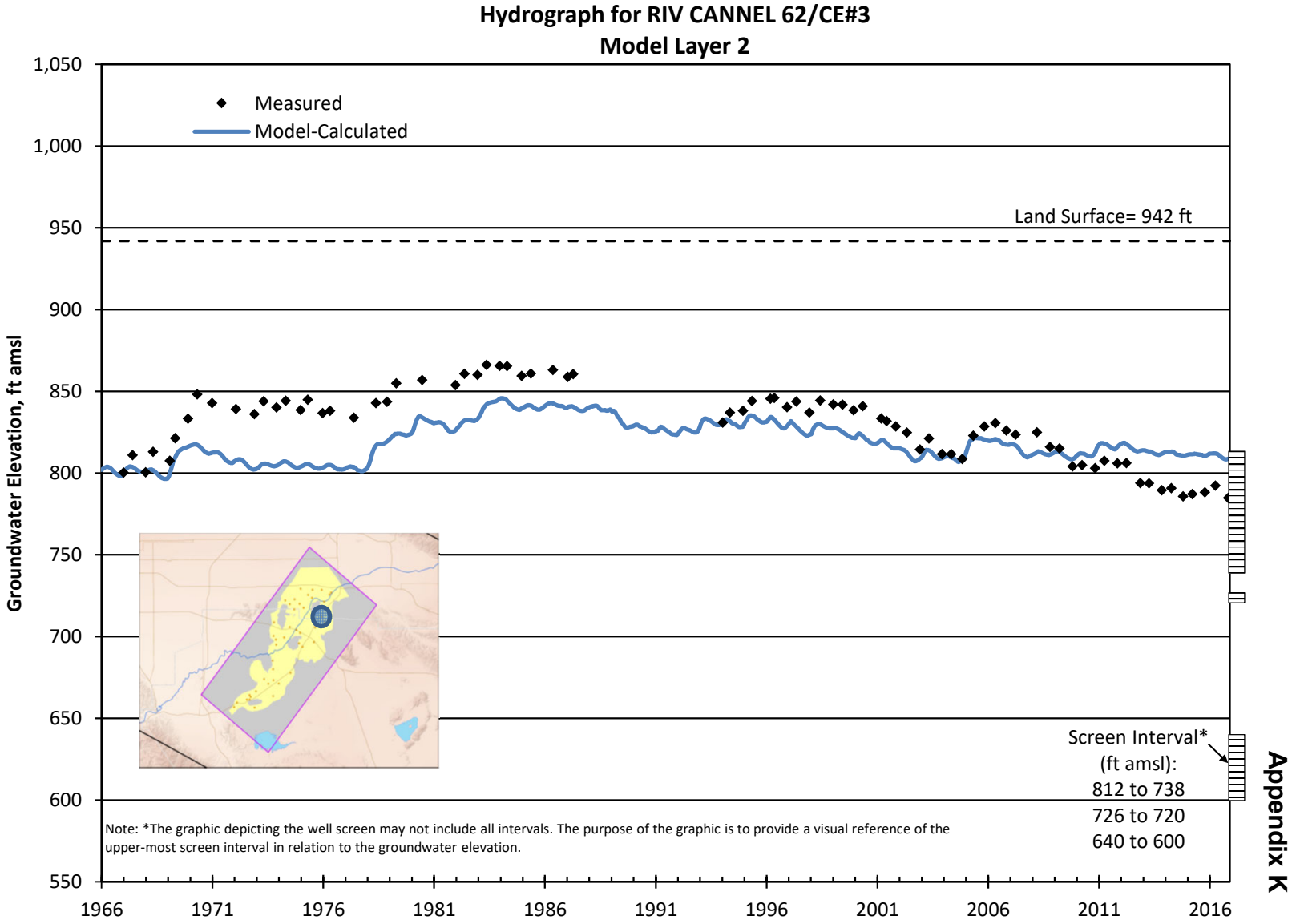
Appendix K

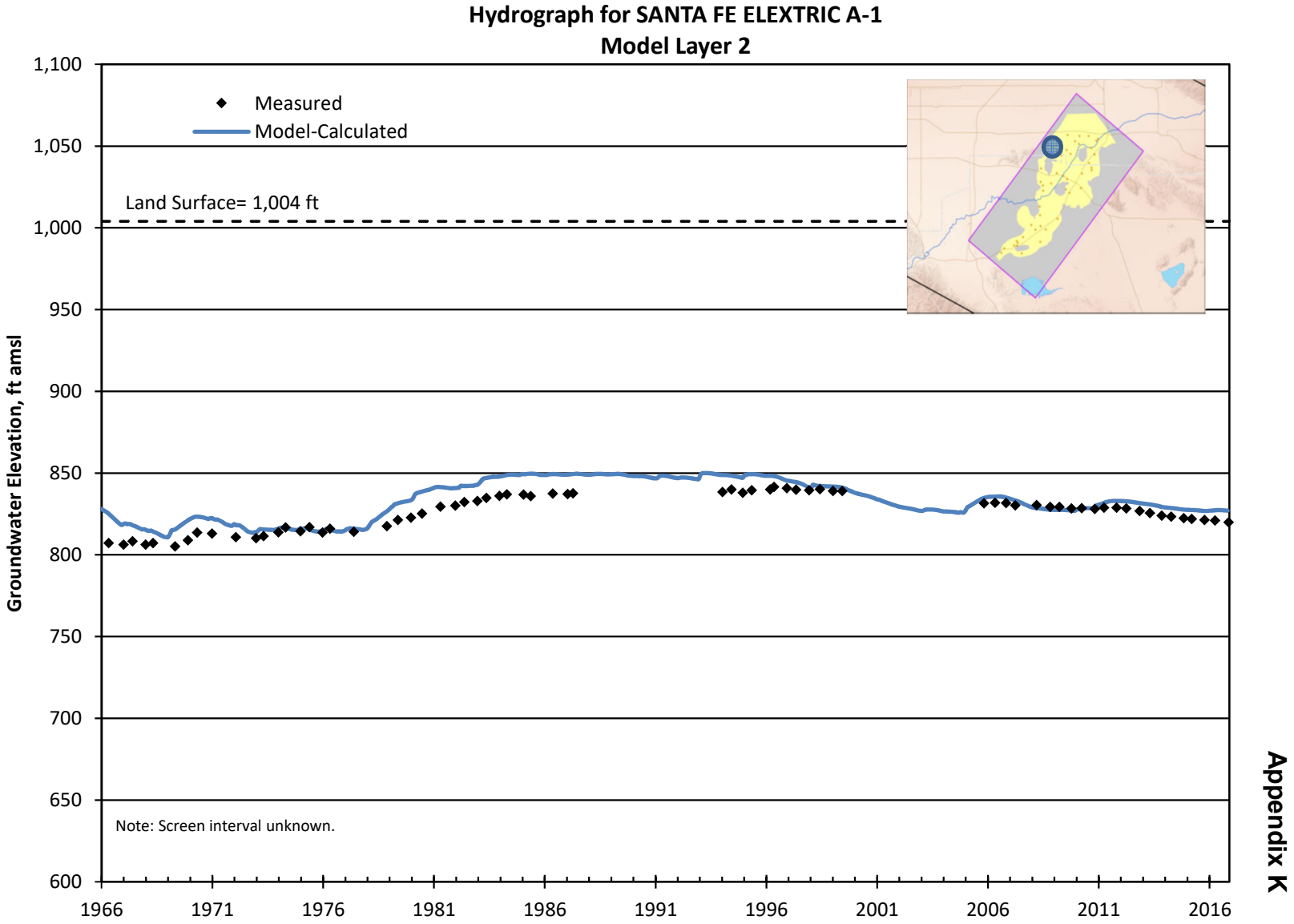

Hydrograph for LAURA LANE
Model Layer 2
Measured
Model-Calculated
Land Surface= 768 ft
Note: Screen interval unknown.
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

Appendix K

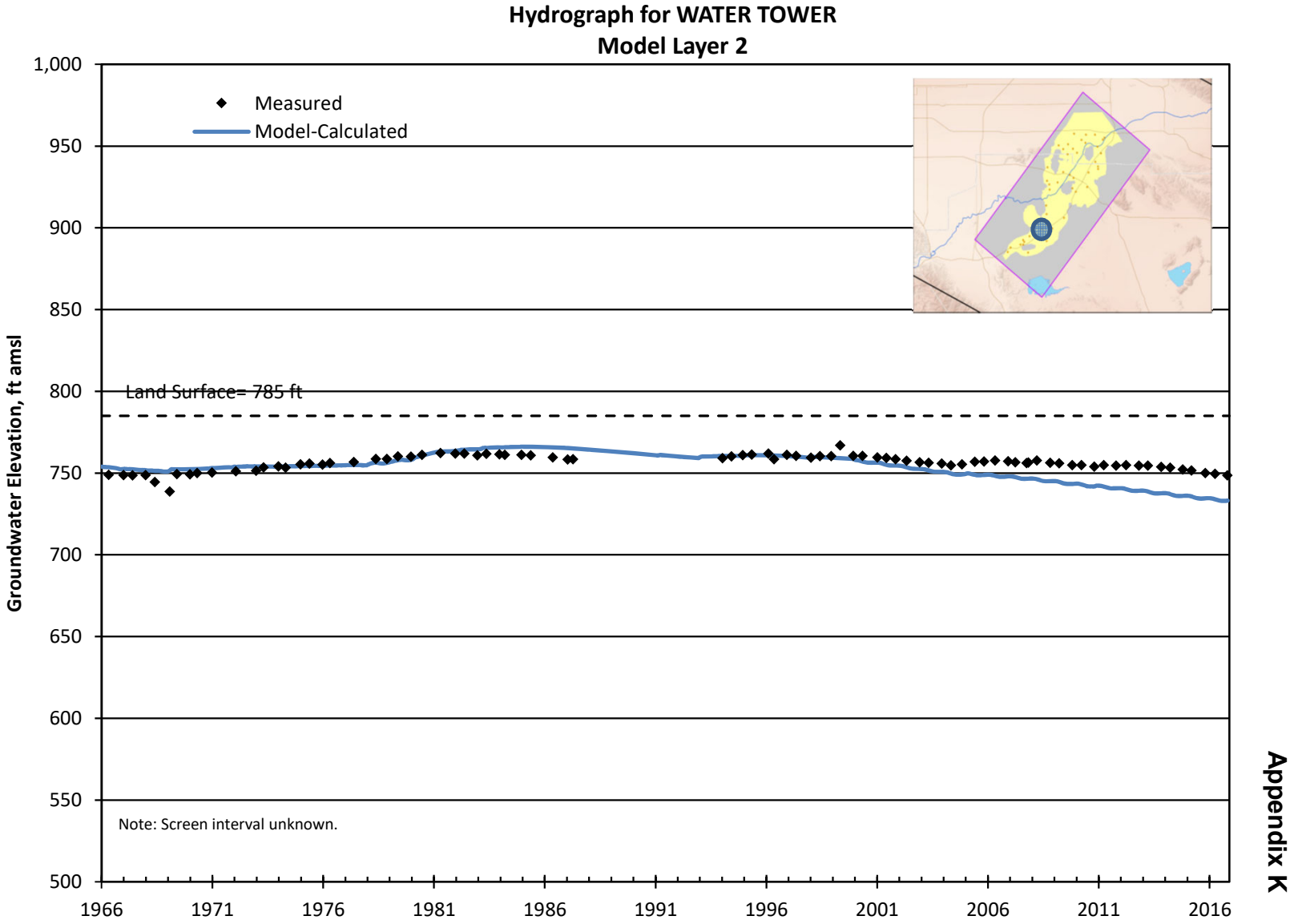

Hydrograph for PIERCE ST SEWER 3
Model Layer 2
Measured
Model-Calculated
Land Surface= 699 ft
Note: Screen interval unknown.
Groundwater Elevation, ft amsl
900
850
800
750
700
650
600
550
500
450
400
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

Appendix K


Hydrograph for RIV CANNEL 62/CE#3
Model Layer 2
Measured
Model-Calculated
Land Surface= 942 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
812 to 738
726 to 720
640 to 600
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Appendix K


Hydrograph for SANTA FE ELEXTRIC A-1
Model Layer 2
Measured
Model-Calculated
Land Surface= 1,004 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

Appendix K

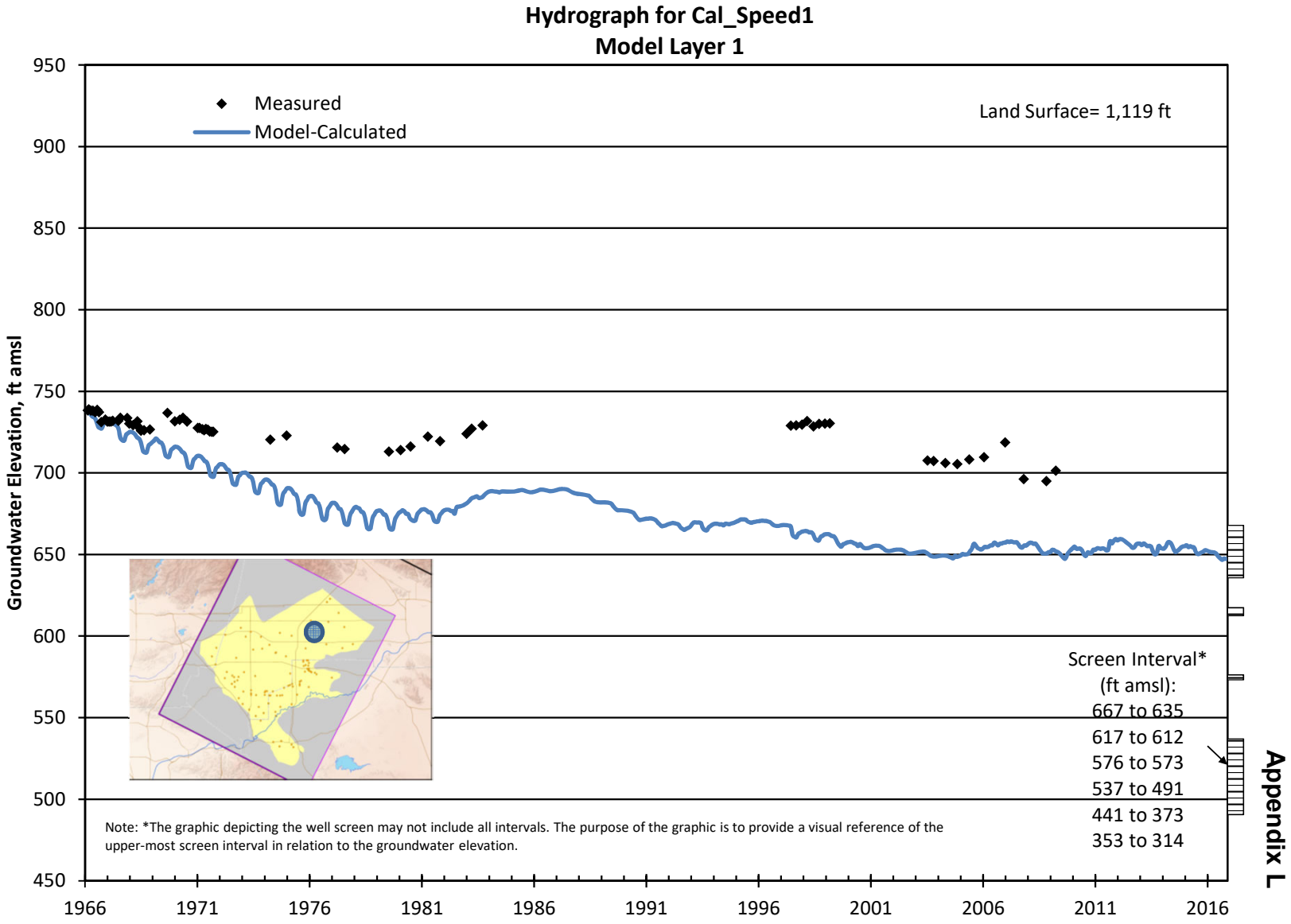

Hydrograph for WATER TOWER
Model Layer 2
Measured
Model-Calculated
Land Surface= 785 ft
Note: Screen interval unknown.
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

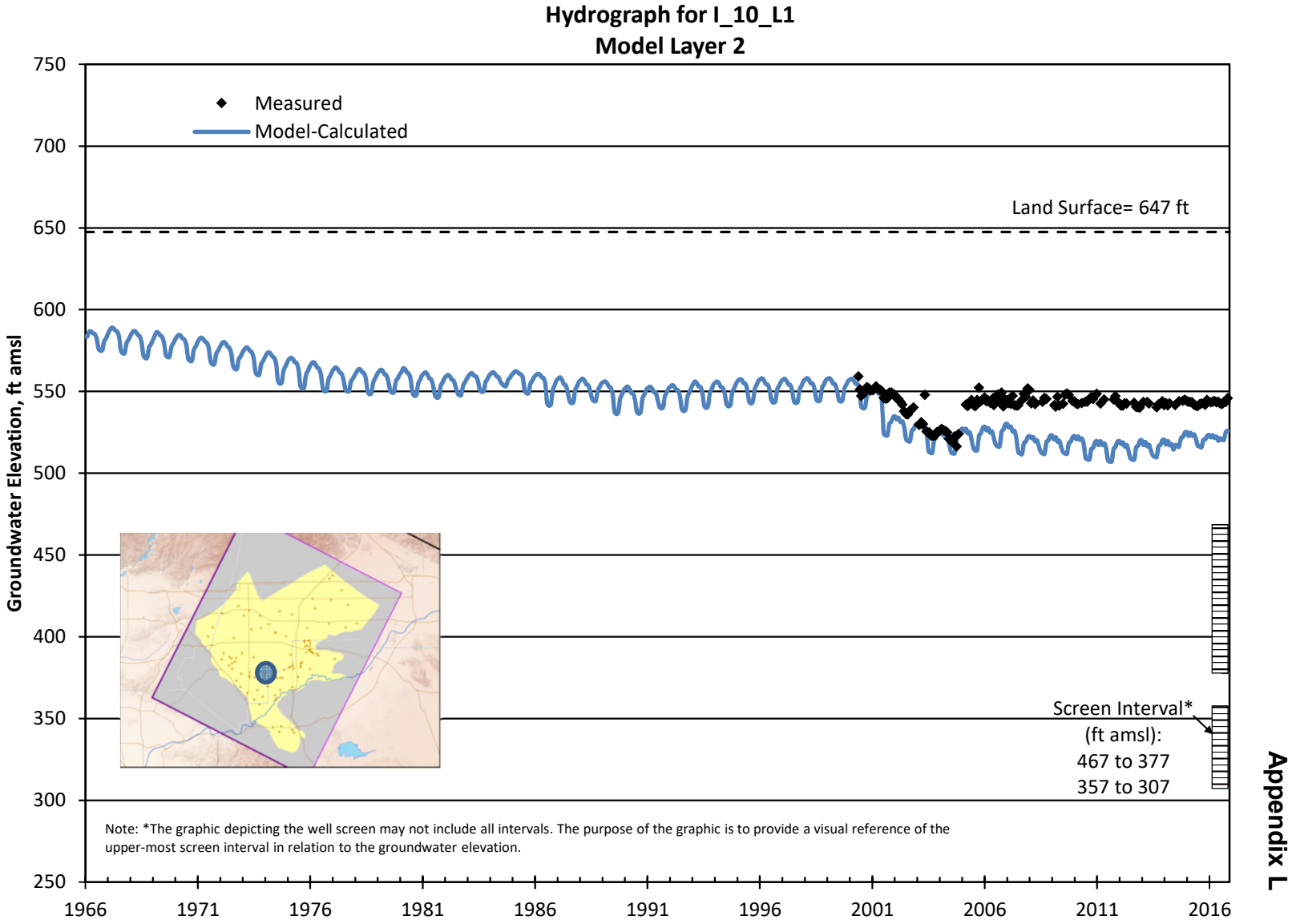
Appendix K

APPENDIX L

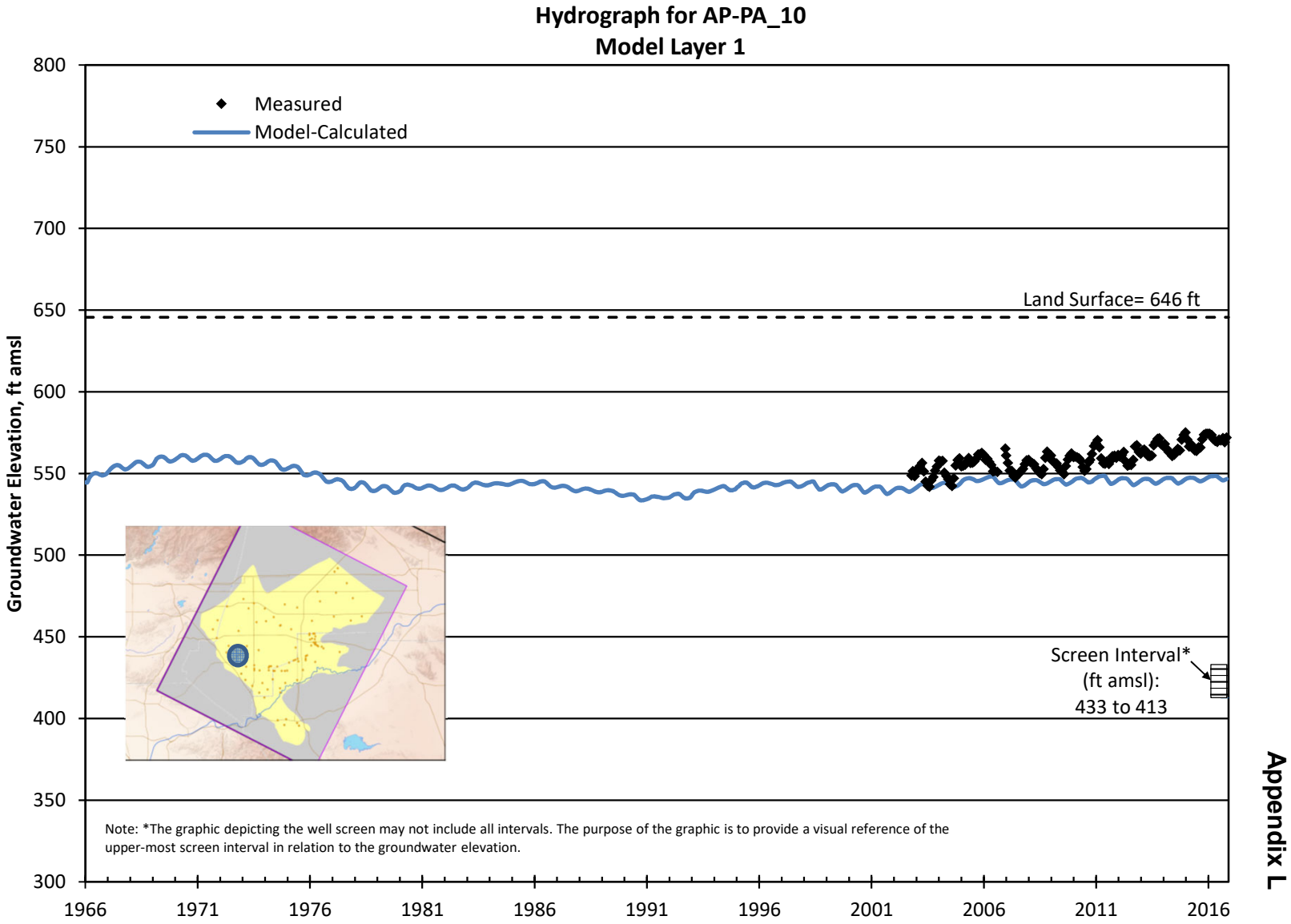
Individual Model Update: Selected Hydrographs for the Chino Basin Model Calibration Target Wells – 1966 to 2016

GEOSCIENCE

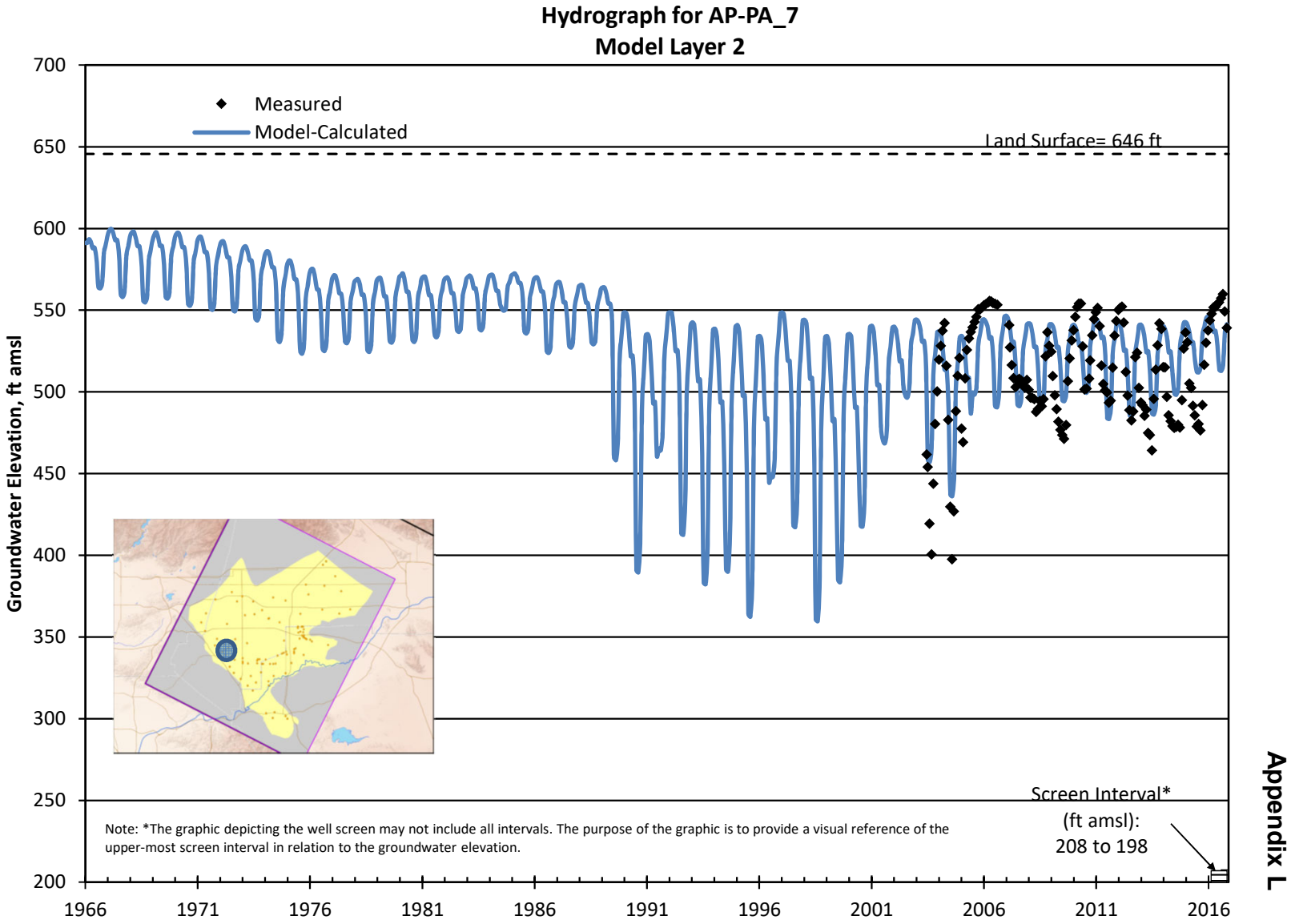

Hydrograph for Cal_Speed1
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,119 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
667 to 635
617 to 612
576 to 573
537 to 491
441 to 373
353 to 314
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Appendix L


Hydrograph for I_10_L1
Model Layer 2
Measured
Model-Calculated
Land Surface= 647 ft
Groundwater Elevation, ft amsl
750
700
650
600
550
500
450
400
350
300
250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
467 to 377
357 to 307
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

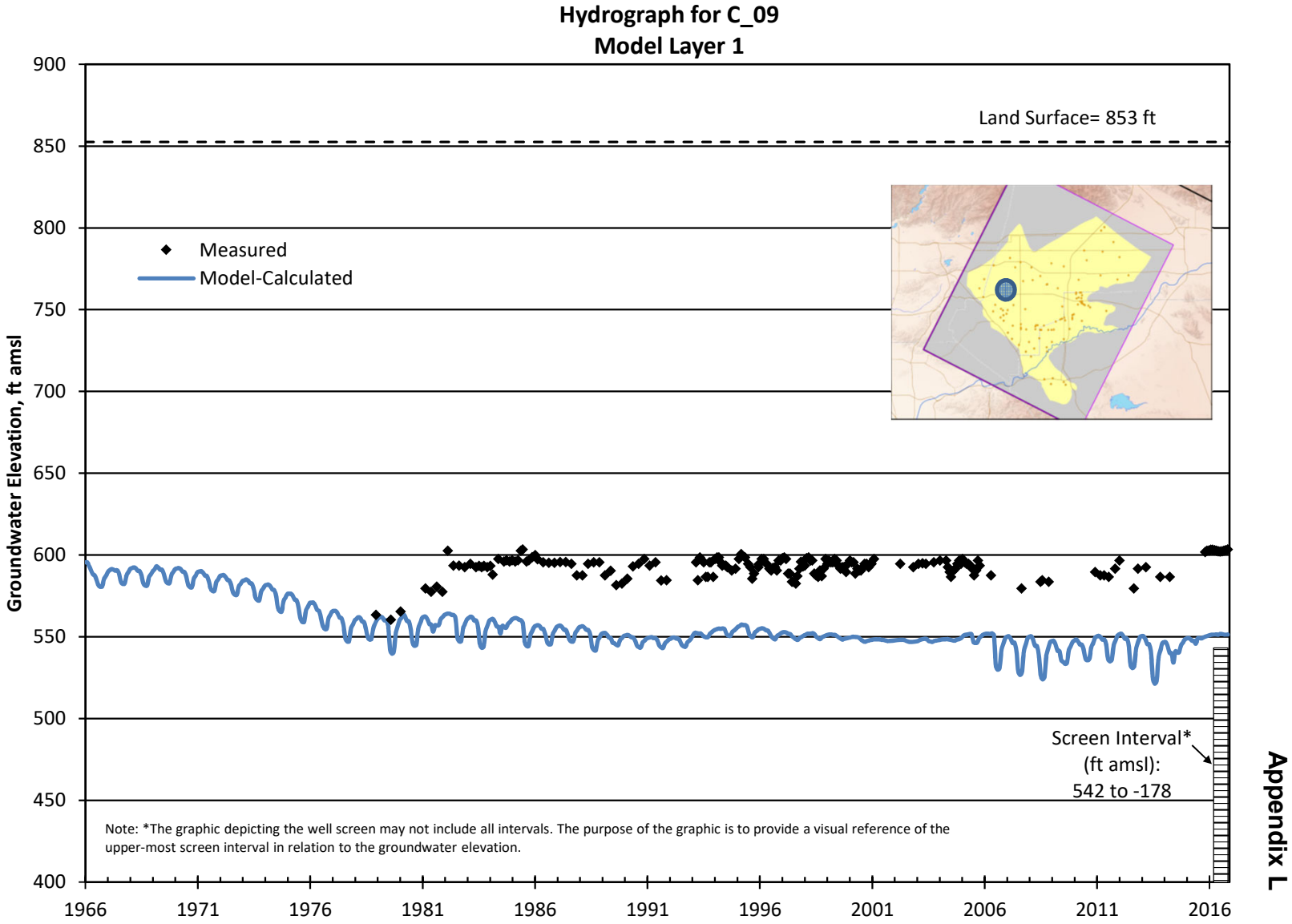
Appendix L


Hydrograph for AP-PA_10
Model Layer 1
Measured
Model-Calculated
Land Surface= 646 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
433 to 413
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

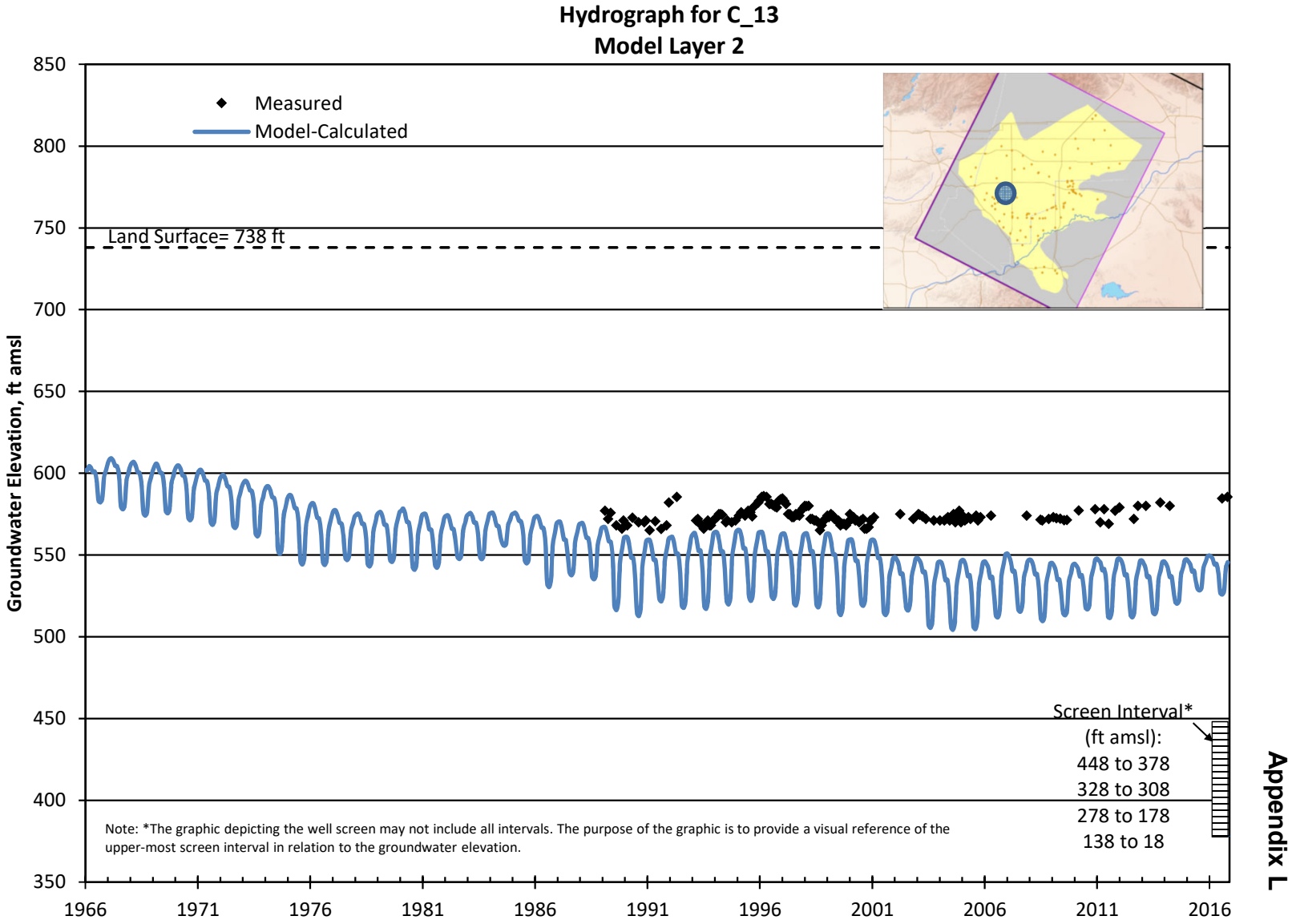
Appendix L


Hydrograph for AP-PA_7
Model Layer 2
Measured
Model-Calculated
Land Surface= 646 ft
Groundwater Elevation, ft amsl
700
650
600
550
500
450
400
350
300
250
200
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Screen Interval*
(ft amsl):
208 to 198

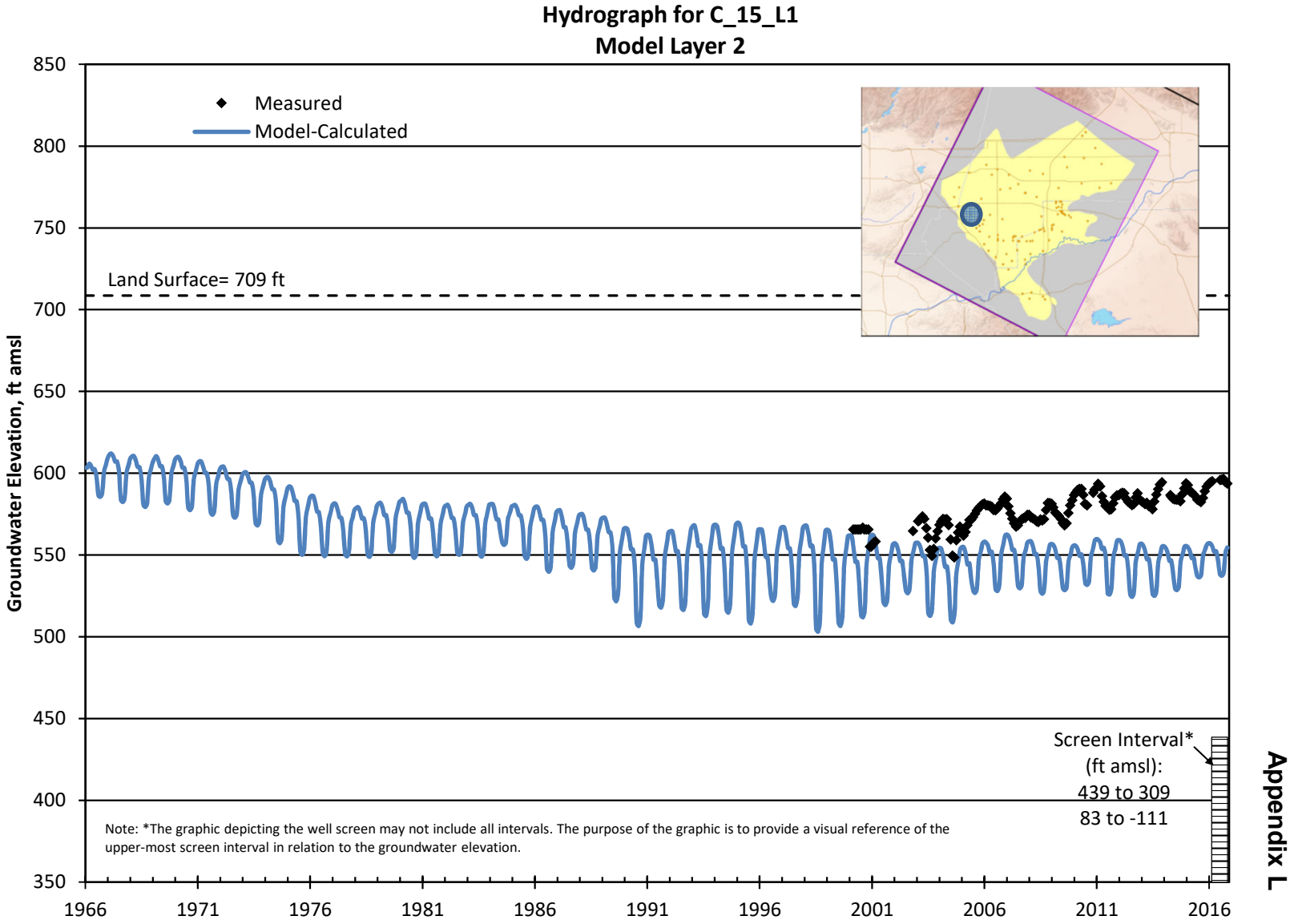
Appendix L


Hydrograph for C_09
Model Layer 1
Groundwater Elevation, ft amsl
900
850
800
750
700
650
600
550
500
450
400
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 853 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
542 to -178
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

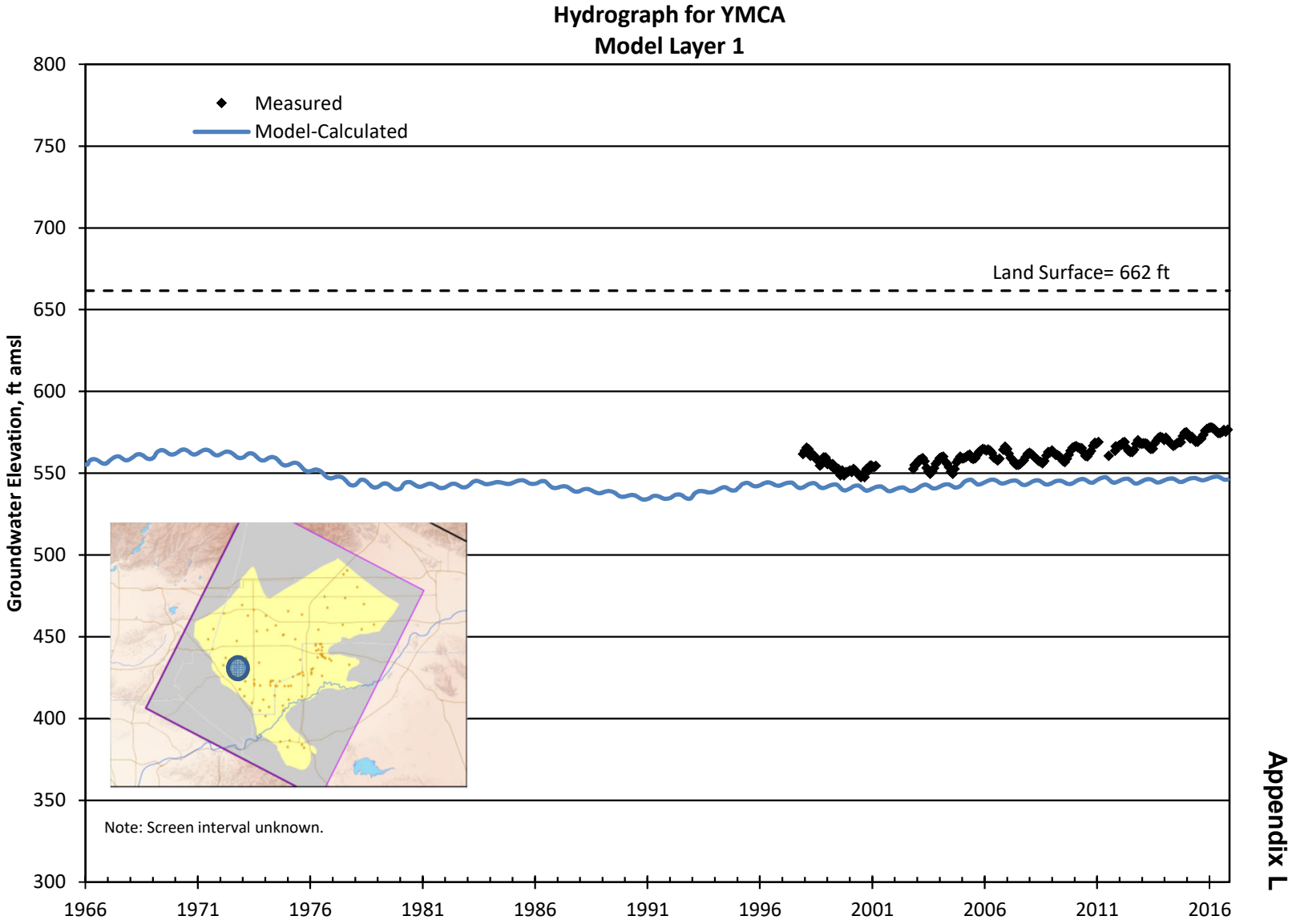
Appendix L


Hydrograph for C_13
Model Layer 2
Measured
Model-Calculated
Land Surface= 738 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
448 to 378
328 to 308
278 to 178
138 to 18
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

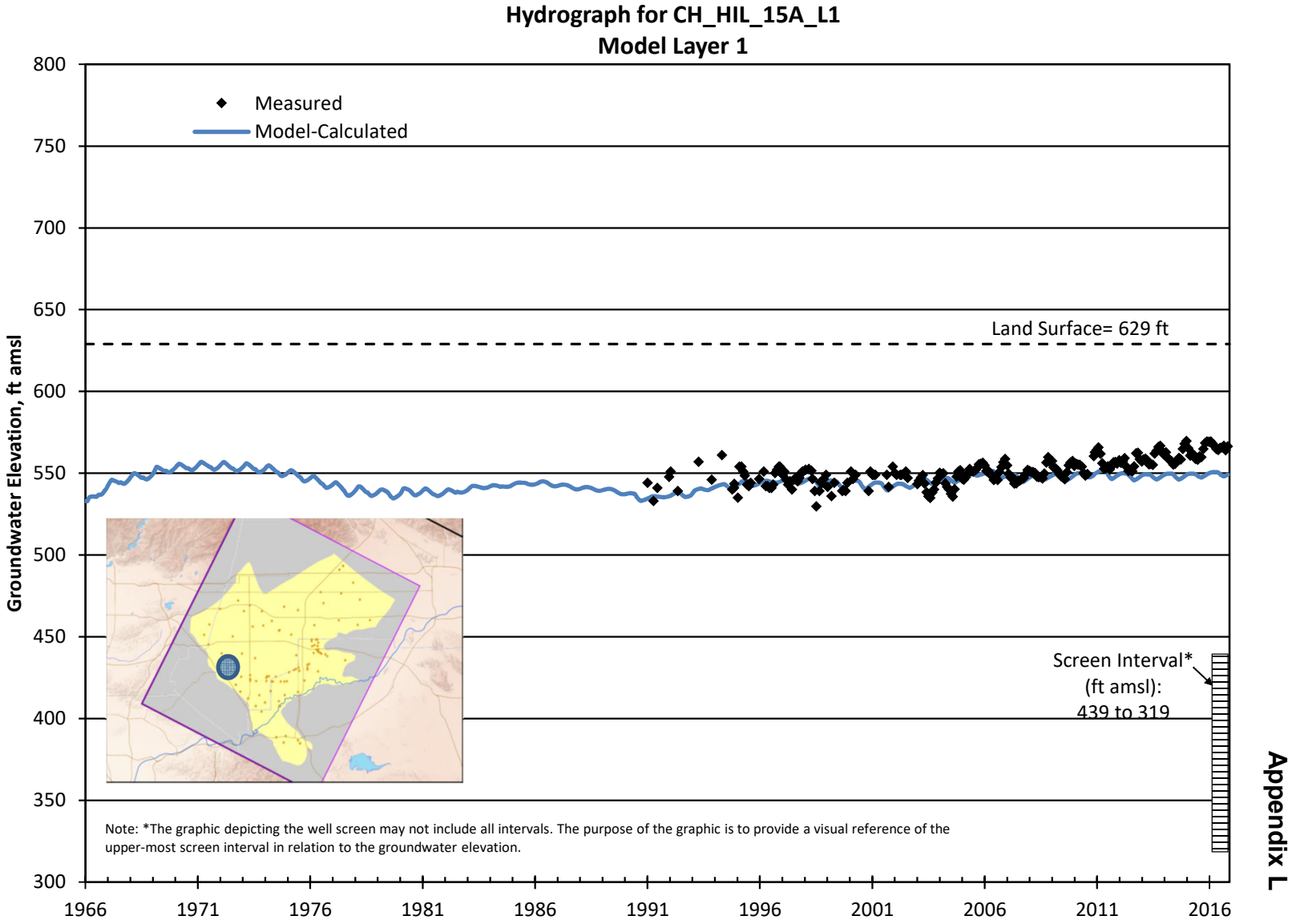
Appendix L


Hydrograph for C_15_L1
Model Layer 2
Measured
Model-Calculated
Land Surface= 709 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
439 to 309
83 to -111
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

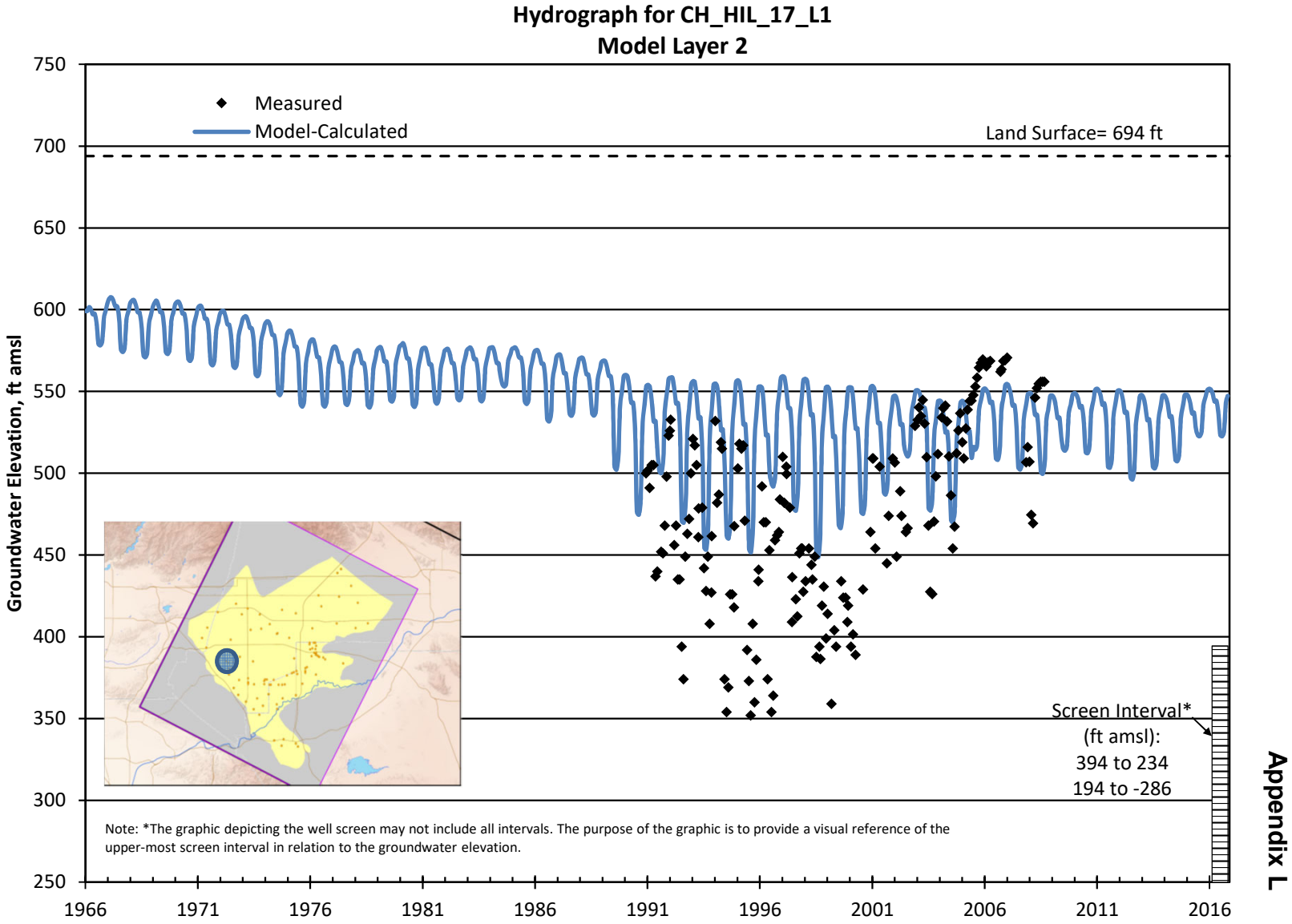
Appendix L


Hydrograph for YMCA
Model Layer 1
Measured
Model-Calculated
Land Surface= 662 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

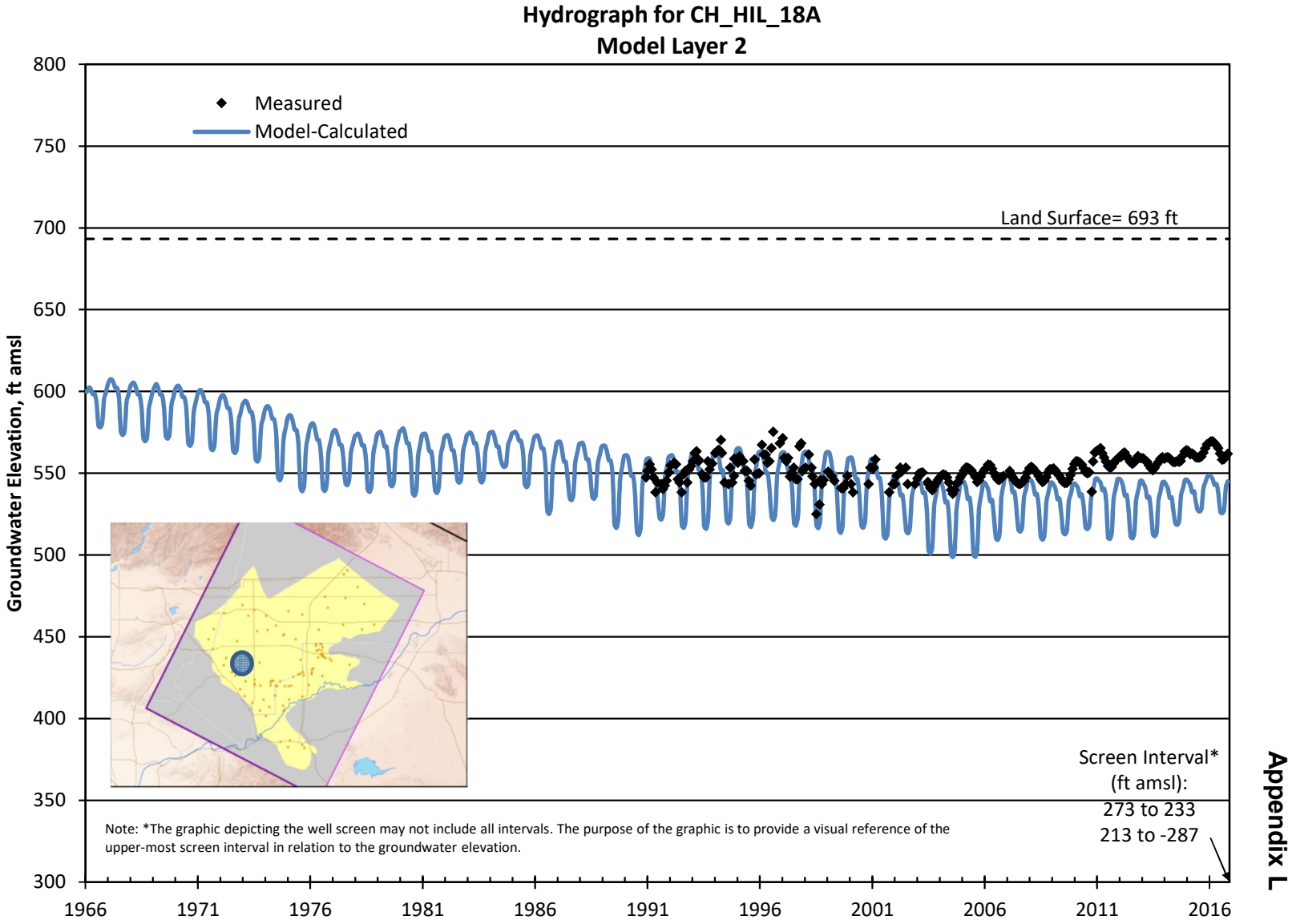
Appendix L


Hydrograph for CH_HIL_15A_L1
Model Layer 1
Measured
Model-Calculated
Land Surface= 629 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
439 to 319
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

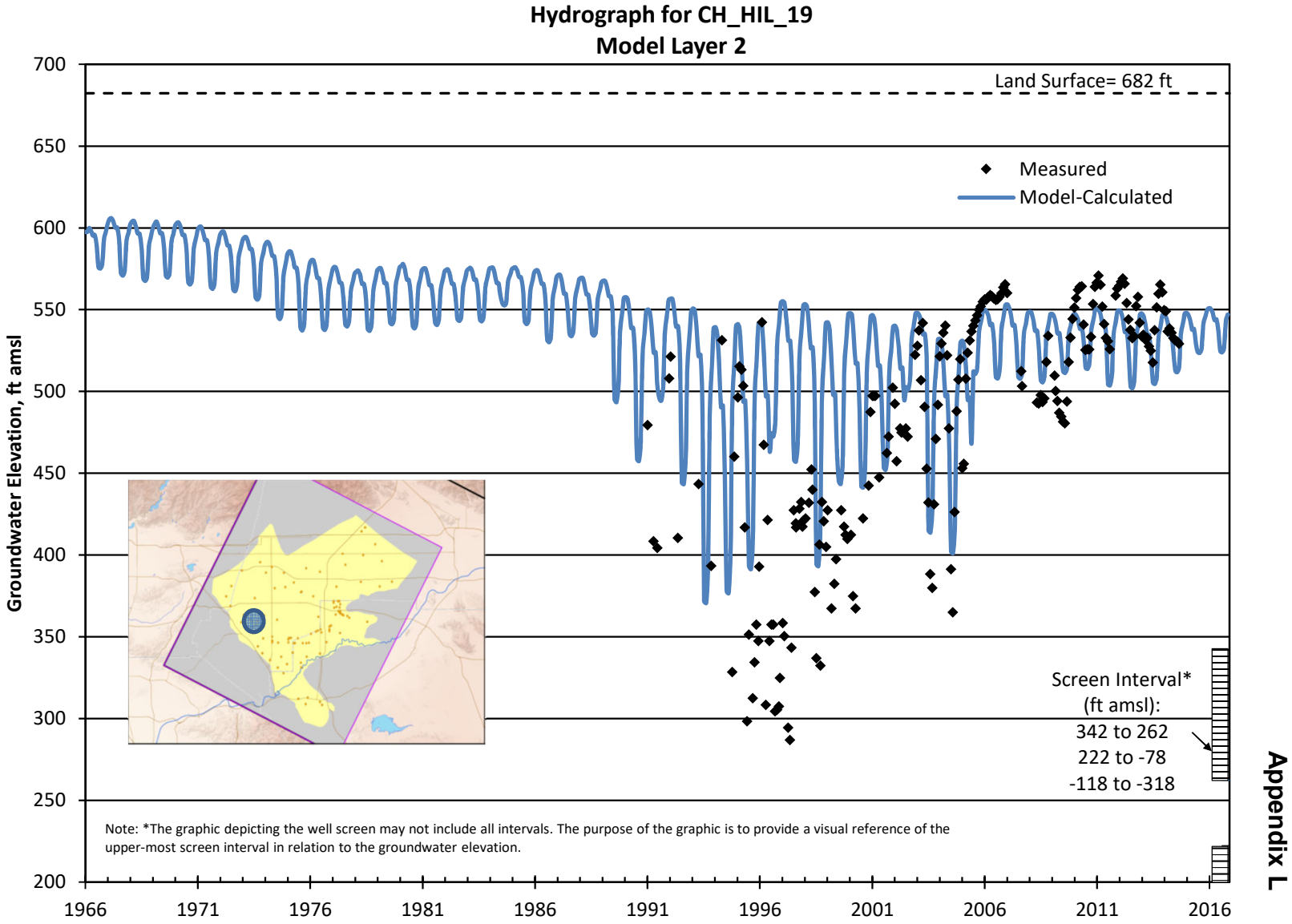
Appendix L


Hydrograph for CH_HIL_17_L1
Model Layer 2
Measured
Model-Calculated
Land Surface= 694 ft
Groundwater Elevation, ft amsl
750
700
650
600
550
500
450
400
350
300
250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
394 to 234
194 to -286
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

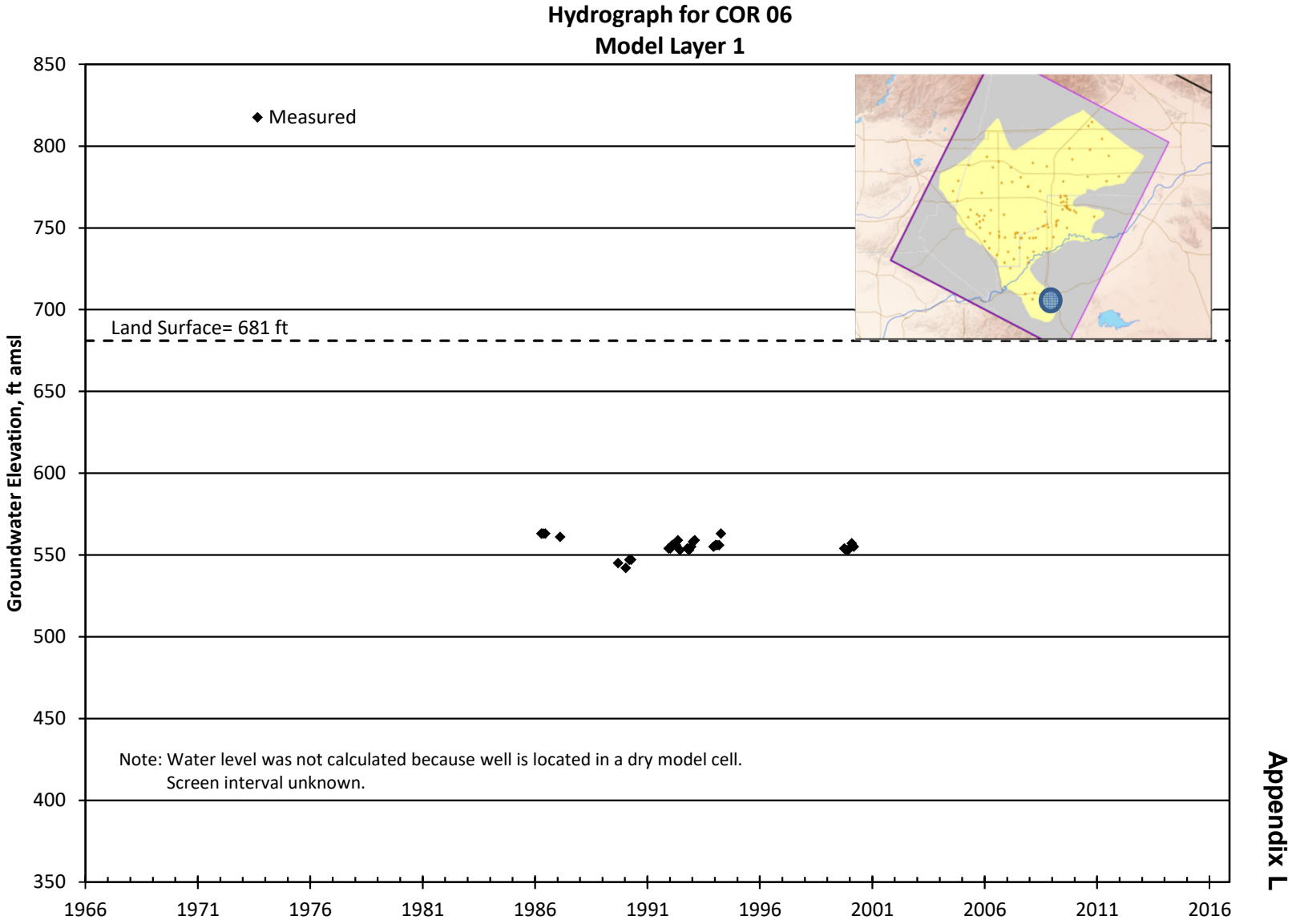
Appendix L


Hydrograph for CH_HIL_18A
Model Layer 2
Measured
Model-Calculated
Land Surface= 693 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
273 to 233
213 to -287
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

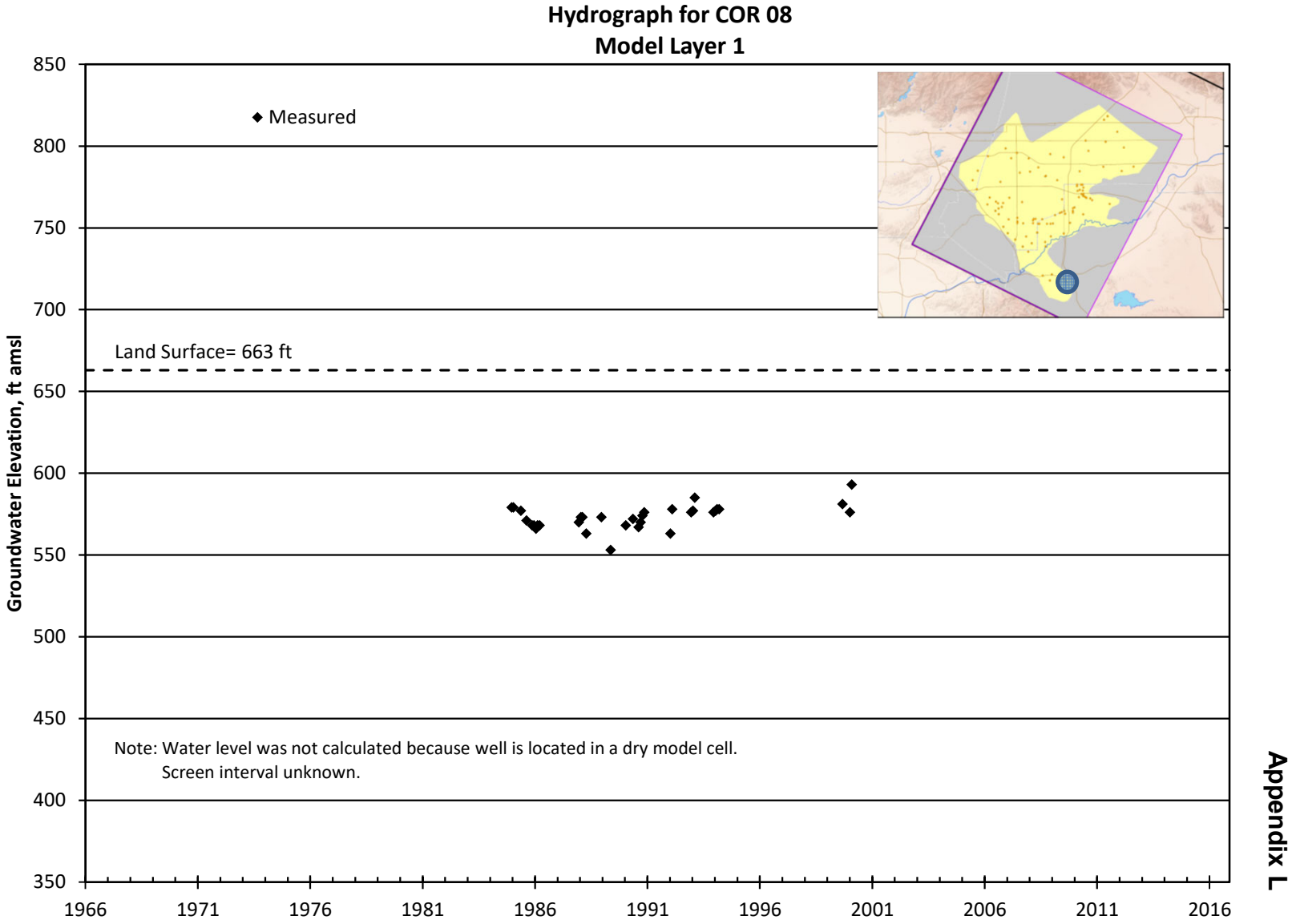
Appendix L


Hydrograph for CH_HIL_19
Model Layer 2
Land Surface= 682 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
700
650
600
550
500
450
400
350
300
250
200
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
342 to 262
222 to -78
-118 to -318
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

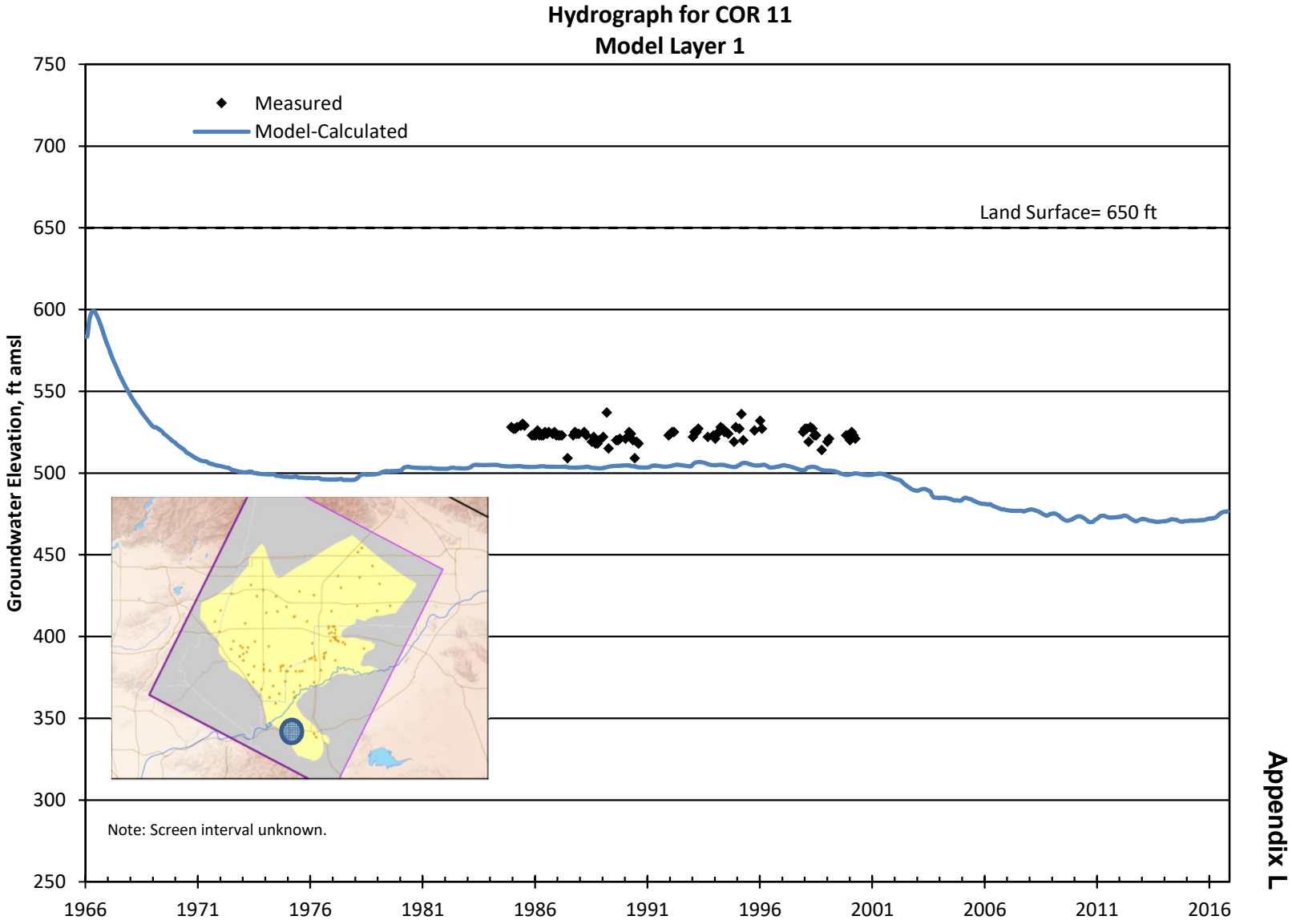
Appendix L


Hydrograph for COR 06
Model Layer 1
Measured
Land Surface= 681 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Water level was not calculated because well is located in a dry model cell.
Screen interval unknown.

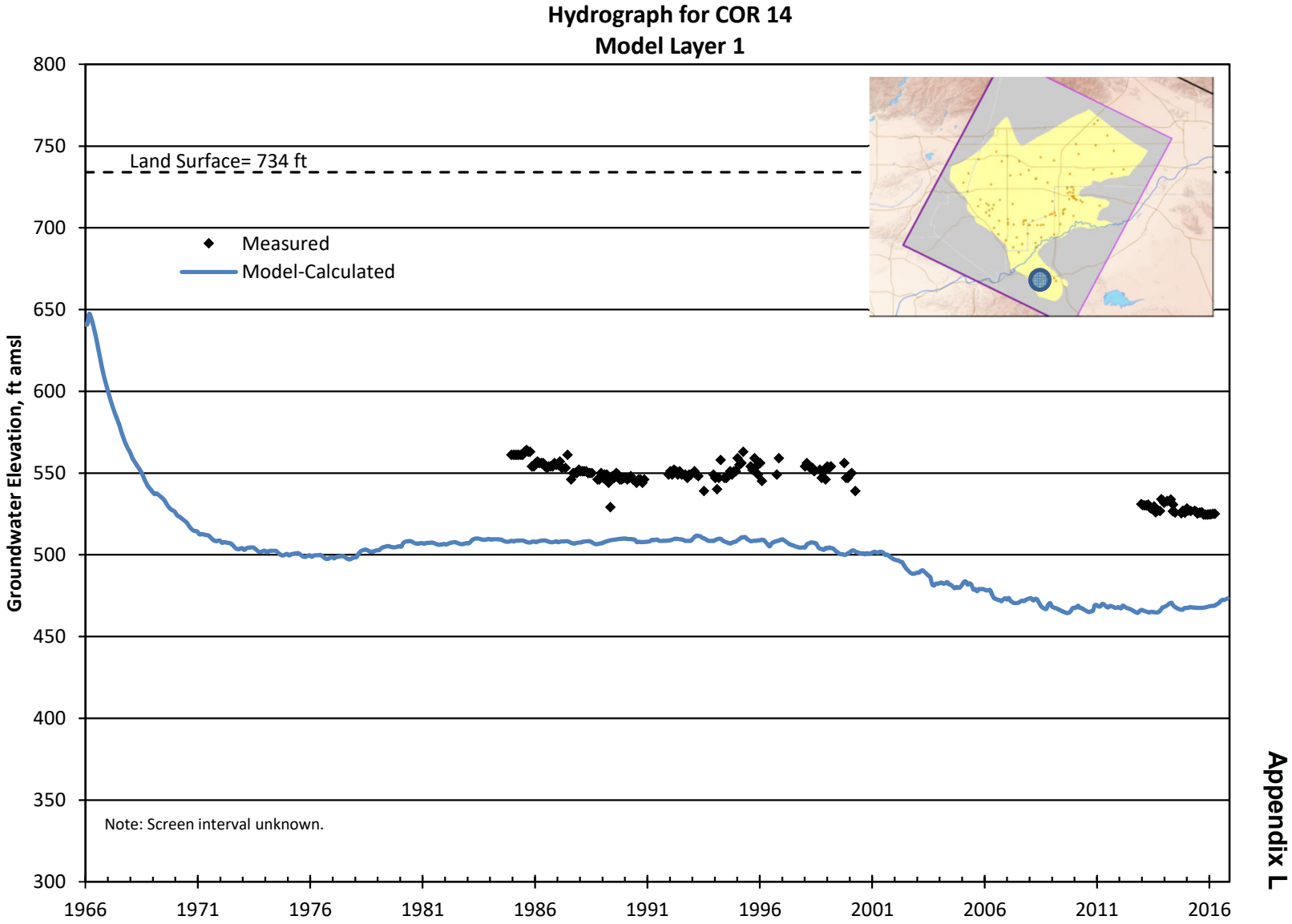
Appendix L


Hydrograph for COR 08
Model Layer 1
Measured
Land Surface= 663 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Water level was not calculated because well is located in a dry model cell.
Screen interval unknown.

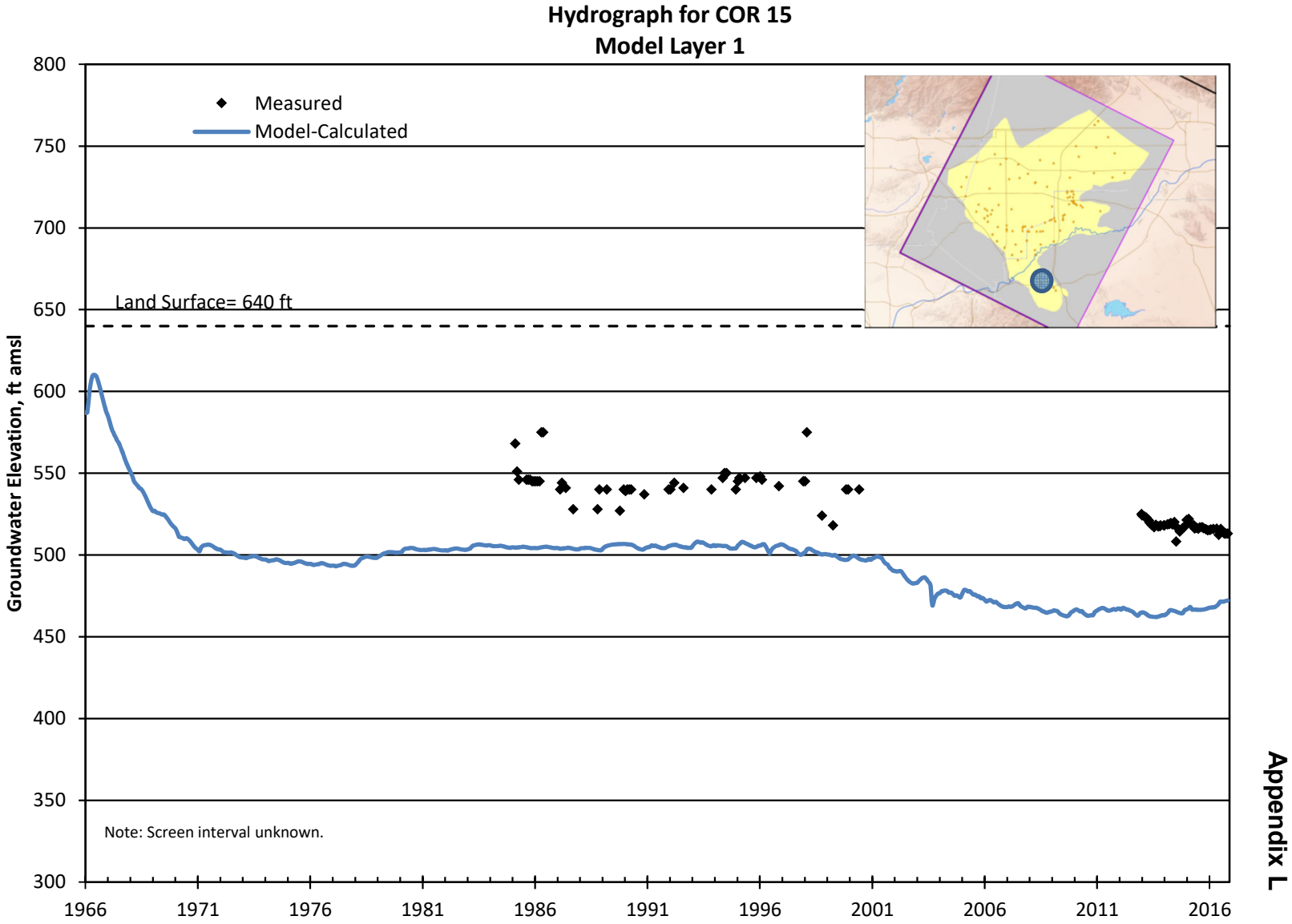
Appendix L


Hydrograph for COR 11
Model Layer 1
Measured
Model-Calculated
Land Surface= 650 ft
Groundwater Elevation, ft amsl
750
700
650
600
550
500
450
400
350
300
250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

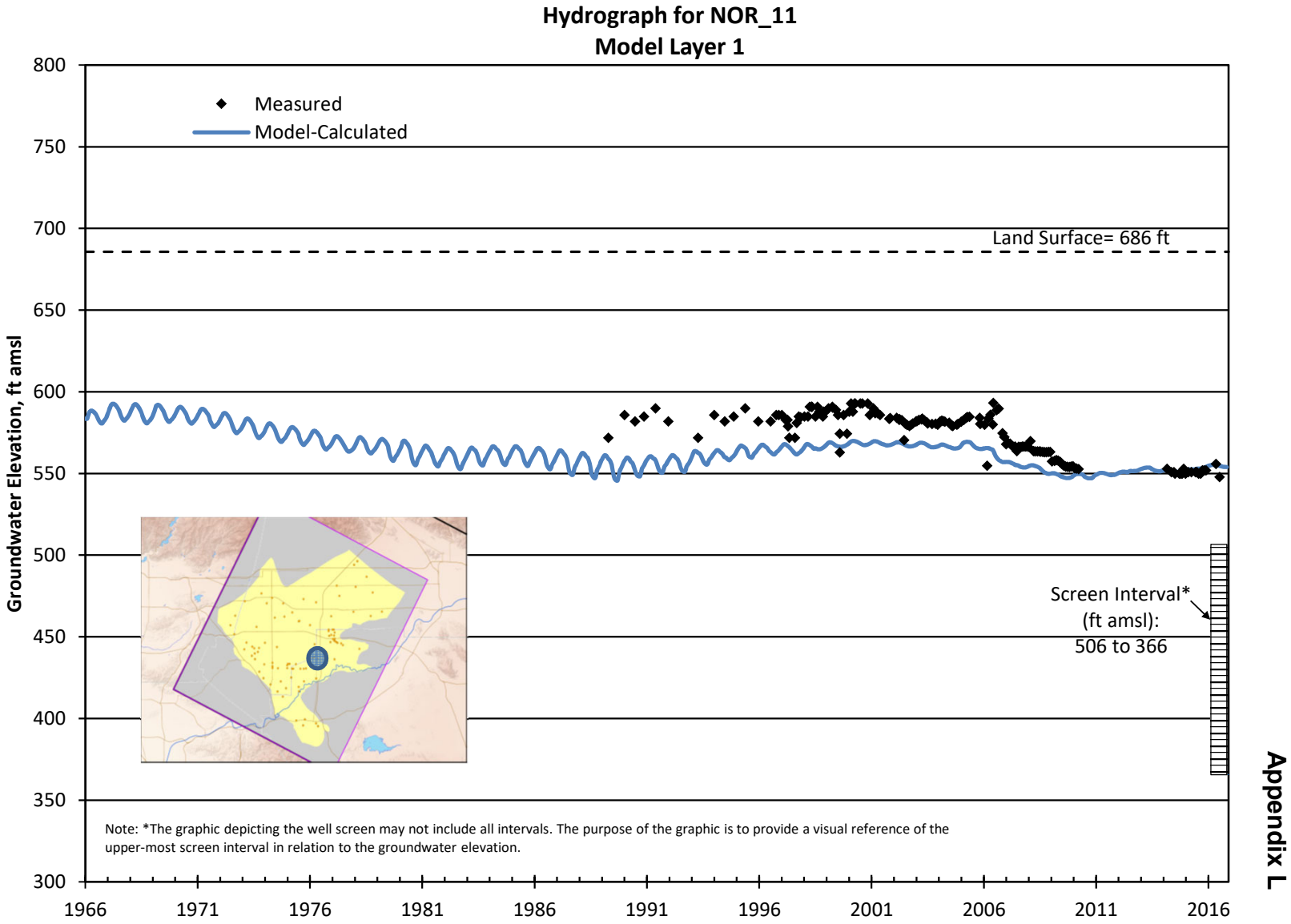
Appendix L


Hydrograph for COR 14
Model Layer 1
Land Surface= 734 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

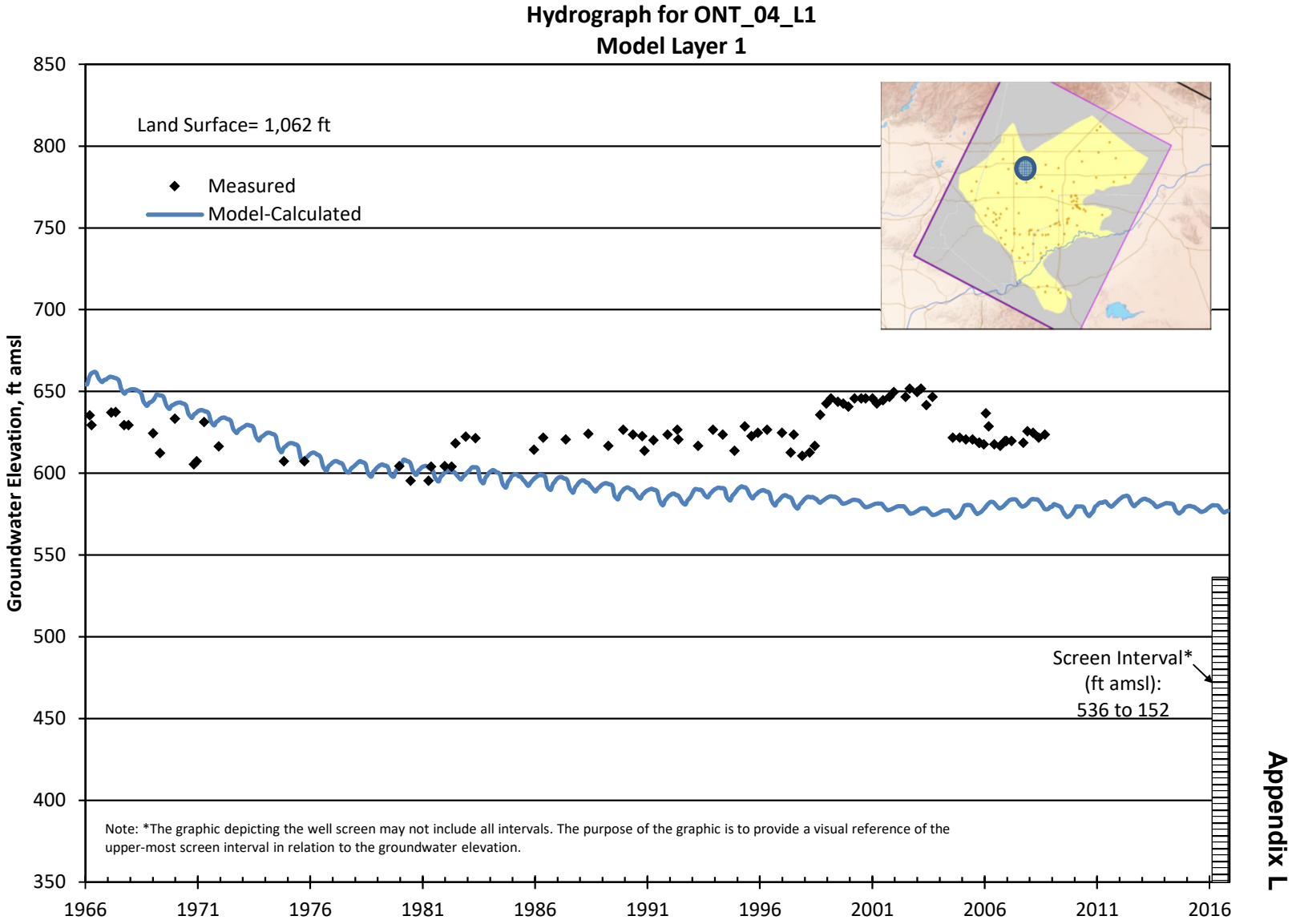
Appendix L


Hydrograph for COR 15
Model Layer 1
Measured
Model-Calculated
Land Surface= 640 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

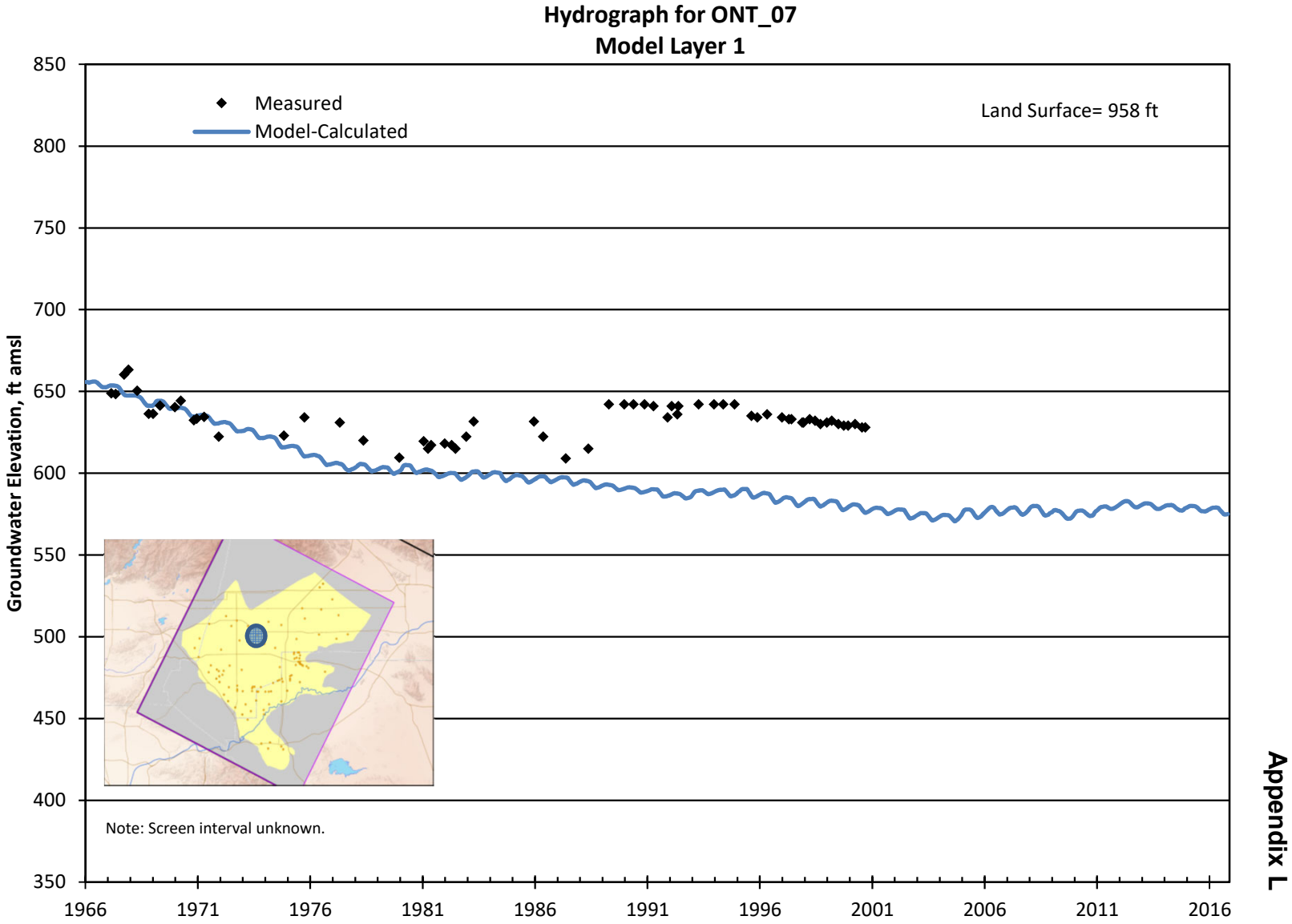
Appendix L


Hydrograph for NOR_11
Model Layer 1
Measured
Model-Calculated
Land Surface= 686 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
506 to 366
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

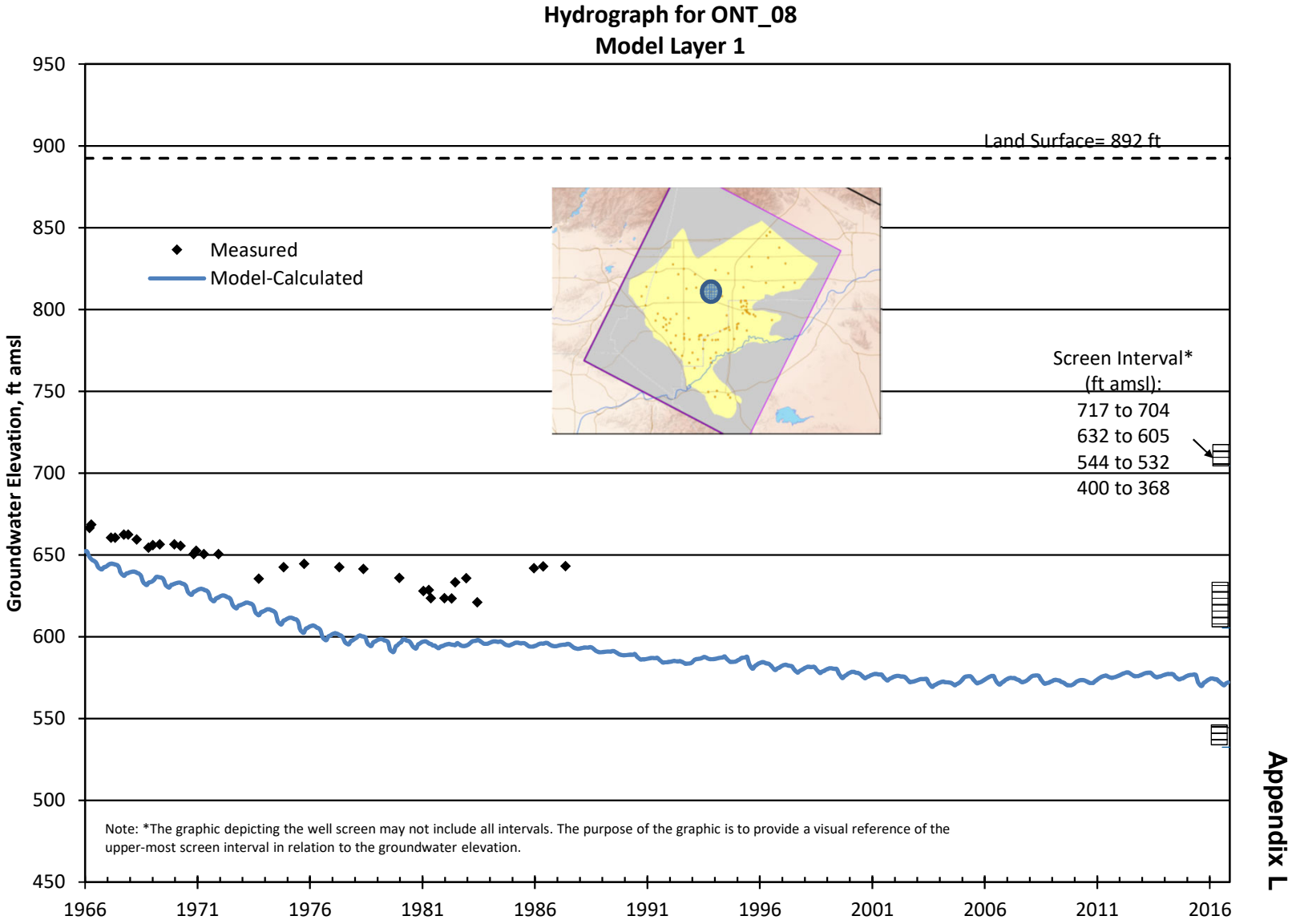
Appendix L


Hydrograph for ONT_04_L1
Model Layer 1
Land Surface= 1,062 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
536 to 152
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

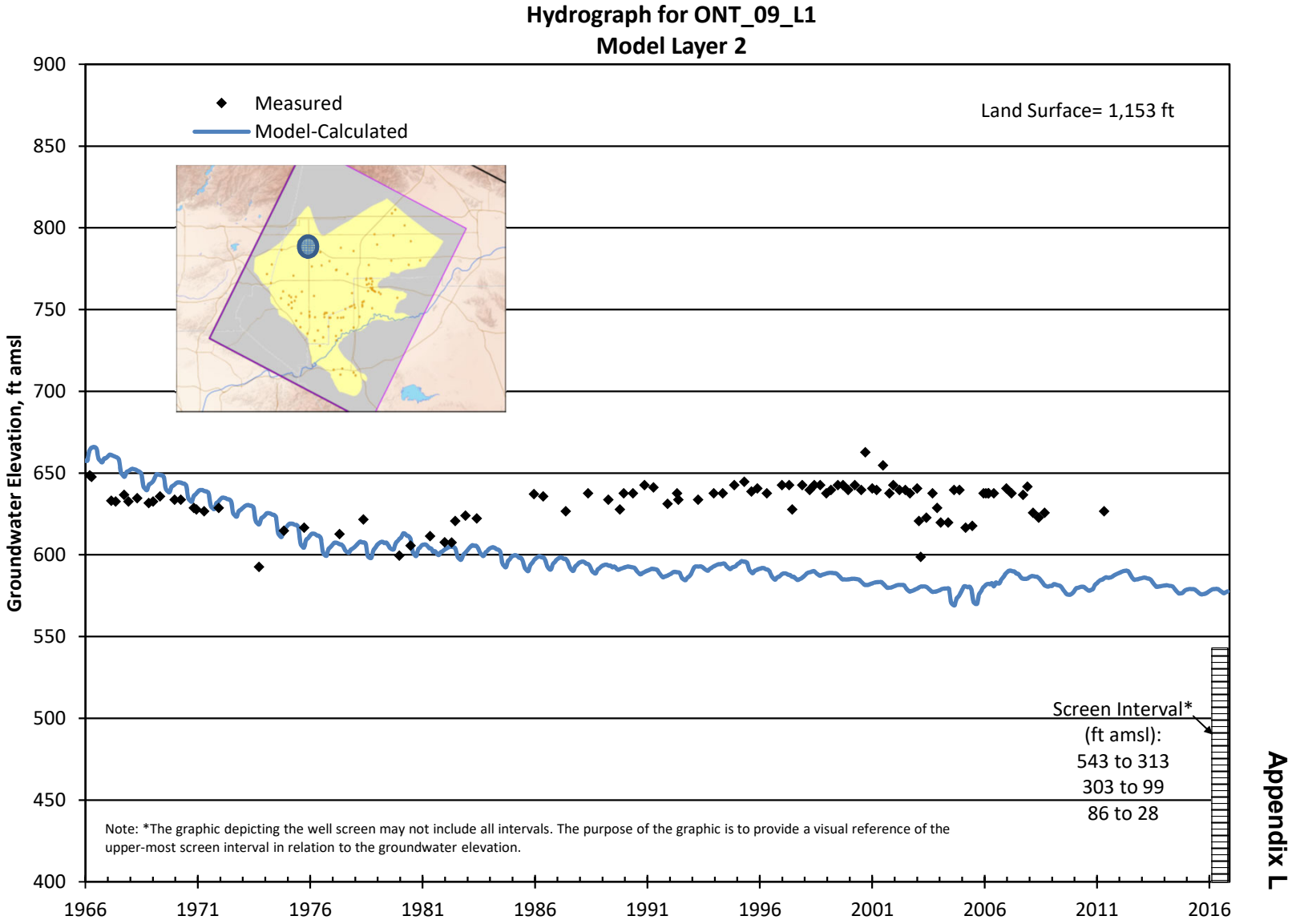
Appendix L


Hydrograph for ONT_07
Model Layer 1
Measured
Model-Calculated
Land Surface= 958 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

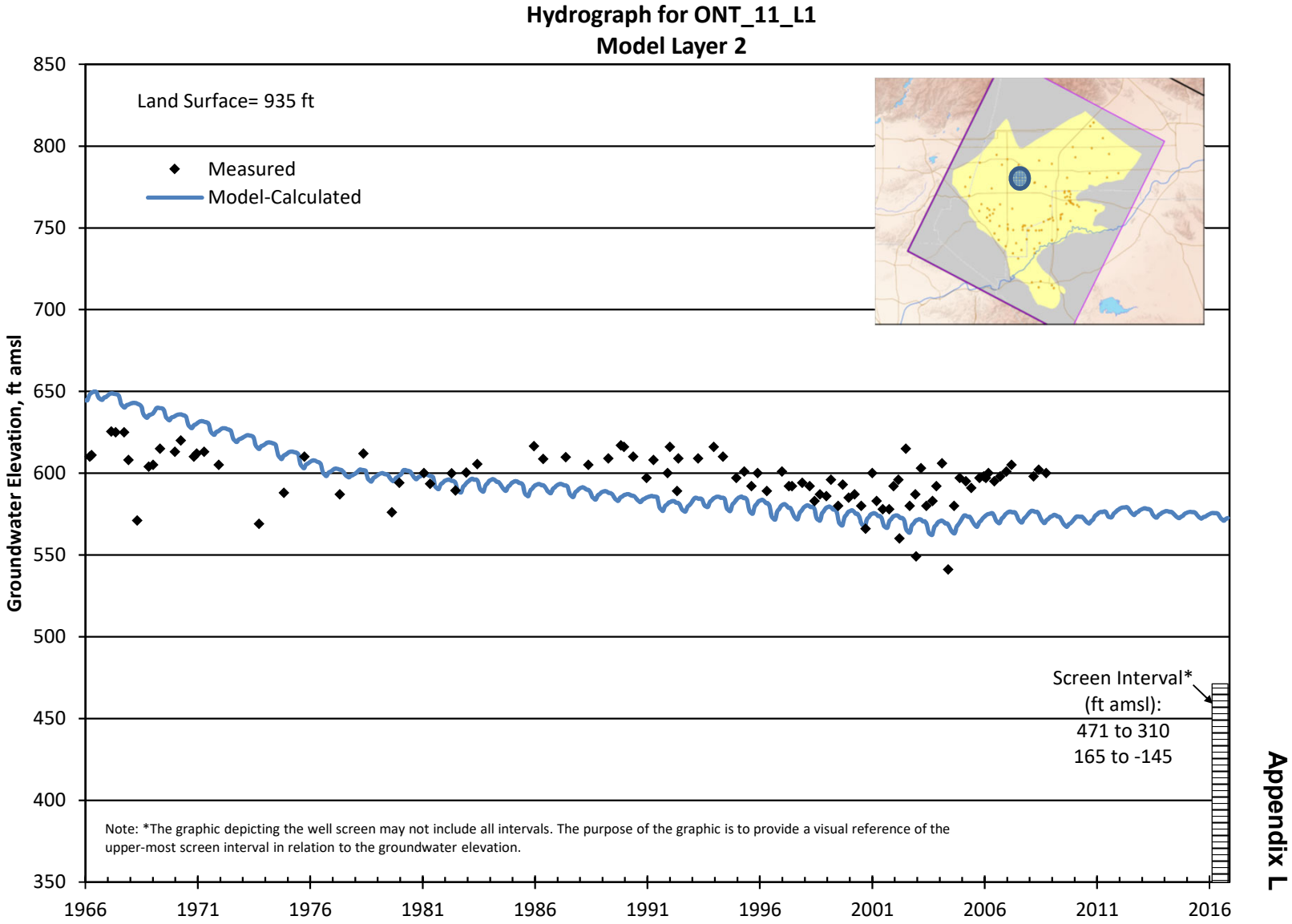
Appendix L


Hydrograph for ONT_08
Model Layer 1
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 892 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
717 to 704
632 to 605
544 to 532
400 to 368
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

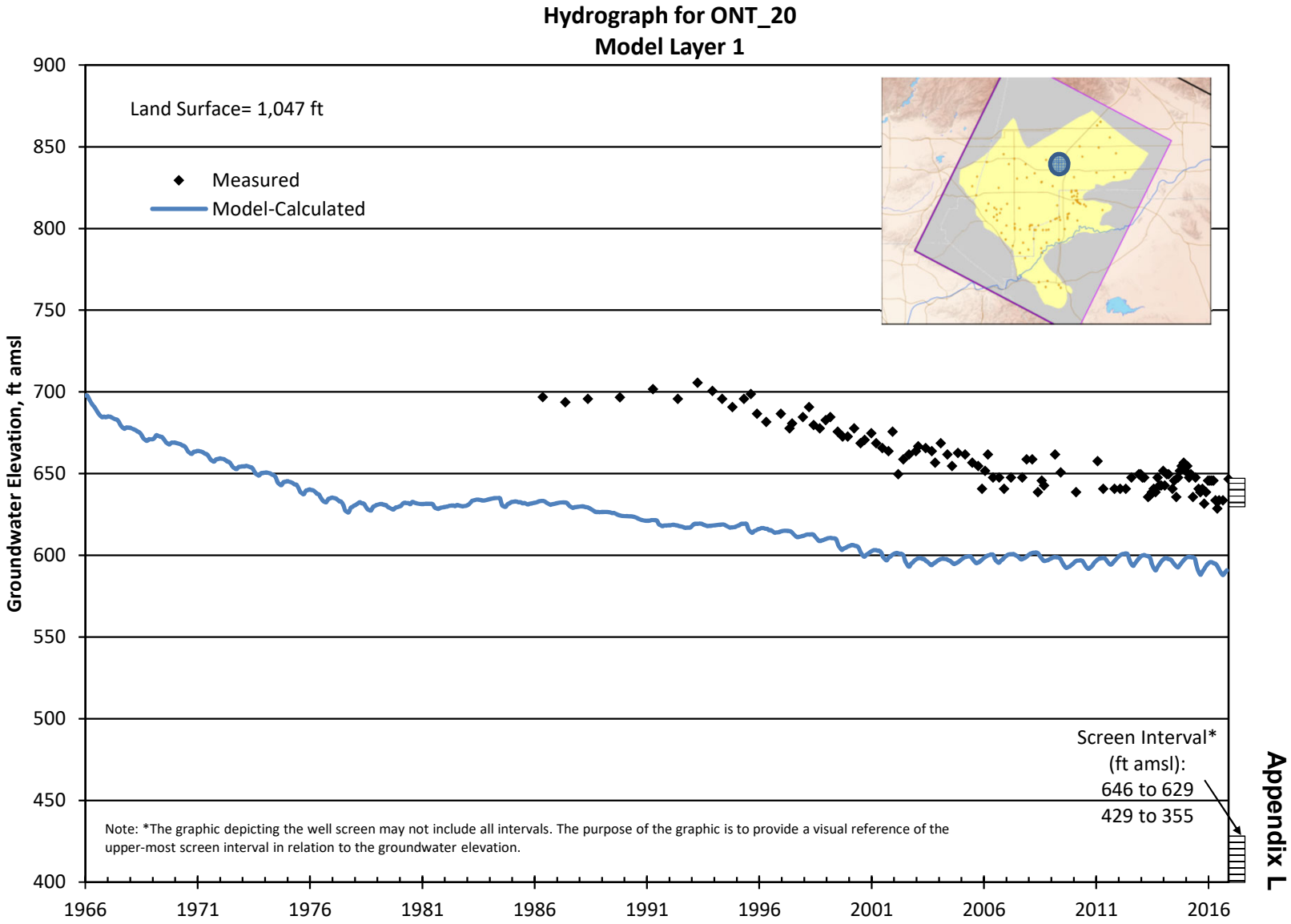
Appendix L


Hydrograph for ONT_09_L1
Model Layer 2
Measured
Model-Calculated
Land Surface= 1,153 ft
Groundwater Elevation, ft amsl
900
850
800
750
700
650
600
550
500
450
400
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
543 to 313
303 to 99
86 to 28
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

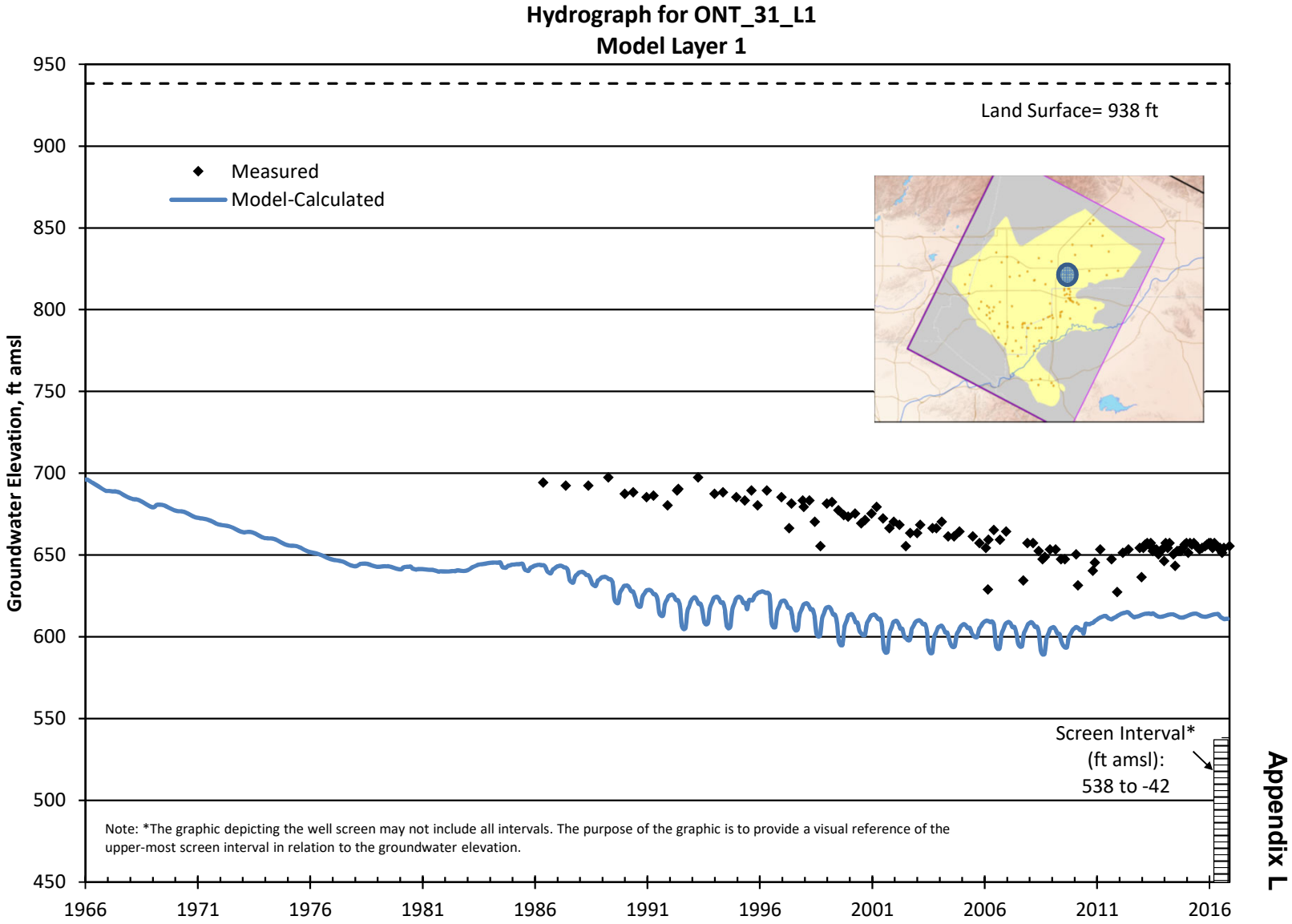
Appendix L


Hydrograph for ONT_11_L1
Model Layer 2
Land Surface= 935 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
471 to 310
165 to -145
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

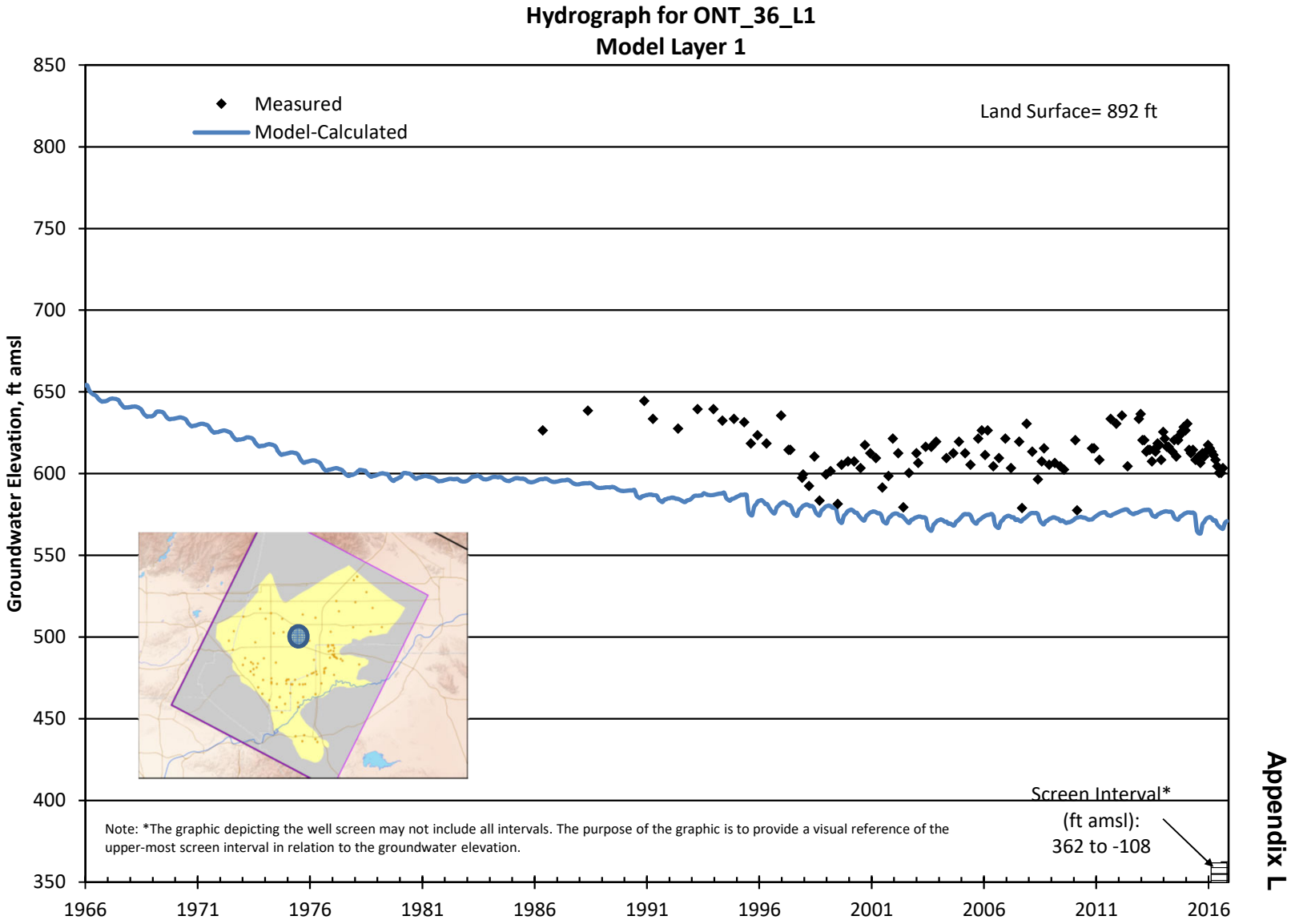
Appendix L


Hydrograph for ONT_20
Model Layer 1
Land Surface= 1,047 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
900
850
800
750
700
650
600
550
500
450
400
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
646 to 629
429 to 355
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

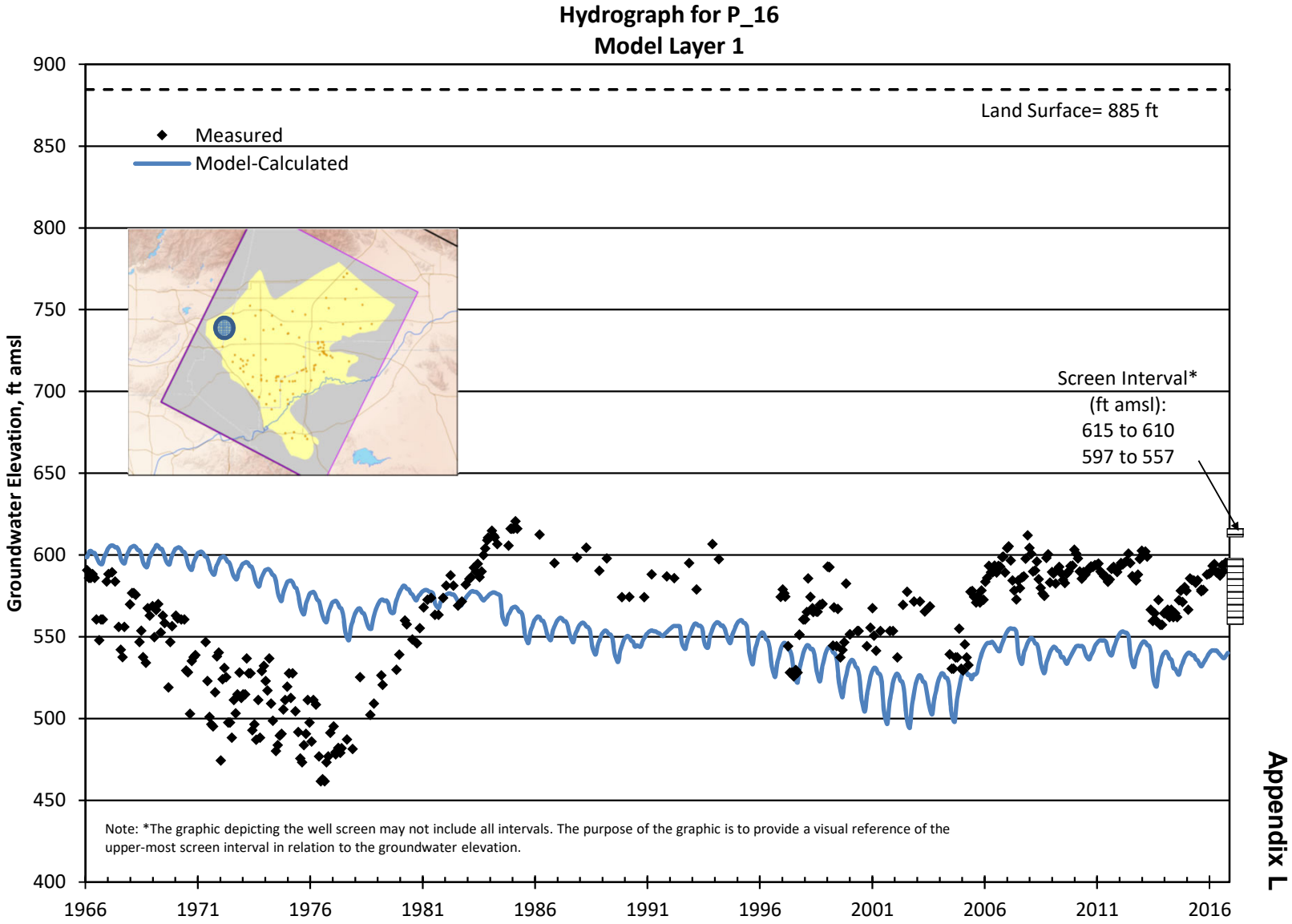
Appendix L


Hydrograph for ONT_31_L1
Model Layer 1
Land Surface= 938 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
538 to -42
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

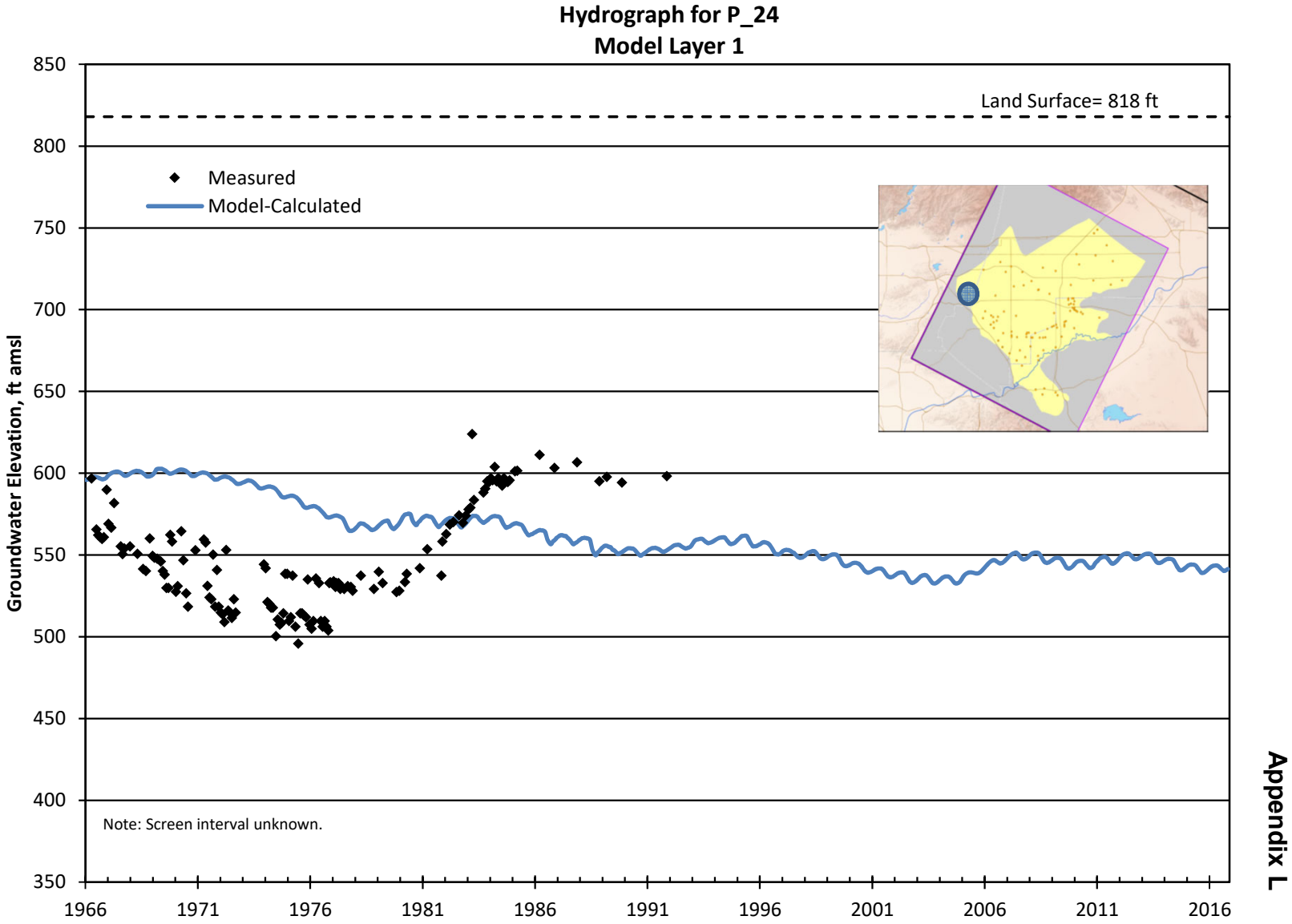
Appendix L


Hydrograph for ONT_36_L1
Model Layer 1
Measured
Model-Calculated
Land Surface= 892 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Screen Interval*
(ft amsl):
362 to -108

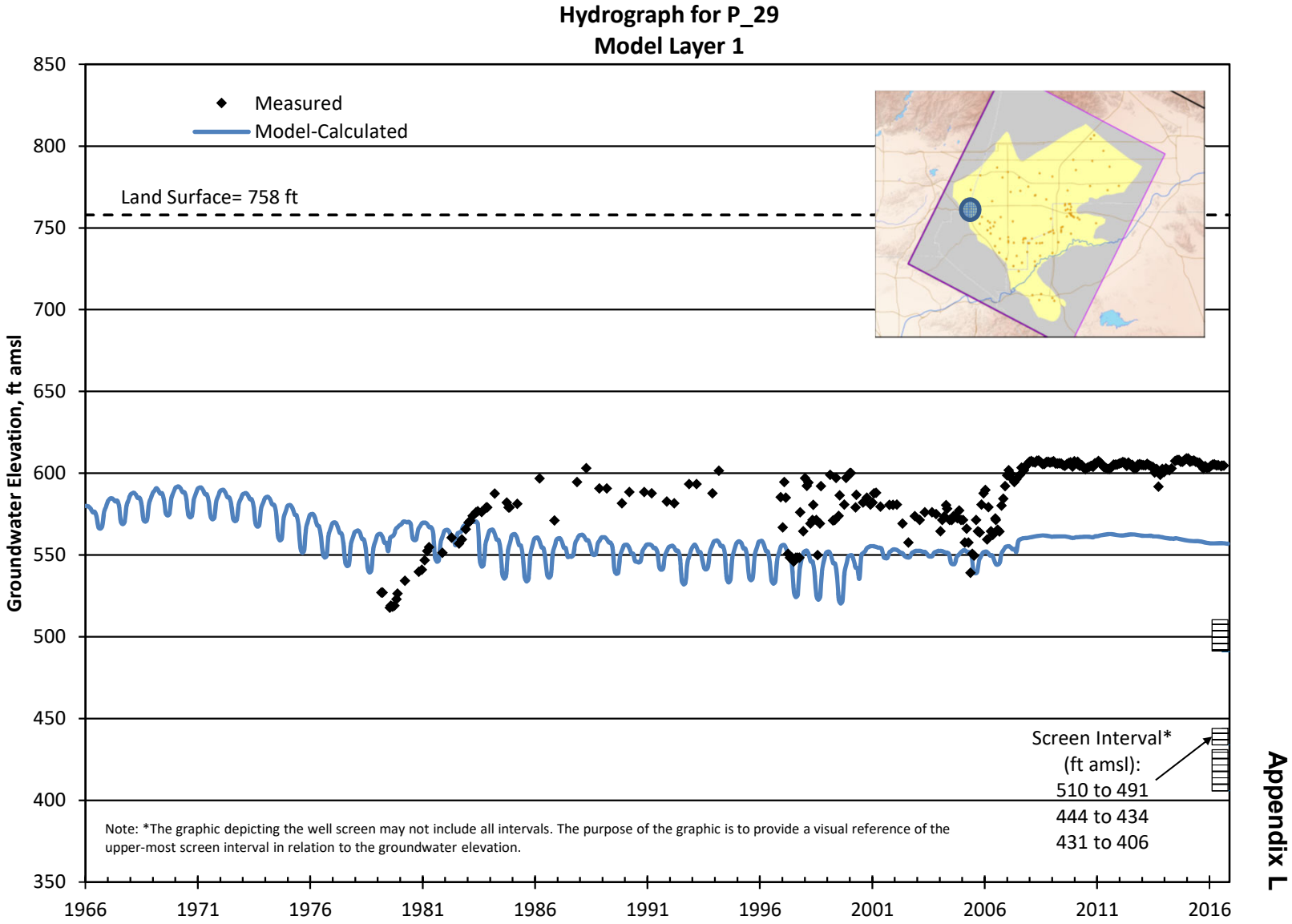
Appendix L


Hydrograph for P_16
Model Layer 1
Groundwater Elevation, ft amsl
900
850
800
750
700
650
600
550
500
450
400
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 885 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
615 to 610
597 to 557
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

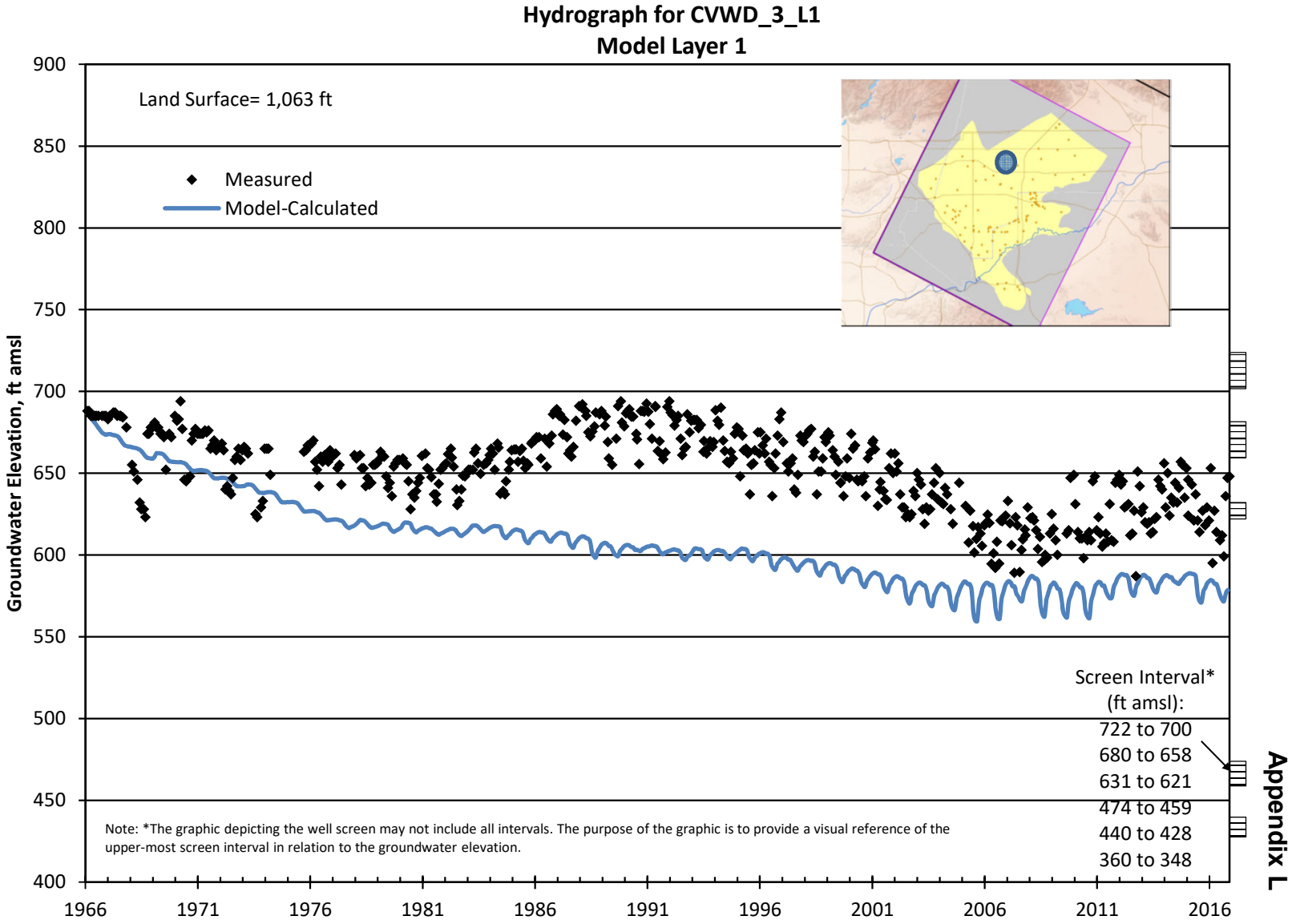
Appendix L

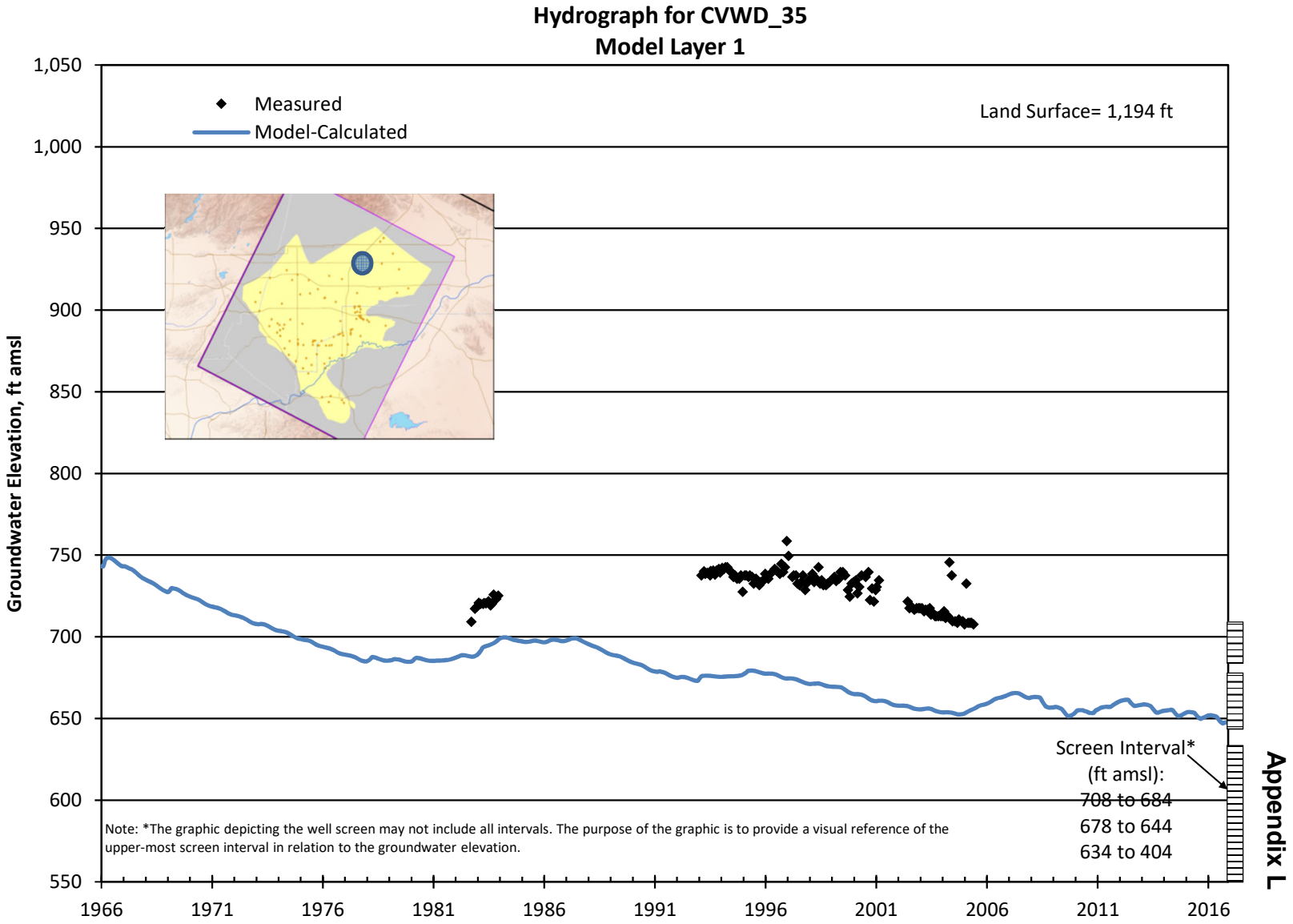

Hydrograph for P_24
Model Layer 1
Land Surface= 818 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

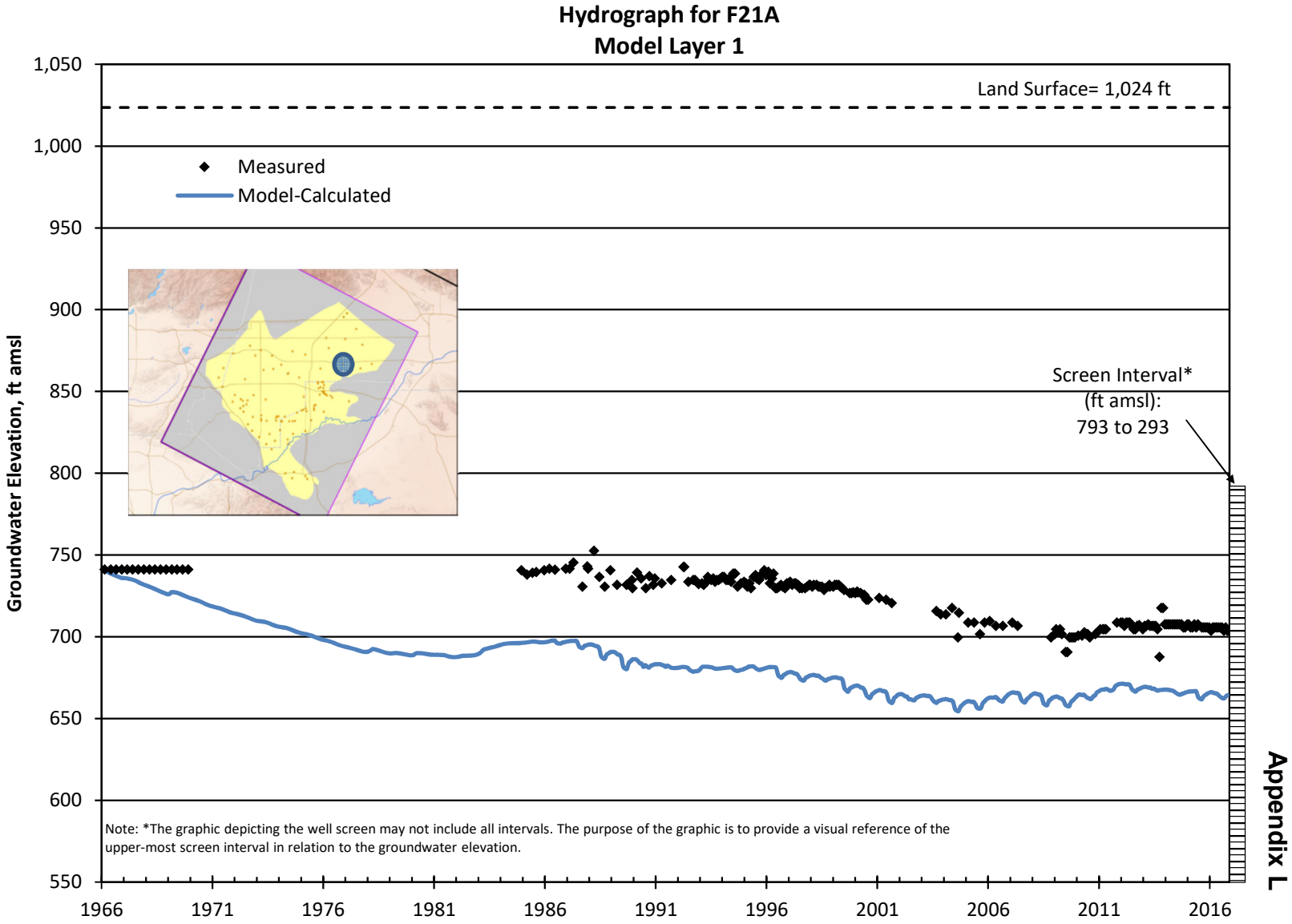
Appendix L


Hydrograph for P_29
Model Layer 1
Measured
Model-Calculated
Land Surface= 758 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
510 to 491
444 to 434
431 to 406
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

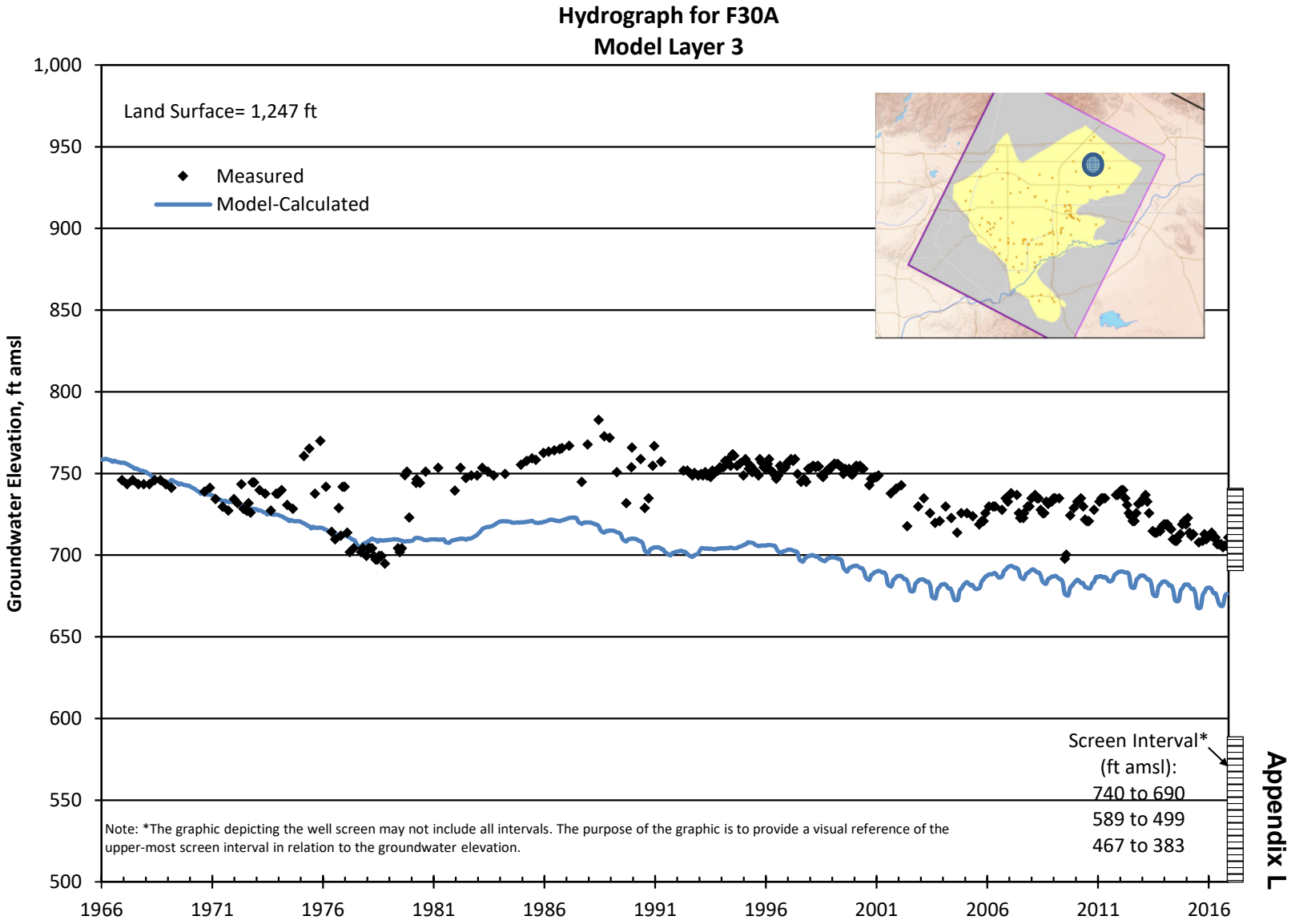
Appendix L


Hydrograph for CVWD_3_L1
Model Layer 1
Land Surface= 1,063 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
900
850
800
750
700
650
600
550
500
450
400
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
722 to 700
680 to 658
631 to 621
474 to 459
440 to 428
360 to 348
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Appendix L

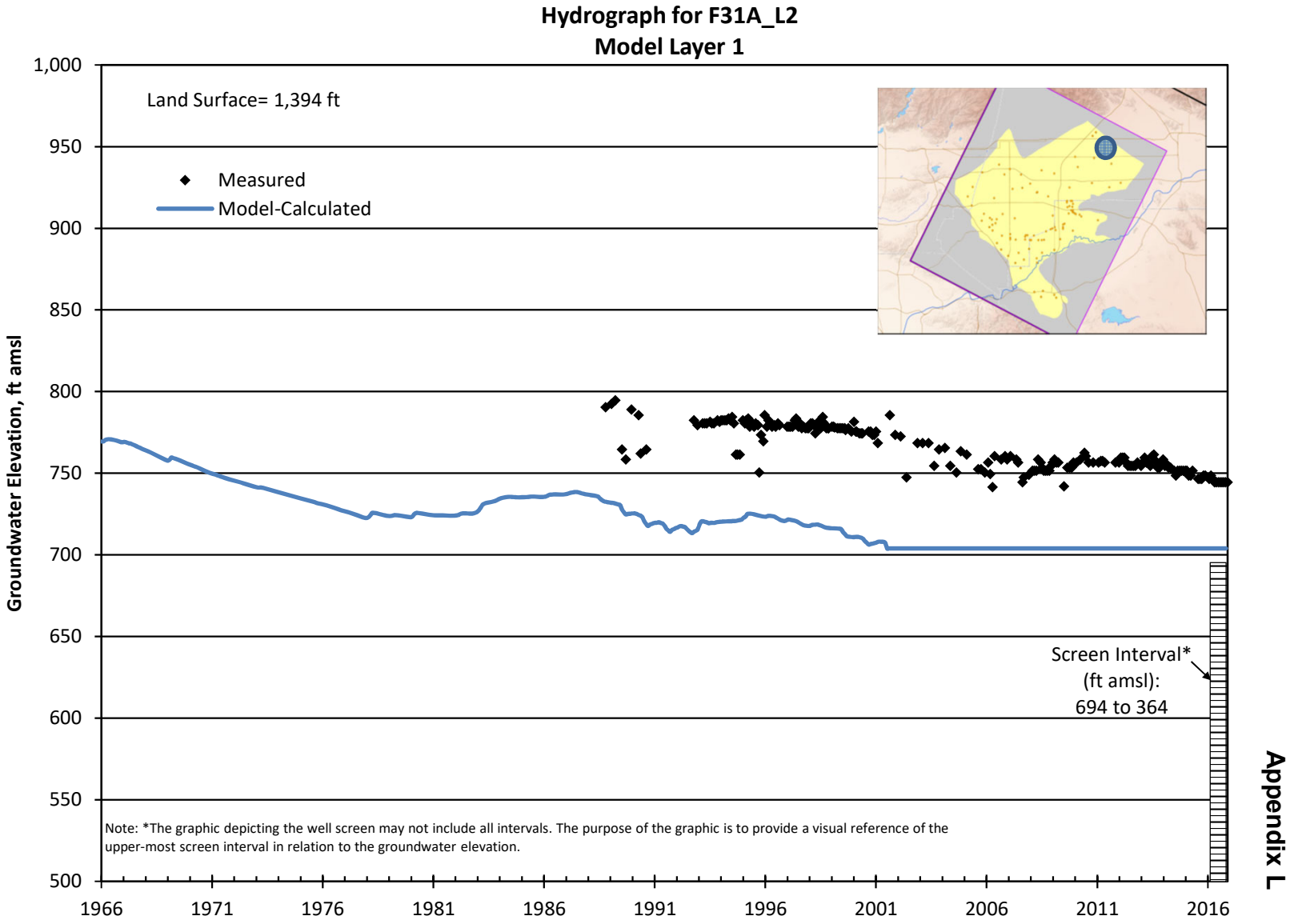

Hydrograph for CVWD_35
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,194 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
708 to 684
678 to 644
634 to 404
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Appendix L


Hydrograph for F21A
Model Layer 1
Land Surface= 1,024 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
793 to 293
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

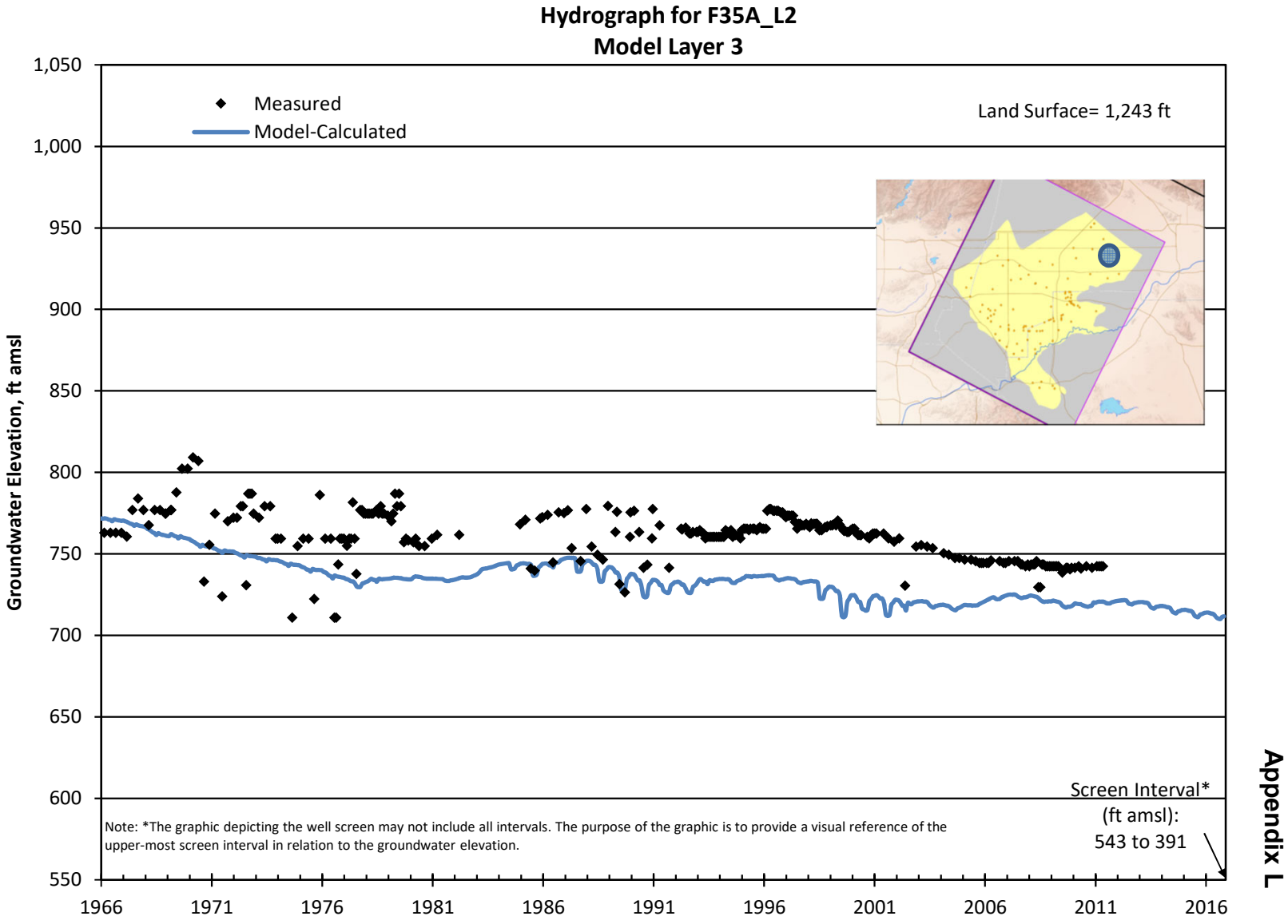
Appendix L


Hydrograph for F30A
Model Layer 3
Land Surface= 1,247 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
740 to 690
589 to 499
467 to 383
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

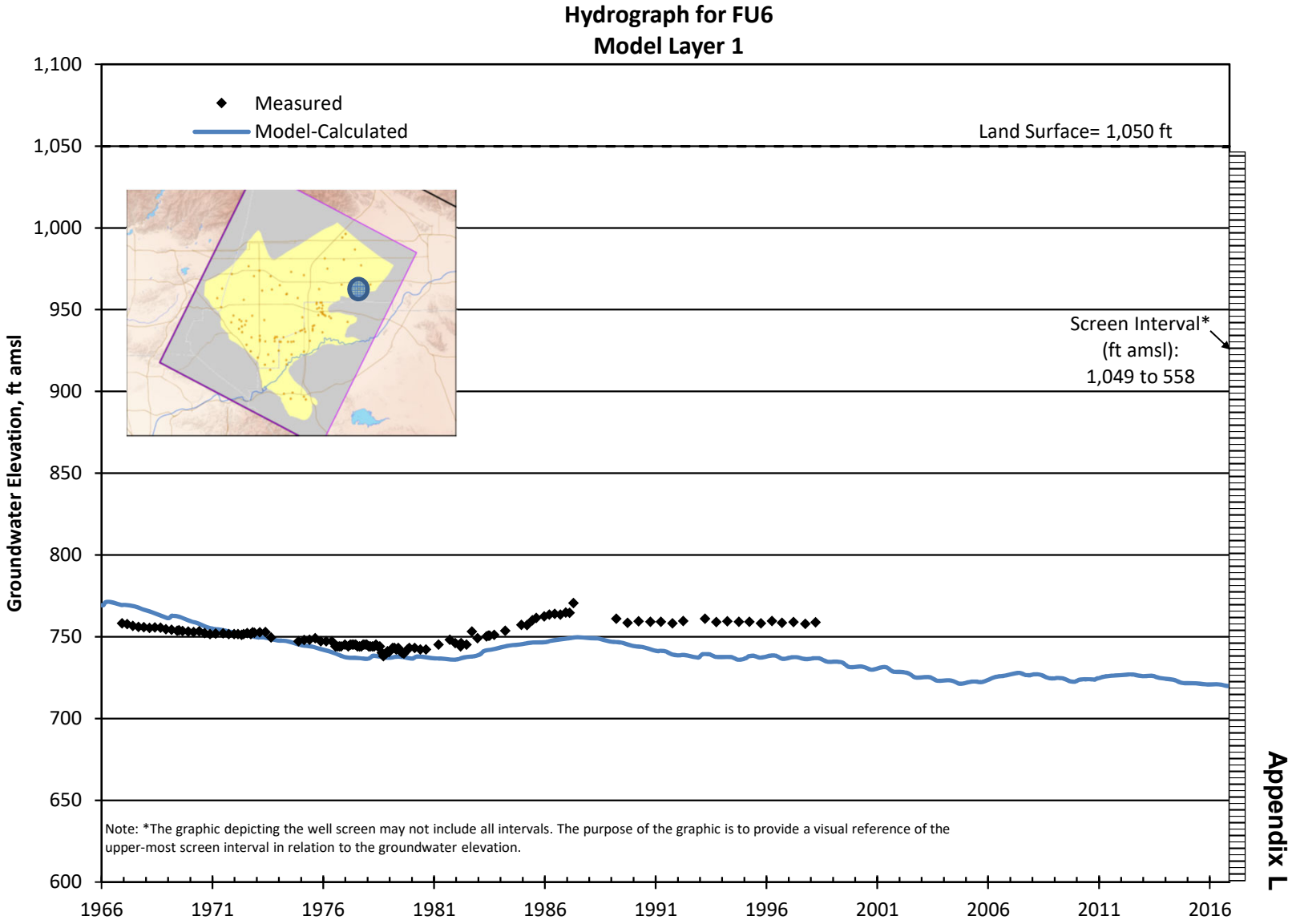
Appendix L


Hydrograph for F31A_L2
Model Layer 1
Land Surface= 1,394 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
694 to 364
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

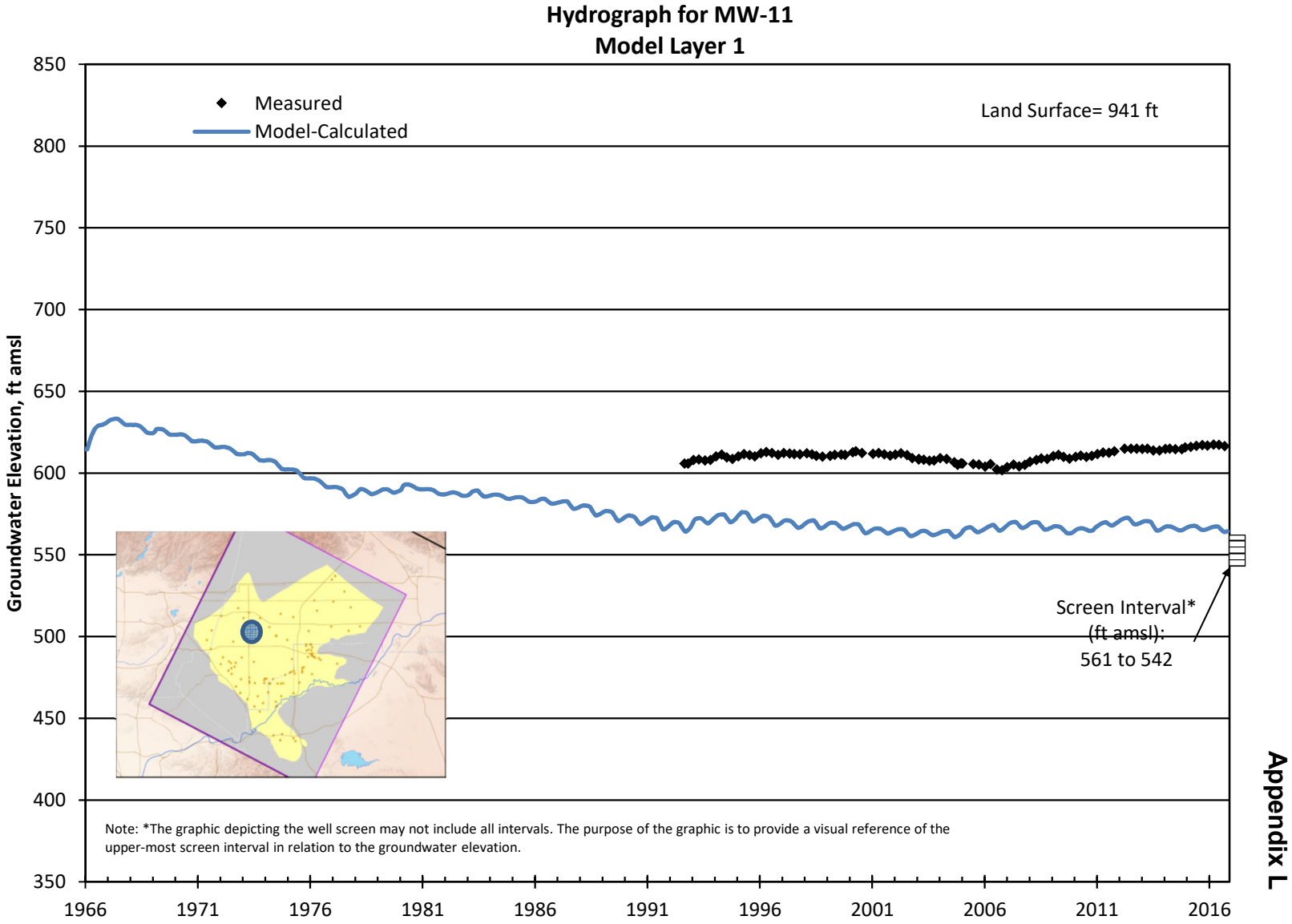
Appendix L


Hydrograph for F35A_L2
Model Layer 3
Measured
Model-Calculated
Land Surface= 1,243 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Screen Interval*
(ft amsl):
543 to 391

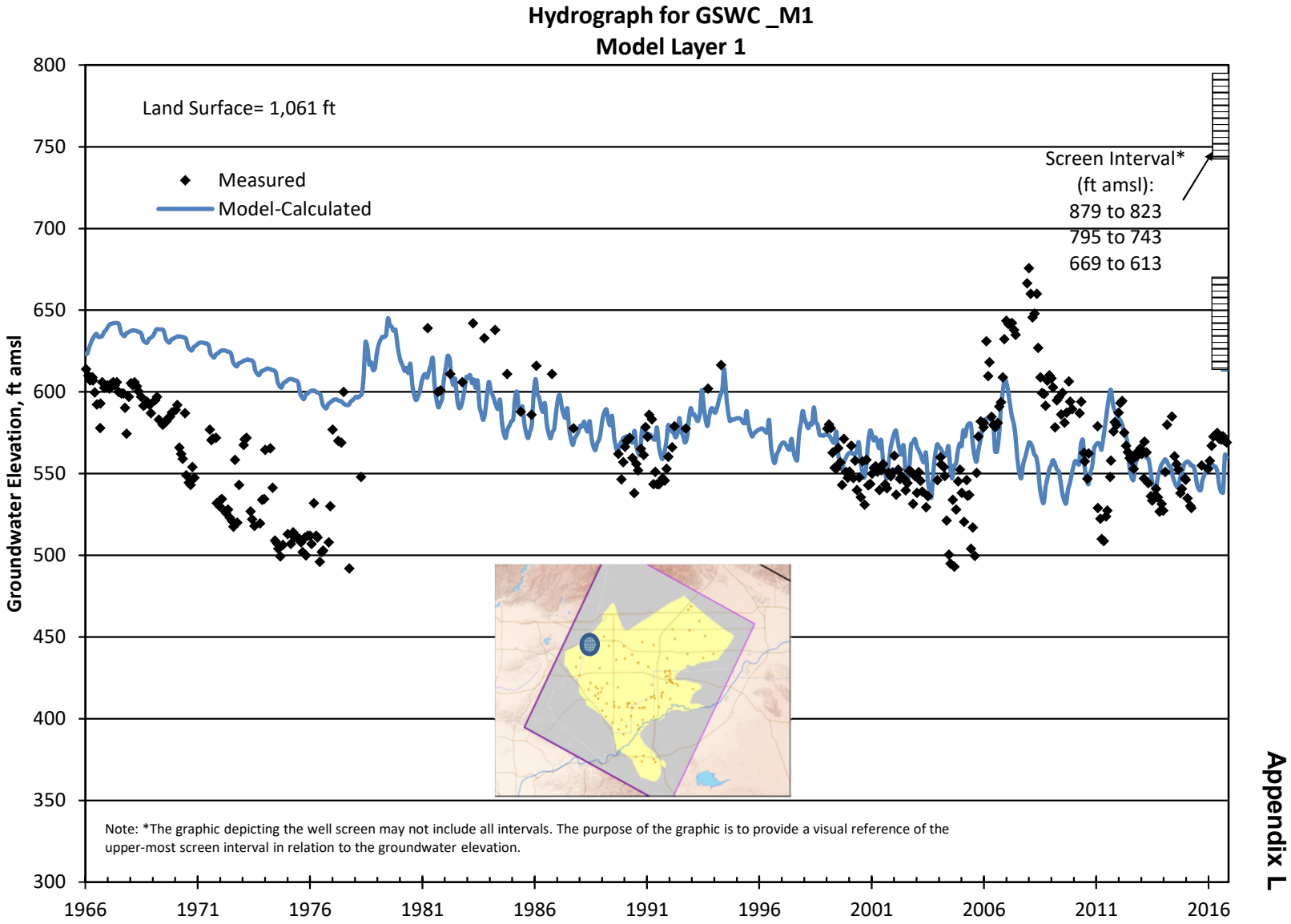
Appendix L


Hydrograph for FU6
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,050 ft
Screen Interval*
(ft amsl):
1,049 to 558
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

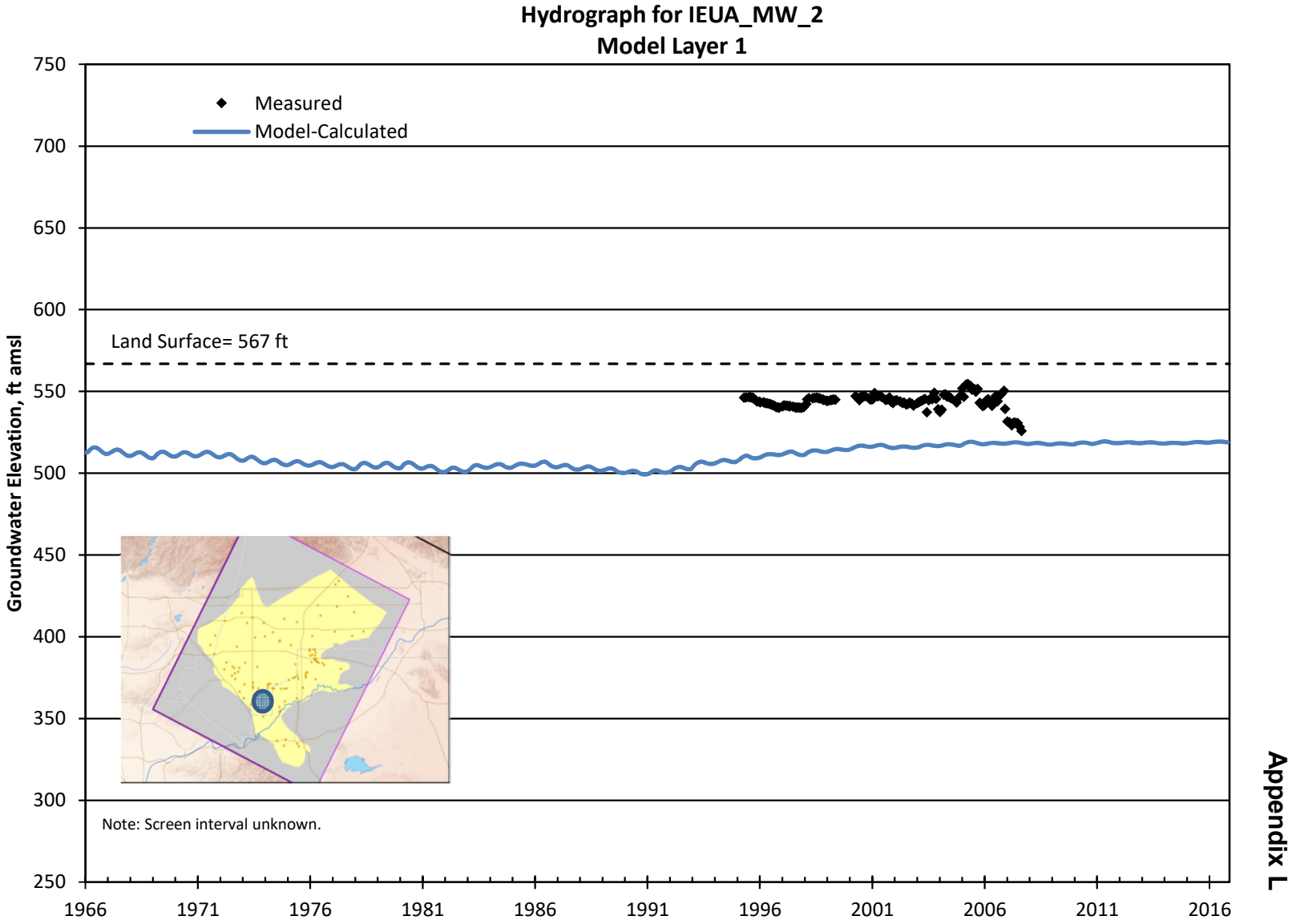
Appendix L


Hydrograph for MW-11
Model Layer 1
Measured
Model-Calculated
Land Surface= 941 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
561 to 542
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

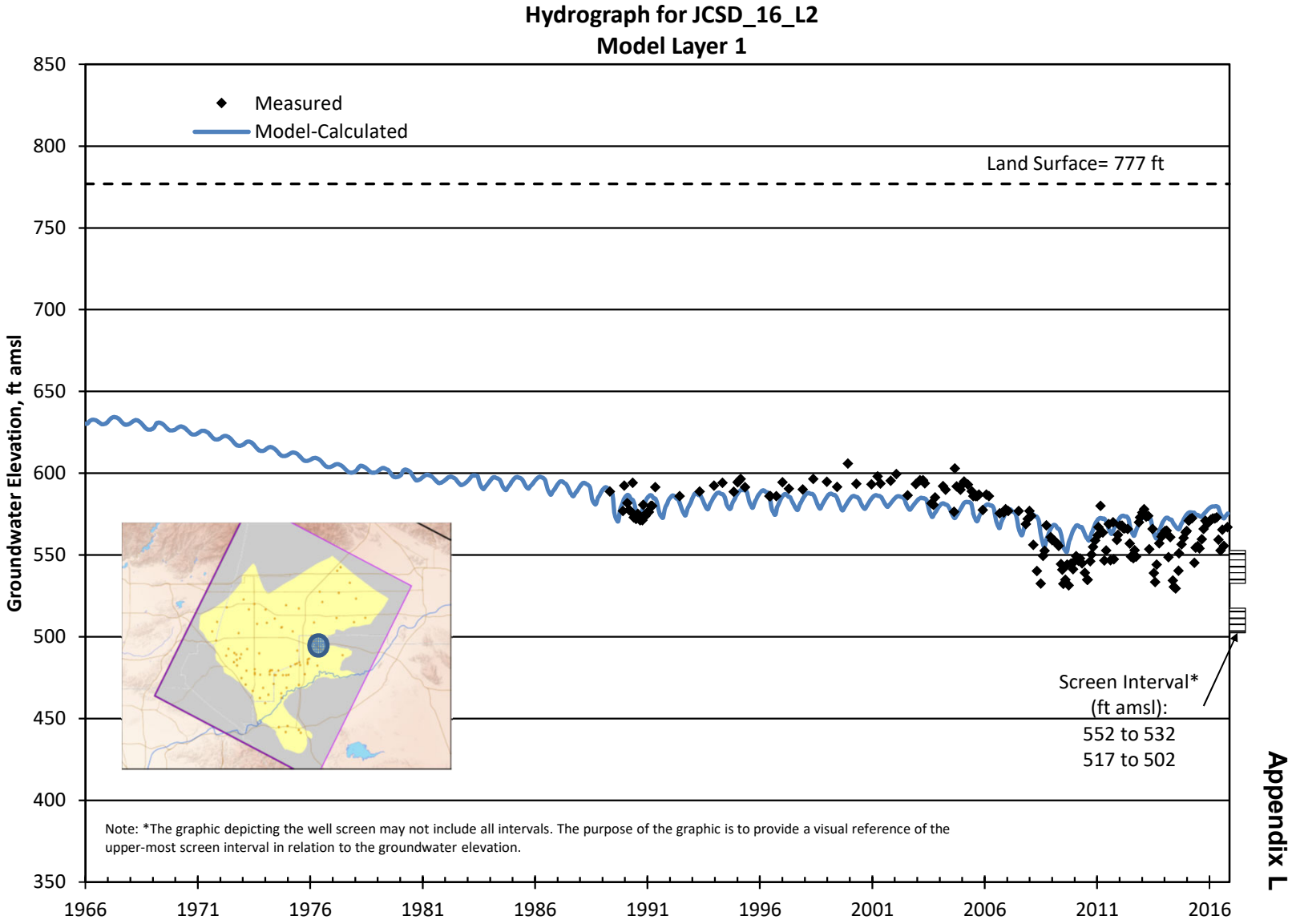
Appendix L


Hydrograph for GSWC _M1
Model Layer 1
Land Surface= 1,061 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
879 to 823
795 to 743
669 to 613
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

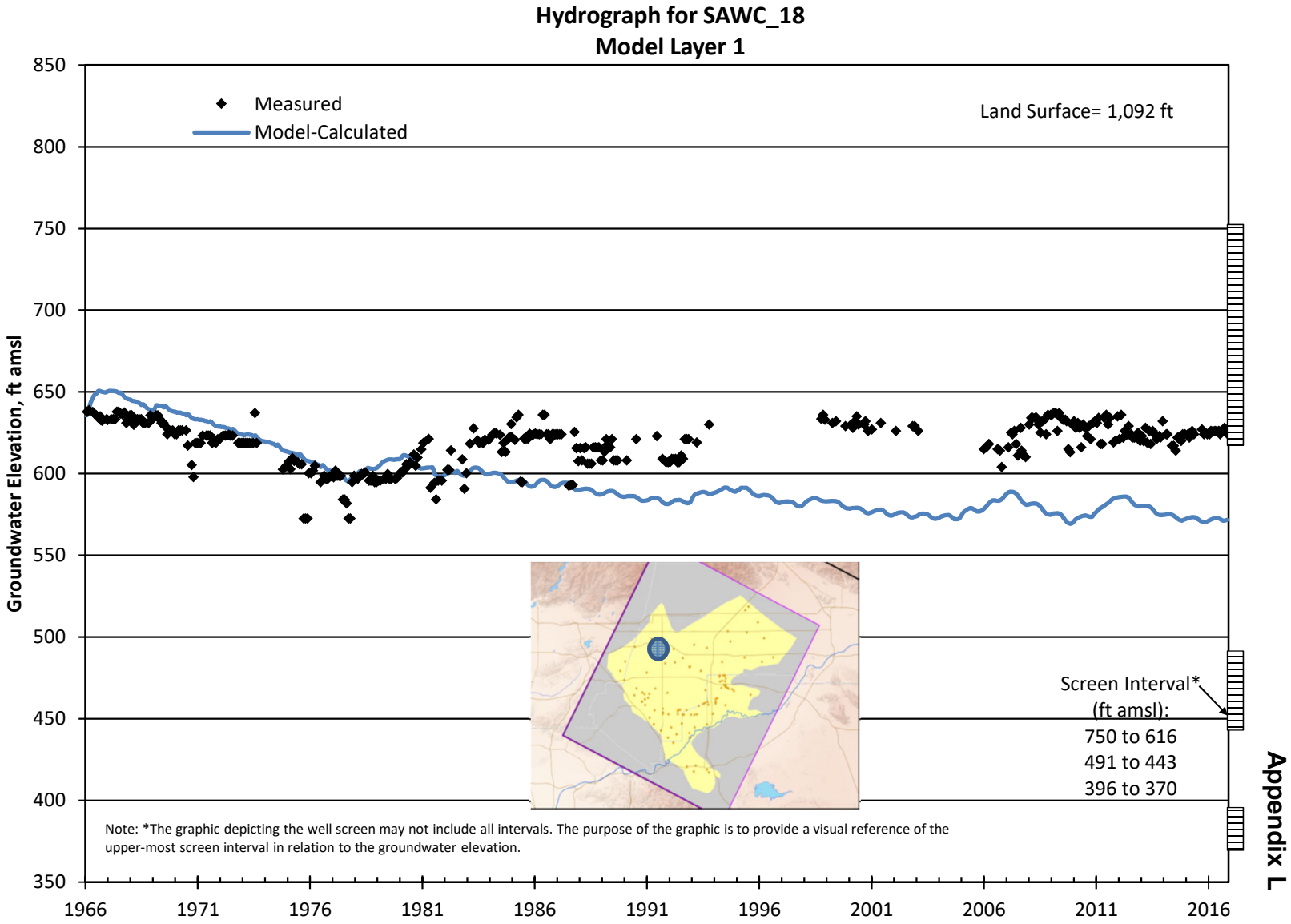
Appendix L


Hydrograph for IEUA_MW_2
Model Layer 1
Measured
Model-Calculated
Land Surface= 567 ft
Groundwater Elevation, ft amsl
750
700
650
600
550
500
450
400
350
300
250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

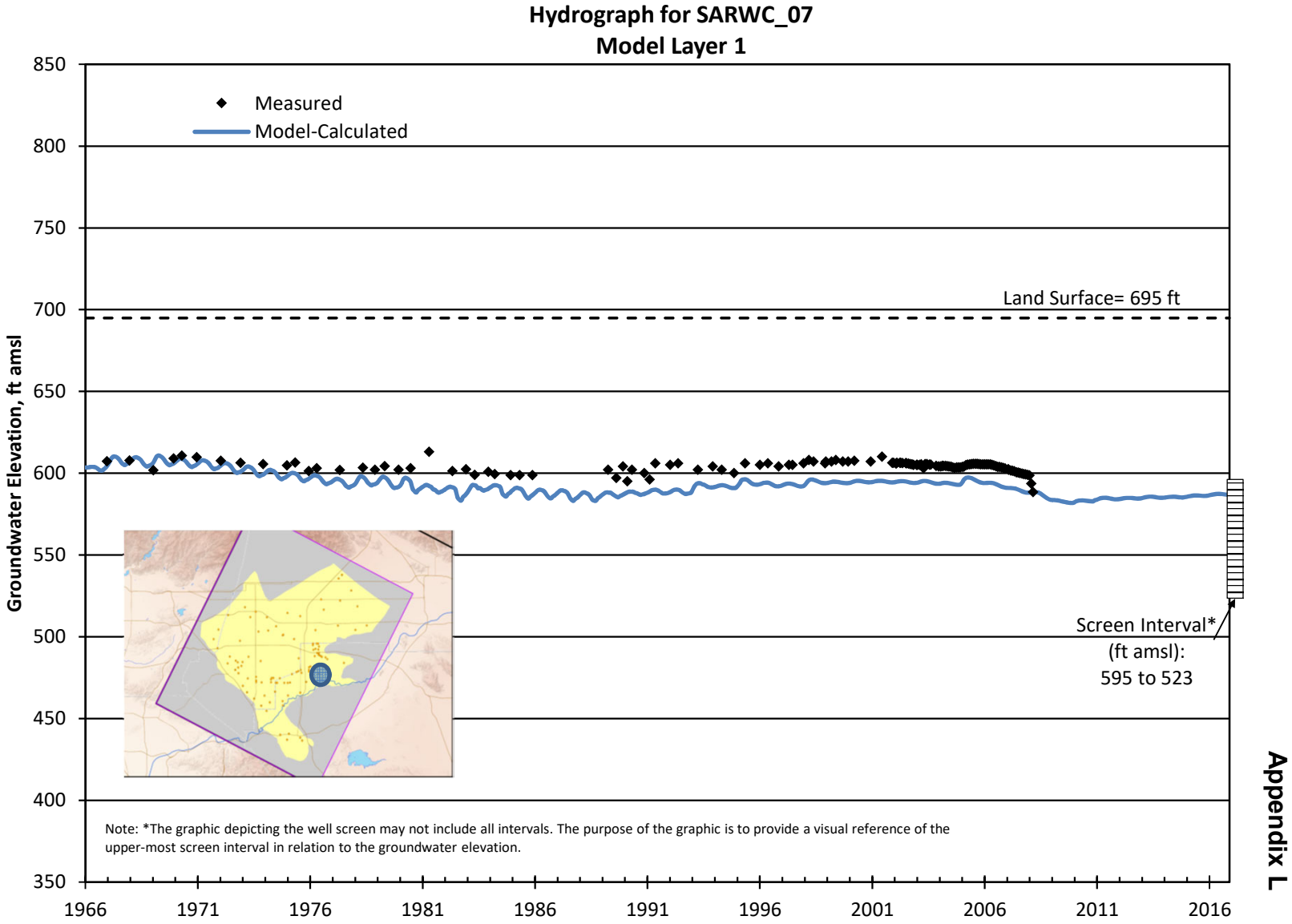
Appendix L


Hydrograph for JCSD_16_L2
Model Layer 1
Measured
Model-Calculated
Land Surface= 777 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
552 to 532
517 to 502
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

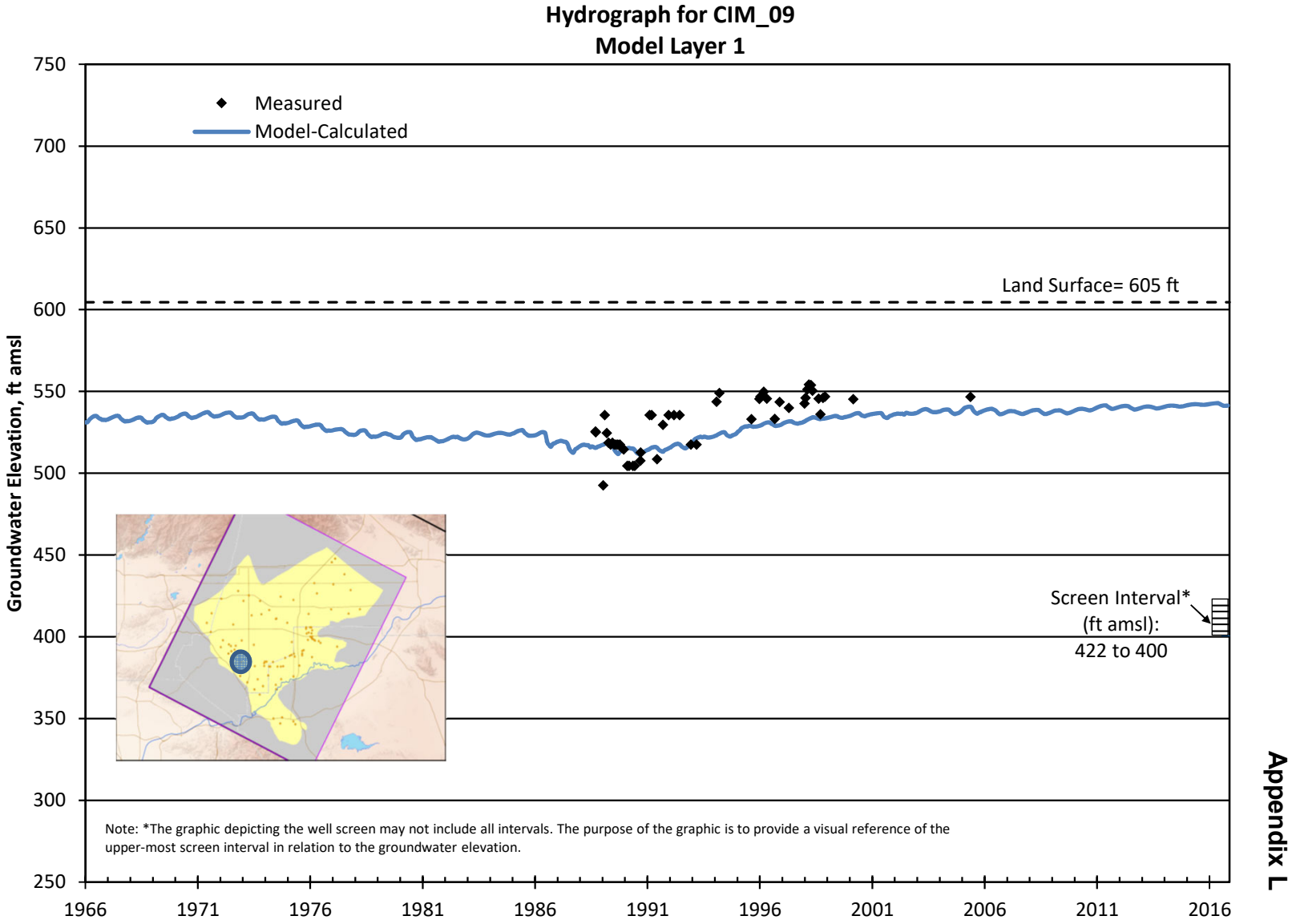
Appendix L


Hydrograph for SAWC_18
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,092 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
750 to 616
491 to 443
396 to 370
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

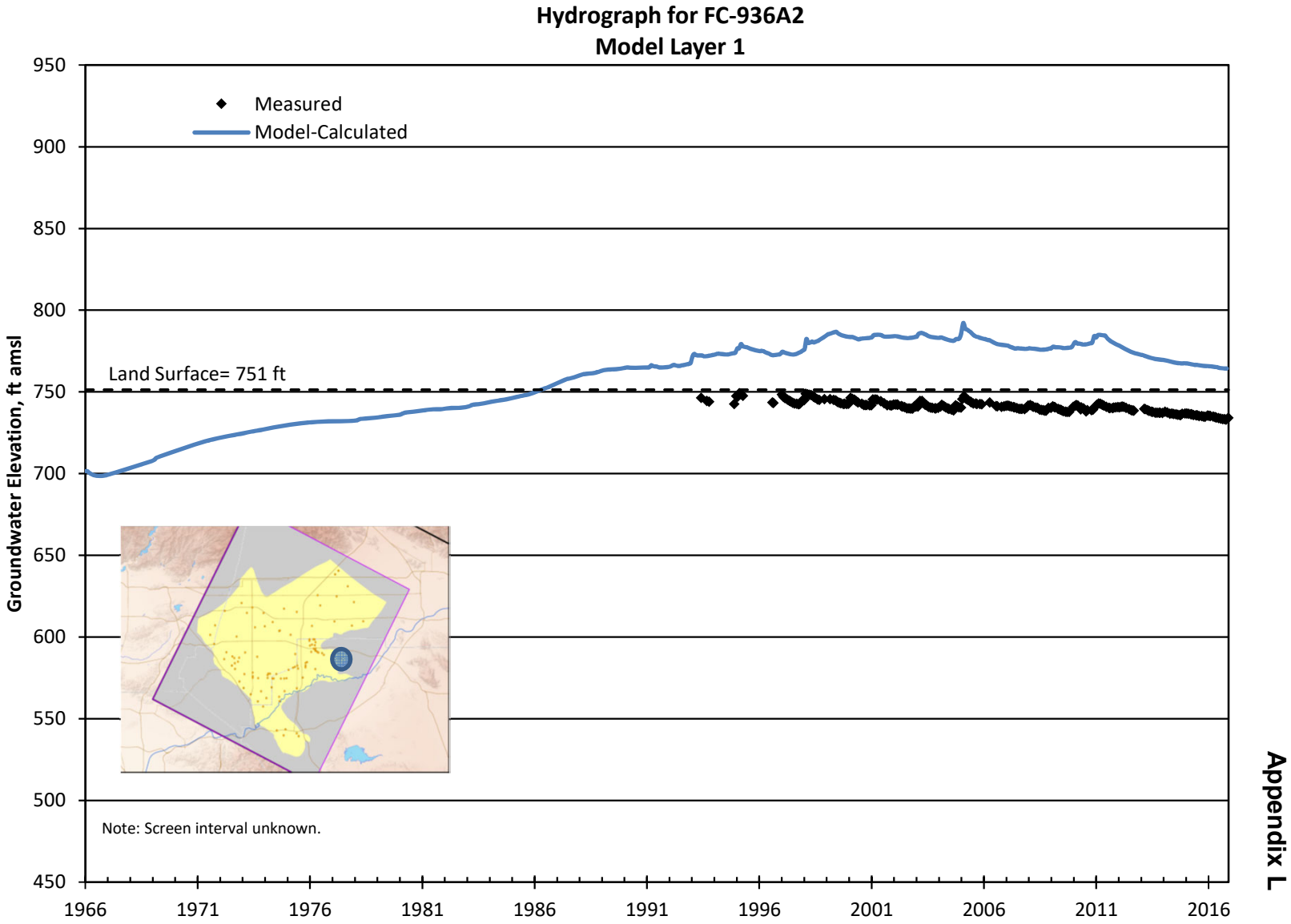
Appendix L


Hydrograph for SARWC_07
Model Layer 1
Measured
Model-Calculated
Land Surface= 695 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
595 to 523
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

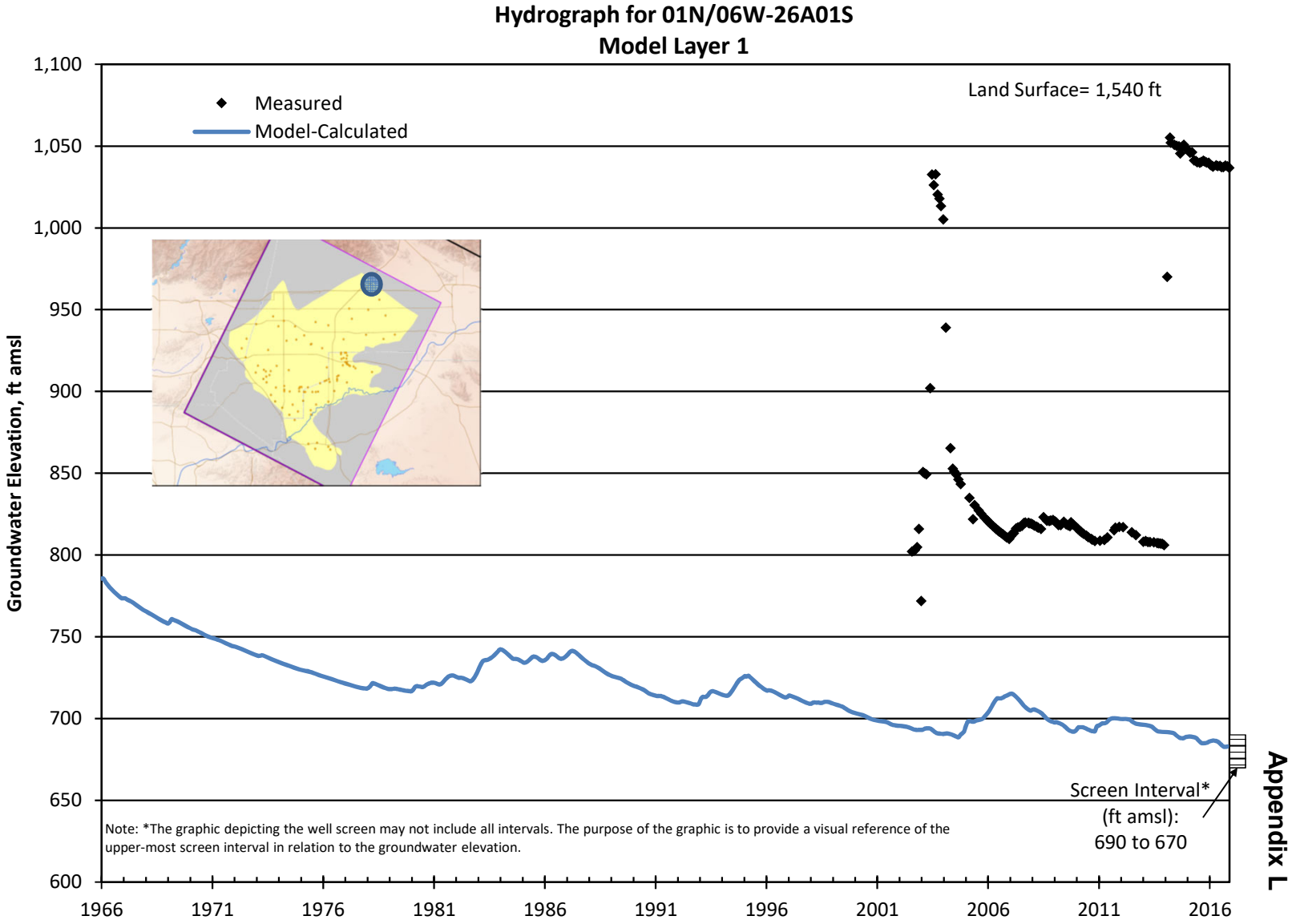
Appendix L

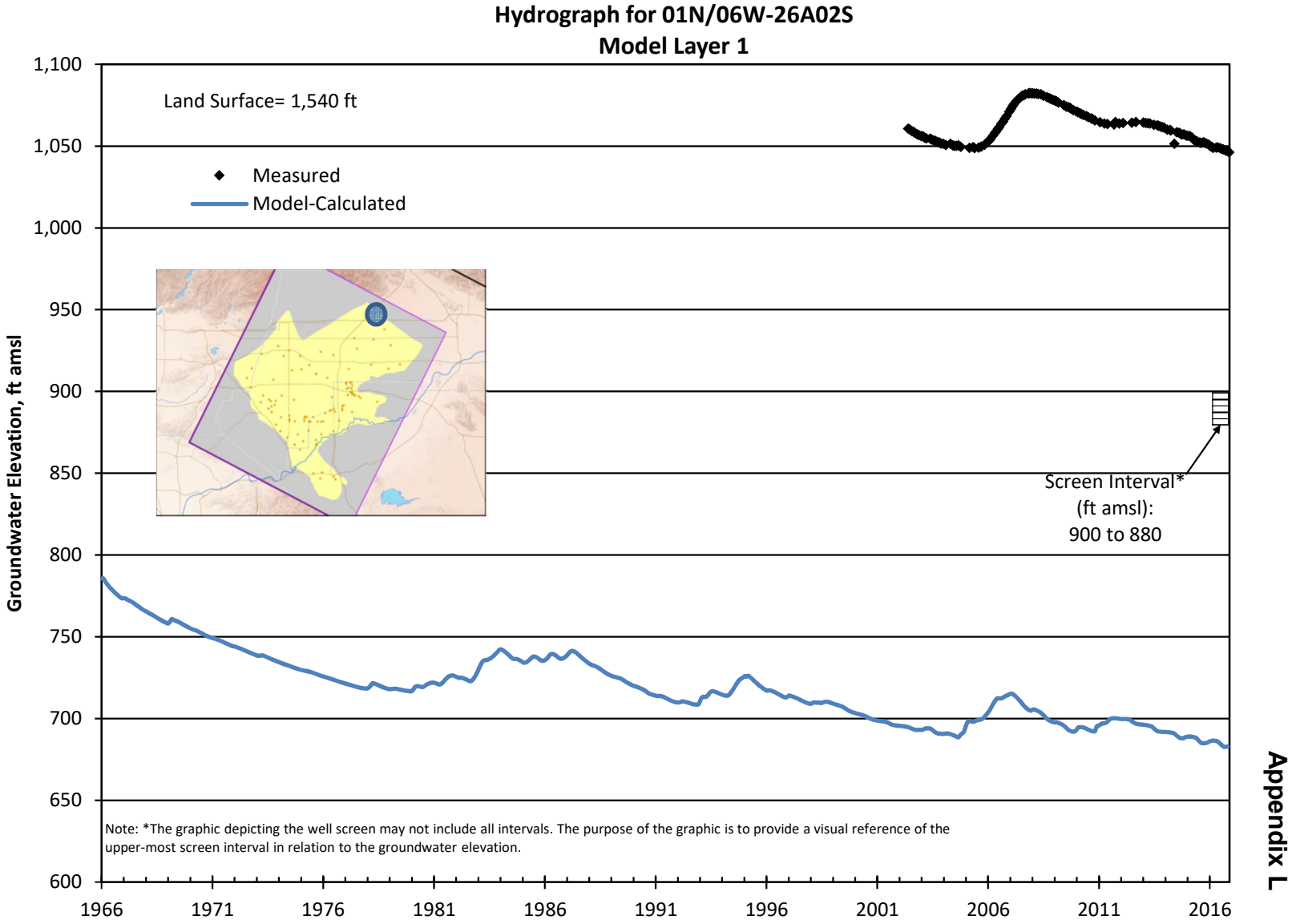

Hydrograph for CIM_09
Model Layer 1
Measured
Model-Calculated
Land Surface= 605 ft
Groundwater Elevation, ft amsl
750
700
650
600
550
500
450
400
350
300
250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
422 to 400
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix L

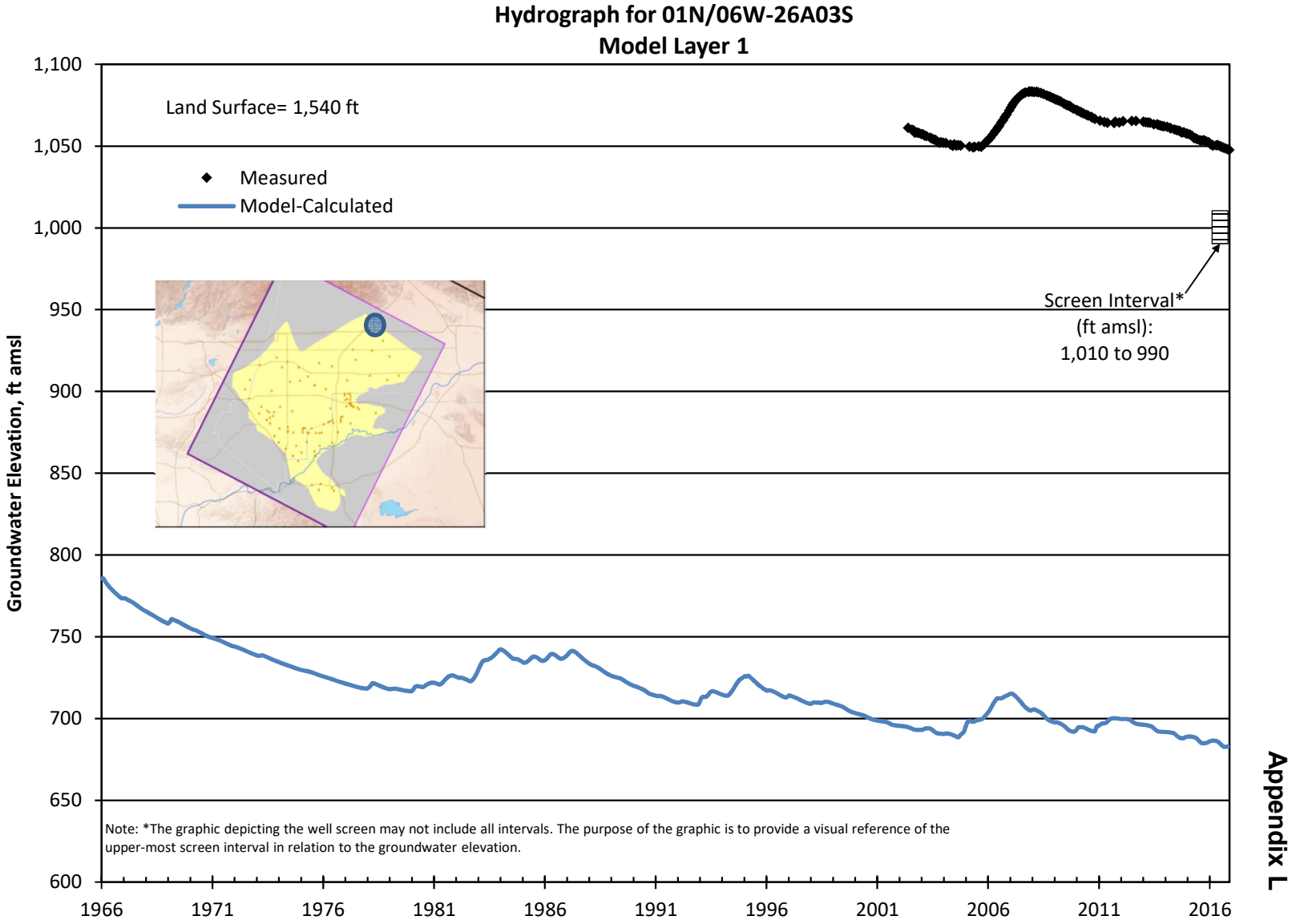

Hydrograph for FC-936A2
Model Layer 1
Measured
Model-Calculated
Land Surface= 751 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.

Appendix L

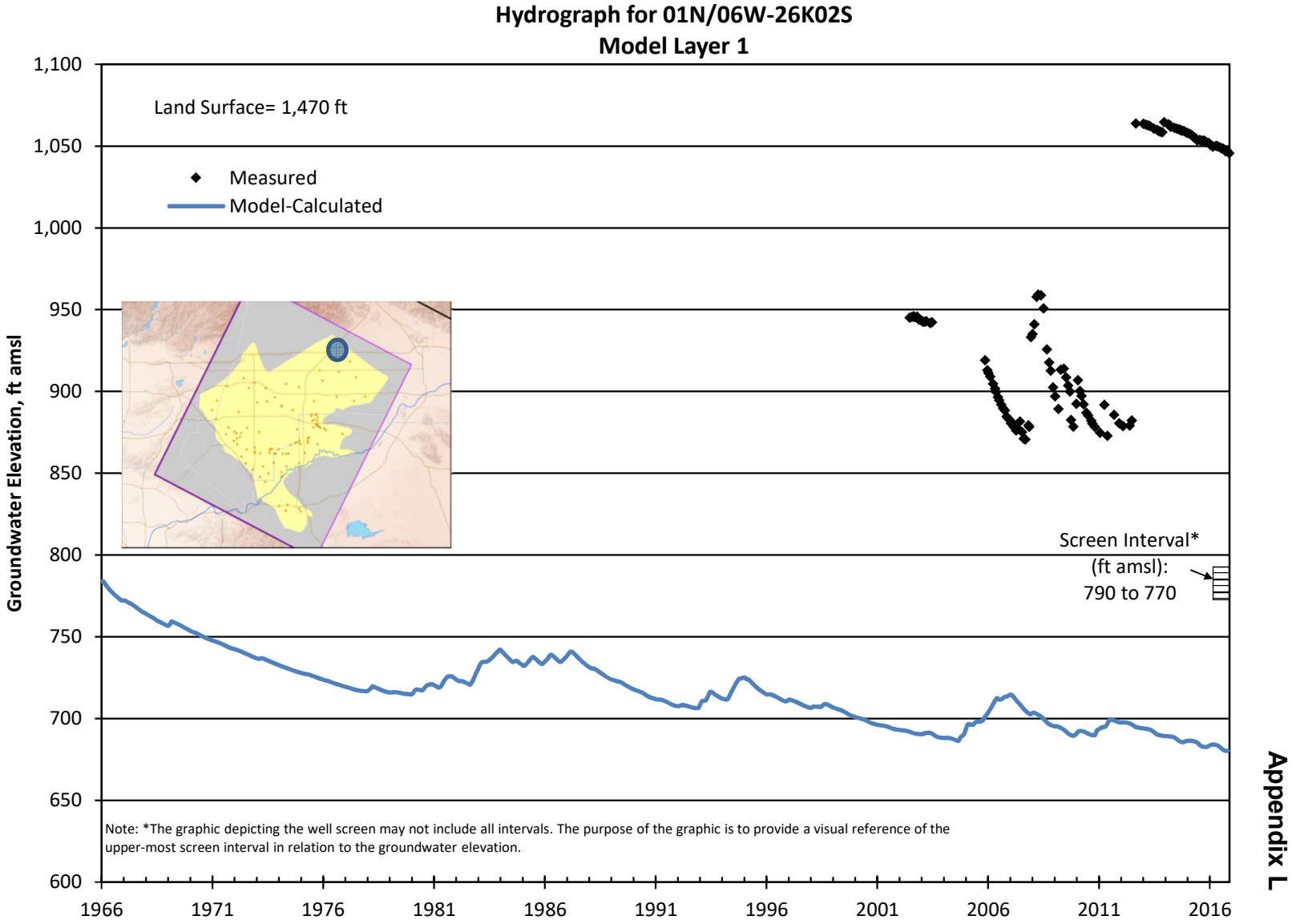

Hydrograph for 01N/06W-26A01S
Model Layer 1
Measured
Model-Calculated
Land Surface= 1,540 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
690 to 670
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
Appendix L


Hydrograph for 01N/06W-26A02S
Model Layer 1
Land Surface= 1,540 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
900 to 880
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

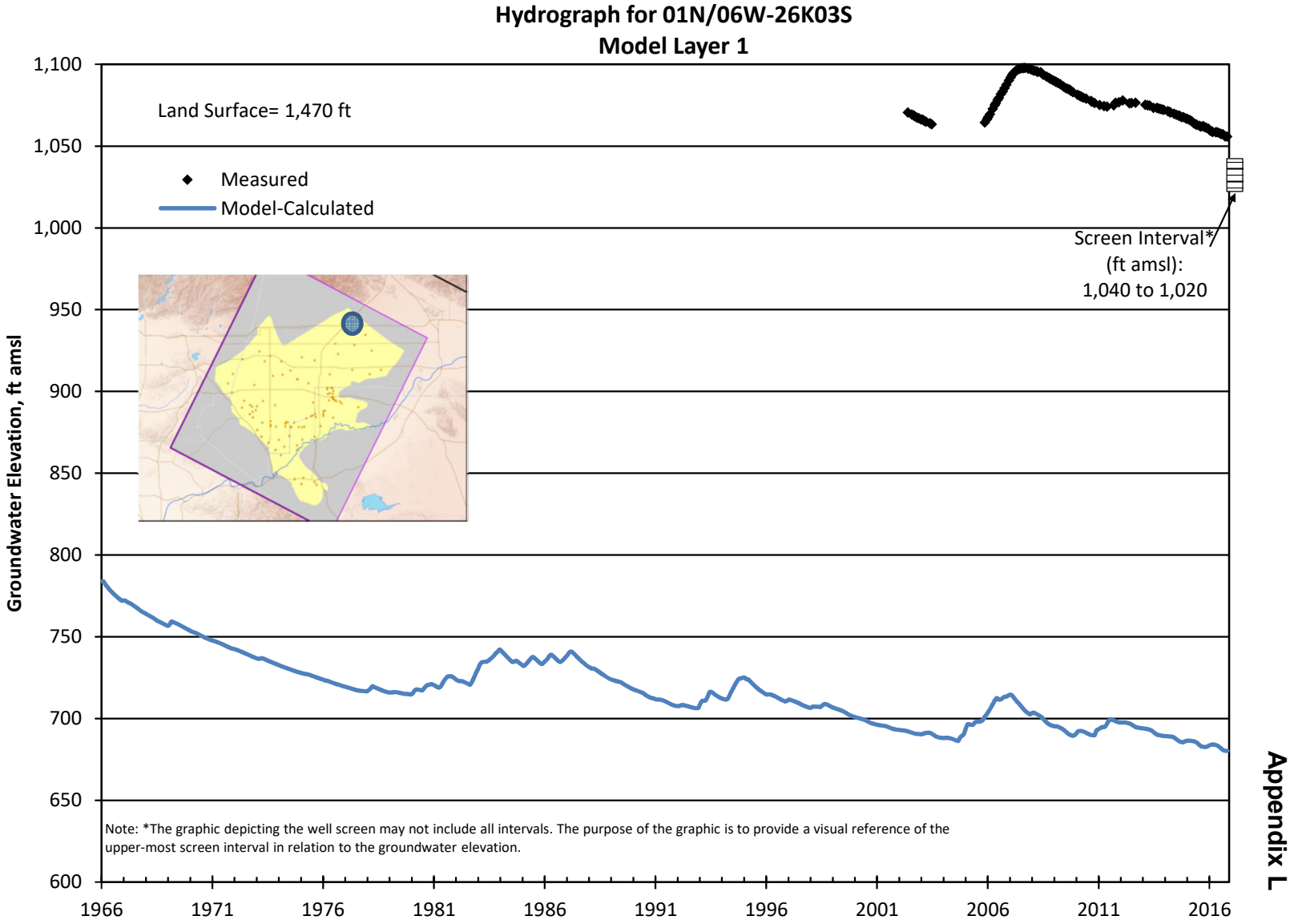
Appendix L


Hydrograph for 01N/06W-26A03S
Model Layer 1
Land Surface= 1,540 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,010 to 990
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

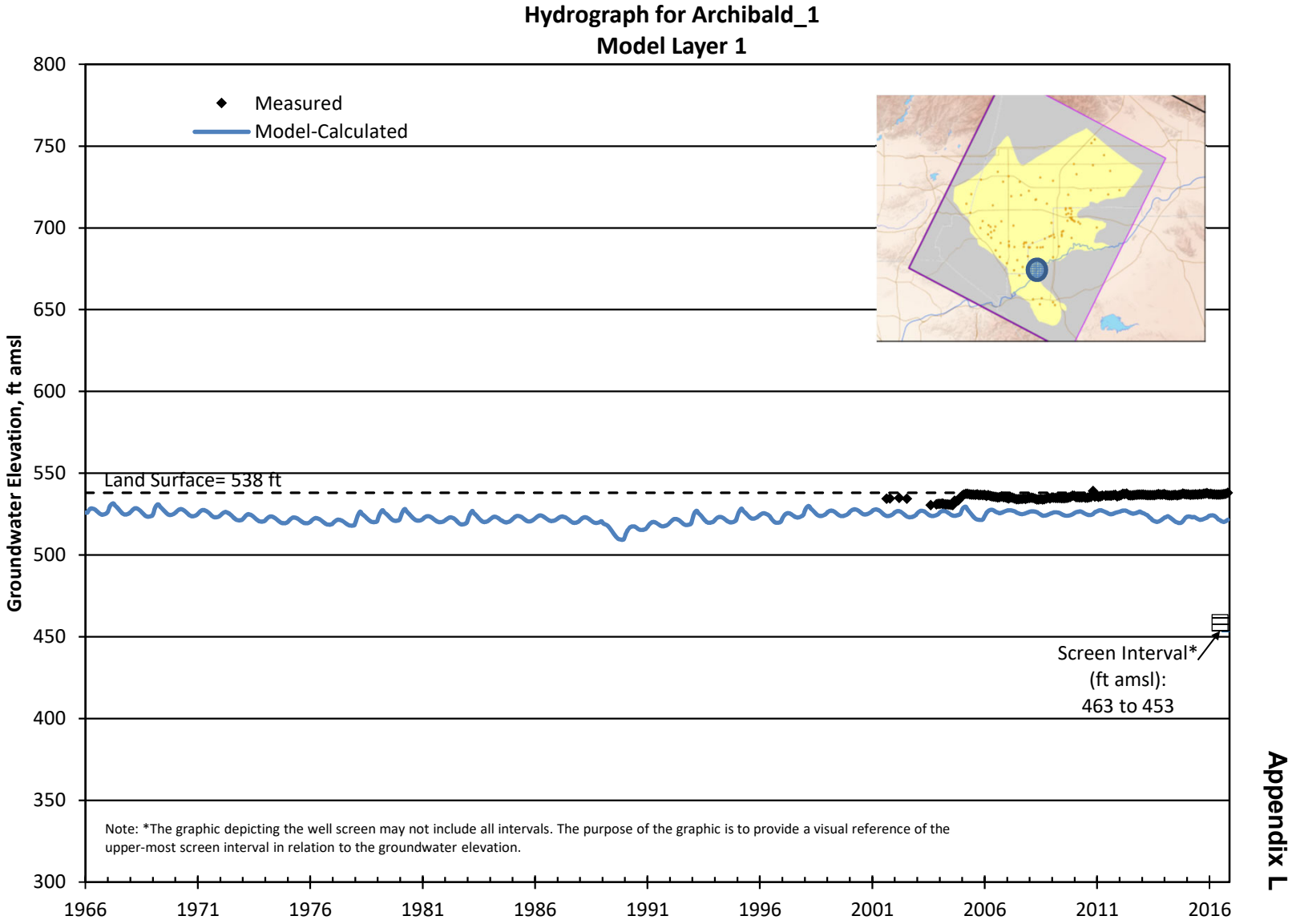
Appendix L


Hydrograph for 01N/06W-26K02S
Model Layer 1
Land Surface= 1,470 ft
Measured
Model-Calculated
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
790 to 770
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

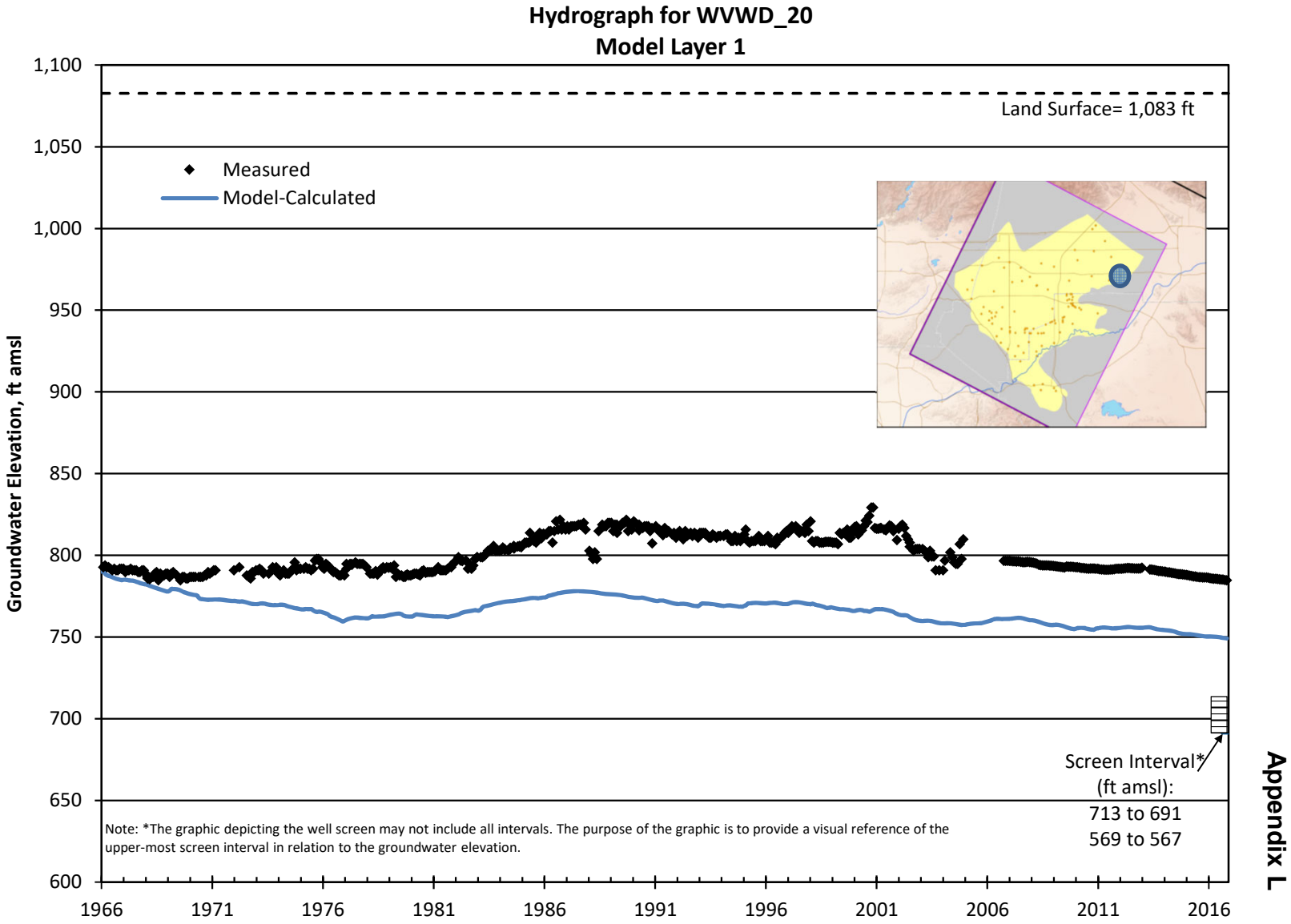
Appendix L


Hydrograph for 01N/06W-26K03S
Model Layer 1
Land Surface= 1,470 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
1,040 to 1,020
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix L


Hydrograph for Archibald_1
Model Layer 1
Measured
Model-Calculated
Land Surface= 538 ft
Screen Interval*
(ft amsl):
463 to 453
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix L


Hydrograph for WVWD_20
Model Layer 1
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 1,083 ft
Measured
Model-Calculated
Screen Interval*
(ft amsl):
713 to 691
569 to 567
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.

Appendix L

APPENDIX M

Integrated SAR Model: Selected Hydrographs for Target Wells in the Yucaipa Basin Model Area – 1966 to 2016

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©2020, GEOSCIENCE Support Services, Inc. All rights reserved. Drawn By: DB. Projection: State Plane 1983, Zone V.

W:\GIS_proj\sbvmwd_SARriverStudyModel_20171\53_SumRpt_Fig_M-1_Yucaipa_Wells_labeled_4-20.mxd

Upper Warm Ck
City Ck
Plunge Ck
Seven Oaks Dam
Santa Ana River
210
10
38
The Zanja
SAN BERNARDINO BASIN AREA
YUCAIPA BASIN
Mill Ck
Zanja Ck
Wilson Ck
Oak Glen Ck
Yucaipa Ck
Wildwood Ck
Noble Ck
San Timoteo Wash
Reche Cyn Ck
60

YVWD_Well_51
YVWD_Well_43
N.E._Yucaipa
YVWD_Well_37
Wilson_Creek_2-5
YVWD_Well_46
YVWD_Well_56
YVWD_Well_25
YVWD_Well_13
YVWD_Well_14
WHWC_Well_3
WHWC_Well_11
USGS_Monitoring_Well_2-6
USGS_6th_Street_and_E_2-6
WHWC_Well_10
YVWD_Well_12
YVWD_Well_6
YVWD_Well_27
YVWD_Well_28
Hog_Canyon_2
Equestrian_Park_1-4
Covington_Well
SMWC_Well_16
SMWC_Well_1

EXPLANATION

Integrated SAR Model Boundary

Well Model Layer
- 1
- 2
- 3
- 4
- 5

Inactive Model Area

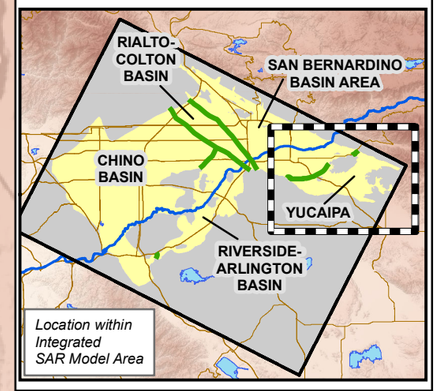
Groundwater Basin Boundary

Groundwater Flow Barrier

Dam Location Used in Upper Santa Ana River Watershed Model

N

0 1.5 3
Miles



SELECTED TARGET WELLS USED FOR HYDROGRAPHS YUCAIPA BASIN MODEL AREA 1966 TO 2016

10-Apr-20

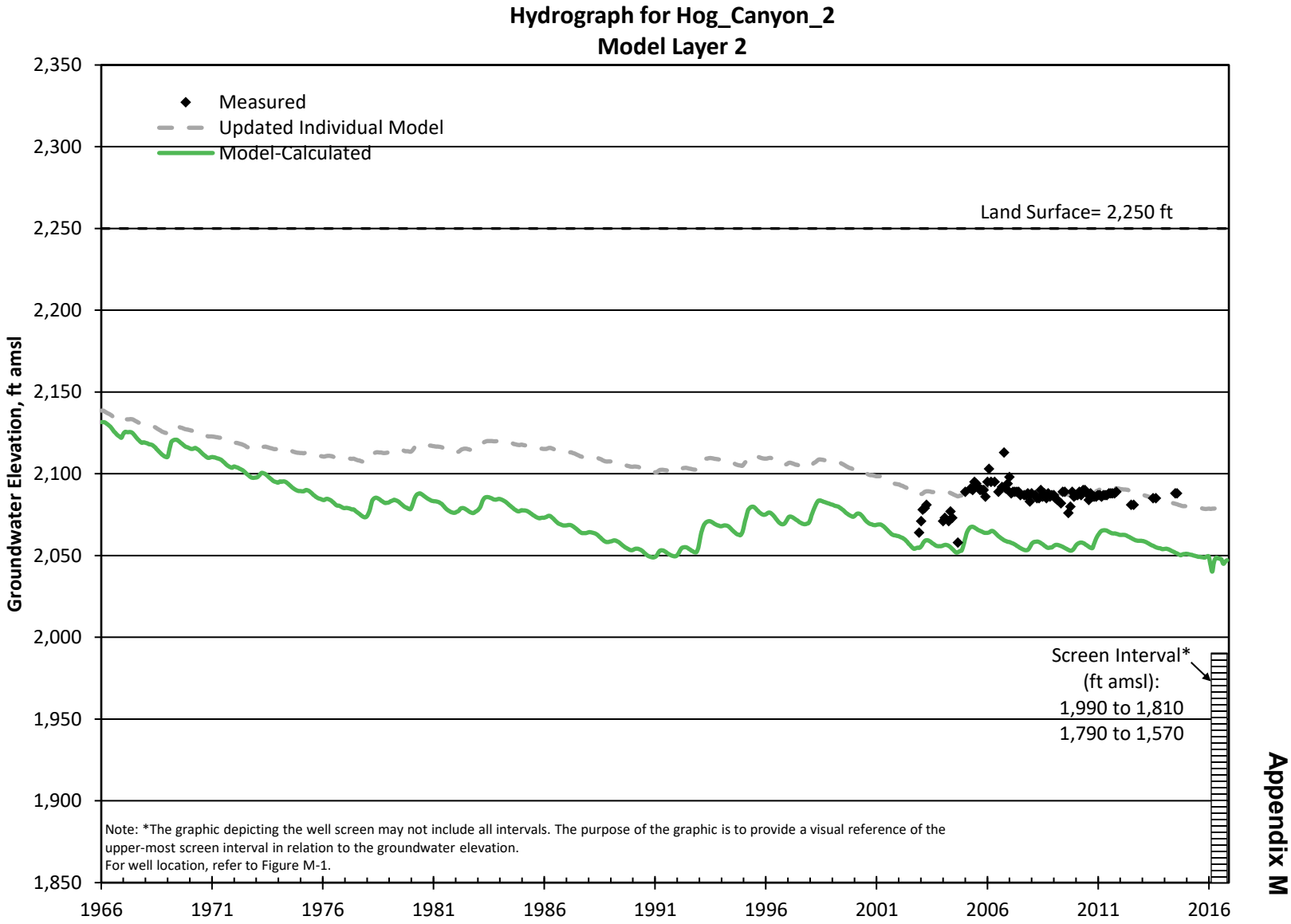
SAN BERNARDINO VALLEY MUNICIPAL WATER DISTRICT

UPPER SANTA ANA RIVER INTEGRATED MODEL - SUMMARY REPORT

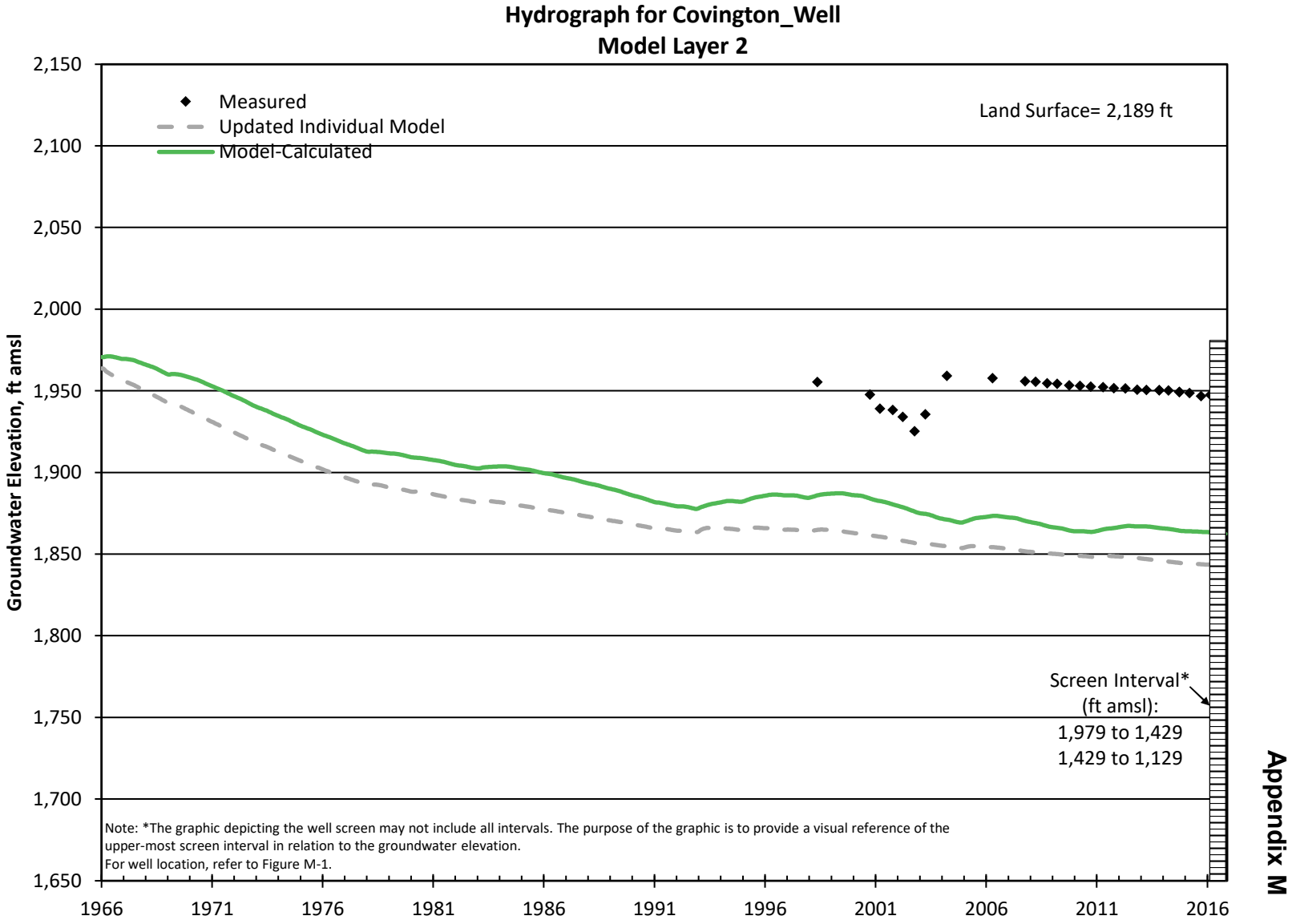
DRAFT

FIGURE M-1

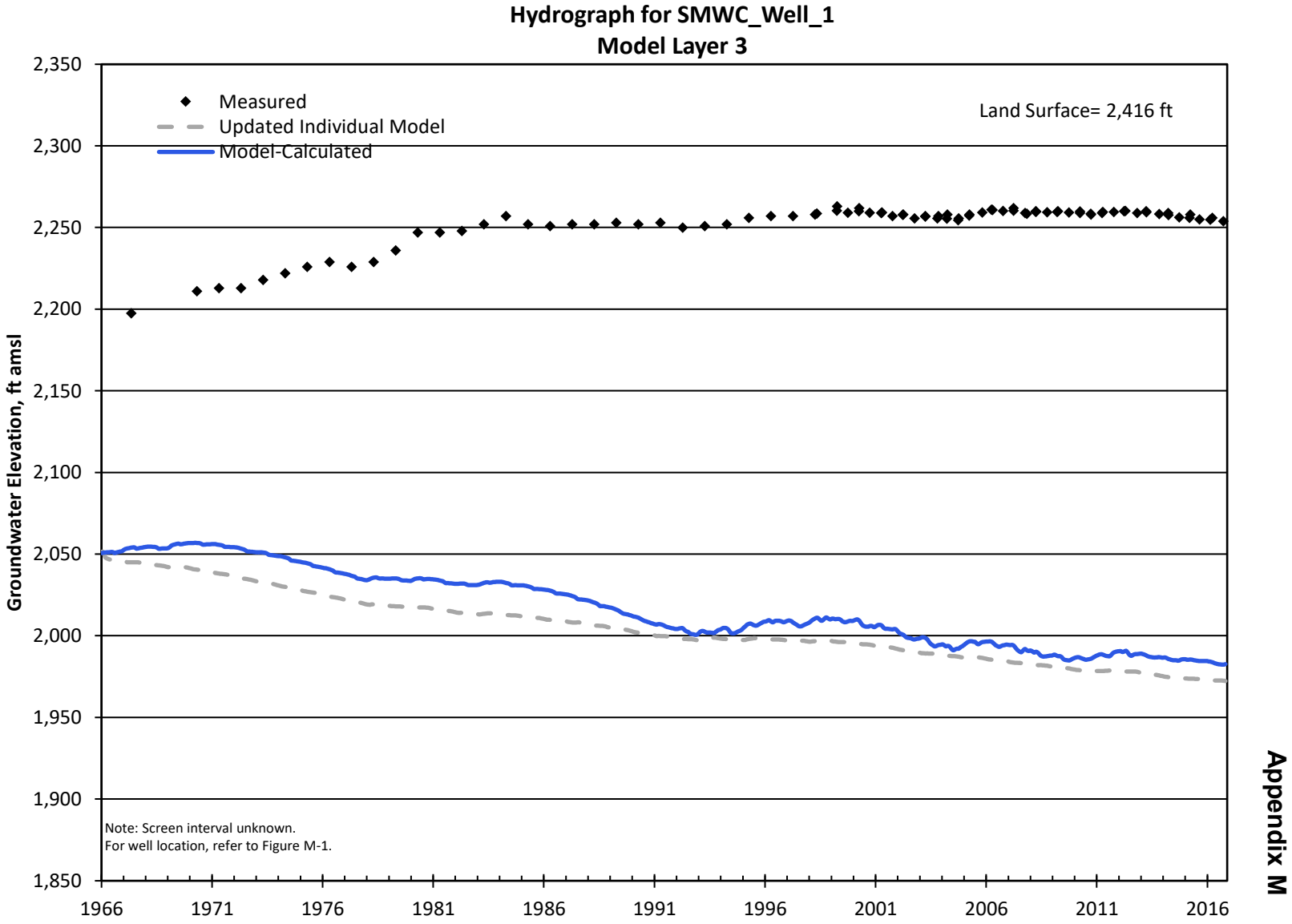
GEOSCIENCE


Hydrograph for Hog_Canyon_2
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,250 ft
Groundwater Elevation, ft amsl
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1,900
1,850
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,990 to 1,810
1,790 to 1,570
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

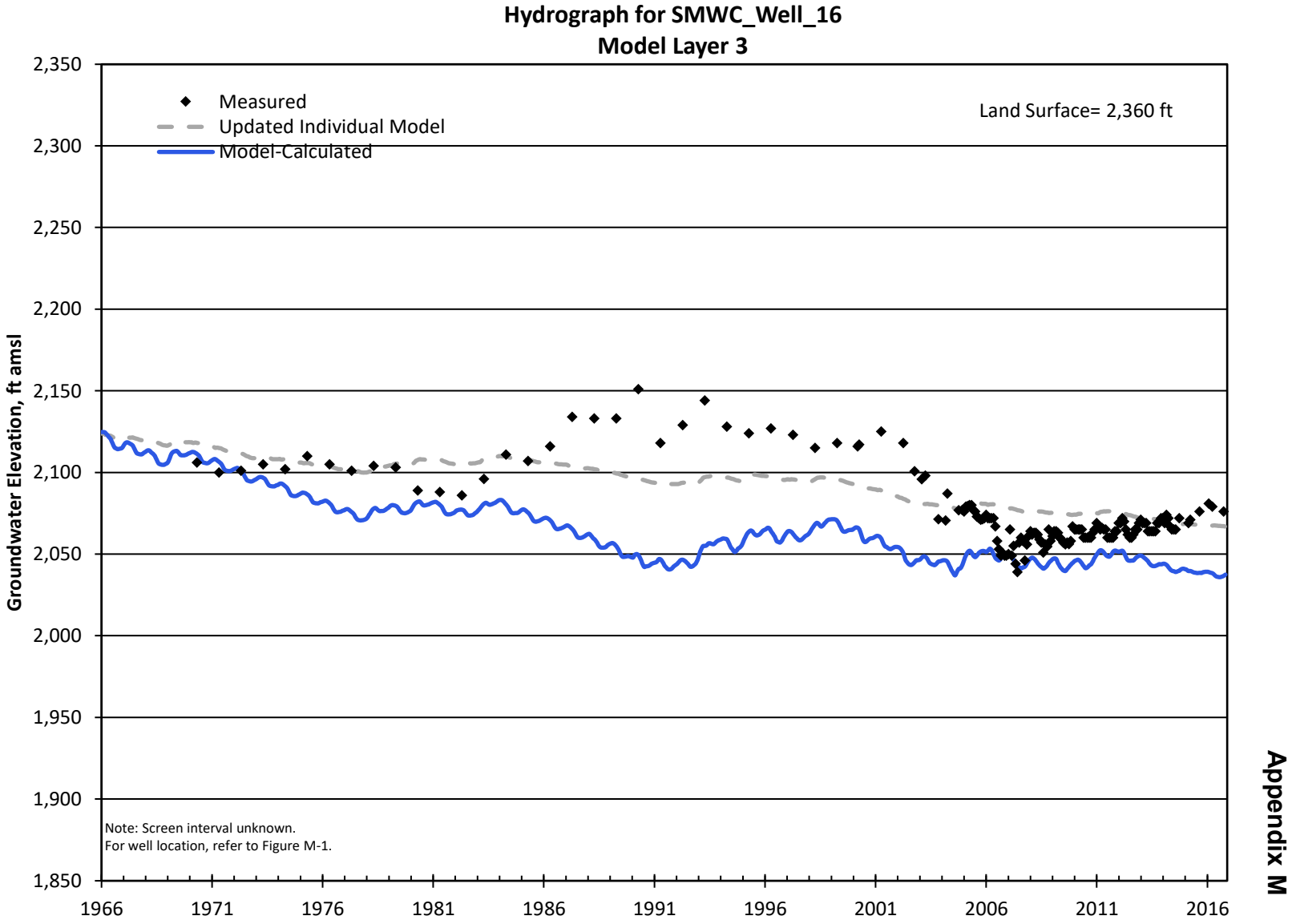
Appendix M


Hydrograph for Covington_Well
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,189 ft
Groundwater Elevation, ft amsl
2,150
2,100
2,050
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,979 to 1,429
1,429 to 1,129
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

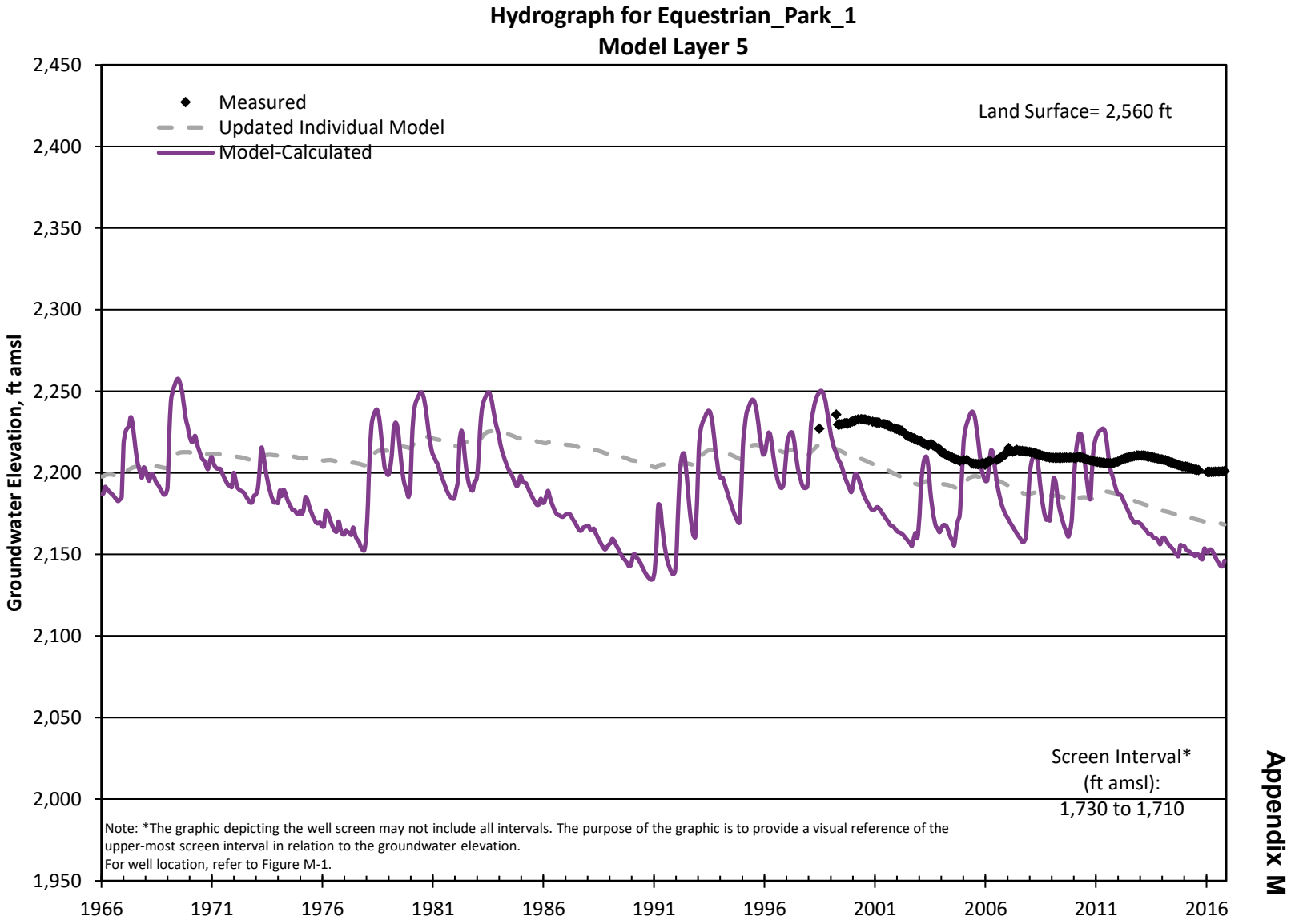
Appendix M


Hydrograph for SMWC_Well_1
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,416 ft
Groundwater Elevation, ft amsl
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1,900
1,850
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure M-1.

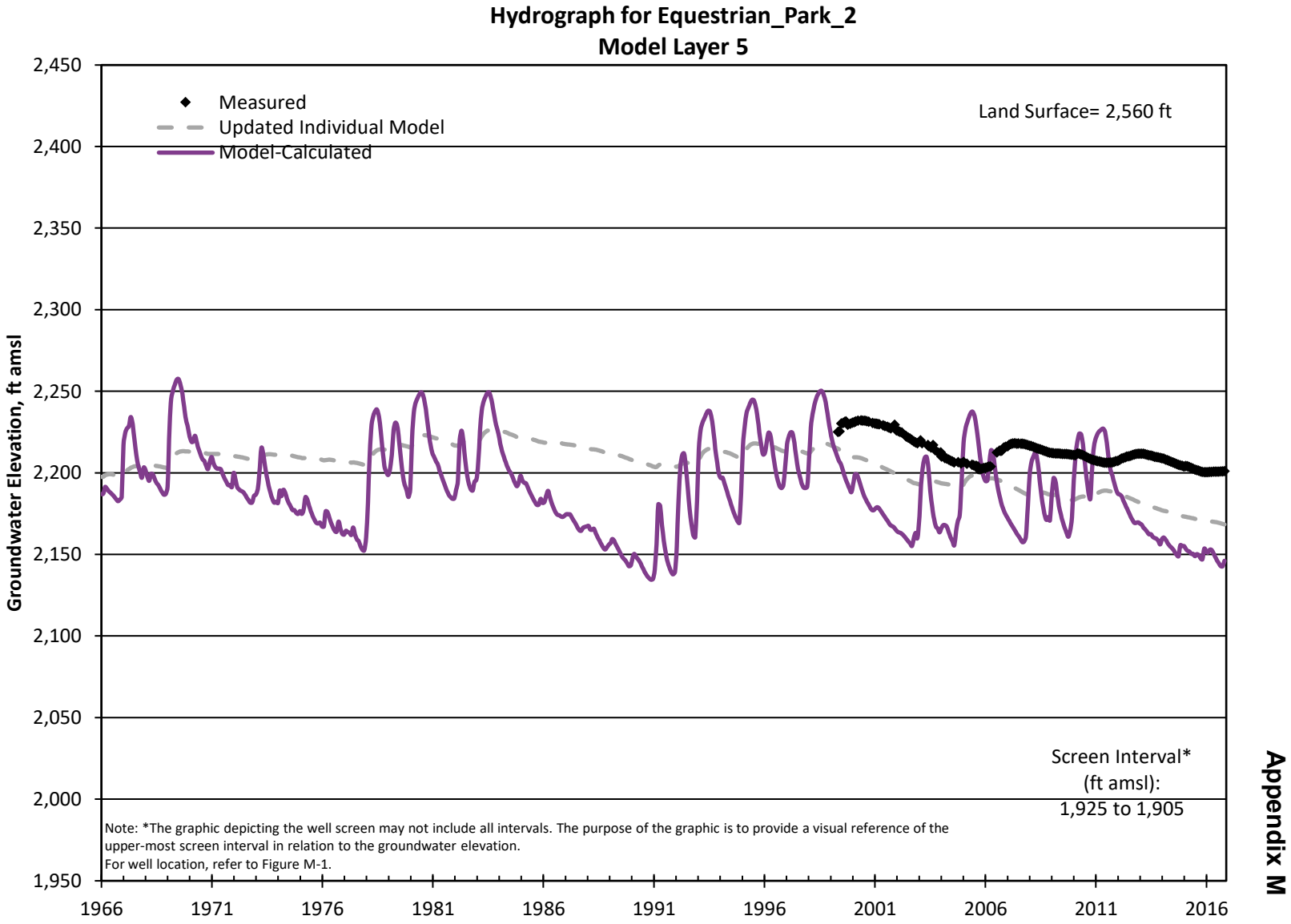
Appendix M


Hydrograph for SMWC_Well_16
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,360 ft
Groundwater Elevation, ft amsl
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1,900
1,850
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure M-1.

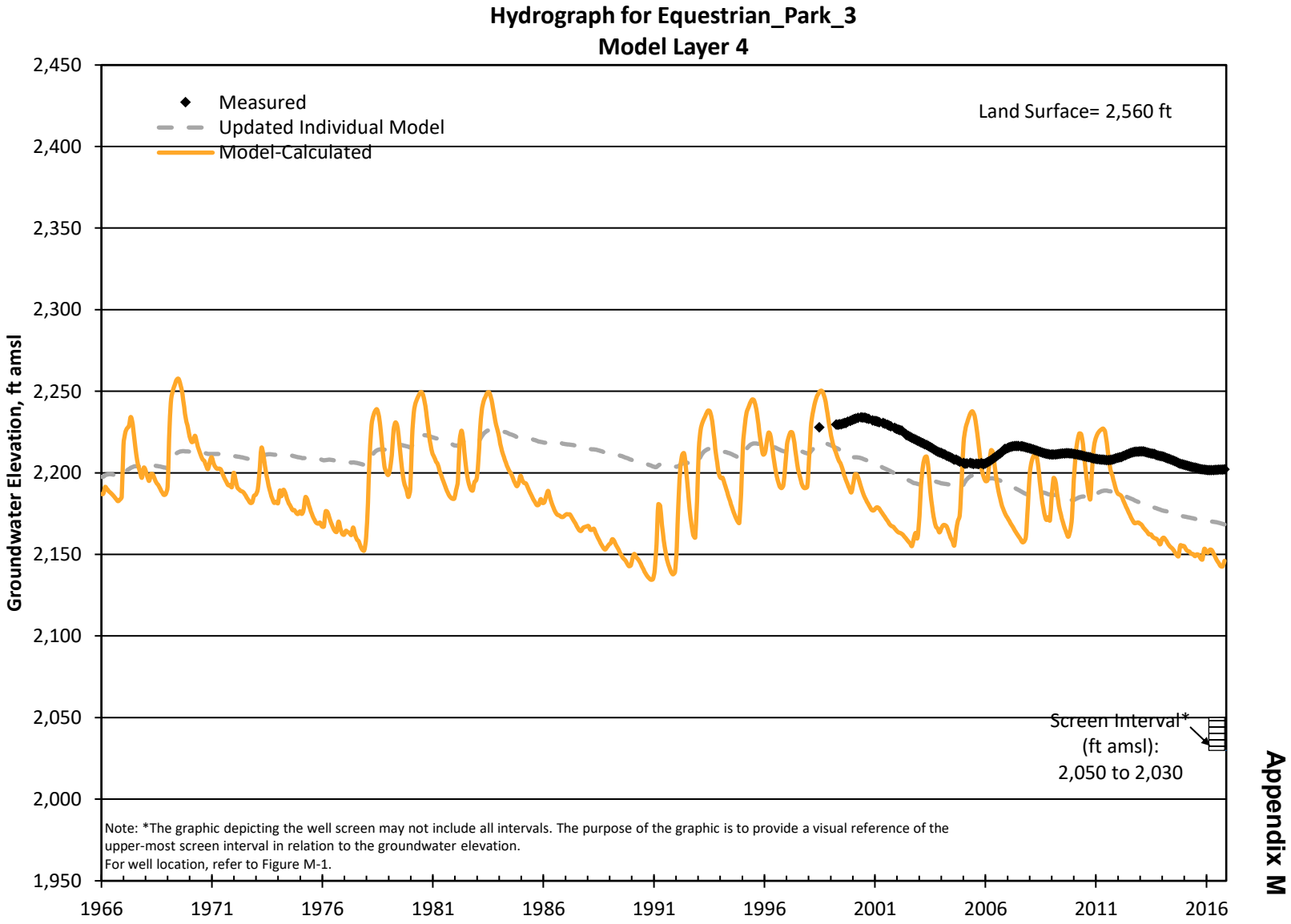
Appendix M


Hydrograph for Equestrian_Park_1
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,560 ft
Groundwater Elevation, ft amsl
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,730 to 1,710
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

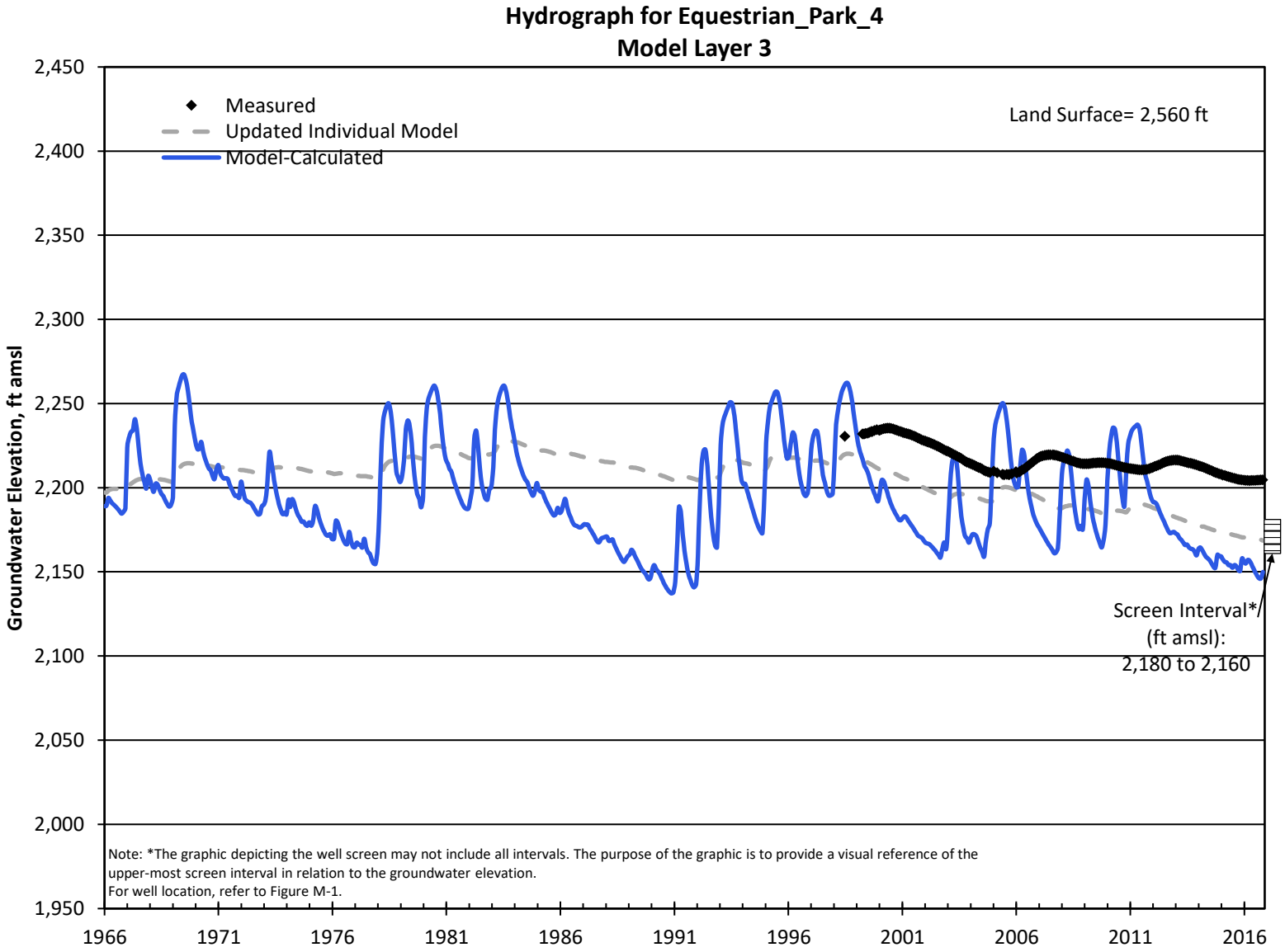
Appendix M


Hydrograph for Equestrian_Park_2
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,560 ft
Groundwater Elevation, ft amsl
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,925 to 1,905
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

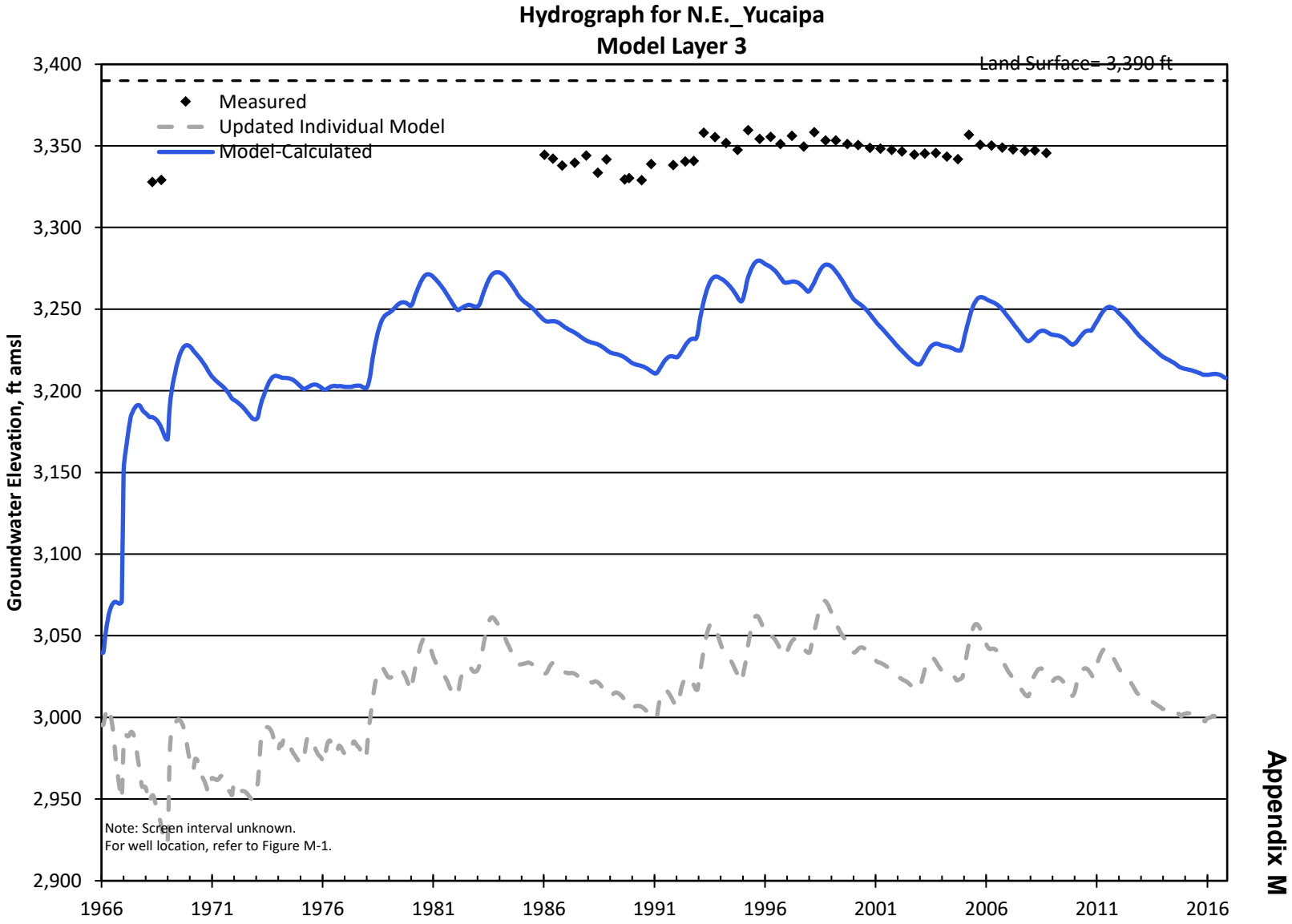
Appendix M


Hydrograph for Equestrian_Park_3
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,560 ft
Groundwater Elevation, ft amsl
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,050 to 2,030
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

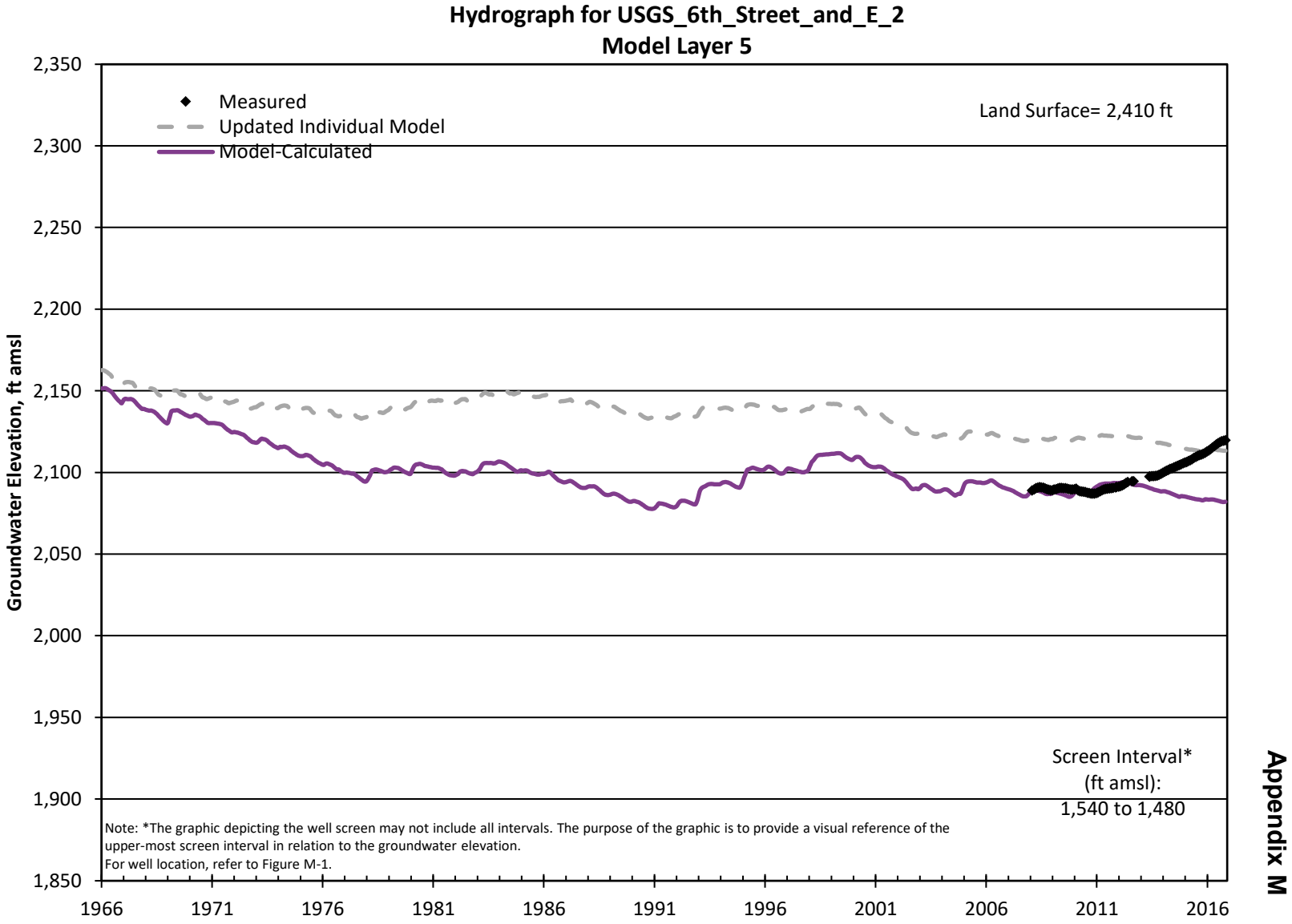
Appendix M


Hydrograph for Equestrian_Park_4
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,560 ft
Groundwater Elevation, ft amsl
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,180 to 2,160
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

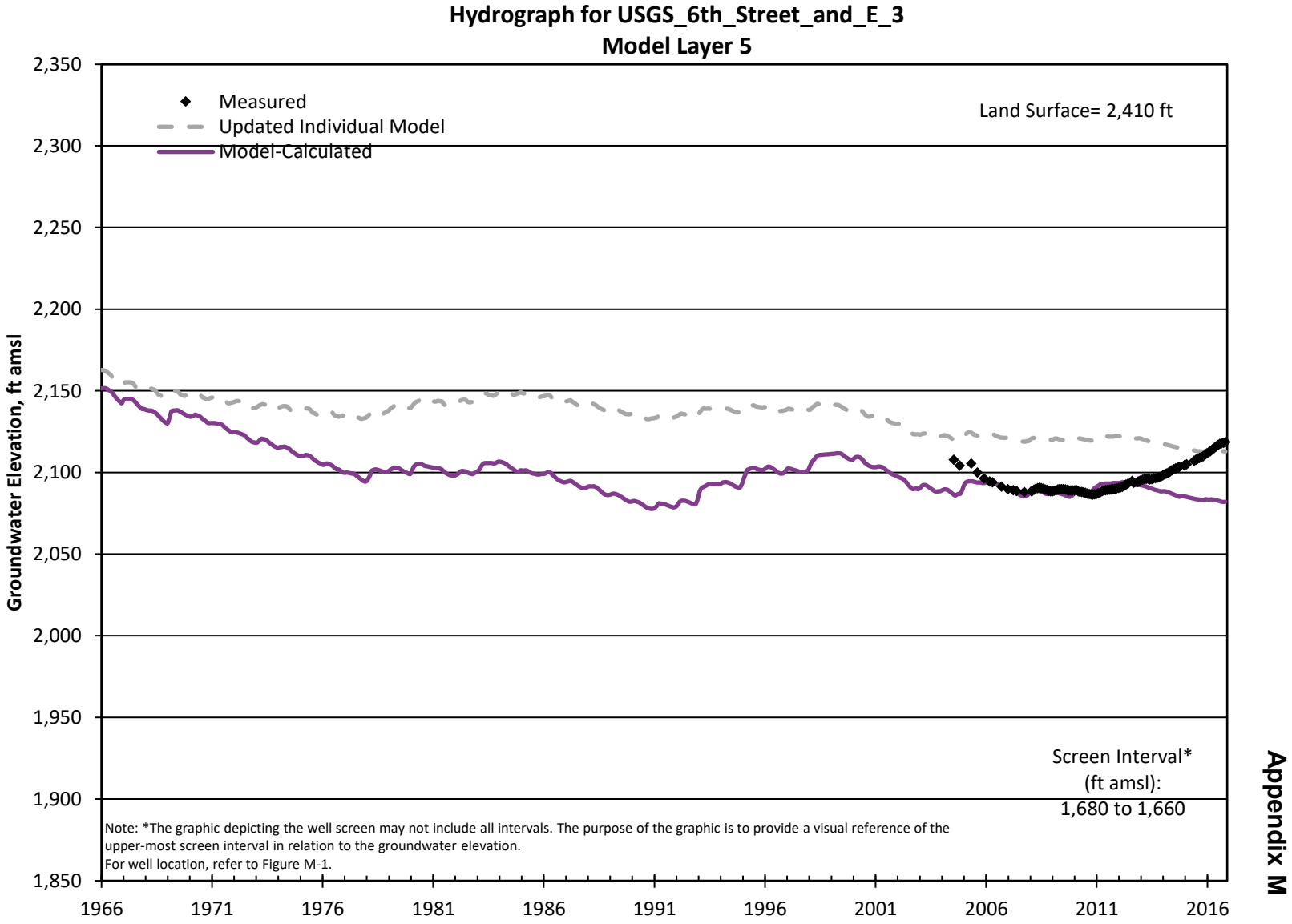
Appendix M


Hydrograph for N.E._Yucaipa
Model Layer 3
Land Surface= 3,390 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
3,400
3,350
3,300
3,250
3,200
3,150
3,100
3,050
3,000
2,950
2,900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure M-1.

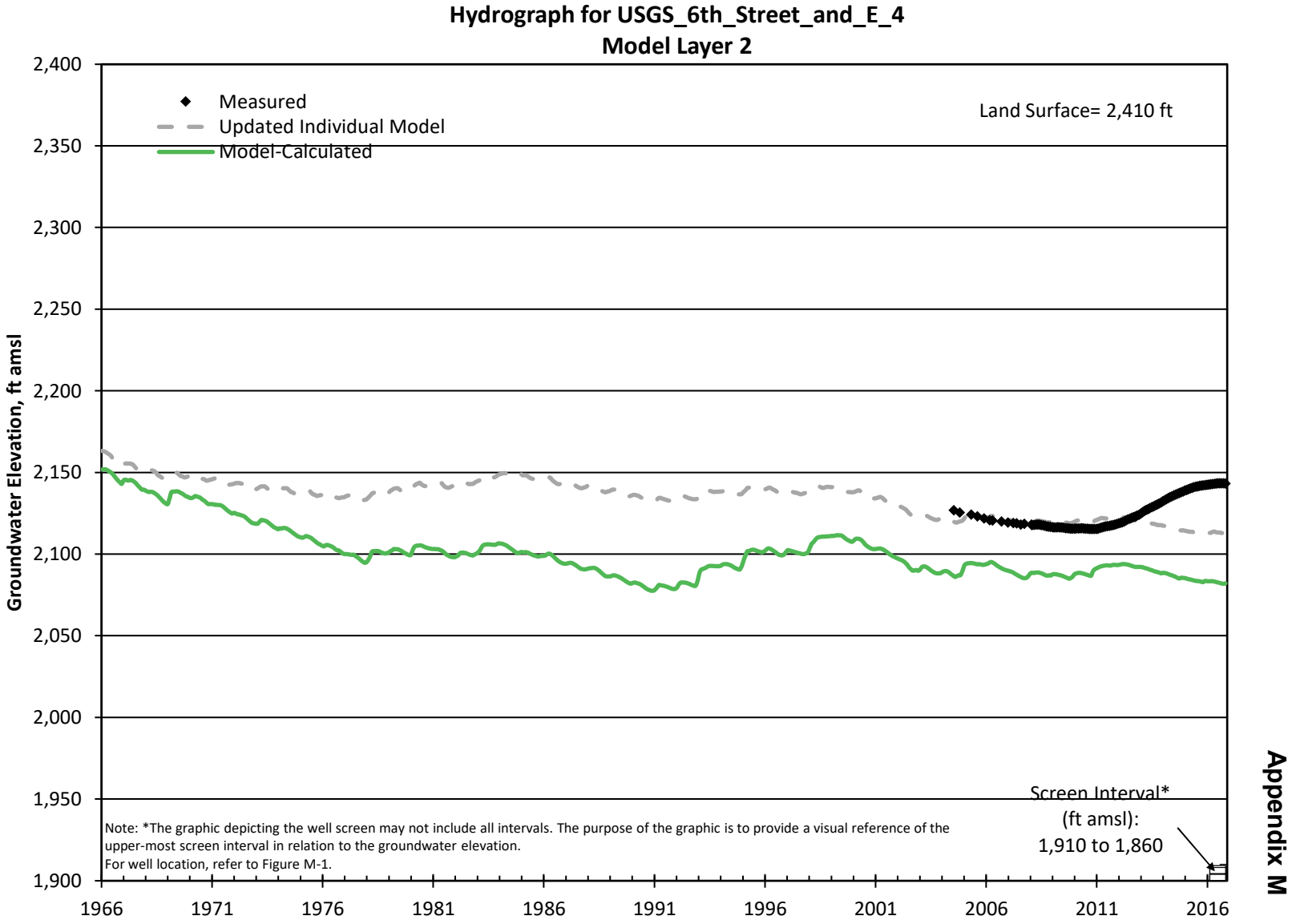
Appendix M


Hydrograph for USGS_6th_Street_and_E_2
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,410 ft
Groundwater Elevation, ft amsl
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1,900
1,850
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,540 to 1,480
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

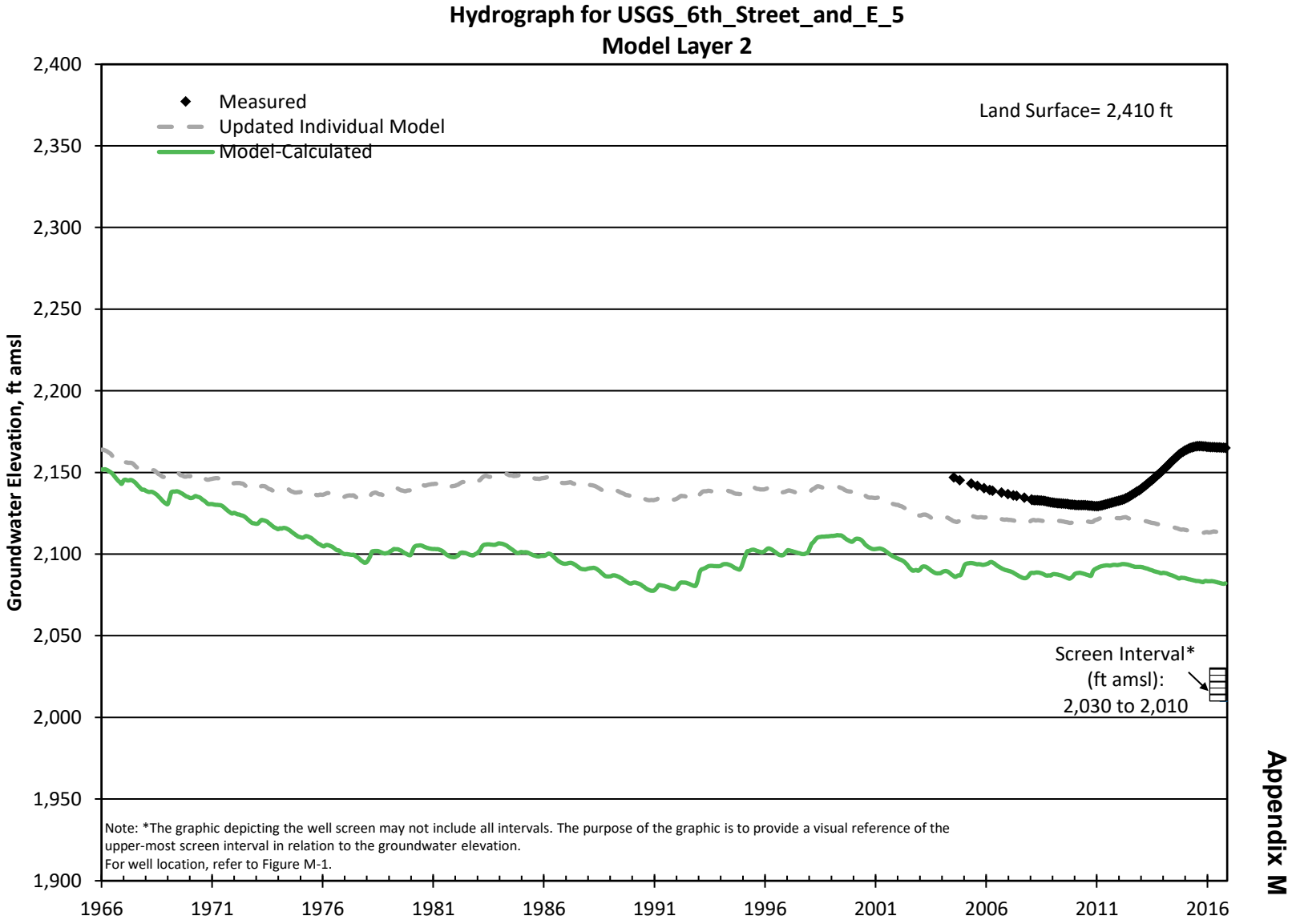
Appendix M


Hydrograph for USGS_6th_Street_and_E_3
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,410 ft
Groundwater Elevation, ft amsl
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1,900
1,850
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,680 to 1,660
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

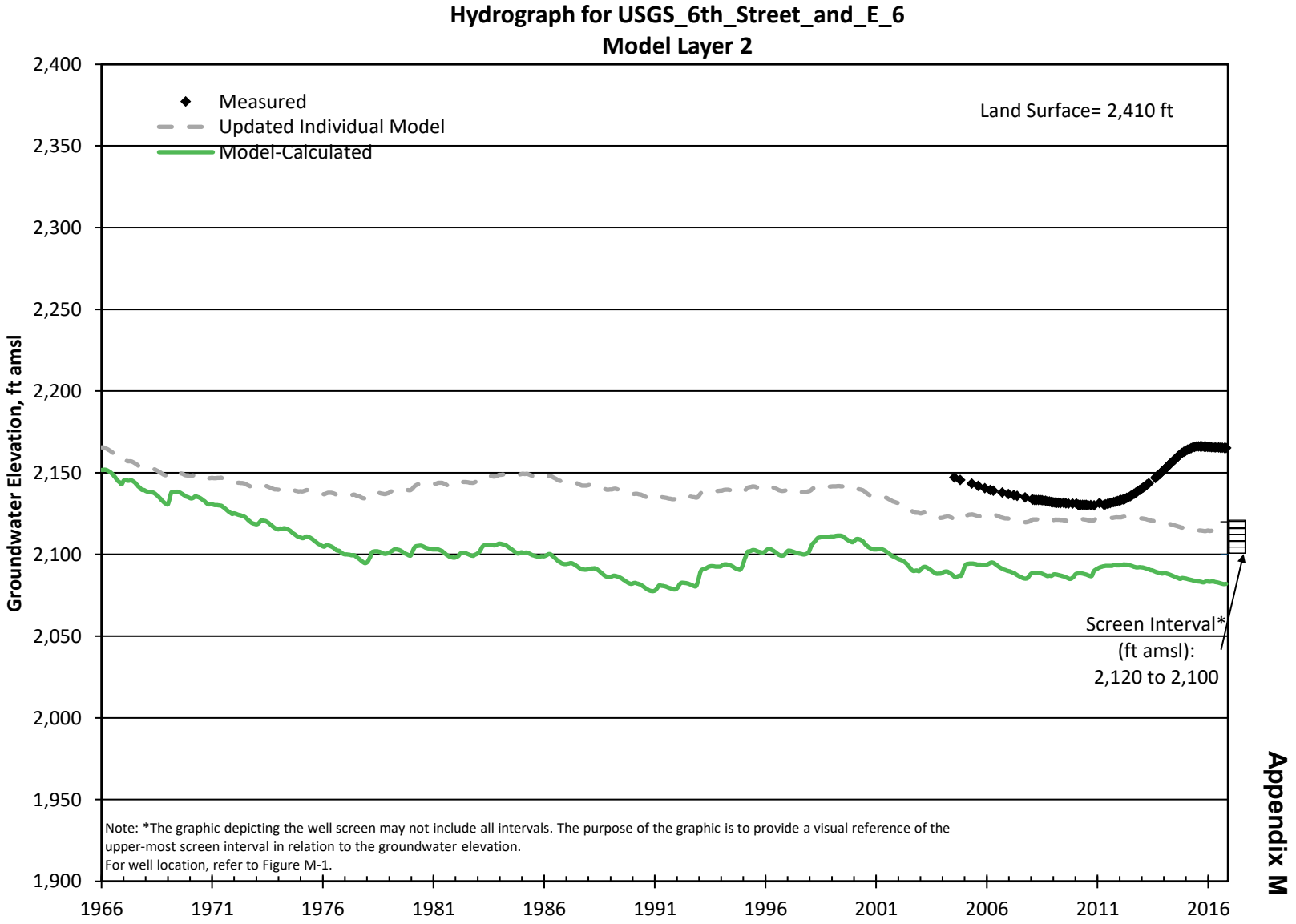
Appendix M


Hydrograph for USGS_6th_Street_and_E_4
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,410 ft
Groundwater Elevation, ft amsl
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1,900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,910 to 1,860
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

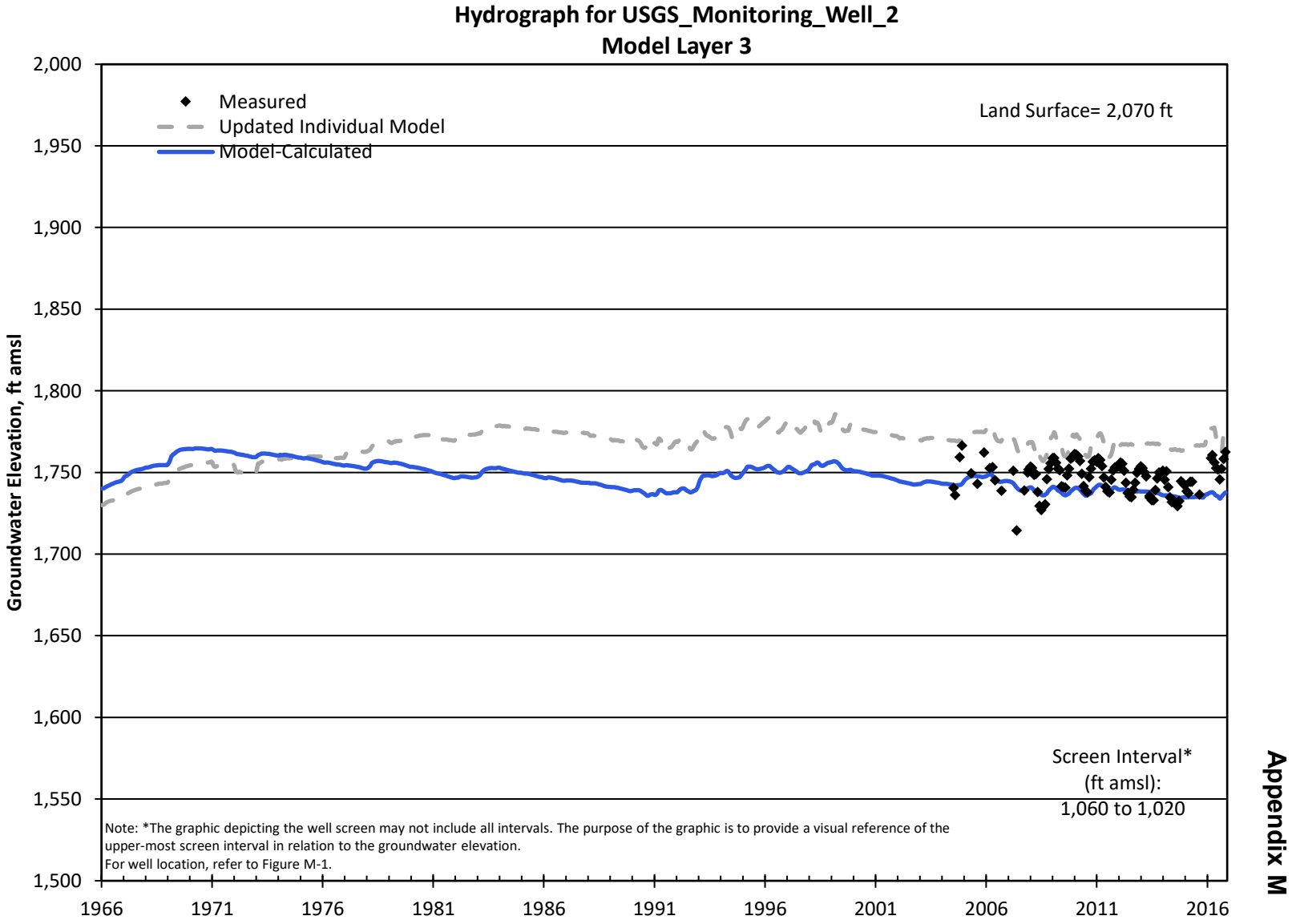
Appendix M


Hydrograph for USGS_6th_Street_and_E_5
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,410 ft
Groundwater Elevation, ft amsl
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1,900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,030 to 2,010
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

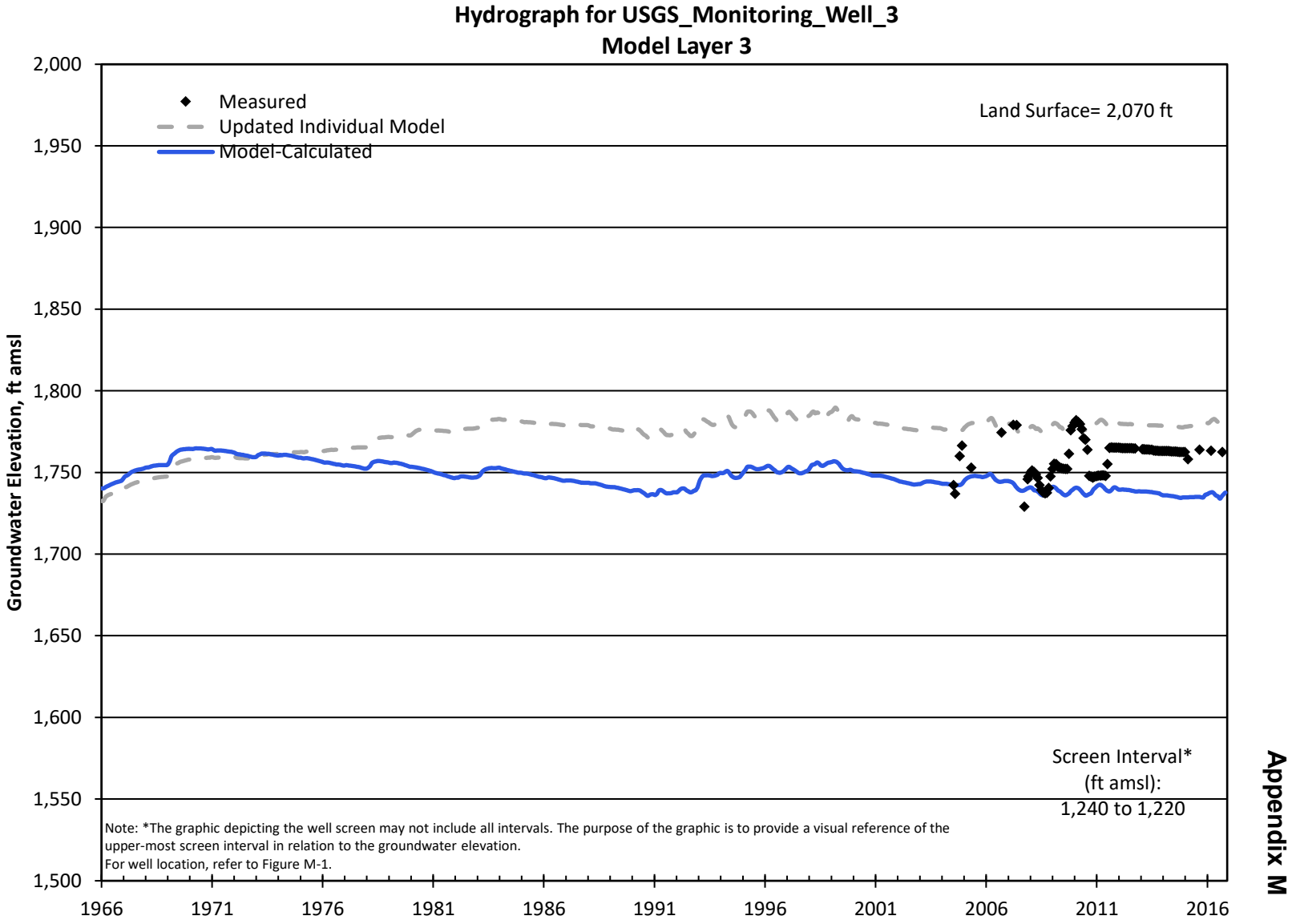
Appendix M


Hydrograph for USGS_6th_Street_and_E_6
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,410 ft
Groundwater Elevation, ft amsl
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1,900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,120 to 2,100
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

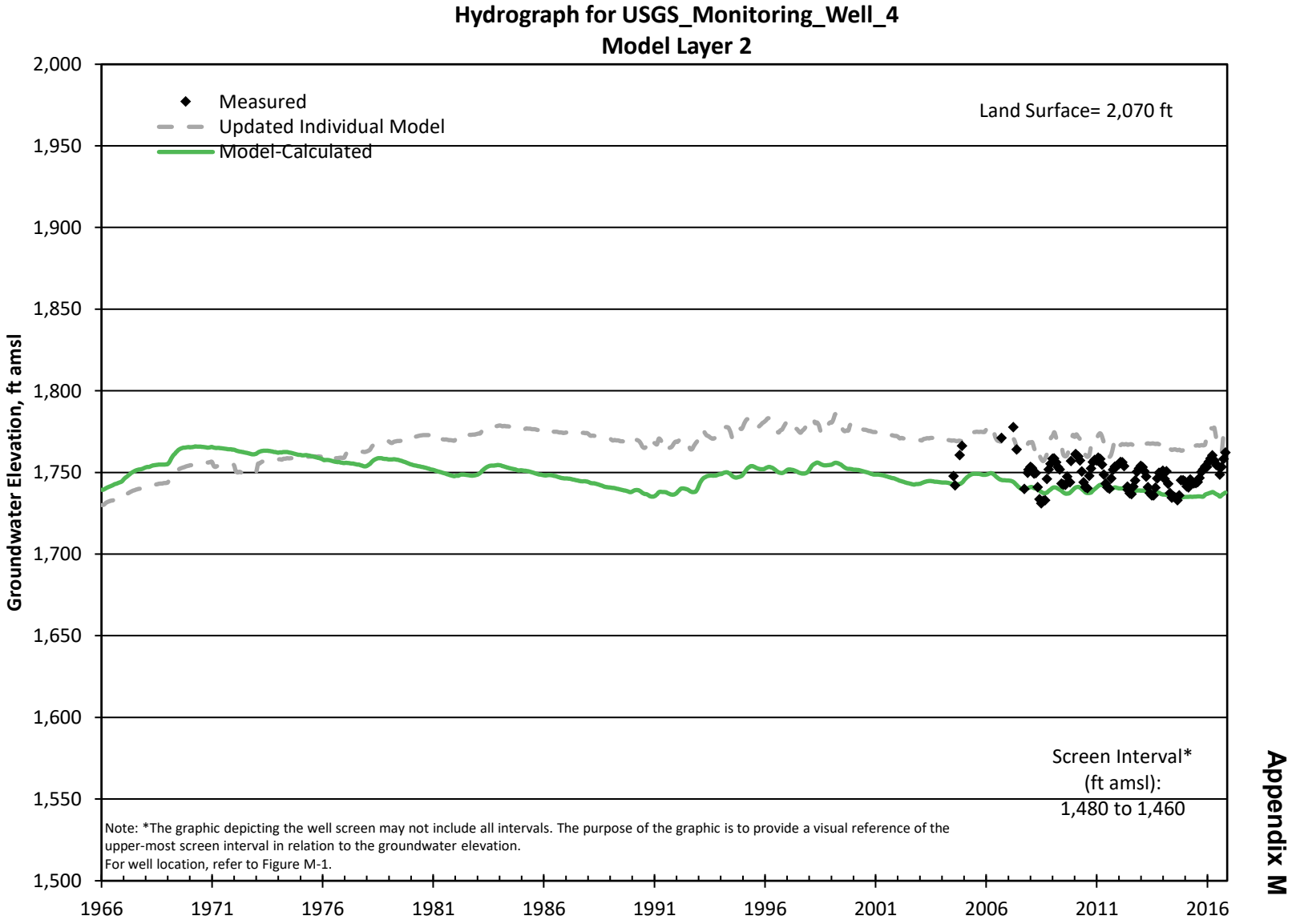
Appendix M


Hydrograph for USGS_Monitoring_Well_2
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,070 ft
Groundwater Elevation, ft amsl
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1,500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,060 to 1,020
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

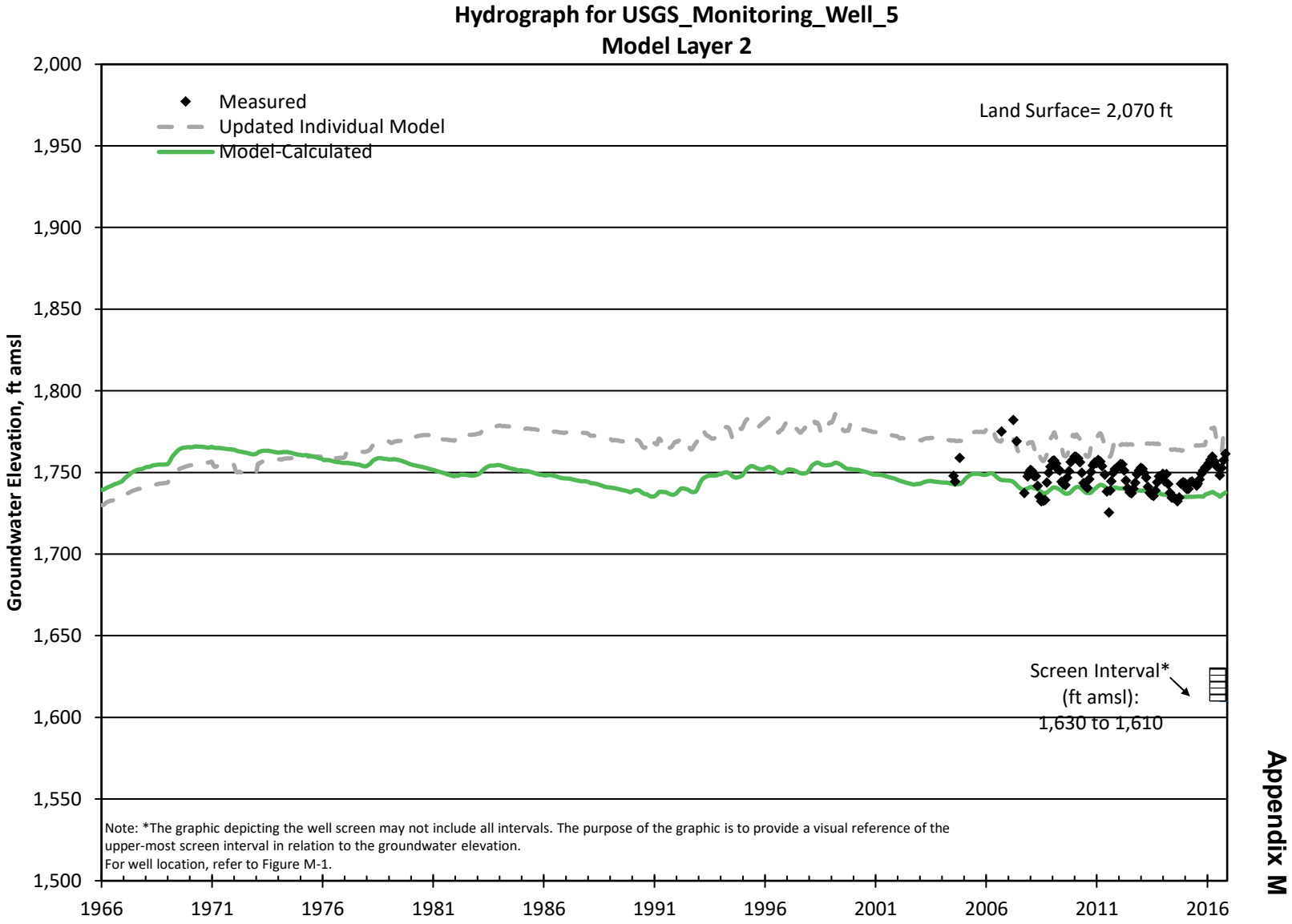
Appendix M


Hydrograph for USGS_Monitoring_Well_3
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,070 ft
Groundwater Elevation, ft amsl
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1,500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,240 to 1,220
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

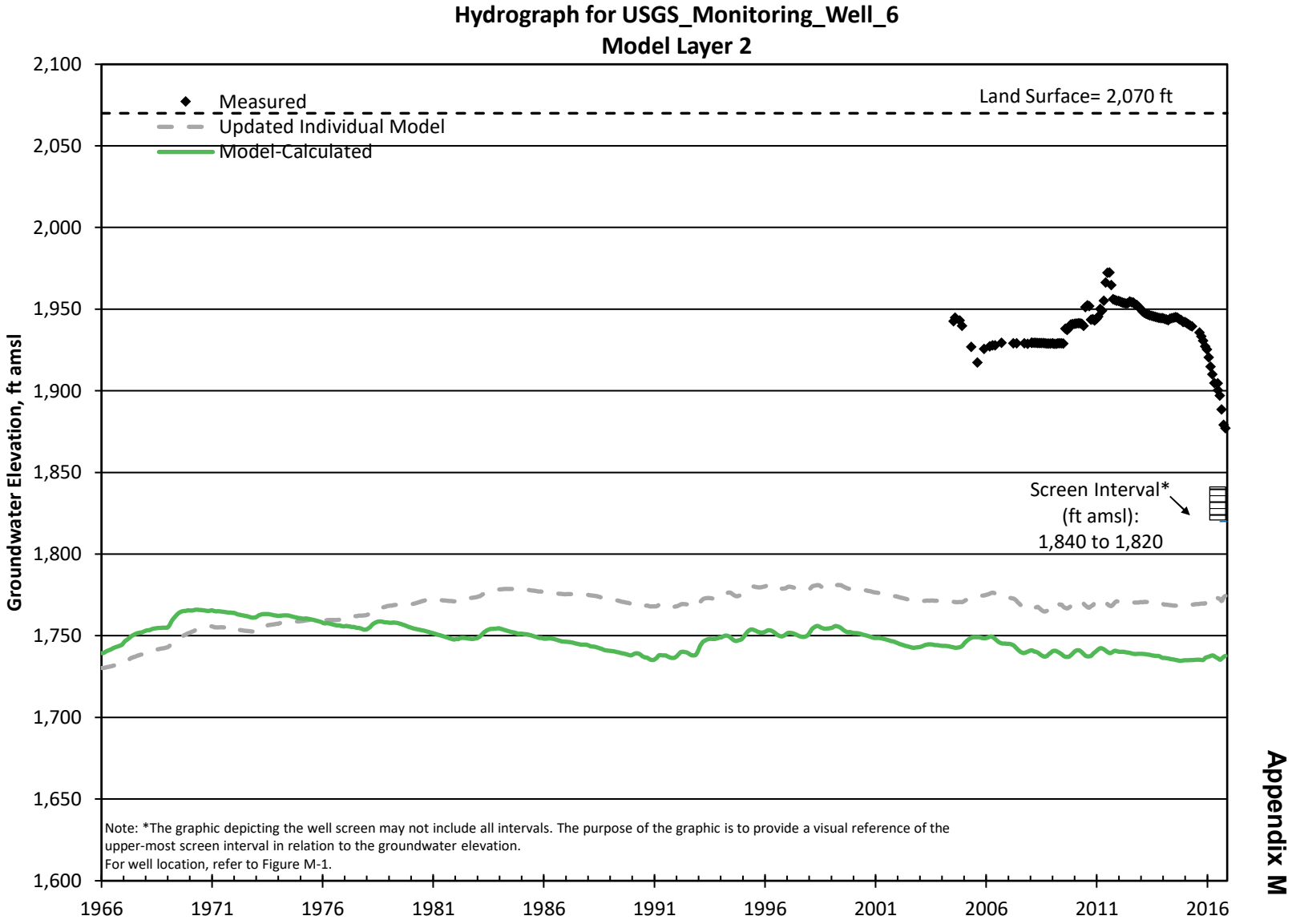
Appendix M


Hydrograph for USGS_Monitoring_Well_4
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,070 ft
Groundwater Elevation, ft amsl
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1,500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,480 to 1,460
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

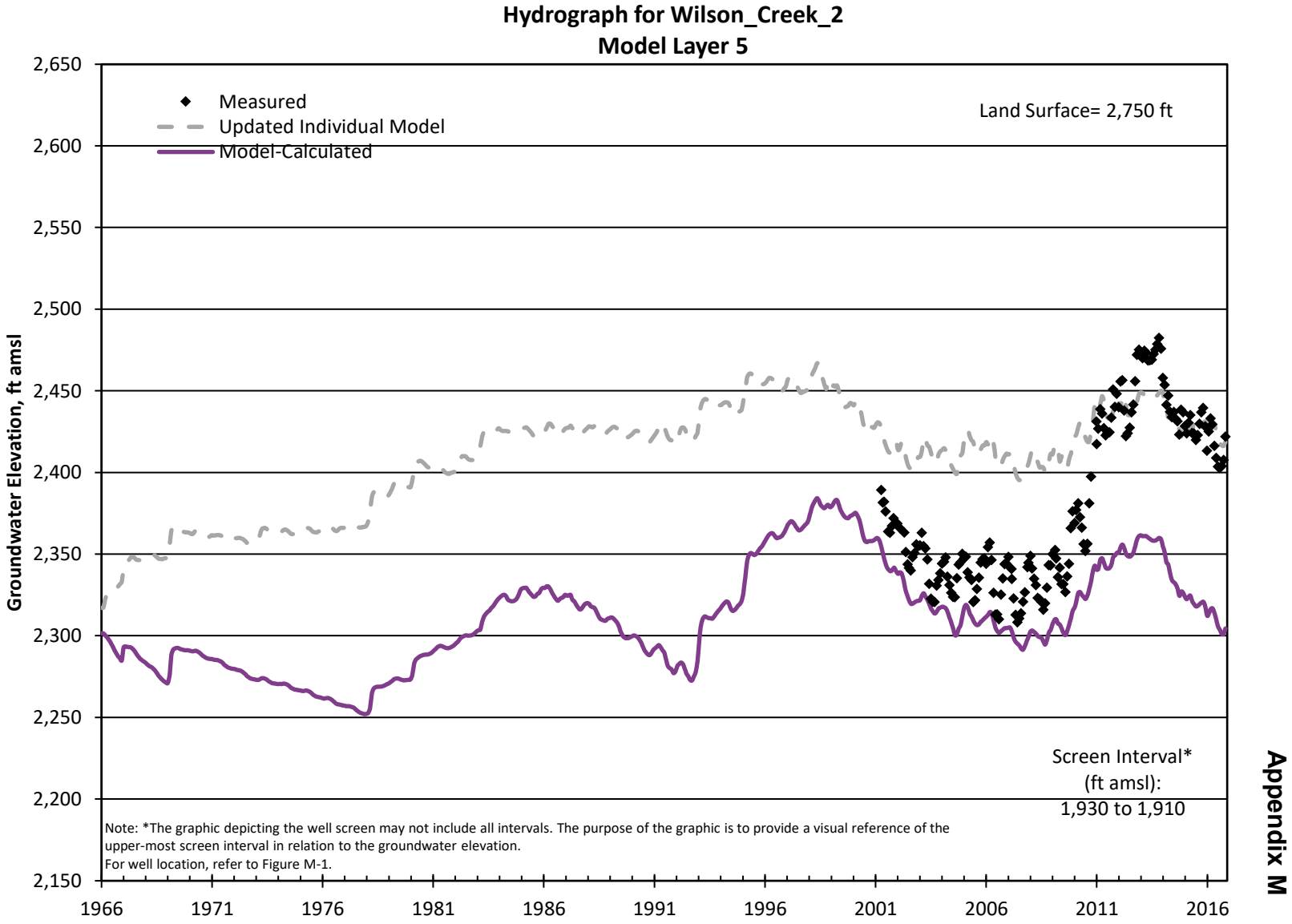
Appendix M


Hydrograph for USGS_Monitoring_Well_5
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,070 ft
Groundwater Elevation, ft amsl
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1,500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,630 to 1,610
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

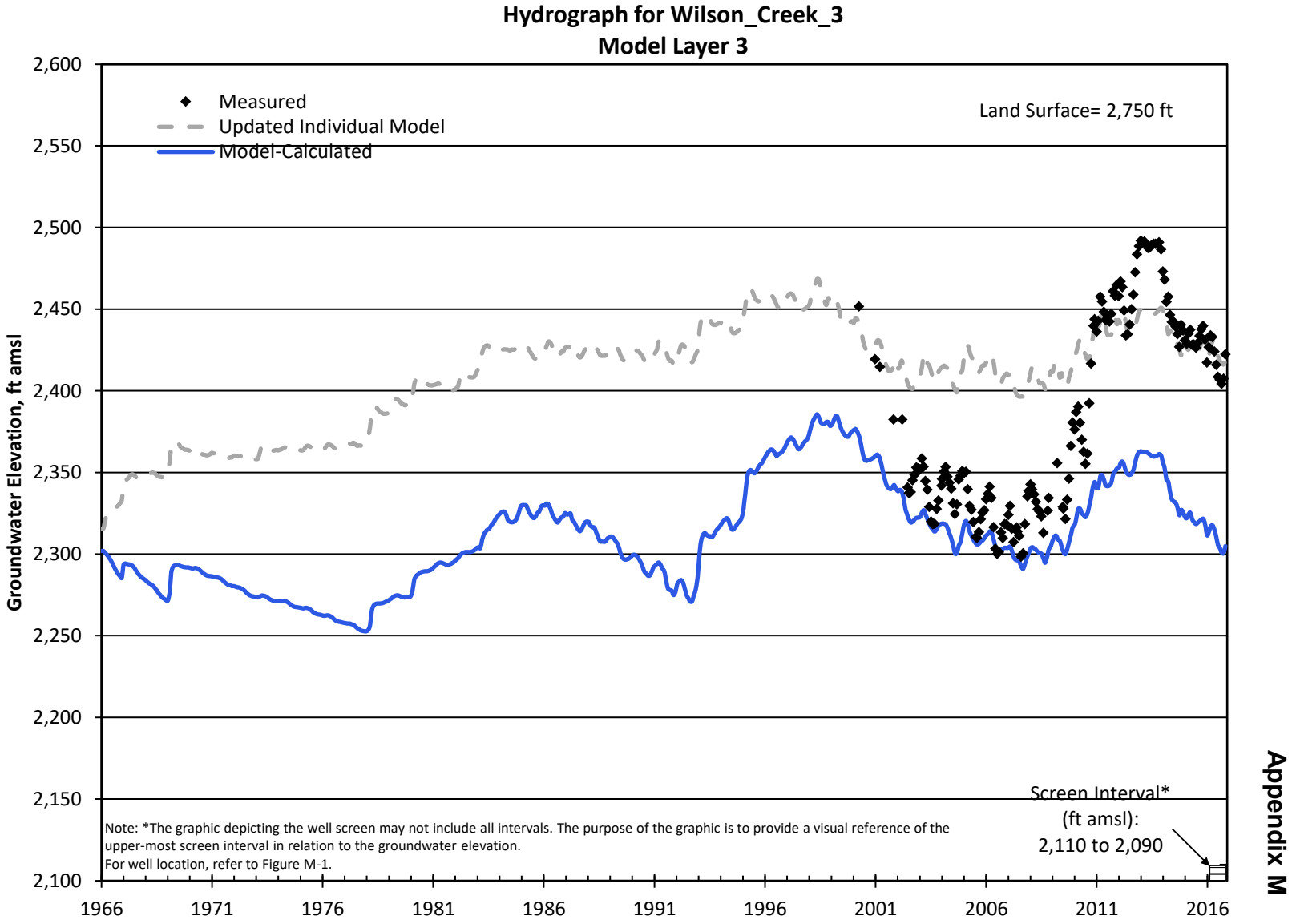
Appendix M


Hydrograph for USGS_Monitoring_Well_6
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,070 ft
Screen Interval*
(ft amsl):
1,840 to 1,820
Groundwater Elevation, ft amsl
2,100
2,050
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

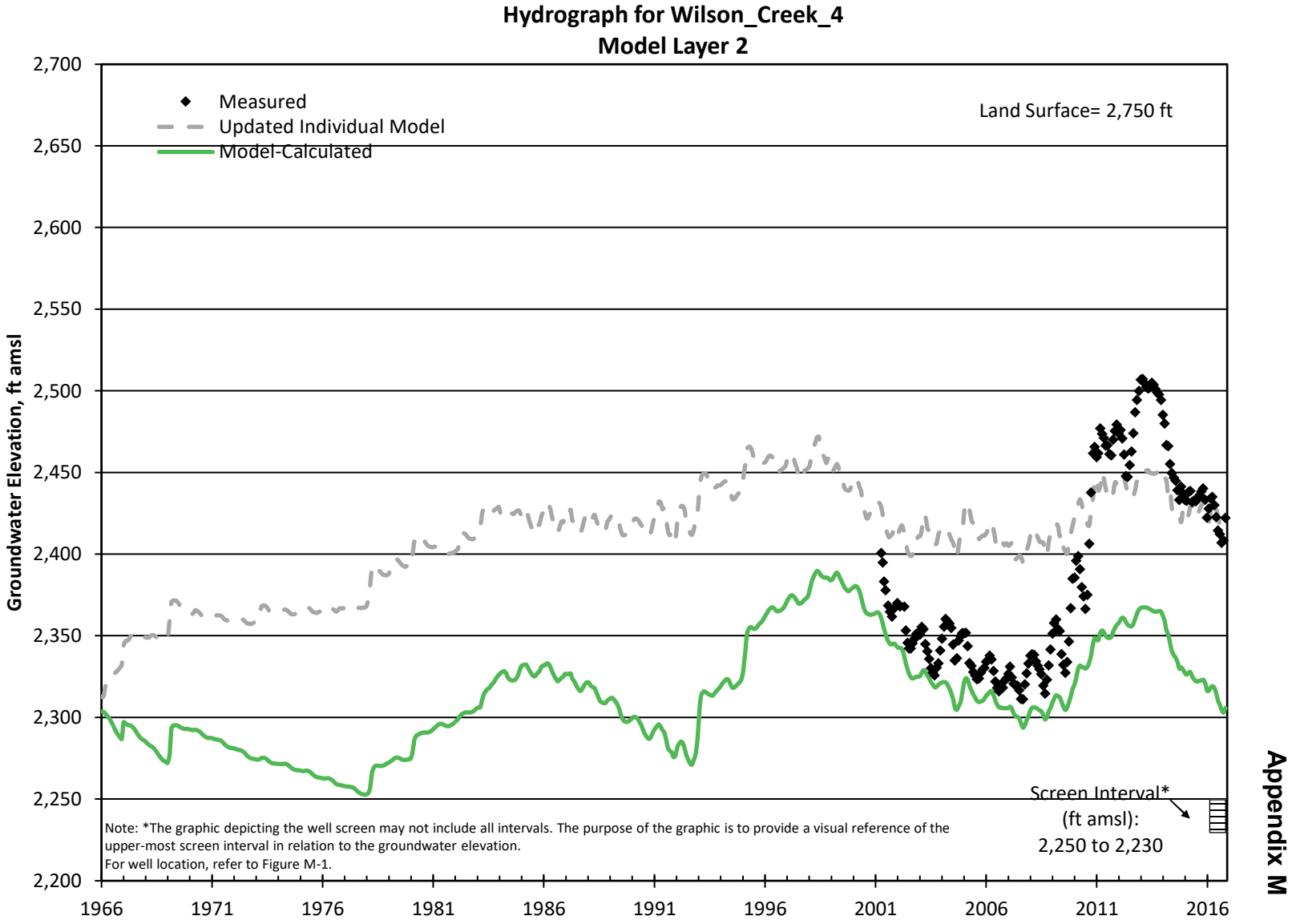
Appendix M


Hydrograph for Wilson_Creek_2
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,750 ft
Groundwater Elevation, ft amsl
2,650
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,930 to 1,910
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

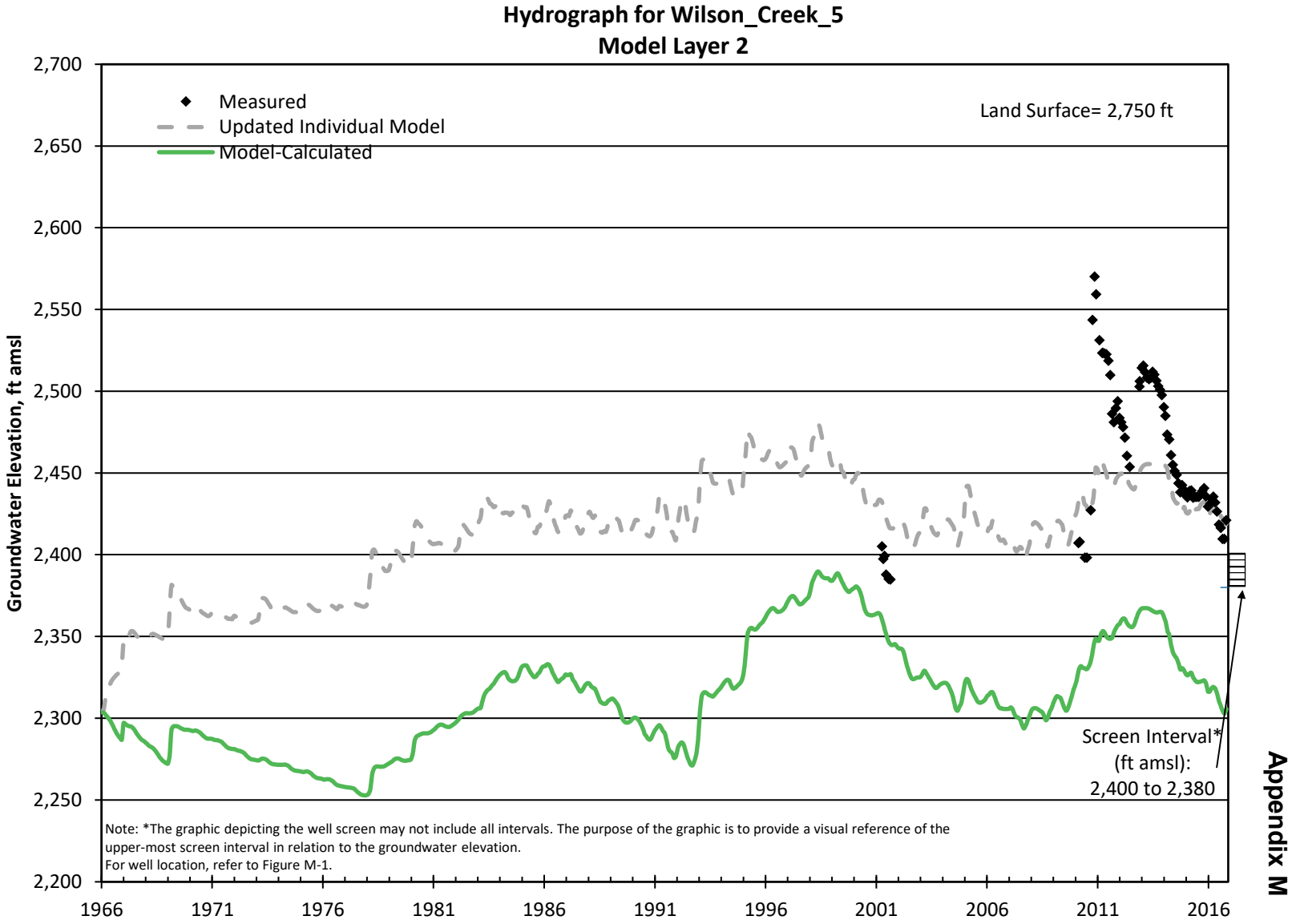
Appendix M


Hydrograph for Wilson_Creek_3
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,750 ft
Groundwater Elevation, ft amsl
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,110 to 2,090
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

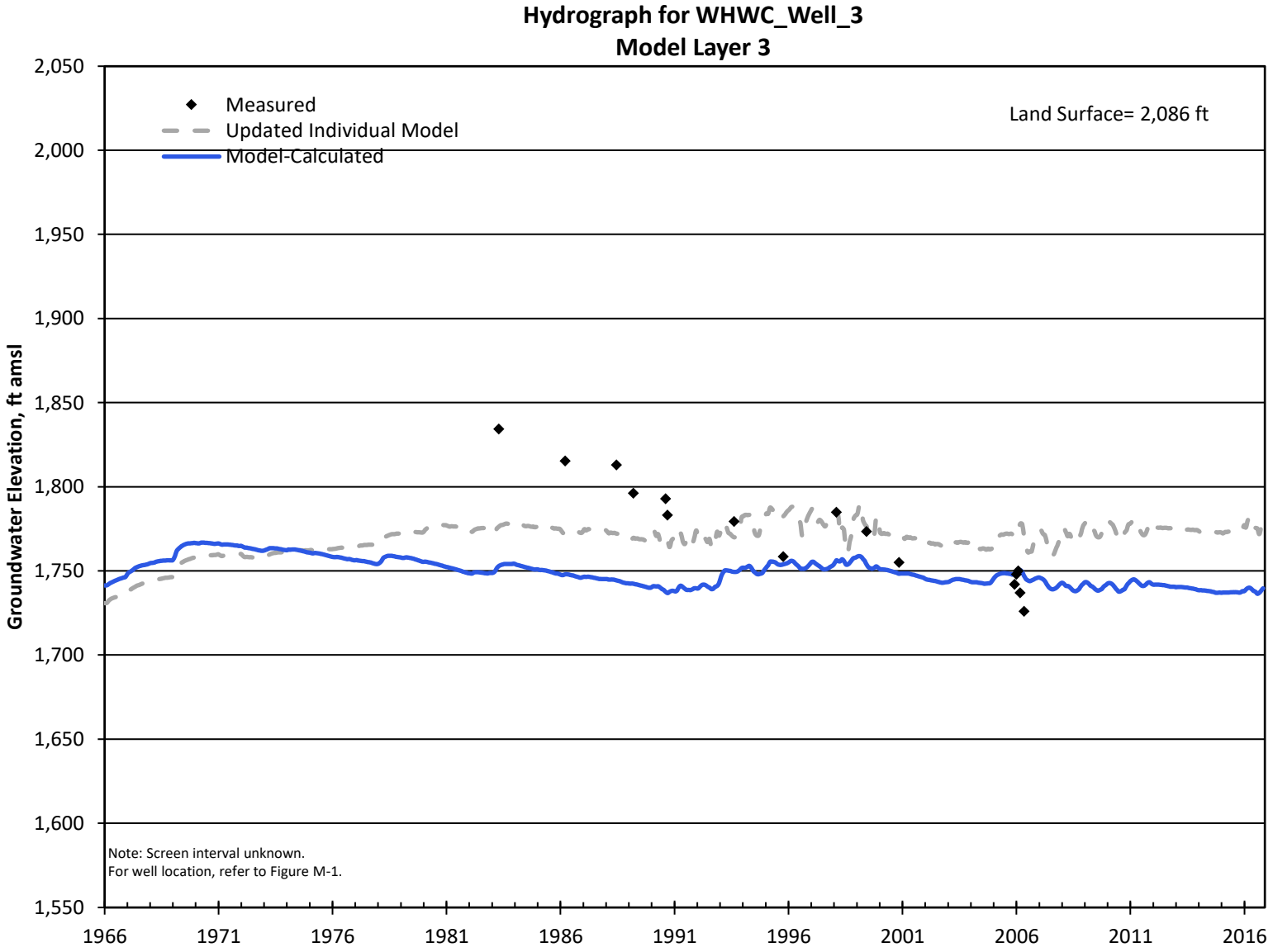
Appendix M


Hydrograph for Wilson_Creek_4
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,750 ft
Groundwater Elevation, ft amsl
2,700
2,650
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,250 to 2,230
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

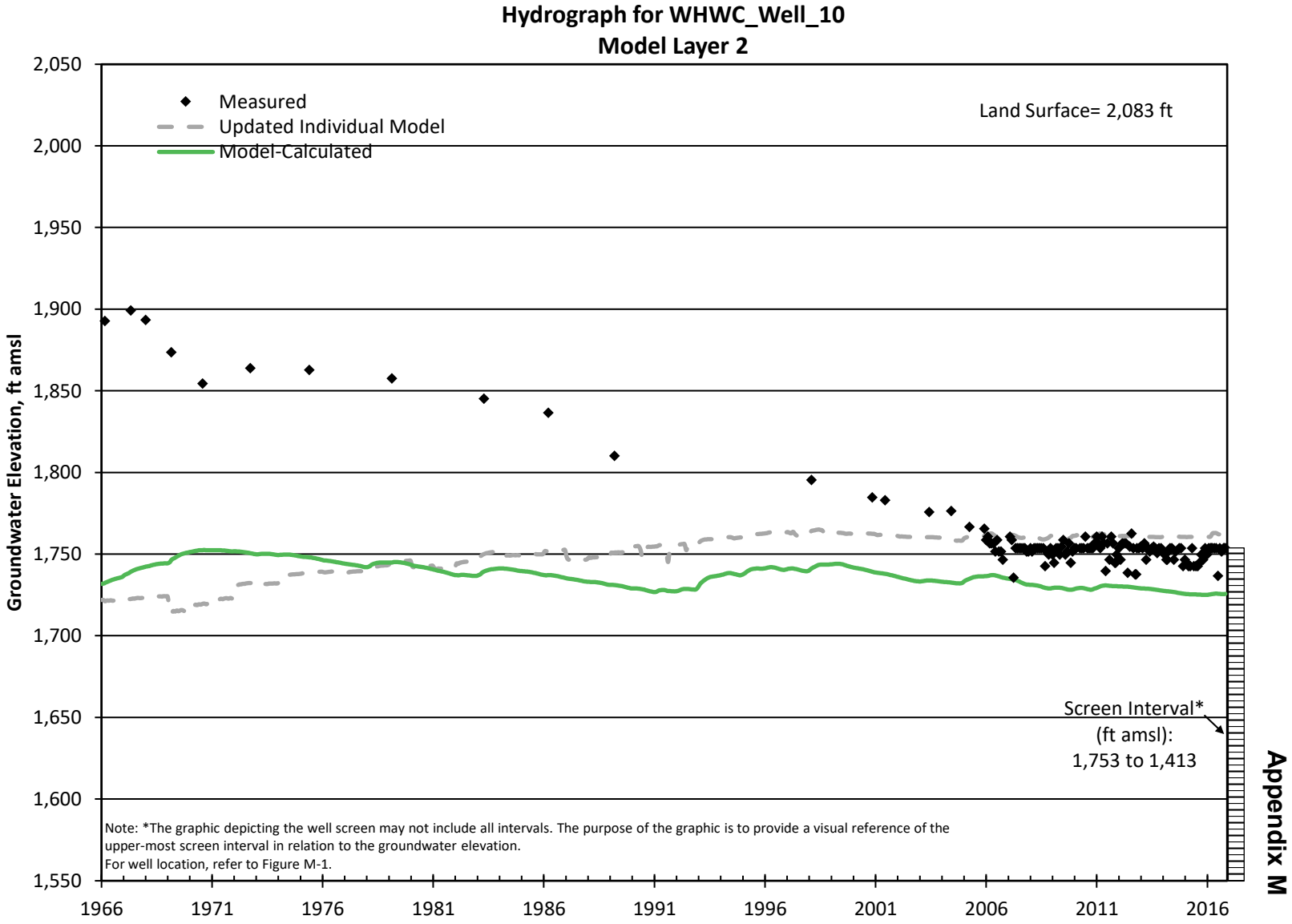
Appendix M

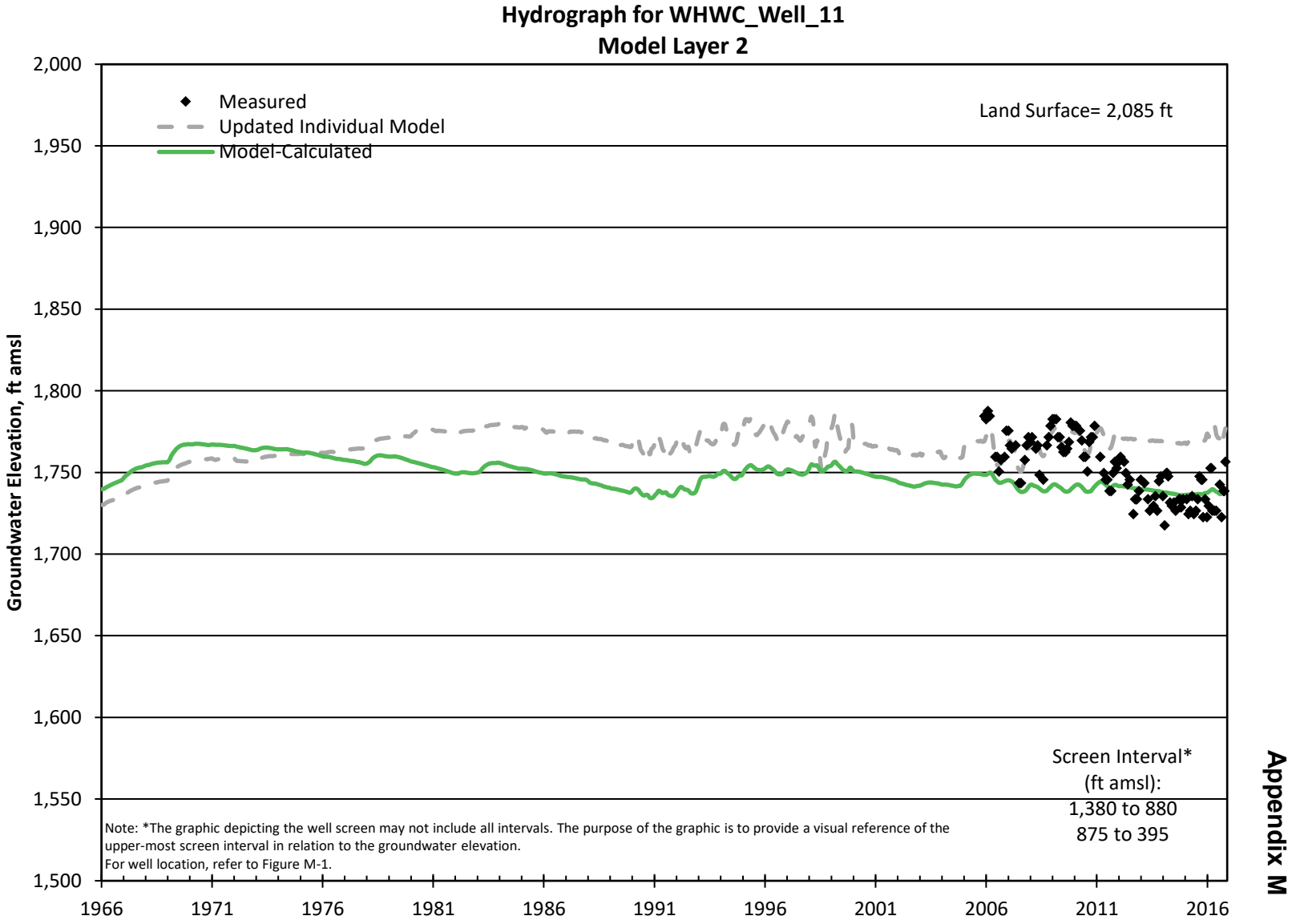

Hydrograph for Wilson_Creek_5
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,750 ft
Groundwater Elevation, ft amsl
2,700
2,650
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,400 to 2,380
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

Appendix M

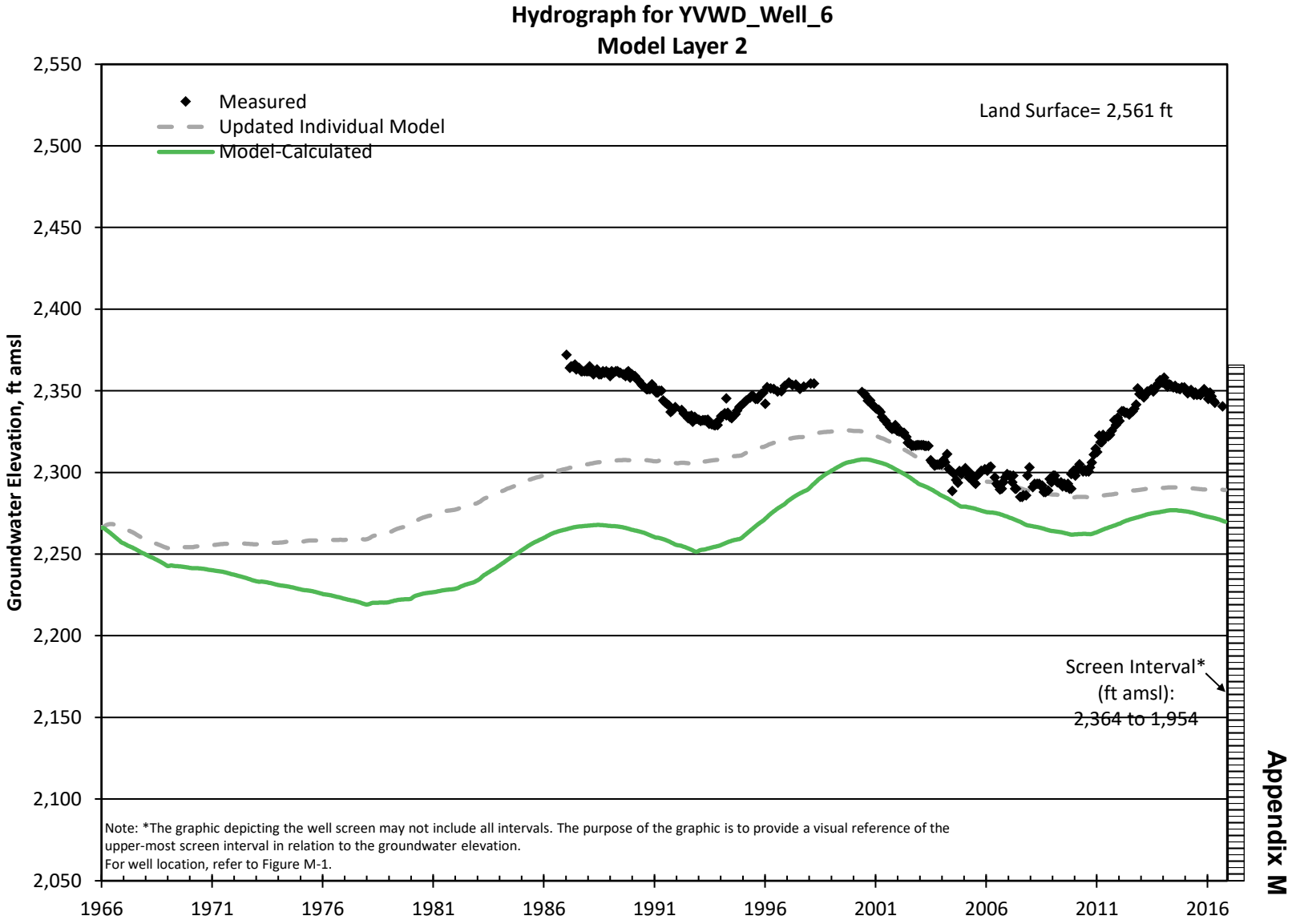

Hydrograph for WHWC_Well_3
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,086 ft
Groundwater Elevation, ft amsl
2,050
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure M-1.

Appendix M

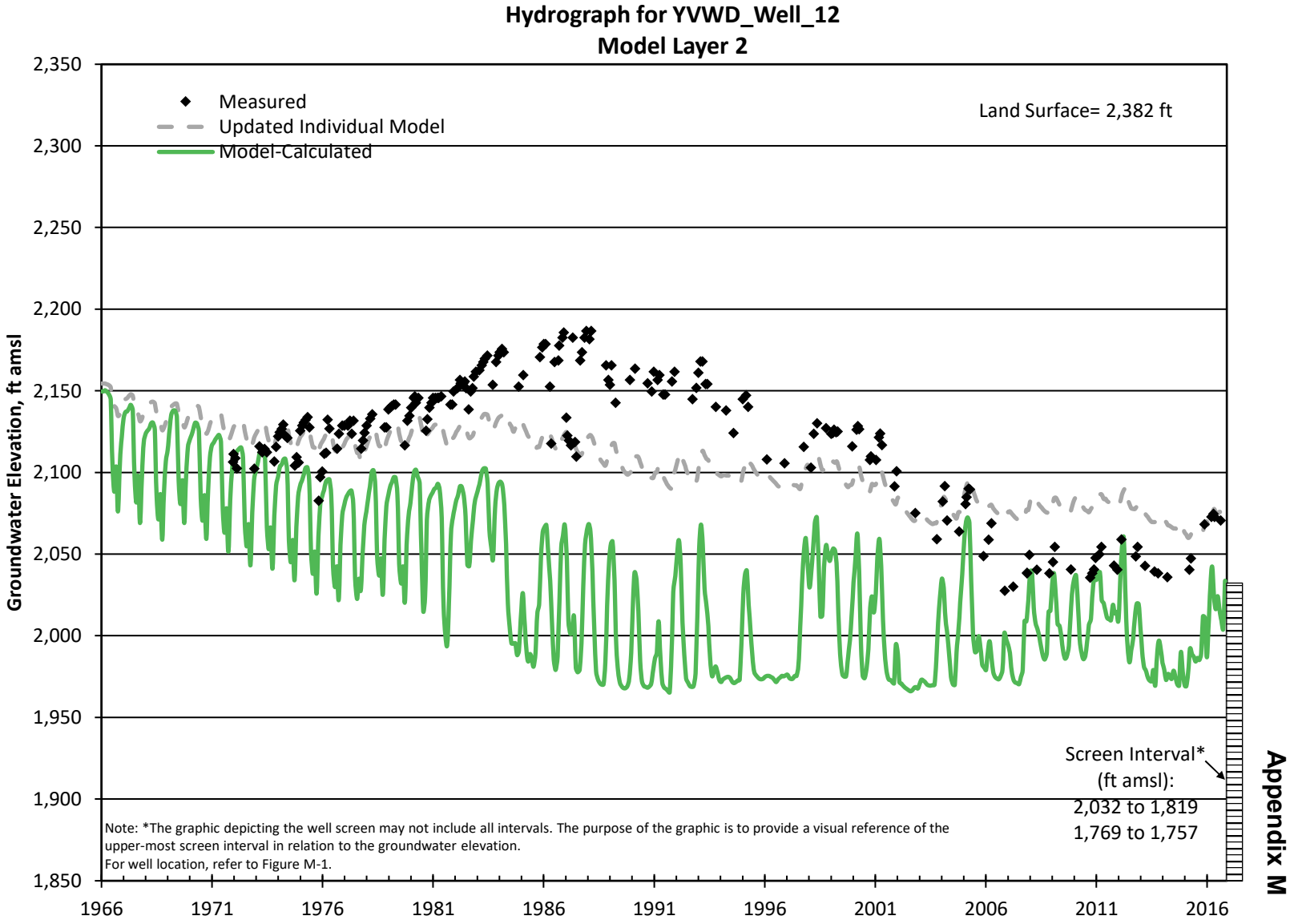

Hydrograph for WHWC_Well_10
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,083 ft
Groundwater Elevation, ft amsl
2,050
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,753 to 1,413
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.
Appendix M

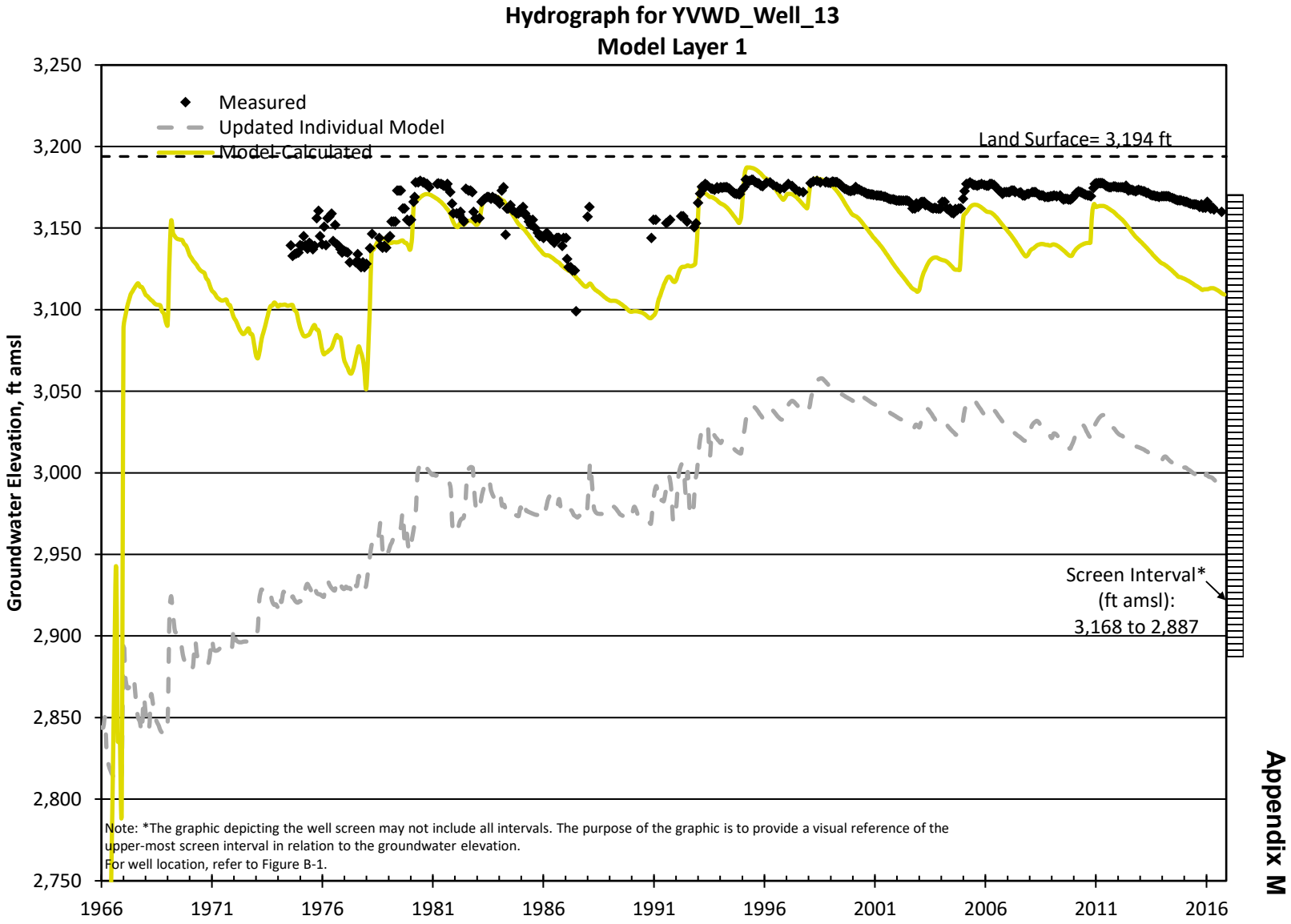

Hydrograph for WHWC_Well_11
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,085 ft
Groundwater Elevation, ft amsl
2,000
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1,500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,380 to 880
875 to 395
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

Appendix M

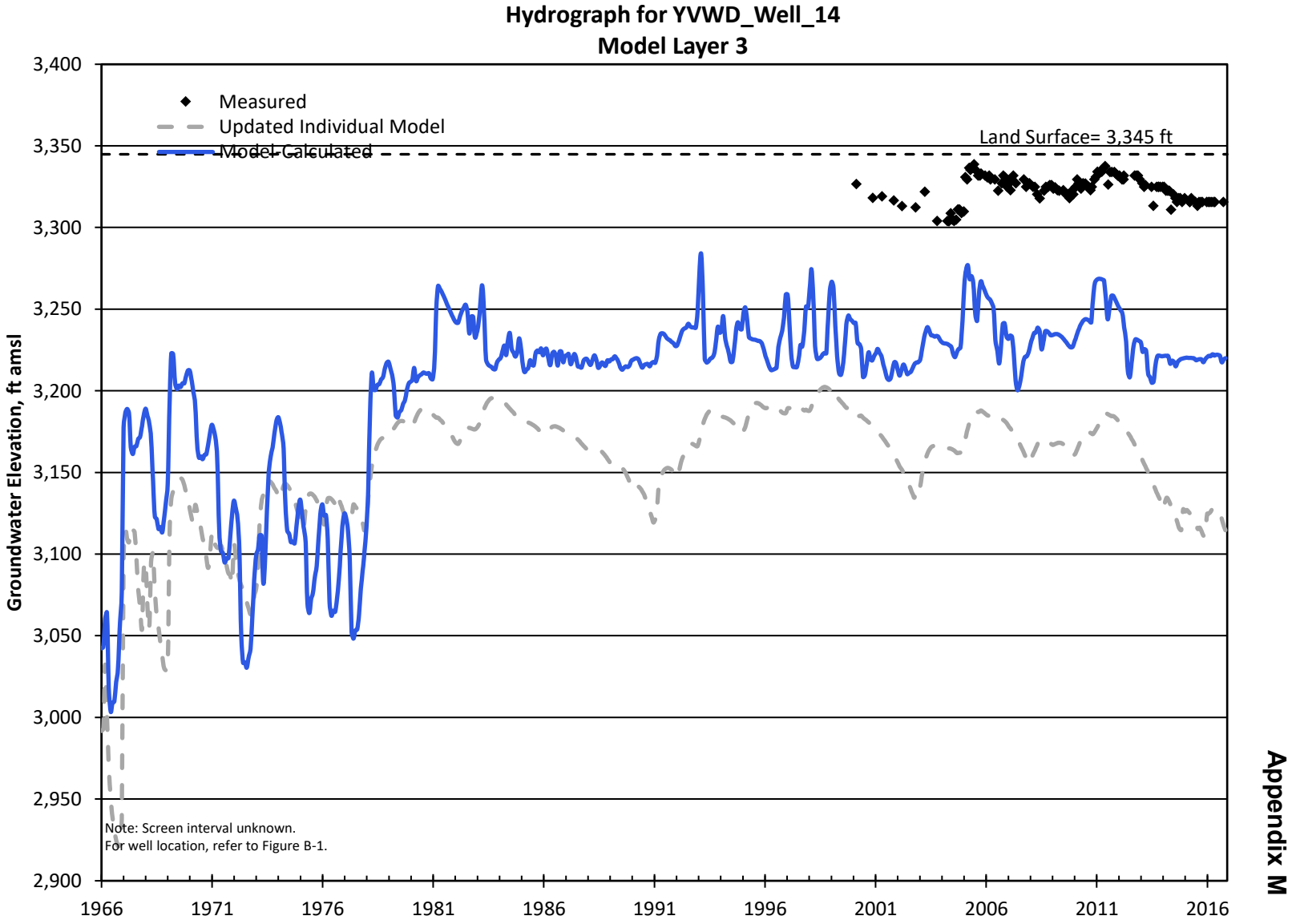

Hydrograph for YVWD_Well_6
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,561 ft
Groundwater Elevation, ft amsl
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,364 to 1,954
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

Appendix M

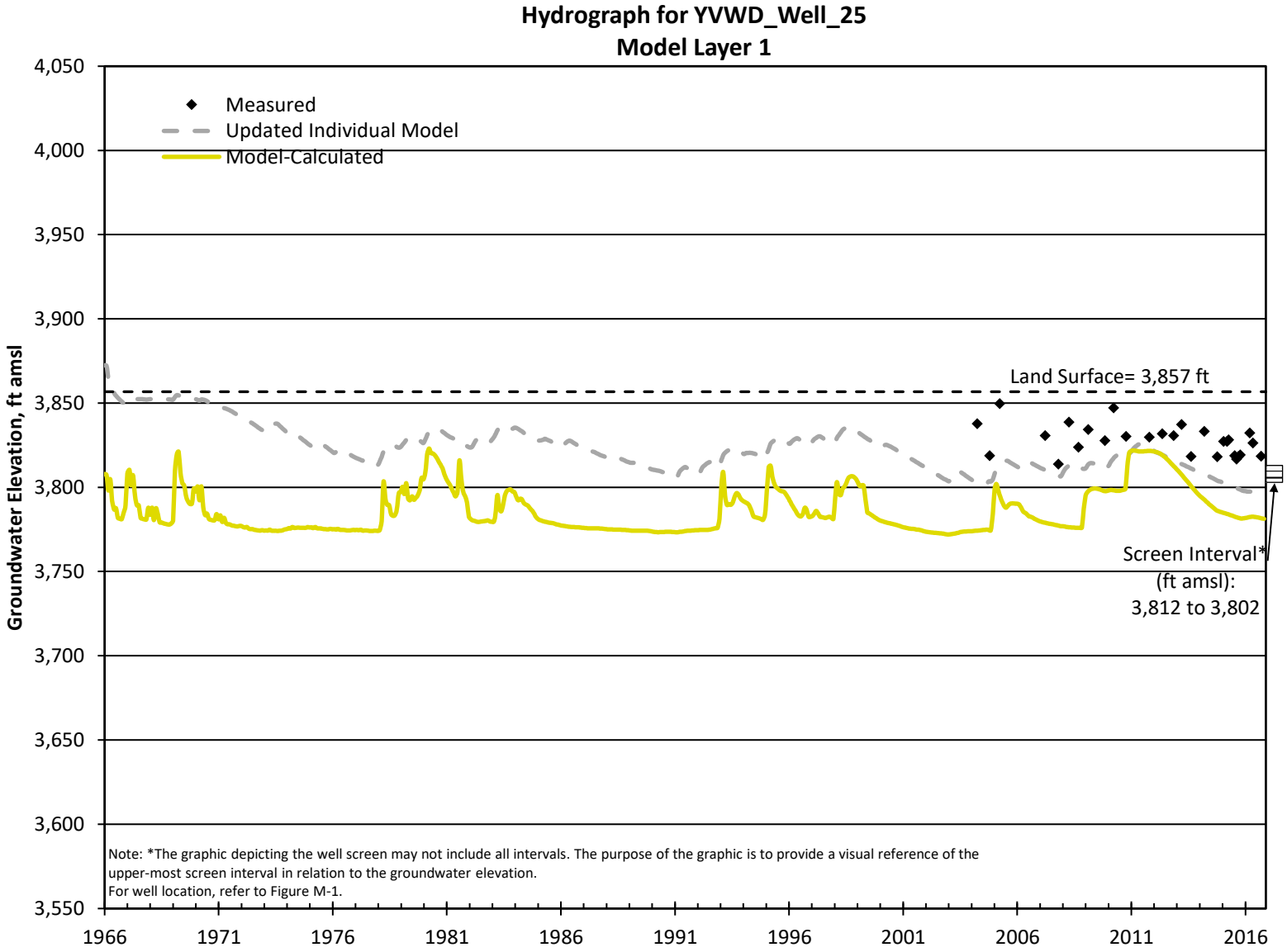

Hydrograph for YVWD_Well_12
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,382 ft
Groundwater Elevation, ft amsl
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1,950
1,900
1,850
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,032 to 1,819
1,769 to 1,757
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.
Appendix M


Hydrograph for YVWD_Well_13
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 3,194 ft
Screen Interval*
(ft amsl):
3,168 to 2,887
Groundwater Elevation, ft amsl
3,250
3,200
3,150
3,100
3,050
3,000
2,950
2,900
2,850
2,800
2,750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure B-1.

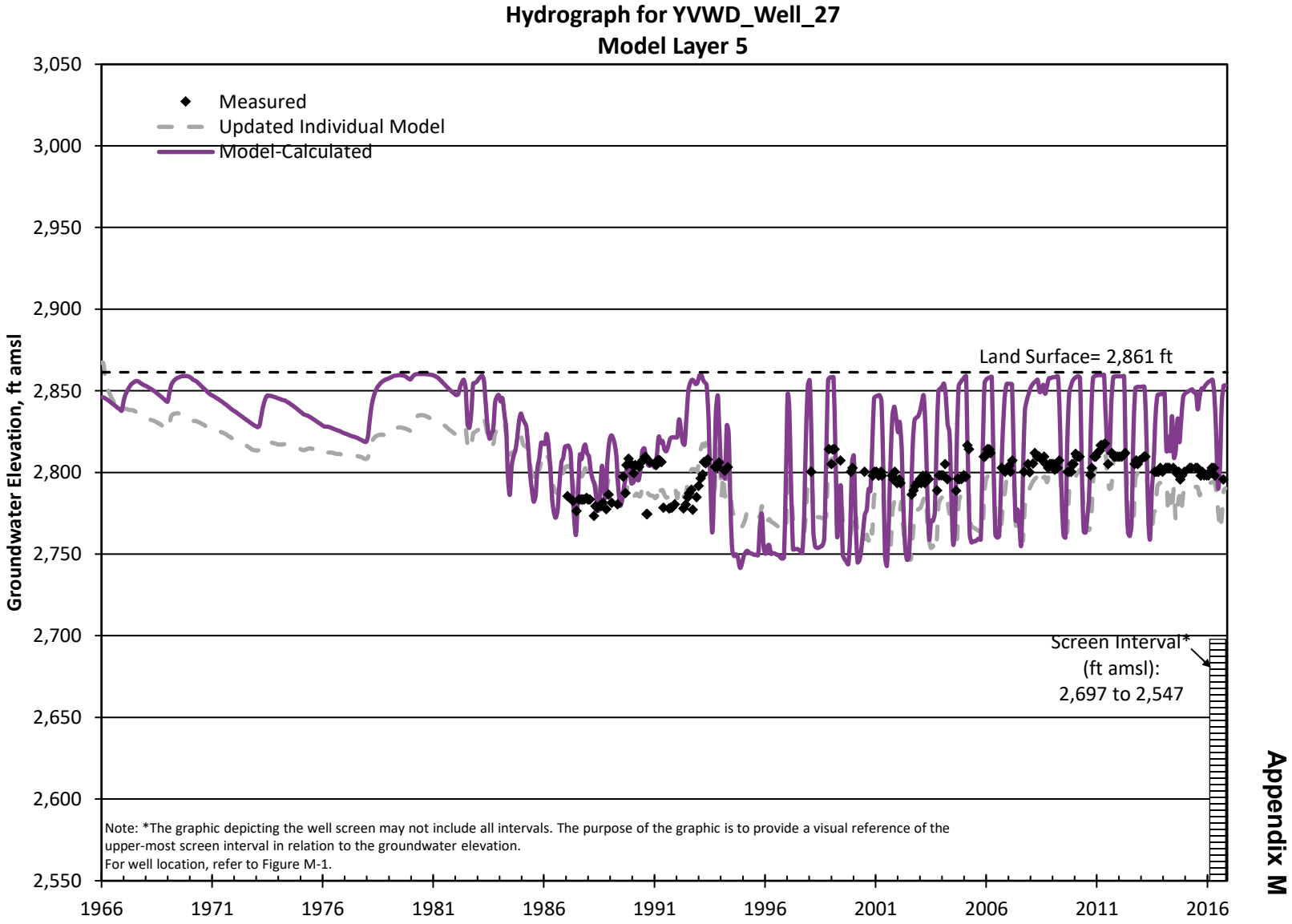
Appendix M


Hydrograph for YVWD_Well_14
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 3,345 ft
Groundwater Elevation, ft amsl
3,400
3,350
3,300
3,250
3,200
3,150
3,100
3,050
3,000
2,950
2,900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure B-1.

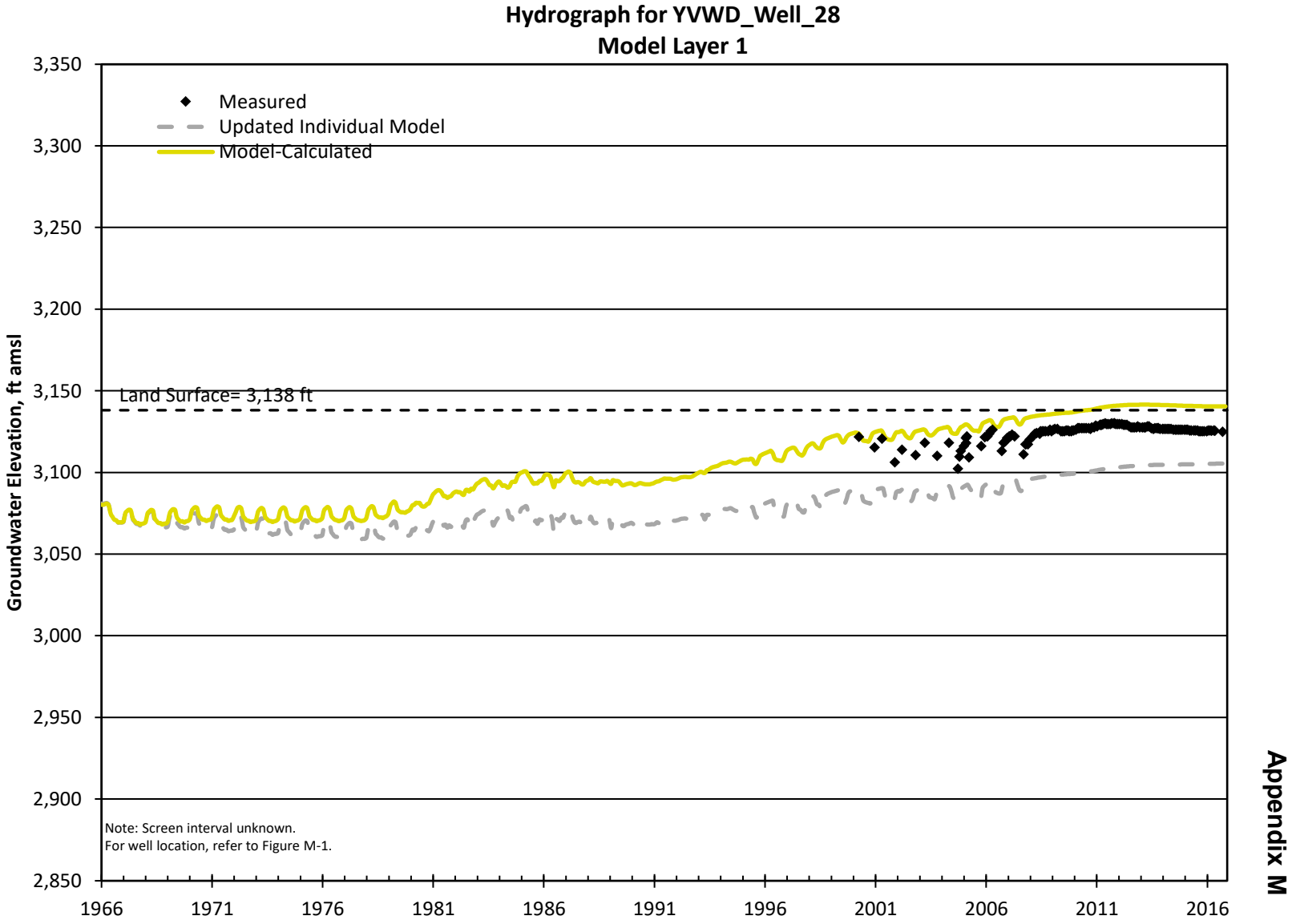
Appendix M


Hydrograph for YVWD_Well_25
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 3,857 ft
Screen Interval*
(ft amsl):
3,812 to 3,802
Groundwater Elevation, ft amsl
4,050
4,000
3,950
3,900
3,850
3,800
3,750
3,700
3,650
3,600
3,550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

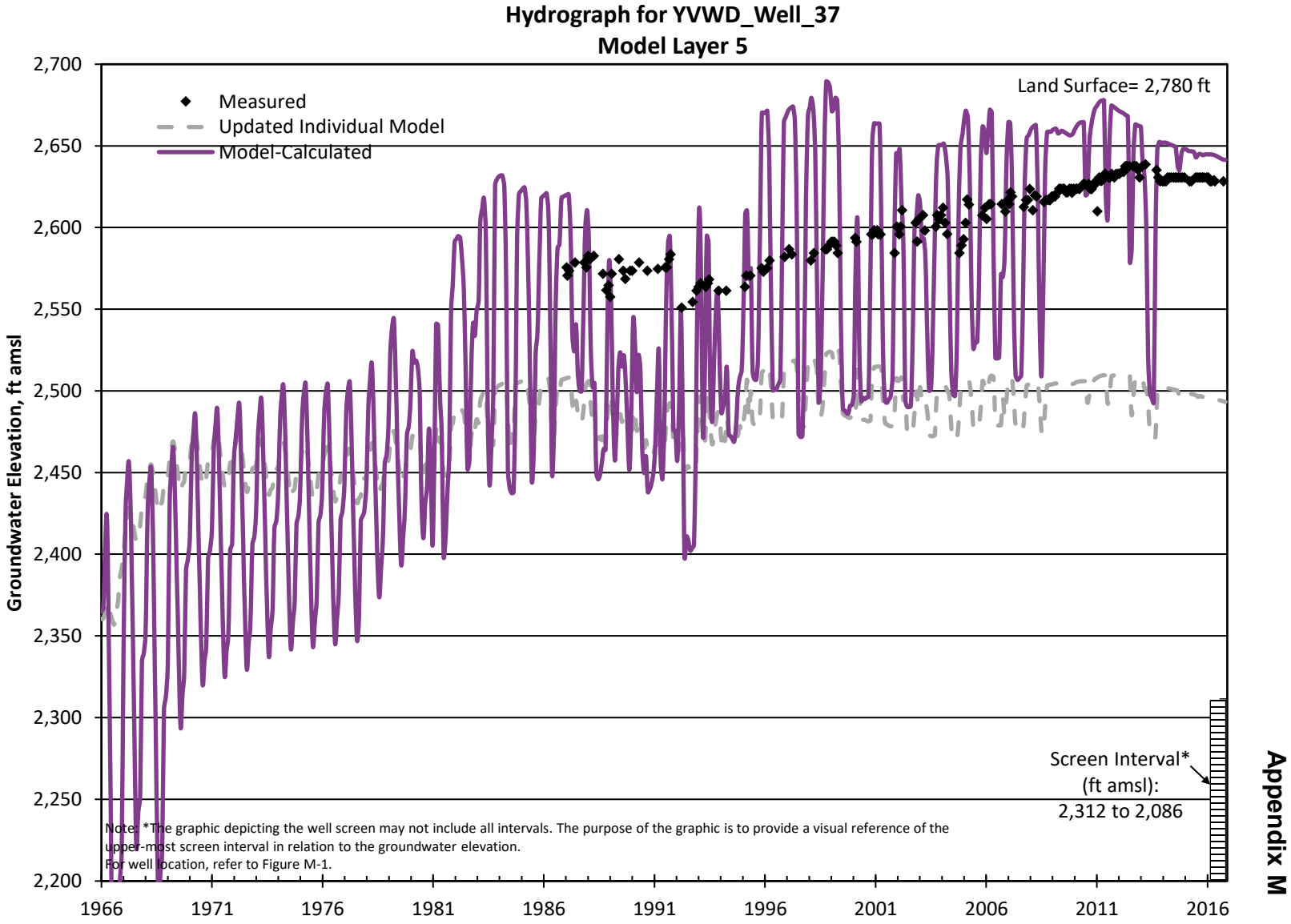
Appendix M


Hydrograph for YVWD_Well_27
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,861 ft
Screen Interval*
(ft amsl):
2,697 to 2,547
Groundwater Elevation, ft amsl
3,050
3,000
2,950
2,900
2,850
2,800
2,750
2,700
2,650
2,600
2,550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

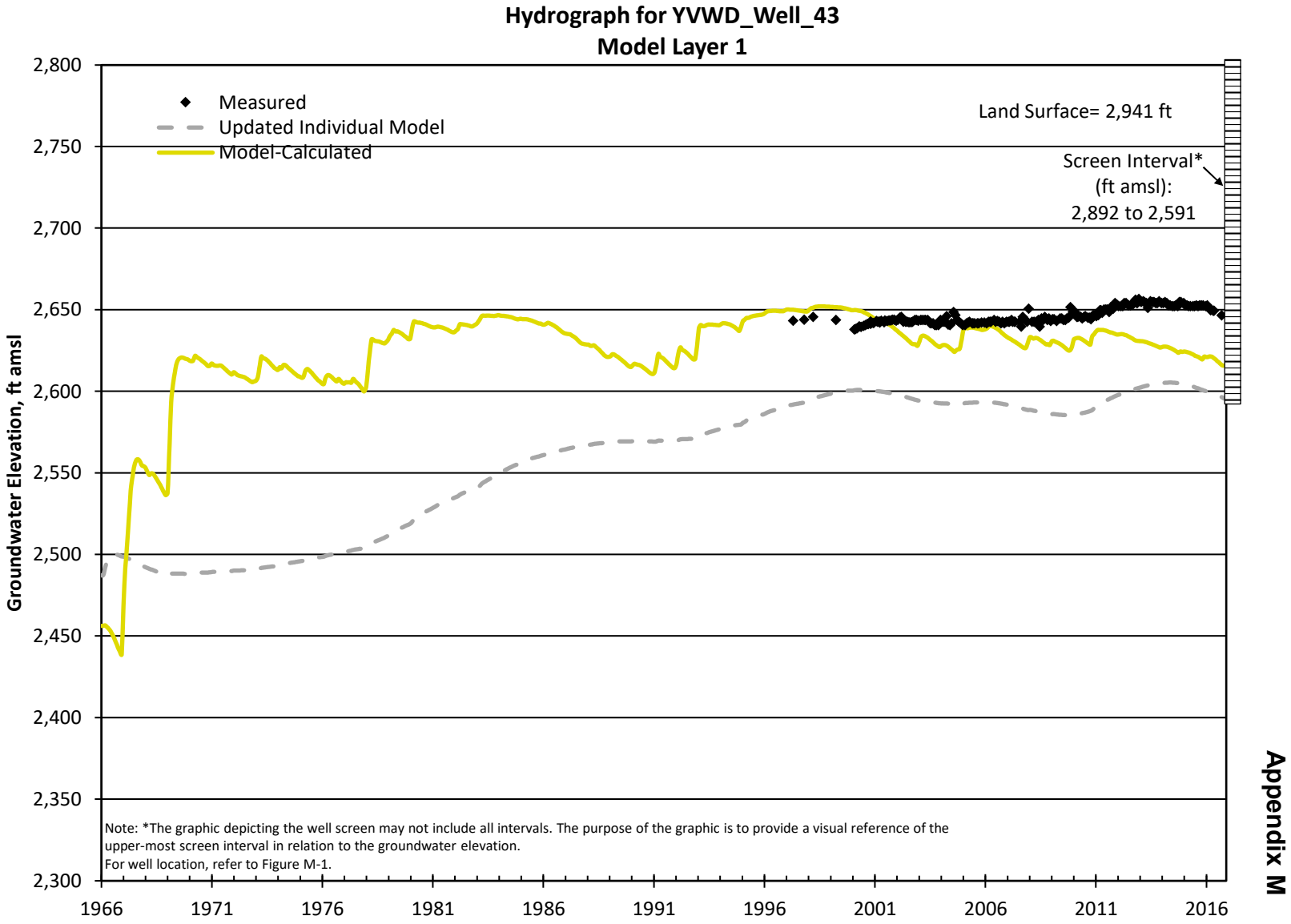
Appendix M


Hydrograph for YVWD_Well_28
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 3,138 ft
Groundwater Elevation, ft amsl
3,350
3,300
3,250
3,200
3,150
3,100
3,050
3,000
2,950
2,900
2,850
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure M-1.

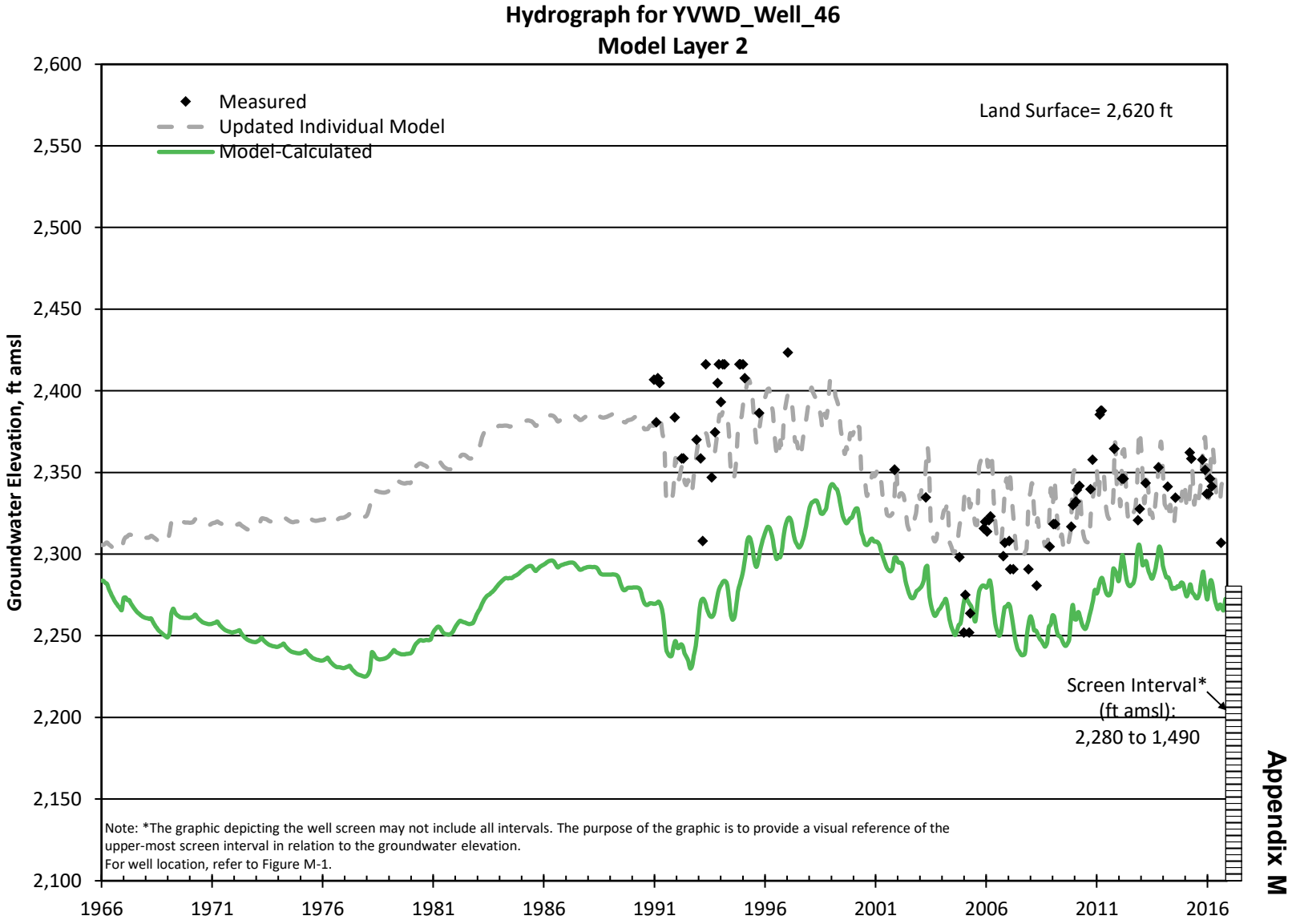
Appendix M


Hydrograph for YVWD_Well_37
Model Layer 5
Land Surface= 2,780 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
2,700
2,650
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,312 to 2,086
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

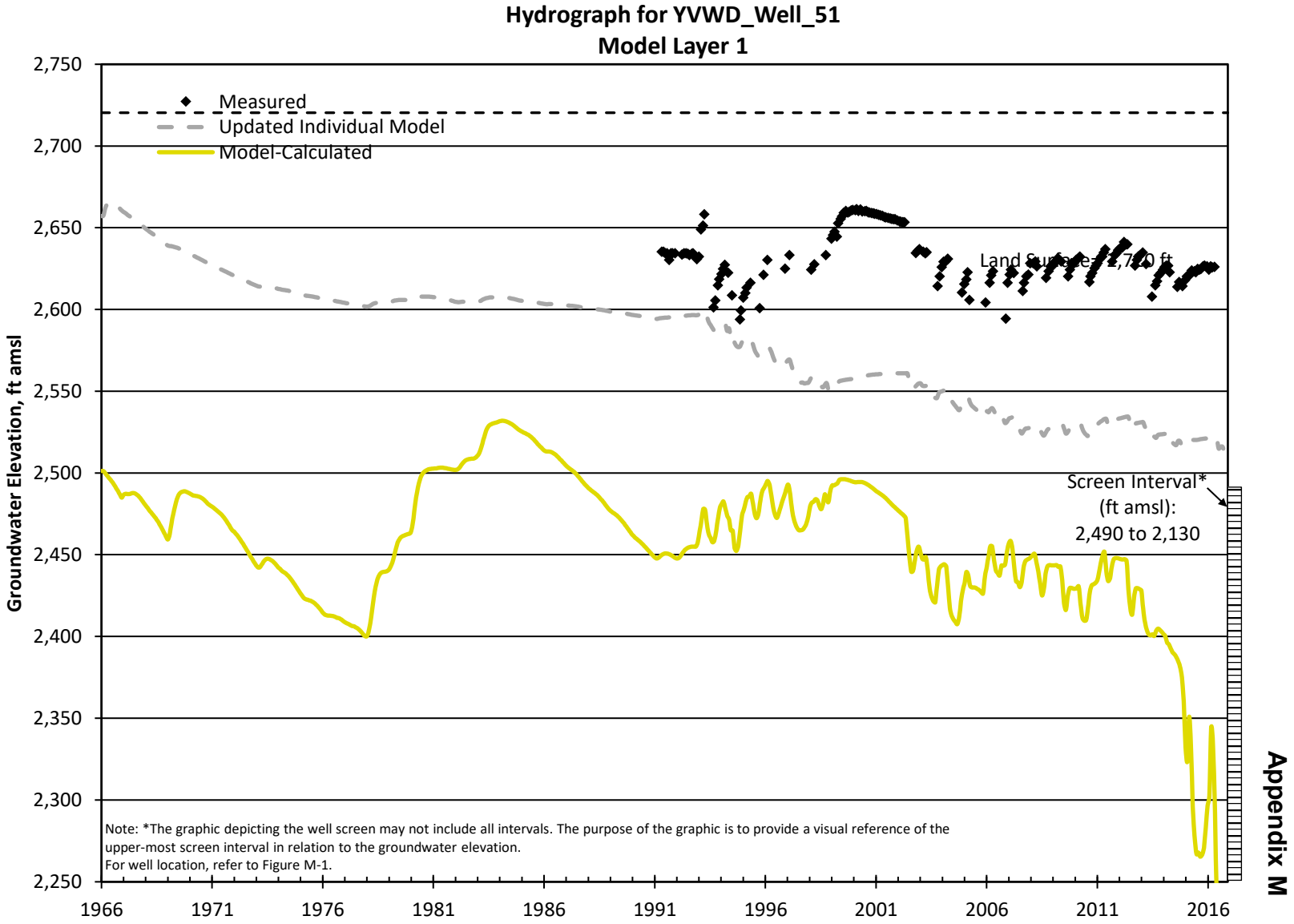
Appendix M


Hydrograph for YVWD_Well_43
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,941 ft
Screen Interval*
(ft amsl):
2,892 to 2,591
Groundwater Elevation, ft amsl
2,800
2,750
2,700
2,650
2,600
2,550
2,500
2,450
2,400
2,350
2,300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

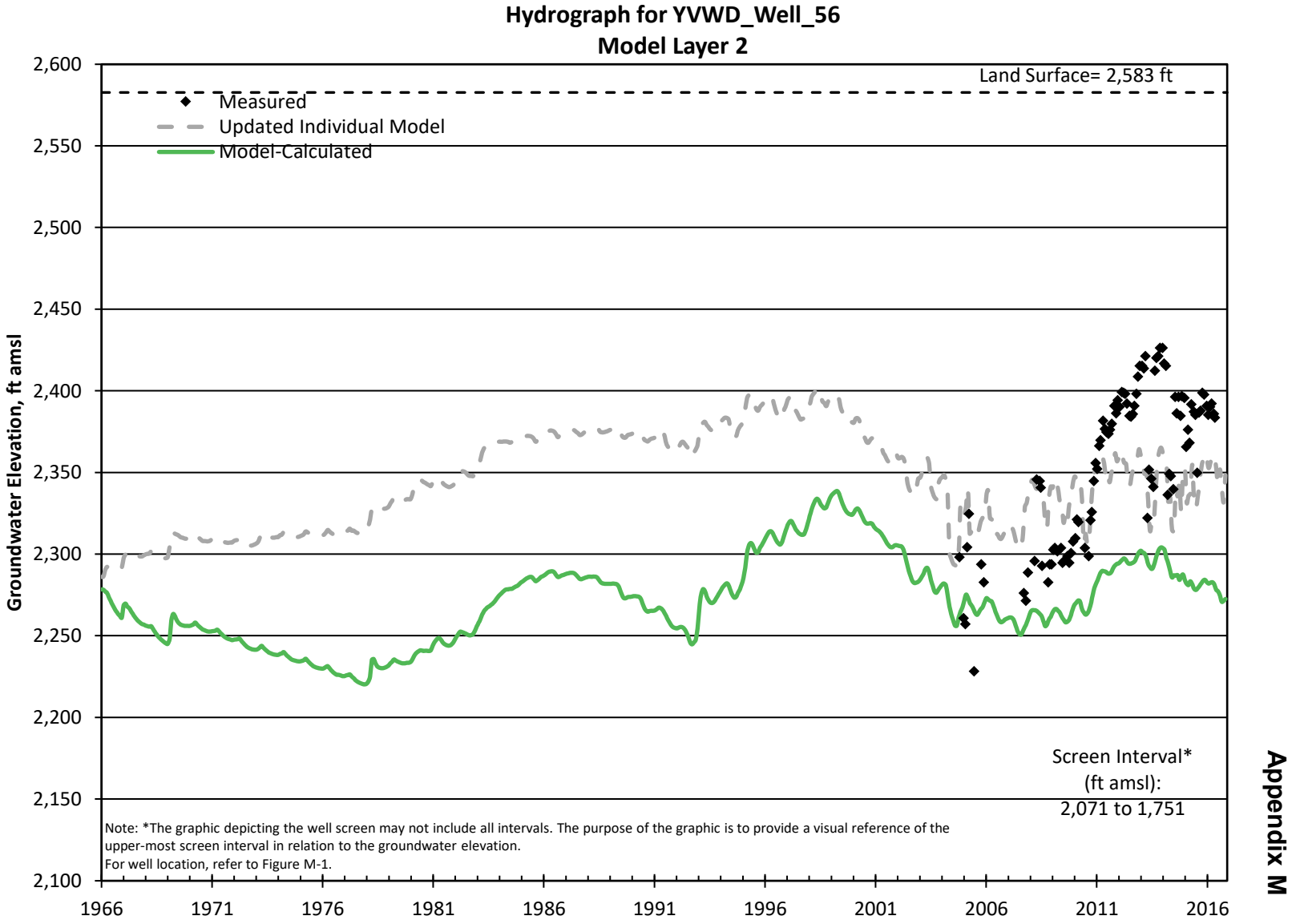
Appendix M


Hydrograph for YVWD_Well_46
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,620 ft
Groundwater Elevation, ft amsl
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,280 to 1,490
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

Appendix M


Hydrograph for YVWD_Well_51
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface: 2,740 ft
Screen Interval*
(ft amsl):
2,490 to 2,130
Groundwater Elevation, ft amsl
2,750
2,700
2,650
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

Appendix M


Hydrograph for YVWD_Well_56
Model Layer 2
Land Surface= 2,583 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
2,071 to 1,751
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure M-1.

Appendix M

APPENDIX N

Integrated SAR Model: Selected Hydrographs for Target Wells in the San Bernardino Basin Model Area – 1966 to 2016

GEOSCIENCE

©2020, GEOSCIENCE Support Services, Inc. All rights reserved. Drawn By: DB. Projection: State Plane 1983, Zone V.

SELECTED TARGET WELLS USED FOR HYDROGRAPHS SAN BERNARDINO BASIN MODEL AREA 1966 TO 2016

W:\GIS_proj\sbvmwd_SARiverStudyModel_2017\53_SumRpt_Fig_N-1_SBBA_Wells_labeled_4-20.mxd

10-Apr-20

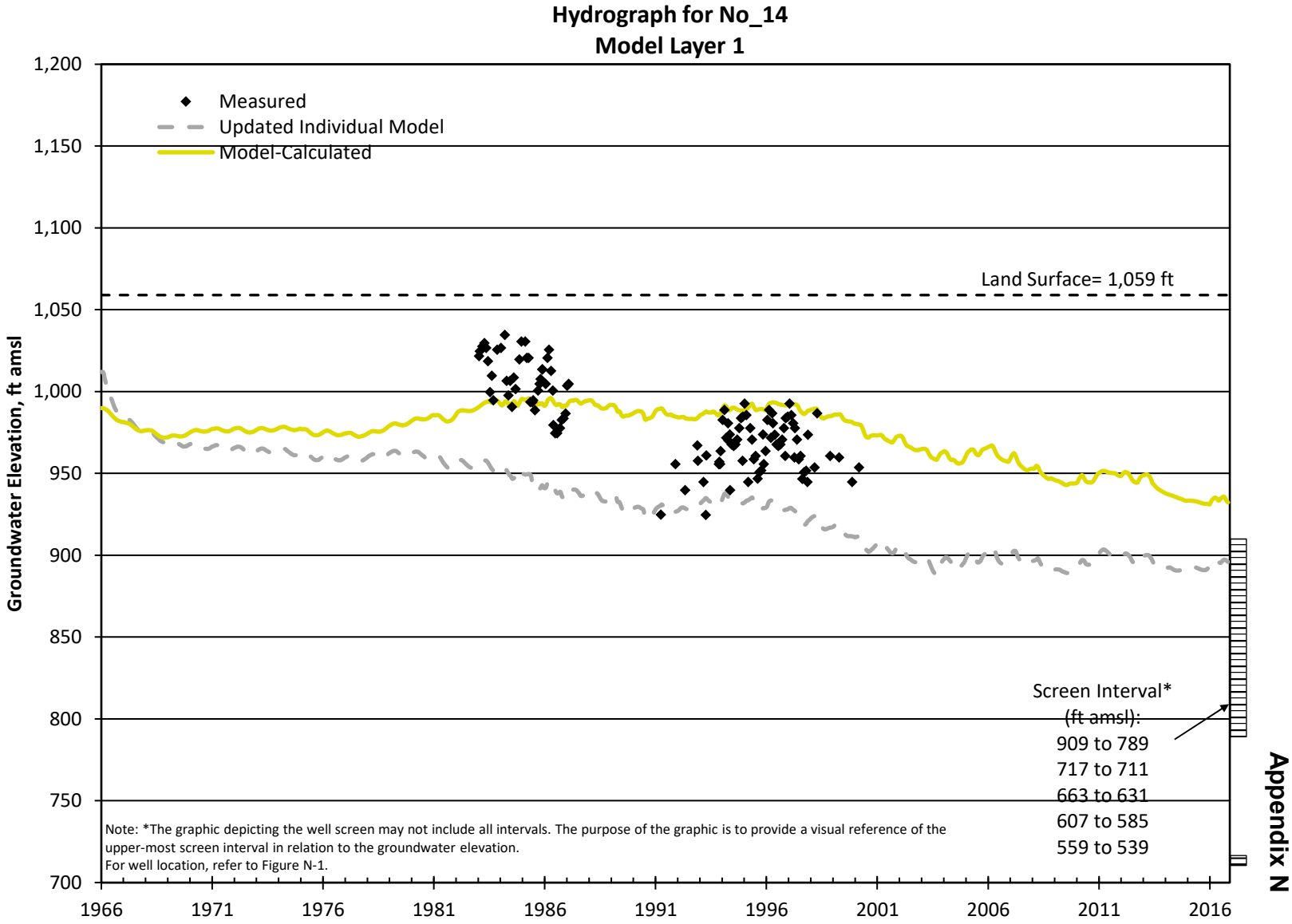
SAN BERNARDINO VALLEY MUNICIPAL WATER DISTRICT

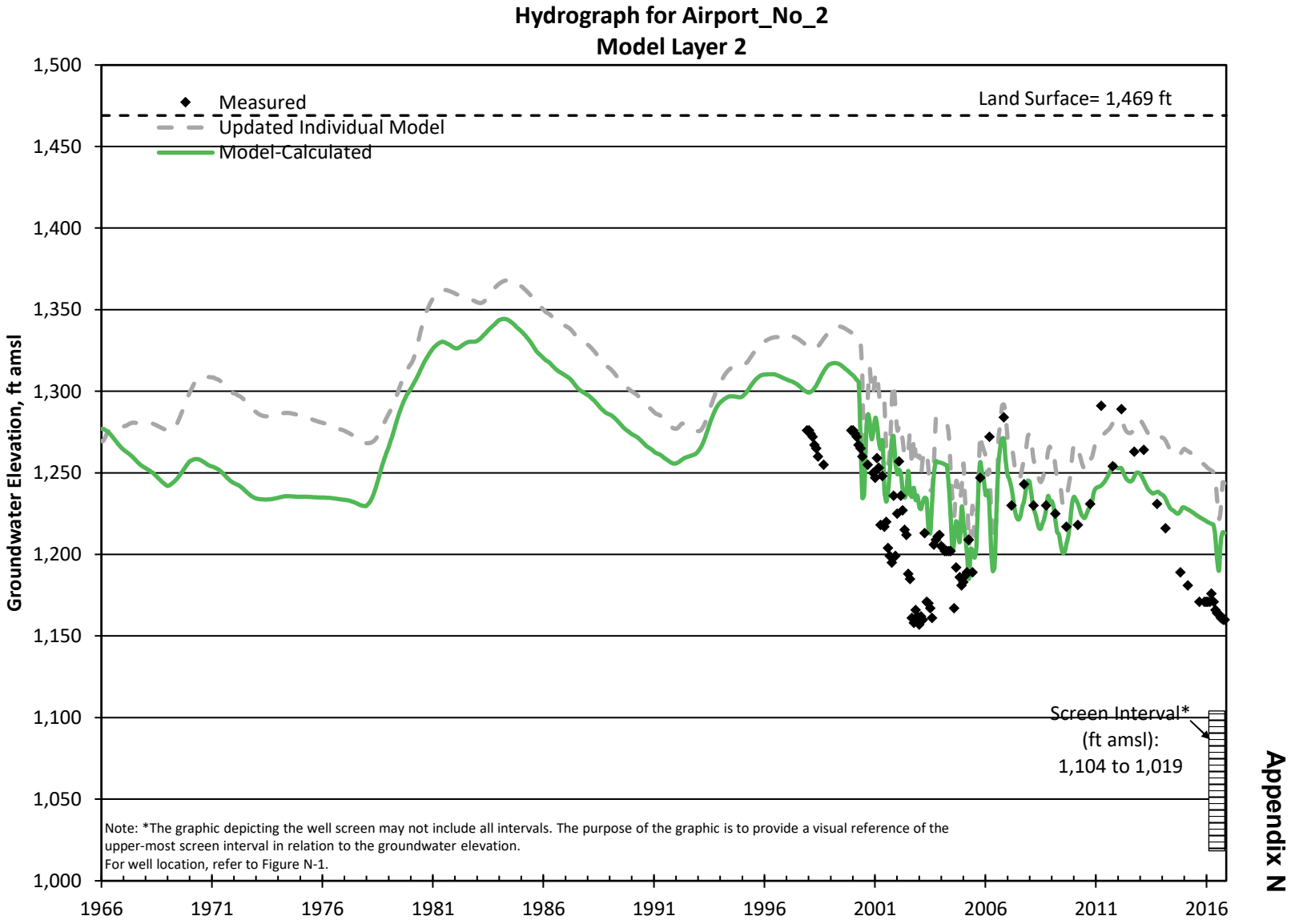
UPPER SANTA ANA RIVER INTEGRATED MODEL - SUMMARY REPORT

DRAFT

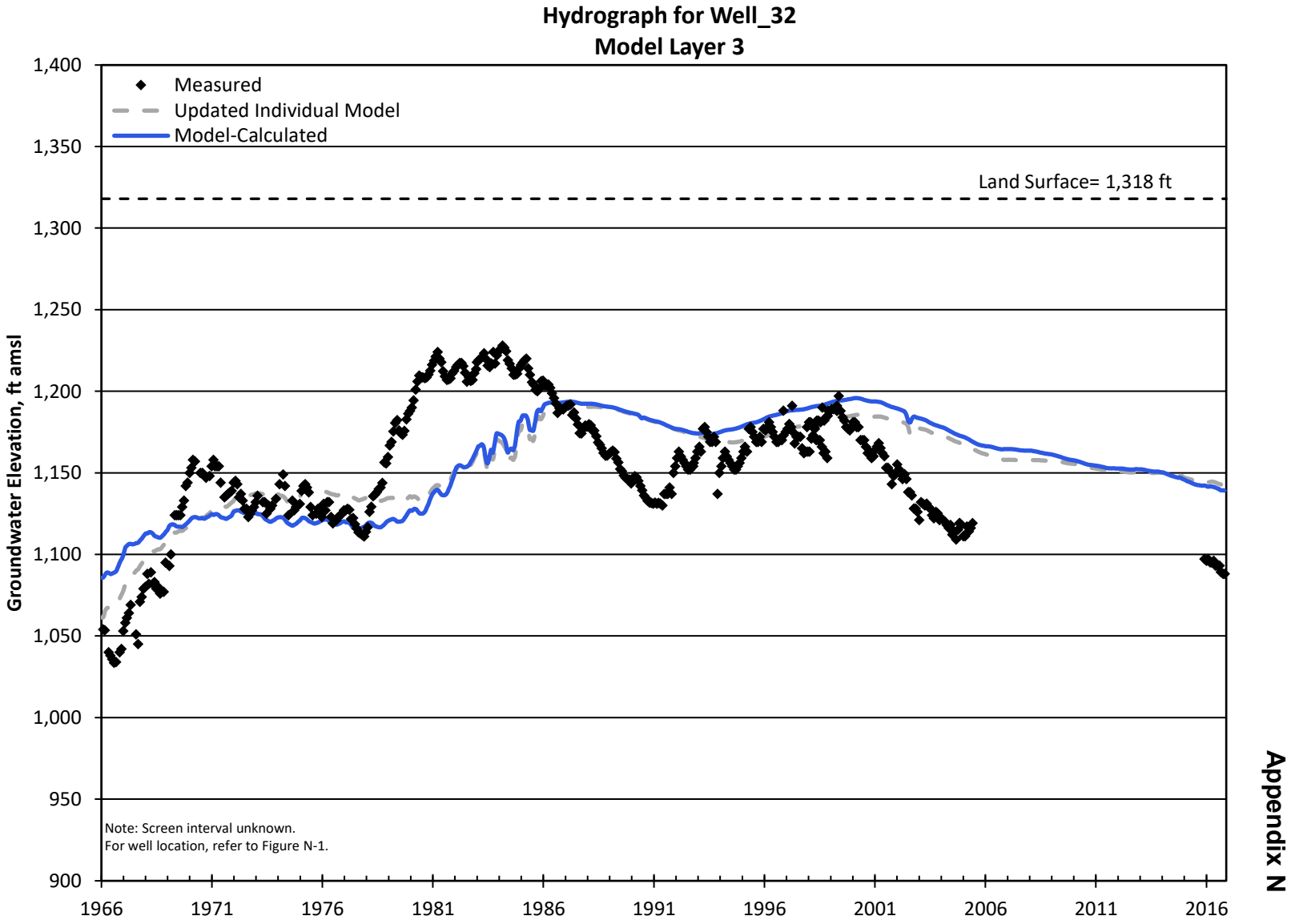
FIGURE N-1

GEOSCIENCE

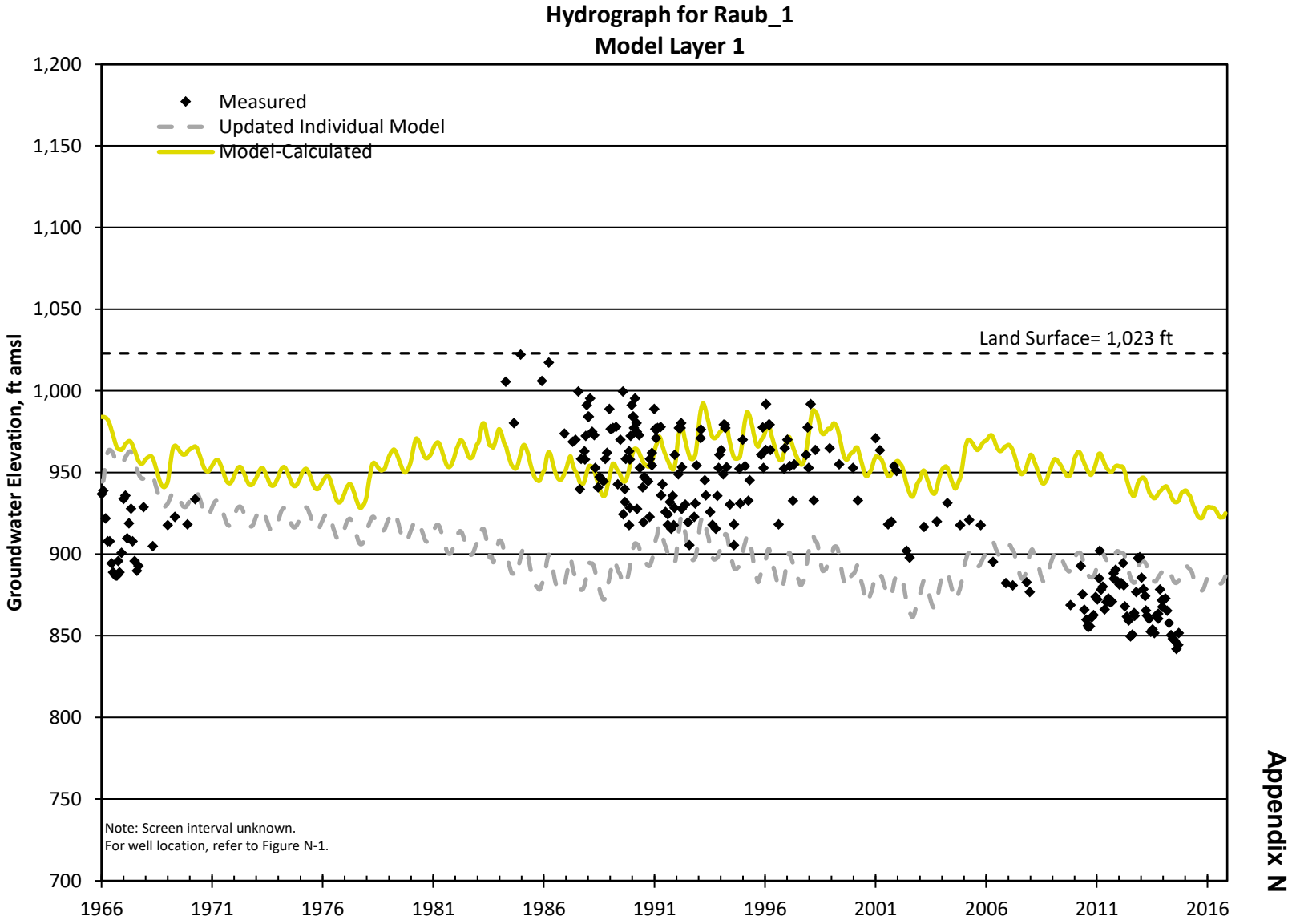

Hydrograph for No_14
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,059 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
909 to 789
717 to 711
663 to 631
607 to 585
559 to 539
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.
Appendix N


Hydrograph for Airport_No_2
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,469 ft
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

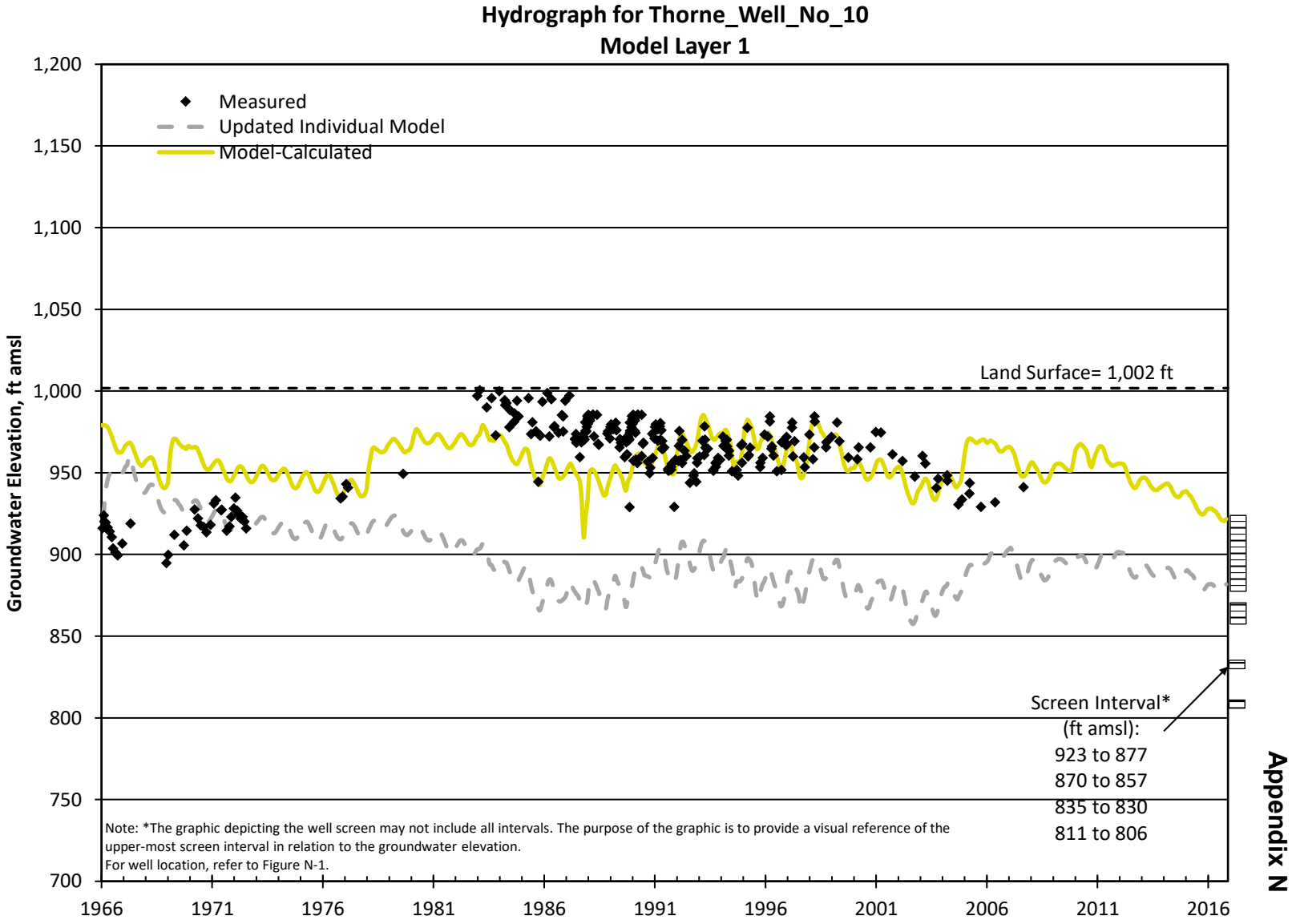
Appendix N


Hydrograph for Well_32
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,318 ft
Groundwater Elevation, ft amsl
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure N-1.

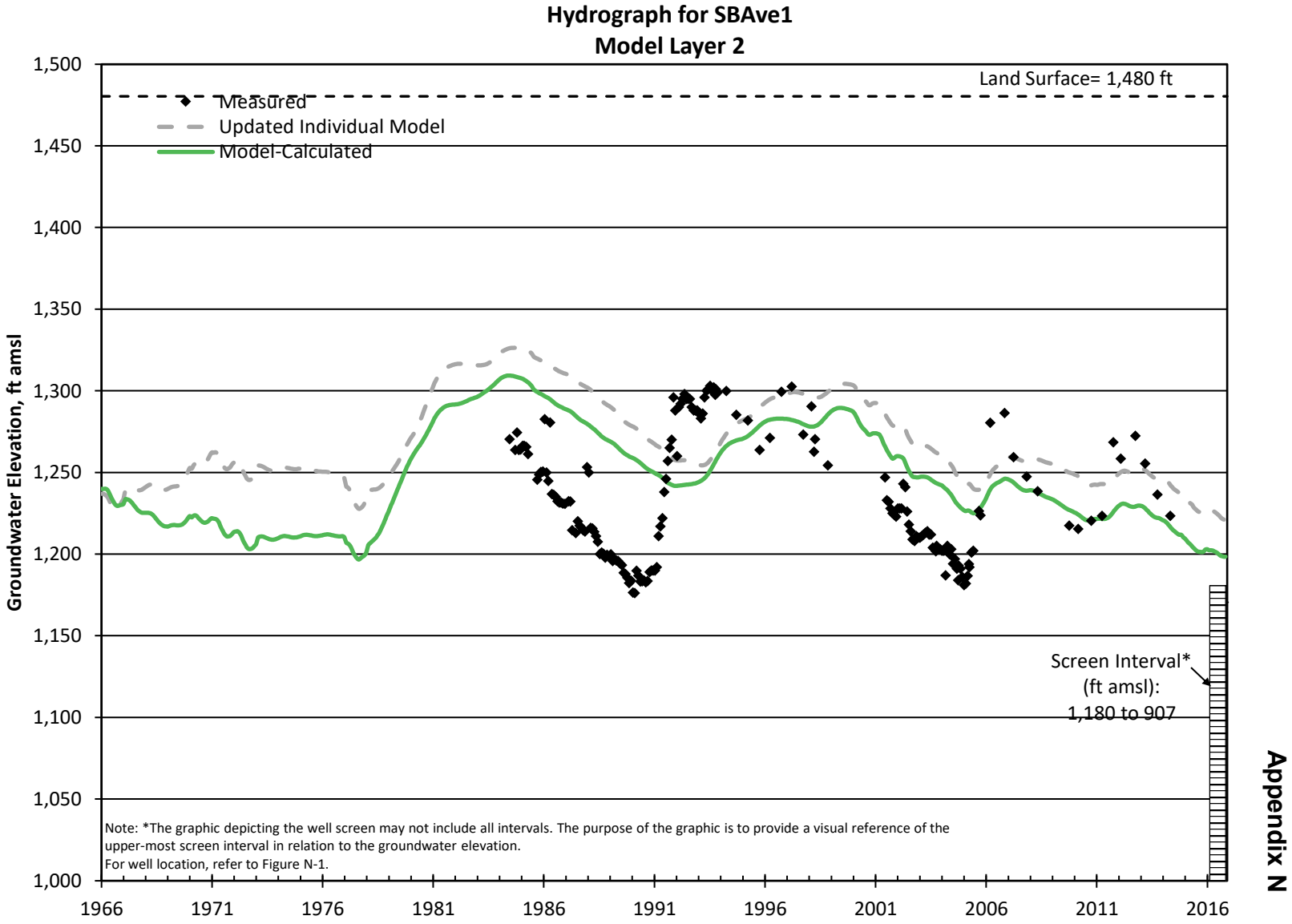
Appendix N


Hydrograph for Raub_1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,023 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure N-1.

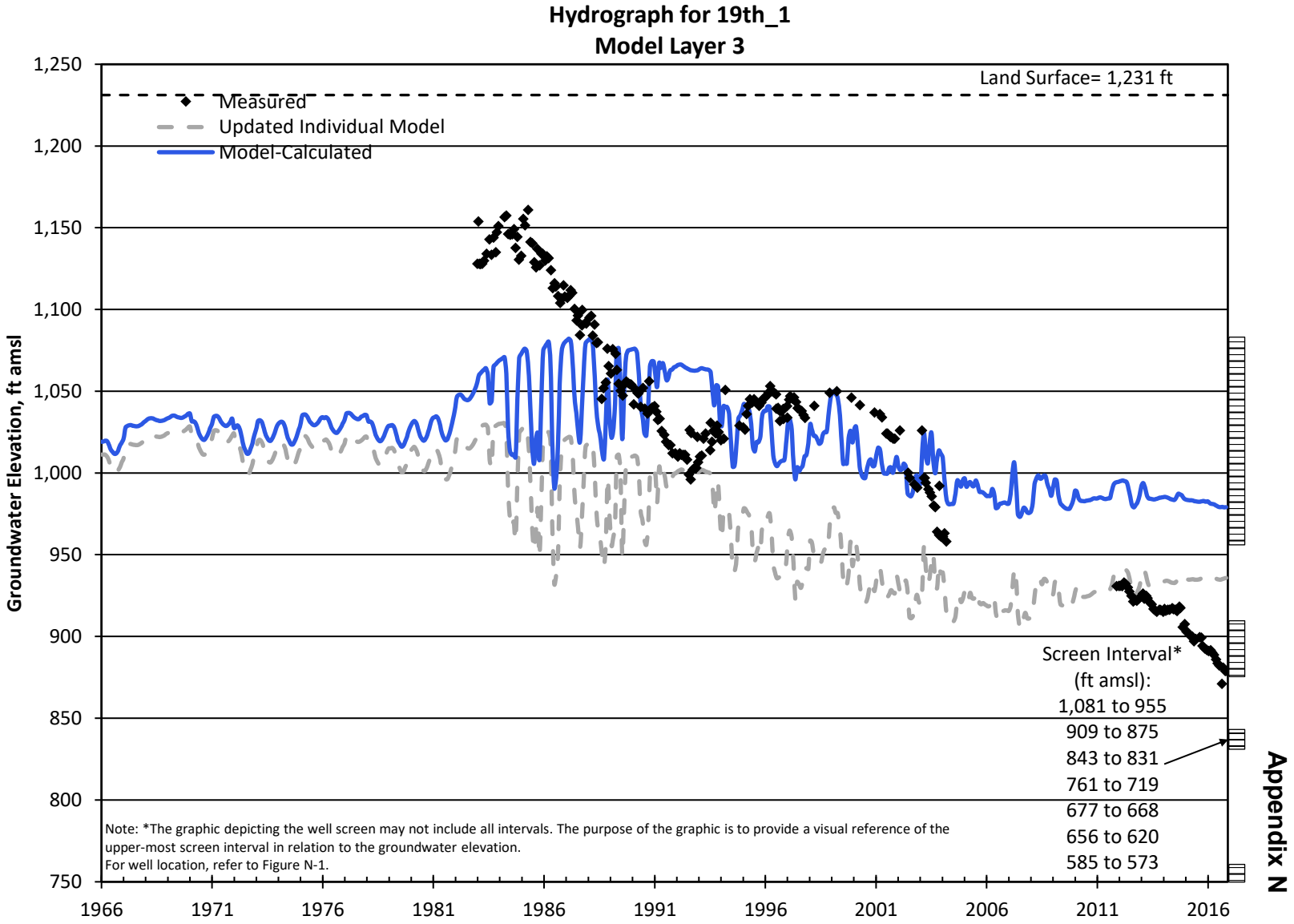
Appendix N

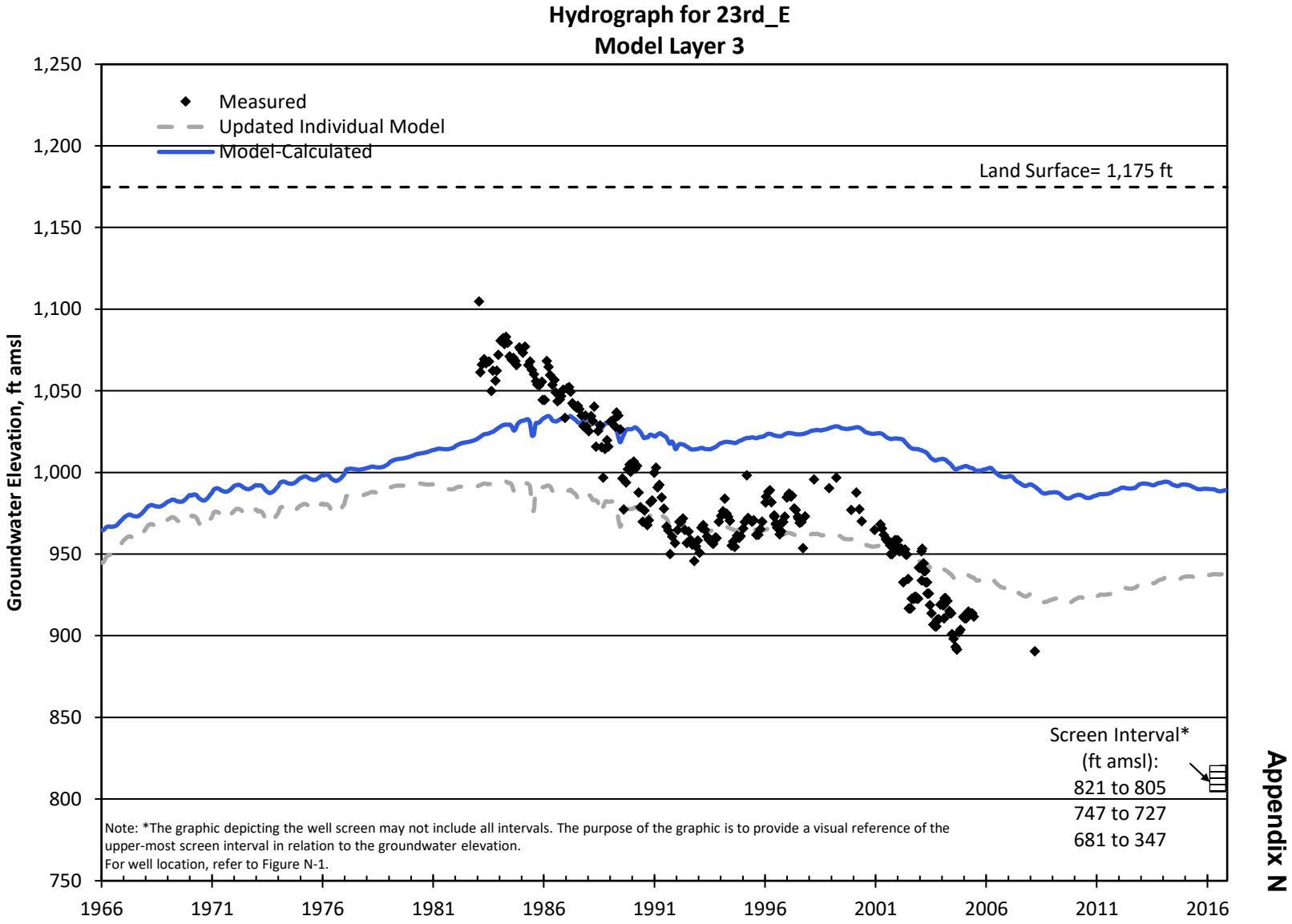

Hydrograph for Thorne_Well_No_10
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,002 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
923 to 877
870 to 857
835 to 830
811 to 806
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

Appendix N

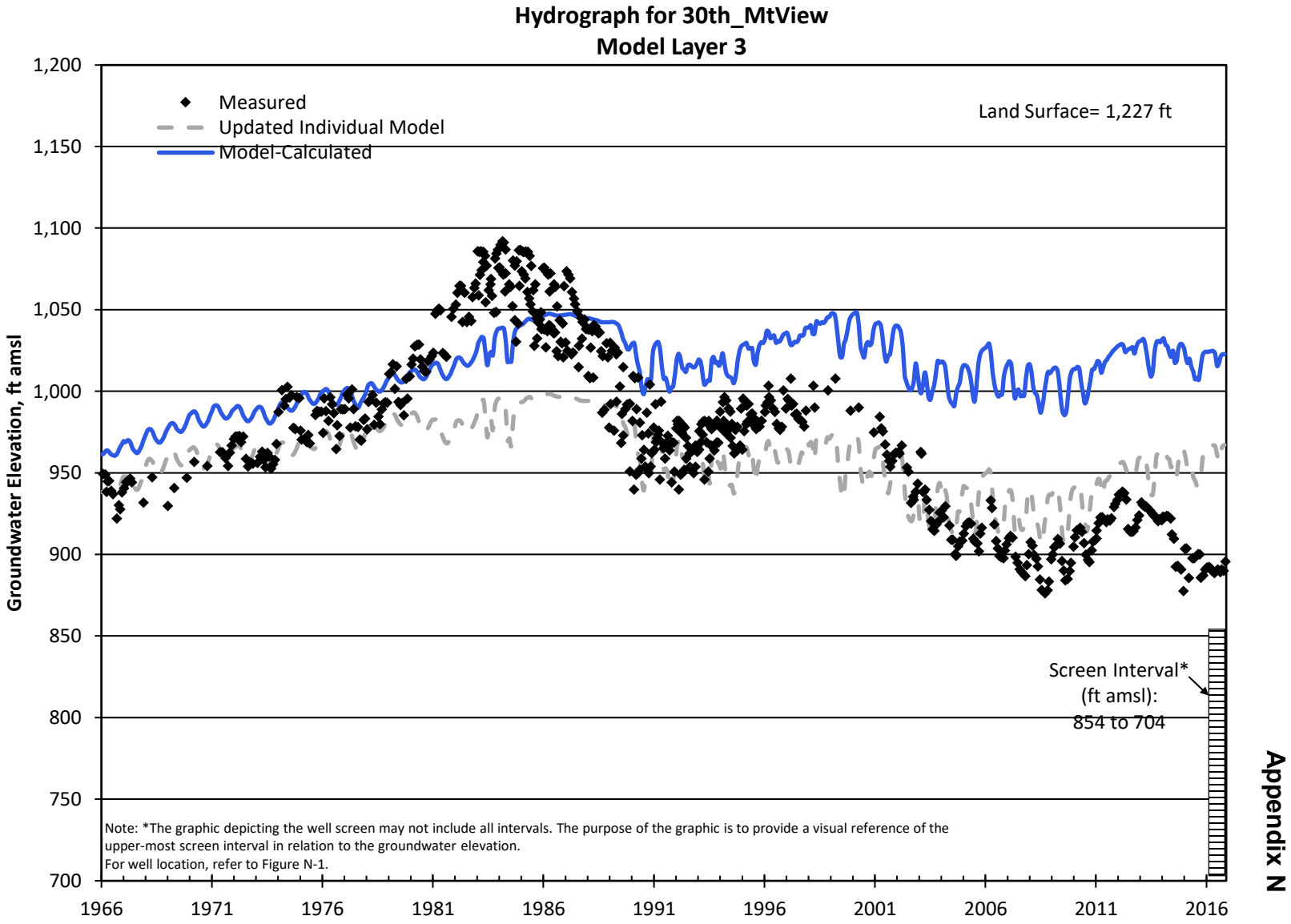

Hydrograph for SBAve1
Model Layer 2
Land Surface= 1,480 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,180 to 907
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

Appendix N

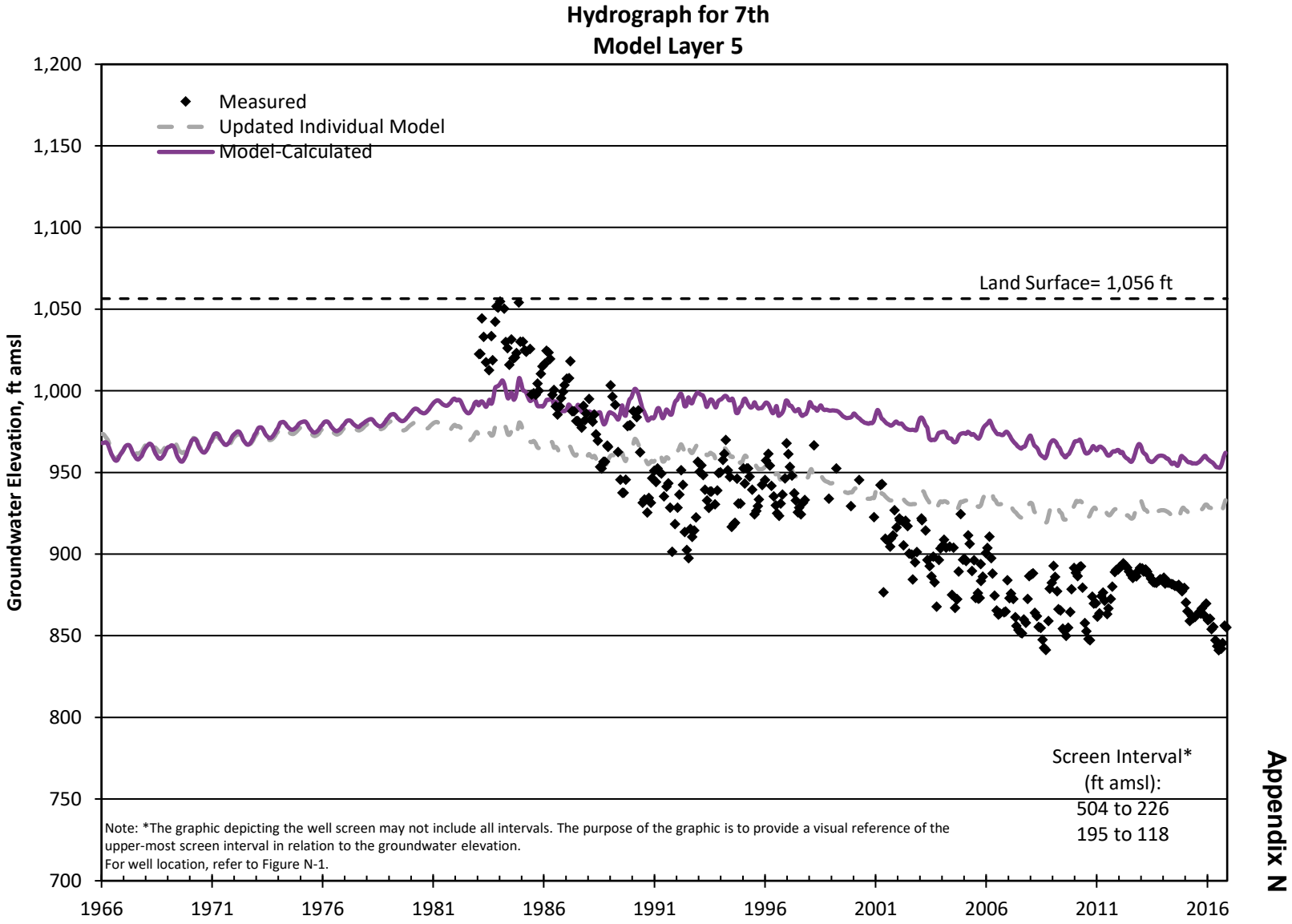

Hydrograph for 19th_1
Model Layer 3
Land Surface= 1,231 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,081 to 955
909 to 875
843 to 831
761 to 719
677 to 668
656 to 620
585 to 573
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.
Appendix N


Hydrograph for 23rd_E
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,175 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
821 to 805
747 to 727
681 to 347
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

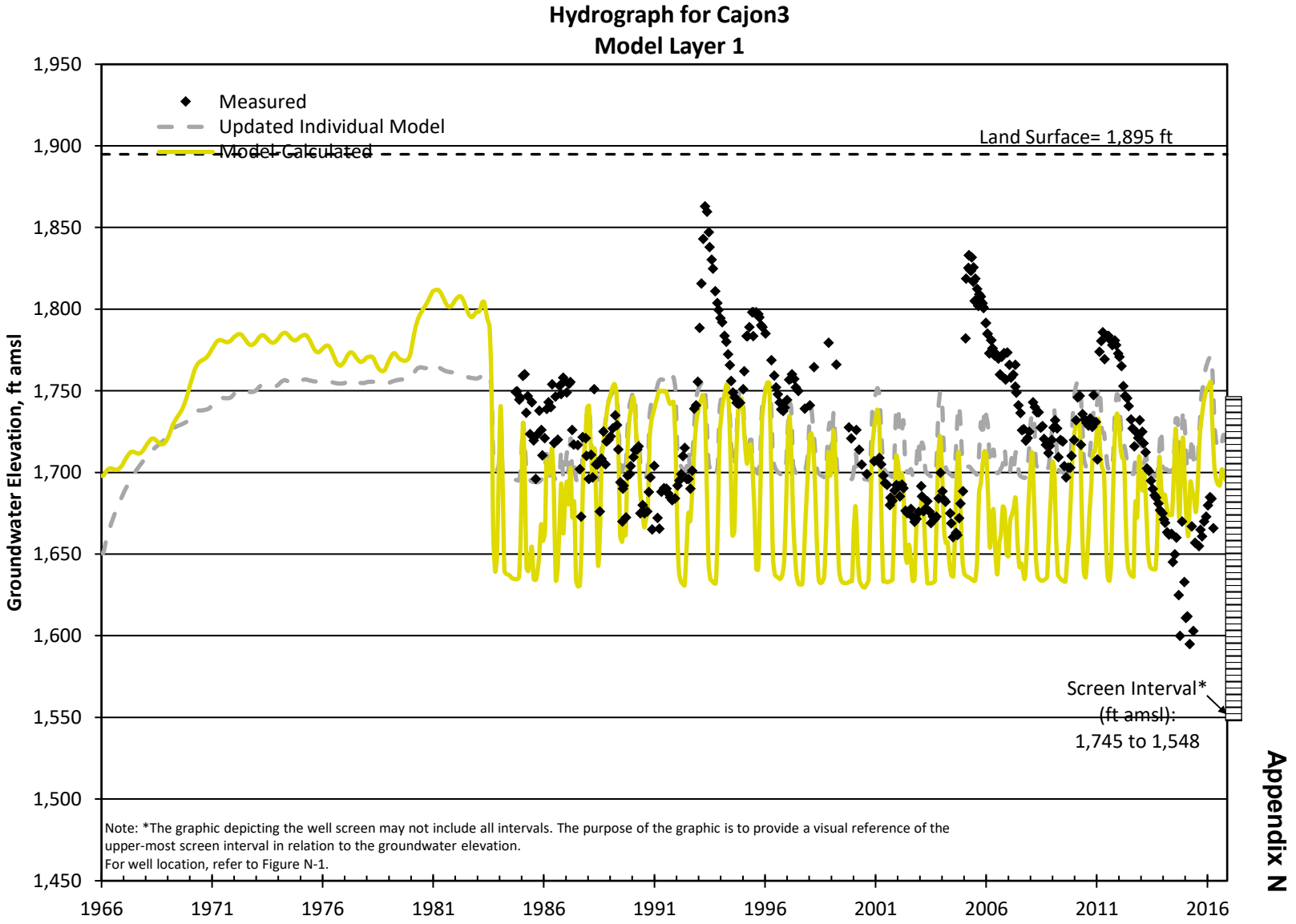
Appendix N


Hydrograph for 30th_MtView
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,227 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
854 to 704
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

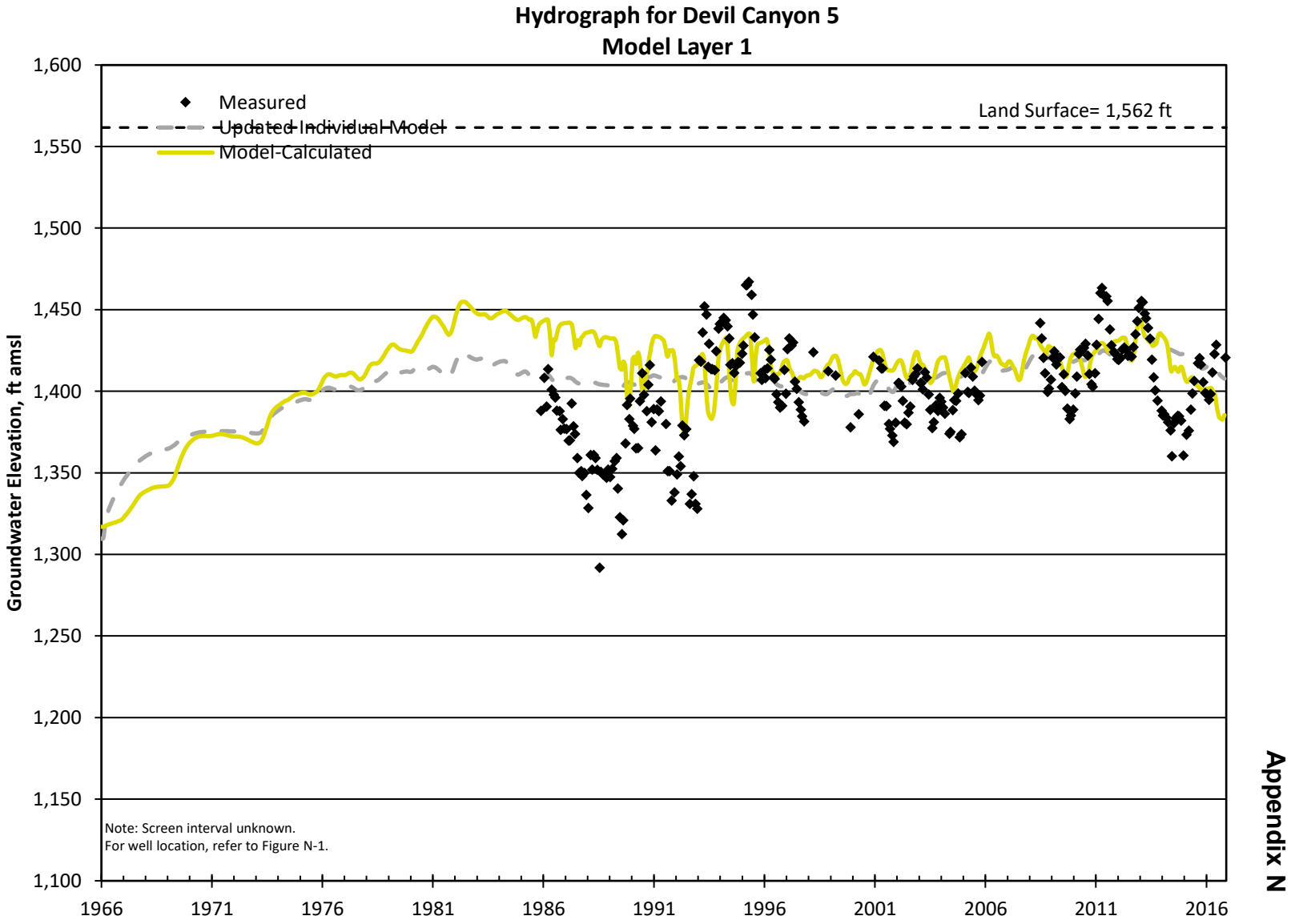
Appendix N


Hydrograph for 7th
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,056 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
504 to 226
195 to 118
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

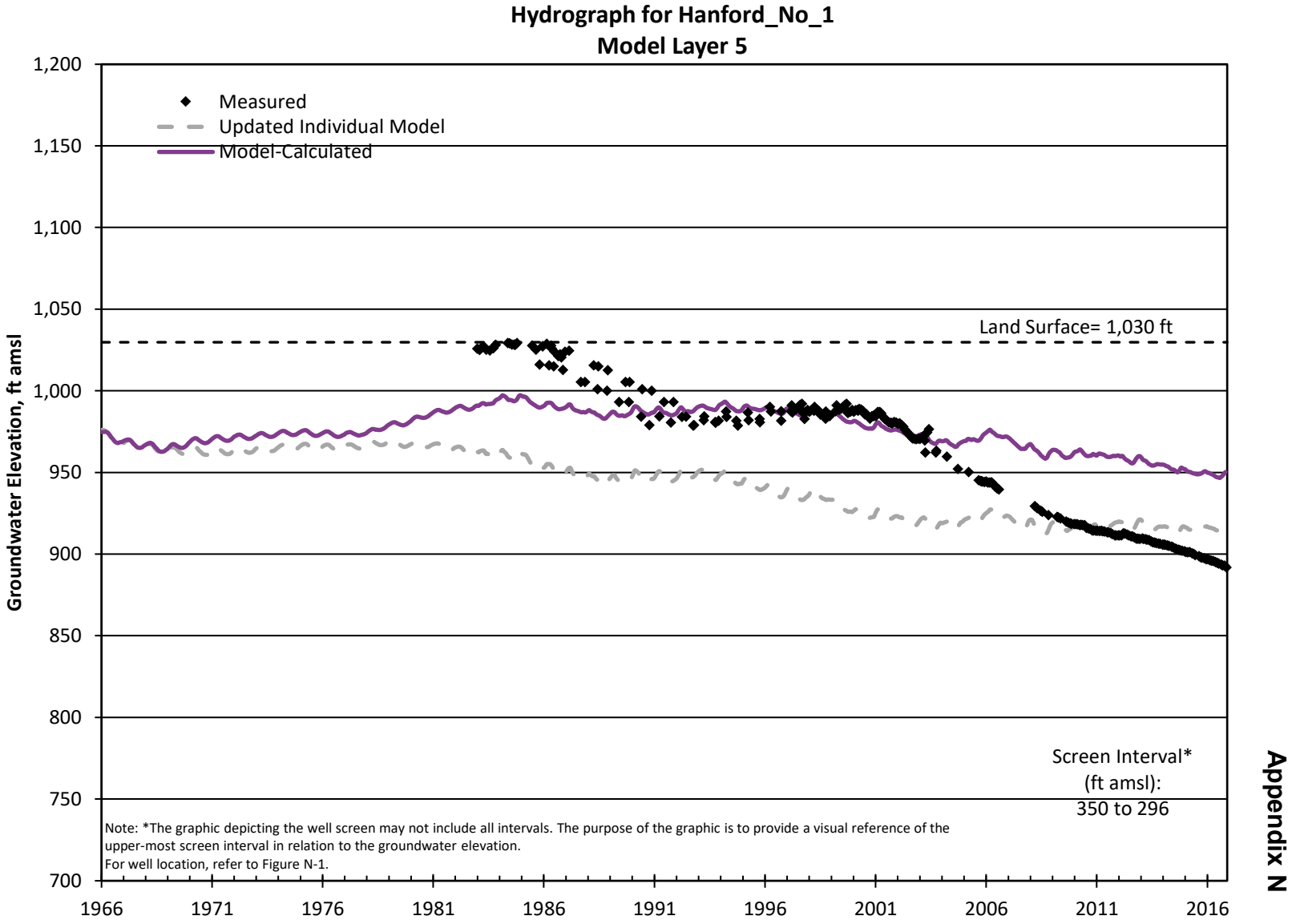
Appendix N


Hydrograph for Cajon3
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,895 ft
Groundwater Elevation, ft amsl
1,950
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,745 to 1,548
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

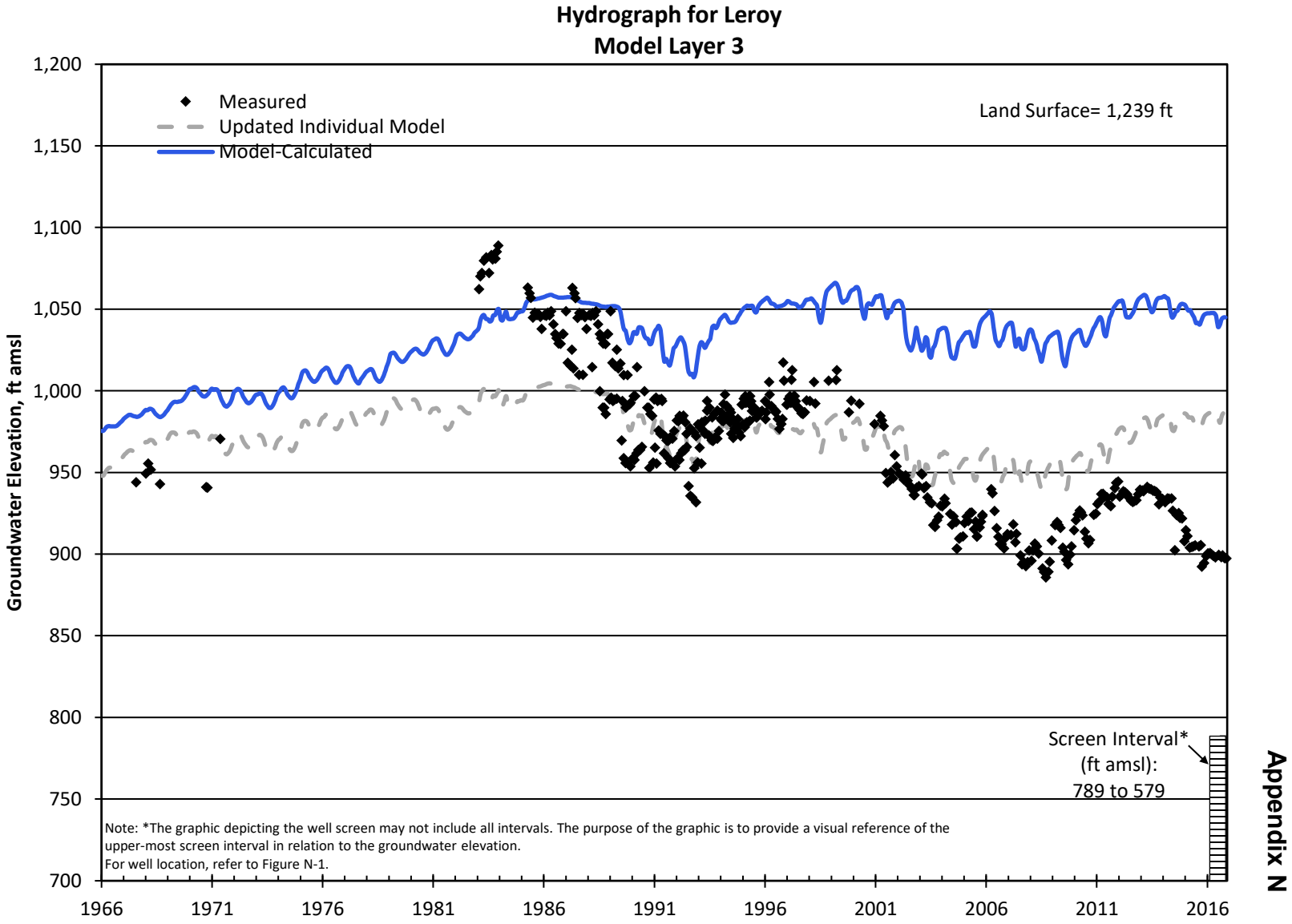
Appendix N


Hydrograph for Devil Canyon 5
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,562 ft
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure N-1.

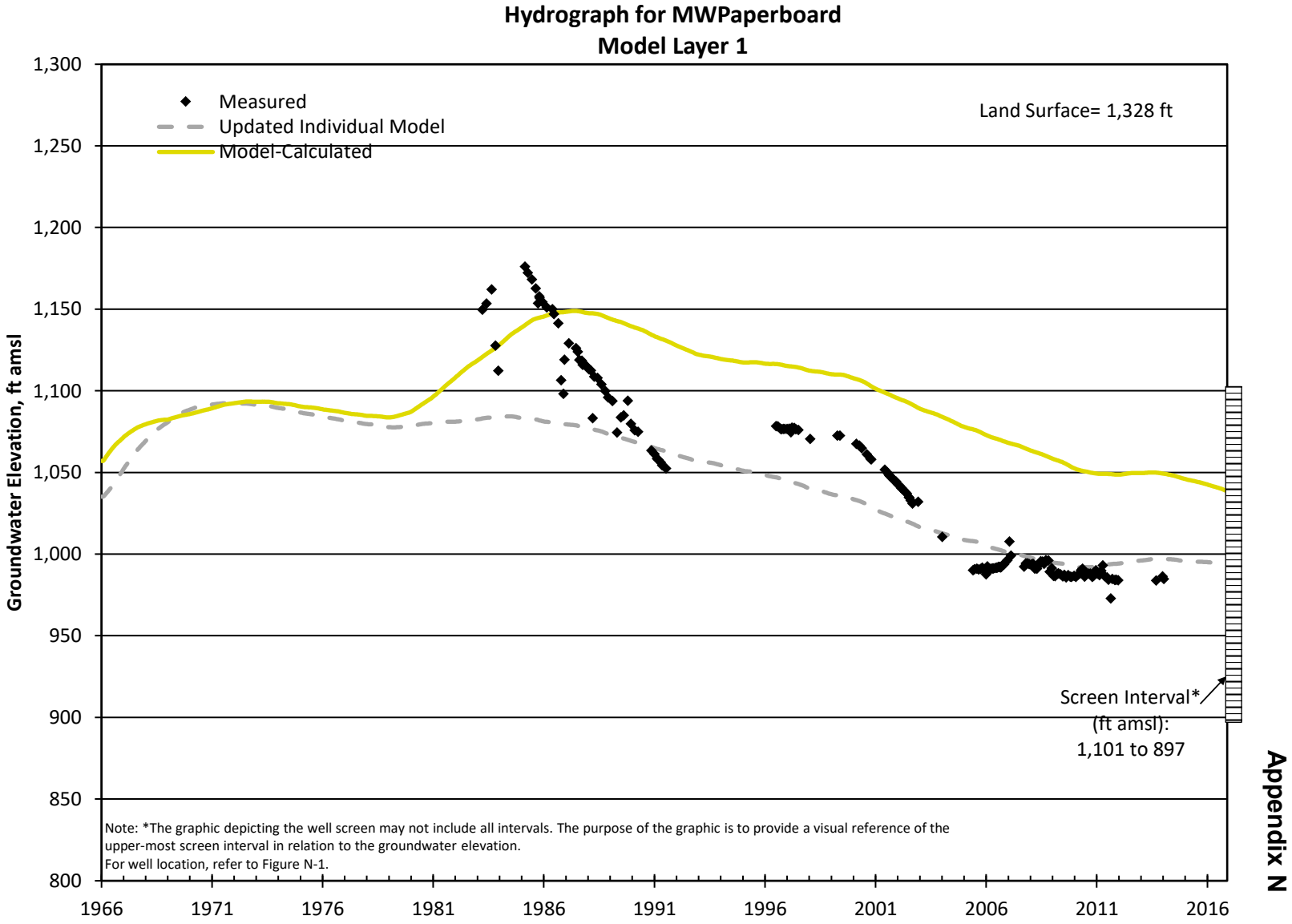
Appendix N


Hydrograph for Hanford_No_1
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,030 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
350 to 296
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

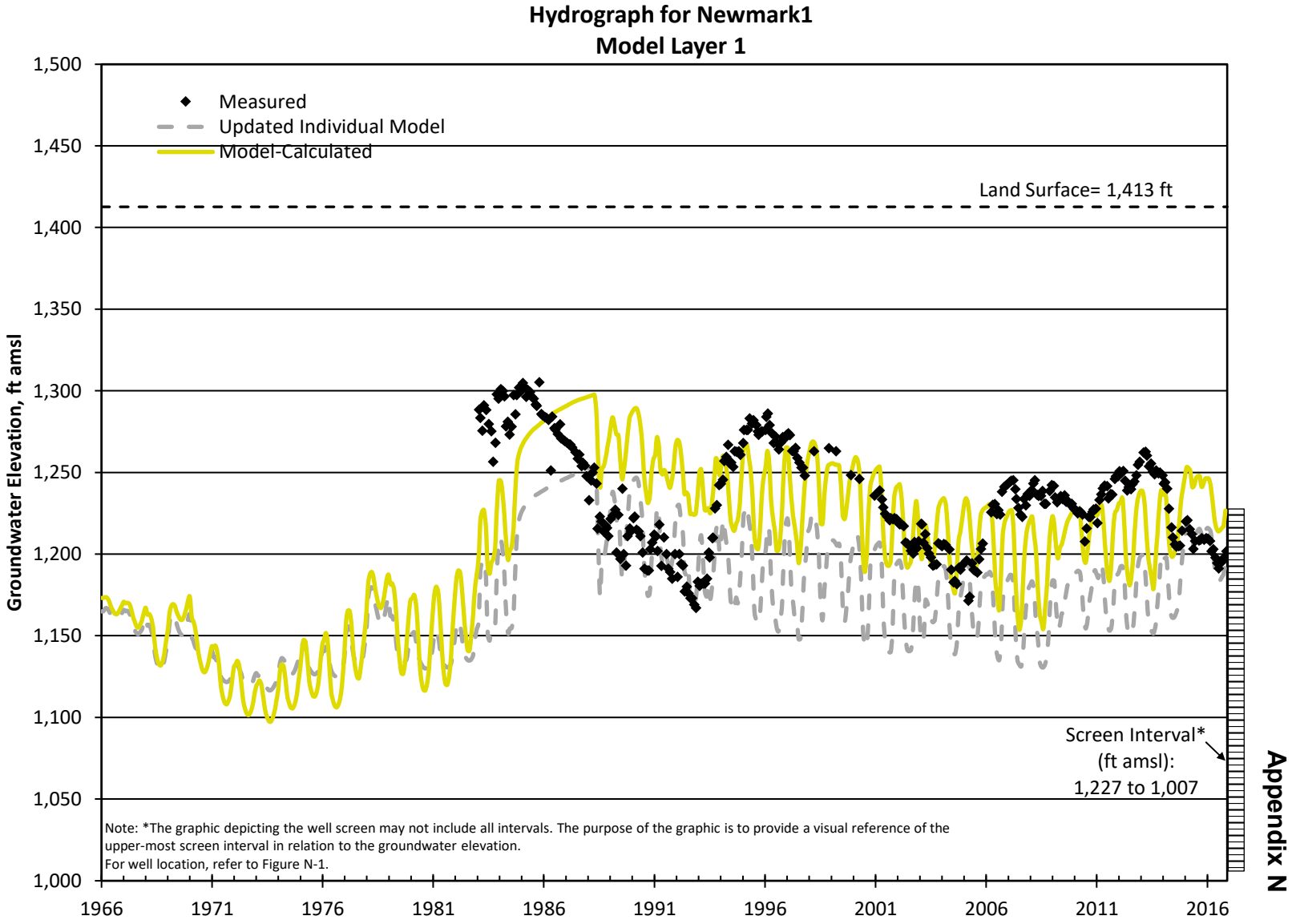
Appendix N

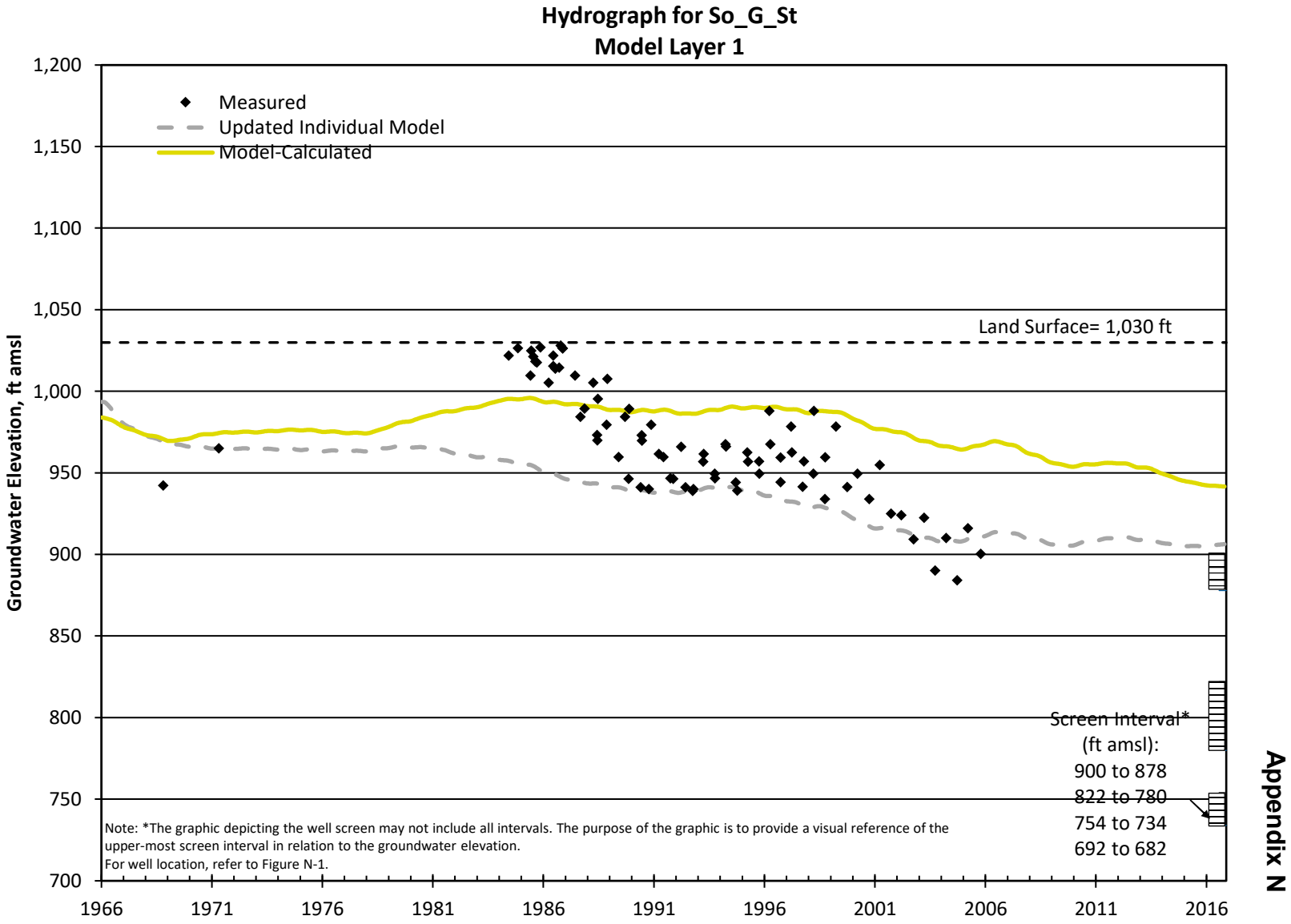

Hydrograph for Leroy
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,239 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
789 to 579
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

Appendix N

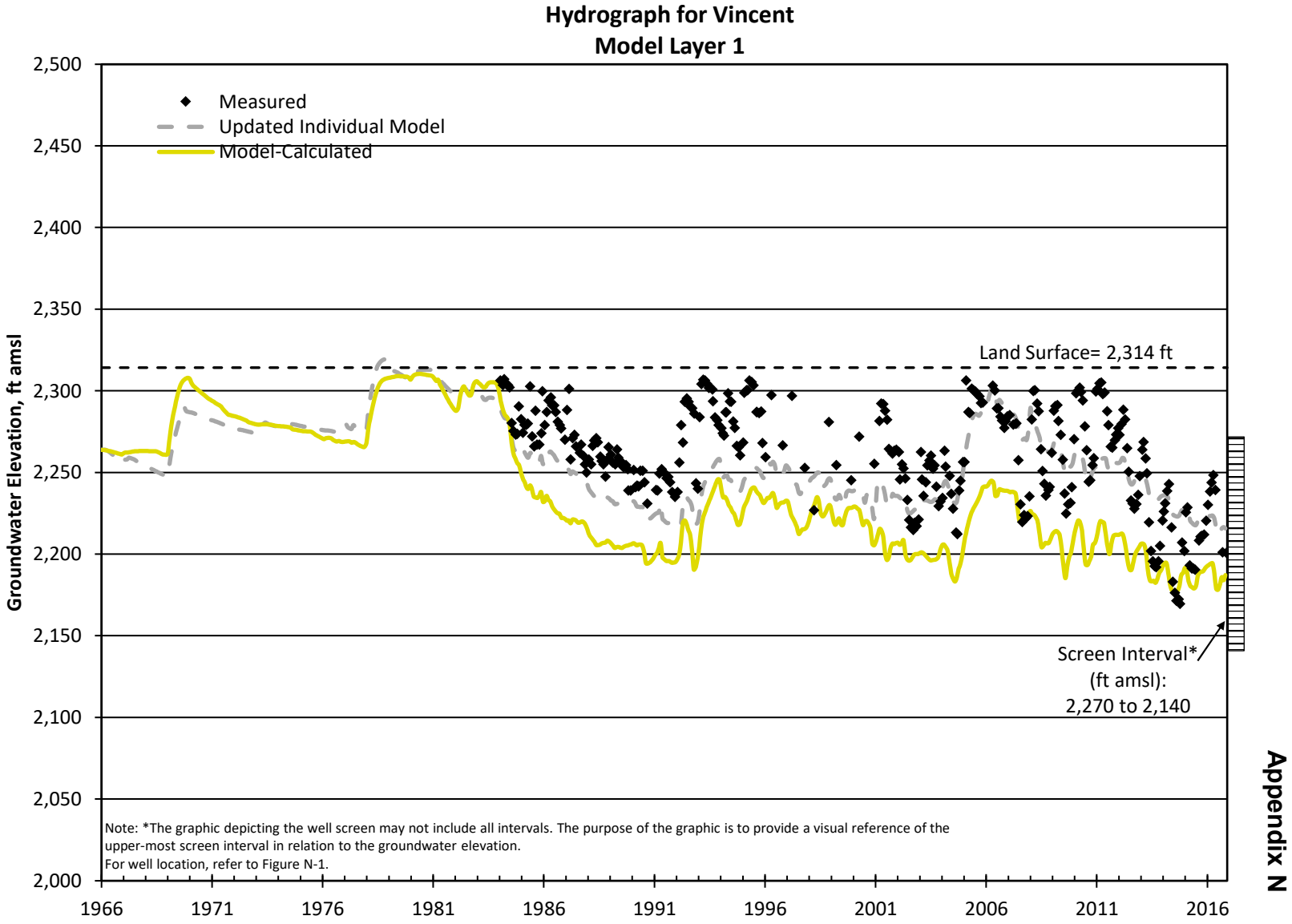

Hydrograph for MWPaperboard
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,328 ft
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,101 to 897
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

Appendix N

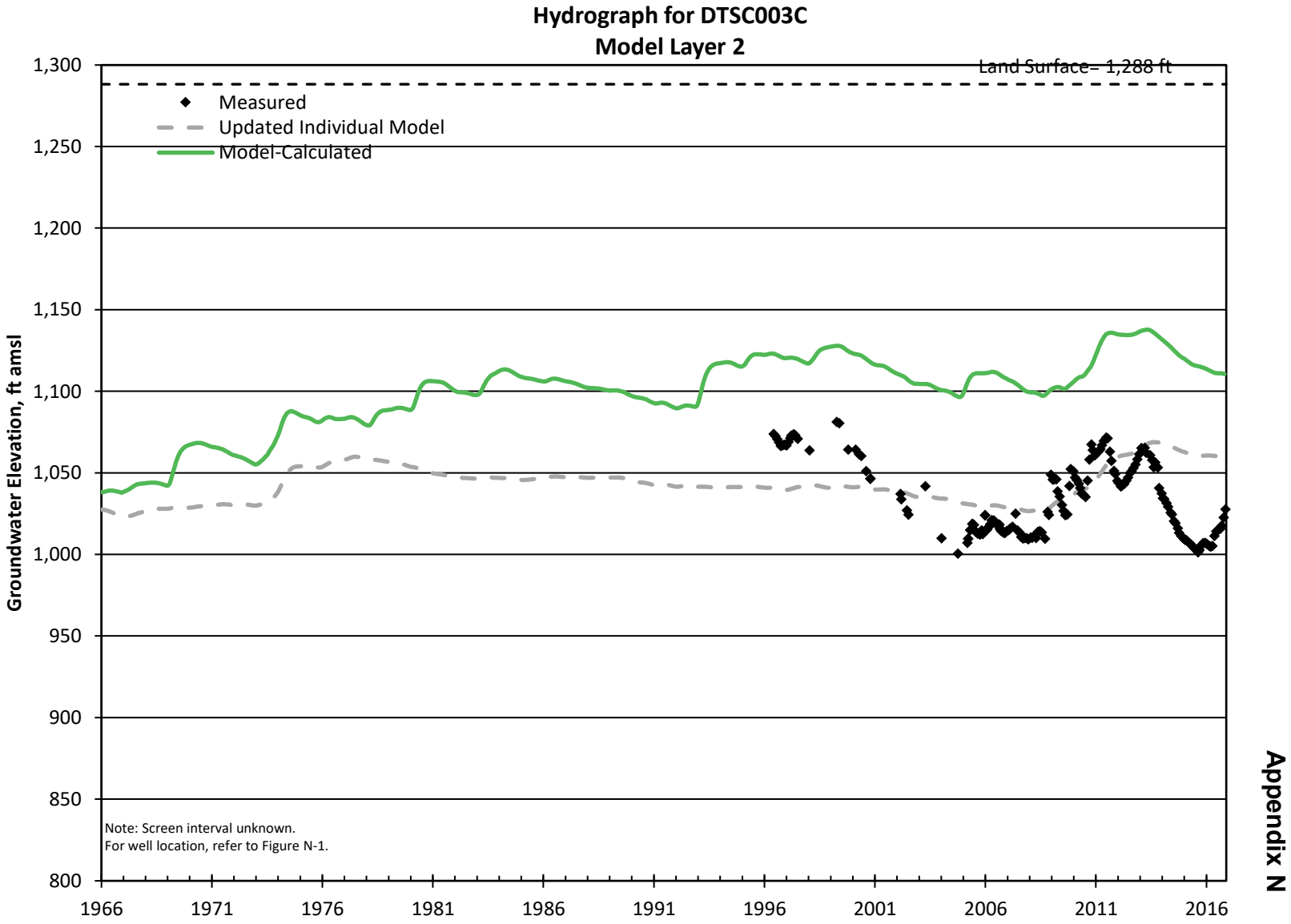

Hydrograph for Newmark1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,413 ft
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,227 to 1,007
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.
Appendix N


Hydrograph for So_G_St
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,030 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
900 to 878
822 to 780
754 to 734
692 to 682
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

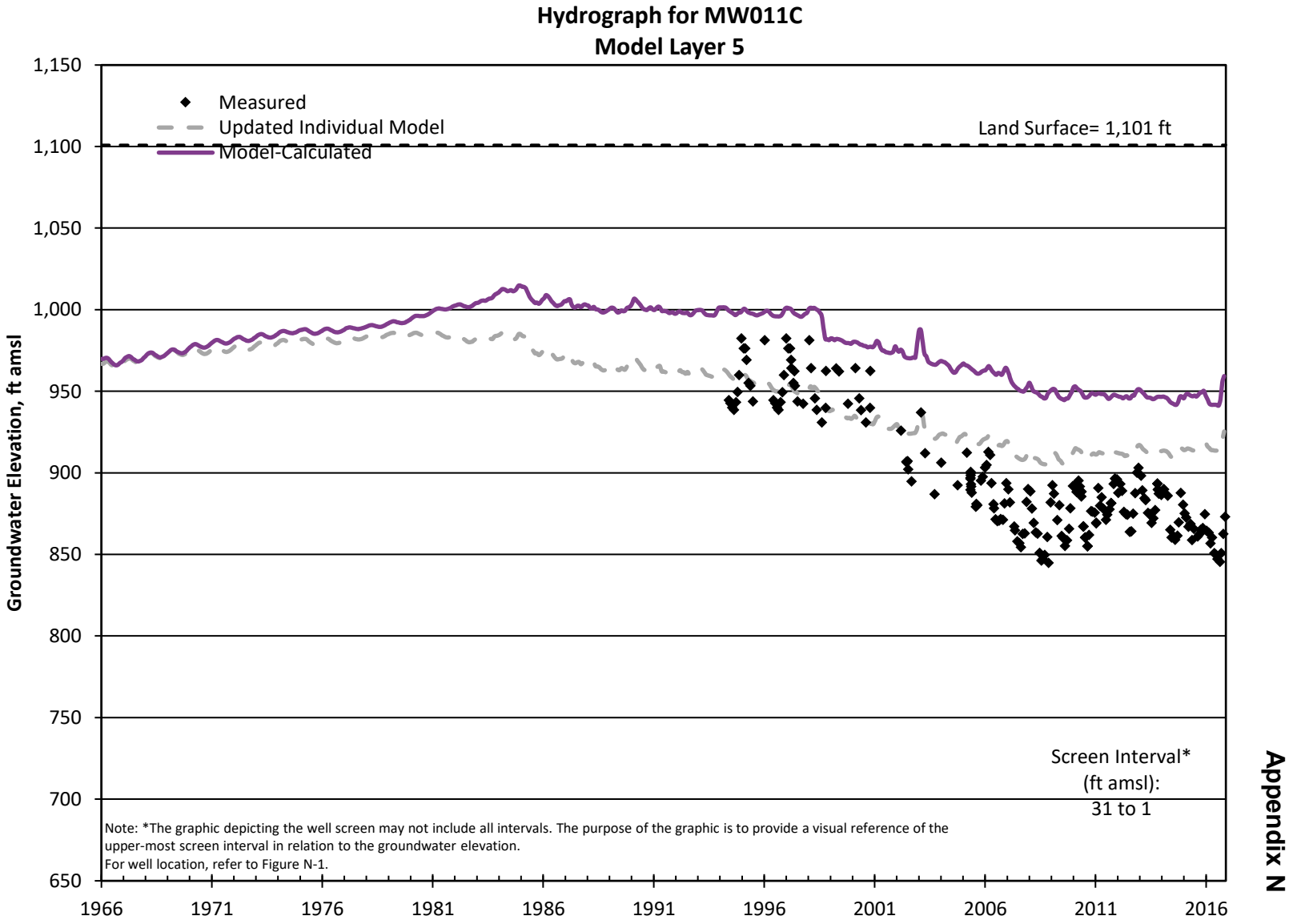
Appendix N


Hydrograph for Vincent
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 2,314 ft
Screen Interval*
(ft amsl):
2,270 to 2,140
Groundwater Elevation, ft amsl
2,500
2,450
2,400
2,350
2,300
2,250
2,200
2,150
2,100
2,050
2,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

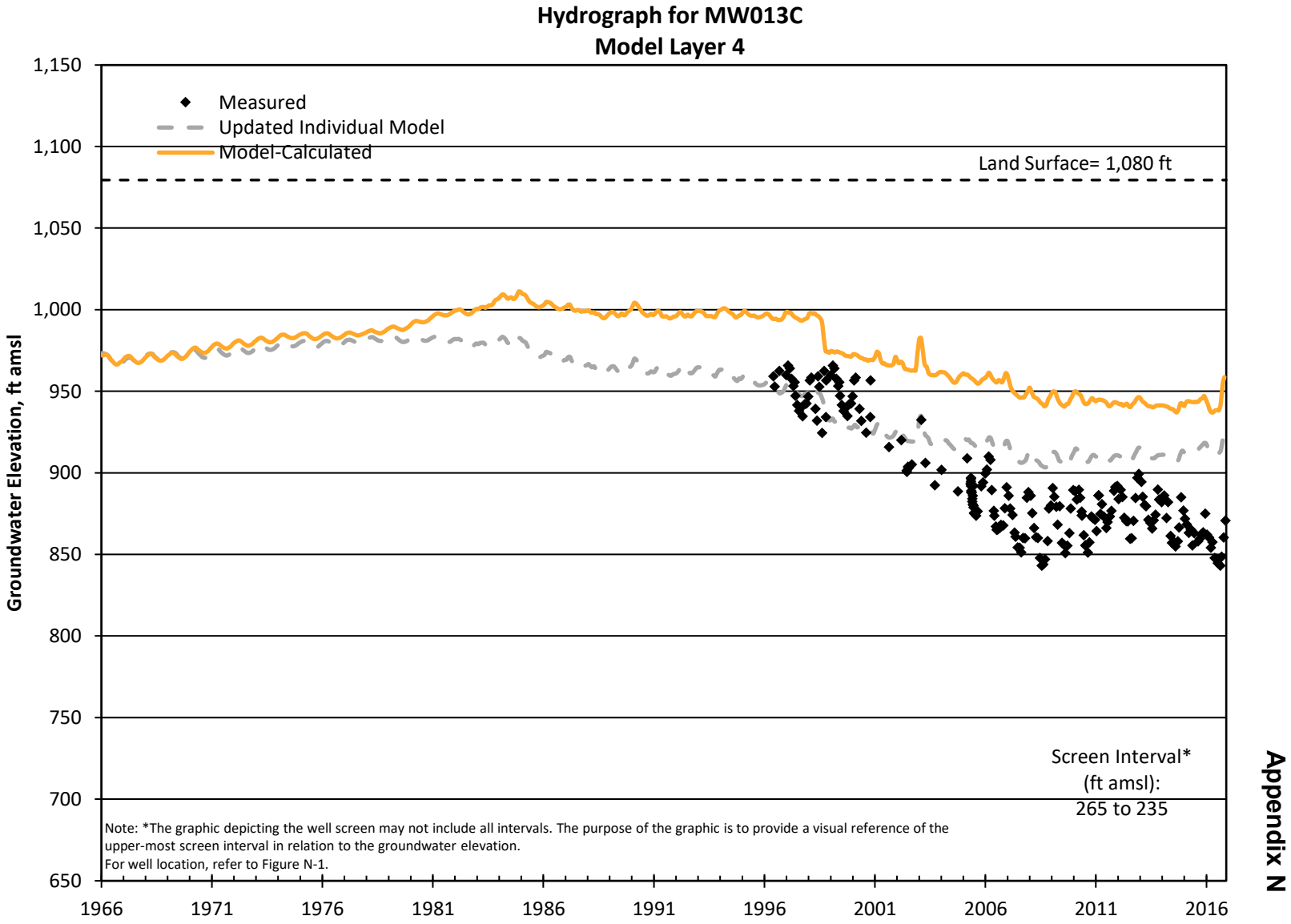
Appendix N


Hydrograph for DTSC003C
Model Layer 2
Land Surface= 1,288 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure N-1.

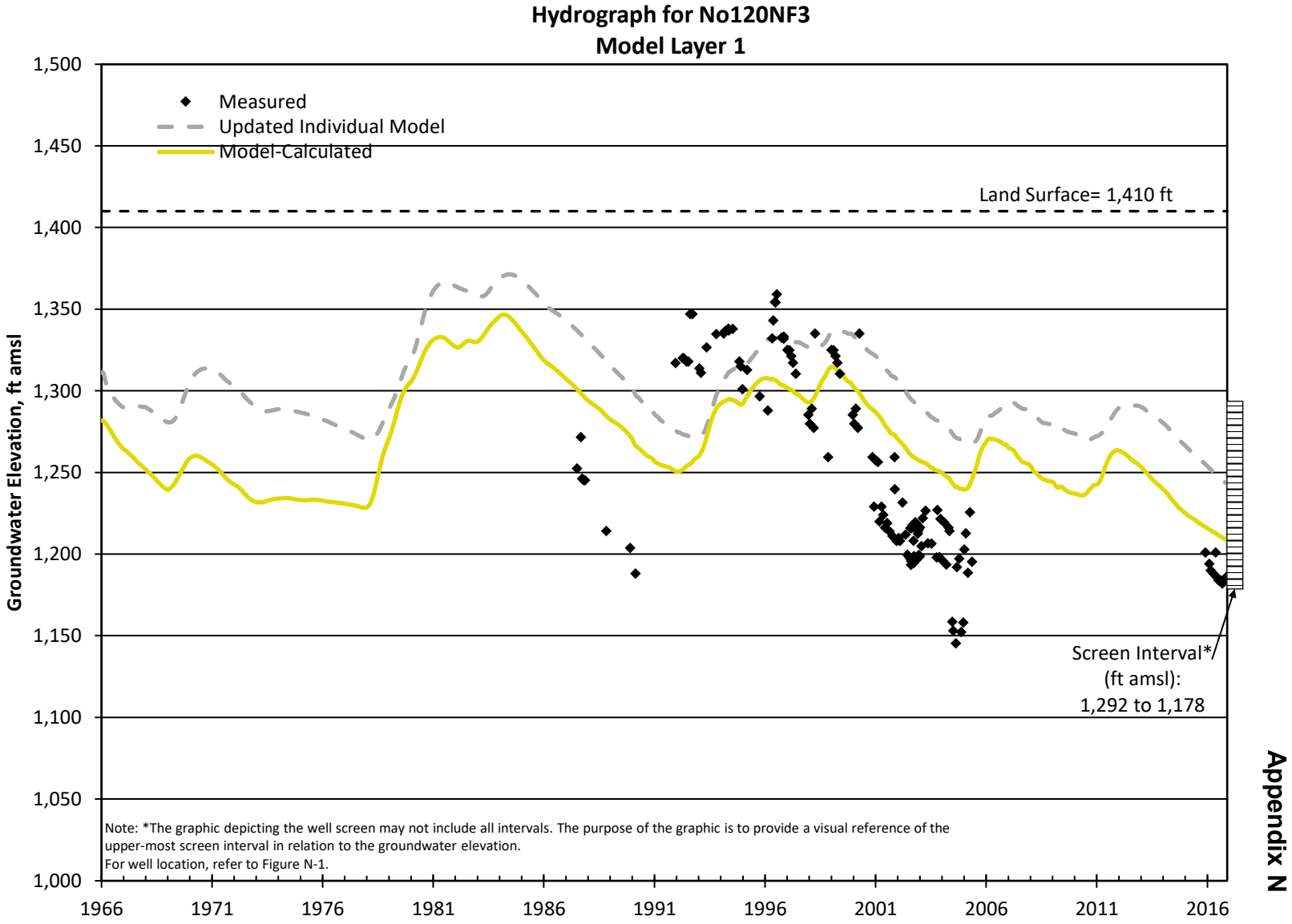
Appendix N


Hydrograph for MW011C
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,101 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
31 to 1
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

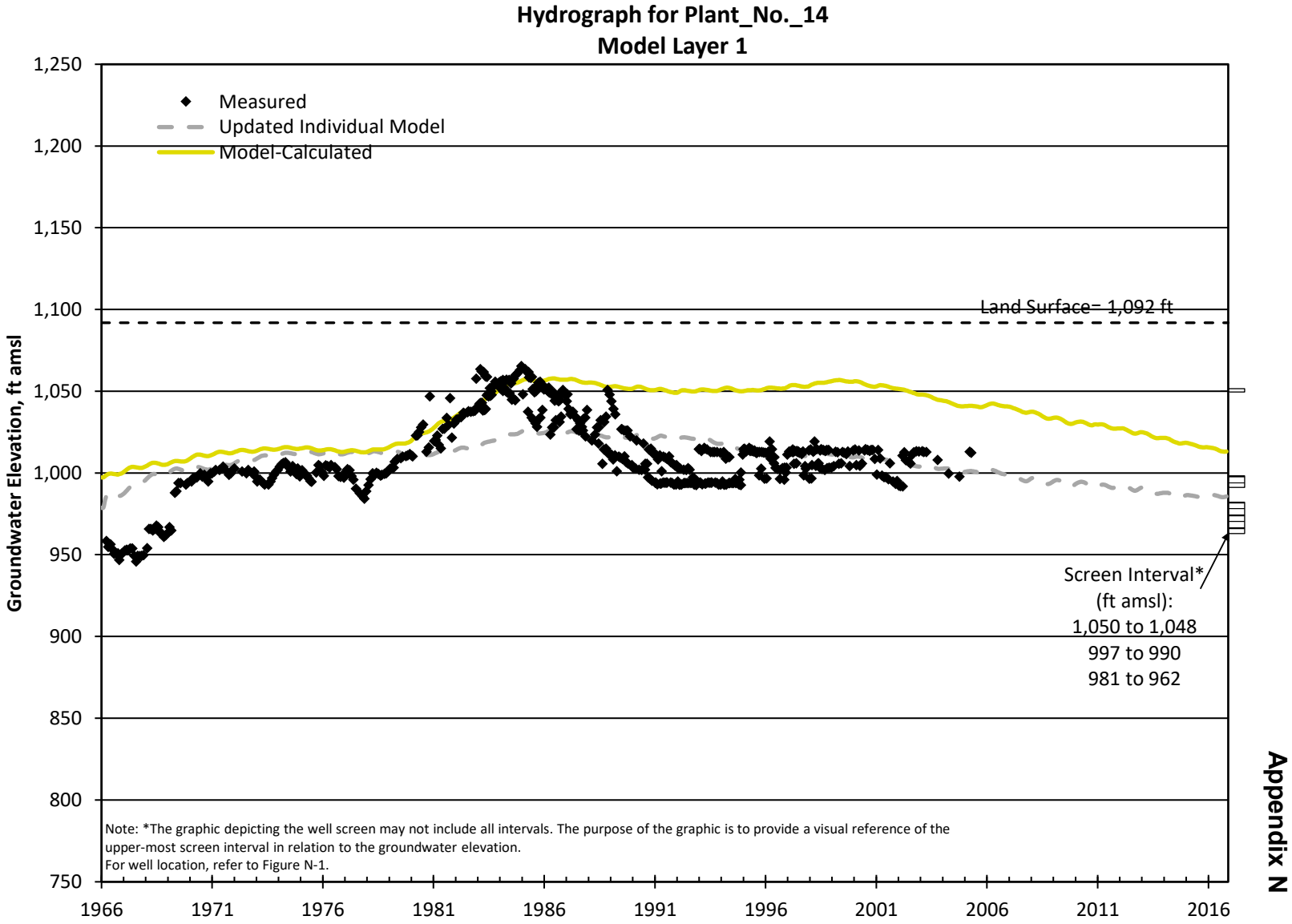
Appendix N


Hydrograph for MW013C
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,080 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
265 to 235
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

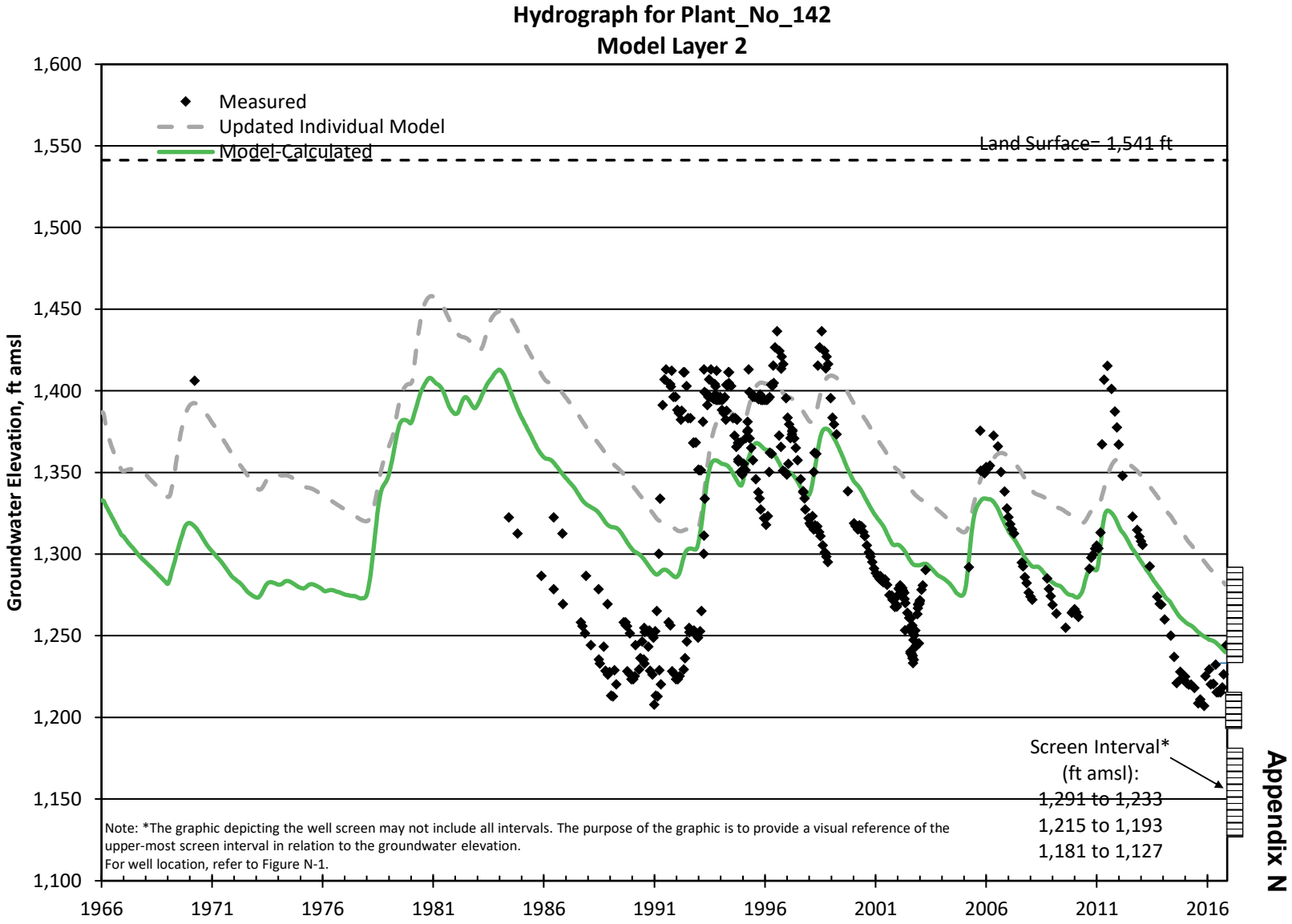
Appendix N

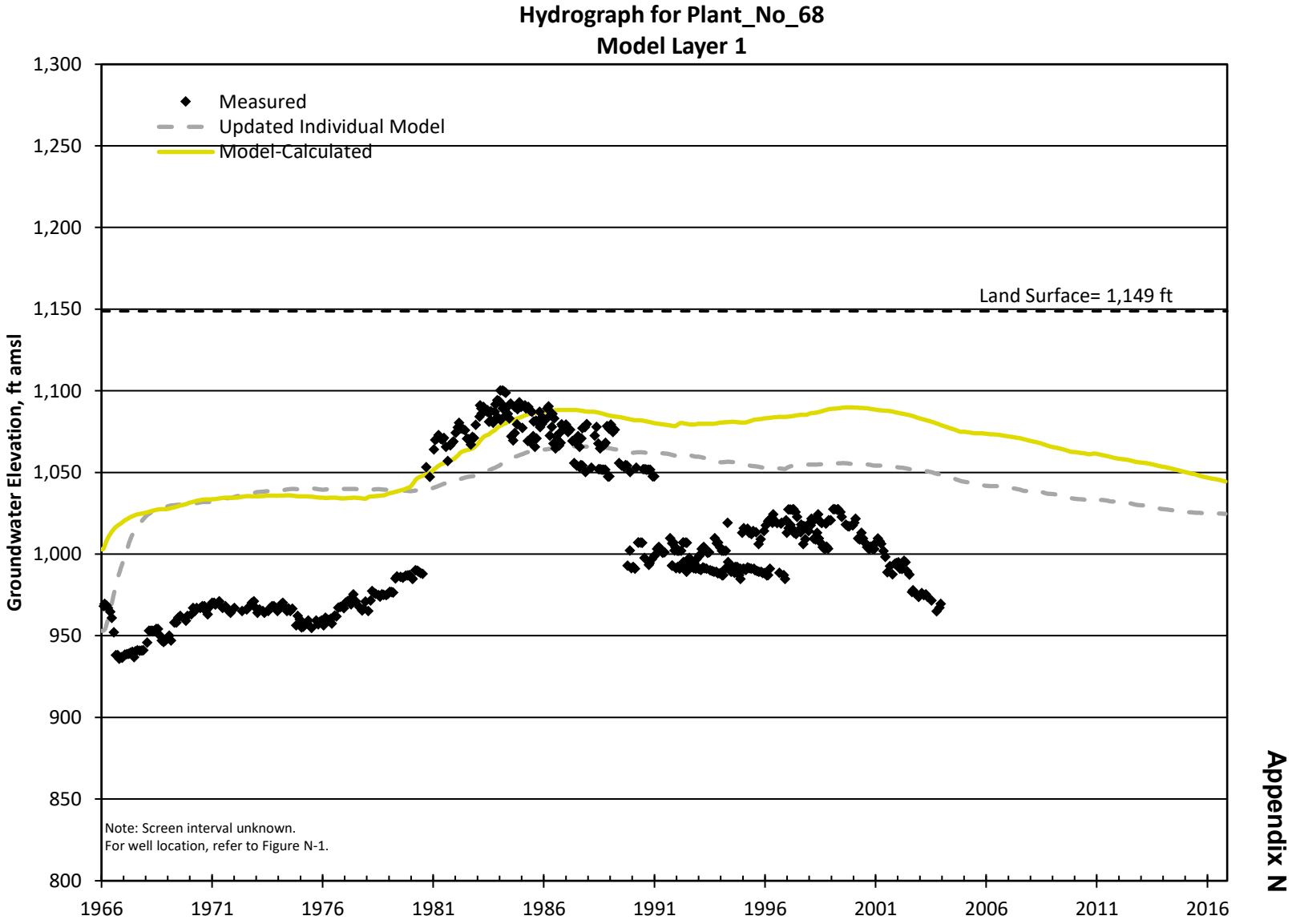

Hydrograph for No120NF3
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,410 ft
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,292 to 1,178
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

Appendix N

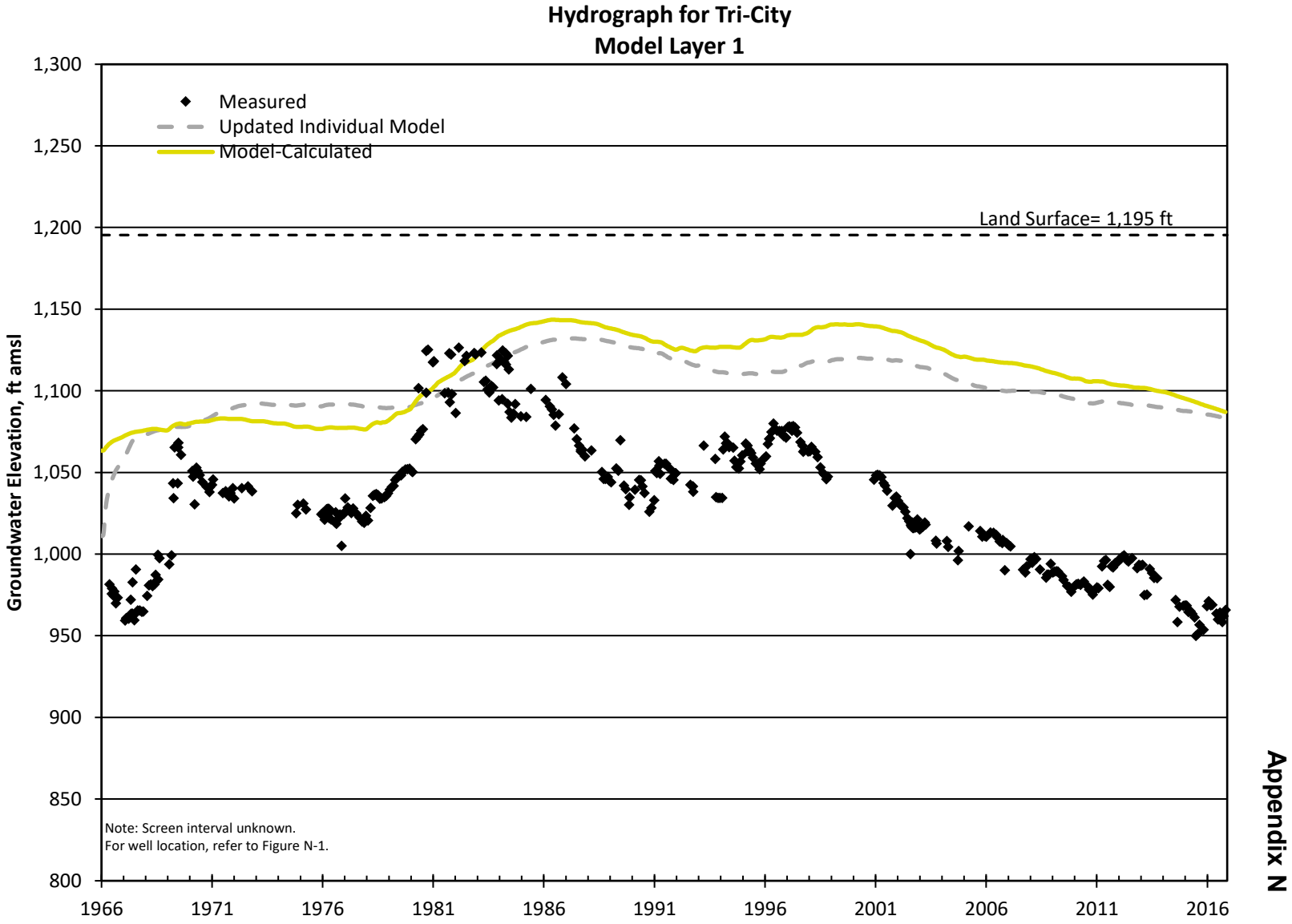

Hydrograph for Plant_No._14
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,092 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,050 to 1,048
997 to 990
981 to 962
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

Appendix N

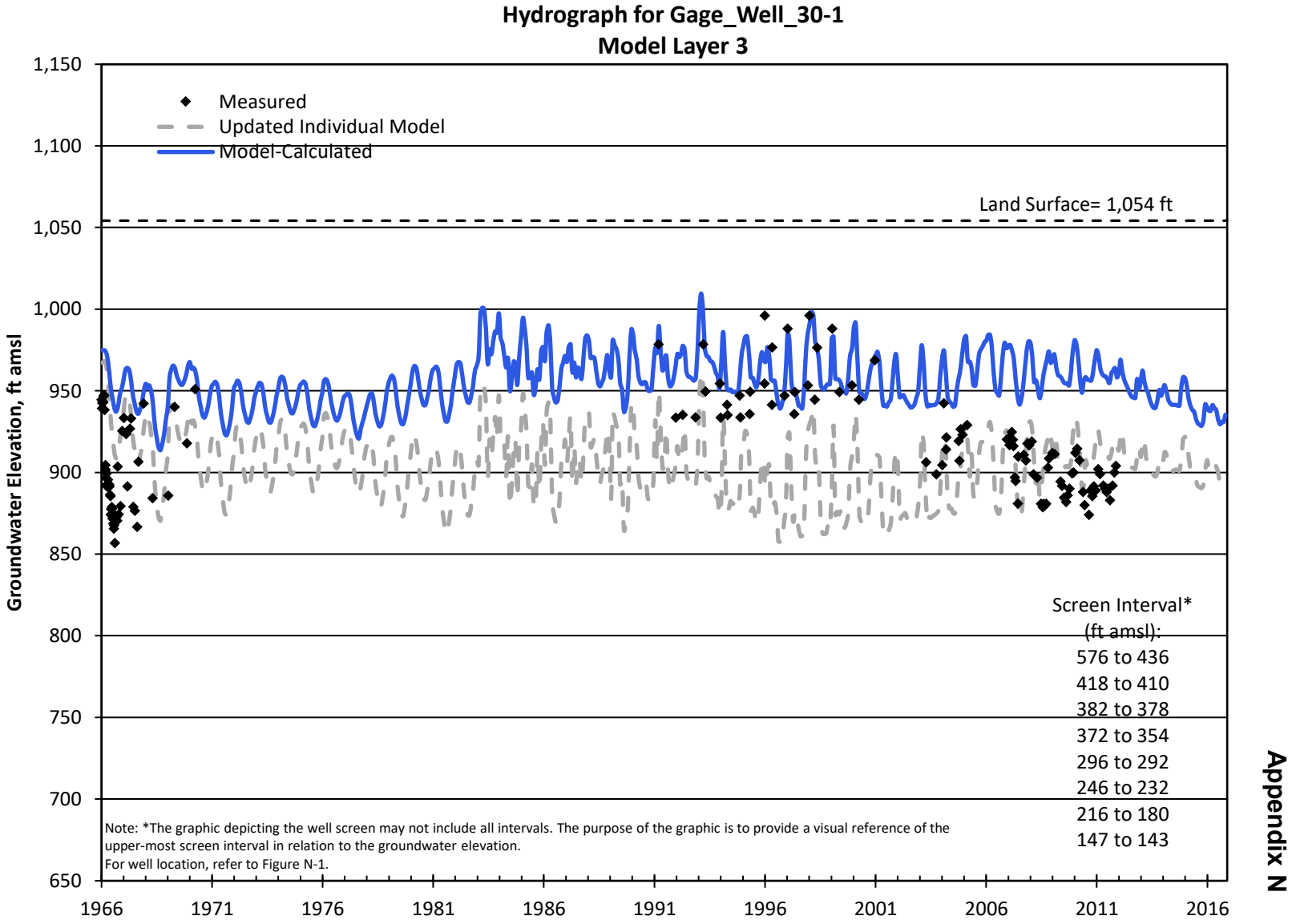

Hydrograph for Plant_No_142
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,541 ft
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,291 to 1,233
1,215 to 1,193
1,181 to 1,127
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.
Appendix N


Hydrograph for Plant_No_68
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,149 ft
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure N-1.

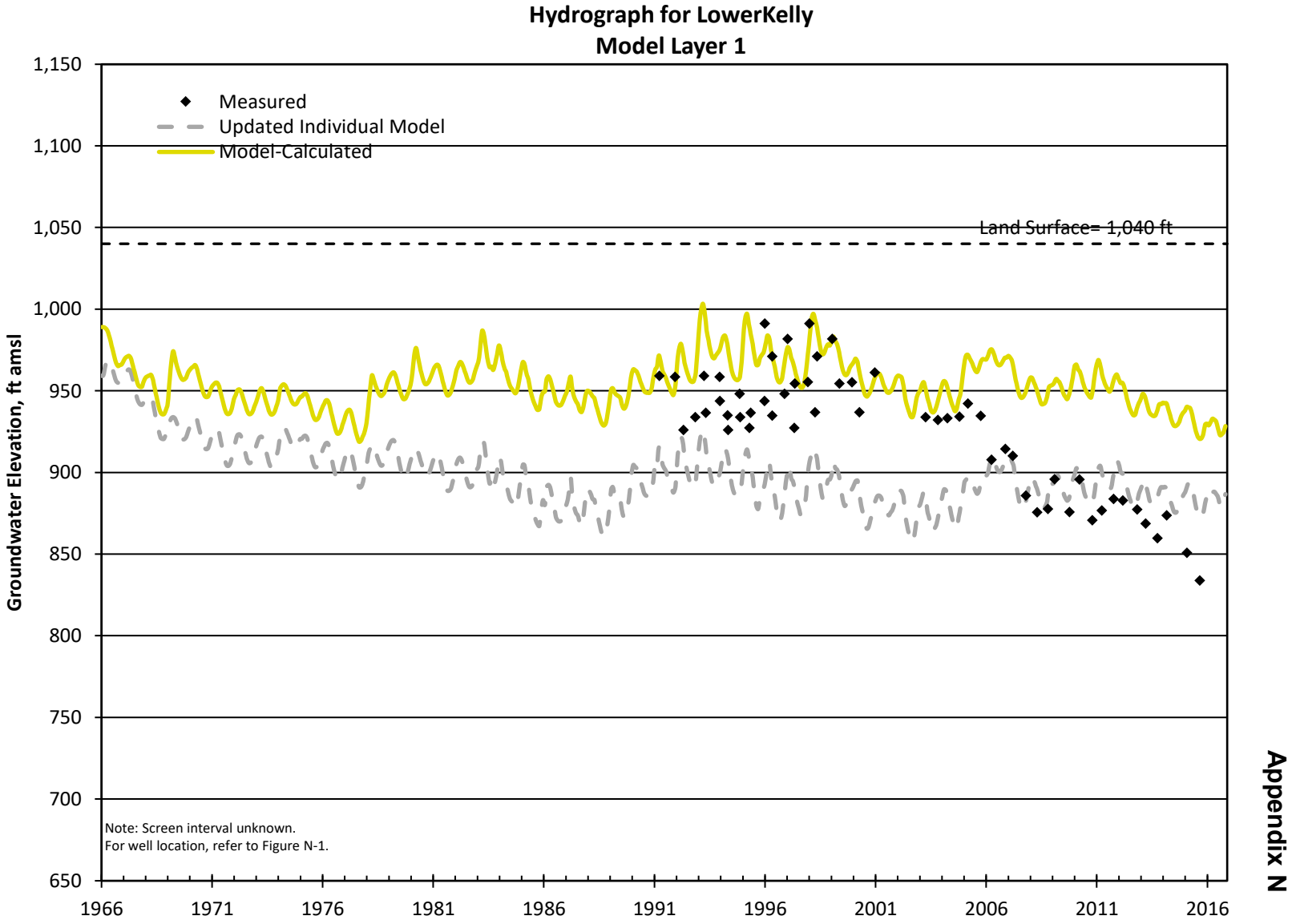
Appendix N


Hydrograph for Tri-City
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,195 ft
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure N-1.

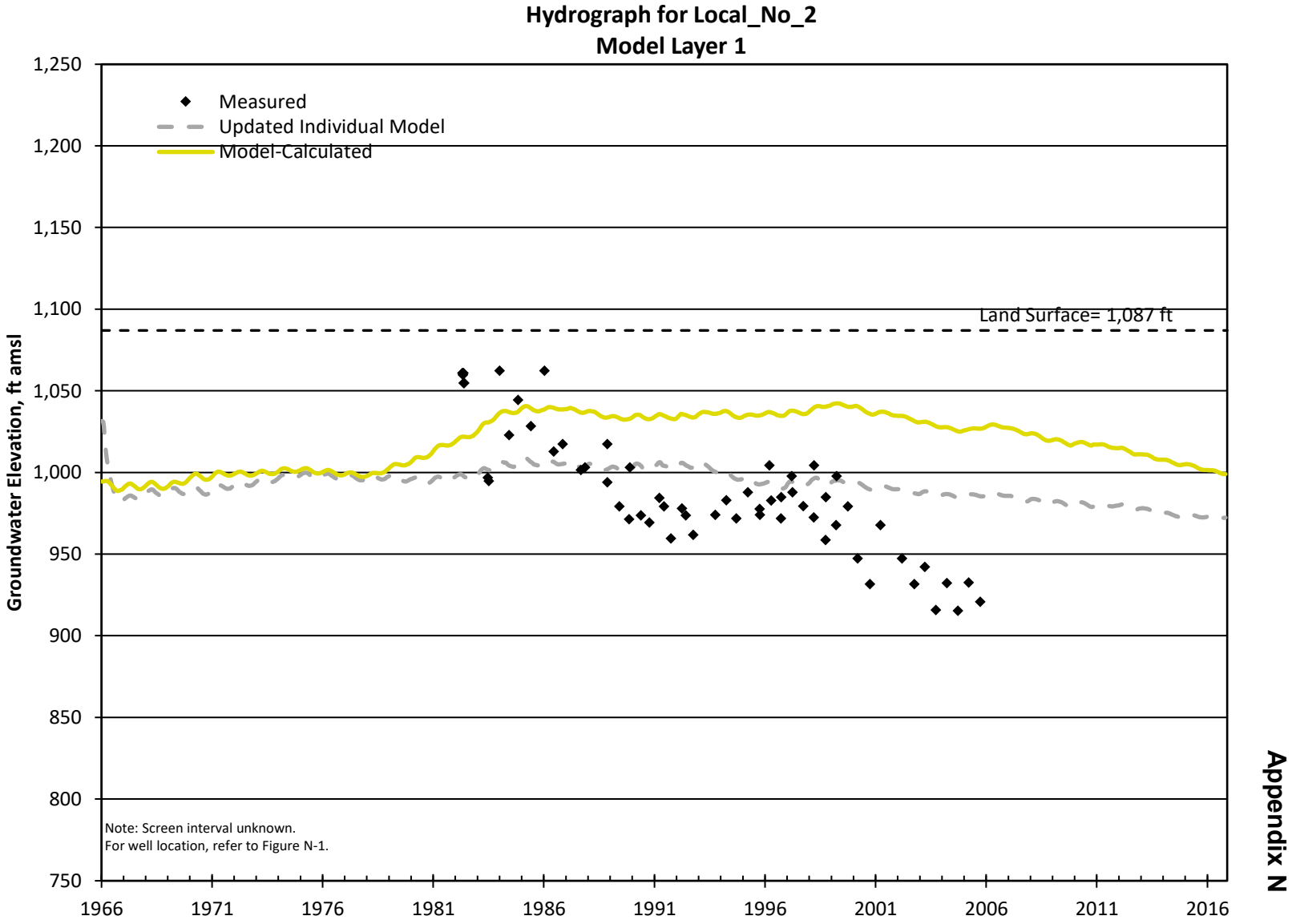
Appendix N


Hydrograph for Gage_Well_30-1
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,054 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
576 to 436
418 to 410
382 to 378
372 to 354
296 to 292
246 to 232
216 to 180
147 to 143
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

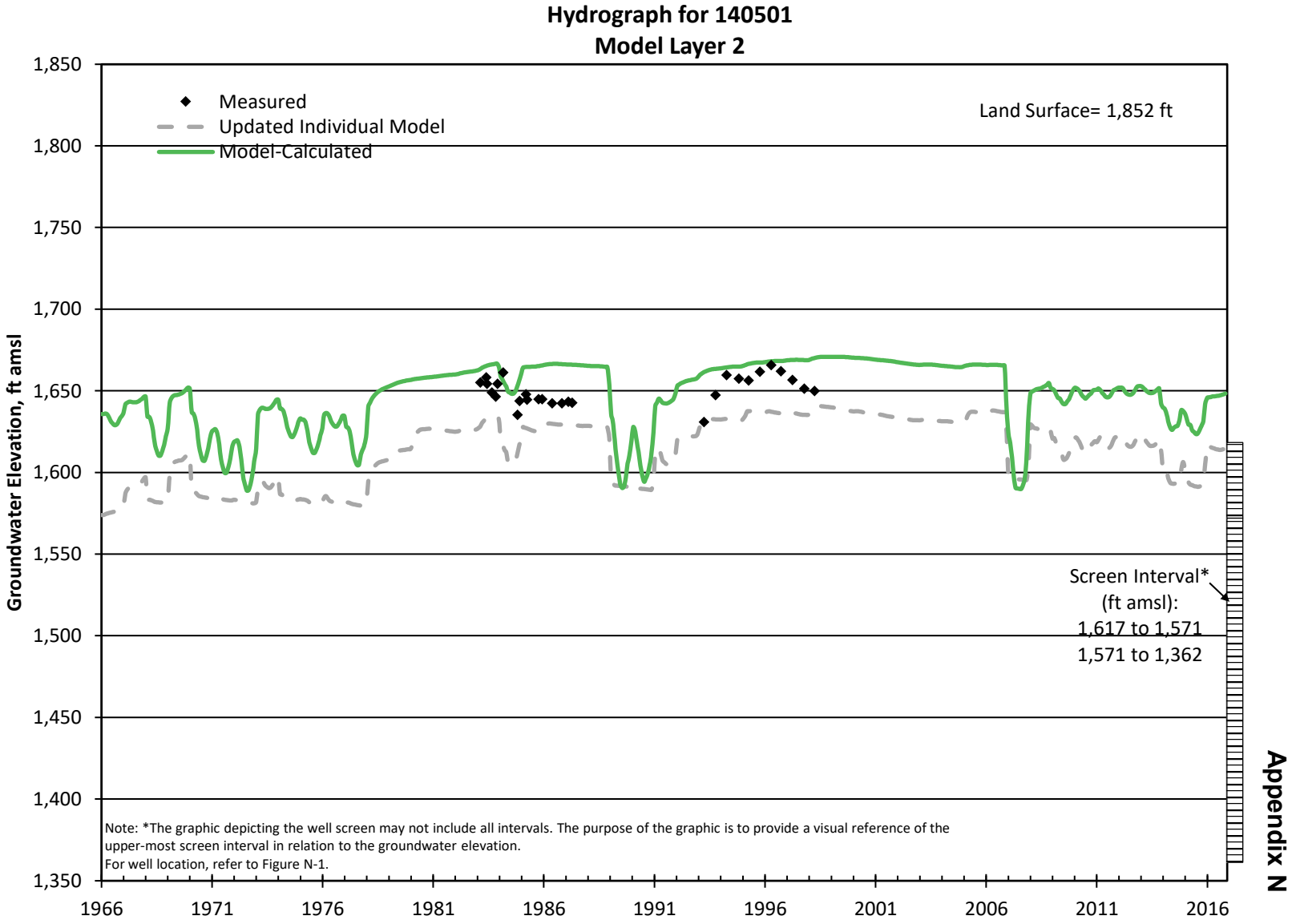
Appendix N


Hydrograph for LowerKelly
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,040 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure N-1.

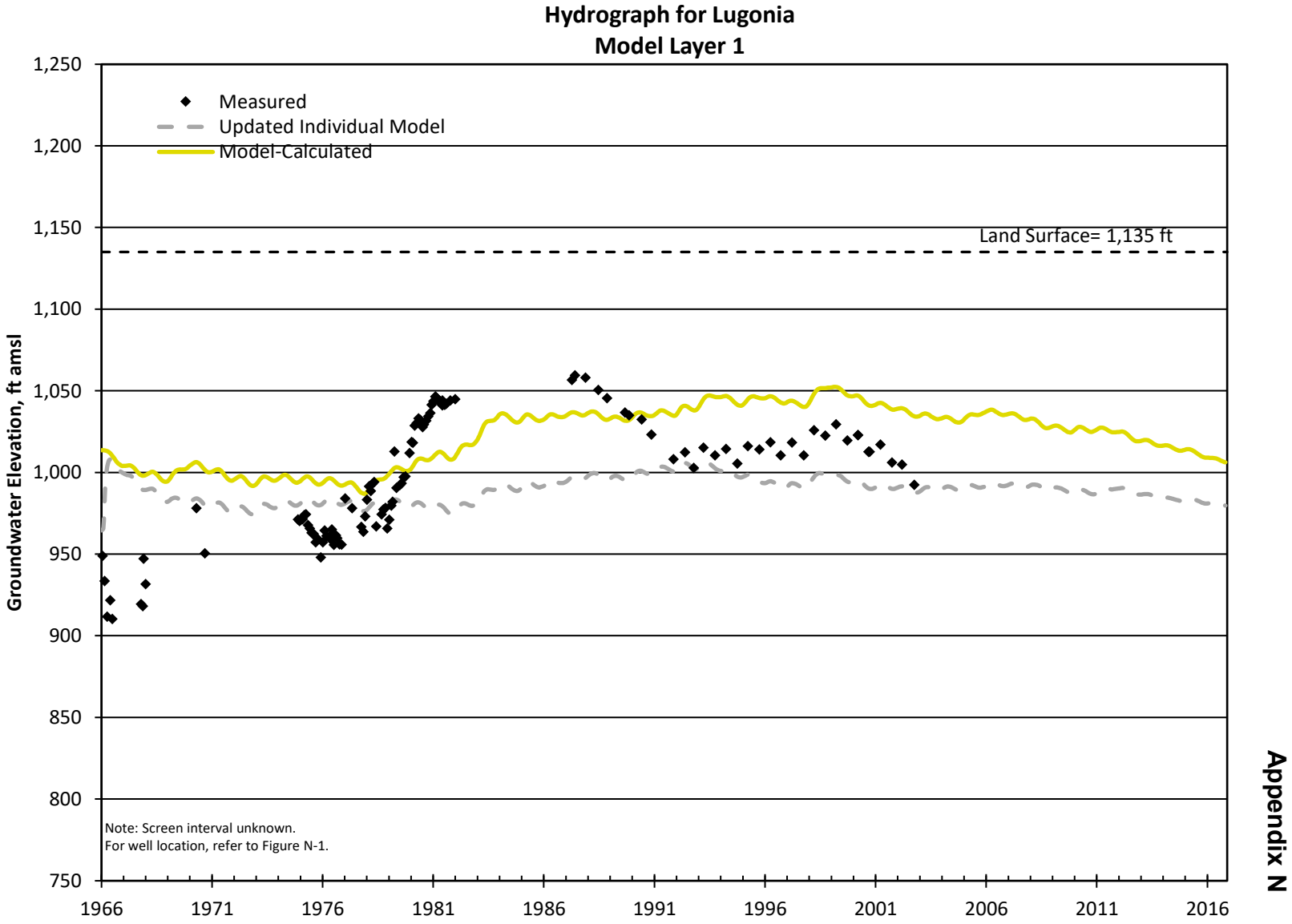
Appendix N


Hydrograph for Local_No_2
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,087 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure N-1.

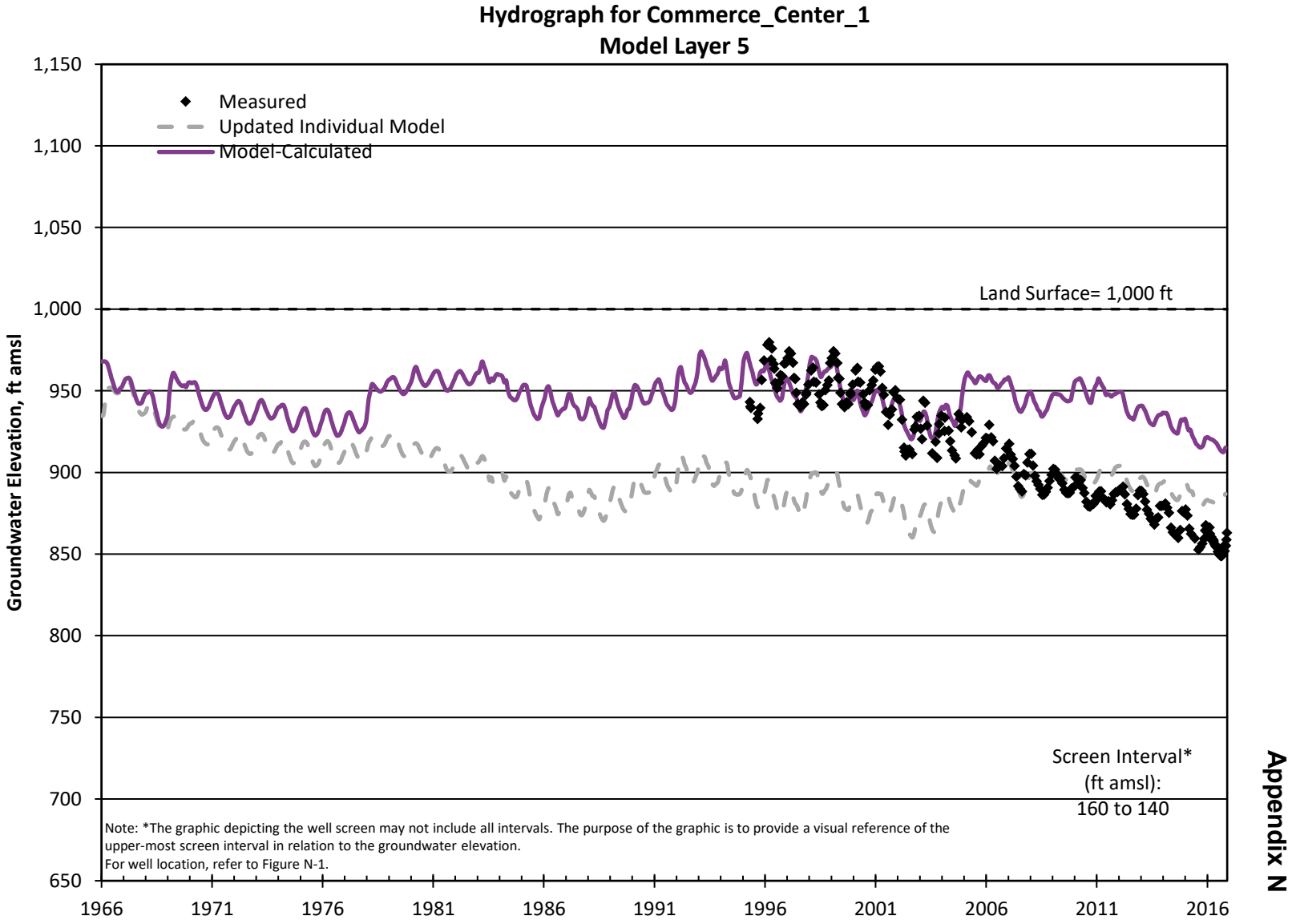
Appendix N


Hydrograph for 140501
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,852 ft
Groundwater Elevation, ft amsl
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,617 to 1,571
1,571 to 1,362
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

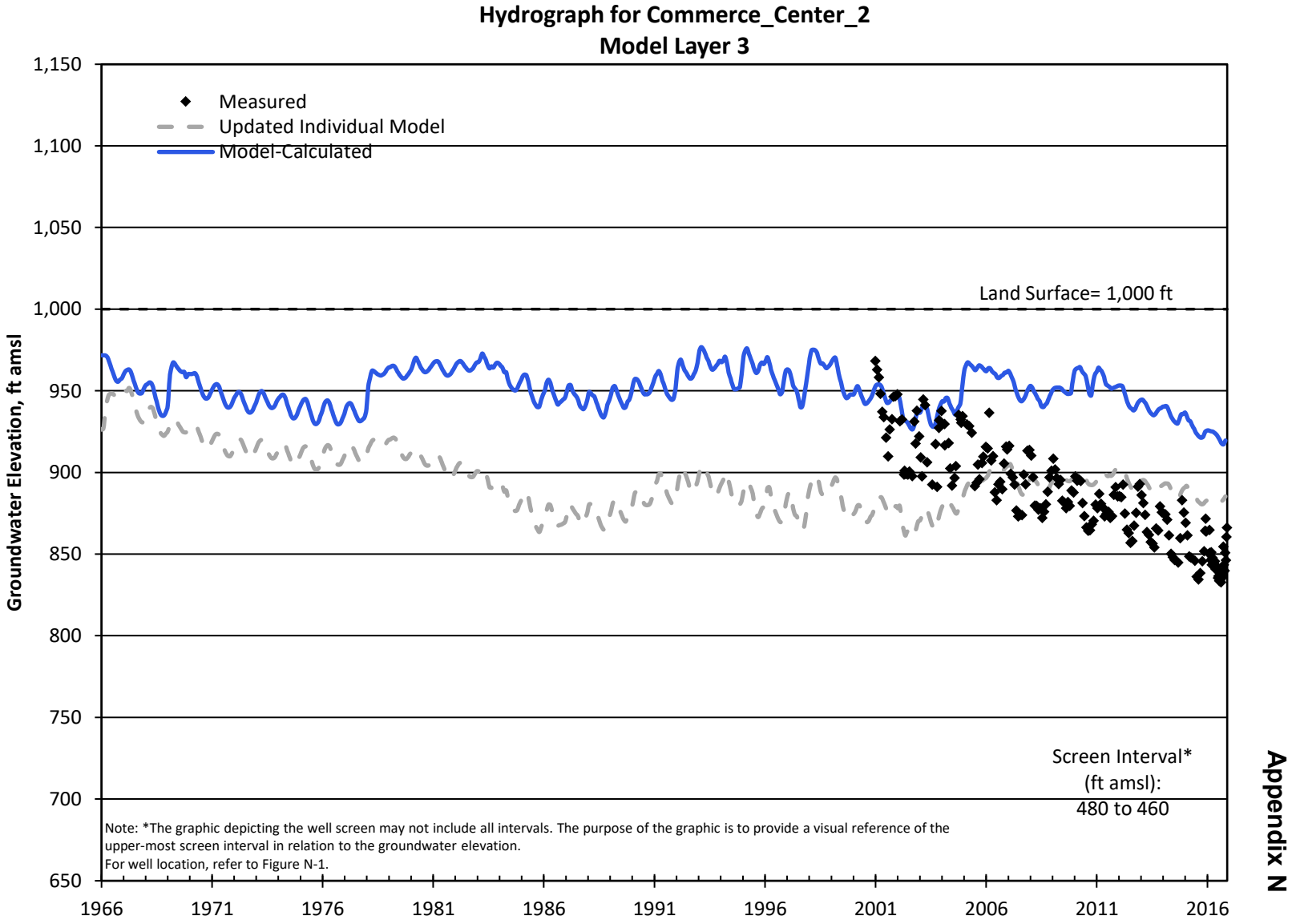
Appendix N


Hydrograph for Lugonia
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,135 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure N-1.

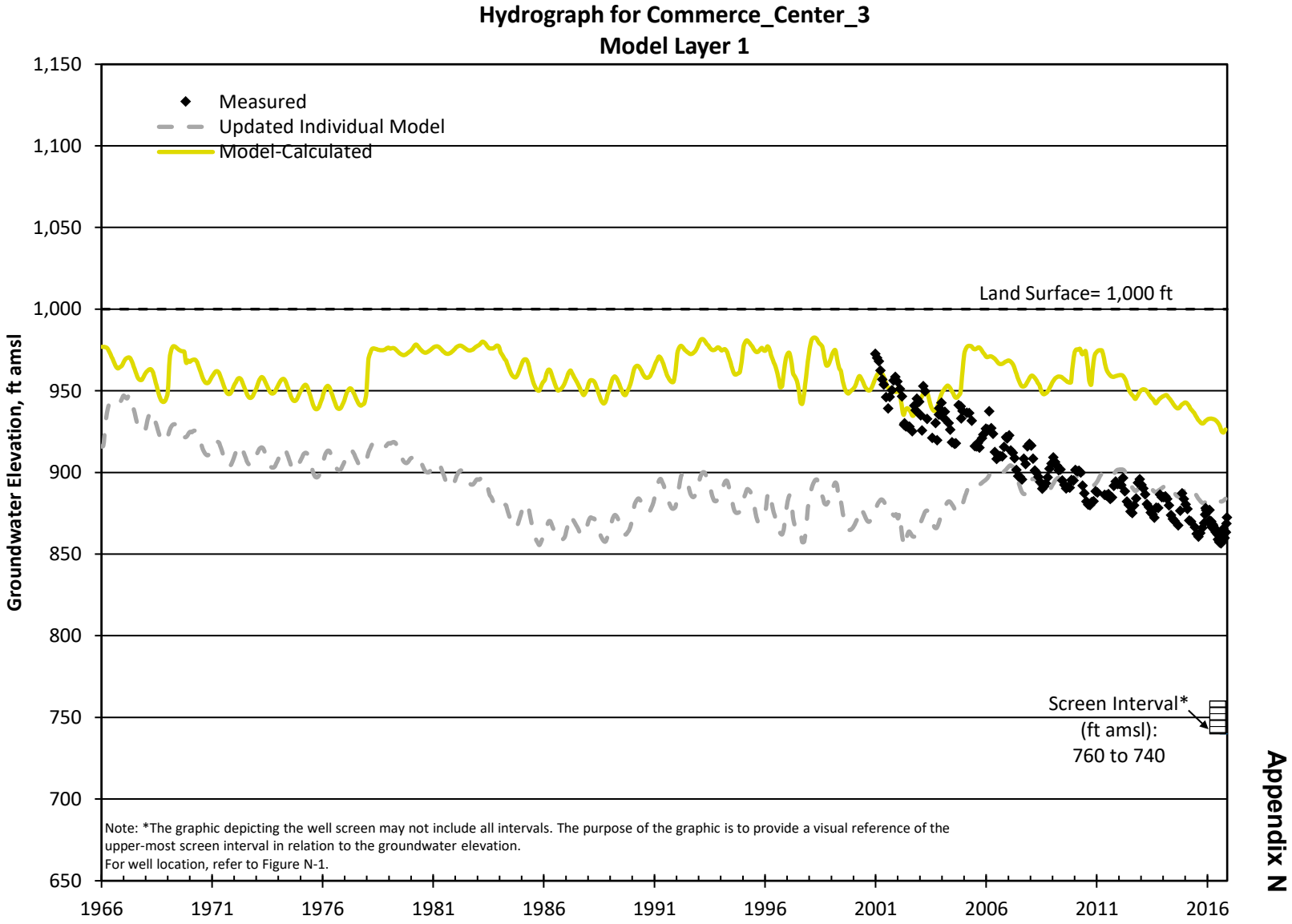
Appendix N


Hydrograph for Commerce_Center_1
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,000 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
160 to 140
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

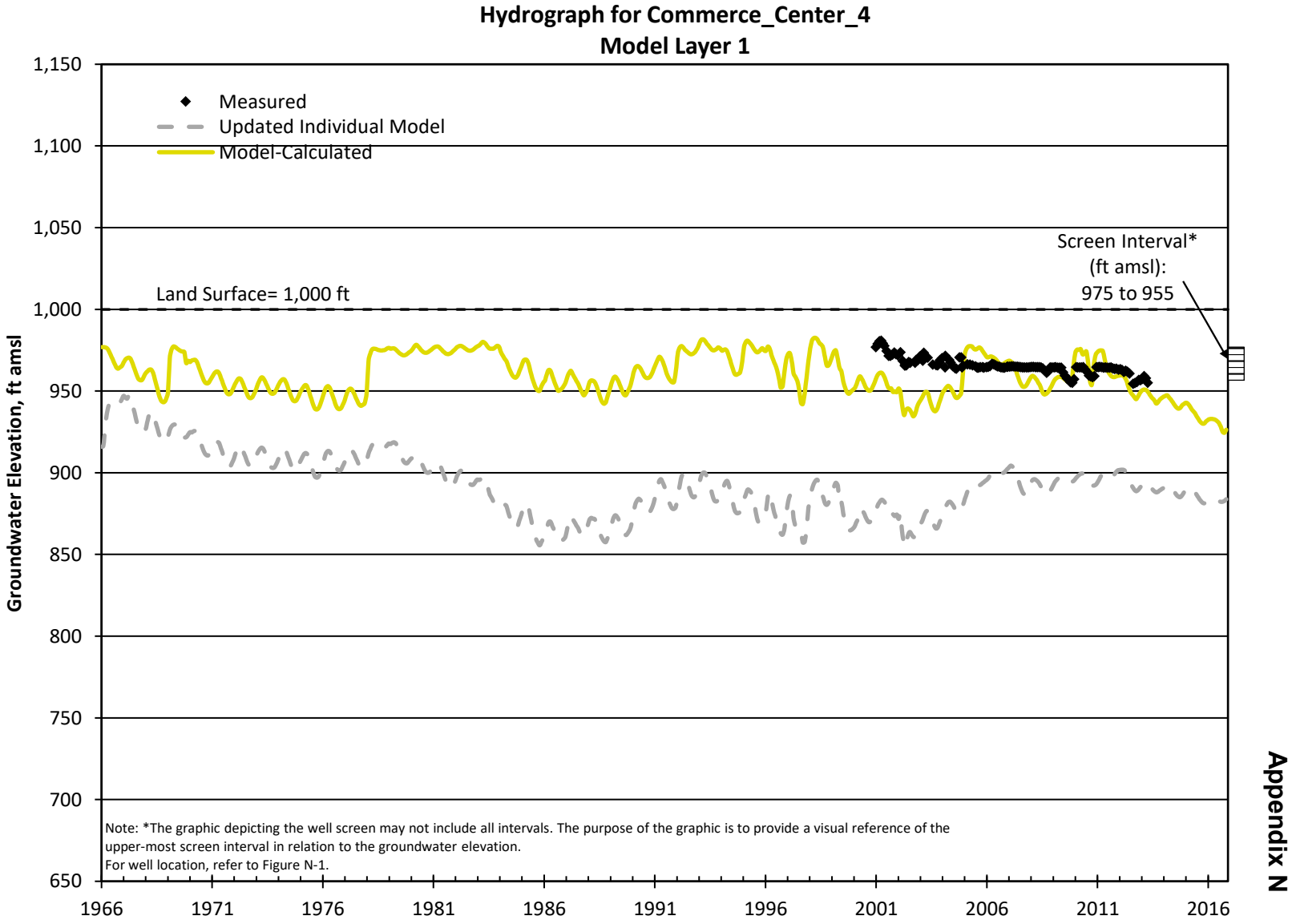
Appendix N


Hydrograph for Commerce_Center_2
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,000 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
480 to 460
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

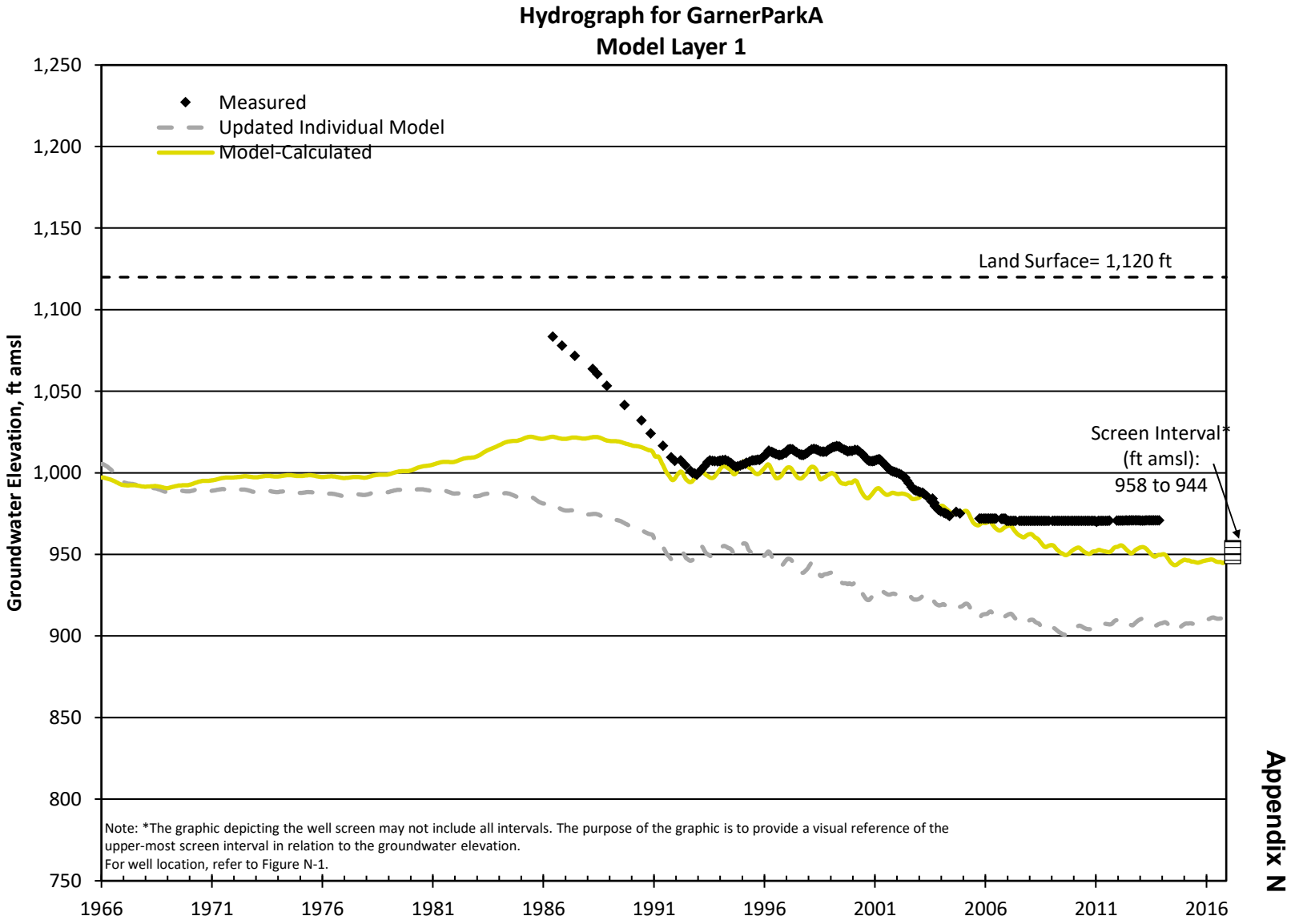
Appendix N


Hydrograph for Commerce_Center_3
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,000 ft
Screen Interval*
(ft amsl):
760 to 740
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

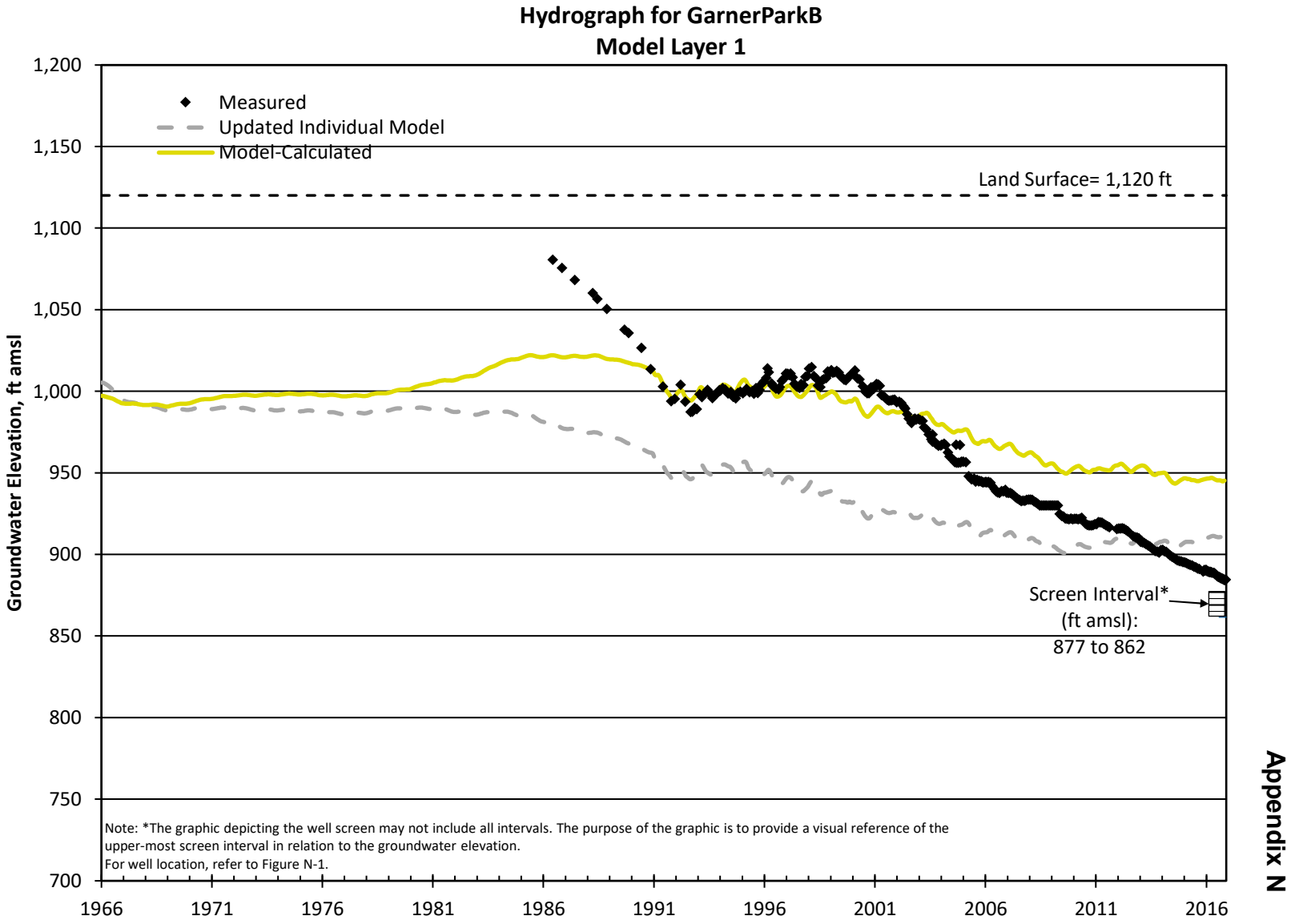
Appendix N


Hydrograph for Commerce_Center_4
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,000 ft
Screen Interval*
(ft amsl):
975 to 955
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

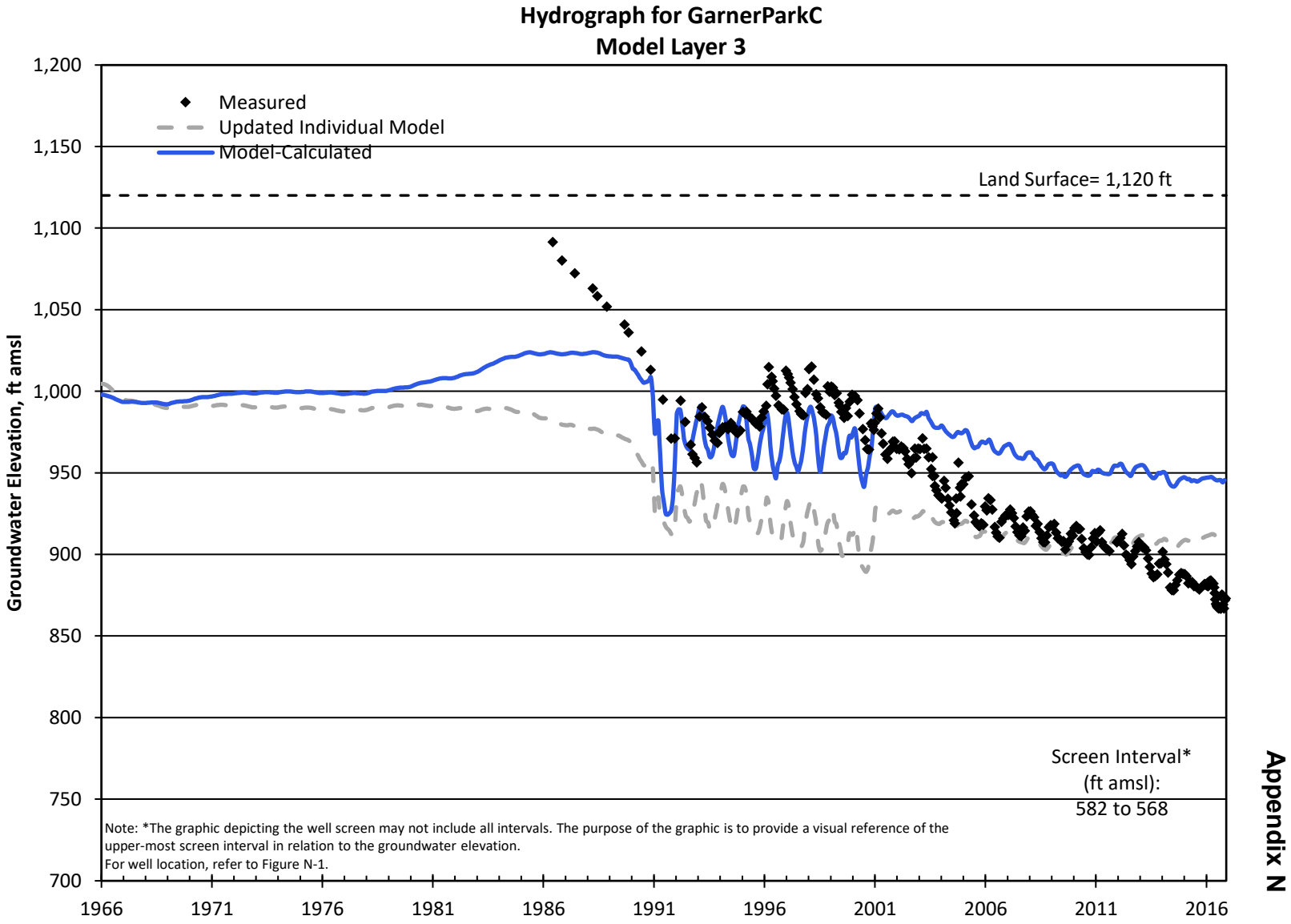
Appendix N


Hydrograph for GarnerParkA
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,120 ft
Screen Interval*
(ft amsl):
958 to 944
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

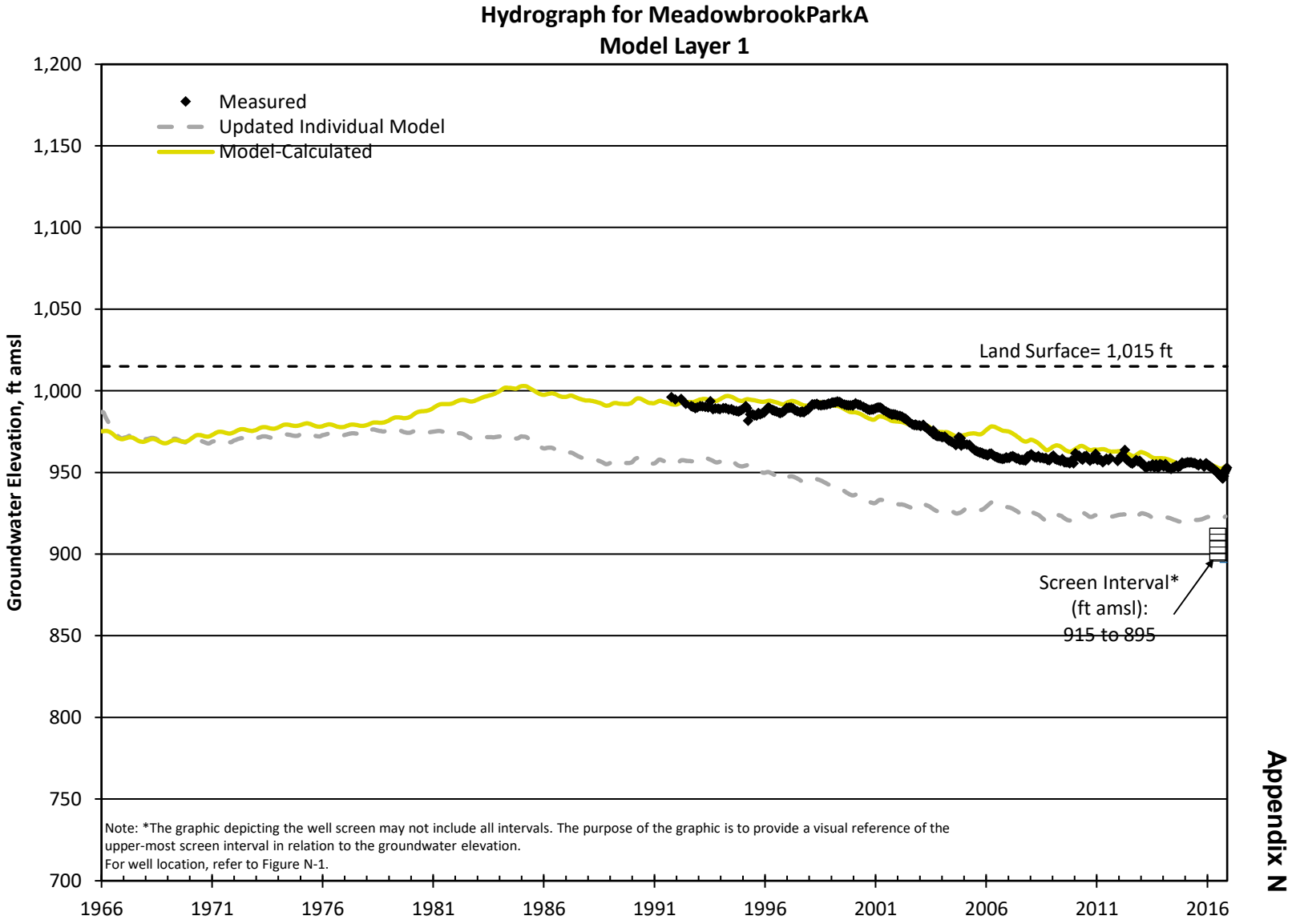
Appendix N


Hydrograph for GarnerParkB
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,120 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
877 to 862
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

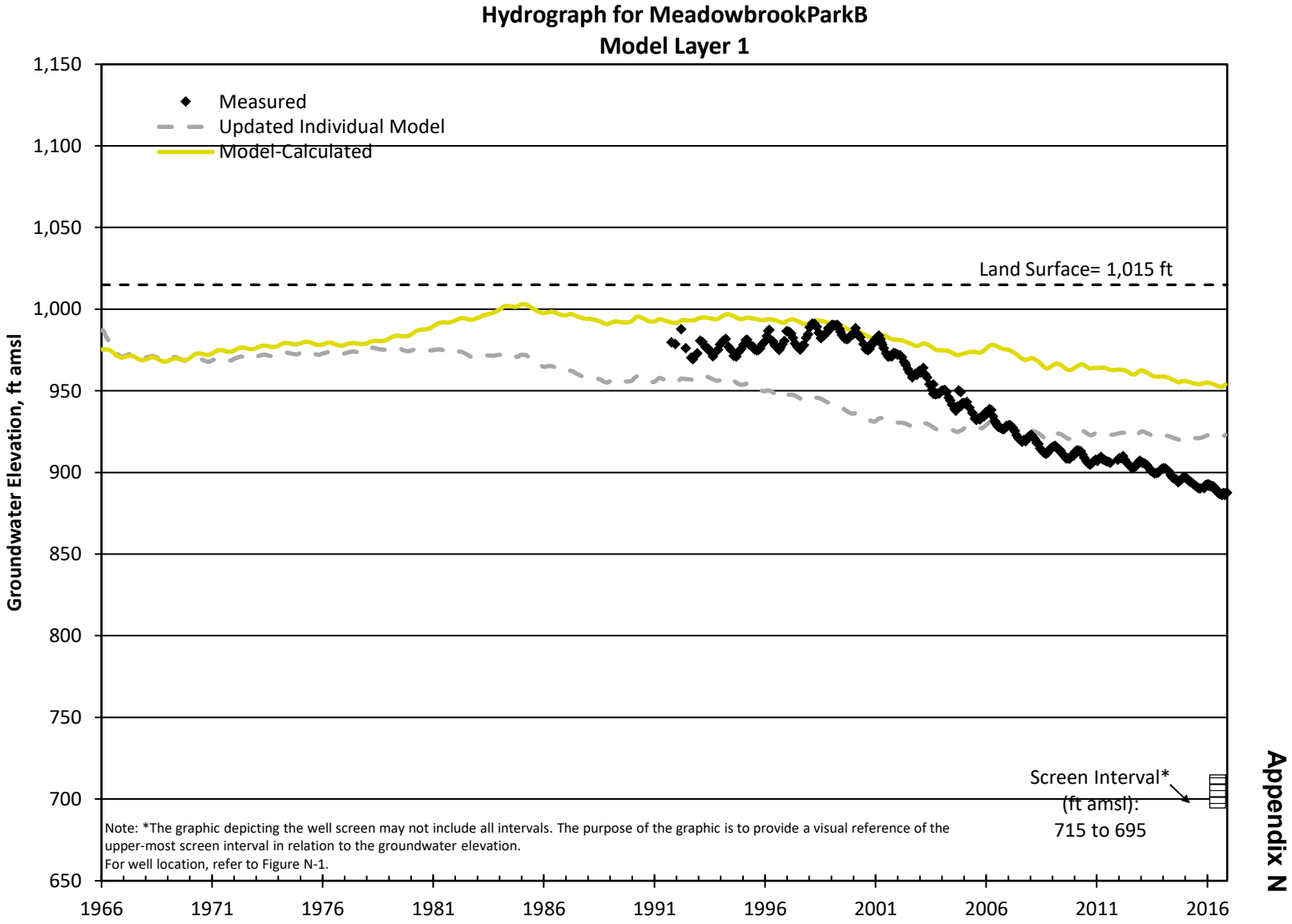
Appendix N


Hydrograph for GarnerParkC
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,120 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
582 to 568
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

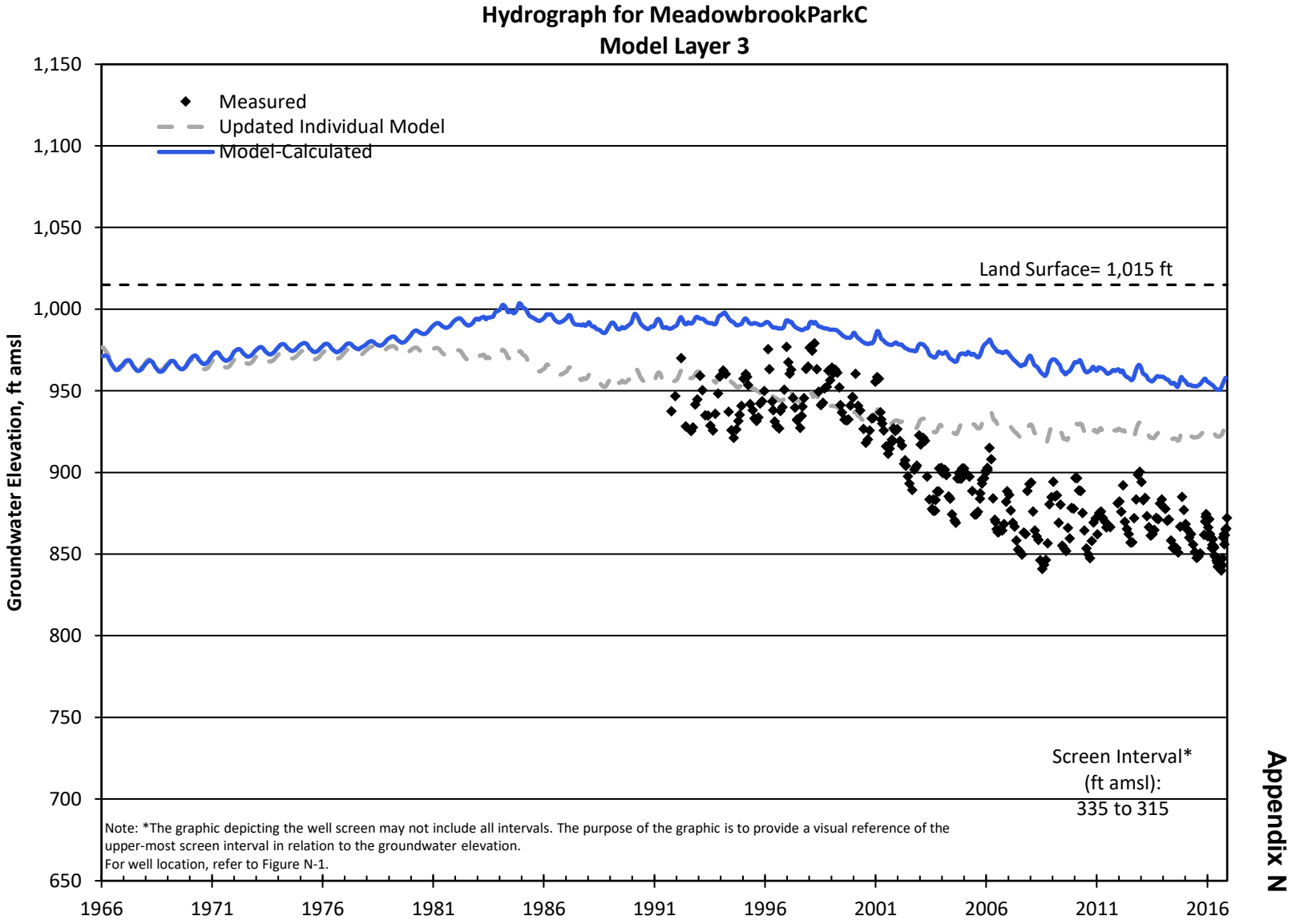
Appendix N


Hydrograph for MeadowbrookParkA
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,015 ft
Screen Interval*
(ft amsl):
915 to 895
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

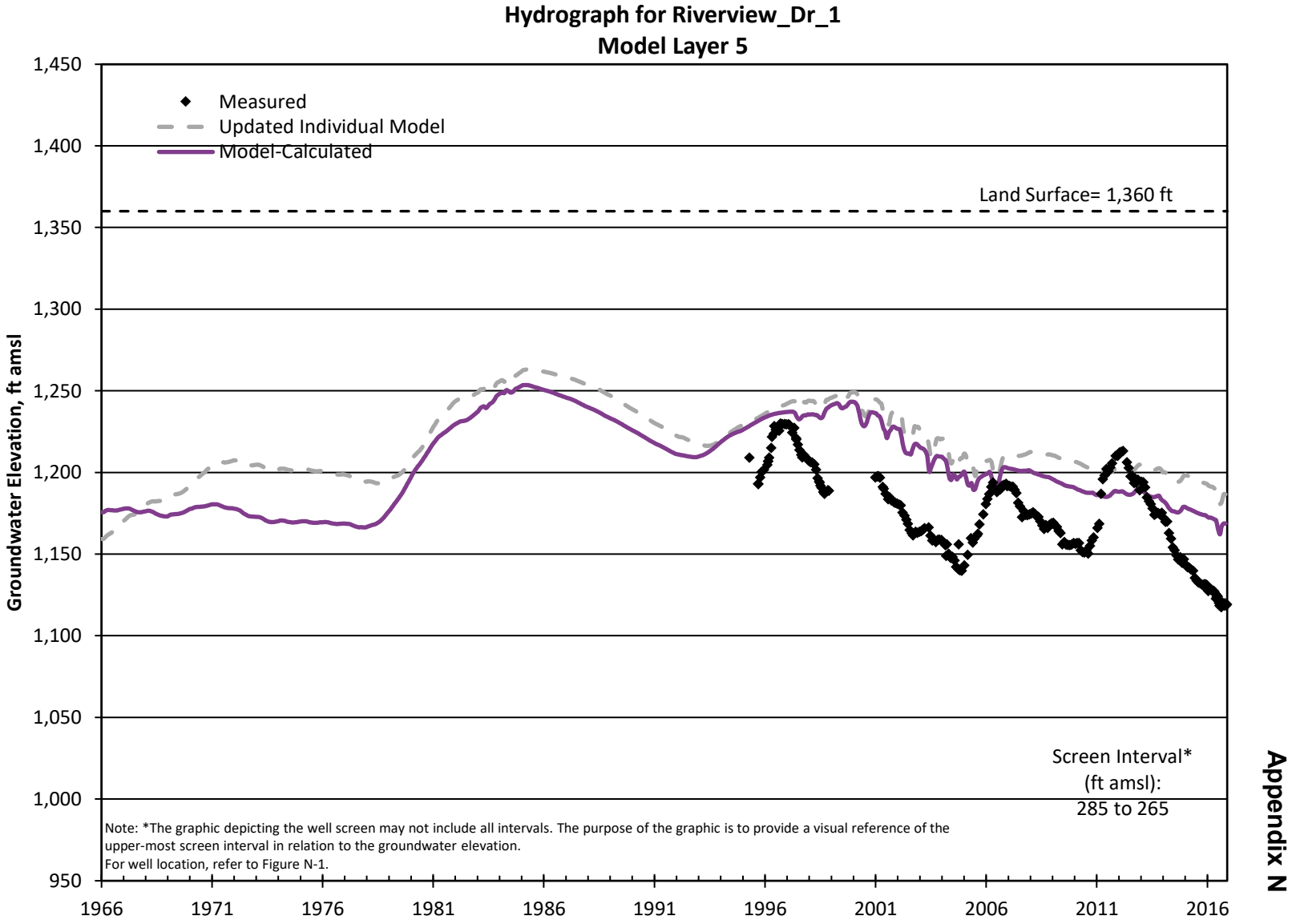
Appendix N


Hydrograph for MeadowbrookParkB
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,015 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
715 to 695
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

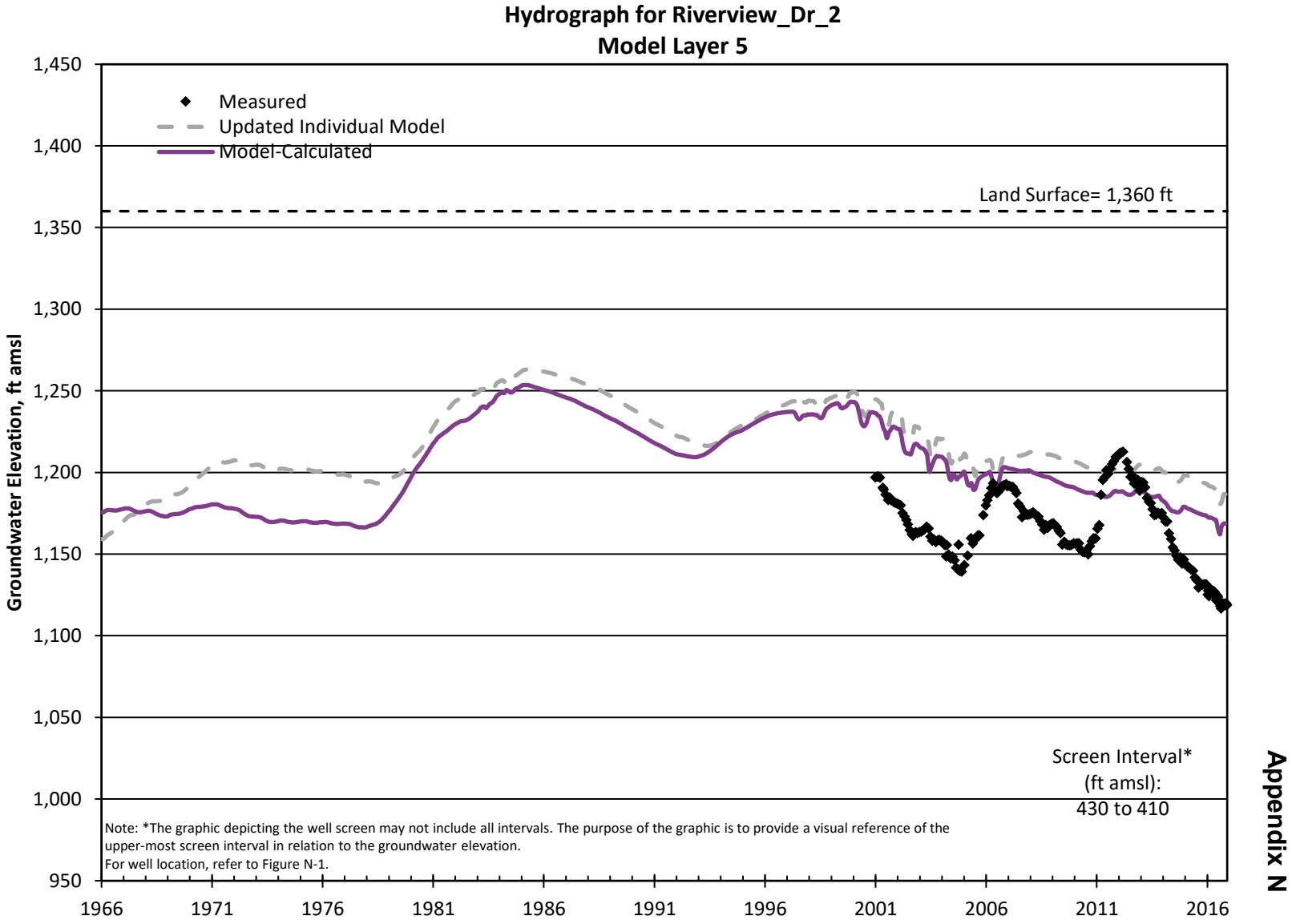
Appendix N


Hydrograph for MeadowbrookParkC
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,015 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
335 to 315
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

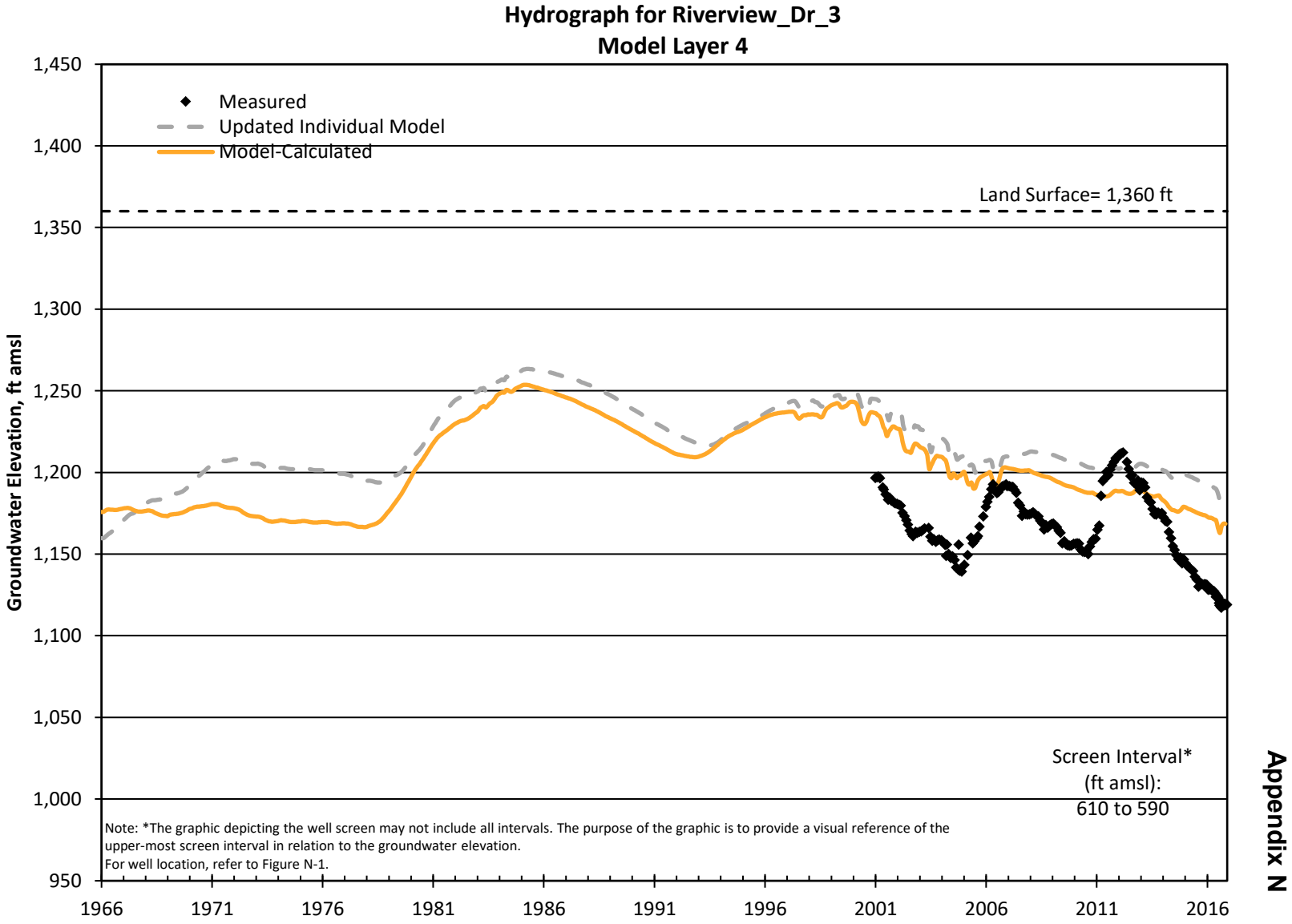
Appendix N


Hydrograph for Riverview_Dr_1
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,360 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
285 to 265
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

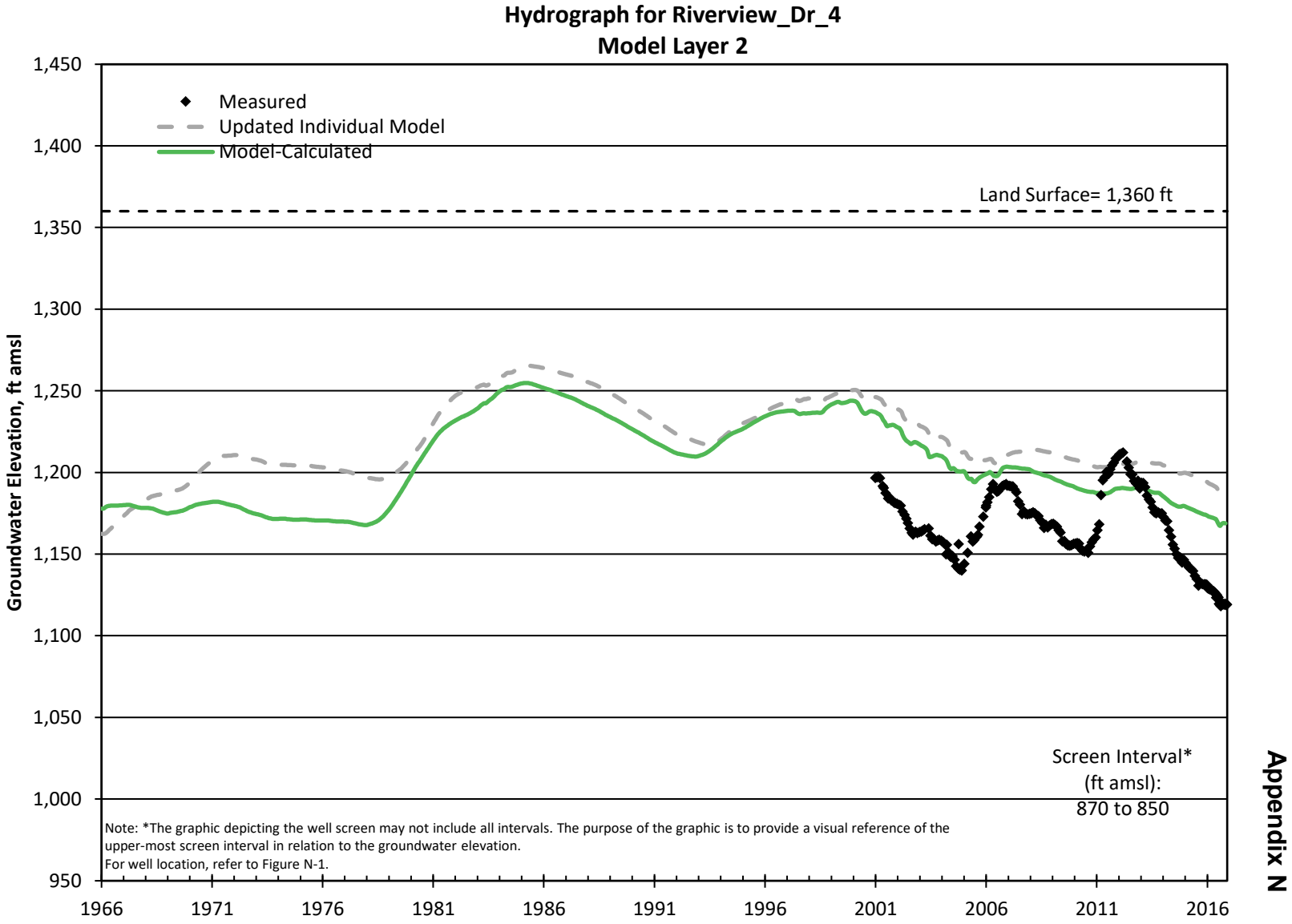
Appendix N


Hydrograph for Riverview_Dr_2
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,360 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
430 to 410
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

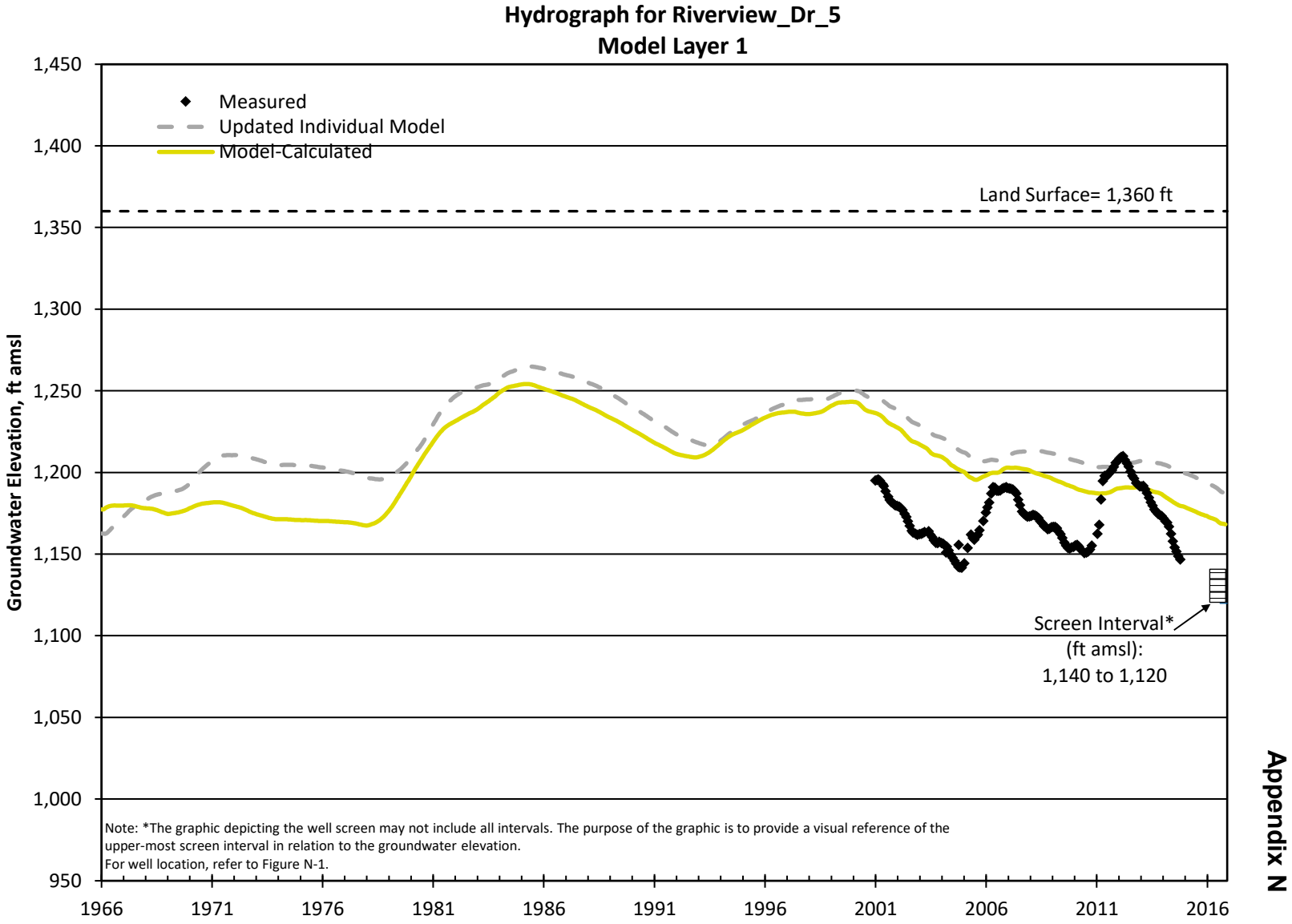
Appendix N


Hydrograph for Riverview_Dr_3
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,360 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
610 to 590
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

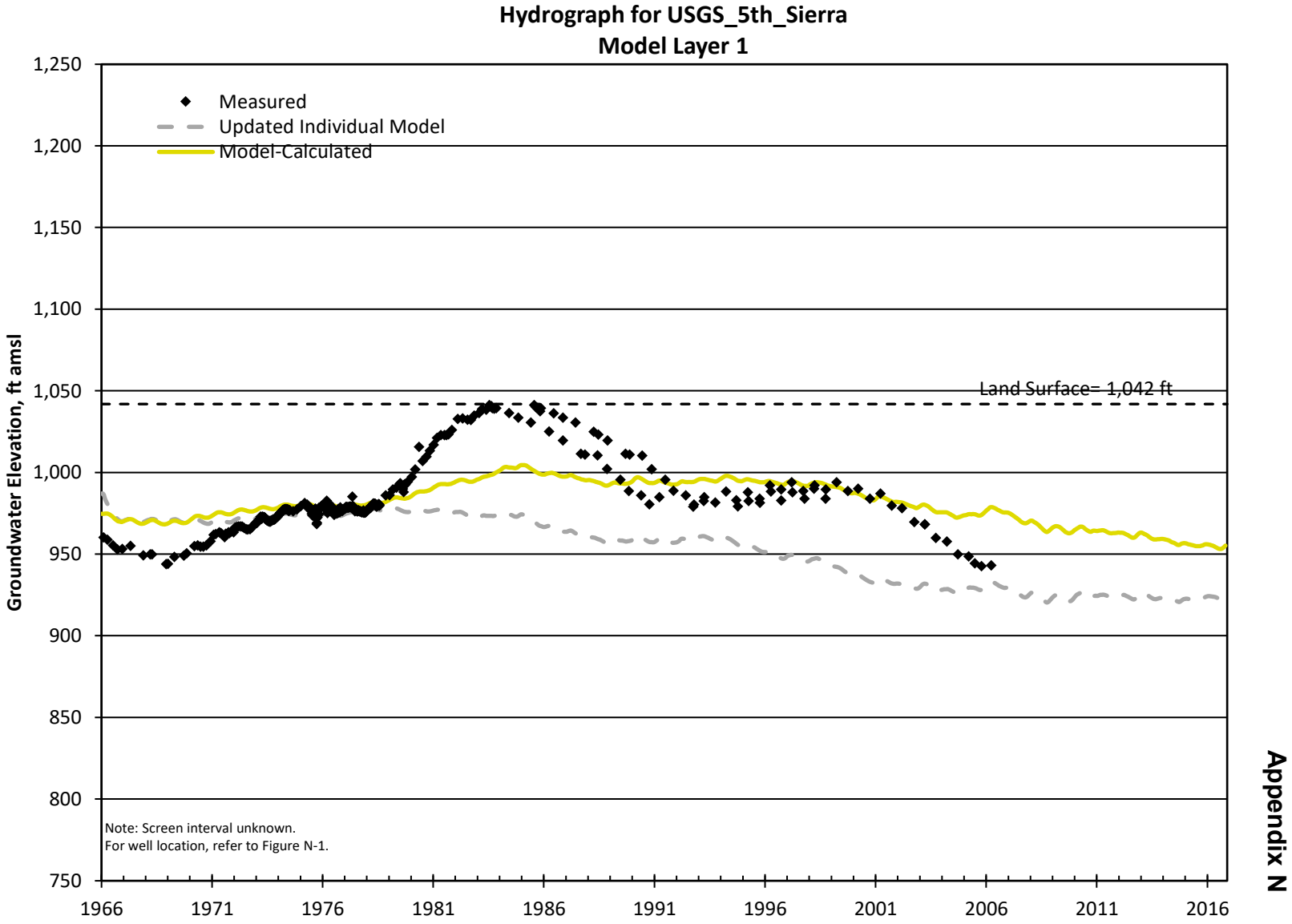
Appendix N


Hydrograph for Riverview_Dr_4
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,360 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
870 to 850
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

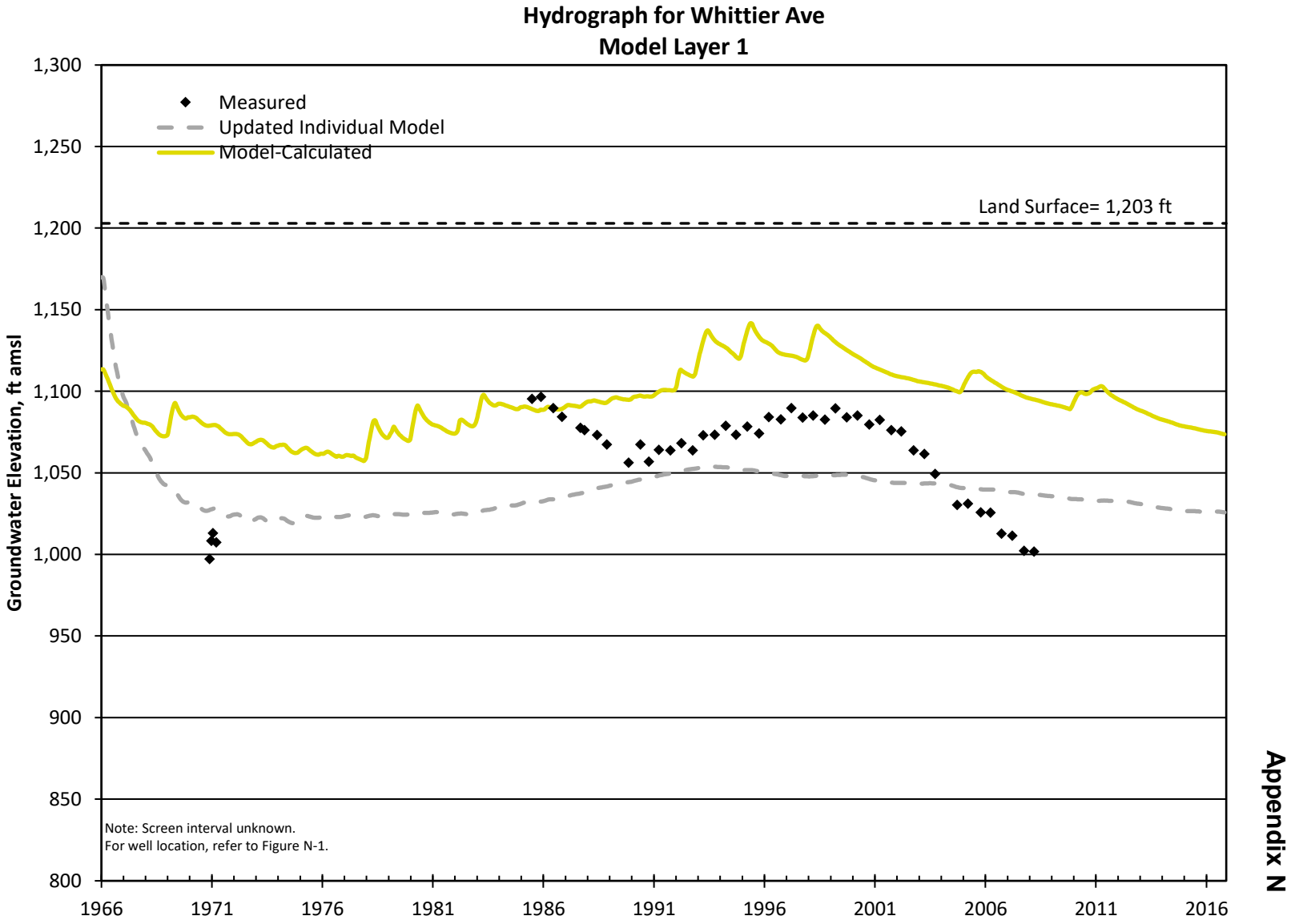
Appendix N


Hydrograph for Riverview_Dr_5
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,360 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,140 to 1,120
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

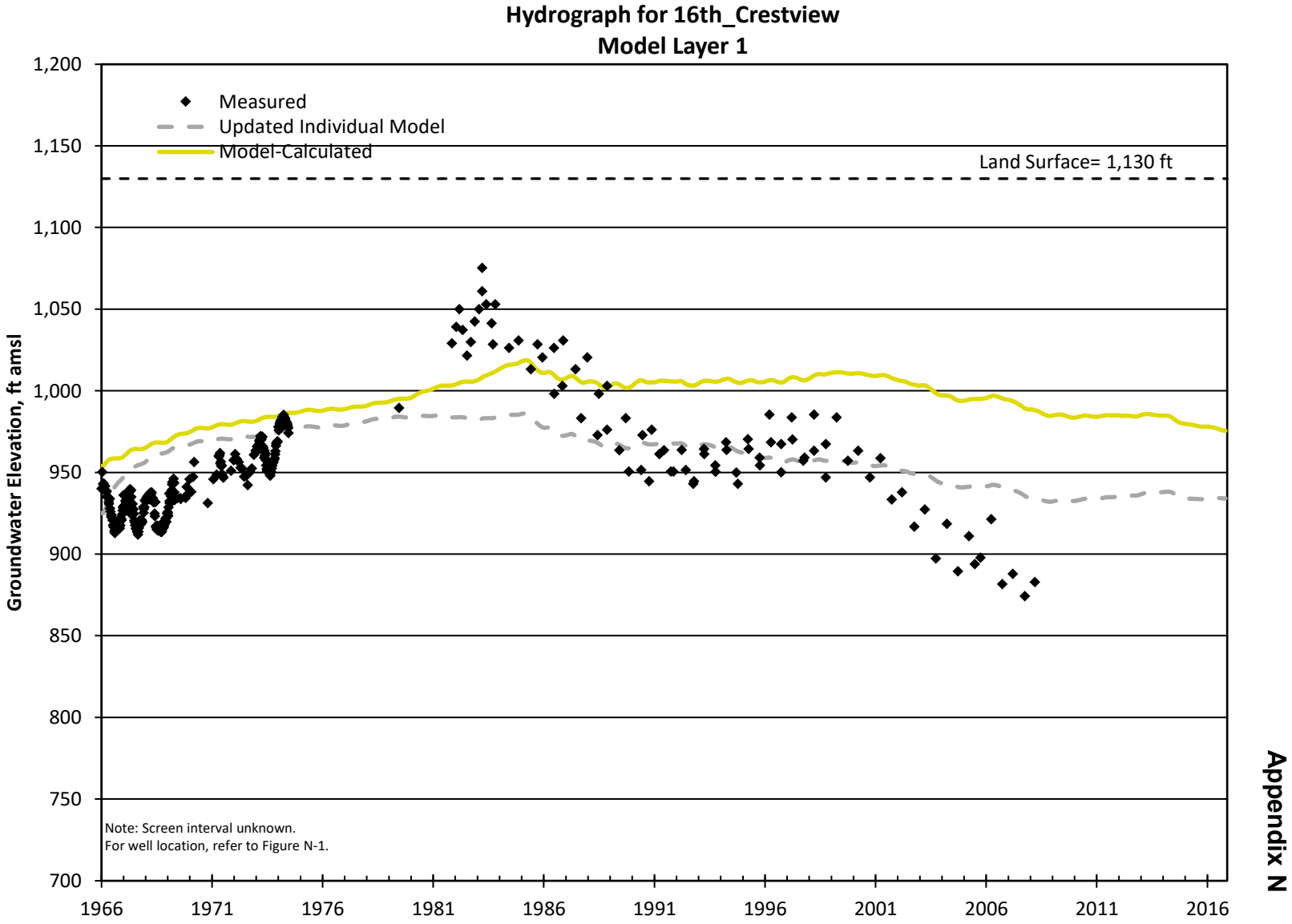
Appendix N


Hydrograph for USGS_5th_Sierra
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,042 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure N-1.

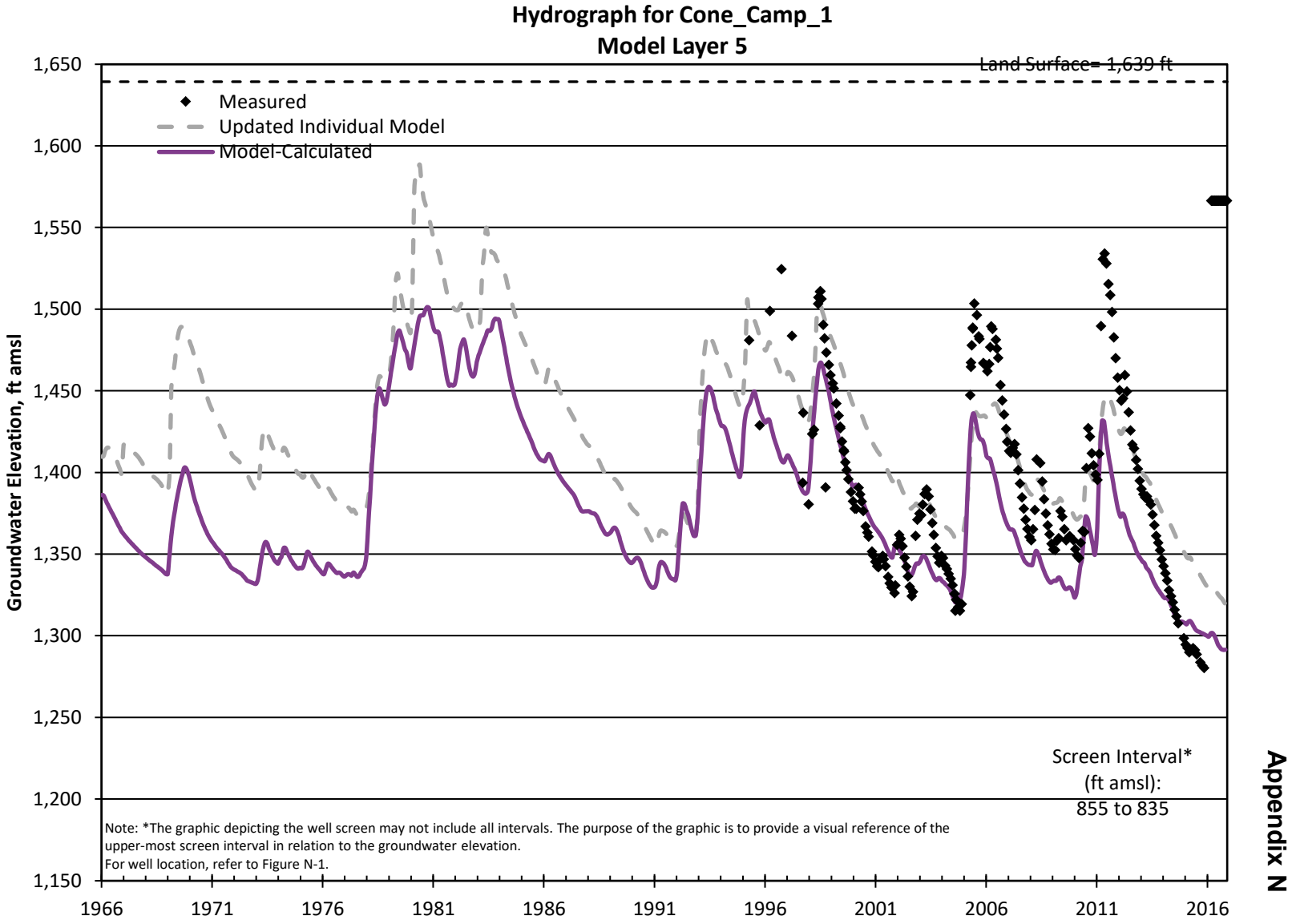
Appendix N


Hydrograph for Whittier Ave
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,203 ft
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure N-1.

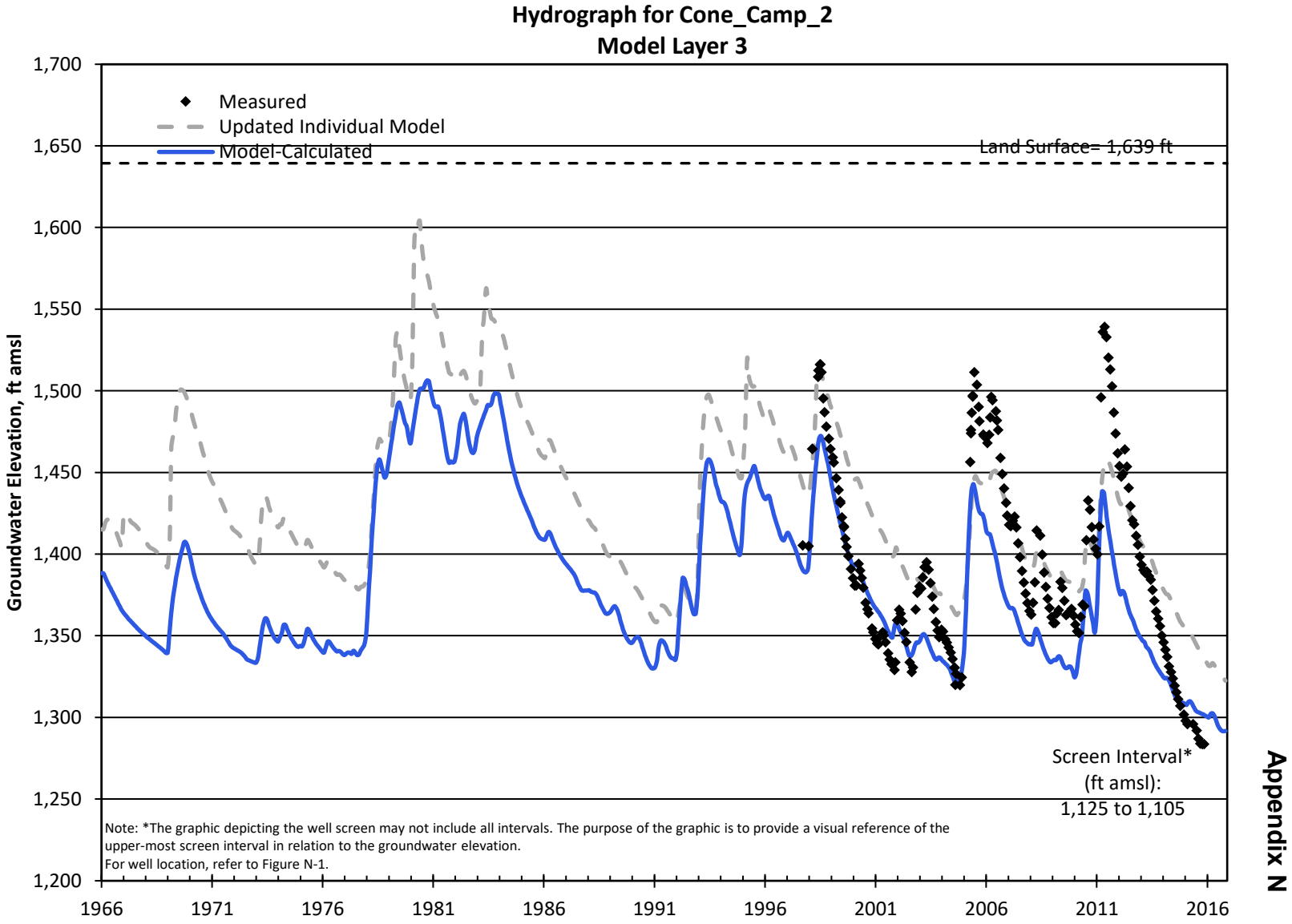
Appendix N


Hydrograph for 16th_Crestview
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,130 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure N-1.

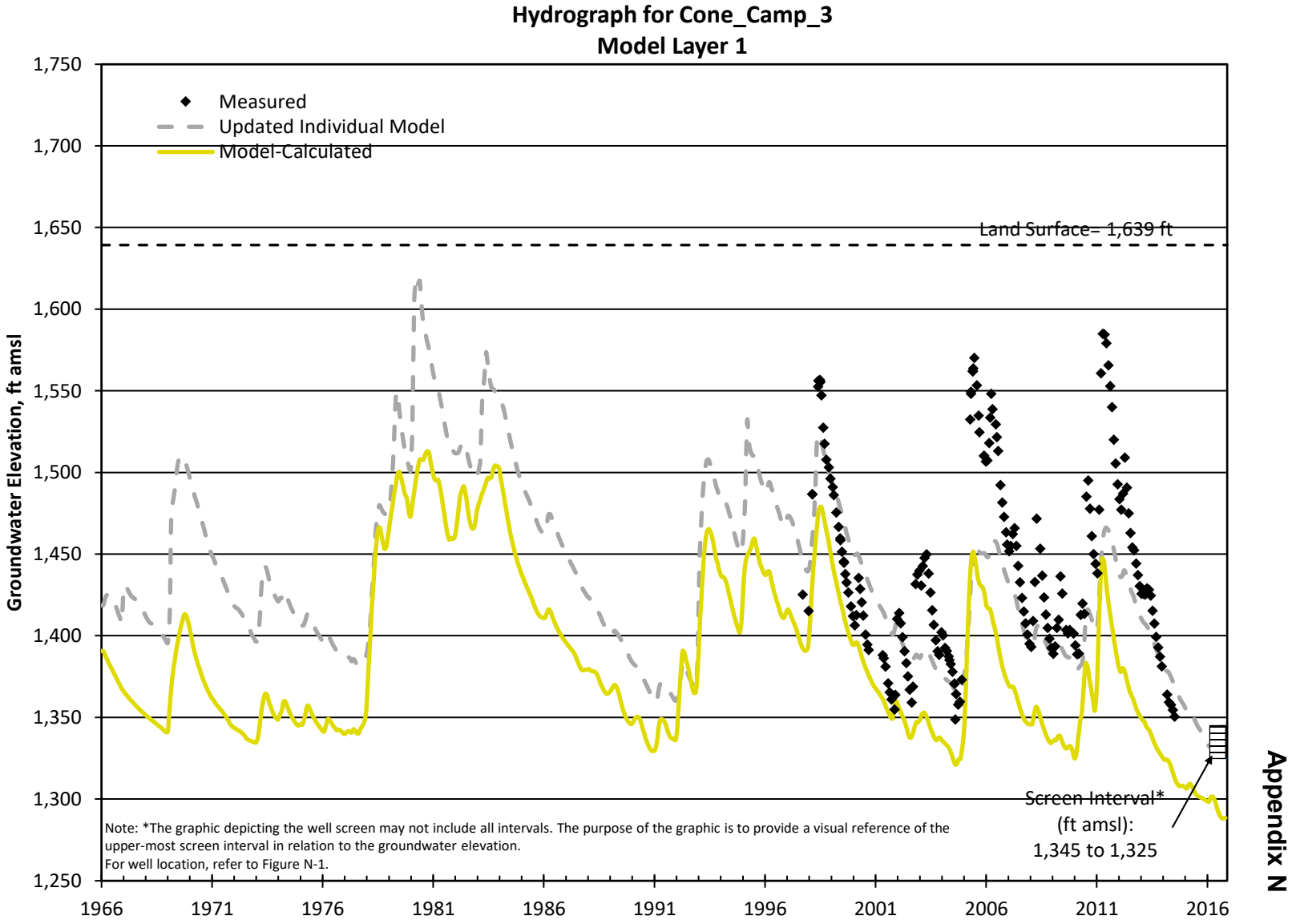
Appendix N


Hydrograph for Cone_Camp_1
Model Layer 5
Land Surface= 1,639 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
855 to 835
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

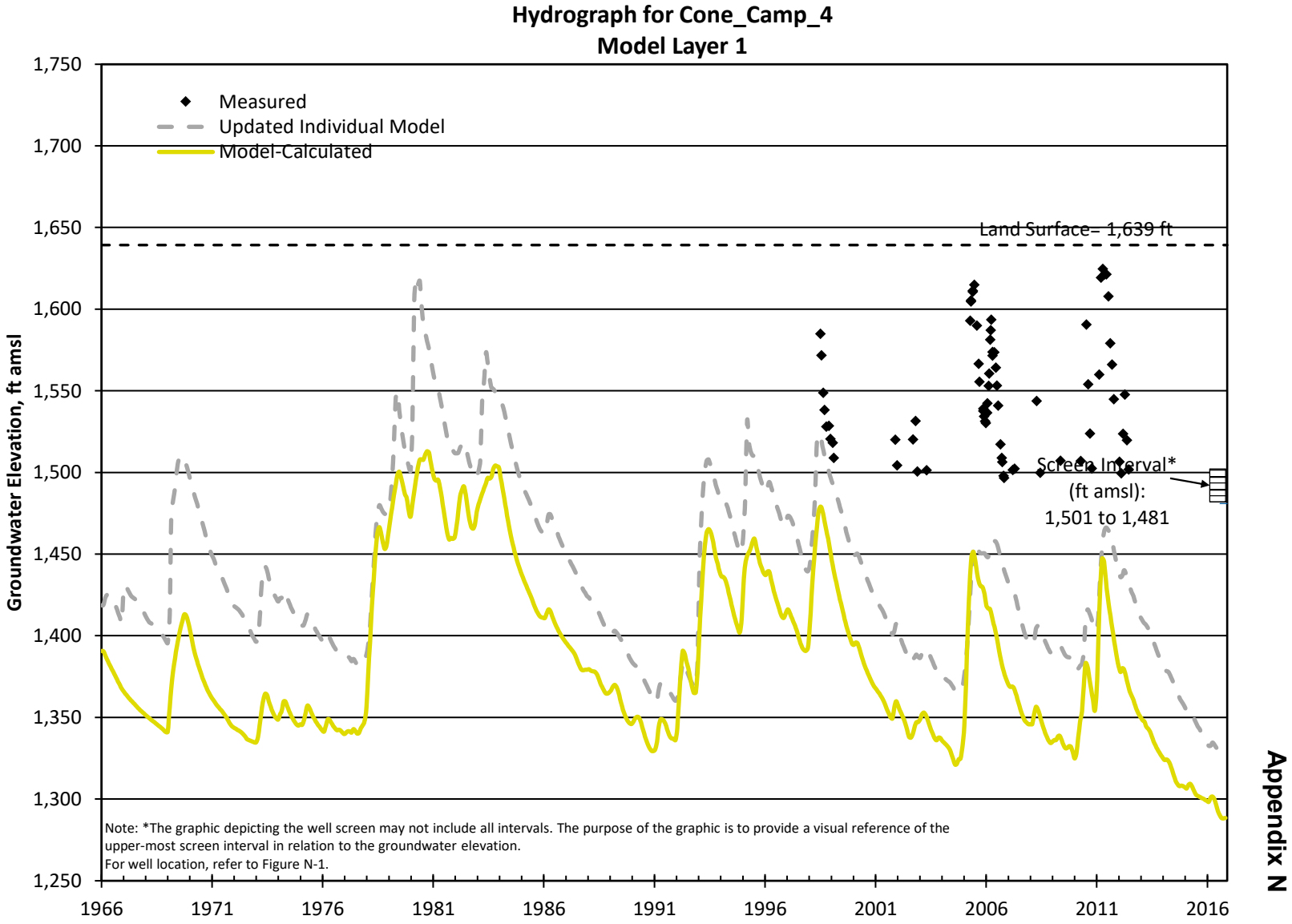
Appendix N


Hydrograph for Cone_Camp_2
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,639 ft
Groundwater Elevation, ft amsl
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,125 to 1,105
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

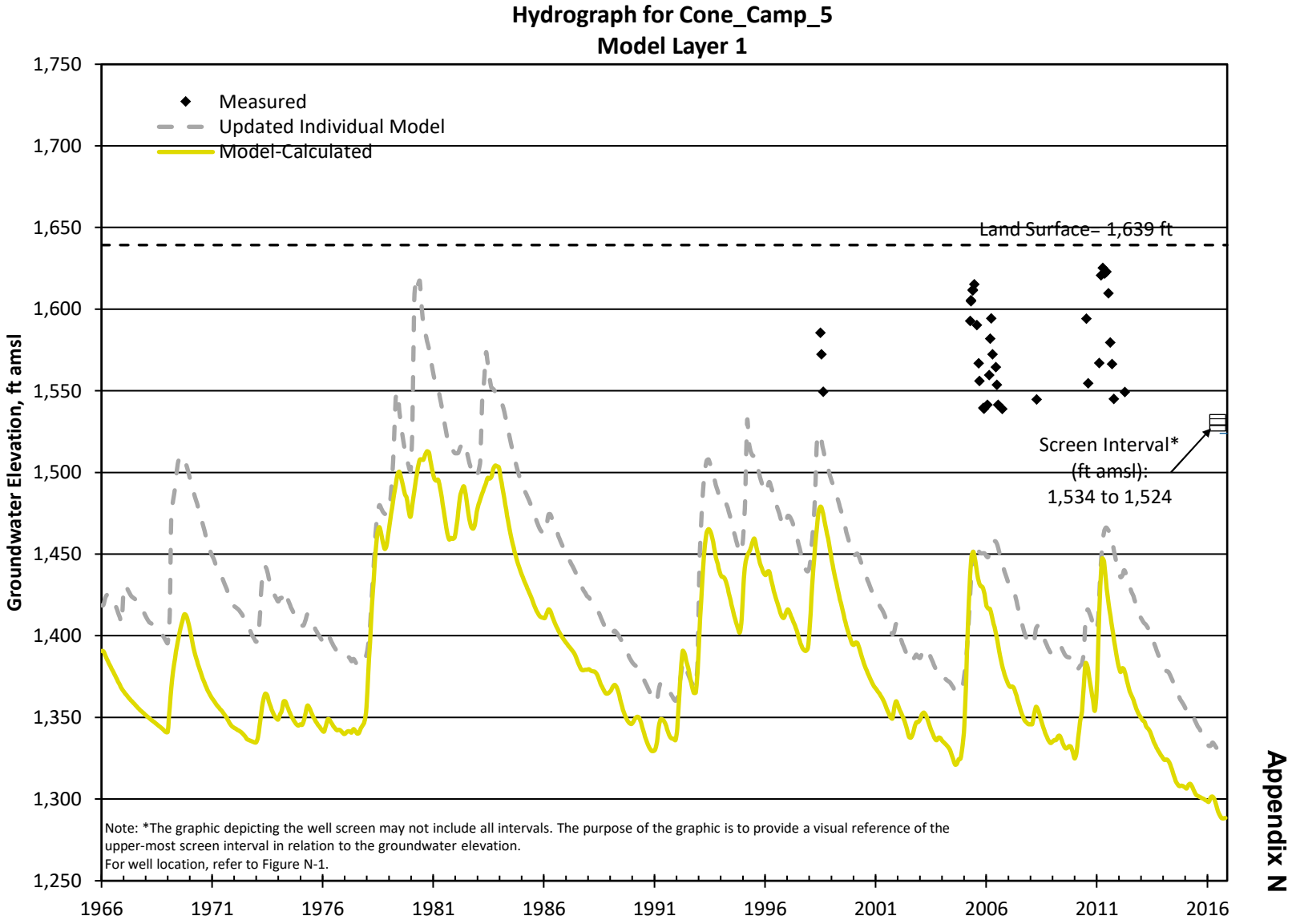
Appendix N


Hydrograph for Cone_Camp_3
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,639 ft
Groundwater Elevation, ft amsl
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,345 to 1,325
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

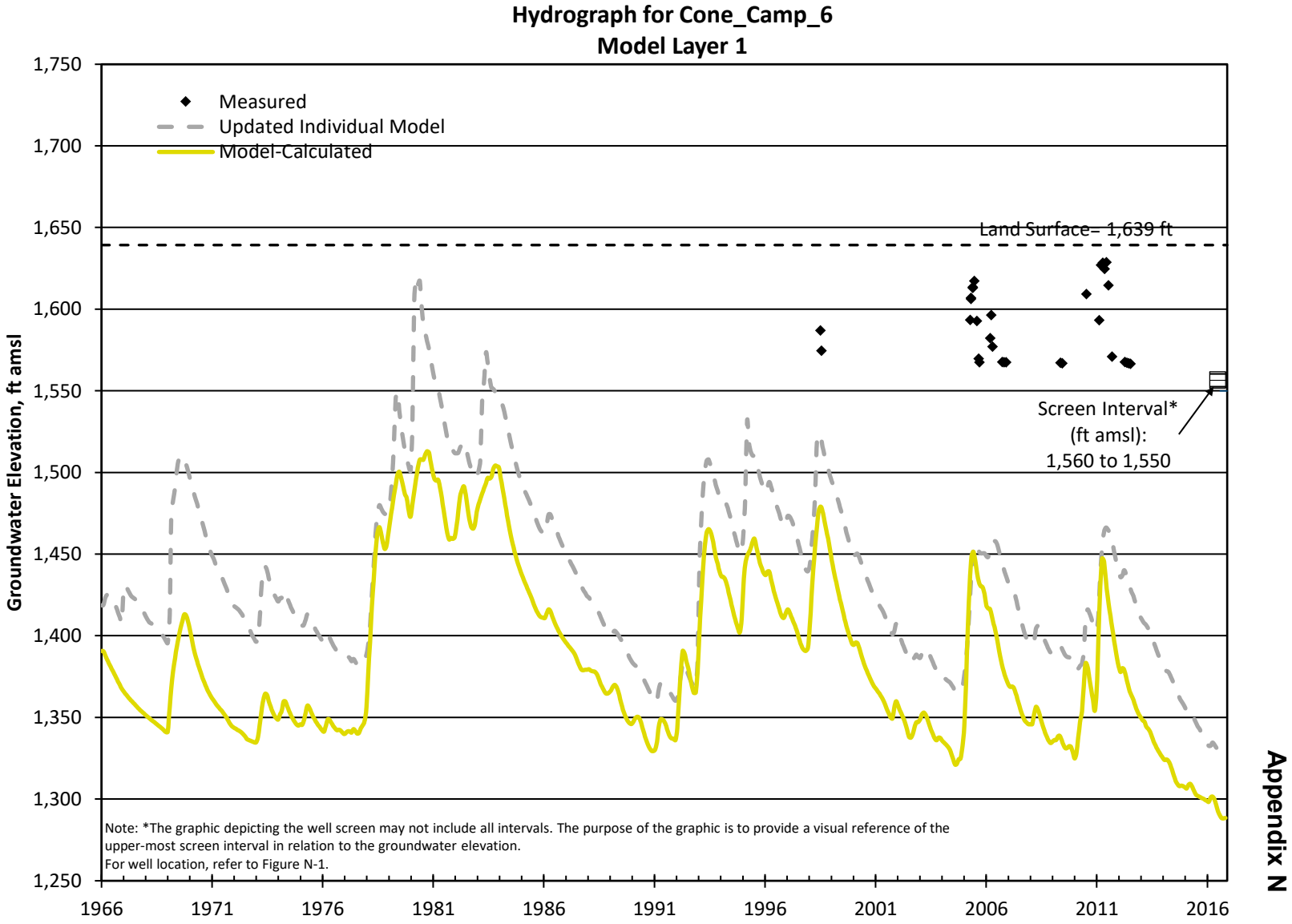
Appendix N


Hydrograph for Cone_Camp_4
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,639 ft
Screen Interval*
(ft amsl):
1,501 to 1,481
Groundwater Elevation, ft amsl
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

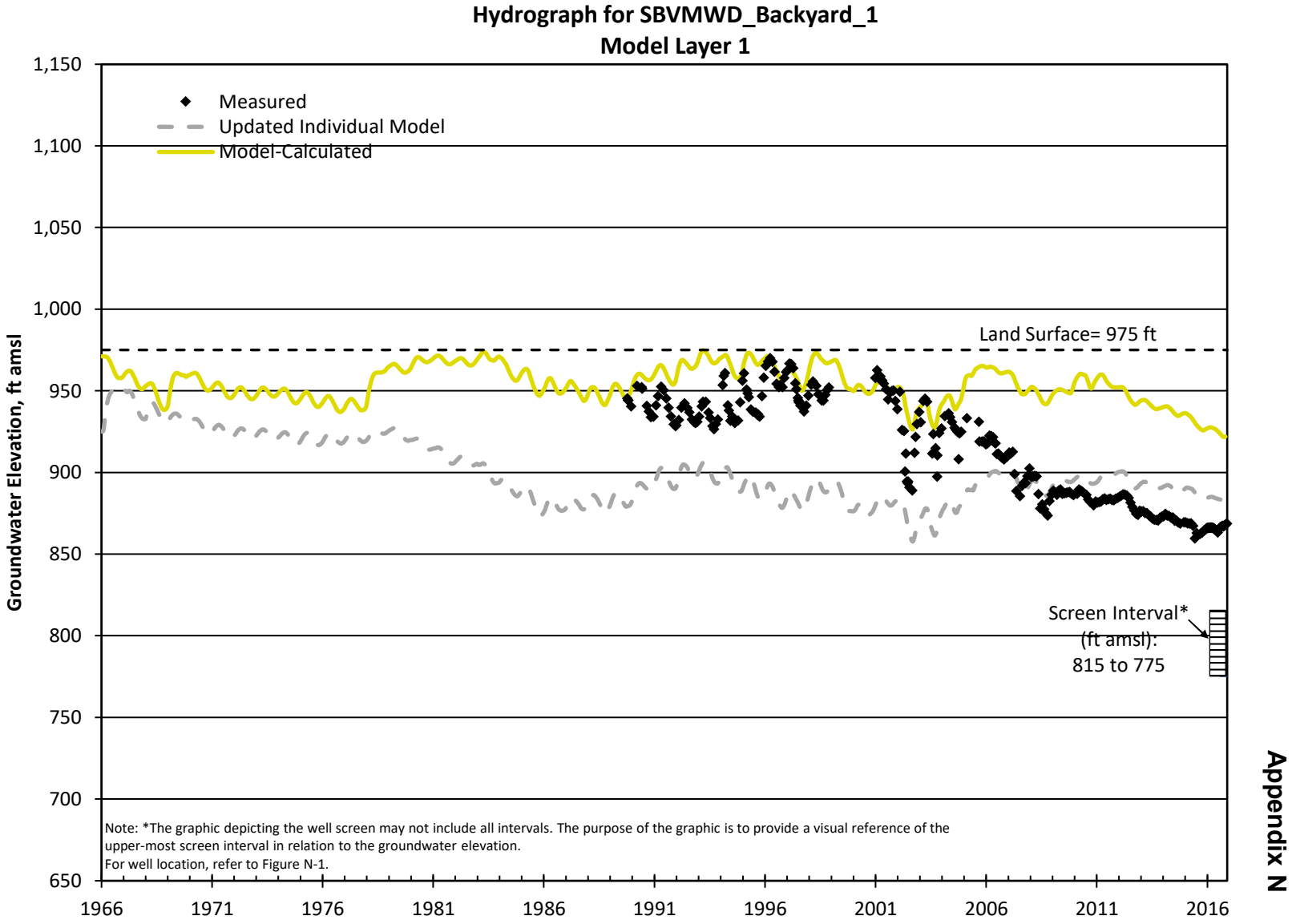
Appendix N


Hydrograph for Cone_Camp_5
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,639 ft
Screen Interval*
(ft amsl):
1,534 to 1,524
Groundwater Elevation, ft amsl
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

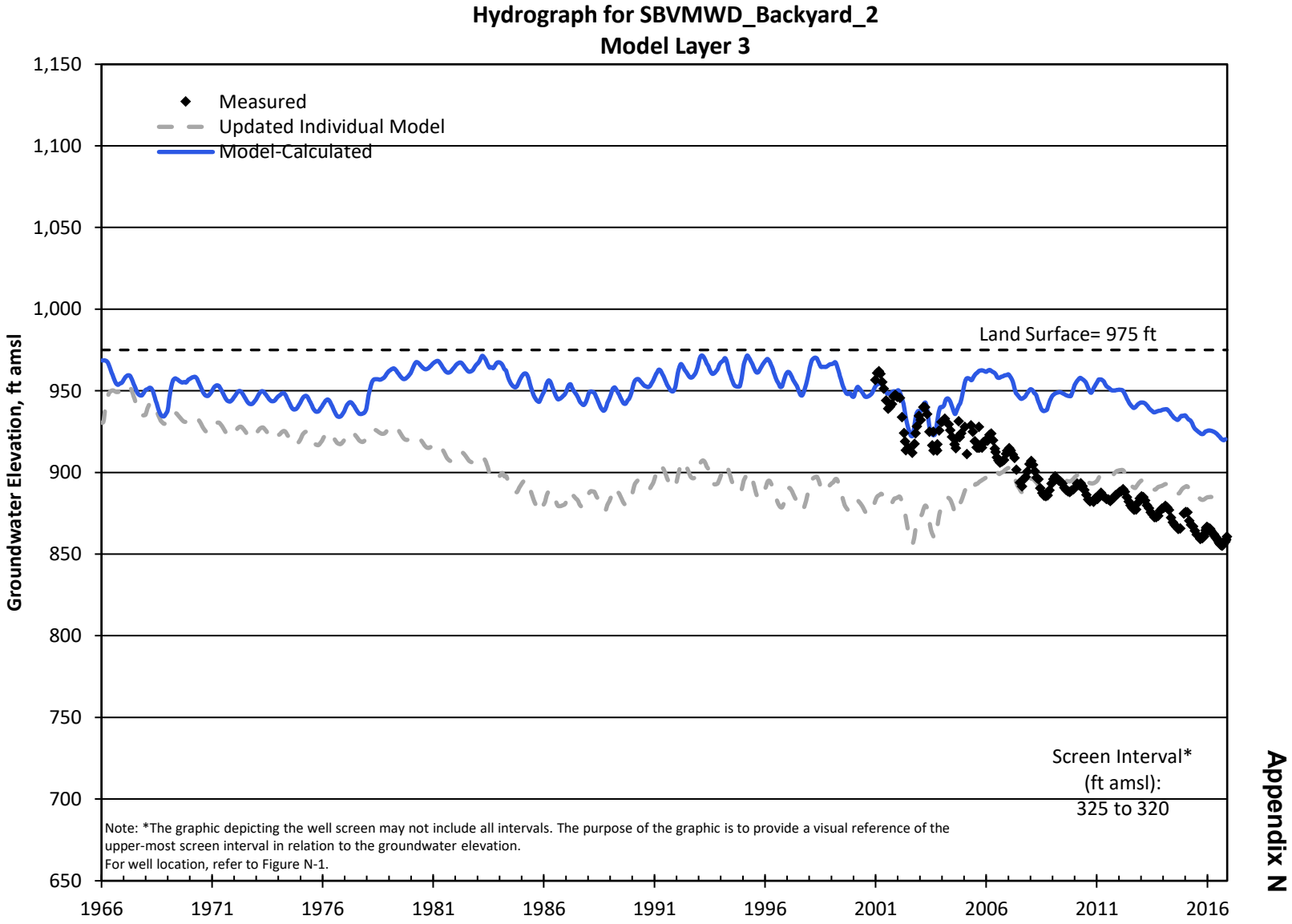
Appendix N


Hydrograph for Cone_Camp_6
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,639 ft
Screen Interval*
(ft amsl):
1,560 to 1,550
Groundwater Elevation, ft amsl
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

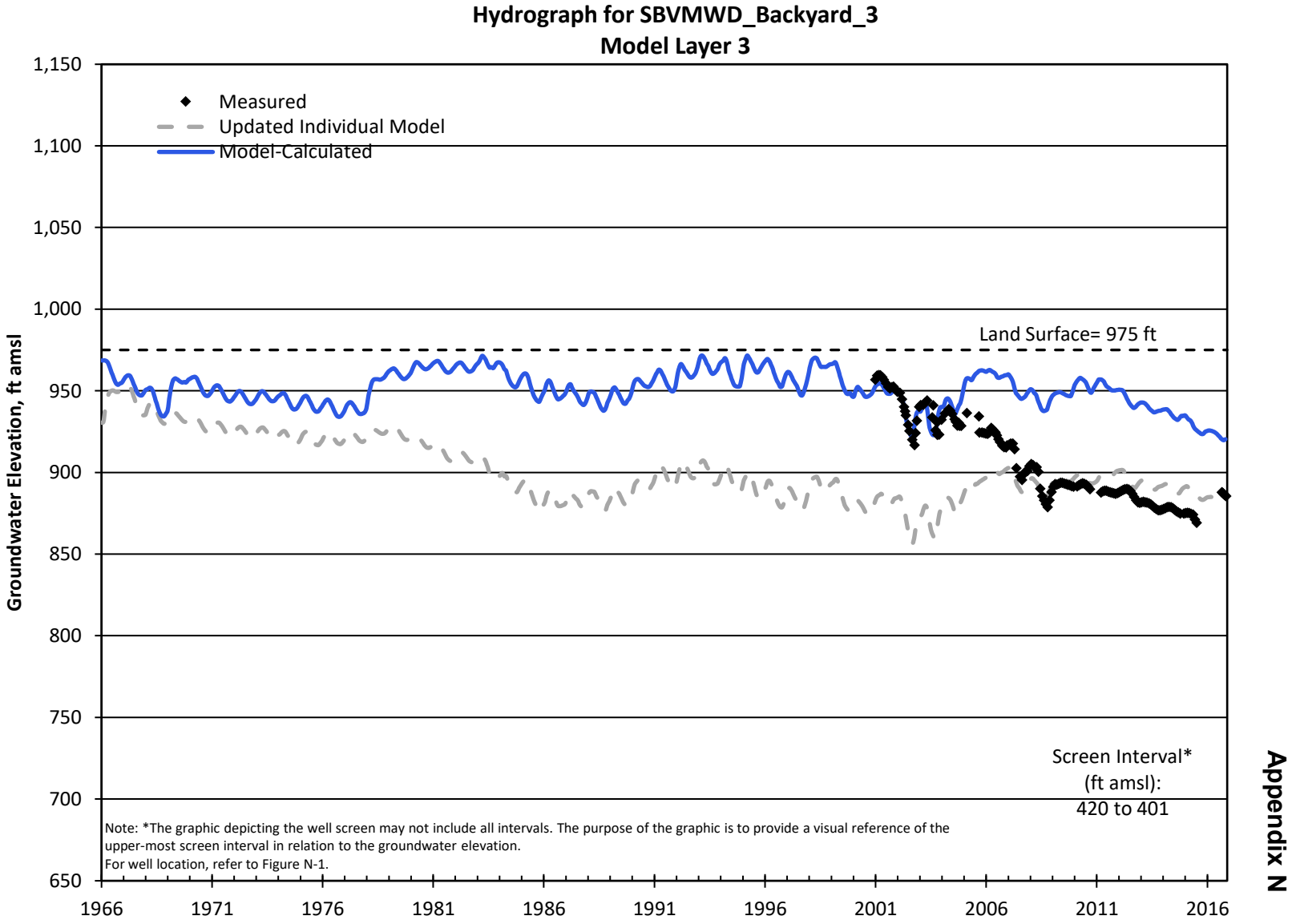
Appendix N


Hydrograph for SBVMWD_Backyard_1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 975 ft
Screen Interval*
(ft amsl):
815 to 775
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

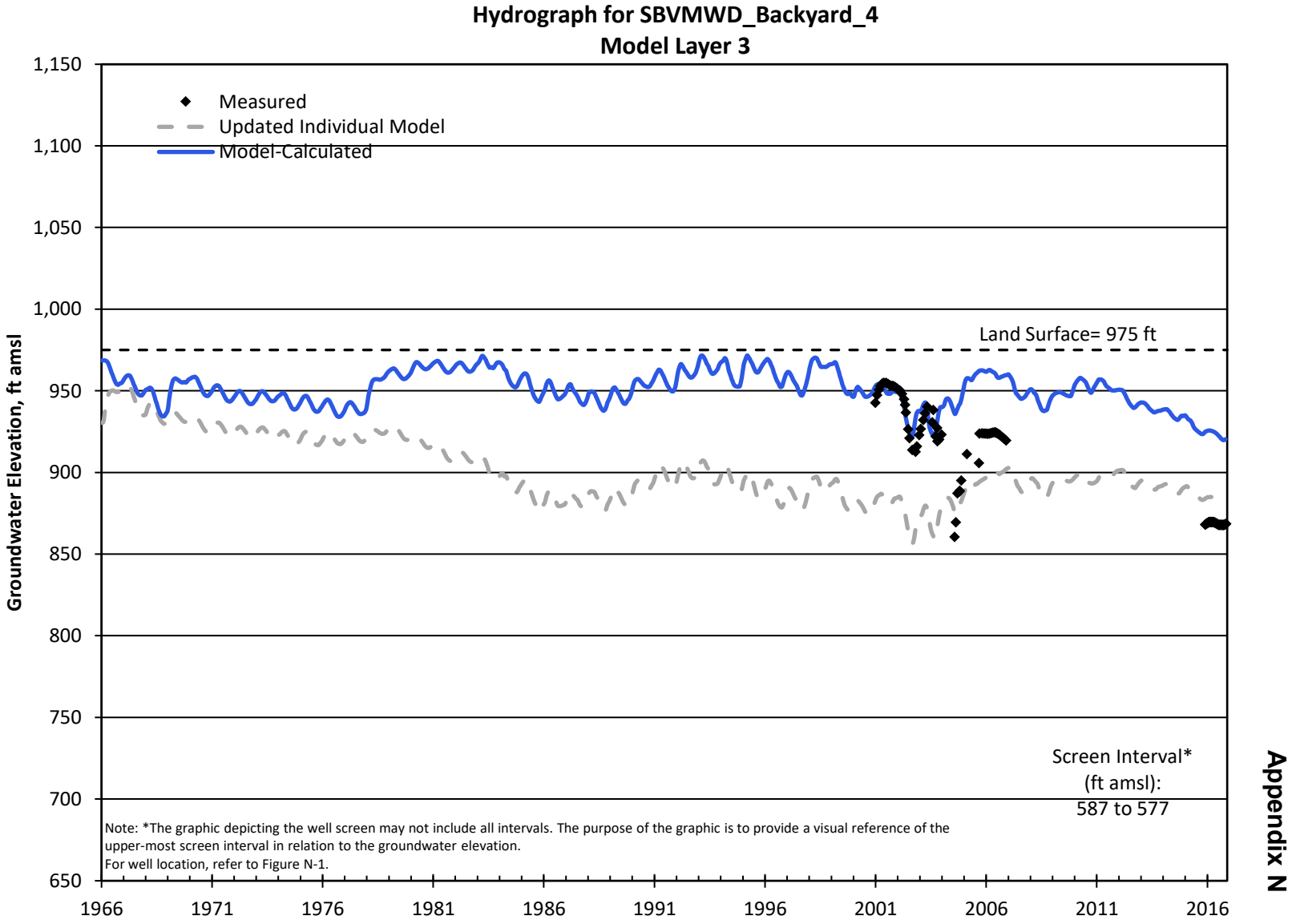
Appendix N


Hydrograph for SBVMWD_Backyard_2
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 975 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
325 to 320
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

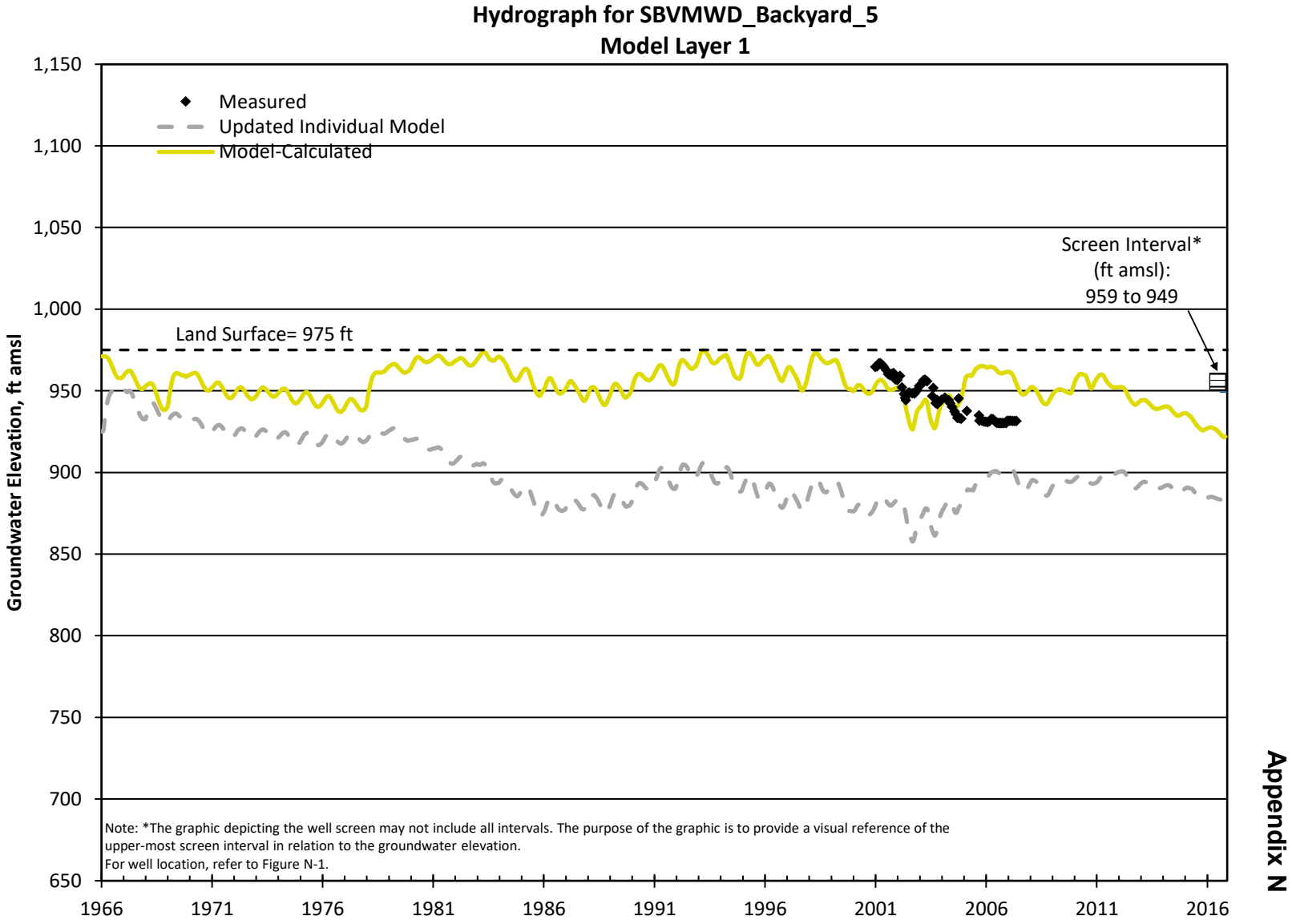
Appendix N


Hydrograph for SBVMWD_Backyard_3
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 975 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
420 to 401
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

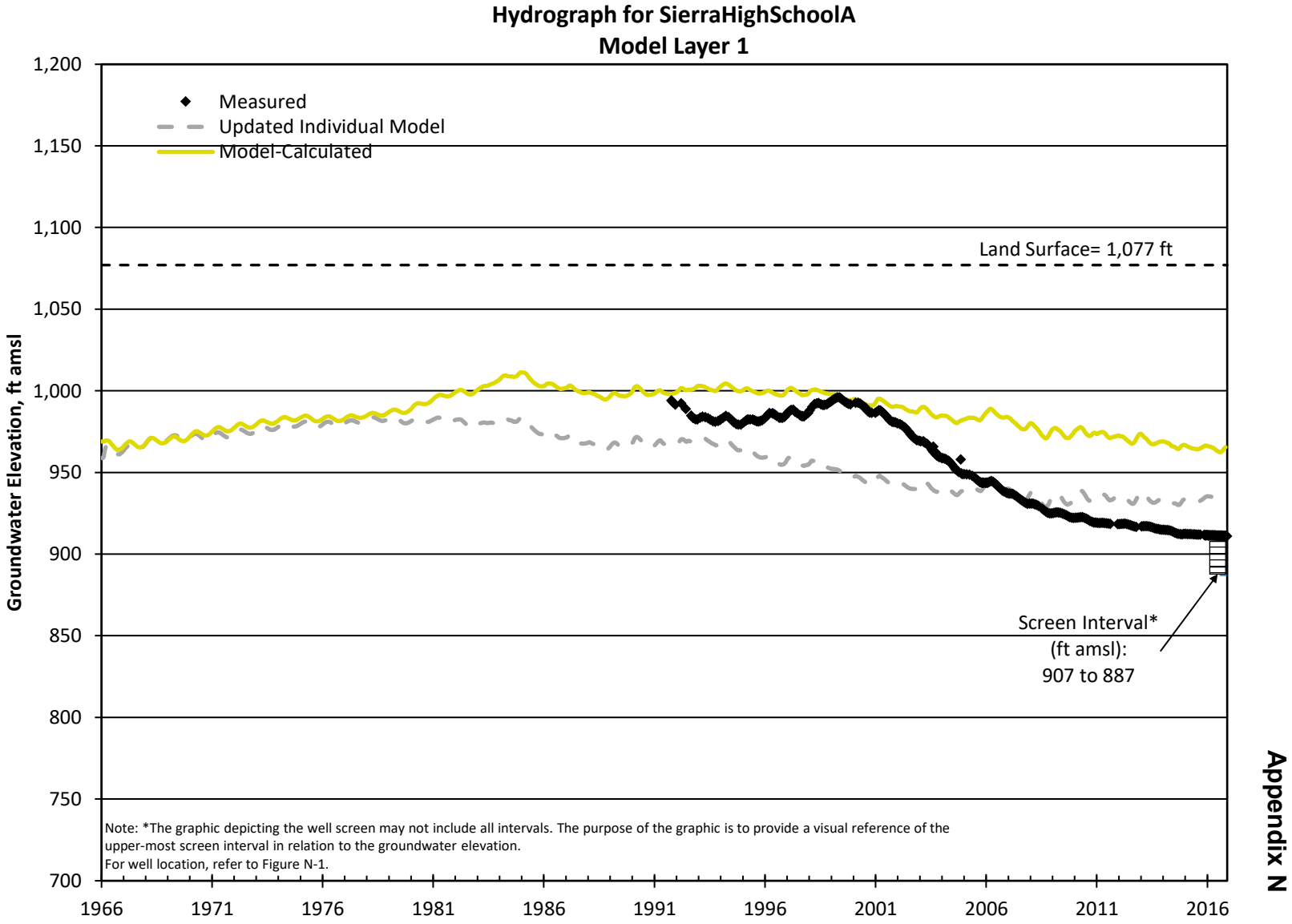
Appendix N


Hydrograph for SBVMWD_Backyard_4
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 975 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
587 to 577
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

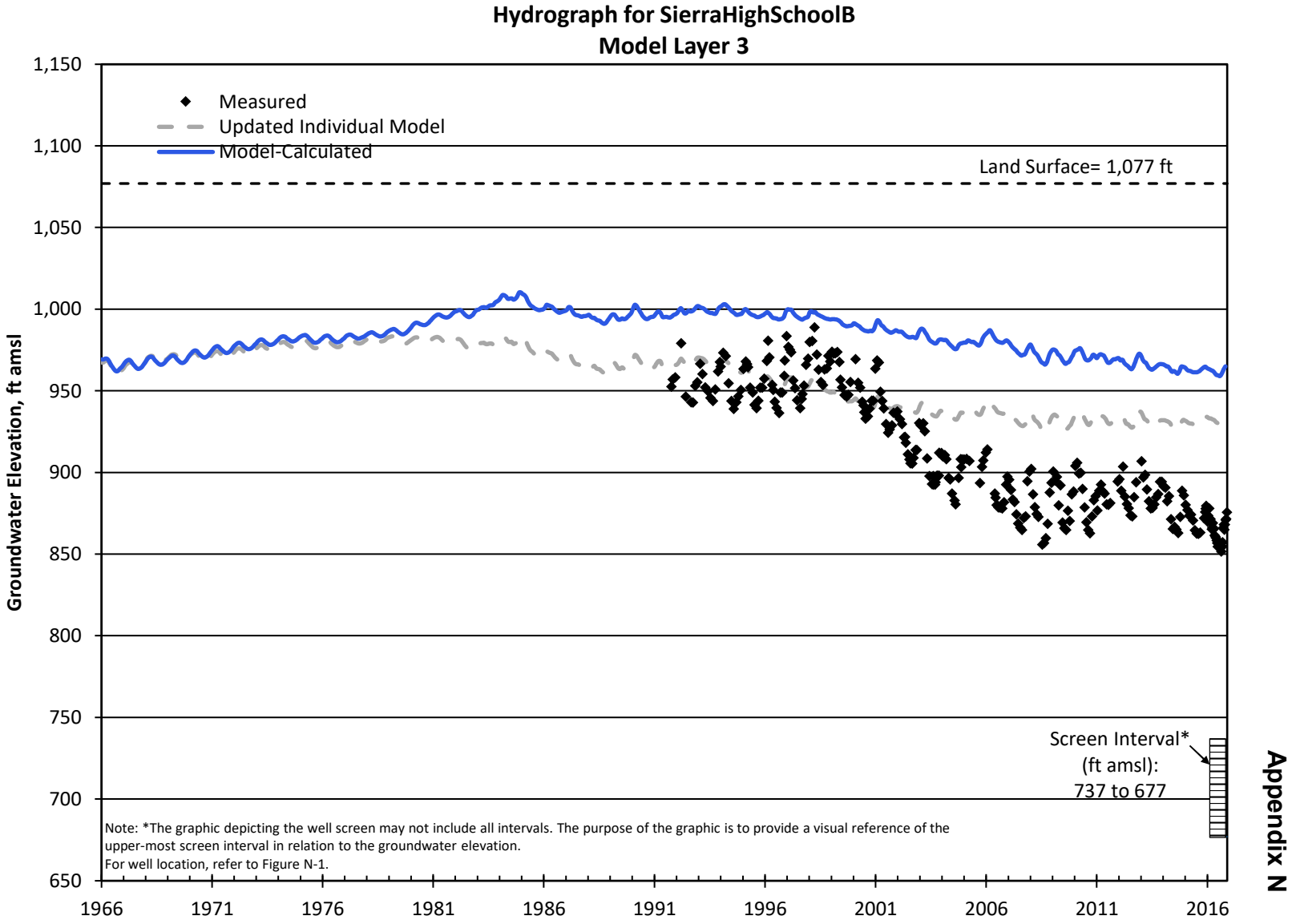
Appendix N


Hydrograph for SBVMWD_Backyard_5
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Screen Interval*
(ft amsl):
959 to 949
Land Surface= 975 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

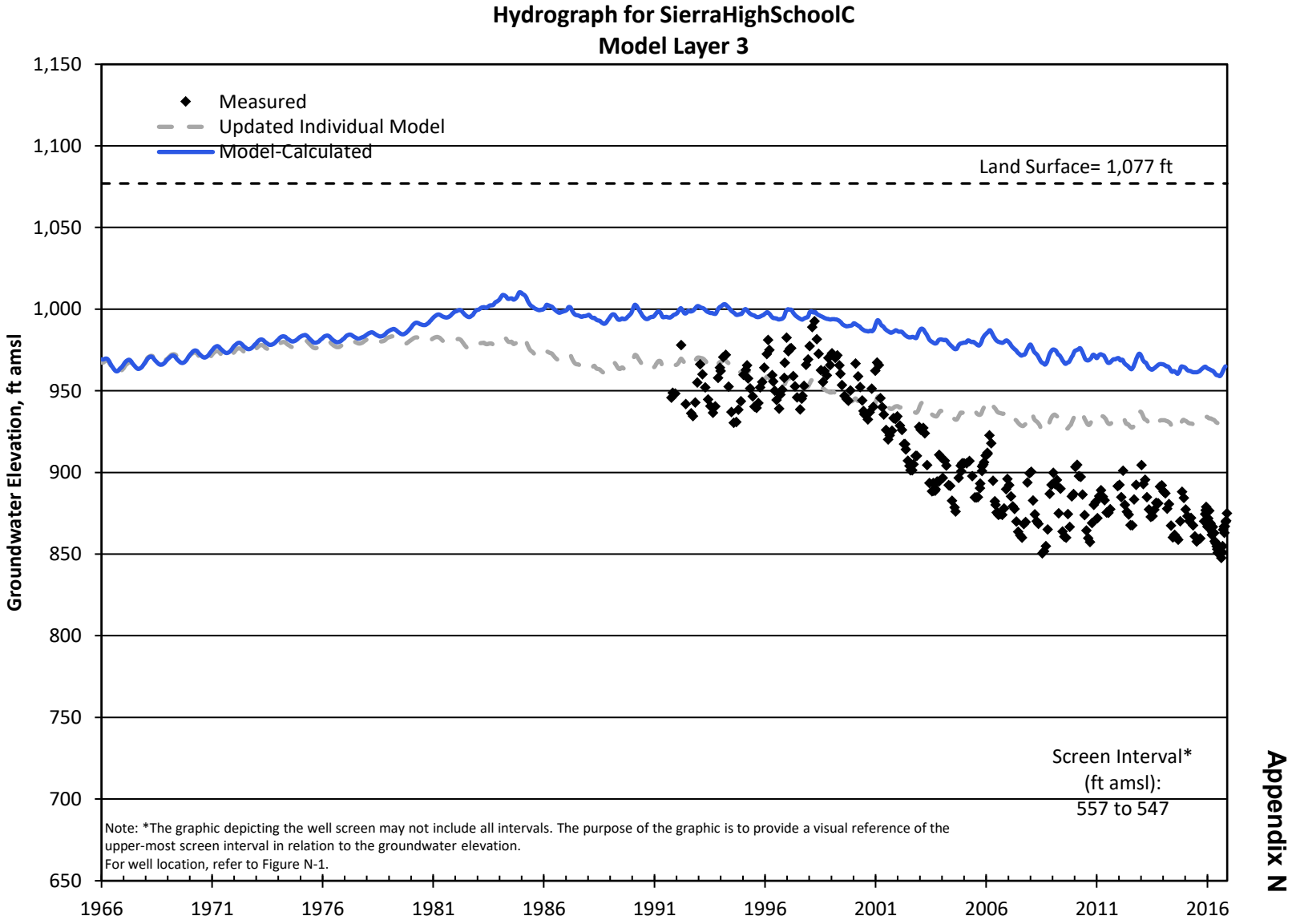
Appendix N


Hydrograph for SierraHighSchoolA
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,077 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
907 to 887
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

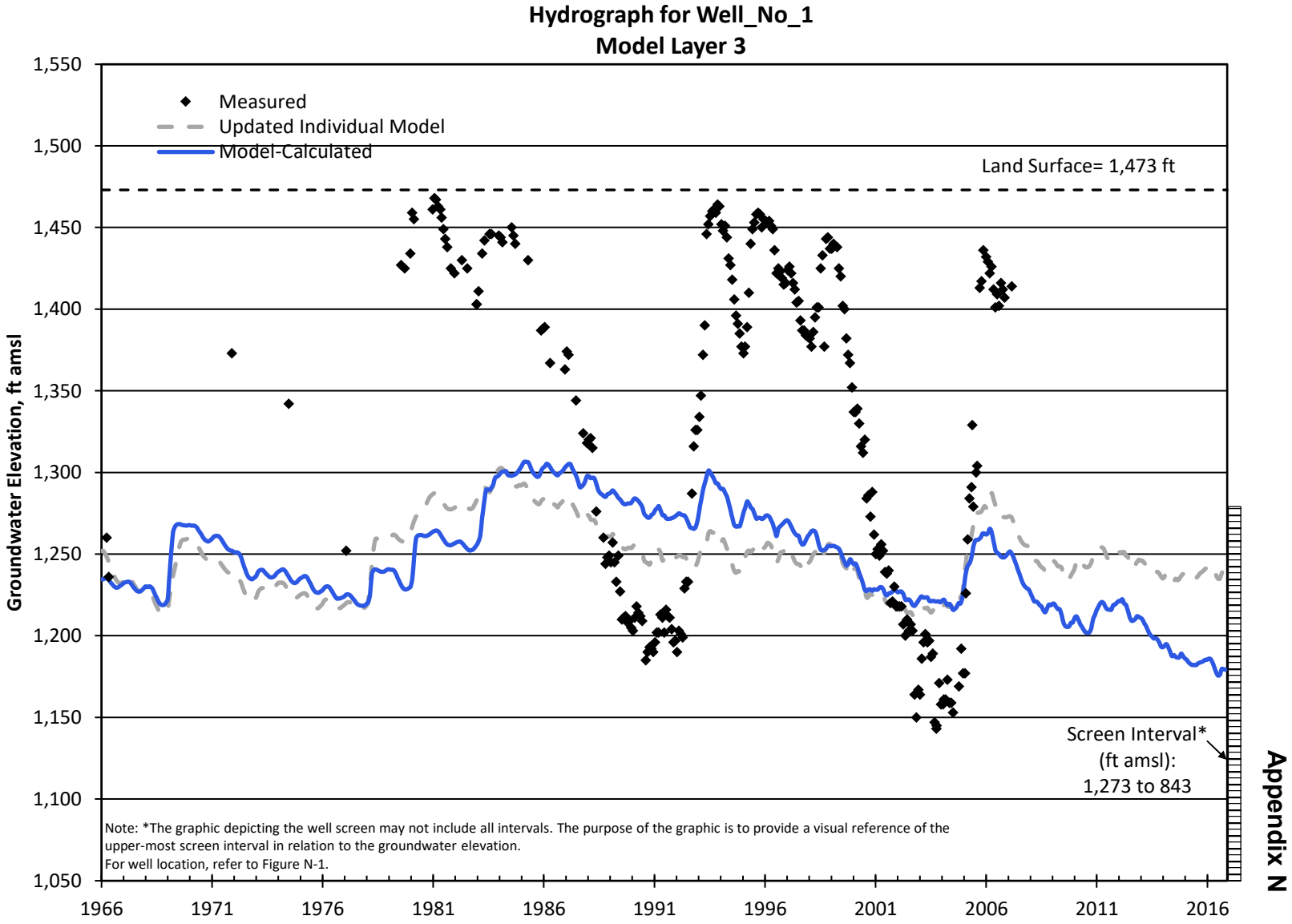
Appendix N

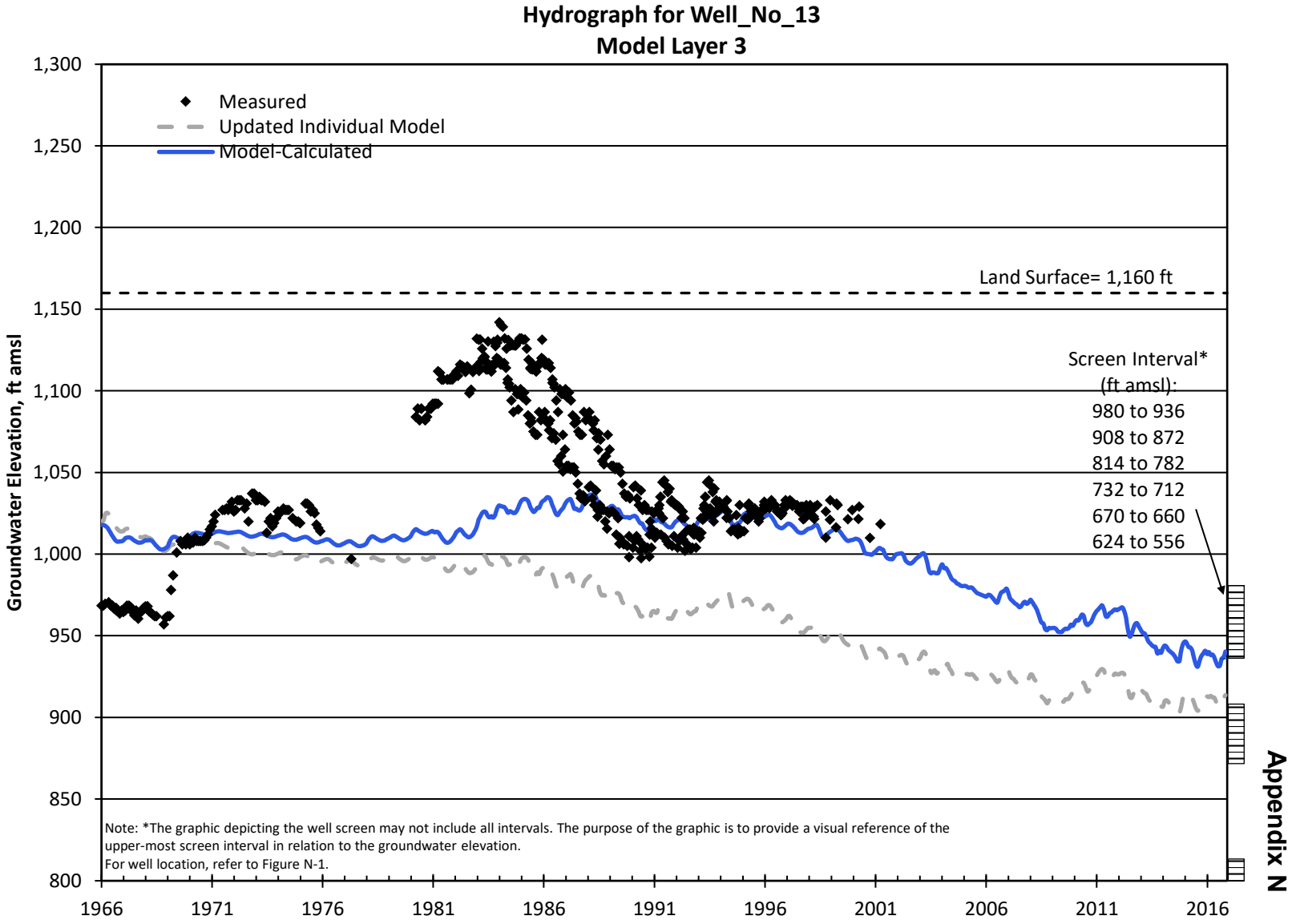

Hydrograph for SierraHighSchoolB
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,077 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
737 to 677
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

Appendix N


Hydrograph for SierraHighSchoolC
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,077 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
557 to 547
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.

Appendix N


Hydrograph for Well_No_1
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,473 ft
Groundwater Elevation, ft amsl
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,273 to 843
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.
Appendix N


Hydrograph for Well_No_13
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,160 ft
Screen Interval*
(ft amsl):
980 to 936
908 to 872
814 to 782
732 to 712
670 to 660
624 to 556
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure N-1.
Appendix N

APPENDIX O

Integrated SAR Model: Selected Hydrographs for Target Wells in the Rialto-Colton Basin Model Area – 1966 to 2016

GEOSCIENCE

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RIALTO-COLTON BASIN

WVWD-23
1N5W21K01-04
WVWD54
1N5W22N01-05
CMW-05A-C
1N5W34D01-04
1N/5W-26L01
F15A
1N/5W-27D02
1N5W35B01-04
1N5W29Q01-05
1N/5W-28J02
F-23
F13B
F38A
F13A
M-1S
1S/5W-03A03
N14D
1S/5W-03A06-07S
Rialto-3
WVWD10
F10A
M-2-Z1
PW9E
EPAMP6C
F10B
WVWD-33
F10C
Rialto-4
Rialto-6
F49A
WVWD-11
EPAMP2C
WVWD-16
1S5W11F01-04
1S4W08E01-04
Fault-13
Colton-23
1S5W13B01-05S
Fault-11
Vaughn
1S4W20H01-05
Johnson-4
Meeks
1S/4W-27M01-03

East Etiwanda Cyn
Day Cyn Wash
Lytle Ck
Cable Ck
Devil Ck
Cajon Wash
Devil Ck Div
Waterman Cyn
East Twin Ck
Strawberry Ck
Daley Cyn
Little Sand Cyn
Little Sand Ck Chan
Sand Ck
Day Ck
Del Rosa Chan
Warm Ck Bypass
East Branch Lytle Ck
Warm Ck
Lytle Cajon Chan
Santa Ana River
Twill Creek Chan
The Zanja
San Timoteo Wash
Reche Cyn Ck
Etiwanda Ck
San Sevaine Ck

15
10
66
18
210
215

EXPLANATION

Integrated SAR Model Boundary

Well Model Layer
- 1
- 2
- 3
- 4
- 5

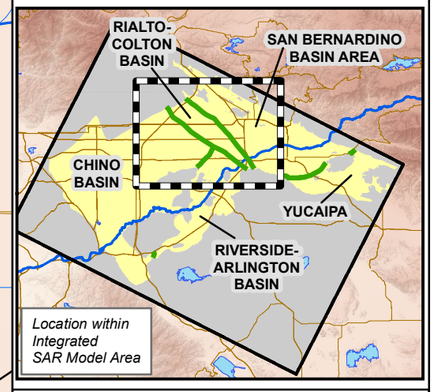
Inactive Model Area

Groundwater Basin Boundary

Groundwater Flow Barrier

N

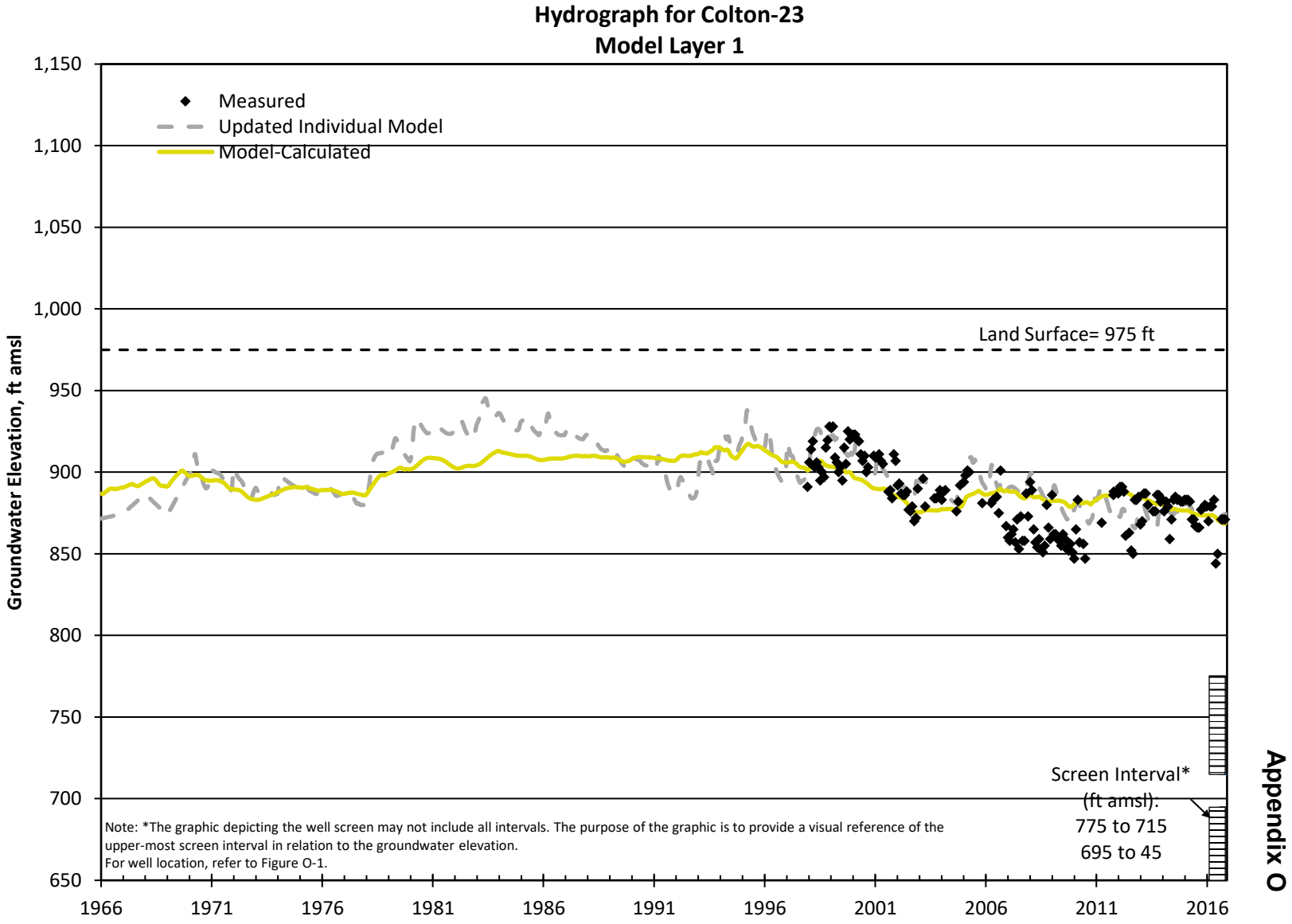
0 1.5 3
Miles



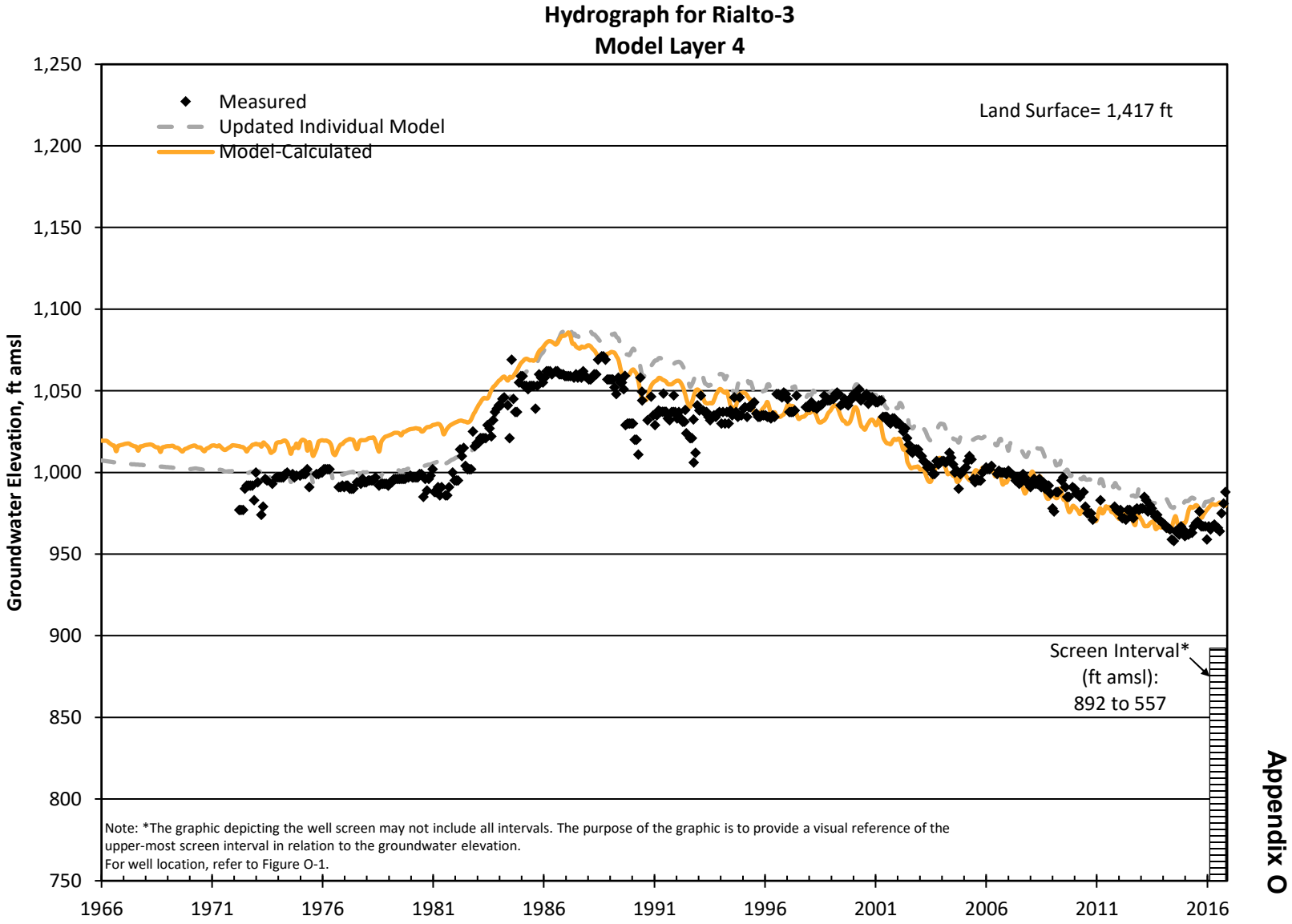
SELECTED TARGET WELLS USED FOR HYDROGRAPHS RIALTO-COLTON BASIN MODEL AREA 1966 TO 2016

W:\GIS_proj\sbvmwd_SARiverStudyModel_201753_SumRpt_Fig_O-1_Rialto-Colton_Wells_labeled_4-20.mxd

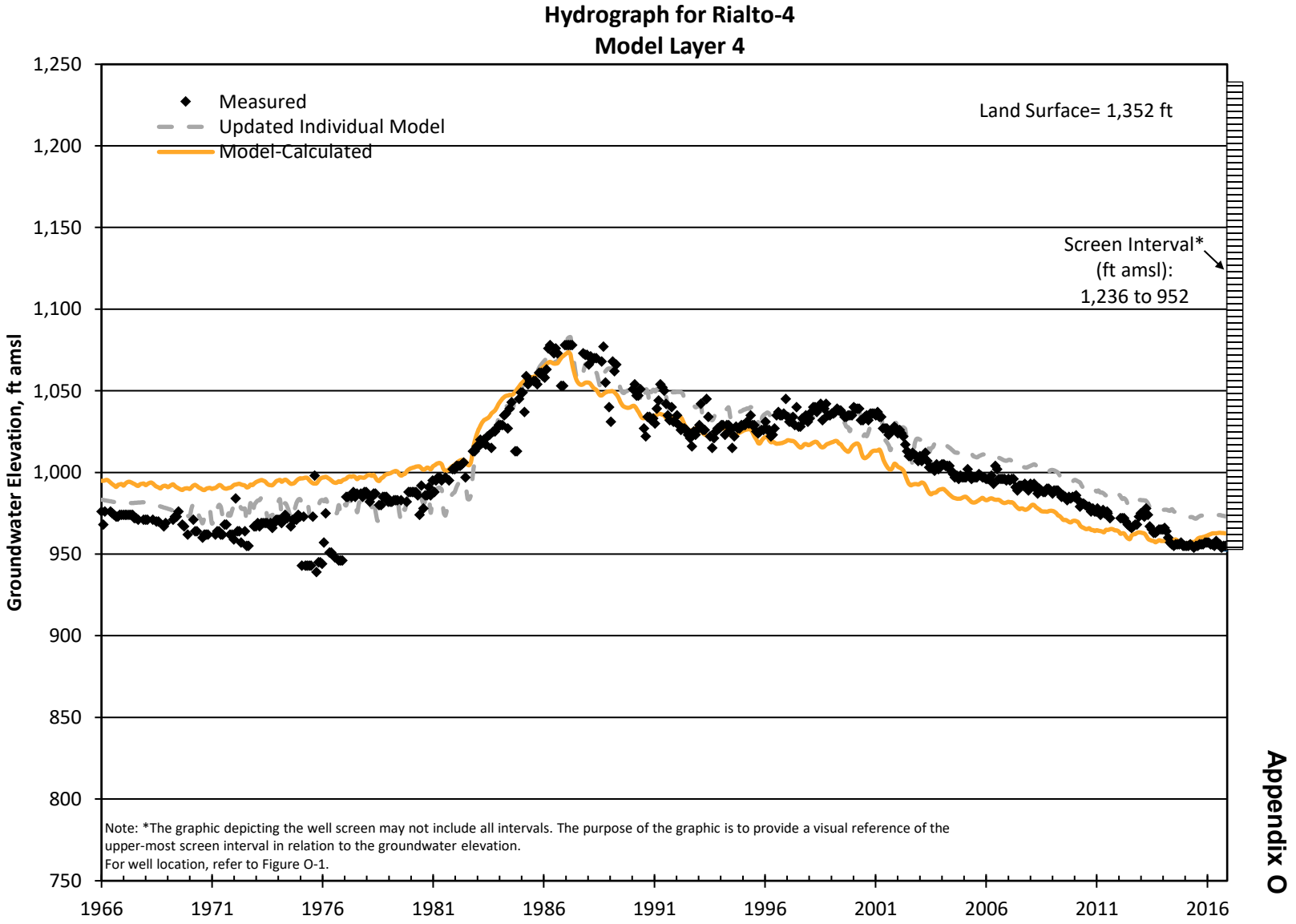
10-Apr-20


Hydrograph for Colton-23
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 975 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
775 to 715
695 to 45
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

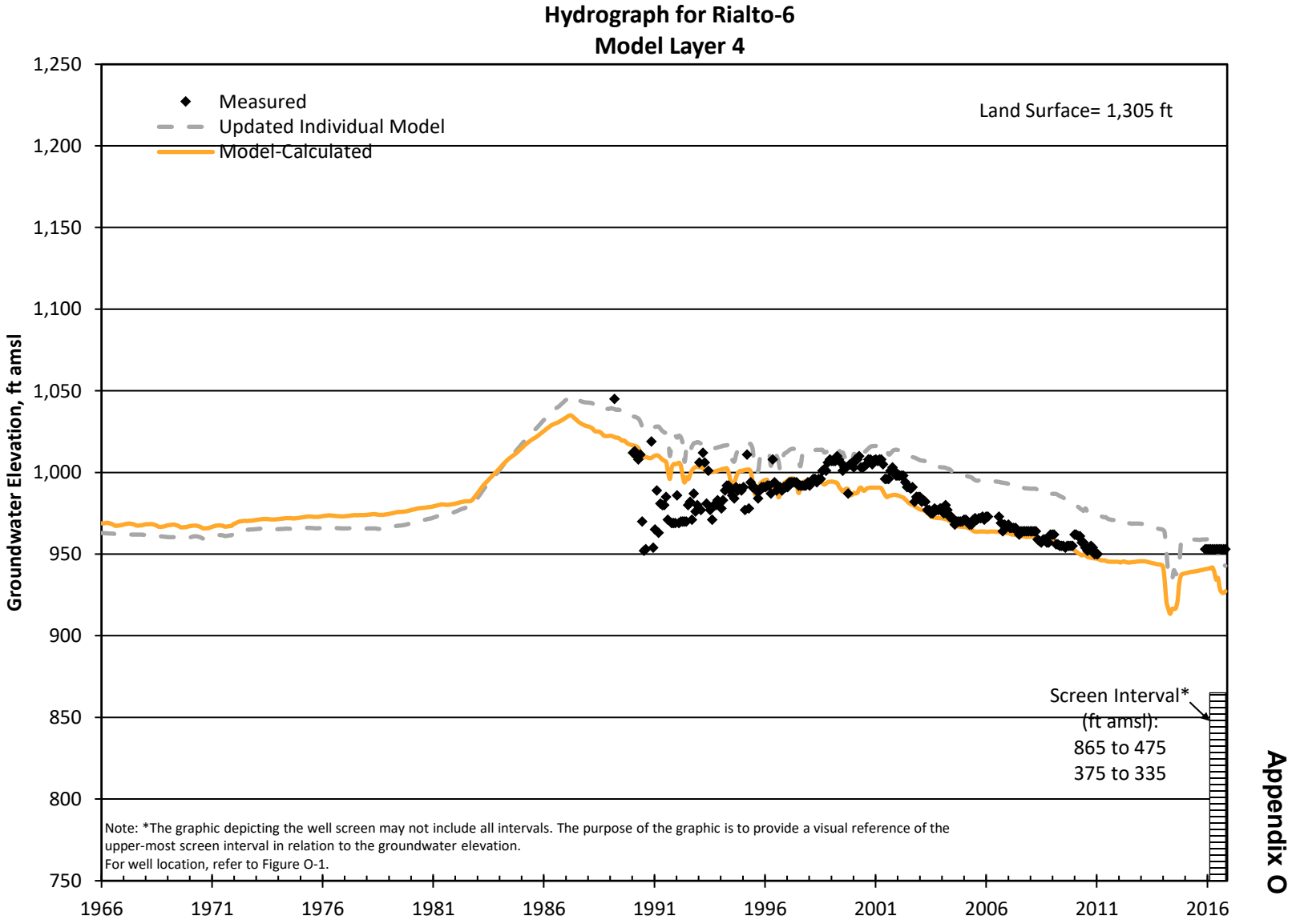
Appendix O


Hydrograph for Rialto-3
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,417 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
892 to 557
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

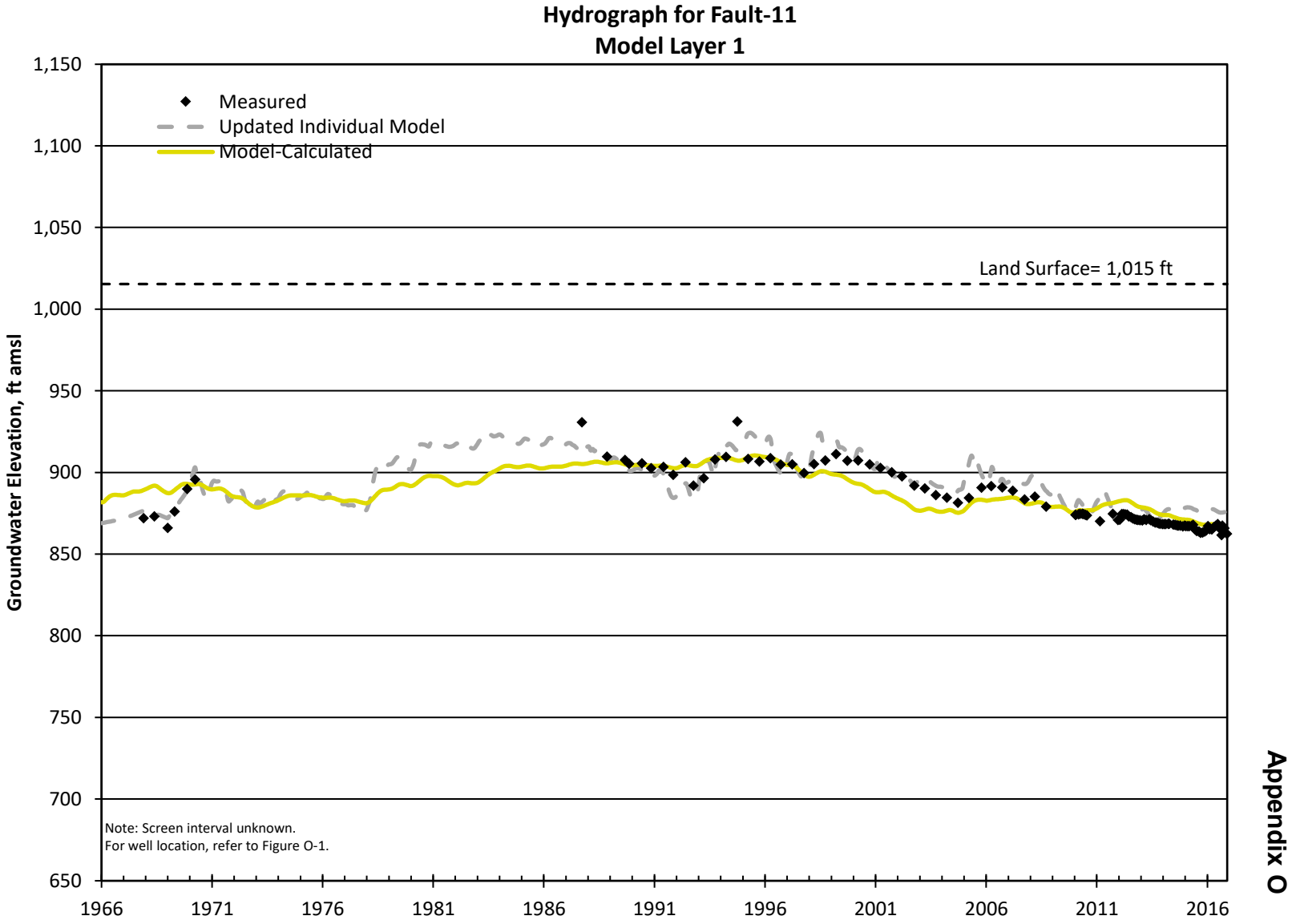
Appendix O


Hydrograph for Rialto-4
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,352 ft
Screen Interval*
(ft amsl):
1,236 to 952
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

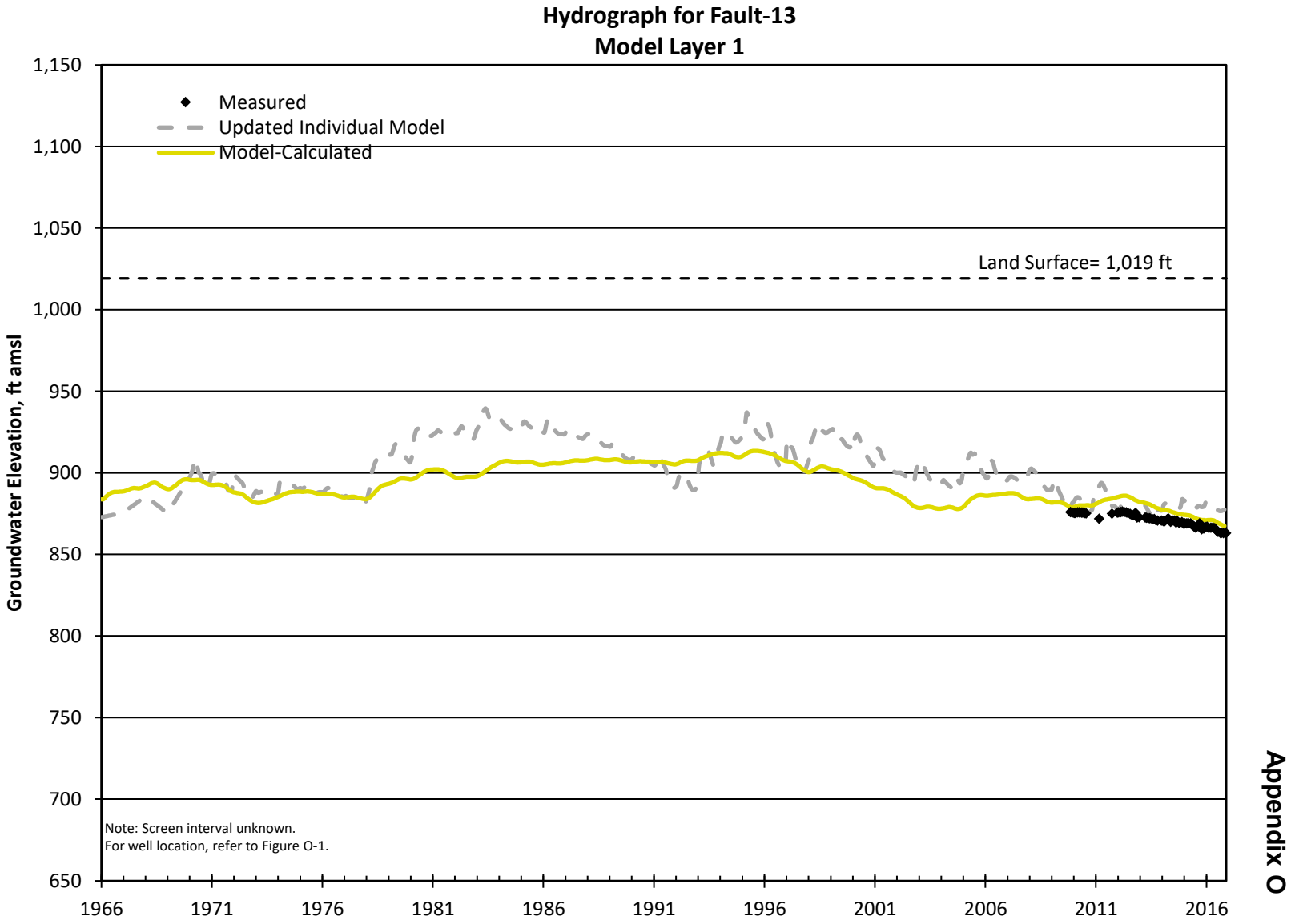
Appendix O


Hydrograph for Rialto-6
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,305 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
865 to 475
375 to 335
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

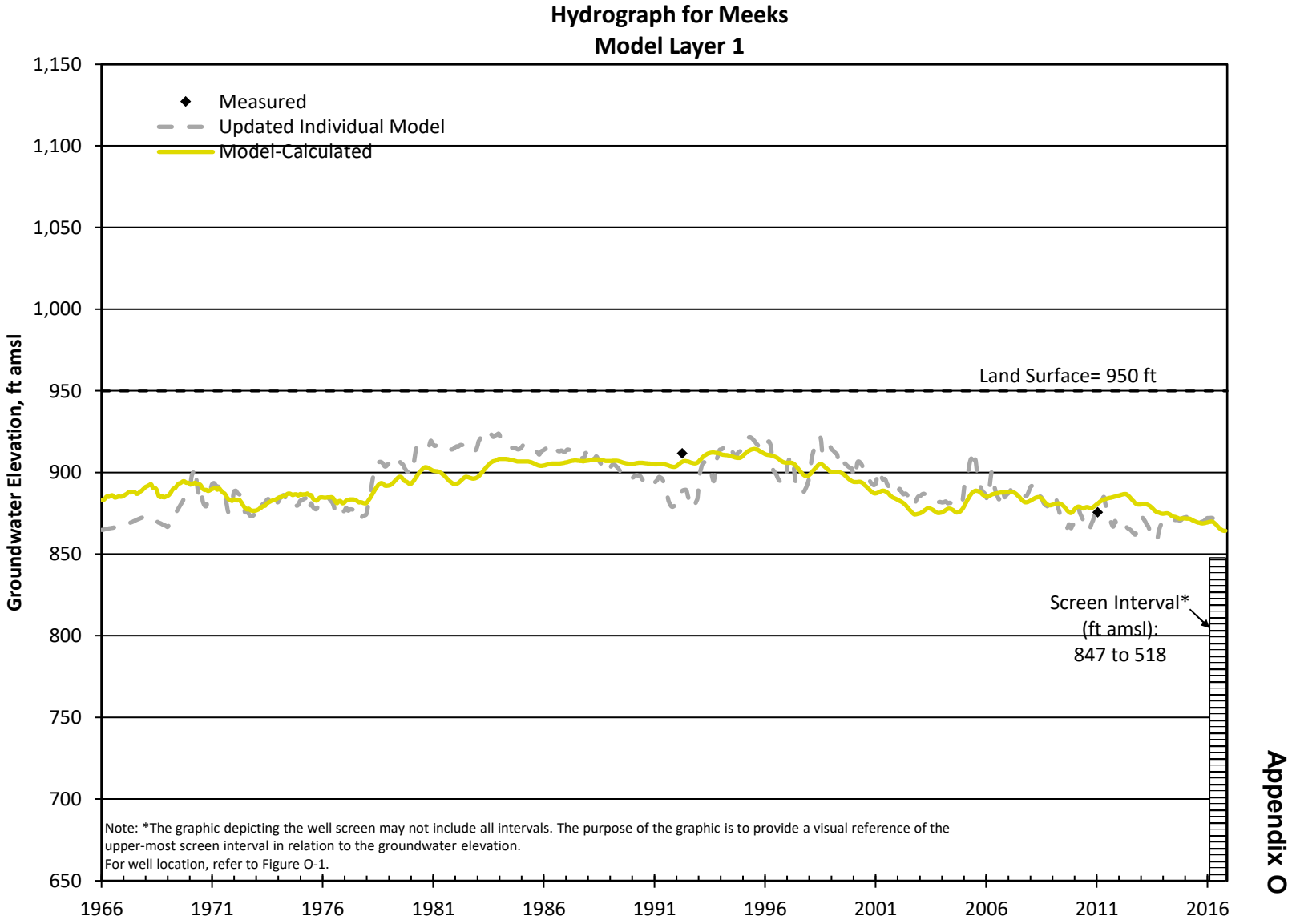
Appendix O


Hydrograph for Fault-11
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,015 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure O-1.

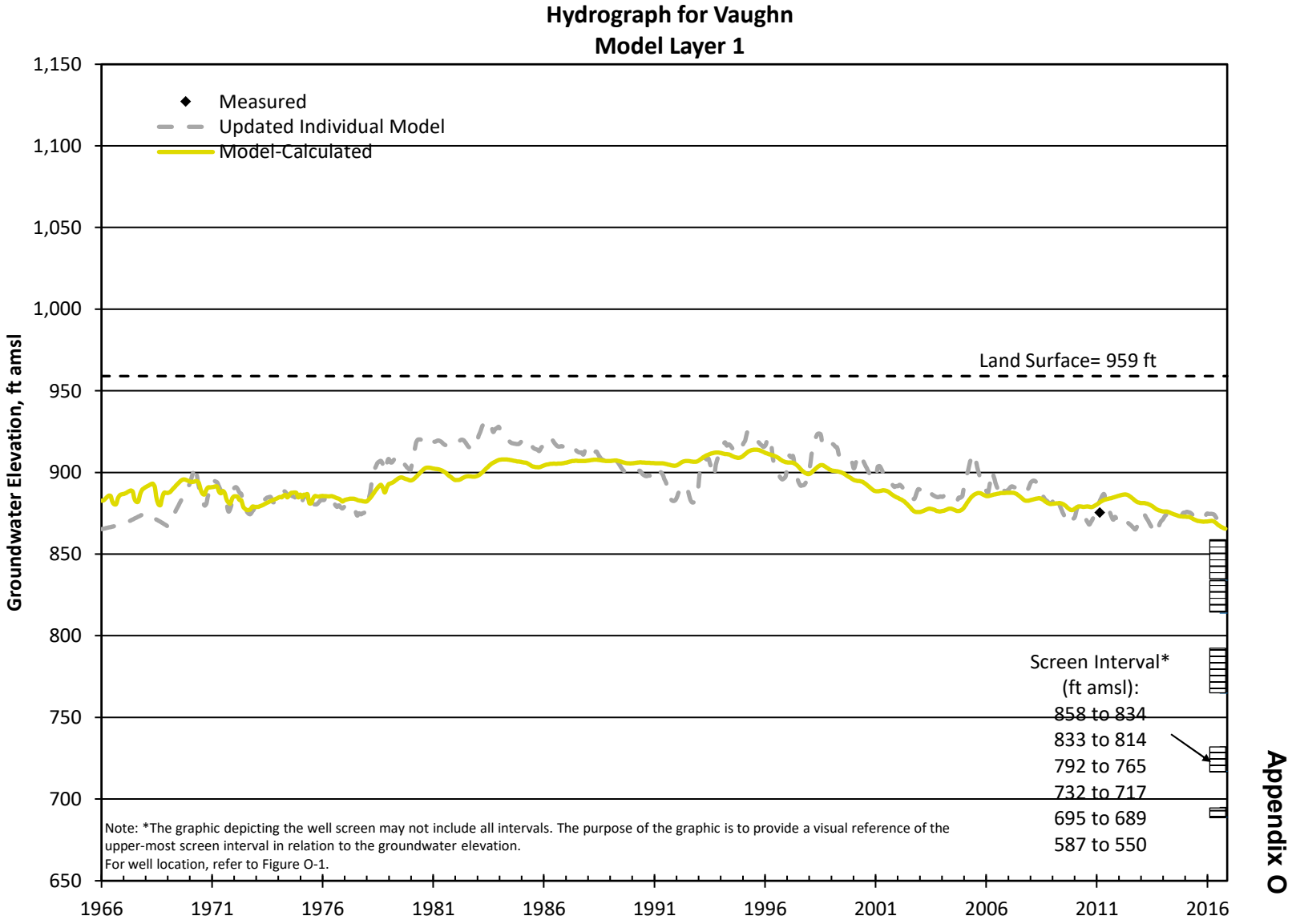
Appendix O


Hydrograph for Fault-13
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,019 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure O-1.

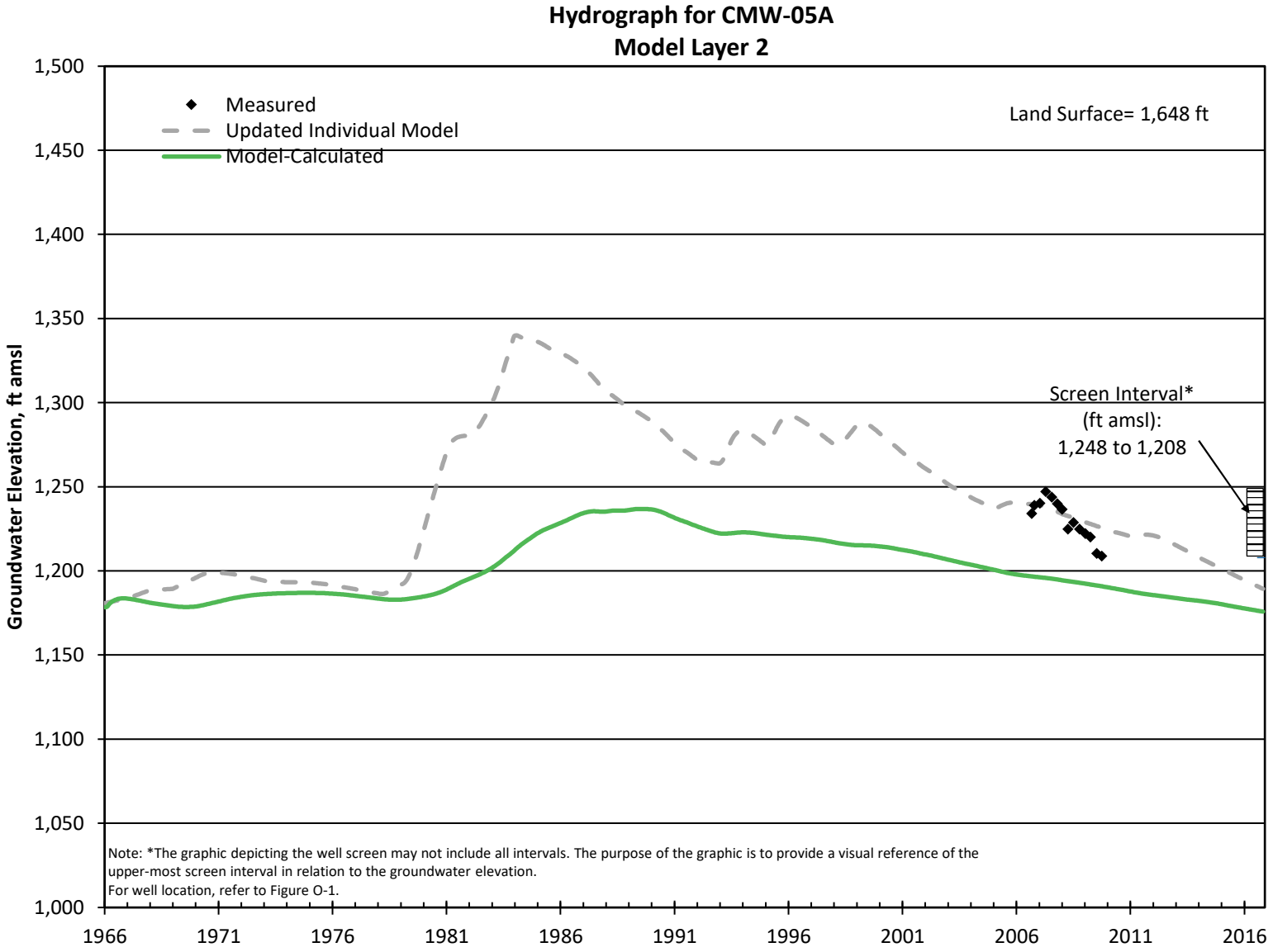
Appendix O


Hydrograph for Meeks
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 950 ft
Screen Interval*
(ft amsl):
847 to 518
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

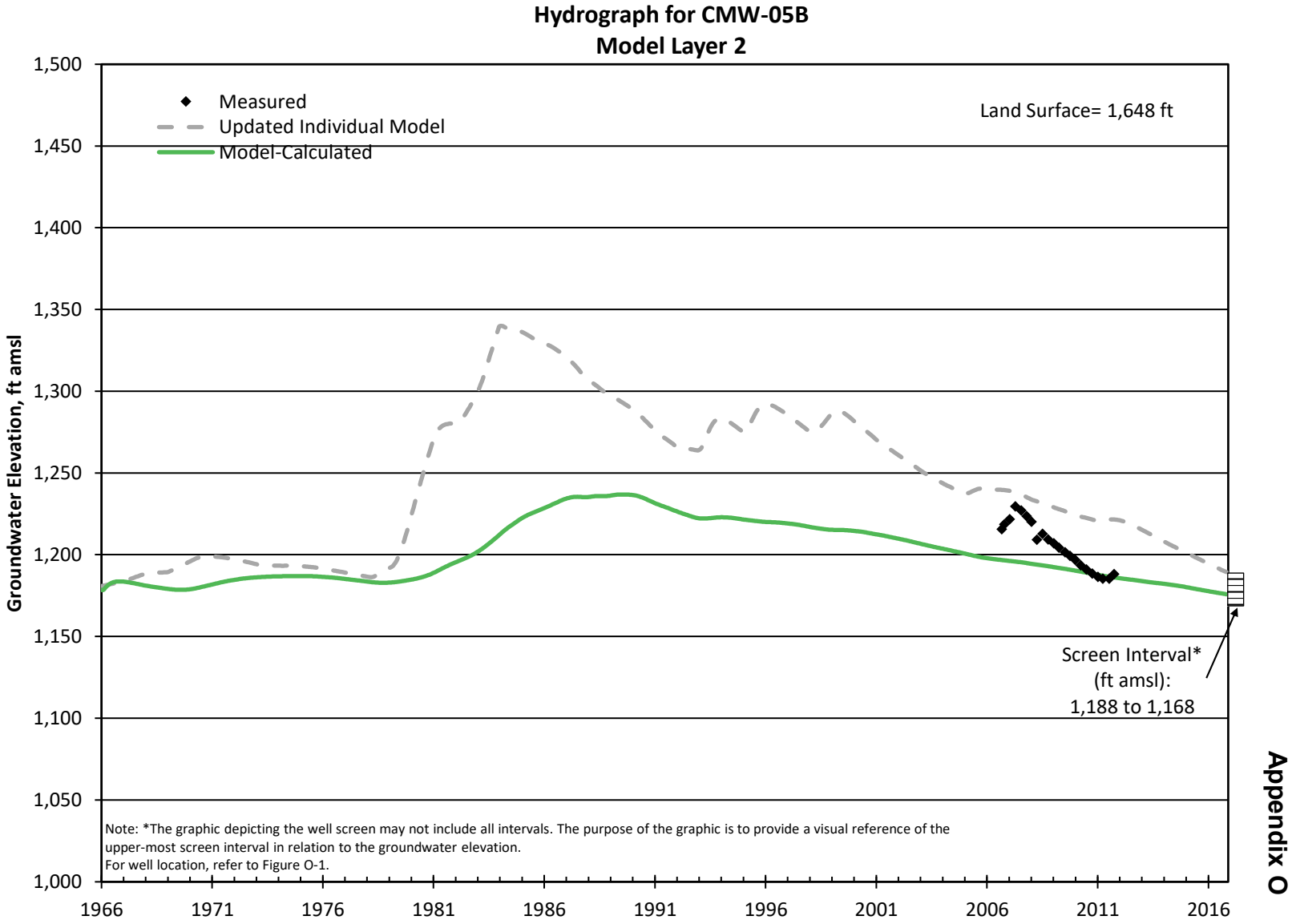
Appendix O


Hydrograph for Vaughn
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 959 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
858 to 834
833 to 814
792 to 765
732 to 717
695 to 689
587 to 550
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

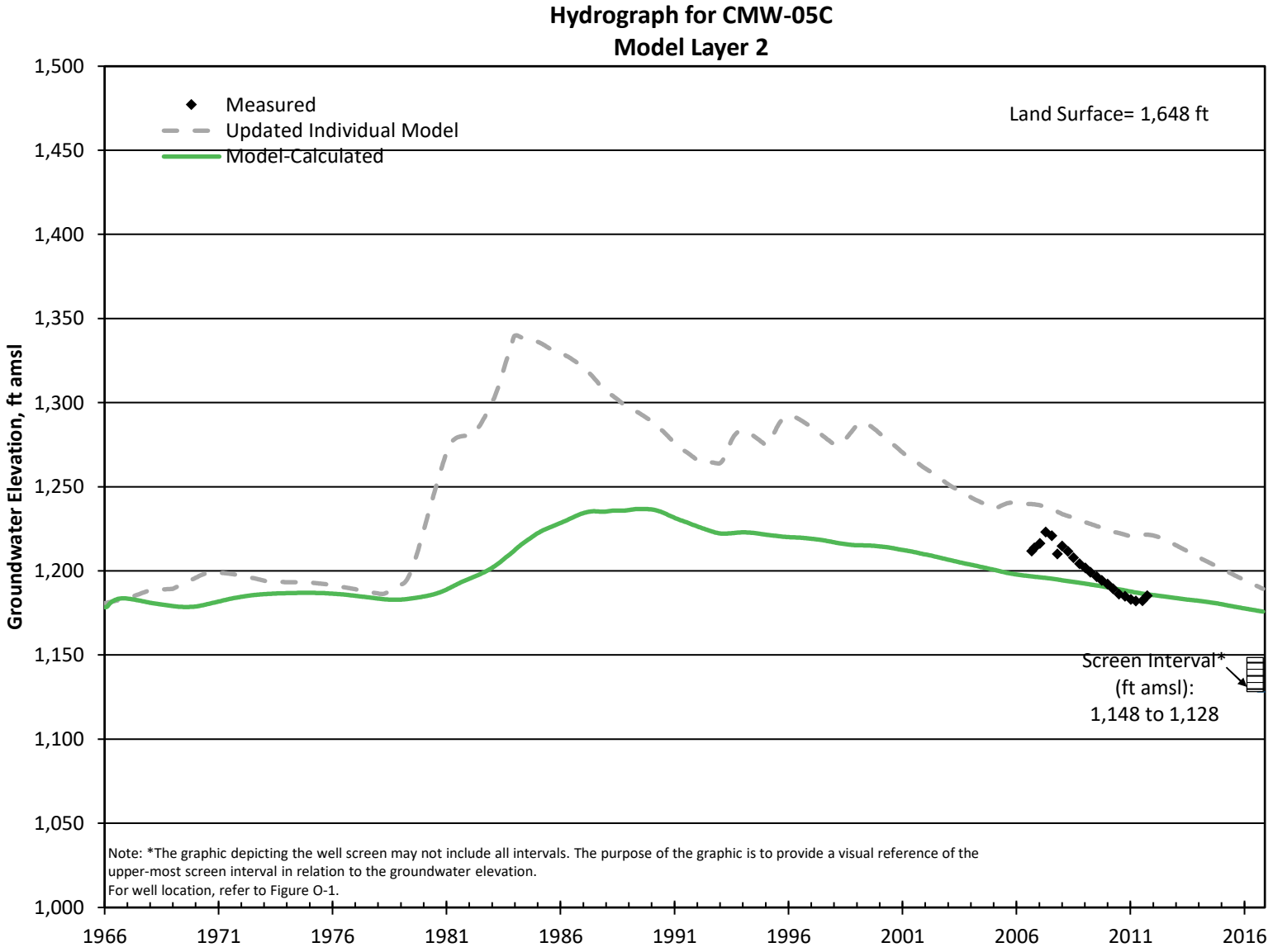
Appendix O


Hydrograph for CMW-05A
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,648 ft
Screen Interval*
(ft amsl):
1,248 to 1,208
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

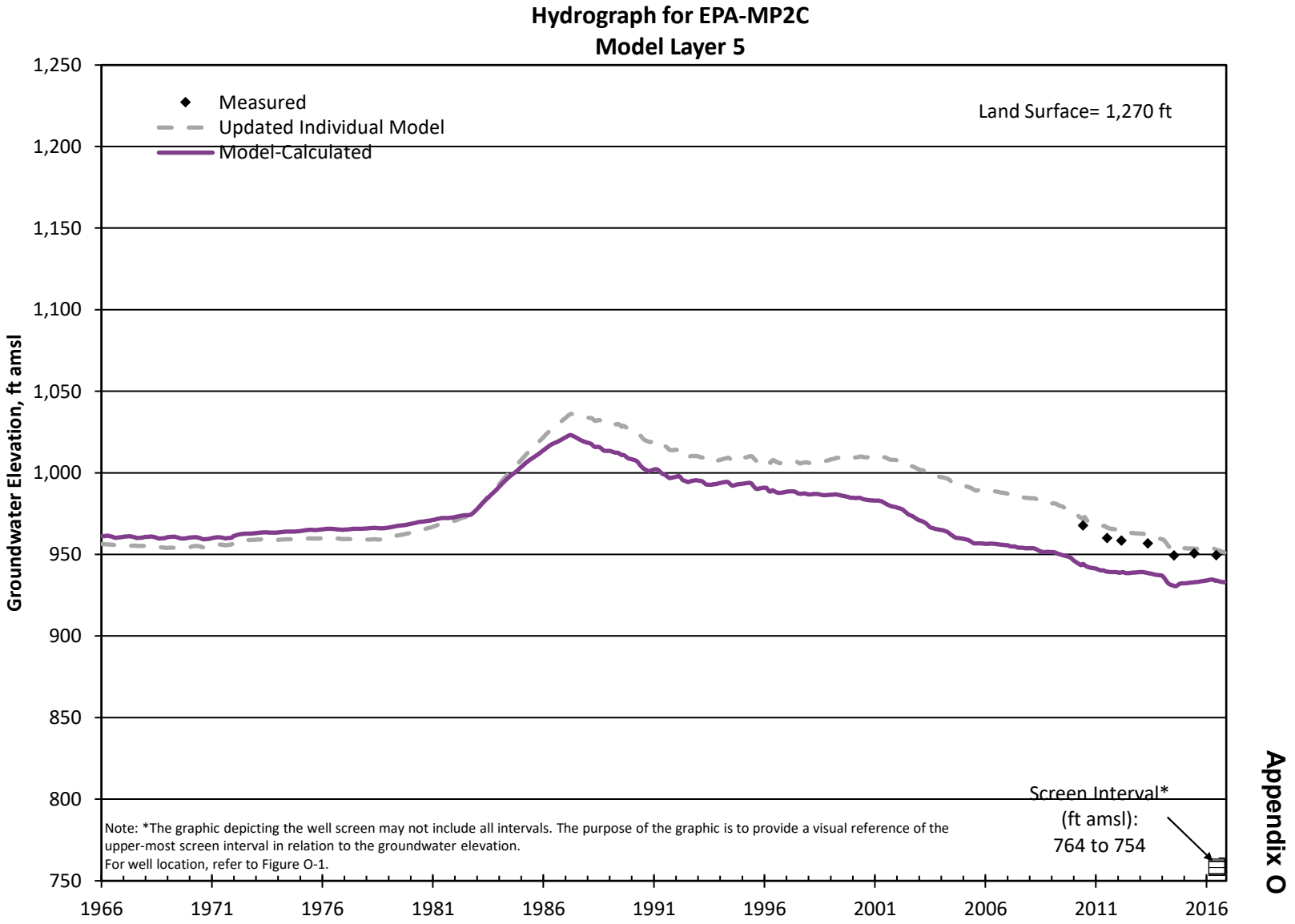
Appendix O


Hydrograph for CMW-05B
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,648 ft
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,188 to 1,168
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

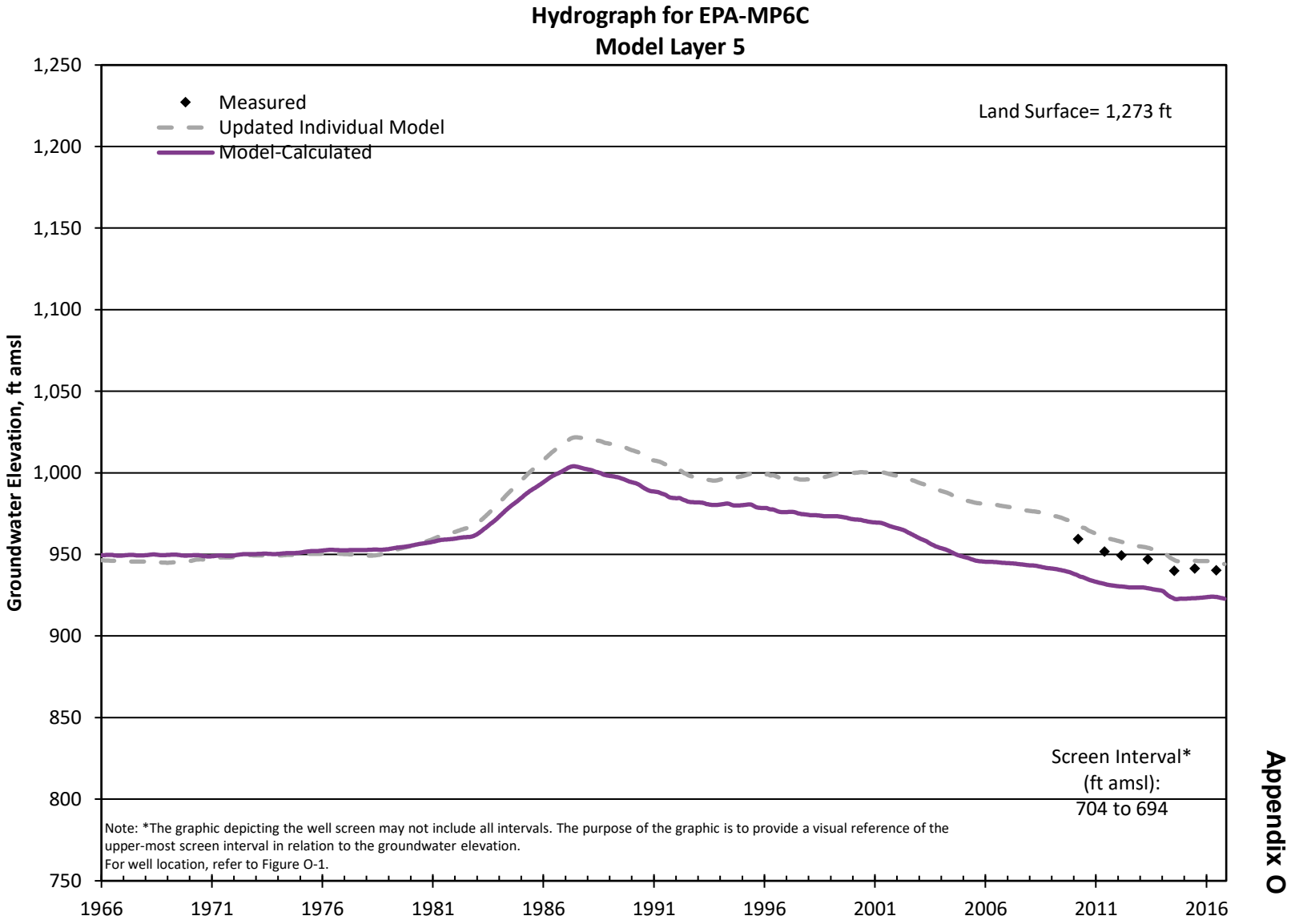
Appendix O


Hydrograph for CMW-05C
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,648 ft
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,148 to 1,128
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

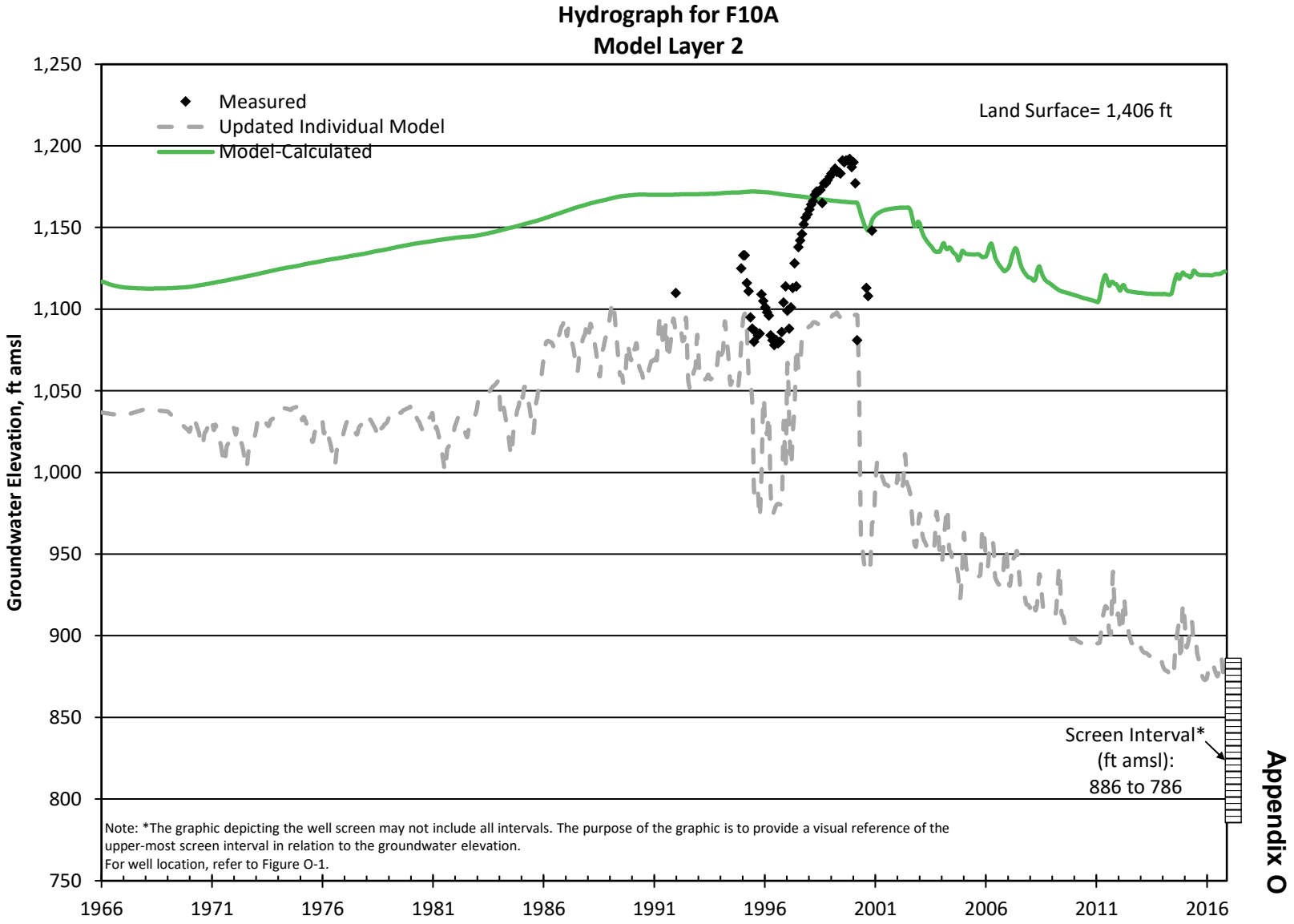
Appendix O


Hydrograph for EPA-MP2C
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,270 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
764 to 754
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

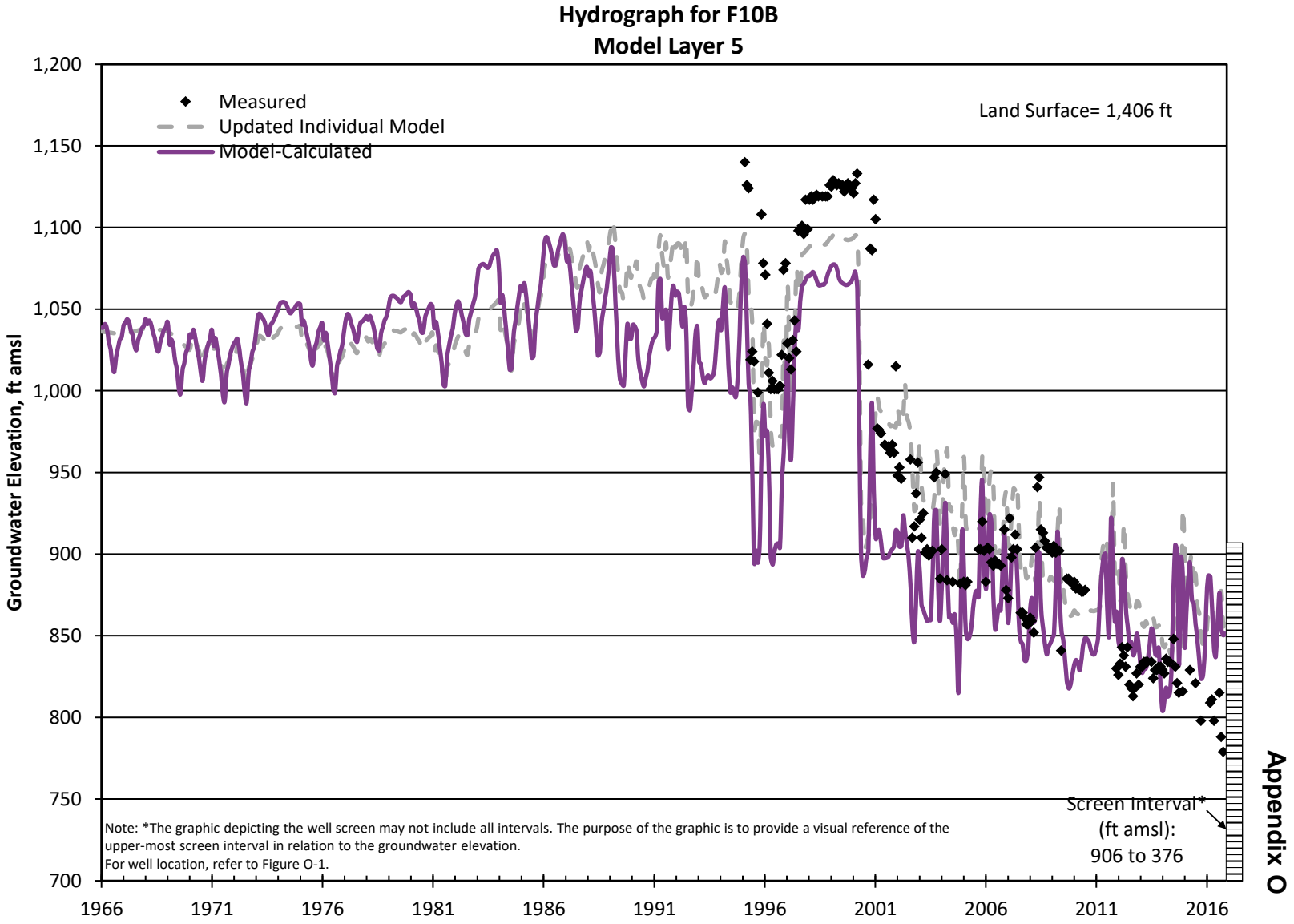
Appendix O


Hydrograph for EPA-MP6C
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,273 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
704 to 694
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

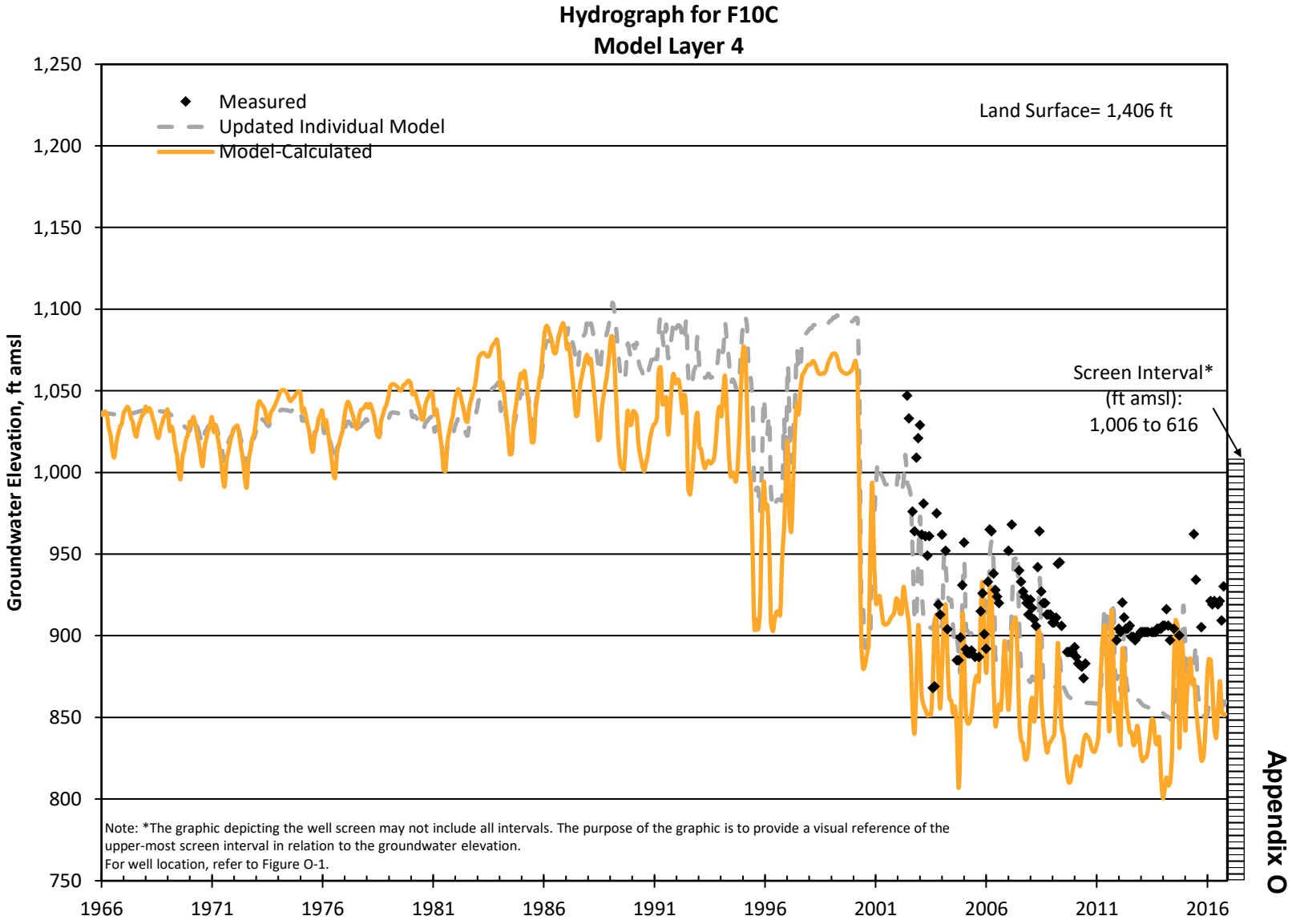
Appendix O


Hydrograph for F10A
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,406 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
886 to 786
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

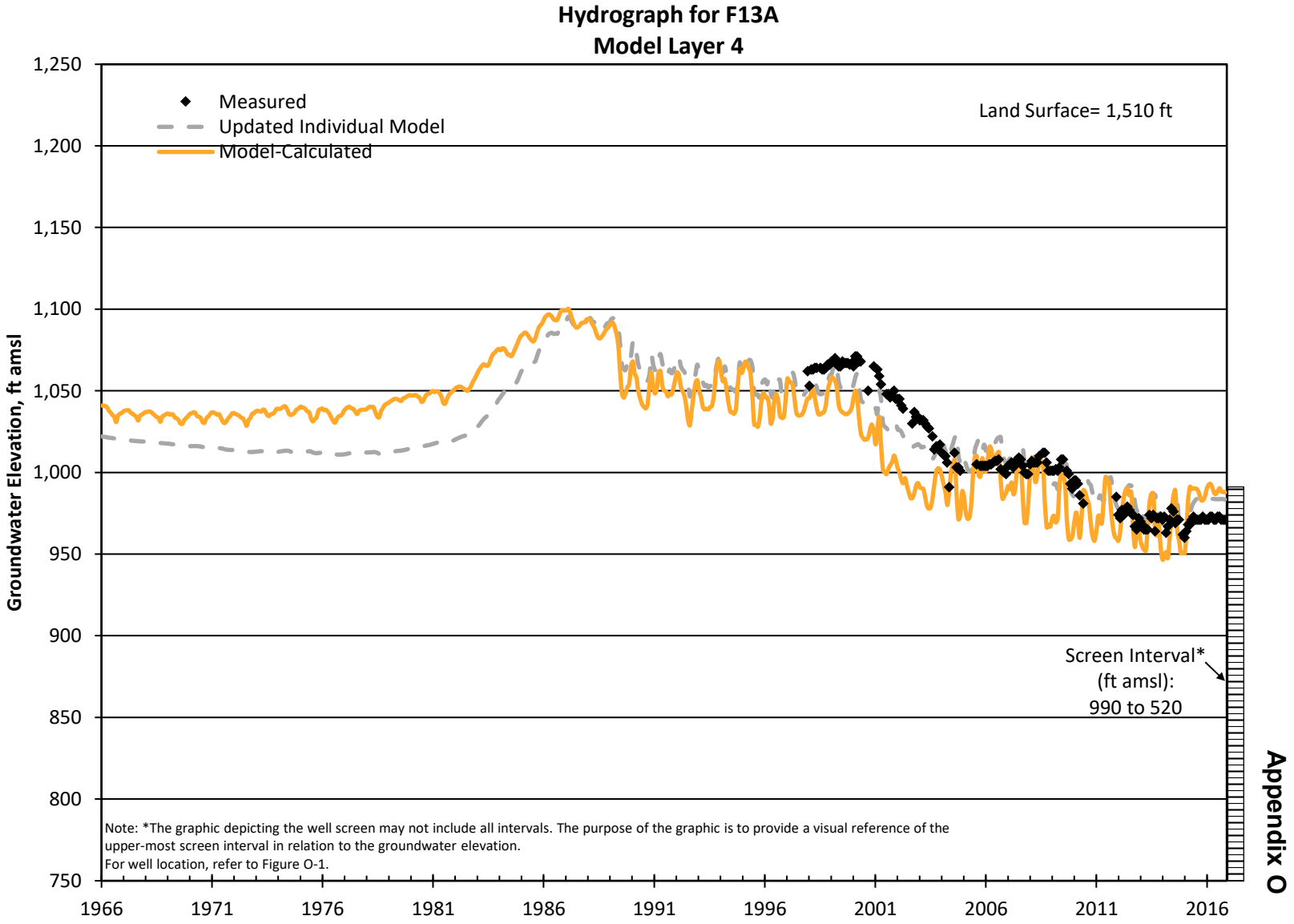
Appendix O


Hydrograph for F10B
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,406 ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
906 to 376
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

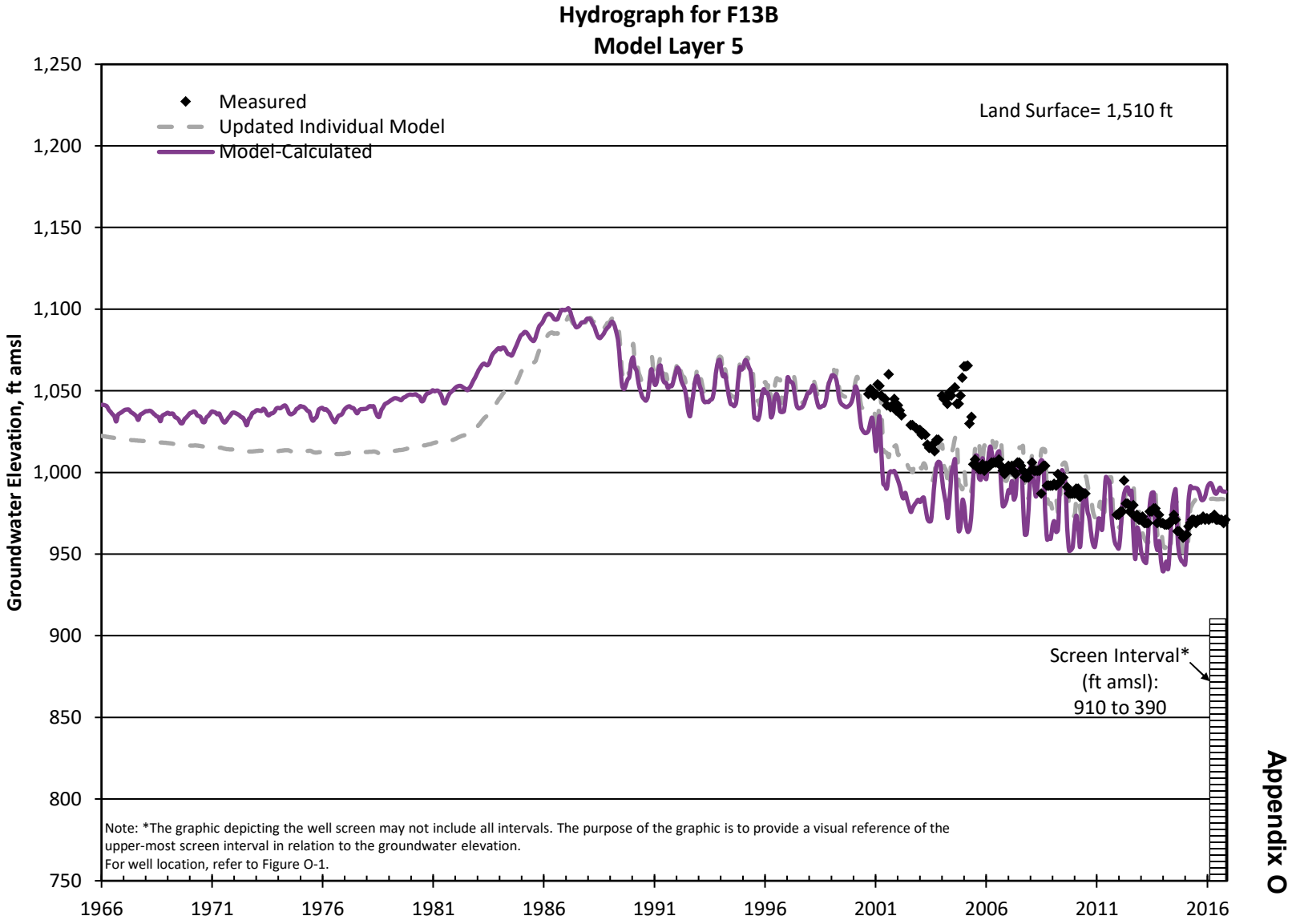
Appendix O


Hydrograph for F10C
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,406 ft
Screen Interval*
(ft amsl):
1,006 to 616
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

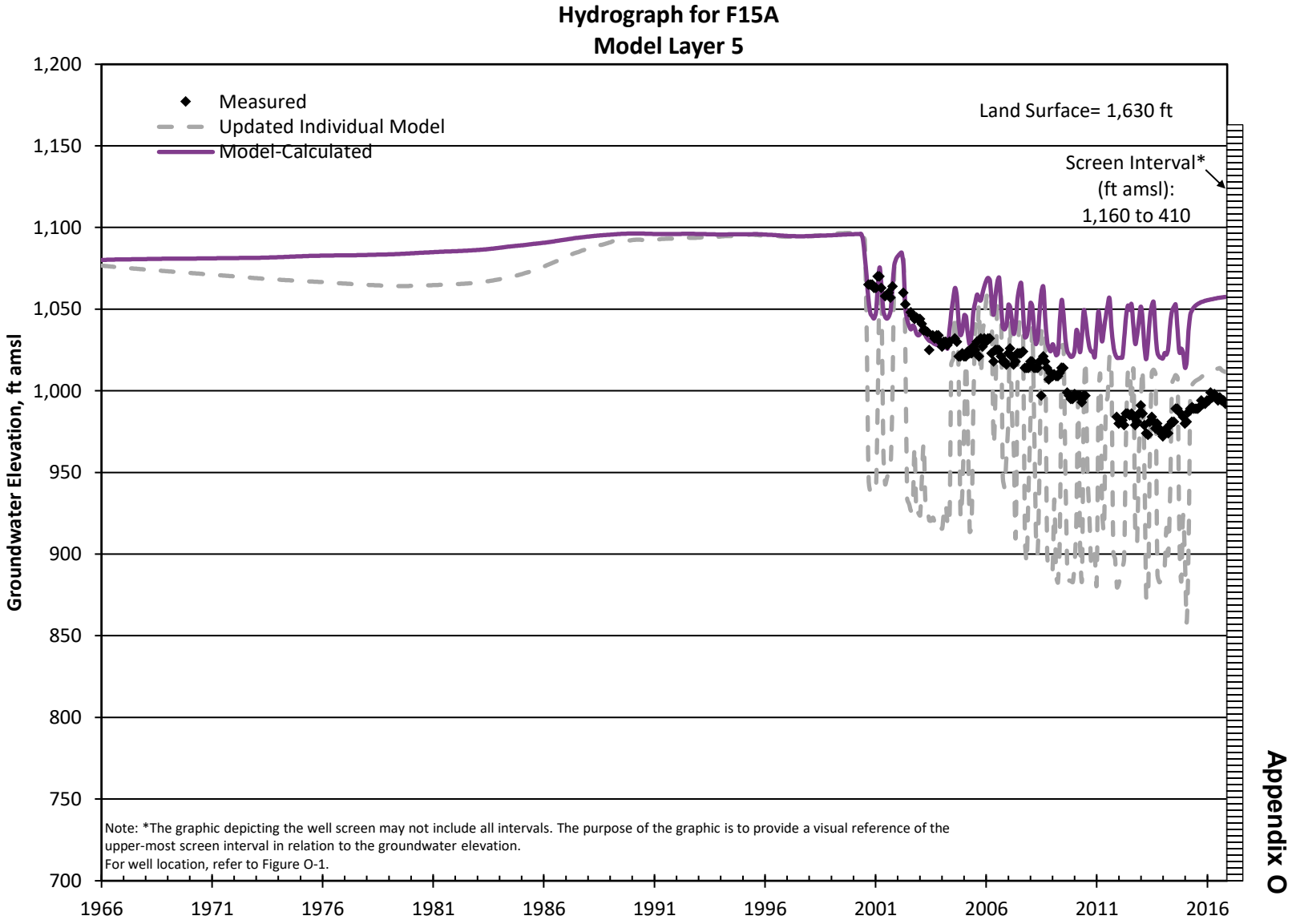
Appendix O


Hydrograph for F13A
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,510 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
990 to 520
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

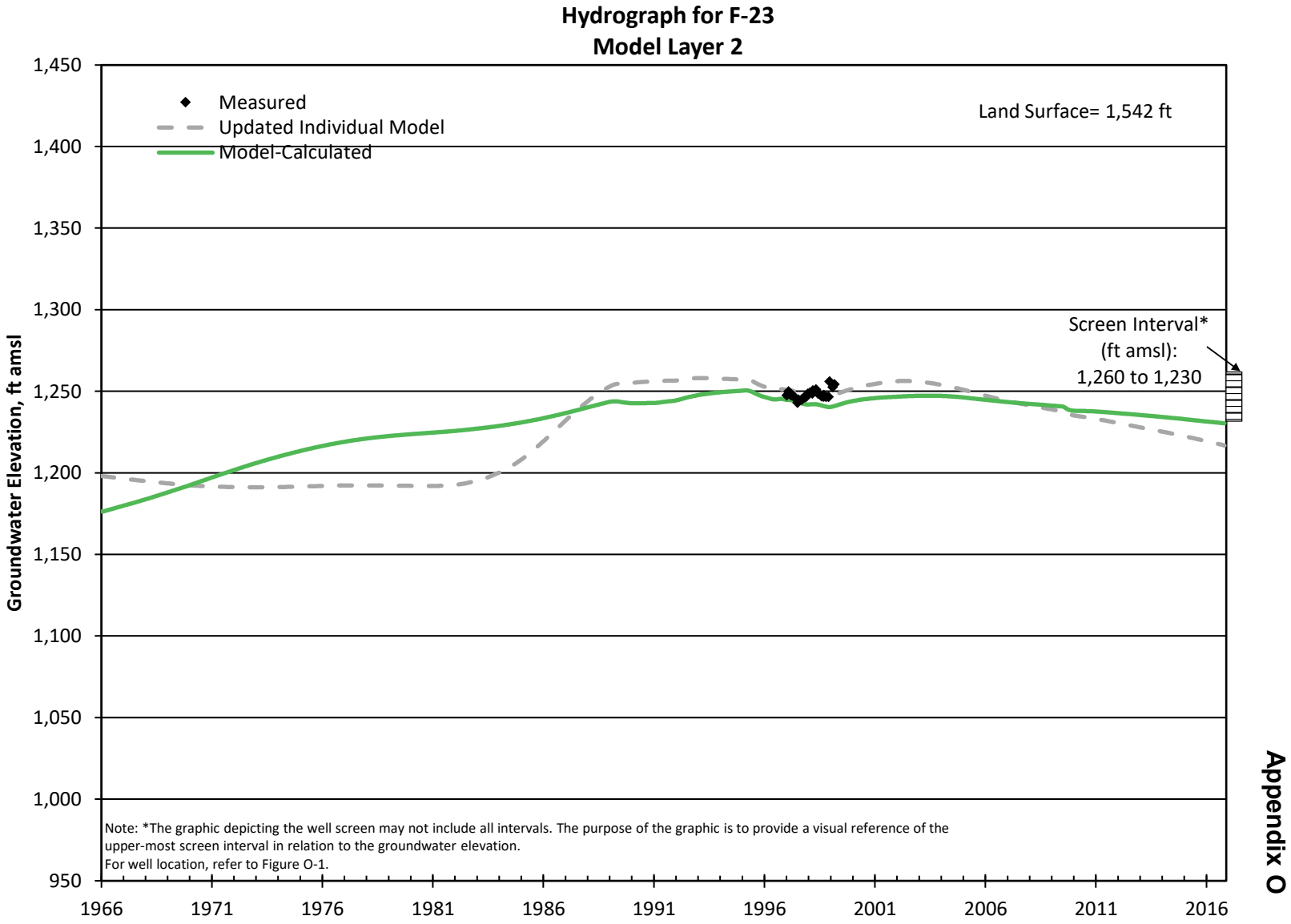
Appendix O


Hydrograph for F13B
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,510 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
910 to 390
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

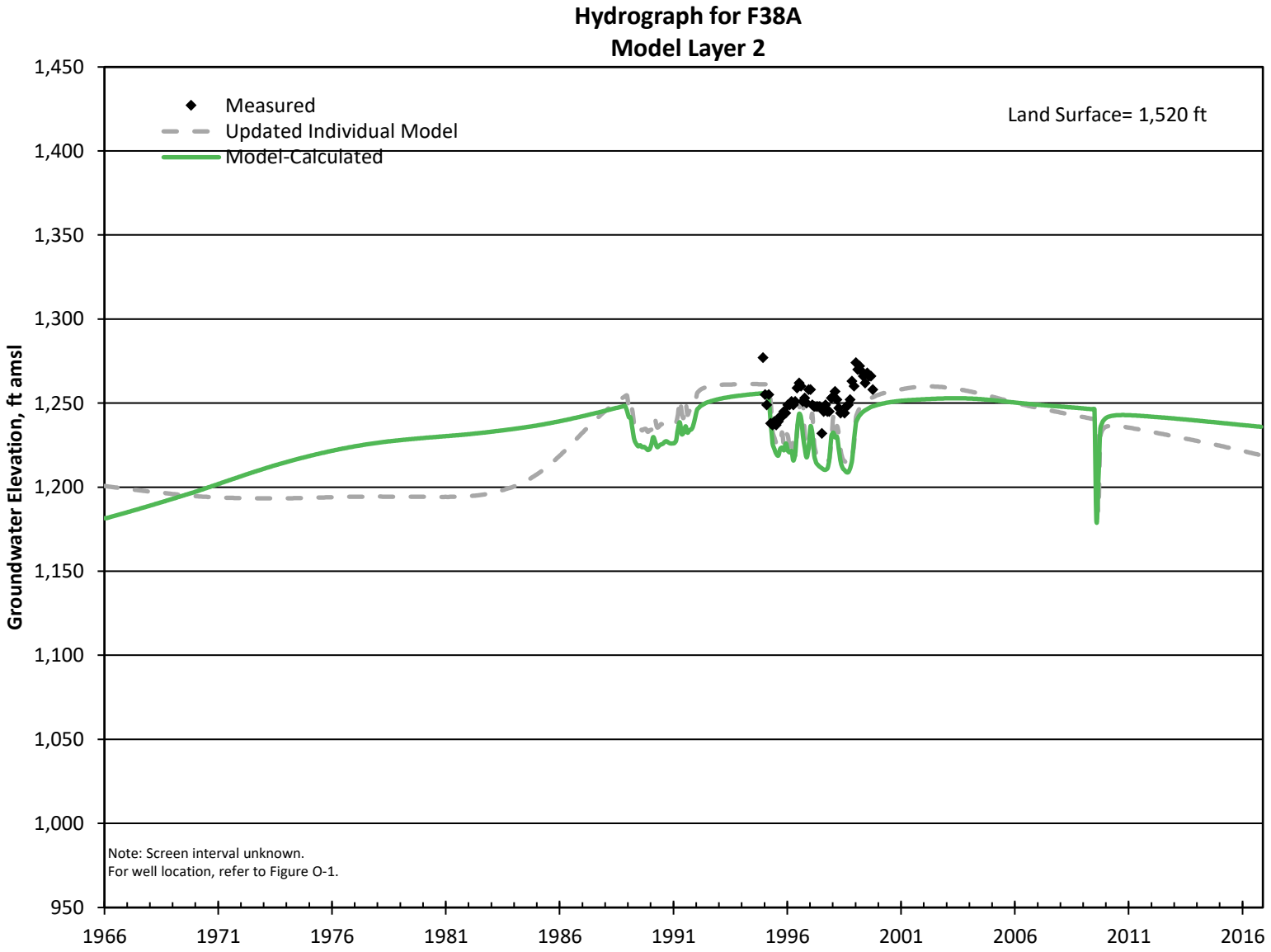
Appendix O


Hydrograph for F15A
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,630 ft
Screen Interval*
(ft amsl):
1,160 to 410
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

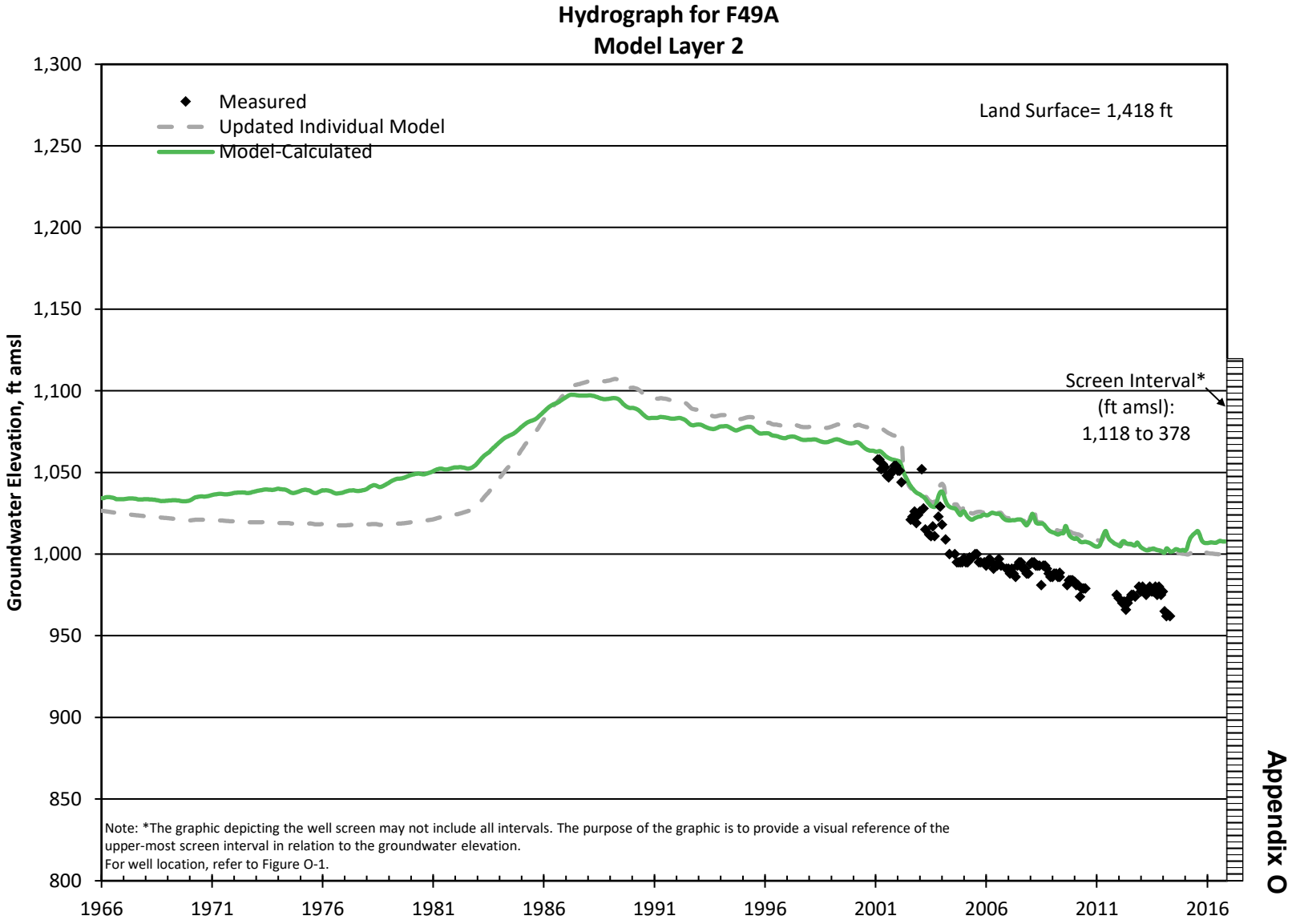
Appendix O


Hydrograph for F-23
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,542 ft
Screen Interval*
(ft amsl):
1,260 to 1,230
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

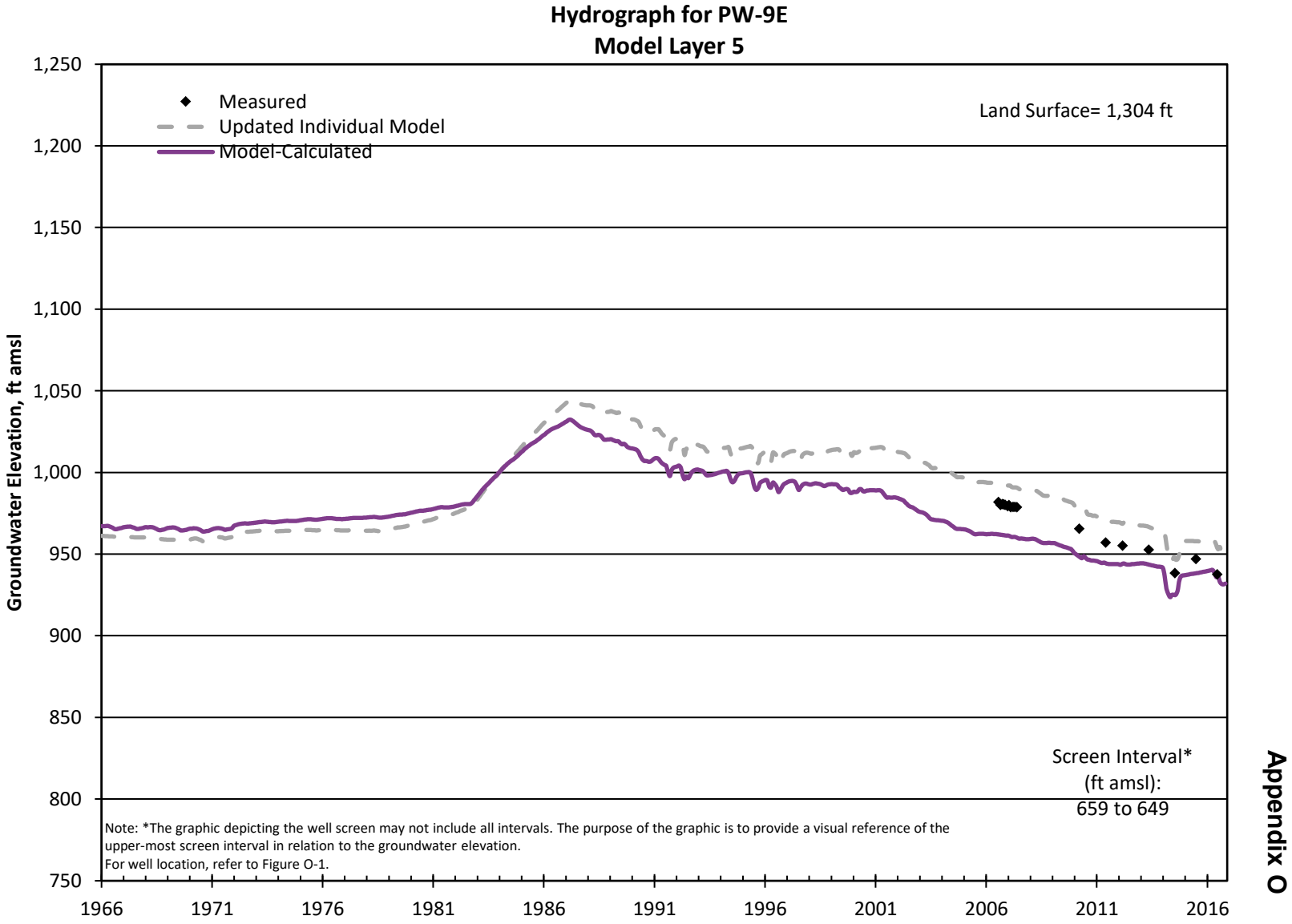
Appendix O


Hydrograph for F38A
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,520 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure O-1.

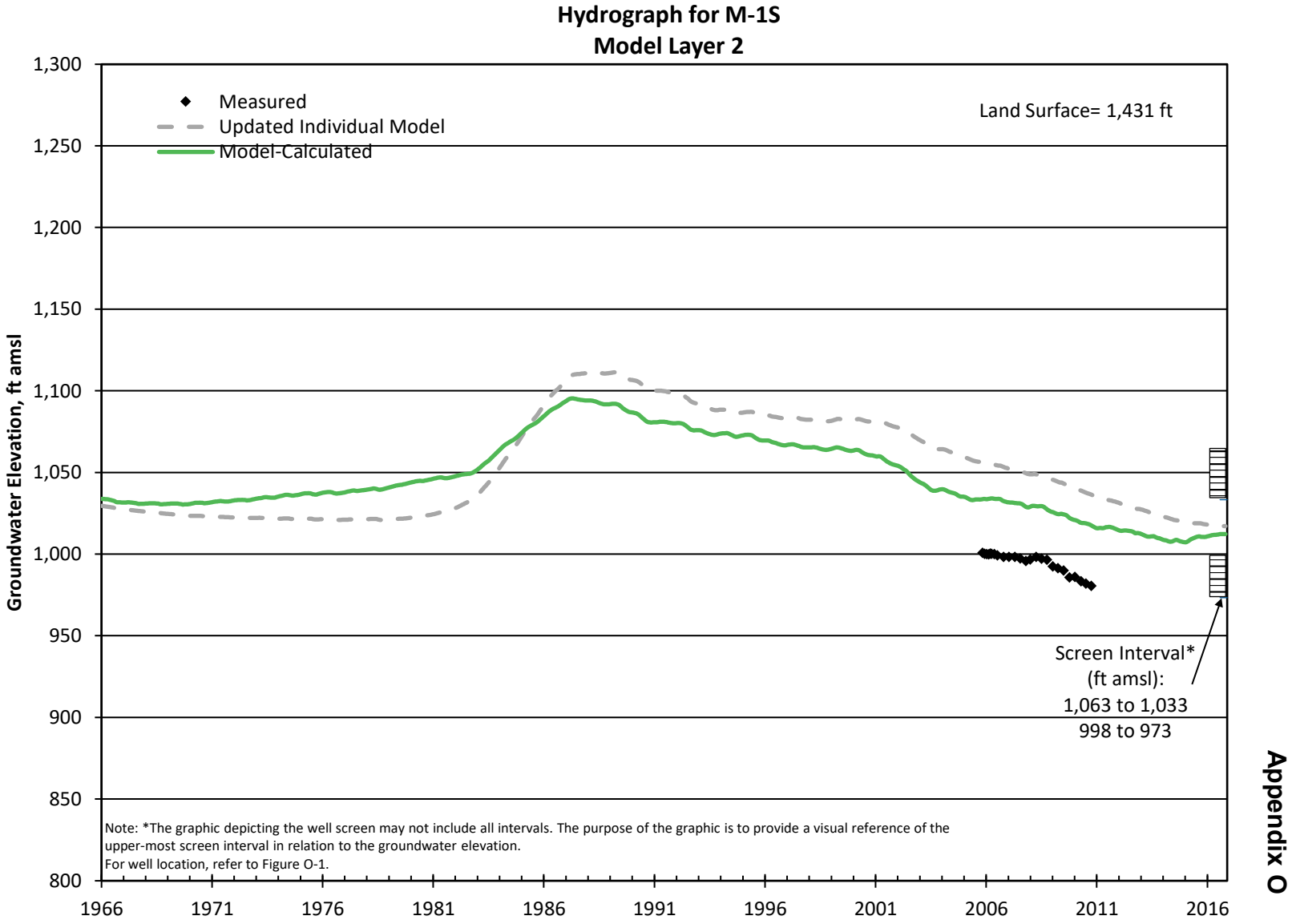
Appendix O


Hydrograph for F49A
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,418 ft
Screen Interval*
(ft amsl):
1,118 to 378
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

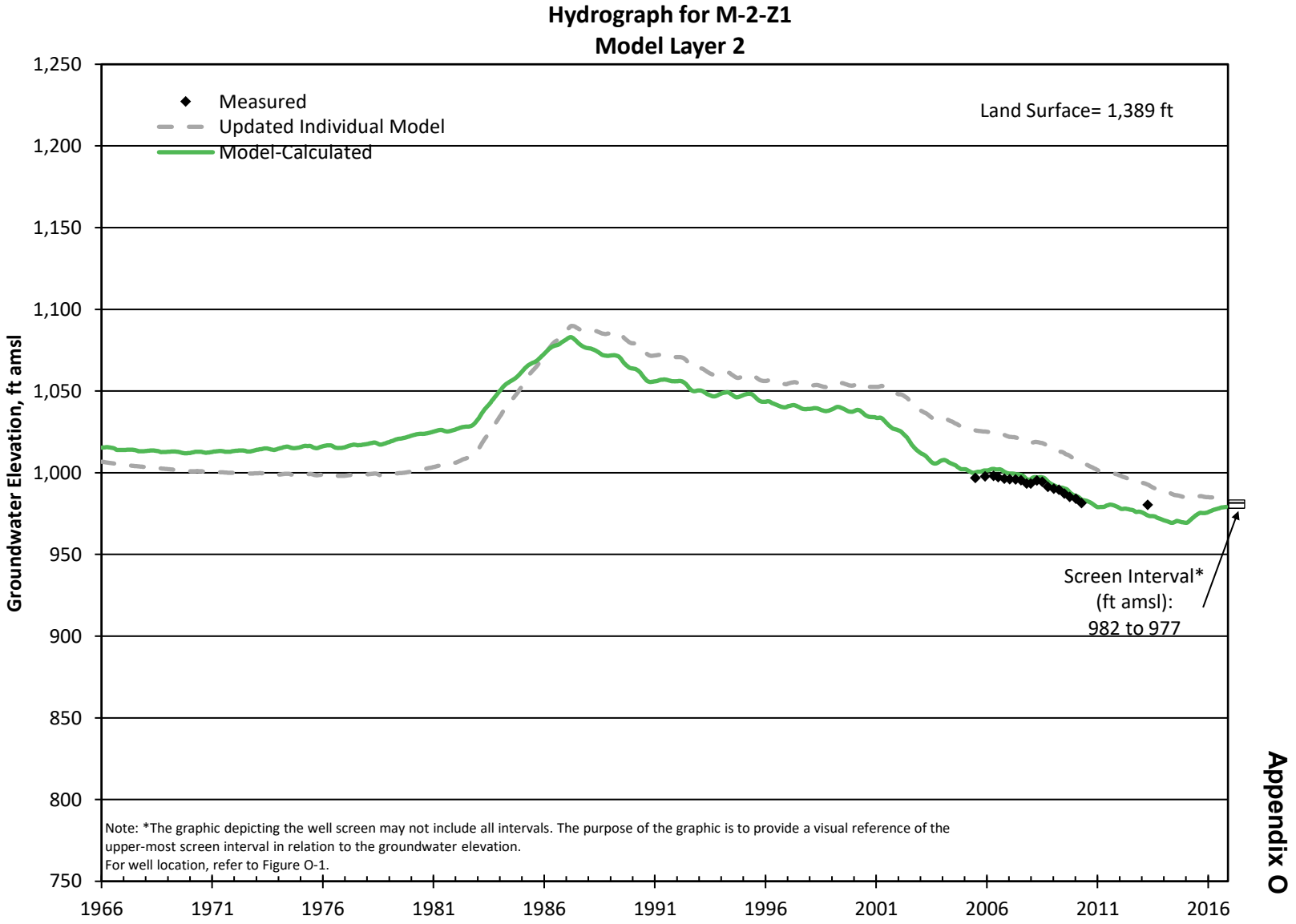
Appendix O


Hydrograph for PW-9E
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,304 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
659 to 649
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

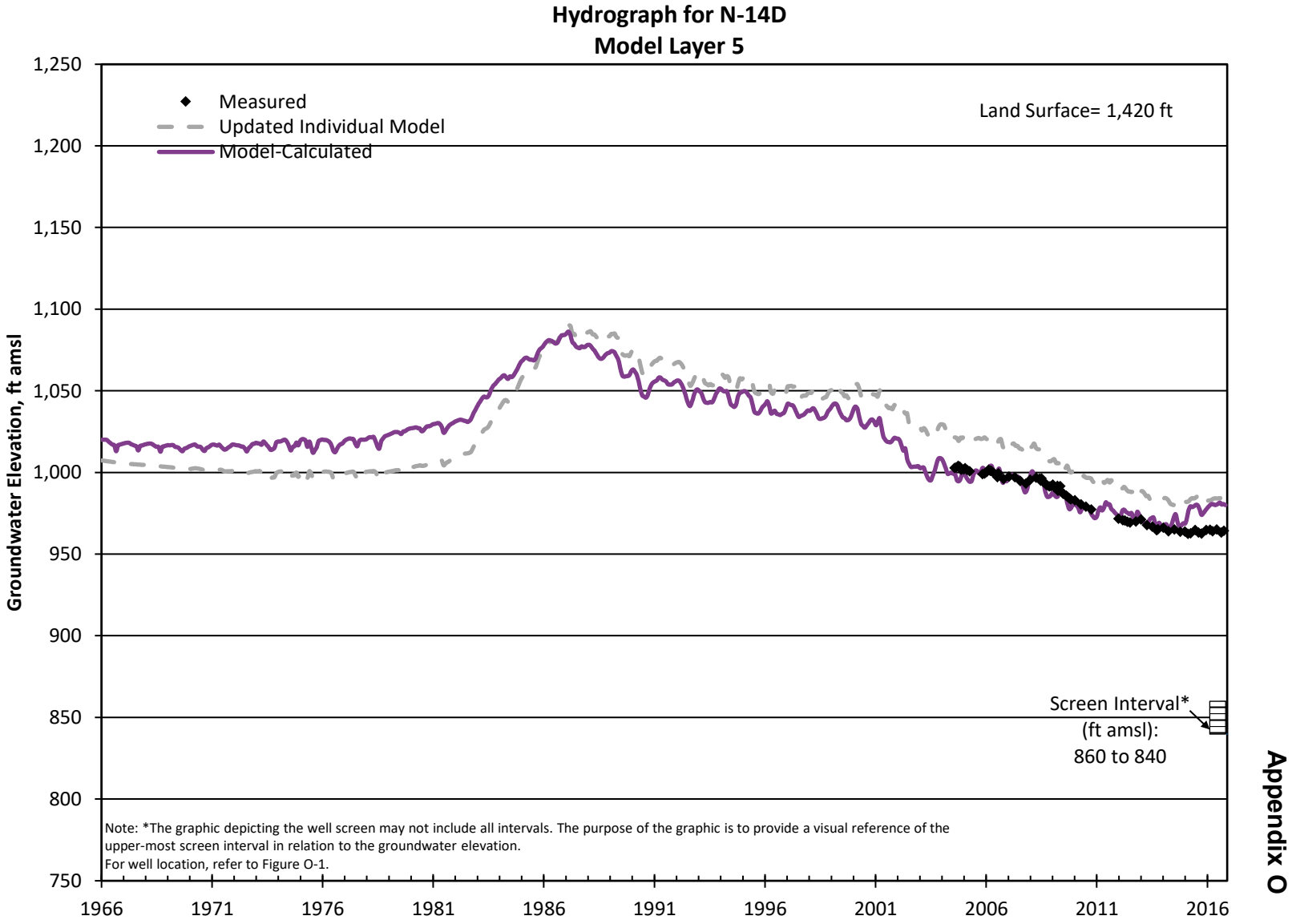
Appendix O


Hydrograph for M-1S
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,431 ft
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,063 to 1,033
998 to 973
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

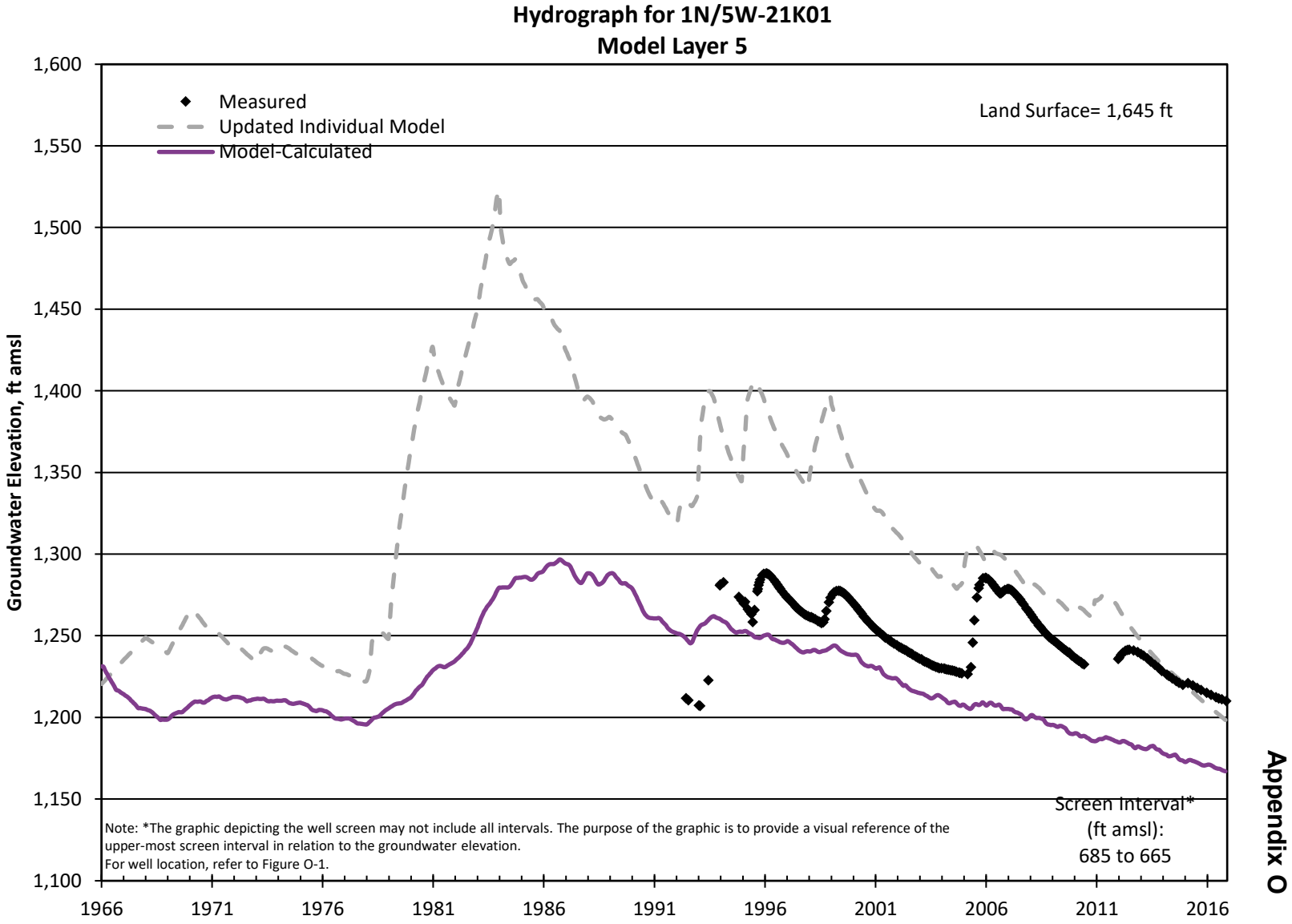
Appendix O


Hydrograph for M-2-Z1
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,389 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
982 to 977
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

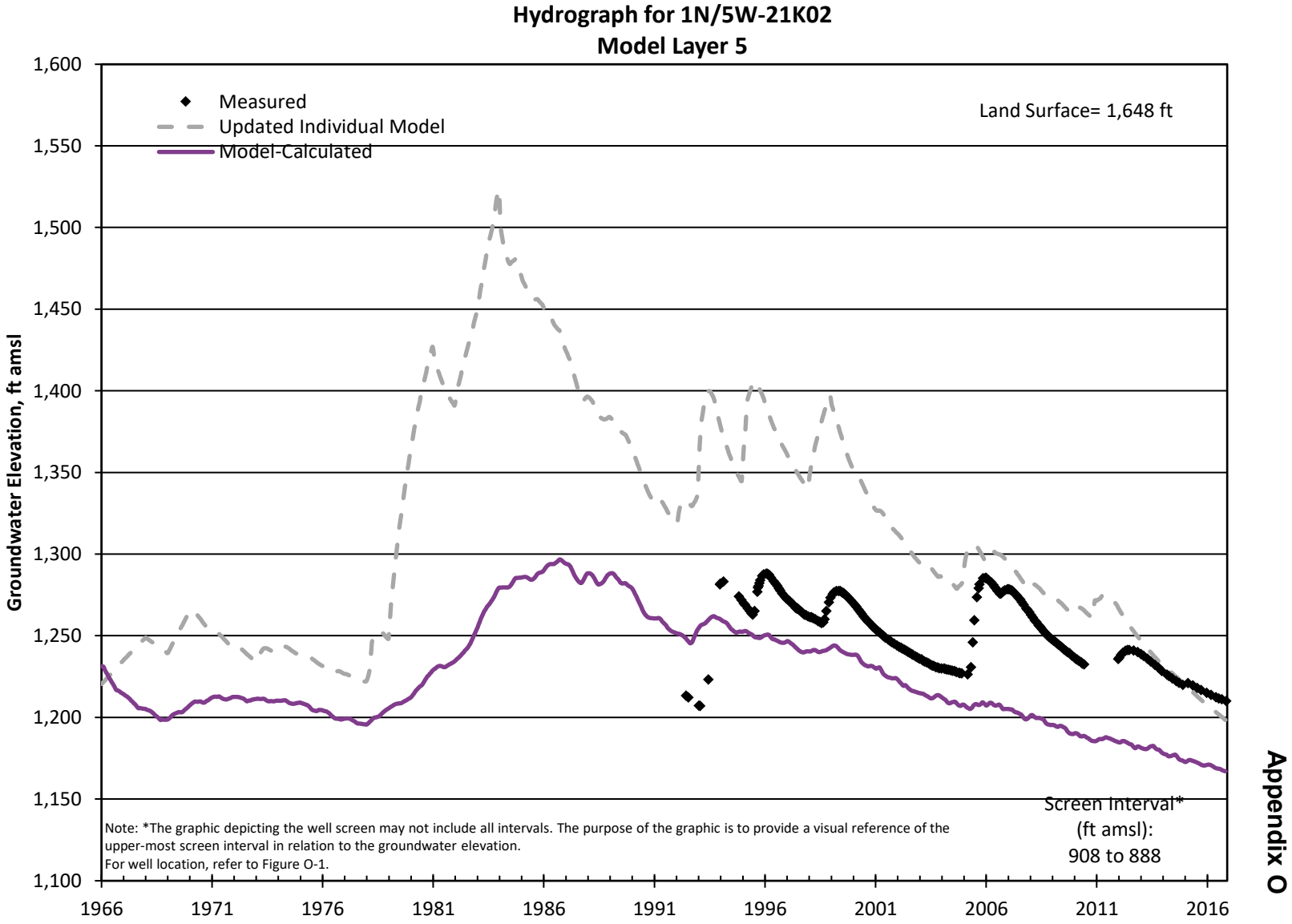
Appendix O


Hydrograph for N-14D
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,420 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
860 to 840
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

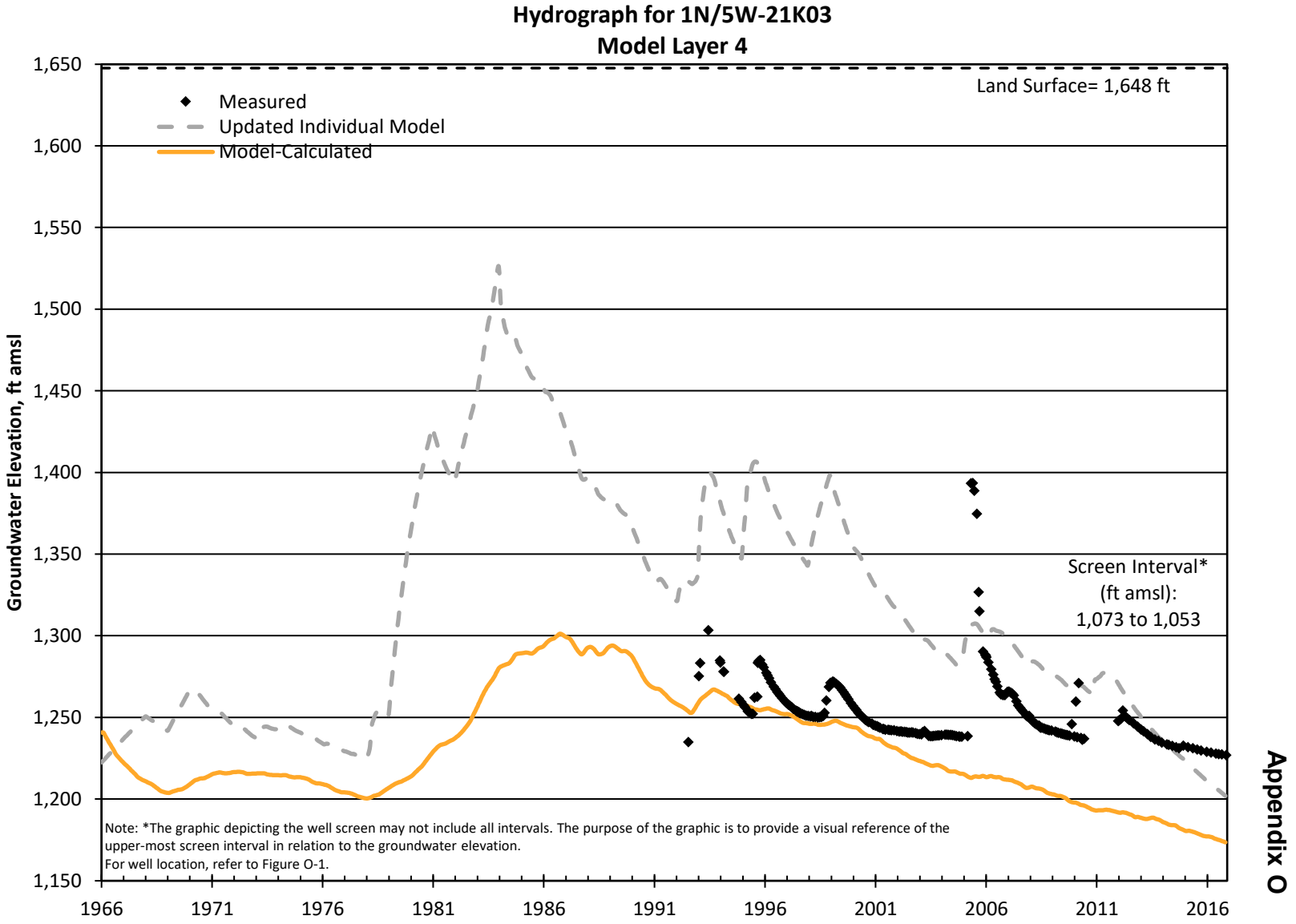
Appendix O


Hydrograph for 1N/5W-21K01
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,645 ft
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.
Screen Interval*
(ft amsl):
685 to 665

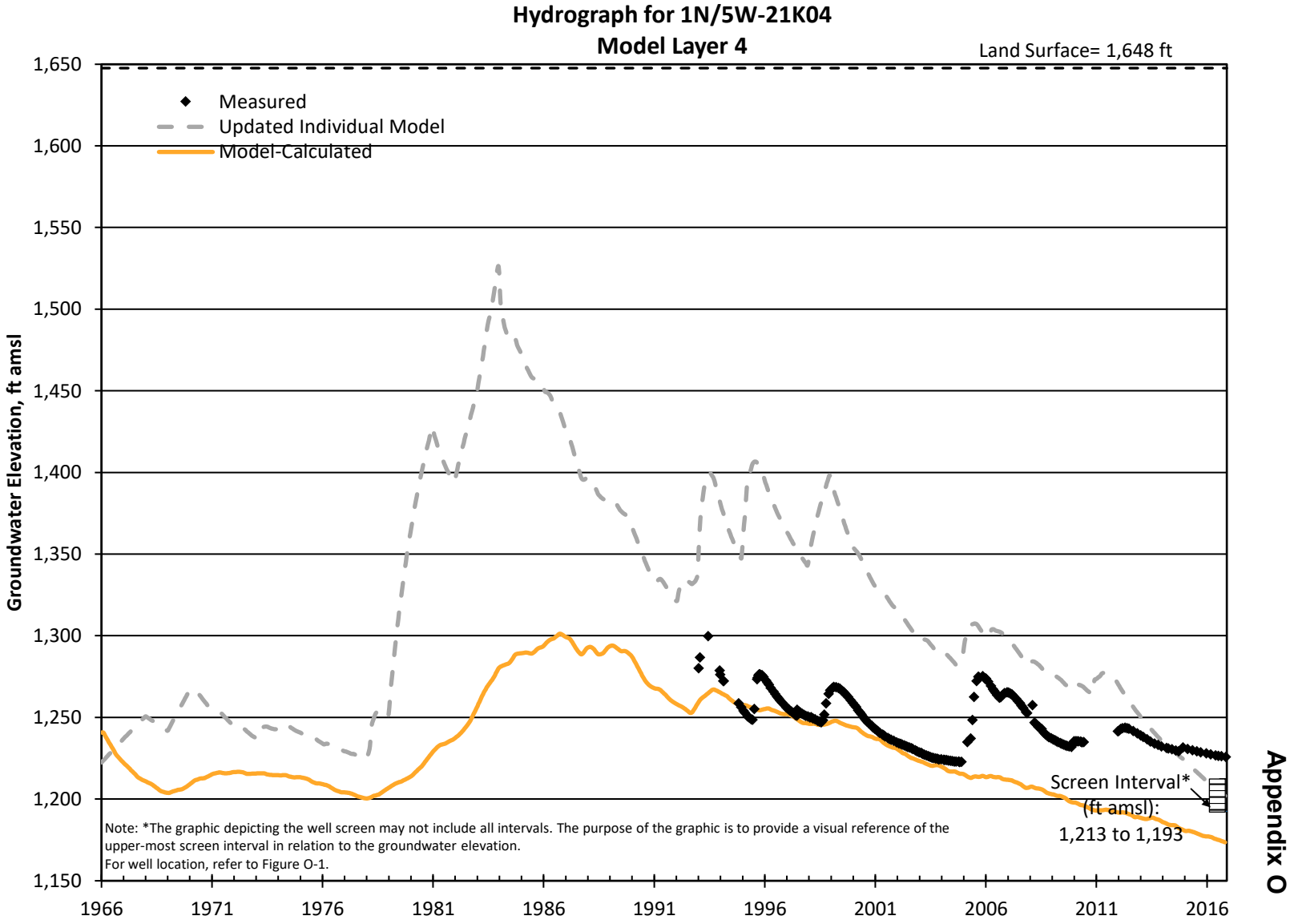
Appendix O


Hydrograph for 1N/5W-21K02
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,648 ft
Groundwater Elevation, ft amsl
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.
Screen Interval*
(ft amsl):
908 to 888

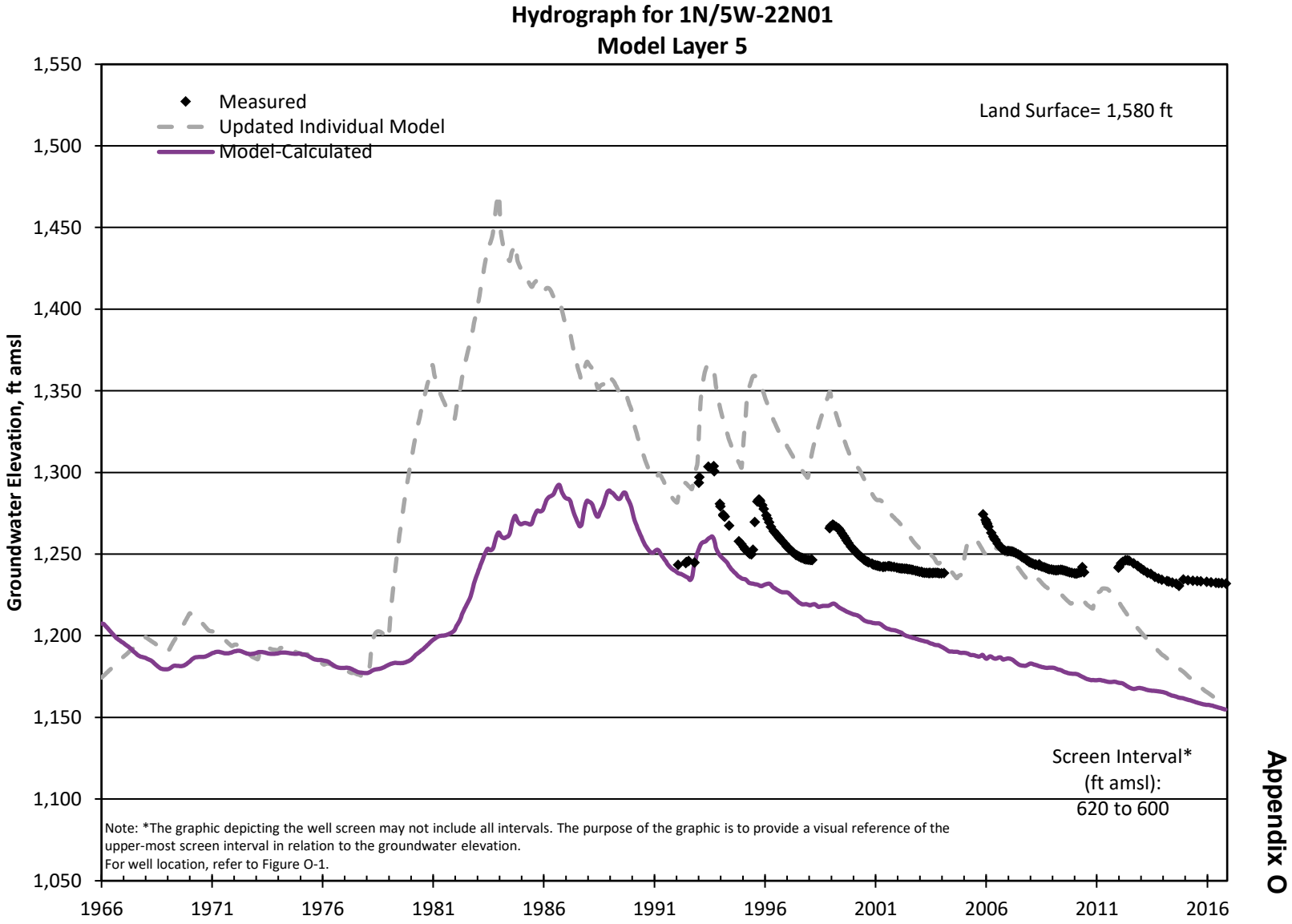
Appendix O


Hydrograph for 1N/5W-21K03
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,648 ft
Screen Interval*
(ft amsl):
1,073 to 1,053
Groundwater Elevation, ft amsl
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

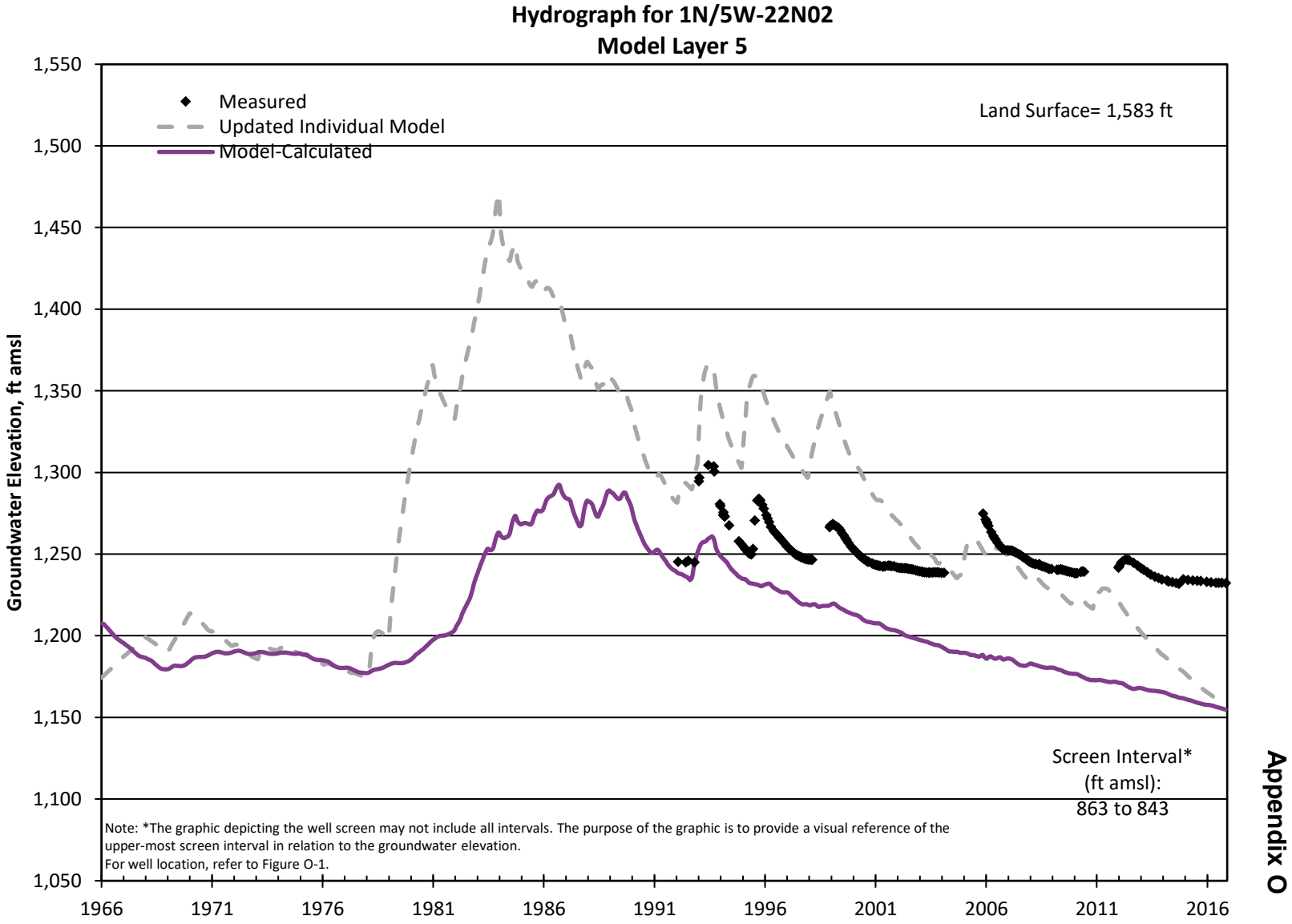
Appendix O


Hydrograph for 1N/5W-21K04
Model Layer 4
Land Surface= 1,648 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
1,650
1,600
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,213 to 1,193
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

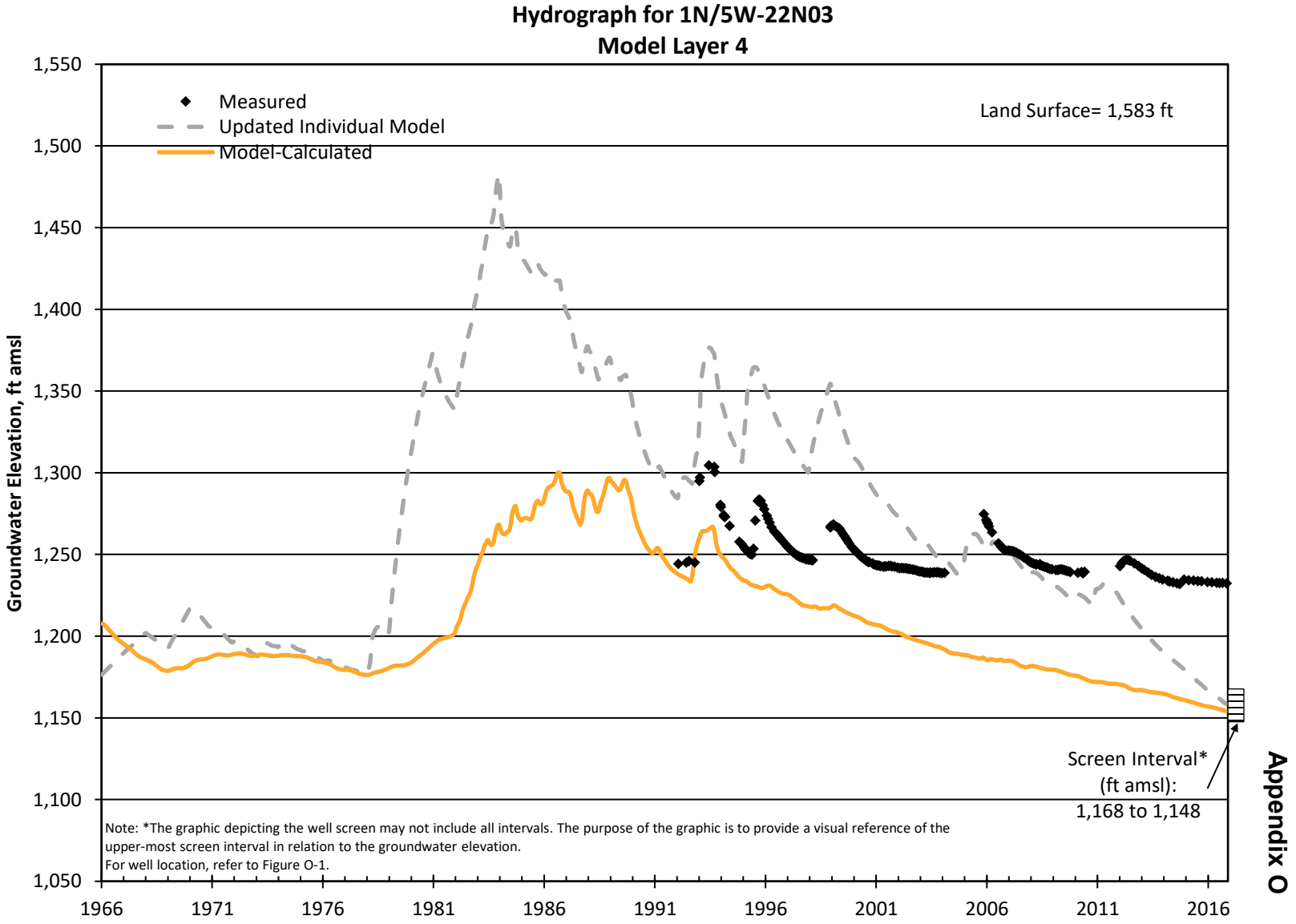
Appendix O


Hydrograph for 1N/5W-22N01
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,580 ft
Groundwater Elevation, ft amsl
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
620 to 600
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

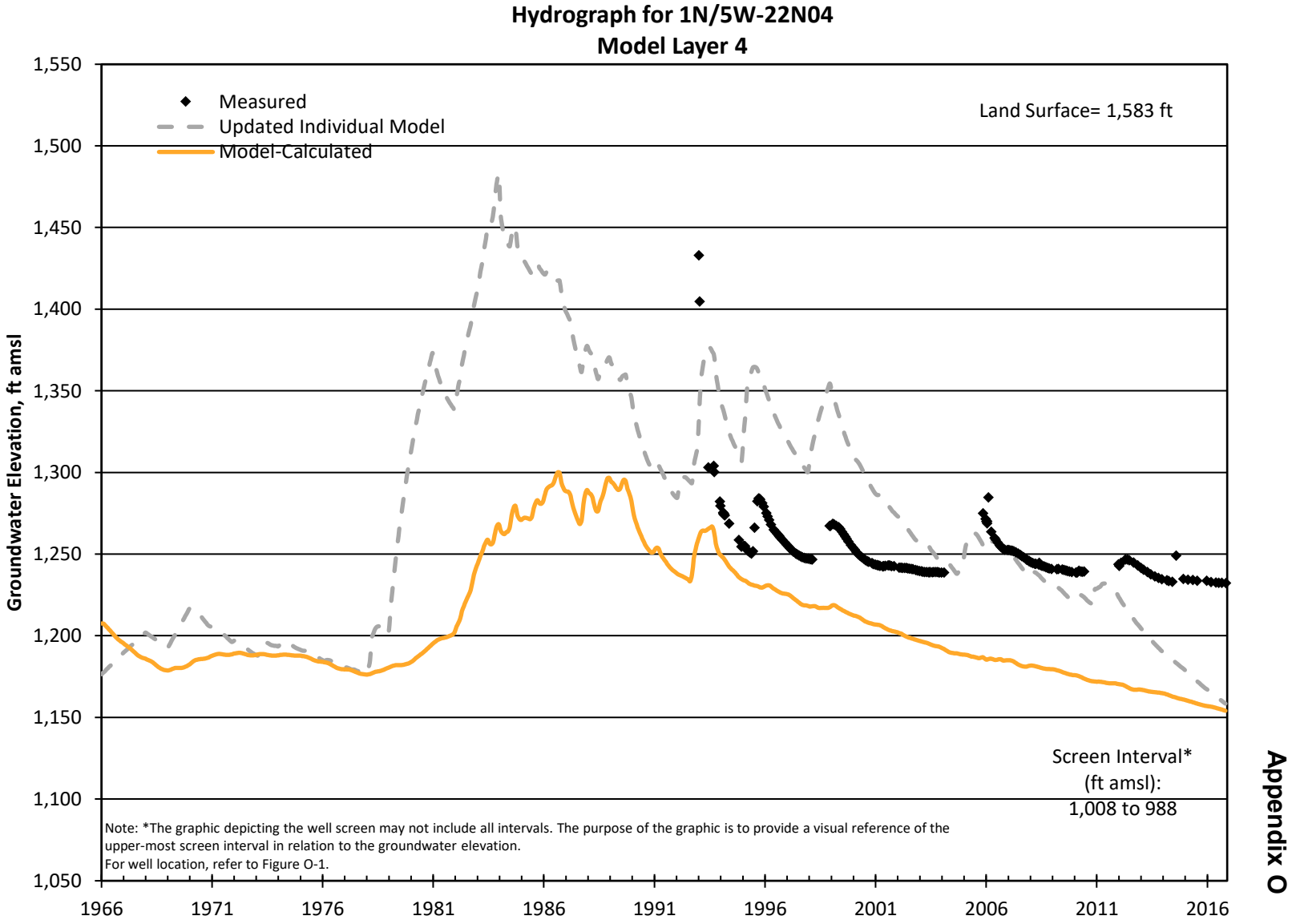
Appendix O


Hydrograph for 1N/5W-22N02
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,583 ft
Groundwater Elevation, ft amsl
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
863 to 843
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

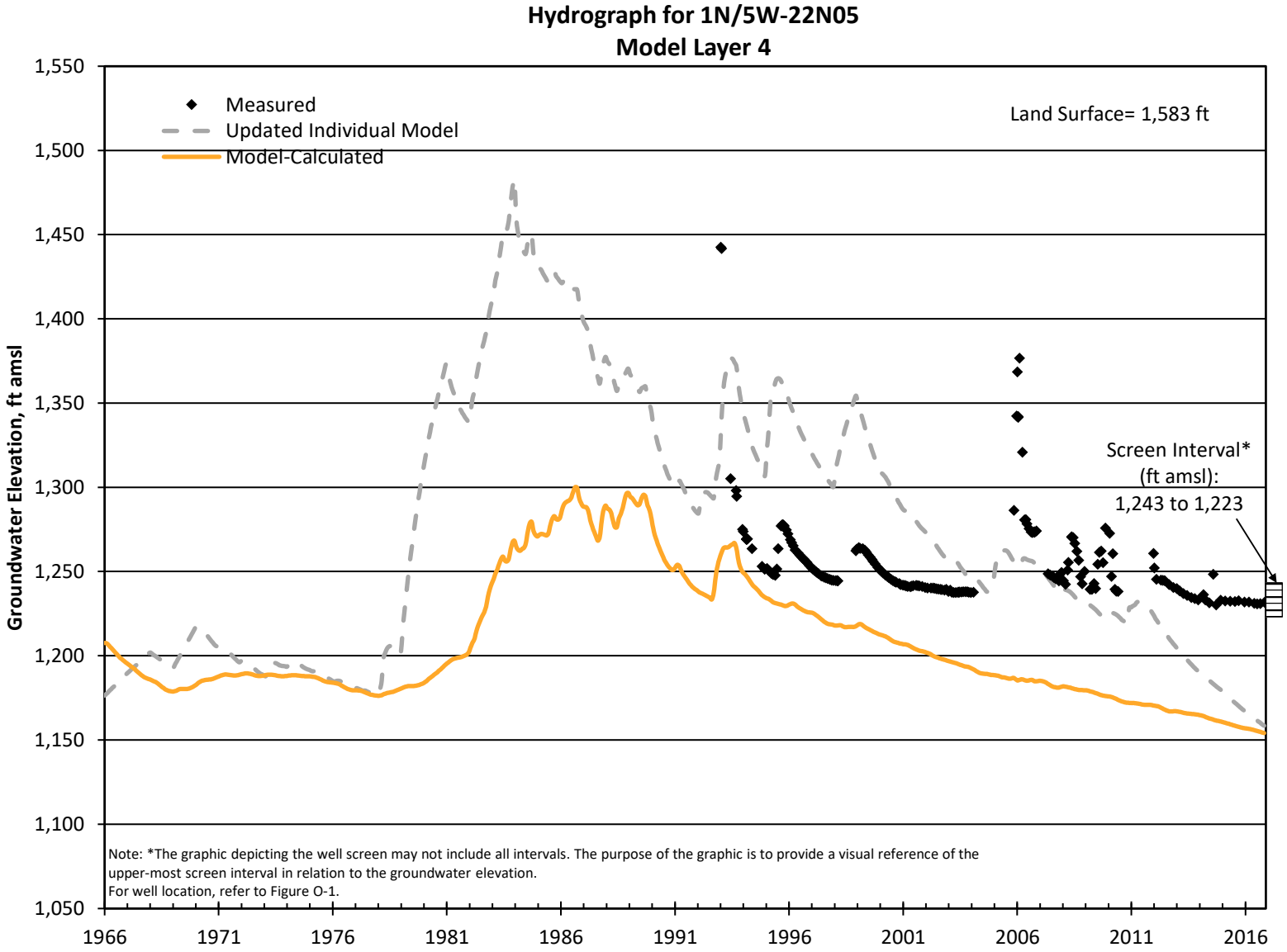
Appendix O


Hydrograph for 1N/5W-22N03
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,583 ft
Groundwater Elevation, ft amsl
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,168 to 1,148
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

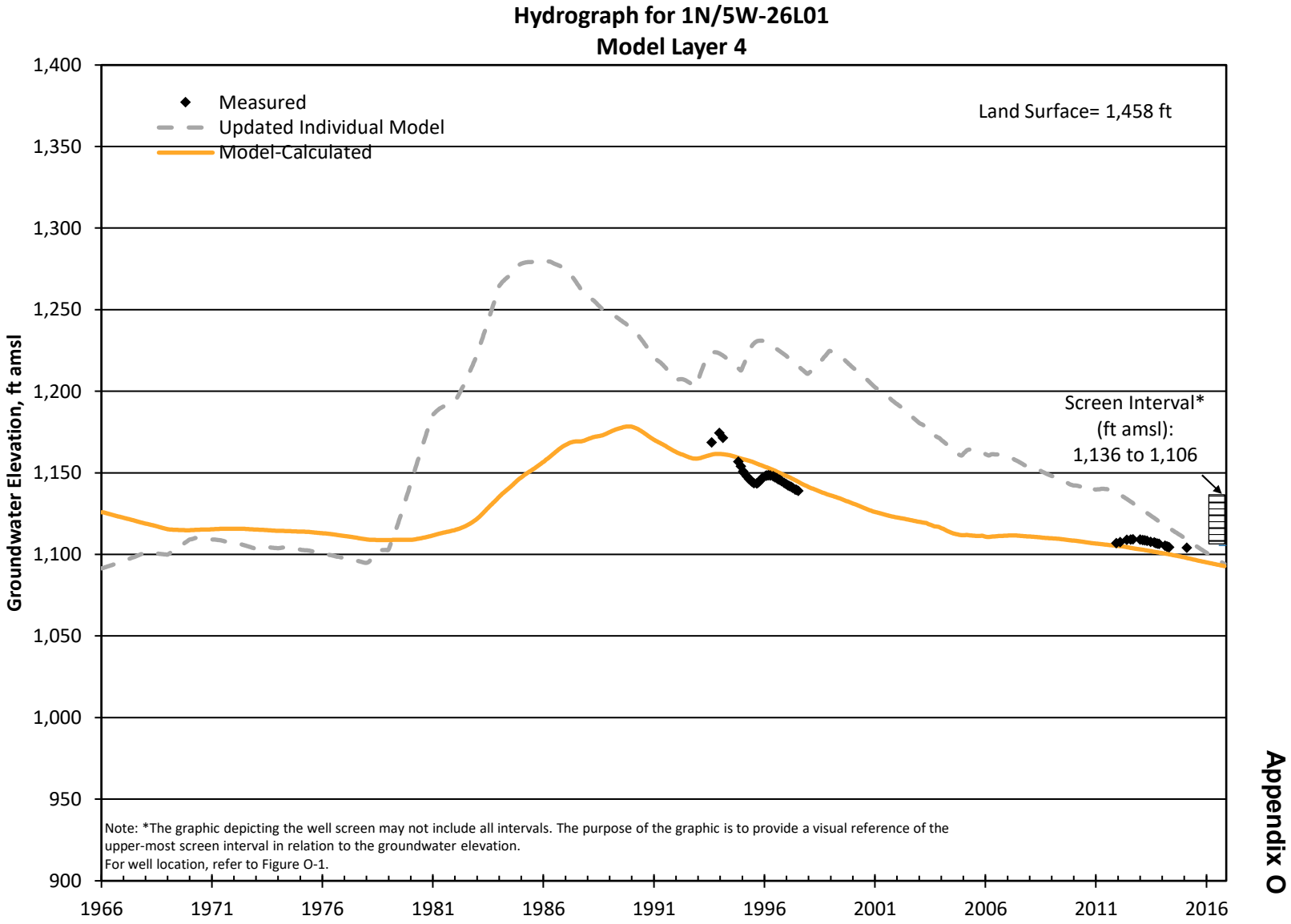
Appendix O


Hydrograph for 1N/5W-22N04
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,583 ft
Groundwater Elevation, ft amsl
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,008 to 988
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

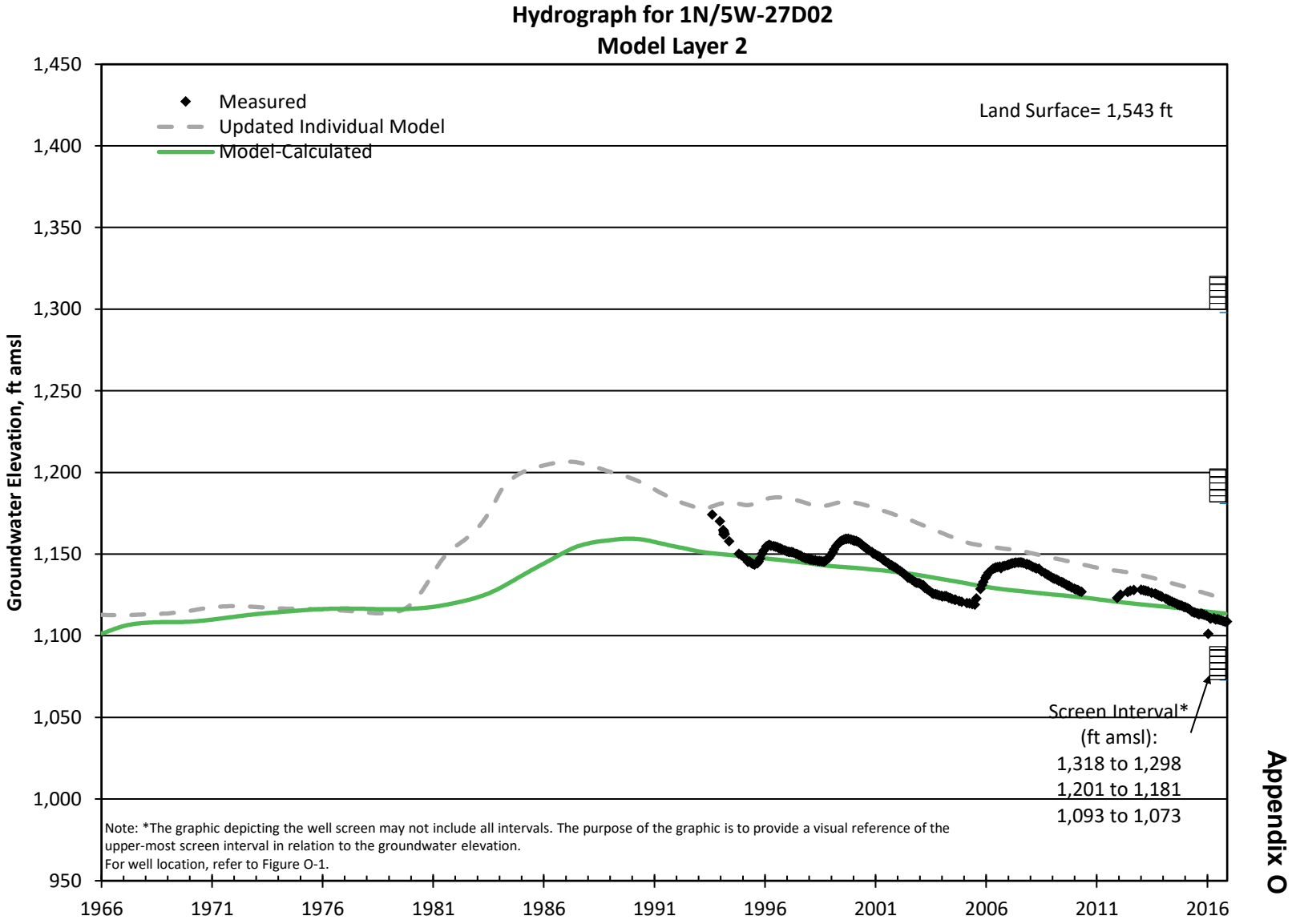
Appendix O


Hydrograph for 1N/5W-22N05
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,583 ft
Screen Interval*
(ft amsl):
1,243 to 1,223
Groundwater Elevation, ft amsl
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

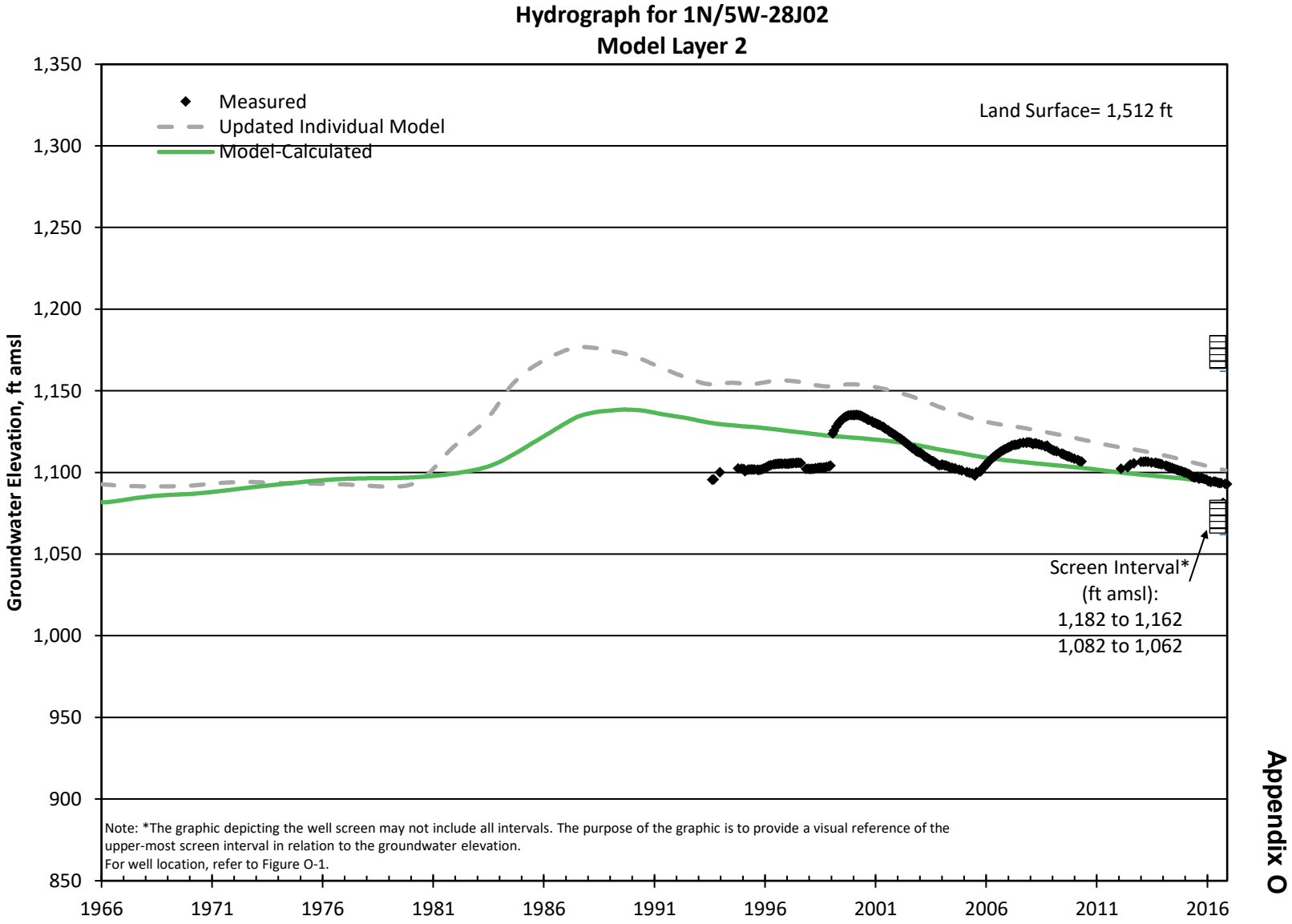
Appendix O


Hydrograph for 1N/5W-26L01
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,458 ft
Screen Interval*
(ft amsl):
1,136 to 1,106
Groundwater Elevation, ft amsl
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

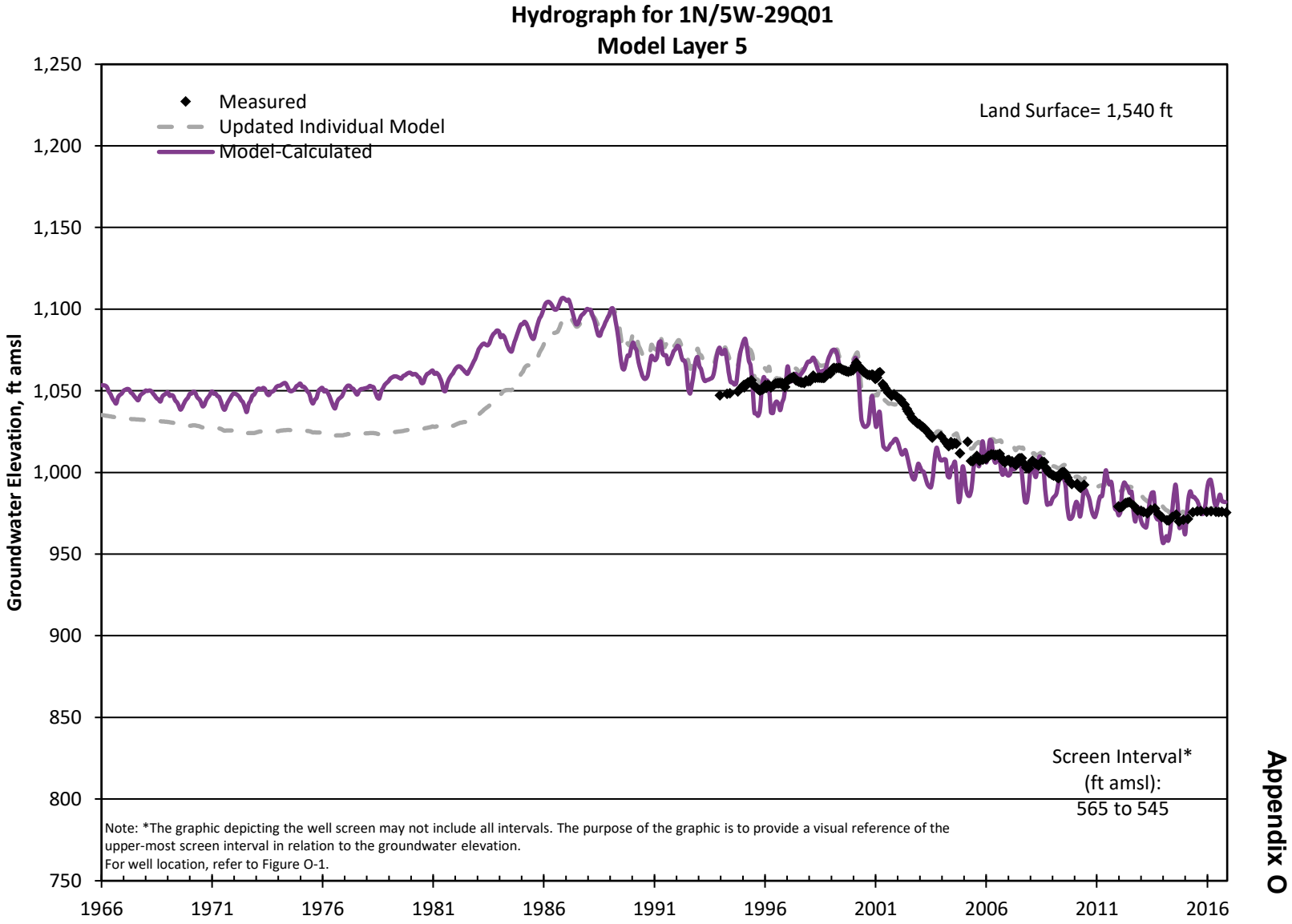
Appendix O


Hydrograph for 1N/5W-27D02
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,543 ft
Groundwater Elevation, ft amsl
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,318 to 1,298
1,201 to 1,181
1,093 to 1,073
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

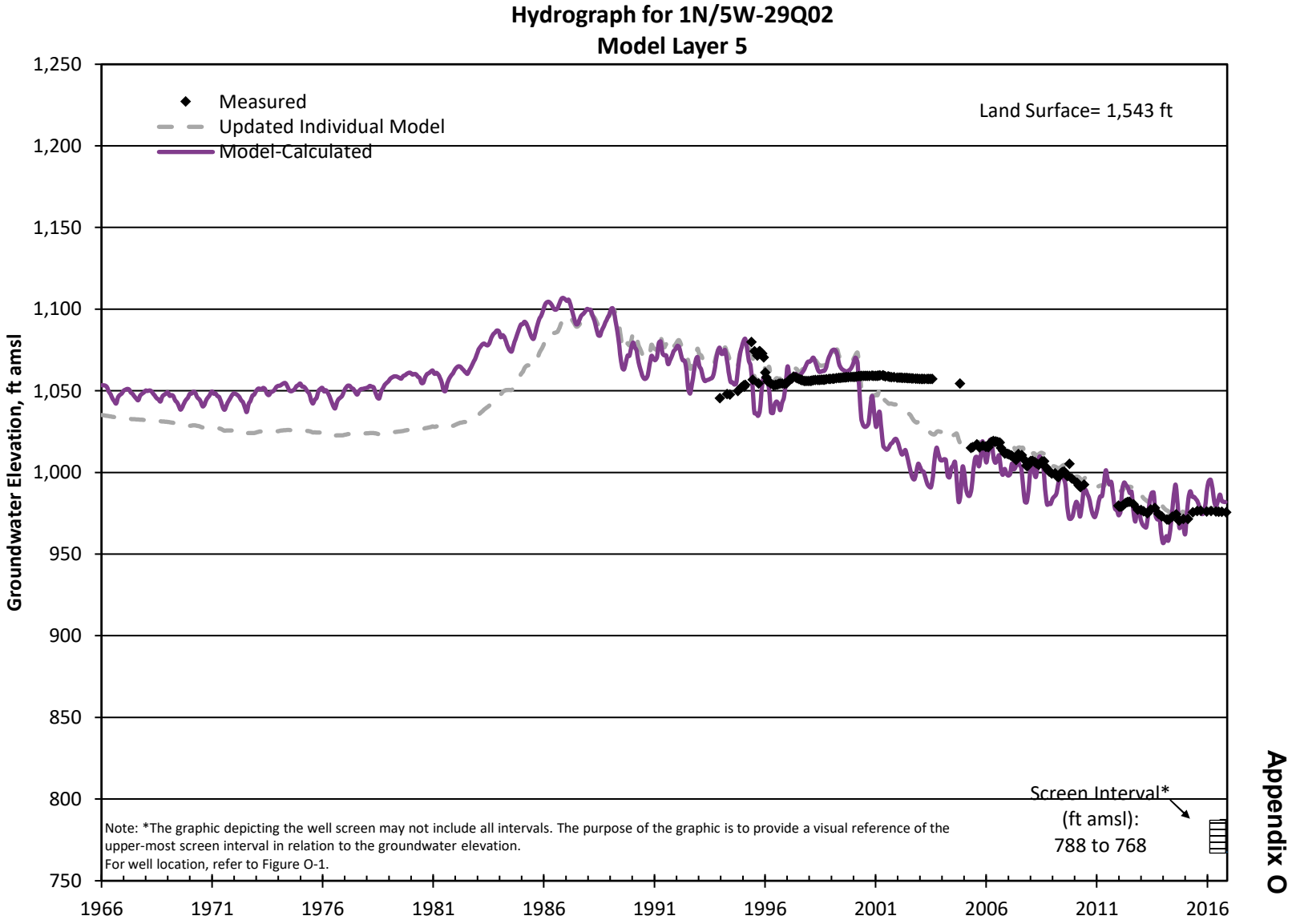
Appendix O


Hydrograph for 1N/5W-28J02
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,512 ft
Groundwater Elevation, ft amsl
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,182 to 1,162
1,082 to 1,062
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

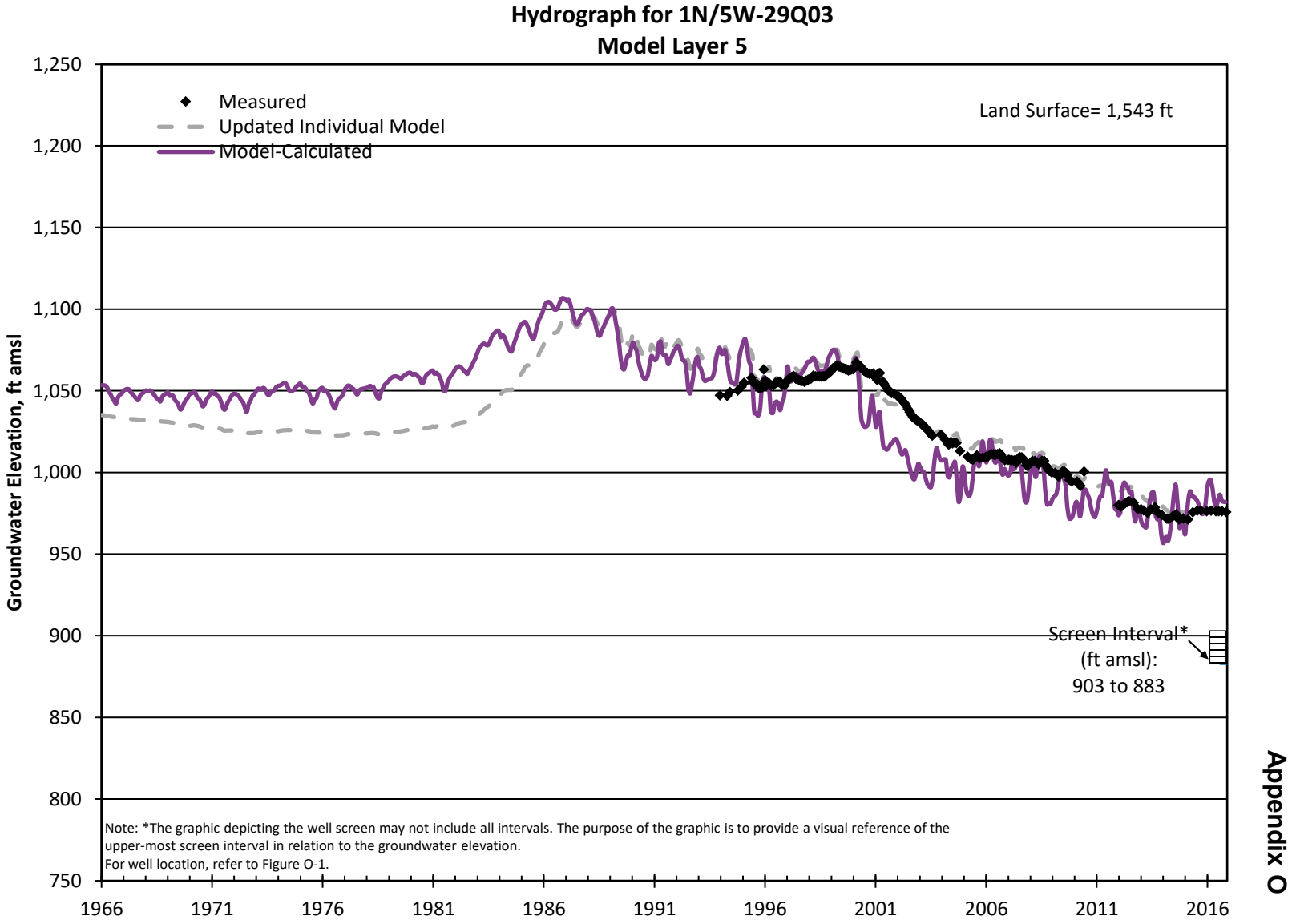
Appendix O


Hydrograph for 1N/5W-29Q01
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,540 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
565 to 545
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

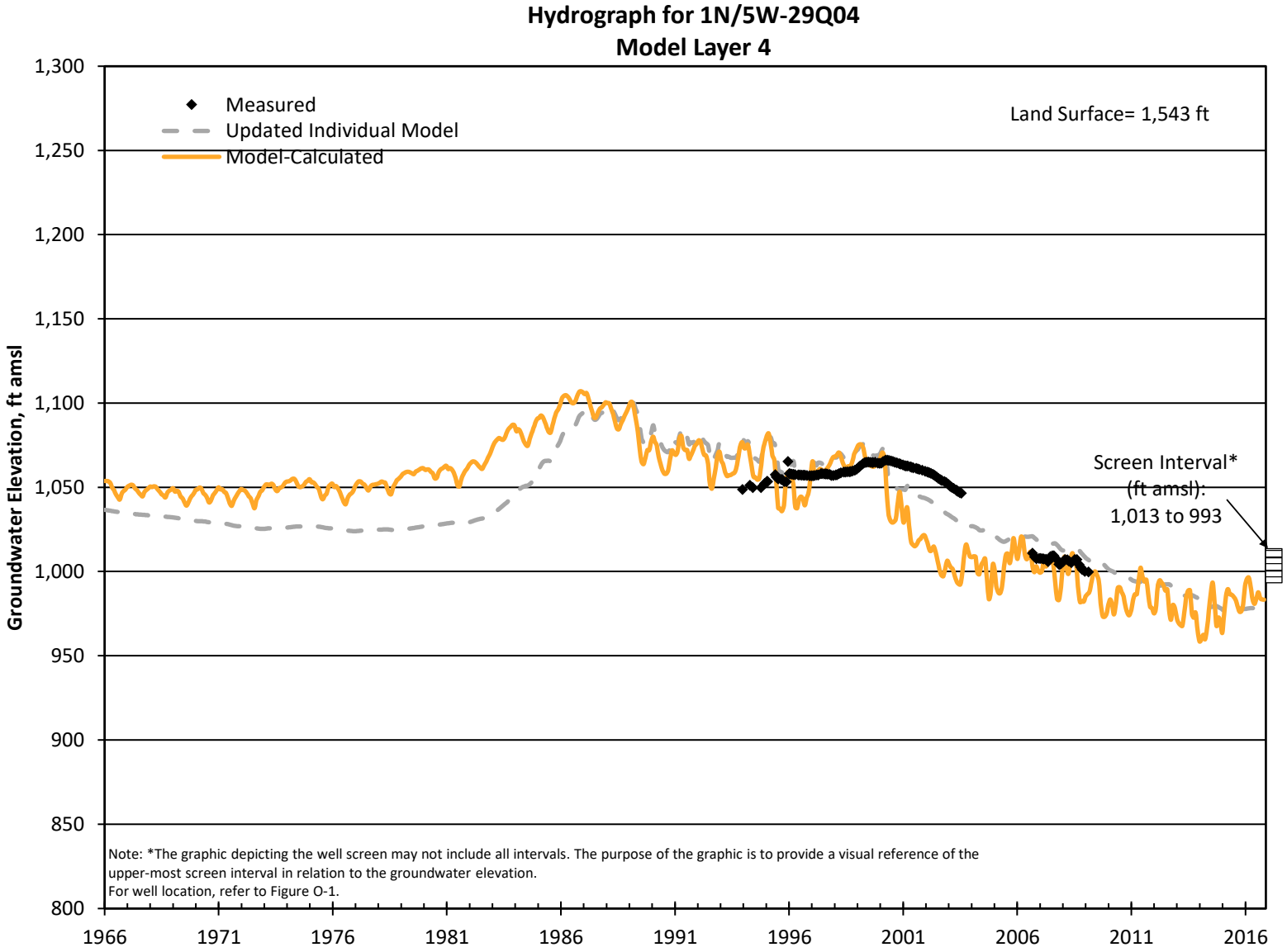
Appendix O


Hydrograph for 1N/5W-29Q02
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,543 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
788 to 768
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

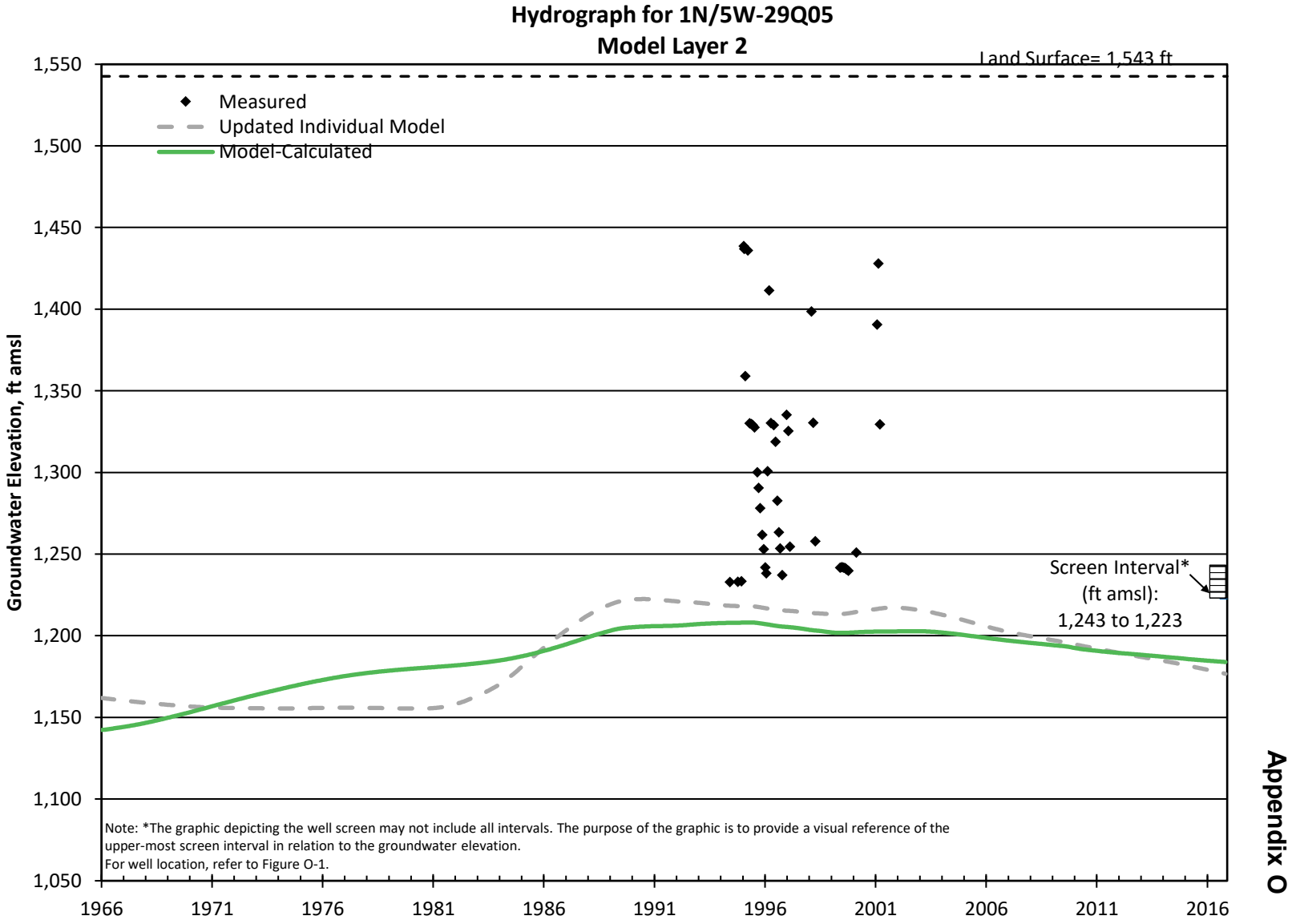
Appendix O


Hydrograph for 1N/5W-29Q03
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,543 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
903 to 883
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

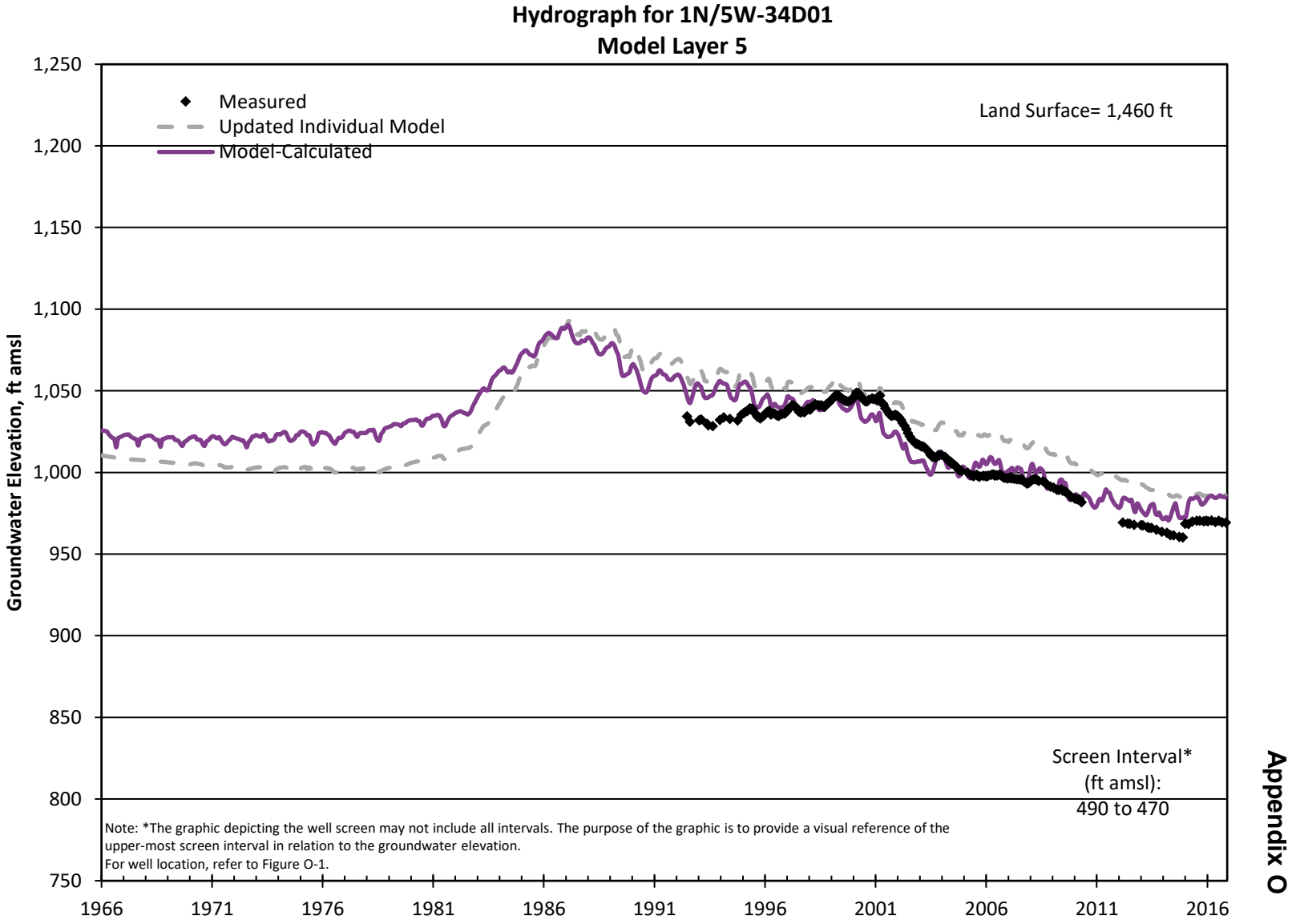
Appendix O


Hydrograph for 1N/5W-29Q04
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,543 ft
Screen Interval*
(ft amsl):
1,013 to 993
Groundwater Elevation, ft amsl
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

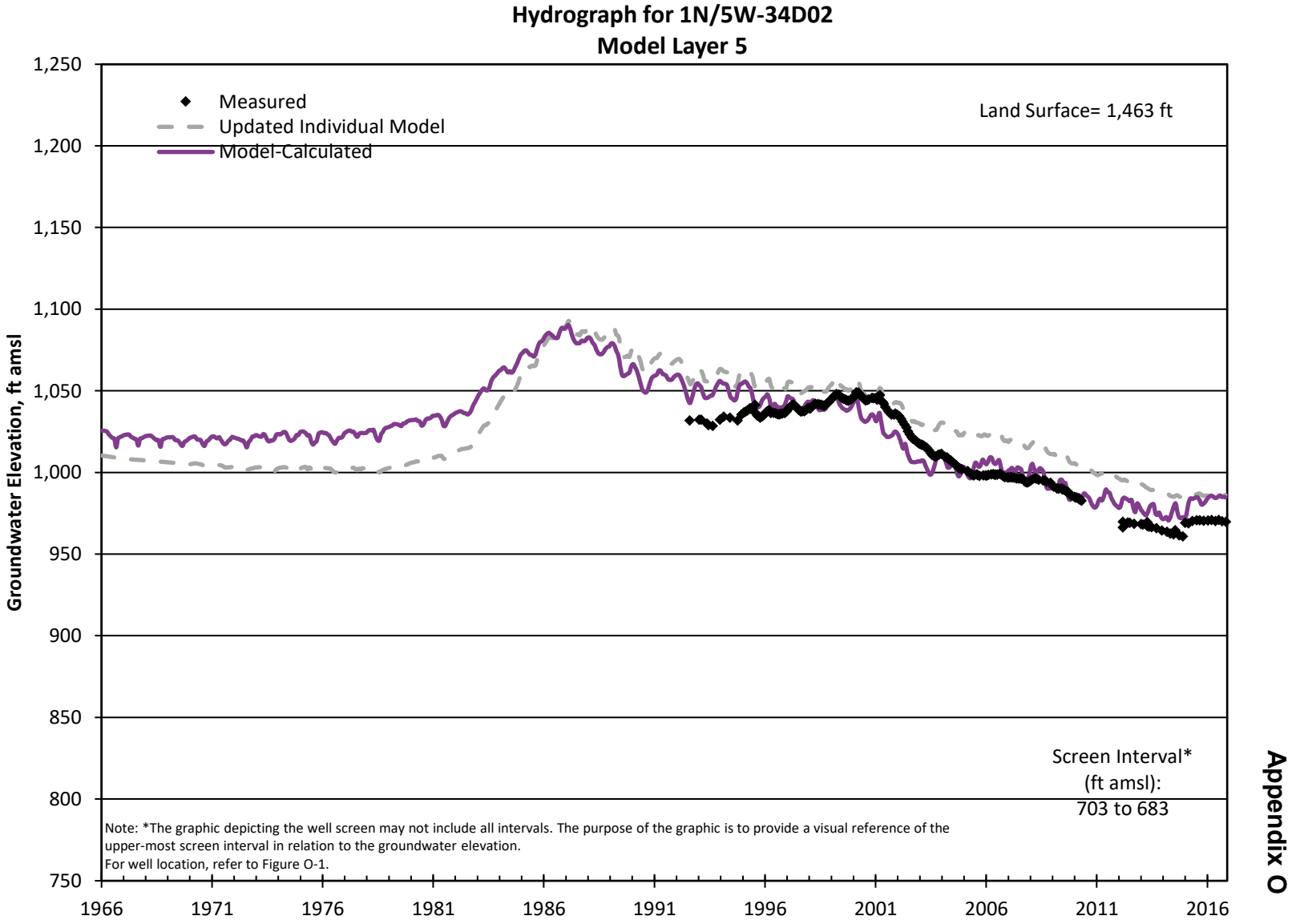
Appendix O


Hydrograph for 1N/5W-29Q05
Model Layer 2
Land Surface= 1,543 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,243 to 1,223
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

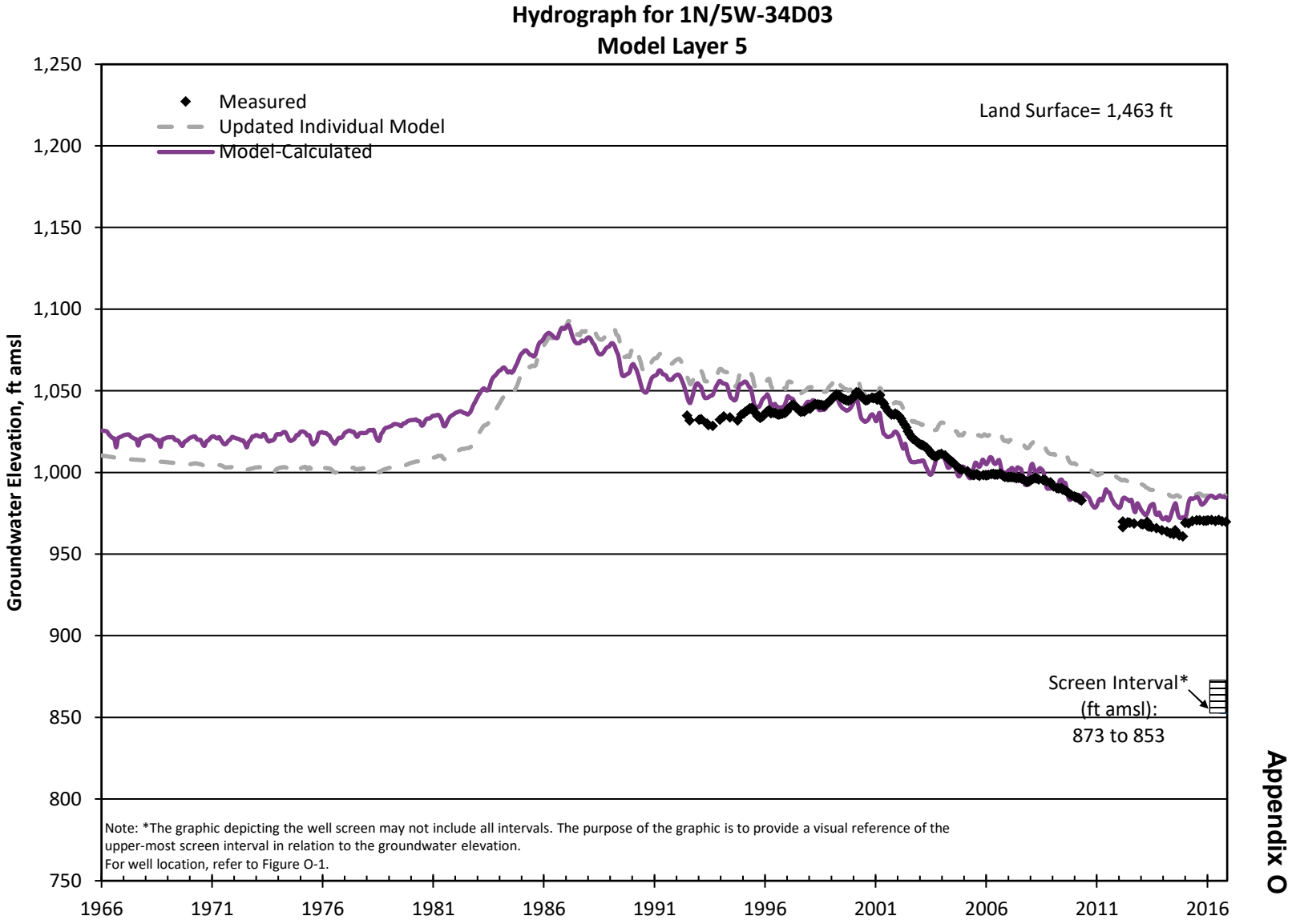
Appendix O


Hydrograph for 1N/5W-34D01
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,460 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
490 to 470
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

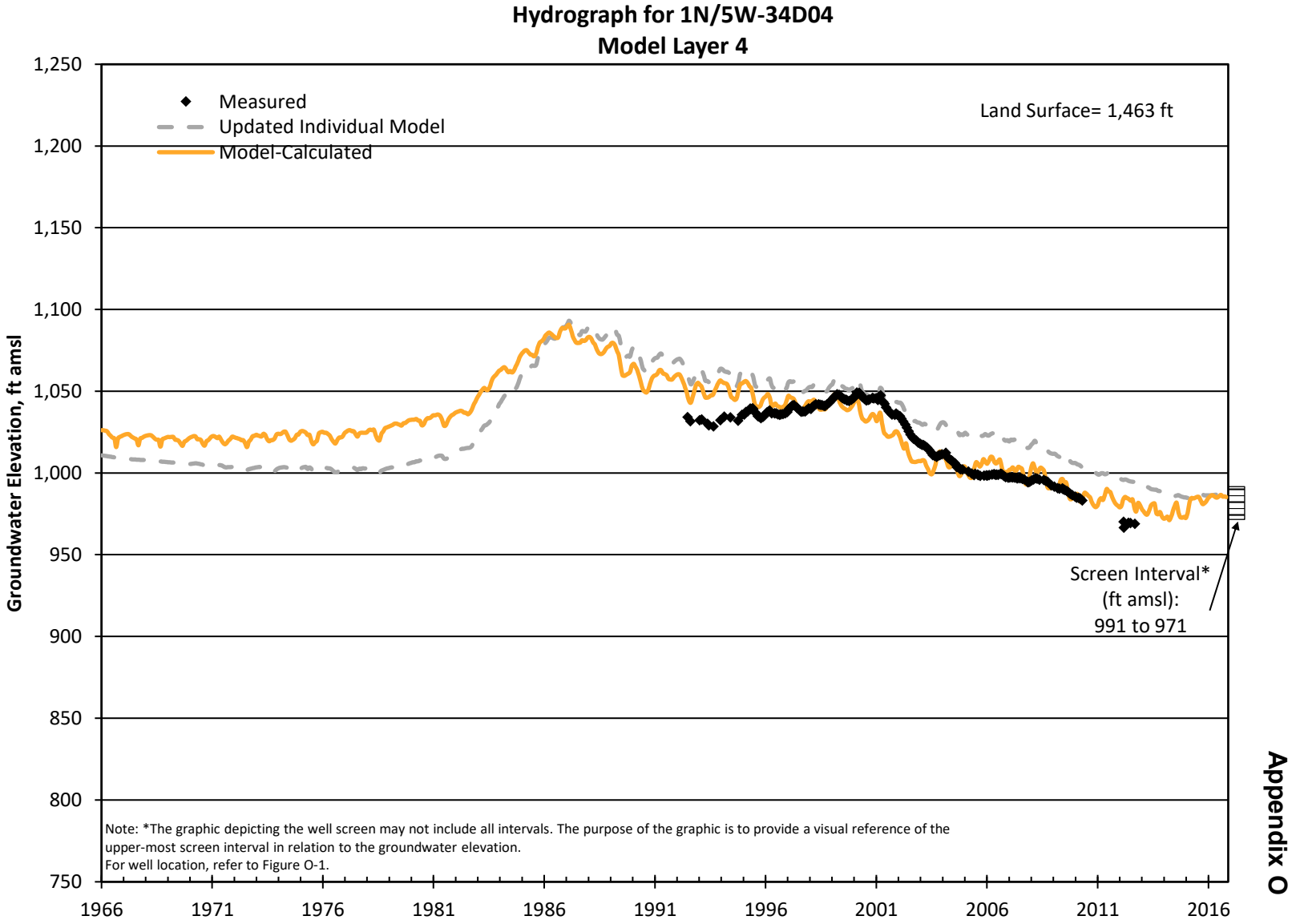
Appendix O


Hydrograph for 1N/5W-34D02
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,463 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
703 to 683
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

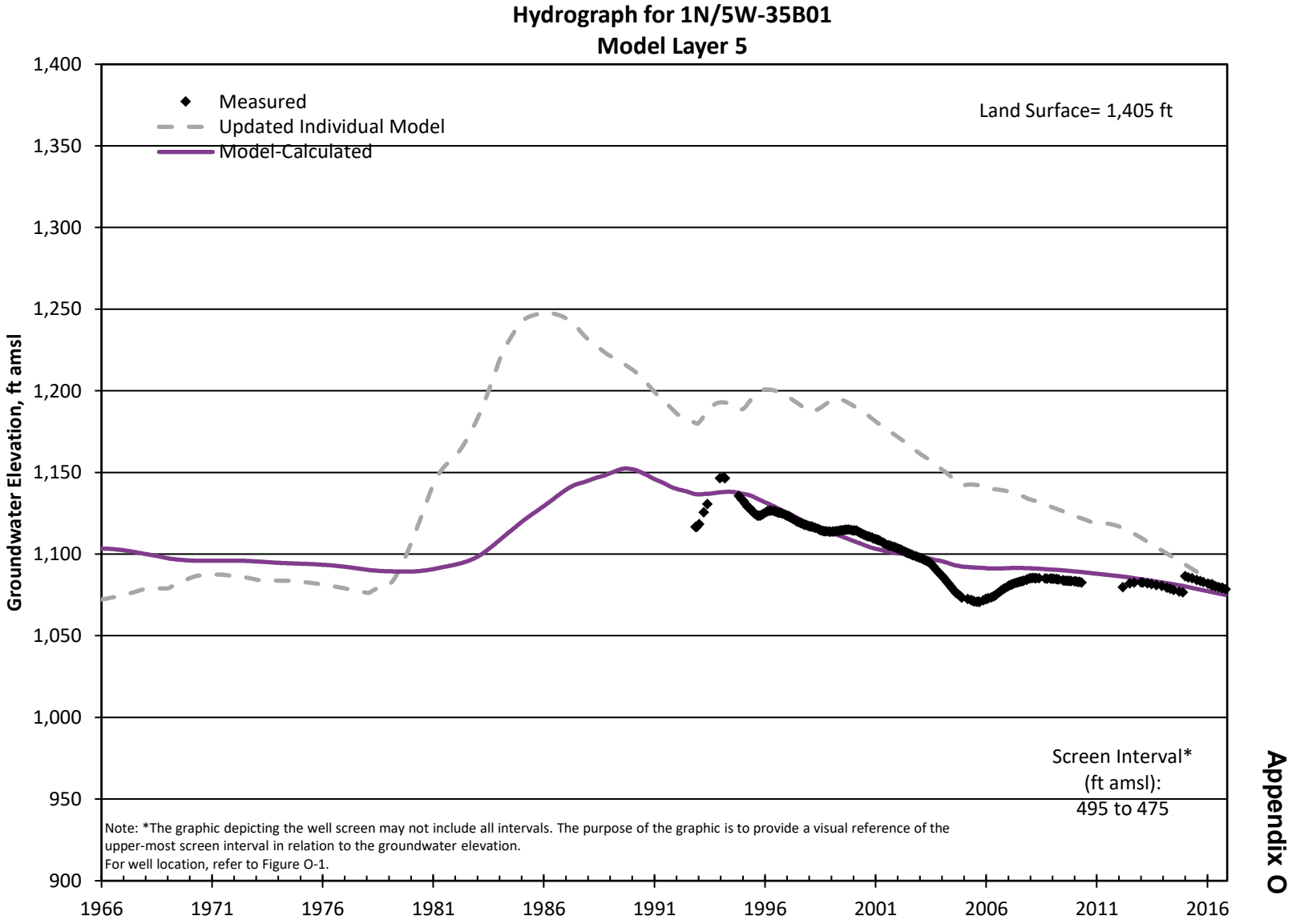
Appendix O


Hydrograph for 1N/5W-34D03
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,463 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
873 to 853
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

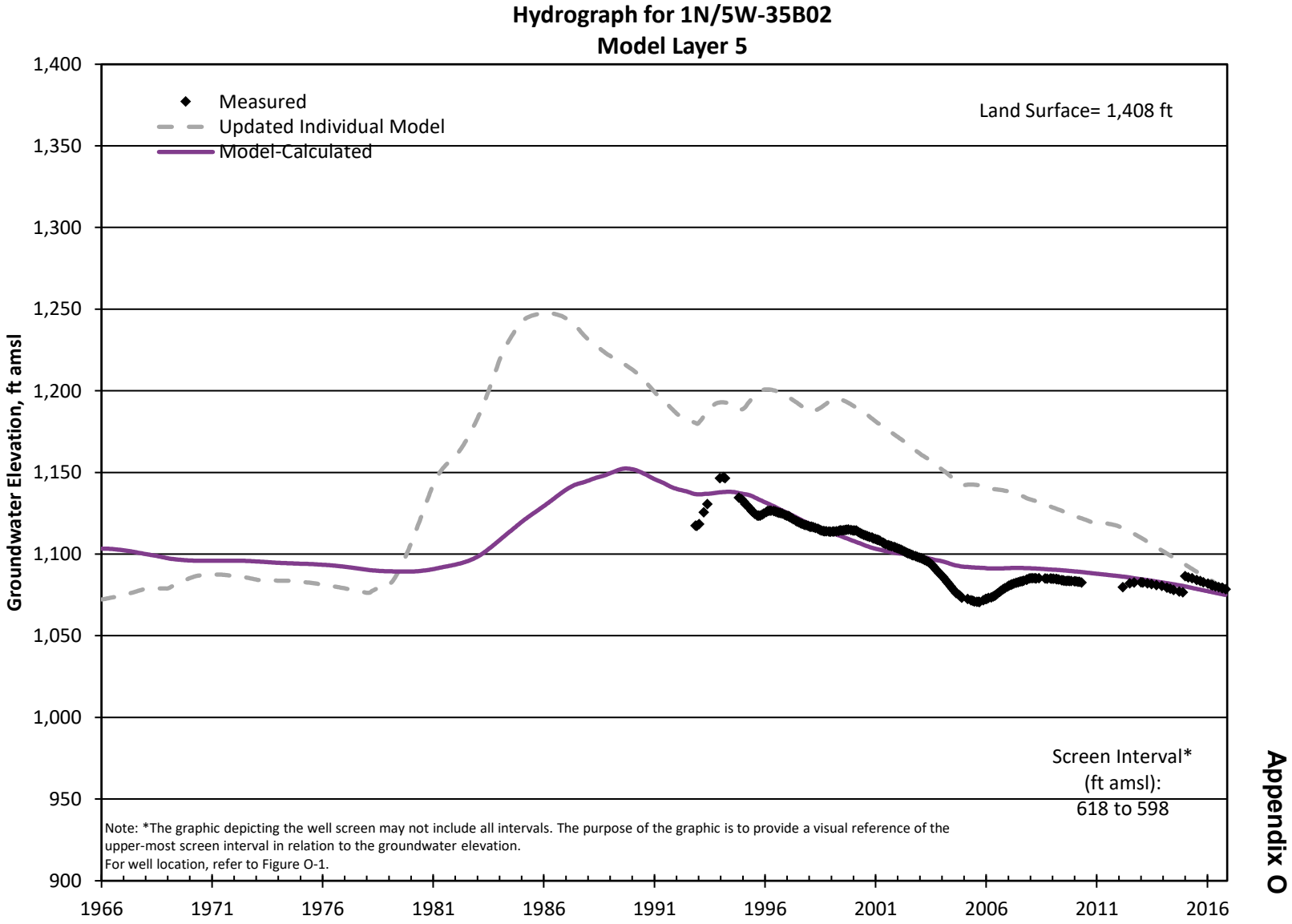
Appendix O


Hydrograph for 1N/5W-34D04
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,463 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
991 to 971
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

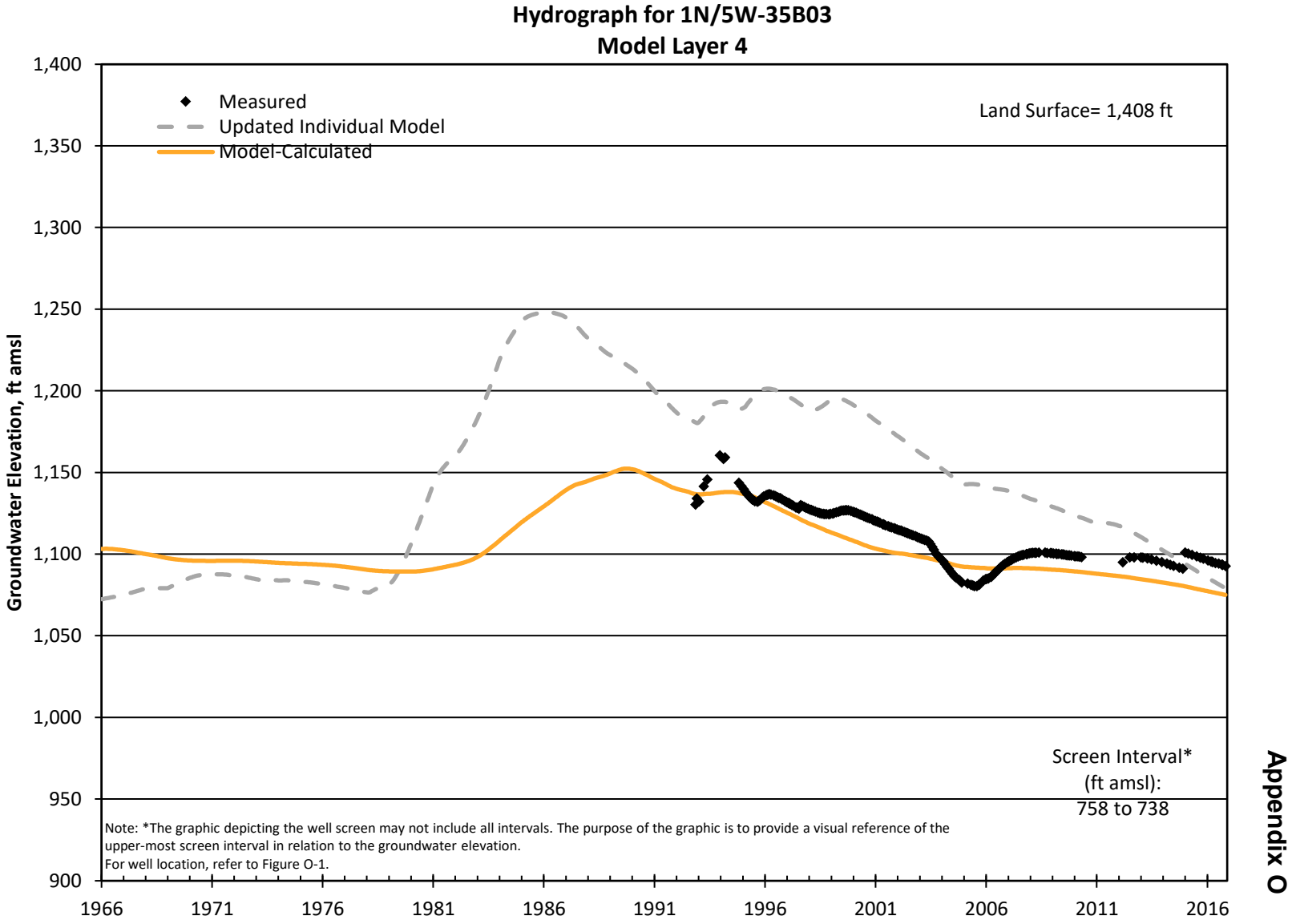
Appendix O


Hydrograph for 1N/5W-35B01
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,405 ft
Groundwater Elevation, ft amsl
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
495 to 475
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

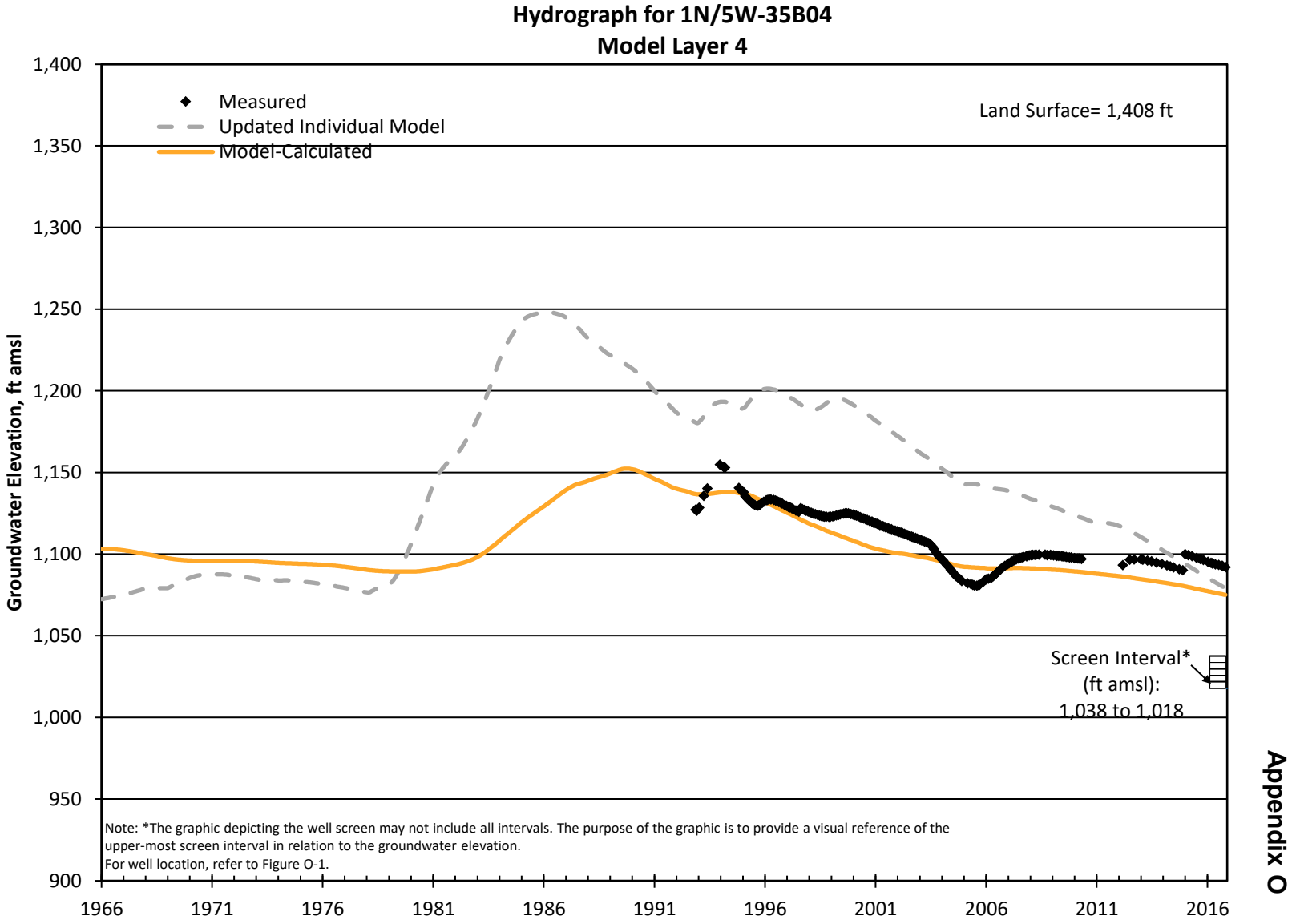
Appendix O


Hydrograph for 1N/5W-35B02
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,408 ft
Groundwater Elevation, ft amsl
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
618 to 598
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

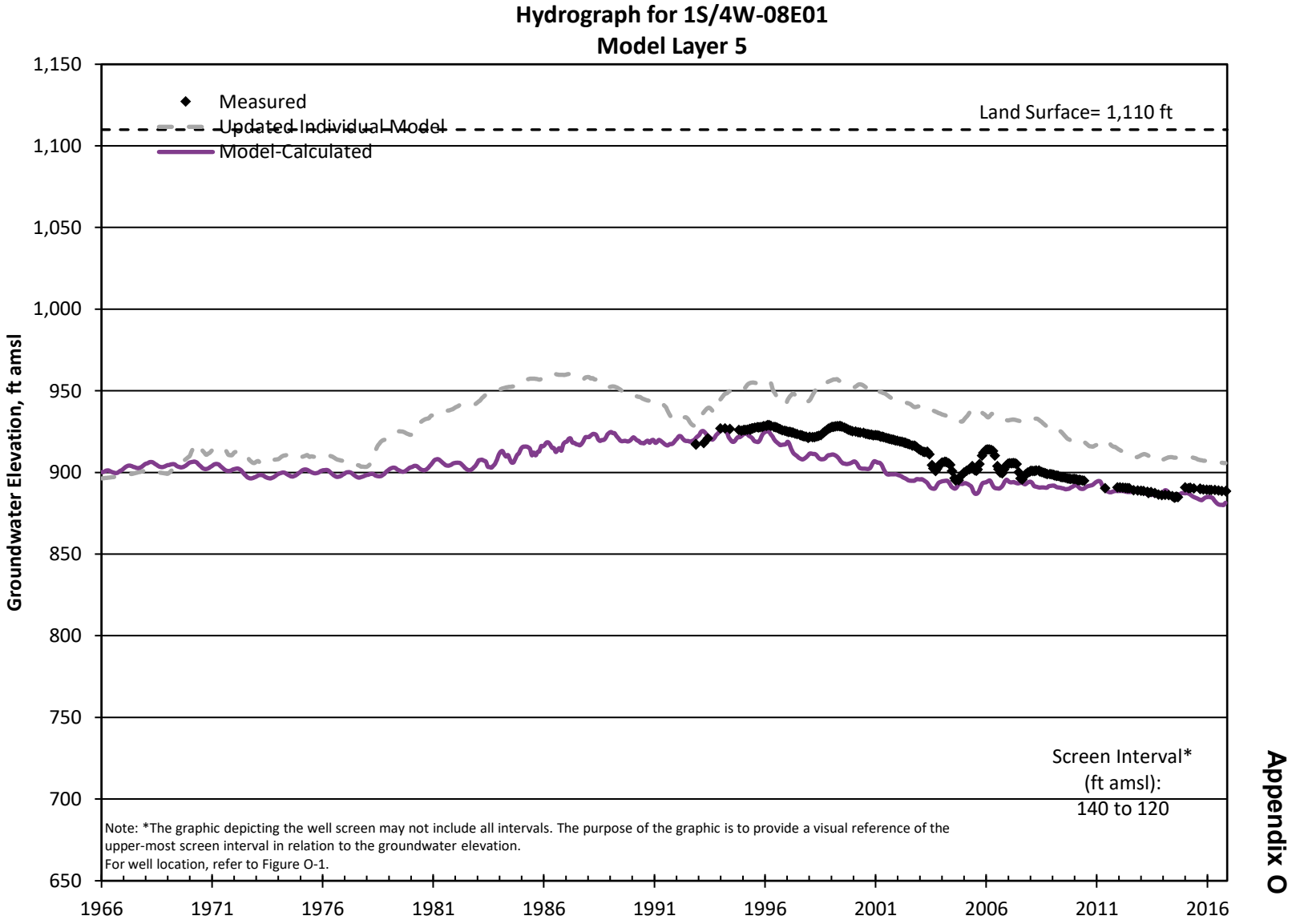
Appendix O


Hydrograph for 1N/5W-35B03
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,408 ft
Groundwater Elevation, ft amsl
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
758 to 738
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

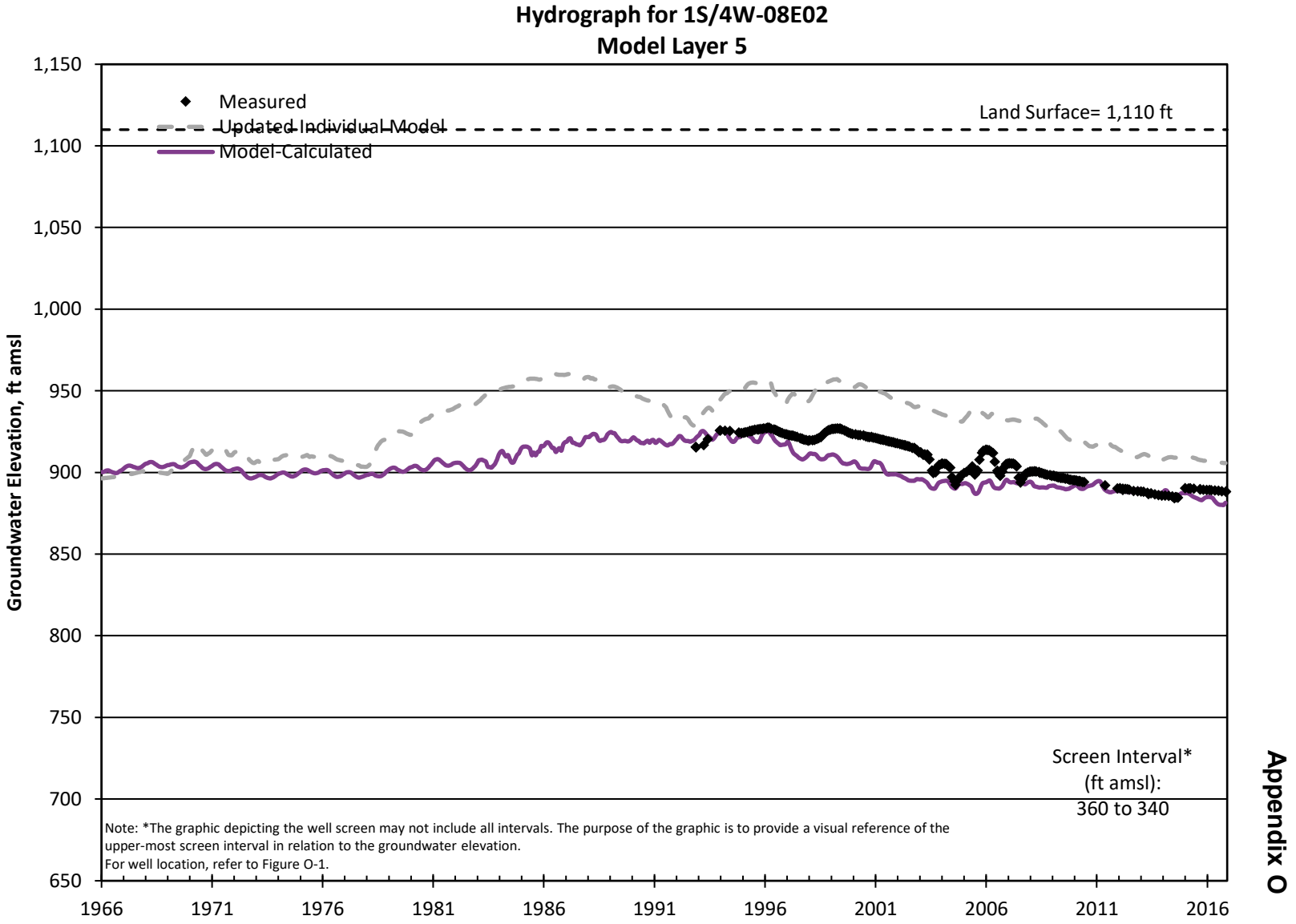
Appendix O


Hydrograph for 1N/5W-35B04
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,408 ft
Groundwater Elevation, ft amsl
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
1,038 to 1,018
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

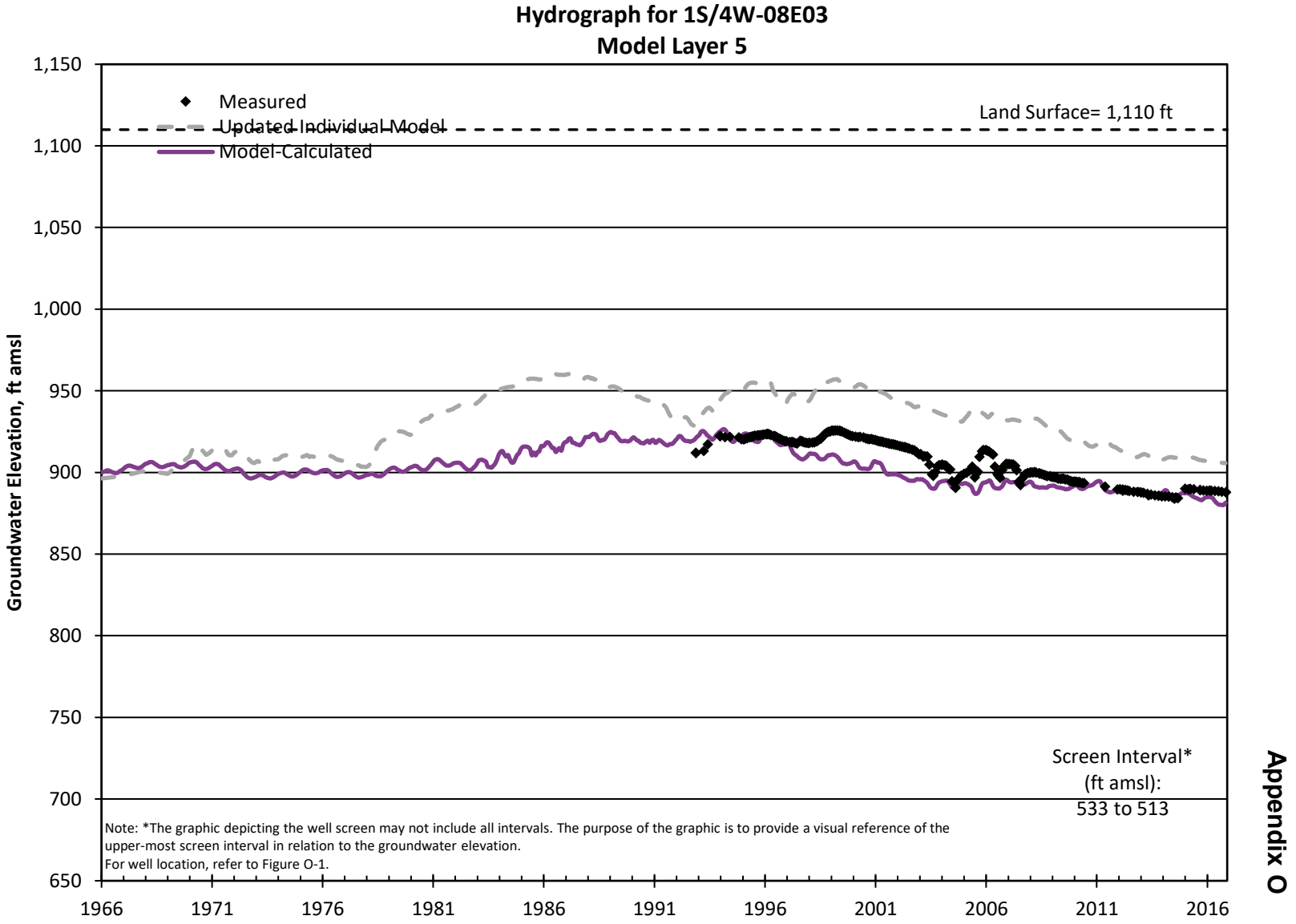
Appendix O


Hydrograph for 1S/4W-08E01
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,110 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
140 to 120
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

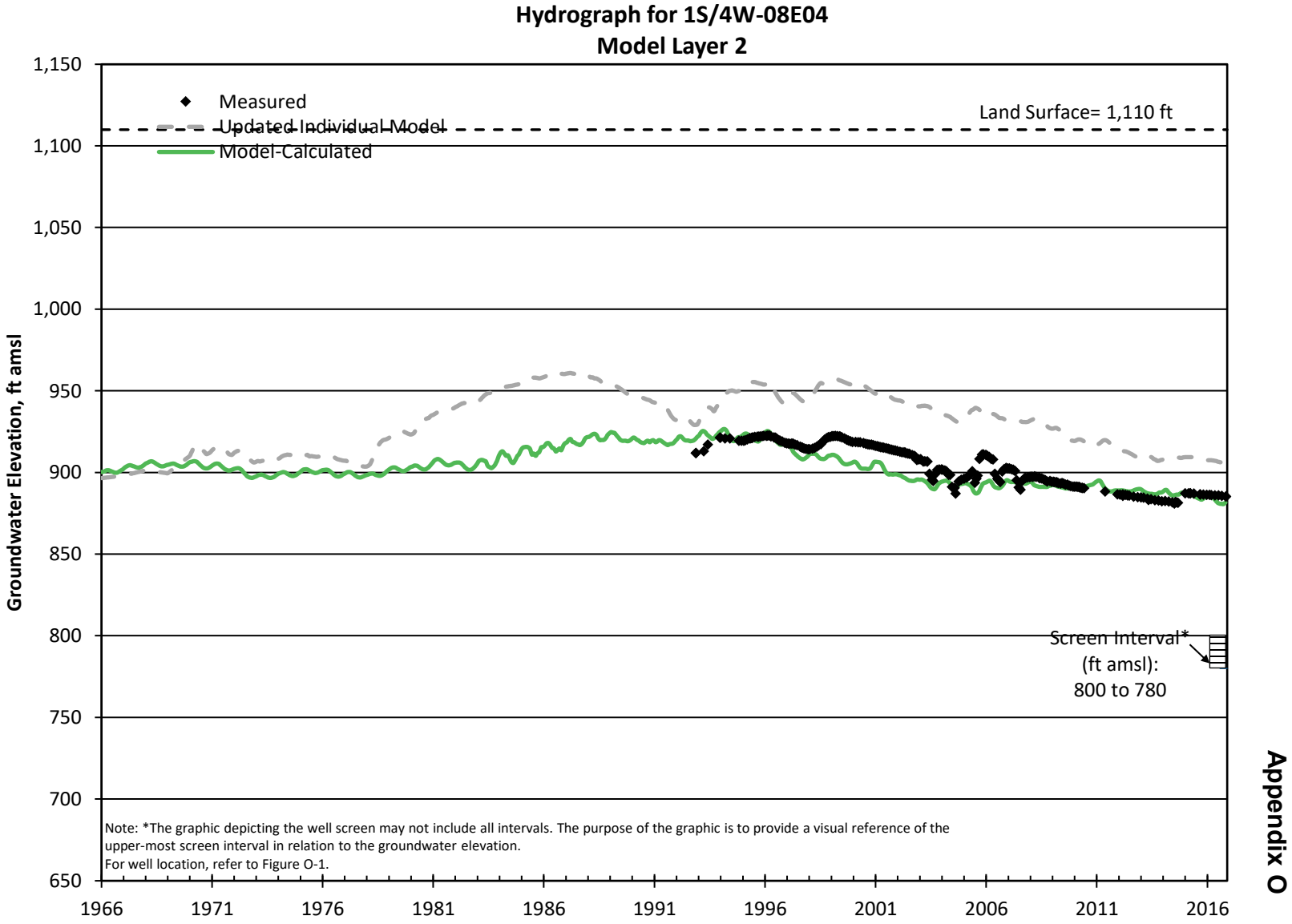
Appendix O


Hydrograph for 1S/4W-08E02
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,110 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
360 to 340
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

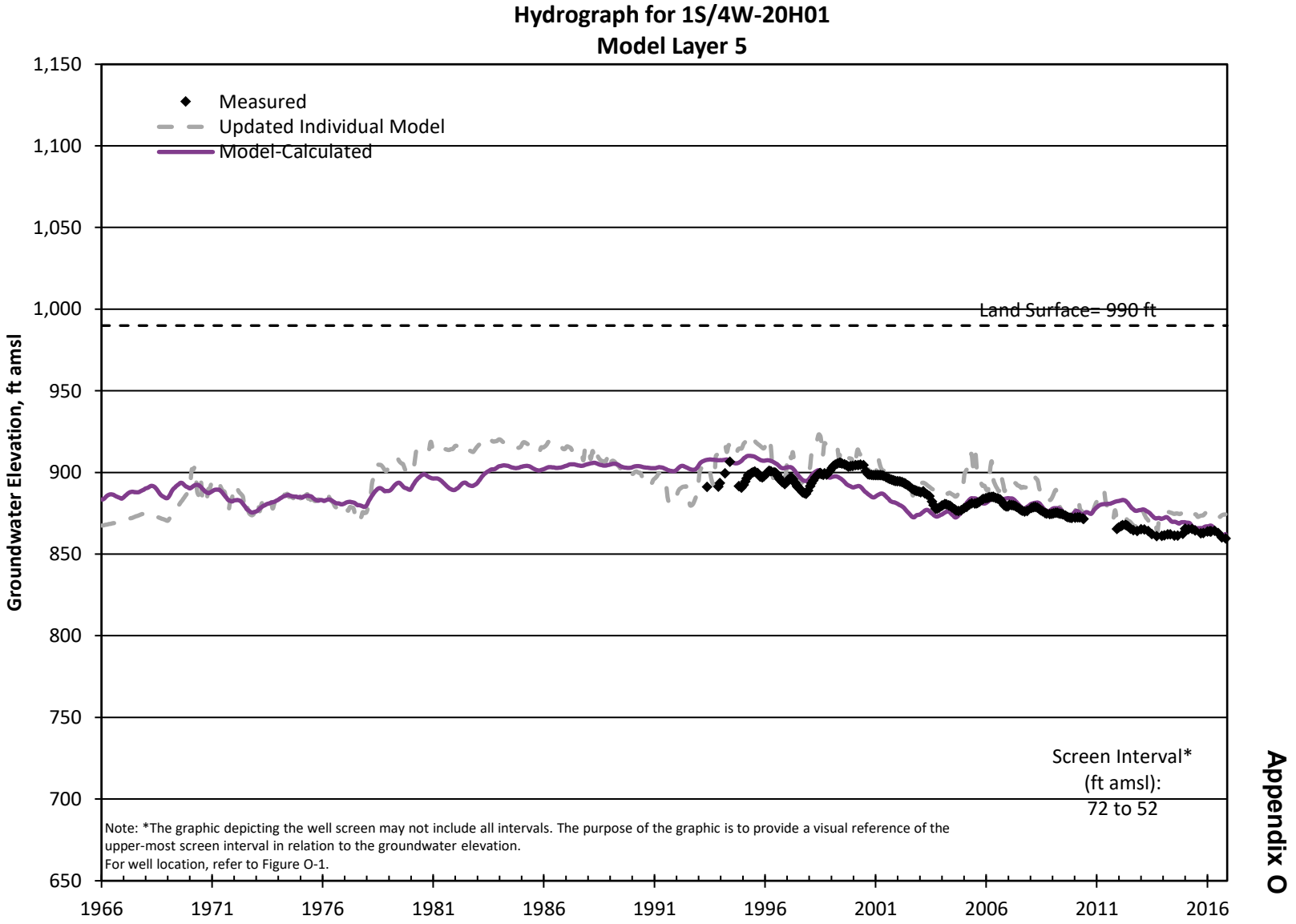
Appendix O


Hydrograph for 1S/4W-08E03
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,110 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
533 to 513
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

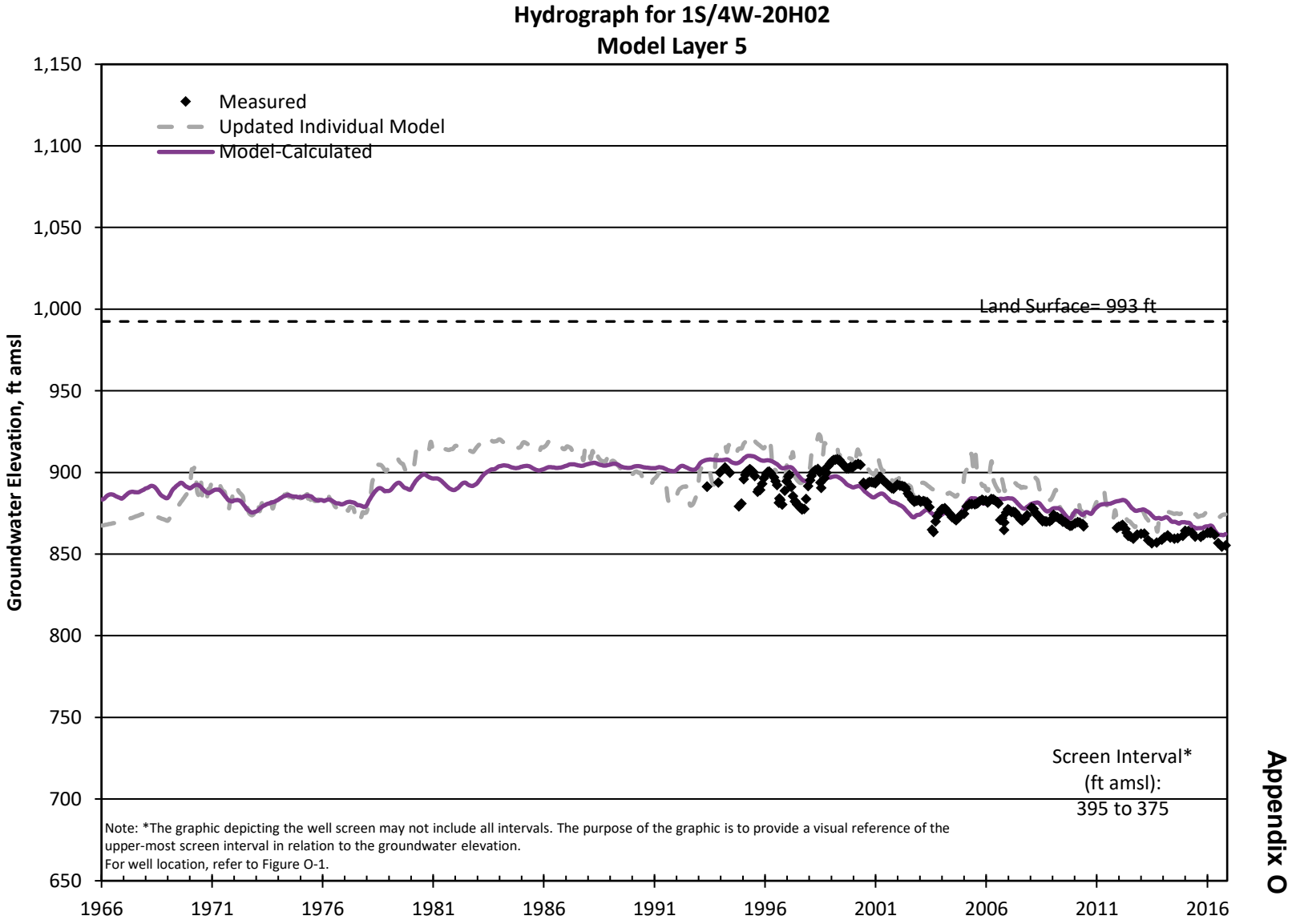
Appendix O


Hydrograph for 1S/4W-08E04
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,110 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
800 to 780
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

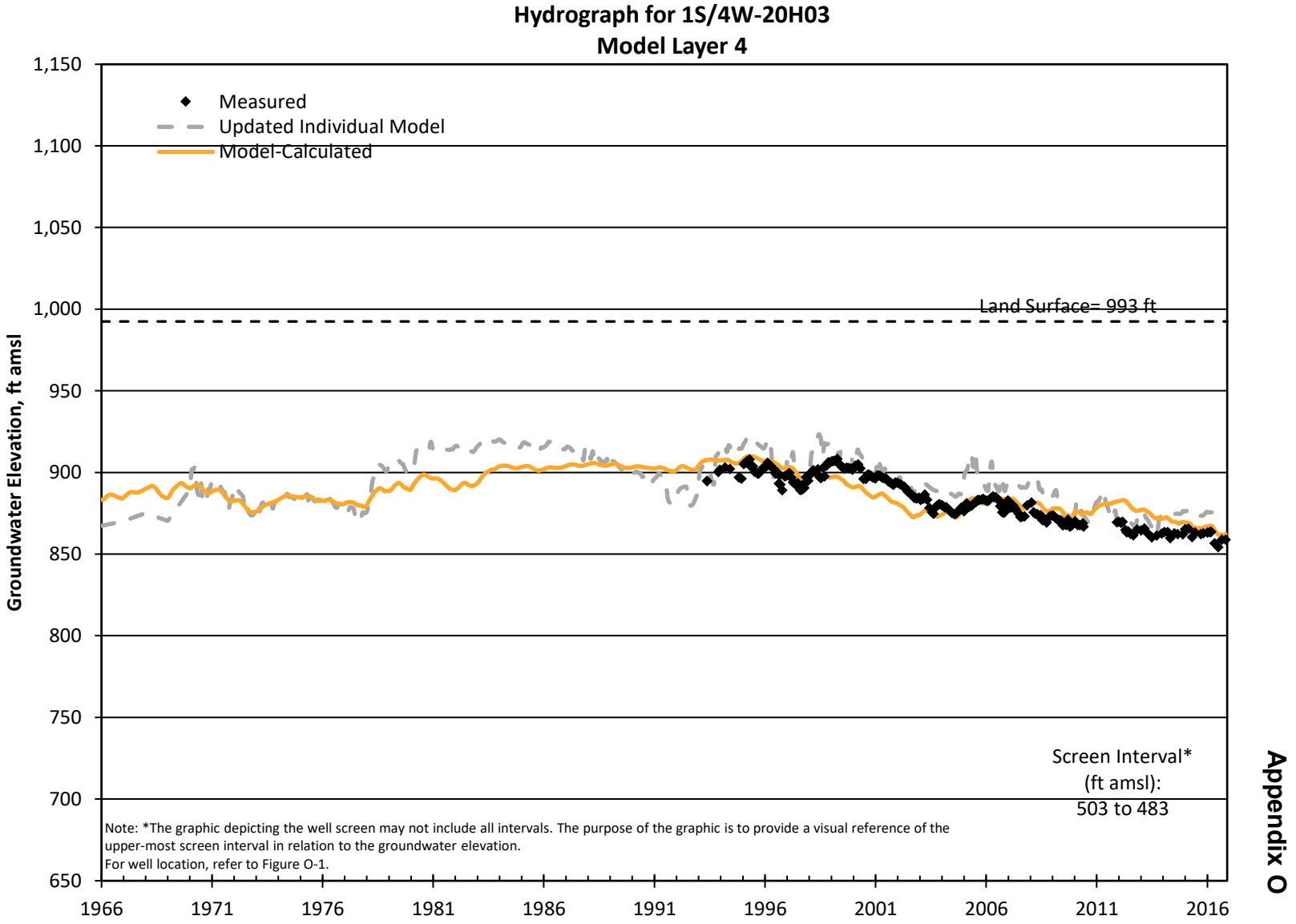
Appendix O


Hydrograph for 1S/4W-20H01
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 990 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
72 to 52
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

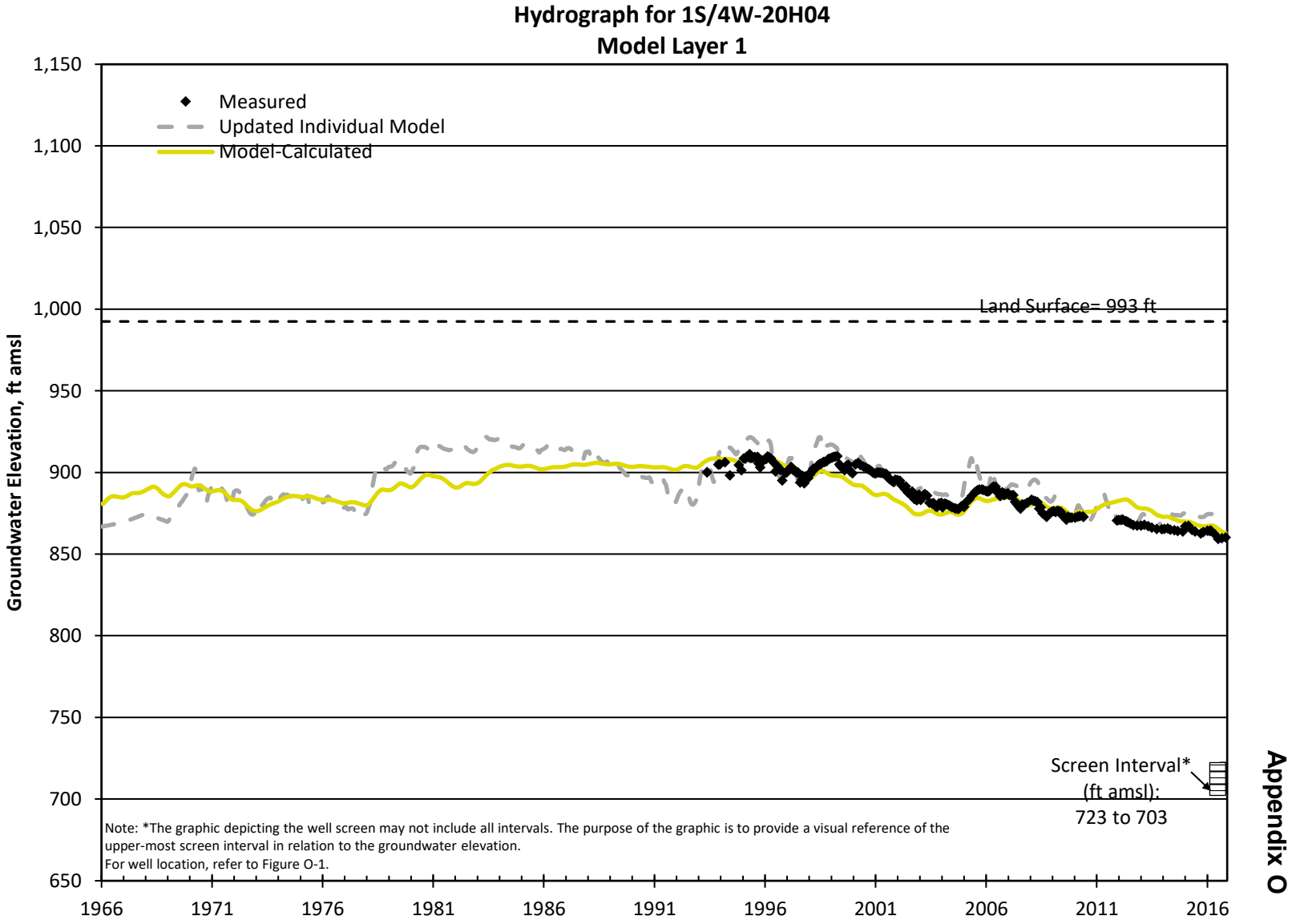
Appendix O


Hydrograph for 1S/4W-20H02
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 993 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
395 to 375
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

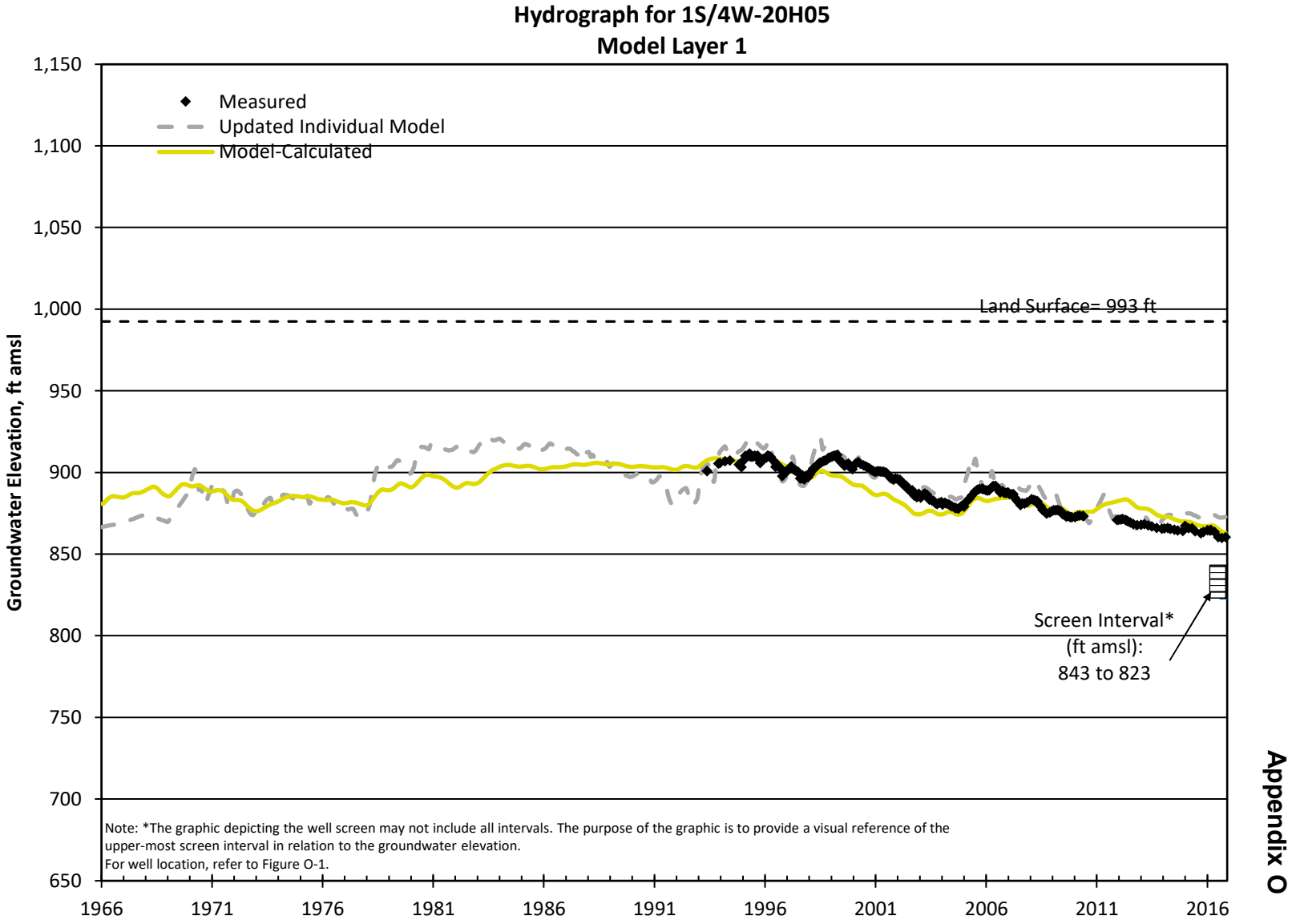
Appendix O


Hydrograph for 1S/4W-20H03
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 993 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

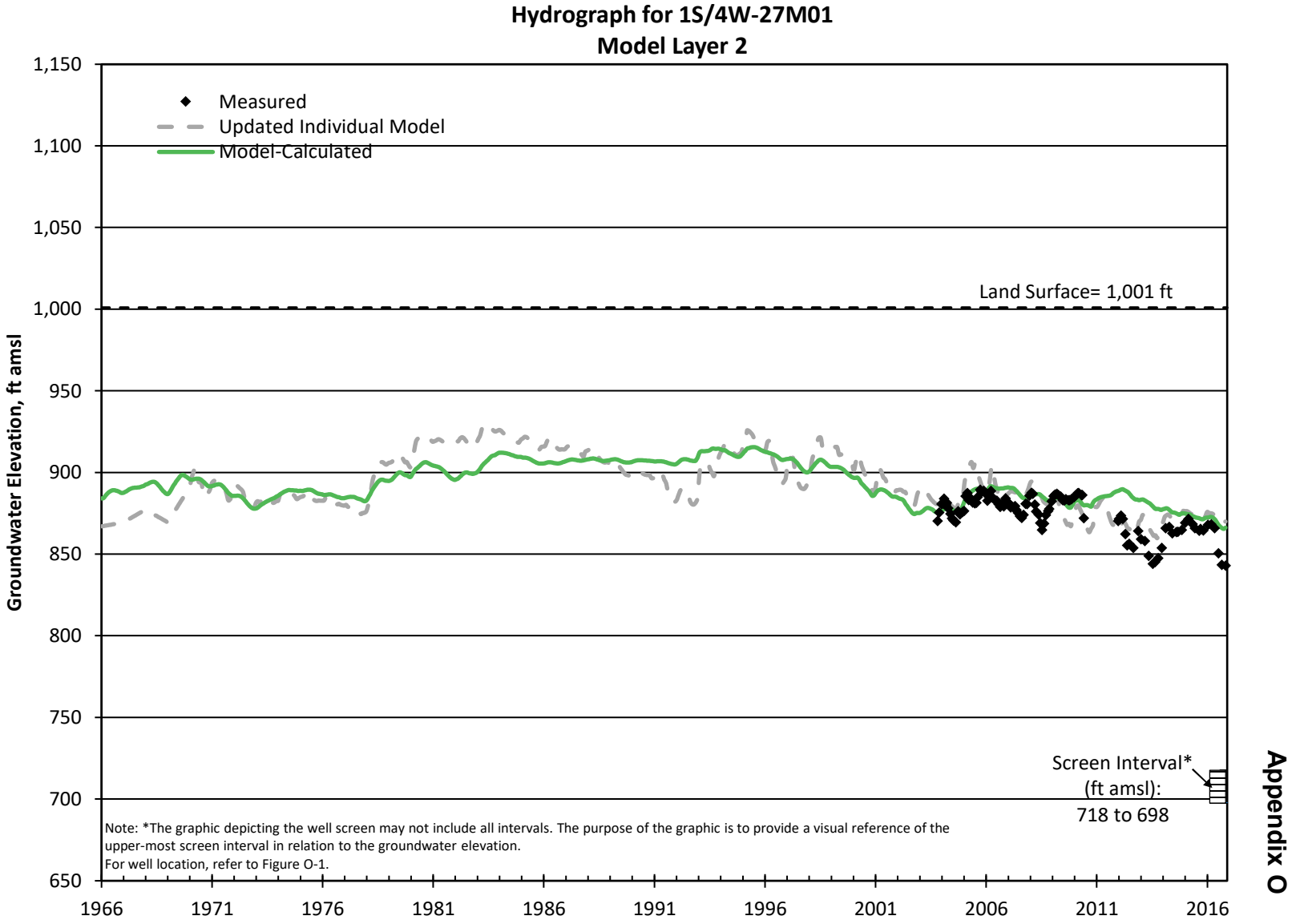
Appendix O


Hydrograph for 1S/4W-20H04
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 993 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
723 to 703
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

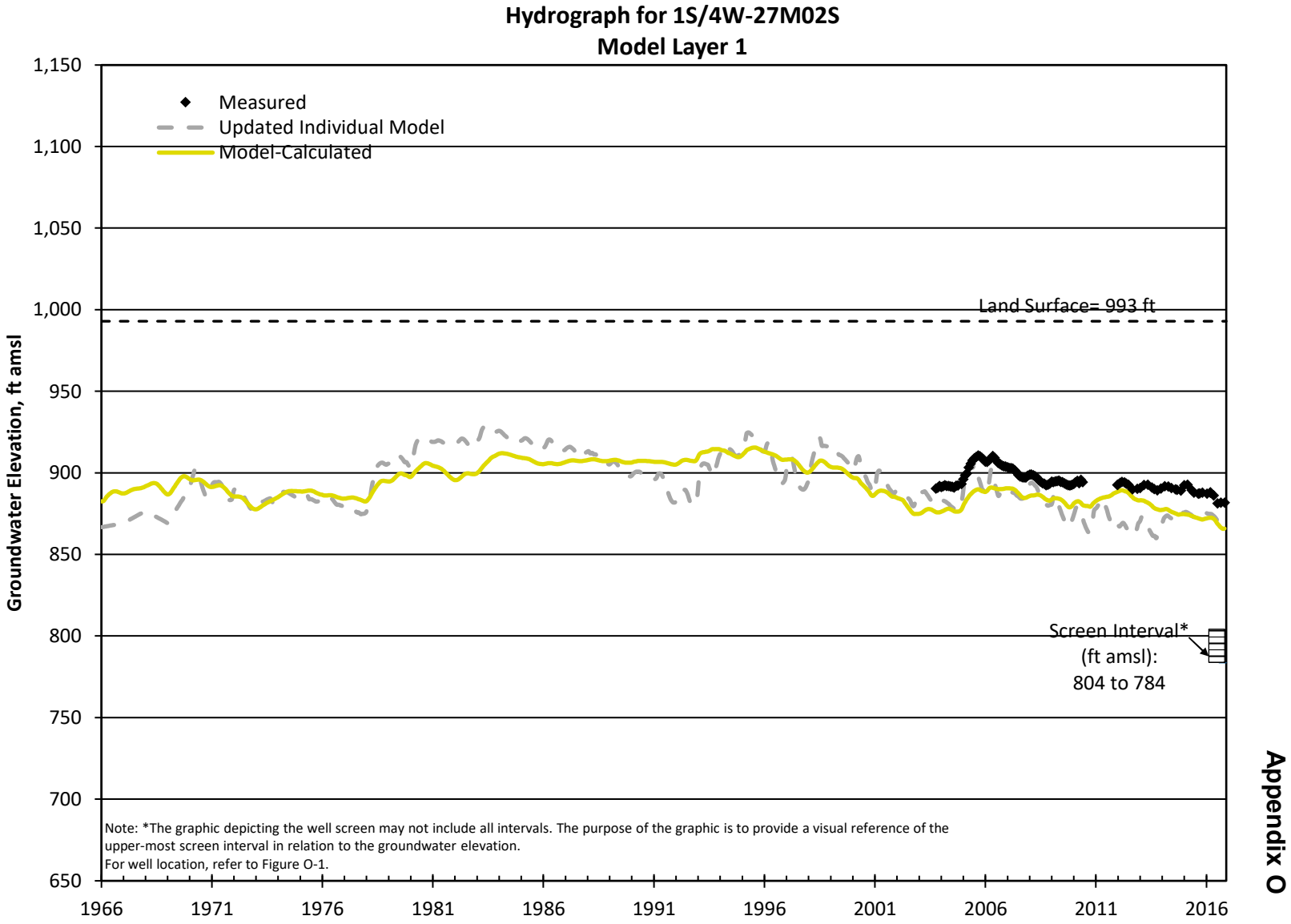
Appendix O


Hydrograph for 1S/4W-20H05
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 993 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
843 to 823
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

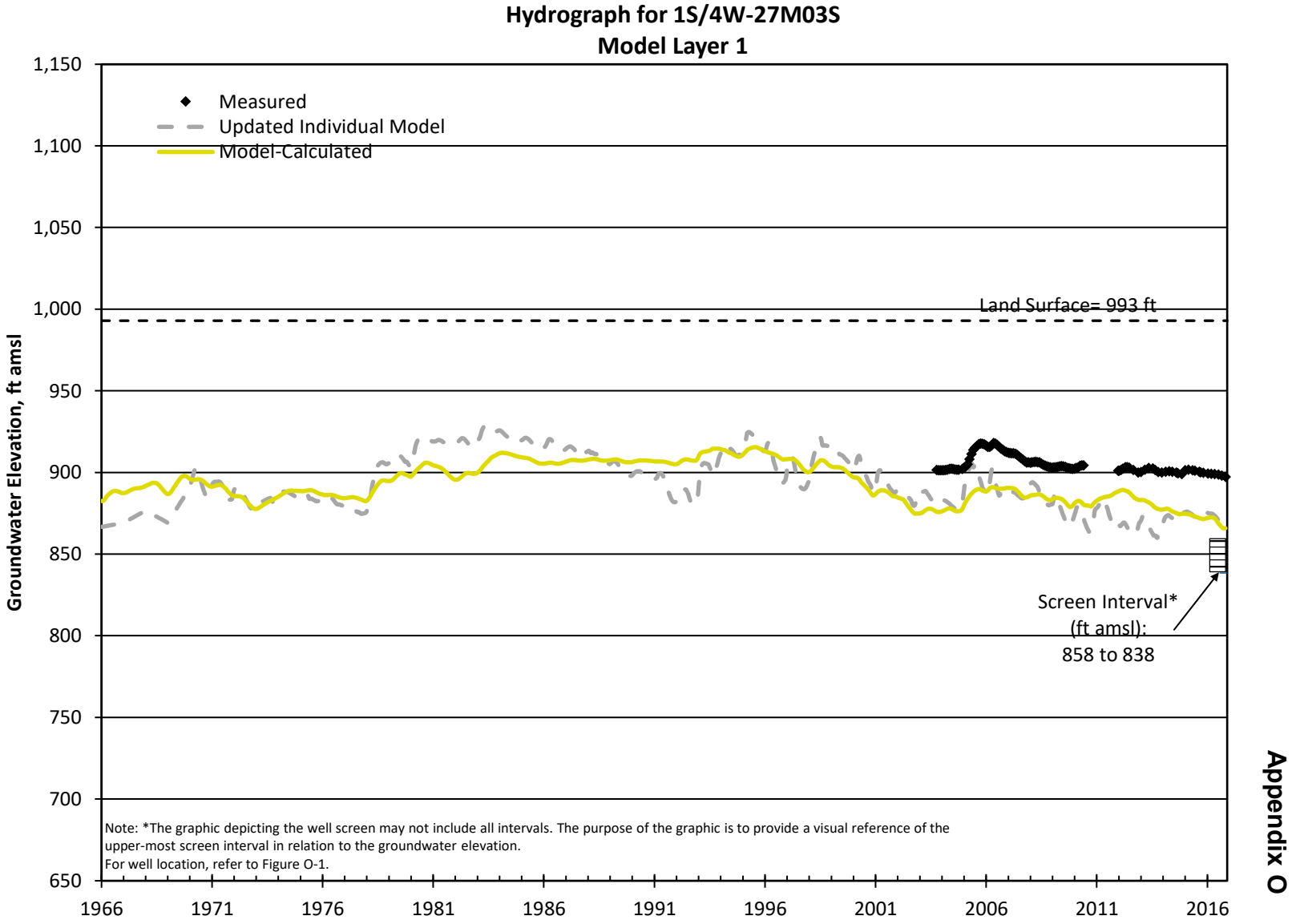
Appendix O


Hydrograph for 1S/4W-27M01
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,001 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
718 to 698
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

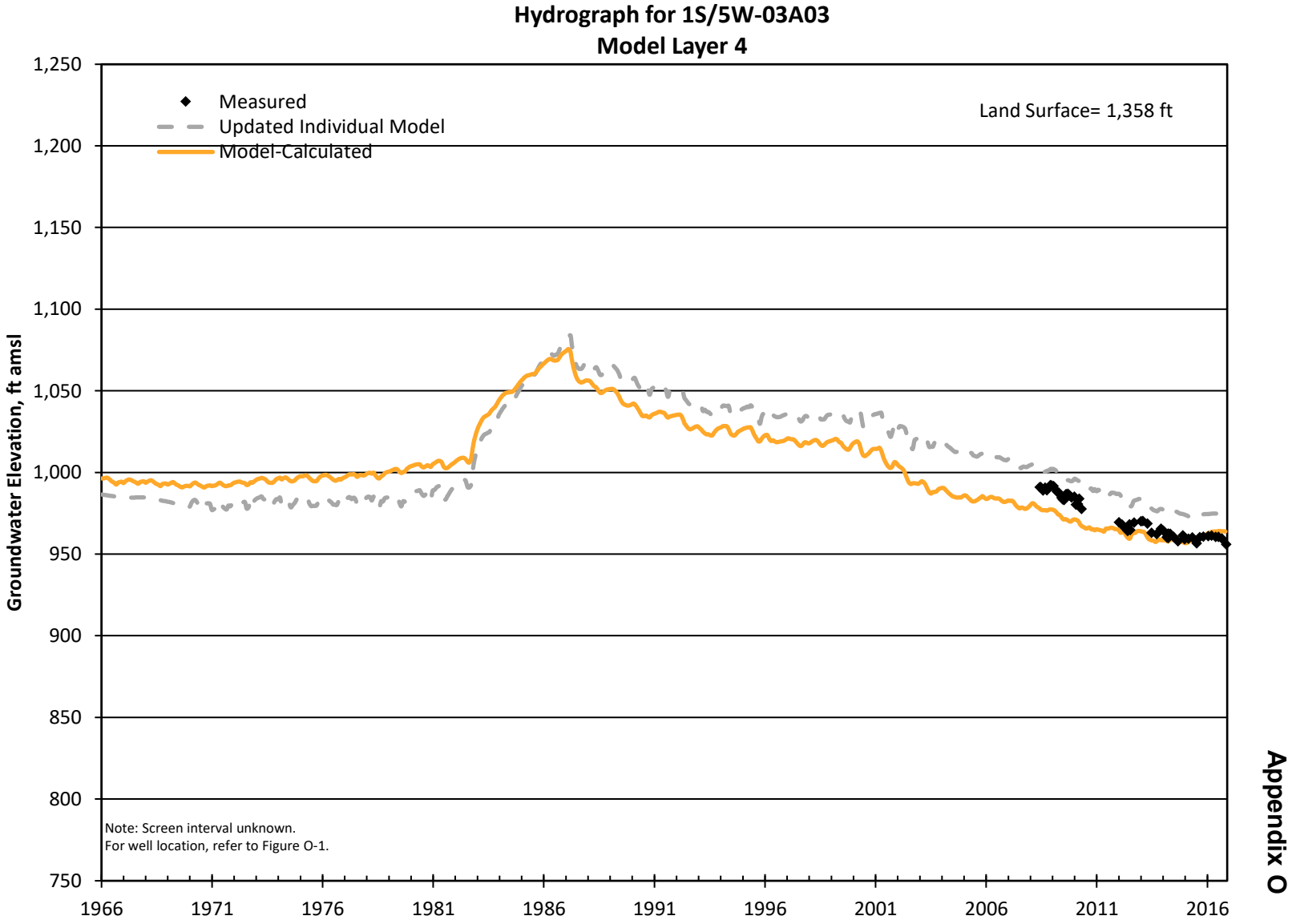
Appendix O


Hydrograph for 1S/4W-27M02S
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 993 ft
Screen Interval*
(ft amsl):
804 to 784
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

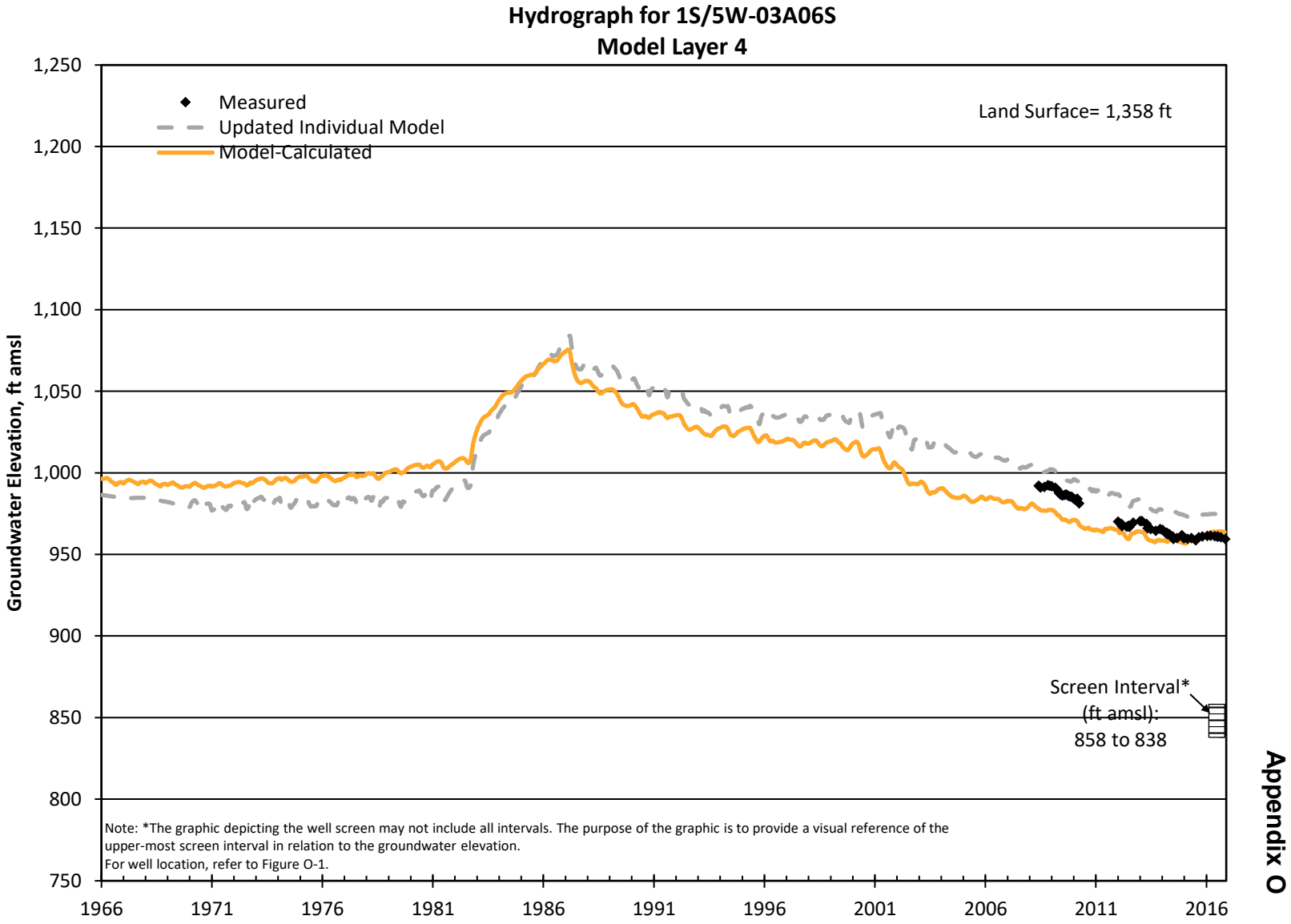
Appendix O


Hydrograph for 1S/4W-27M03S
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 993 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
858 to 838
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

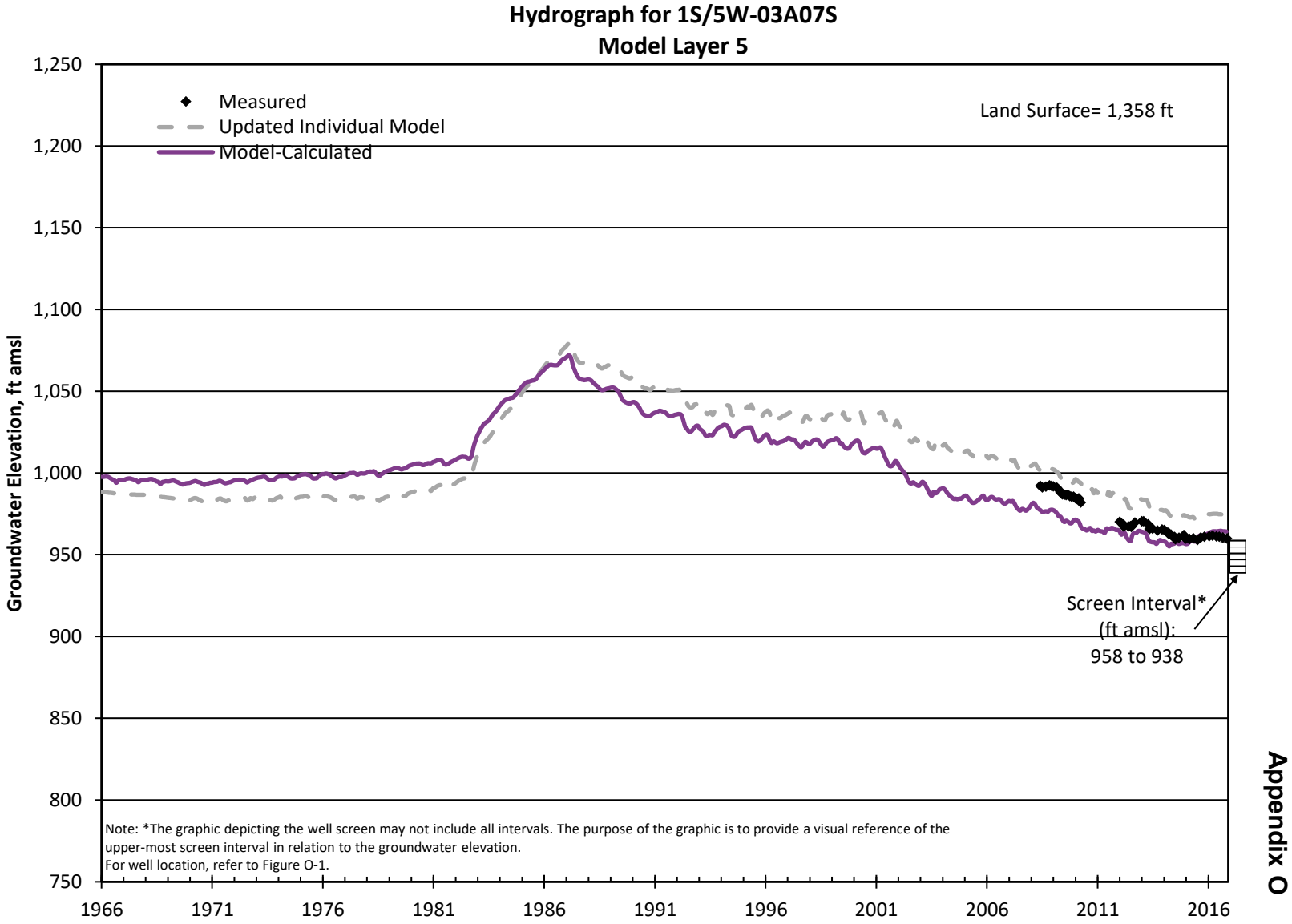
Appendix O


Hydrograph for 1S/5W-03A03
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,358 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure O-1.

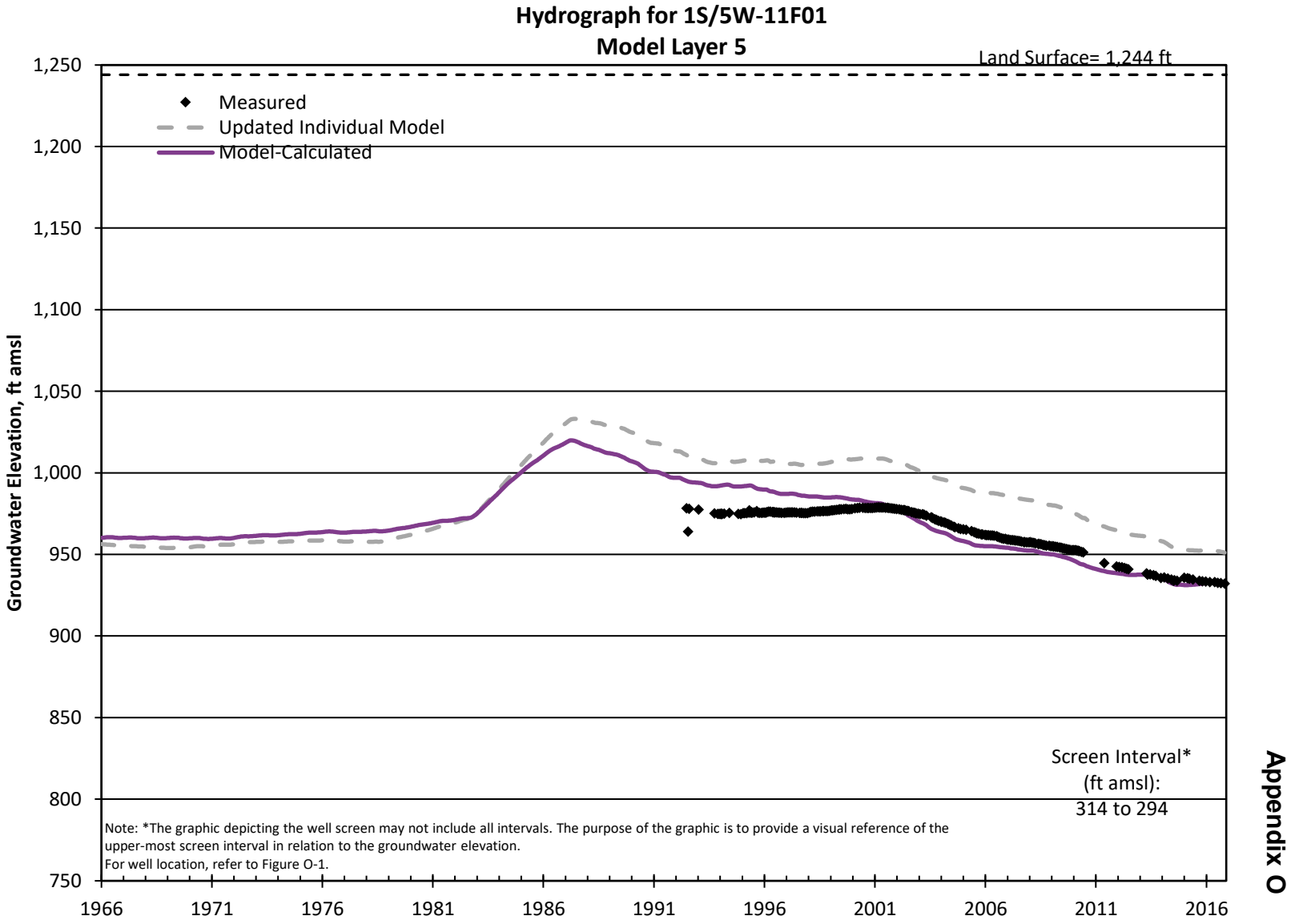
Appendix O


Hydrograph for 1S/5W-03A06S
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,358 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
858 to 838
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

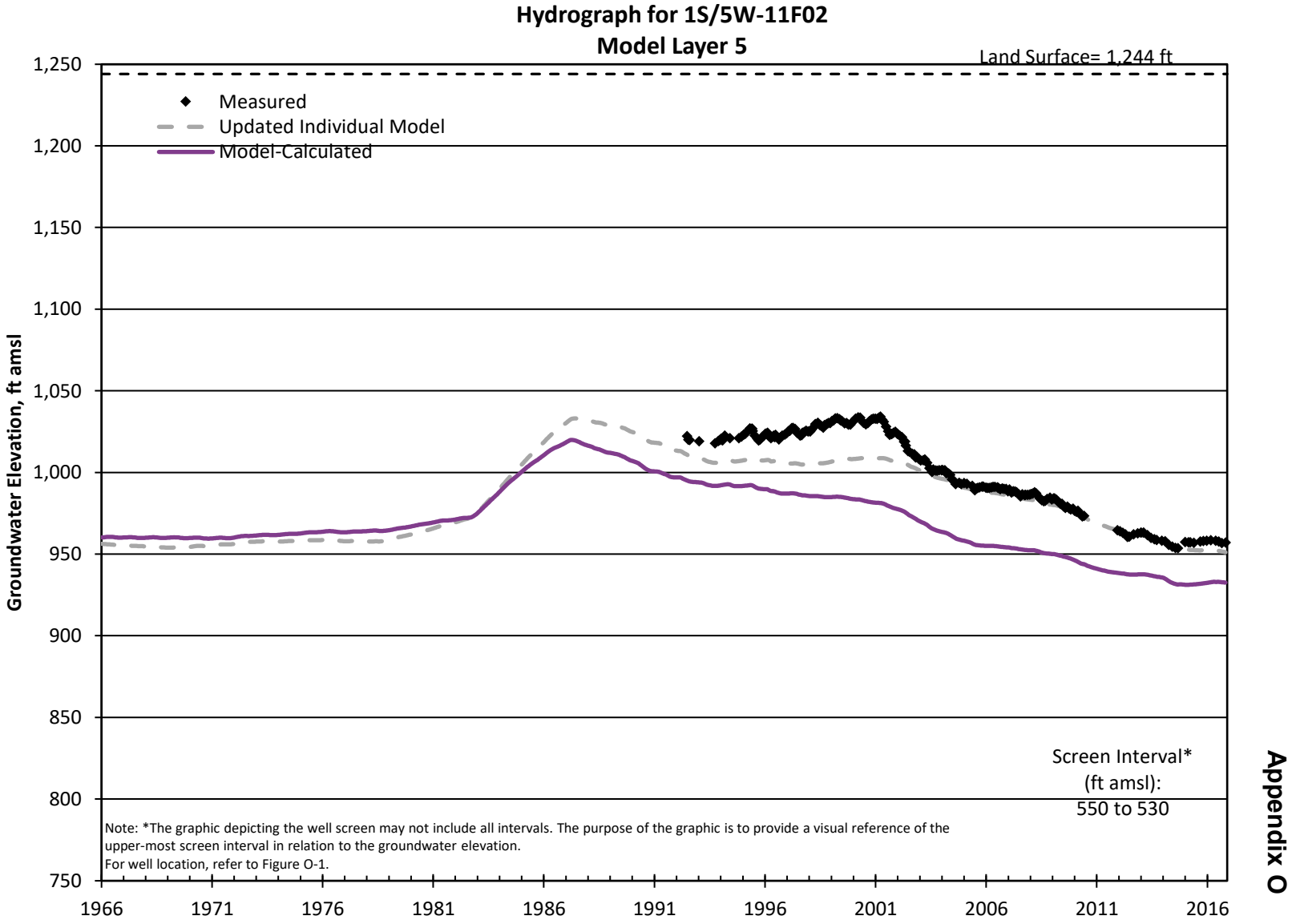
Appendix O


Hydrograph for 1S/5W-03A07S
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,358 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
958 to 938
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

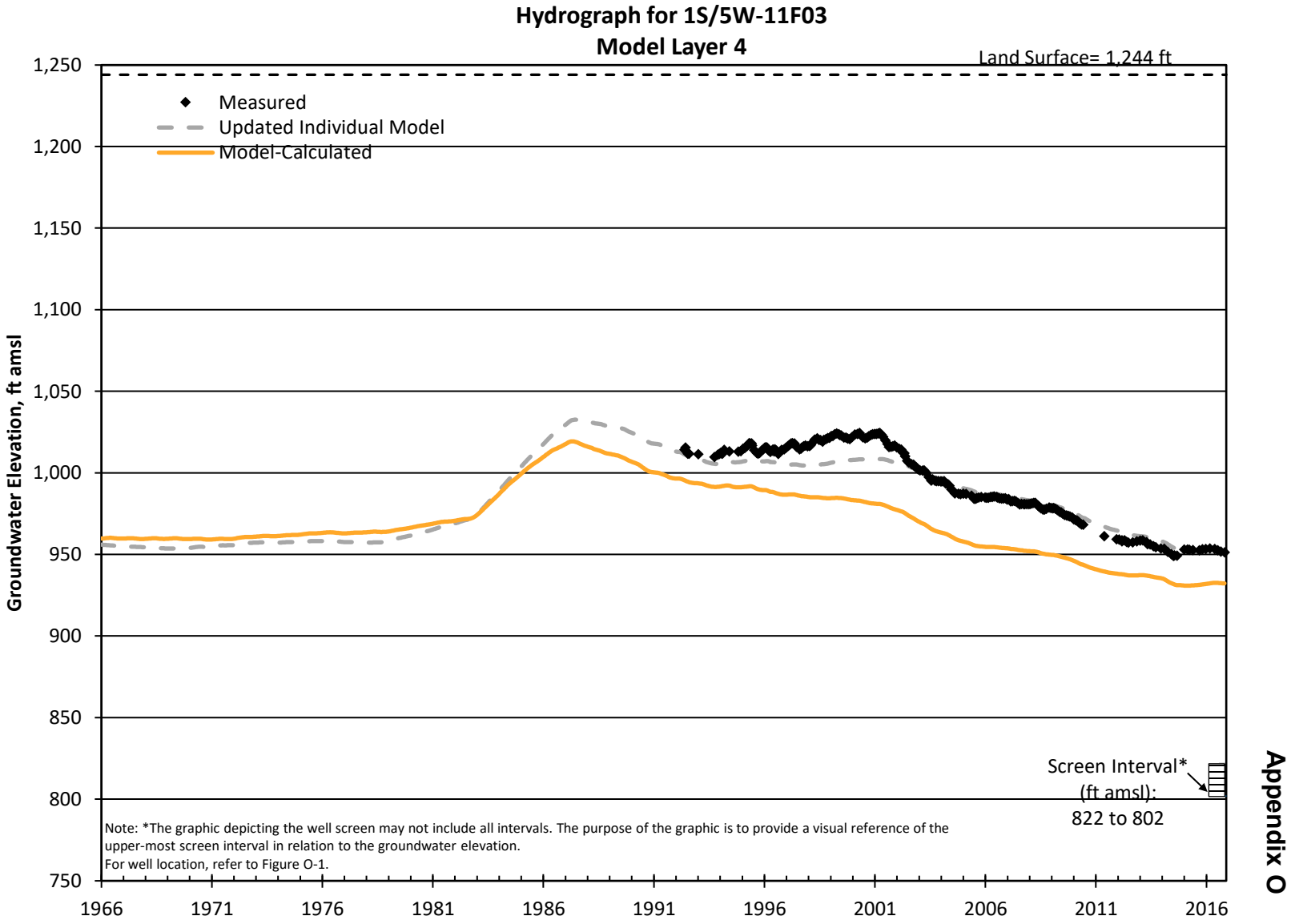
Appendix O


Hydrograph for 1S/5W-11F01
Model Layer 5
Land Surface= 1,244 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
314 to 294
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

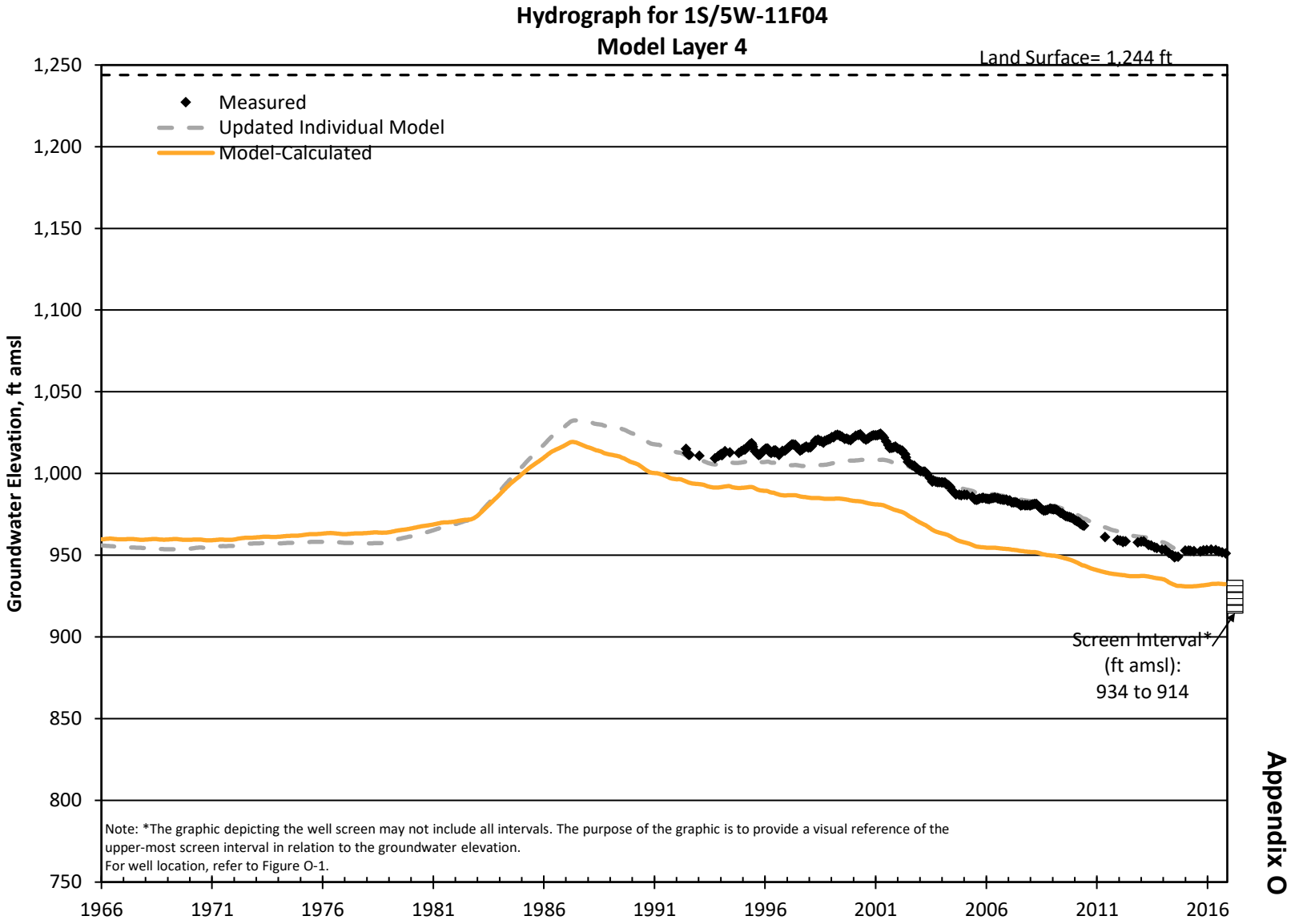
Appendix O


Hydrograph for 1S/5W-11F02
Model Layer 5
Land Surface= 1,244 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
550 to 530
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

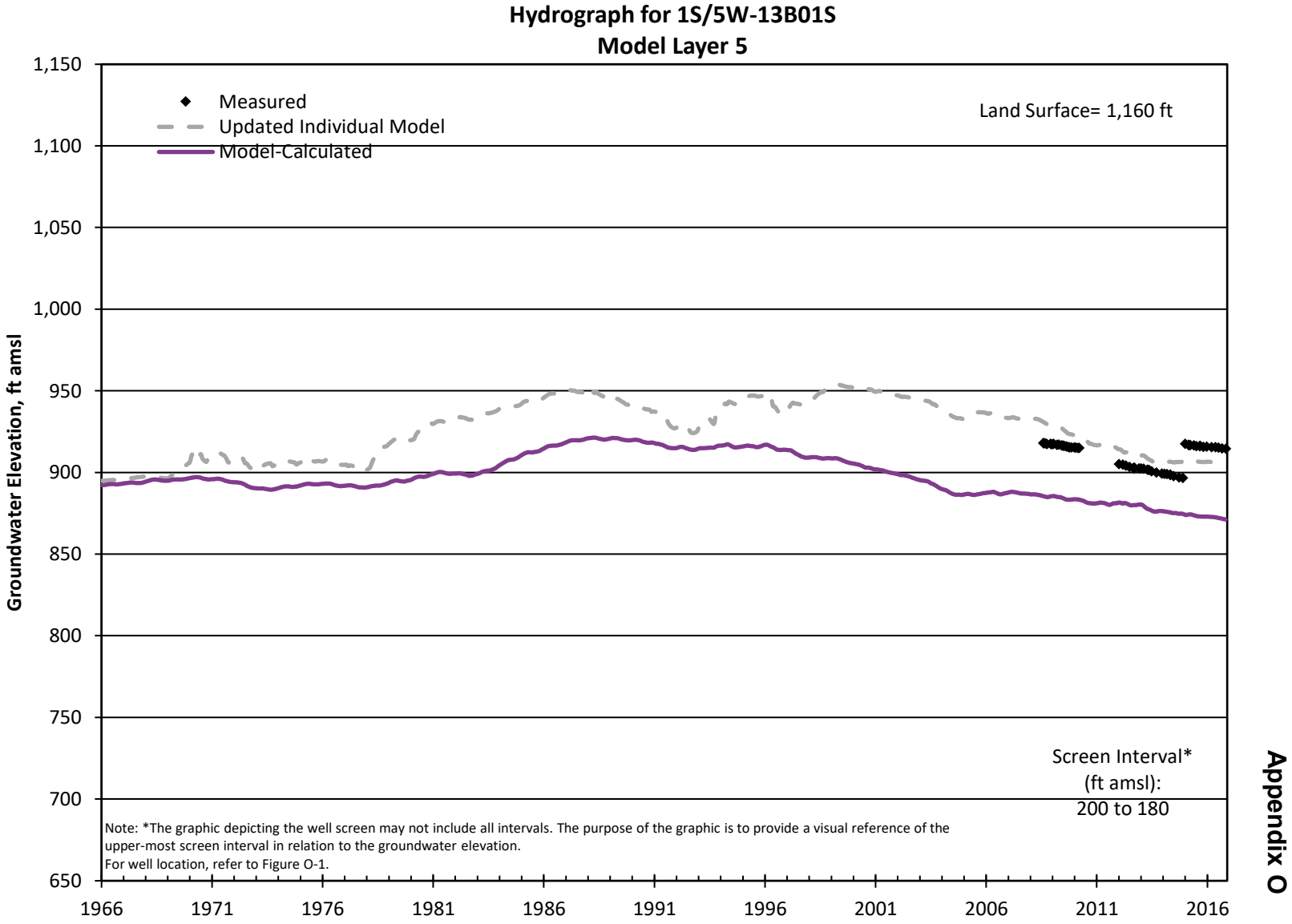
Appendix O


Hydrograph for 1S/5W-11F03
Model Layer 4
Land Surface= 1,244 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
822 to 802
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

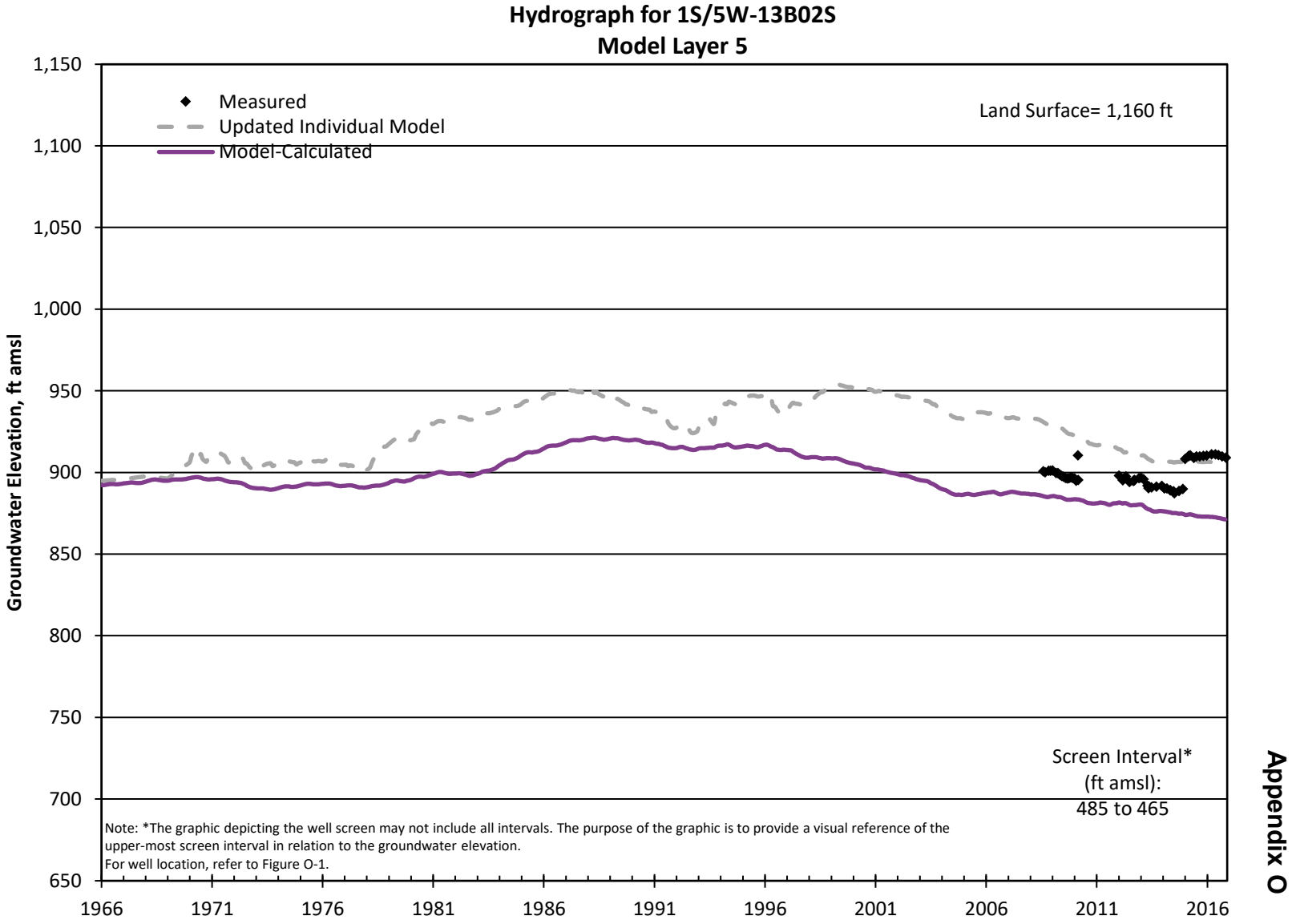
Appendix O


Hydrograph for 1S/5W-11F04
Model Layer 4
Land Surface= 1,244 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
934 to 914
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

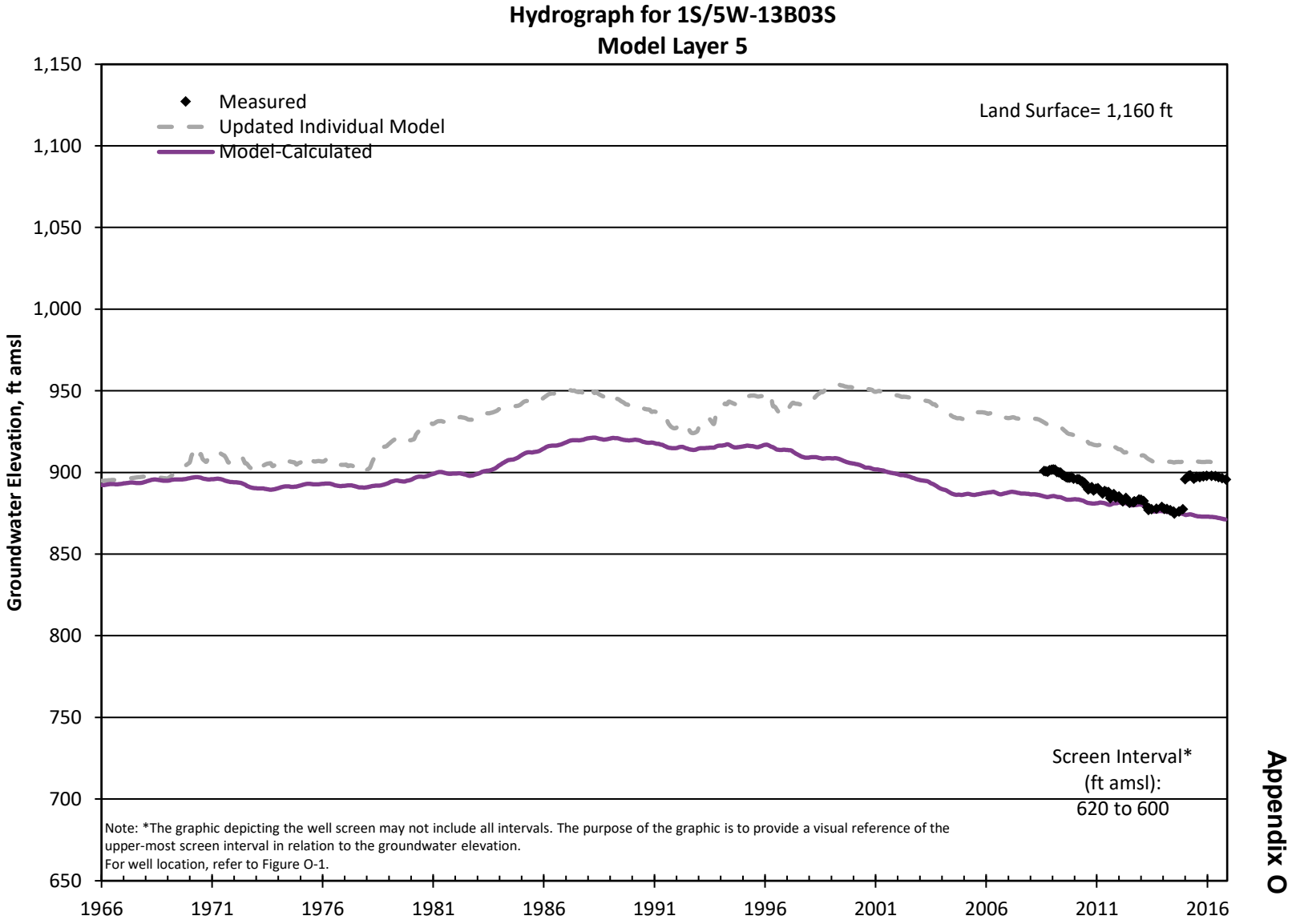
Appendix O


Hydrograph for 1S/5W-13B01S
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,160 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
200 to 180
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

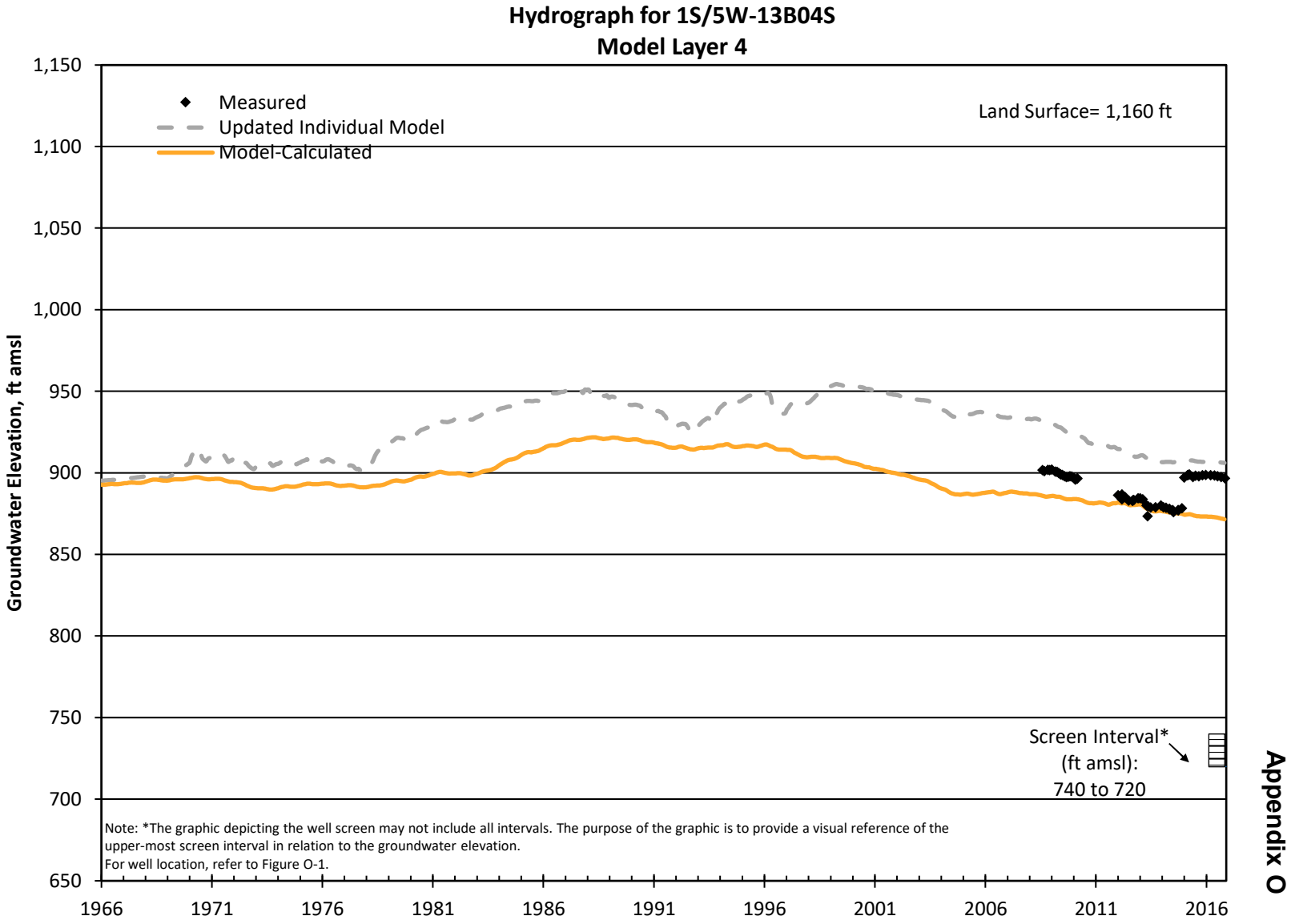
Appendix O


Hydrograph for 1S/5W-13B02S
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,160 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
485 to 465
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

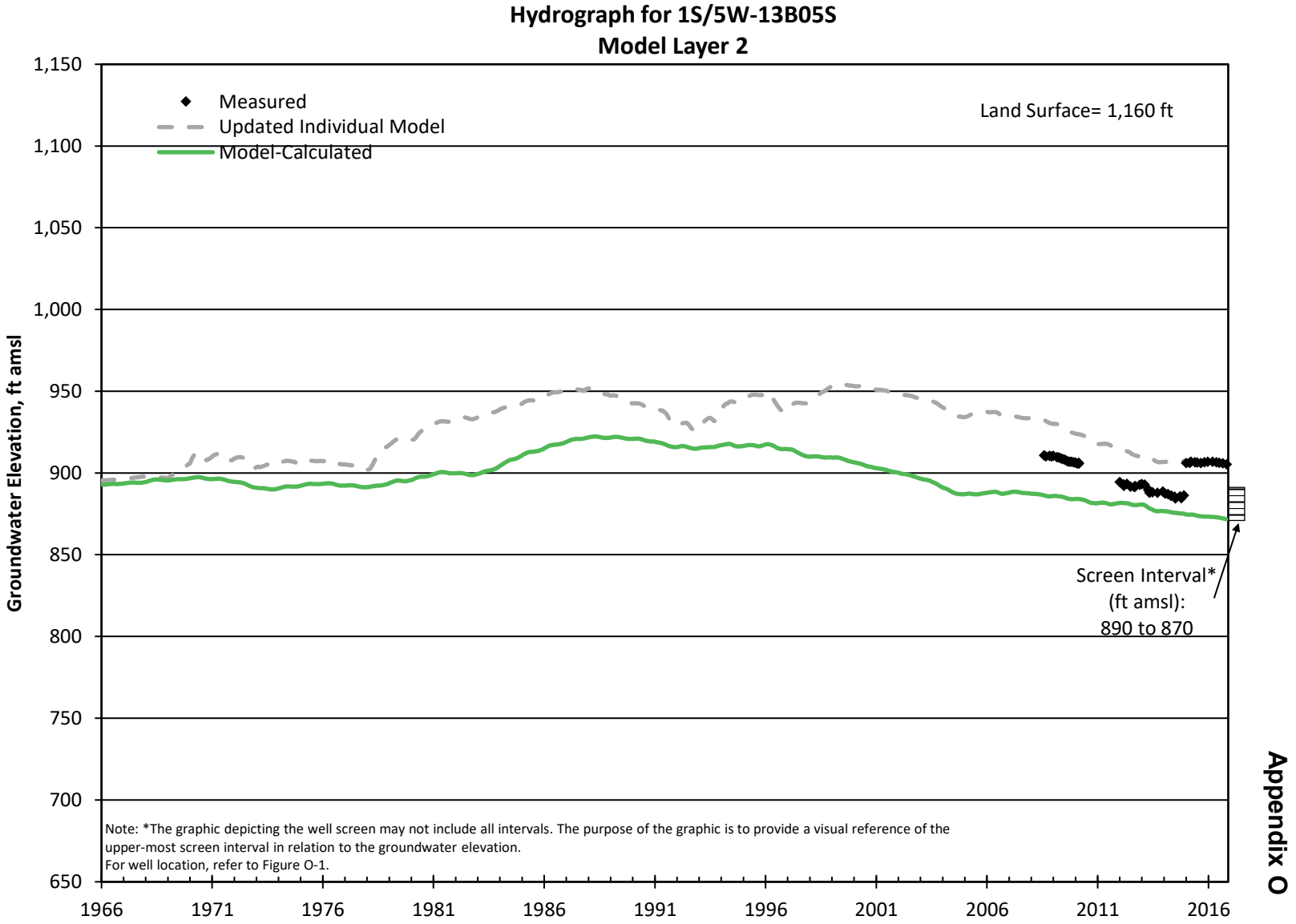
Appendix O


Hydrograph for 1S/5W-13B03S
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,160 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
620 to 600
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

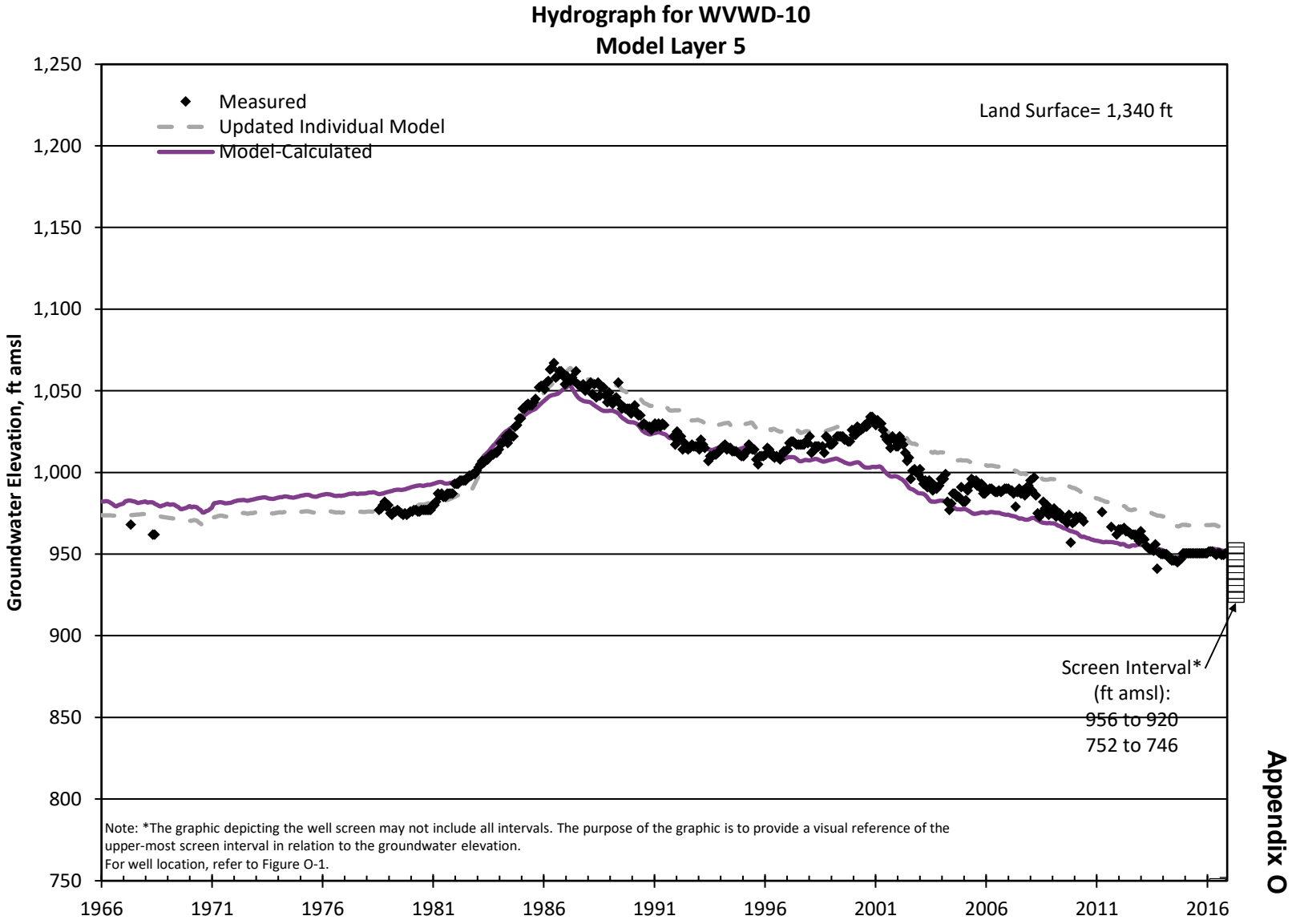
Appendix O


Hydrograph for 1S/5W-13B04S
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,160 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
740 to 720
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

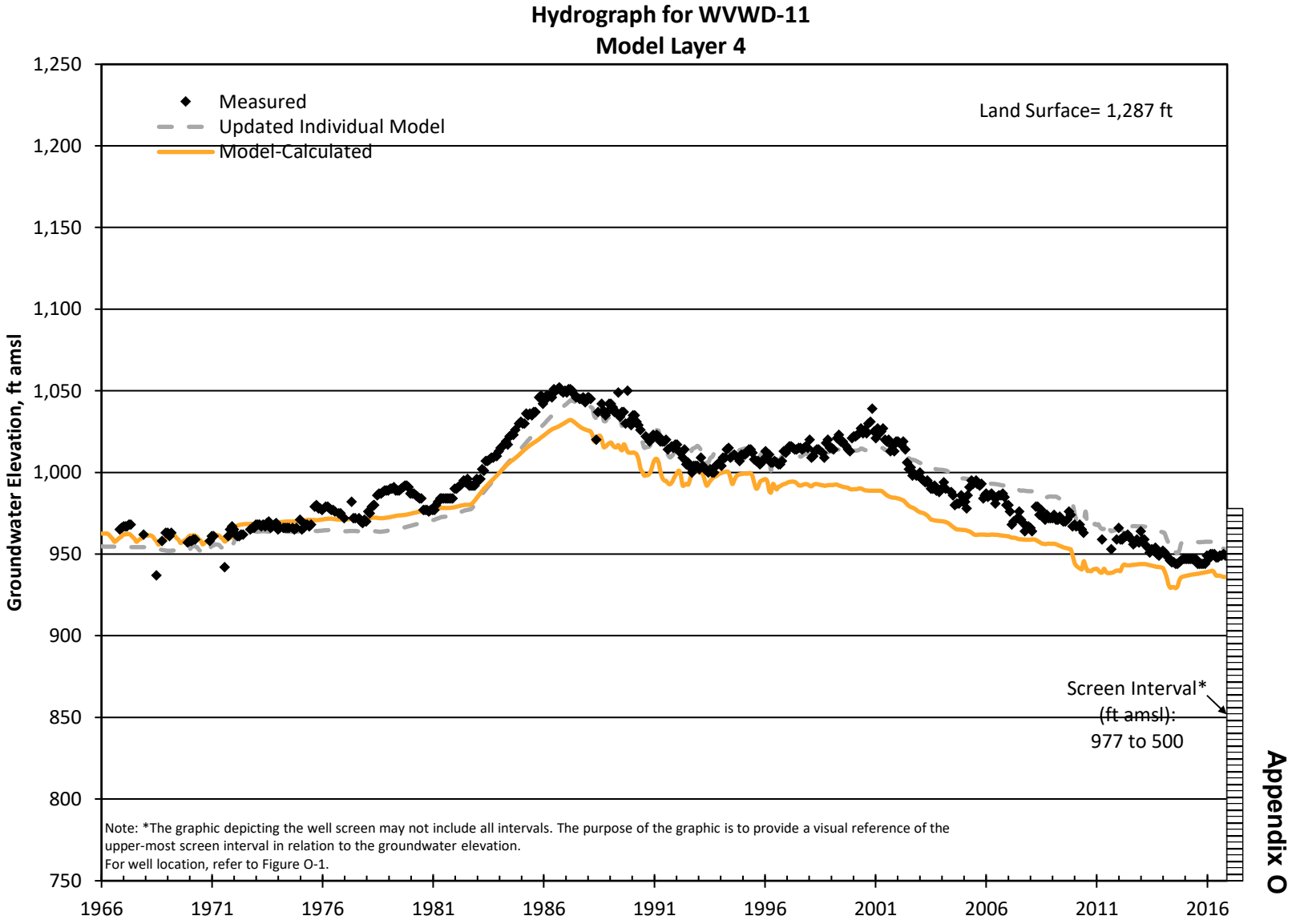
Appendix O


Hydrograph for 1S/5W-13B05S
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,160 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
890 to 870
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

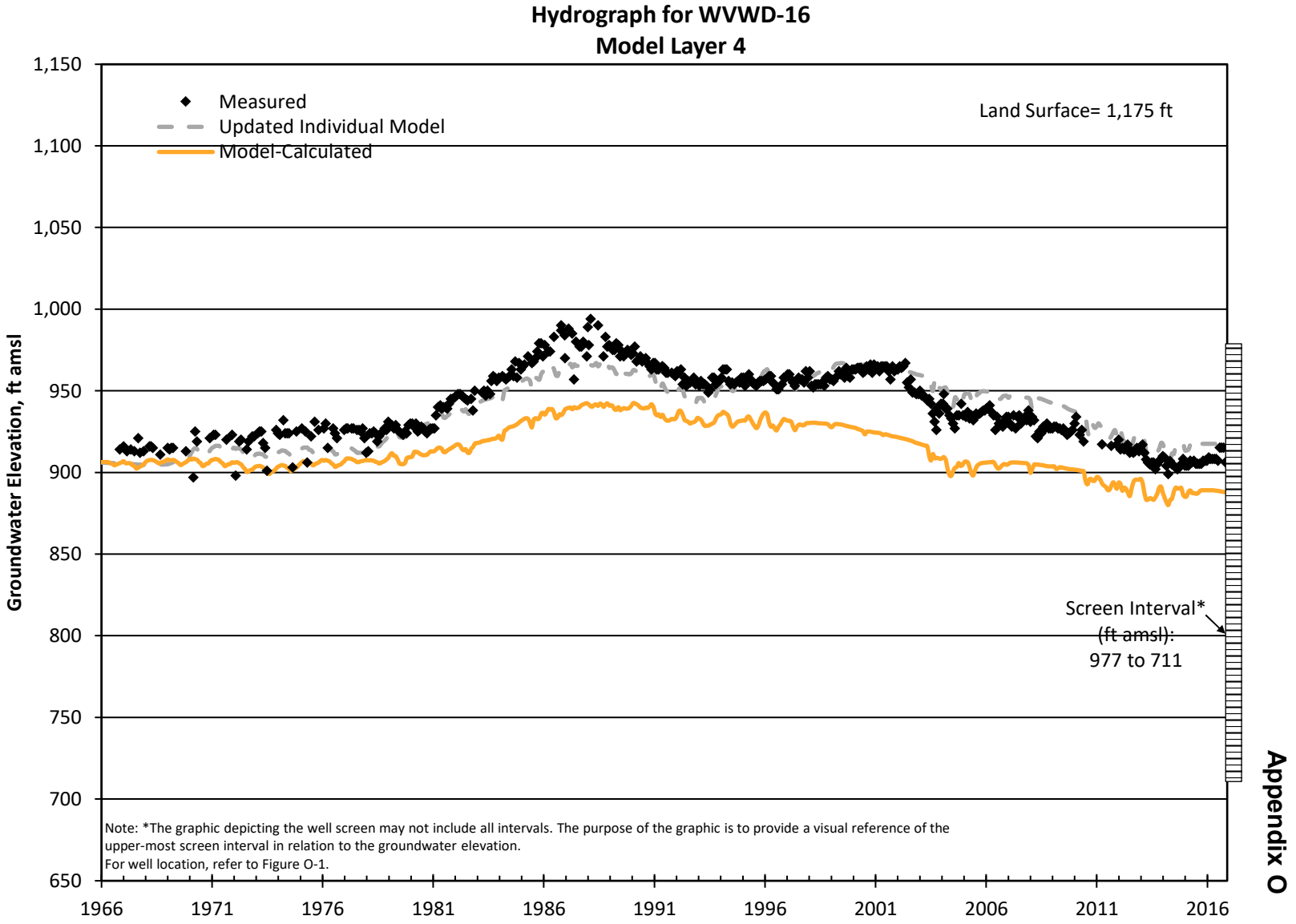
Appendix O


Hydrograph for WVWD-10
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,340 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
956 to 920
752 to 746
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

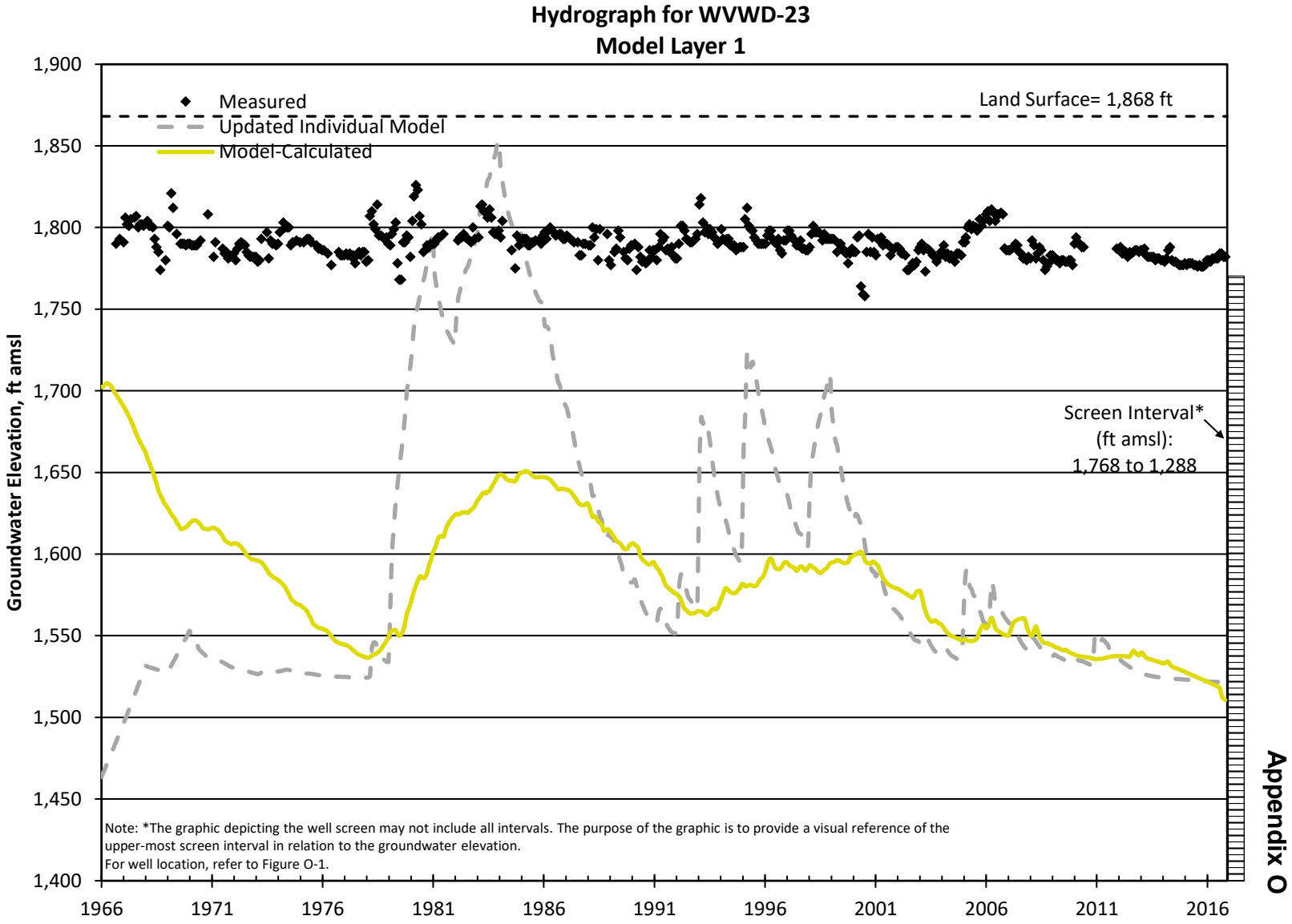
Appendix O


Hydrograph for WVWD-11
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,287 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
977 to 500
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

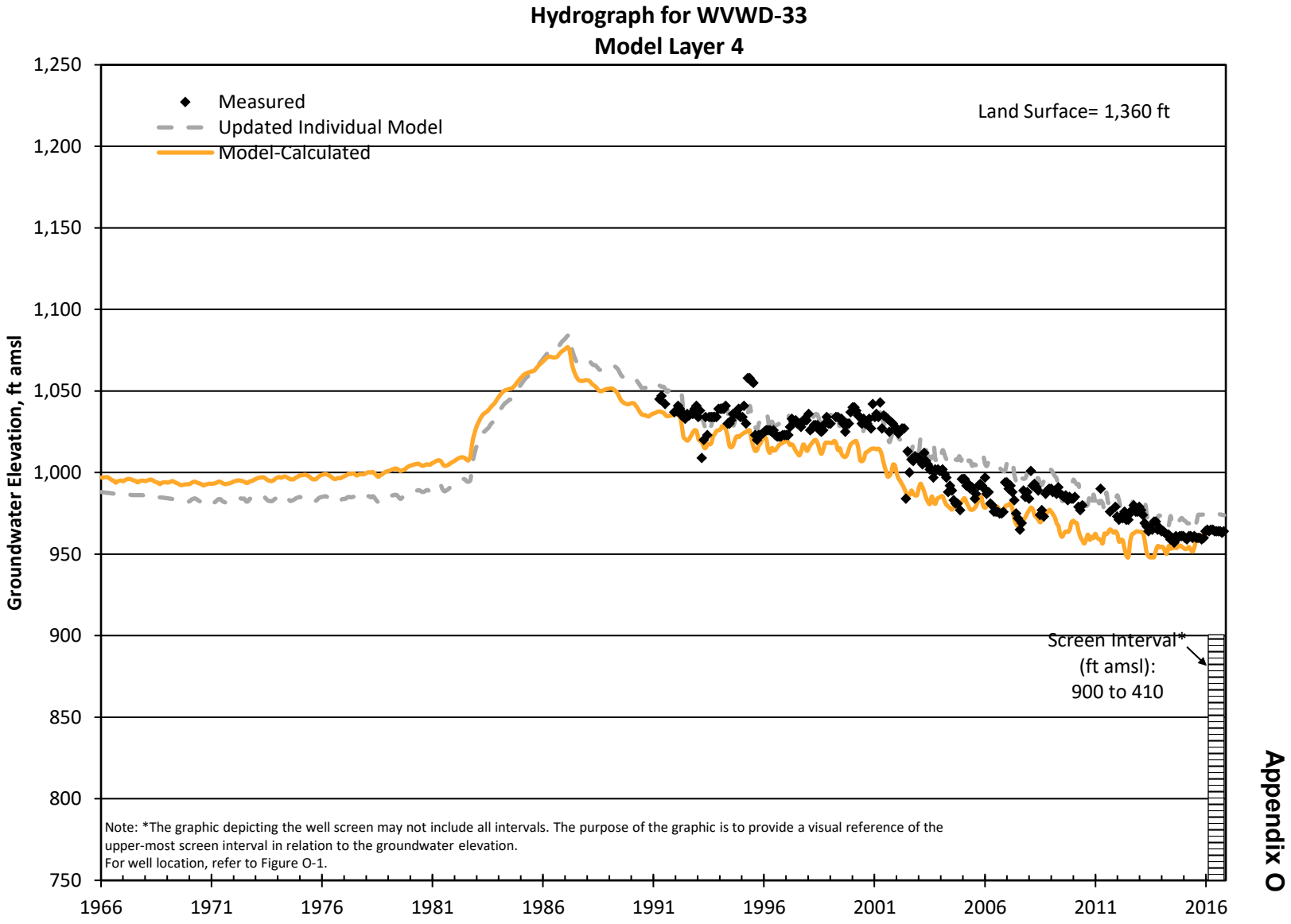
Appendix O


Hydrograph for WVWD-16
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,175 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
977 to 711
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

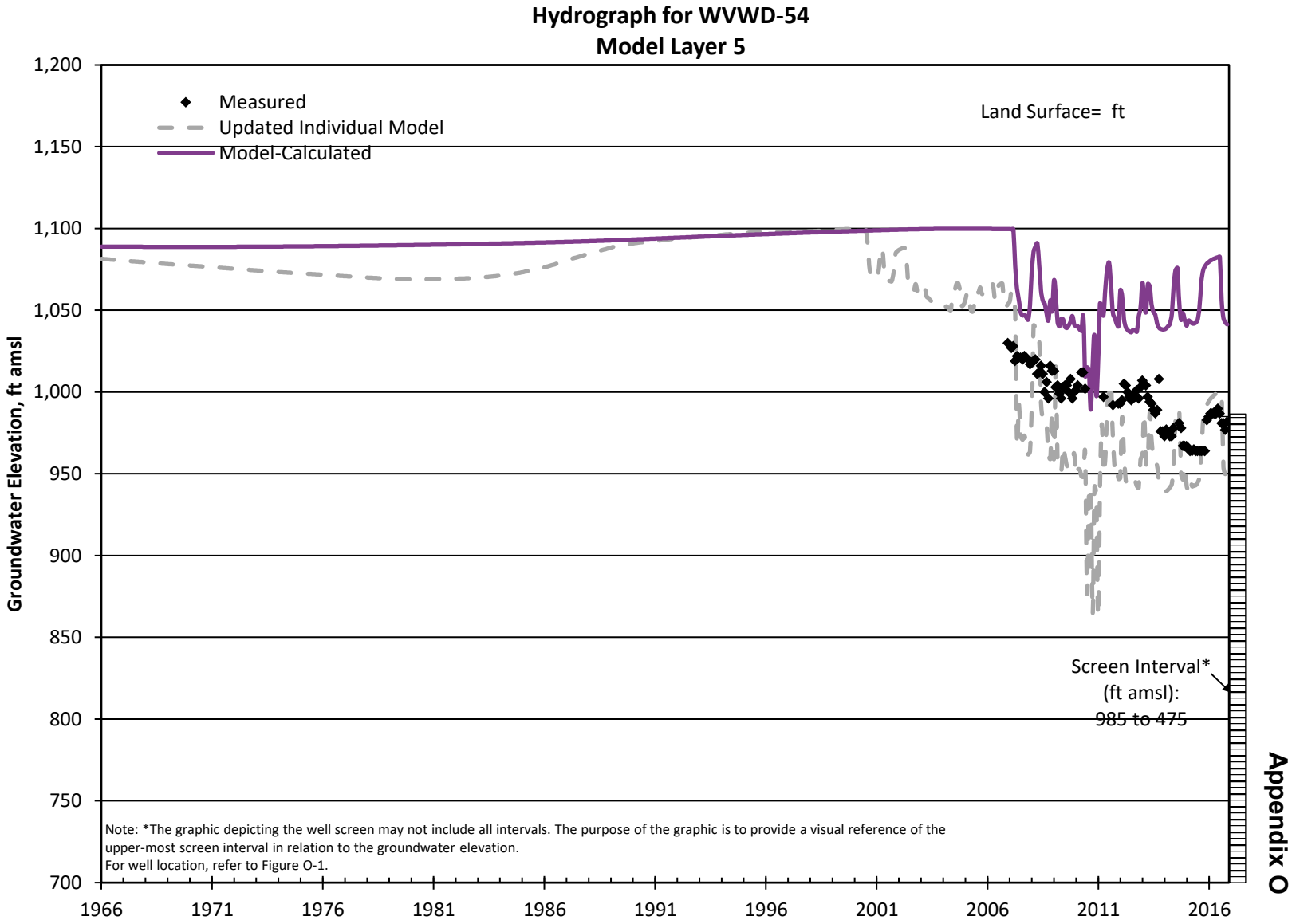
Appendix O


Hydrograph for WVWD-23
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,868 ft
Screen Interval*
(ft amsl):
1,768 to 1,288
Groundwater Elevation, ft amsl
1,900
1,850
1,800
1,750
1,700
1,650
1,600
1,550
1,500
1,450
1,400
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

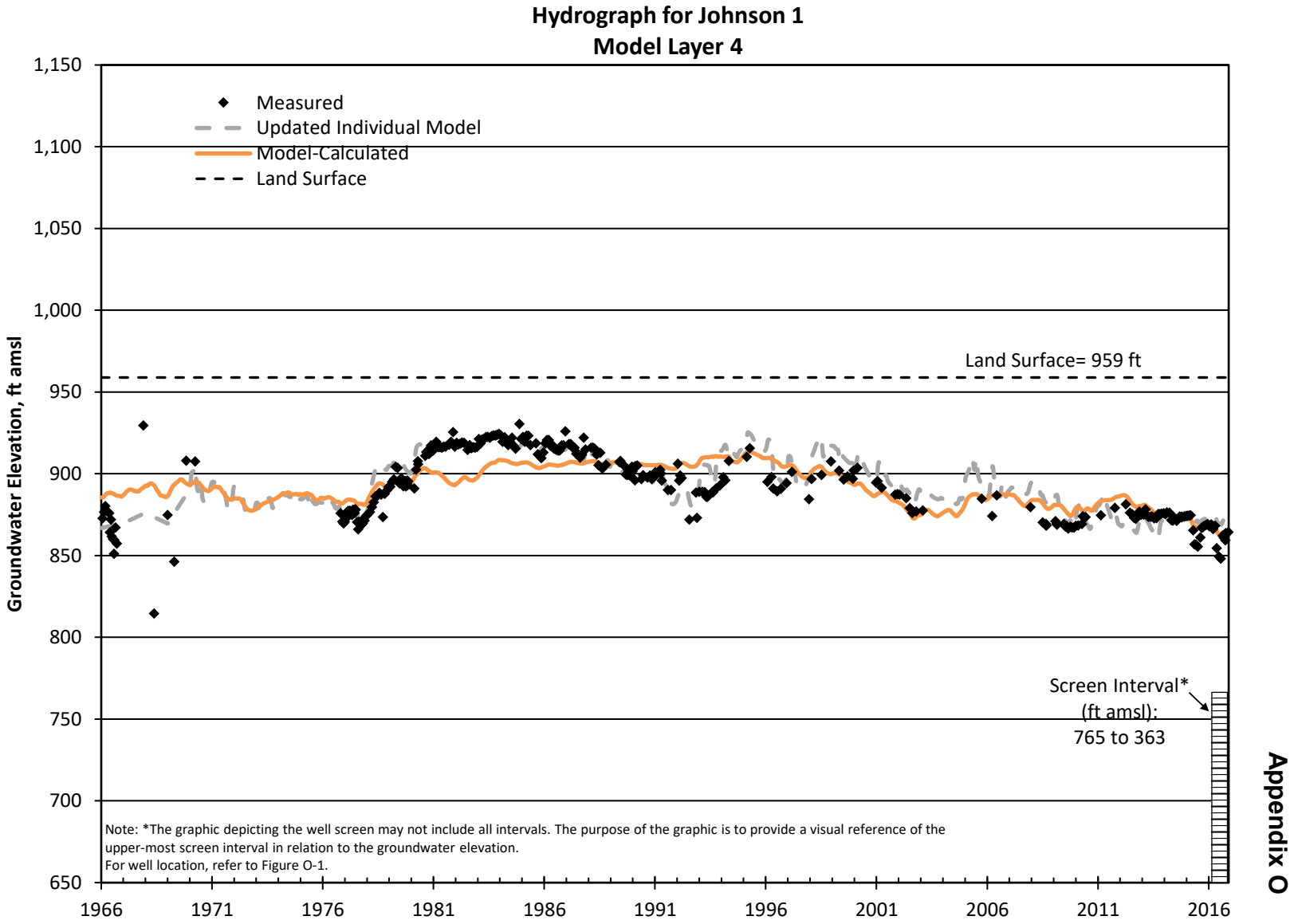
Appendix O


Hydrograph for WVWD-33
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,360 ft
Groundwater Elevation, ft amsl
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
900 to 410
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

Appendix O


Hydrograph for WVWD-54
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= ft
Groundwater Elevation, ft amsl
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
985 to 475
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

Appendix O


Hydrograph for Johnson 1
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface
Land Surface= 959 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
765 to 363
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure O-1.

Appendix O

APPENDIX P

Integrated SAR Model: Selected Hydrographs for Target Wells in the Riverside-Arlington Basin Model Area – 1966 to 2016

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Deer Ck
Day Ck
Etiwanda Ck
San Sevaine Ck
Cucamonga Ck
Mill Ck
Lytle Ck
Lytle Creek Chan
Upper Warm Ck
Warm Ck
Warm Ck Bypass
City Ck
Santa Ana River
The Zanja
San Timoteo Wash
Reche Cyn Ck
Arlington Channel
Temescal Wash
Prado Dam

15
10
215
60
91

Colton_24
PL29/CRAM-WRIGHT
CPC EAST SIDE
CPC #6
SANTA FE ELEXTRIC A-1
DISPOSAL
TWIN BUTTE #6
1
8TH ST
1, AUGA MENSA
8
01S/04W-29H04-08S
01S/04W-29K01-05S
CUTIS
58-1
DOUBLE D RANCH
SUNNYSLOPE #5
IRRIGATION
#3 28TH ST
RIV CANNEL 62/CE#3
NA
RN #21
PALMYRITA 1
1 (RIO RANCHO)
02S05W17K01
FAIRMONT PARK 2
#14, 46ST
#16 HUNTER
02S04W19E01
MULBERRY
02S05W23F01
RIVERSIDE-ARLINGTON BASIN
RR1
LAURA LANE
IRRIGATION
ARMY 3
WATER TOWER
ORANGE ACRES
HOLES
POLK
WALTON
PIERCE ST SEWER 3
DOI
JACKSON
LINCOLN HEIGHTS
BUCHANAN
ABRAHAM
DAILY 2

EXPLANATION

Well Model Layer
- 1
- 2
- 3
- 4
- 5

Inactive Model Area

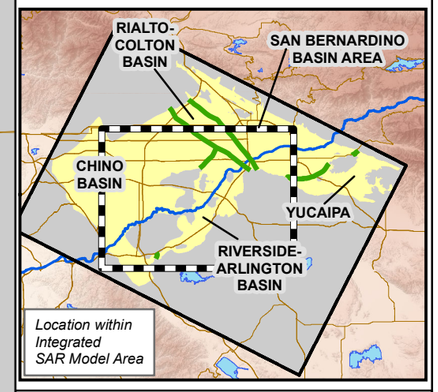
Groundwater Basin Boundary

Groundwater Flow Barrier

Dam Location Used in Upper Santa Ana River Watershed Model

N

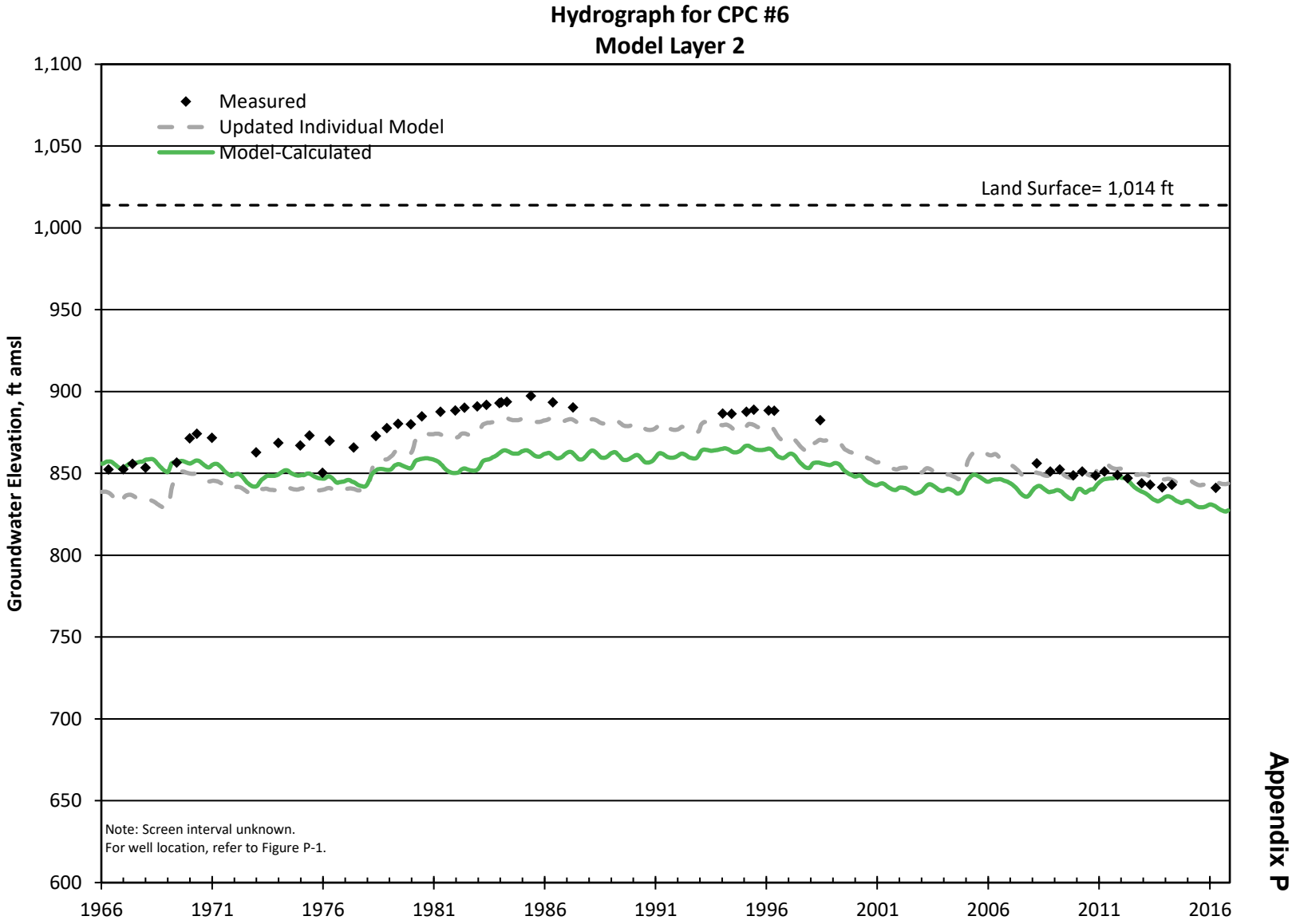
0 2 4
Miles



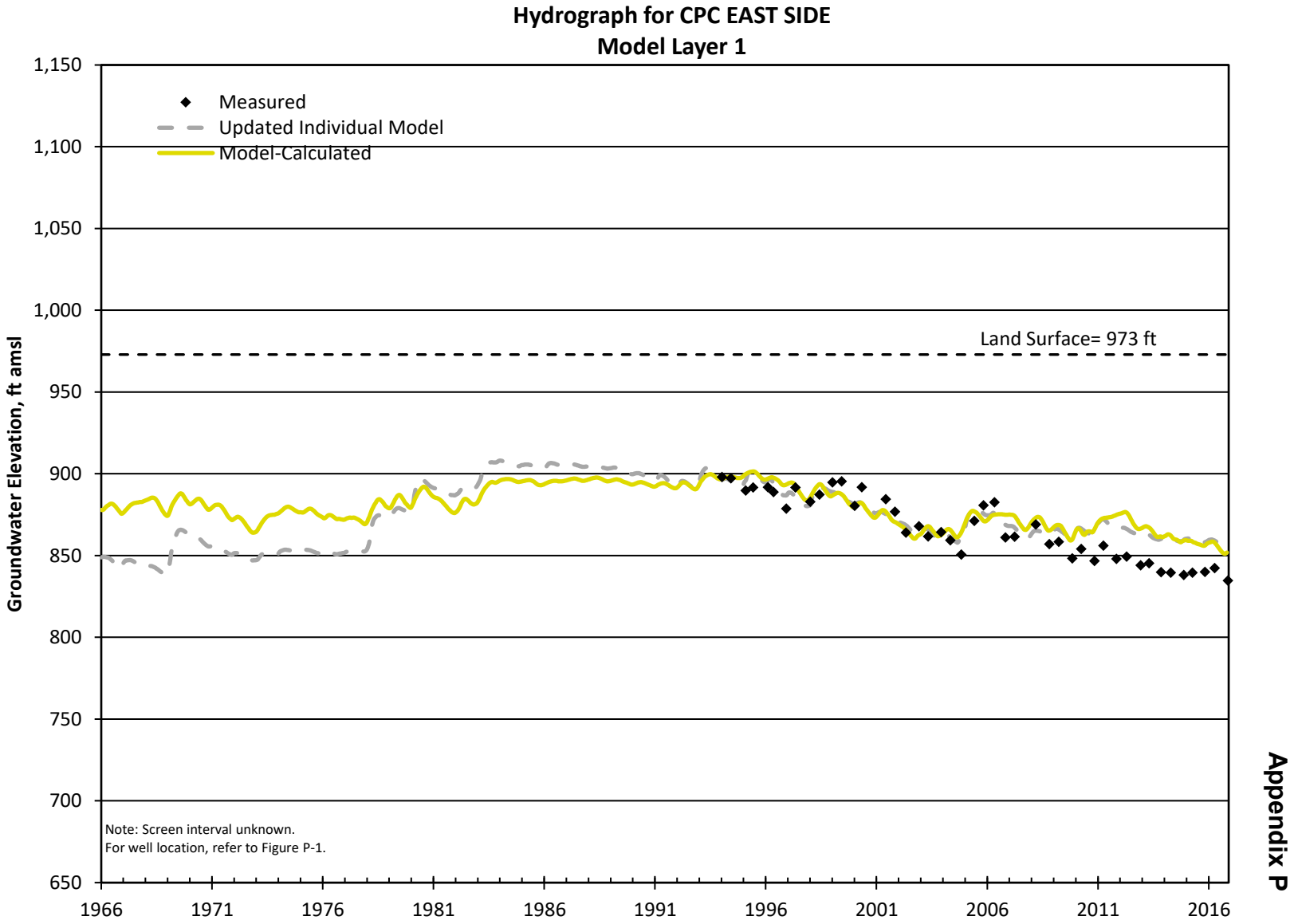
SELECTED TARGET WELLS USED FOR HYDROGRAPHS RIVERSIDE-ARLINGTON BASIN MODEL AREA 1966 TO 2016

W:\GIS_proj\stvrnwd_SARiverStudyModel_2017\53_SumRpt_Fig_P-1_Riv-Arl_Wells_labeled_4-20.mxd

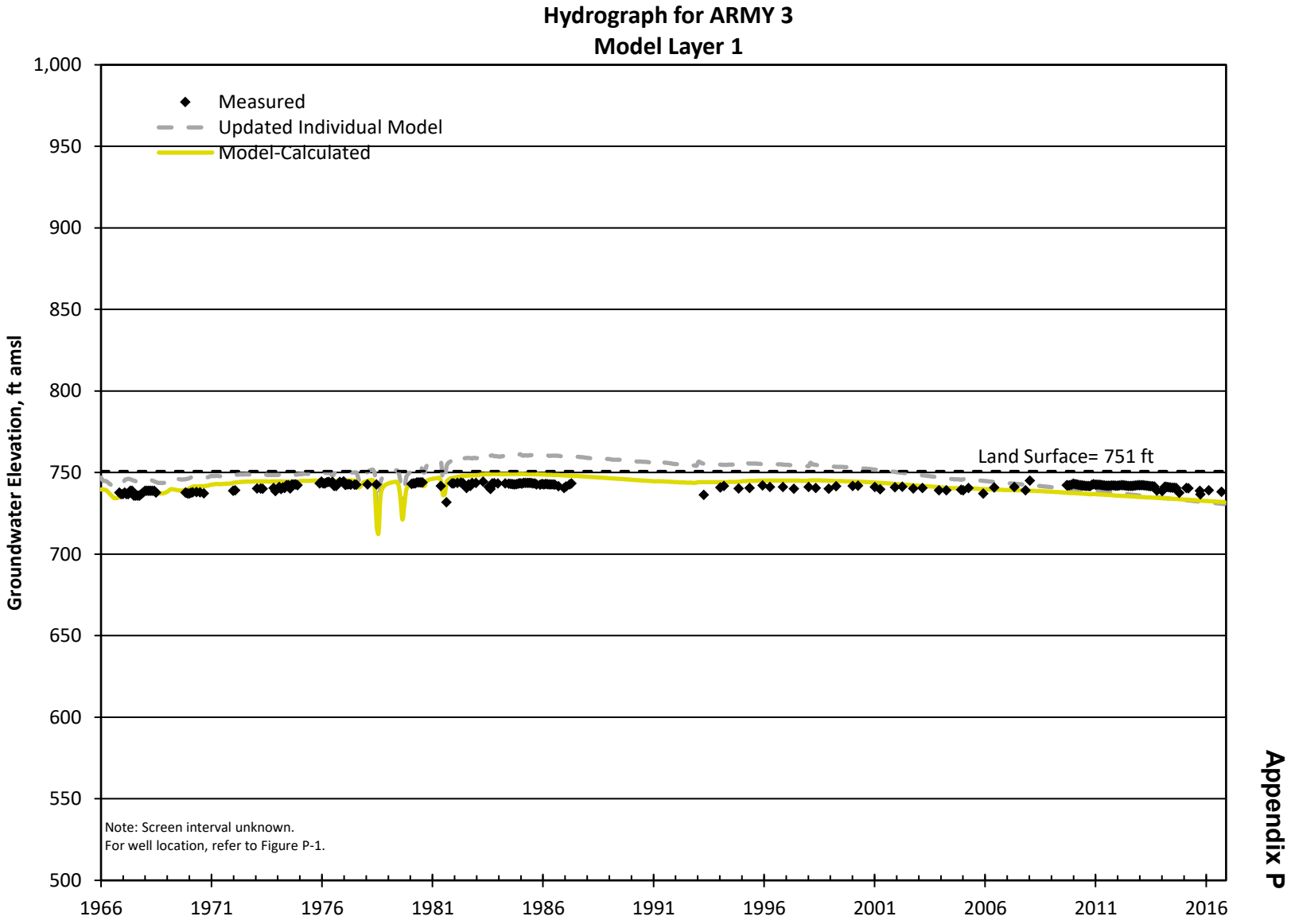
10-Apr-20


Hydrograph for CPC #6
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,014 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

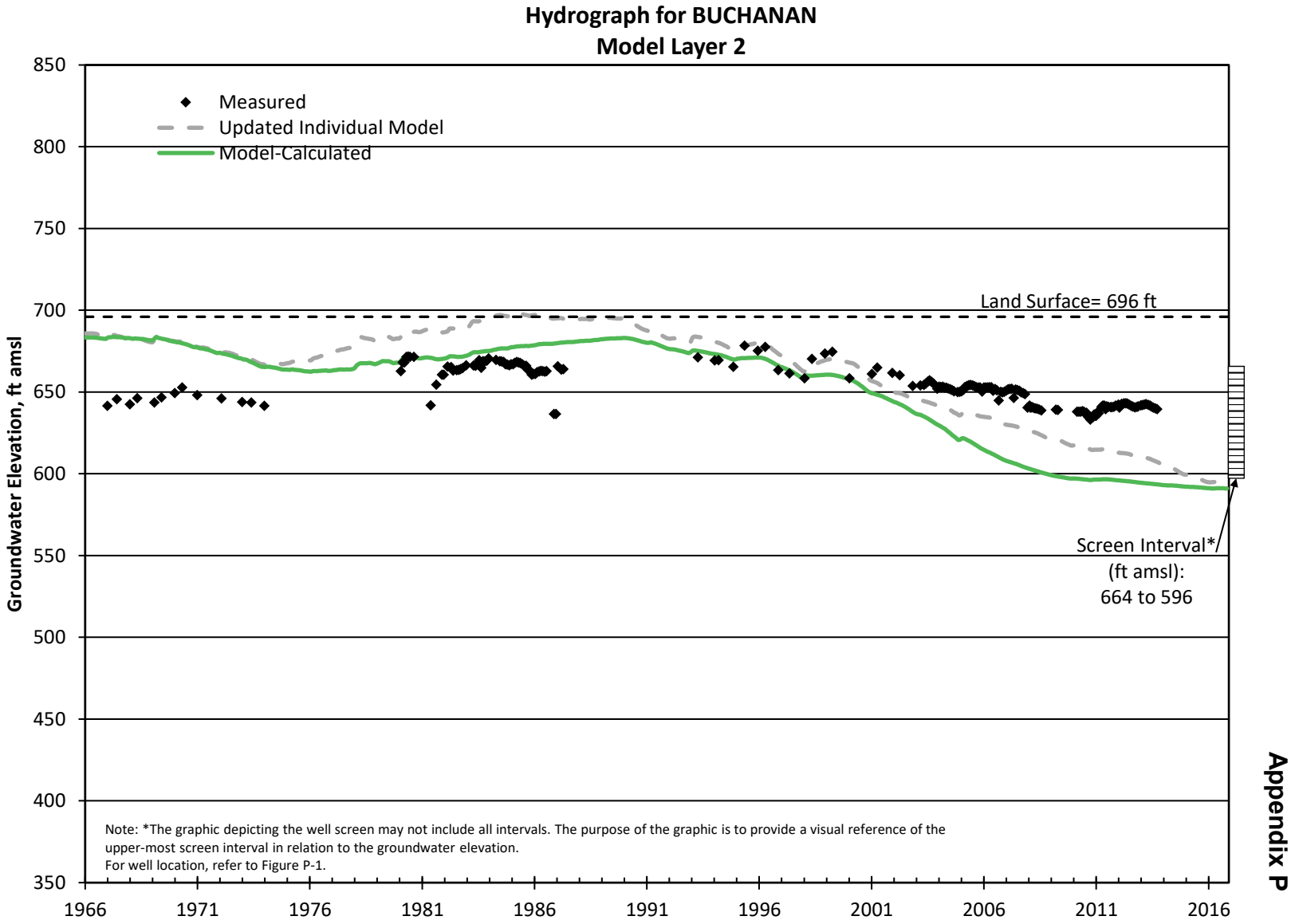
Appendix P


Hydrograph for CPC EAST SIDE
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 973 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

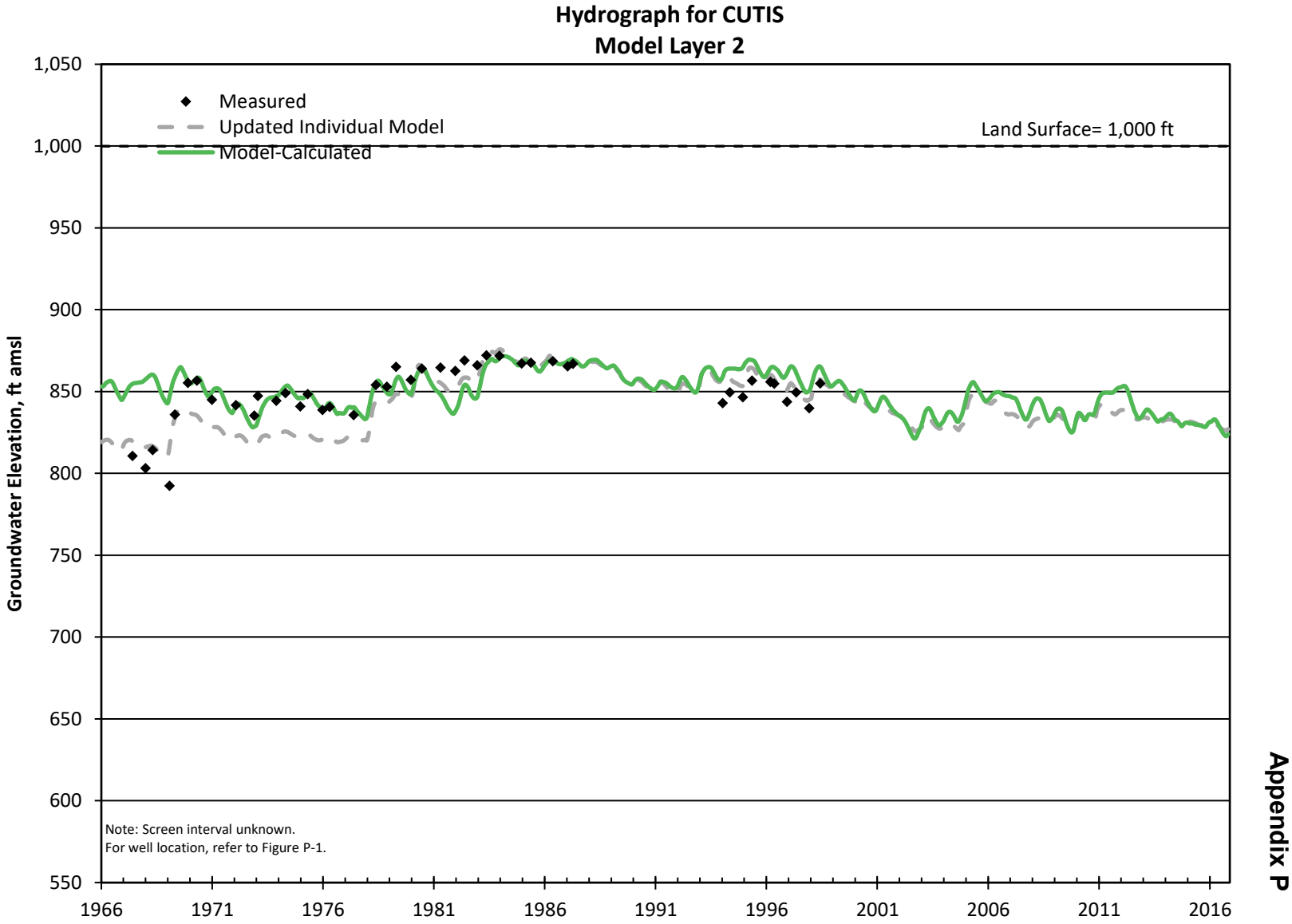
Appendix P


Hydrograph for ARMY 3
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 751 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

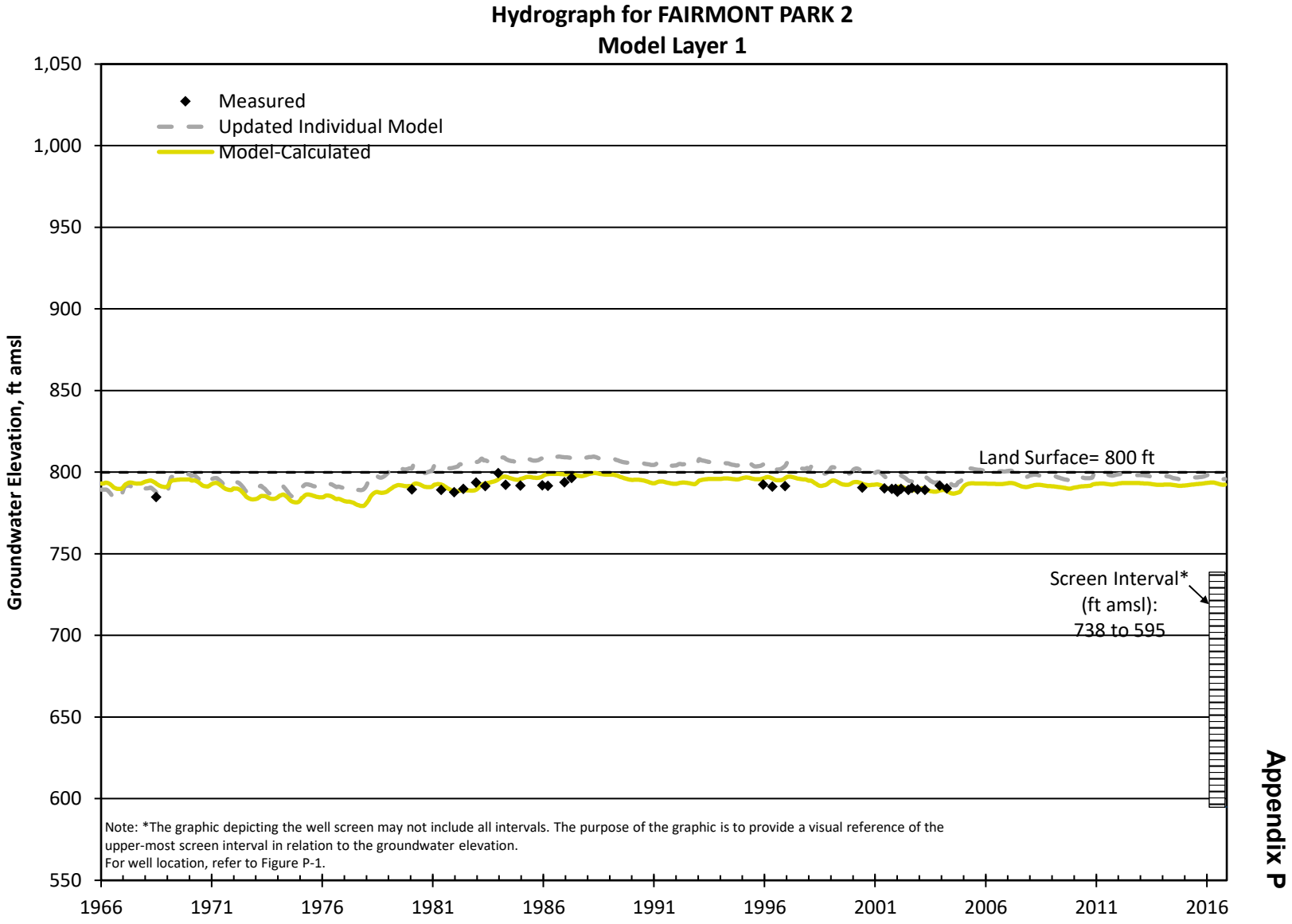
Appendix P


Hydrograph for BUCHANAN
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 696 ft
Screen Interval*
(ft amsl):
664 to 596
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

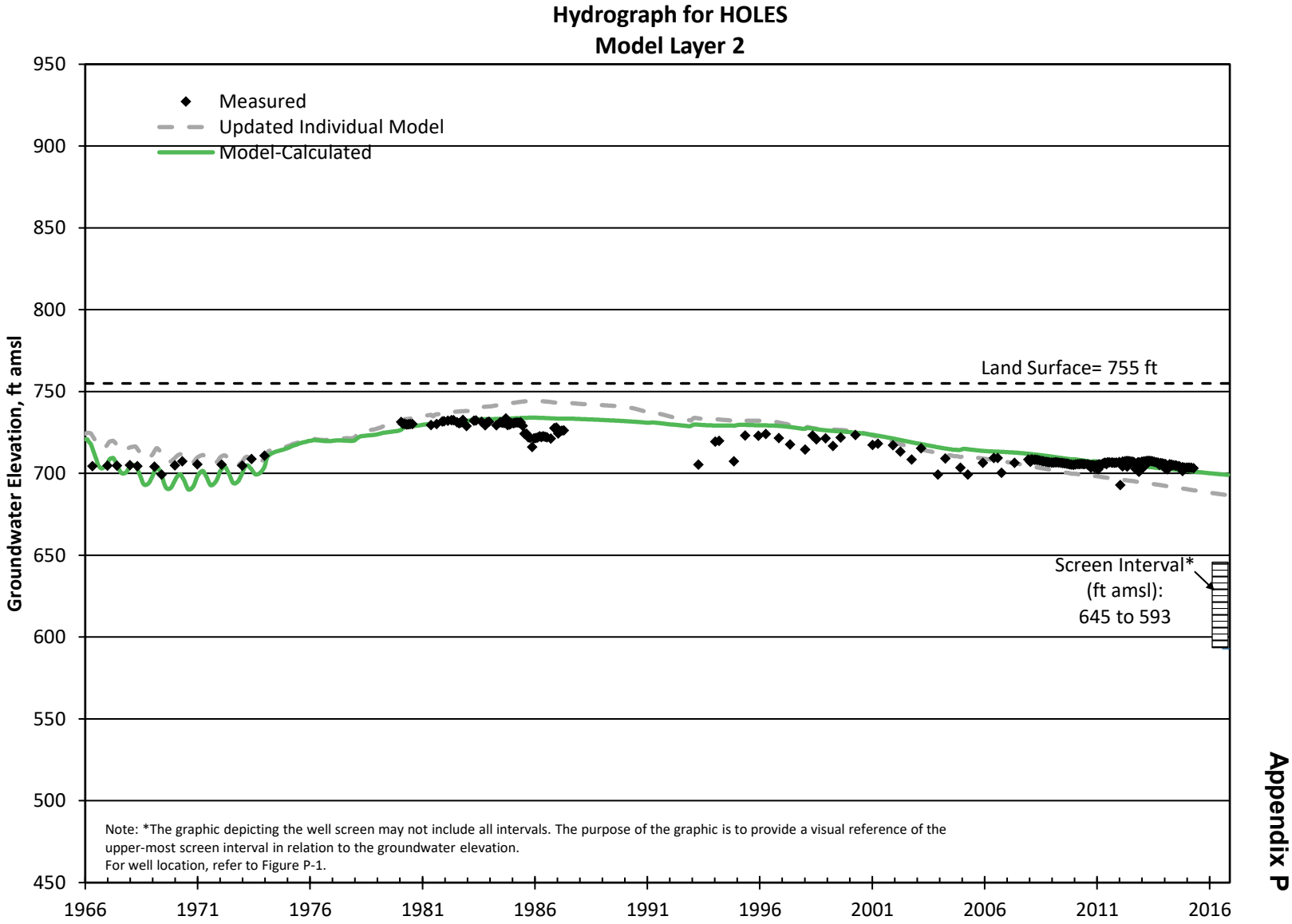
Appendix P


Hydrograph for CUTIS
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,000 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

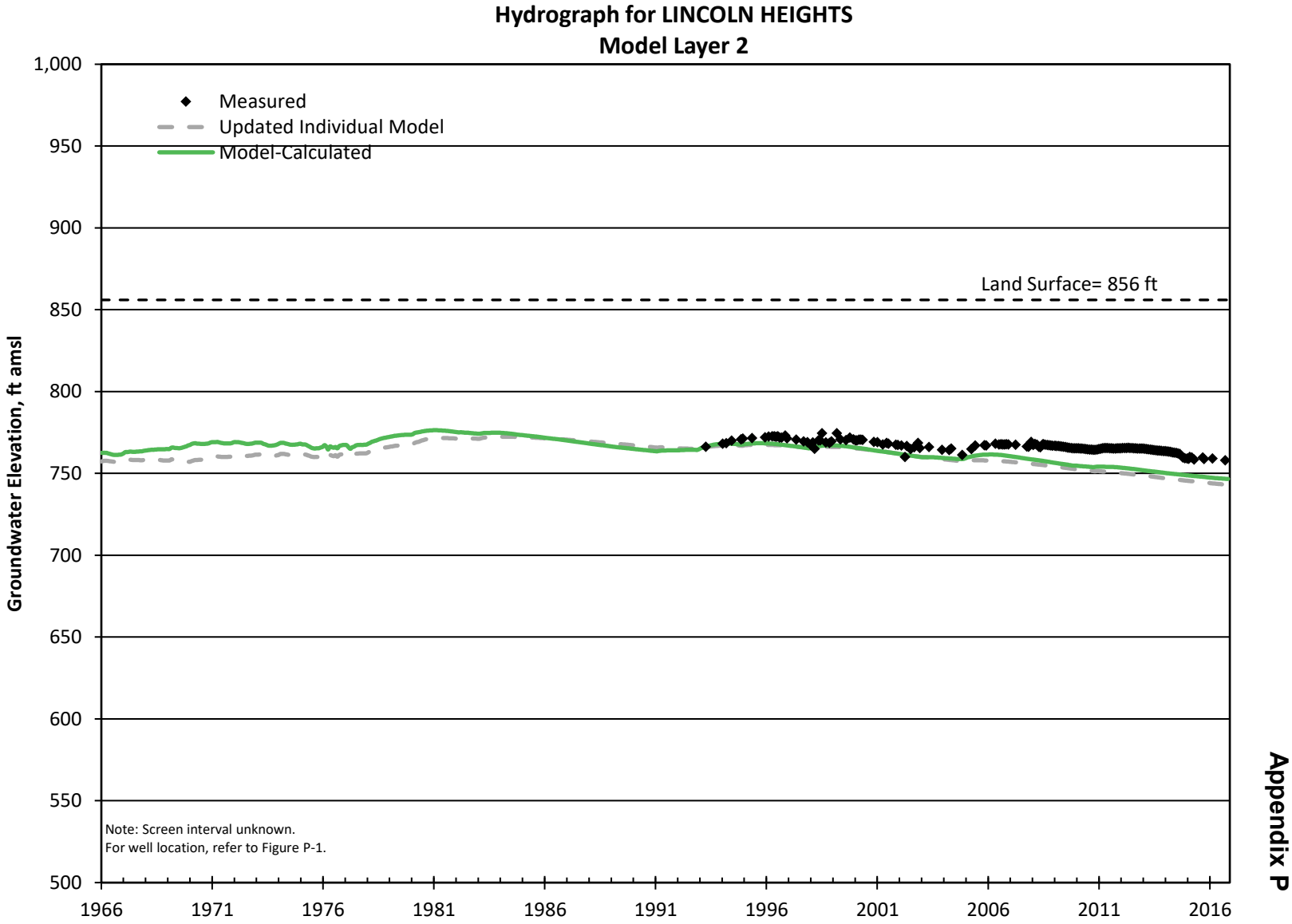
Appendix P


Hydrograph for FAIRMONT PARK 2
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 800 ft
Screen Interval*
(ft amsl):
738 to 595
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

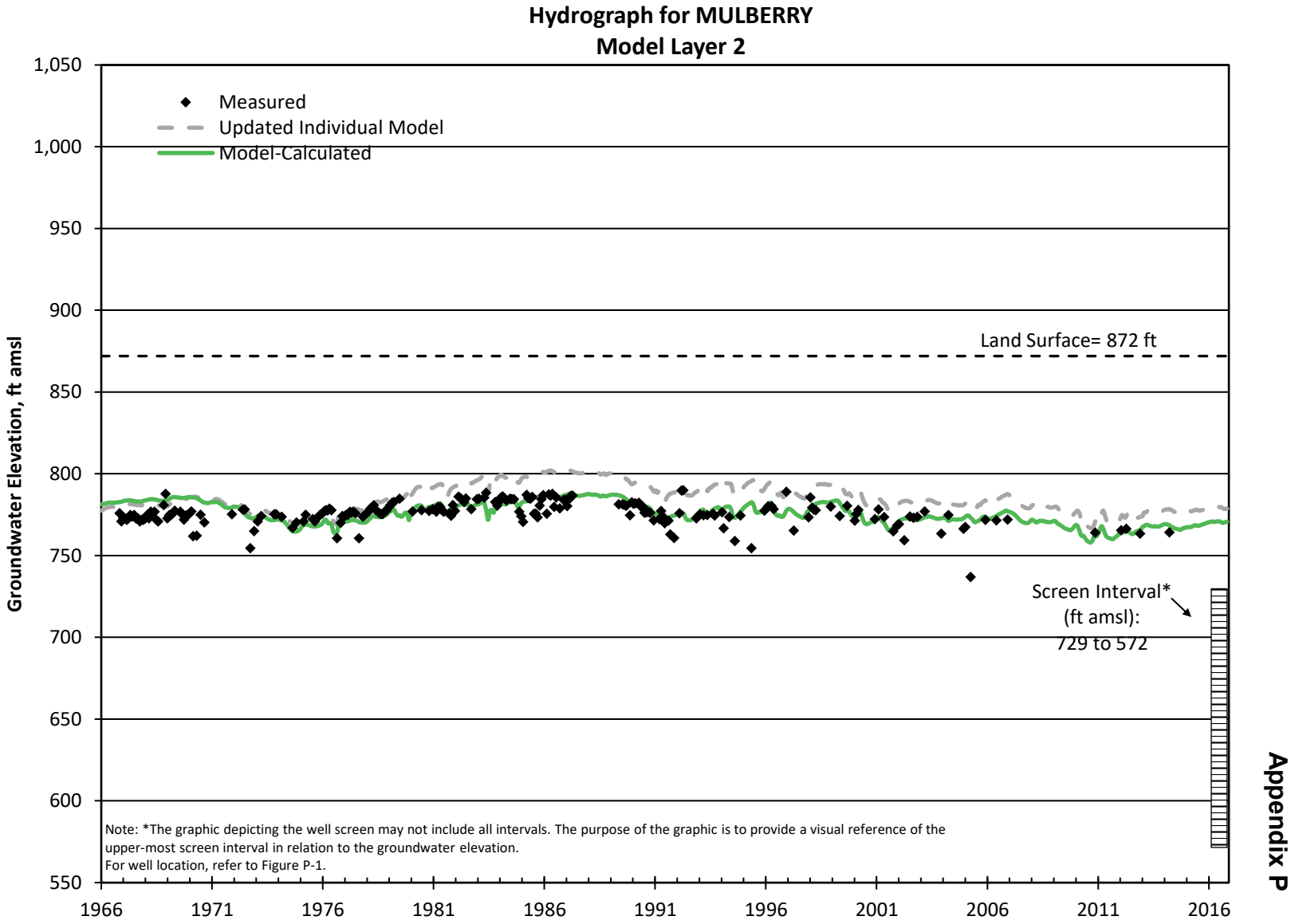
Appendix P


Hydrograph for HOLES
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 755 ft
Screen Interval*
(ft amsl):
645 to 593
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

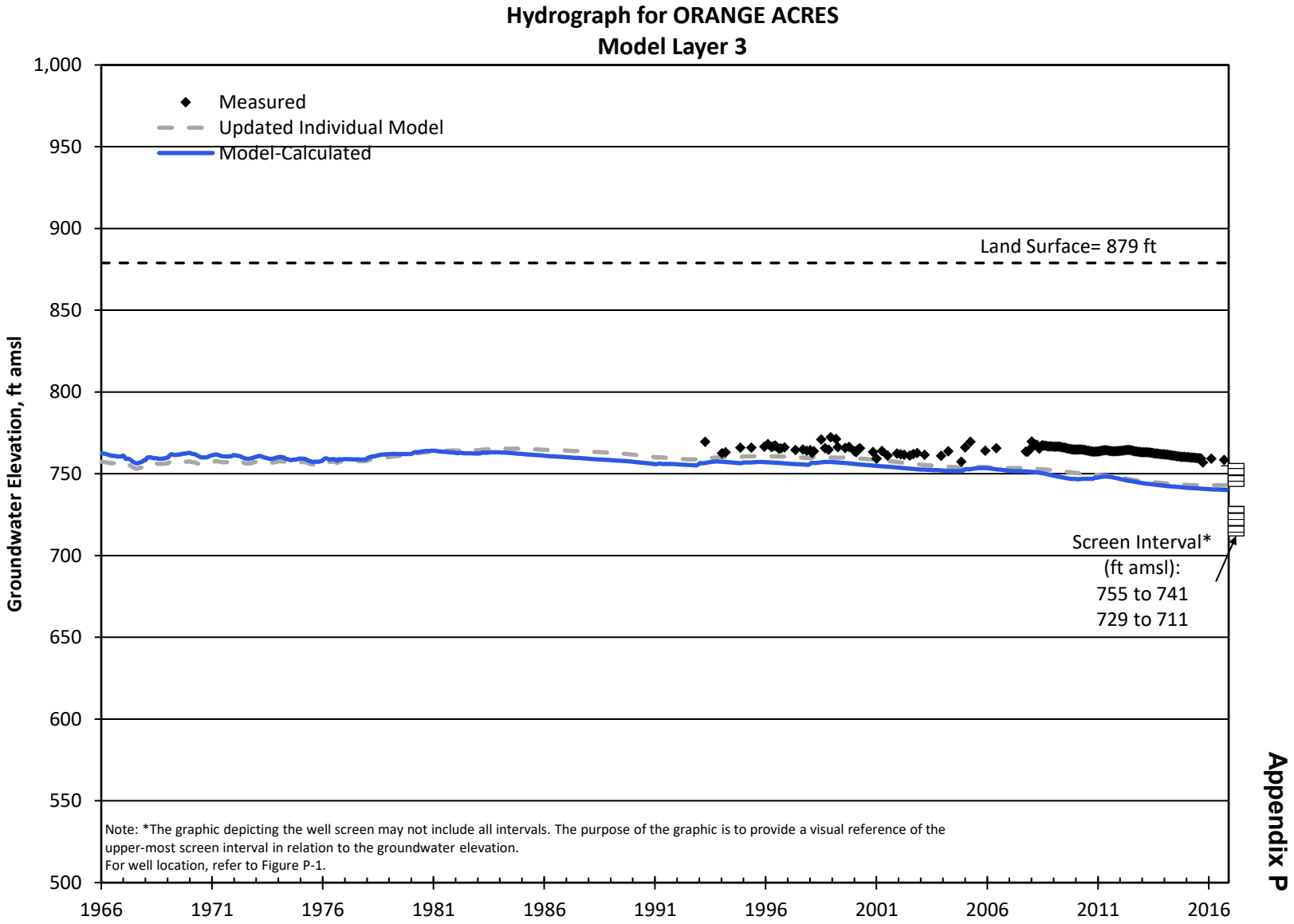
Appendix P


Hydrograph for LINCOLN HEIGHTS
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 856 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

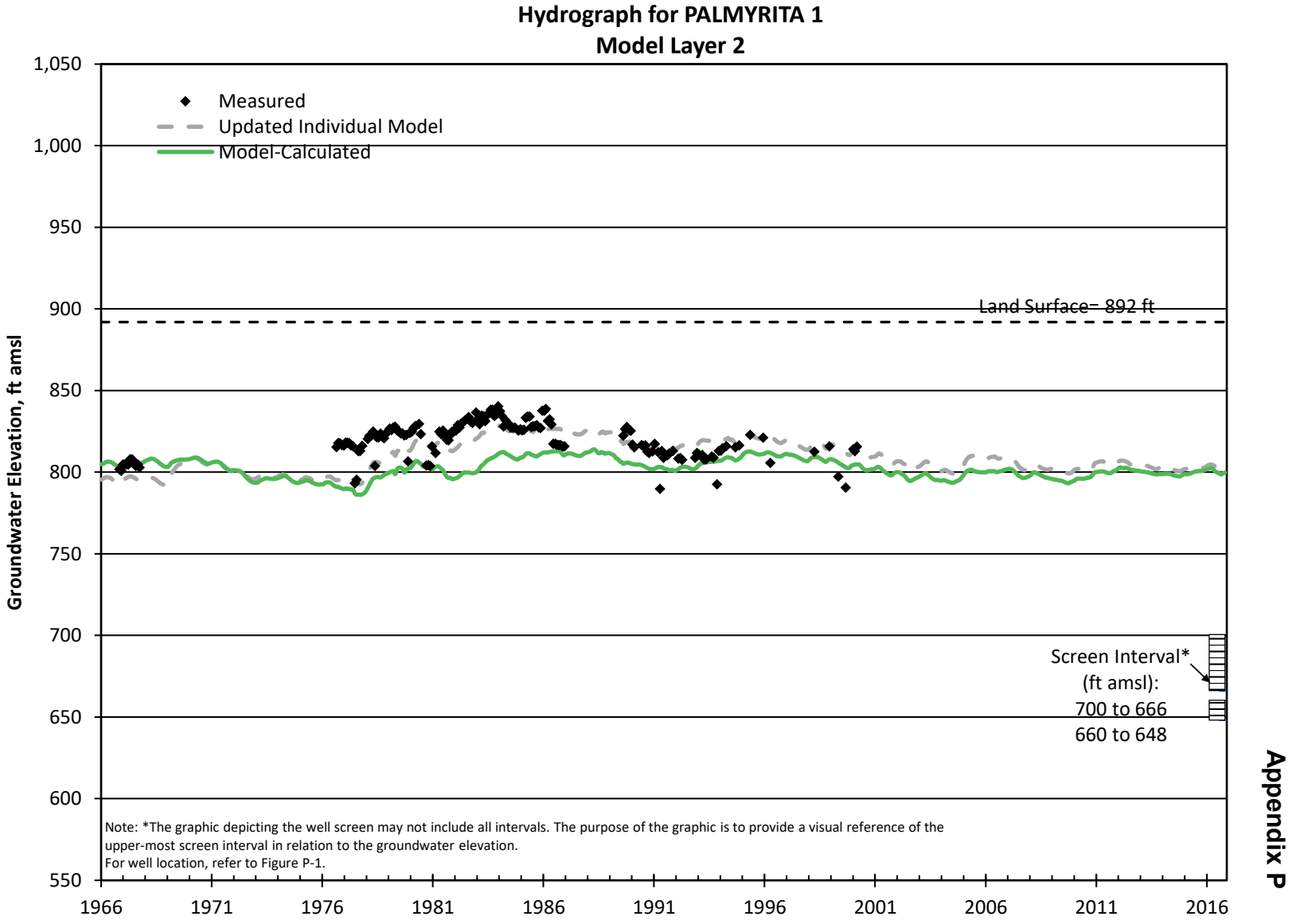
Appendix P


Hydrograph for MULBERRY
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 872 ft
Screen Interval*
(ft amsl):
729 to 572
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

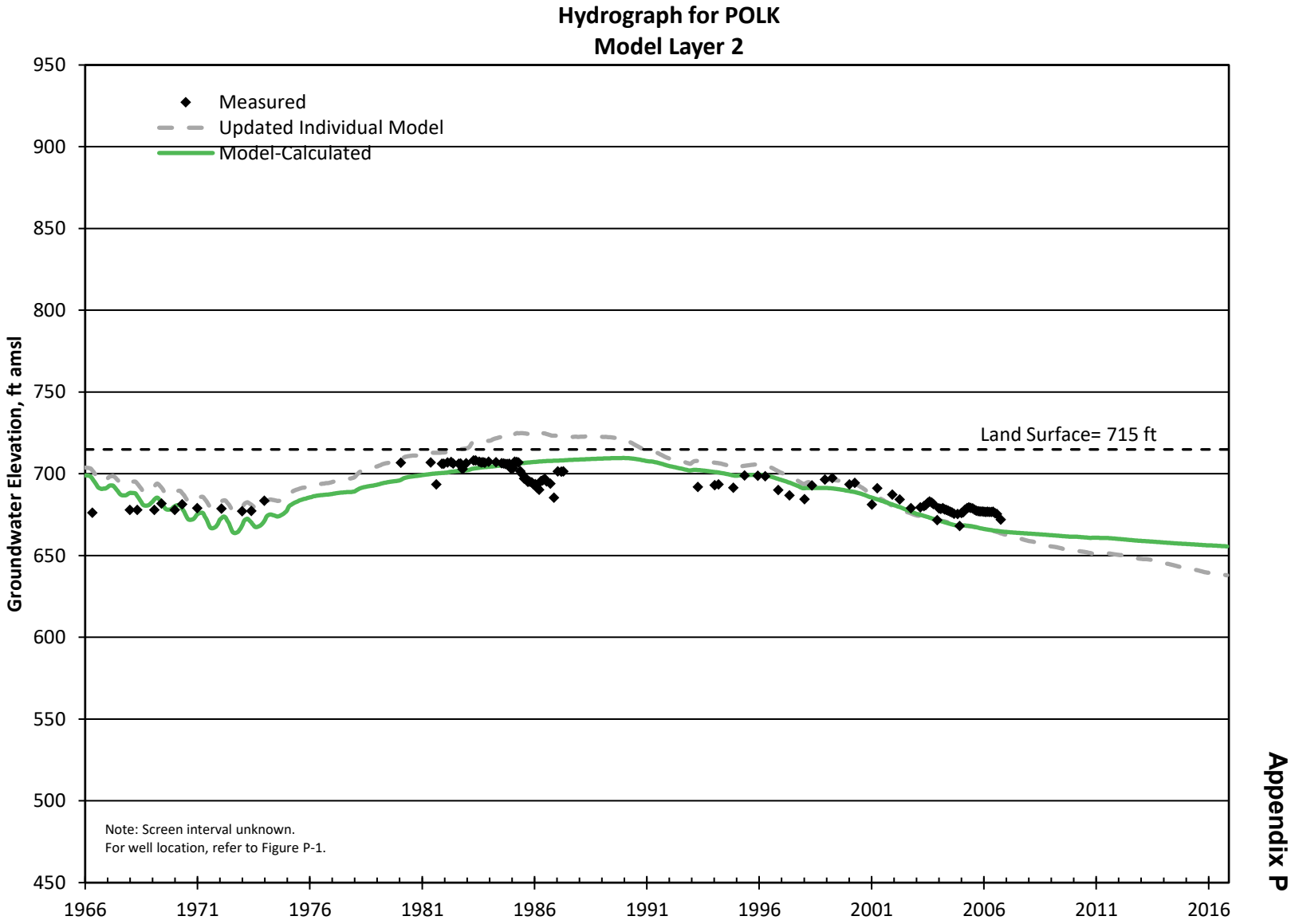
Appendix P


Hydrograph for ORANGE ACRES
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 879 ft
Screen Interval*
(ft amsl):
755 to 741
729 to 711
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

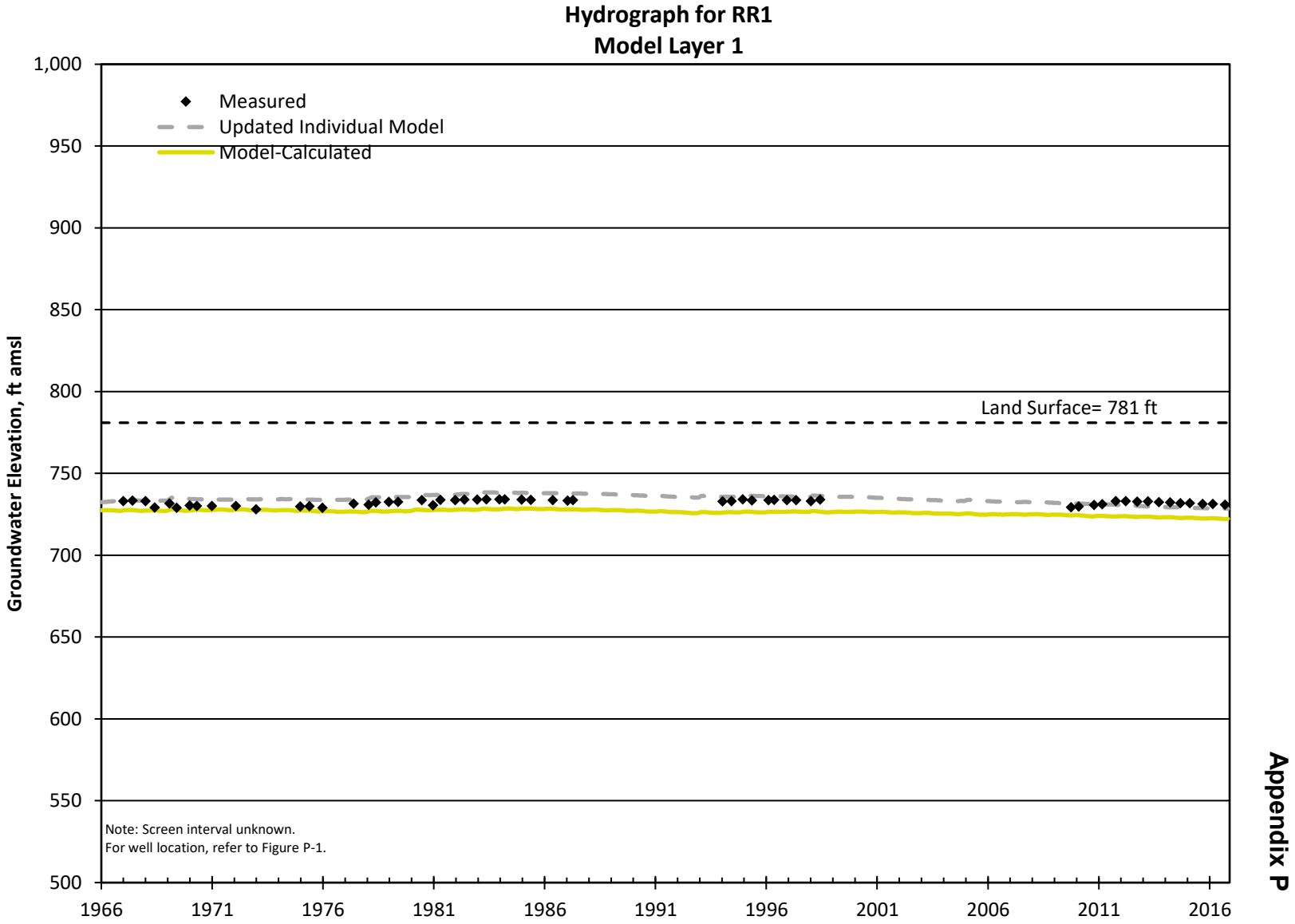
Appendix P


Hydrograph for PALMYRITA 1
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 892 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
700 to 666
660 to 648
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

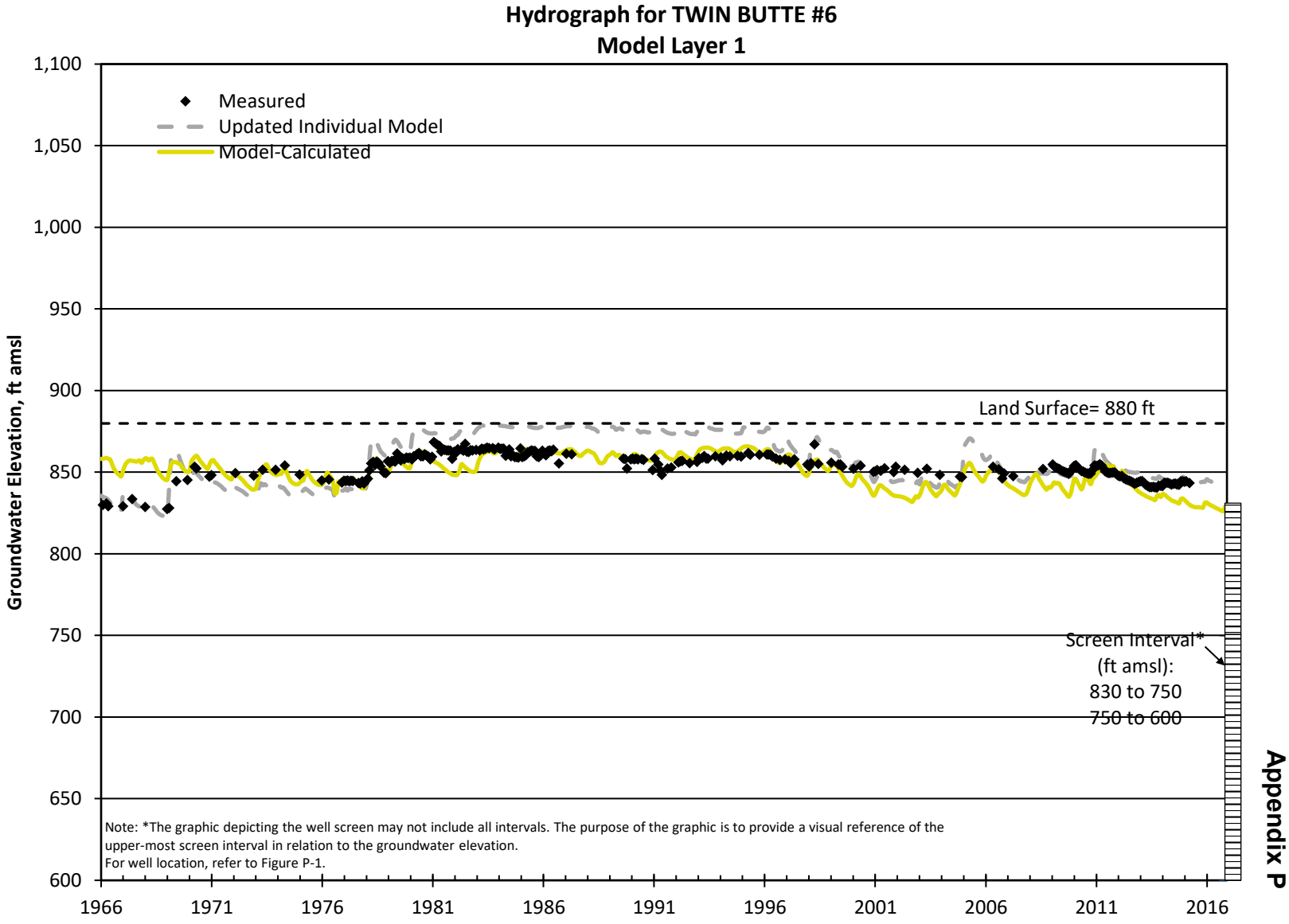
Appendix P

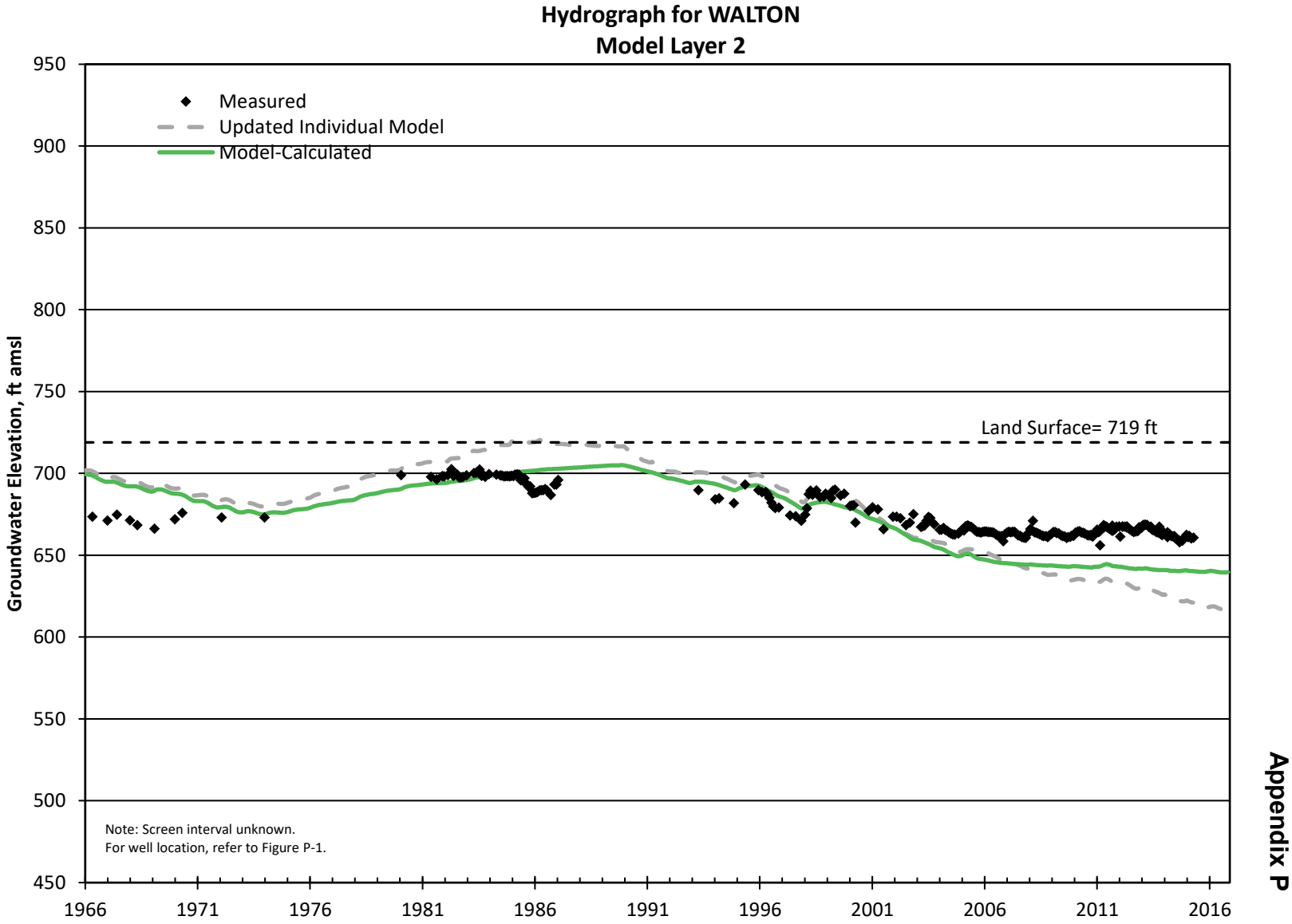

Hydrograph for POLK
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 715 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

Appendix P

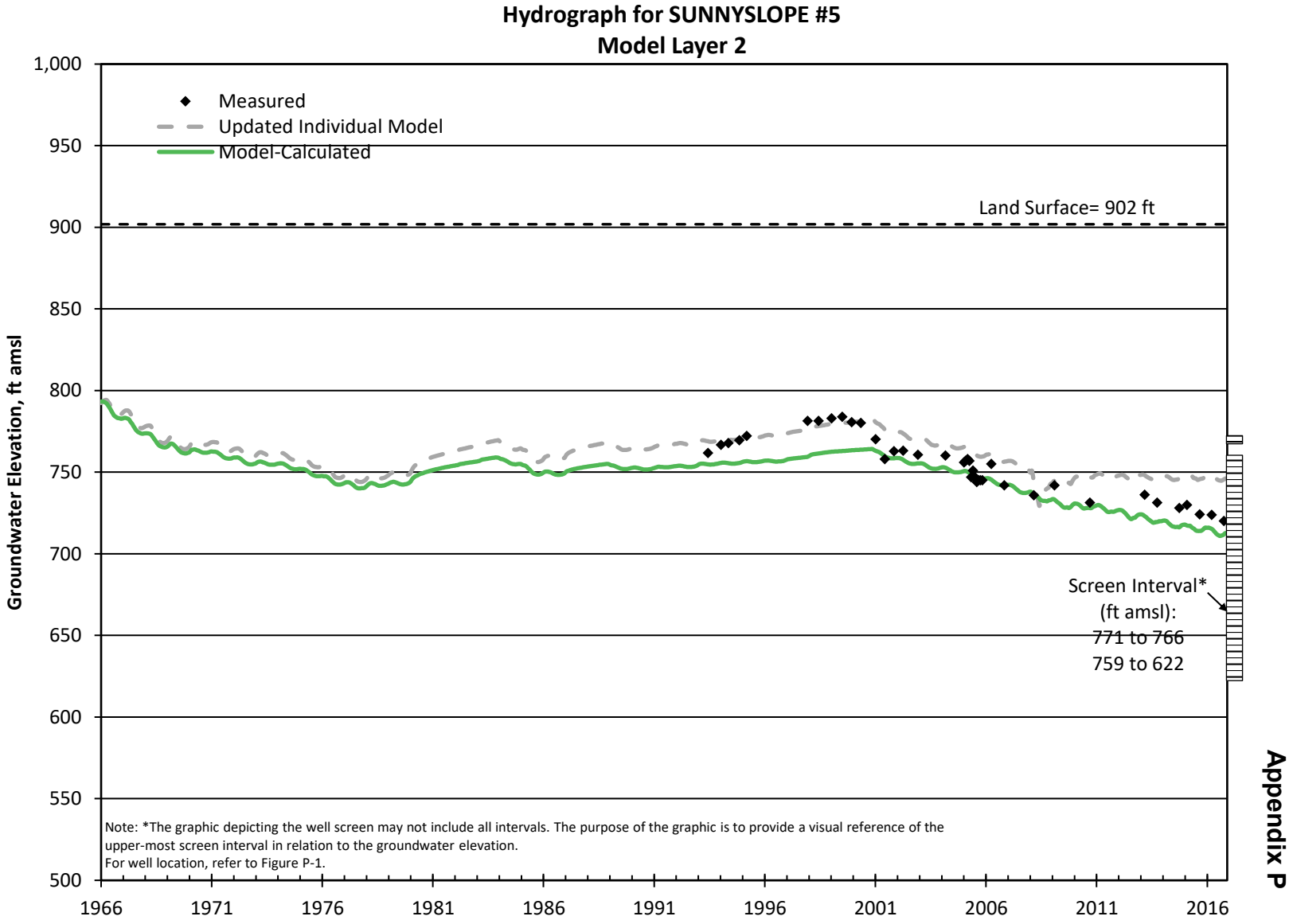

Hydrograph for RR1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 781 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

Appendix P

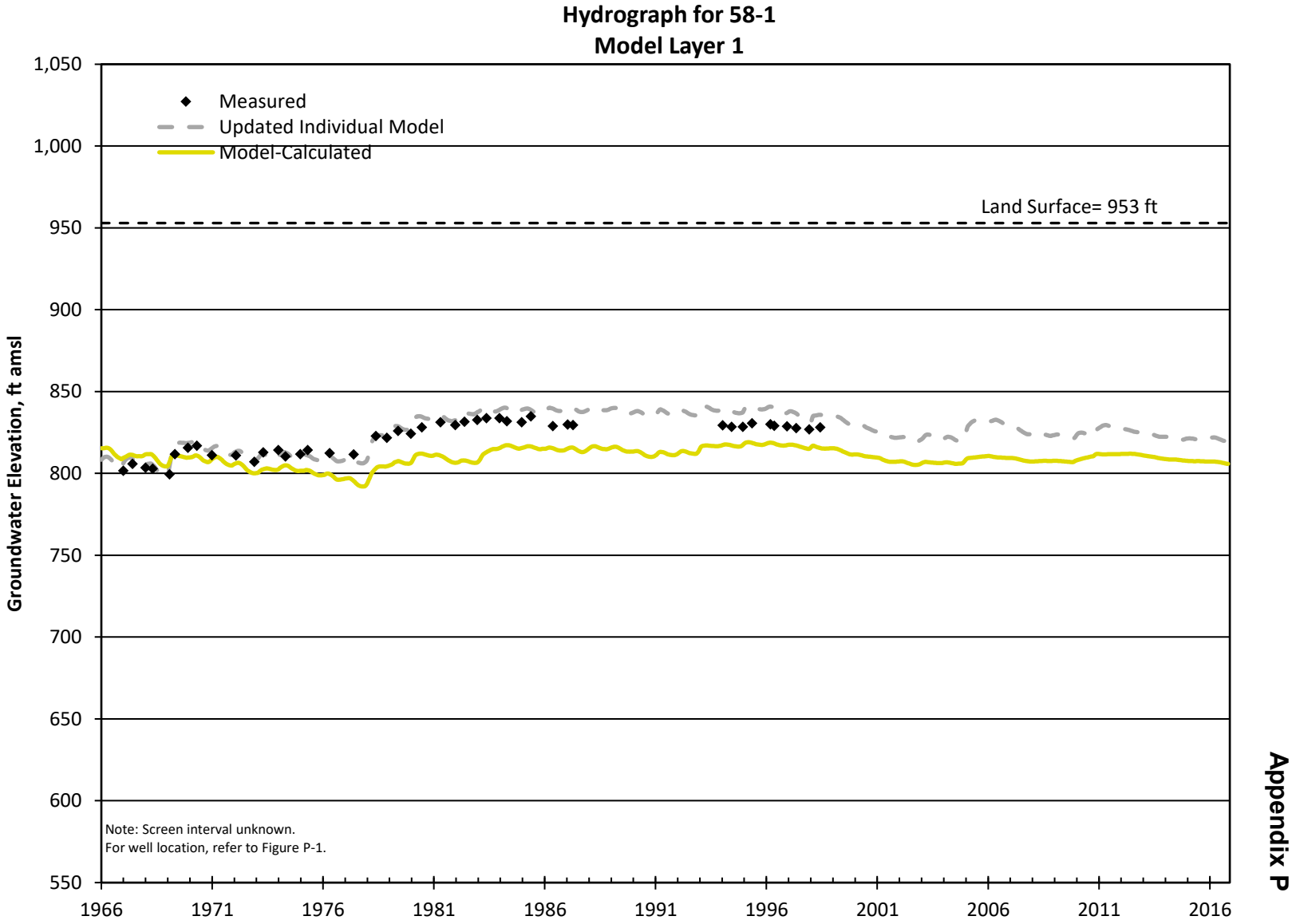

Hydrograph for TWIN BUTTE #6
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 880 ft
Screen Interval*
(ft amsl):
830 to 750
750 to 600
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.
Appendix P


Hydrograph for WALTON
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 719 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

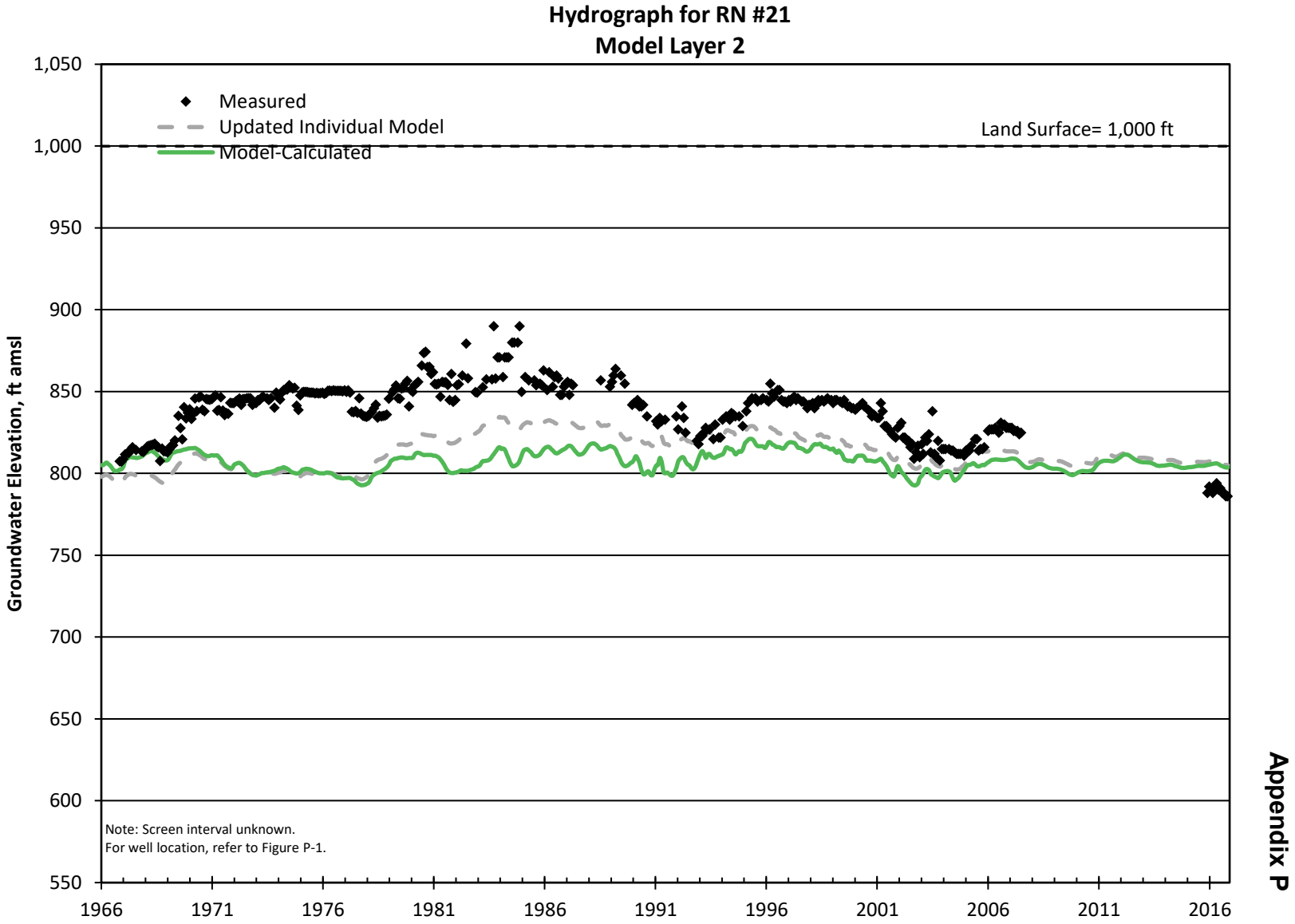
Appendix P


Hydrograph for SUNNYSLOPE #5
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 902 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
771 to 766
759 to 622
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

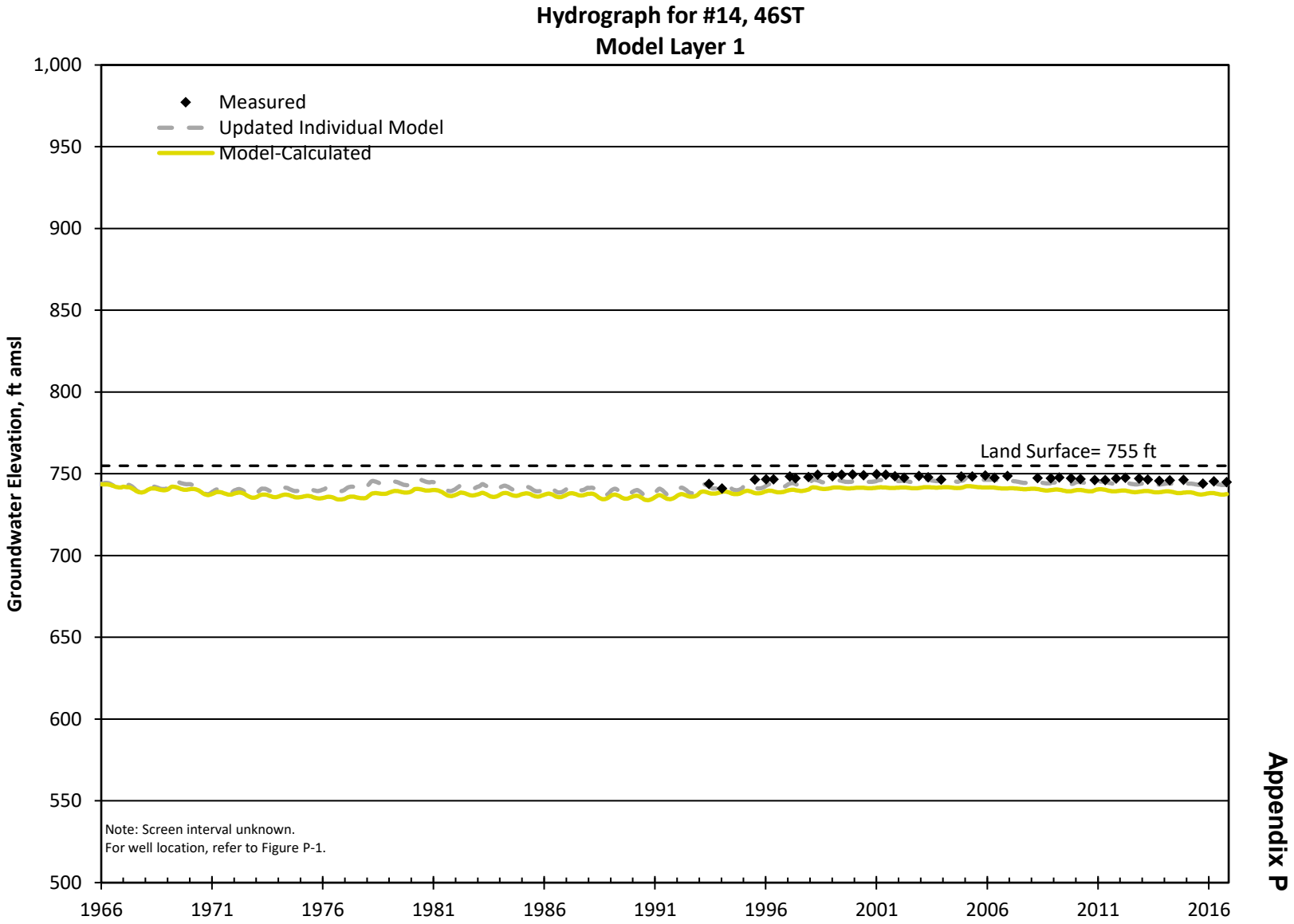
Appendix P


Hydrograph for 58-1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 953 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

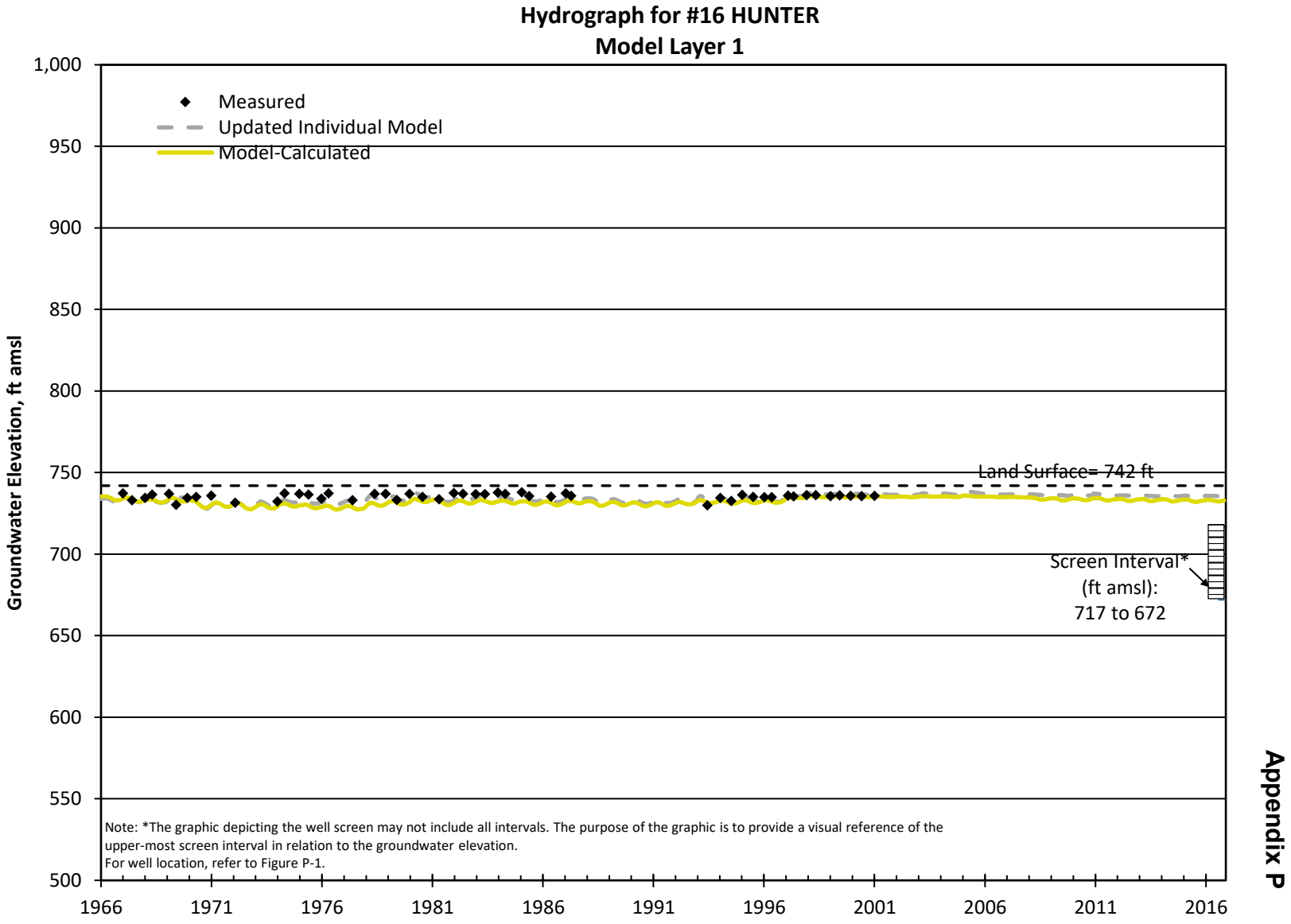
Appendix P


Hydrograph for RN #21
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,000 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

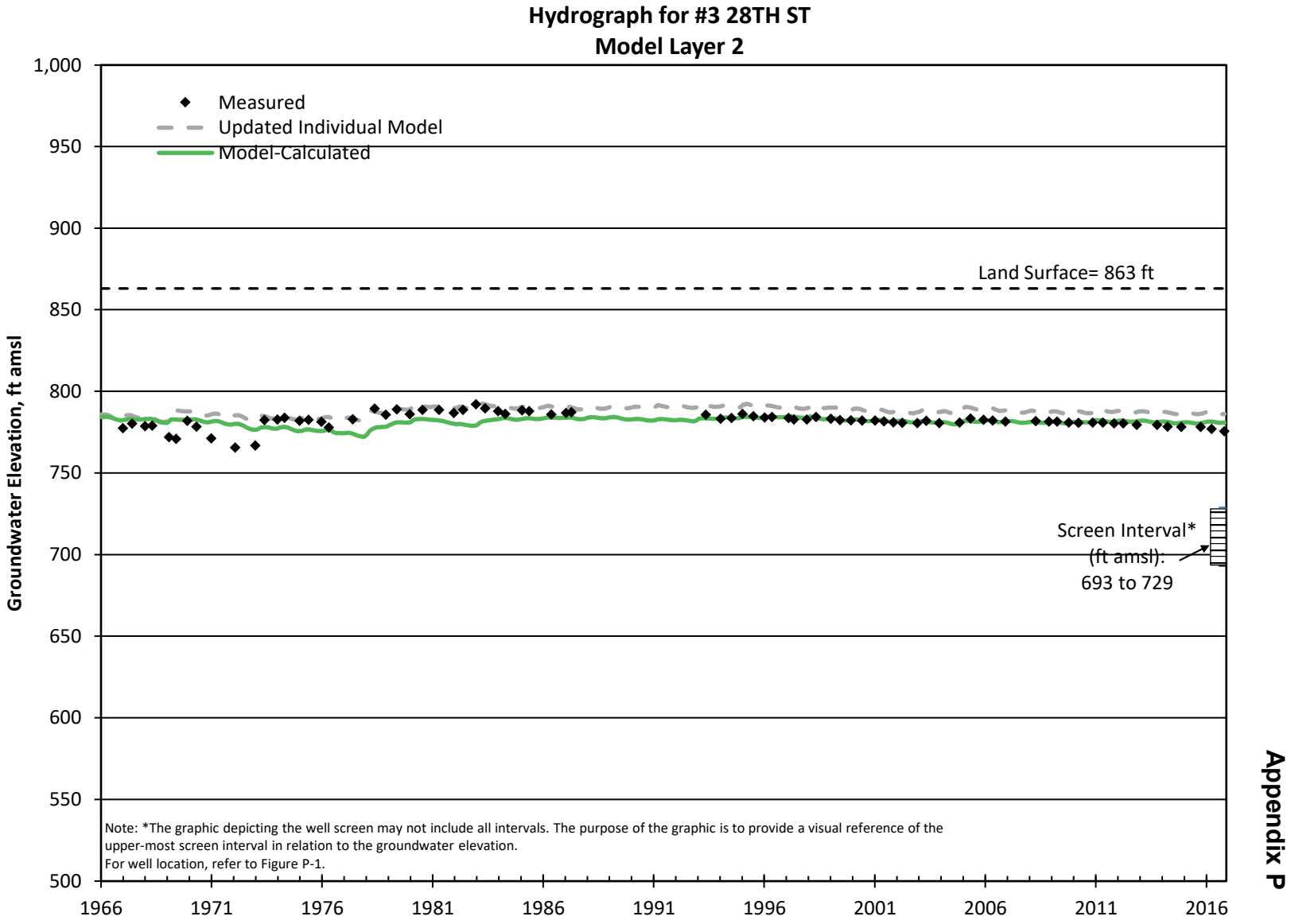
Appendix P


Hydrograph for #14, 46ST
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 755 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

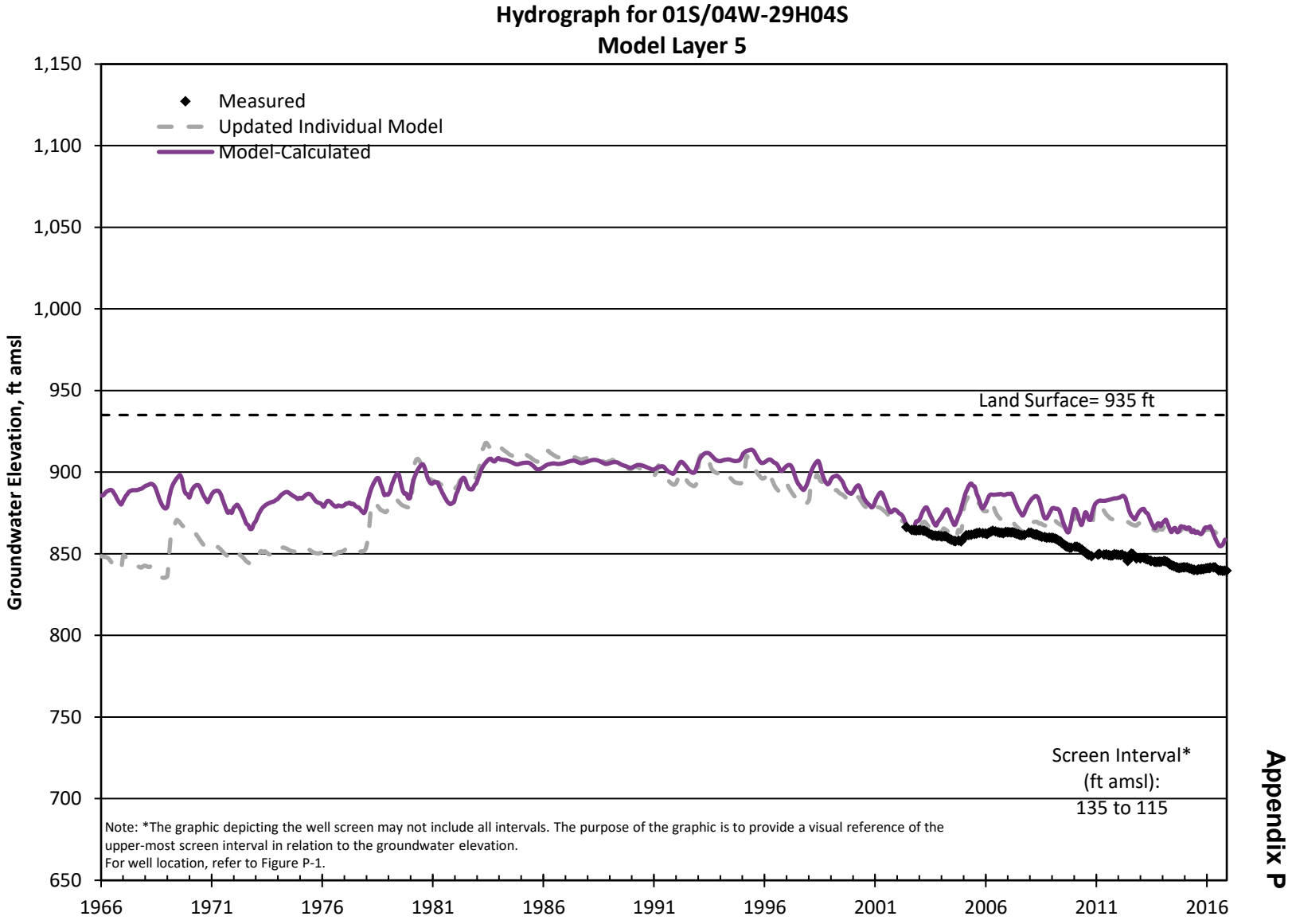
Appendix P


Hydrograph for #16 HUNTER
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 742 ft
Screen Interval*
(ft amsl):
717 to 672
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

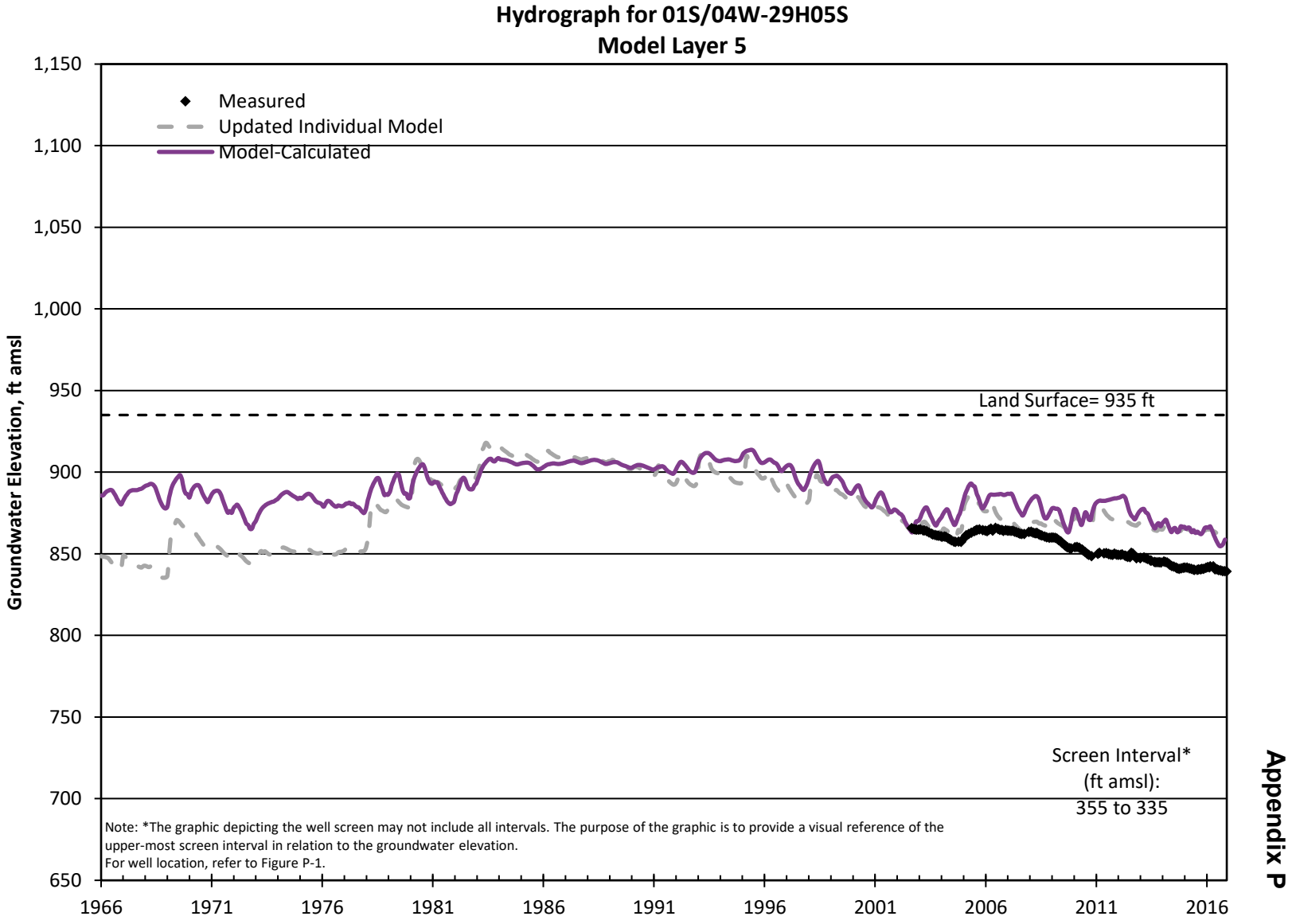
Appendix P


Hydrograph for #3 28TH ST
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

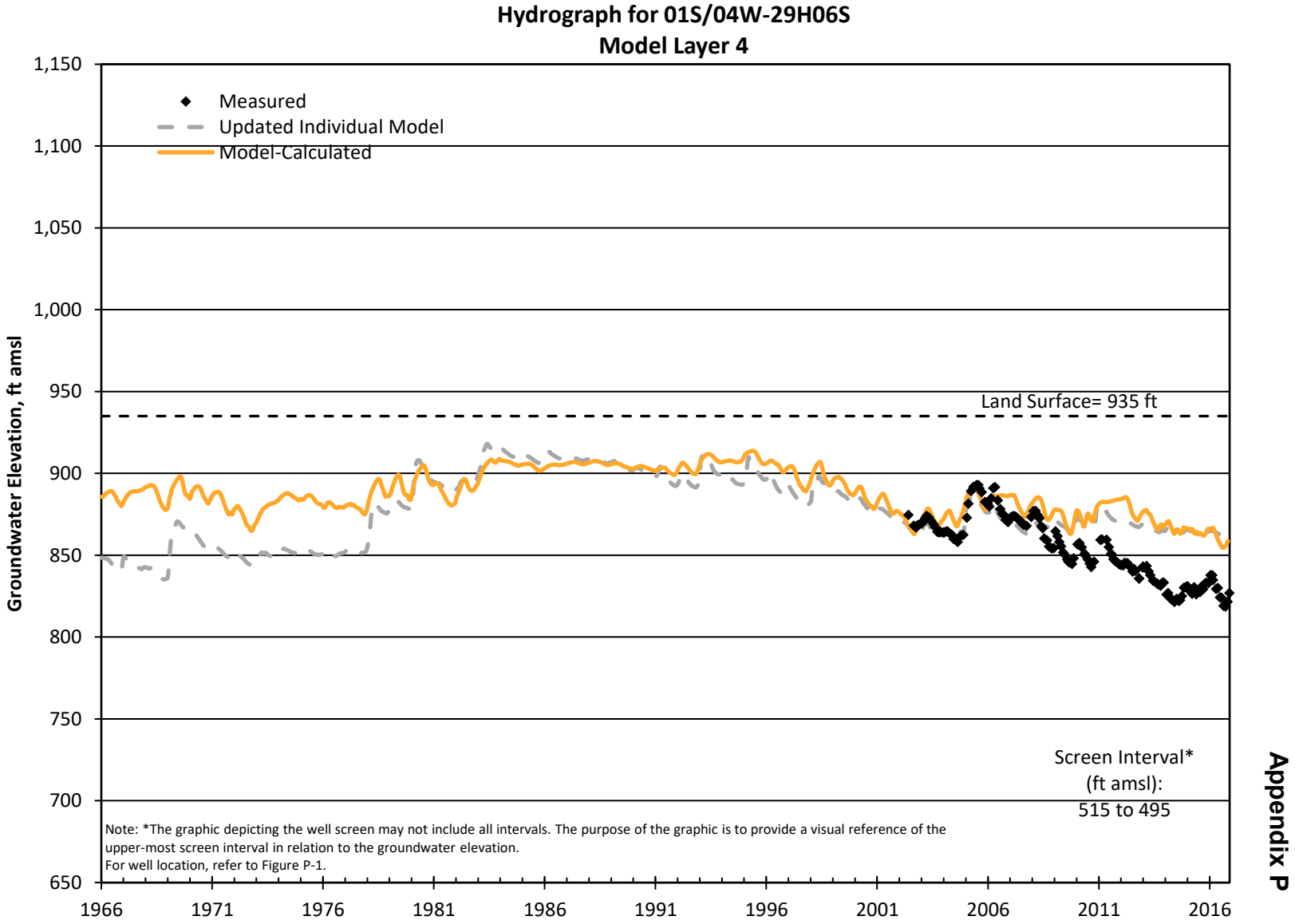
Appendix P


Hydrograph for 01S/04W-29H04S
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 935 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
135 to 115
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

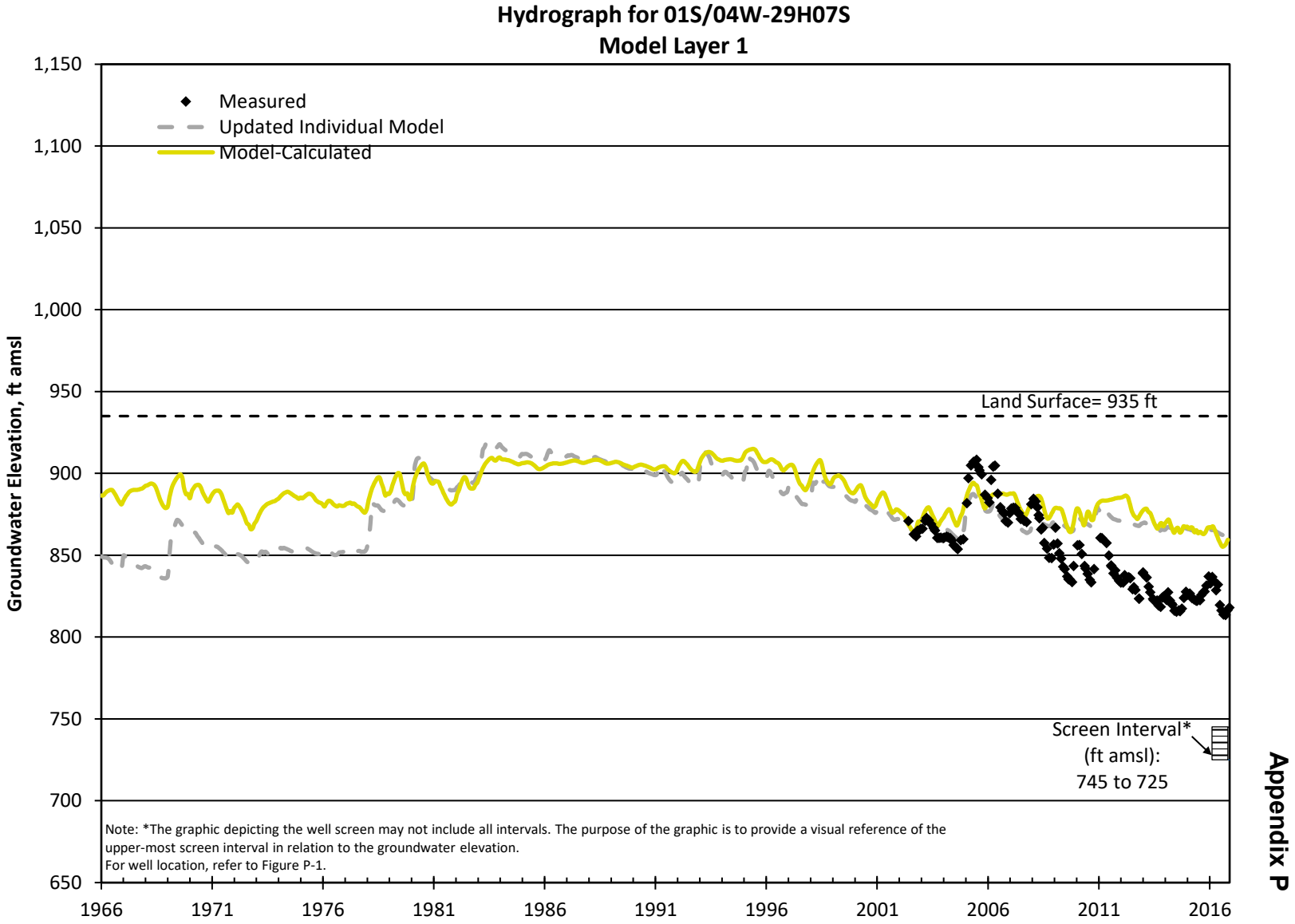
Appendix P


Hydrograph for 01S/04W-29H05S
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 935 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
355 to 335
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

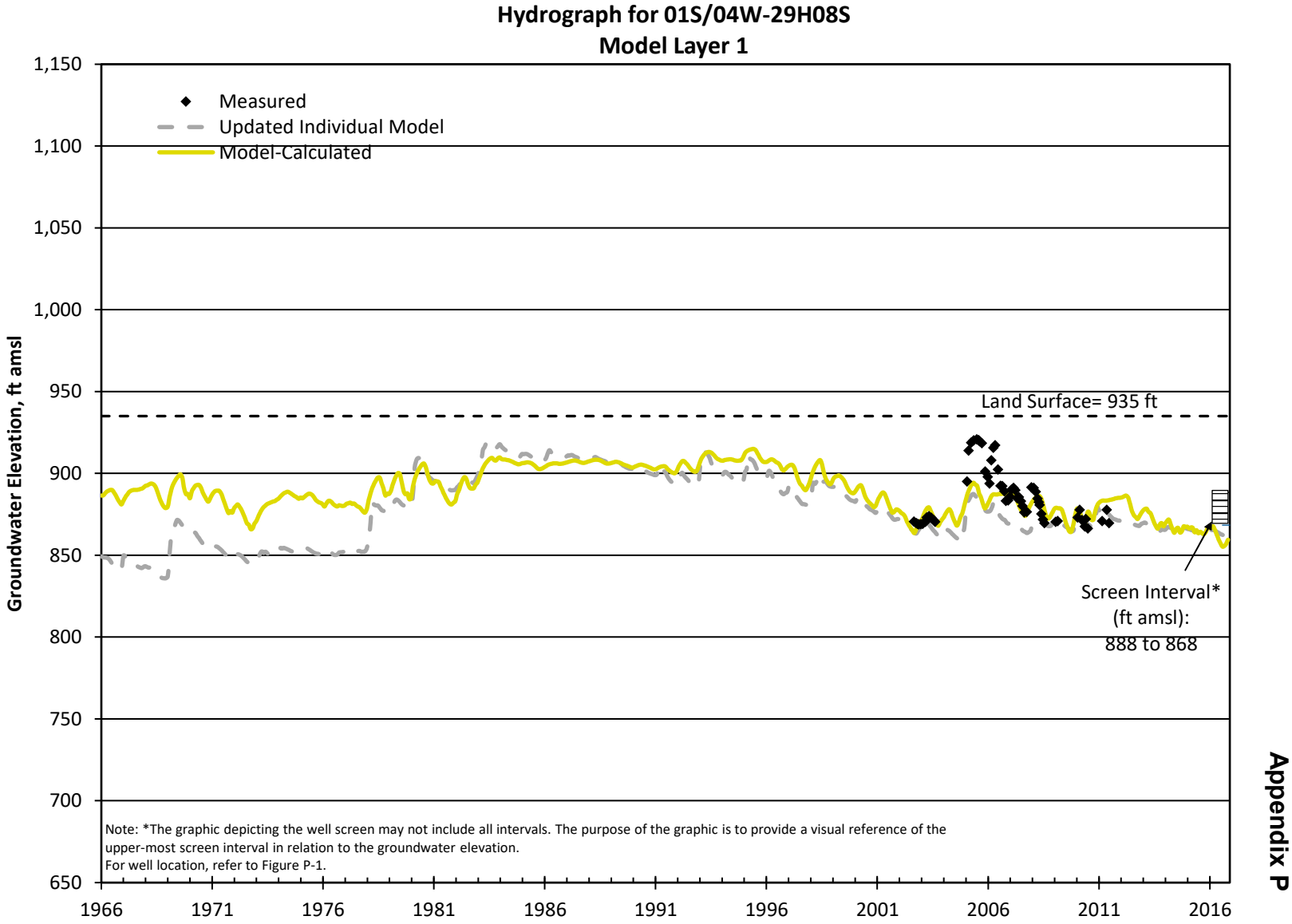
Appendix P


Hydrograph for 01S/04W-29H06S
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 935 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
515 to 495
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

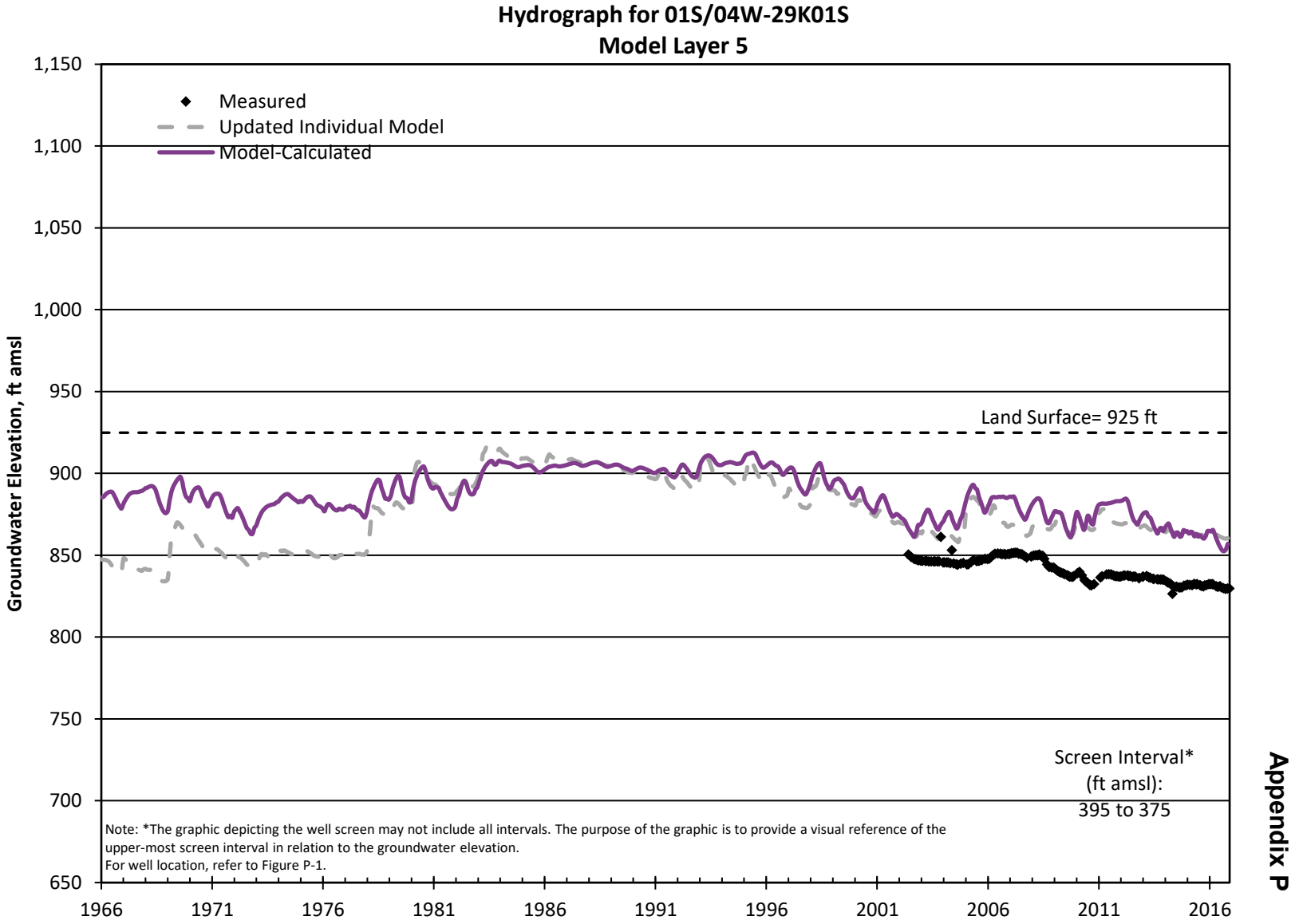
Appendix P


Hydrograph for 01S/04W-29H07S
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 935 ft
Screen Interval*
(ft amsl):
745 to 725
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

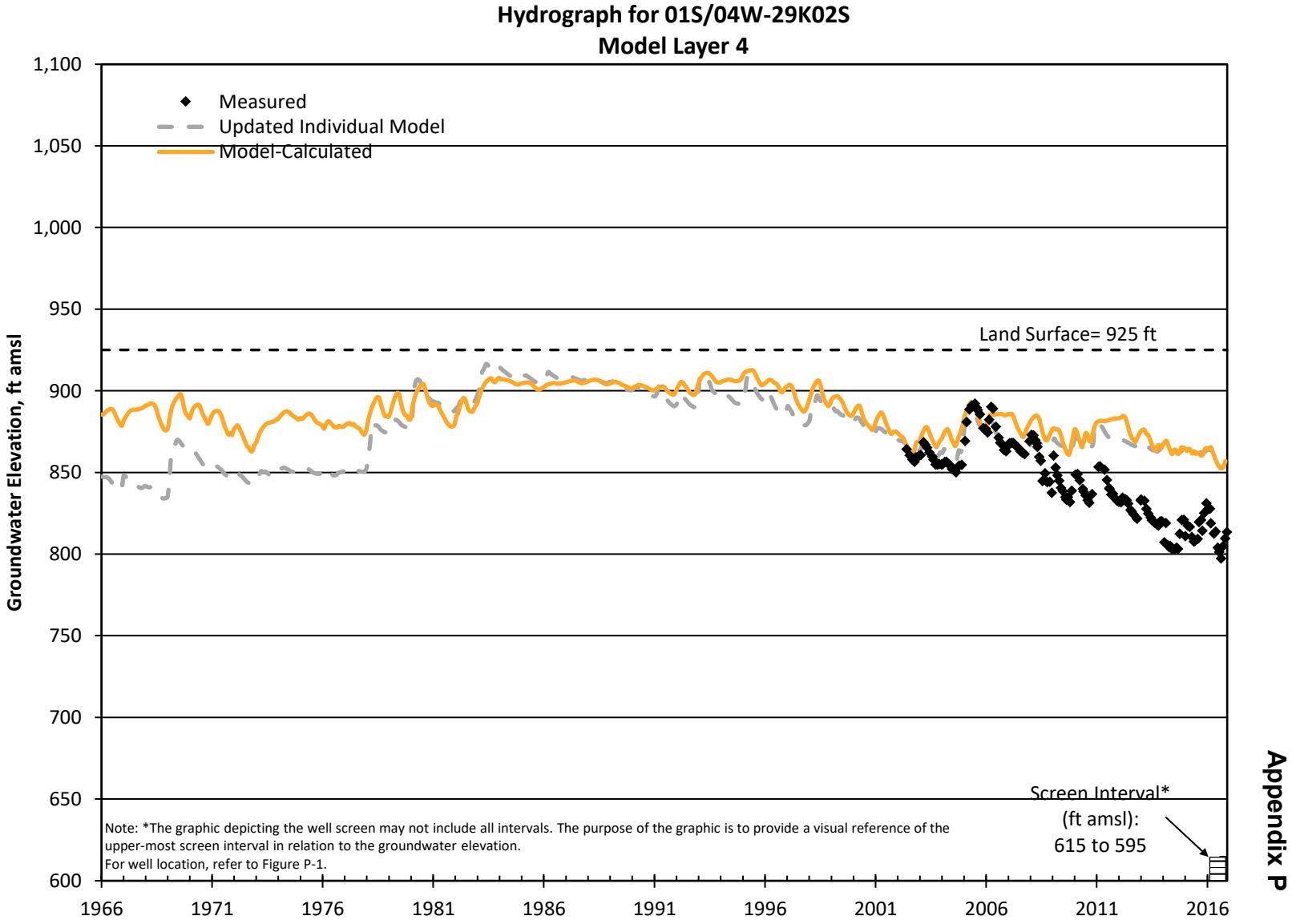
Appendix P


Hydrograph for 01S/04W-29H08S
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 935 ft
Screen Interval*
(ft amsl):
888 to 868
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

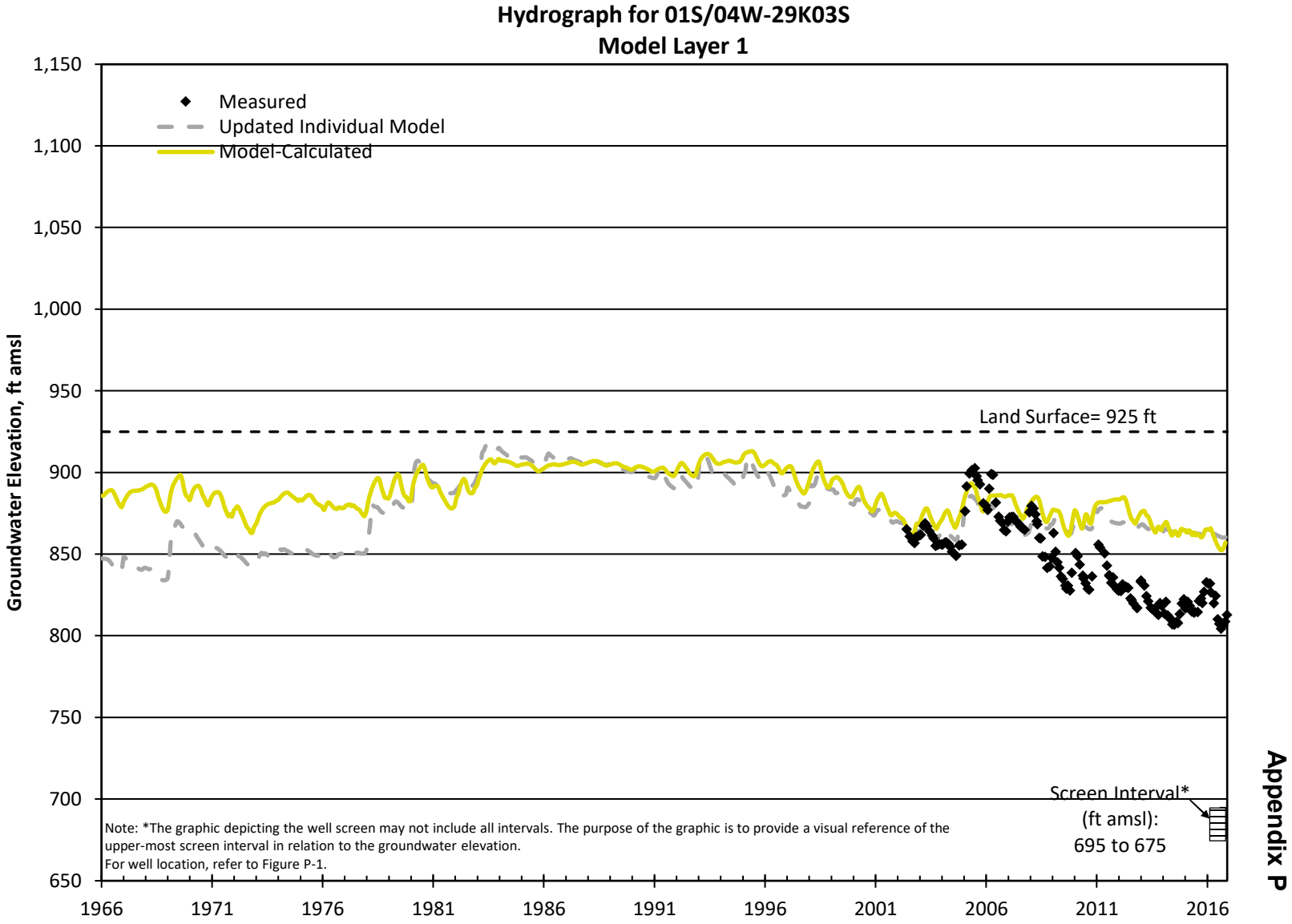
Appendix P


Hydrograph for 01S/04W-29K01S
Model Layer 5
Measured
Updated Individual Model
Model-Calculated
Land Surface= 925 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
395 to 375
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

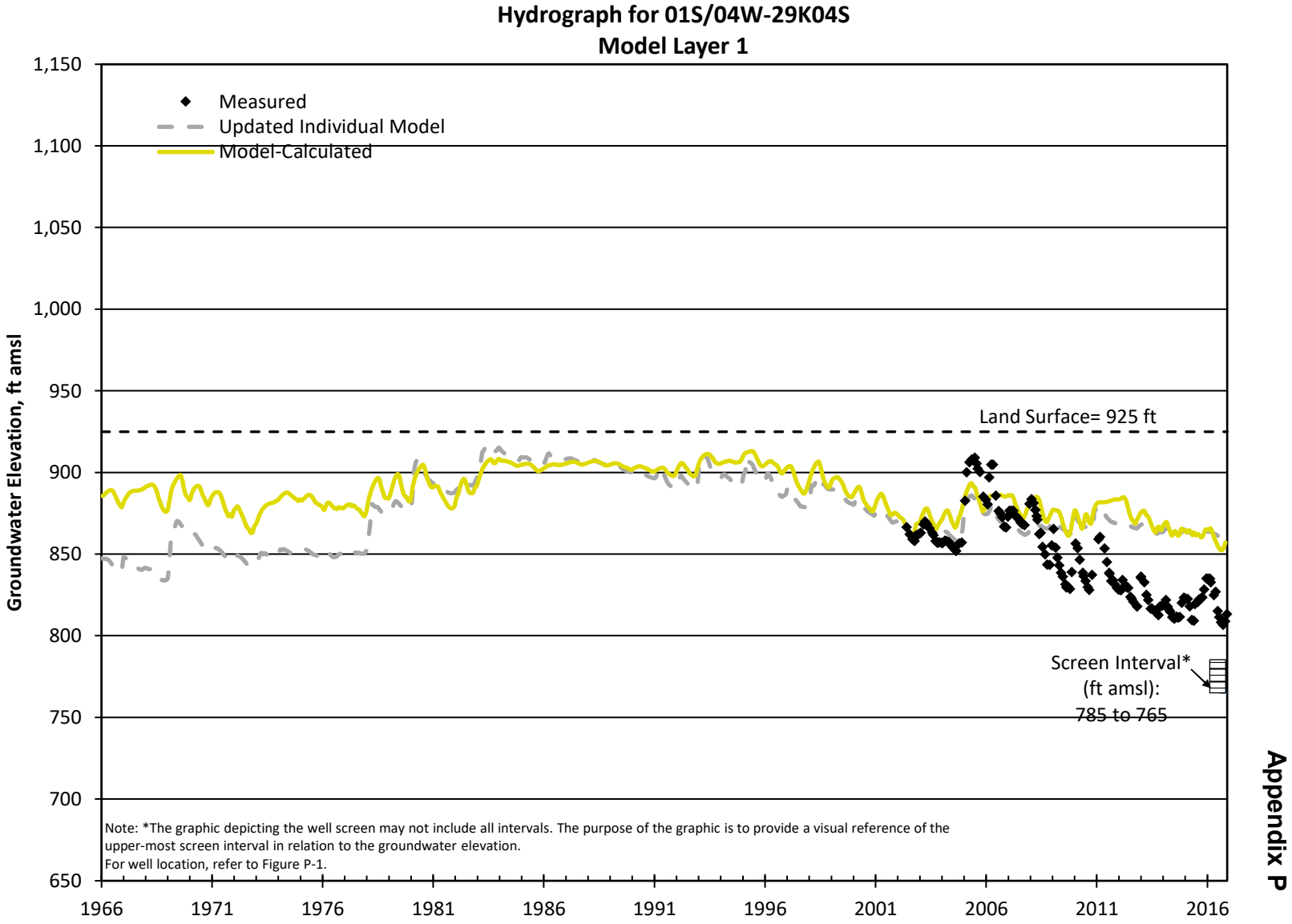
Appendix P


Hydrograph for 01S/04W-29K02S
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 925 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
615 to 595
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

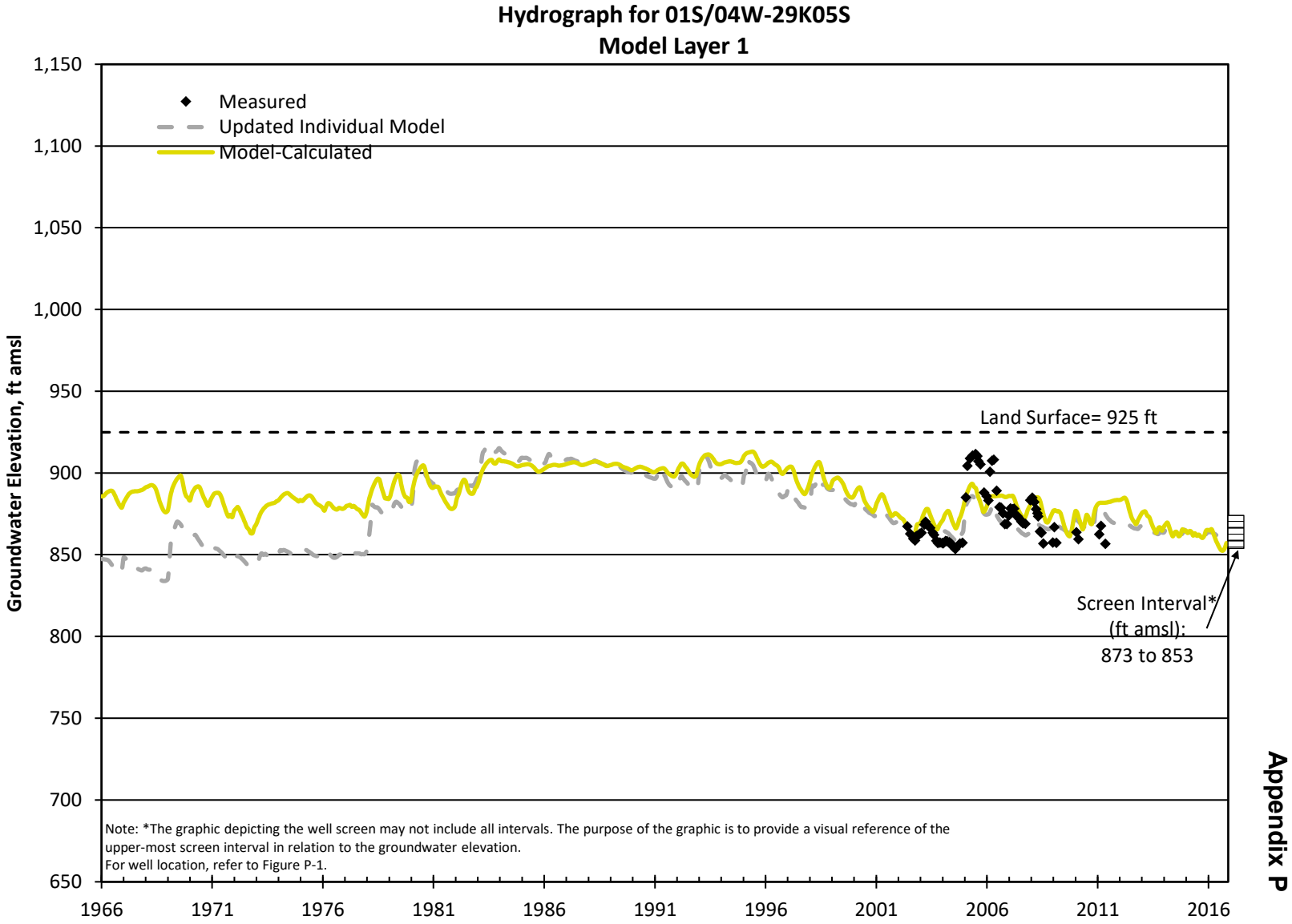
Appendix P


Hydrograph for 01S/04W-29K03S
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 925 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
695 to 675
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

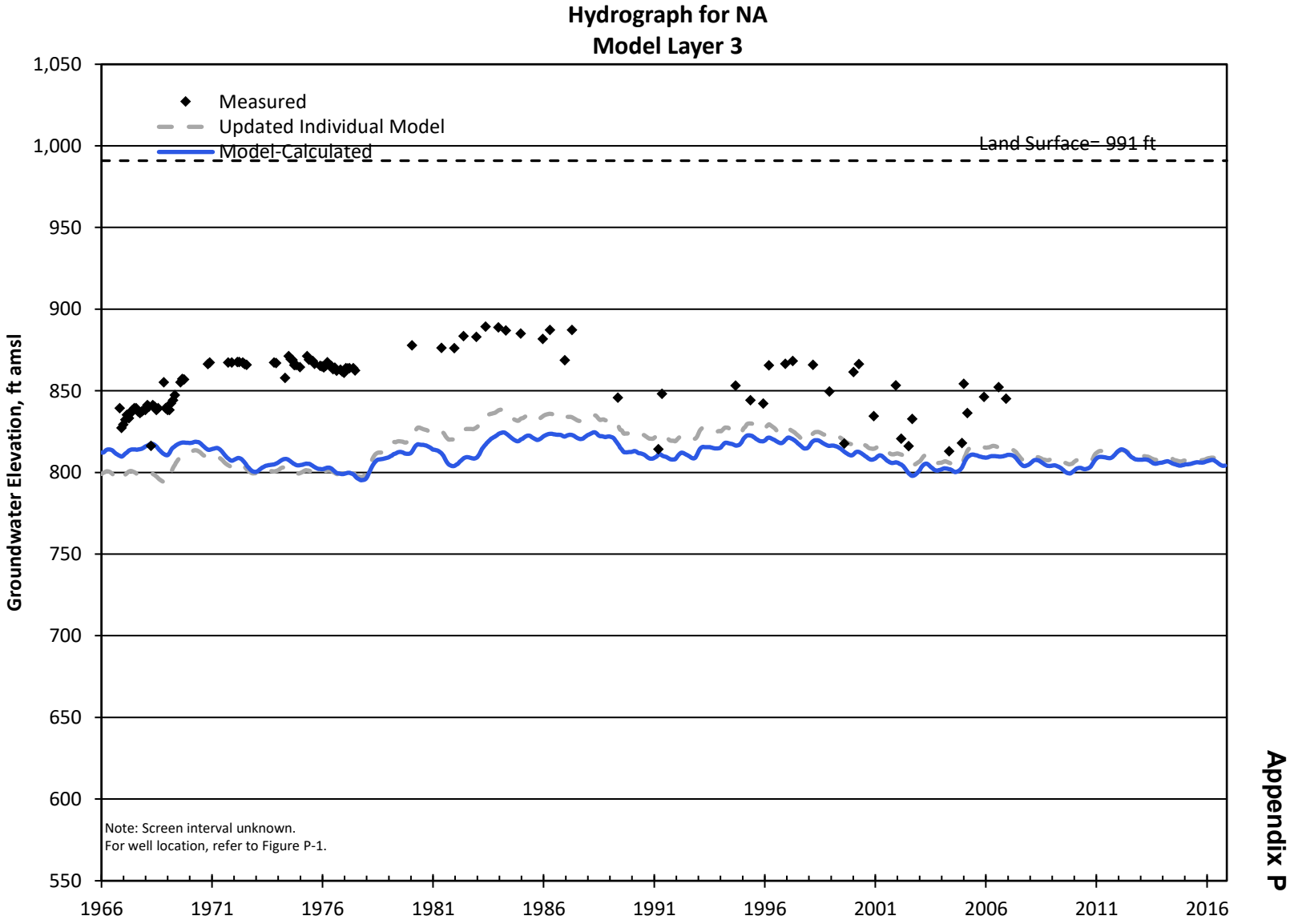
Appendix P


Hydrograph for 01S/04W-29K04S
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 925 ft
Screen Interval*
(ft amsl):
785 to 765
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

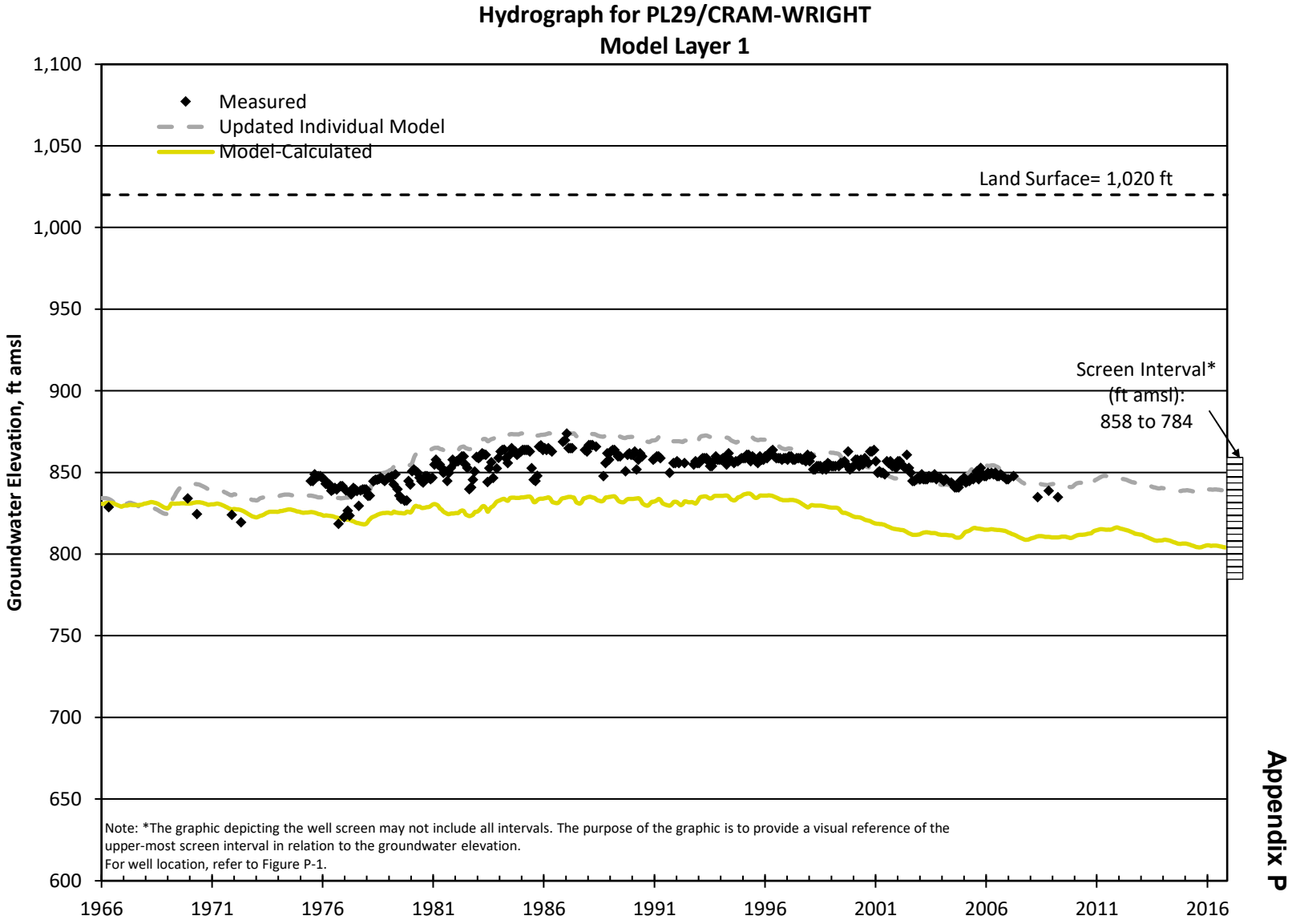
Appendix P


Hydrograph for 01S/04W-29K05S
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Land Surface= 925 ft
Screen Interval*
(ft amsl):
873 to 853
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

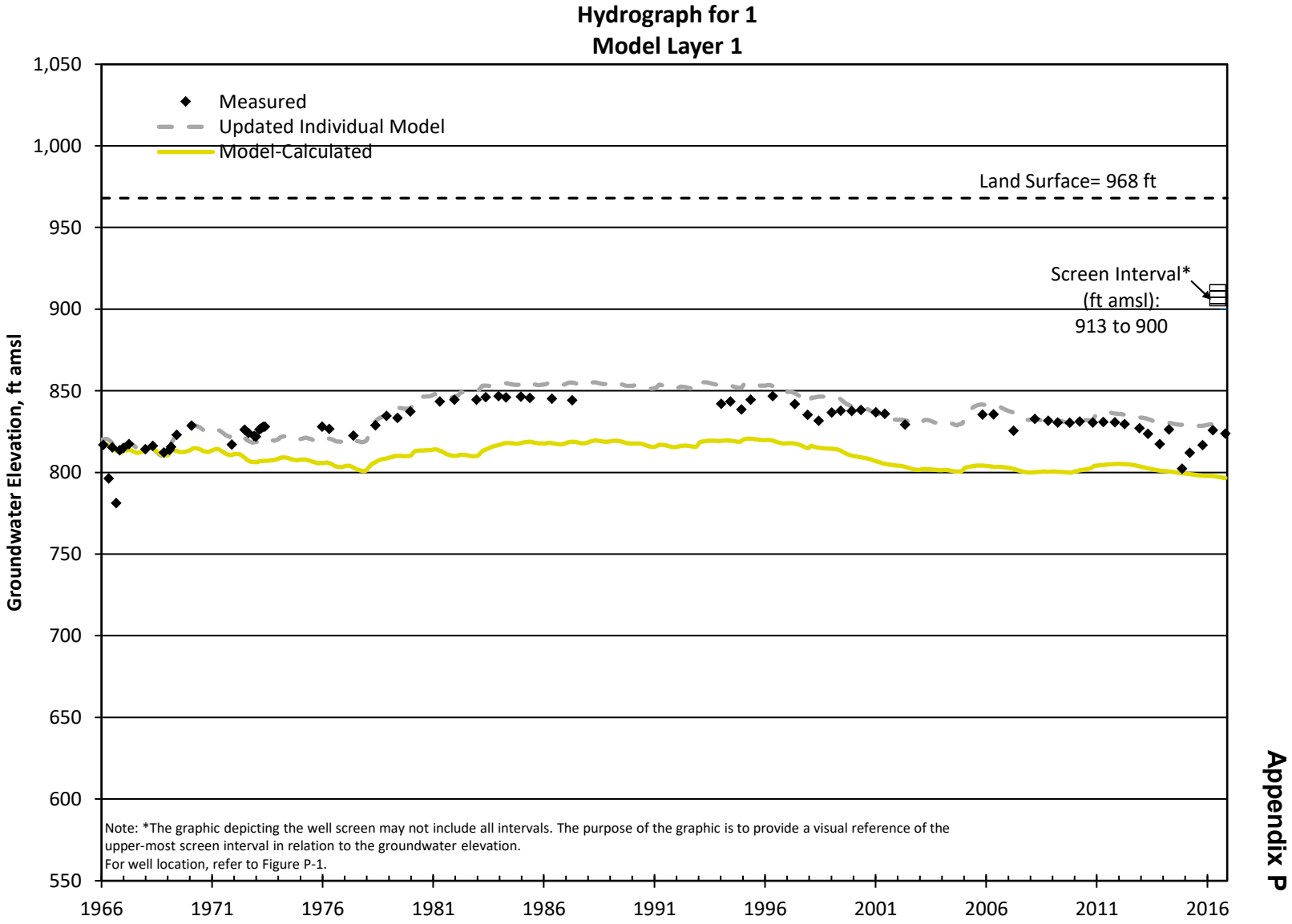
Appendix P


Hydrograph for NA
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 991 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

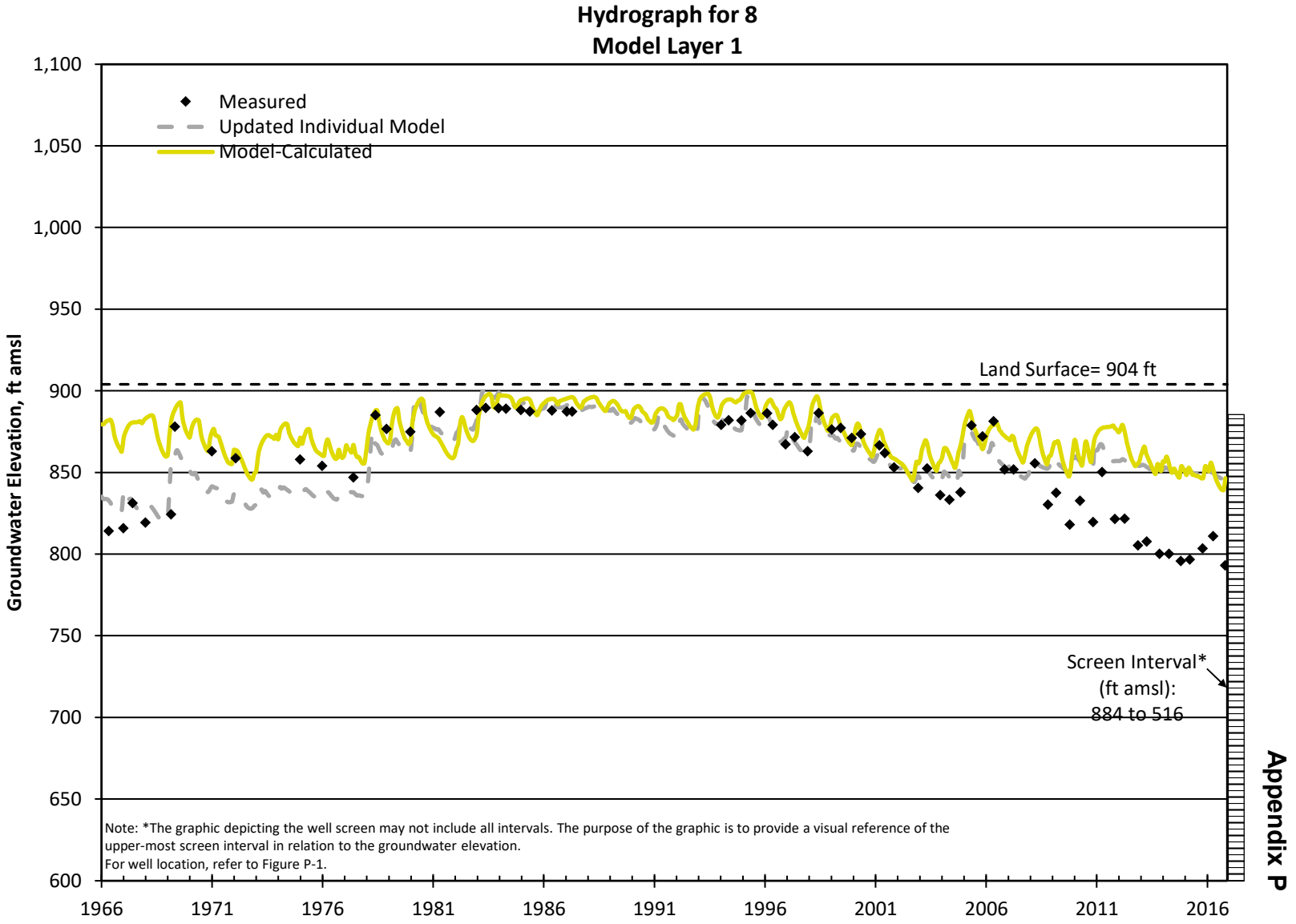
Appendix P

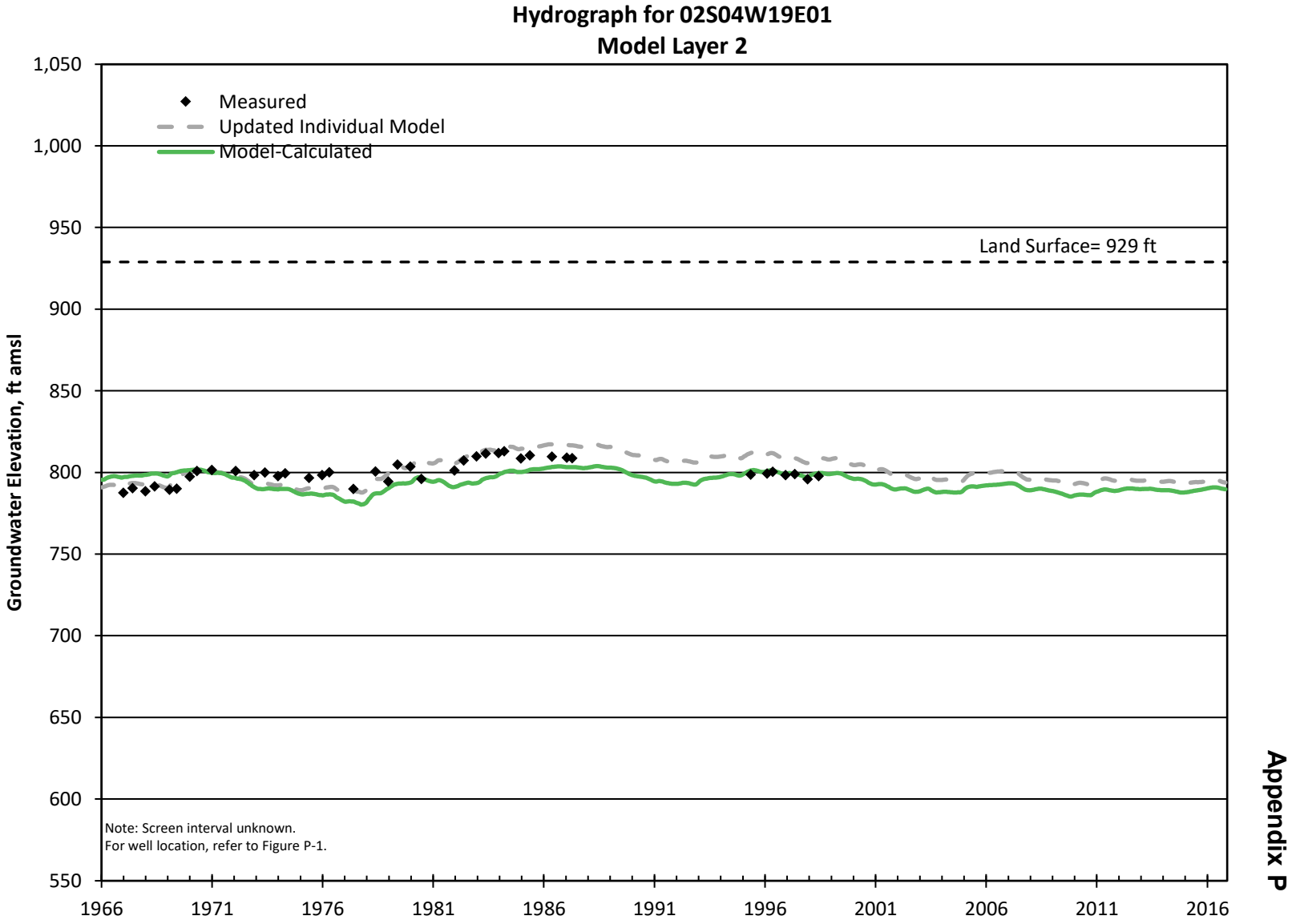

Hydrograph for PL29/CRAM-WRIGHT
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,020 ft
Screen Interval*
(ft amsl):
858 to 784
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

Appendix P

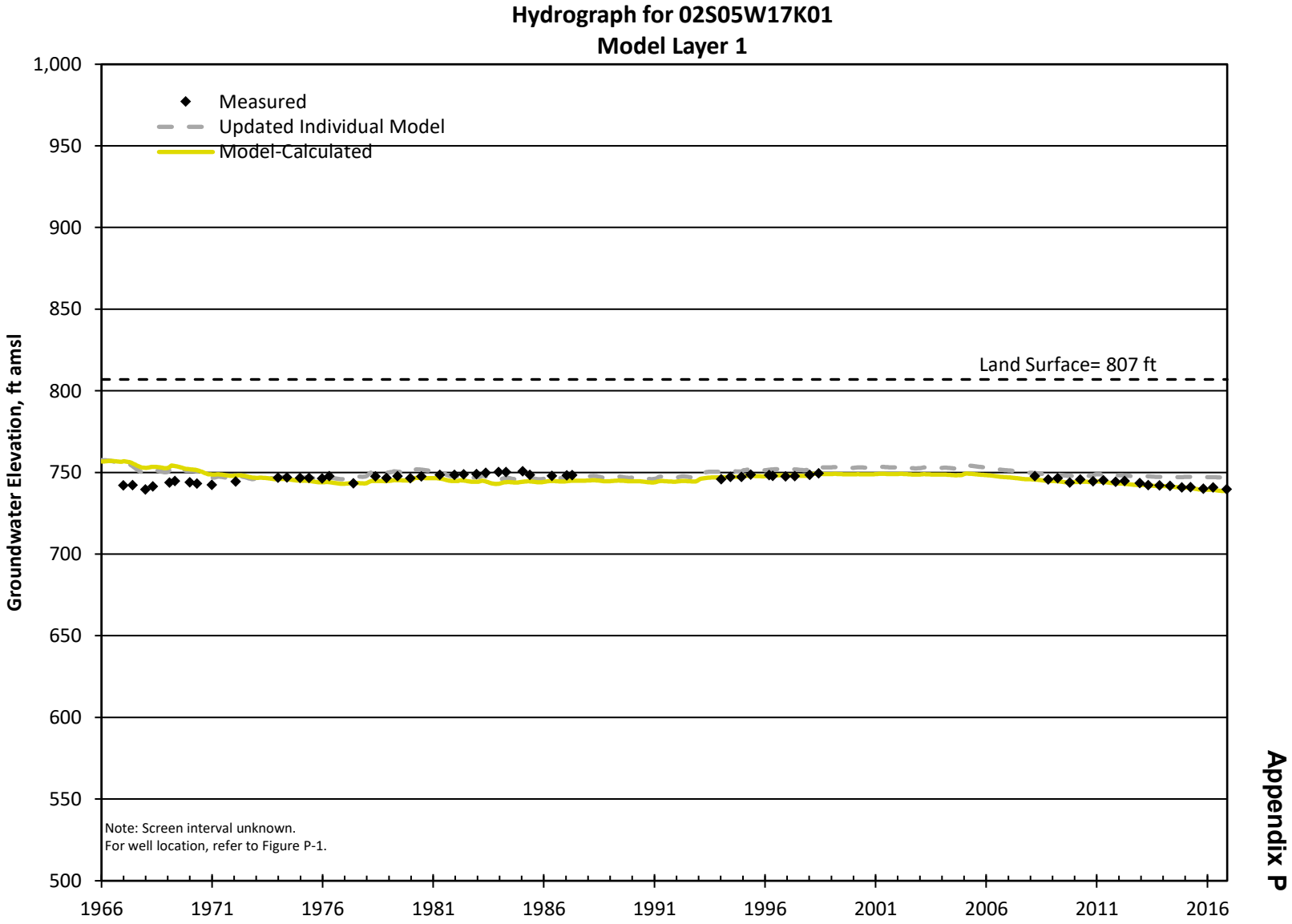

Hydrograph for 1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 968 ft
Screen Interval*
(ft amsl):
913 to 900
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

Appendix P

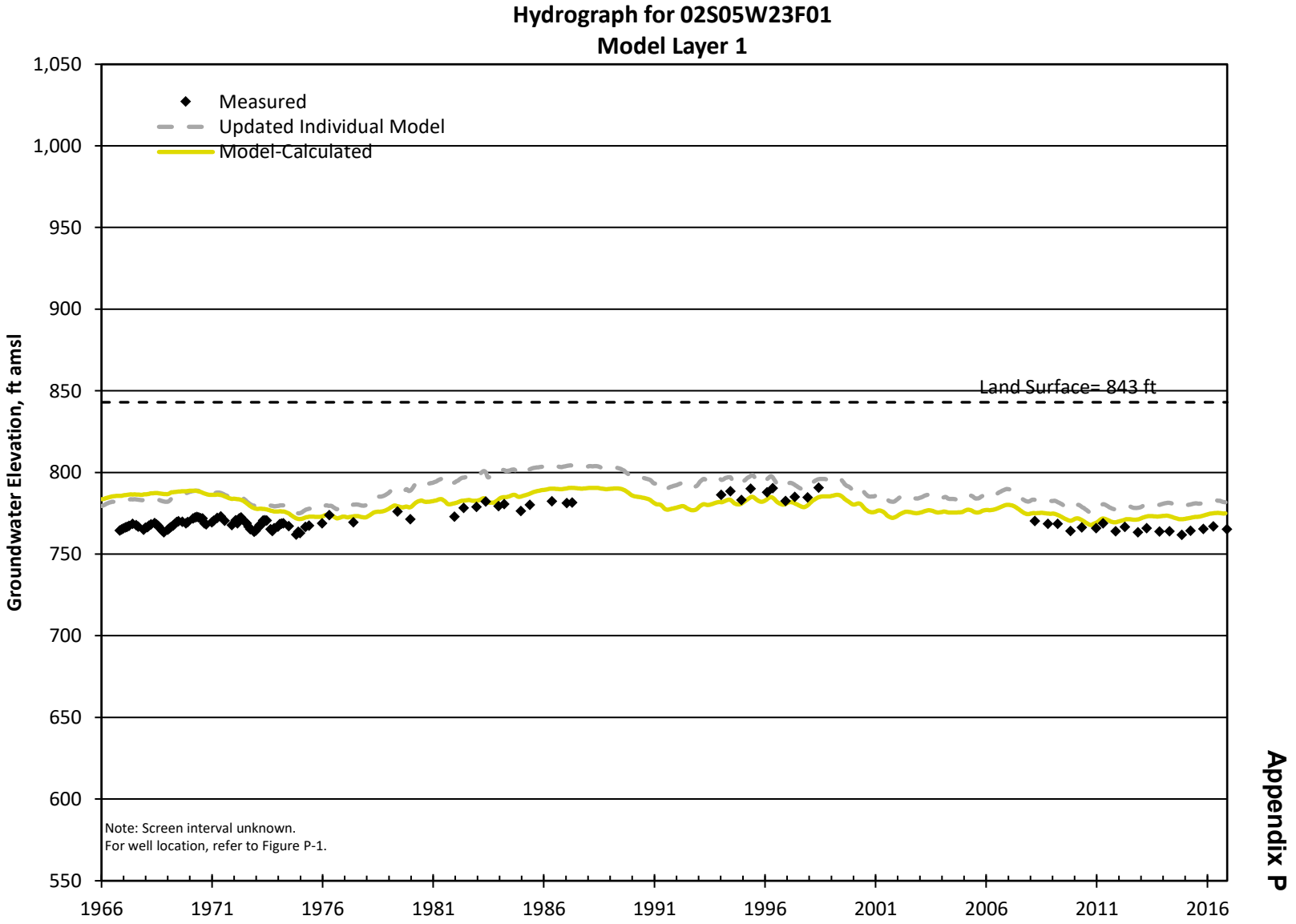

Hydrograph for 8
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 904 ft
Screen Interval*
(ft amsl):
884 to 516
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.
Appendix P


Hydrograph for 02S04W19E01
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 929 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

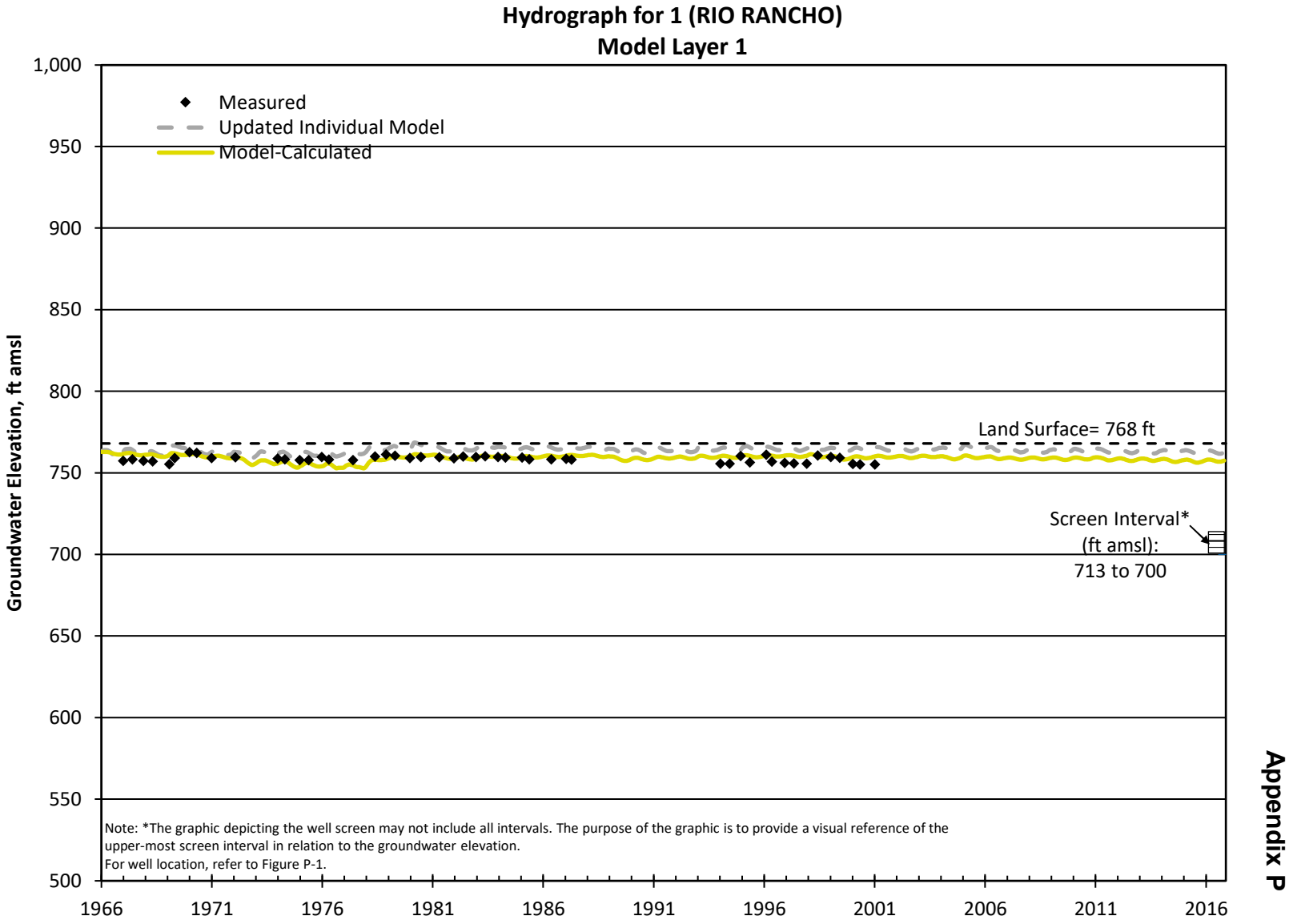
Appendix P


Hydrograph for 02S05W17K01
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 807 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

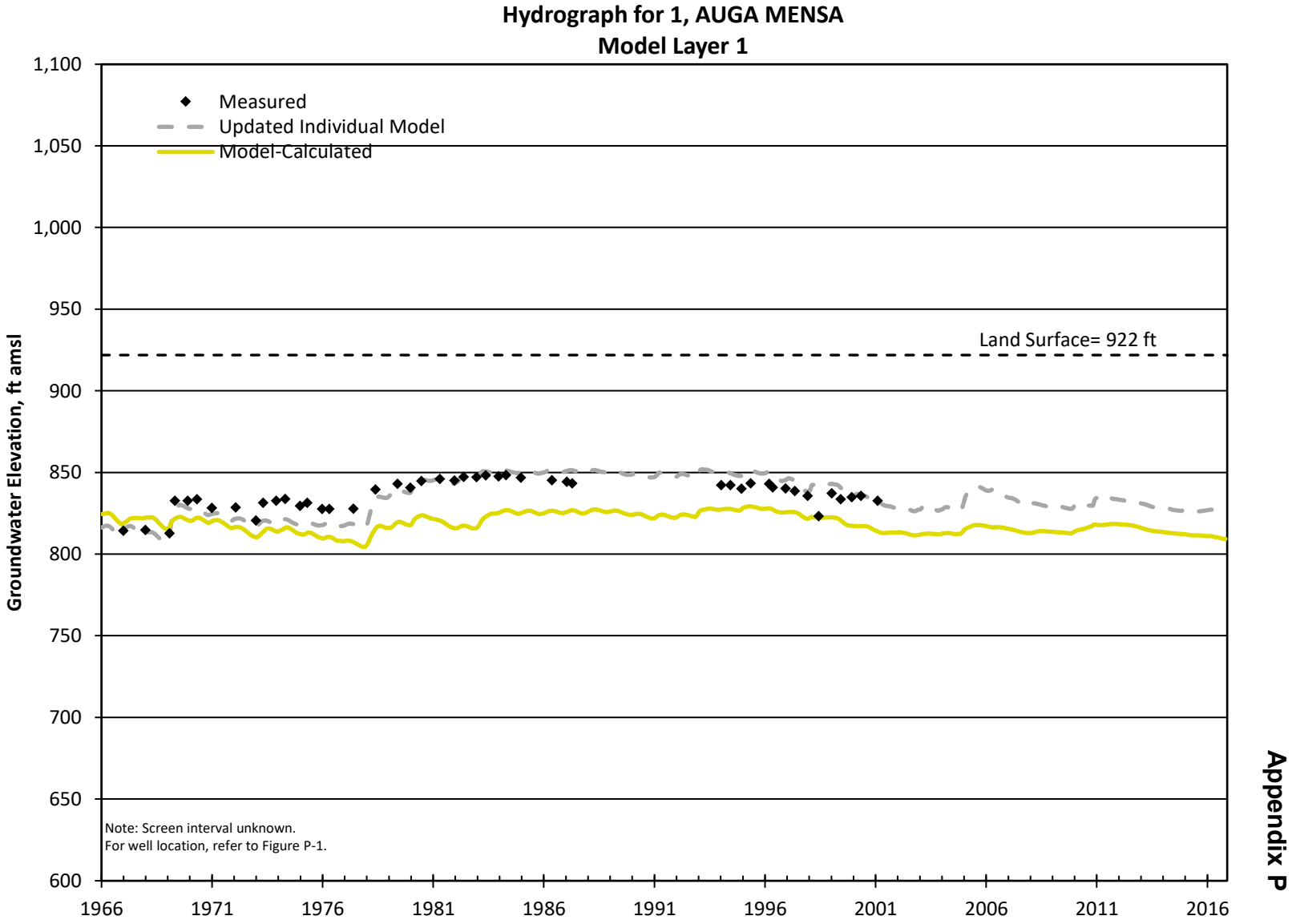
Appendix P


Hydrograph for 02S05W23F01
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 843 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

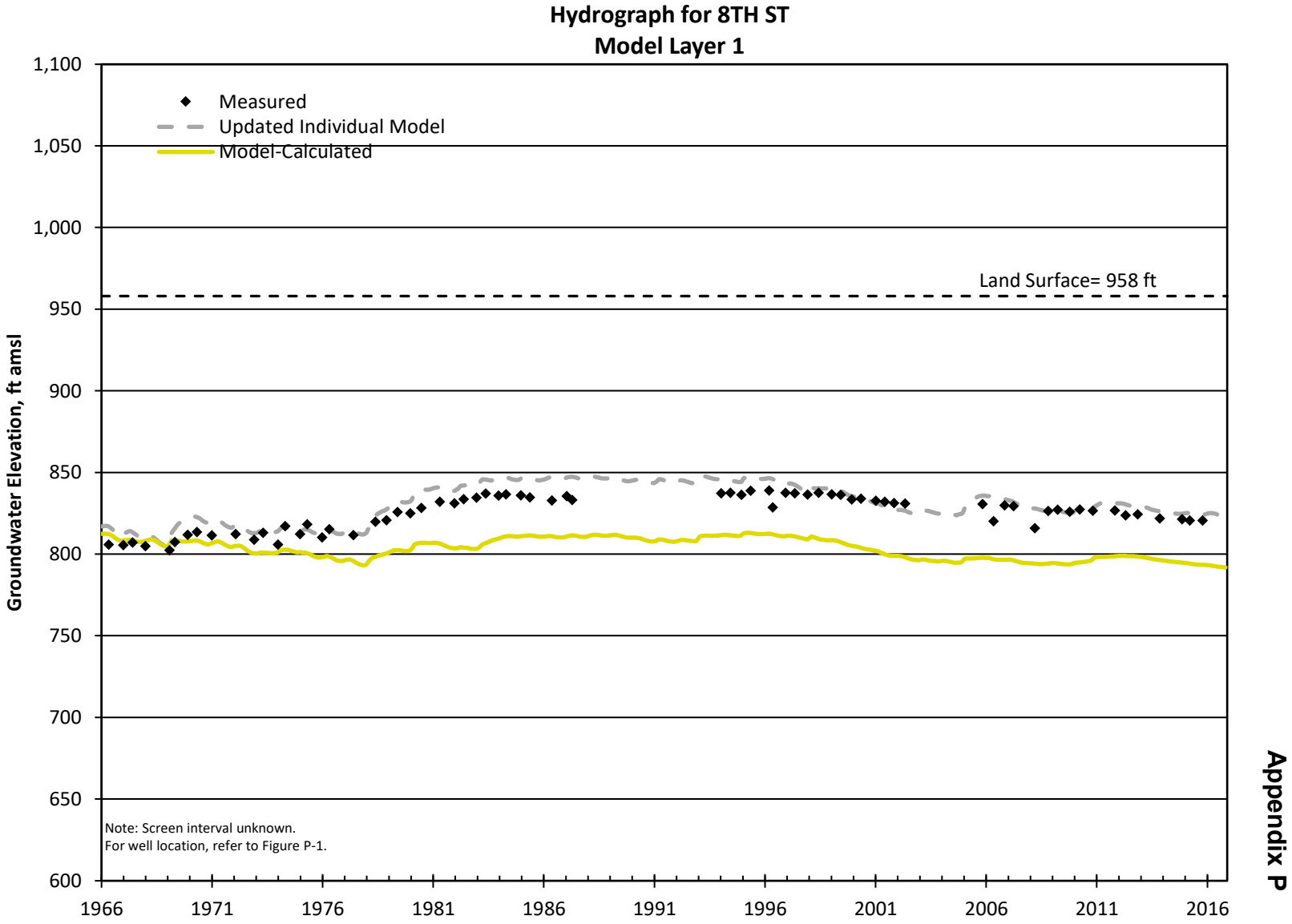
Appendix P


Hydrograph for 1 (RIO RANCHO)
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 768 ft
Screen Interval*
(ft amsl):
713 to 700
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

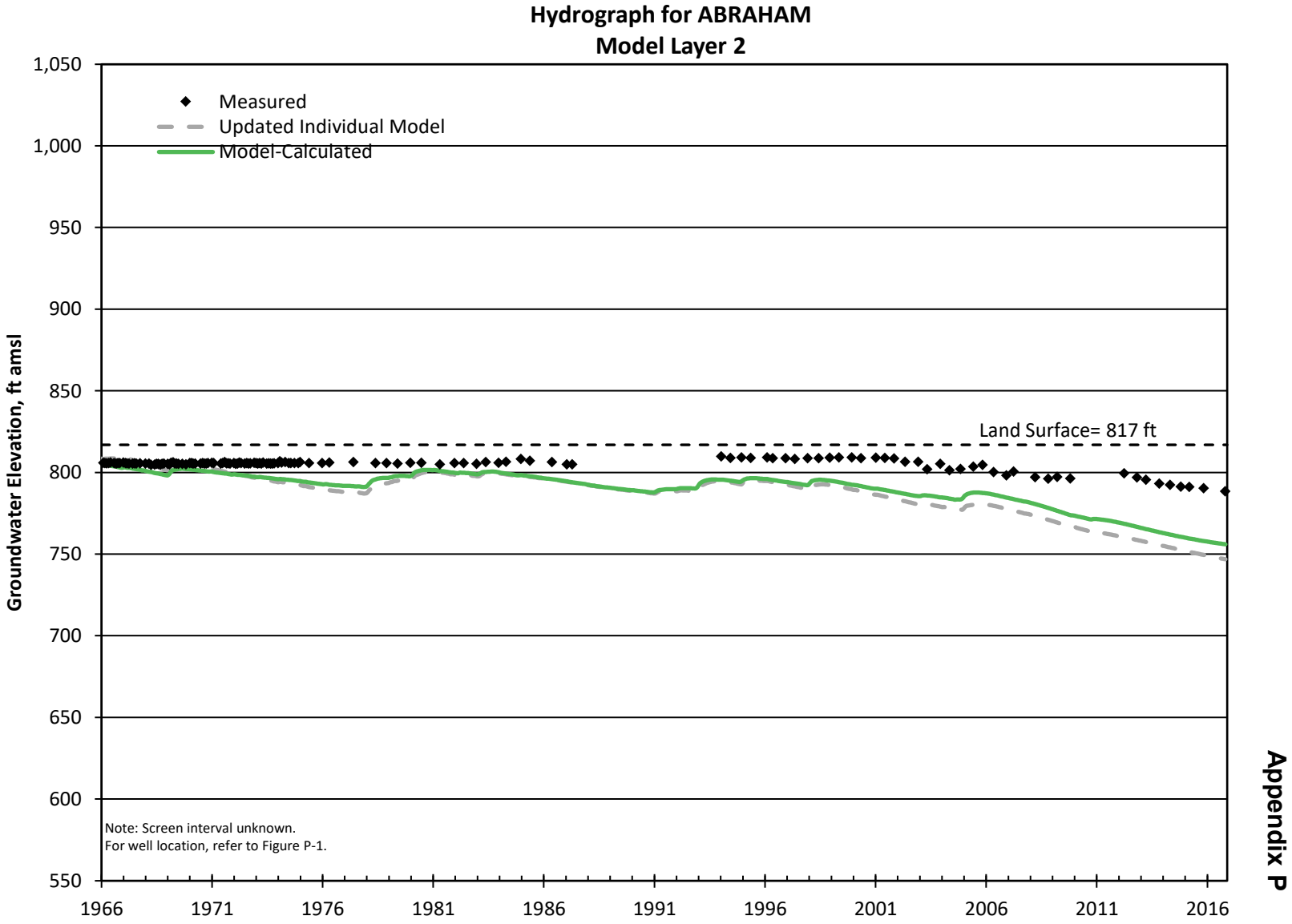
Appendix P


Hydrograph for 1, AUGA MENSA
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 922 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

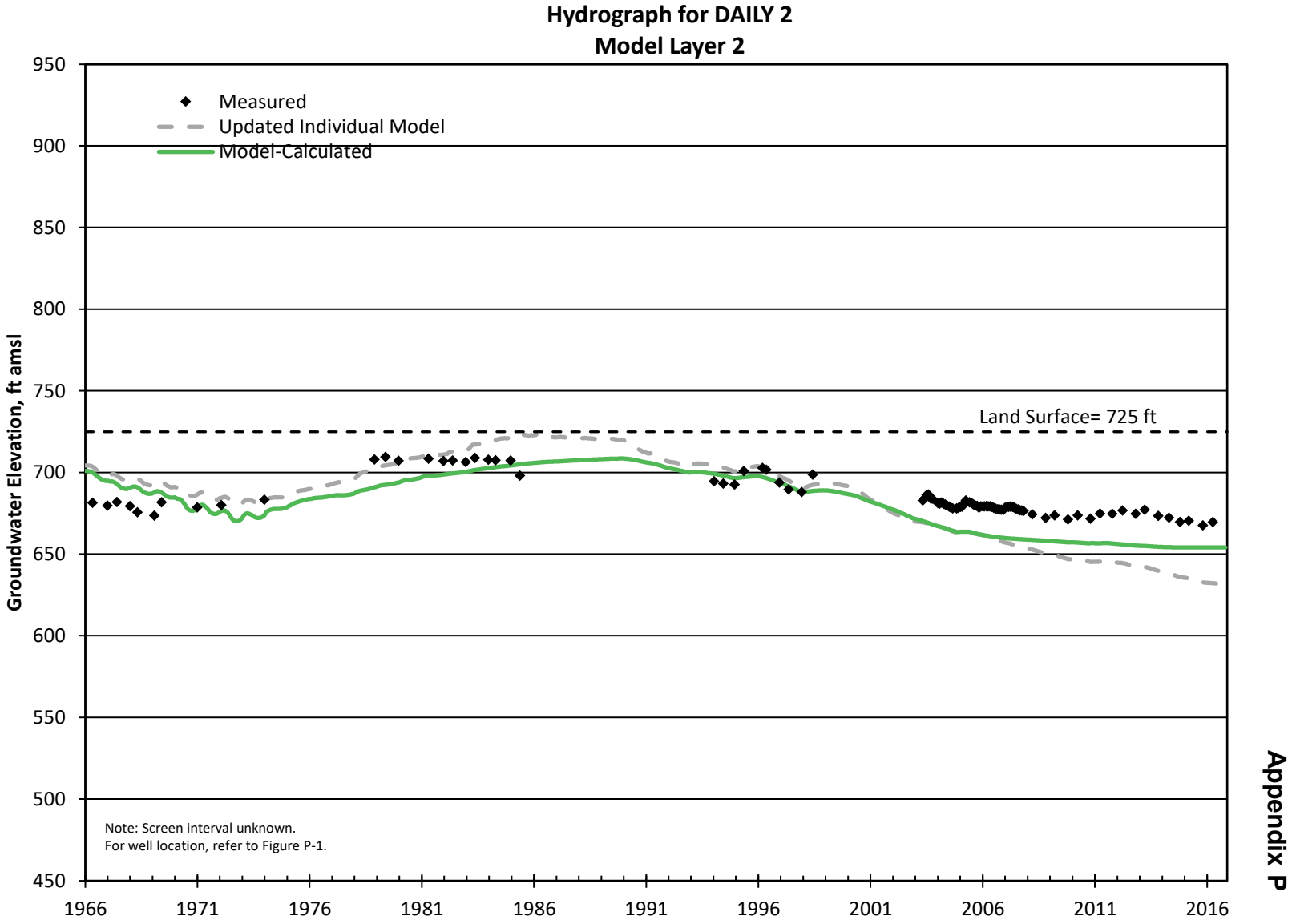
Appendix P


Hydrograph for 8TH ST
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 958 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

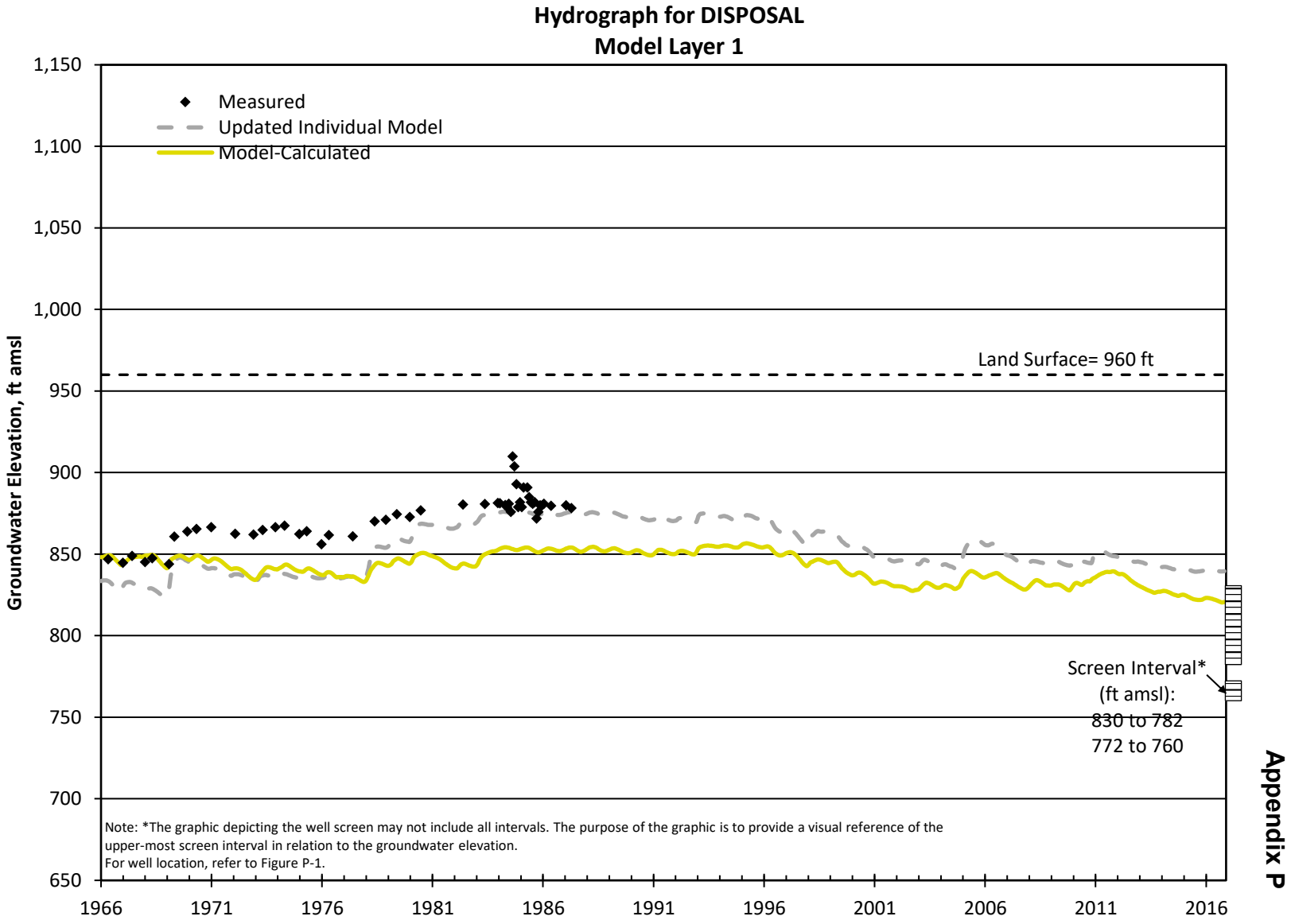
Appendix P


Hydrograph for ABRAHAM
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 817 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

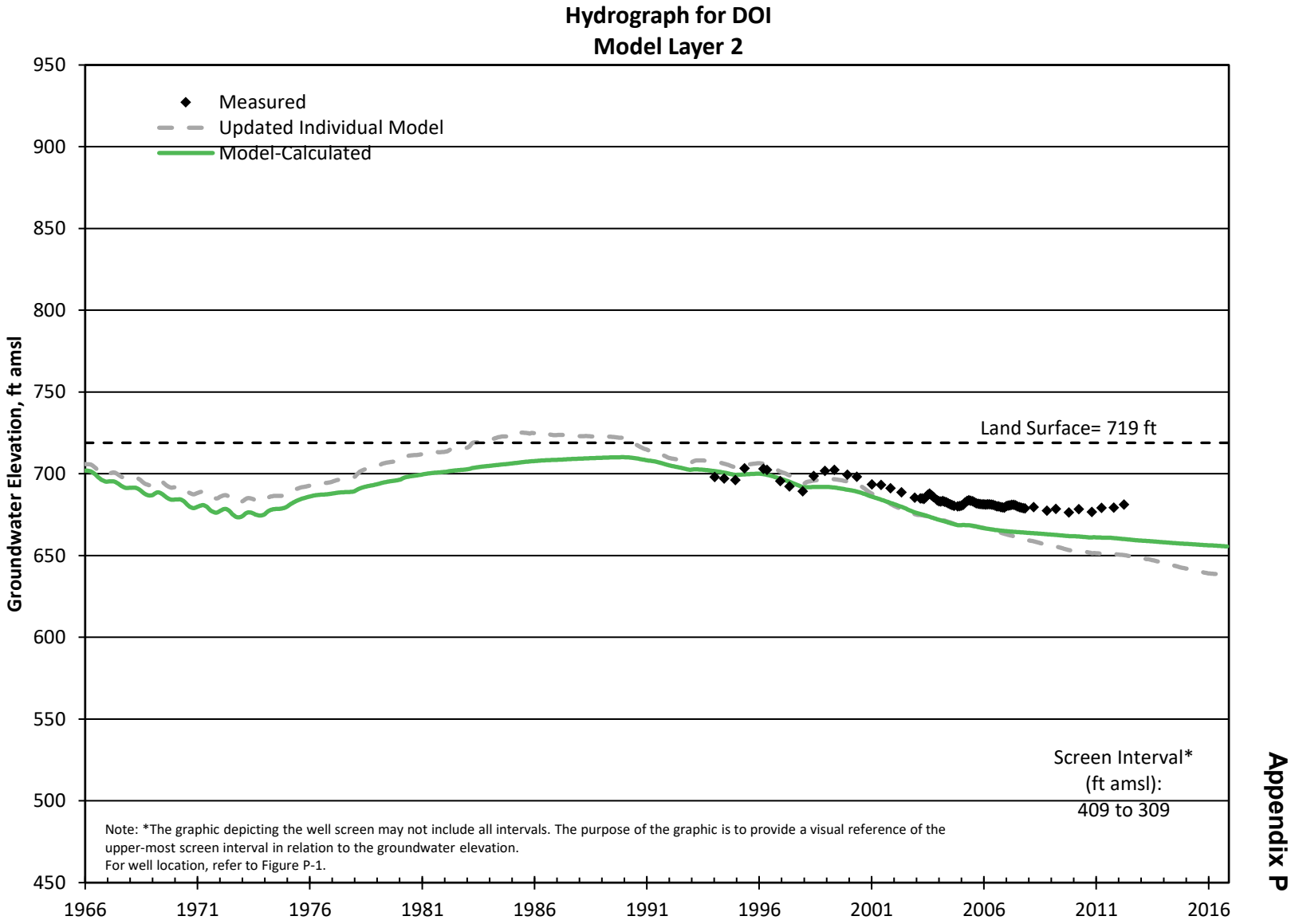
Appendix P


Hydrograph for DAILY 2
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 725 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

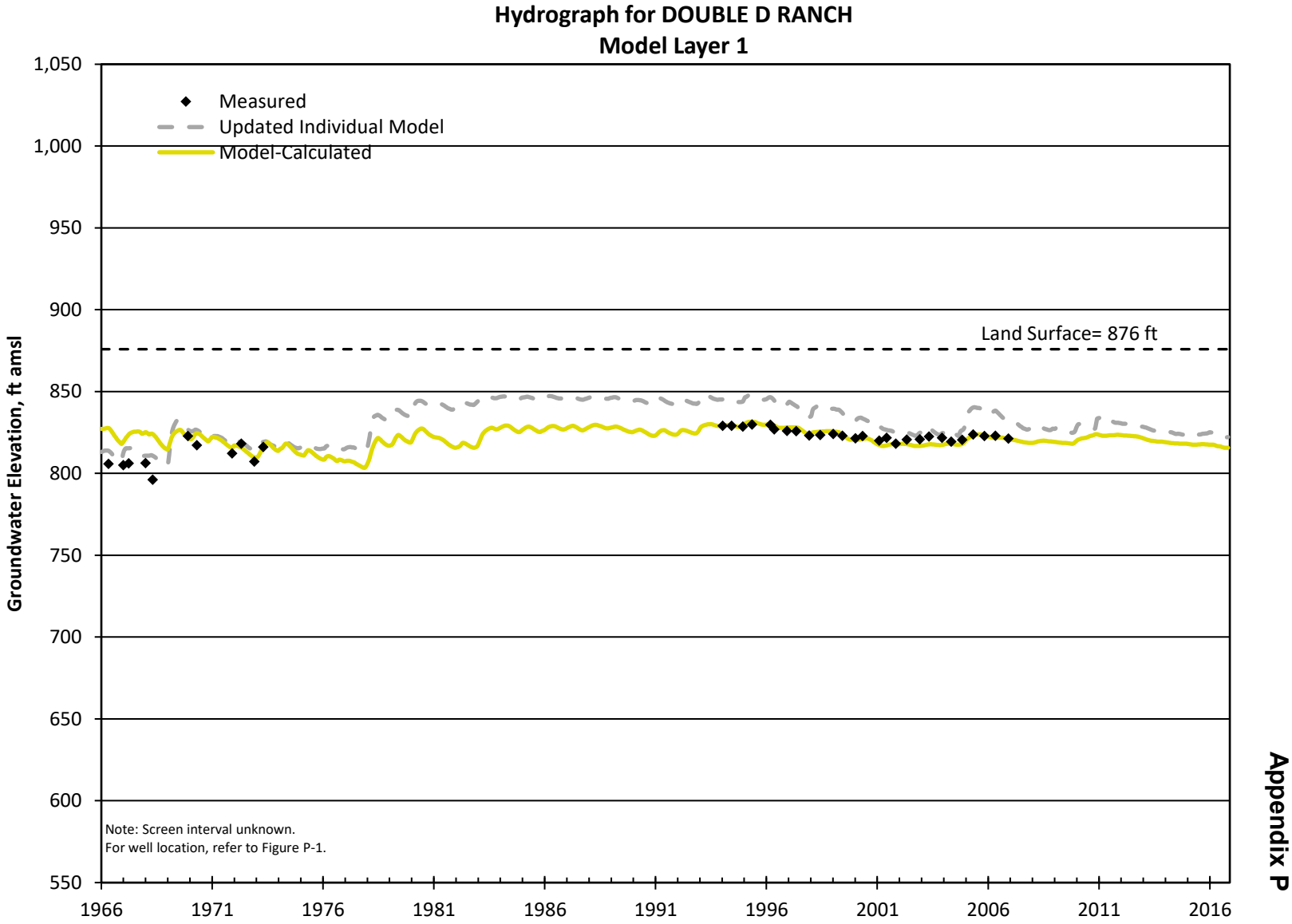
Appendix P


Hydrograph for DISPOSAL
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 960 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
830 to 782
772 to 760
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

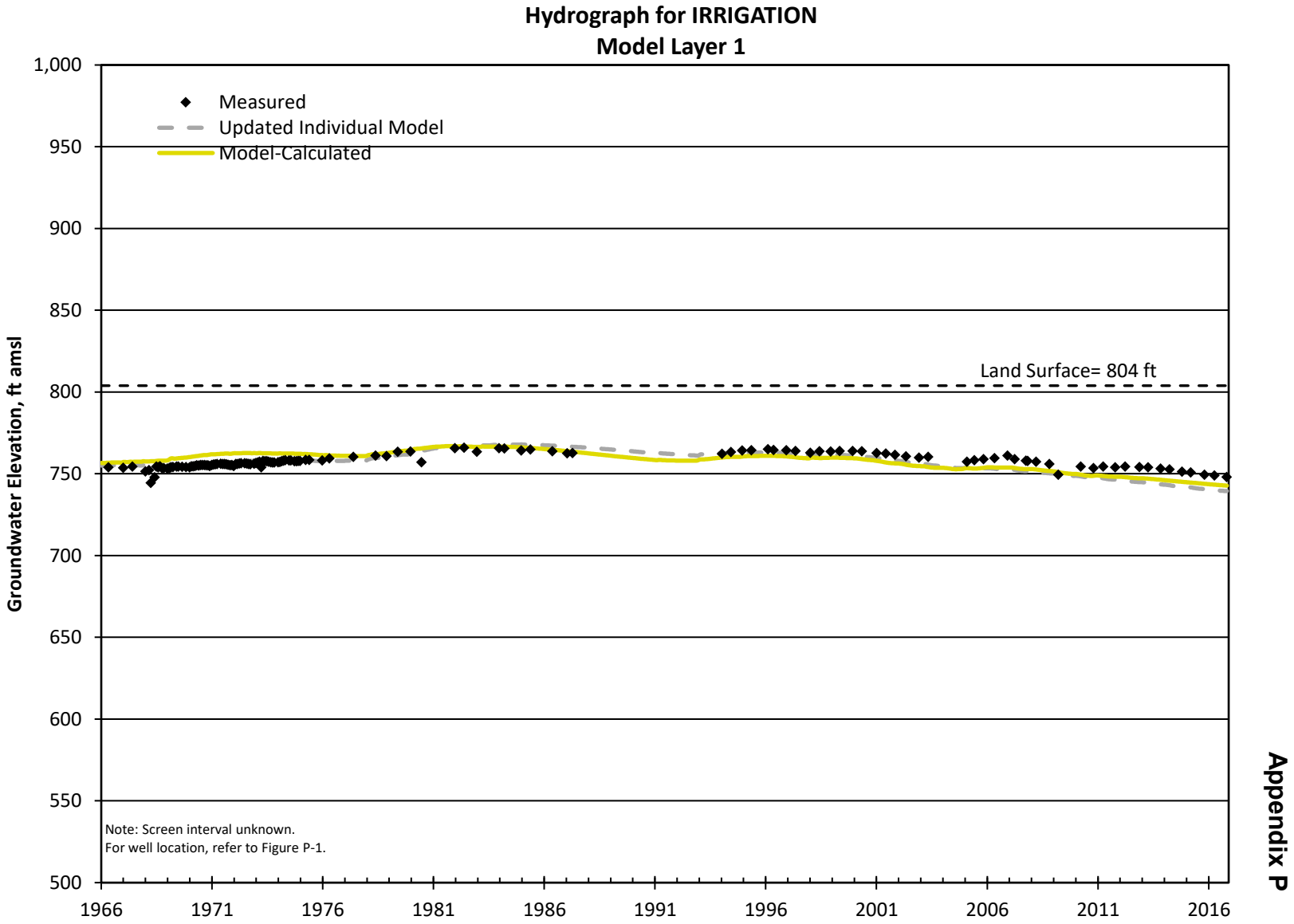
Appendix P


Hydrograph for DOI
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 719 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
409 to 309
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.

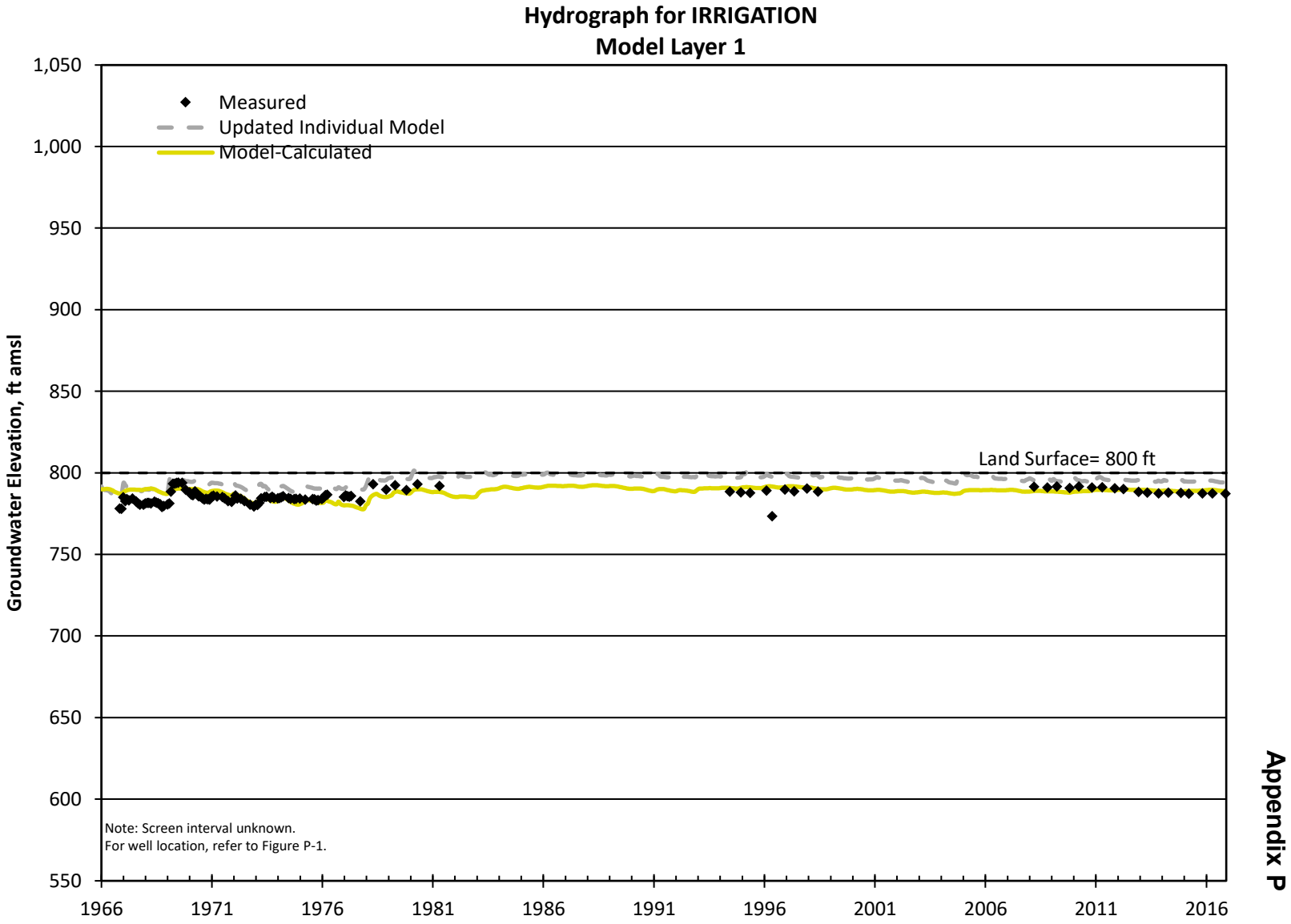
Appendix P


Hydrograph for DOUBLE D RANCH
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 876 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

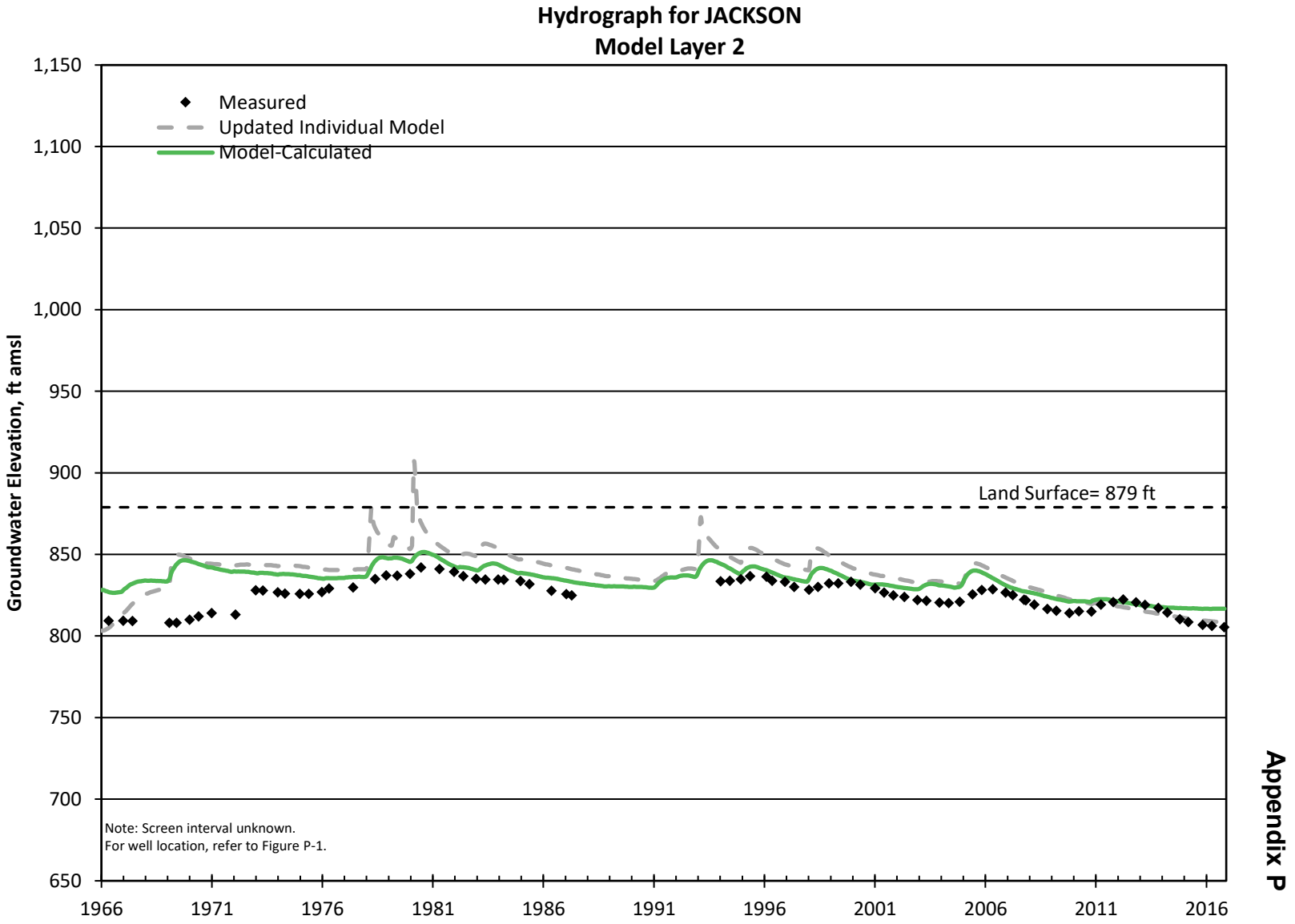
Appendix P


Hydrograph for IRRIGATION
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 804 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

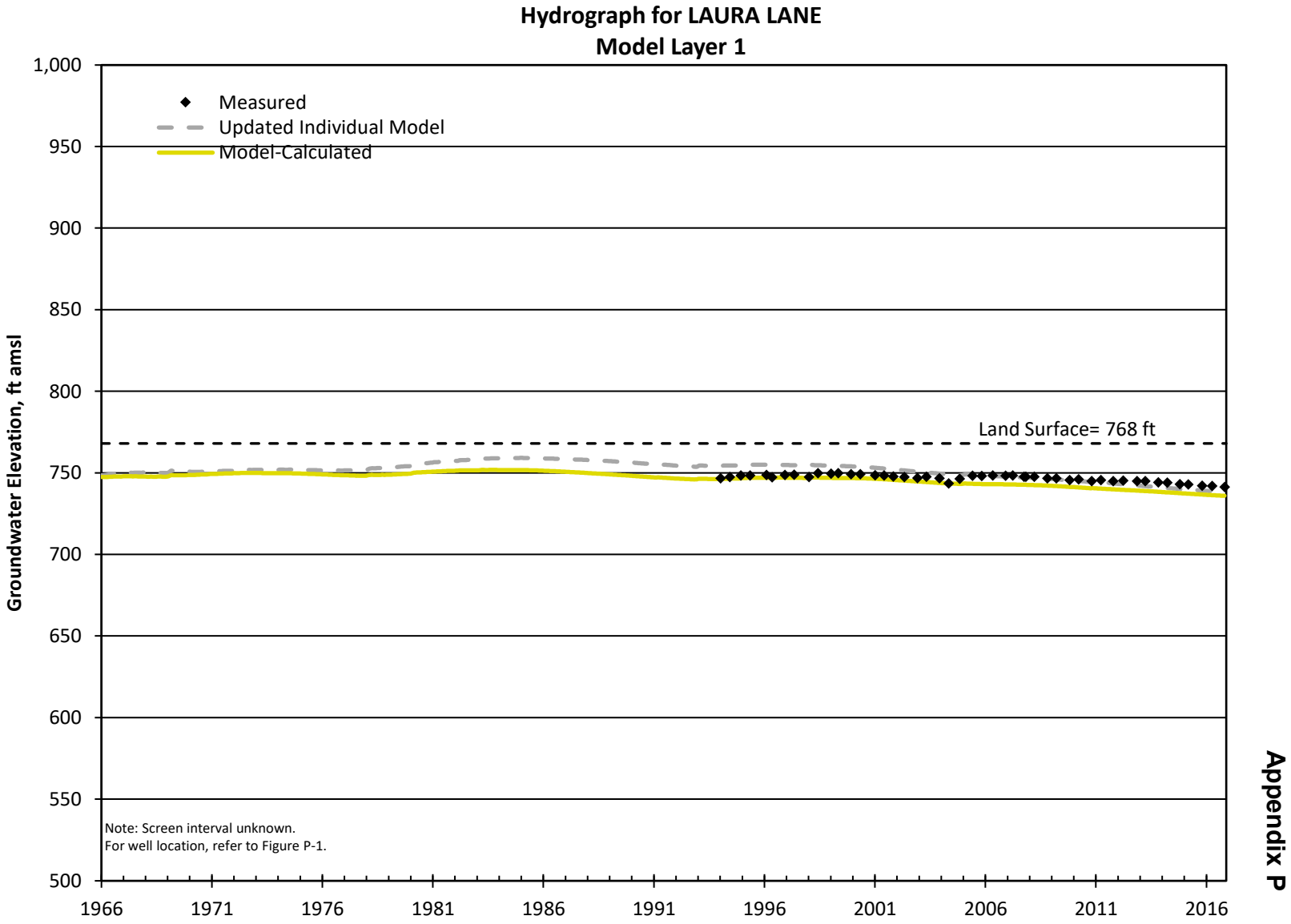
Appendix P


Hydrograph for IRRIGATION
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 800 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

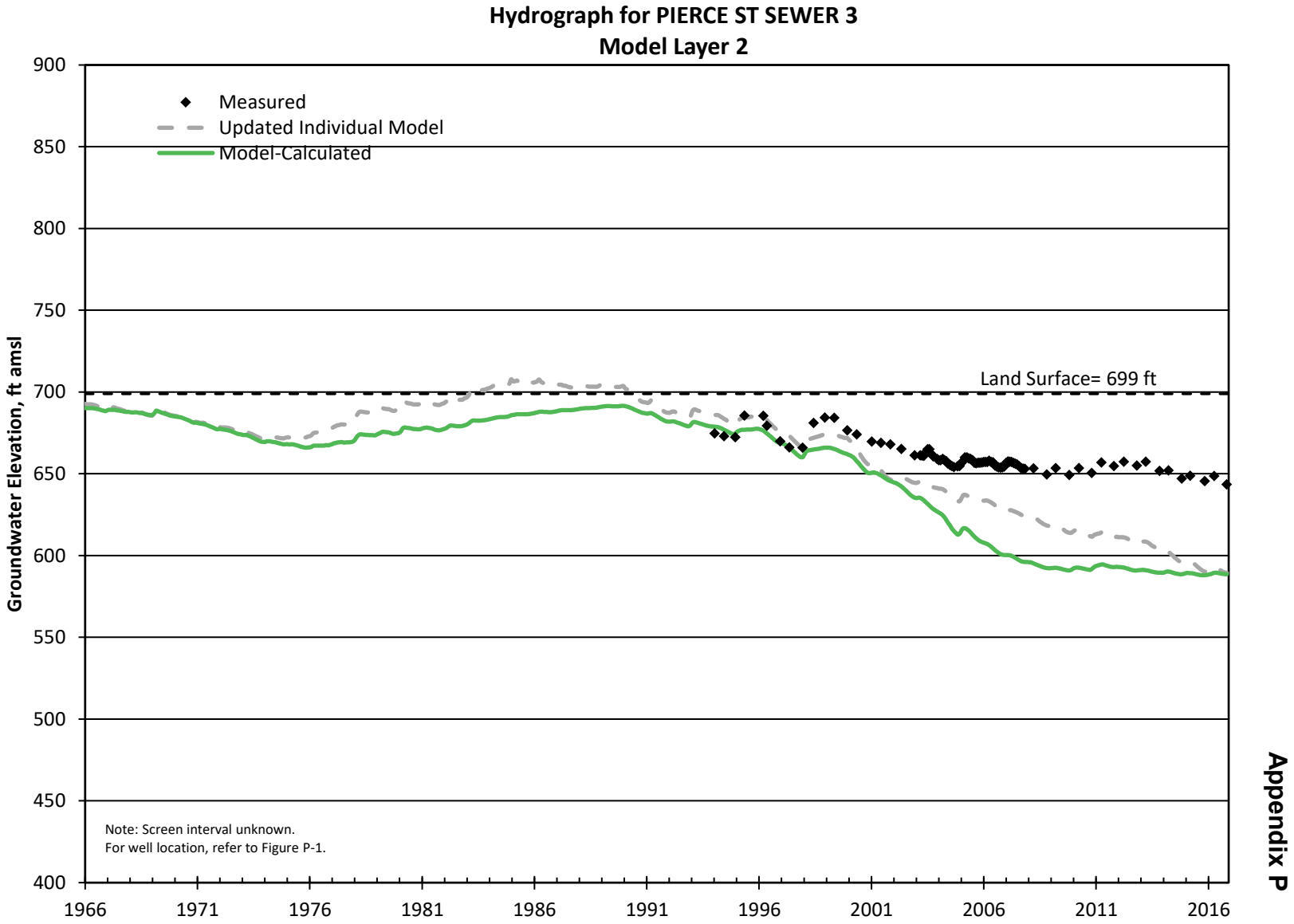
Appendix P


Hydrograph for JACKSON
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 879 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

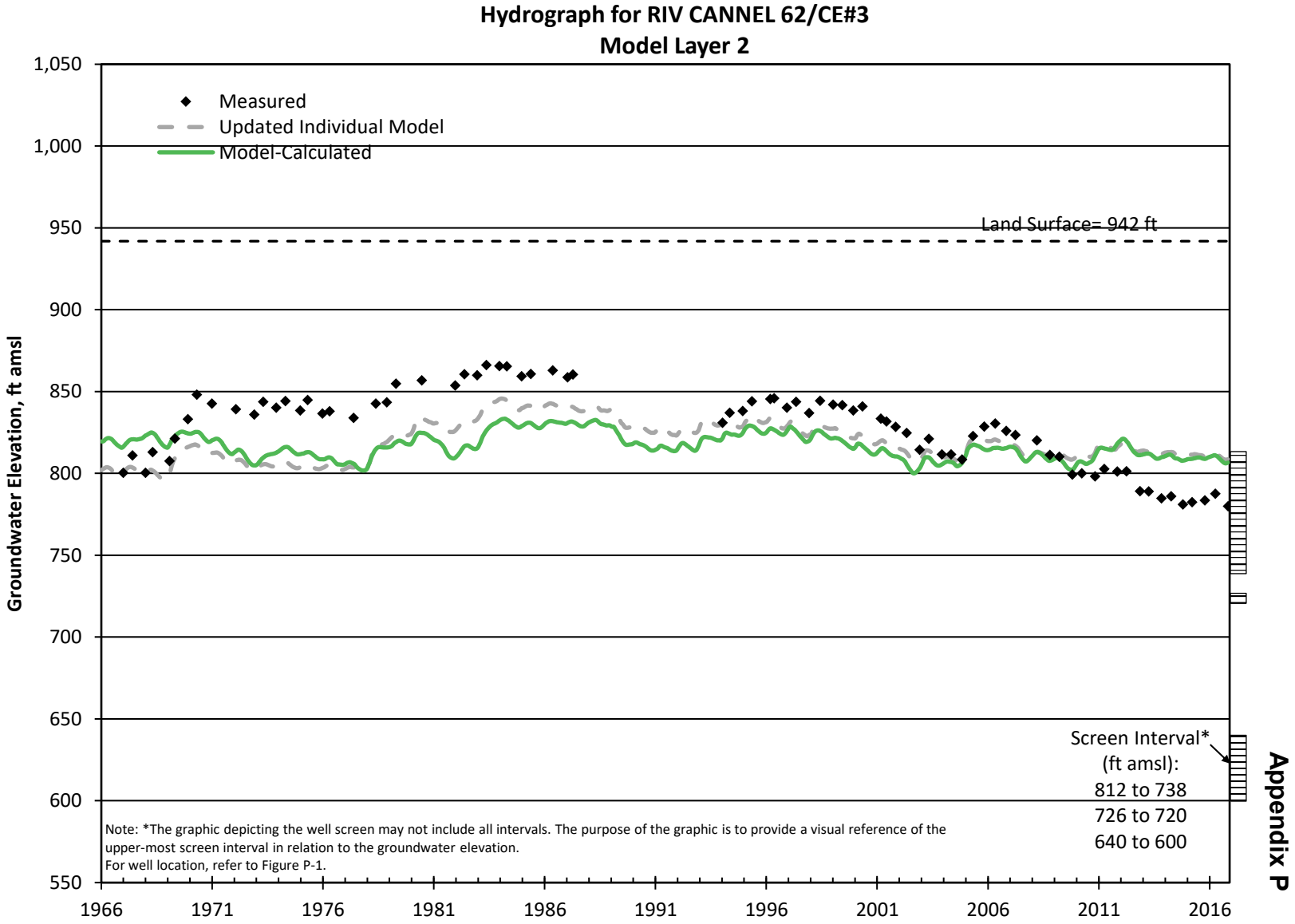
Appendix P

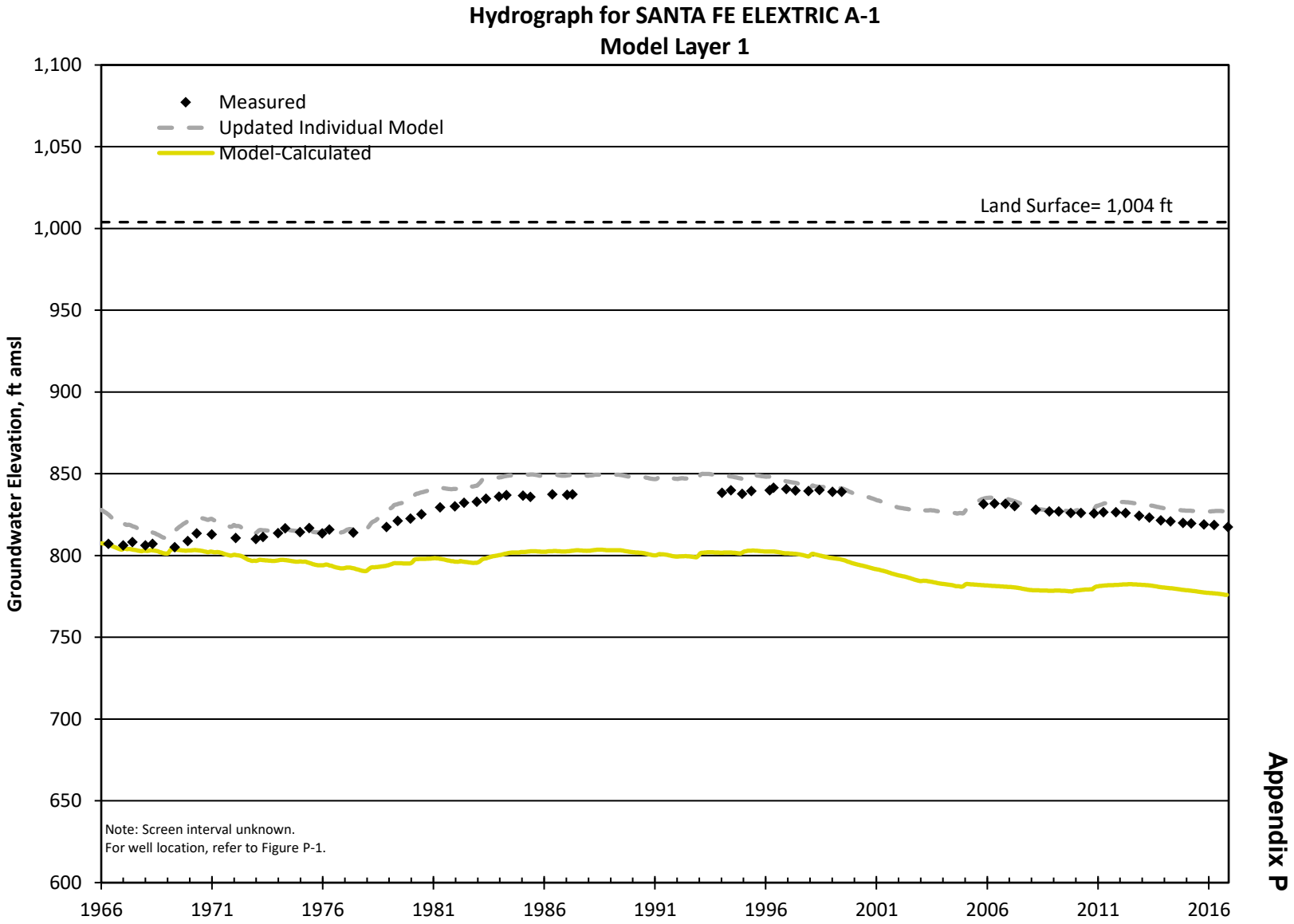

Hydrograph for LAURA LANE
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 768 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

Appendix P

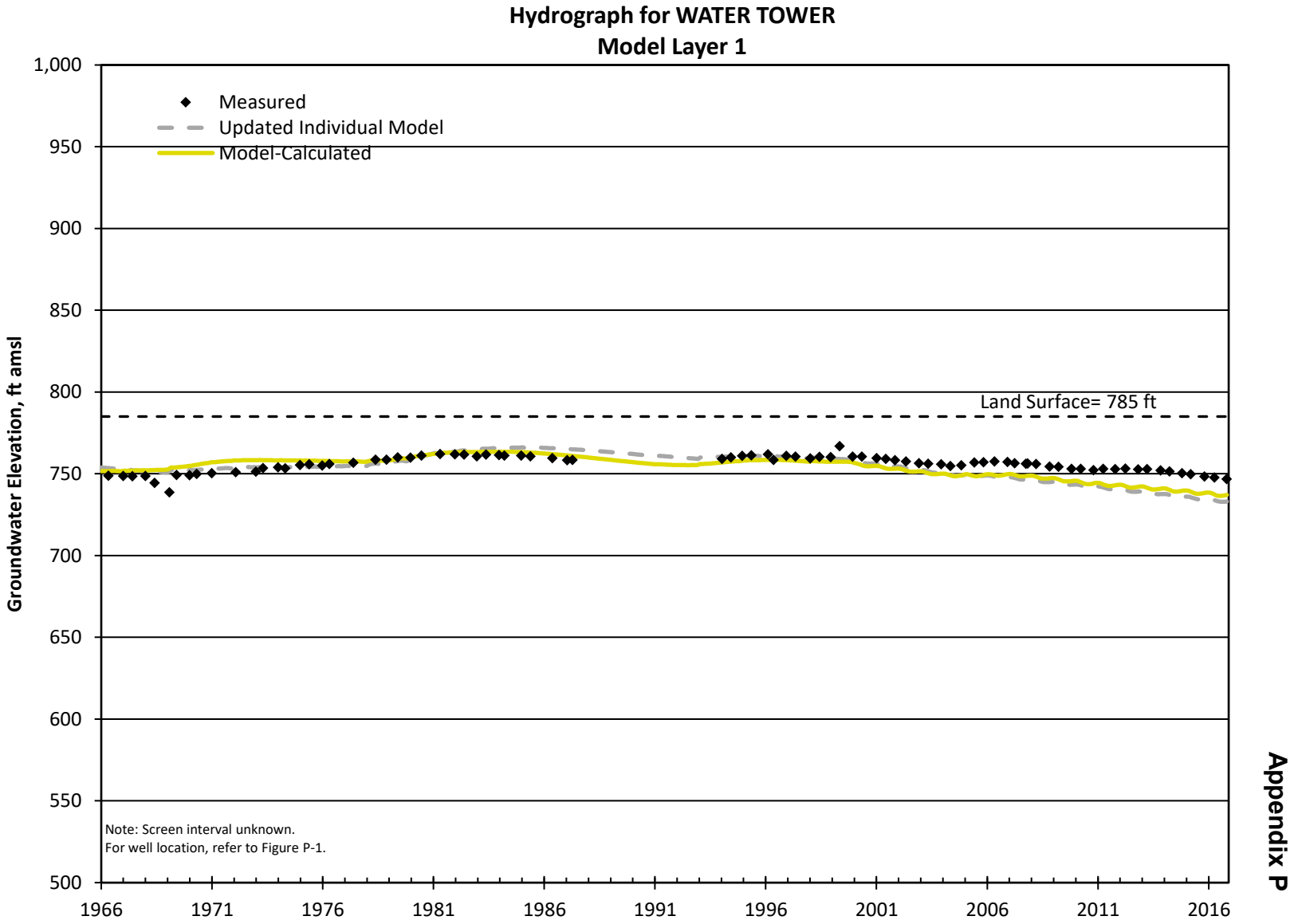

Hydrograph for PIERCE ST SEWER 3
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 699 ft
Groundwater Elevation, ft amsl
900
850
800
750
700
650
600
550
500
450
400
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

Appendix P

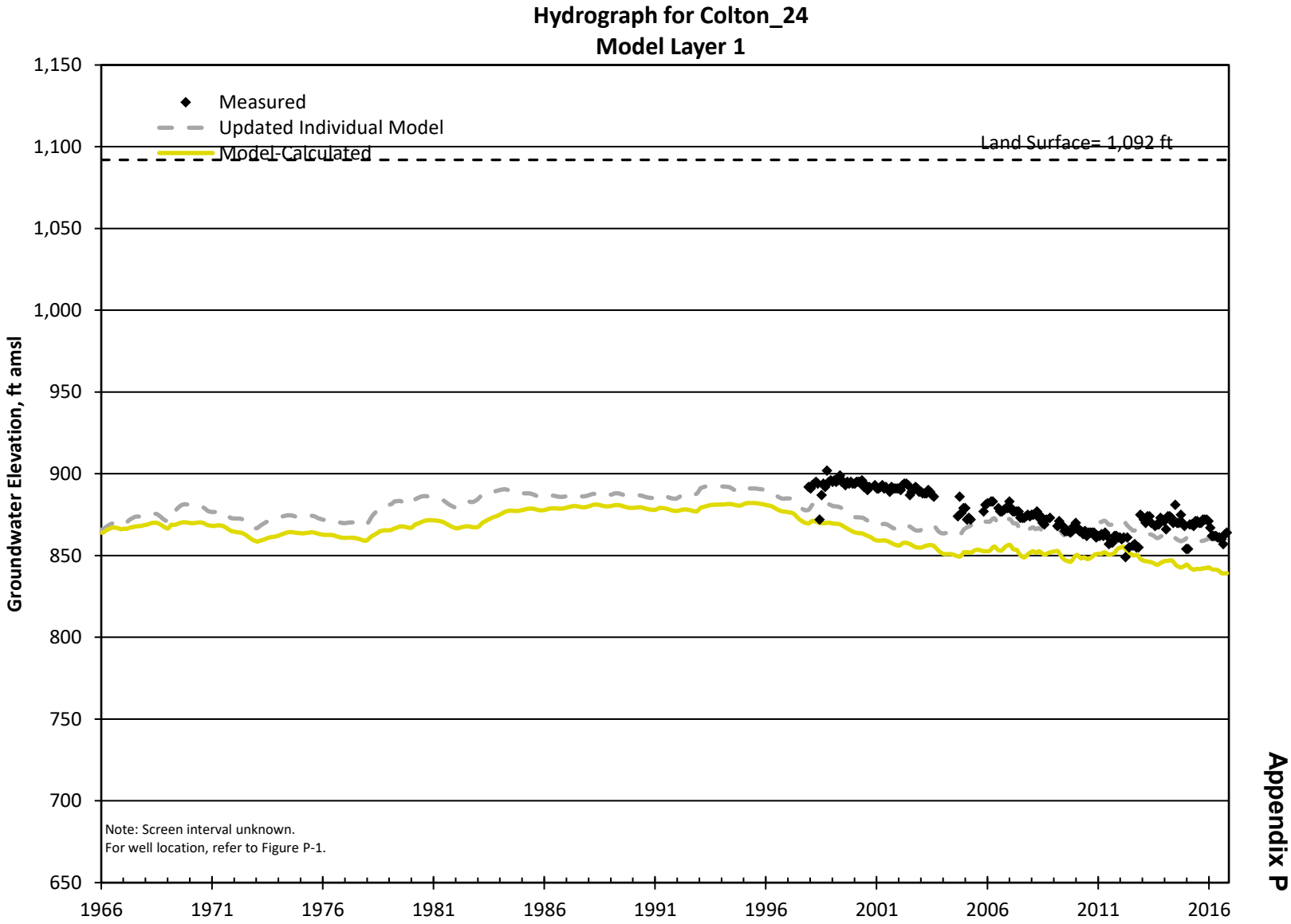

Hydrograph for RIV CANNEL 62/CE#3
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 942 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
812 to 738
726 to 720
640 to 600
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure P-1.
Appendix P


Hydrograph for SANTA FE ELEXTRIC A-1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,004 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

Appendix P


Hydrograph for WATER TOWER
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 785 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

Appendix P


Hydrograph for Colton_24
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,092 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure P-1.

Appendix P

APPENDIX Q

Integrated SAR Model: Selected Hydrographs for Target Wells in the Chino Basin Model Area – 1966 to 2016

GEOSCIENCE

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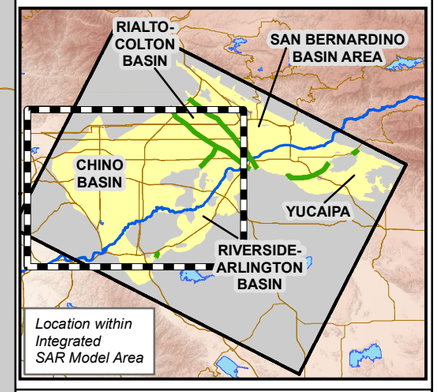
01N/06W-26A01-03S
01N/06W-26K02-03S
F31A_L2
F30A
CVWD_35
F35A_L2
Cal_Speed1
CHINO BASIN
WVWD_20
F21A
FU6
ONT_31_L1
ONT_09_L1
SAWC_18
ONT_04_L1
CVWD_3_L1
ONT_20
ONT_07
ONT_36_L1
ONT_08
MW-11
ONT_11_L1
P_16
C_09
P_29
C_15_L1
CH_HIL_19
C_13
CH_HIL_18A
YMCA
AP-PA_10
AP-PA_7
CH_HIL_15A_L1
CIM_09
CDF Well 17
I_10_L1
NA_1202311
JCSD_16_L2
FC-936A2
SARWC_07
NOR_11
PB-2
IEUA_MW_2
PB-7_2
PB-1_2
Archibald_1
COR 11
COR 15
COR 08
COR 14
COR 06
Prado Dam
San Antonio Ck
Deer Ck
Day Ck
Etiwanda Ck
San Sevaine Ck
Cucamonga Ck
Chino Ck
Aliso Ck
Mill Ck
Temescal Wash
Arlington Channel
Lytle Ck
Lytle Creek Chan
Santa Ana River
210
66
83
15
10
71
60
91

EXPLANATION

- Integrated SAR Model Boundary
- Well Model Layer
  - 1
  - 2
  - 3
  - 4
  - 5
- Inactive Model Area
- Groundwater Basin Boundary
- Groundwater Flow Barrier
- Dam Location Used in Upper Santa Ana River Watershed Model

N

0 2 4
Miles



SELECTED TARGET WELLS USED FOR HYDROGRAPHS CHINO BASIN MODEL AREA 1966 TO 2016

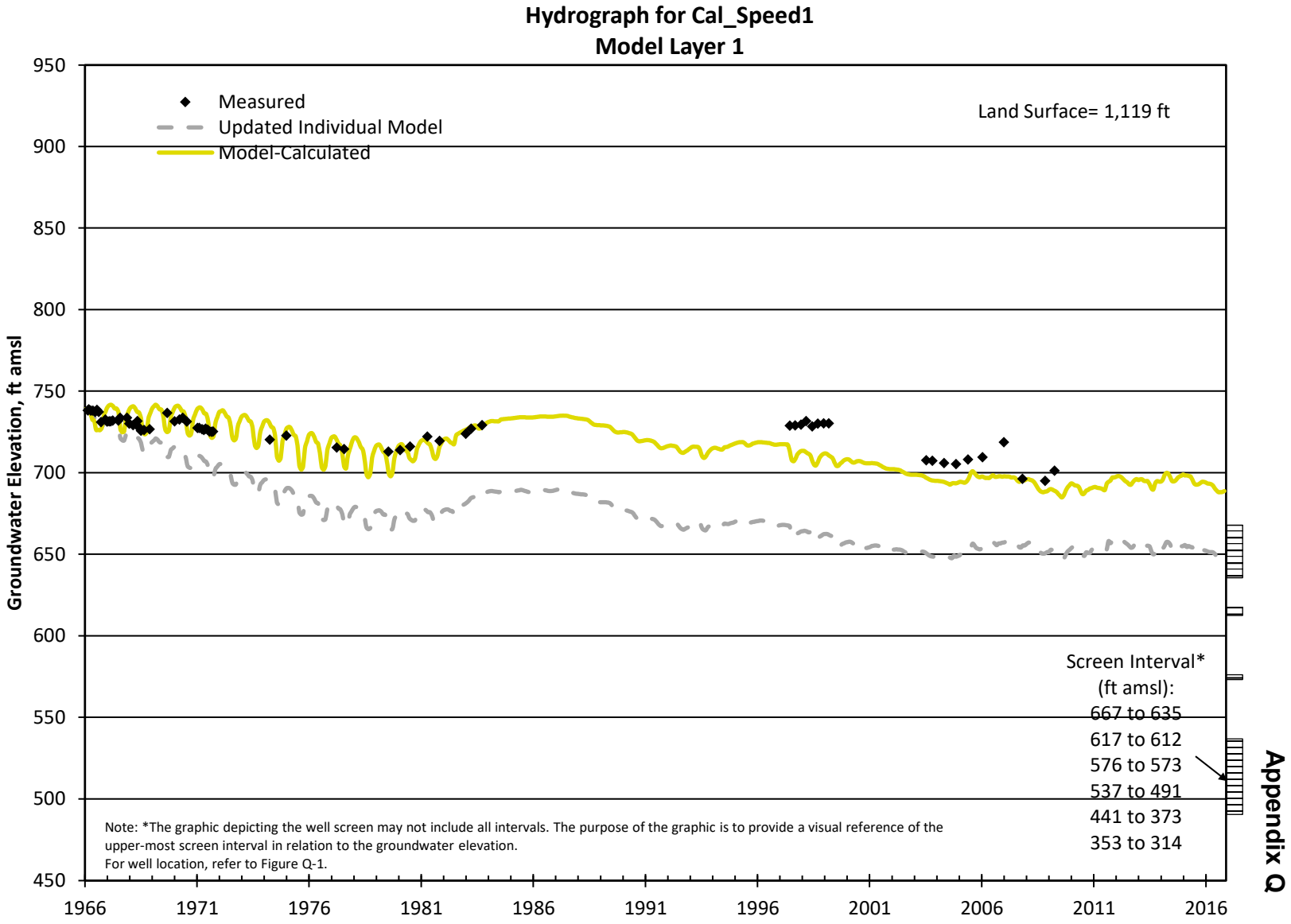
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10-Apr-20

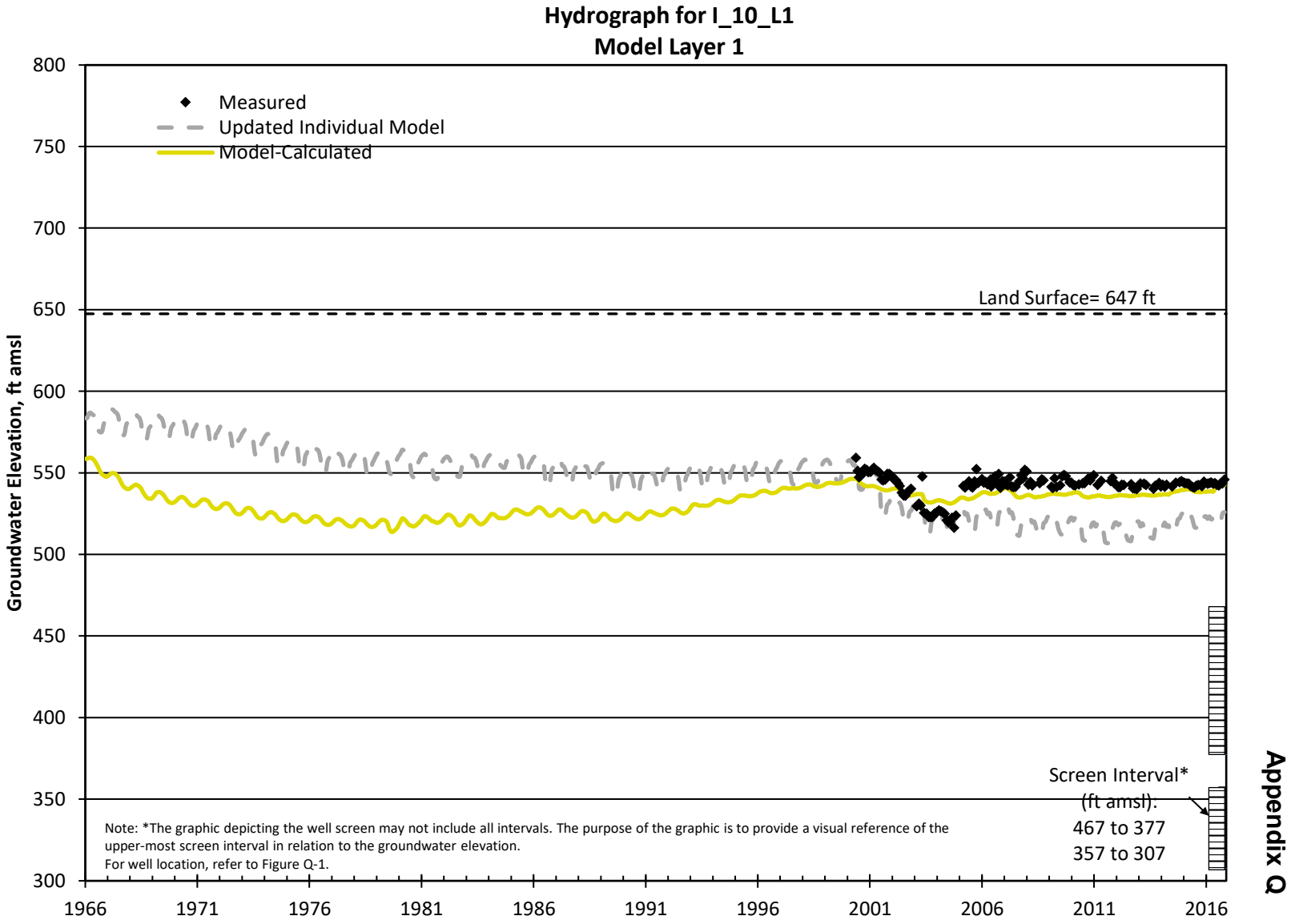
SAN BERNARDINO VALLEY MUNICIPAL WATER DISTRICT
UPPER SANTA ANA RIVER INTEGRATED MODEL - SUMMARY REPORT

DRAFT

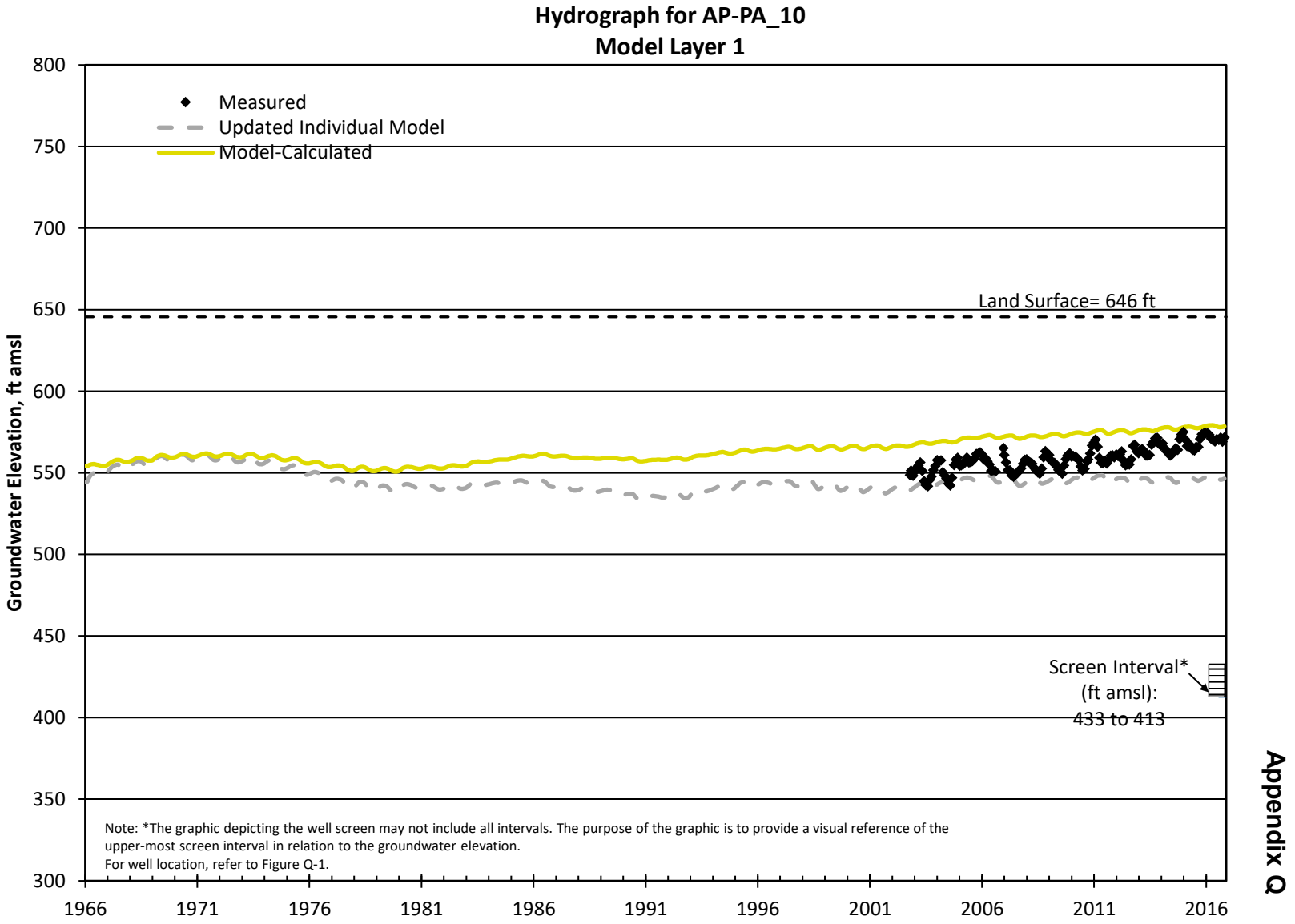
FIGURE Q-1

GEOSCIENCE

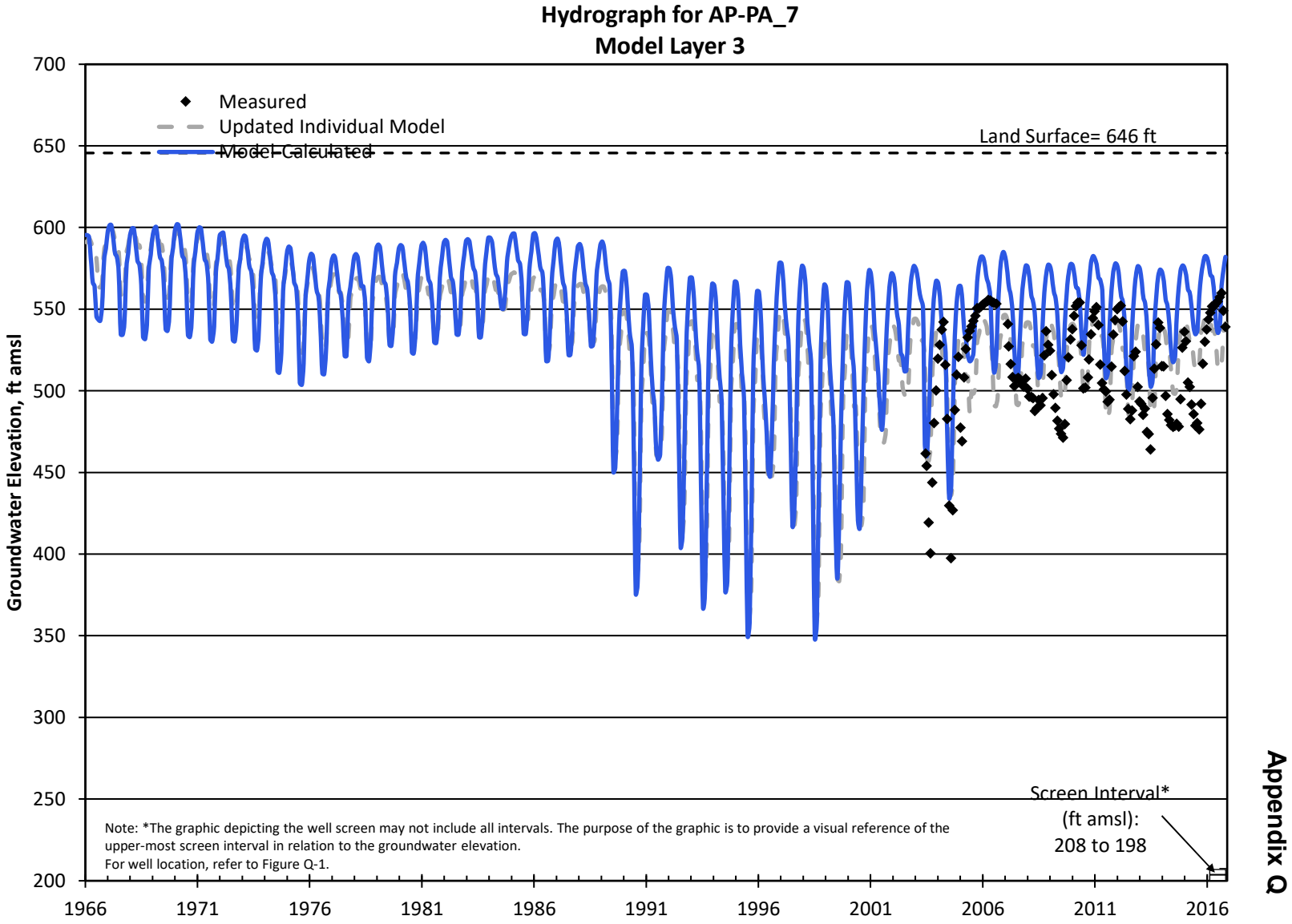

Hydrograph for Cal_Speed1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,119 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
667 to 635
617 to 612
576 to 573
537 to 491
441 to 373
353 to 314
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.
Appendix Q


Hydrograph for I_10_L1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 647 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
467 to 377
357 to 307
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

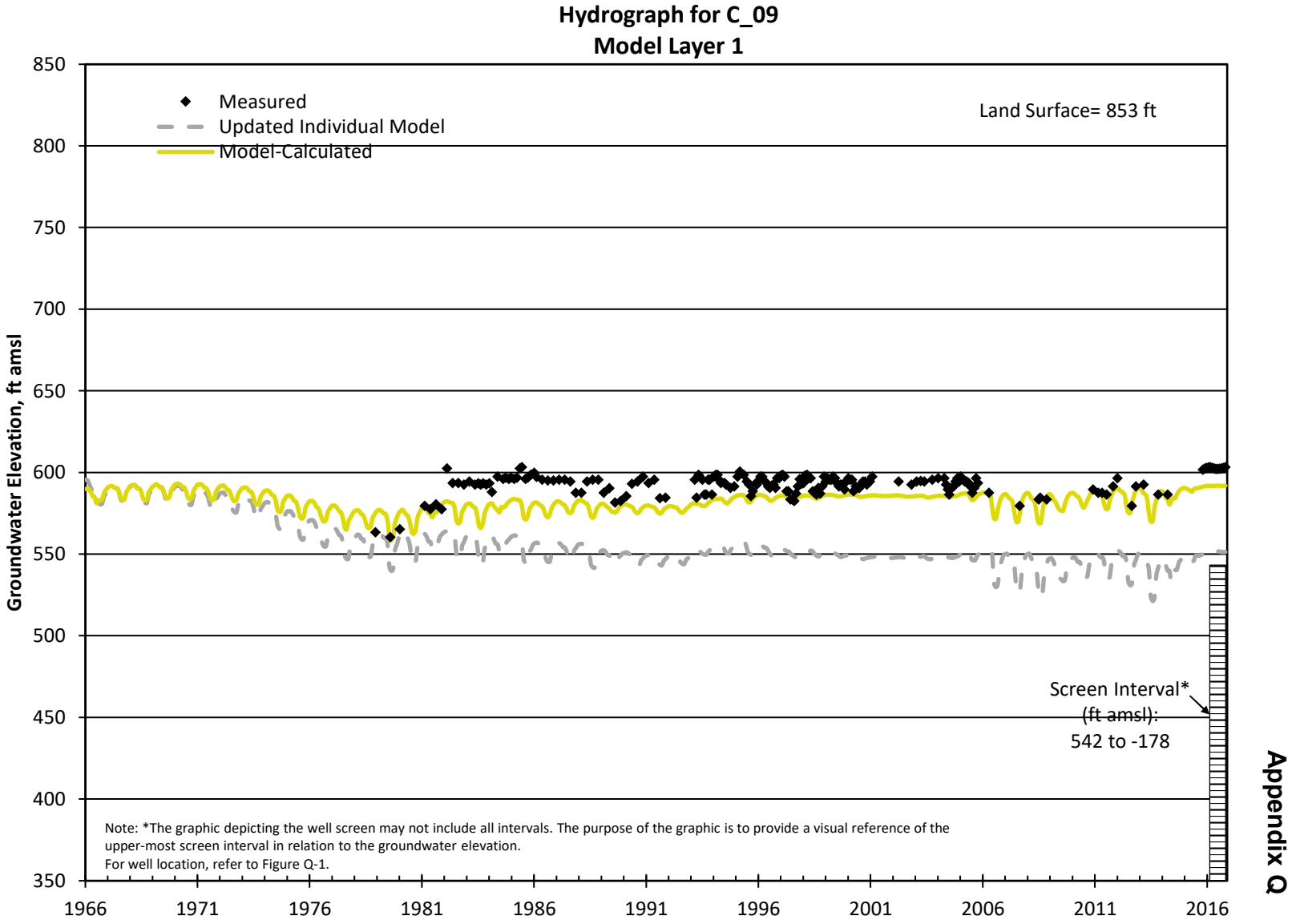
Appendix Q


Hydrograph for AP-PA_10
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 646 ft
Screen Interval*
(ft amsl):
433 to 413
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

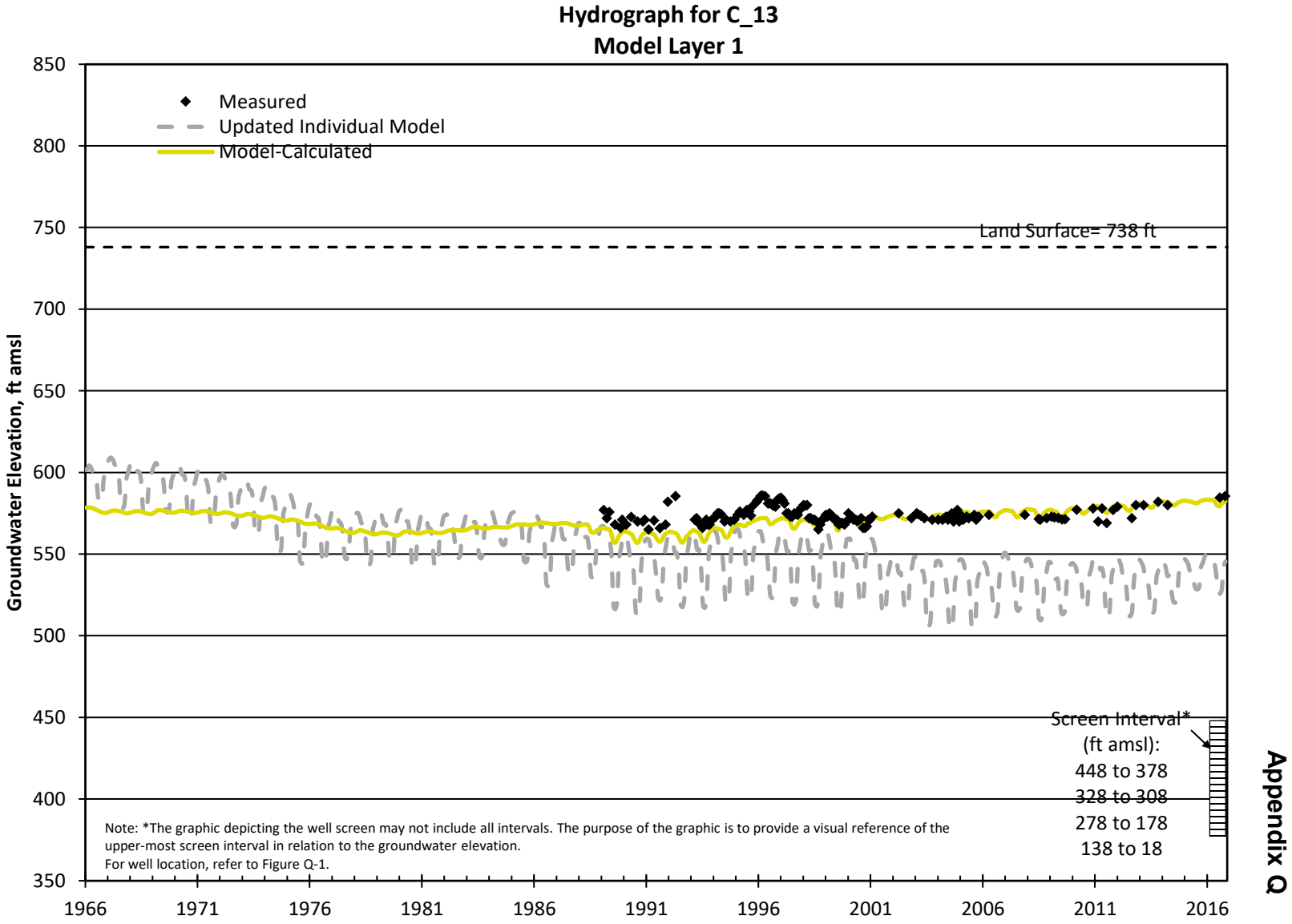
Appendix Q


Hydrograph for AP-PA_7
Model Layer 3
Measured
Updated Individual Model
Model Calculated
Land Surface= 646 ft
Groundwater Elevation, ft amsl
700
650
600
550
500
450
400
350
300
250
200
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
208 to 198
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

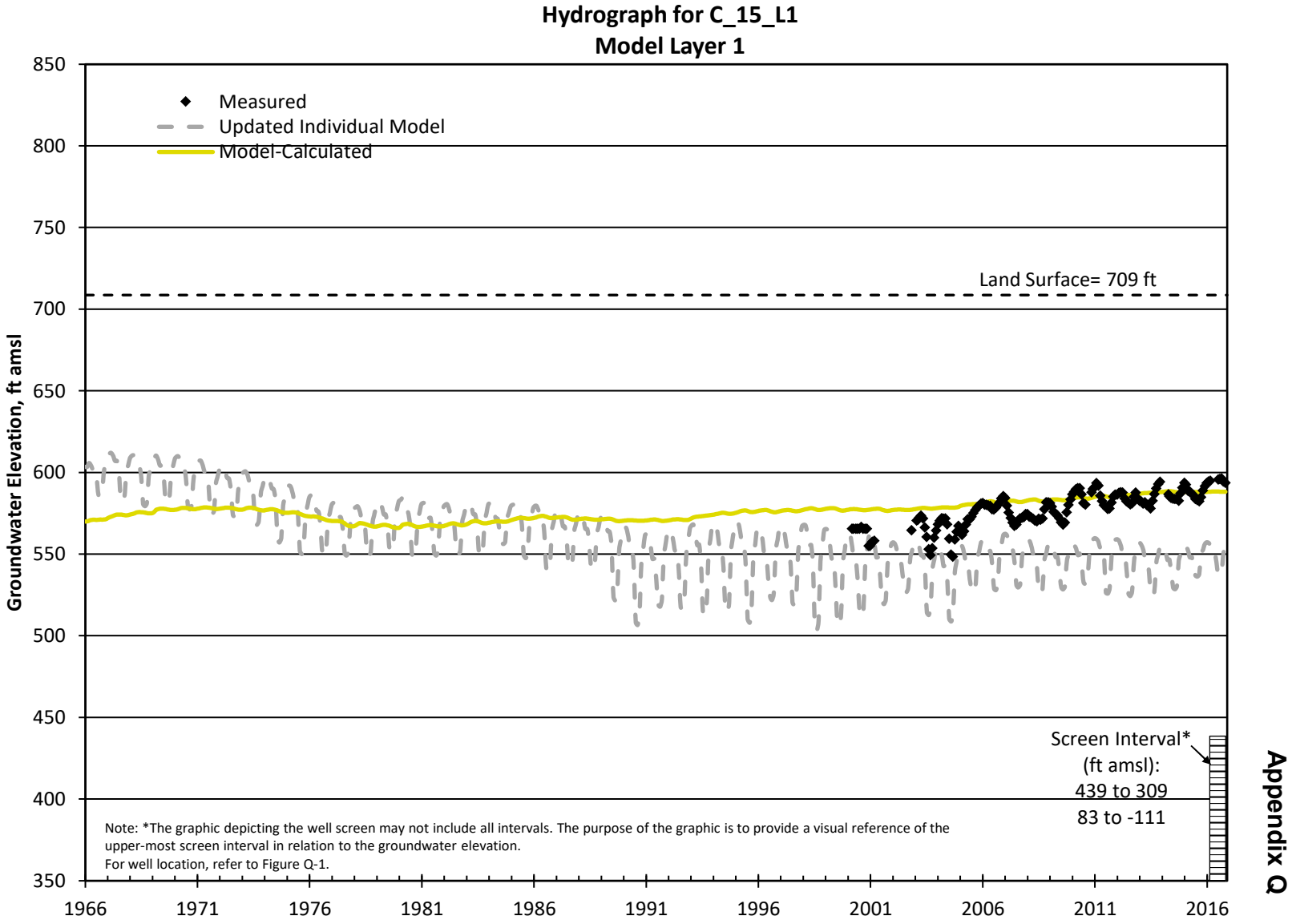
Appendix Q


Hydrograph for C_09
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 853 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
542 to -178
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

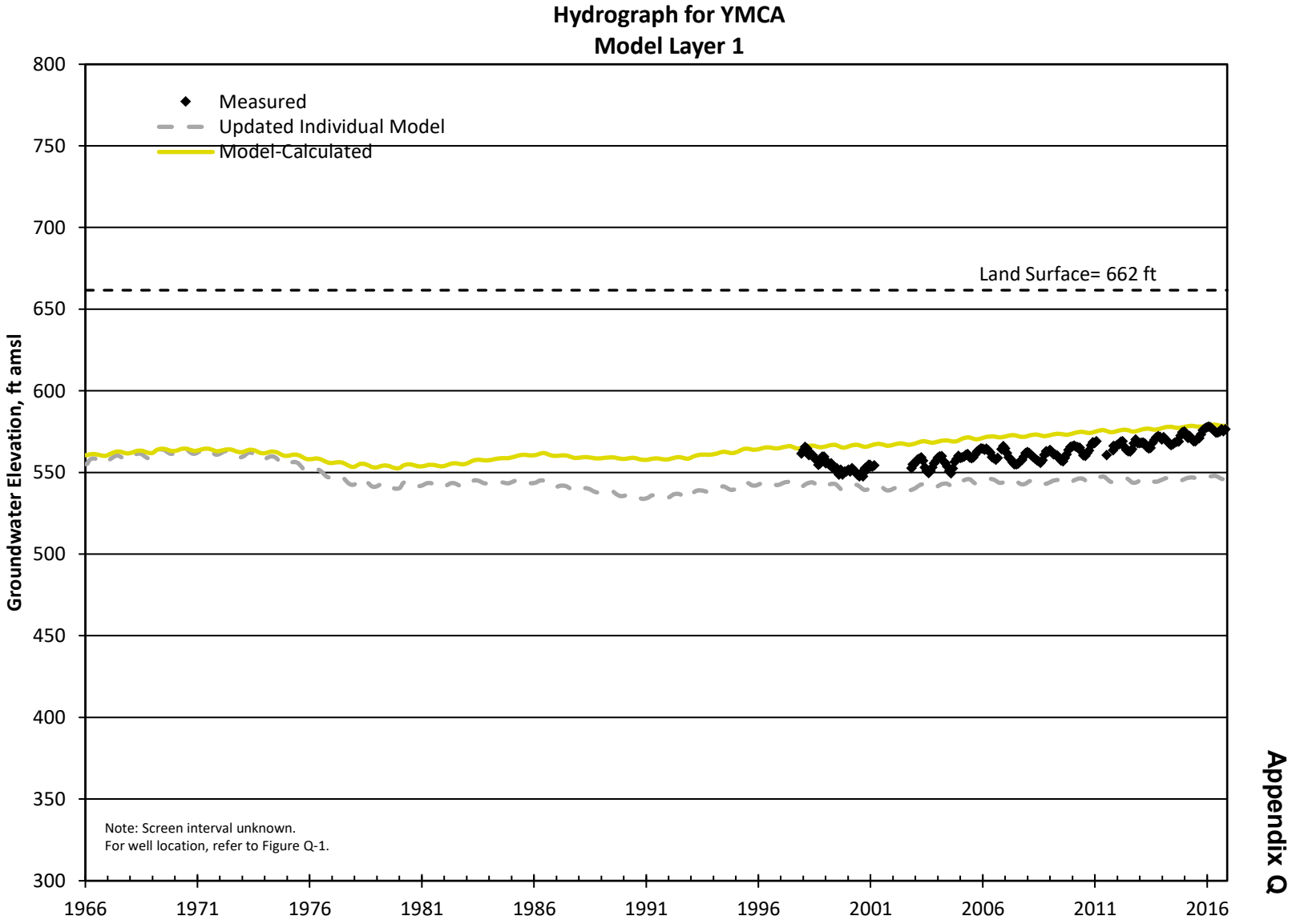
Appendix Q


Hydrograph for C_13
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 738 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
448 to 378
328 to 308
278 to 178
138 to 18
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

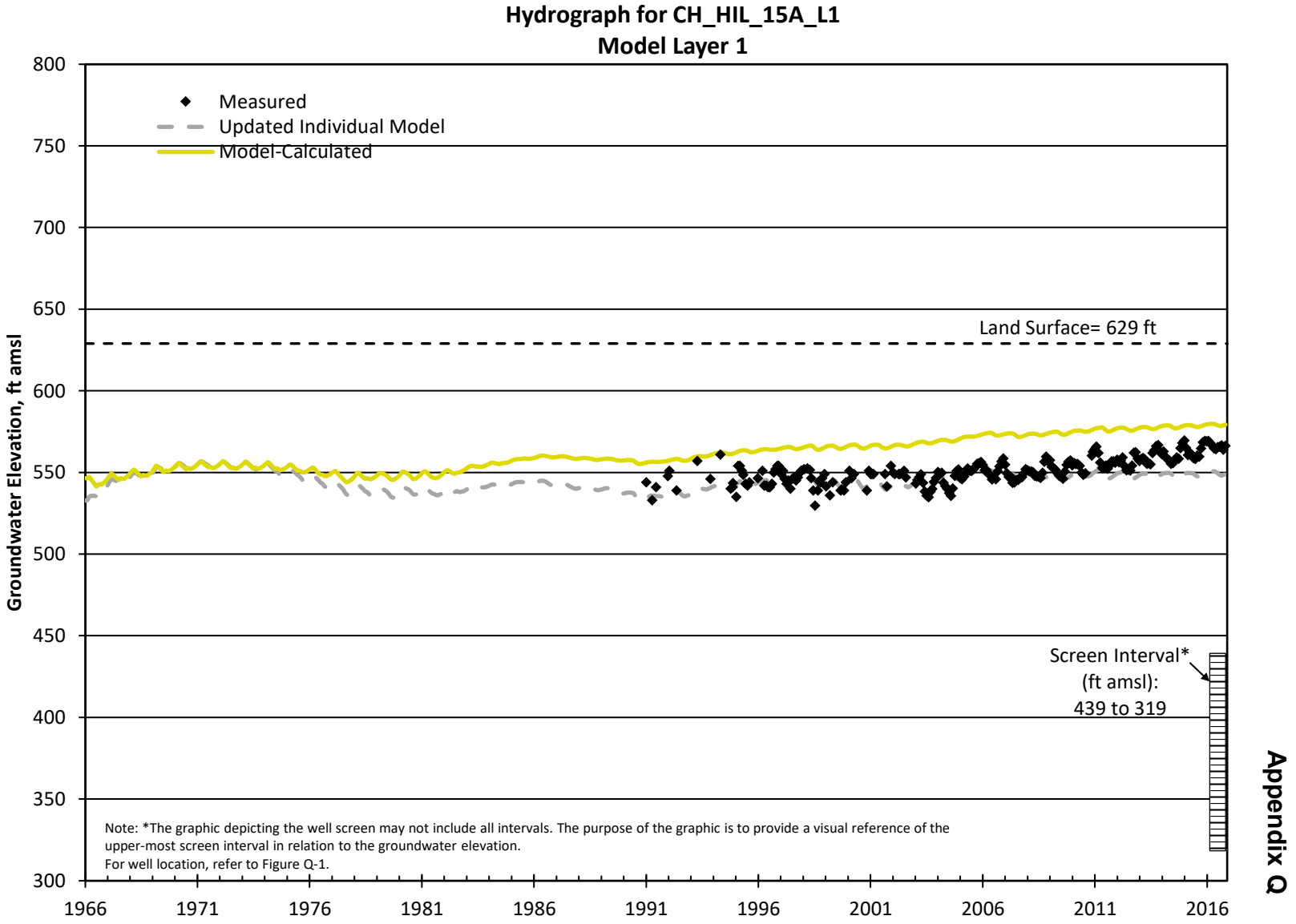
Appendix Q


Hydrograph for C_15_L1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 709 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
439 to 309
83 to -111
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

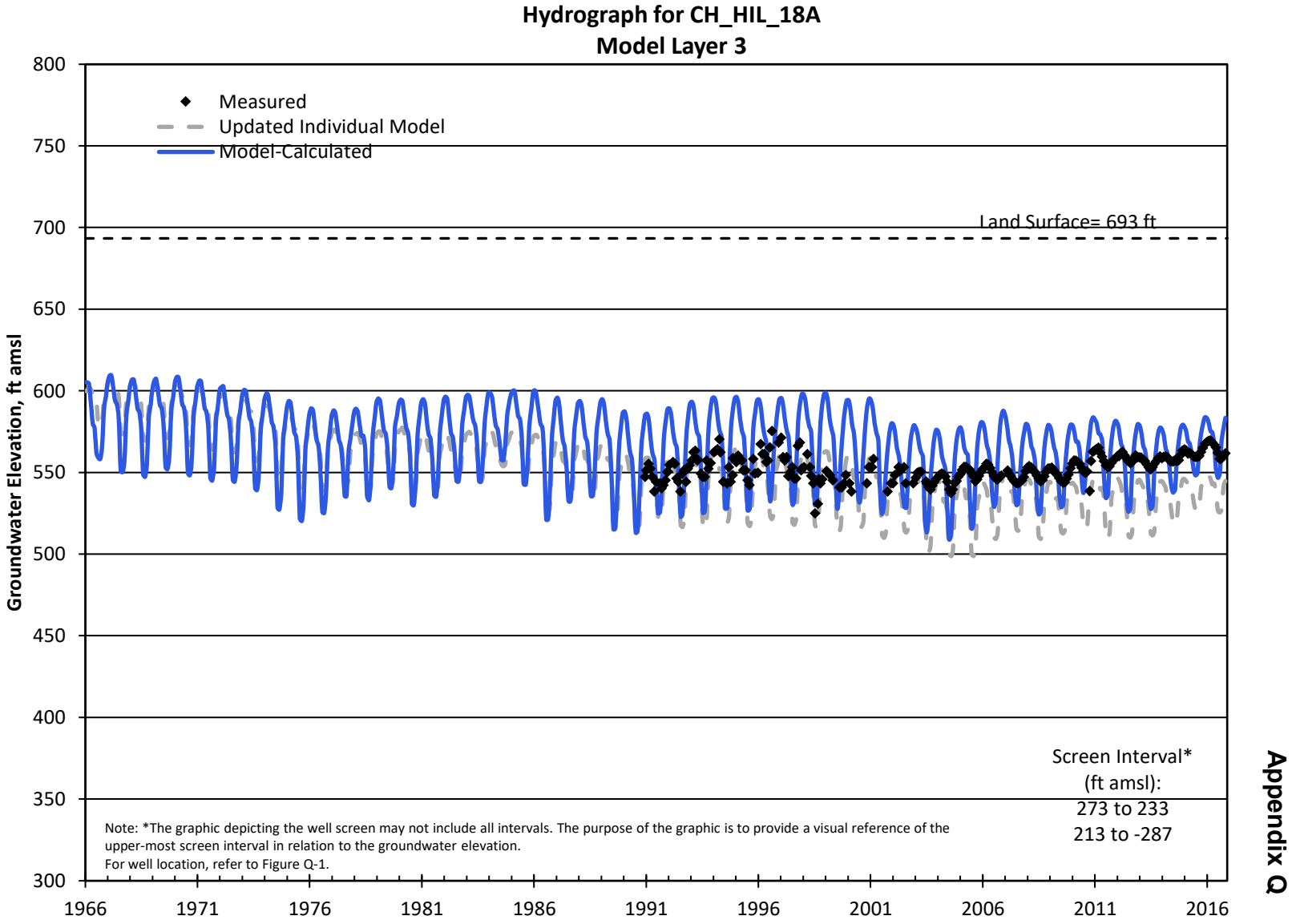
Appendix Q


Hydrograph for YMCA
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 662 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

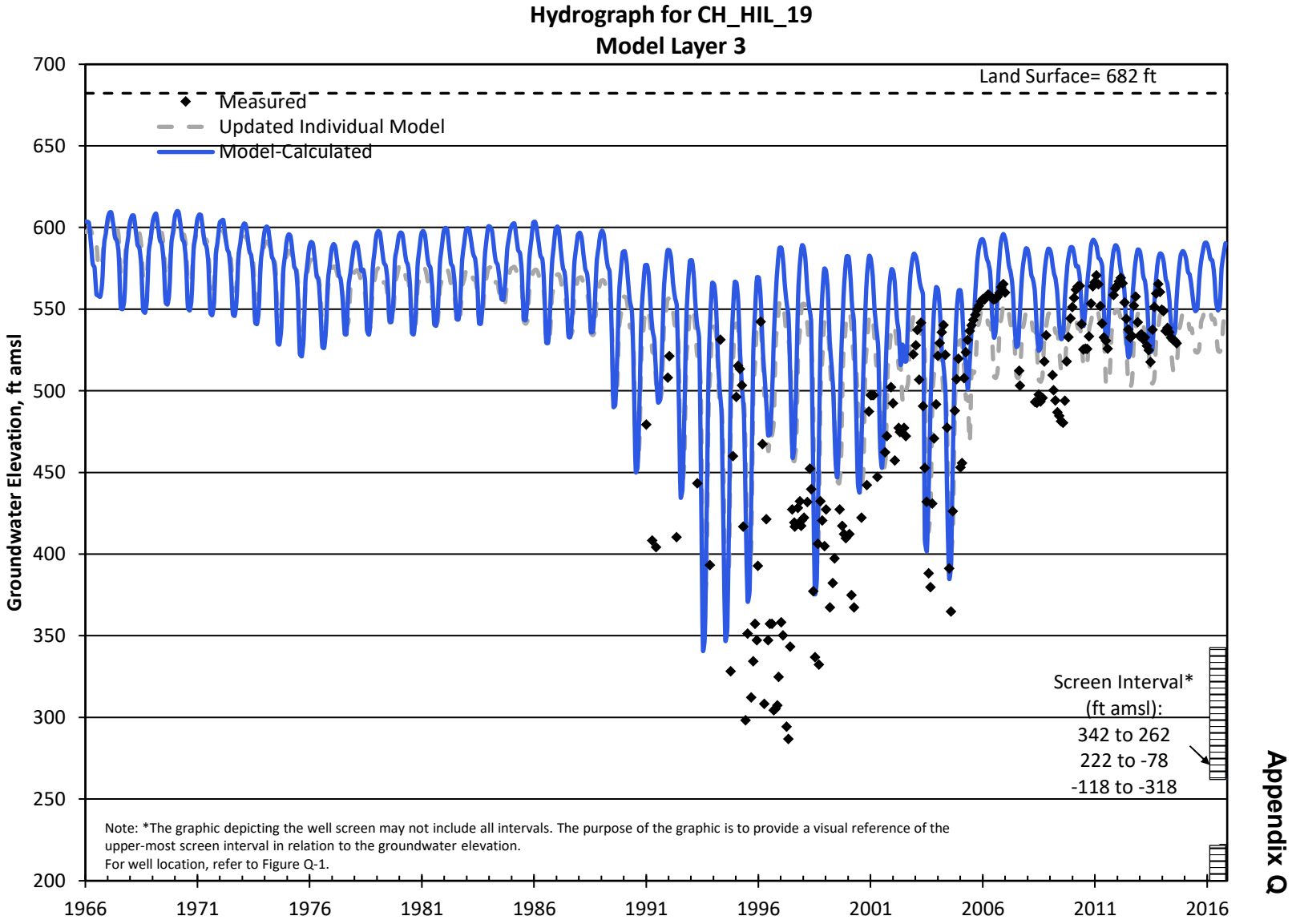
Appendix Q


Hydrograph for CH_HIL_15A_L1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 629 ft
Screen Interval*
(ft amsl):
439 to 319
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

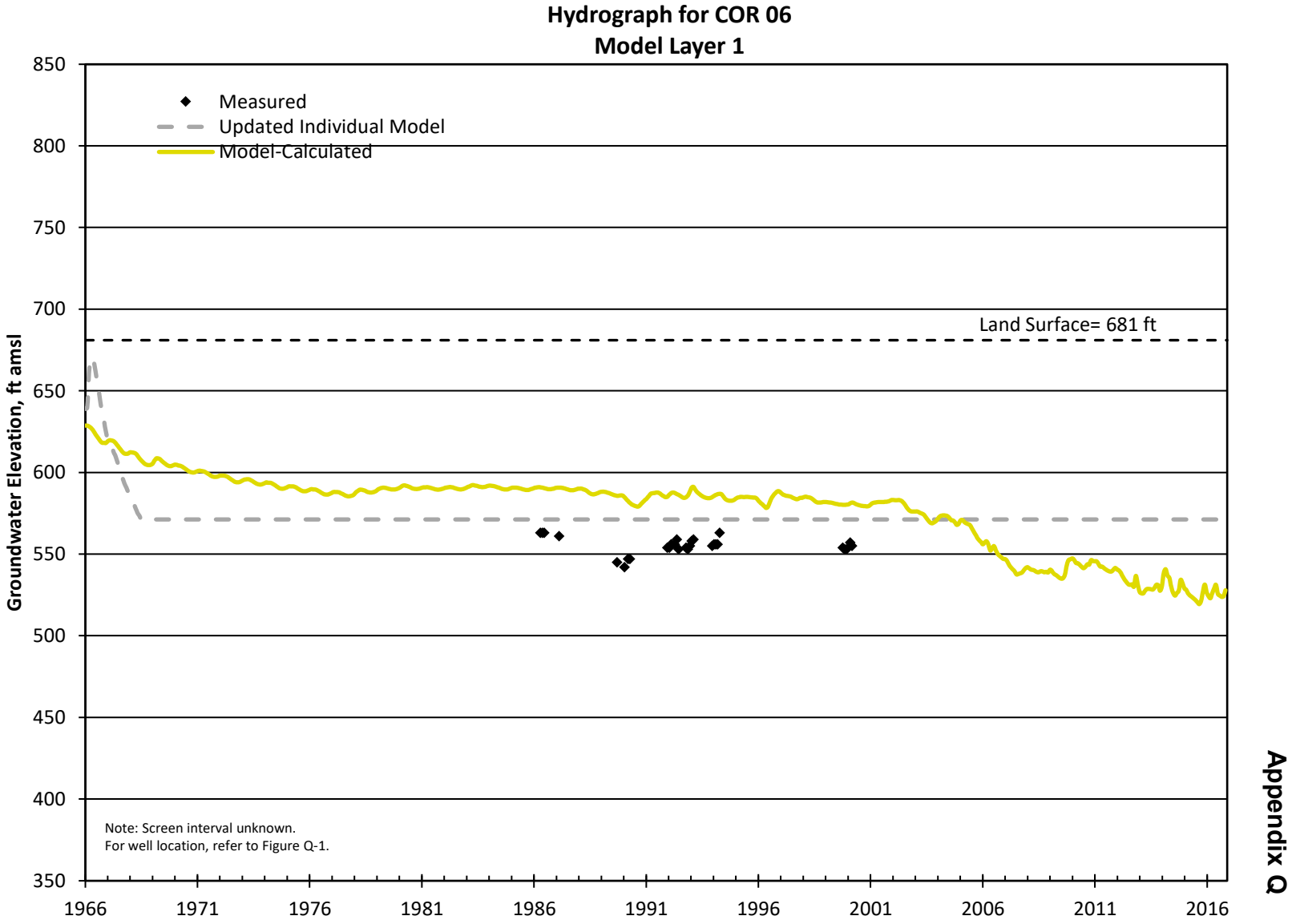
Appendix Q


Hydrograph for CH_HIL_18A
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 693 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
273 to 233
213 to -287
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

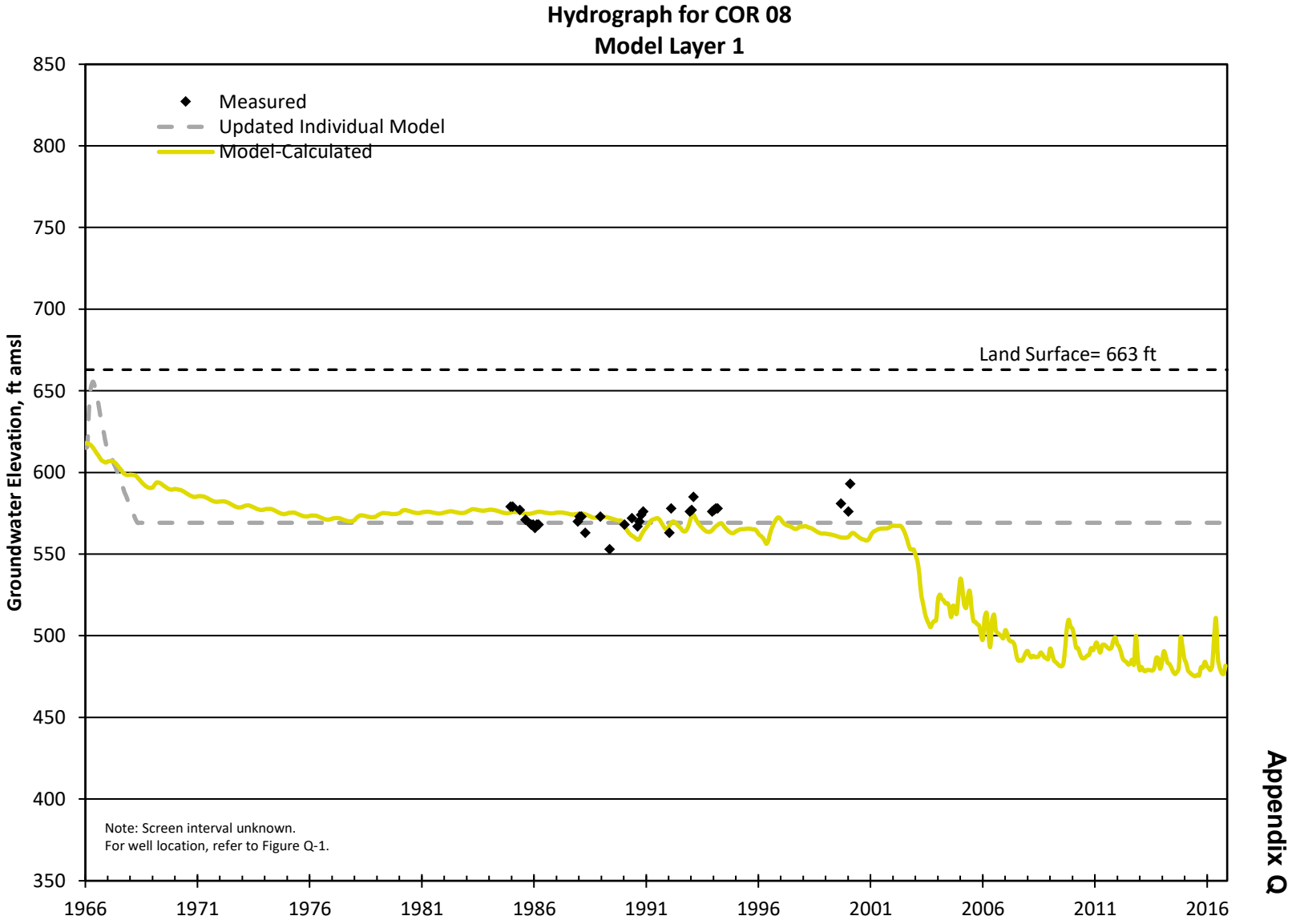
Appendix Q


Hydrograph for CH_HIL_19
Model Layer 3
Land Surface= 682 ft
Measured
Updated Individual Model
Model-Calculated
Groundwater Elevation, ft amsl
700
650
600
550
500
450
400
350
300
250
200
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
342 to 262
222 to -78
-118 to -318
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

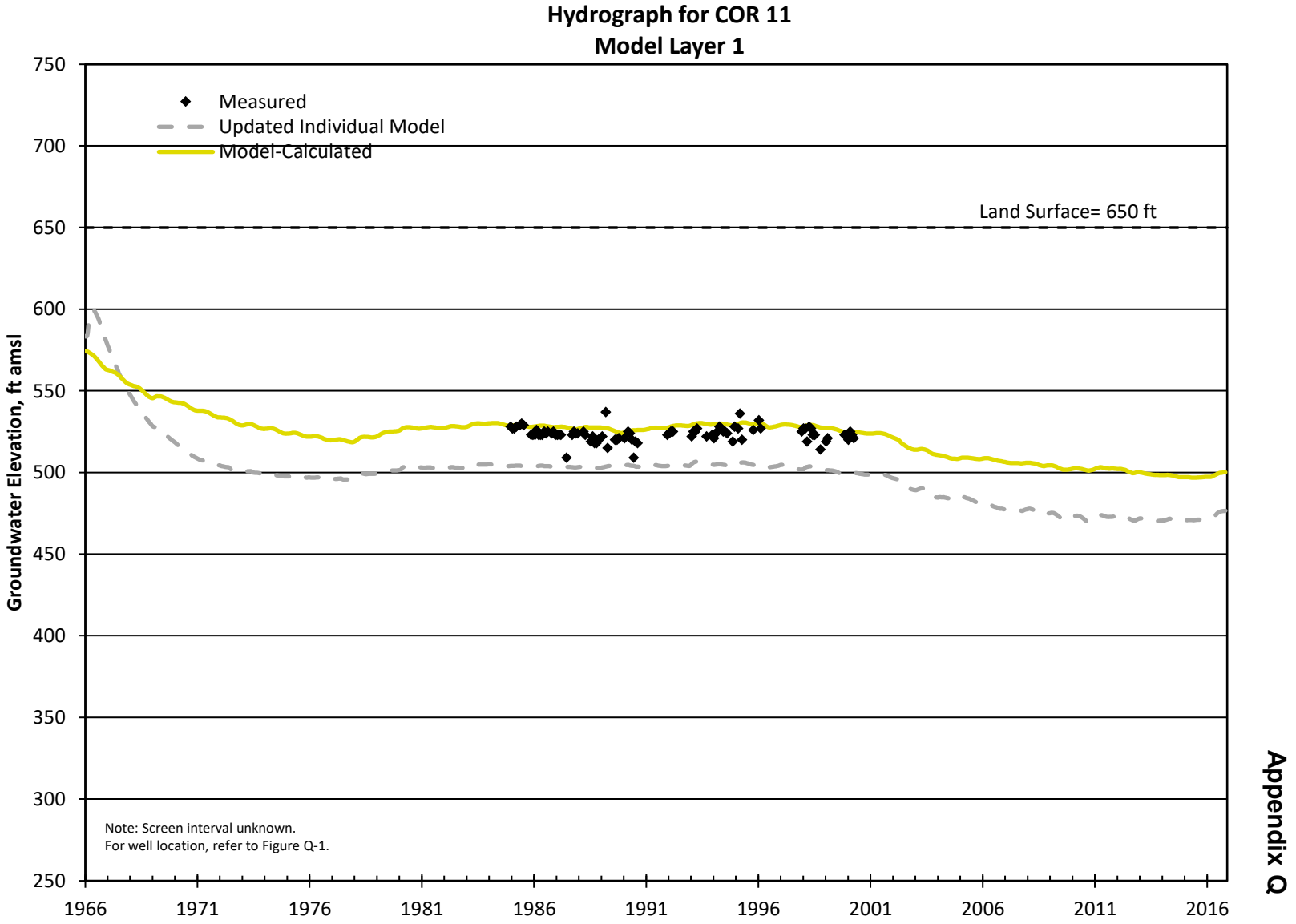
Appendix Q


Hydrograph for COR 06
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 681 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

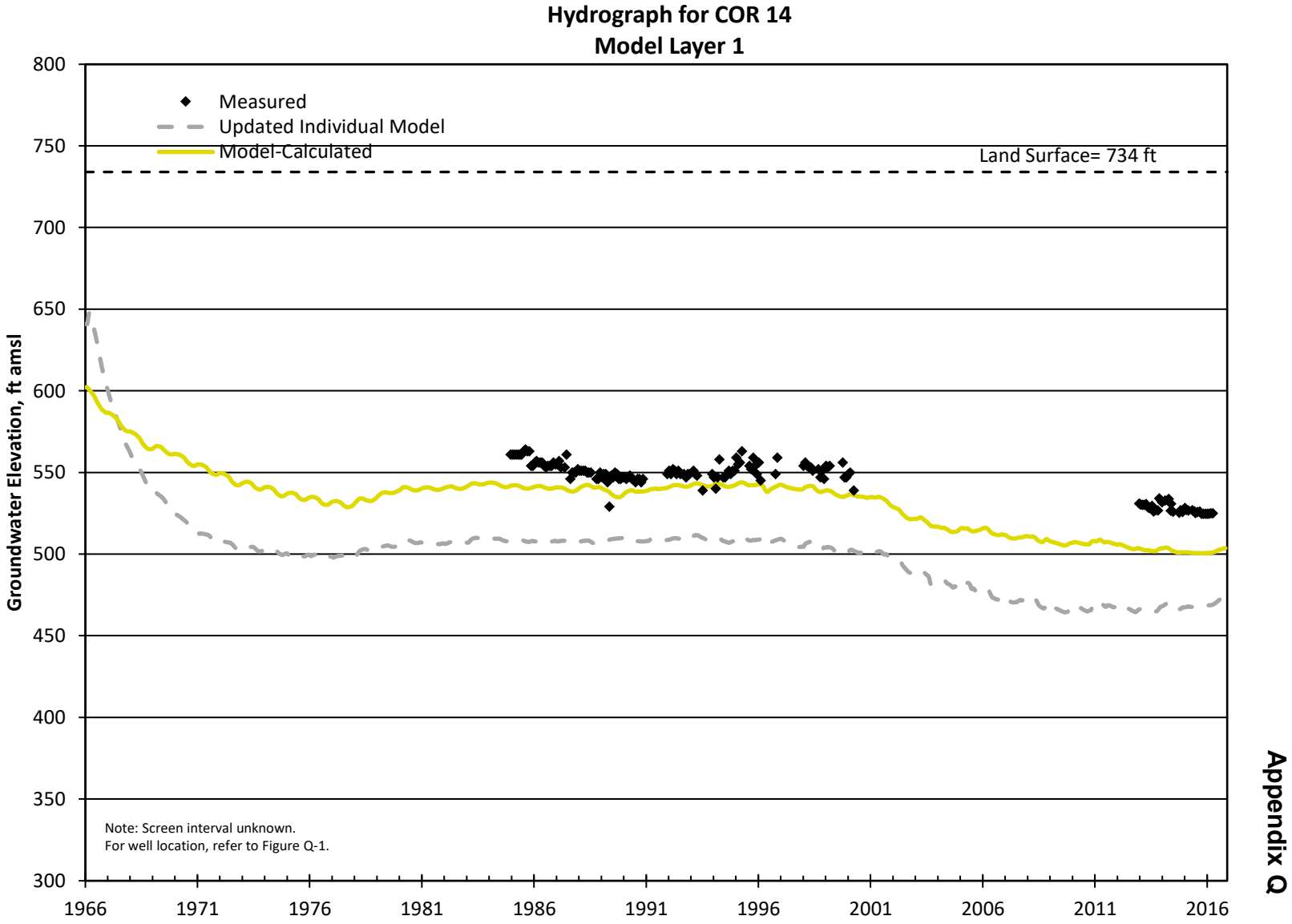
Appendix Q


Hydrograph for COR 08
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 663 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

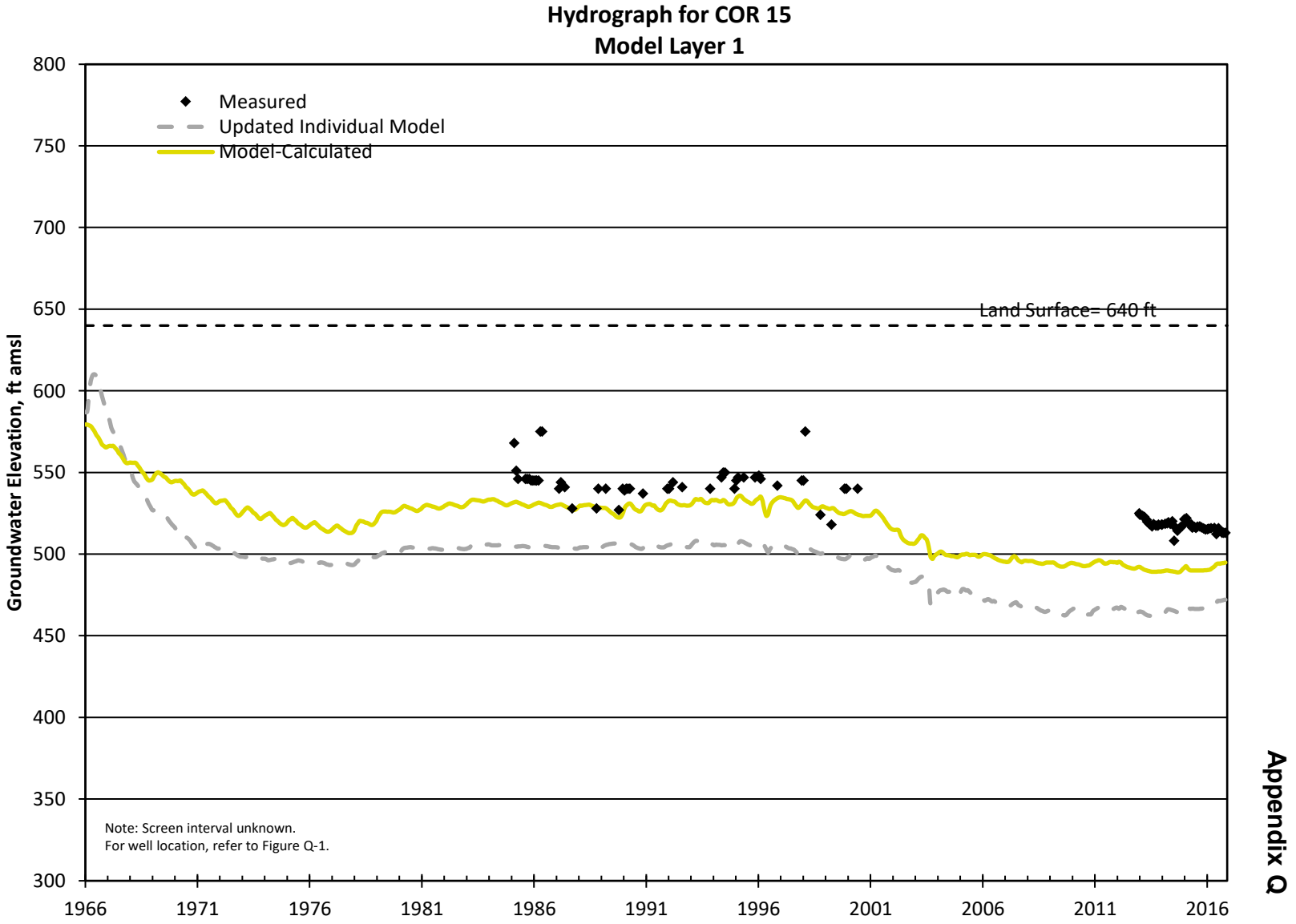
Appendix Q


Hydrograph for COR 11
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 650 ft
Groundwater Elevation, ft amsl
750
700
650
600
550
500
450
400
350
300
250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

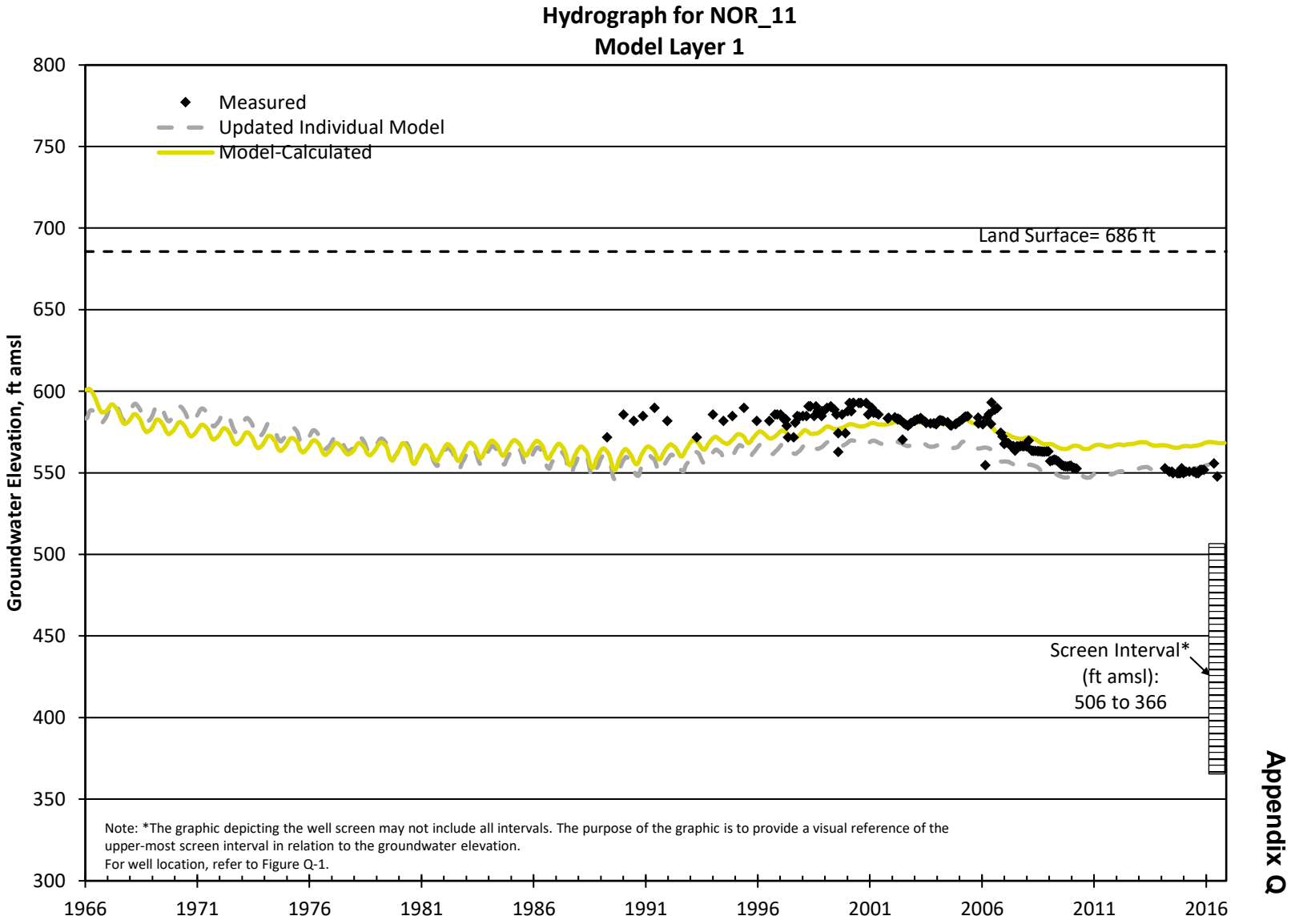
Appendix Q


Hydrograph for COR 14
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 734 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

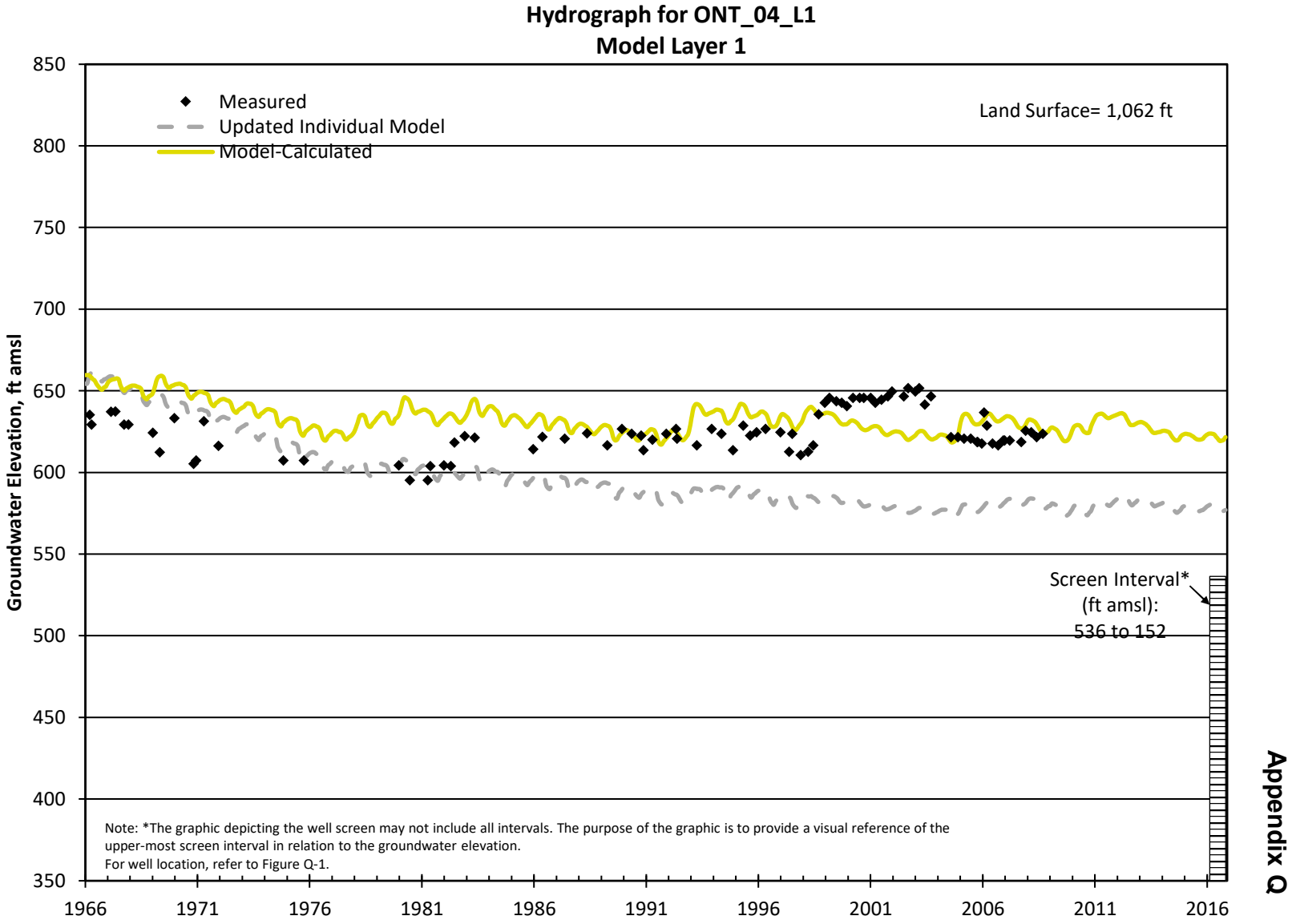
Appendix Q


Hydrograph for COR 15
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 640 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

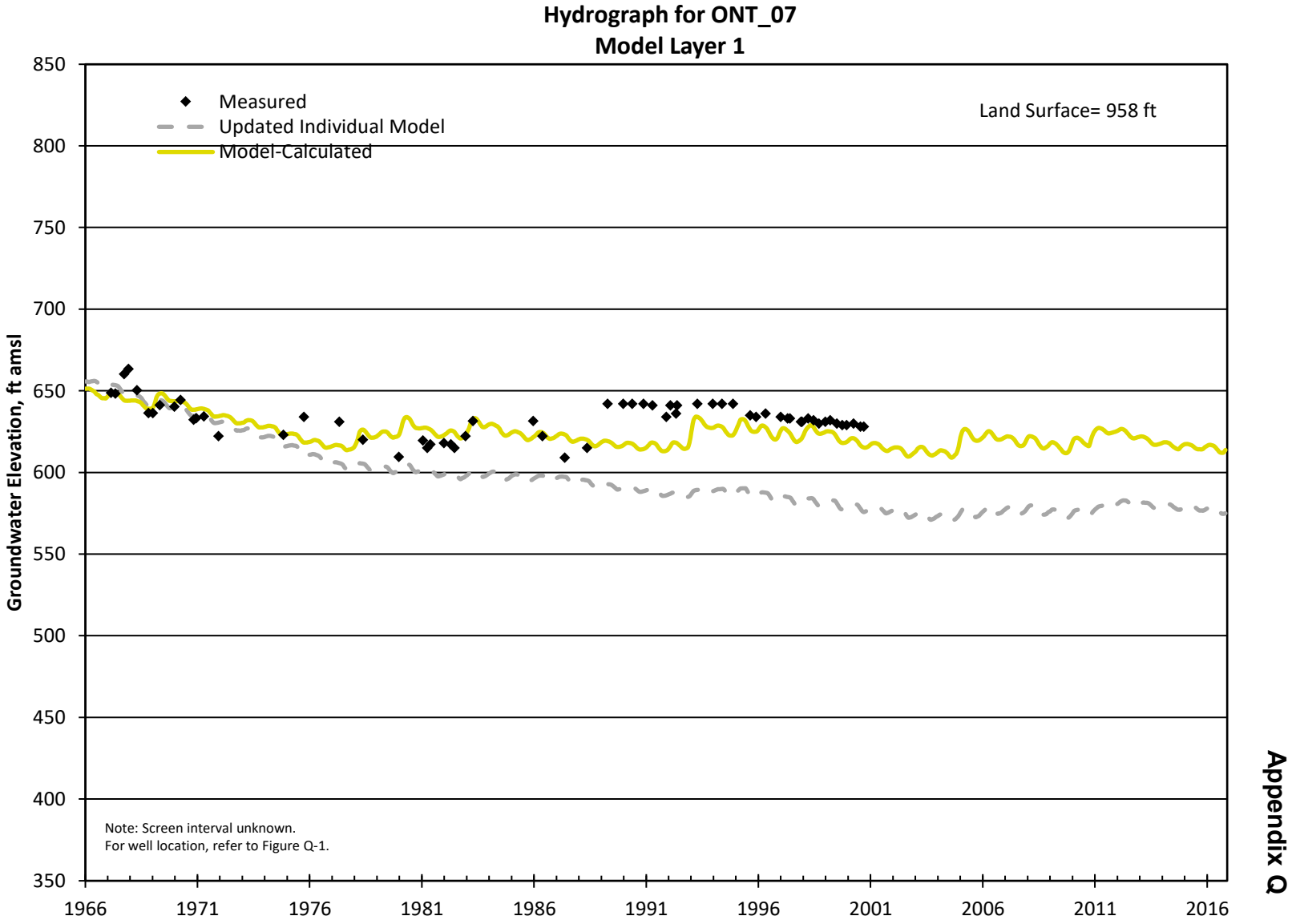
Appendix Q


Hydrograph for NOR_11
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 686 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
506 to 366
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

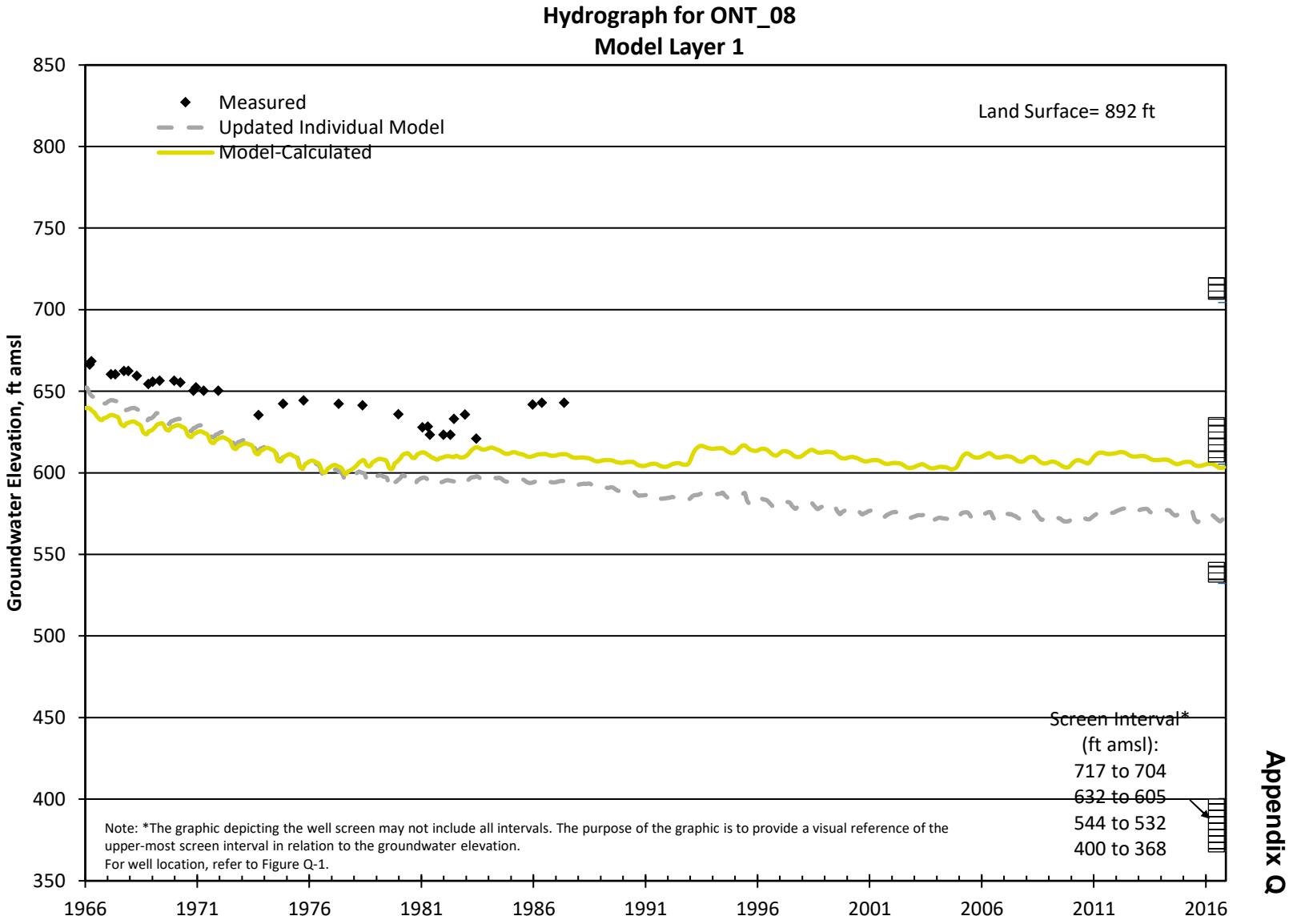
Appendix Q


Hydrograph for ONT_04_L1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,062 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
536 to 152
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

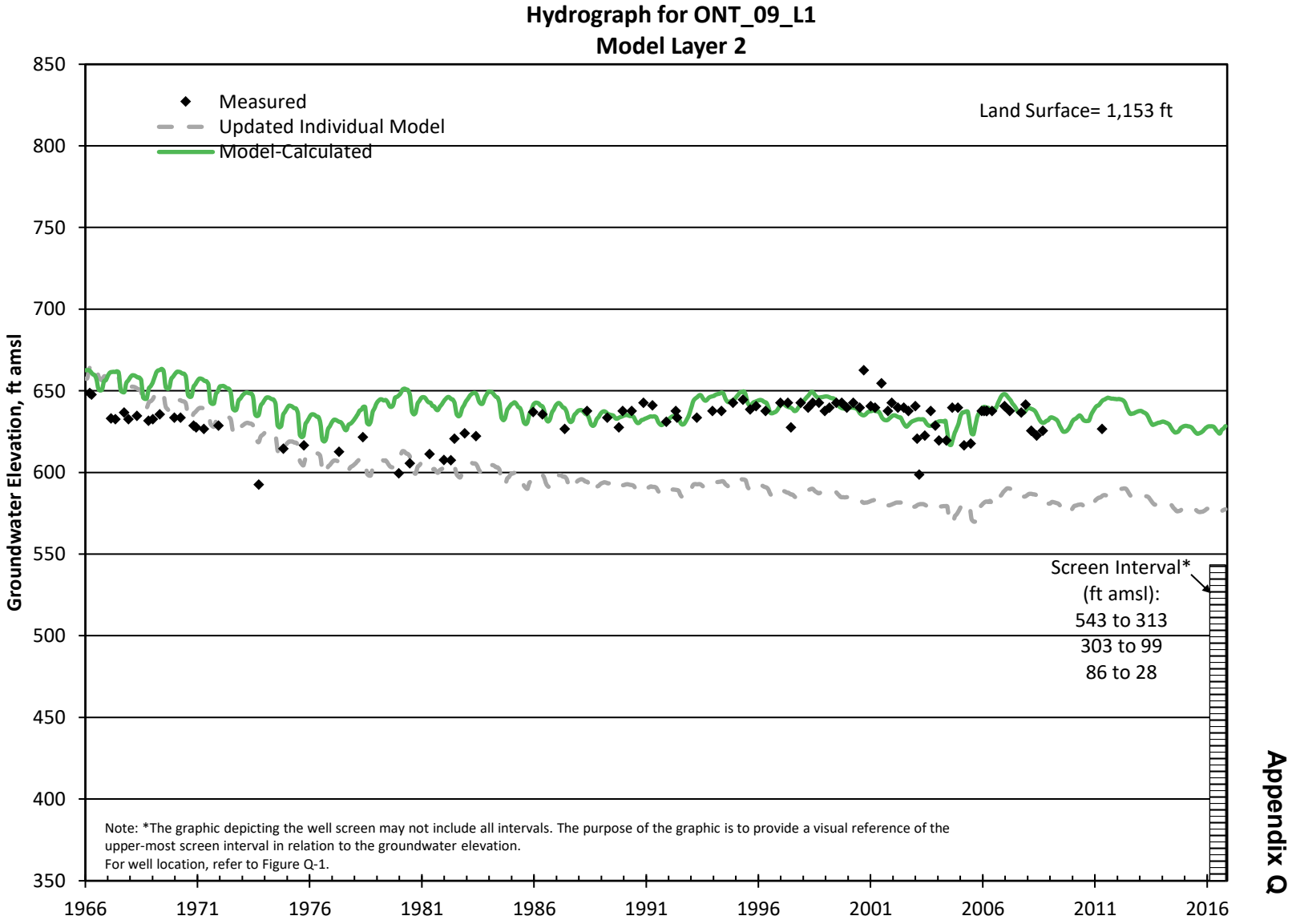
Appendix Q


Hydrograph for ONT_07
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 958 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

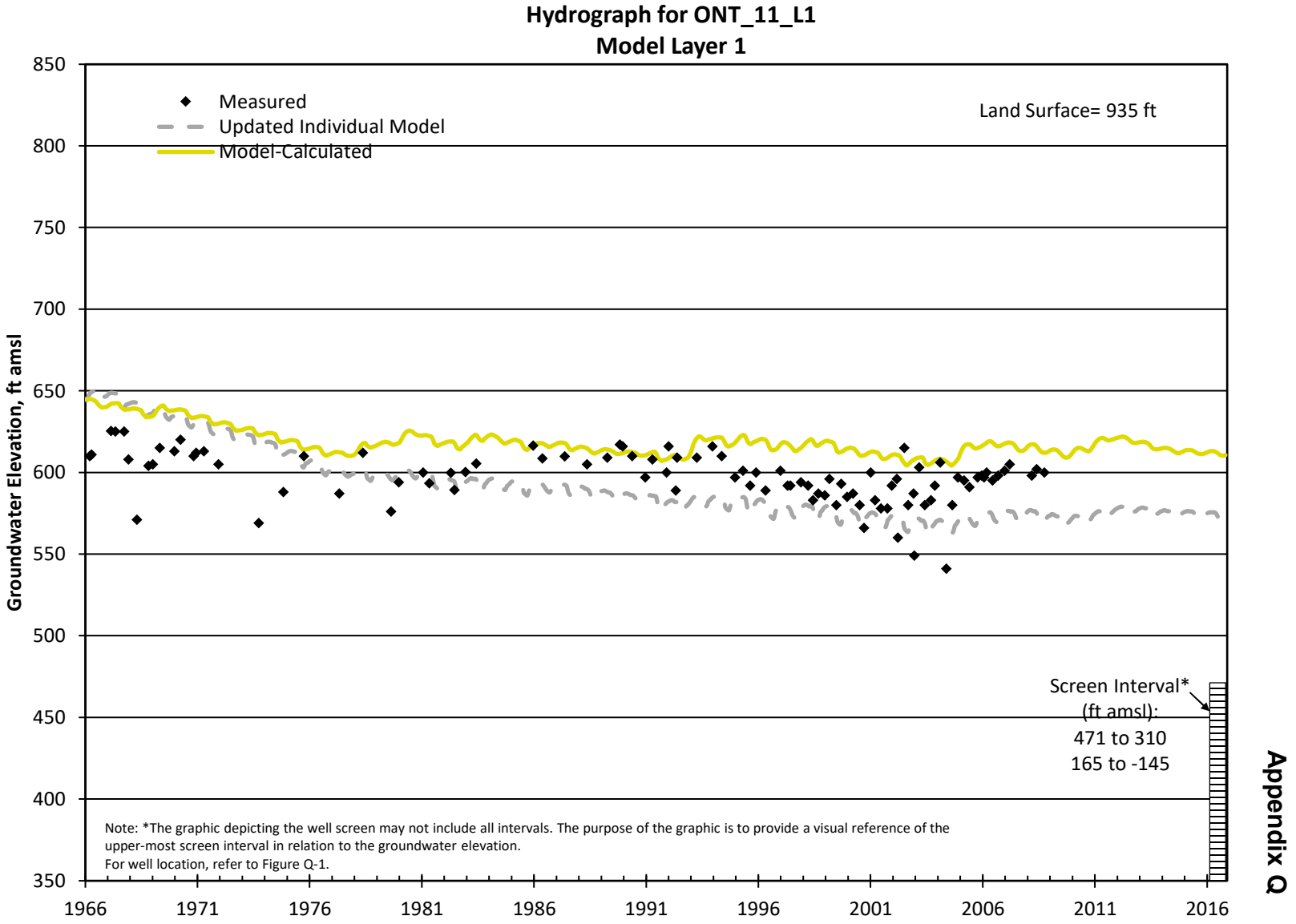
Appendix Q


Hydrograph for ONT_08
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 892 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
717 to 704
632 to 605
544 to 532
400 to 368
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

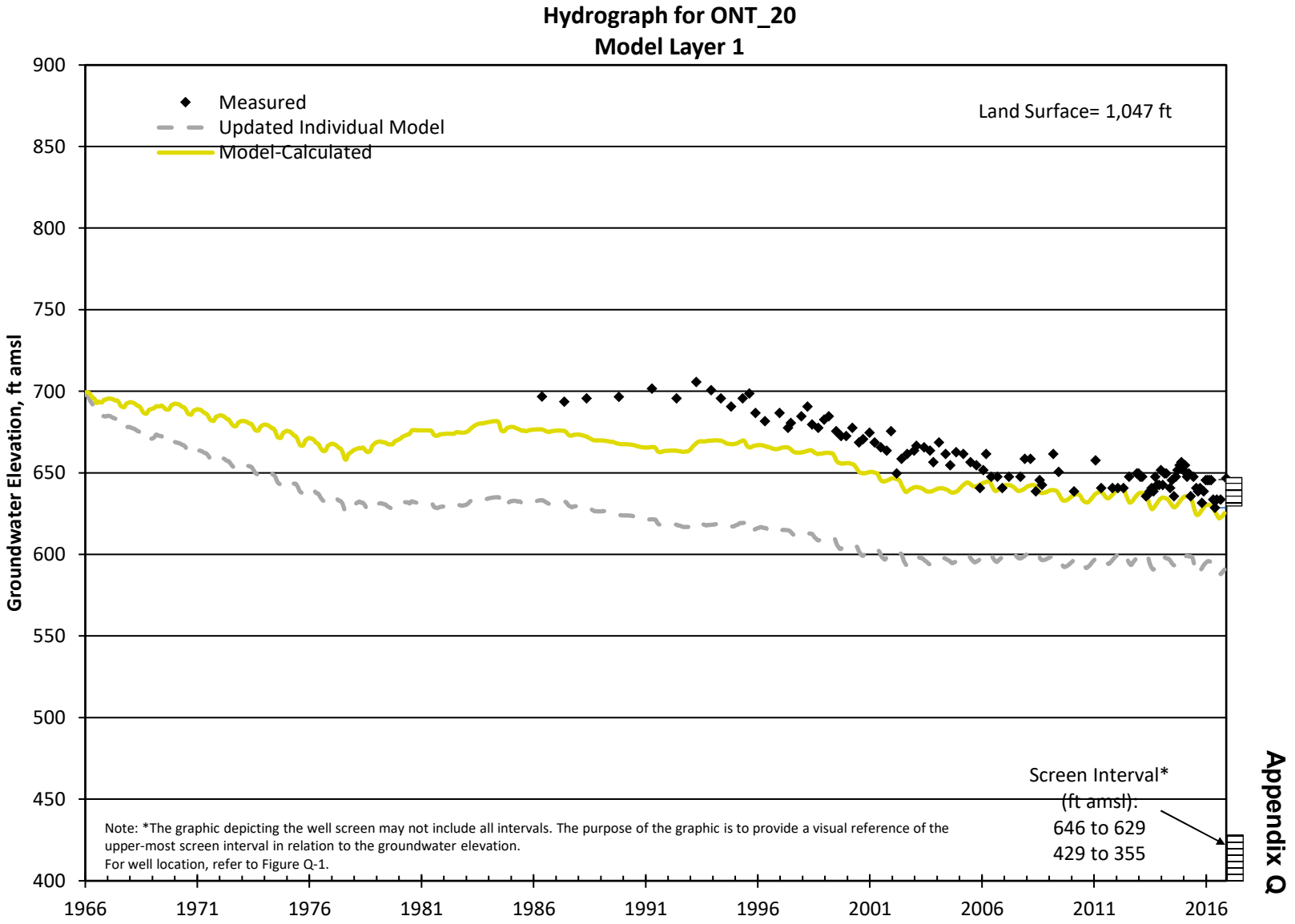
Appendix Q

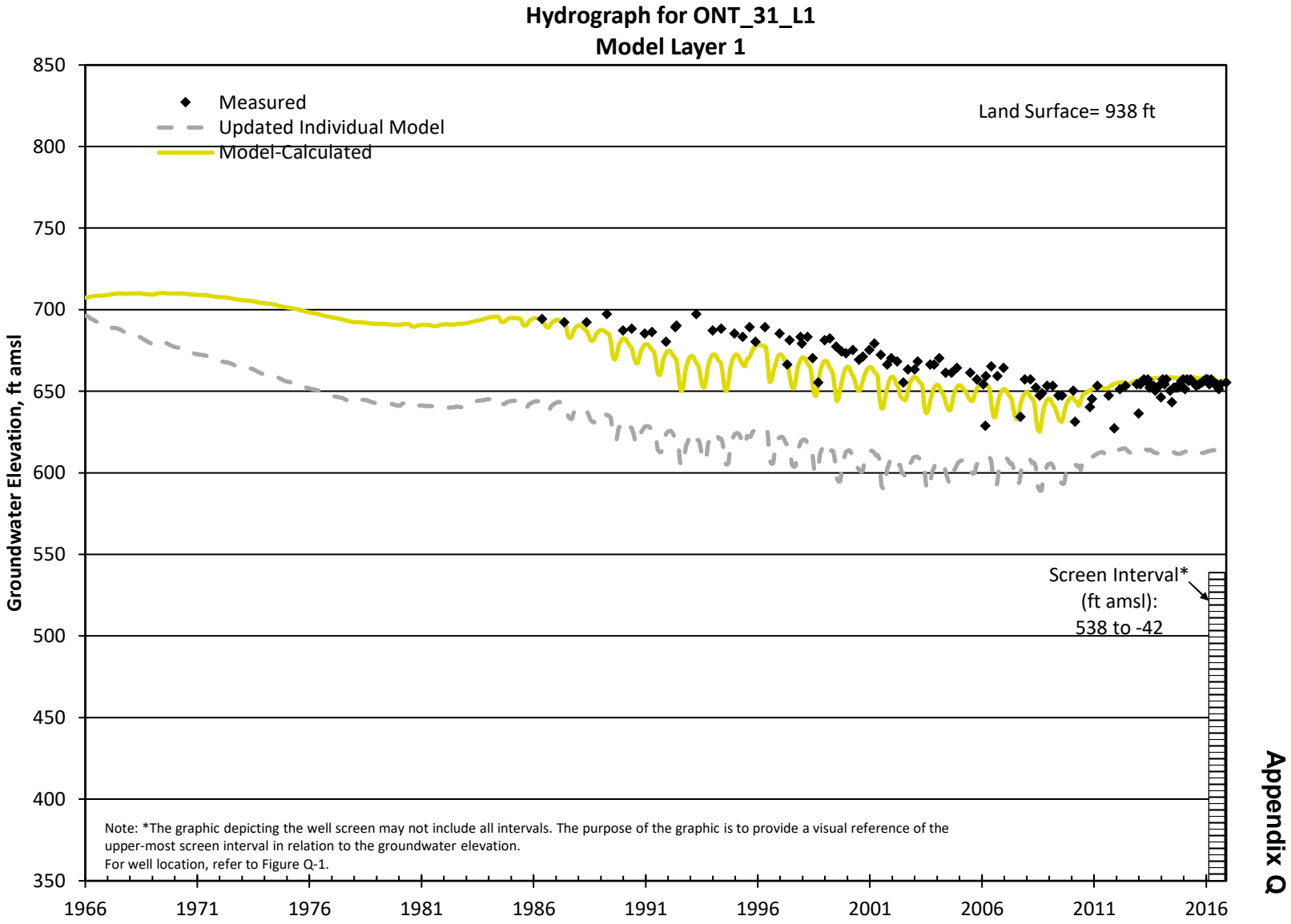

Hydrograph for ONT_09_L1
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,153 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
543 to 313
303 to 99
86 to 28
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

Appendix Q

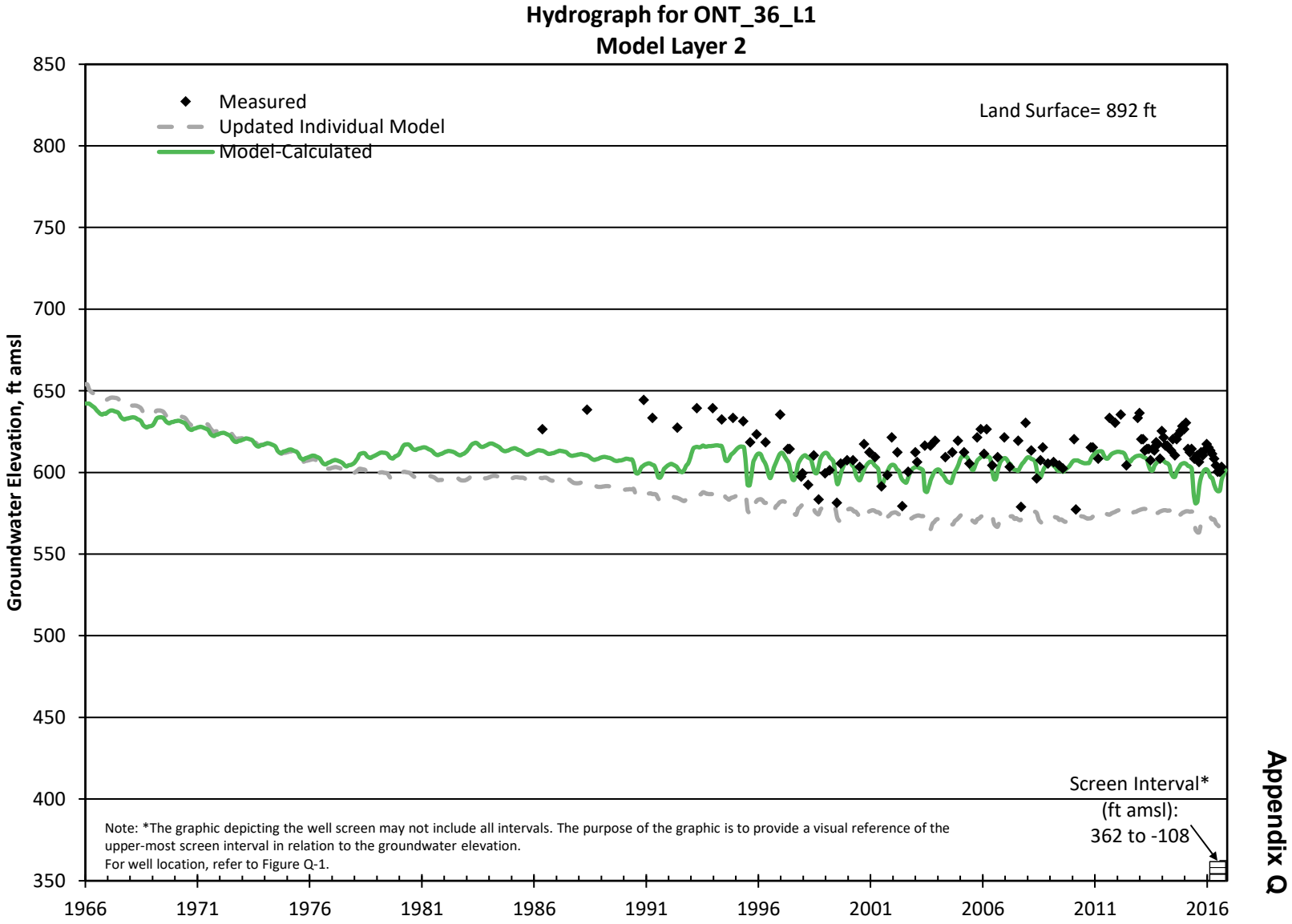

Hydrograph for ONT_11_L1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 935 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
471 to 310
165 to -145
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

Appendix Q

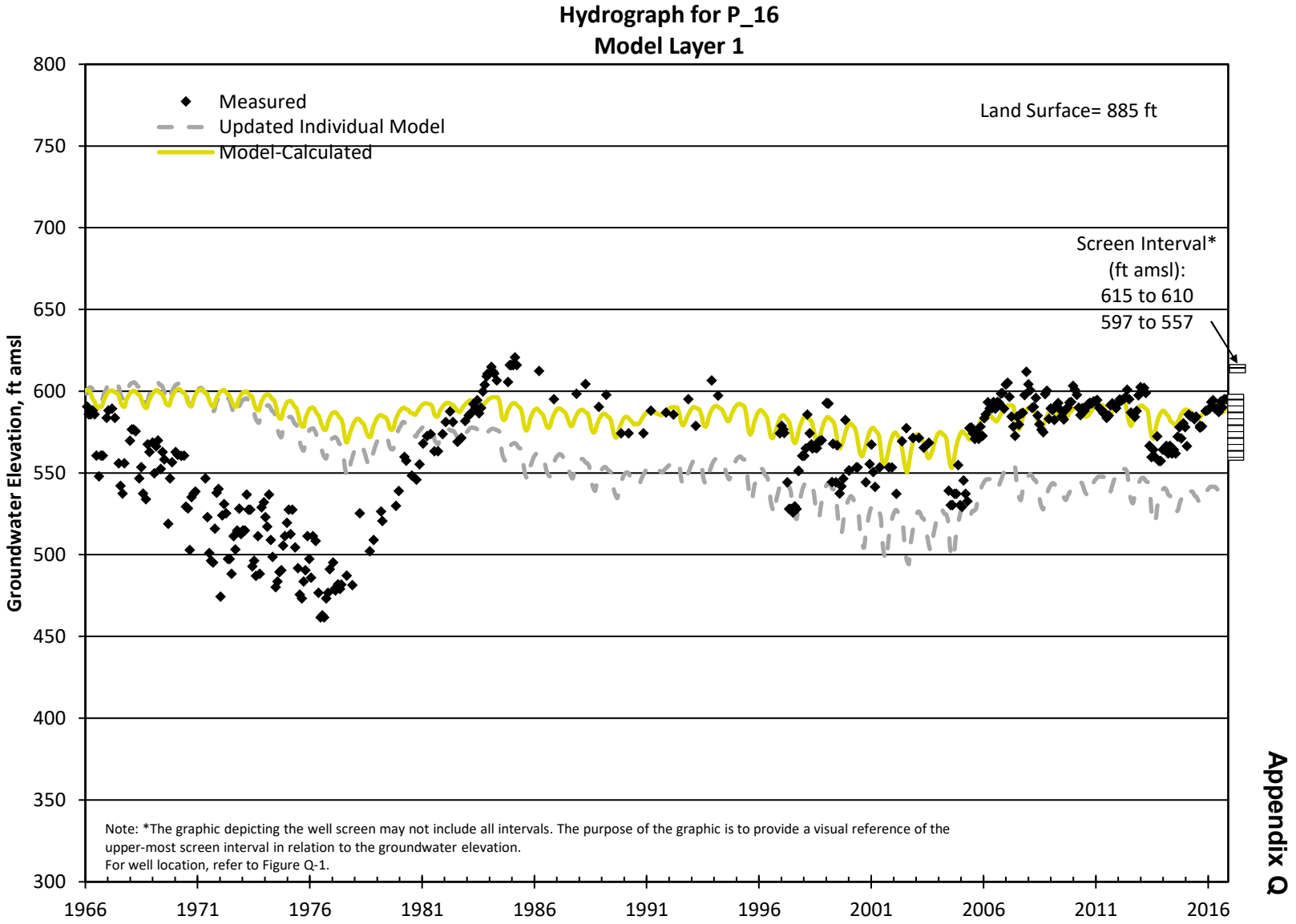

Hydrograph for ONT_20
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,047 ft
Groundwater Elevation, ft amsl
900
850
800
750
700
650
600
550
500
450
400
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
646 to 629
429 to 355
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.
Appendix Q


Hydrograph for ONT_31_L1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 938 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
538 to -42
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

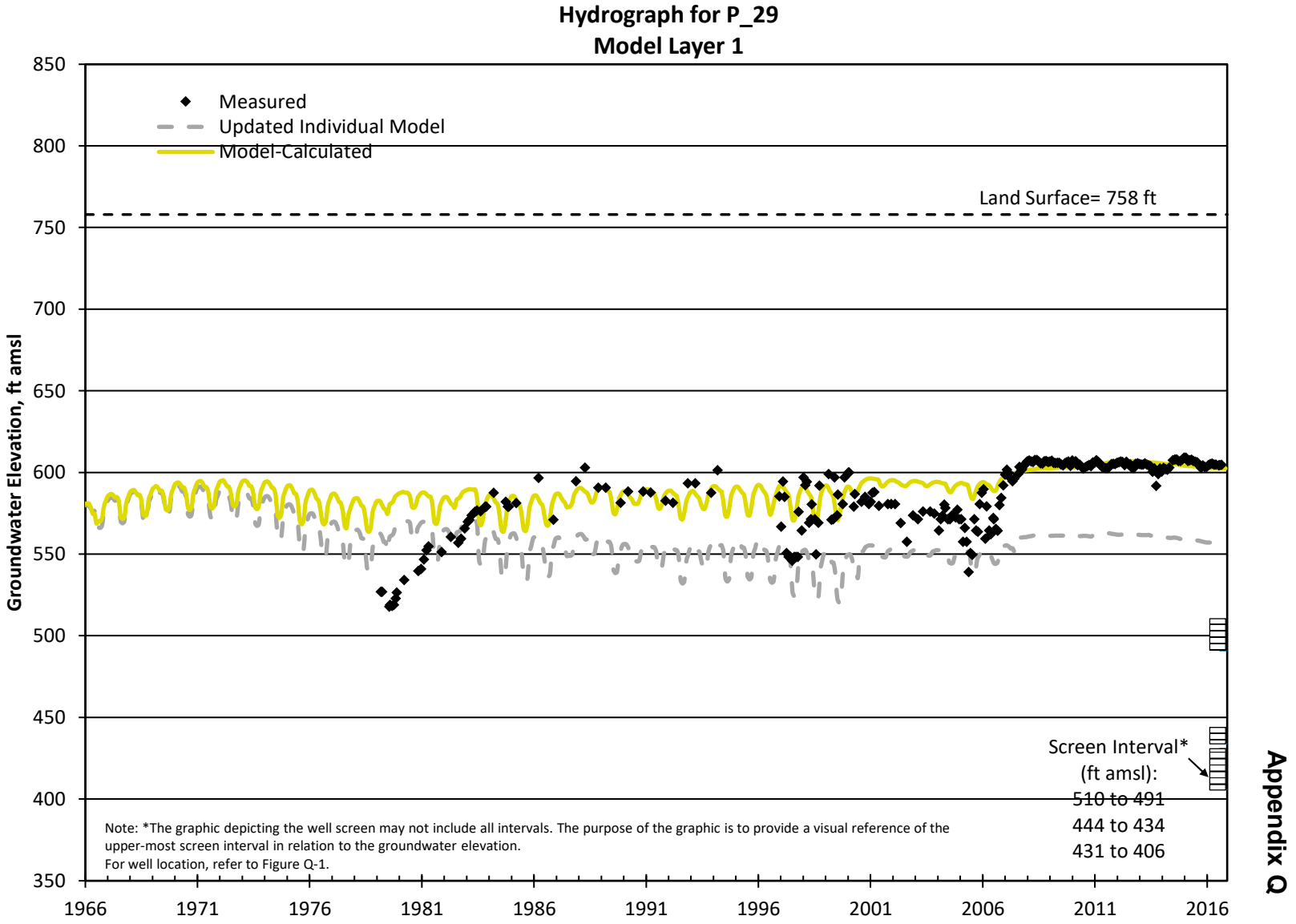
Appendix Q


Hydrograph for ONT_36_L1
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 892 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
362 to -108
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

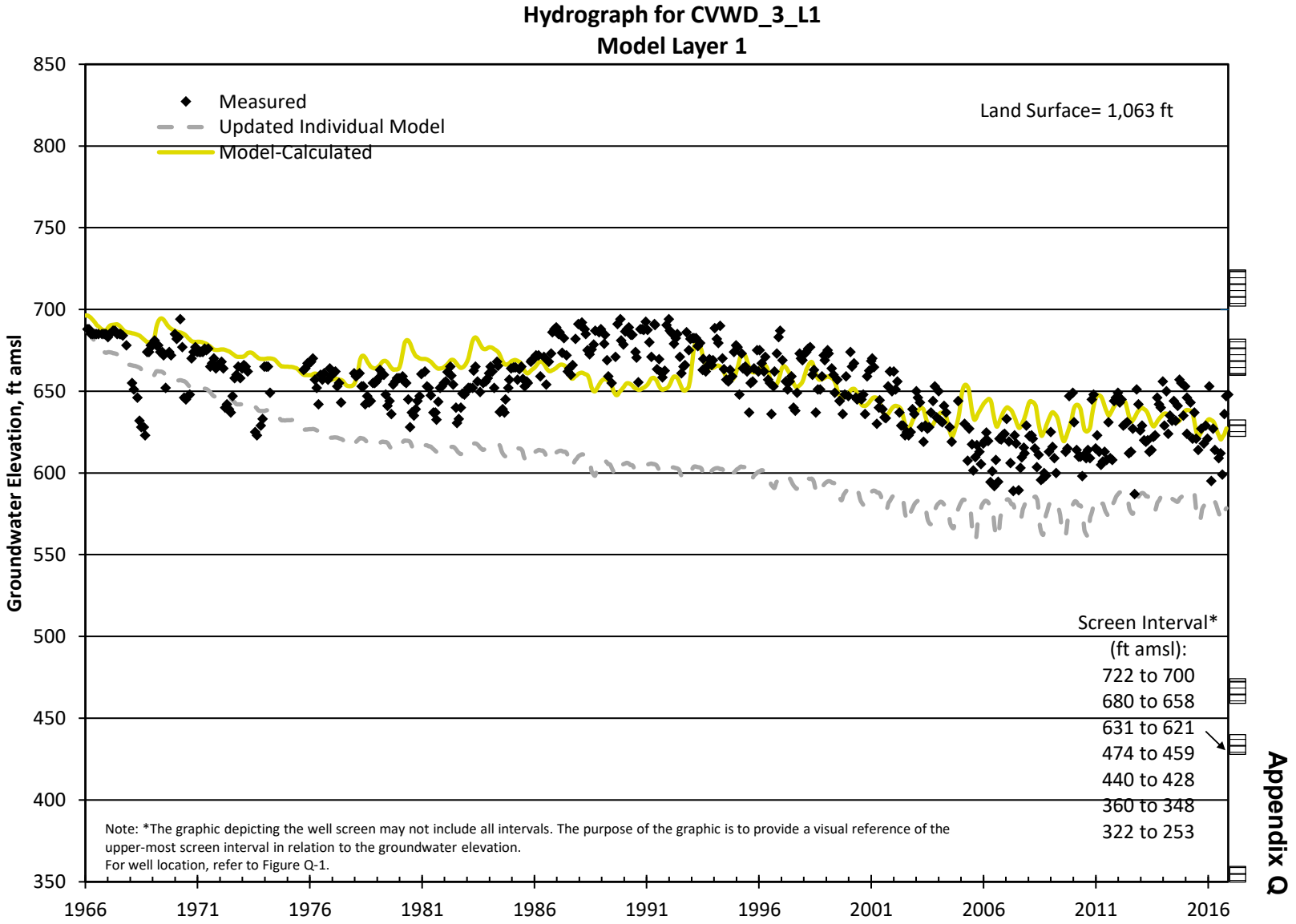
Appendix Q

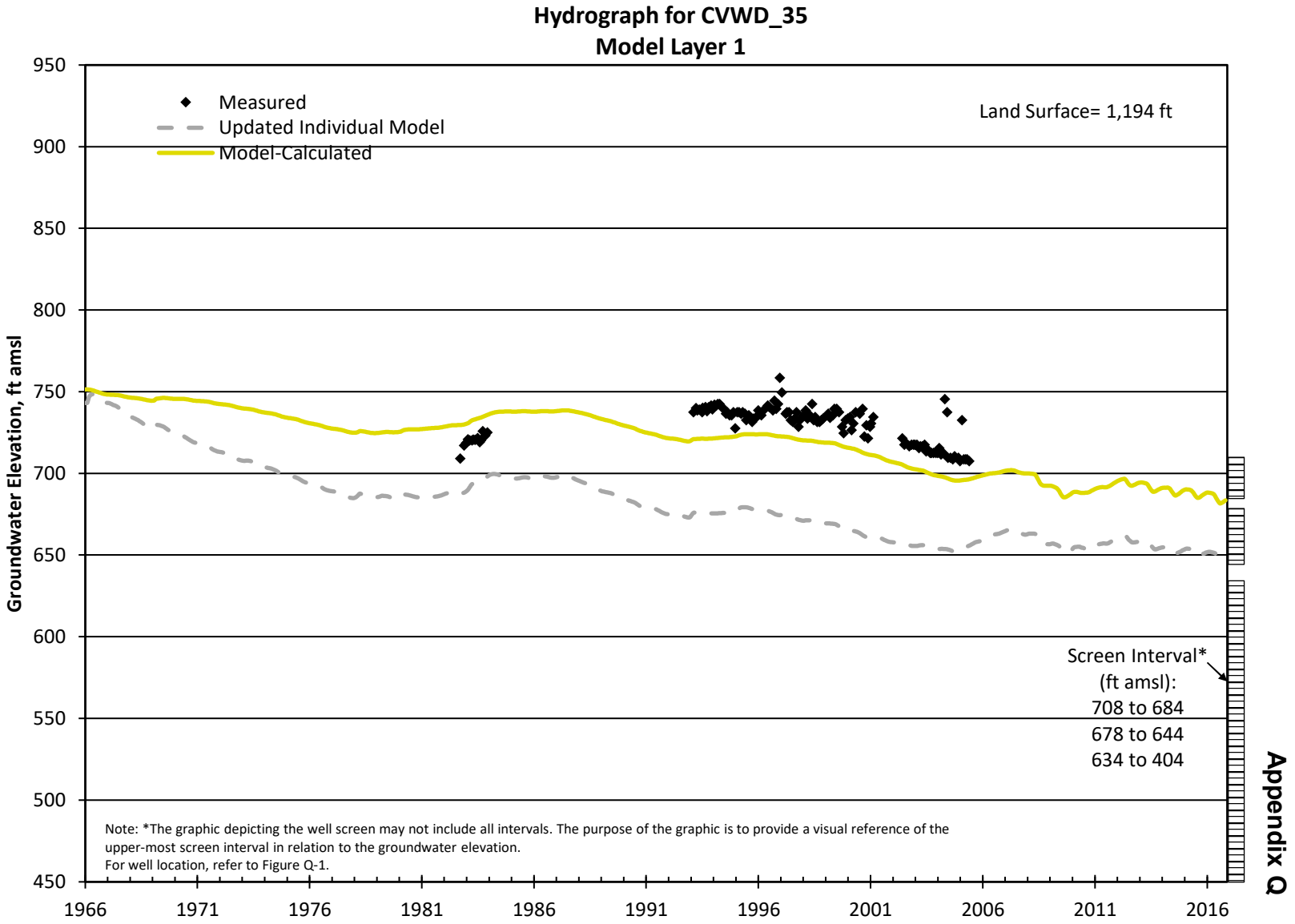

Hydrograph for P_16
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 885 ft
Screen Interval*
(ft amsl):
615 to 610
597 to 557
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

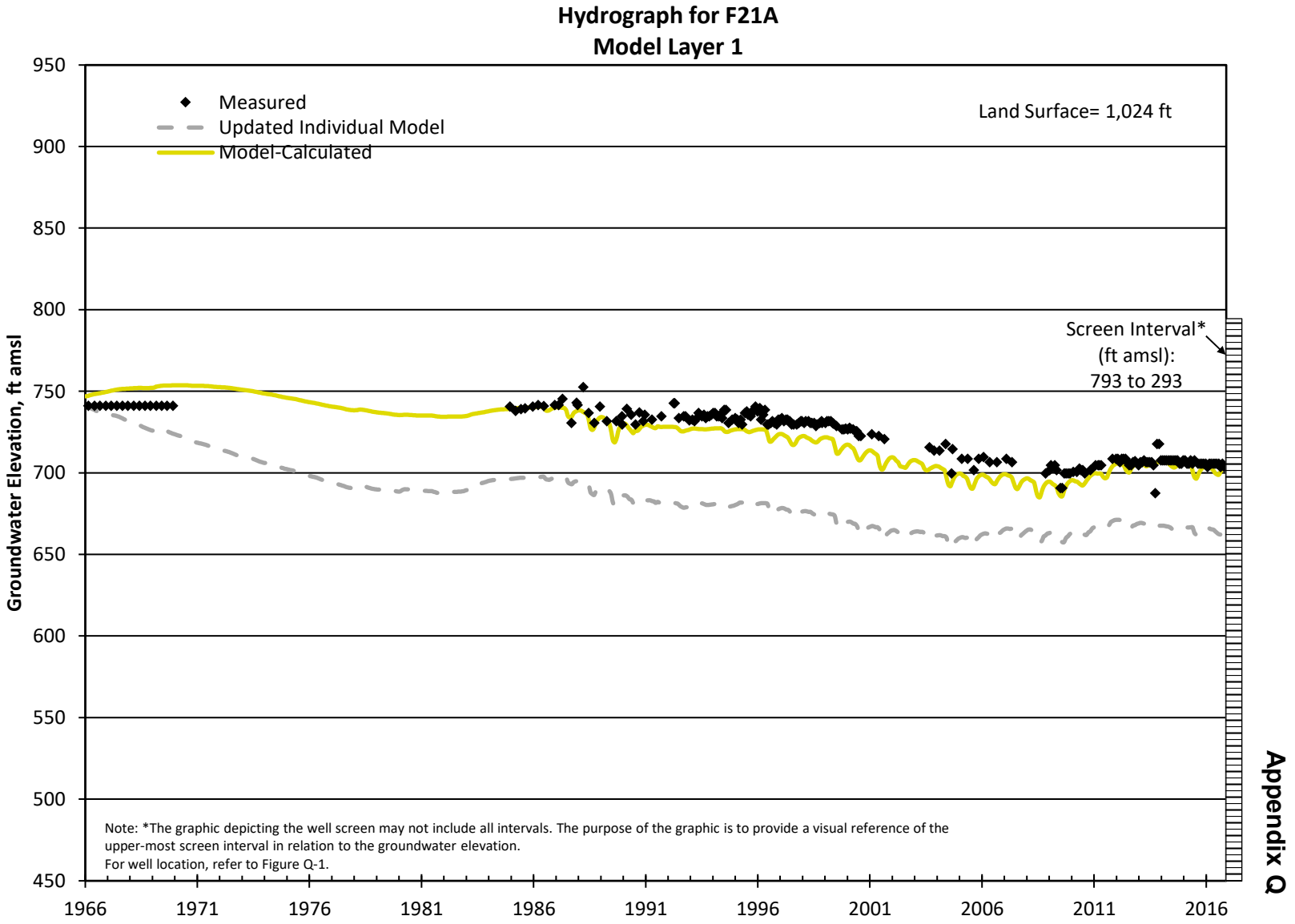
Appendix Q


Hydrograph for P_29
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 758 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
510 to 491
444 to 434
431 to 406
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

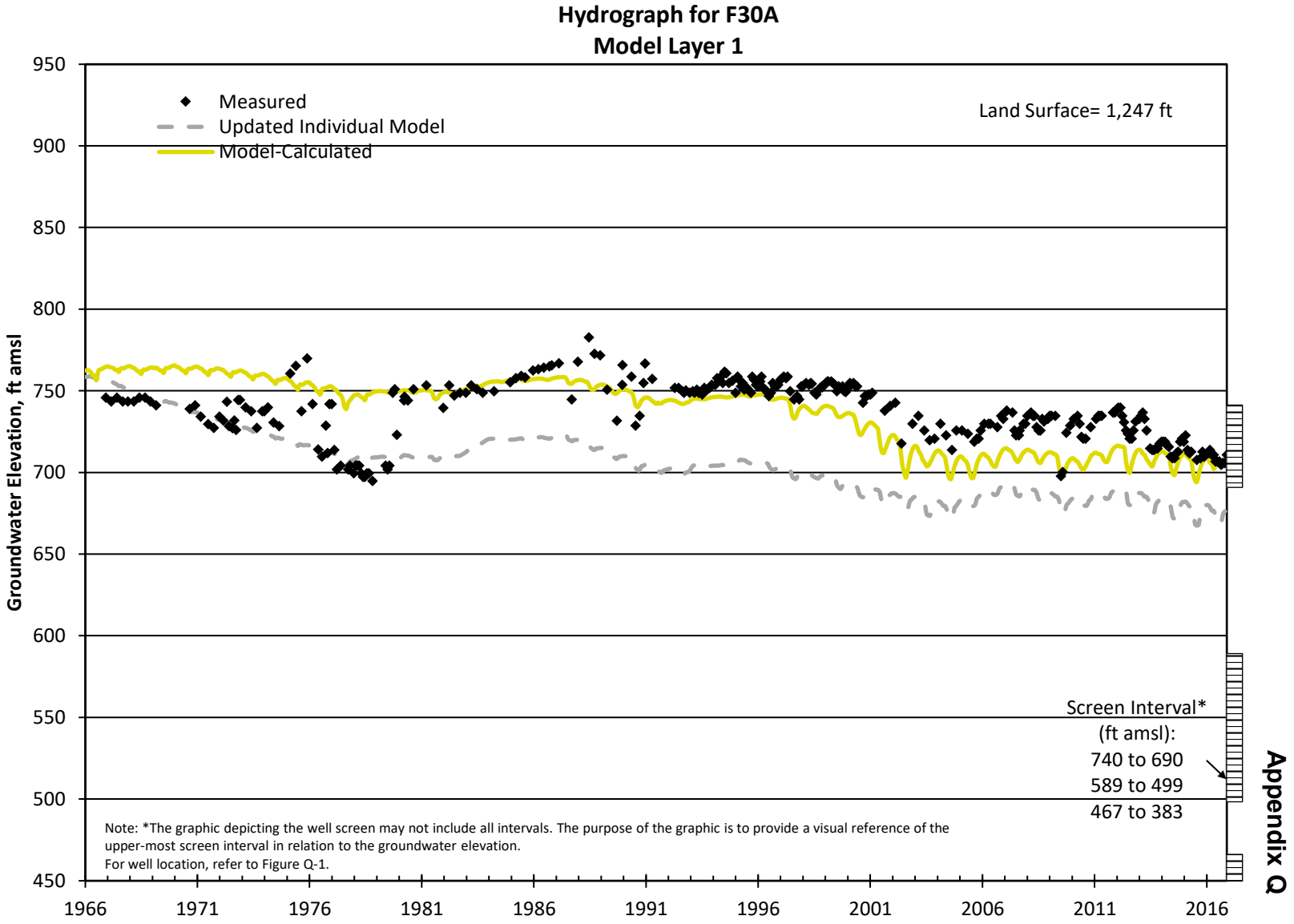
Appendix Q

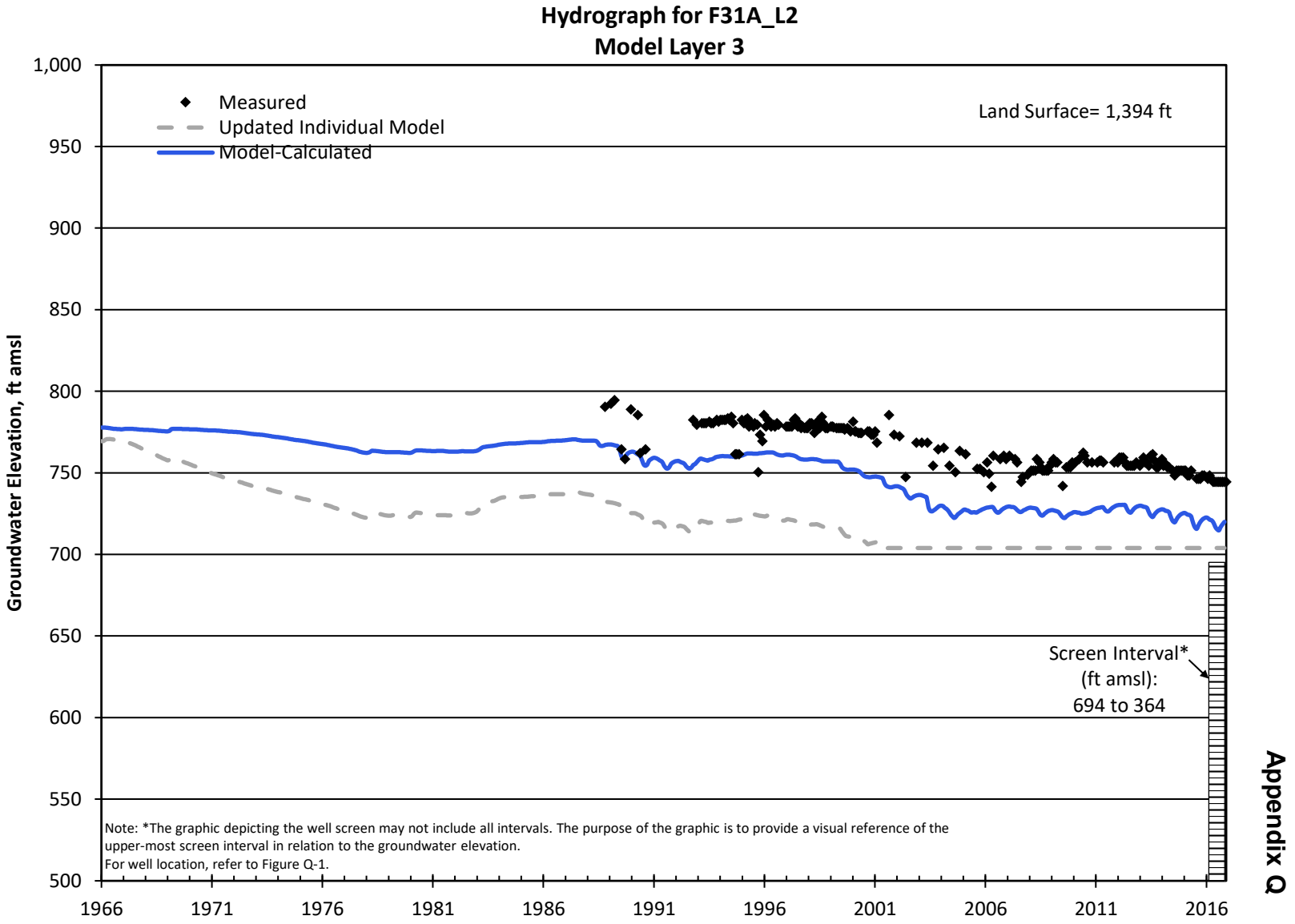

Hydrograph for CVWD_3_L1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,063 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
722 to 700
680 to 658
631 to 621
474 to 459
440 to 428
360 to 348
322 to 253
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.
Appendix Q


Hydrograph for CVWD_35
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,194 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
708 to 684
678 to 644
634 to 404
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.
Appendix Q

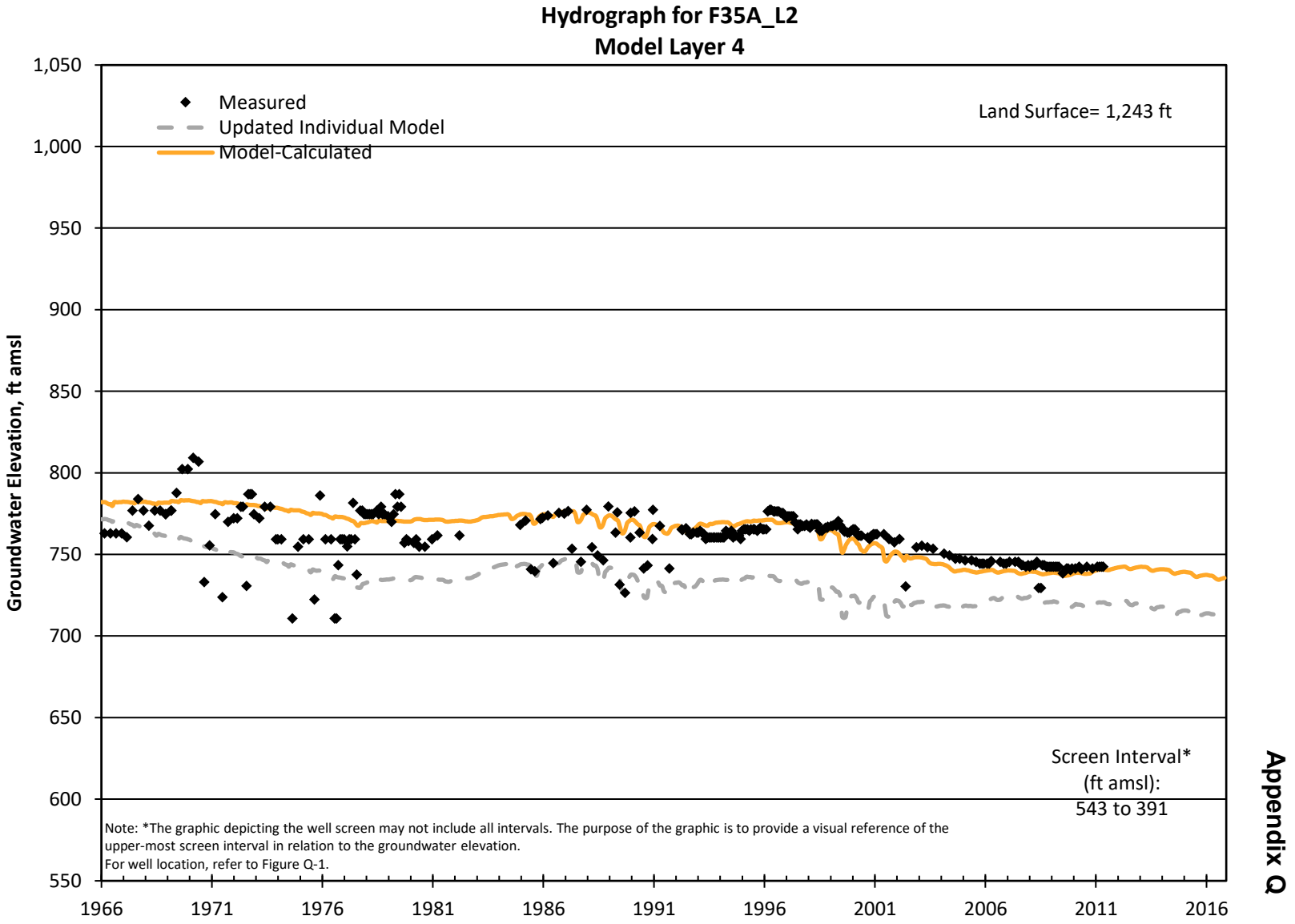

Hydrograph for F21A
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,024 ft
Screen Interval*
(ft amsl):
793 to 293
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

Appendix Q

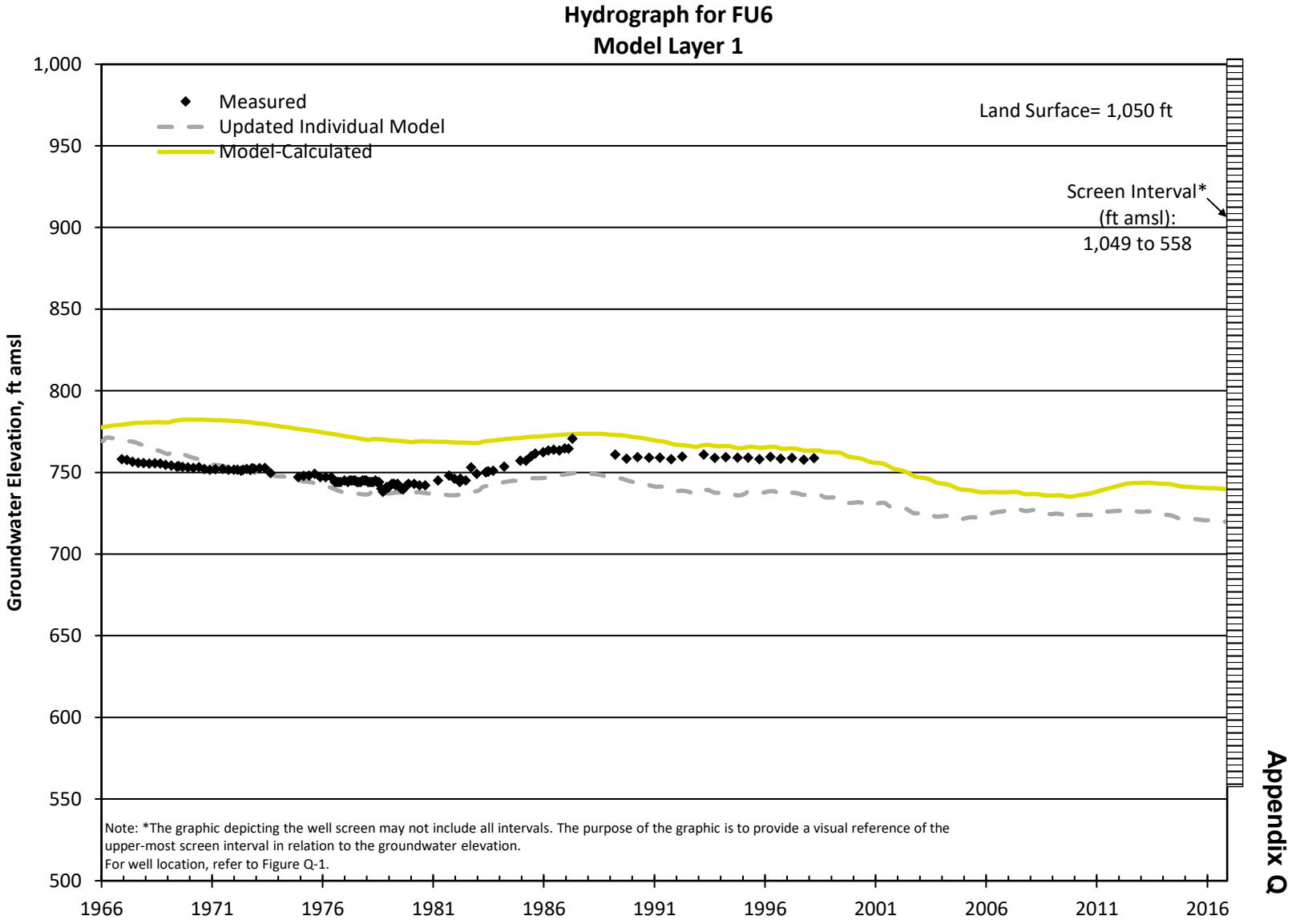

Hydrograph for F30A
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,247 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
740 to 690
589 to 499
467 to 383
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.
Appendix Q


Hydrograph for F31A_L2
Model Layer 3
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,394 ft
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
694 to 364
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

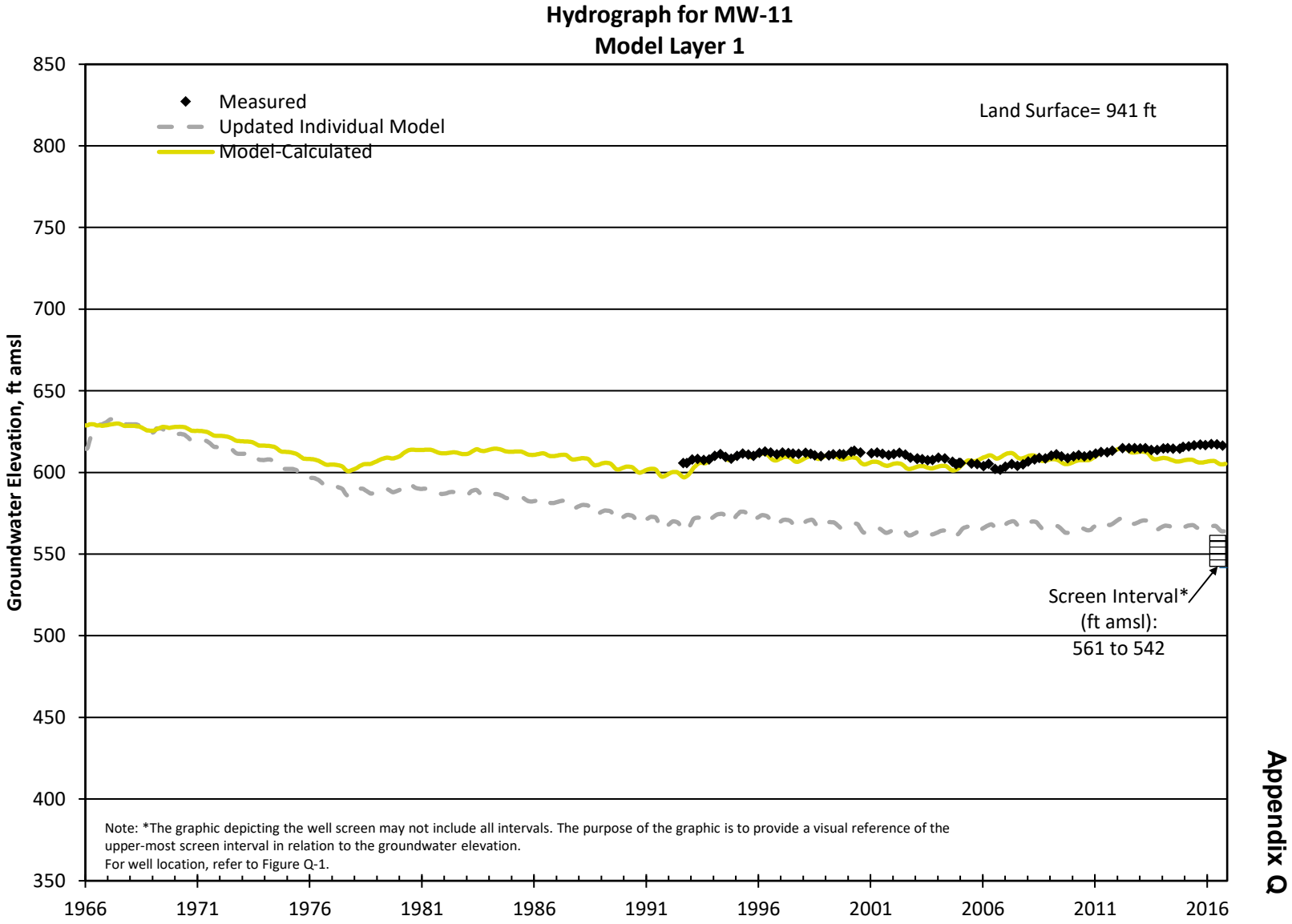
Appendix Q


Hydrograph for F35A_L2
Model Layer 4
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,243 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
543 to 391
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

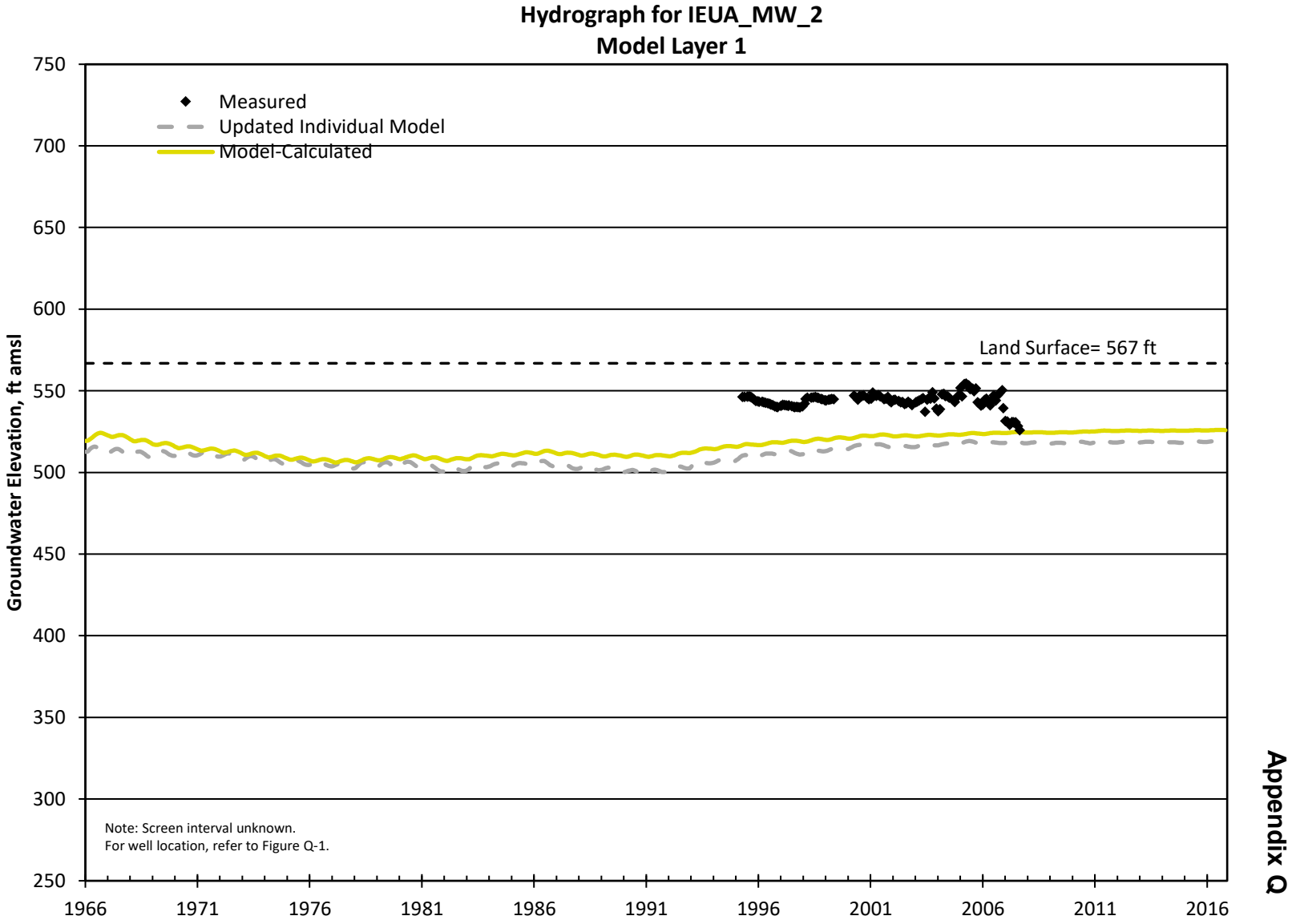
Appendix Q


Hydrograph for FU6
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,050 ft
Screen Interval*
(ft amsl):
1,049 to 558
Groundwater Elevation, ft amsl
1,000
950
900
850
800
750
700
650
600
550
500
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

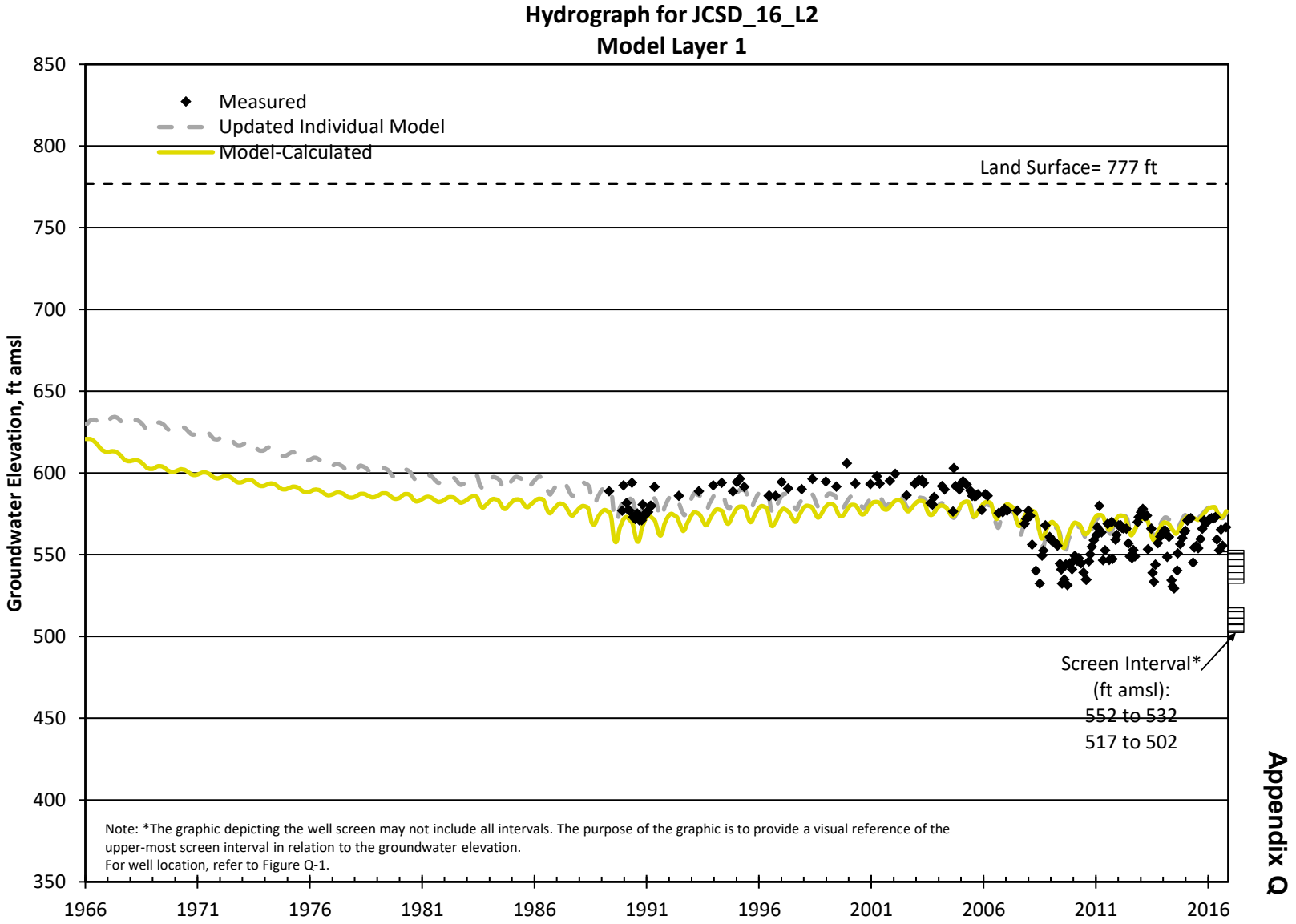
Appendix Q


Hydrograph for MW-11
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 941 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
561 to 542
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

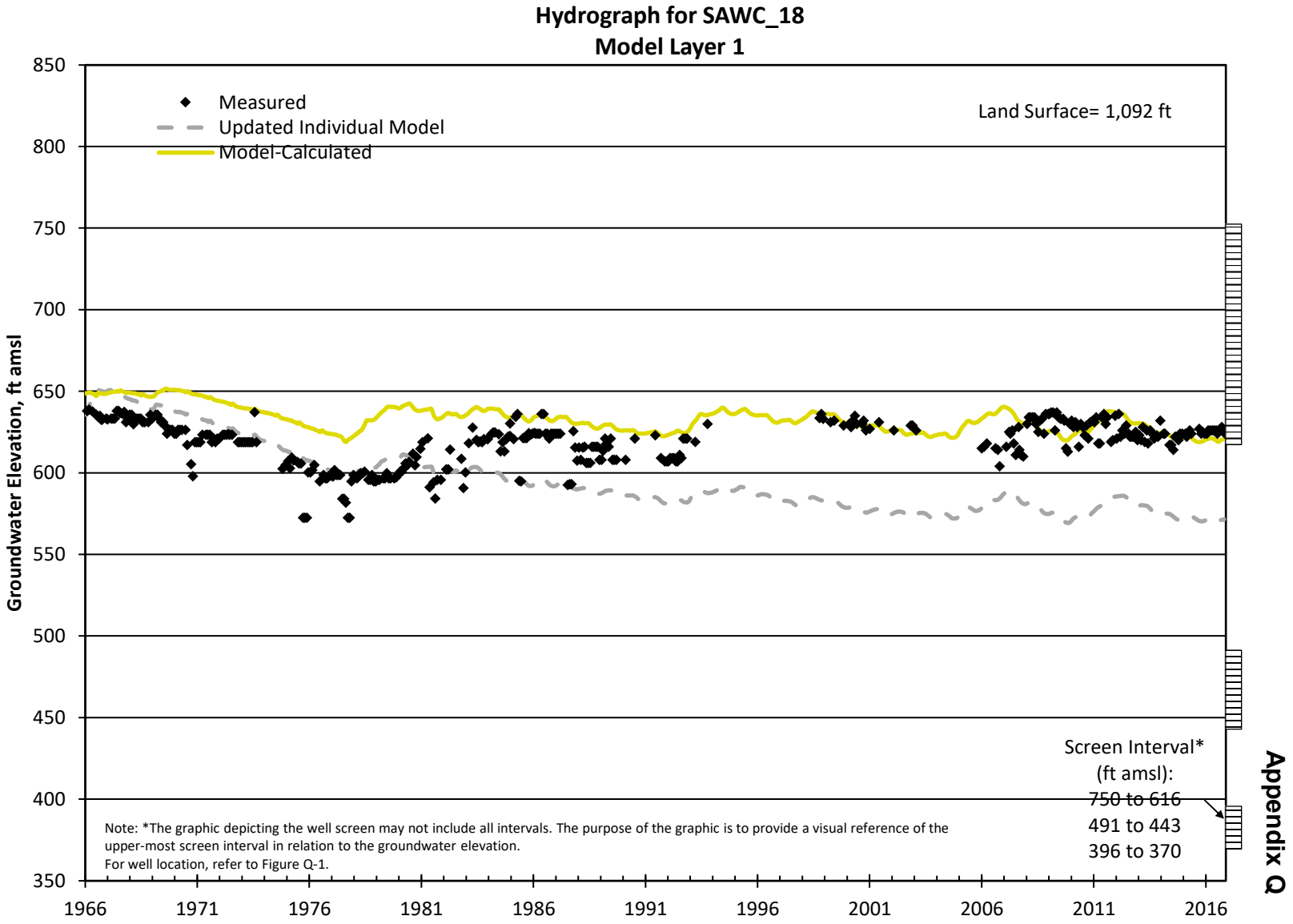
Appendix Q

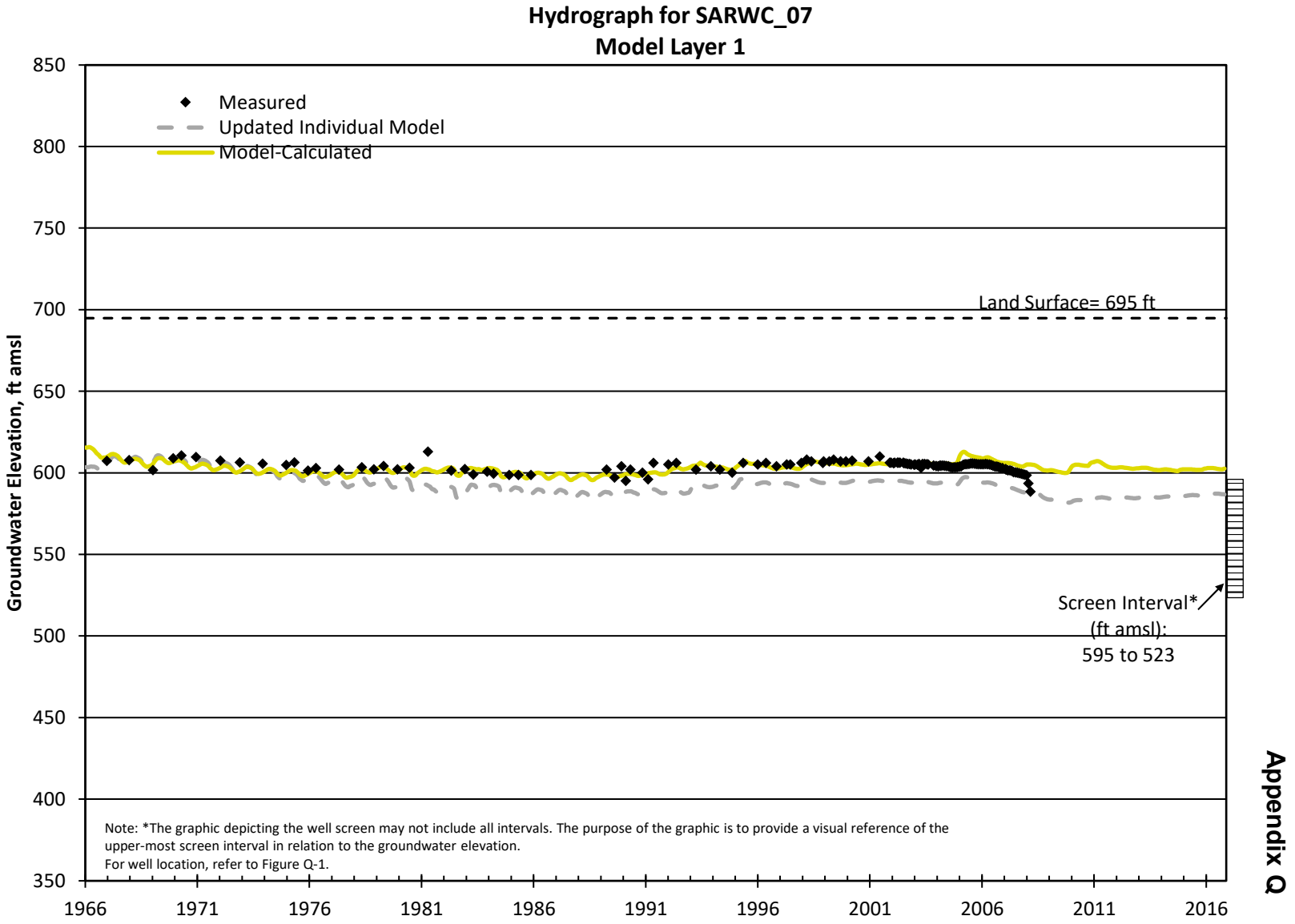

Hydrograph for IEUA_MW_2
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 567 ft
Groundwater Elevation, ft amsl
750
700
650
600
550
500
450
400
350
300
250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

Appendix Q

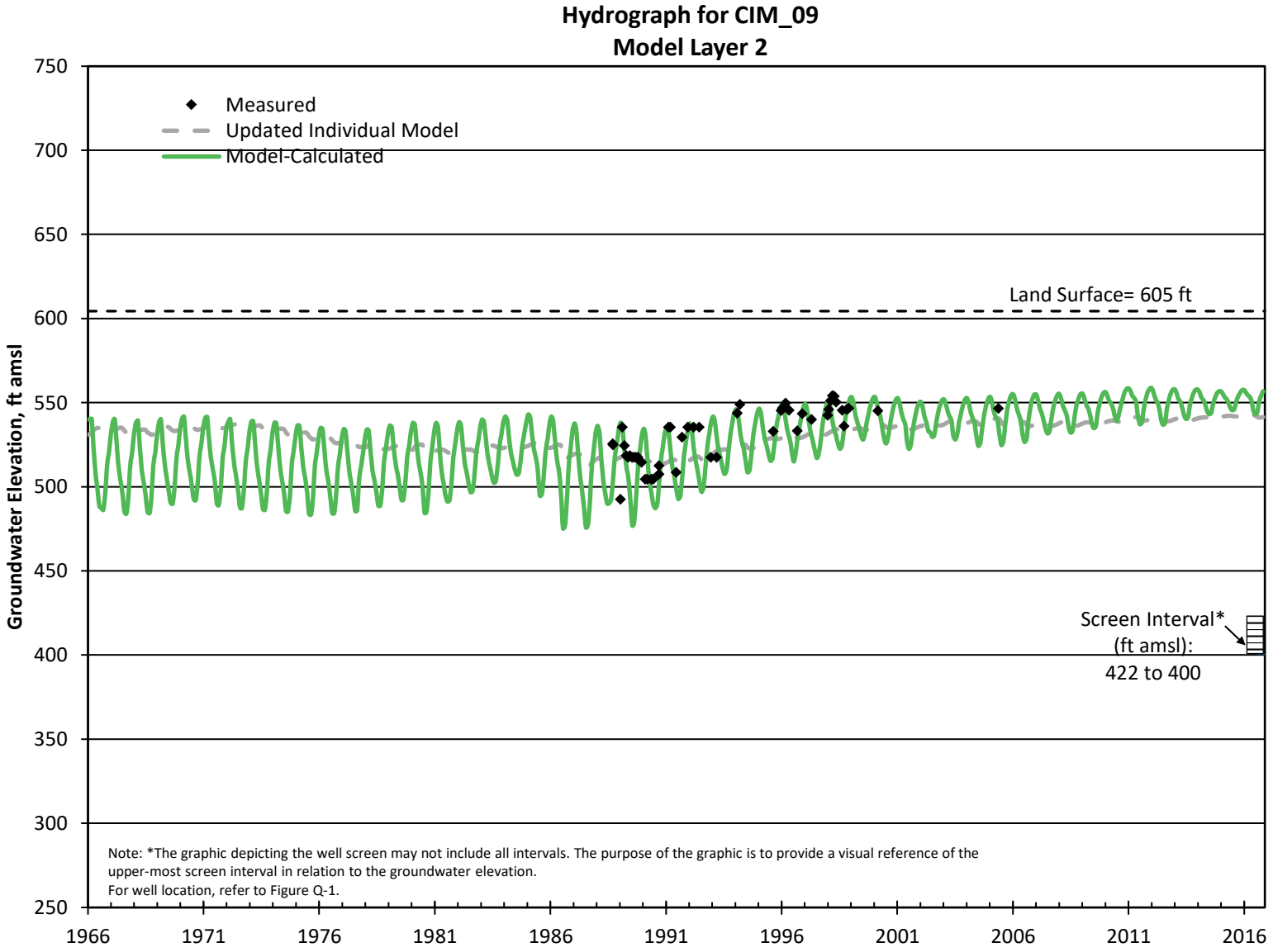

Hydrograph for JCSD_16_L2
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 777 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
552 to 532
517 to 502
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

Appendix Q

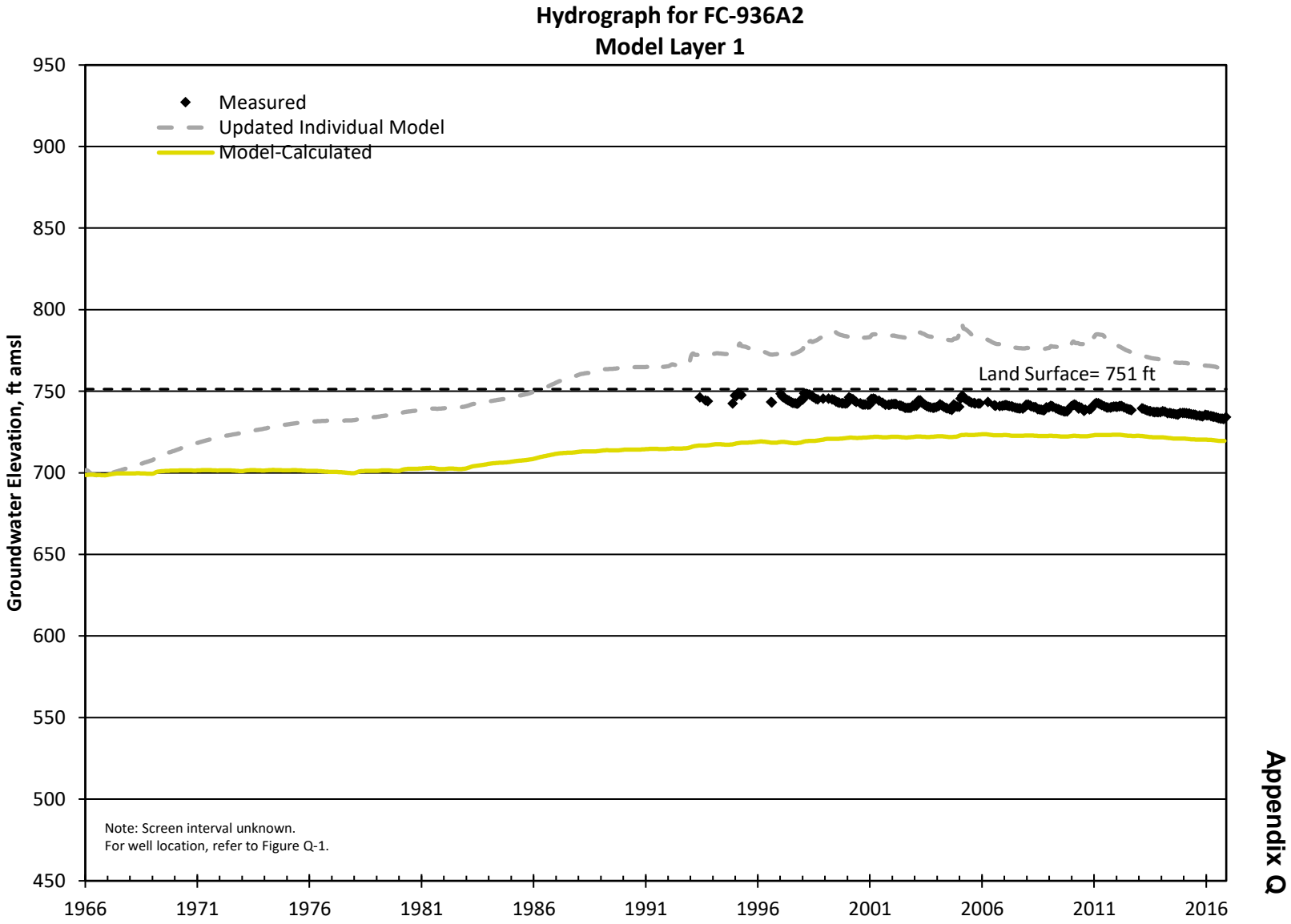

Hydrograph for SAWC_18
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,092 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
750 to 616
491 to 443
396 to 370
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.
Appendix Q


Hydrograph for SARWC_07
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 695 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
595 to 523
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

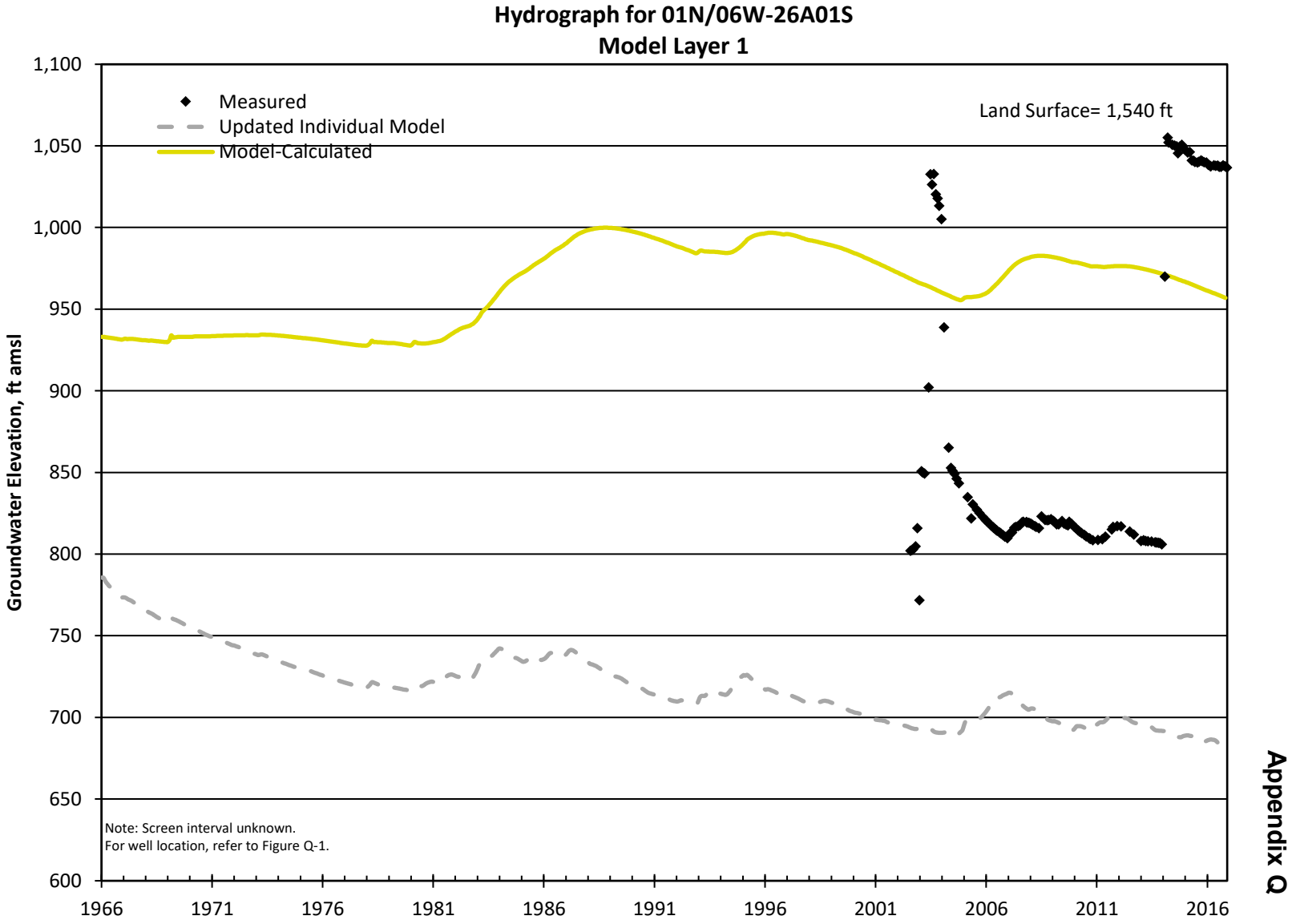
Appendix Q


Hydrograph for CIM_09
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 605 ft
Groundwater Elevation, ft amsl
750
700
650
600
550
500
450
400
350
300
250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
422 to 400
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

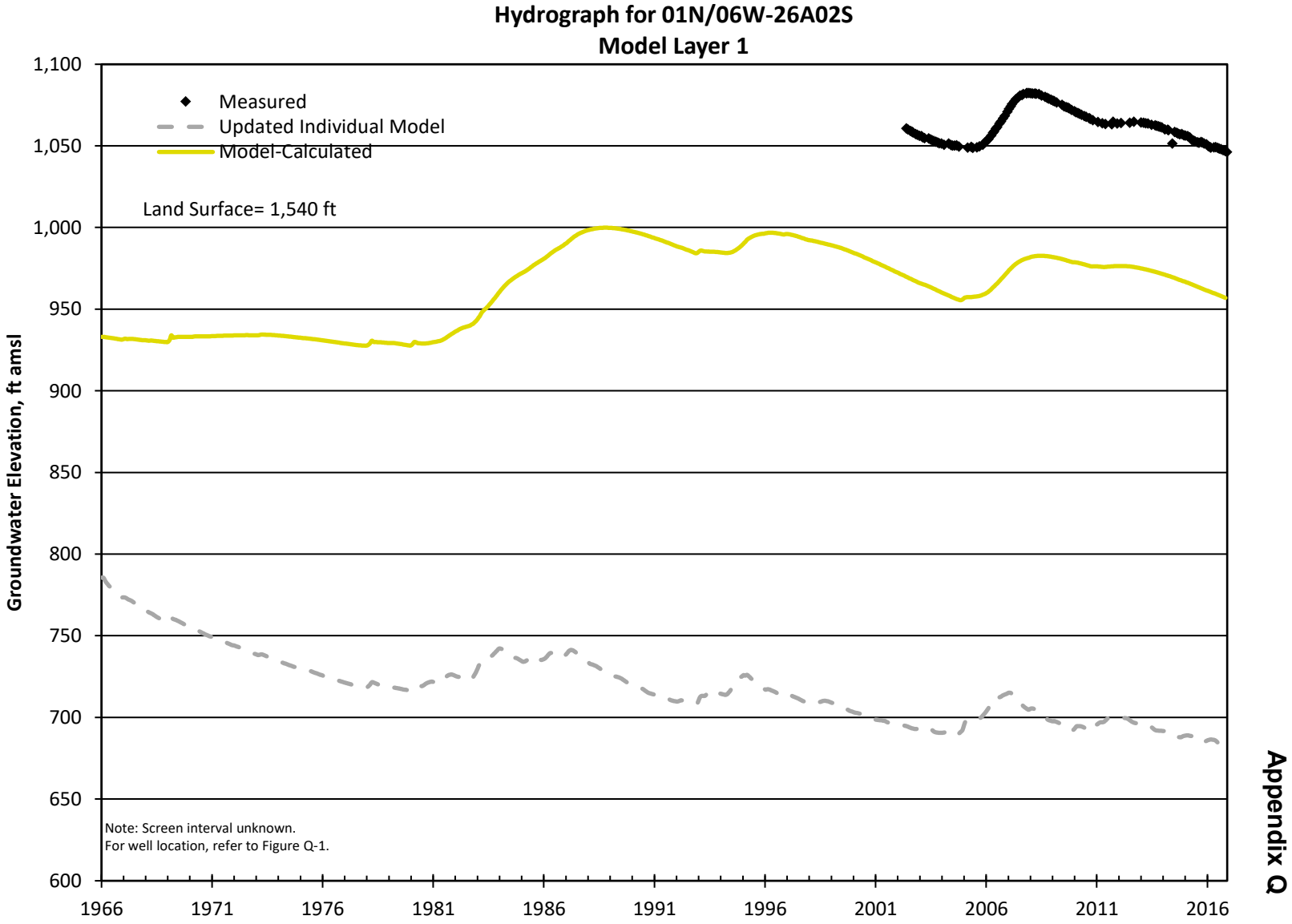
Appendix Q


Hydrograph for FC-936A2
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 751 ft
Groundwater Elevation, ft amsl
950
900
850
800
750
700
650
600
550
500
450
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

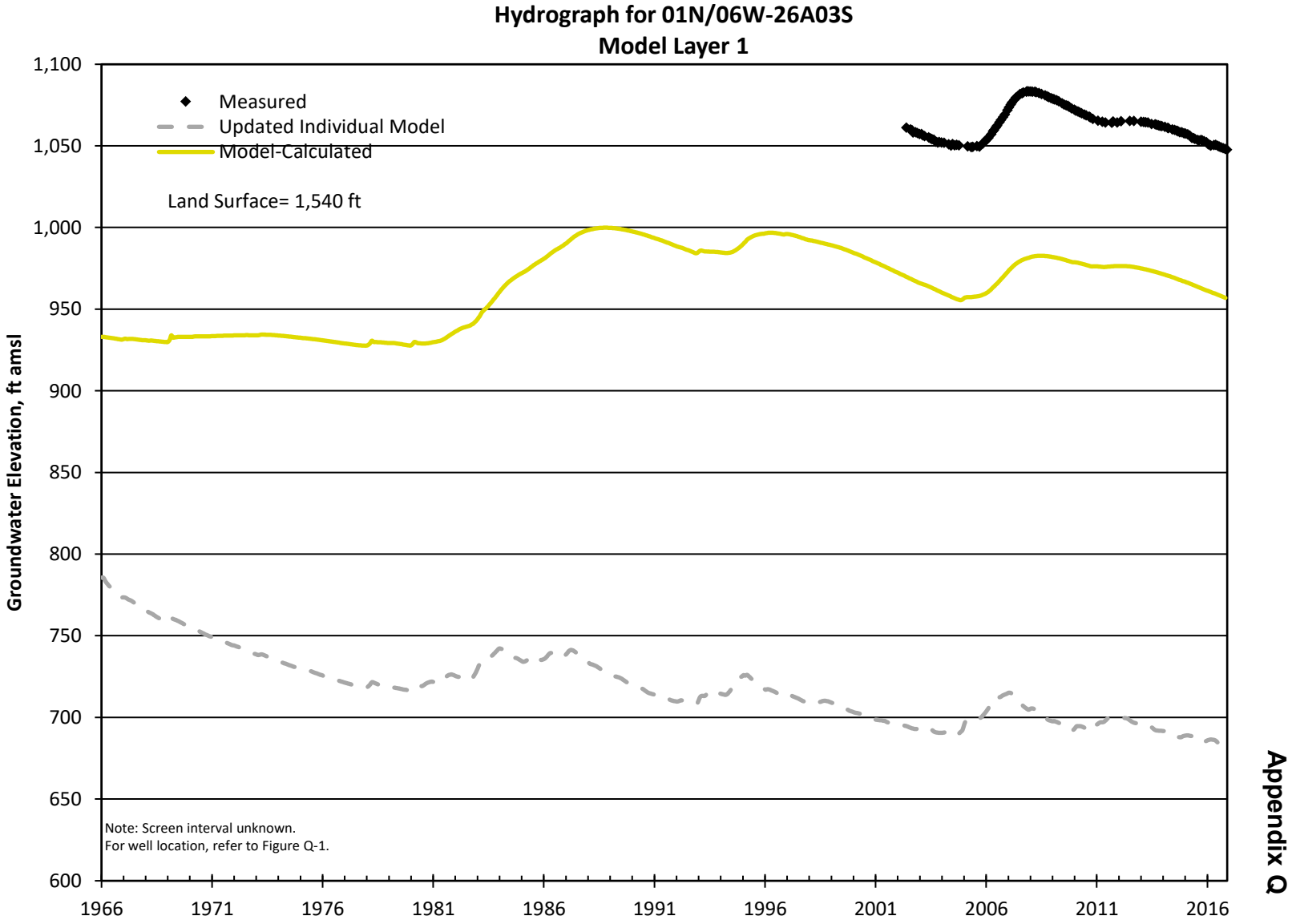
Appendix Q


Hydrograph for 01N/06W-26A01S
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,540 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

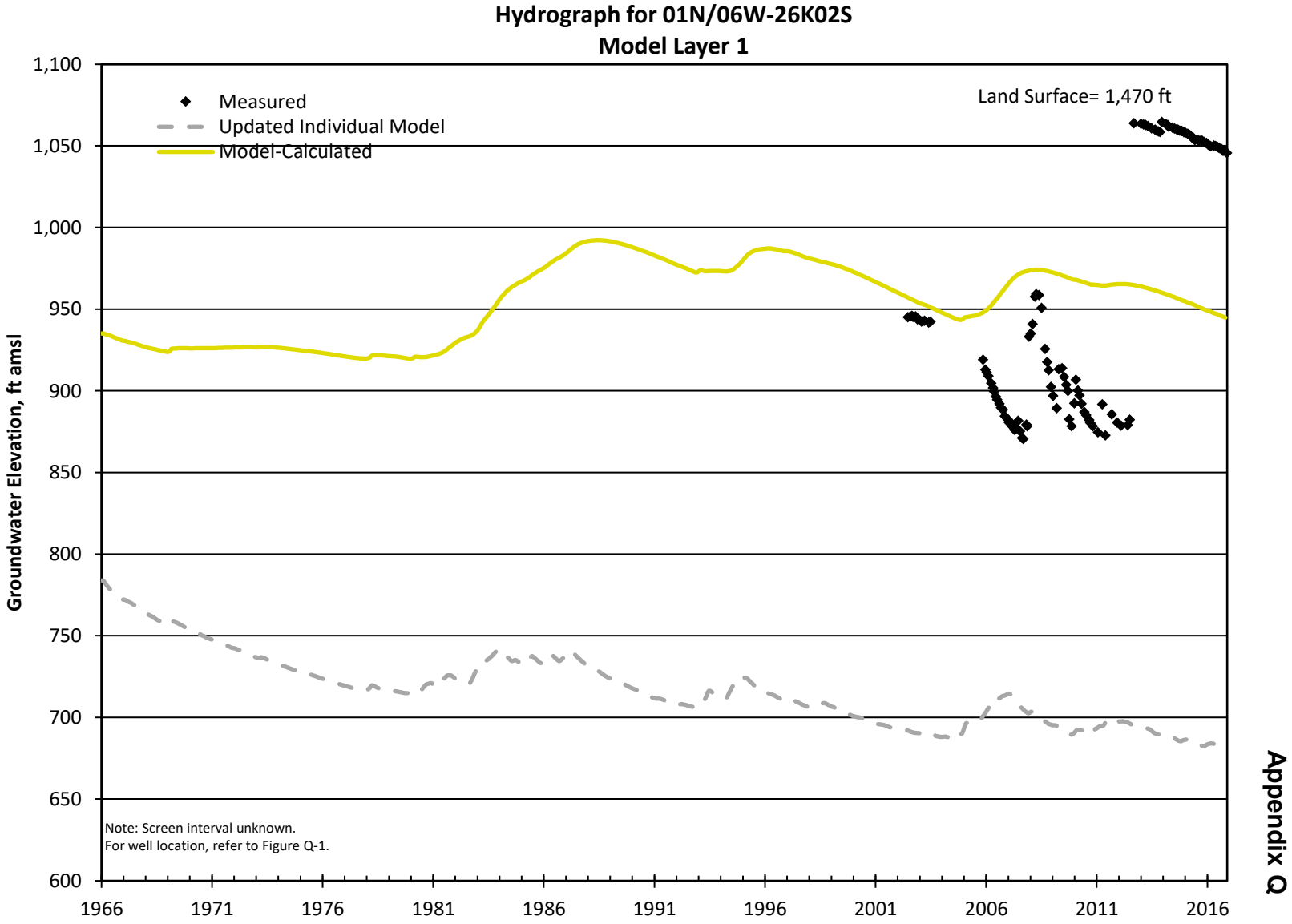
Appendix Q


Hydrograph for 01N/06W-26A02S
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,540 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

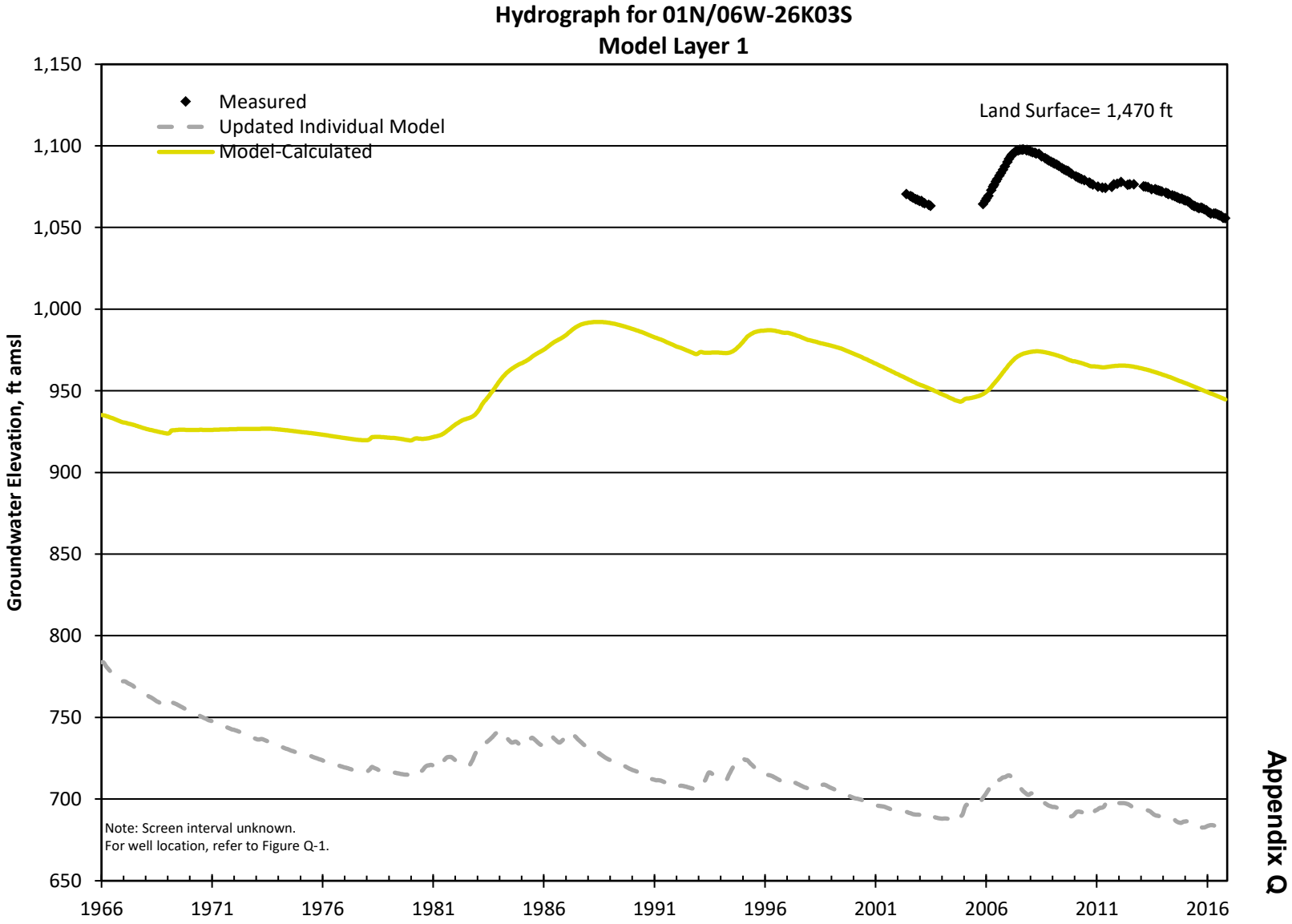
Appendix Q


Hydrograph for 01N/06W-26A03S
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,540 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

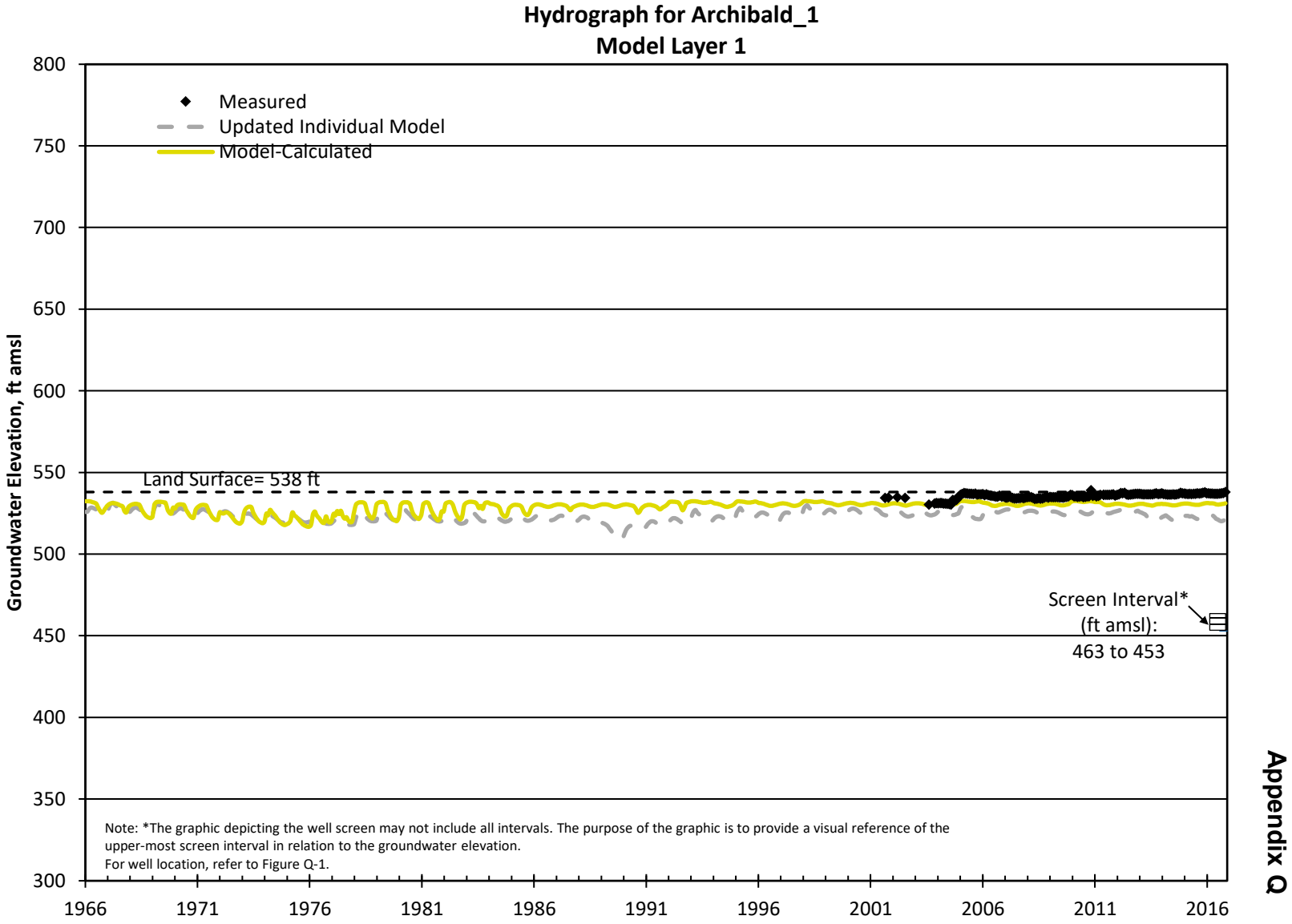
Appendix Q


Hydrograph for 01N/06W-26K02S
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,470 ft
Groundwater Elevation, ft amsl
1,100
1,050
1,000
950
900
850
800
750
700
650
600
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

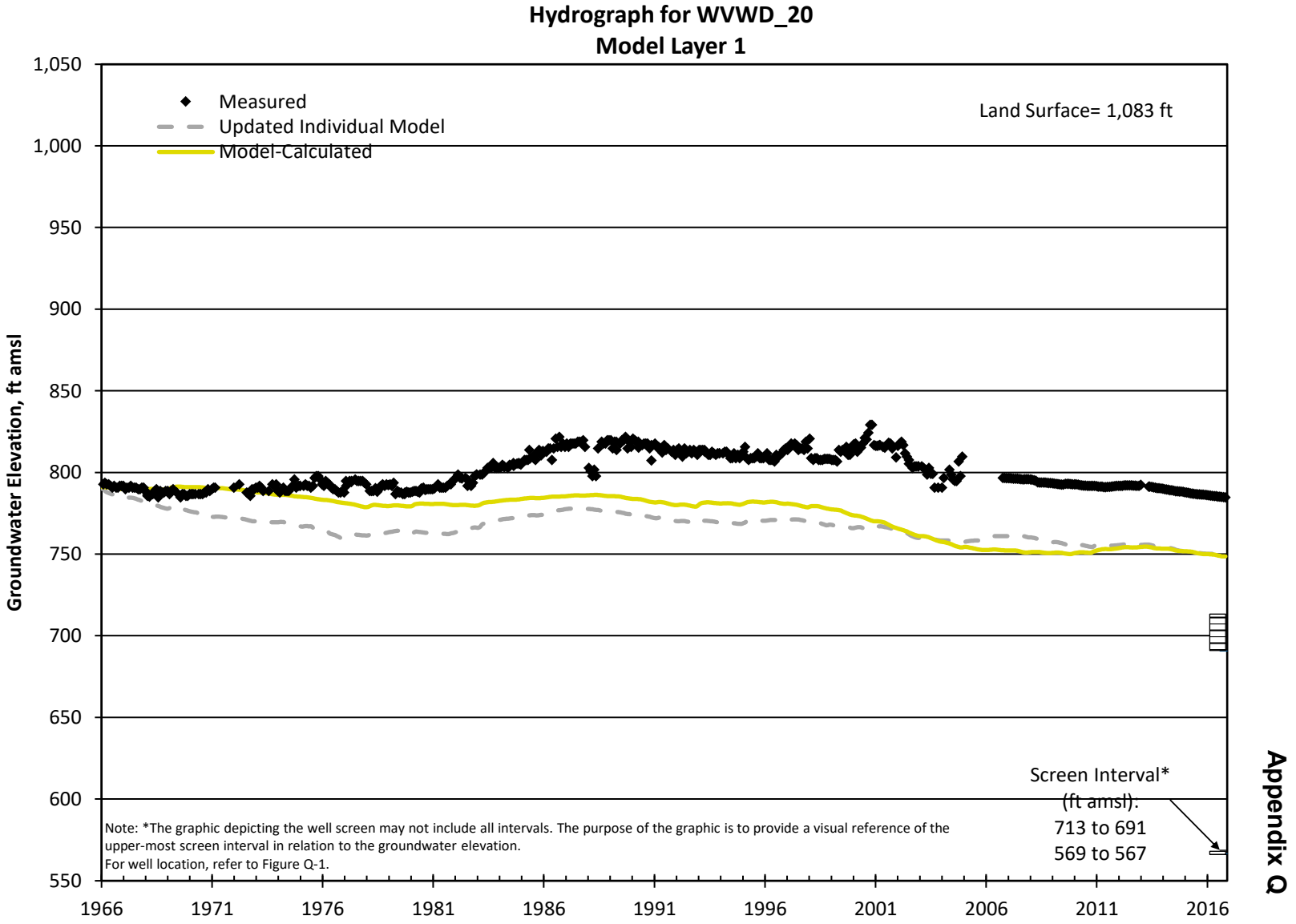
Appendix Q


Hydrograph for 01N/06W-26K03S
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,470 ft
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

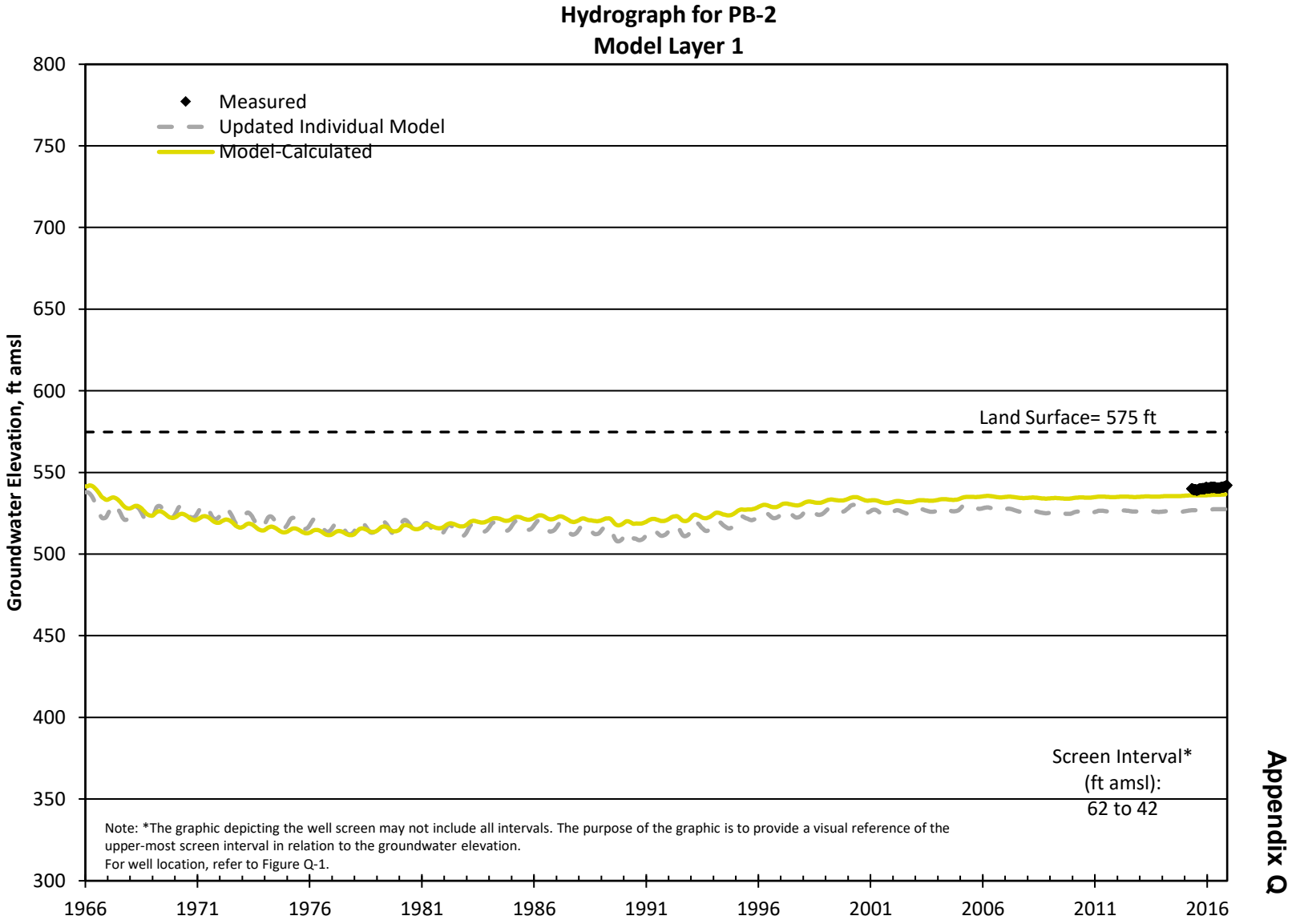
Appendix Q


Hydrograph for Archibald_1
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 538 ft
Screen Interval*
(ft amsl):
463 to 453
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

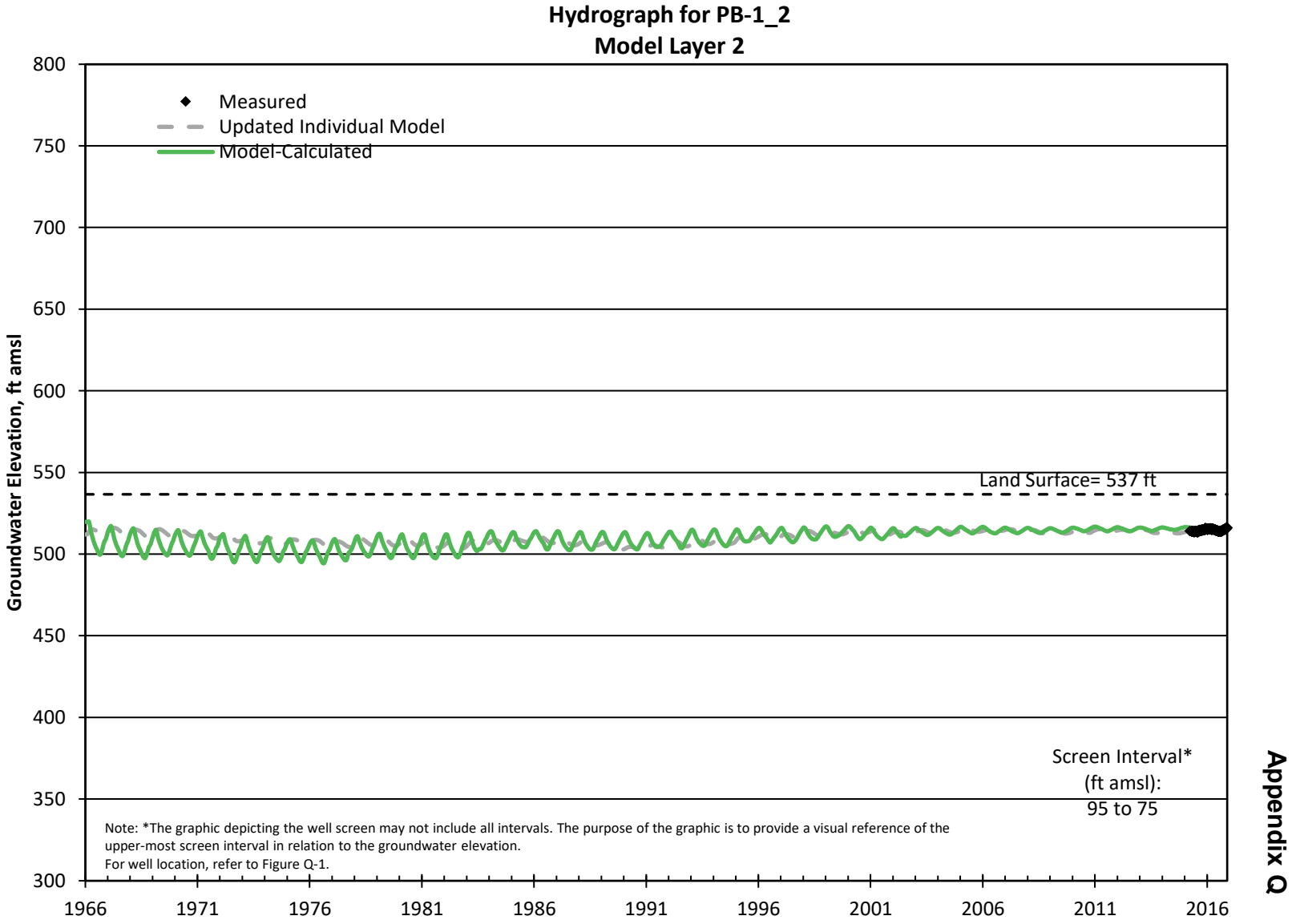
Appendix Q


Hydrograph for WVWD_20
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 1,083 ft
Groundwater Elevation, ft amsl
1,050
1,000
950
900
850
800
750
700
650
600
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
713 to 691
569 to 567
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

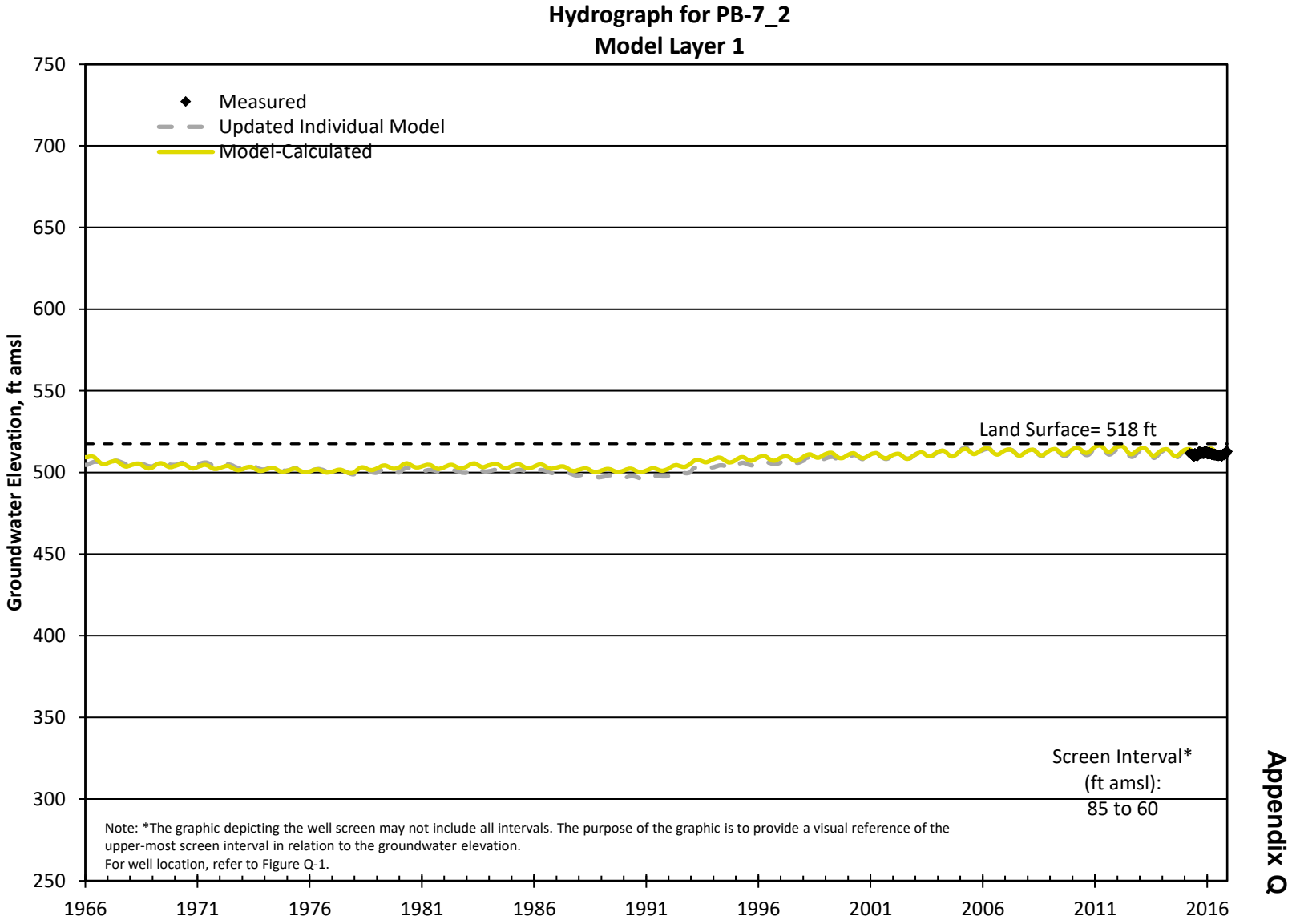
Appendix Q


Hydrograph for PB-2
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 575 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
62 to 42
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

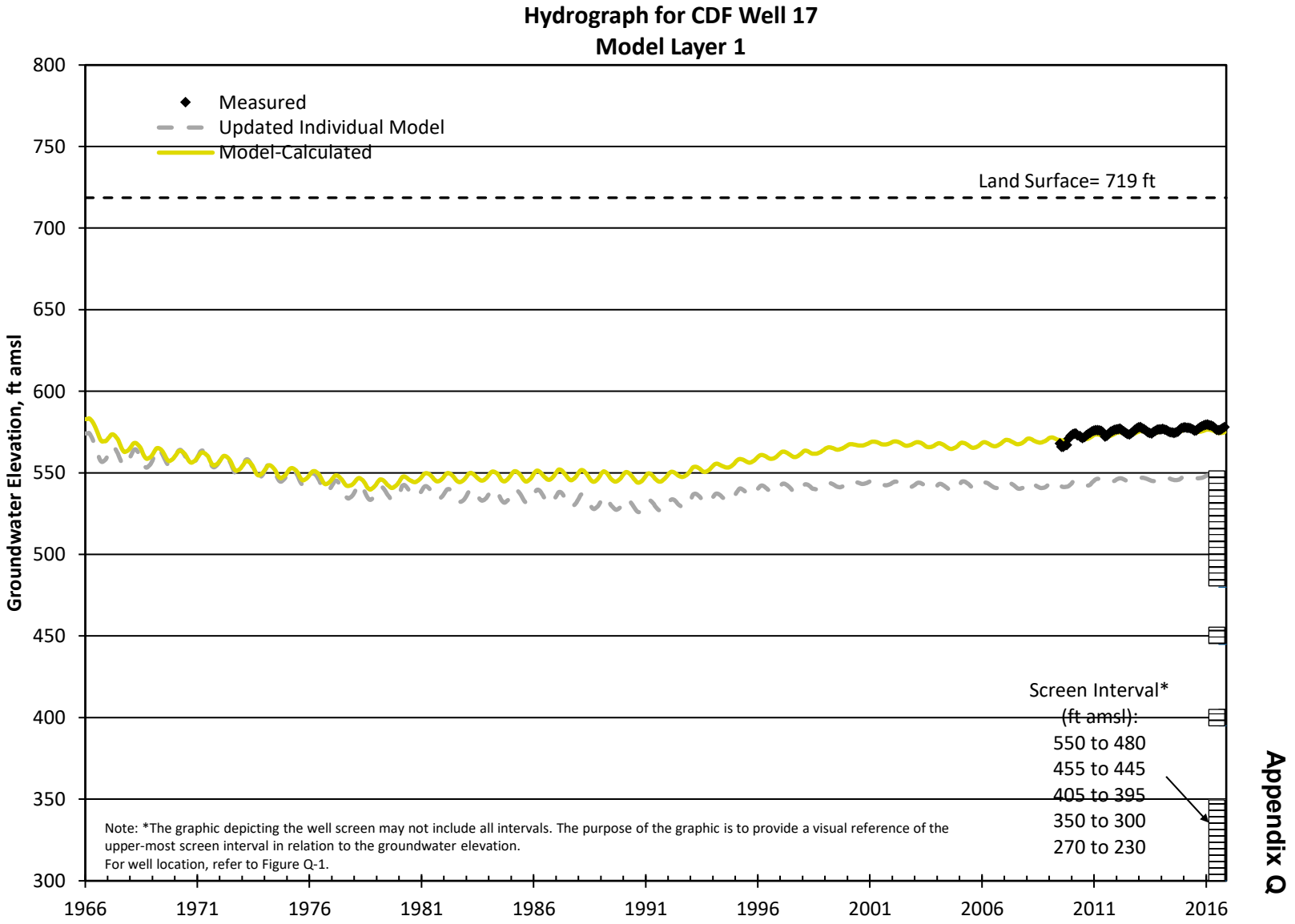
Appendix Q


Hydrograph for PB-1_2
Model Layer 2
Measured
Updated Individual Model
Model-Calculated
Land Surface= 537 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
95 to 75
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

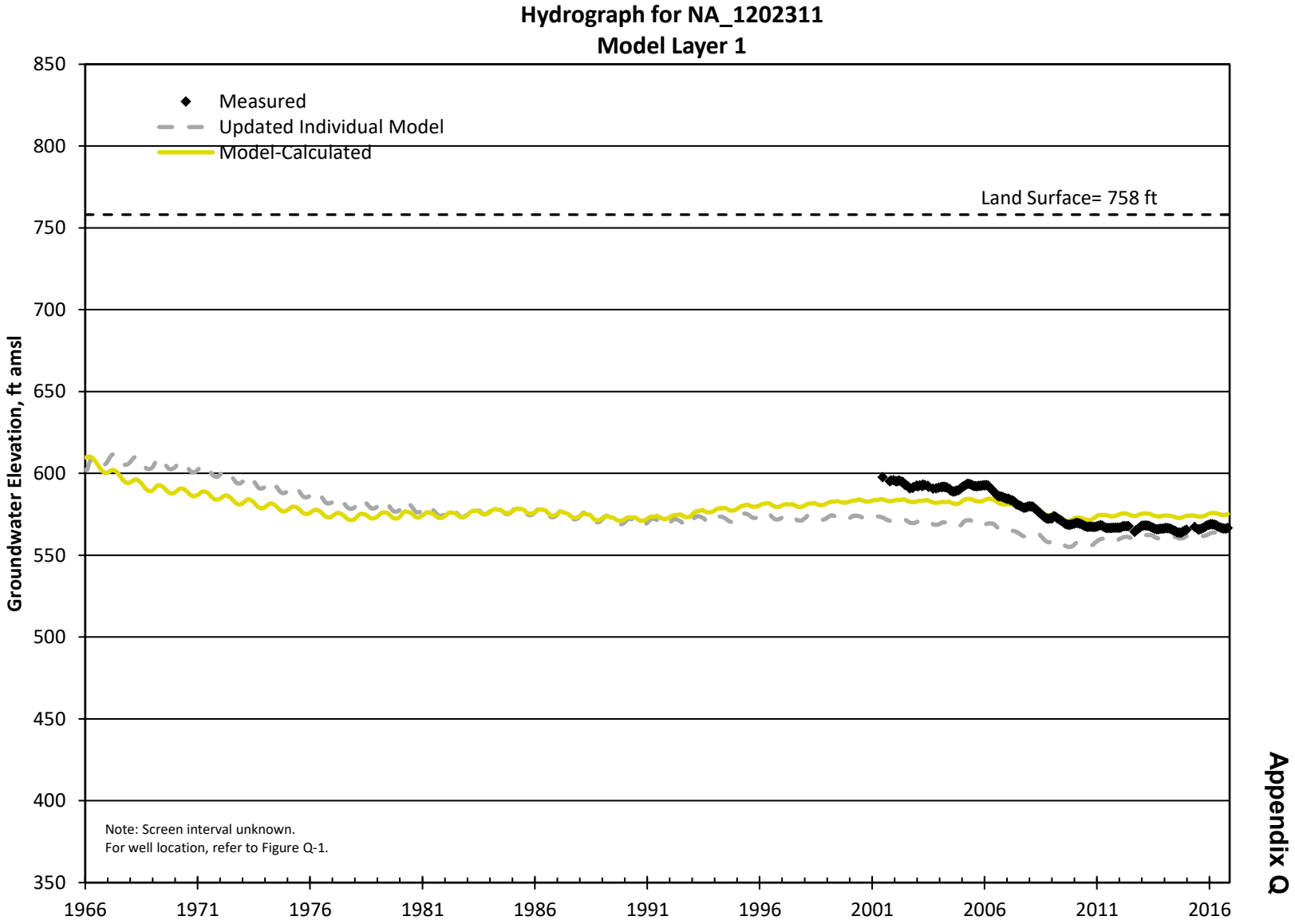
Appendix Q


Hydrograph for PB-7_2
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 518 ft
Groundwater Elevation, ft amsl
750
700
650
600
550
500
450
400
350
300
250
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
85 to 60
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

Appendix Q


Hydrograph for CDF Well 17
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 719 ft
Groundwater Elevation, ft amsl
800
750
700
650
600
550
500
450
400
350
300
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Screen Interval*
(ft amsl):
550 to 480
455 to 445
405 to 395
350 to 300
270 to 230
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure Q-1.

Appendix Q


Hydrograph for NA_1202311
Model Layer 1
Measured
Updated Individual Model
Model-Calculated
Land Surface= 758 ft
Groundwater Elevation, ft amsl
850
800
750
700
650
600
550
500
450
400
350
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Note: Screen interval unknown.
For well location, refer to Figure Q-1.

Appendix Q

APPENDIX R

Riverside North Aquifer Storage & Recovery – Operation & Maintenance Model Technical Memorandum (Draft) by Scheevel Engineering (dated December 16, 2018)

GEOSCIENCE

December 16, 2018

GEOSCIENCE Support Services Inc.
Attn: Johnson Yeh, Ph.D, PG, CHG, Principal Geohydrologist
620 Arrow Highway, Suite 2000
La Verne, CA 91750

RE: Riverside North Aquifer Storage & Recovery – Operation & Maintenance Model Technical Memorandum (Draft)

Dear Mr. Yeh:

This report summarizes the operation and maintenance (O&M) computer model simulations performed for the Riverside North Aquifer Storage & Recovery (RNASR) Project. Model simulations were performed to quantify the amount of infiltration in the impoundment area upstream of the proposed rubber dam as well as in the proposed recharge basins. Two separate scenarios were modeled with flow data provided by GEOSCIENCE Support Services Inc. (Geoscience) to Scheevel Engineering (Scheevel). Each scenario modeled included 25 years of flow data. A description of the project features, model input assumptions, model configuration, model outputs and summary of results is presented in this report.

Background

The RNASR Project includes the construction of multiple storm water capture and groundwater recharge structures/facilities in, and adjacent to, the Santa Ana River in San Bernardino County, CA. The Project site is located approximately 1.1 miles south-west of the Interstate 10 and Interstate 215 Freeways intersection in the City of Colton, CA (Figure 1).

The Project is being cooperatively developed through a three-agency agreement between San Bernardino Valley Municipal Water District (Valley District), Western Municipal Water District (Western) and Riverside Public Utilities (RPU), with Valley District acting as the lead agency. The Project includes the construction of an inflatable rubber dam (or similar facility), diversion head works, pipelines, groundwater recharge basins and related appurtenances (Figure 2). The Project benefit will be realized by capturing and infiltrating storm water in the SAR channel immediately upstream of the rubber dam as well as in the off-channel recharge basins.

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Figure 1: Project Vicinity Map

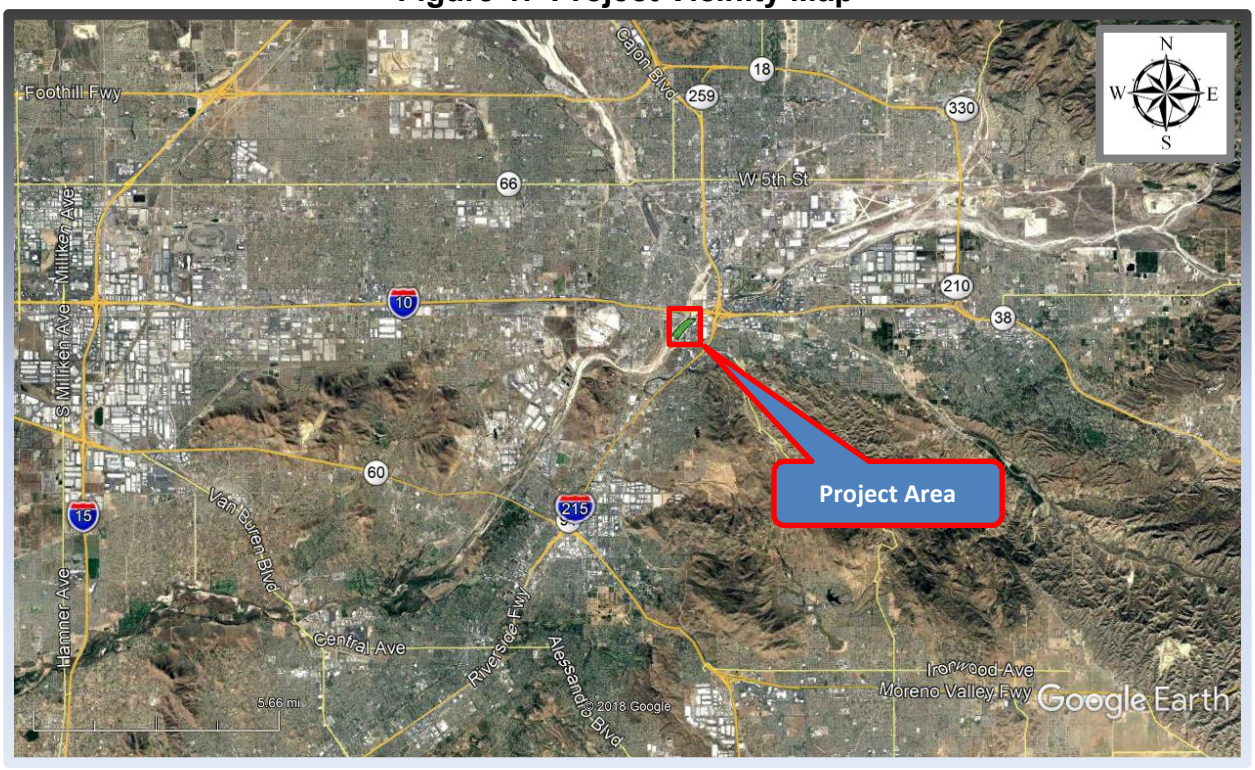
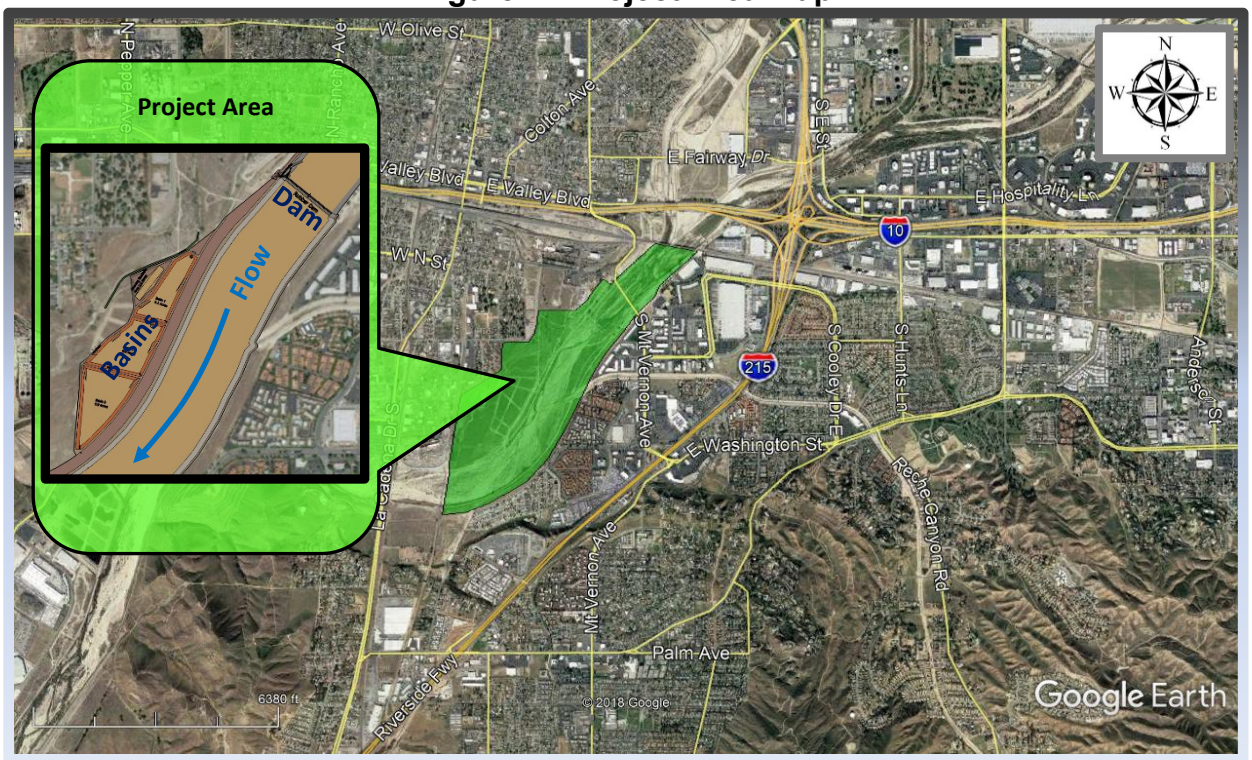


Figure 2: Project Area Map



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Flow in the Santa Ana River (SAR) will be impounded by an inflatable rubber dam (dam) and recharged in the SAR. The dam component of the project will provide an adjustable barrier spanning the entire width of the SAR channel. The barrier will obstruct SAR flows resulting in a temporary impoundment of water upstream of the dam. The dam will also create the necessary hydraulic grade to divert water out of the SAR channel and into the proposed recharge basins. The impoundment formed by the dam will slow the velocity of the flowing water, increase the depth of the water in the channel and increase the wetted surface area upstream of the dam. These conditions will result in an increase to the infiltration rate of the channel upstream of the proposed dam location. The wetted area of the dam impoundment will be approximately 24 to 28 acres depending on the final location selected for dam placement. Previous geotechnical investigations and infiltration rate testing indicate that the in-channel infiltration rates may range between 2 to 10 feet per day (ft/day) resulting in an in-channel recharge capacity ranging from 24 cubic feet per second (cfs) to 140 cfs. The O&M modeling work performed by Scheevel has assumed an infiltration rate of 3 ft/day over 28 acres (42 cfs) as the achievable long-term infiltration rate for the area upstream of the rubber dam. Three feet per day is the assumed starting infiltration rate with the impoundment area relatively clean and free of accumulated silt and clay (clogging material).

A diversion head works structure will be located immediately upstream of the rubber dam within the impoundment pool. The diversion head works will provide the structures, piping and equipment needed to control the diversion flow rate and prevent large pieces of trash and debris from entering the recharge basin system. Flow control slide gates will provide operators the ability to throttle the flow and adjust the flow rate diverted into the off-river basins. Piping will convey flows from the head gates to the basins. The O&M model assumes a maximum diversion capacity of 500 cfs. However, a maximum diversion capacity of 250 cfs may be adequate to realize the same benefit defined in this report. Additional analysis should be performed during final design to determine the size of the diversion headworks.

The assumed basin design incudes 3 recharge basins adjacent to the SAR. Basin 1 is approximately 7 acres in size, Basin 2 is approximately 9 acres in size and Basin 3 is approximately 9 acres in size (25 acres total). Water would be delivered to each basin via a manifold pipeline and/or via surface transfer, allowing the basins to operate in series or in parallel. The proposed basin depth is an average of 11 feet. With an assumed freeboard of 2 feet, the resultant operating volume of the three basins is approximately 200 af. The long-term average infiltration rate for the recharge basins has been assumed to be 3 ft/day, resulting in a total recharge capacity of 37.5 cfs when the basins are clean.

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O&M Model Overview

The operations and maintenance model (O&M Model) used for the evaluation of the RNASR Project is a Microsoft Excel Spread Sheet based model. The O&M Model uses average hourly flow data (in cfs) as the primary input and calculates the volume of flow that goes to storage in the dam impoundment and basins. The O&M Model also simulates the recharge rate in the dam impoundment area and the basins (in cfs). Input flows which exceed the diversion or conveyance capacity, storage capacity and recharge capacity flow past the project site are defined as "un-captured" by the Project. At each one-hour time-step, the O&M Model, accounts for changes in wetted area, changes in volume, infiltration rate decay, diversion and conveyance flow capacity limitations, rubber dam deflation setpoint and which basin(s) are on or off-line for maintenance.

Initial values are manually set in the model for basin geometry, conveyance capacity and other physical attributes of the system including operational constraints or operating rules specific to the RNASR Project system. Initial values are also manually entered for water in storage and starting infiltration rates for the dam impoundment area and each individual basin. Flow data is manually entered into the model in 31-day (745 hour) increments for each model iteration. The model outputs are reviewed after every iteration to assure reasonable model response and to provide an opportunity for the model operator to make operational decisions based on available storage volumes, total recharge capacity and infiltration rates. Throughout a series of iterations (or model scenario), any one, or all of the recharge areas are taken out of service for cleaning or other maintenance as needed. Model outputs are exported from the primary dynamic model sheet and manually saved to a static output sheet for further analysis and summation.

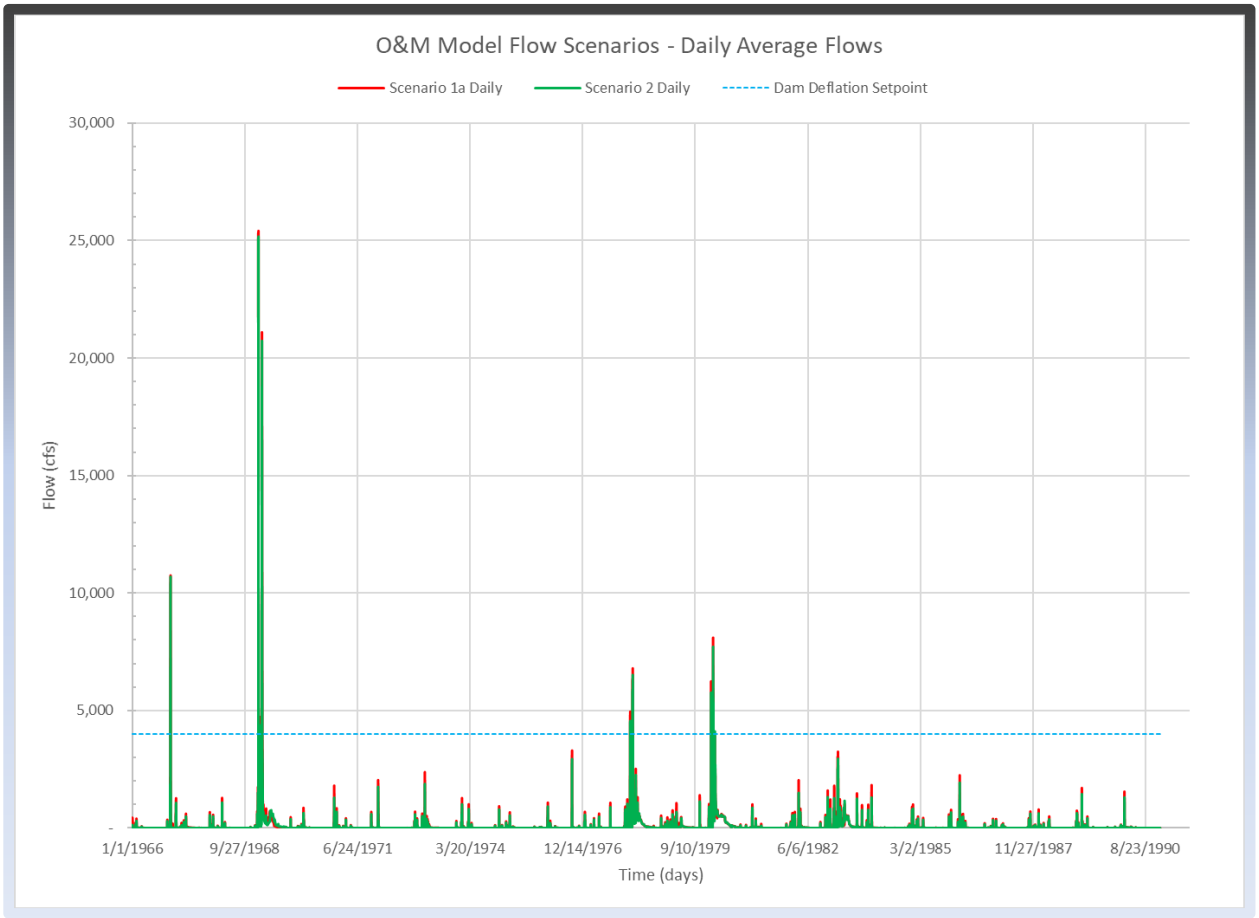
A small subset of the total available data is selected for output prior to the start of a model scenario and the output sheet is tailored to receive that data. The data selected for output is relevant to the primary focus of the study. The scenarios modeled for the RNASR Project O&M Model were focused on evaluating recharge rates in the impoundment area and the recharge basins, ultimately revealing how much water would be captured by the Project for each flow scenario.

O&M Model Flow Series Input

Two flow scenarios were modeled for the RNASR Project and are identified in this report as Scenario 1a and Scenario 2. Each scenario included a total of 25 years of flow data modeled (Figure 3) for an overall total of 50 years of modeling output. Data for the flow series modeled was provided by Geoscience to Scheevel in daily average values of flow in cfs. Average daily flow data is too course for evaluating the performance of a recharge system, therefore Scheevel converted the average daily flow into average hourly flow data. Flows in Scenario 1a are generally slightly higher than Scenario 2 (Figure 3).

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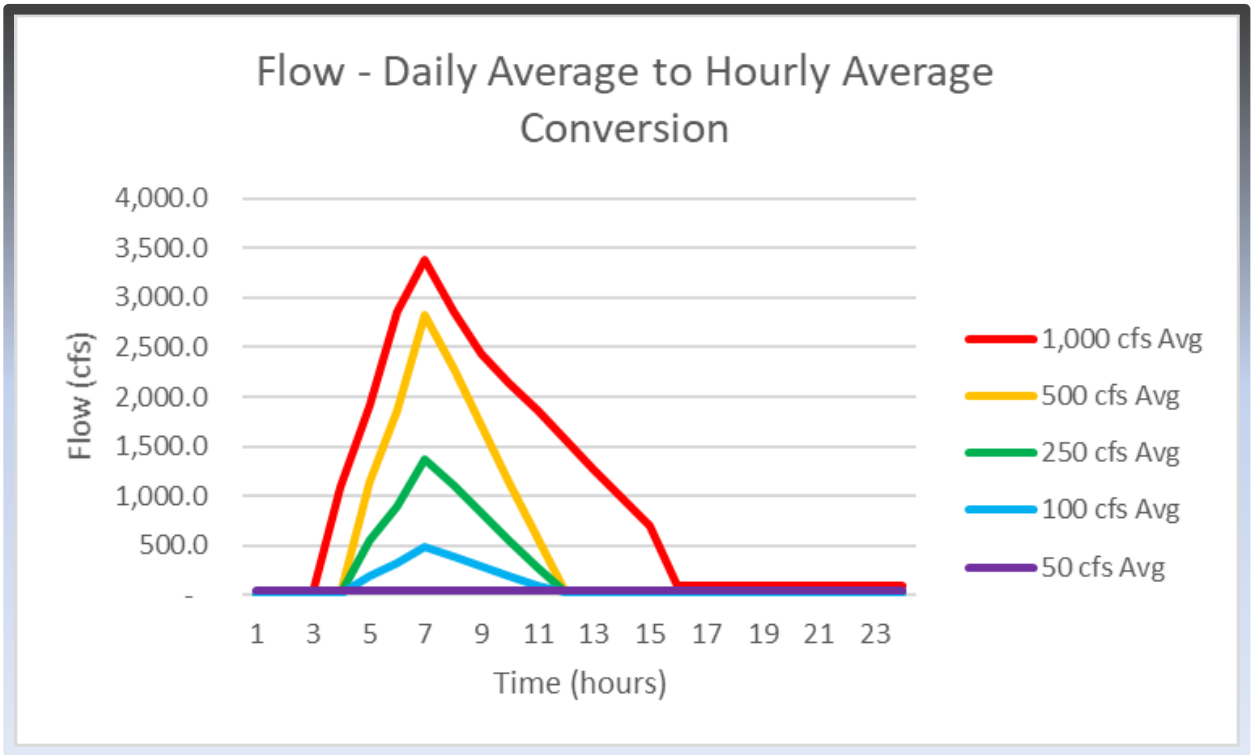
Figure 3: Flow Scenarios – Input Flows Daily Average



Conversion of the flow data from daily average to hourly average flow rates was accomplished by reviewing a wide array of historical USGS data sets. The E Street Gage and the MWD Crossing Gage on the SAR were used to develop an approximate time period and peak flow rate for various storm events. The daily average flows were then assigned a time period (less than 24 hours) for a range of storm intensities and the flows were scaled up in one-hour time steps on the rising limb of the hydrograph to a peak value and then decreased in hour time steps on the receding limb. In general, there is approximately one-third of the total flow volume of the storm event on the rising limb and two-thirds of the total flow volume on the receding limb. Every 24-hour period of synthesized flow was then averaged and cross-checked back to the original data set to assure it equaled the original daily average flow rate provided in the Geoscience data set. Figure 4 below provides a sample of the flow rate conversions.

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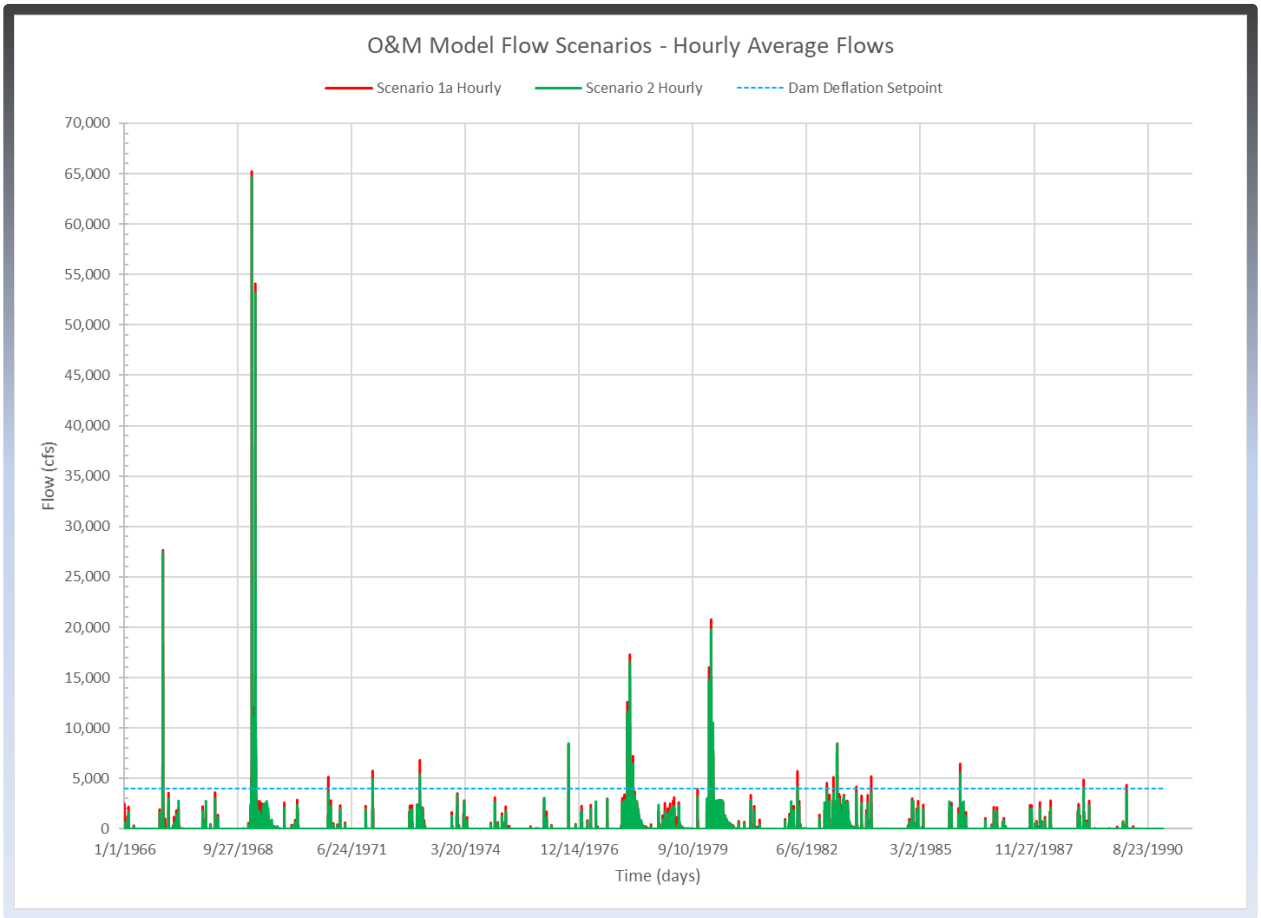
Figure 4: Daily Flow to Hourly Flow Conversion Samples



All 25 years of flow data used in the model converted from daily data to hourly data can be seen in Figure 5 below.

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Figure 5: Flow Scenarios – Input Flows Hourly Average



Once outputs were generated from the O&M Model iterations, then the hourly data was averaged for each 24-hour period to provide results back to Geoscience in daily average flow rates.

O&M Model Results

The groundwater recharge capacity of the RNASR Project has been simulated by routing flows through an O&M Model. The model takes the hourly flow (in cfs) at the upstream end of the Project site and calculates the volume of water that goes to storage and the volume of water that is infiltrated by the various Project features in one-hour increments. The O&M Model simulates infiltration rate decay in the impoundment area and in each basin based on separate infiltration rate decay curves. The infiltration rate decay curves are based on field data that has been used to define a suspended sediment concentration (SSC) curve at various flow rates. The infiltration rate decay curves were developed using historical recharge basin data from other basins in the watershed in conjunction with SSC curves to calculate the infiltration rate decay specific to each Project feature. A fundamental assumption to the infiltration rate decay curves is that the upstream most

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feature (in this case the impoundment area) receives the highest SSC, and therefore decays the fastest. Each subsequent feature decays at a slower rate than the feature upstream of it. After a Project feature is removed from service and cleaned, the infiltration rate is restored to the initial value and the decay process starts over again. Impoundment area and basin cleanings were performed in the model, on avenge one time per year, during a time period when the available flow was very low and/or when all of the feature's infiltration rates had decayed to an unacceptable level (typically less than 0.5 feet per day).

Table 1 below summarizes the available volume of water in each scenario, the total volume recharged in the dam impoundment area, the total volume recharged in the basins as well as the approximate total amount of sediment deposited in the impoundment area and recharge basins. The total values were also dived by 25 years to provide an annual average value for each output.

Table 1: O&M Model Results

Totals For 25 Year Model Period	Scenario 1a	Scenario 2
Available Flow (acre feet)	1,379,858	1,187,653
Flow Recharged In Impoundment Area (acre feet)	57,132	70,804
Flow Recharged In Basins (acre feet)	88,589	82,109
Combined Flow Recharged (acre feet)	145,721	152,913
Flow Un-Captured (acre feet)	1,234,137	1,034,740
Sediment Deposited In Impoundment & Basins (cubic yards)	58,315	66,263
Annual Averages Based On 25 Year Model Period	**Scenario 1a**	**Scenario 2**
Available Flow (acre feet)	55,194	47,506
Flow Recharged In Impoundment Area (acre feet)	2,285	2,832
Flow Recharged In Basins (acre feet)	3,544	3,284
Combined Flow Recharged (acre feet)	5,829	6,116
Flow Un-Captured (acre feet)	49,366	41,390
Sediment Deposited In Impoundment & Basins (cubic yards)	2,333	2,651

A one-time per year cleaning cycle was held constant for both scenarios to limit variability in the model scenarios and better understand the Project's performance relative to each scenario. Recall that Scenario 1a includes peak flows that are slightly greater than Scenario 2, resulting in more total flow available in Scenario 1a. The O&M Model results show that a slightly lower volume of water is captured and recharged in Scenario 1a than in Scenario 2. This is because the higher peak flows in Scenario 1a result in the dam being down more frequently resulting in less recharge in the impoundment area and higher SSC resulting in faster infiltration rate decay in the impoundment area.

To achieve a higher recharge benefit in the impoundment area, one potential design change would be to design and permit the dam to be operated at higher peak flows for longer periods. The current O&M Model assumes that flows greater than 4,000 cfs result in the dam being dropped. If the dam were operated fully inflated at higher peak flow

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rates for longer durations, then the impoundment benefit would increase. However, operating the dam at higher flow rates for longer periods will increase the clogging rates in the basins. A faster decline of basin recharge capacity may occur in the basins requiring a more frequent and aggressive cleaning schedule.

The “sediment deposited in the impoundment area and basins” output provides an estimate of the volume of material that will need to be managed each year. The variation between the volumes of the two scenarios is primarily due to the frequency of the dam being down during higher peak flows in Scenario 1a. The increased duration of flow delivery to the basins during lower peak flow events contributes to the larger amount of sediment deposited in the basins. In most recharge systems the volume of sediment removed by basin cleanings is dictated by minimum heavy equipment cut depths to efficiently remove the clogging layer (typically 2 to 3 inches). For example, a thee-inch cut across the 25-acre basin area equates to approximately 10,000 cubic yards of sediment removal per year.

The detailed model outputs for the daily average recharge rates in the dam impoundment area and basins has been provided to Geoscience in Excel format under separate electronic submittal.

Scheevel Engineering greatly appreciates the opportunity to provide consulting services to GEOSCIENCE Support Services Inc. and the San Bernardino Valley Municipal Water District and looks forward to working with you on the next phase of this project. Please do not hesitate to contact Scheevel Engineering with any questions or concerns you might have.

Sincerely,
Scheevel Engineering



Nate Scheevel, P.E.
President/Principal



Scheevel Engineering ● P.O. Box 28745 ● Anaheim, CA 92809 ● Phone: (714) 470-9045 ● Email: nathanscheevel@yahoo.com

APPENDIX S

Groundwater Level Hydrographs along the Santa Ana River – Scenario Runs

GEOSCIENCE

APPENDIX S:

GROUNDWATER LEVEL HYDROGRAPHS ALONG THE SANTA ANA RIVER – SCENARIO RUNS

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San Bernardino Basin Area

Airport 1 Well
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Rialto-Colton Basin

Well 1S/4W-20H03

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Riverside-Arlington Basin

Well #3 28th St

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Chino Basin

Well PB-1_2

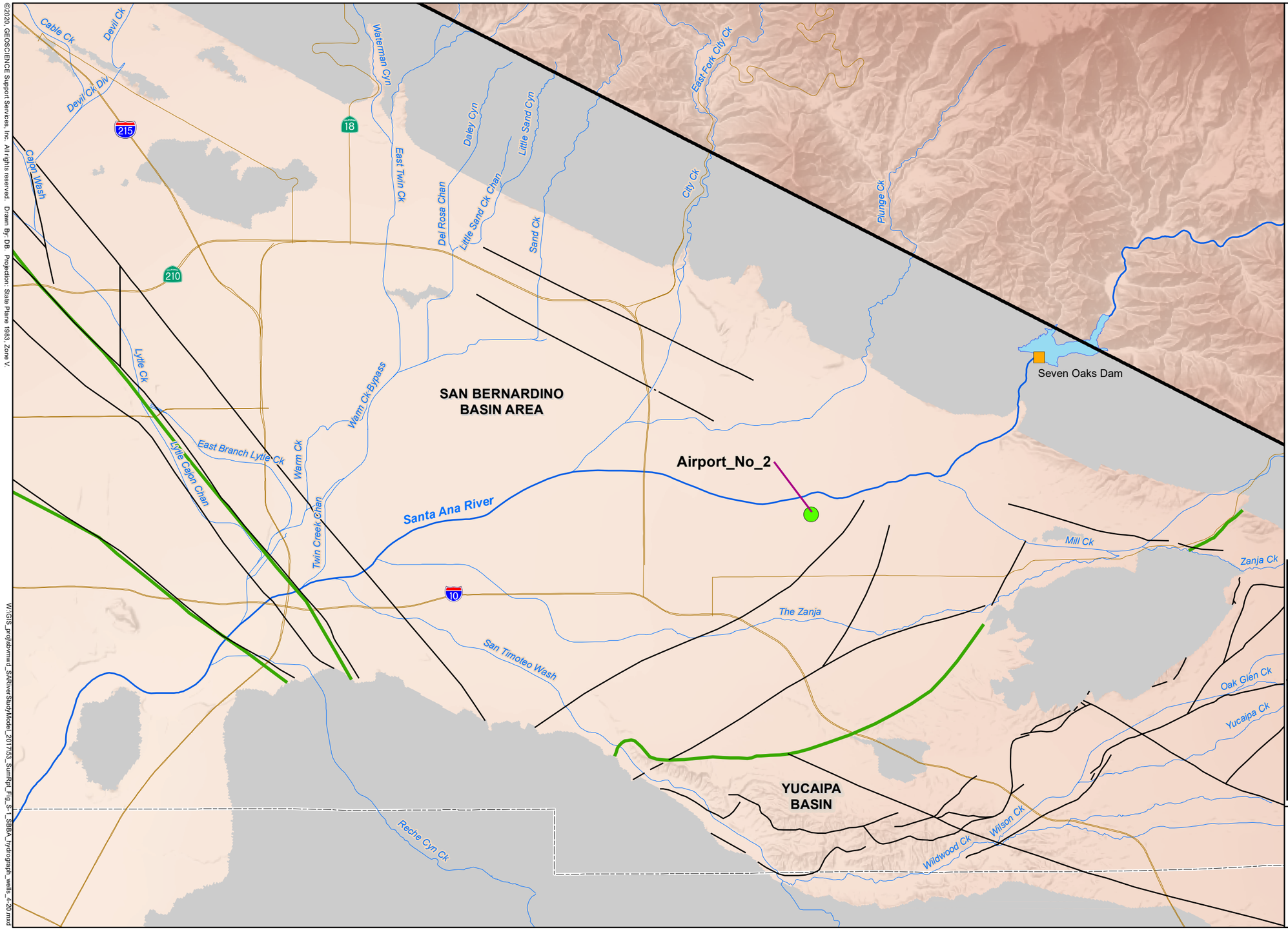
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Well PB-7_2
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Well SARWC 07
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EXPLANATION

- Integrated SAR Model Boundary

Well Model Layer

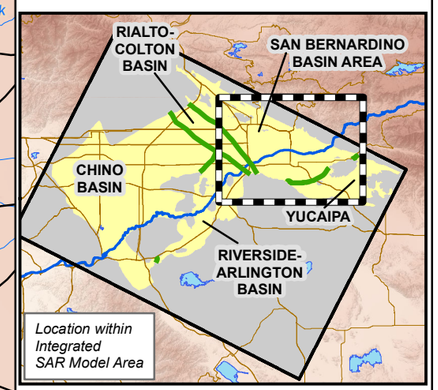
- 1
- 2
- 3
- 4
- 5

- Inactive Model Area
- Groundwater Basin Boundary
- Groundwater Flow Barrier

N

0 1.5 3

Miles

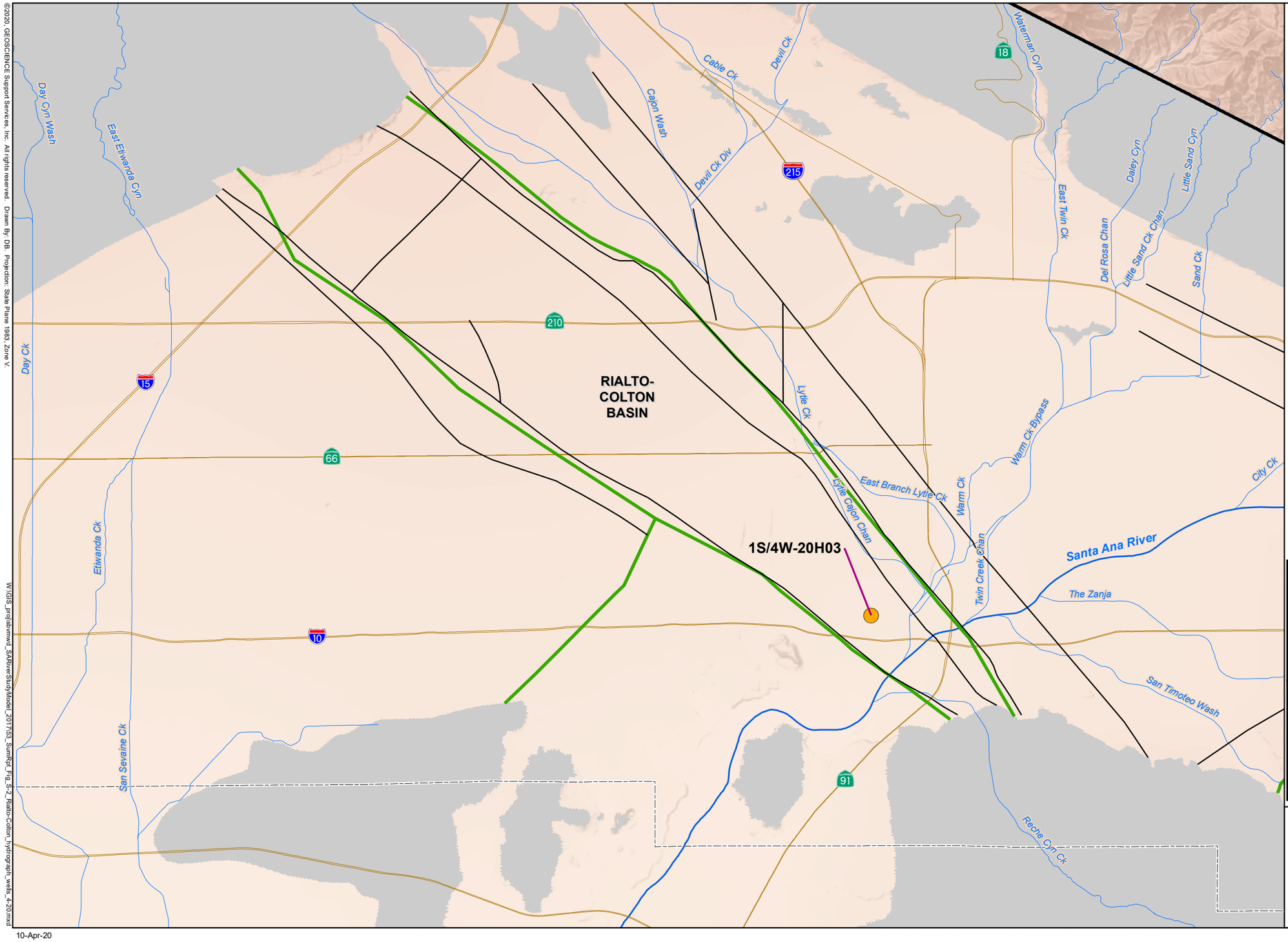


SELECTED TARGET WELL USED FOR HYDROGRAPHS SBBA MODEL AREA

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10-Apr-20

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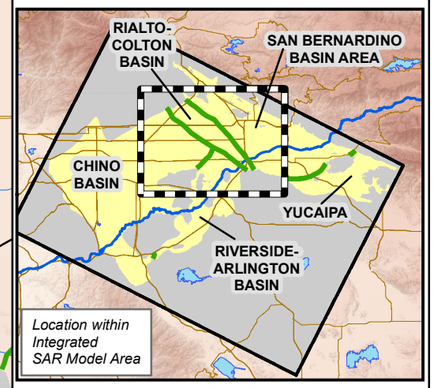
EXPLANATION

- Integrated SAR Model Boundary
- Well Model Layer
  - 1
  - 2
  - 3
  - 4
  - 5
- Inactive Model Area
- Groundwater Basin Boundary
- Groundwater Flow Barrier

N

0 1.5 3

Miles



SELECTED TARGET WELLS USED FOR HYDROGRAPHS RIALTO-COLTON BASIN MODEL AREA

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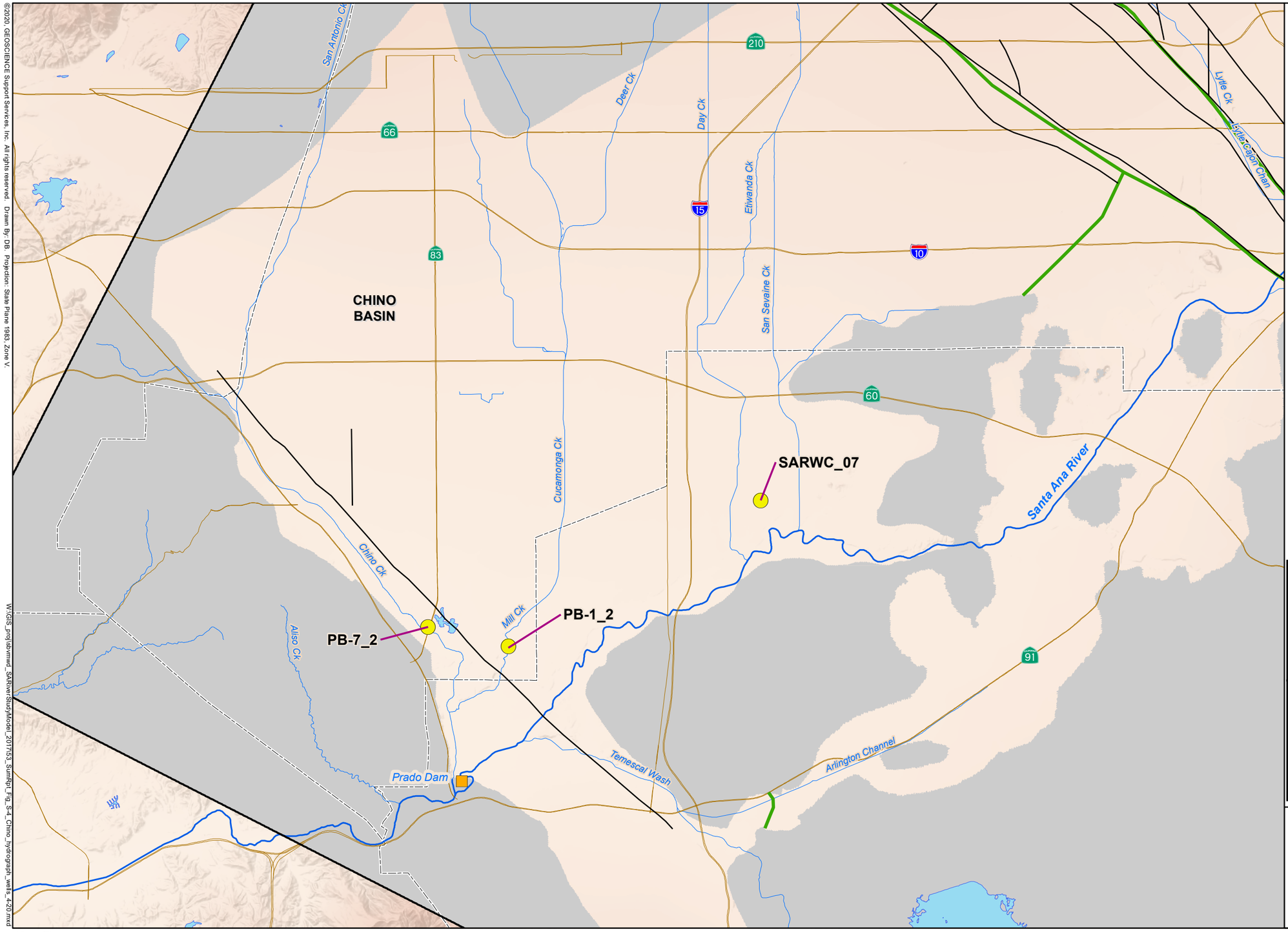
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SELECTED TARGET WELLS USED FOR HYDROGRAPHS RIVERSIDE-ARLINGTON BASIN MODEL AREA

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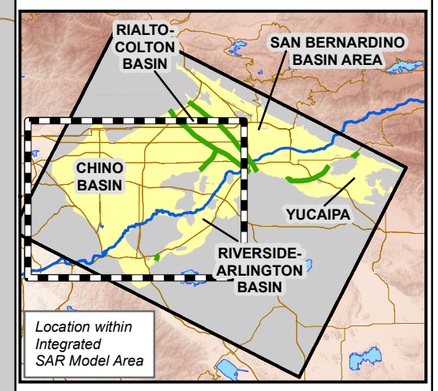
EXPLANATION

- Integrated SAR Model Boundary
- Well Model Layer
  - 1
  - 2
  - 3
  - 4
  - 5
- Inactive Model Area
- Groundwater Basin Boundary
- Groundwater Flow Barrier

N

0 2 4

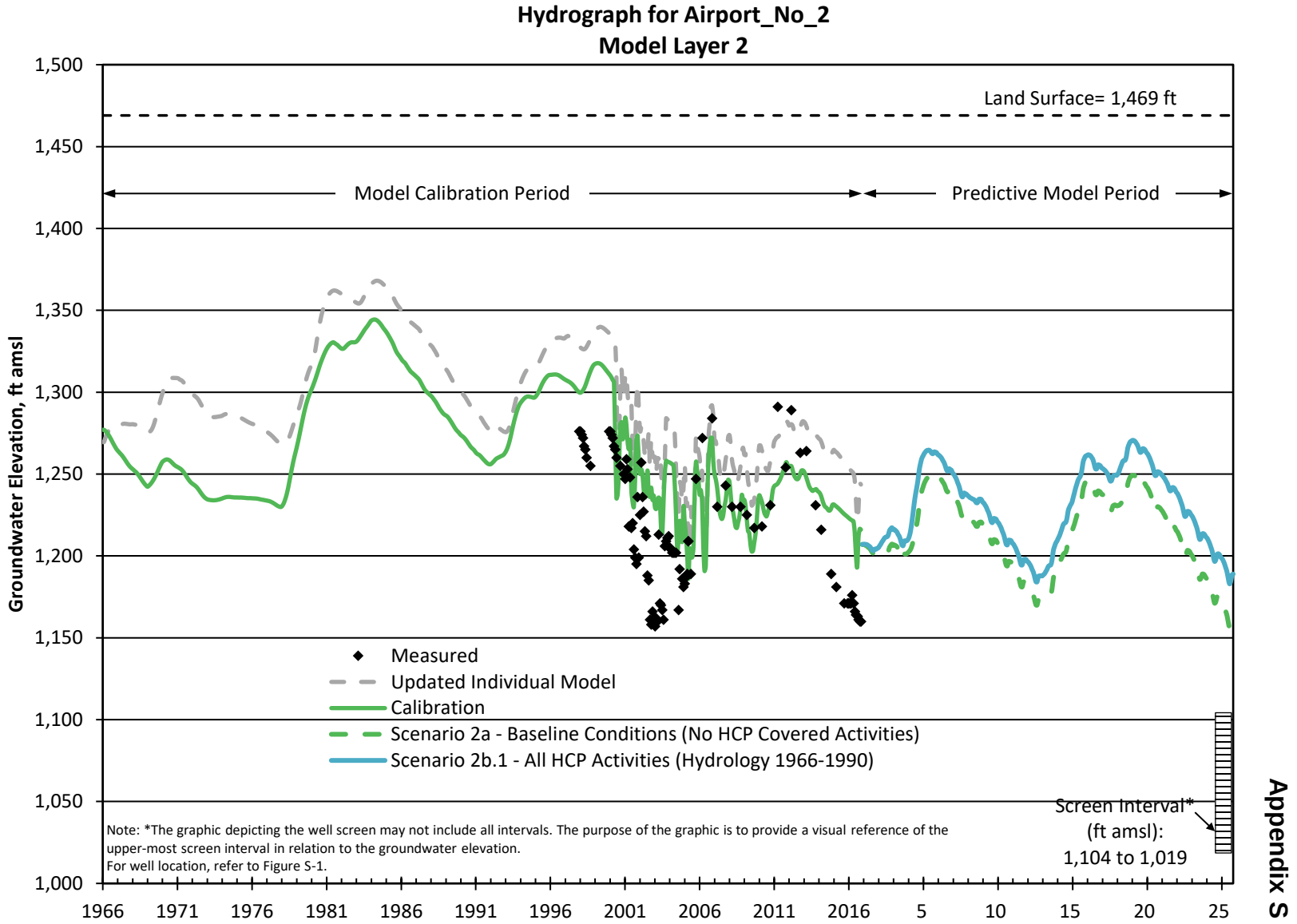
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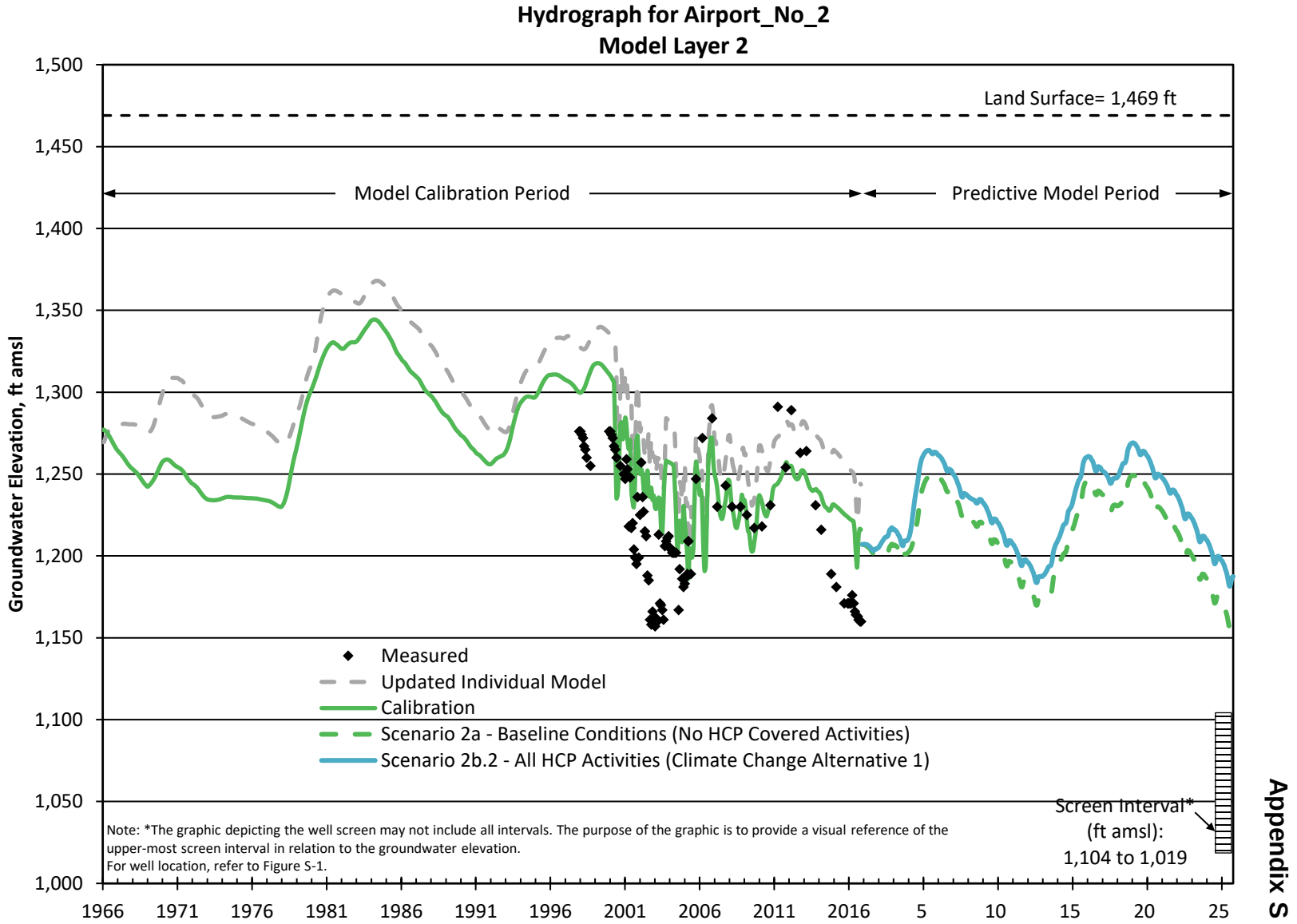
SELECTED TARGET WELLS USED FOR HYDROGRAPHS CHINO BASIN MODEL AREA

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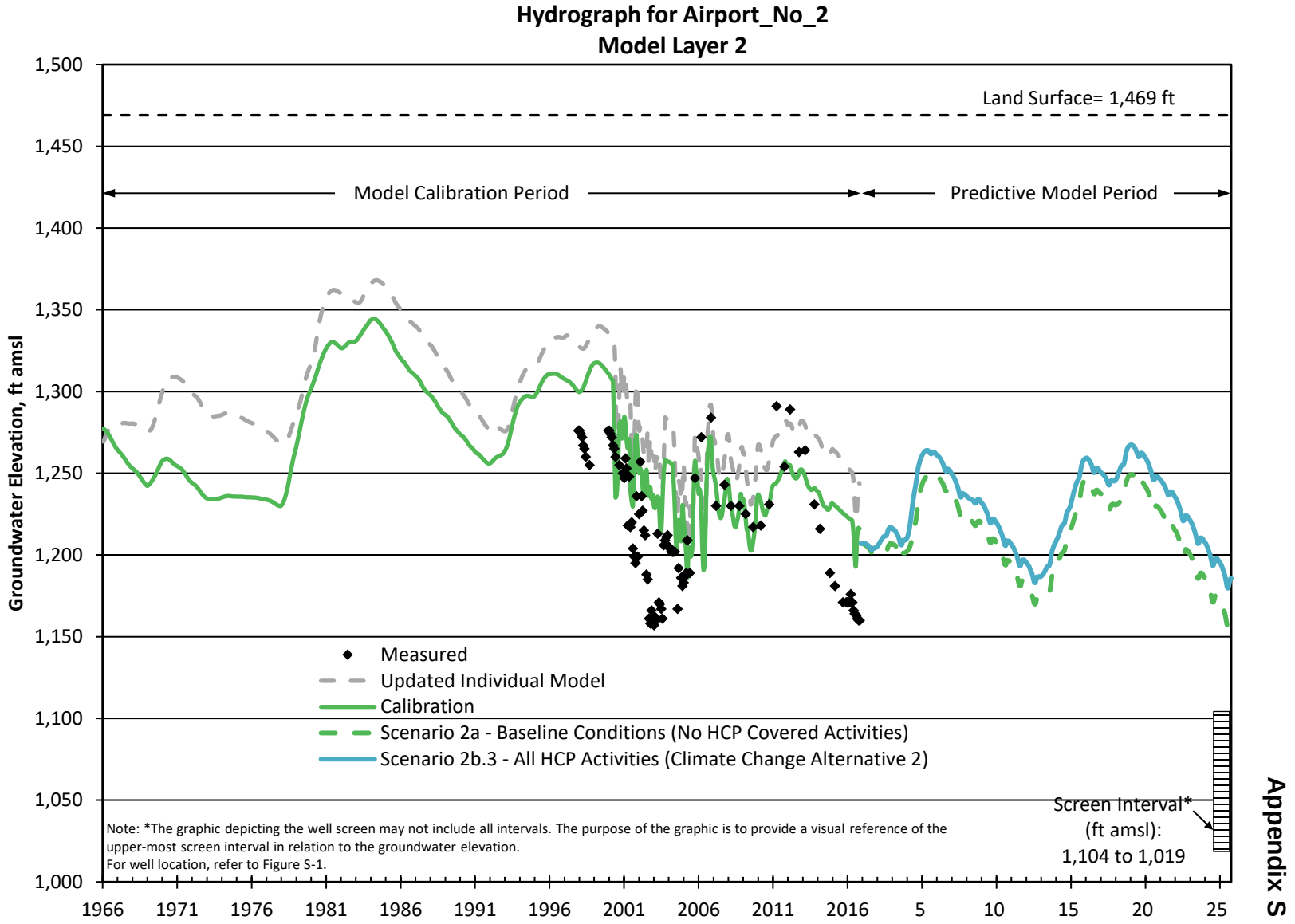
10-Apr-20


Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.1 - All HCP Activities (Hydrology 1966-1990)
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

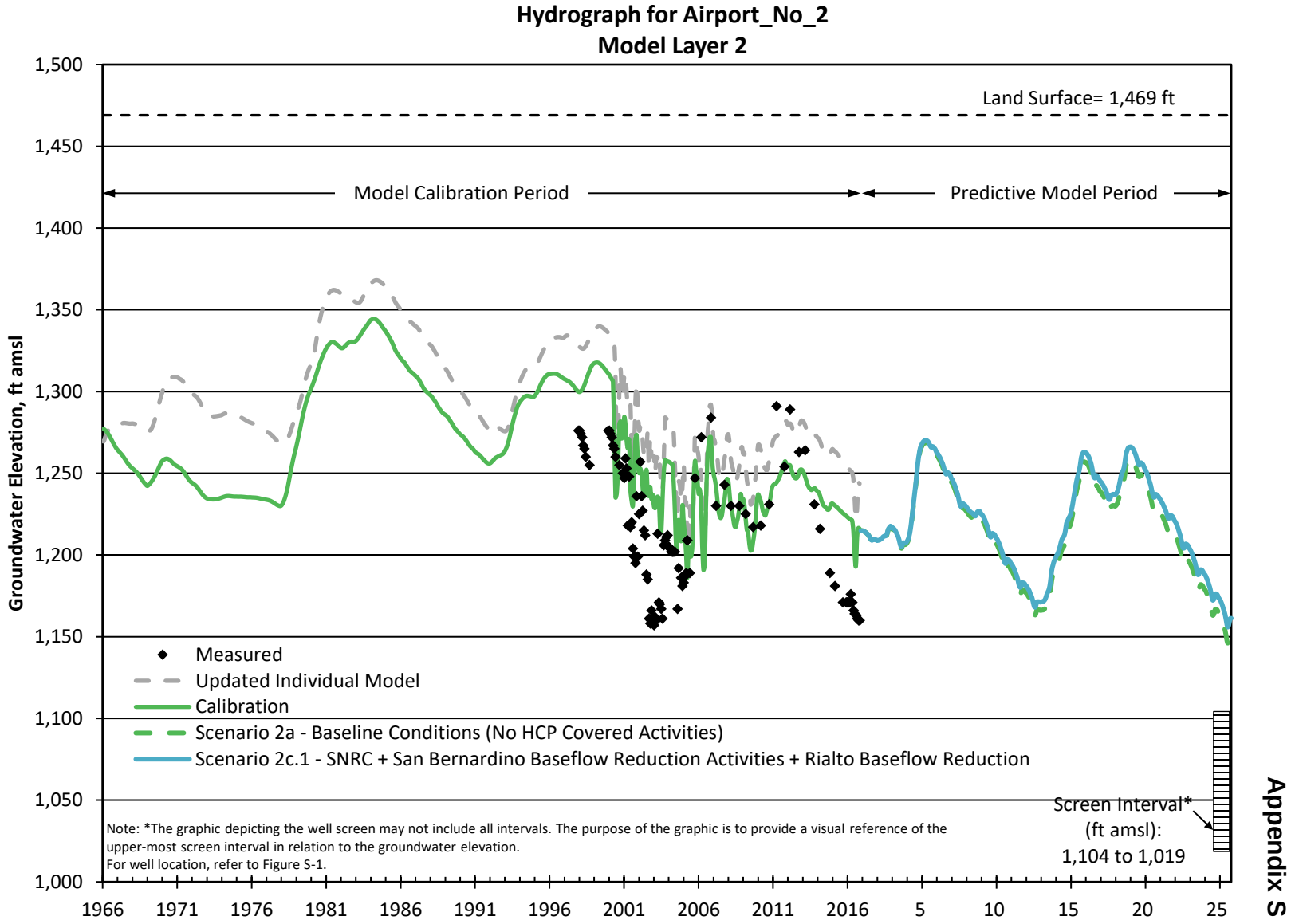
Appendix S


Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.2 - All HCP Activities (Climate Change Alternative 1)
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

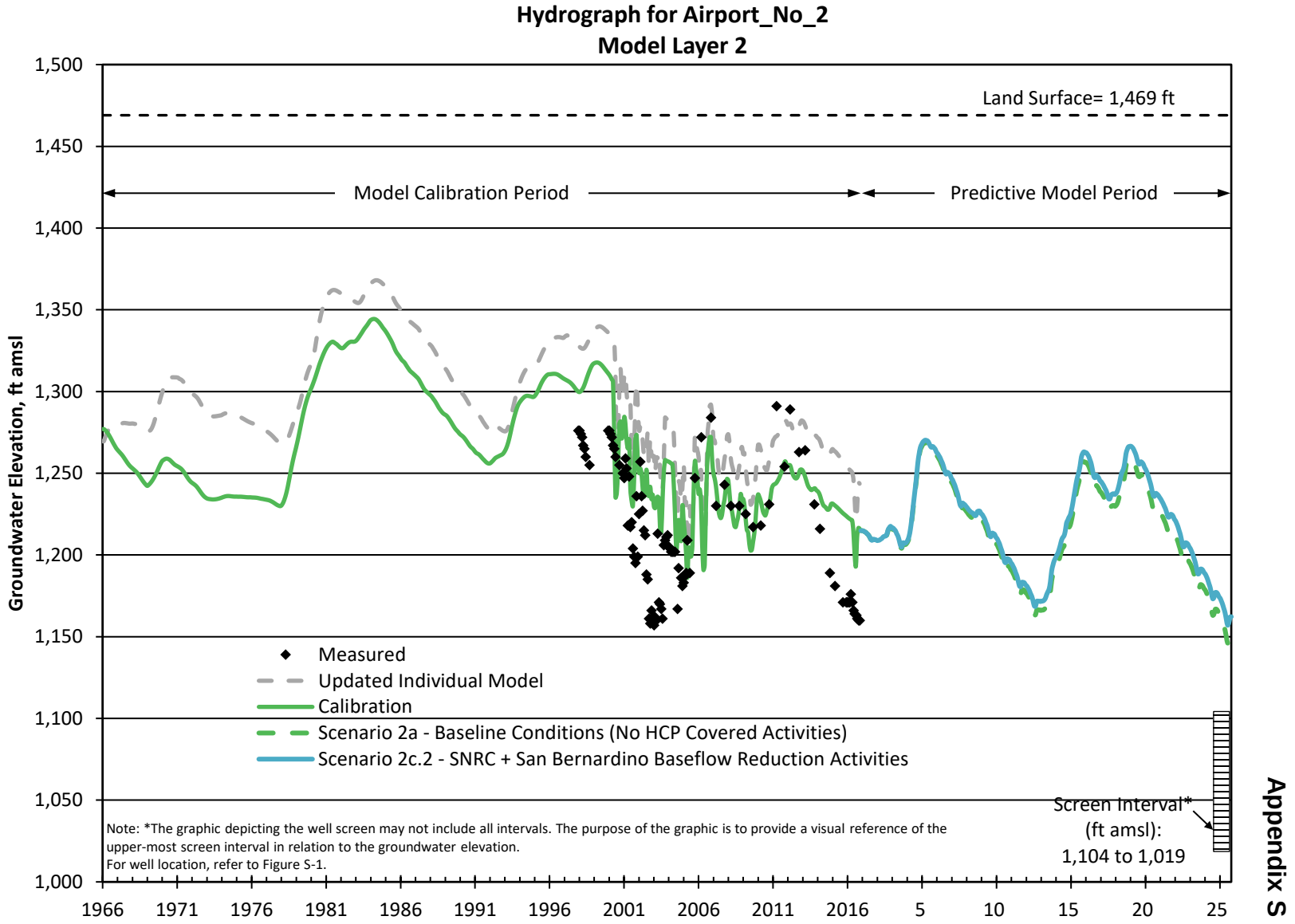
Appendix S

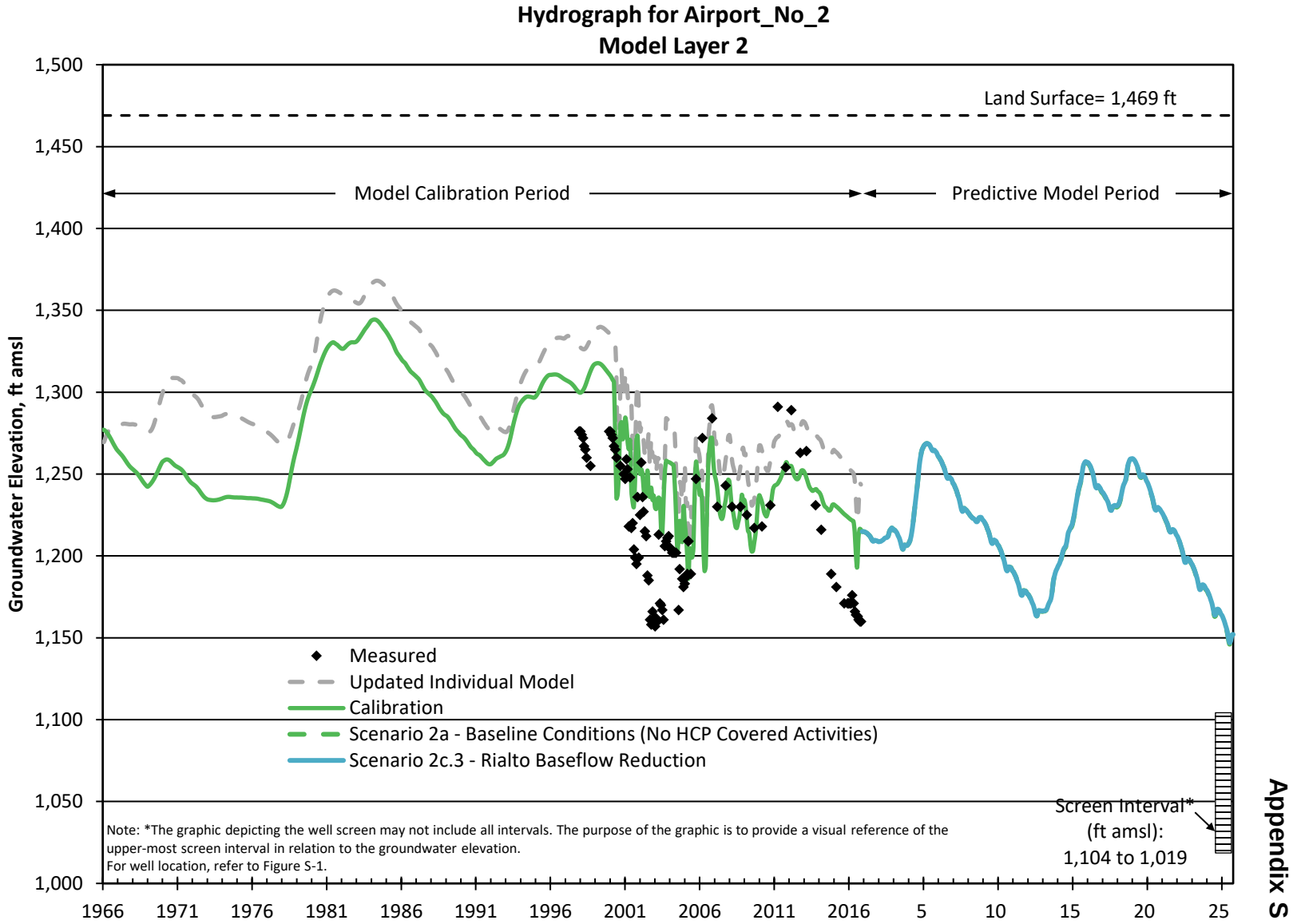

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.3 - All HCP Activities (Climate Change Alternative 2)
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

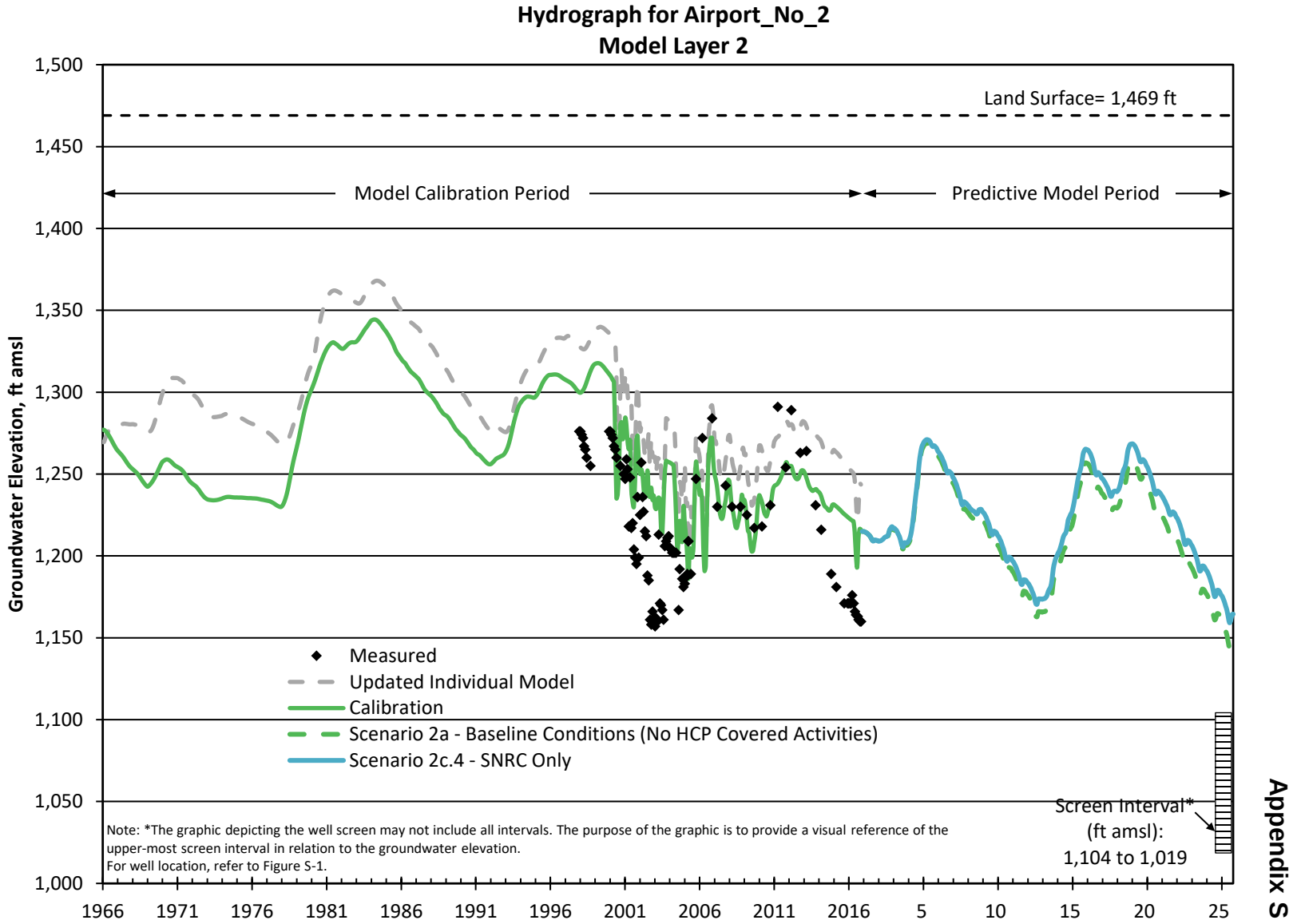
Appendix S


Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.1 - SNRC + San Bernardino Baseflow Reduction Activities + Rialto Baseflow Reduction
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

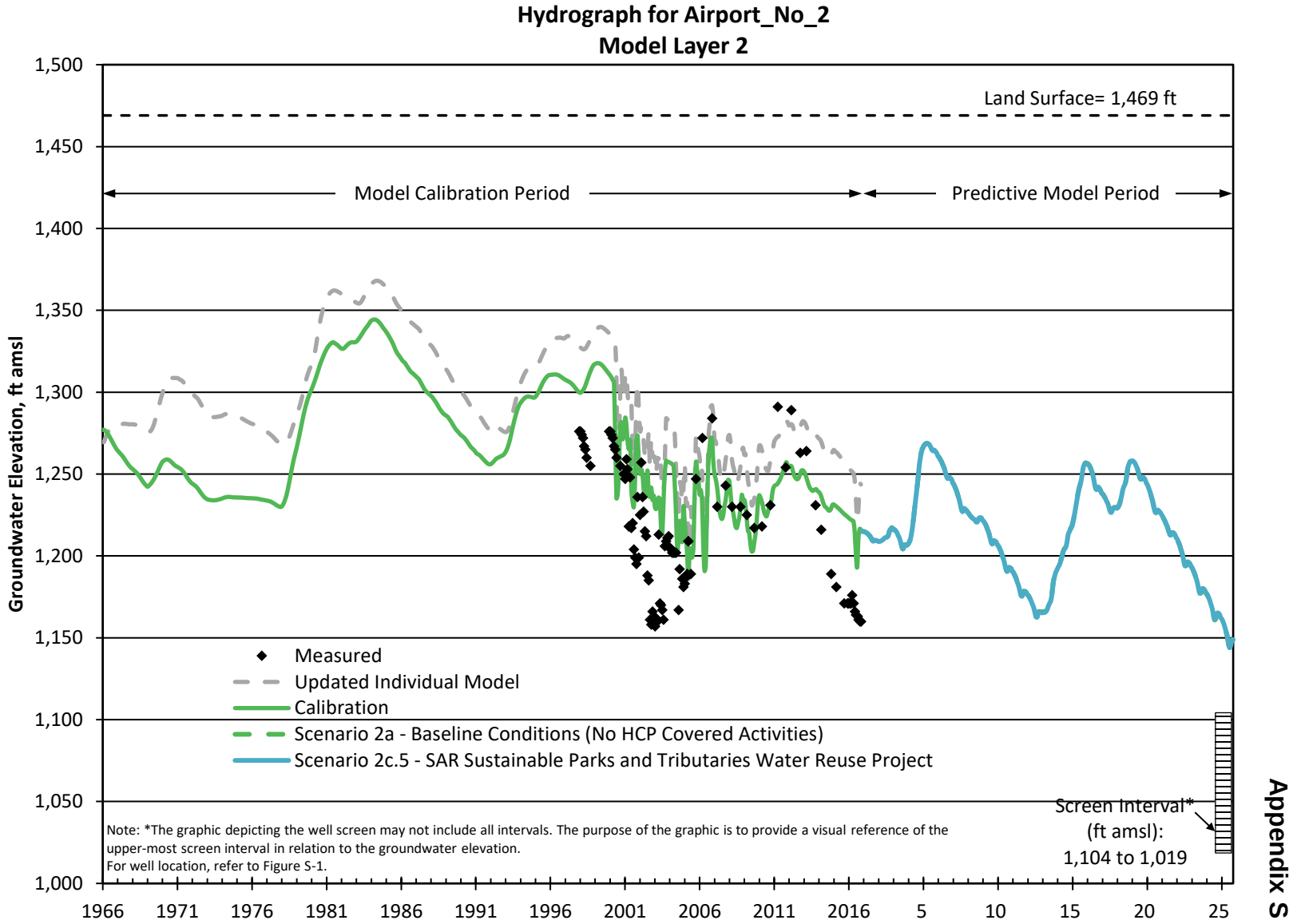
Appendix S

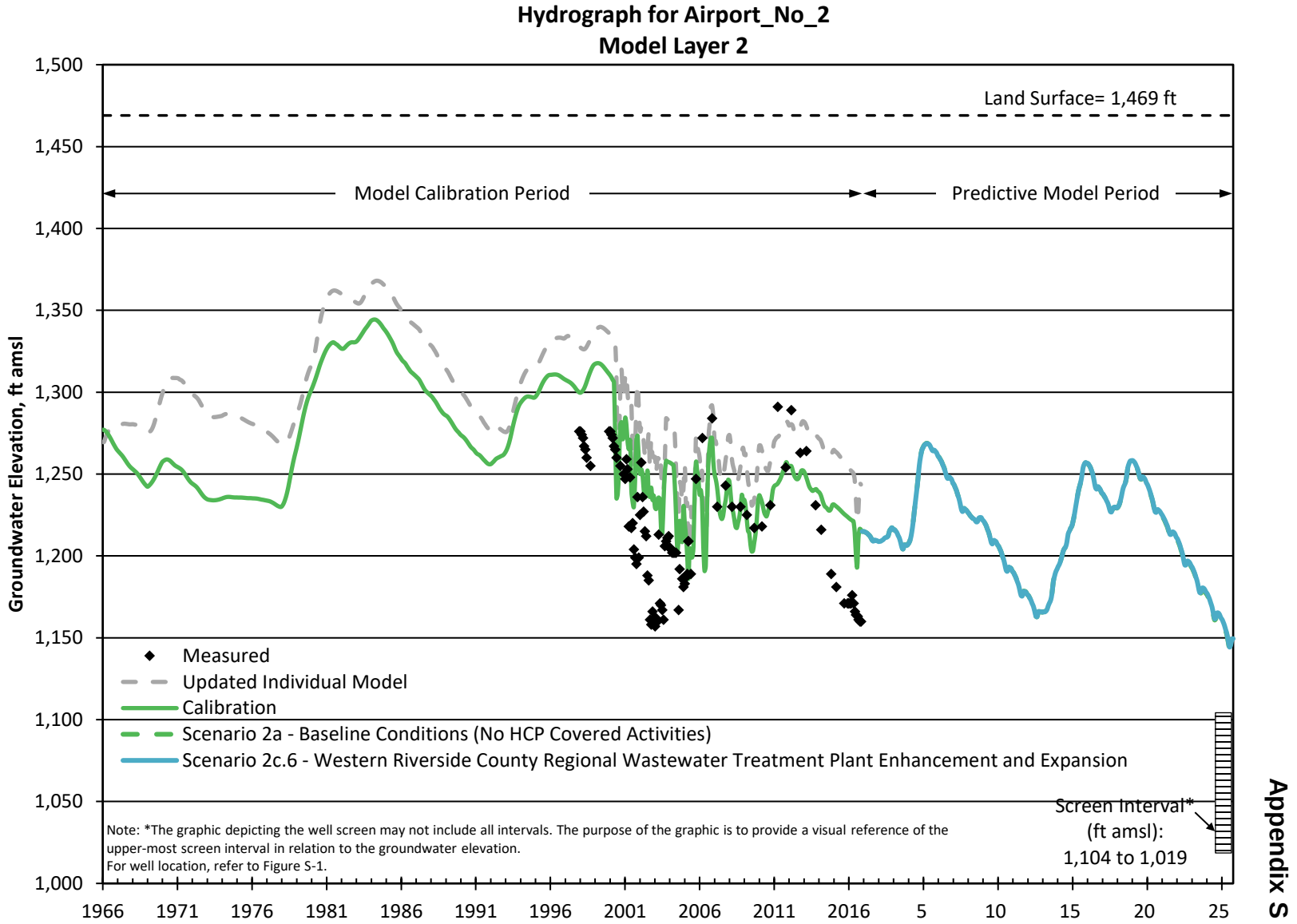

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.2 - SNRC + San Bernardino Baseflow Reduction Activities
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.
Appendix S

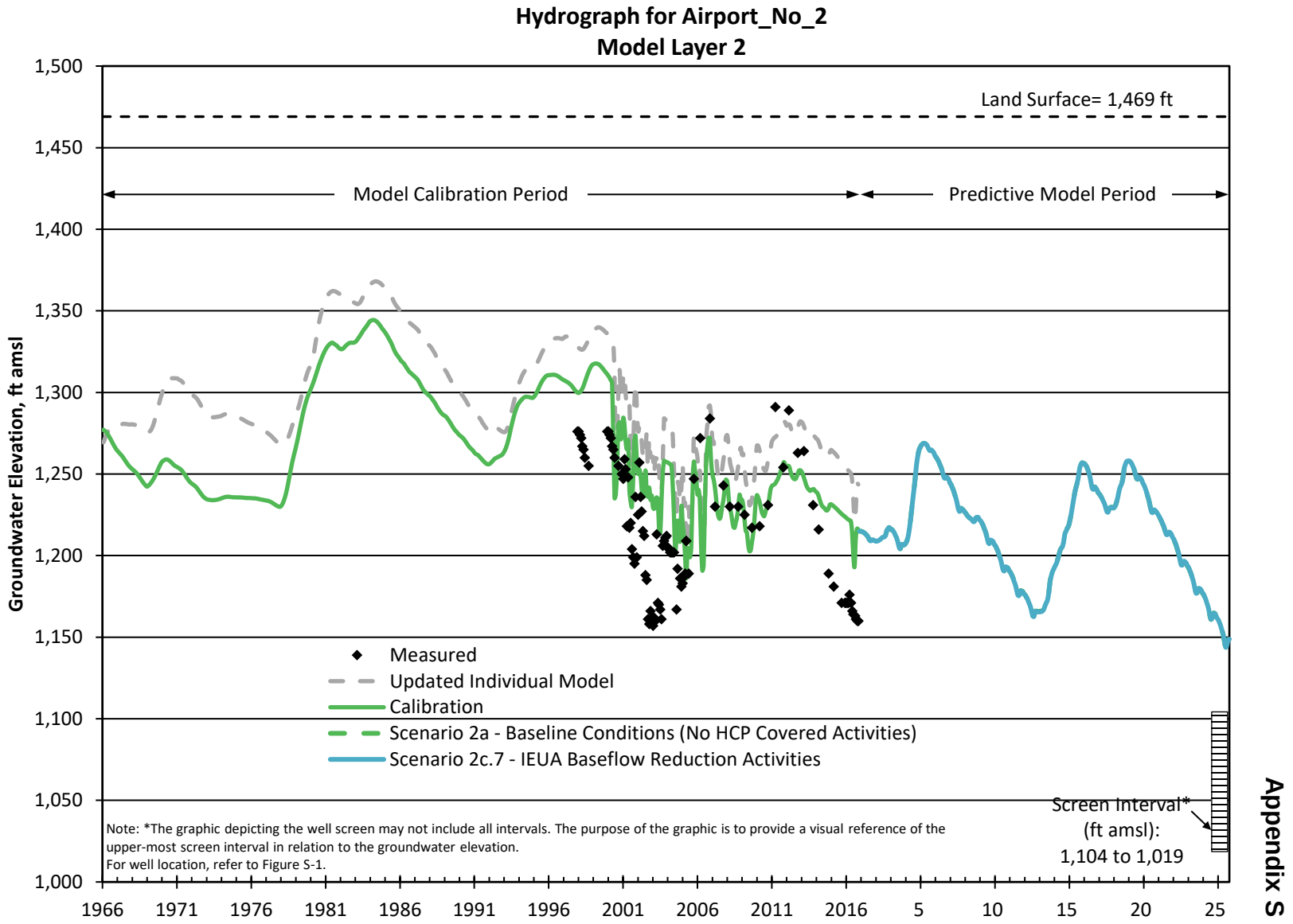

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.3 - Rialto Baseflow Reduction
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.
Appendix S


Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.4 - SNRC Only
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

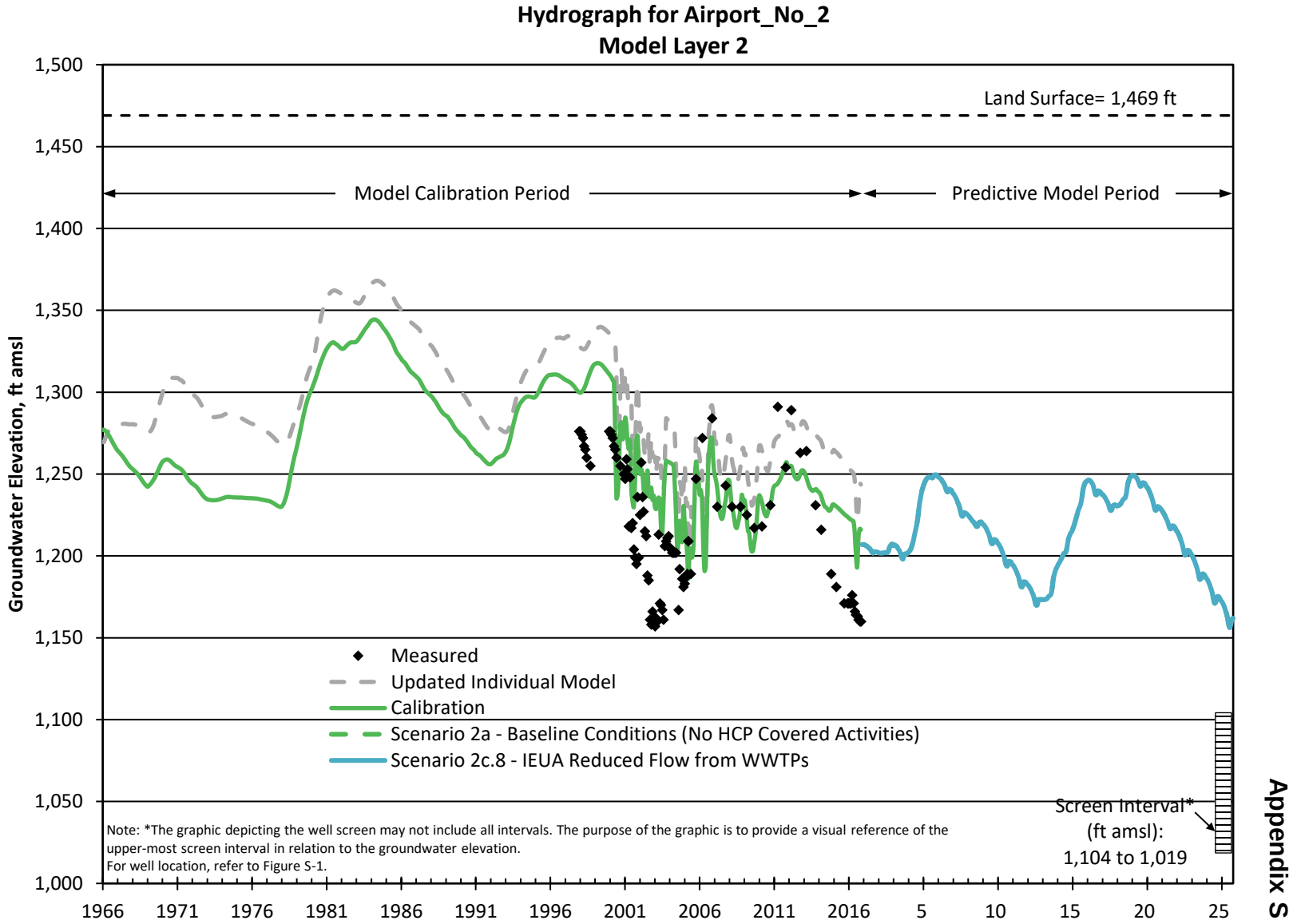
Appendix S


Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
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1981
1986
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2016
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.5 - SAR Sustainable Parks and Tributaries Water Reuse Project
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.
Appendix S

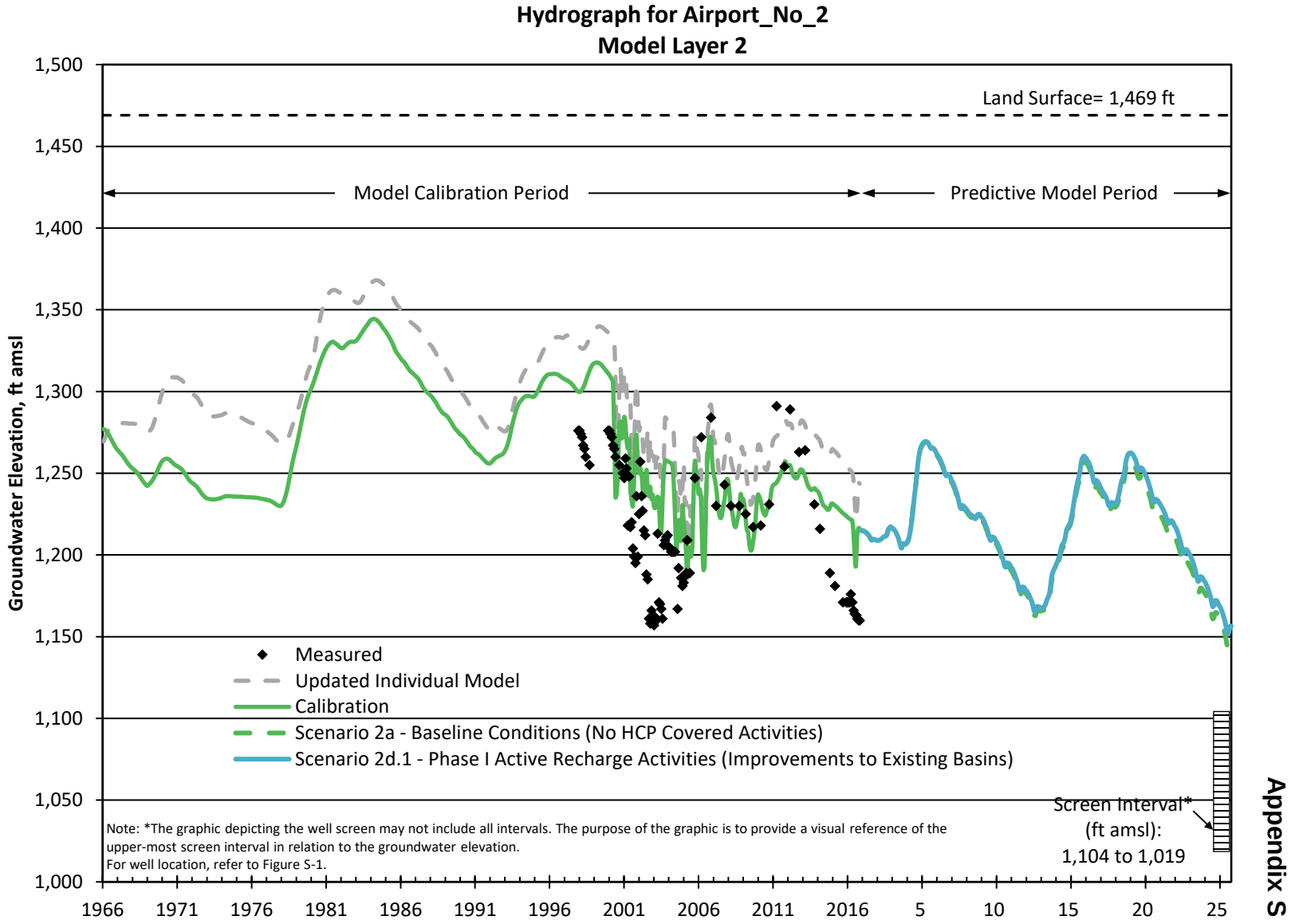

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
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1,200
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1,100
1,050
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1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.6 - Western Riverside County Regional Wastewater Treatment Plant Enhancement and Expansion
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.
Appendix S

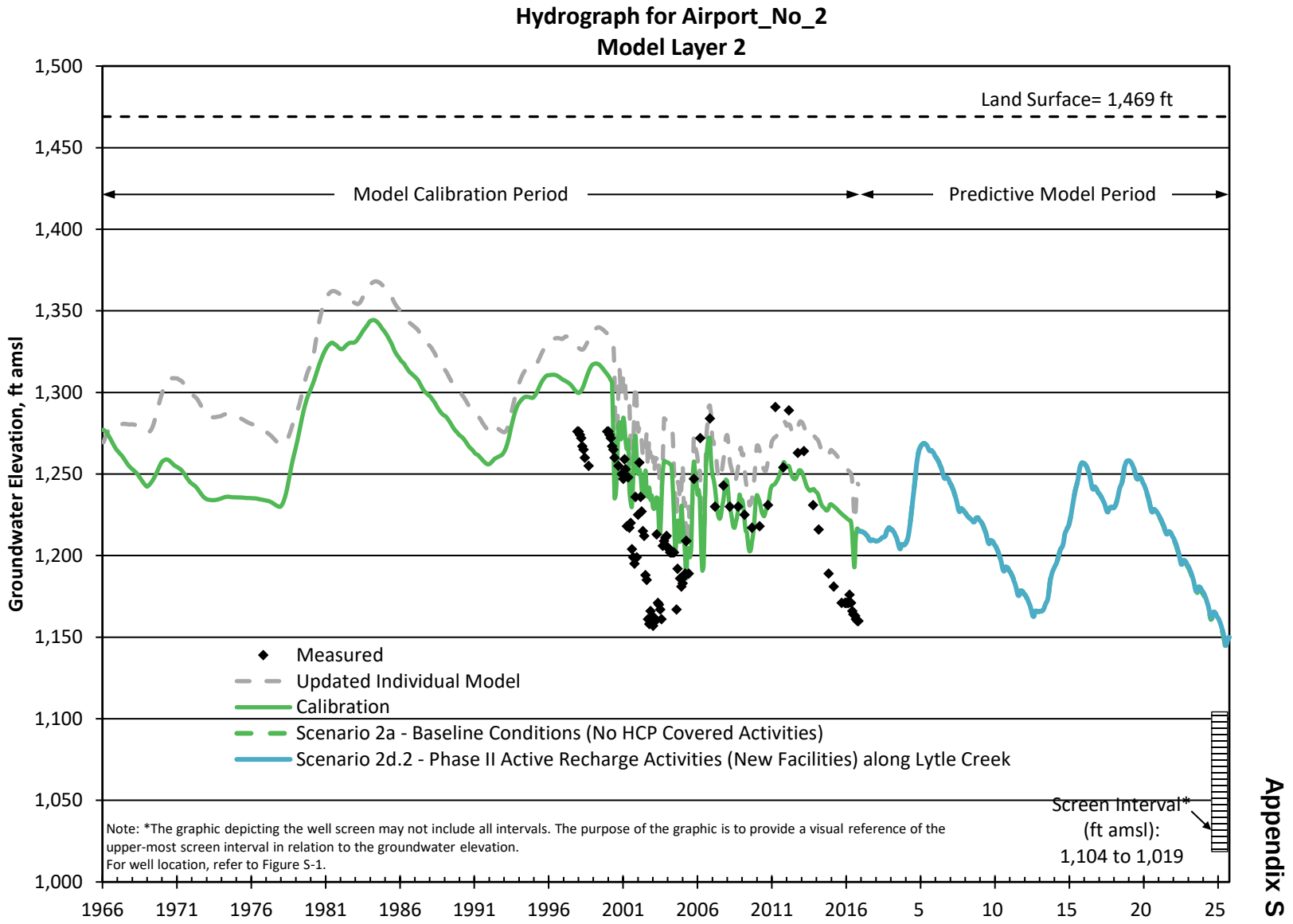

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
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2016
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.7 - IEUA Baseflow Reduction Activities
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

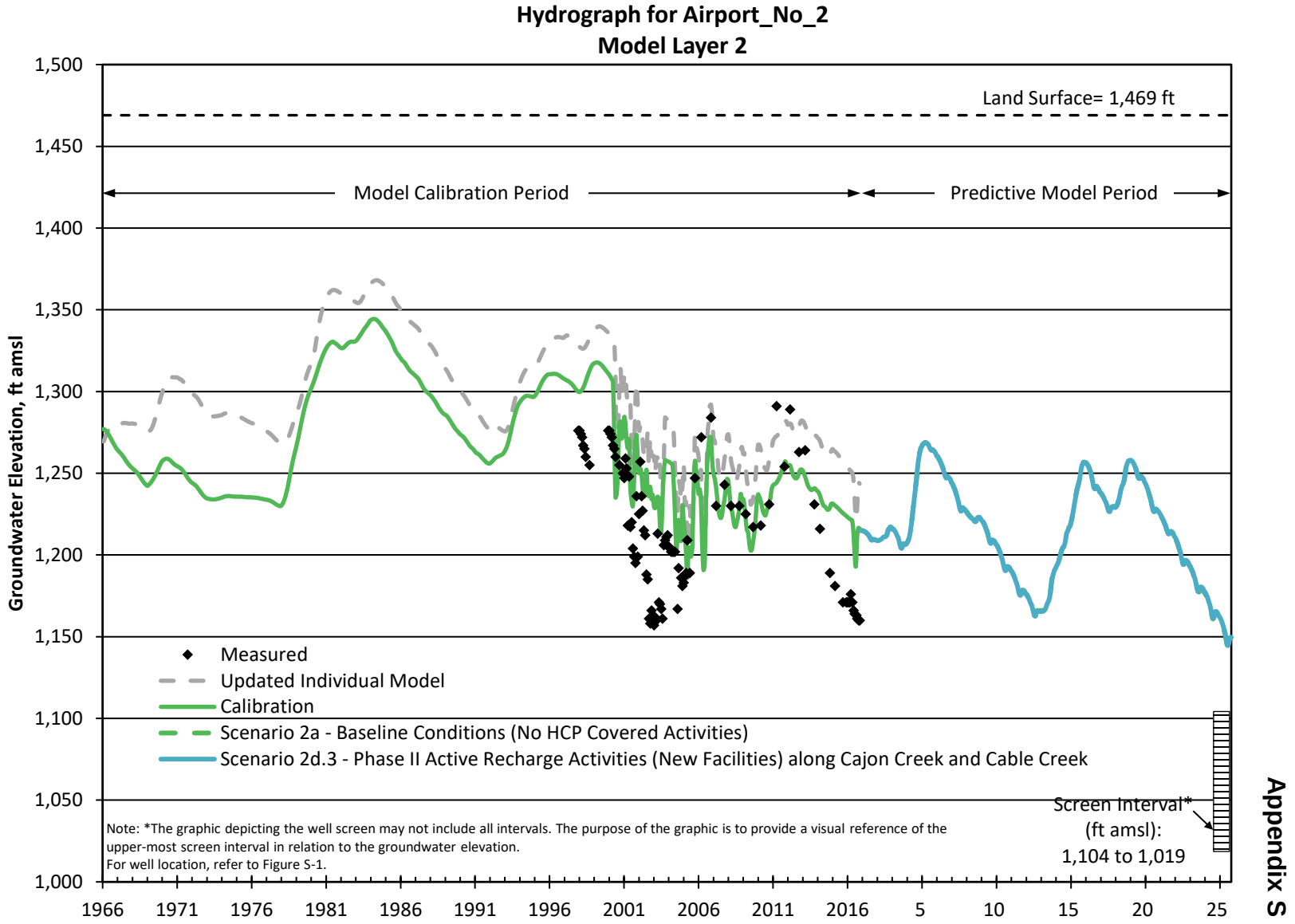
Appendix S

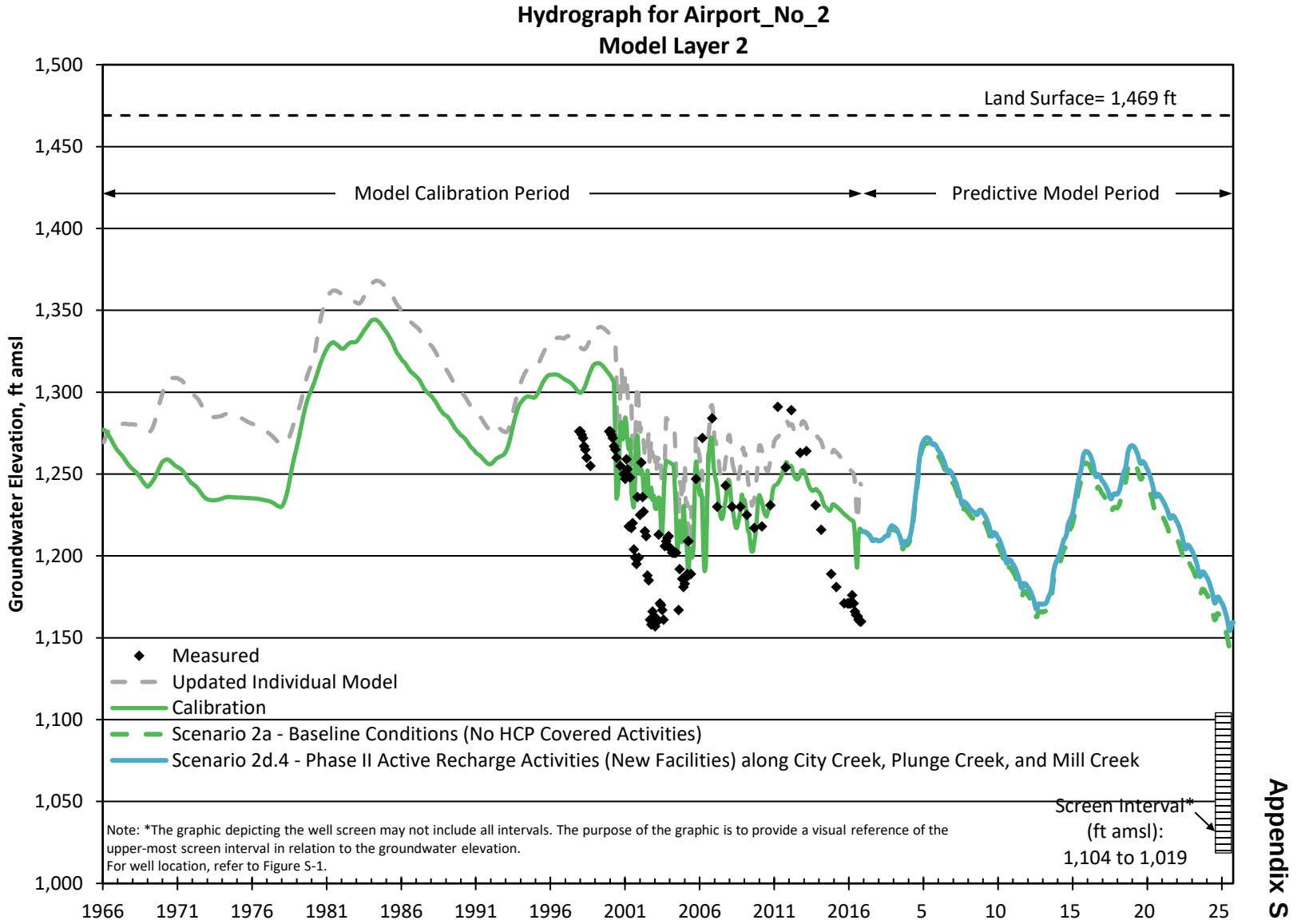

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.8 - IEUA Reduced Flow from WWTPs
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

Appendix S

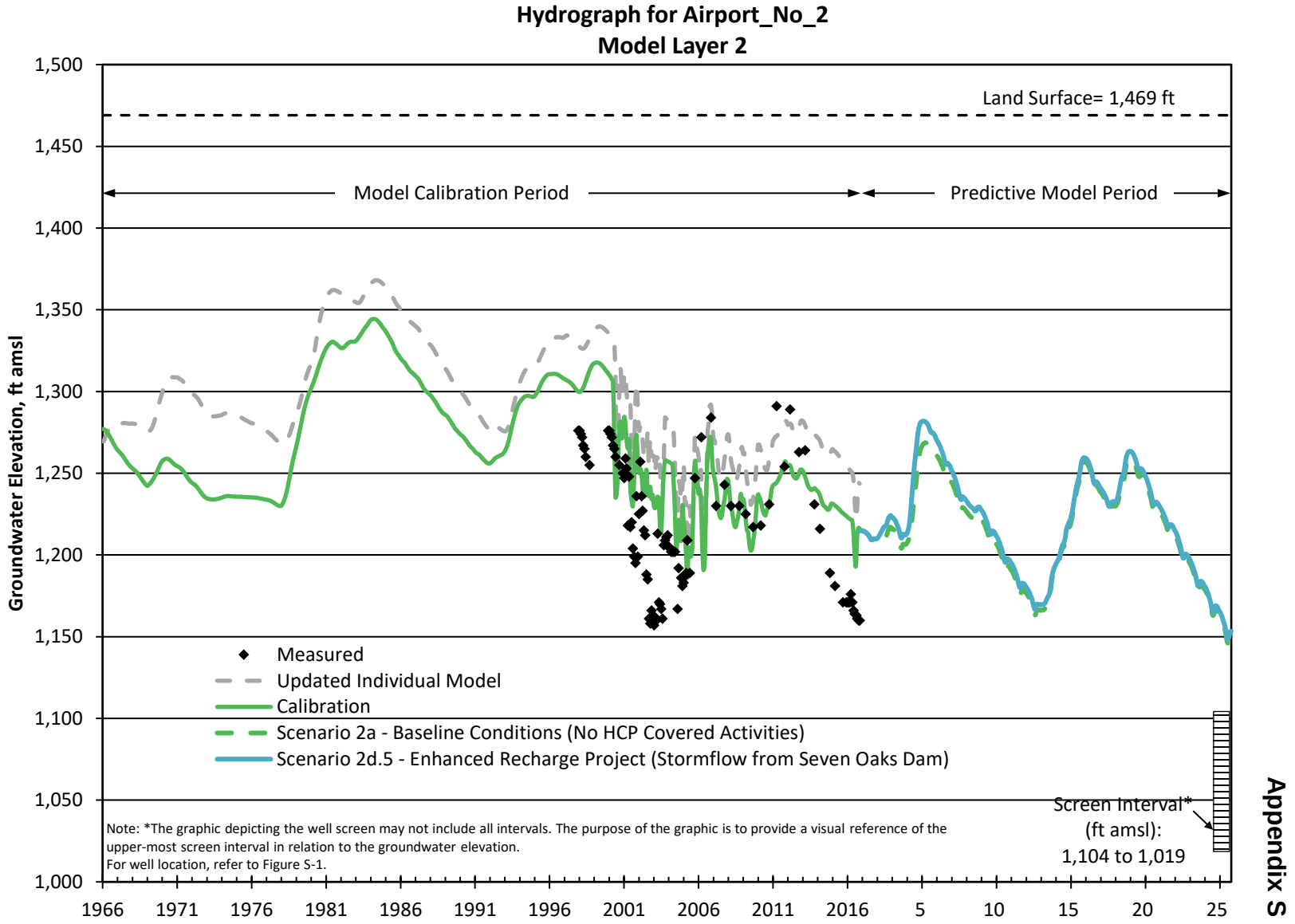

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
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1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.1 - Phase I Active Recharge Activities (Improvements to Existing Basins)
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.
Appendix S


Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.2 - Phase II Active Recharge Activities (New Facilities) along Lytle Creek
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.
Appendix S

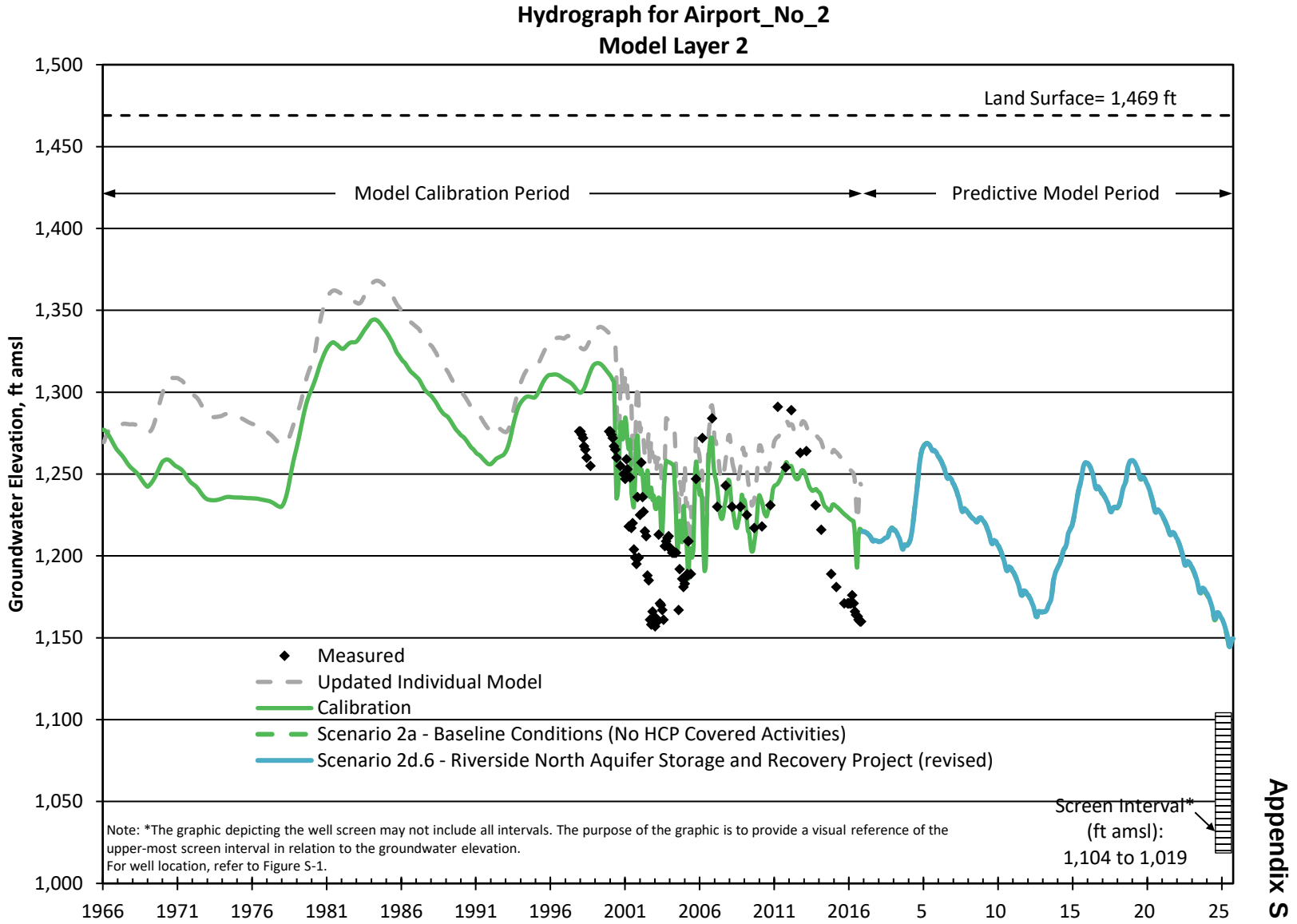

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
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1,400
1,350
1,300
1,250
1,200
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.3 - Phase II Active Recharge Activities (New Facilities) along Cajon Creek and Cable Creek
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.
Appendix S

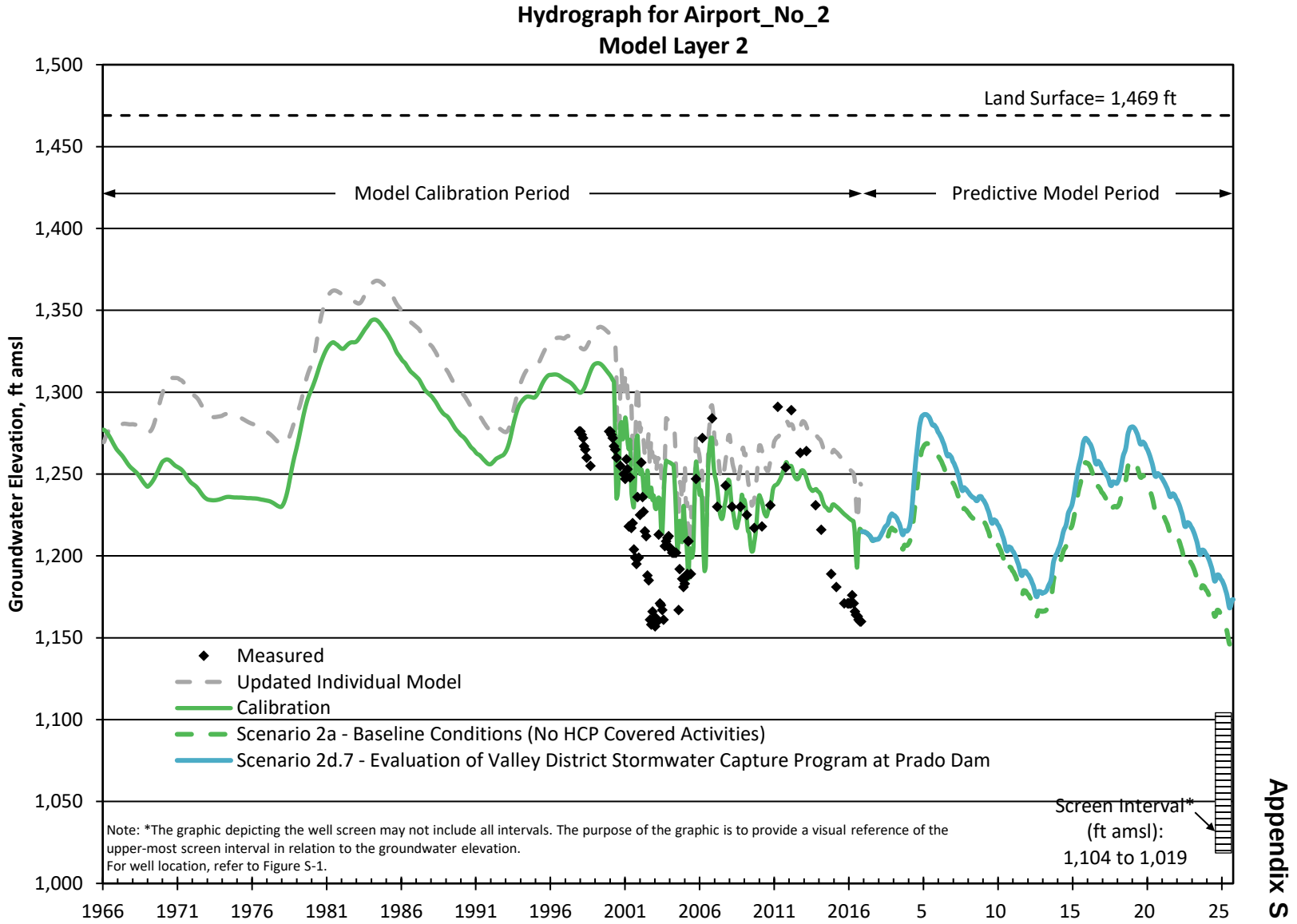

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.4 - Phase II Active Recharge Activities (New Facilities) along City Creek, Plunge Creek, and Mill Creek
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

Appendix S

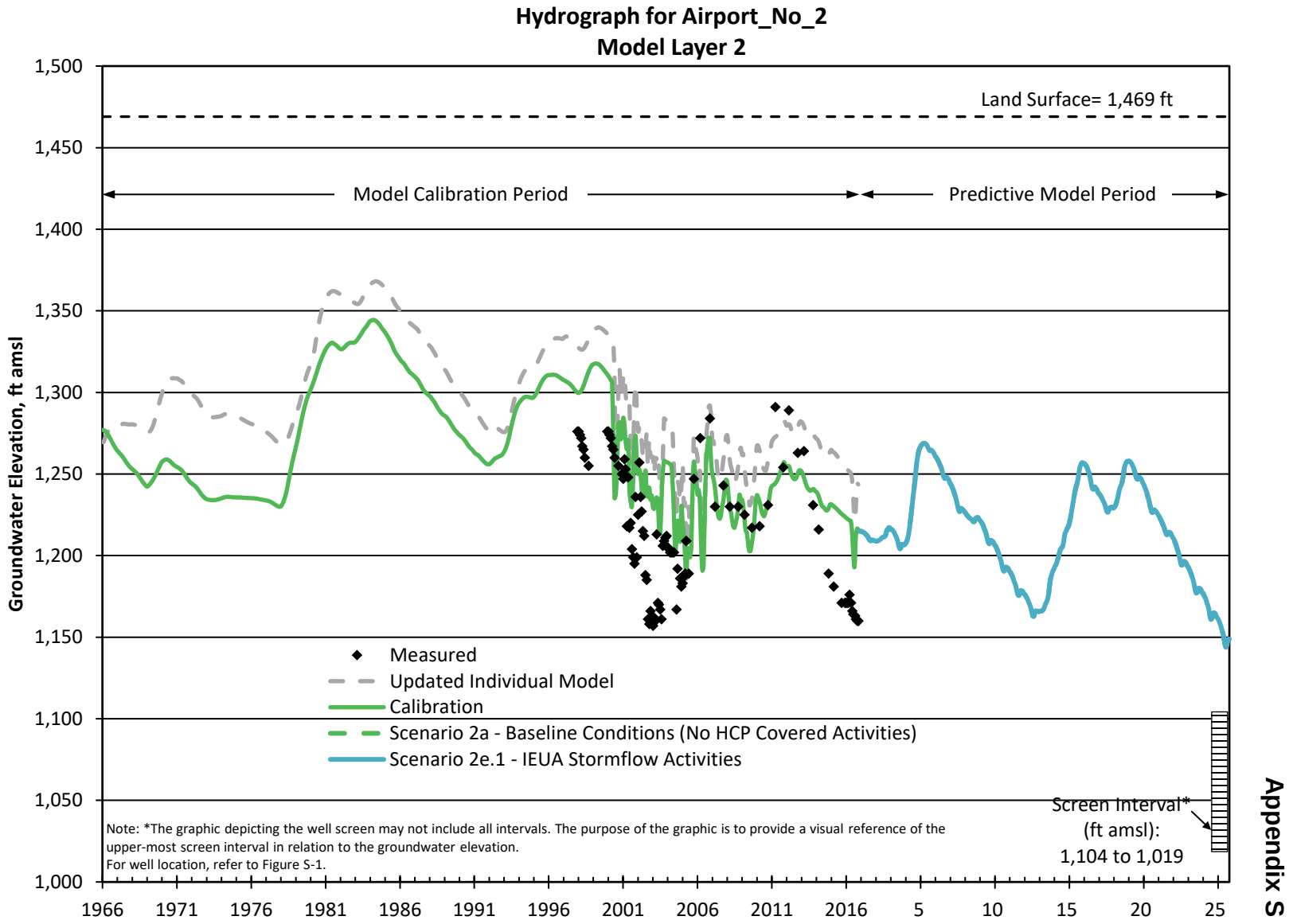

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
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1,400
1,350
1,300
1,250
1,200
1,150
1,100
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.5 - Enhanced Recharge Project (Stormflow from Seven Oaks Dam)
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

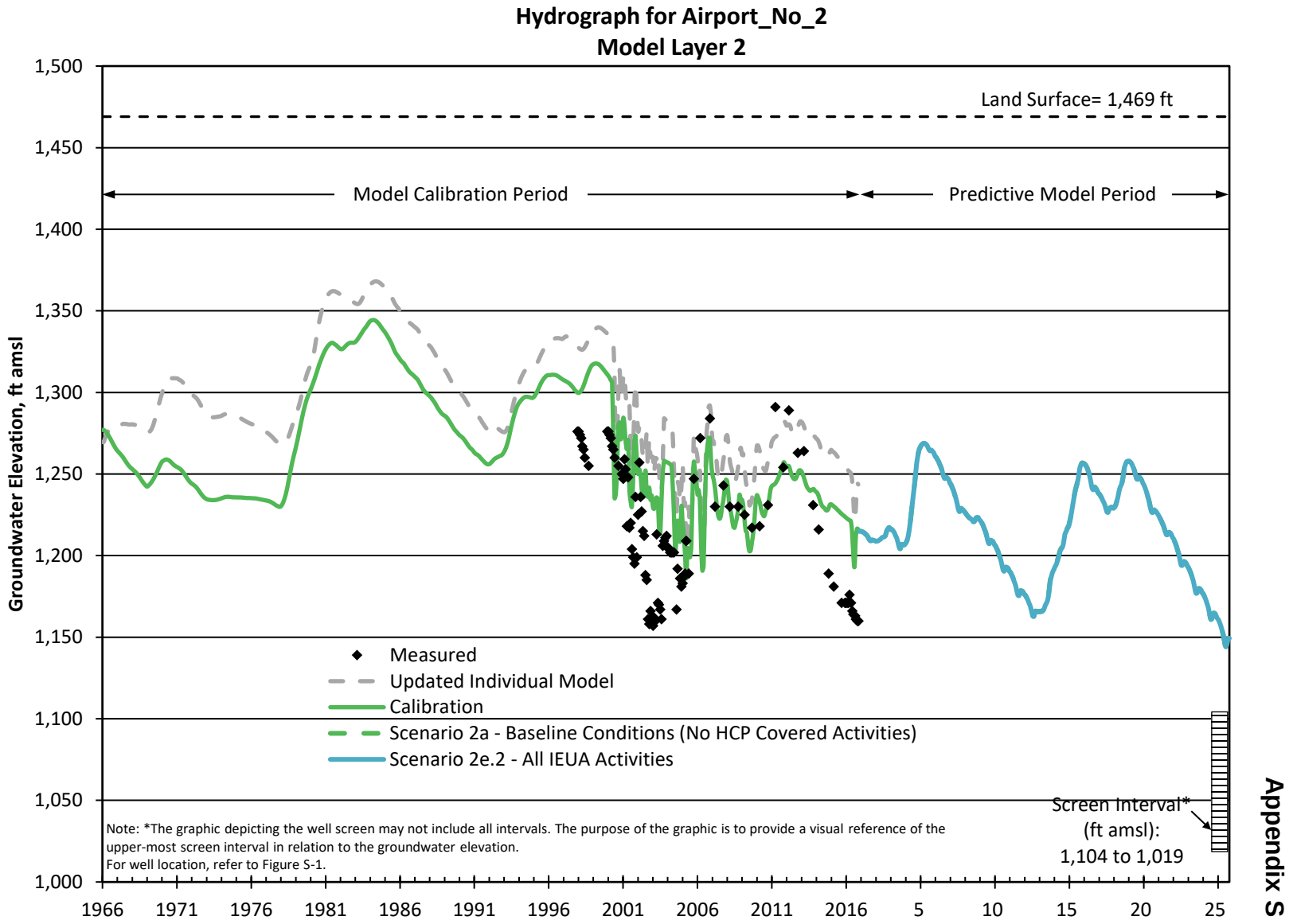
Appendix S


Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
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1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.6 - Riverside North Aquifer Storage and Recovery Project (revised)
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.
Appendix S

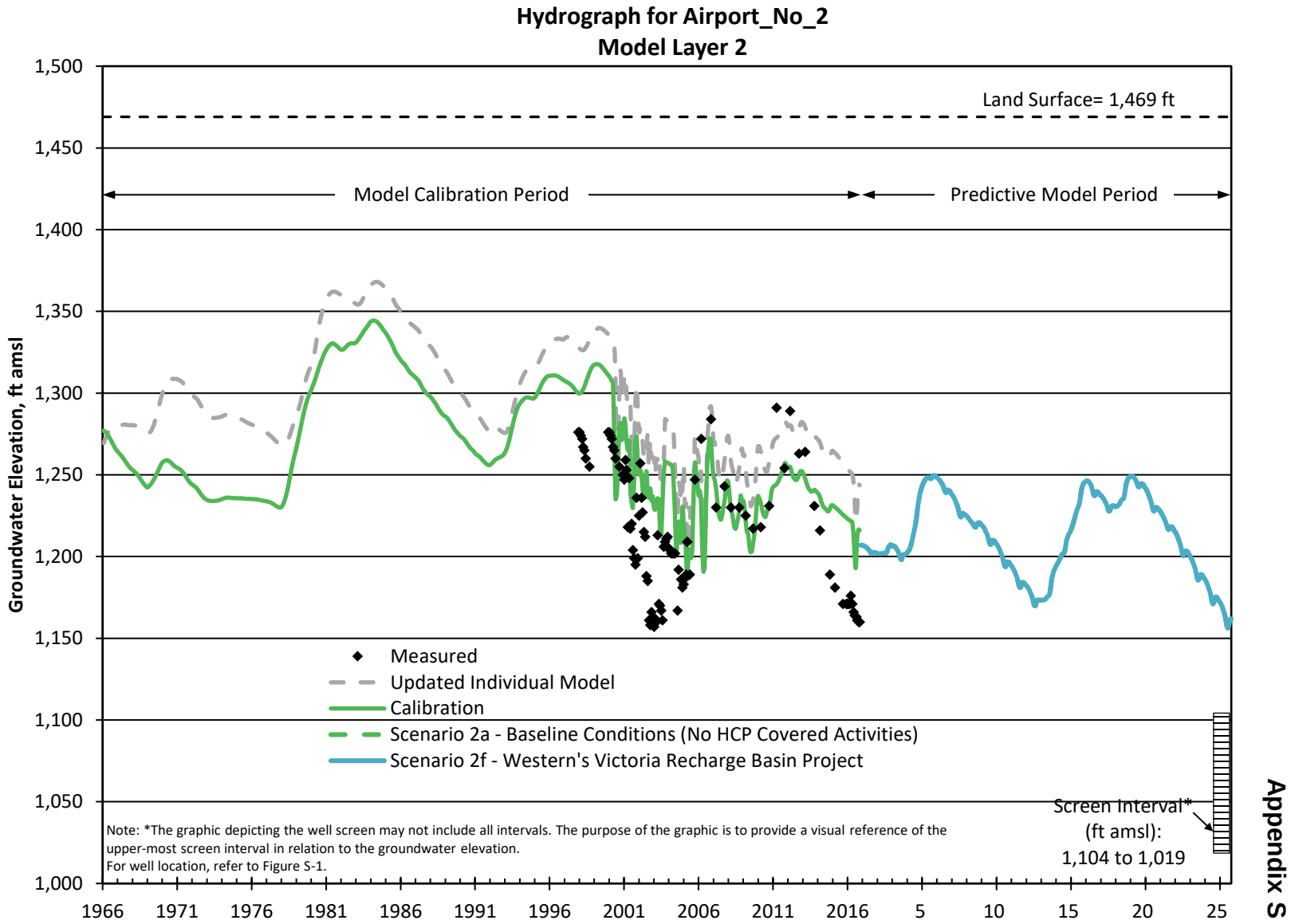

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
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1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.7 - Evaluation of Valley District Stormwater Capture Program at Prado Dam
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

Appendix S

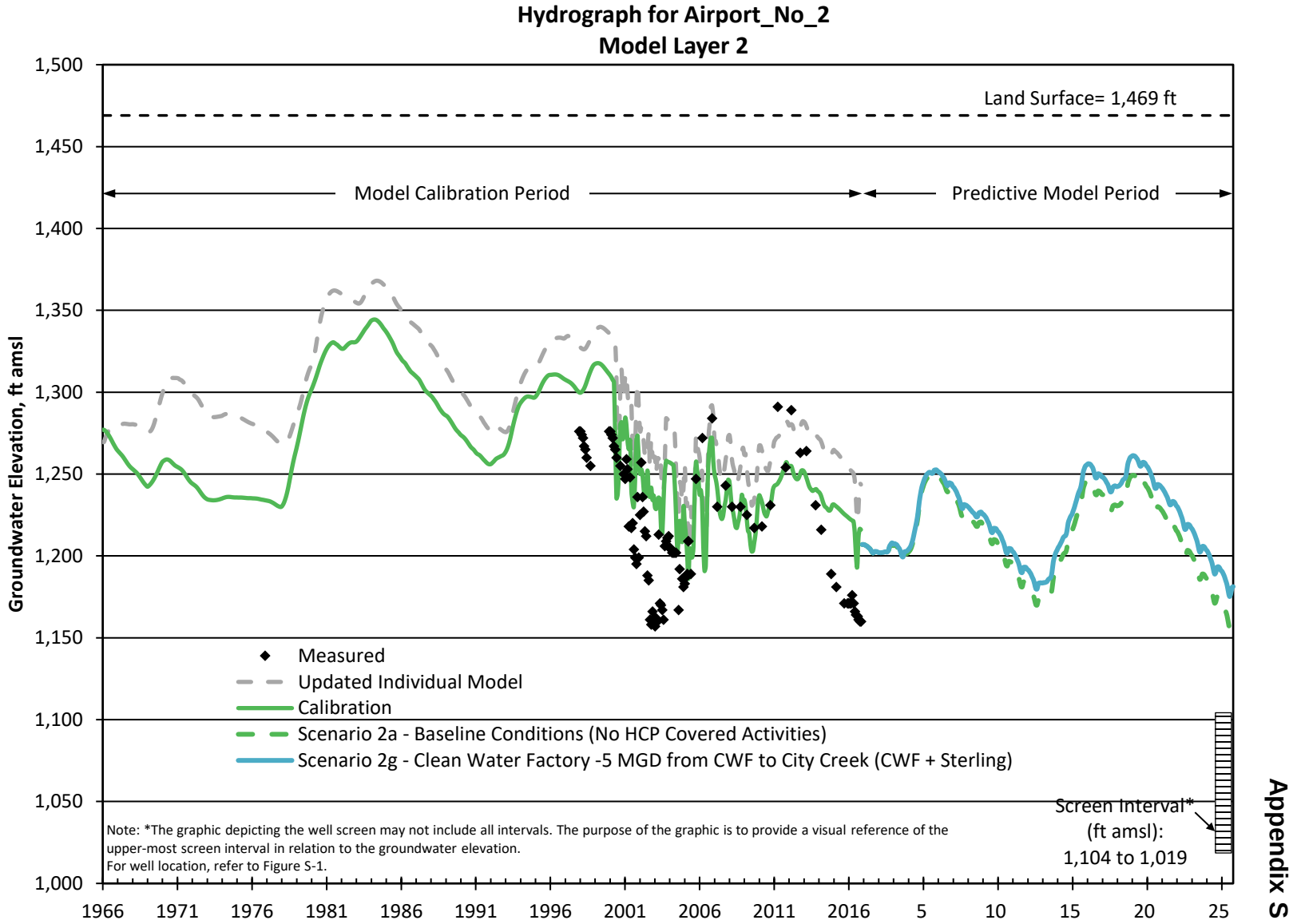

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2e.1 - IEUA Stormflow Activities
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.
Appendix S


Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
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1,150
1,100
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1,000
1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2e.2 - All IEUA Activities
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

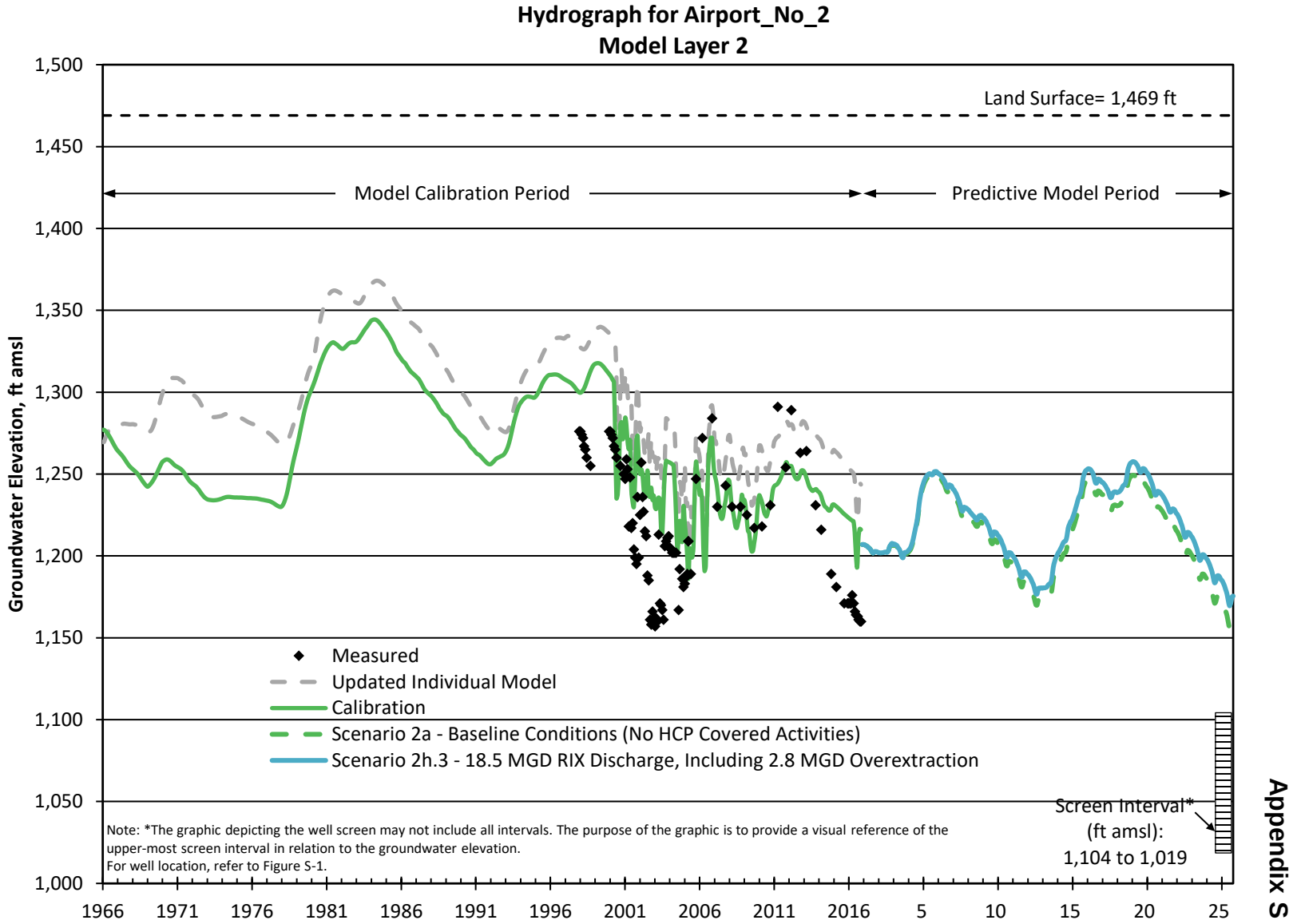
Appendix S


Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2f - Western's Victoria Recharge Basin Project
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

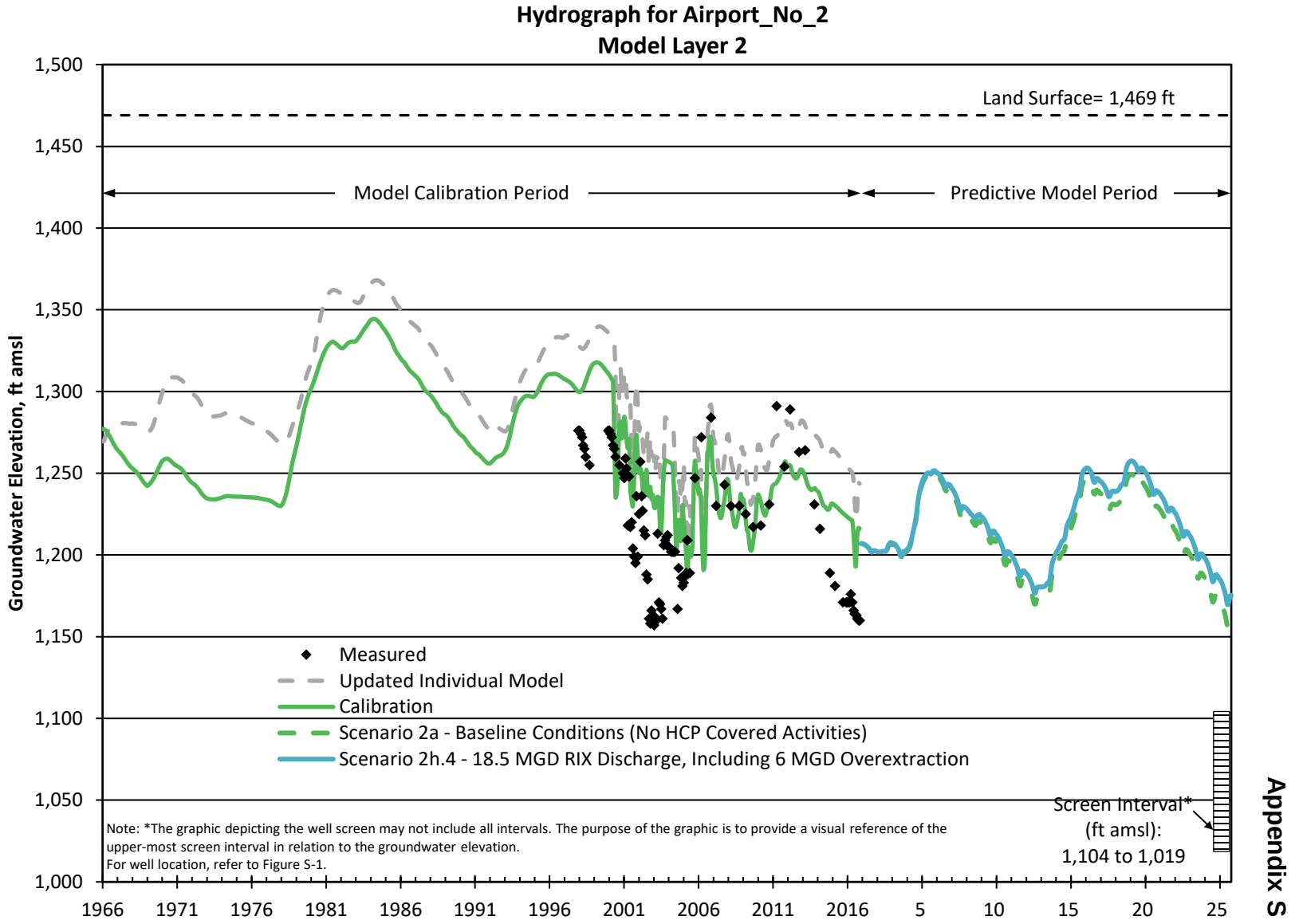
Appendix S


Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
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1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2g - Clean Water Factory -5 MGD from CWF to City Creek (CWF + Sterling)
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

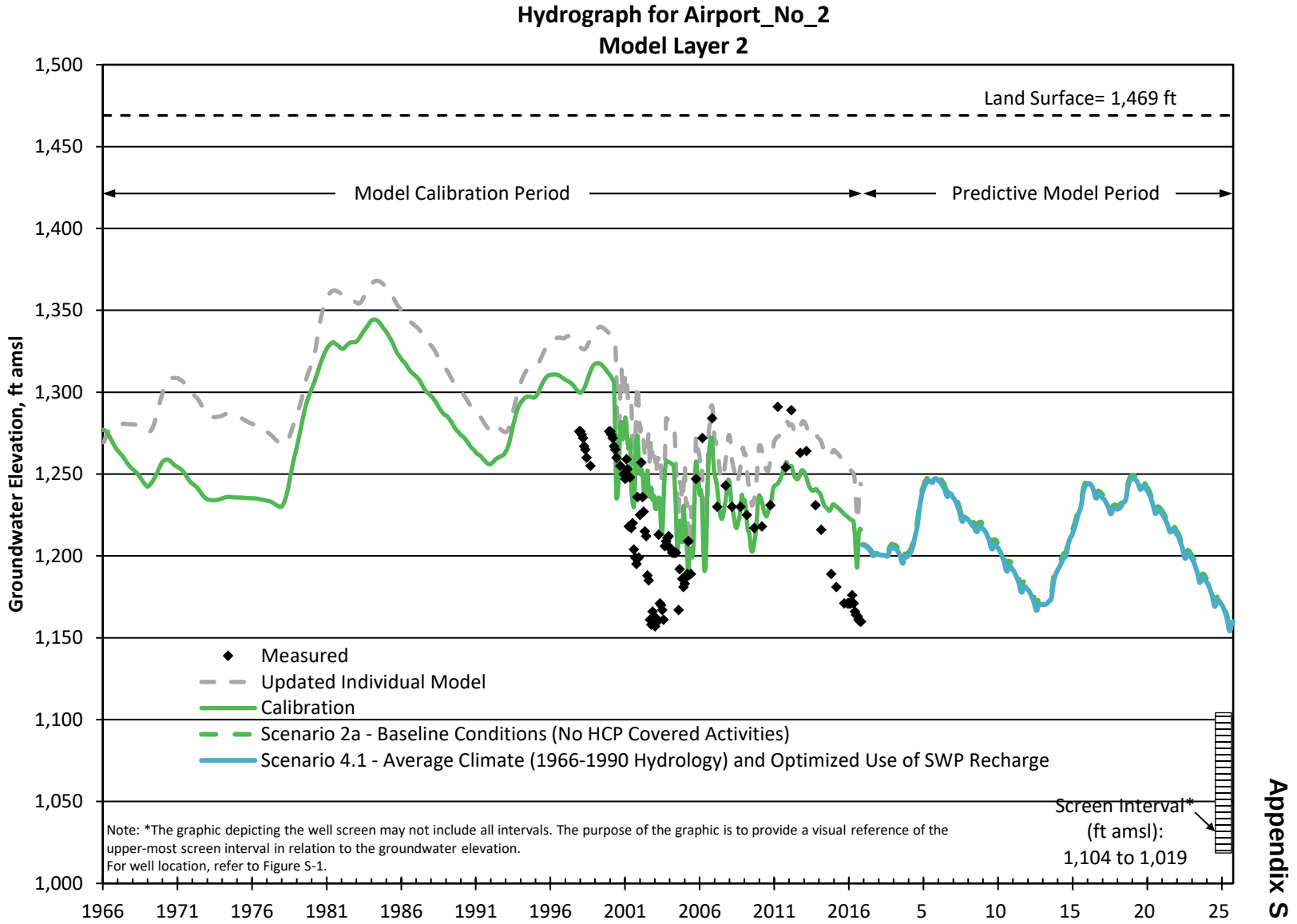
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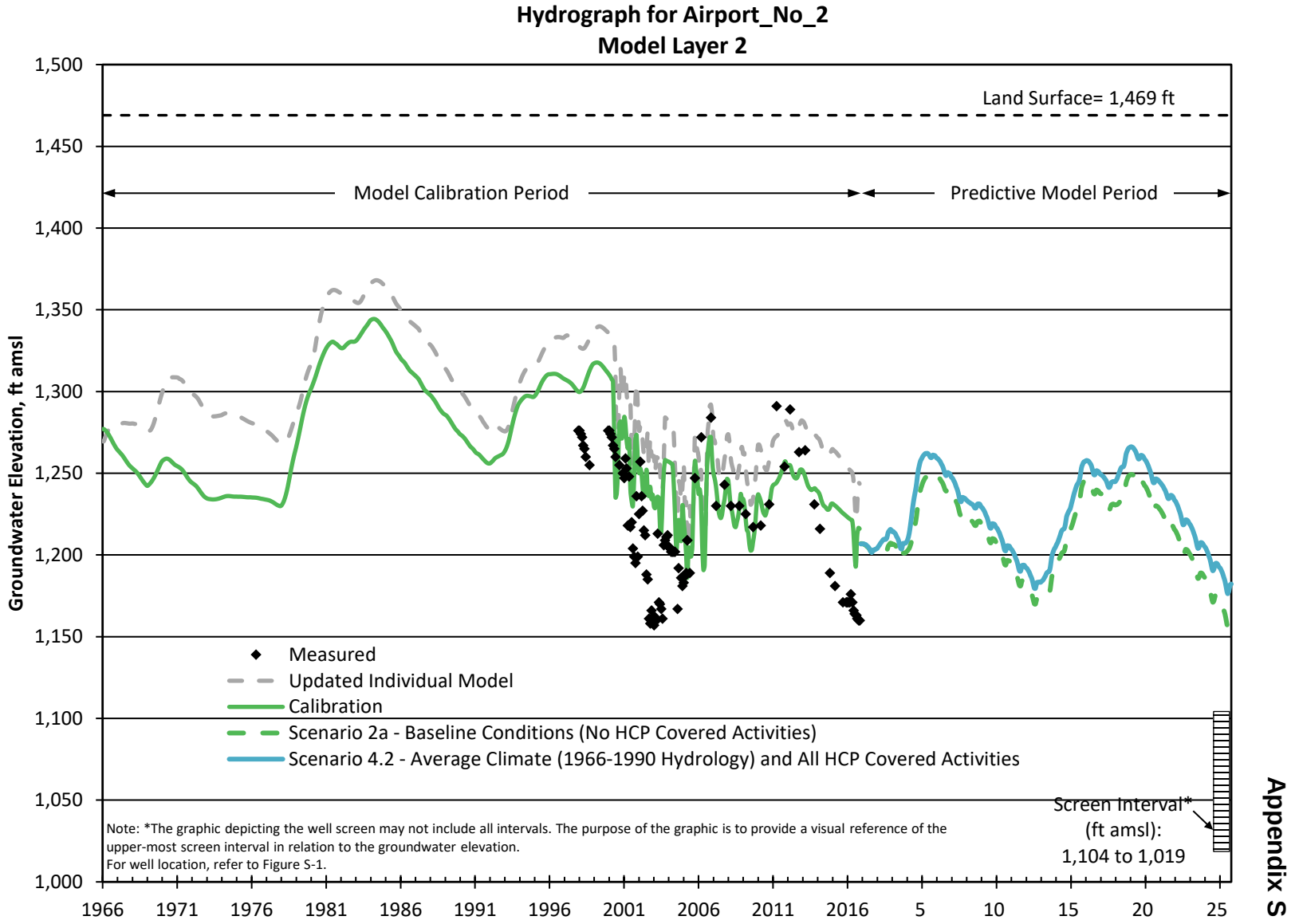

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
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1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2h.3 - 18.5 MGD RIX Discharge, Including 2.8 MGD Overextraction
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

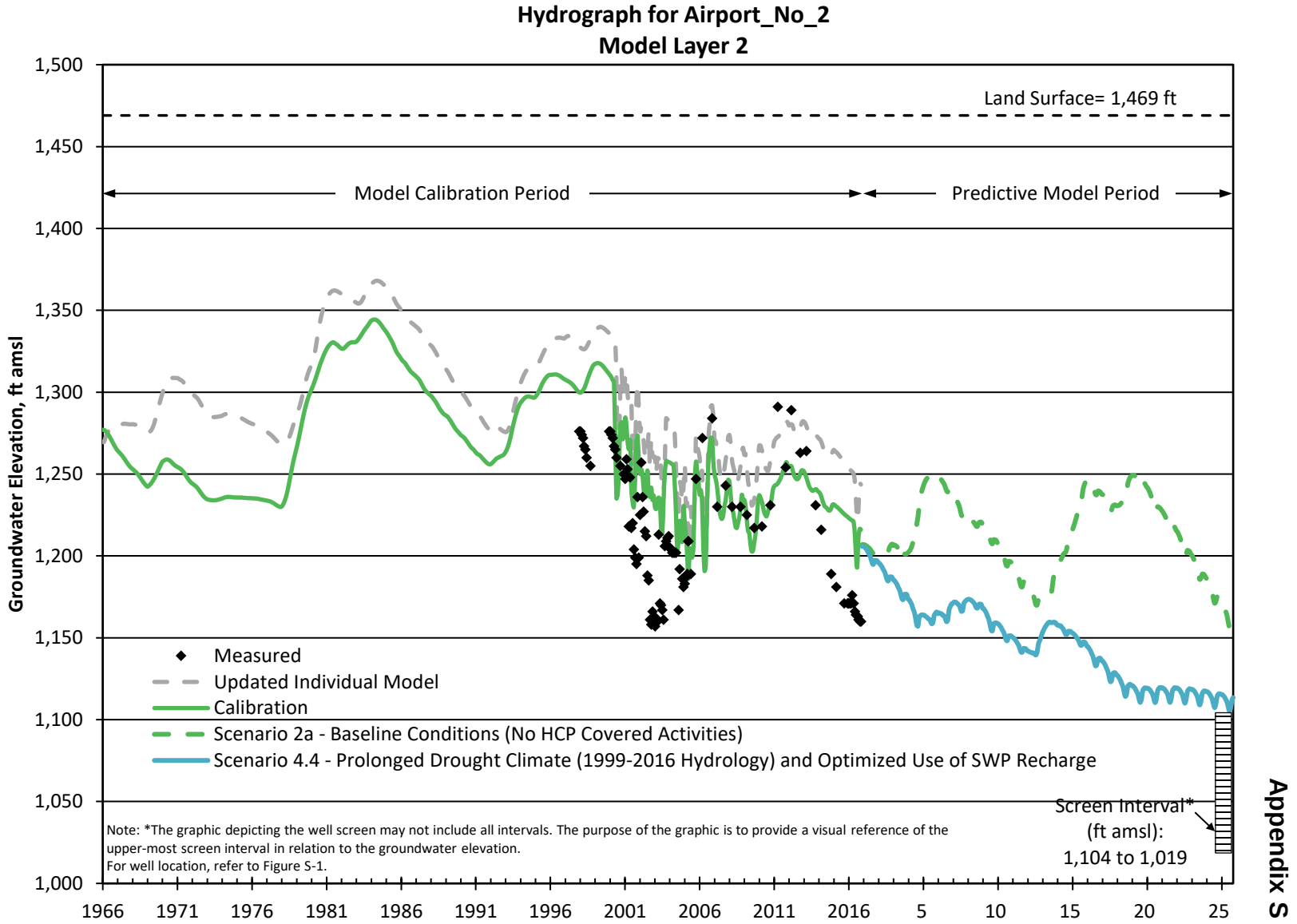
Appendix S


Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
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1,000
1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2h.4 - 18.5 MGD RIX Discharge, Including 6 MGD Overextraction
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

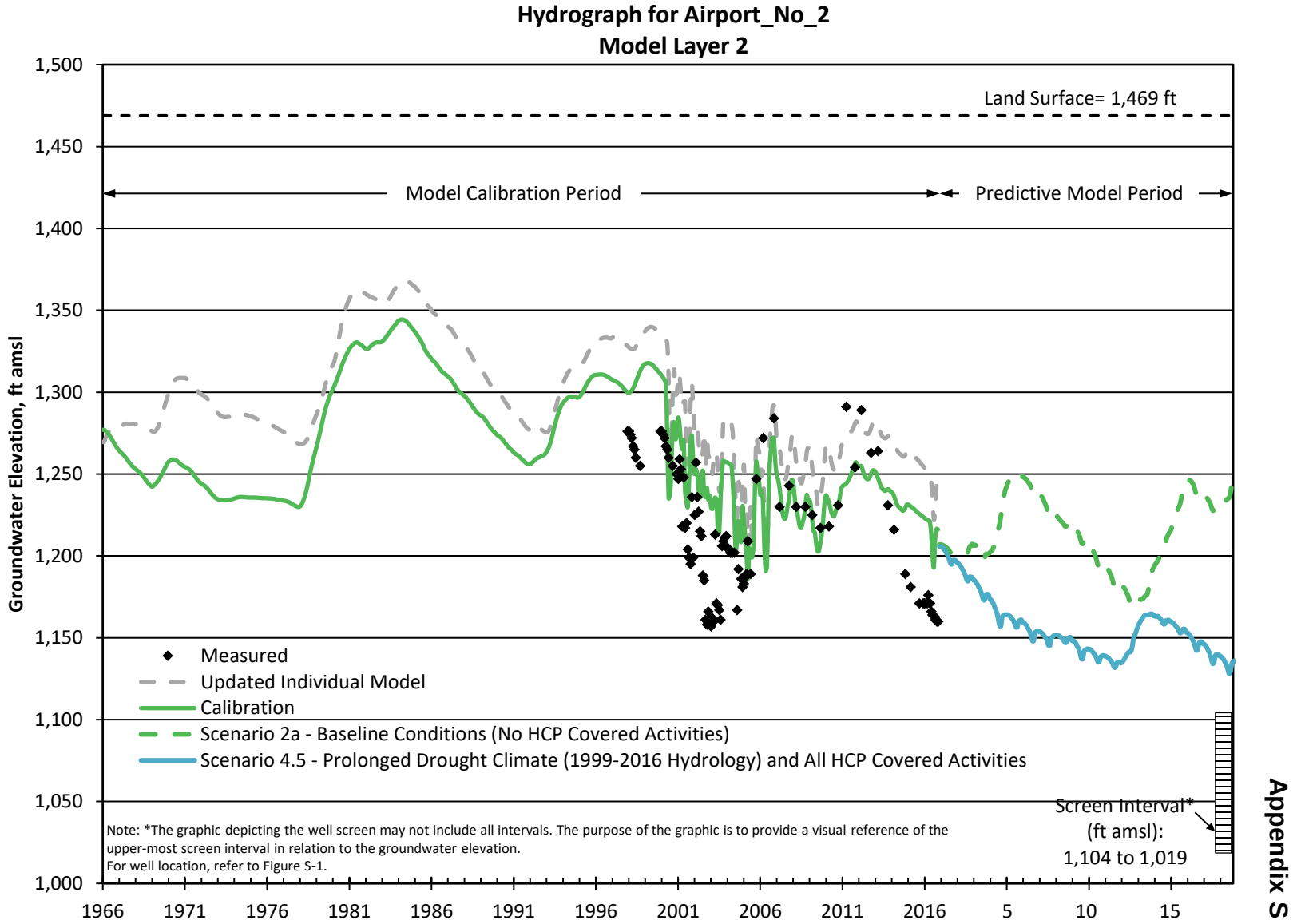
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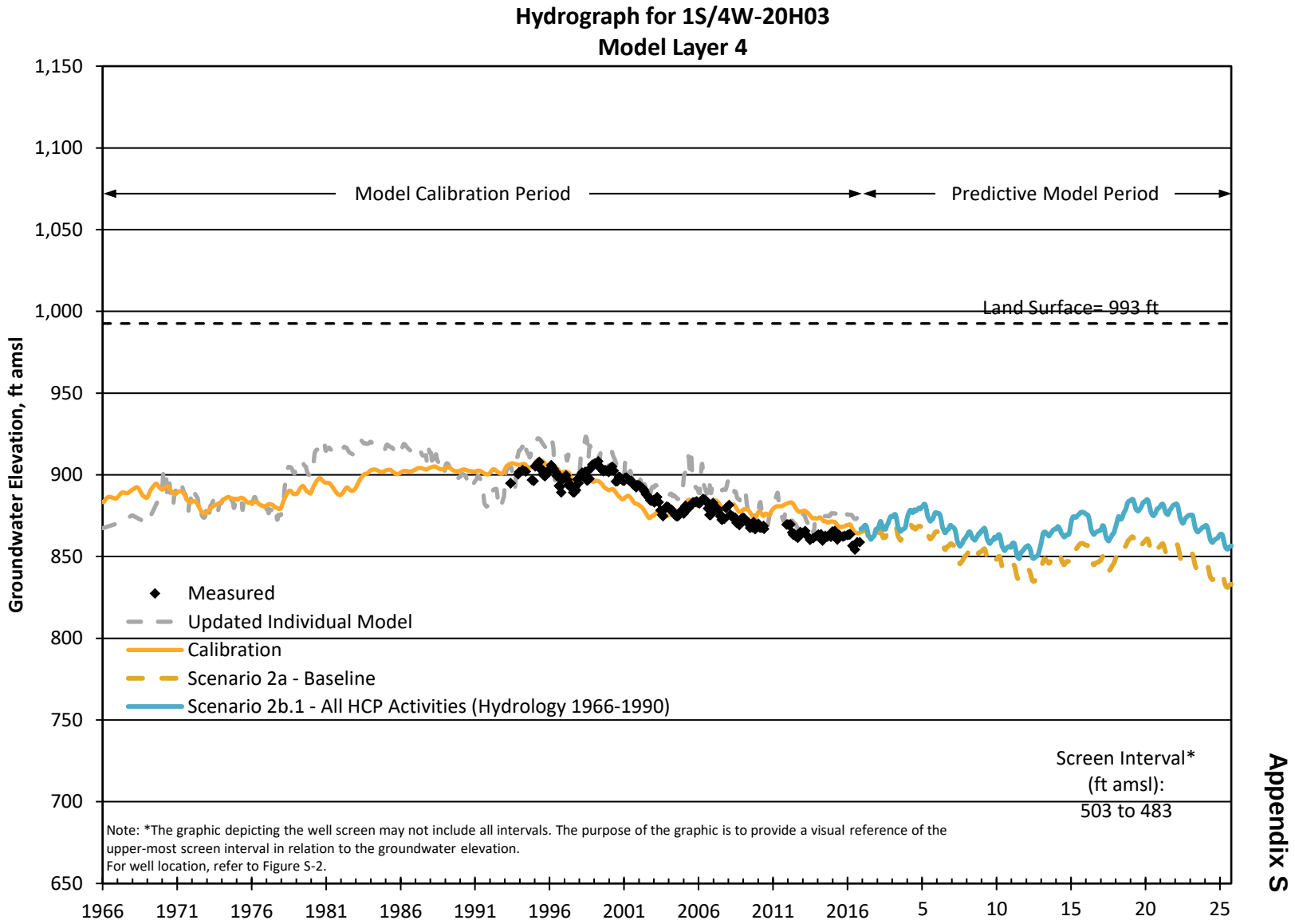

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.1 - Average Climate (1966-1990 Hydrology) and Optimized Use of SWP Recharge
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.
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Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.2 - Average Climate (1966-1990 Hydrology) and All HCP Covered Activities
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.
Appendix S

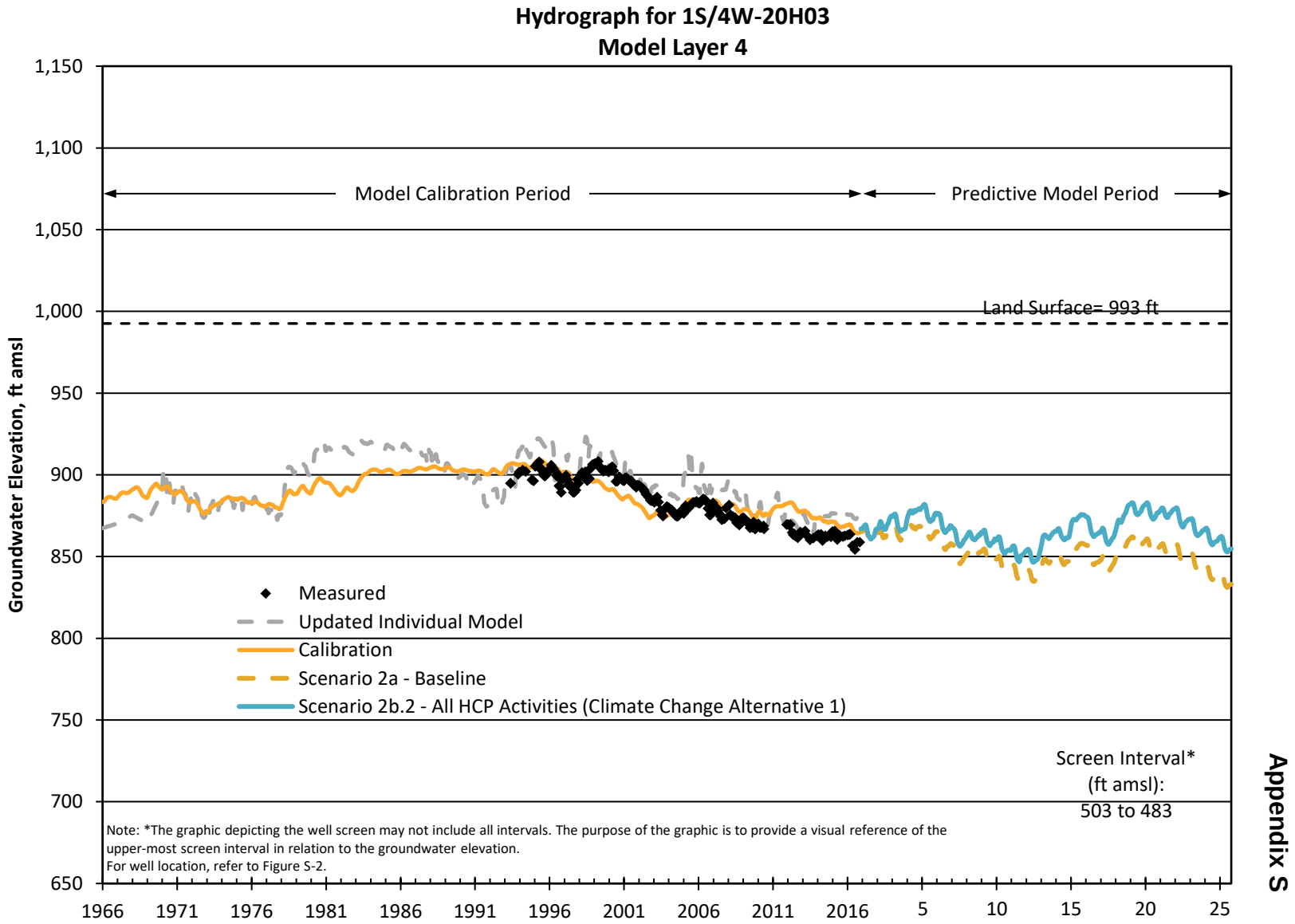

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
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2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.4 - Prolonged Drought Climate (1999-2016 Hydrology) and Optimized Use of SWP Recharge
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.

Appendix S

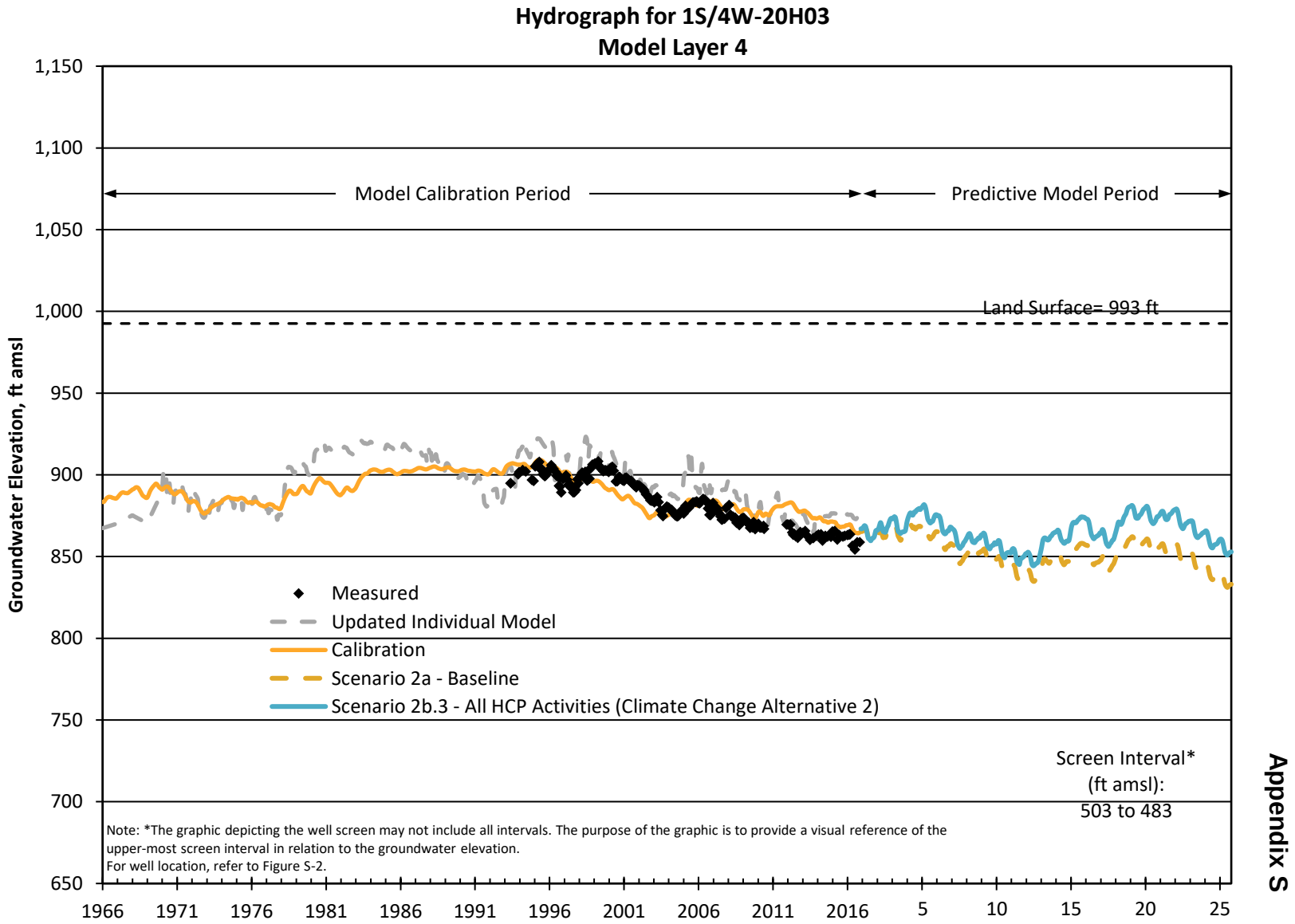

Hydrograph for Airport_No_2
Model Layer 2
Land Surface= 1,469 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.5 - Prolonged Drought Climate (1999-2016 Hydrology) and All HCP Covered Activities
Screen Interval*
(ft amsl):
1,104 to 1,019
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-1.
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2b.1 - All HCP Activities (Hydrology 1966-1990)
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25

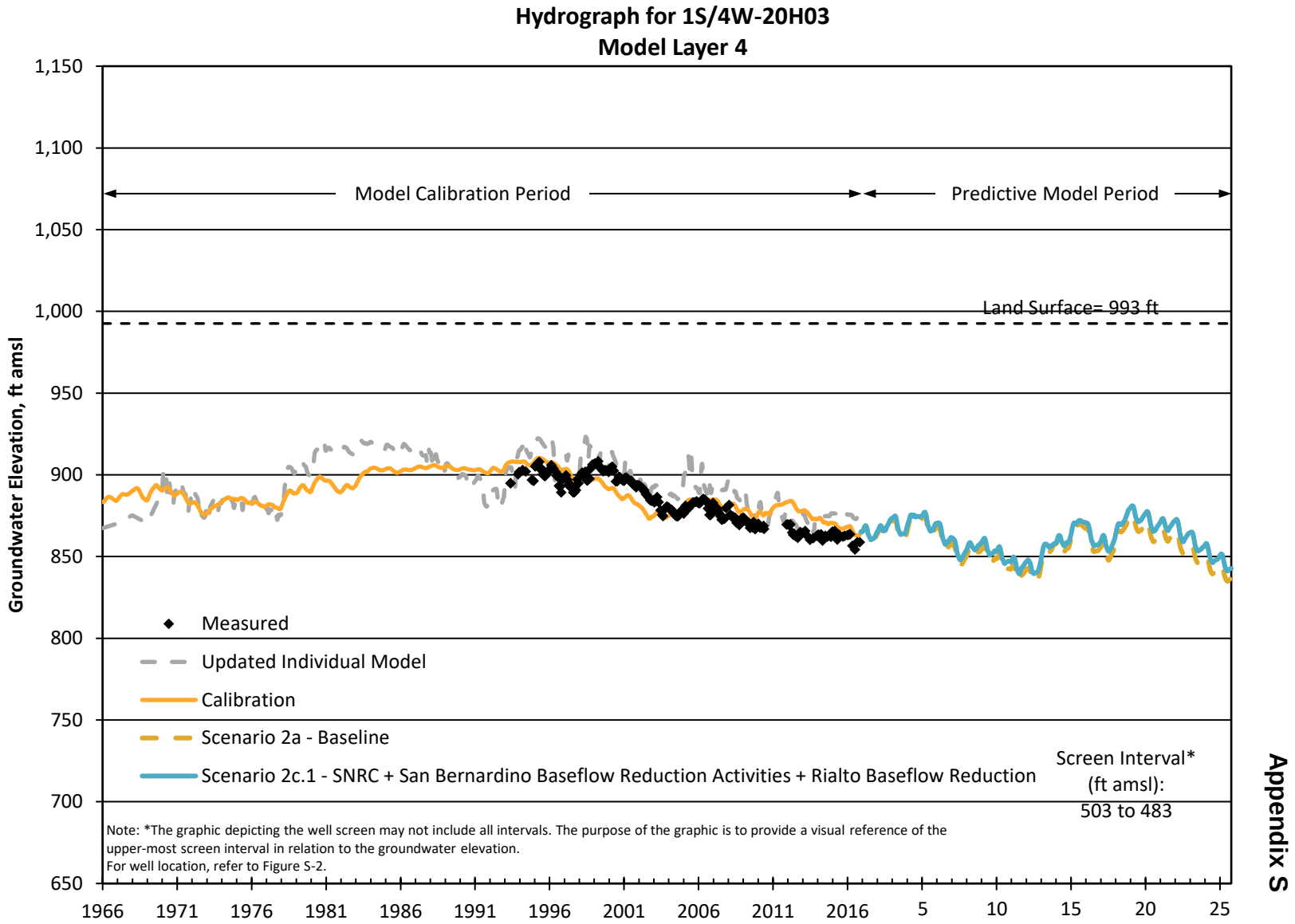
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2b.2 - All HCP Activities (Climate Change Alternative 1)
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
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2006
2011
2016
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15
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25

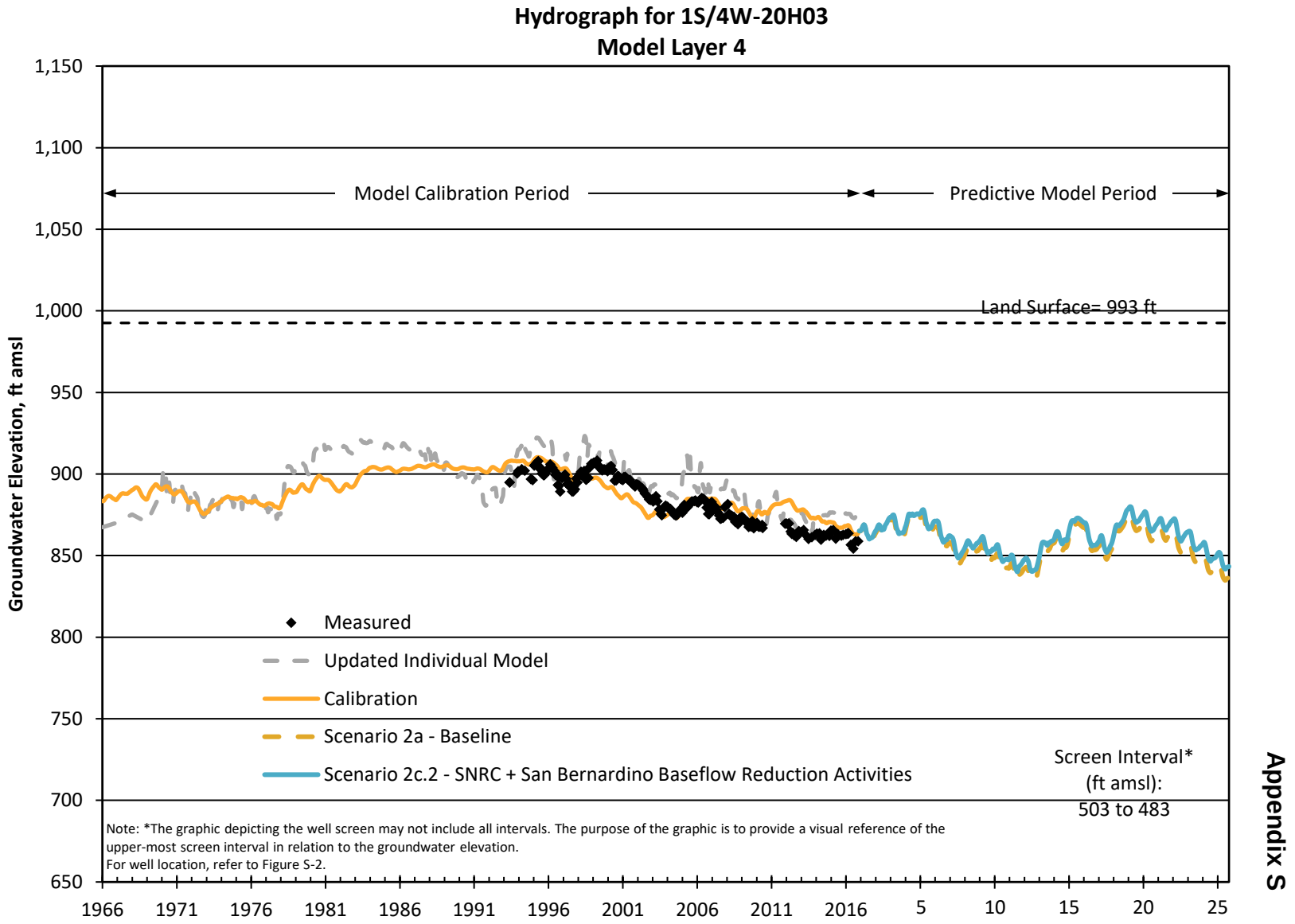
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2b.3 - All HCP Activities (Climate Change Alternative 2)
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
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2016
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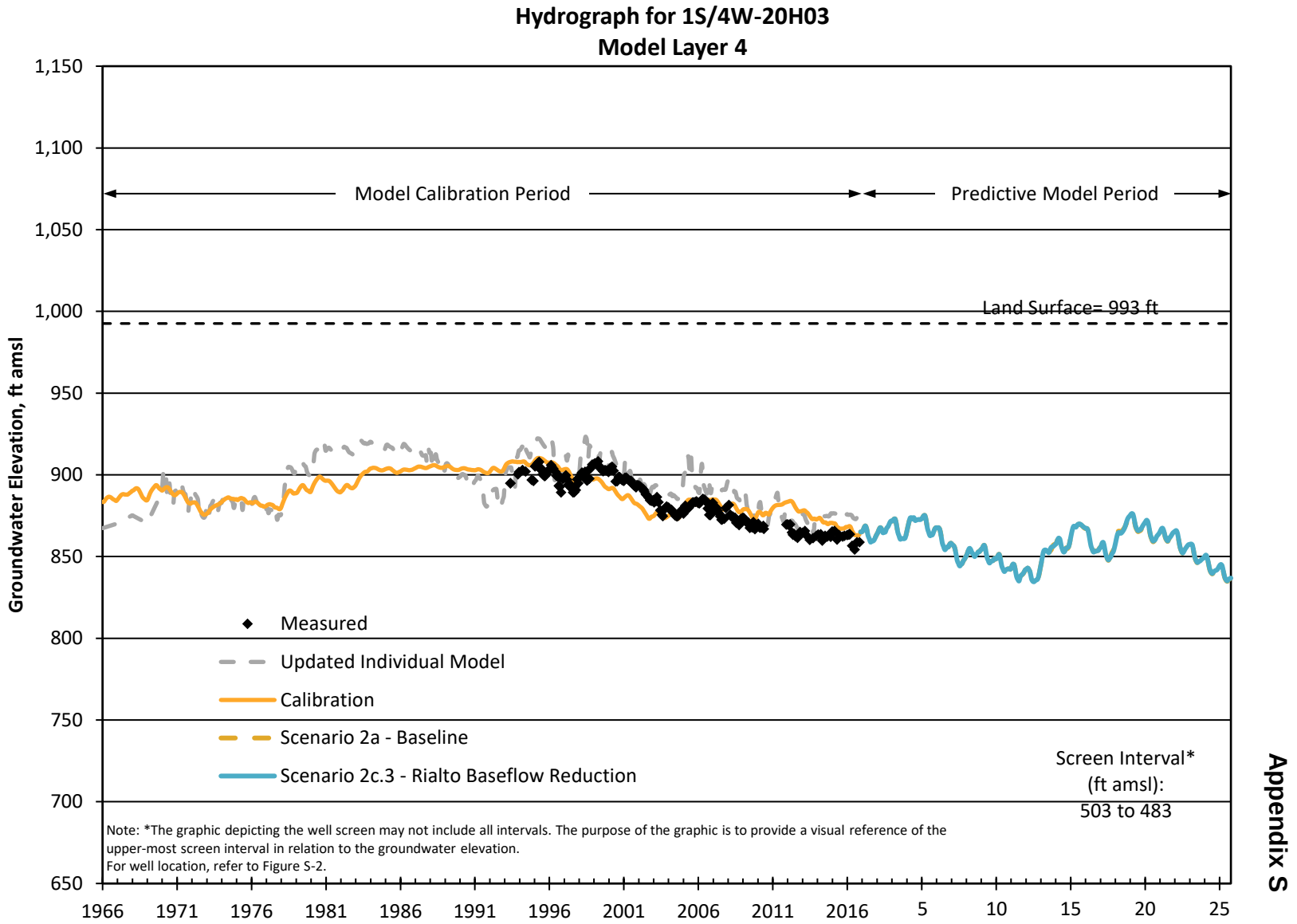
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2c.1 - SNRC + San Bernardino Baseflow Reduction Activities + Rialto Baseflow Reduction
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
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2006
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2016
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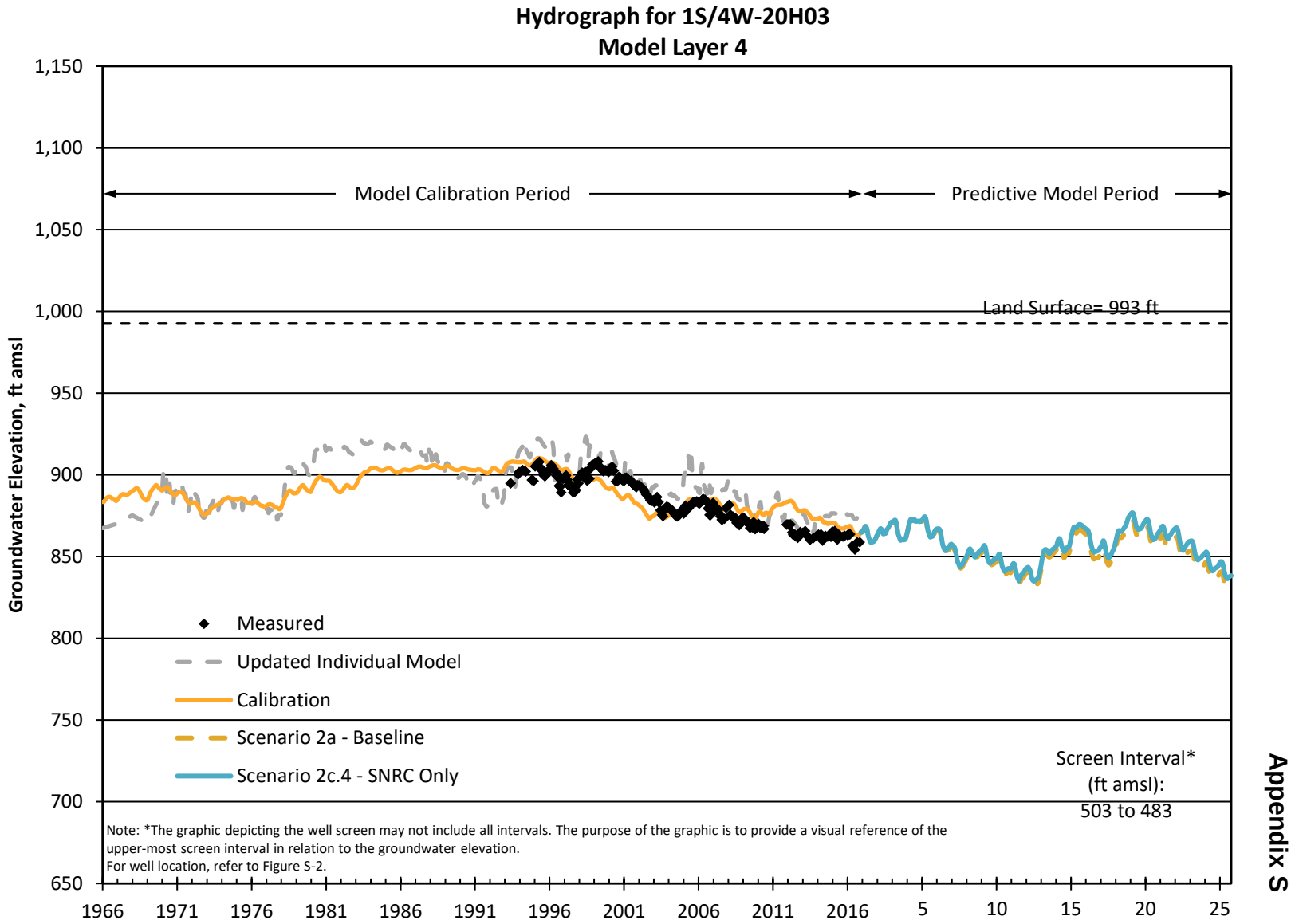
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2c.2 - SNRC + San Bernardino Baseflow Reduction Activities
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
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2016
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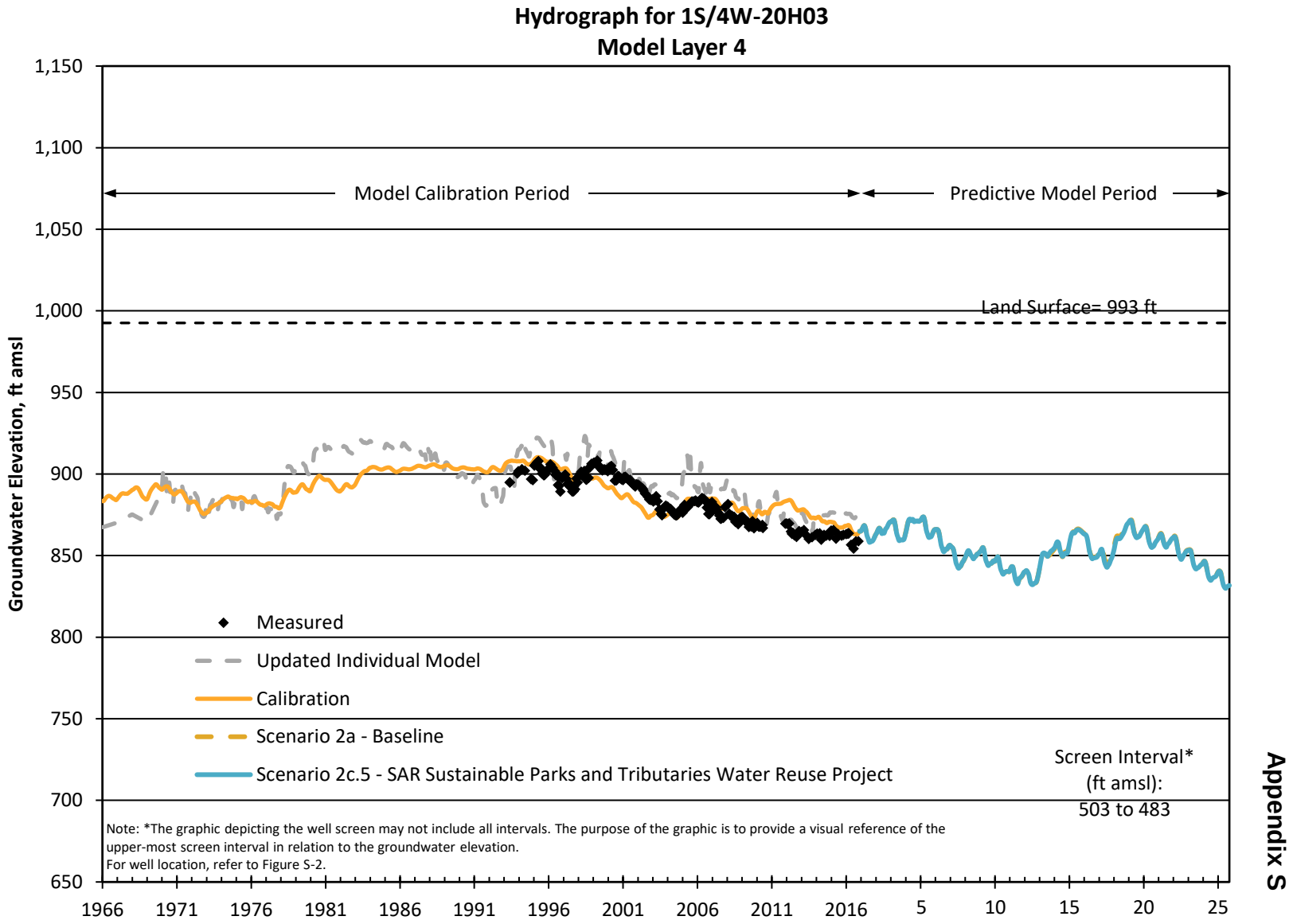
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2c.3 - Rialto Baseflow Reduction
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
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Appendix S

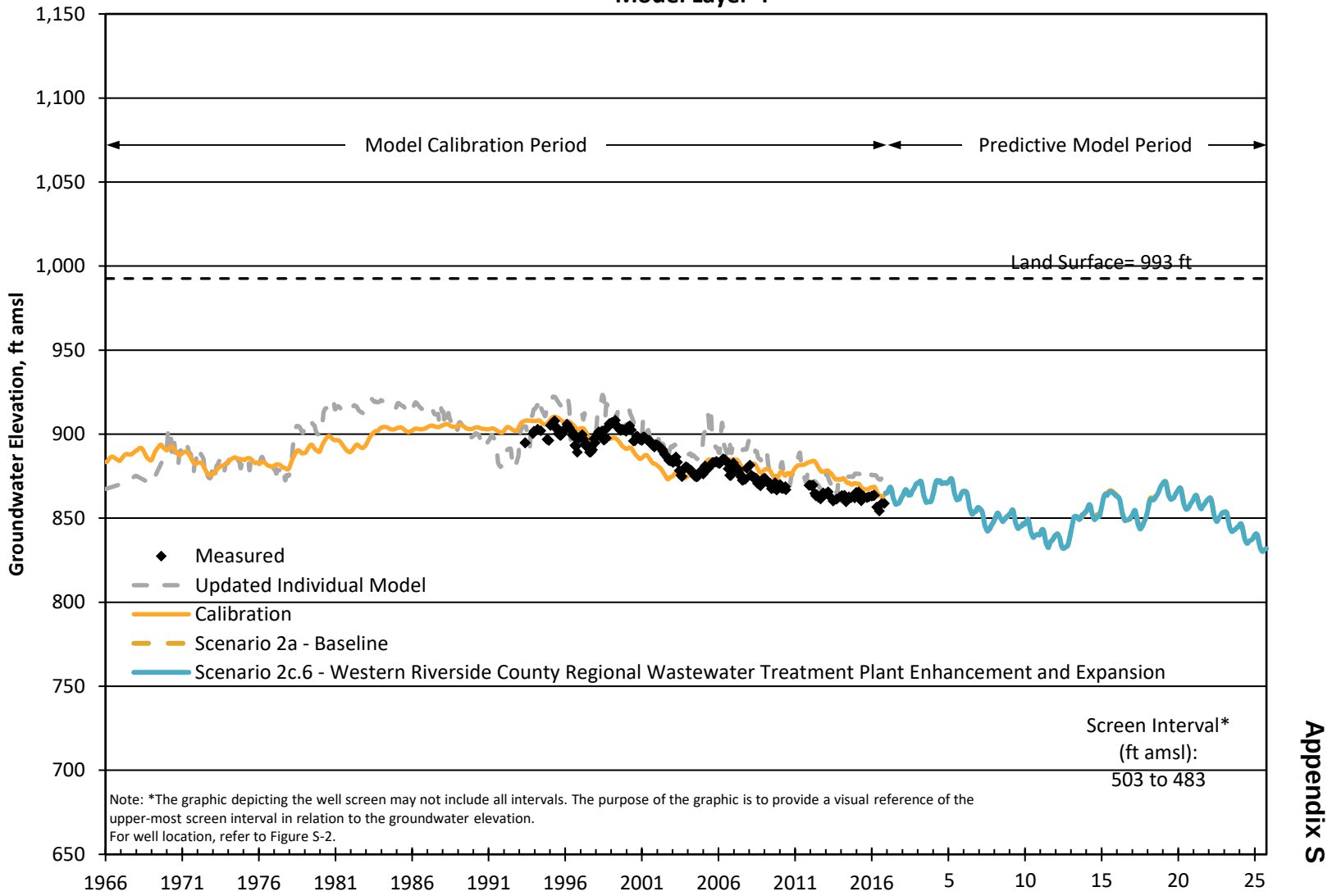

Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2c.4 - SNRC Only
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
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Appendix S

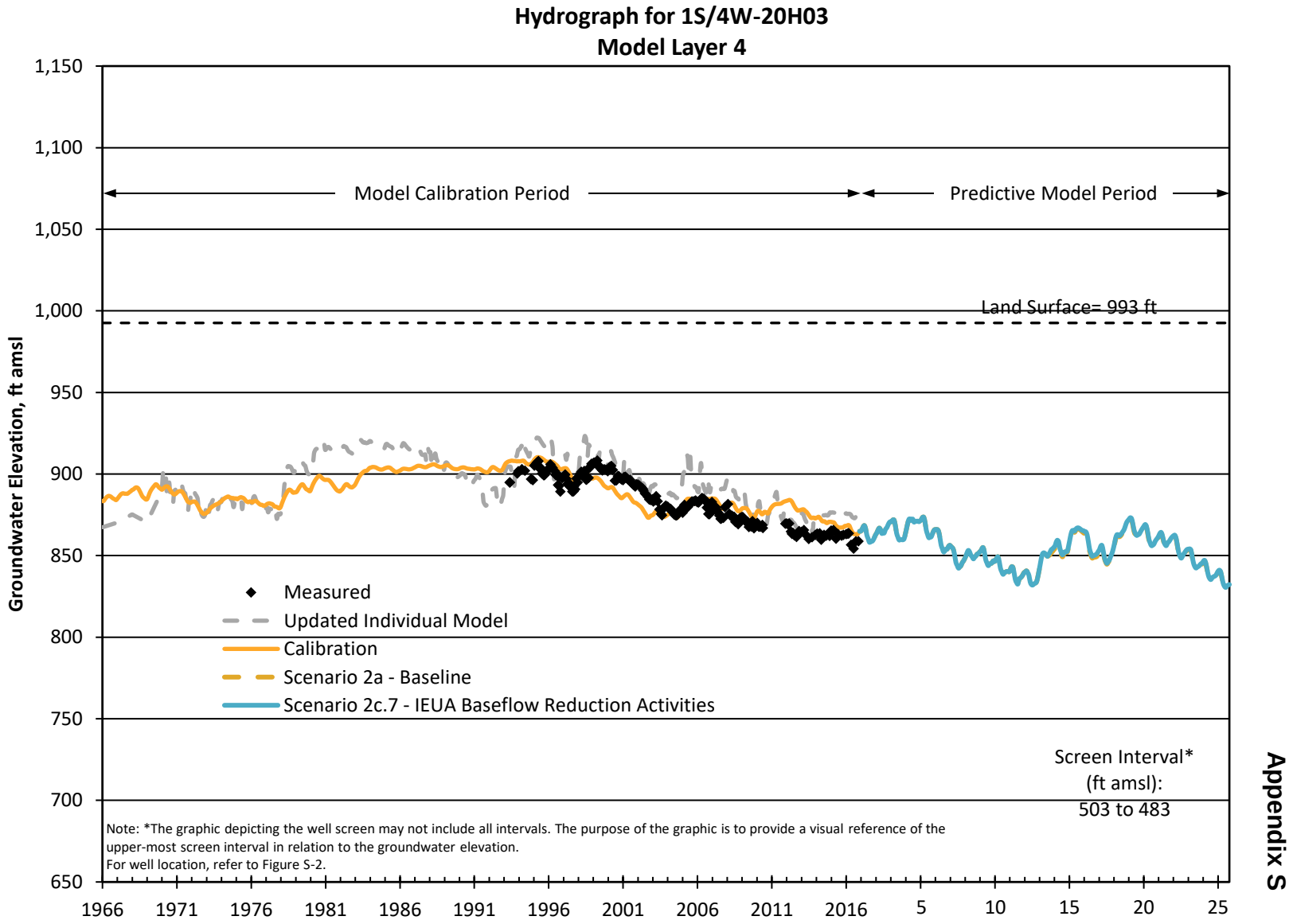

Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2c.5 - SAR Sustainable Parks and Tributaries Water Reuse Project
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
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2016
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Appendix S

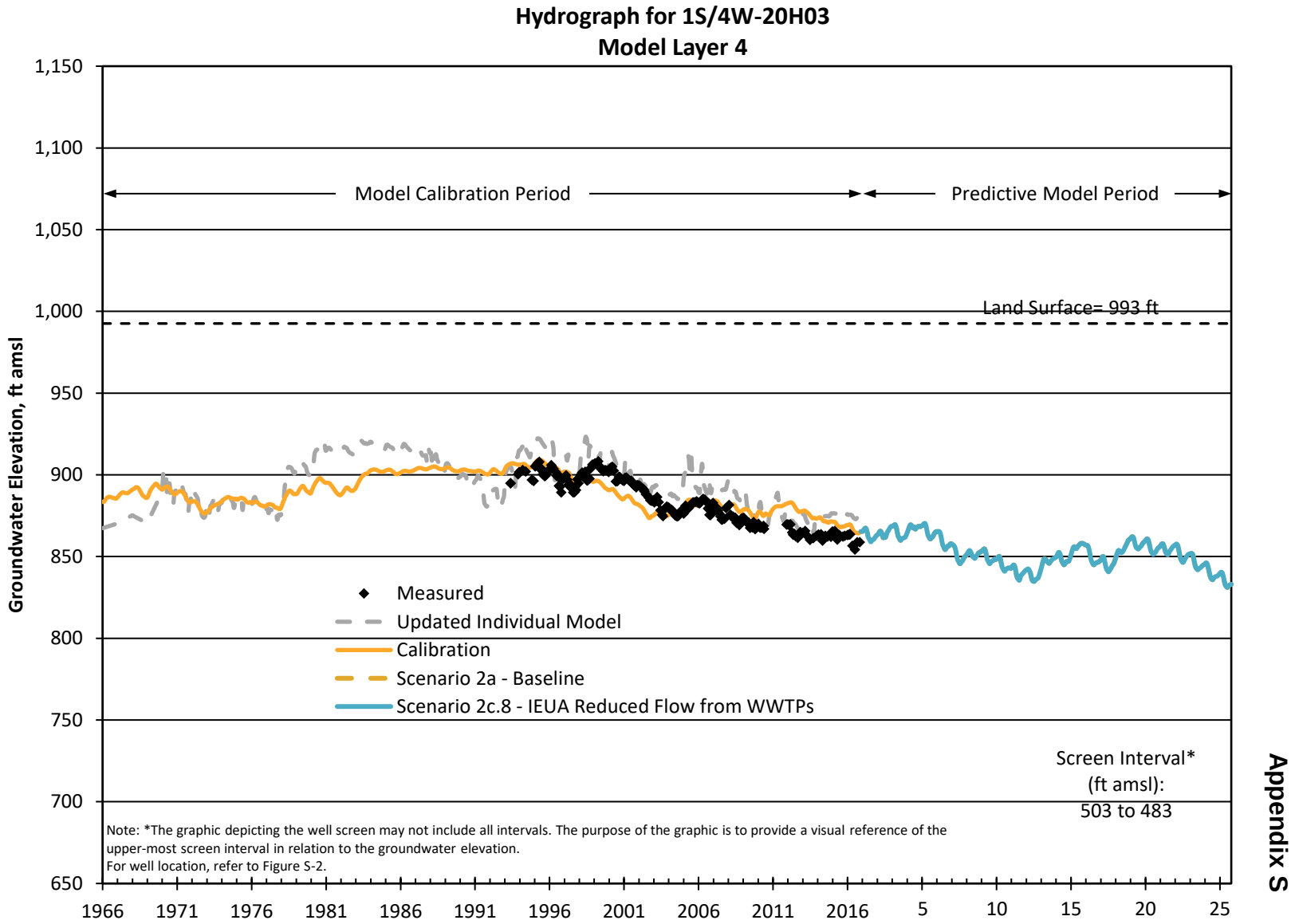
Hydrograph for 1S/4W-20H03
Model Layer 4



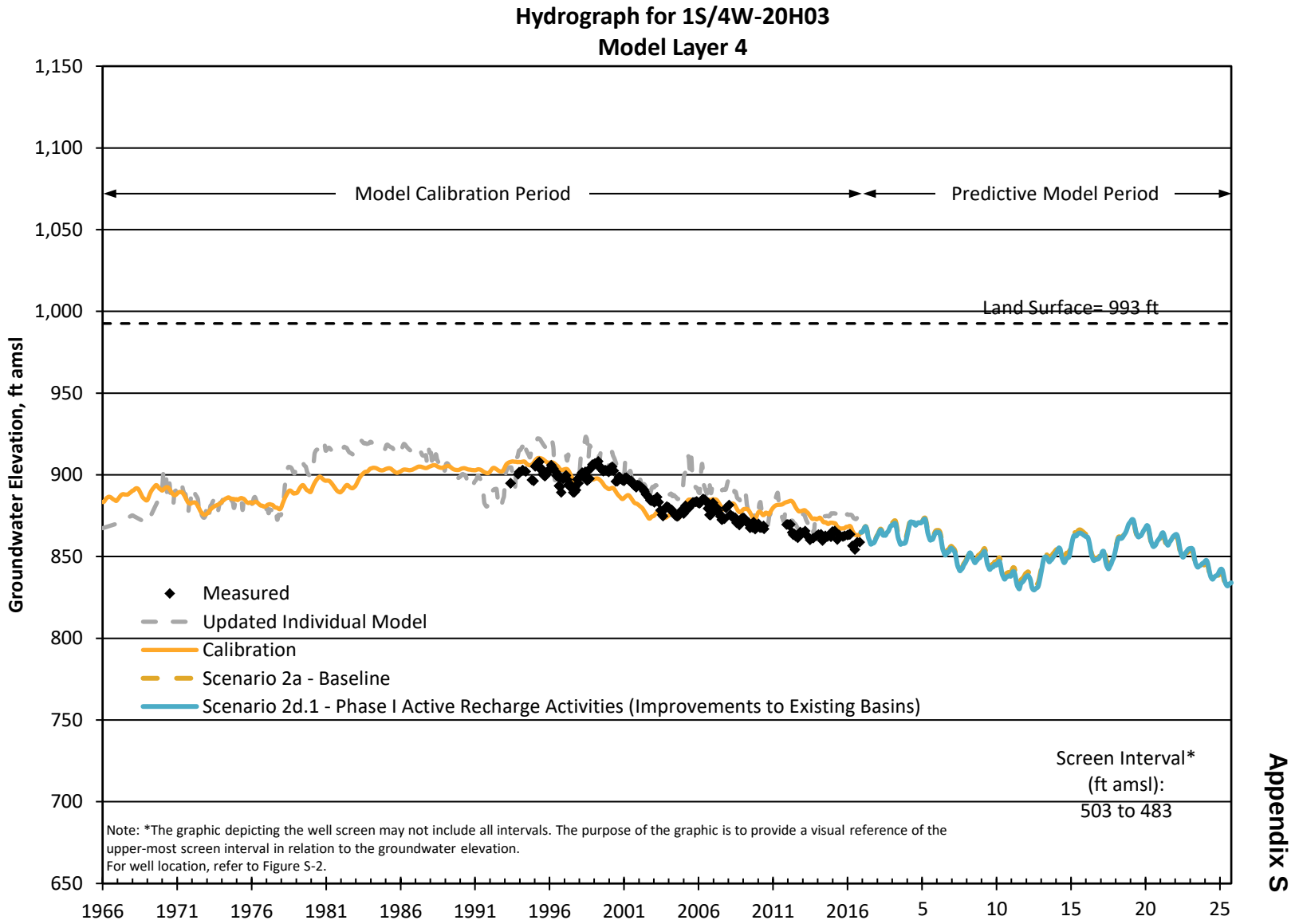
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2c.7 - IEUA Baseflow Reduction Activities
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
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2016
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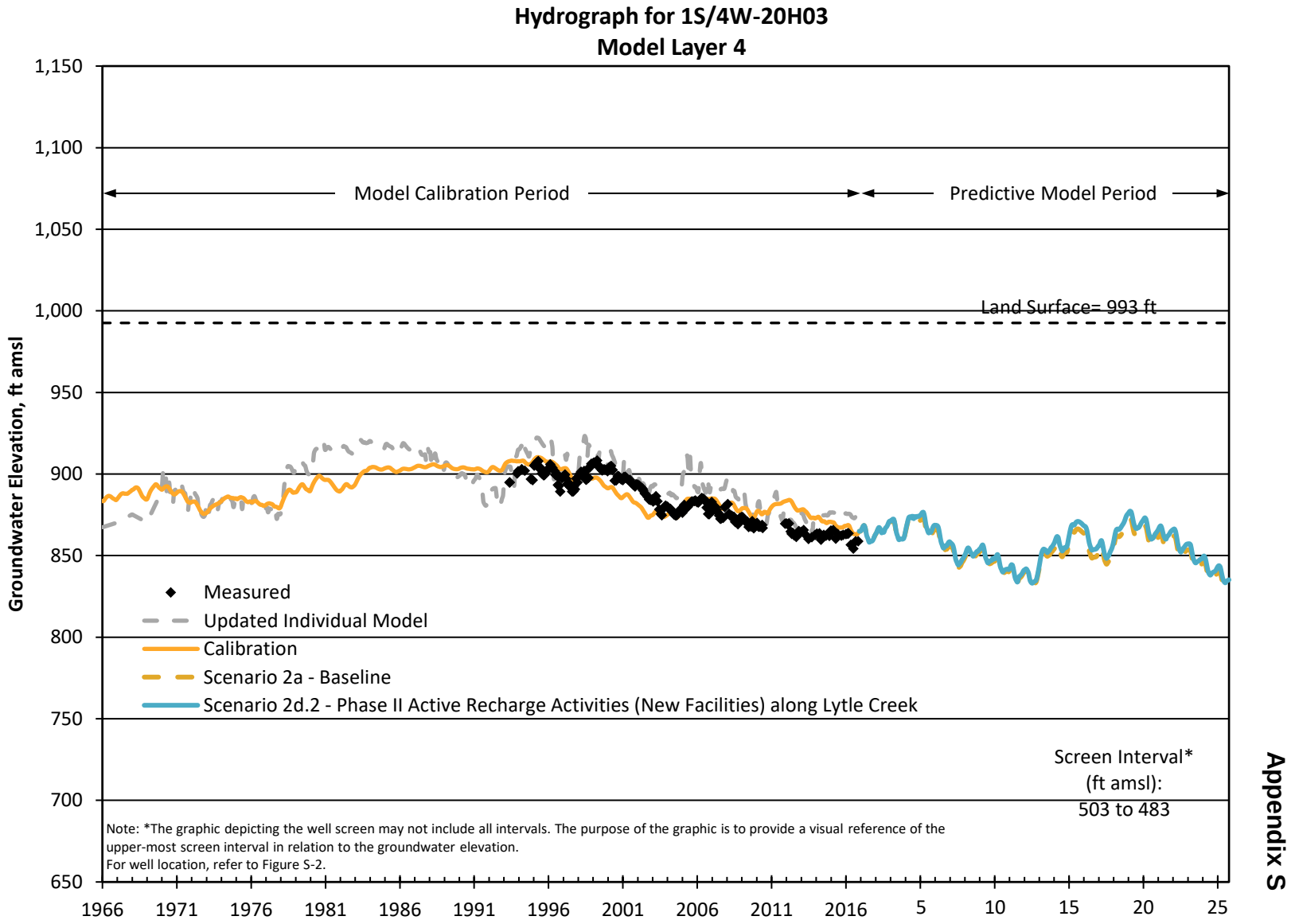
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2c.8 - IEUA Reduced Flow from WWTPs
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
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1986
1991
1996
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2016
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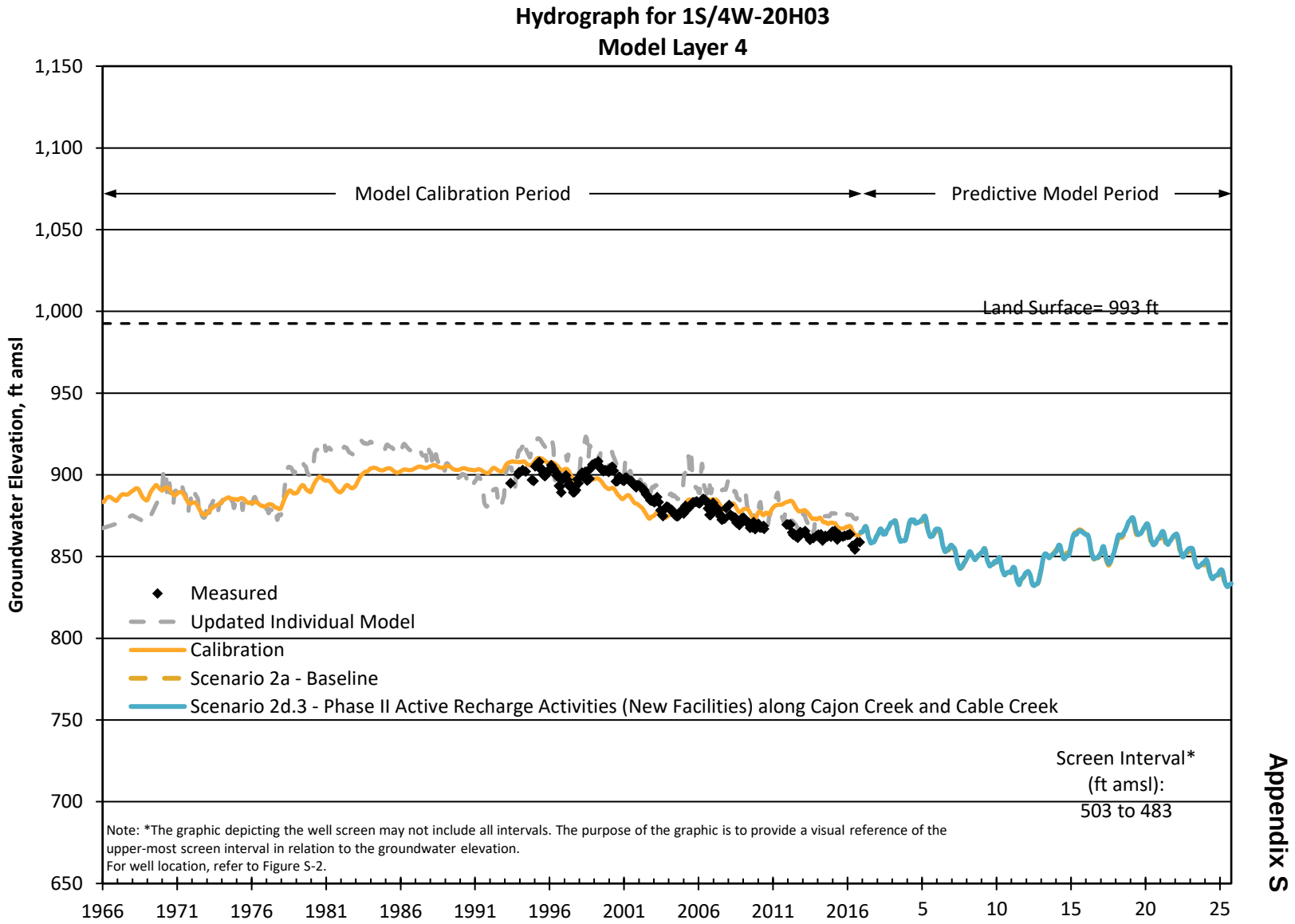
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2d.1 - Phase I Active Recharge Activities (Improvements to Existing Basins)
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25

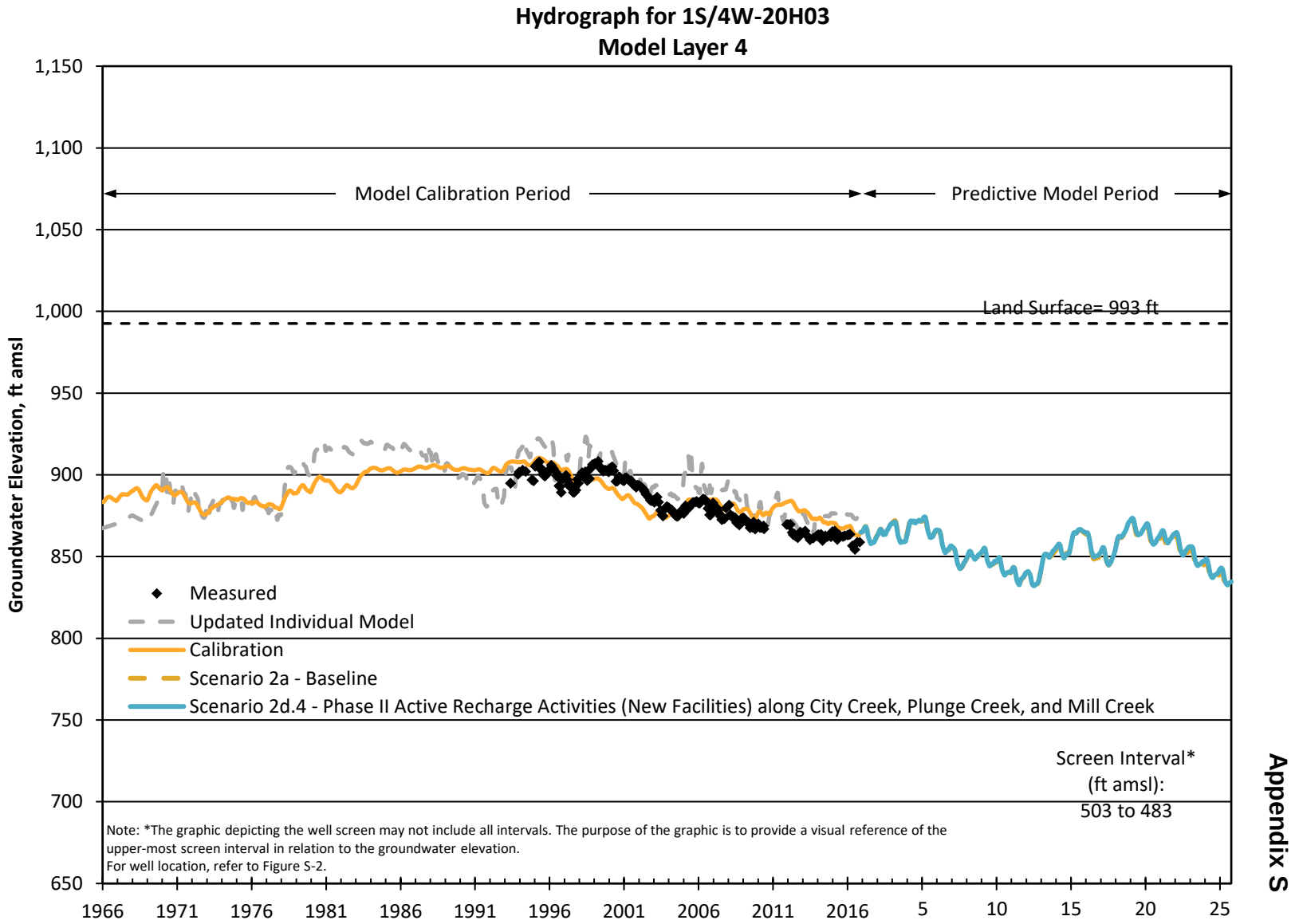
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2d.2 - Phase II Active Recharge Activities (New Facilities) along Lytle Creek
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
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10
15
20
25

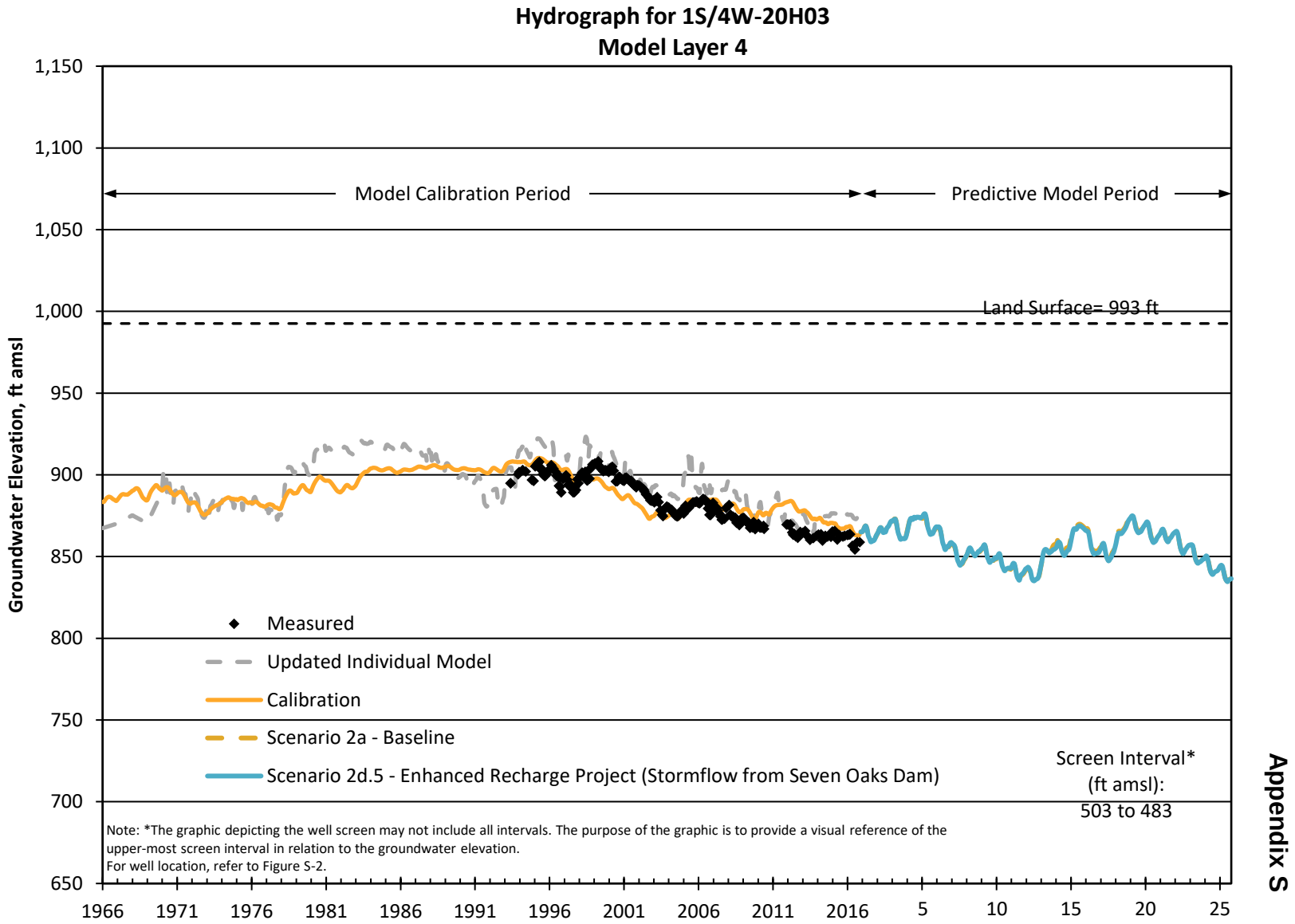
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2d.3 - Phase II Active Recharge Activities (New Facilities) along Cajon Creek and Cable Creek
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25

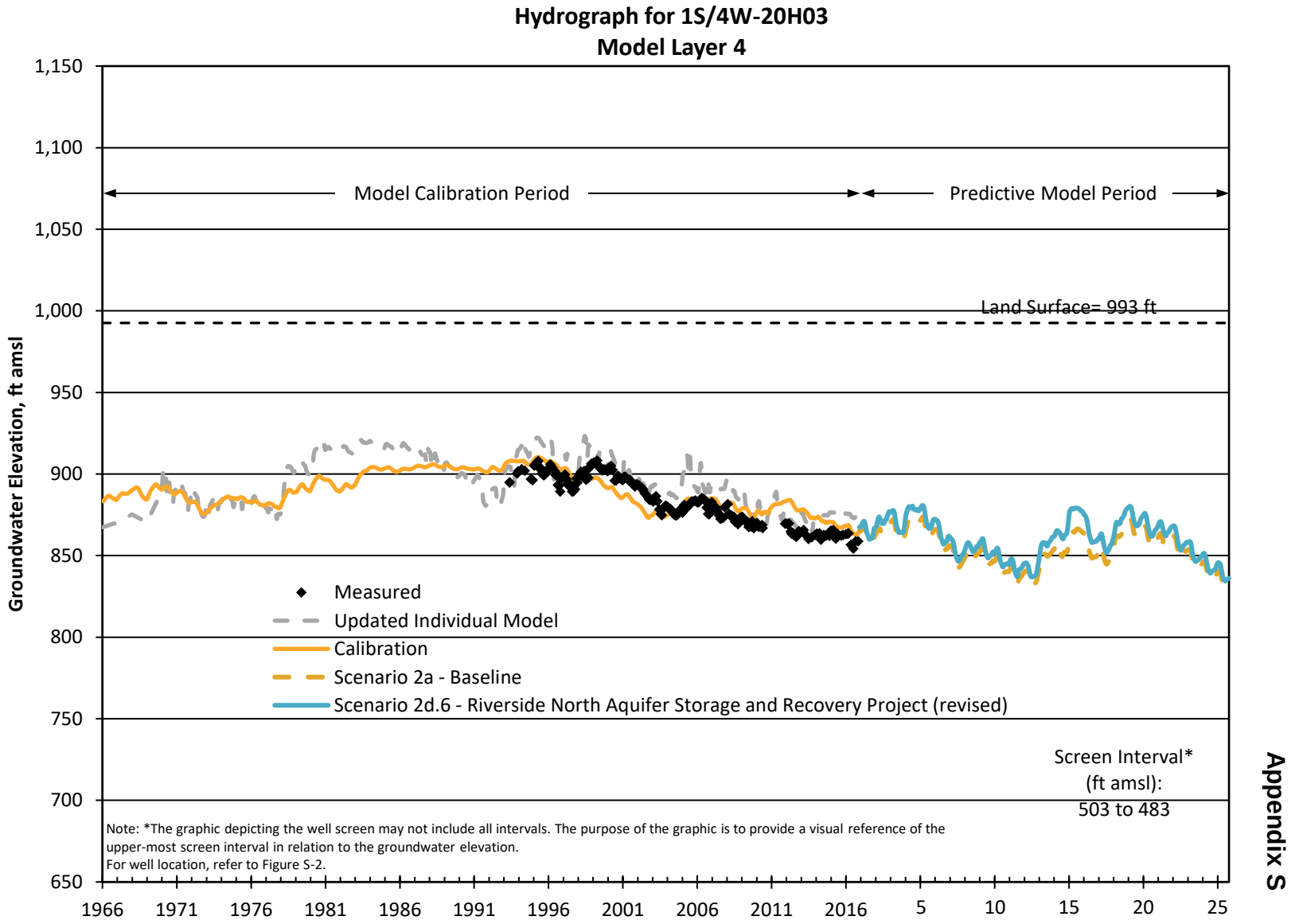
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2d.4 - Phase II Active Recharge Activities (New Facilities) along City Creek, Plunge Creek, and Mill Creek
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
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2006
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2016
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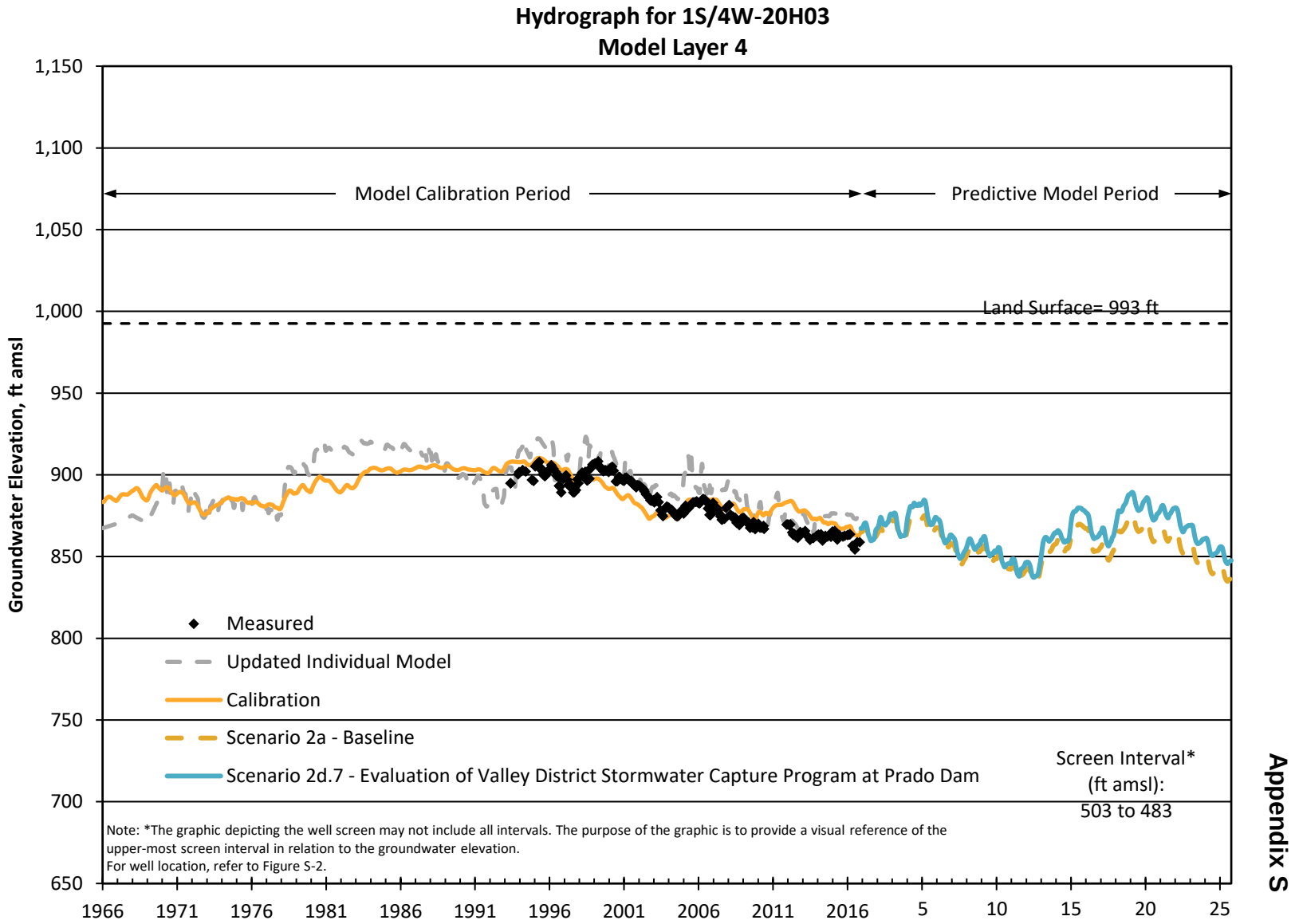
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2d.5 - Enhanced Recharge Project (Stormflow from Seven Oaks Dam)
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
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1996
2001
2006
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2016
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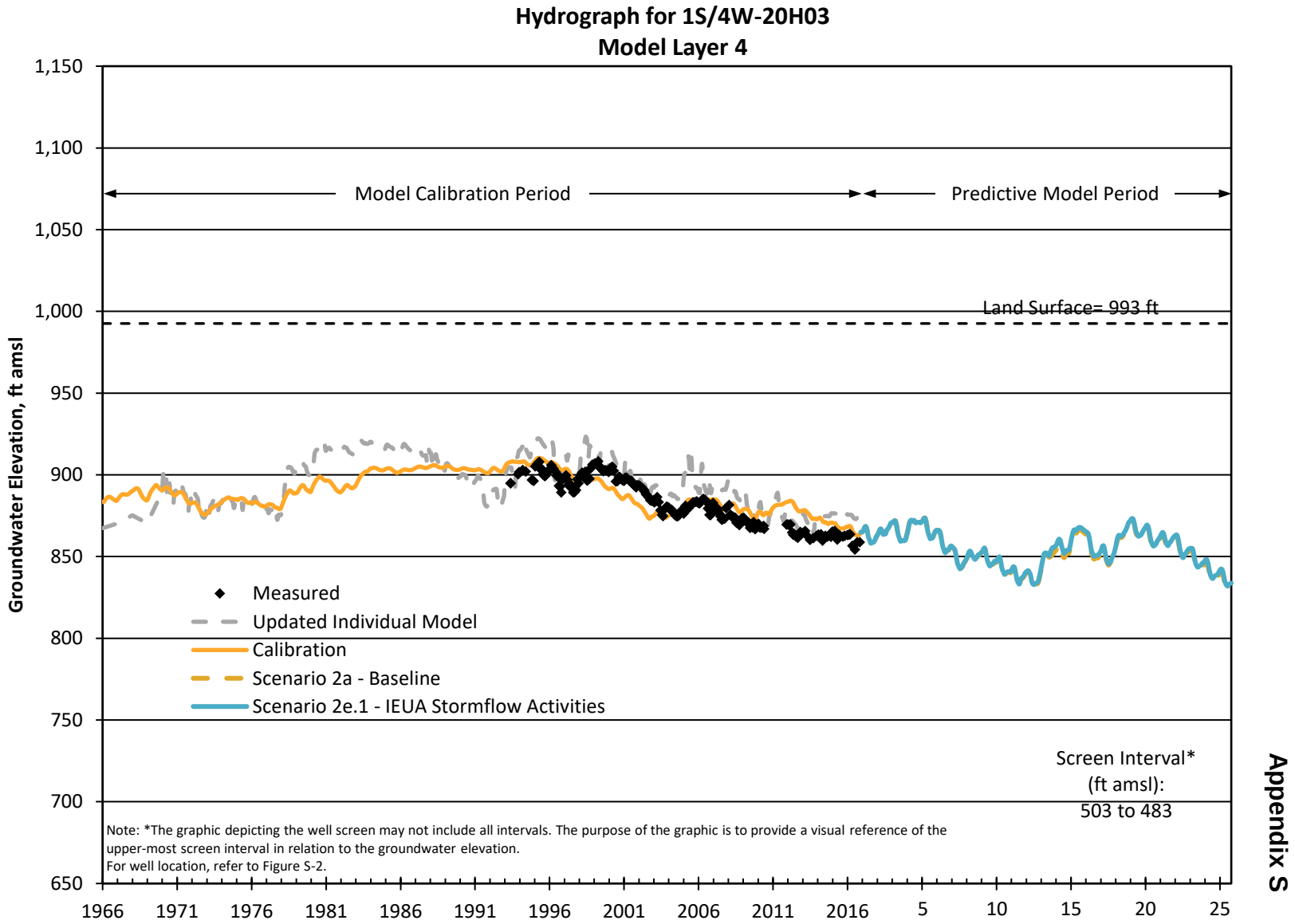
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2d.6 - Riverside North Aquifer Storage and Recovery Project (revised)
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
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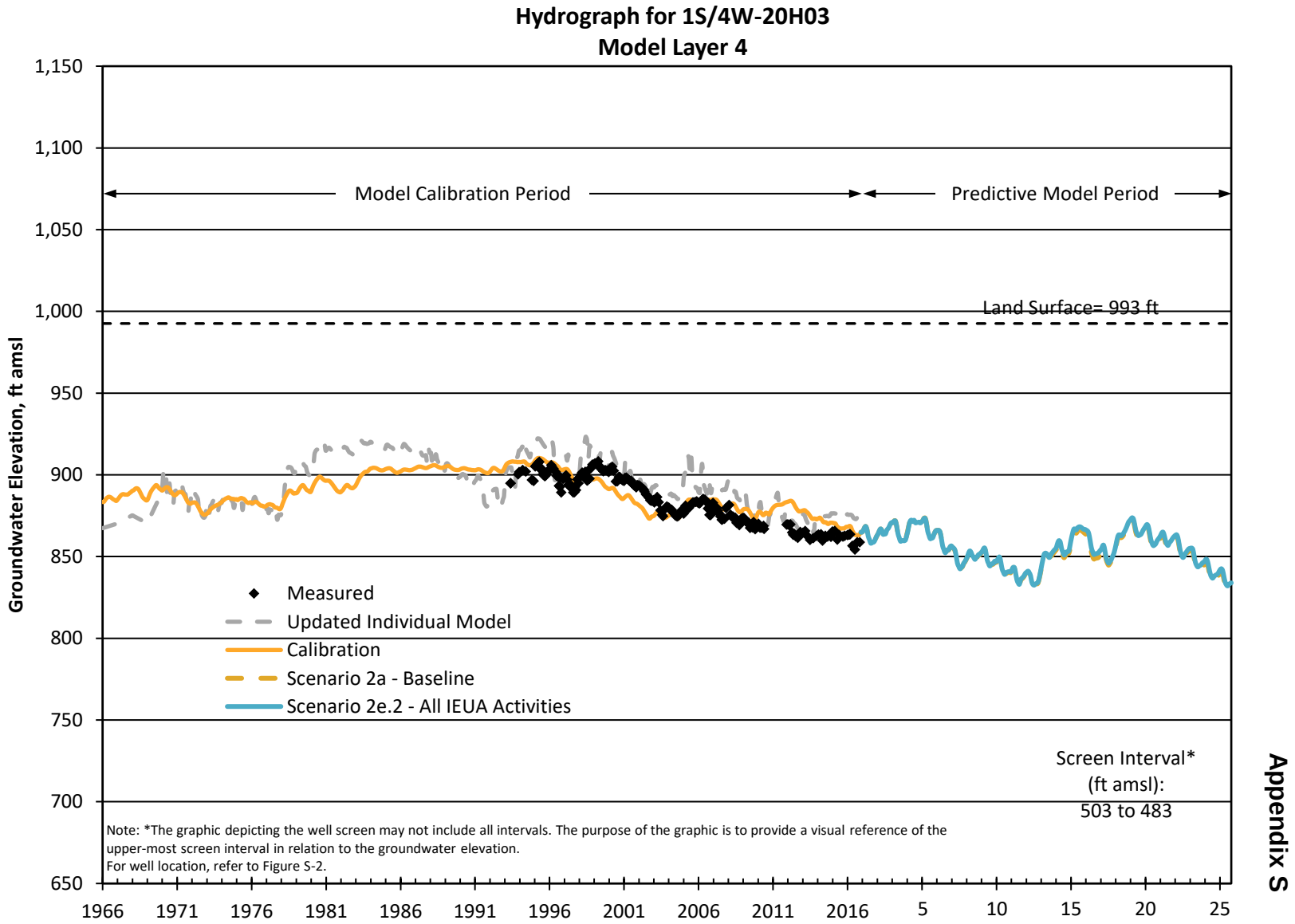
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2d.7 - Evaluation of Valley District Stormwater Capture Program at Prado Dam
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
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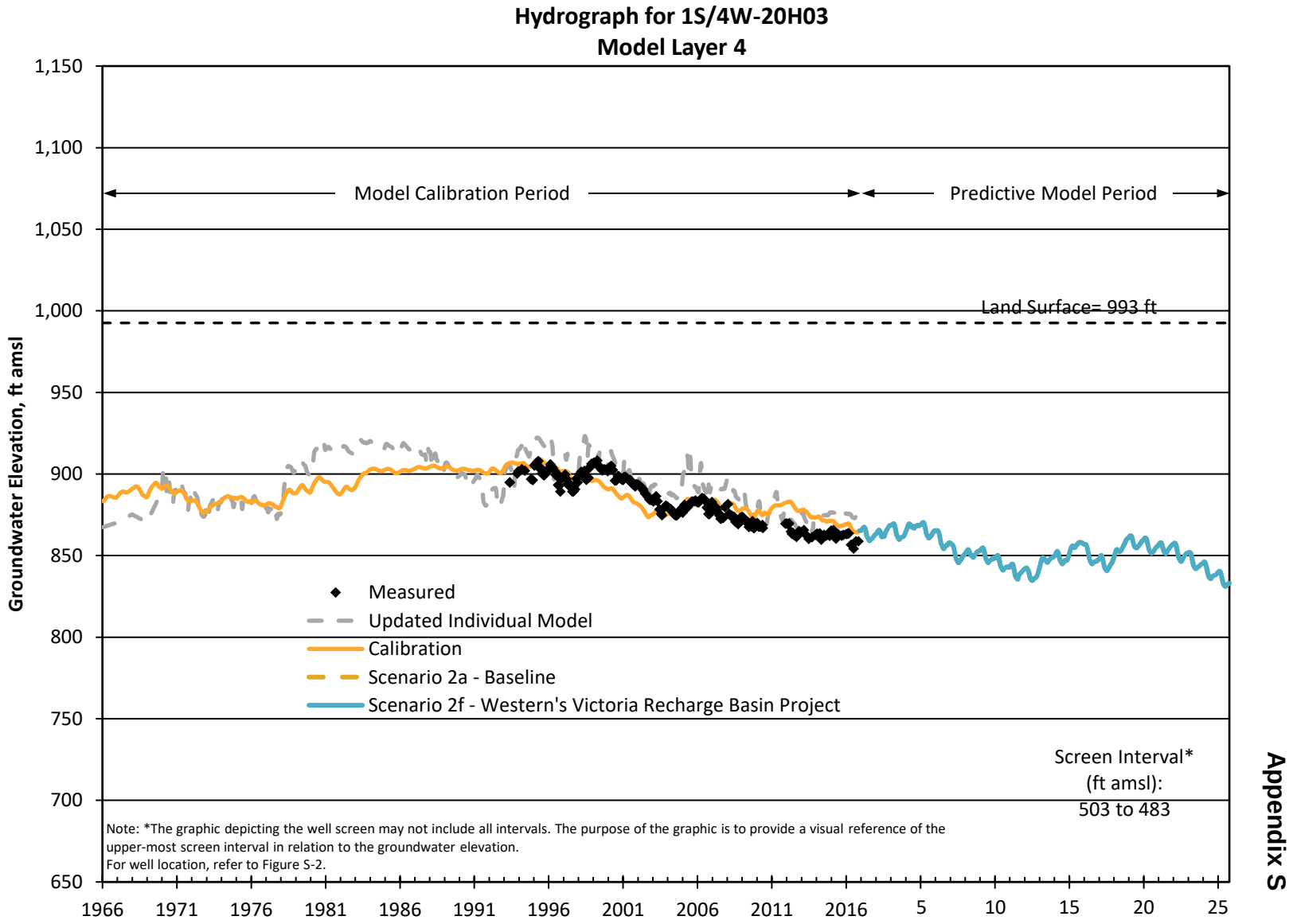
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2e.1 - IEUA Stormflow Activities
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
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2016
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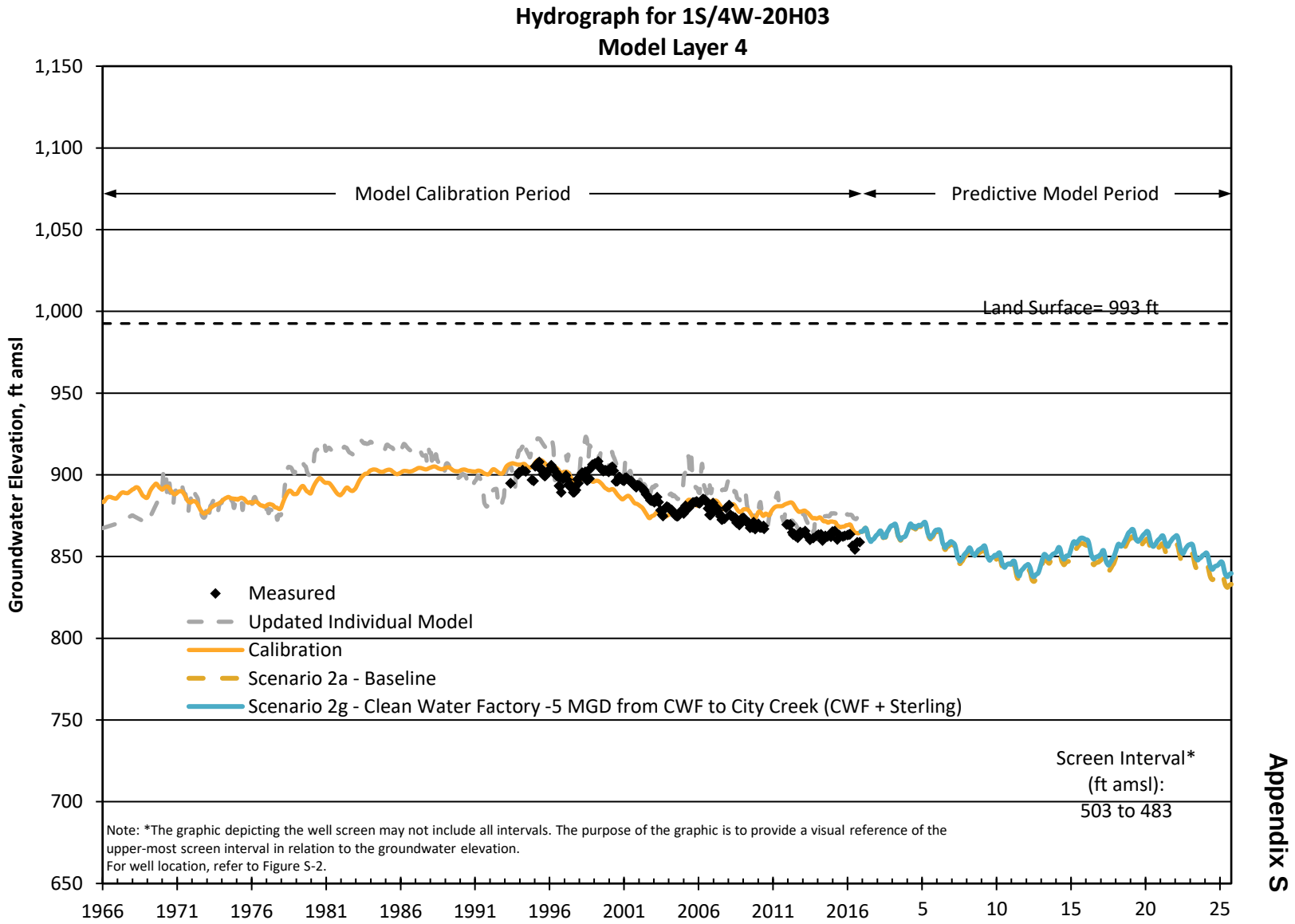
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2e.2 - All IEUA Activities
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
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2016
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20
25

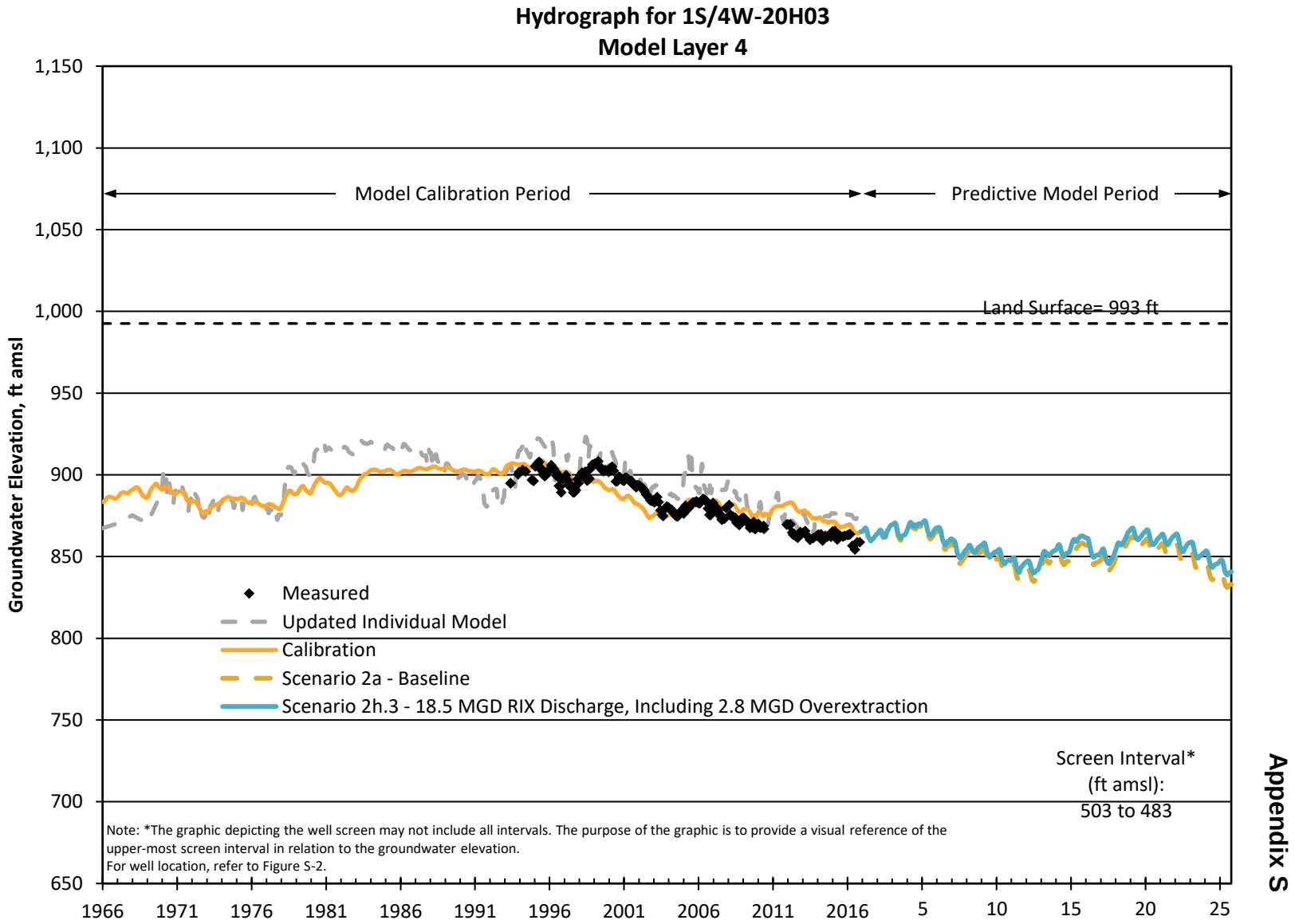
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2f - Western's Victoria Recharge Basin Project
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
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15
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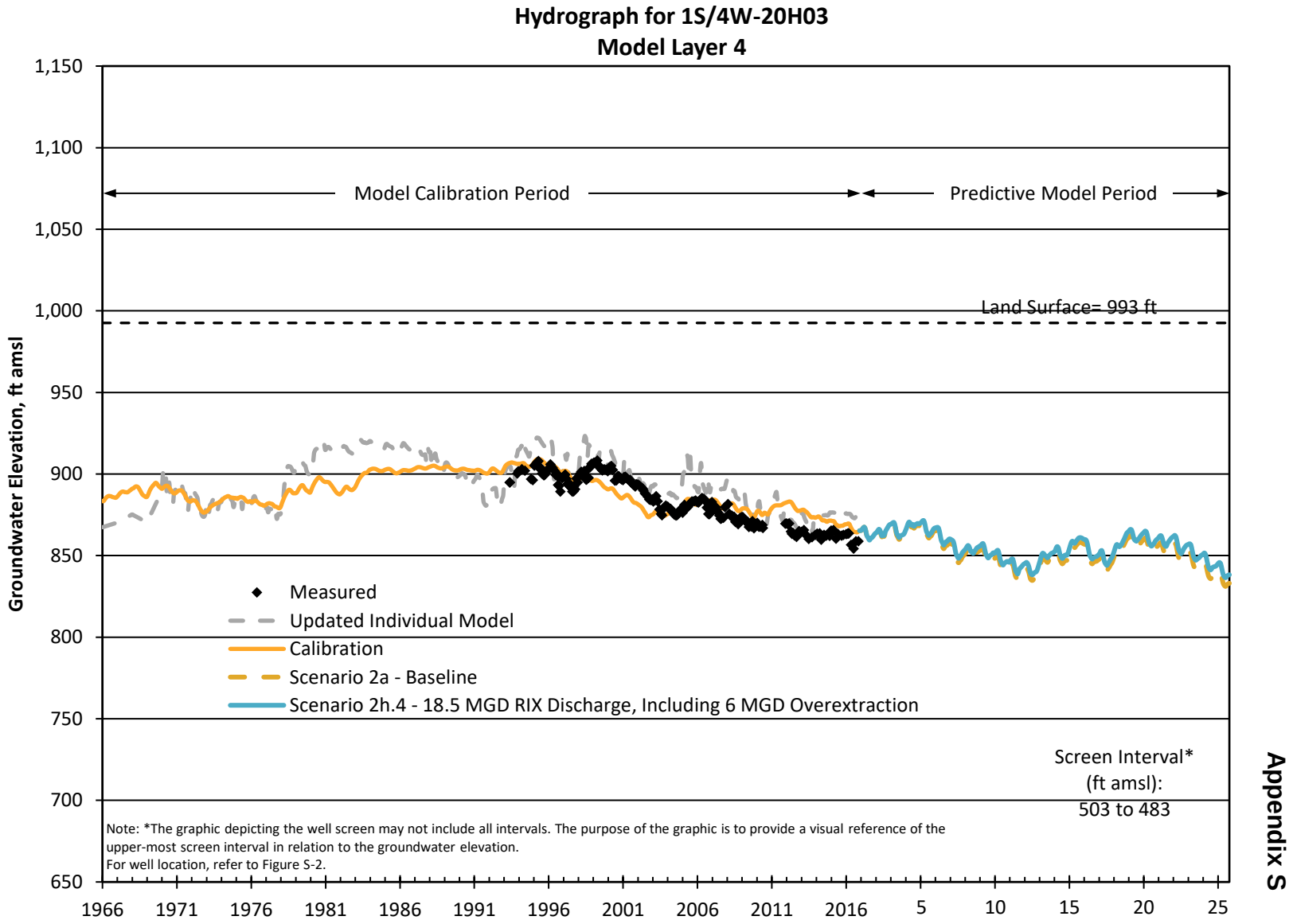
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2g - Clean Water Factory -5 MGD from CWF to City Creek (CWF + Sterling)
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
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2011
2016
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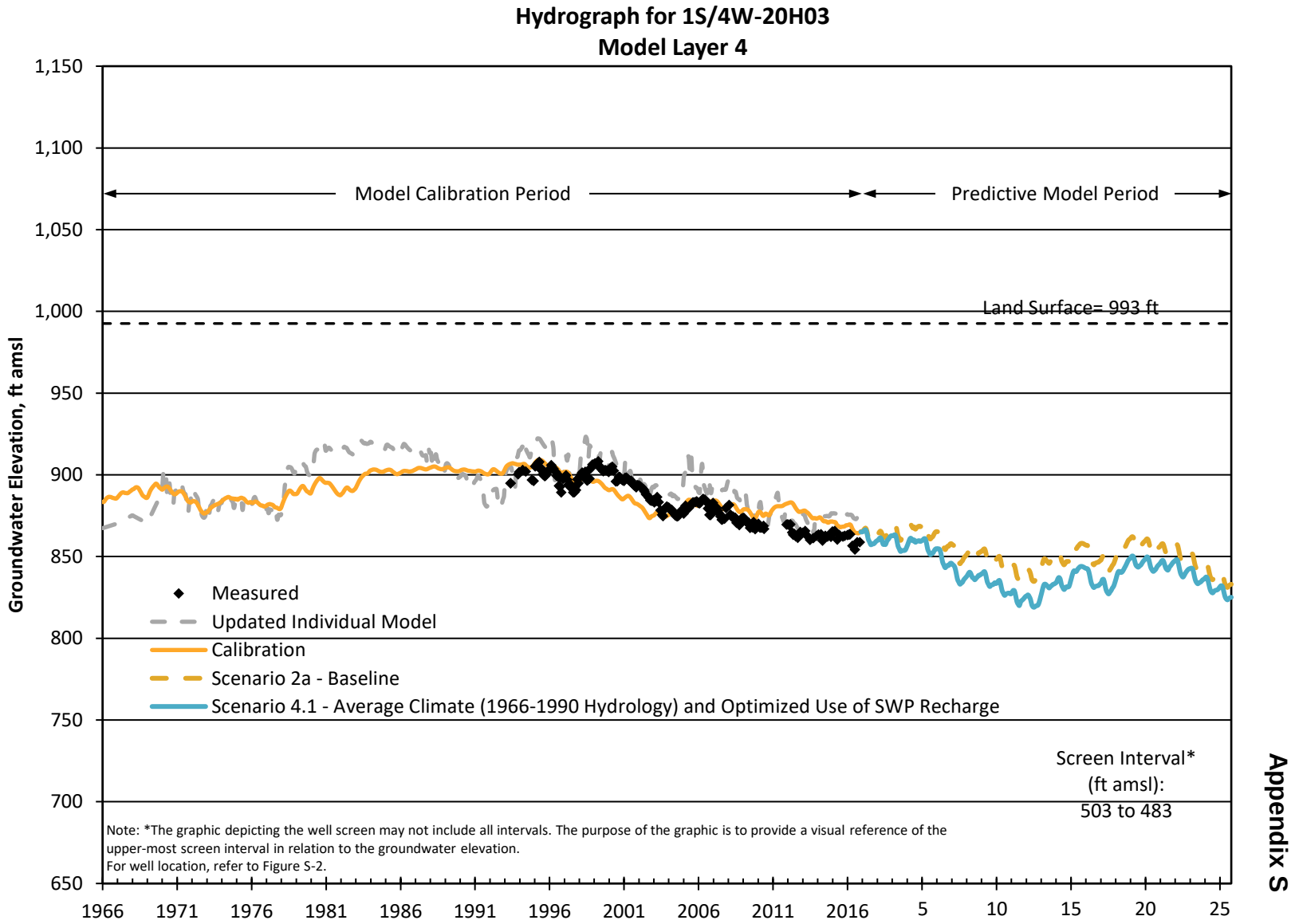
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2h.3 - 18.5 MGD RIX Discharge, Including 2.8 MGD Overextraction
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
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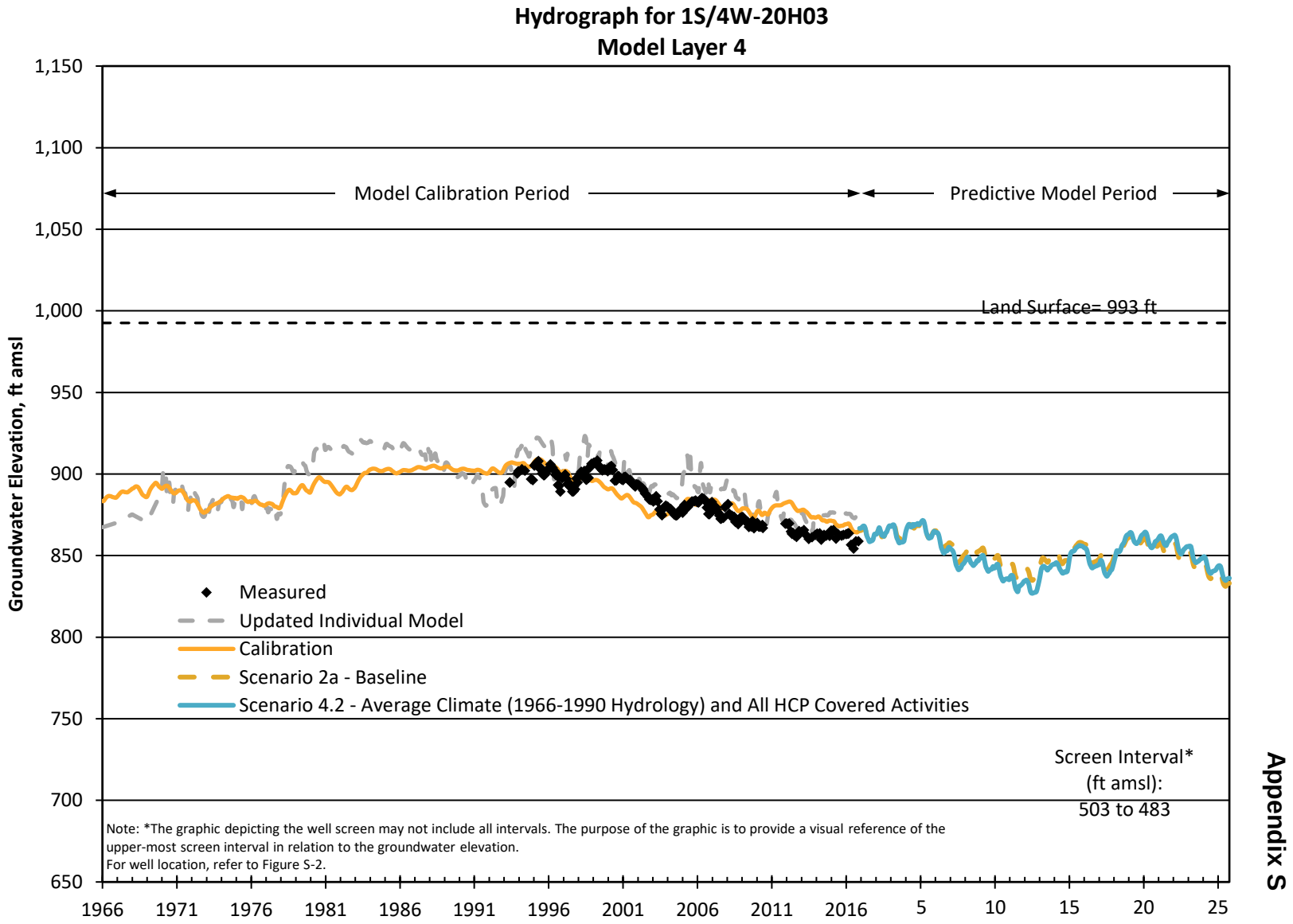
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 2h.4 - 18.5 MGD RIX Discharge, Including 6 MGD Overextraction
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
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1996
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2006
2011
2016
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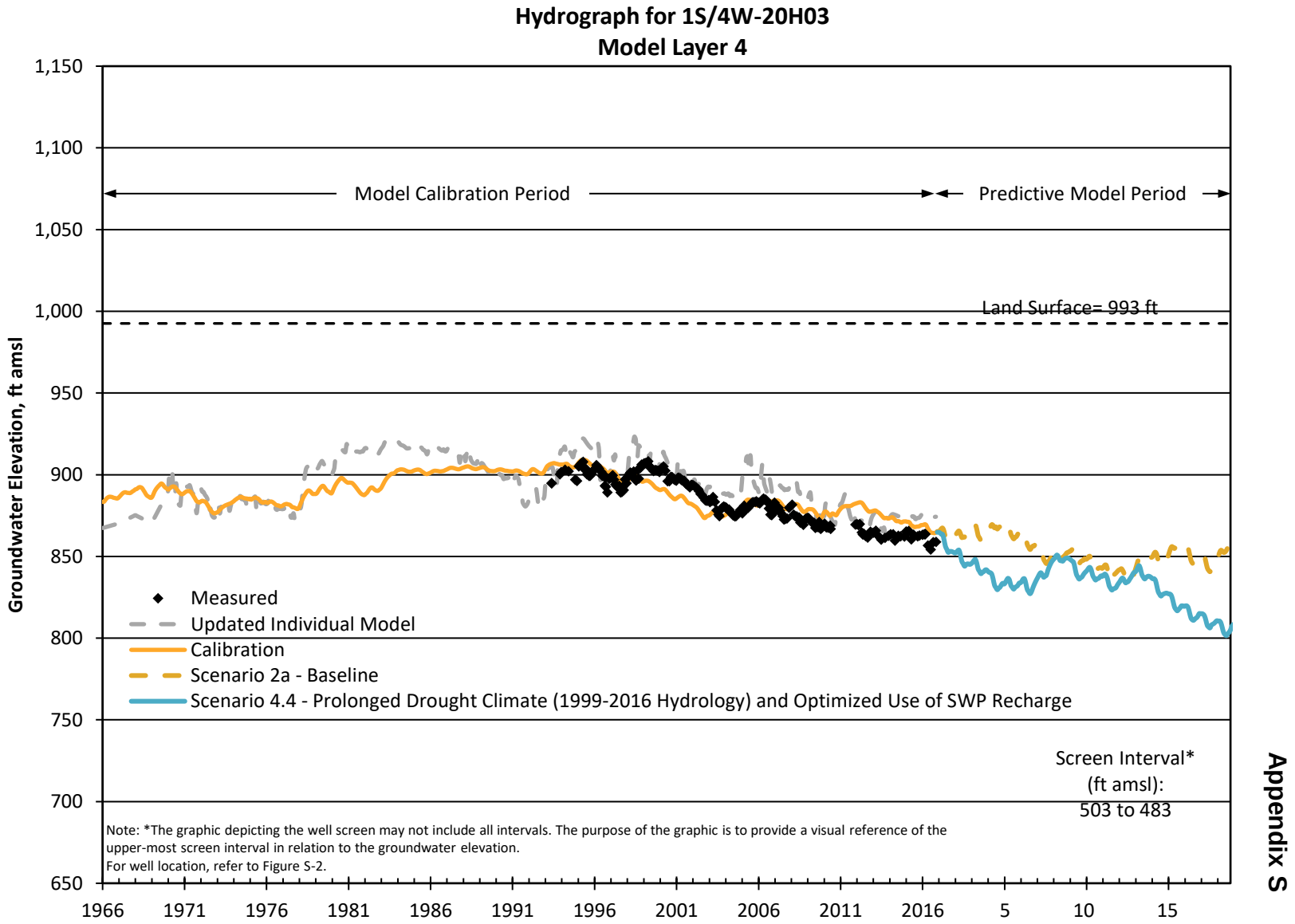
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 4.1 - Average Climate (1966-1990 Hydrology) and Optimized Use of SWP Recharge
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
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25

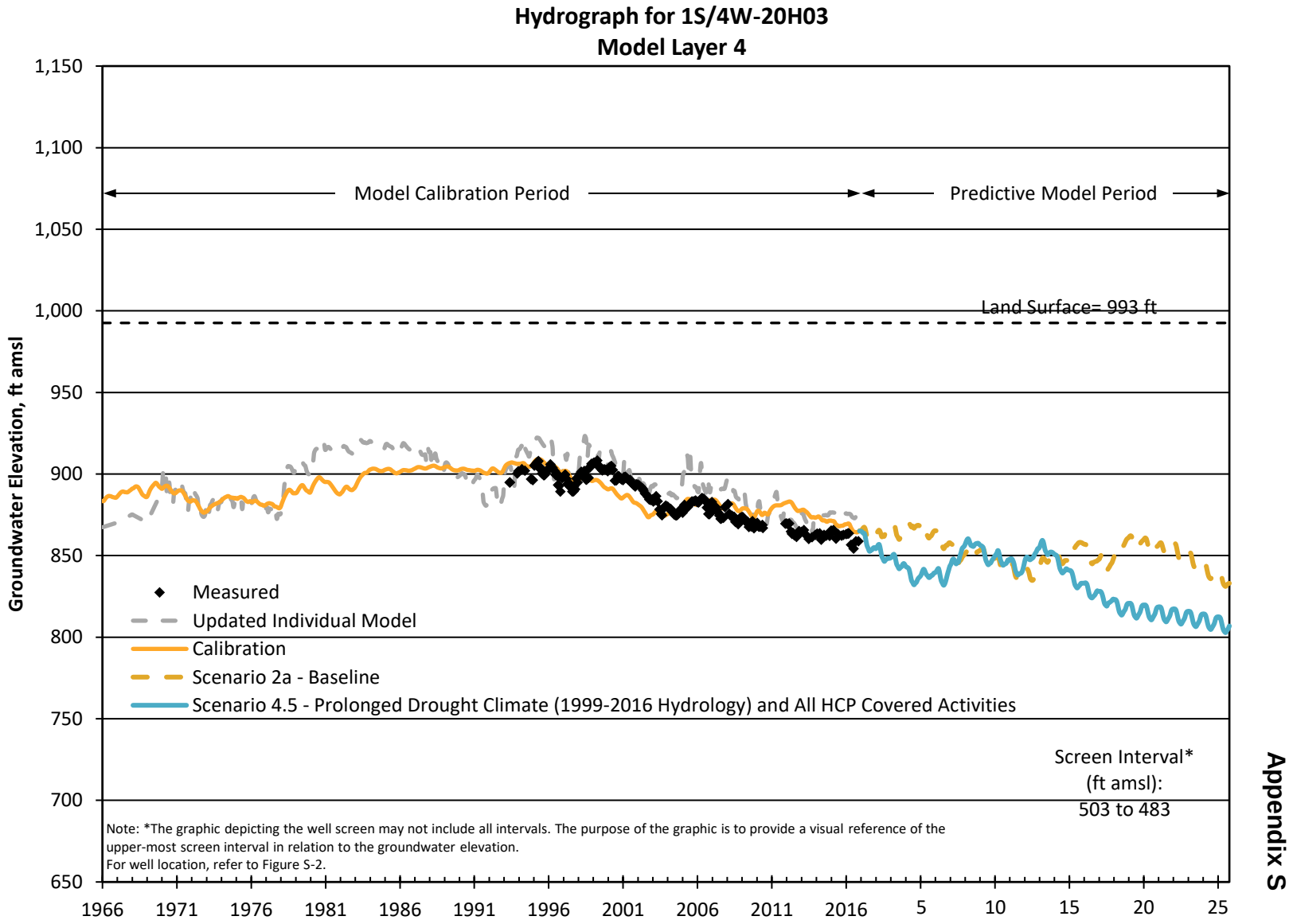
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 4.2 - Average Climate (1966-1990 Hydrology) and All HCP Covered Activities
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25

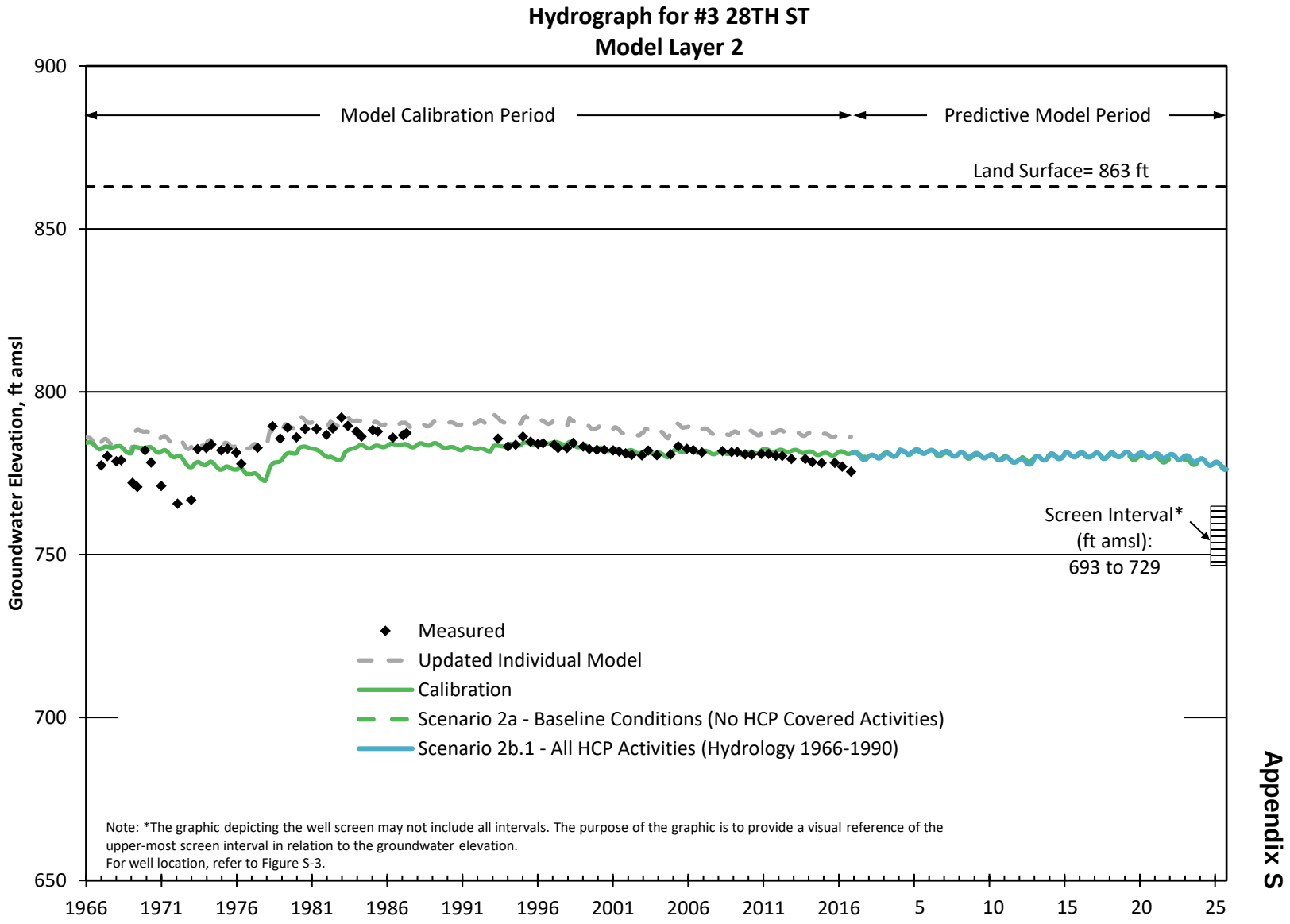
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 4.4 - Prolonged Drought Climate (1999-2016 Hydrology) and Optimized Use of SWP Recharge
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15

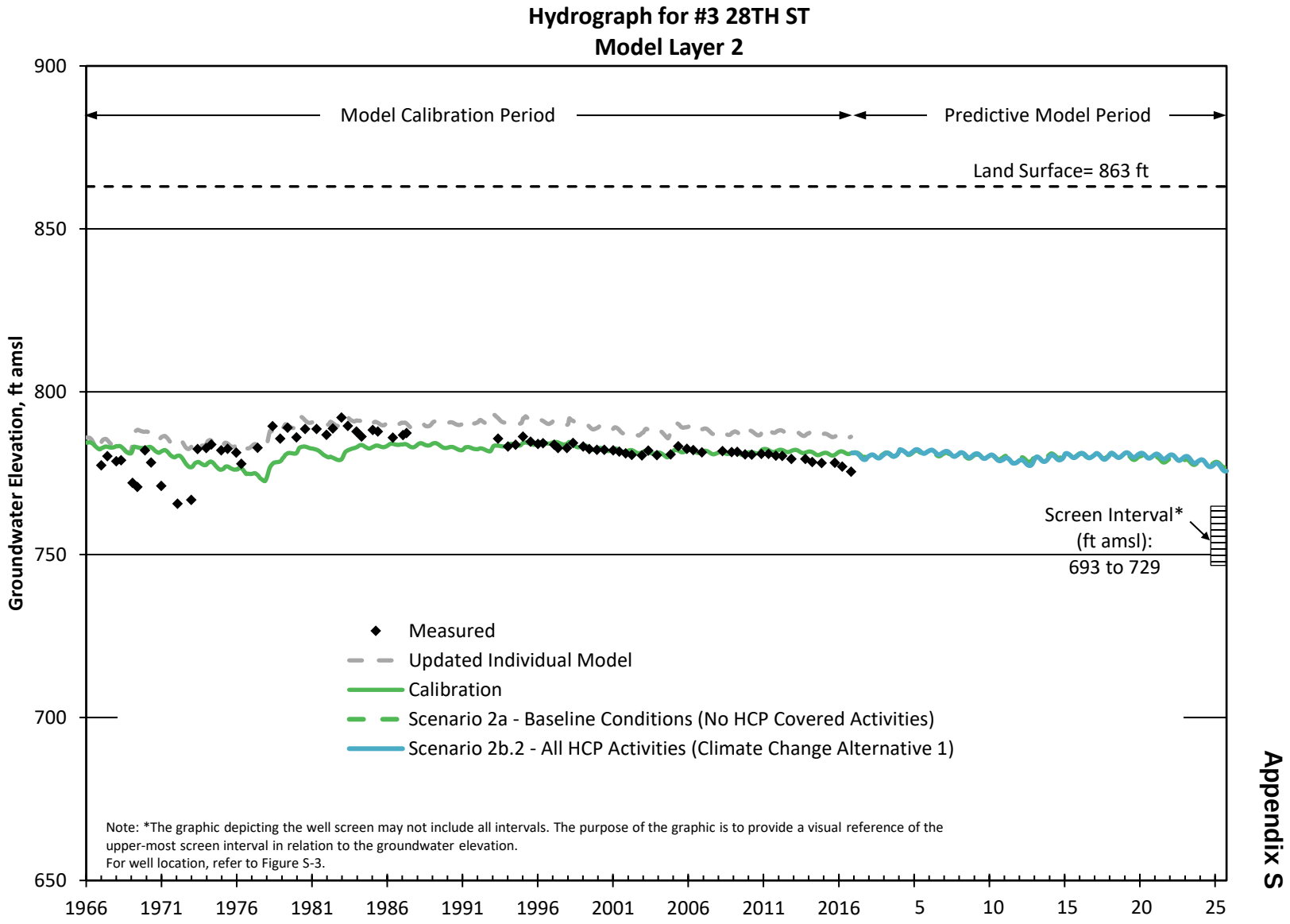
Appendix S


Hydrograph for 1S/4W-20H03
Model Layer 4
Groundwater Elevation, ft amsl
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 993 ft
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline
Scenario 4.5 - Prolonged Drought Climate (1999-2016 Hydrology) and All HCP Covered Activities
Screen Interval*
(ft amsl):
503 to 483
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-2.
1966
1971
1976
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2016
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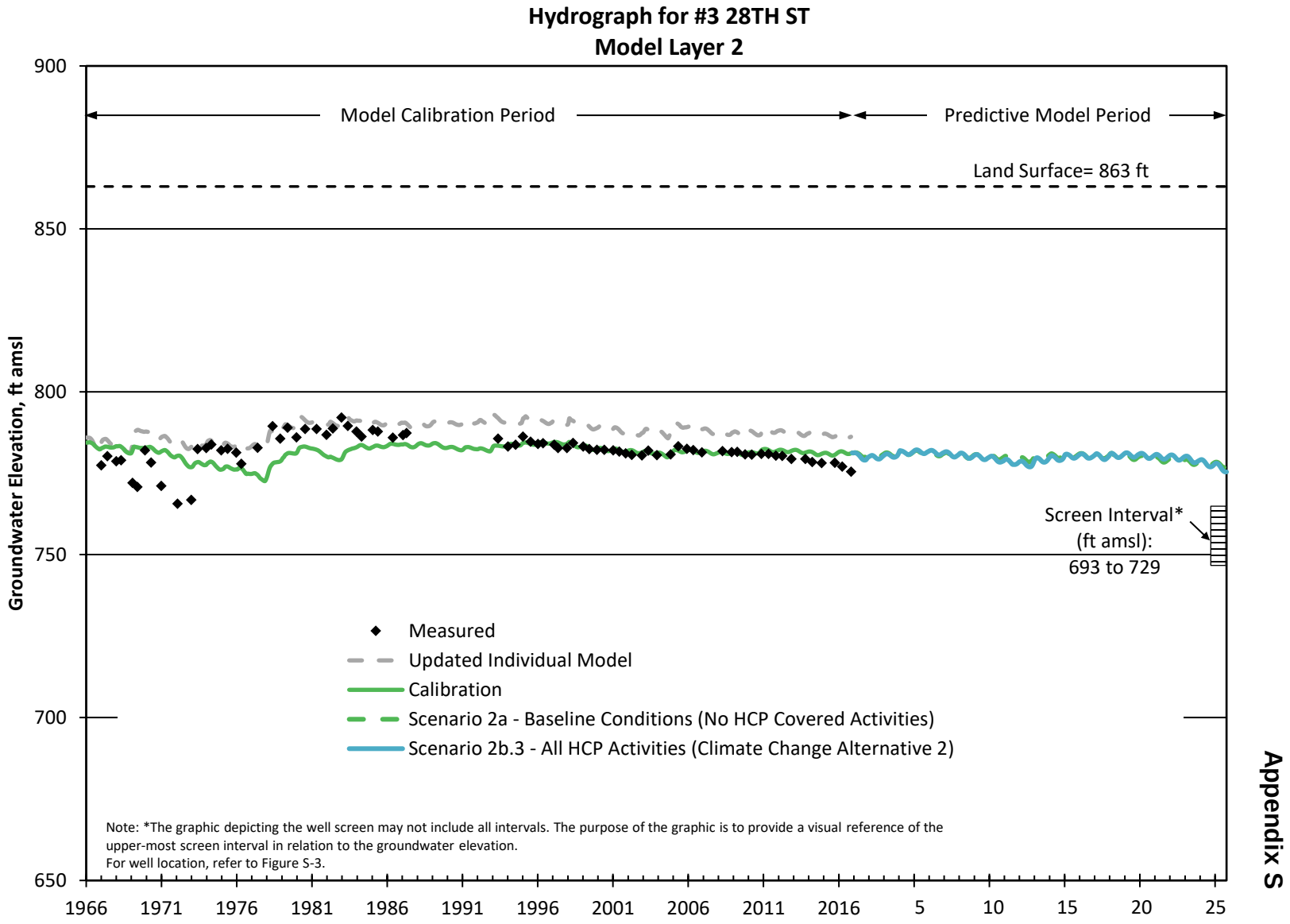
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Groundwater Elevation, ft amsl
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.1 - All HCP Activities (Hydrology 1966-1990)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.

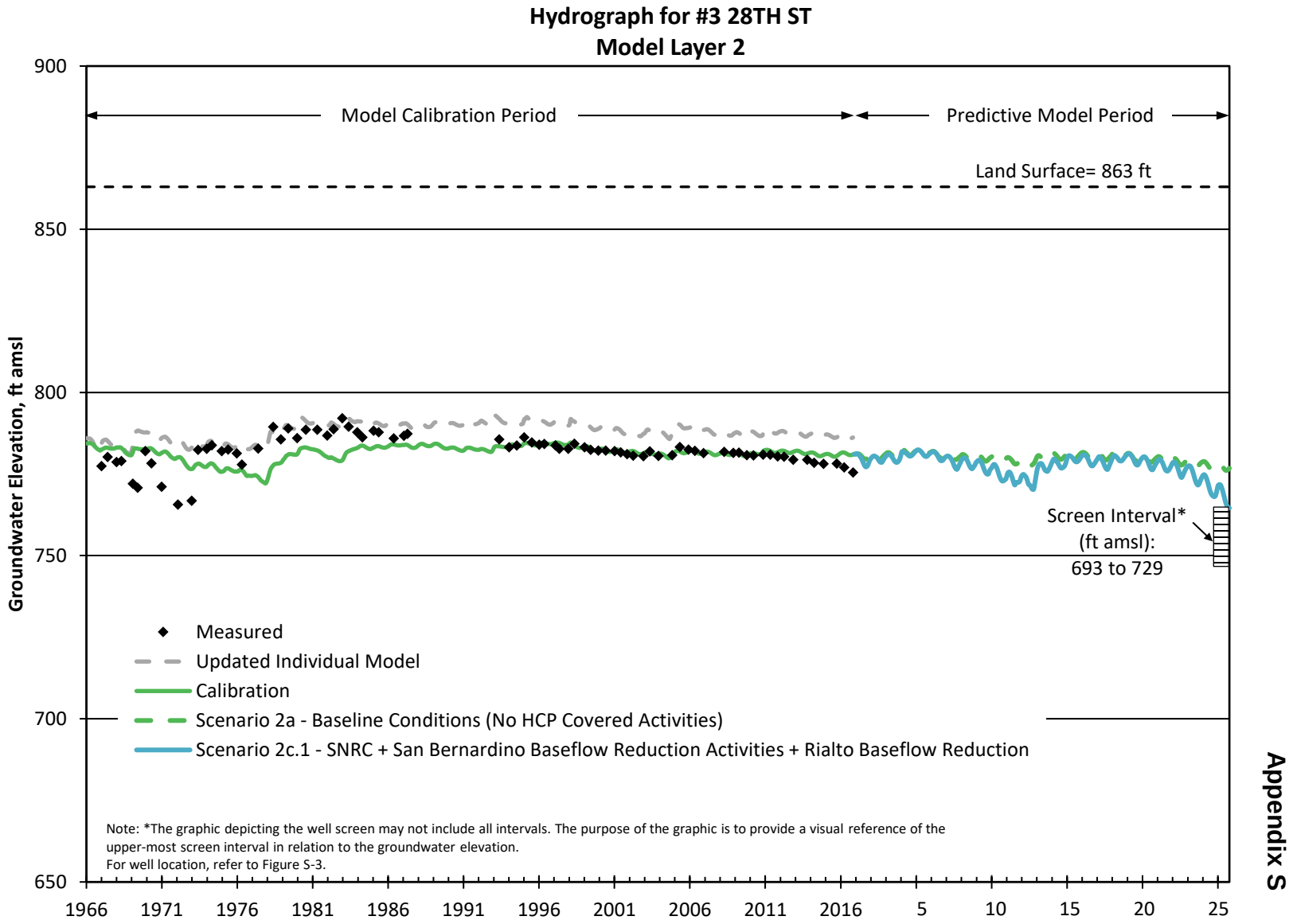
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.2 - All HCP Activities (Climate Change Alternative 1)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
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2016
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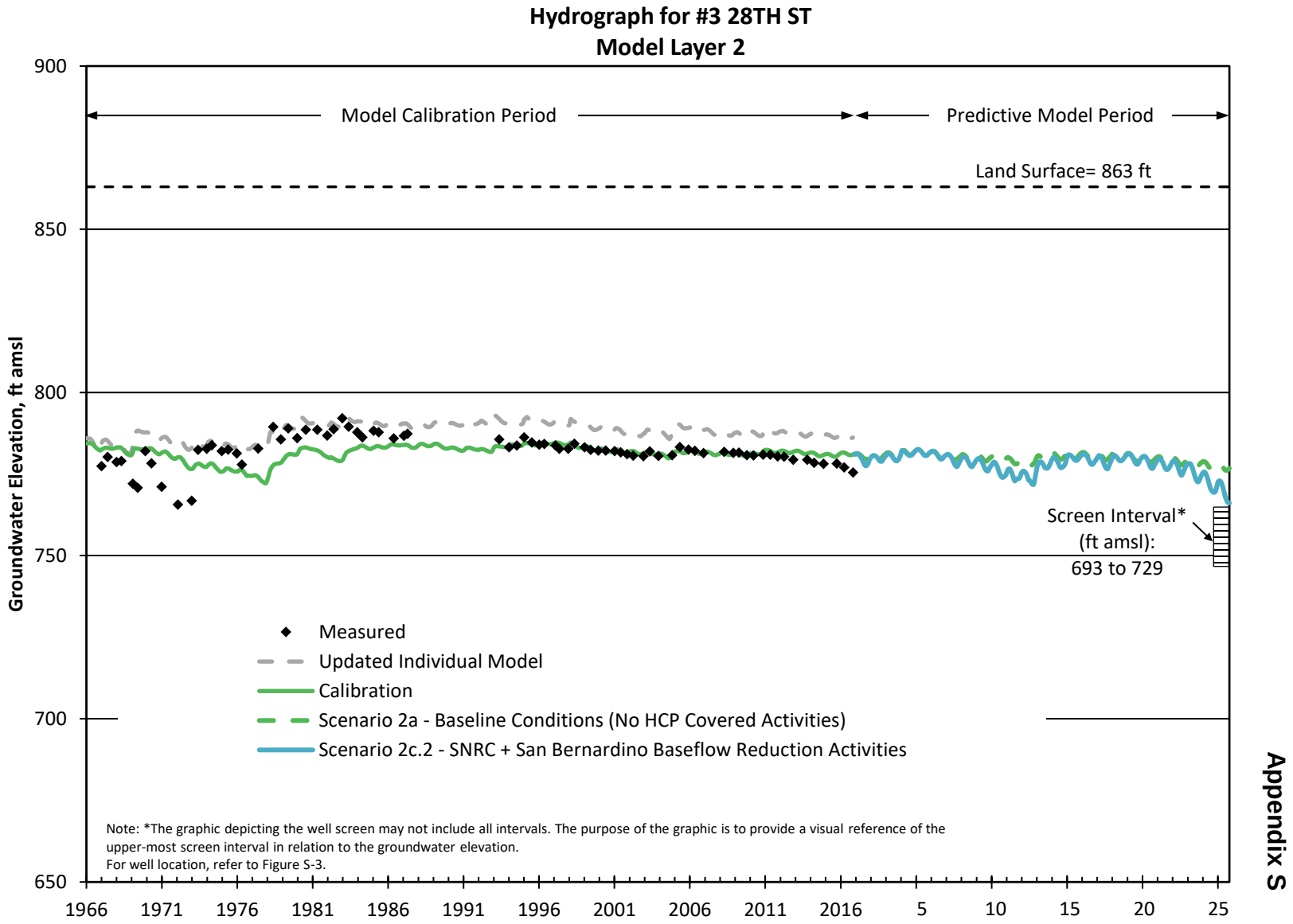
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.3 - All HCP Activities (Climate Change Alternative 2)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
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2006
2011
2016
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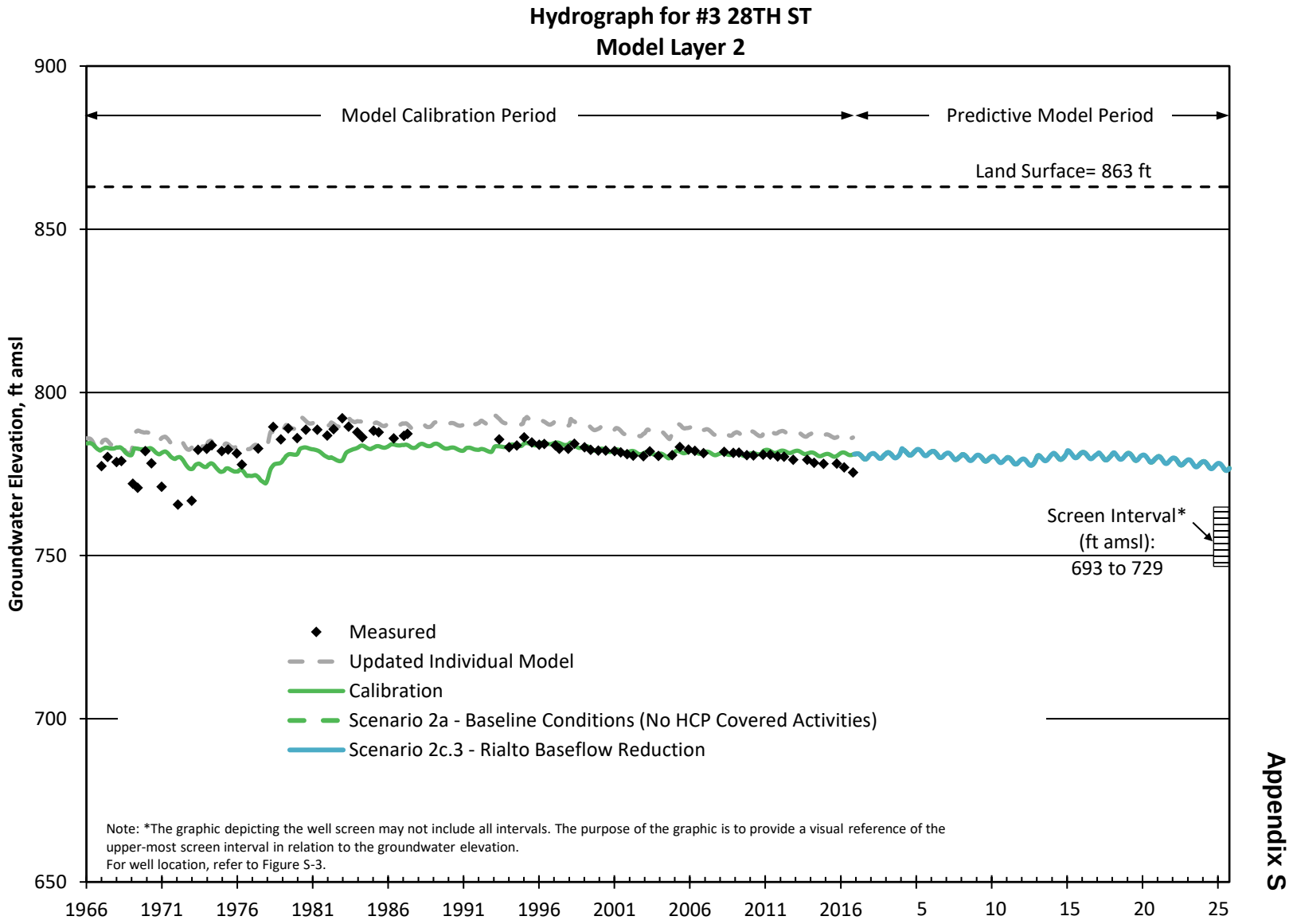
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.1 - SNRC + San Bernardino Baseflow Reduction Activities + Rialto Baseflow Reduction
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
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2006
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2016
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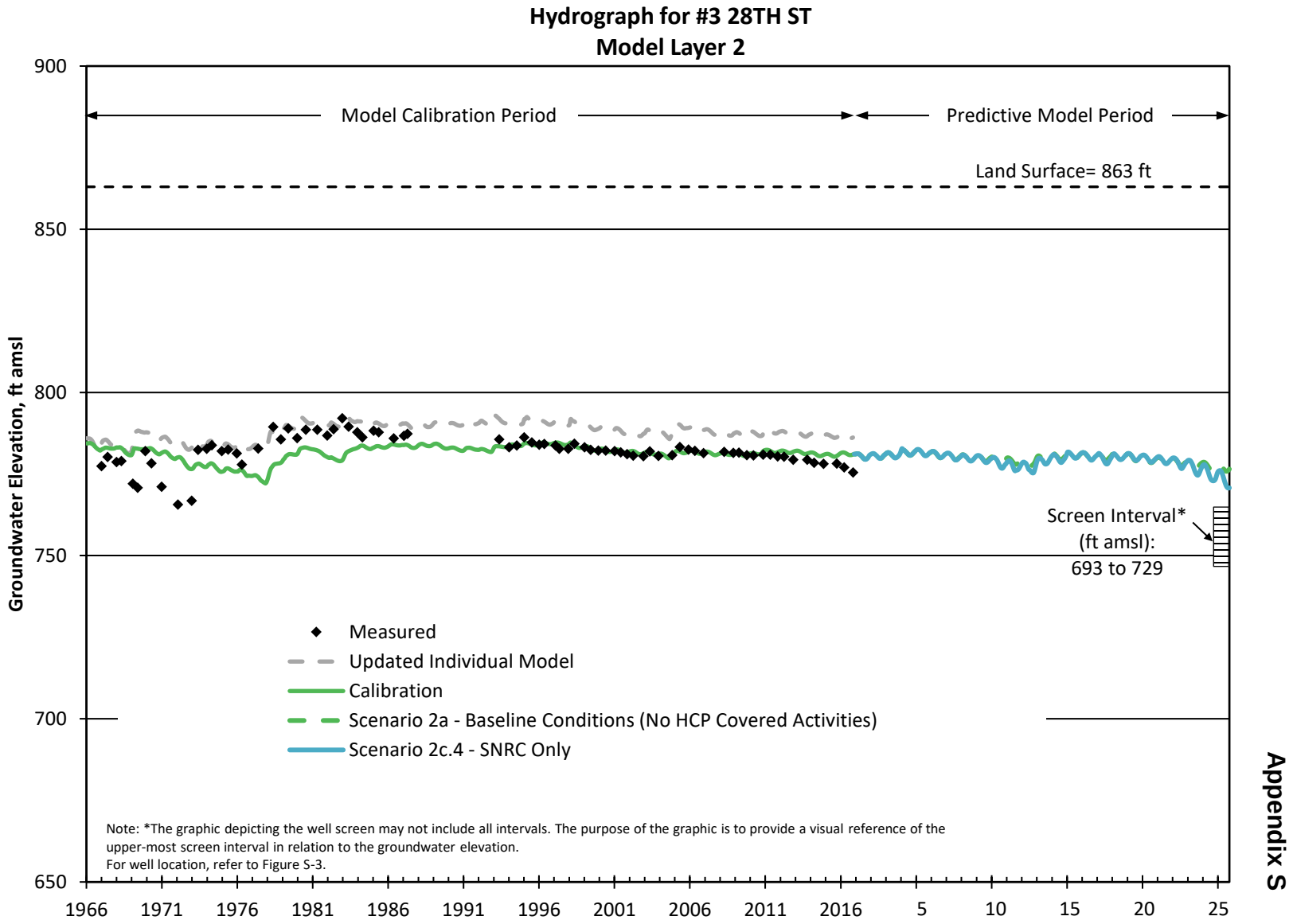
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.2 - SNRC + San Bernardino Baseflow Reduction Activities
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
2001
2006
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2016
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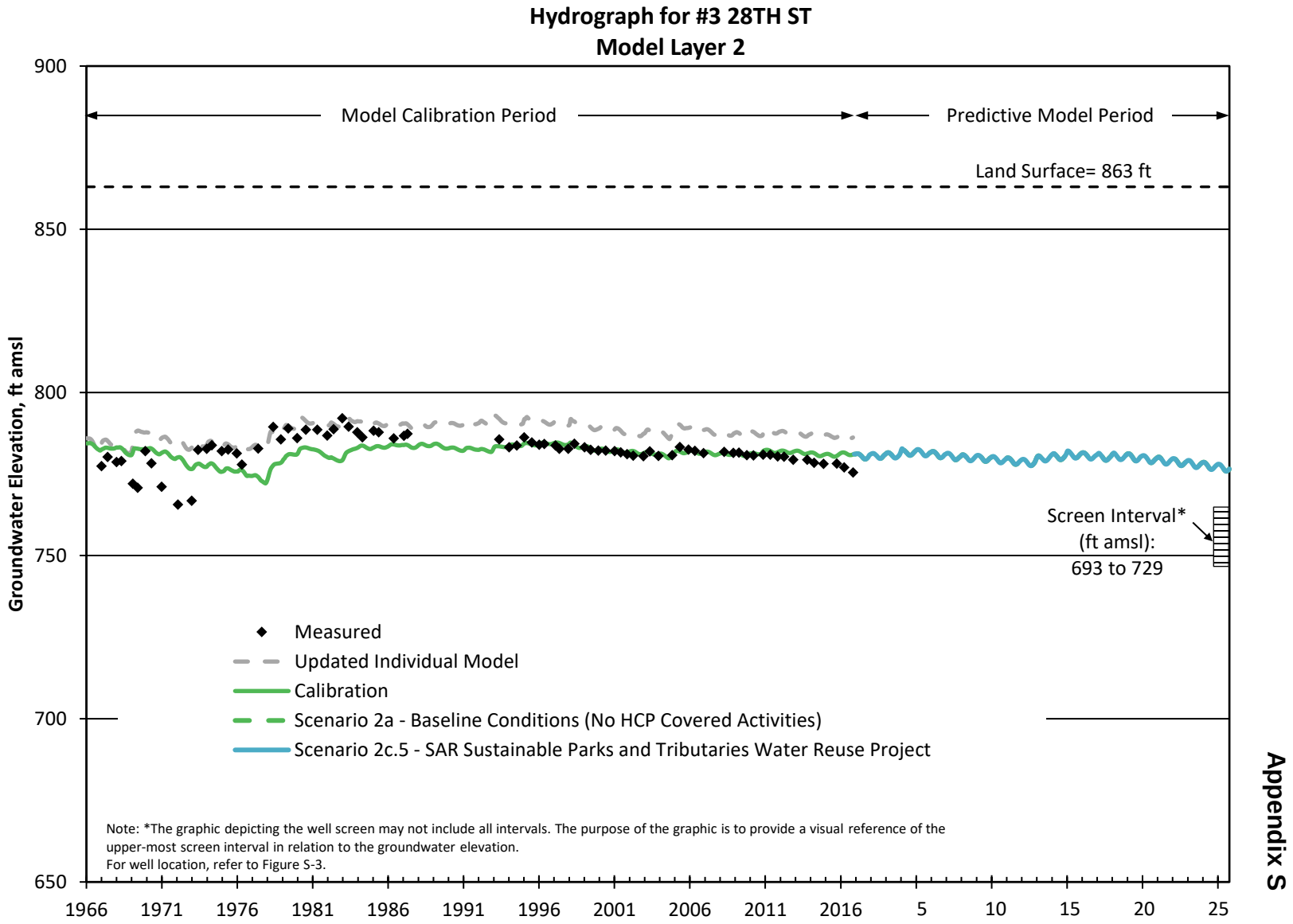
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
900
850
800
750
700
650
Groundwater Elevation, ft amsl
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.3 - Rialto Baseflow Reduction
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
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2016
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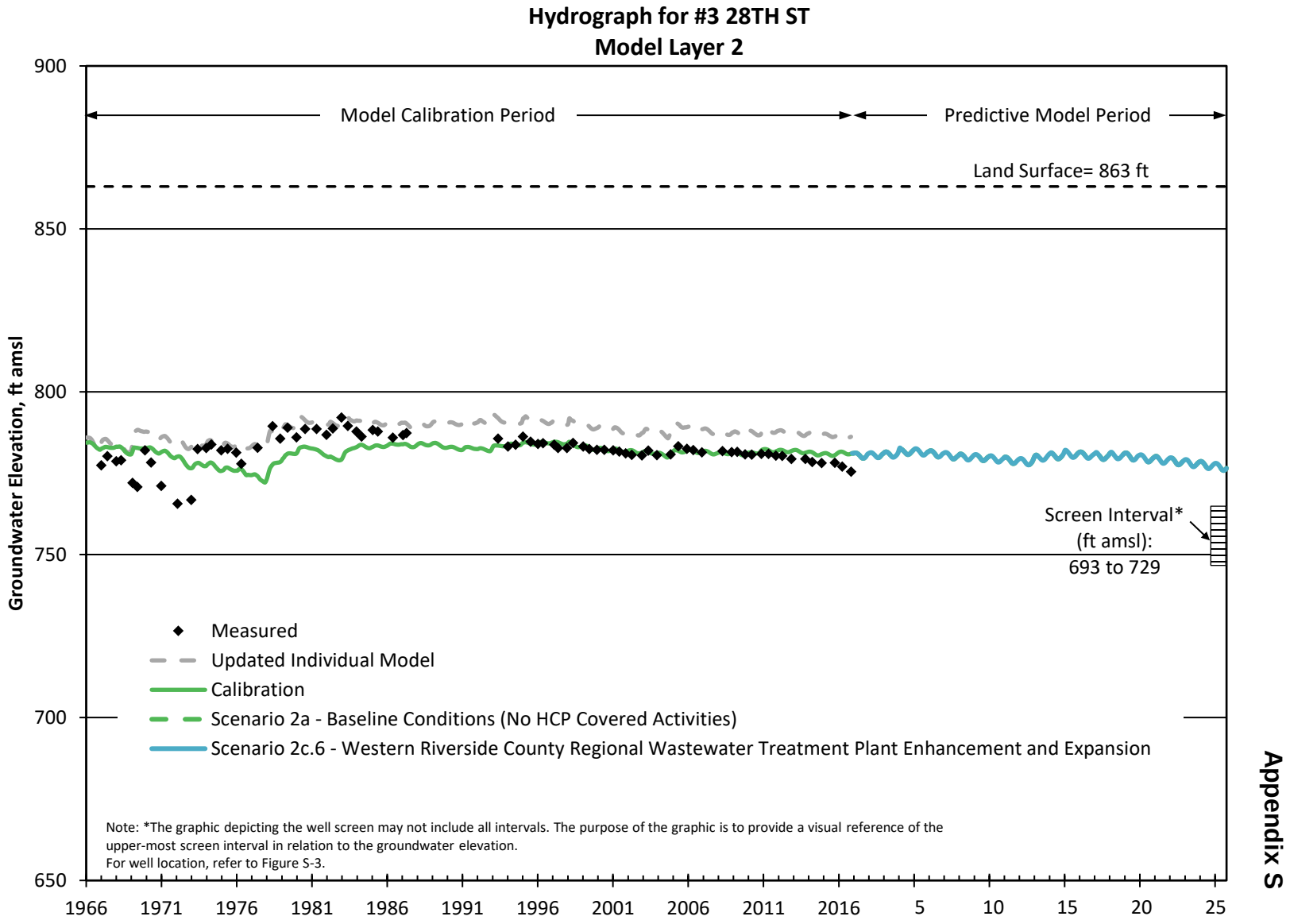
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.4 - SNRC Only
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
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2006
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2016
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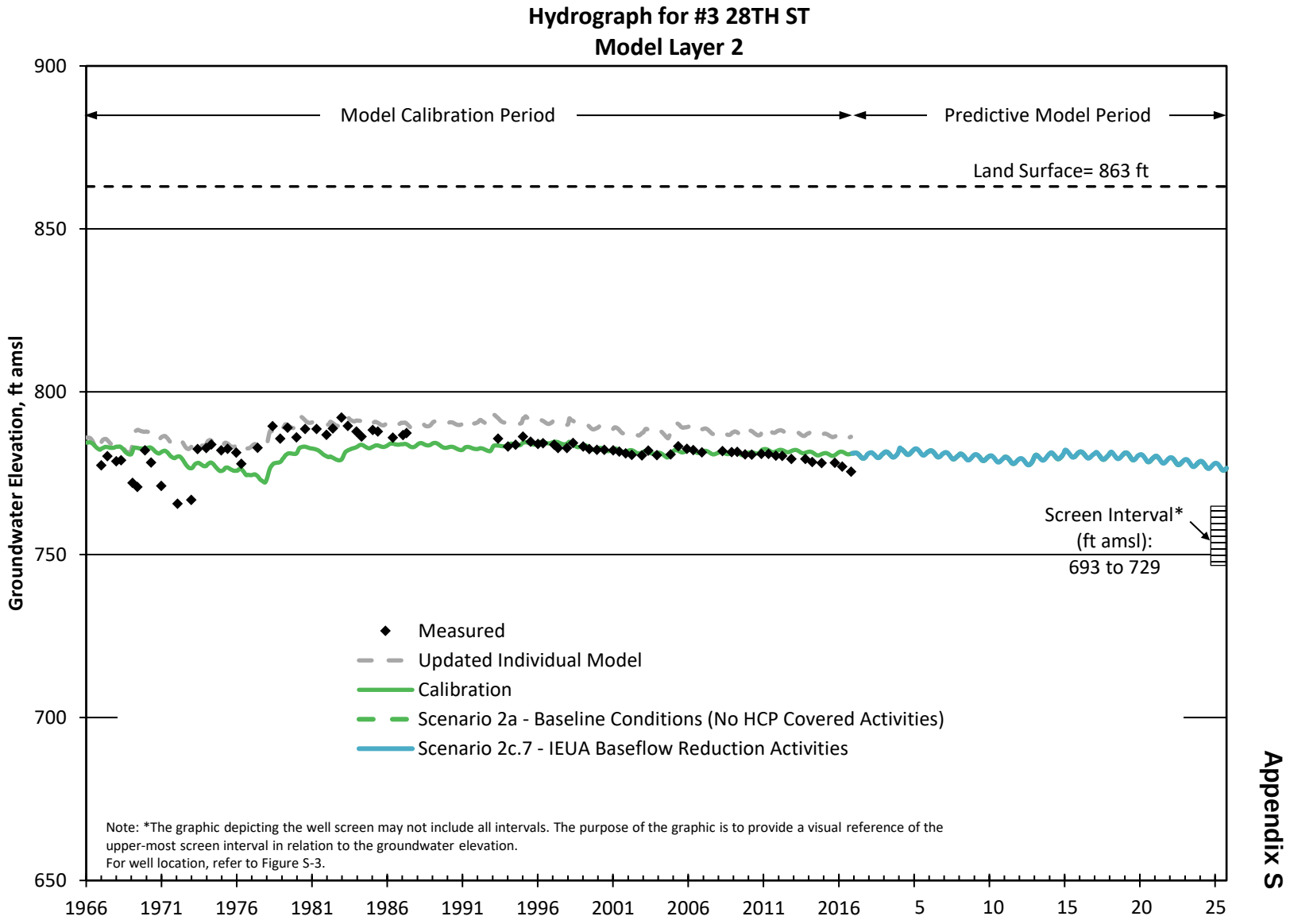
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
900
850
800
750
700
650
Groundwater Elevation, ft amsl
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.5 - SAR Sustainable Parks and Tributaries Water Reuse Project
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
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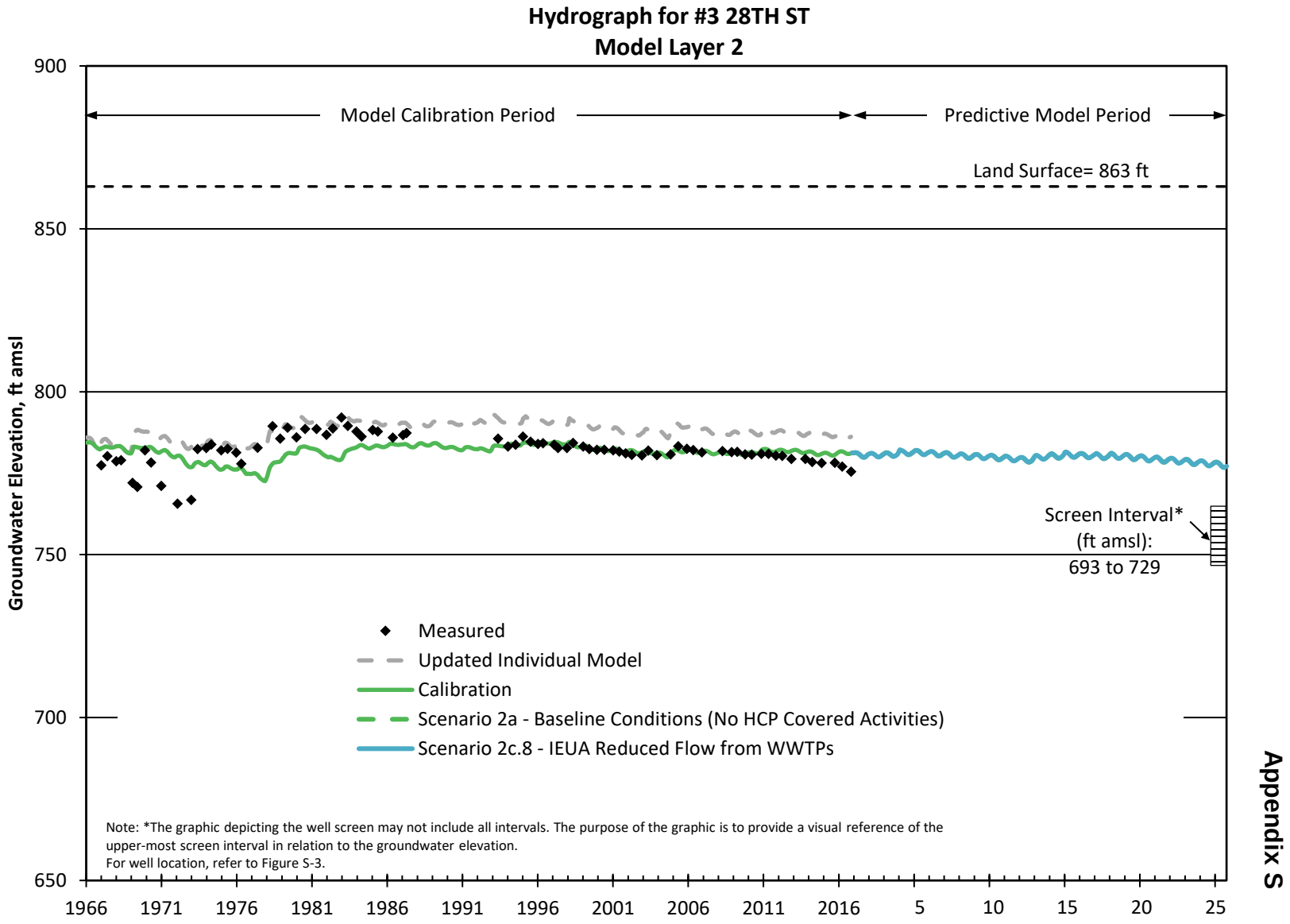
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.6 - Western Riverside County Regional Wastewater Treatment Plant Enhancement and Expansion
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
2001
2006
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2016
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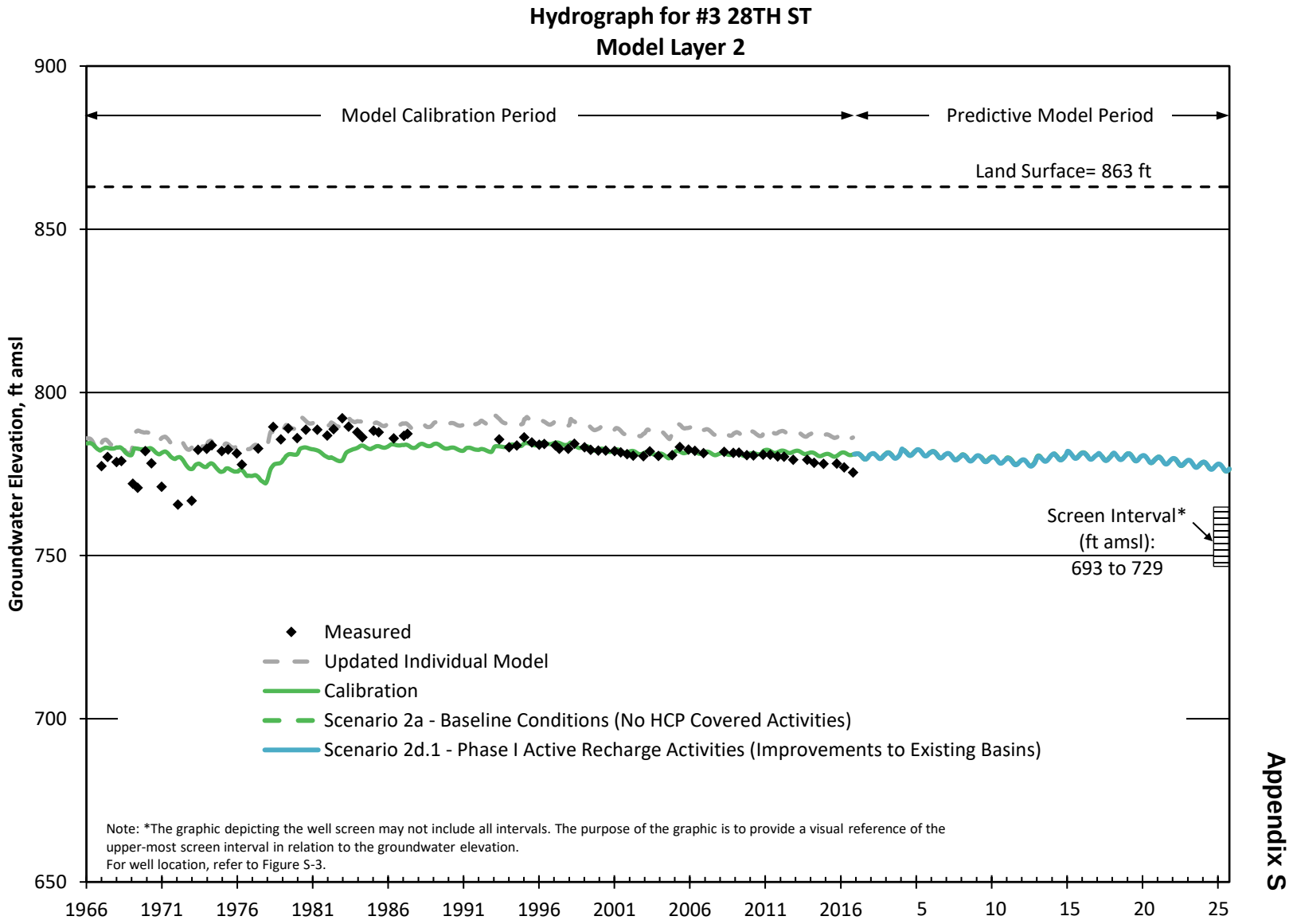
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
900
850
800
750
700
650
Groundwater Elevation, ft amsl
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.7 - IEUA Baseflow Reduction Activities
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
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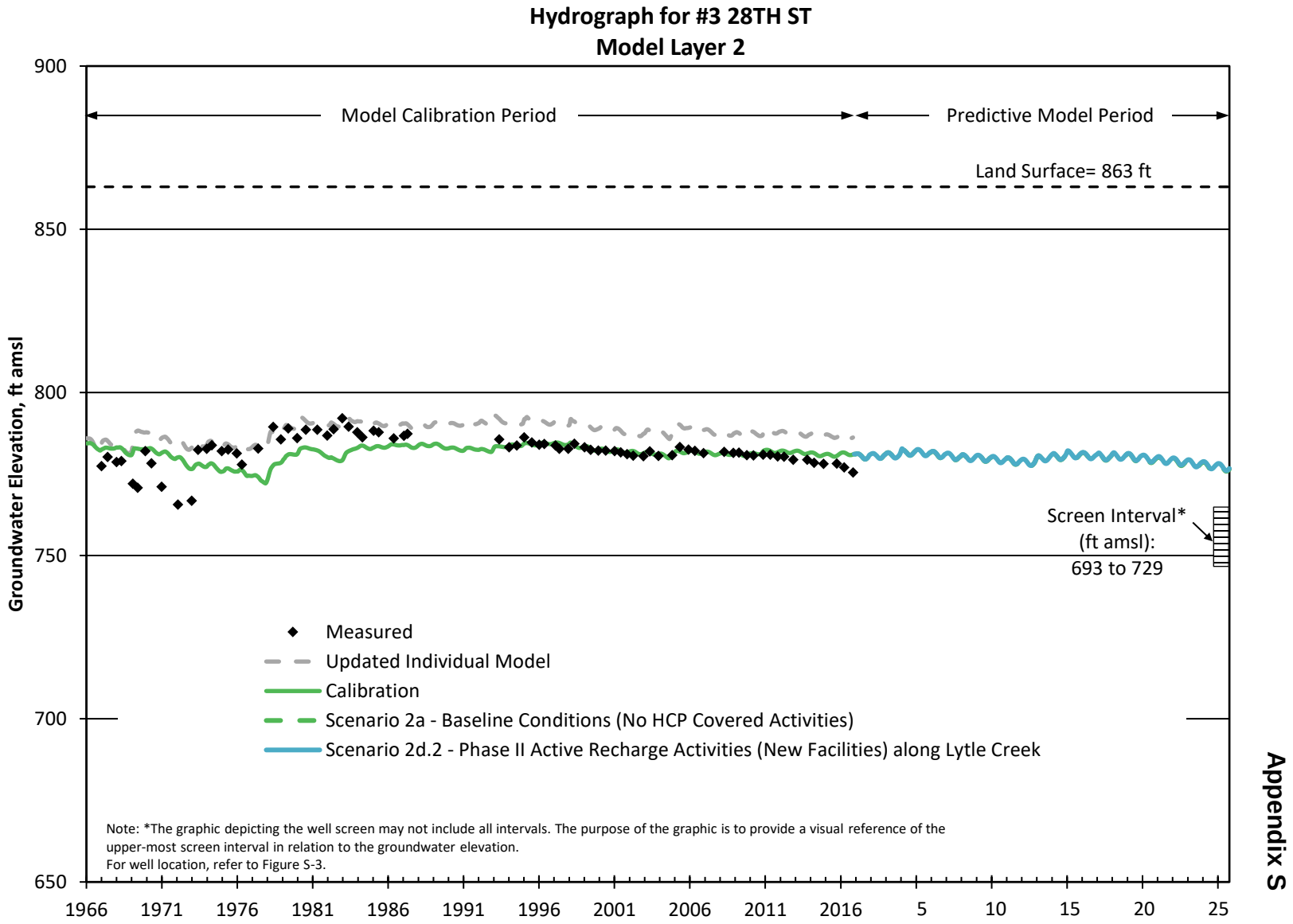
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Groundwater Elevation, ft amsl
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.8 - IEUA Reduced Flow from WWTPs
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.

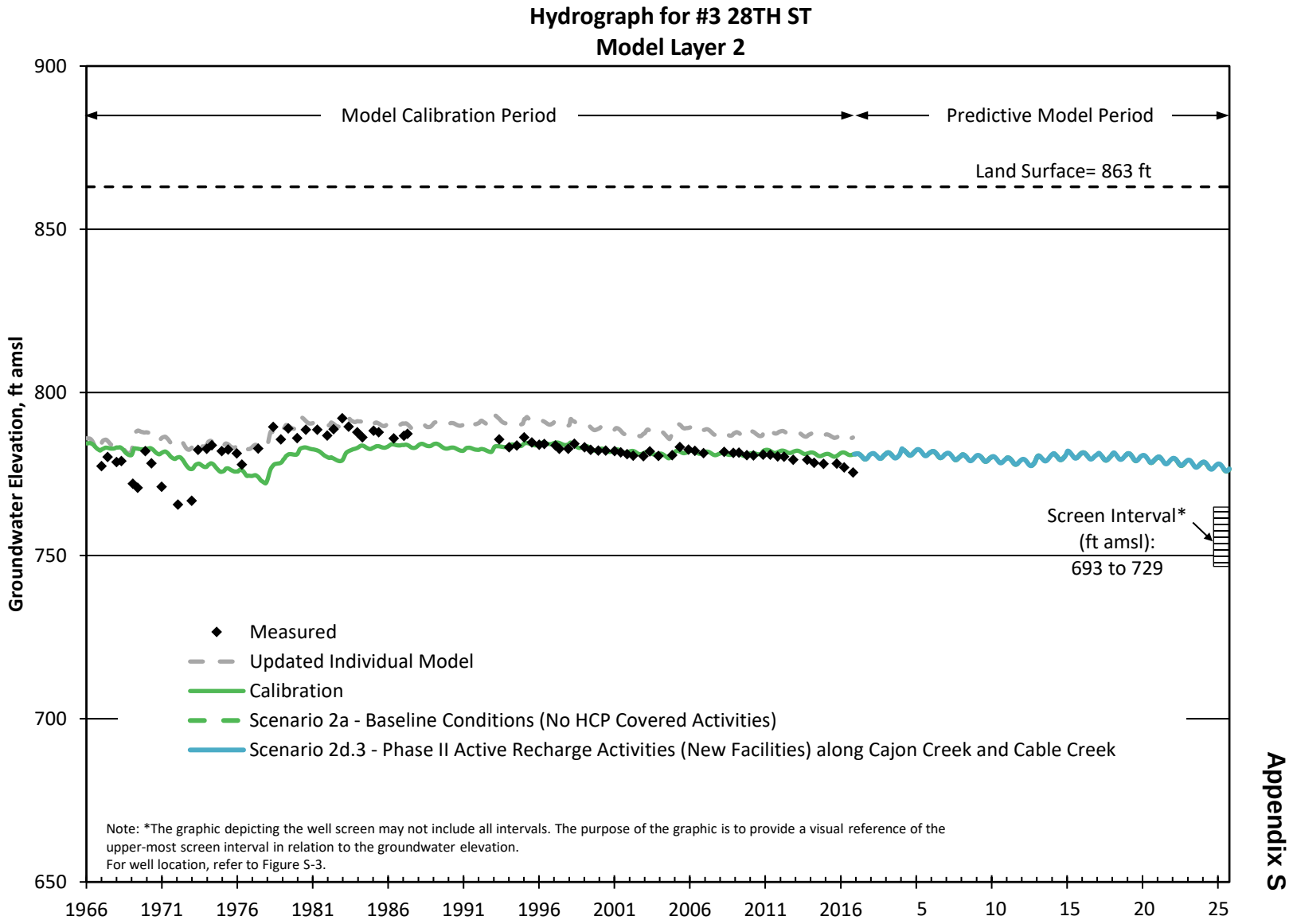
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
900
850
800
750
700
650
Groundwater Elevation, ft amsl
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.1 - Phase I Active Recharge Activities (Improvements to Existing Basins)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
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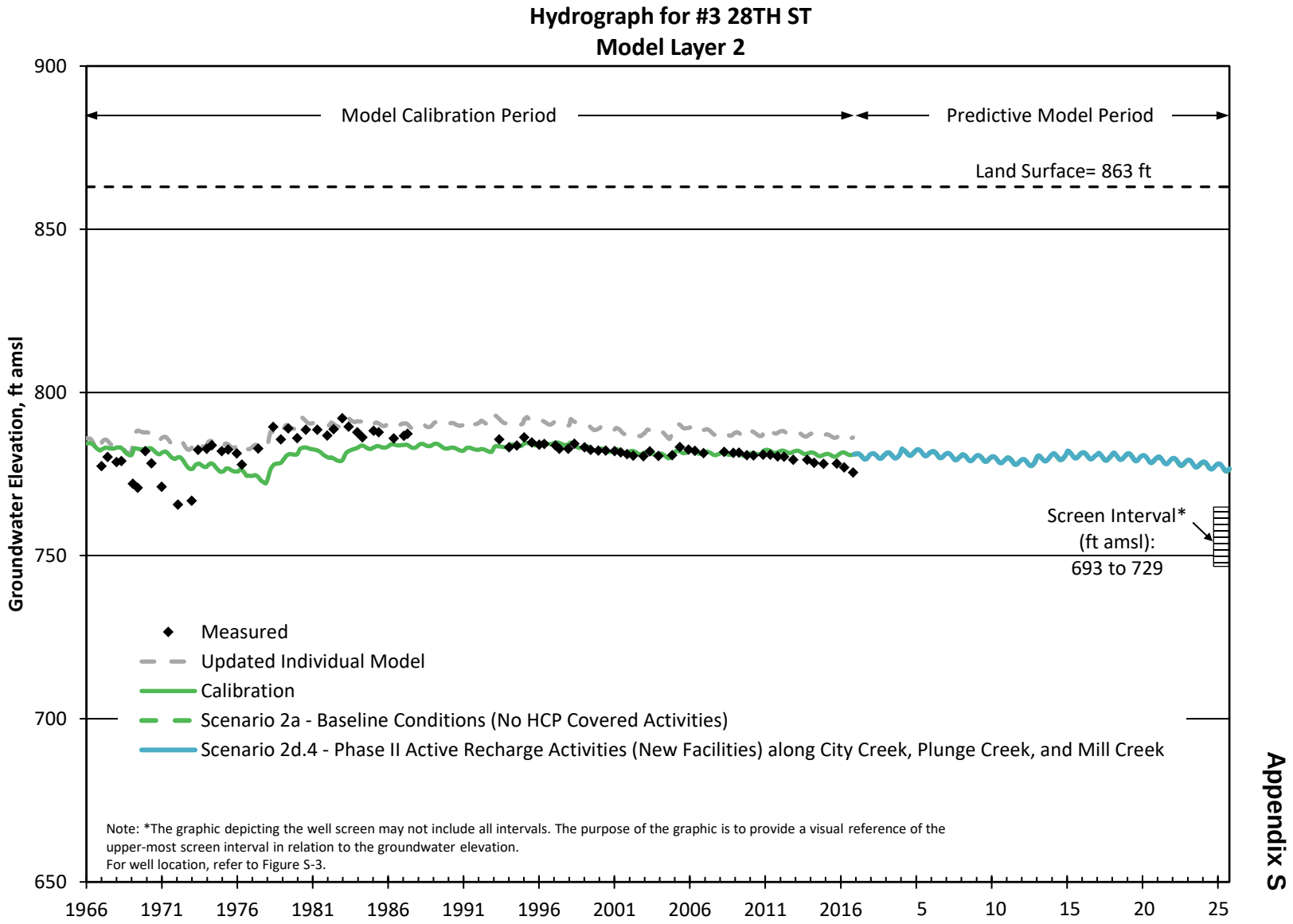
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
900
850
800
750
700
650
Groundwater Elevation, ft amsl
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.2 - Phase II Active Recharge Activities (New Facilities) along Lytle Creek
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
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2006
2011
2016
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25

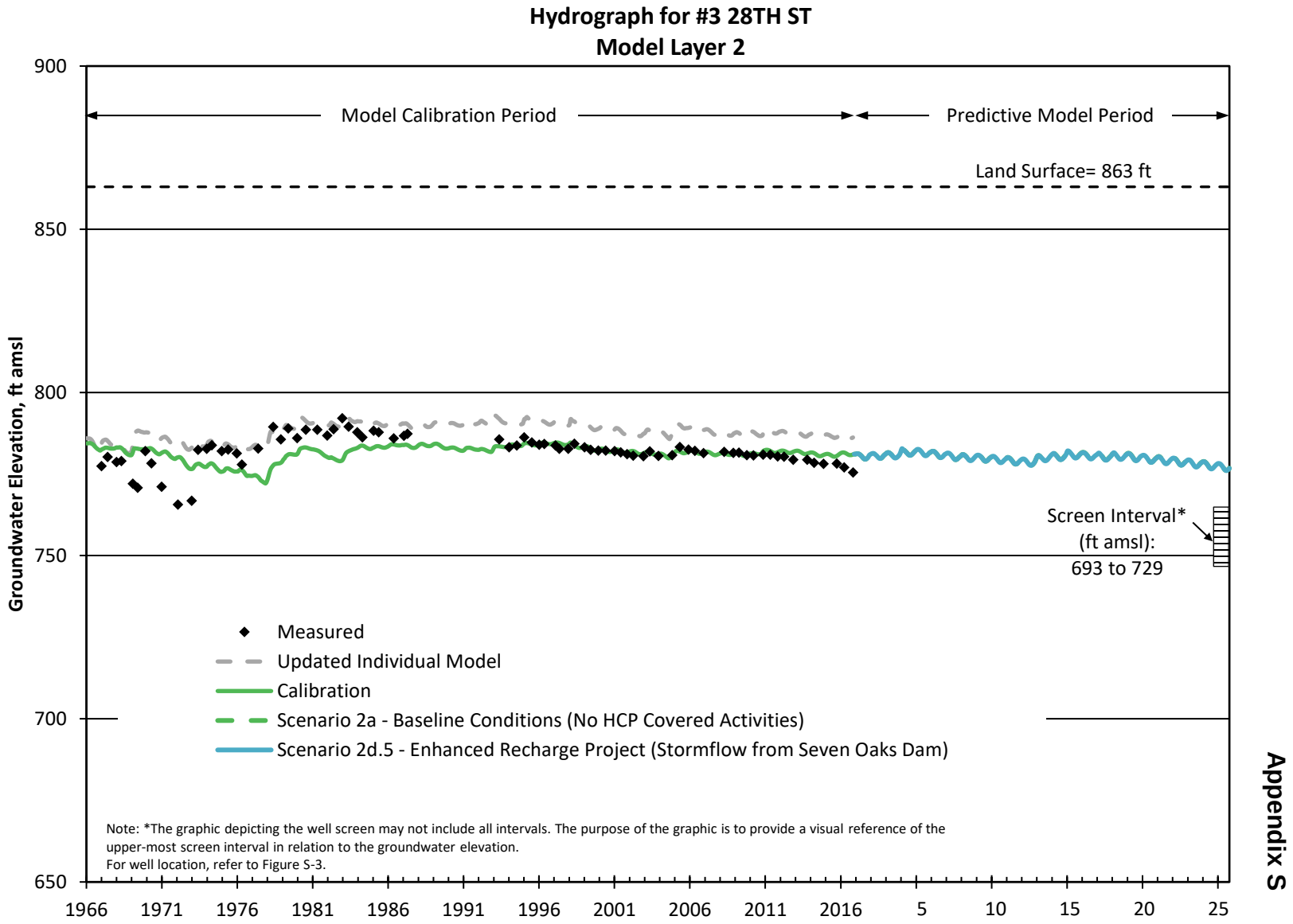
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.3 - Phase II Active Recharge Activities (New Facilities) along Cajon Creek and Cable Creek
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
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2016
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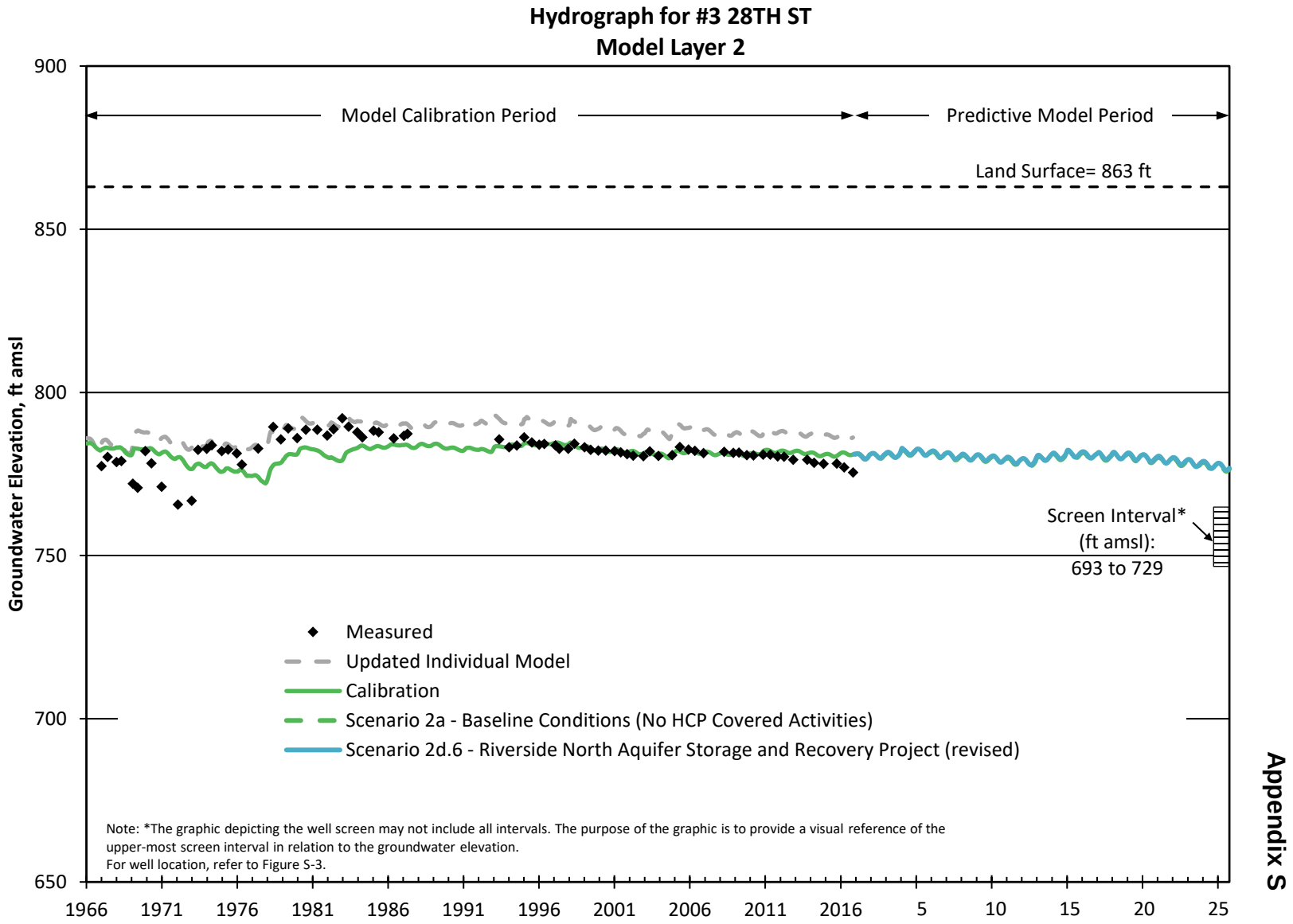
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.4 - Phase II Active Recharge Activities (New Facilities) along City Creek, Plunge Creek, and Mill Creek
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
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1996
2001
2006
2011
2016
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15
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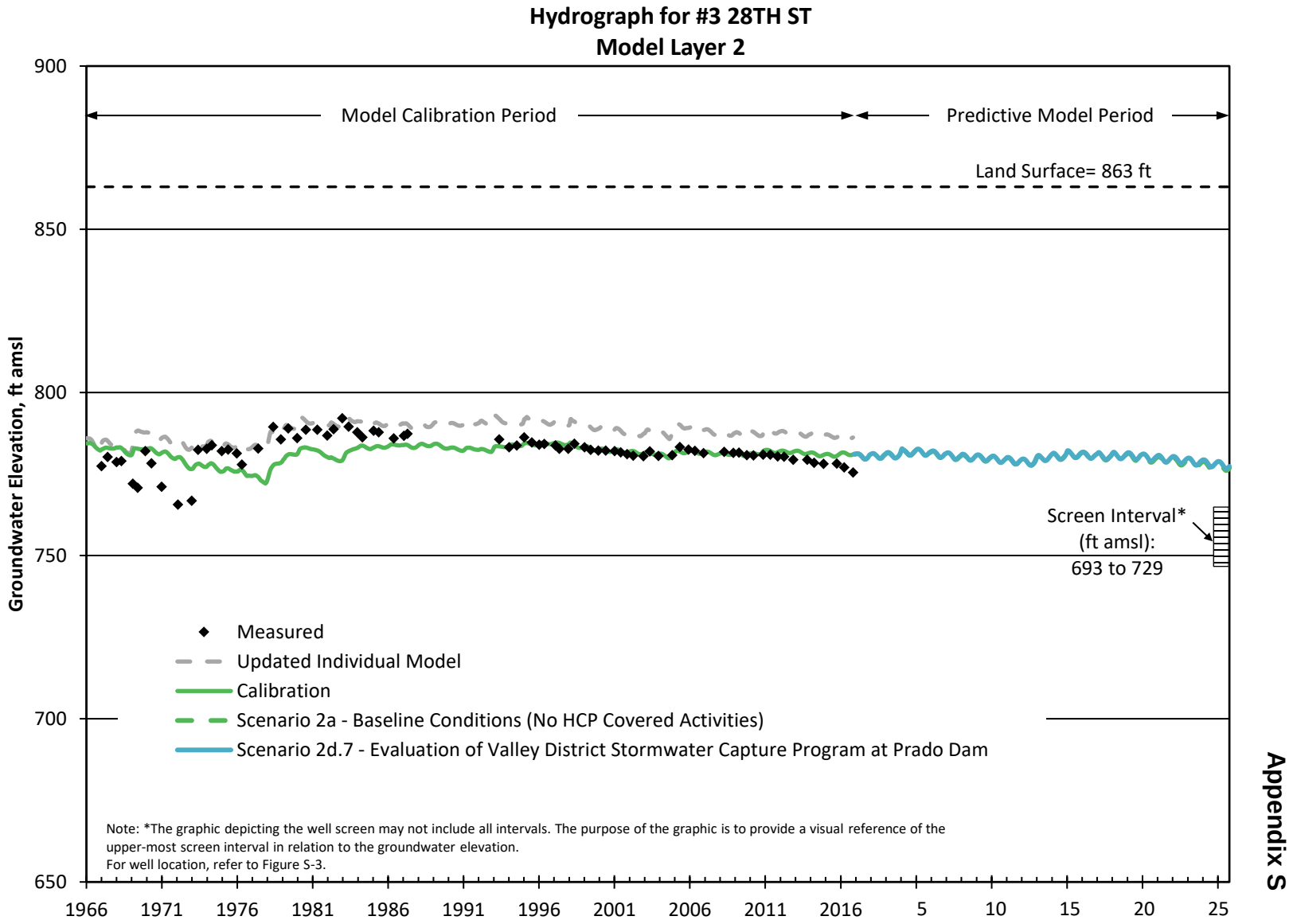
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
900
850
800
750
700
650
Groundwater Elevation, ft amsl
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.5 - Enhanced Recharge Project (Stormflow from Seven Oaks Dam)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
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1996
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2016
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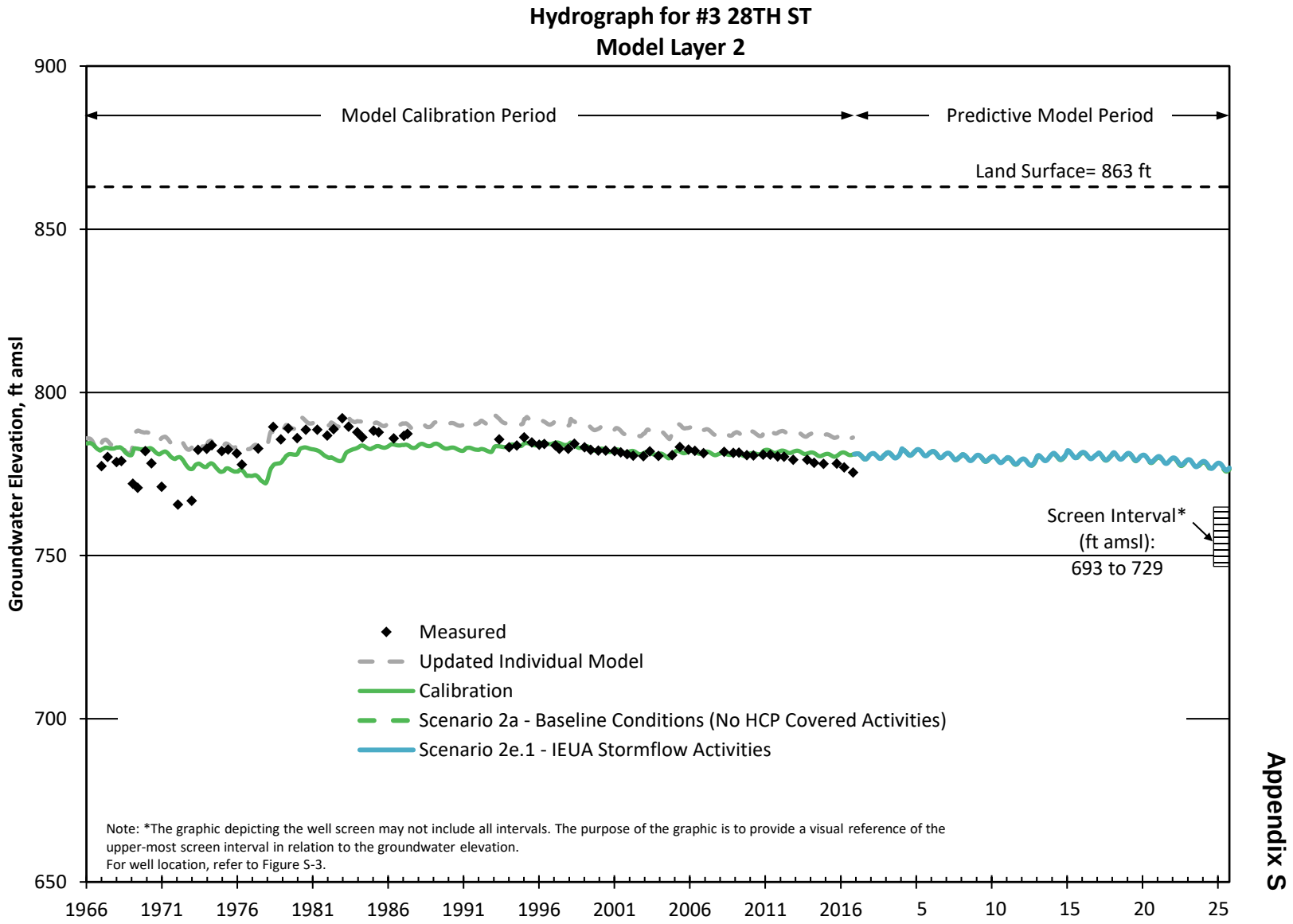
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
900
850
800
750
700
650
Groundwater Elevation, ft amsl
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.6 - Riverside North Aquifer Storage and Recovery Project (revised)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
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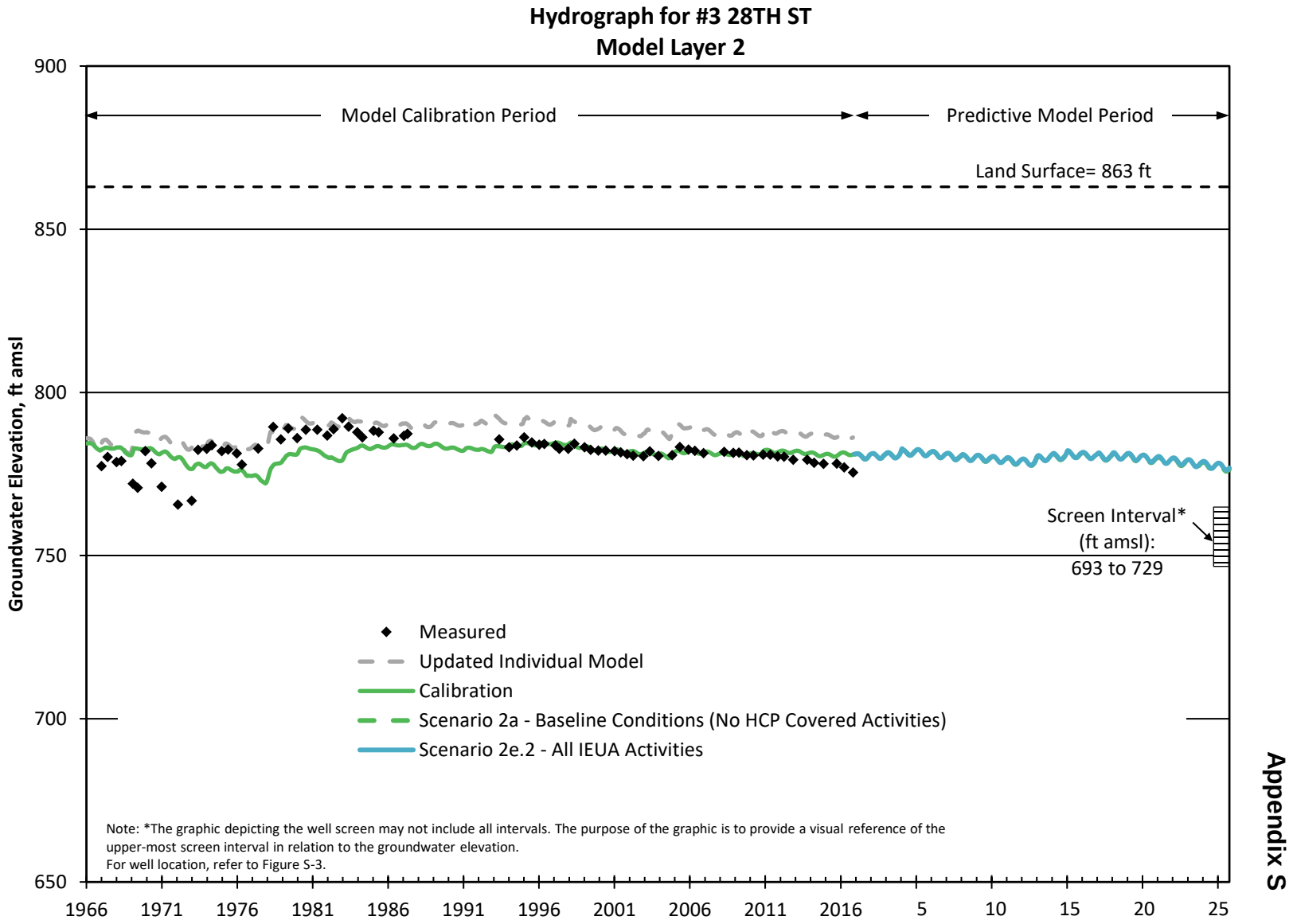
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
900
850
800
750
700
650
Groundwater Elevation, ft amsl
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.7 - Evaluation of Valley District Stormwater Capture Program at Prado Dam
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
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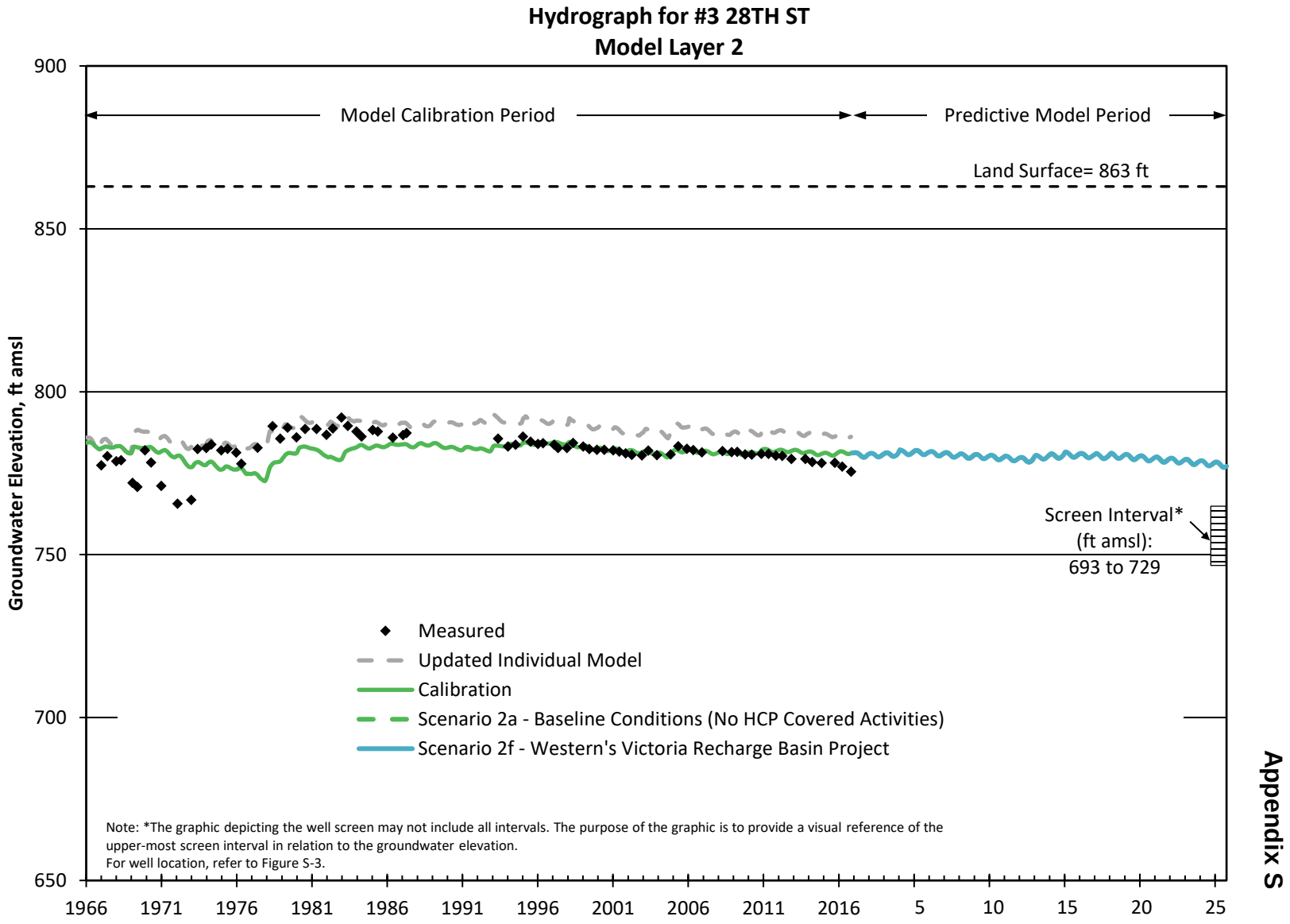
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2e.1 - IEUA Stormflow Activities
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
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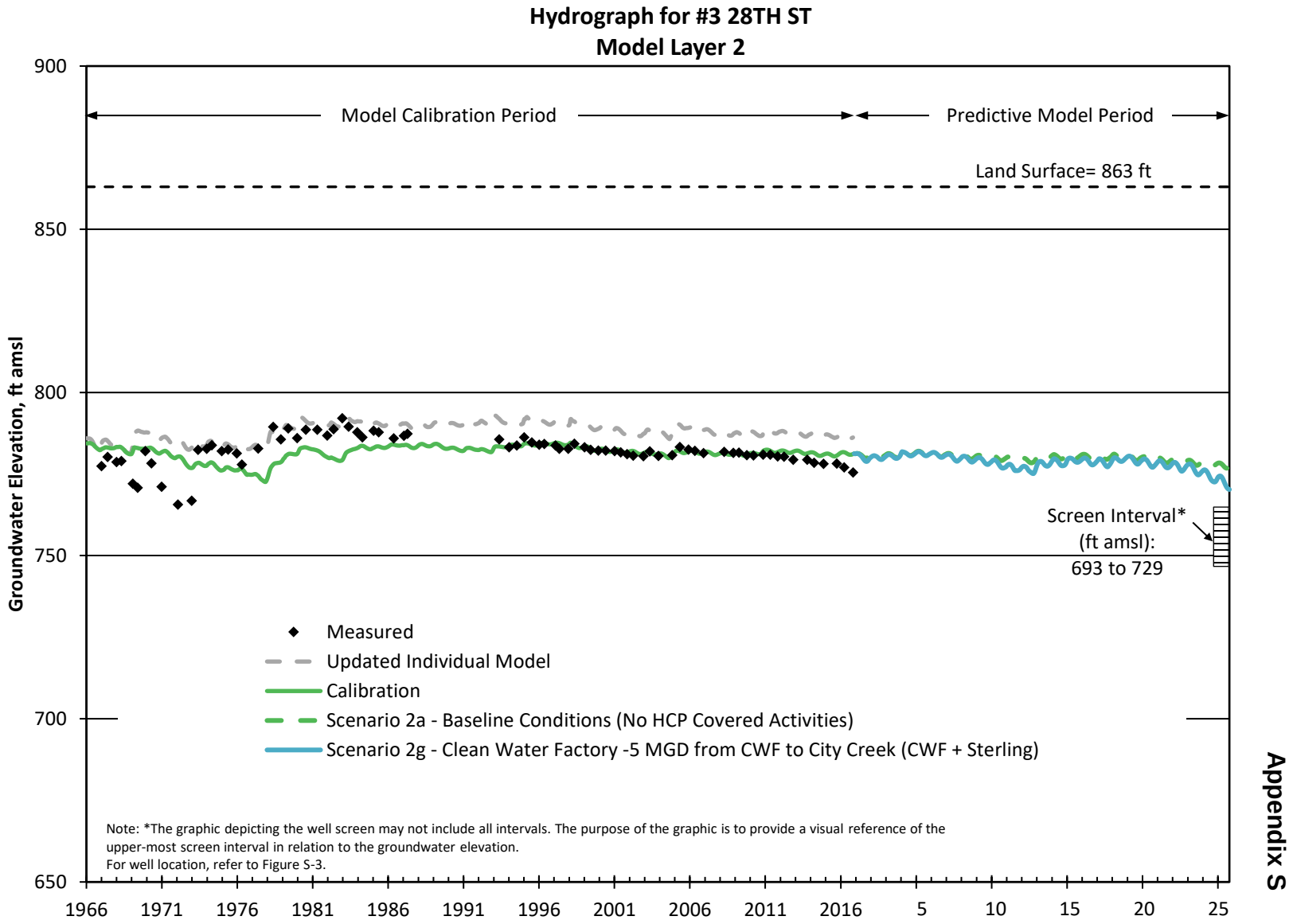
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2e.2 - All IEUA Activities
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
2001
2006
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2016
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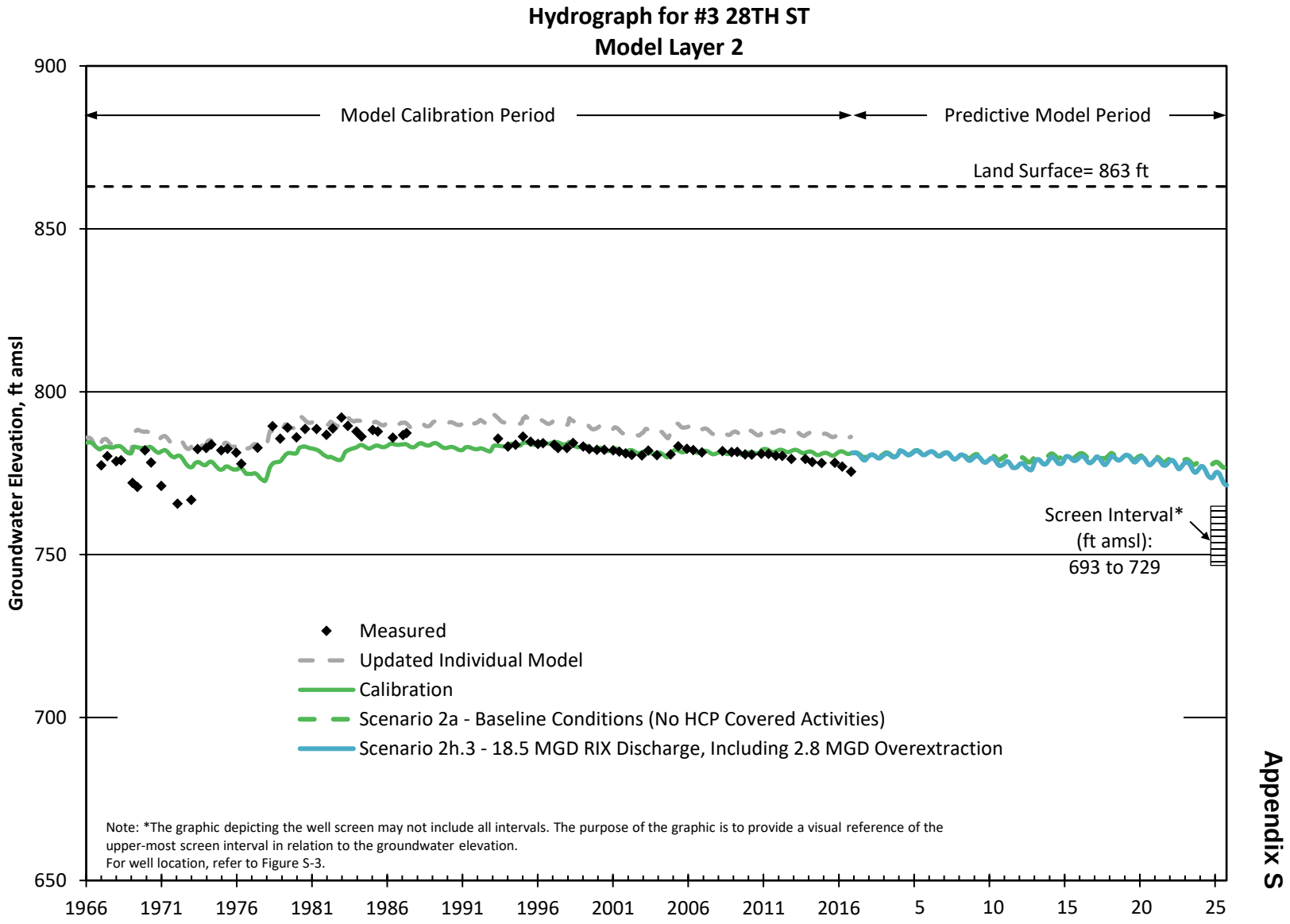
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2f - Western's Victoria Recharge Basin Project
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
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2016
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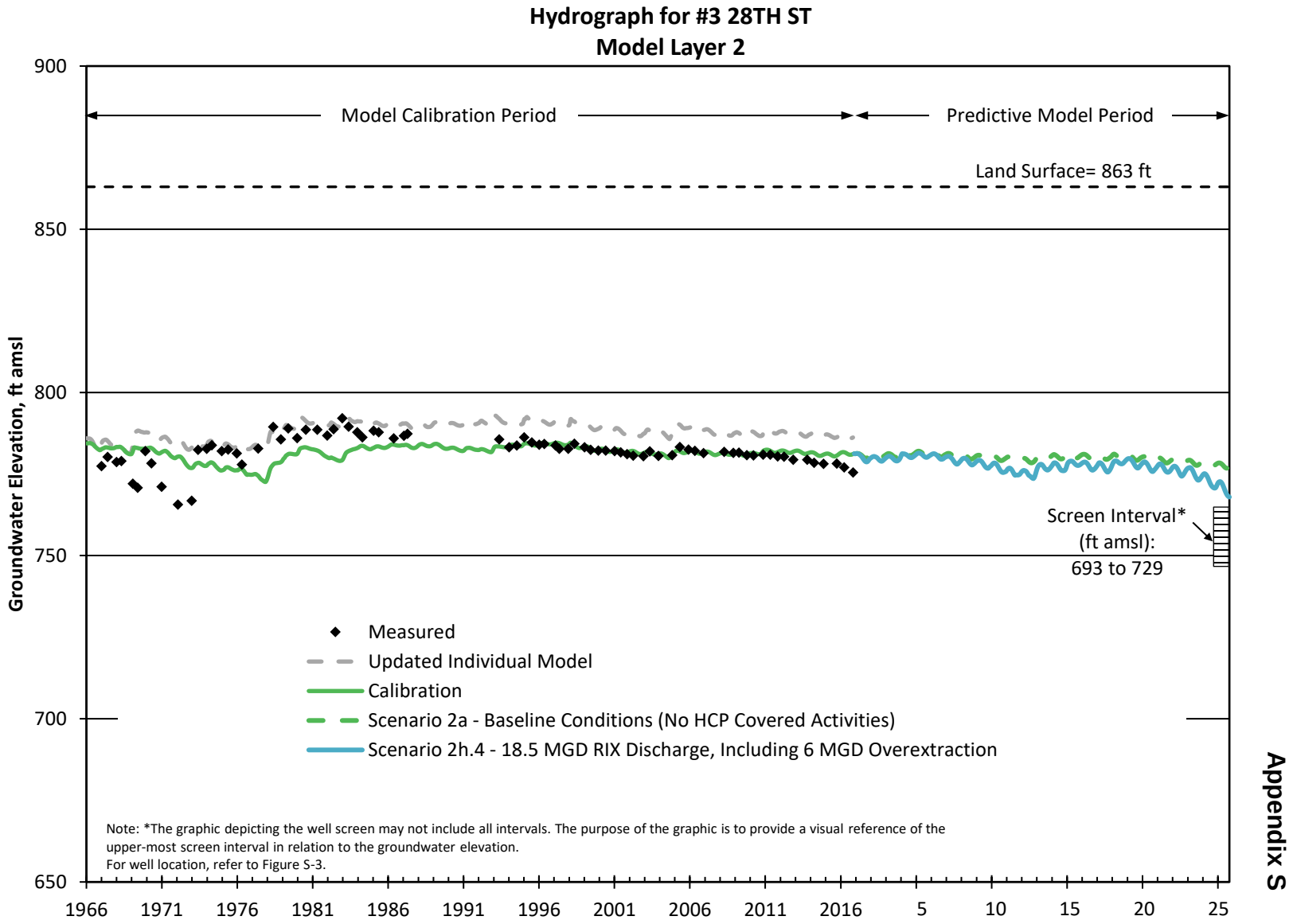
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2g - Clean Water Factory -5 MGD from CWF to City Creek (CWF + Sterling)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
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1996
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2006
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2016
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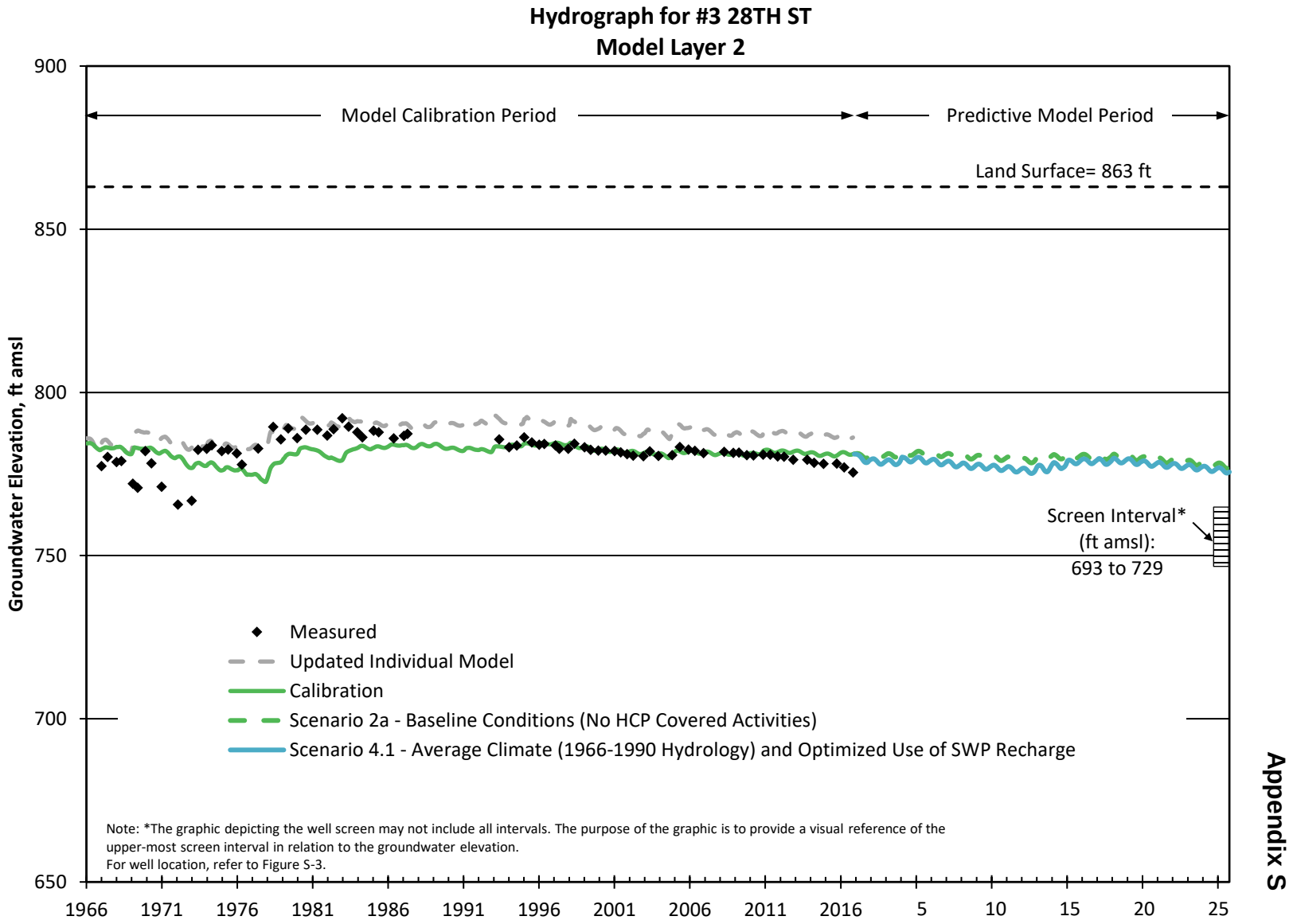
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2h.3 - 18.5 MGD RIX Discharge, Including 2.8 MGD Overextraction
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
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2006
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2016
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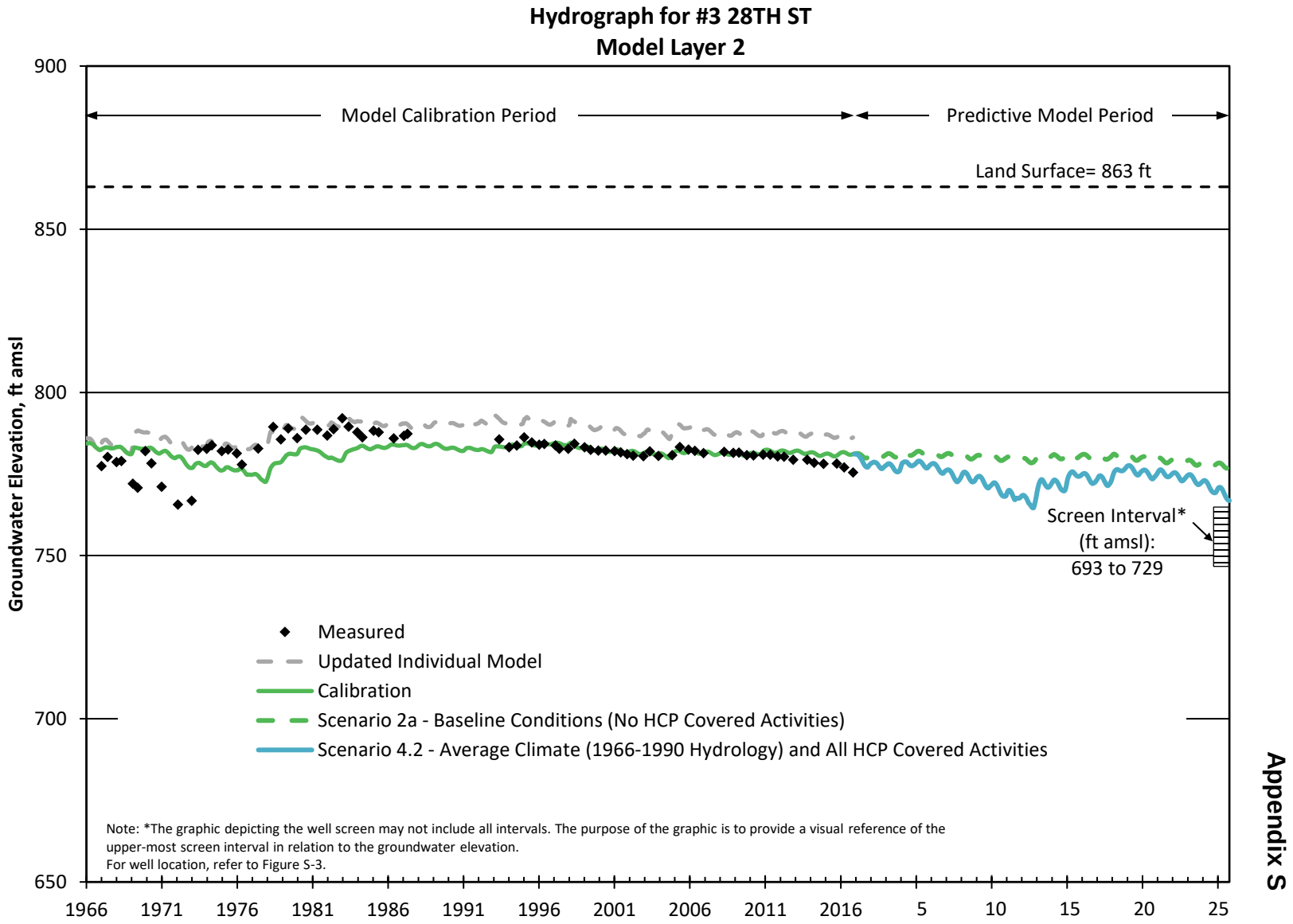
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Groundwater Elevation, ft amsl
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2h.4 - 18.5 MGD RIX Discharge, Including 6 MGD Overextraction
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.

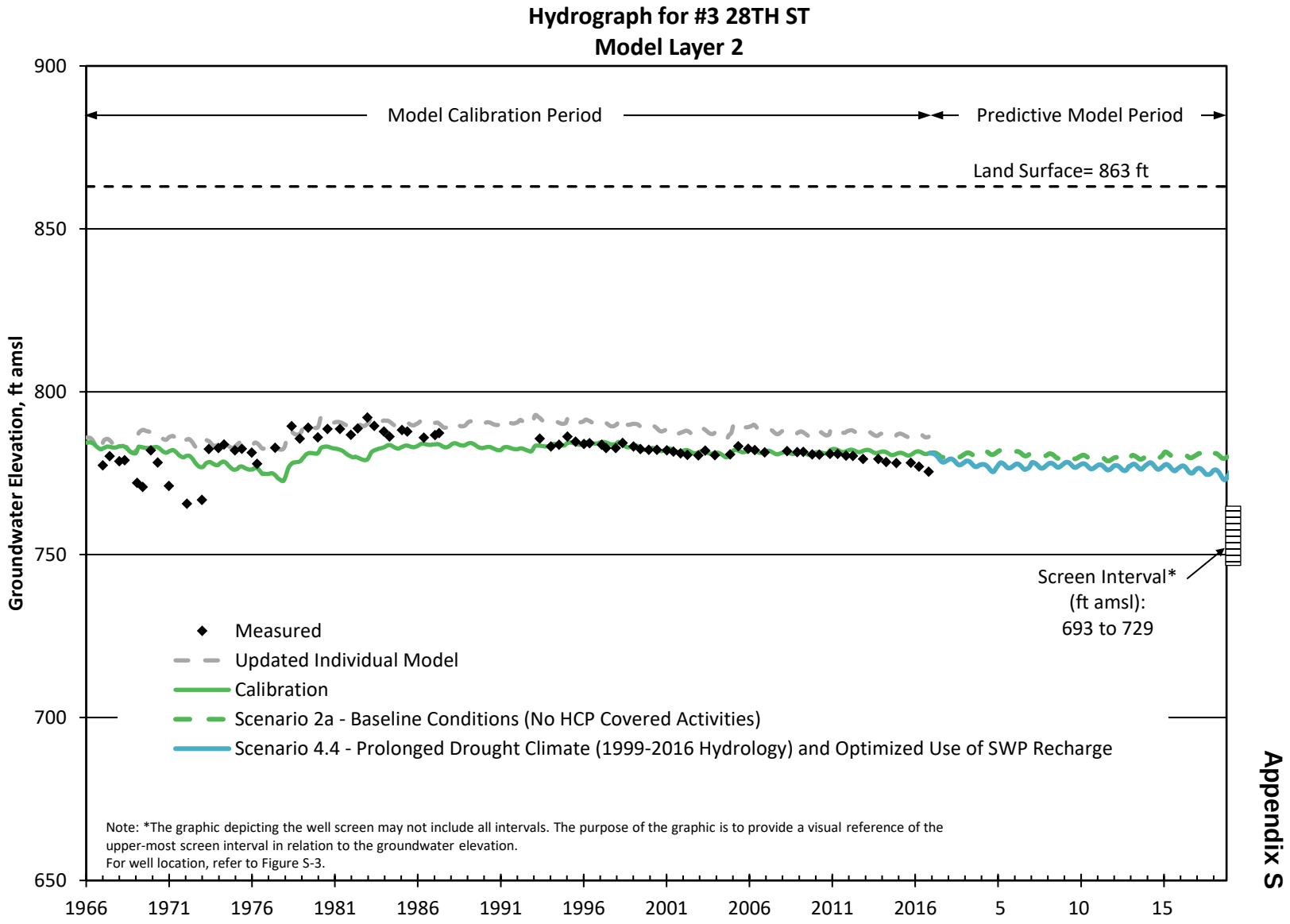
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.1 - Average Climate (1966-1990 Hydrology) and Optimized Use of SWP Recharge
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
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25

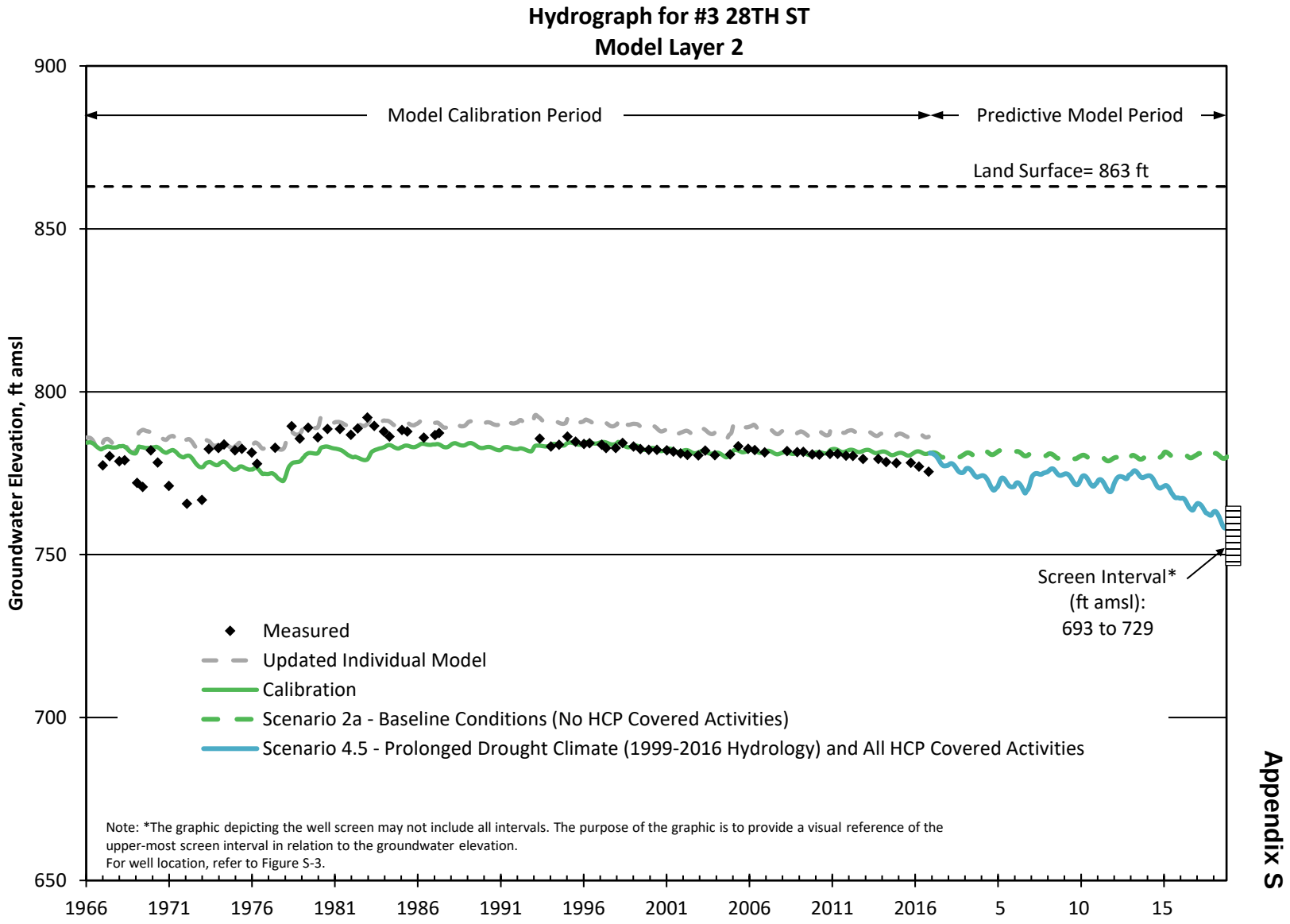
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.2 - Average Climate (1966-1990 Hydrology) and All HCP Covered Activities
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
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2006
2011
2016
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10
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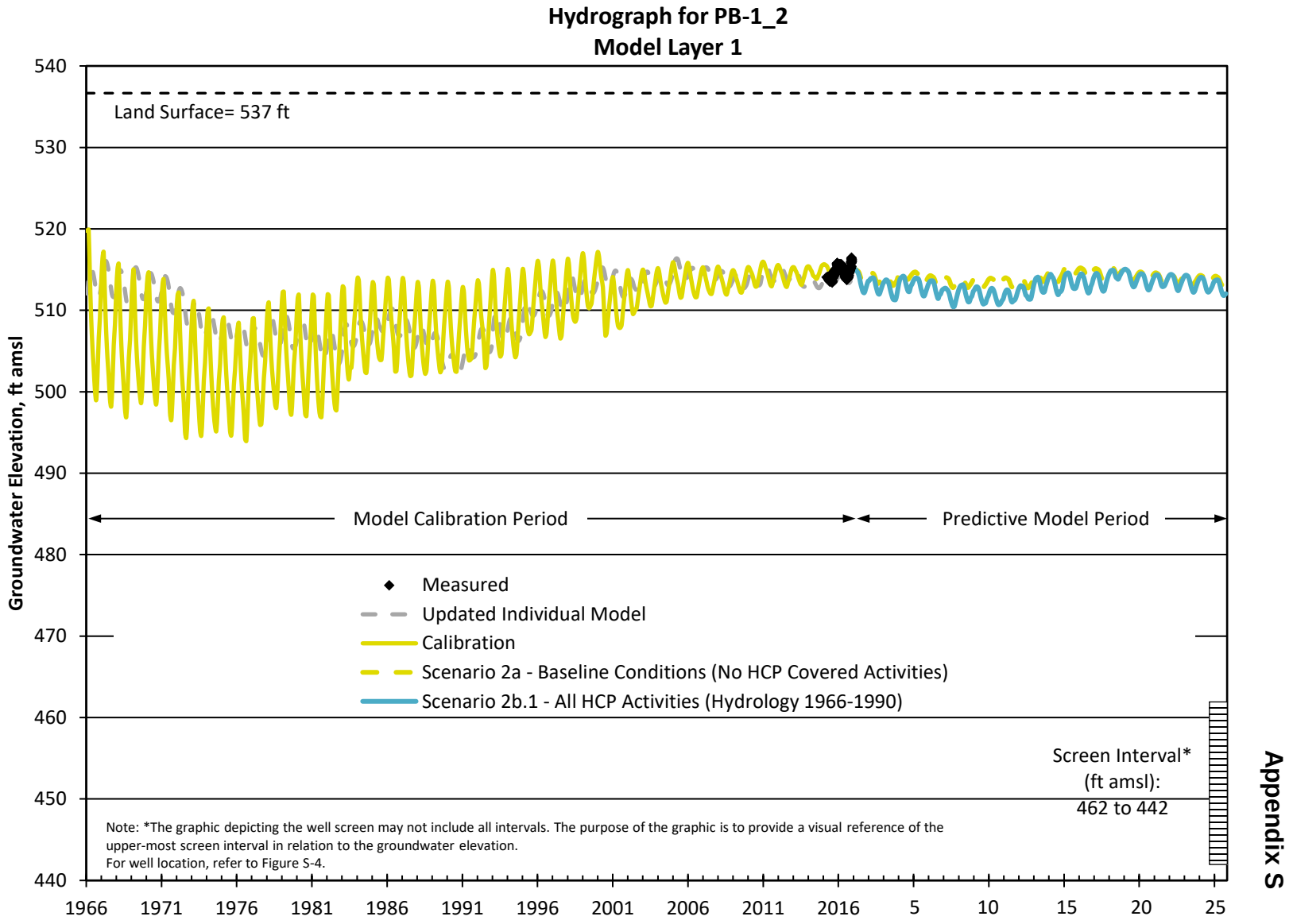
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
Groundwater Elevation, ft amsl
900
850
800
750
700
650
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.4 - Prolonged Drought Climate (1999-2016 Hydrology) and Optimized Use of SWP Recharge
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.

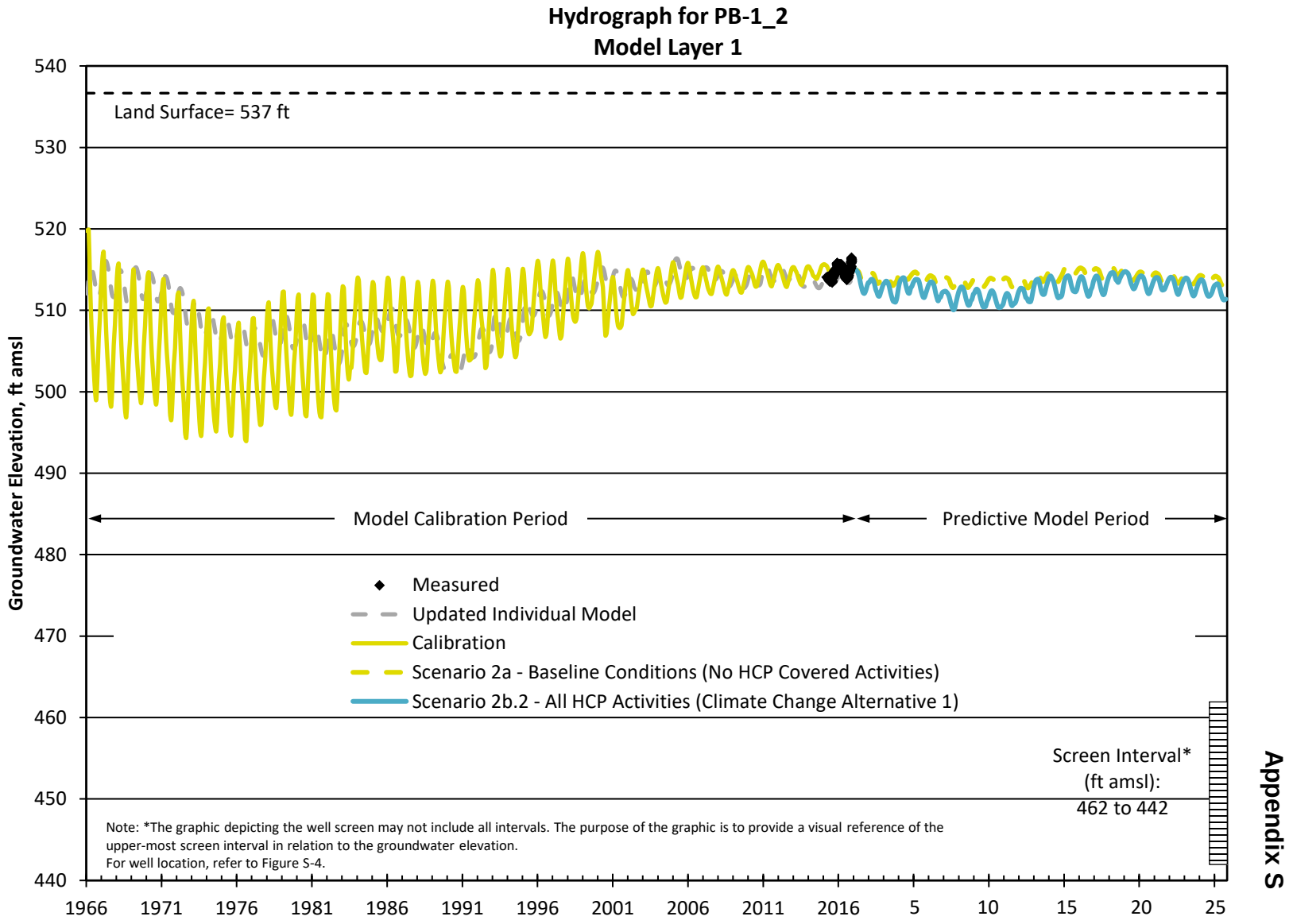
Appendix S


Hydrograph for #3 28TH ST
Model Layer 2
900
850
800
750
700
650
Groundwater Elevation, ft amsl
Model Calibration Period
Predictive Model Period
Land Surface= 863 ft
Screen Interval*
(ft amsl):
693 to 729
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.5 - Prolonged Drought Climate (1999-2016 Hydrology) and All HCP Covered Activities
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-3.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15

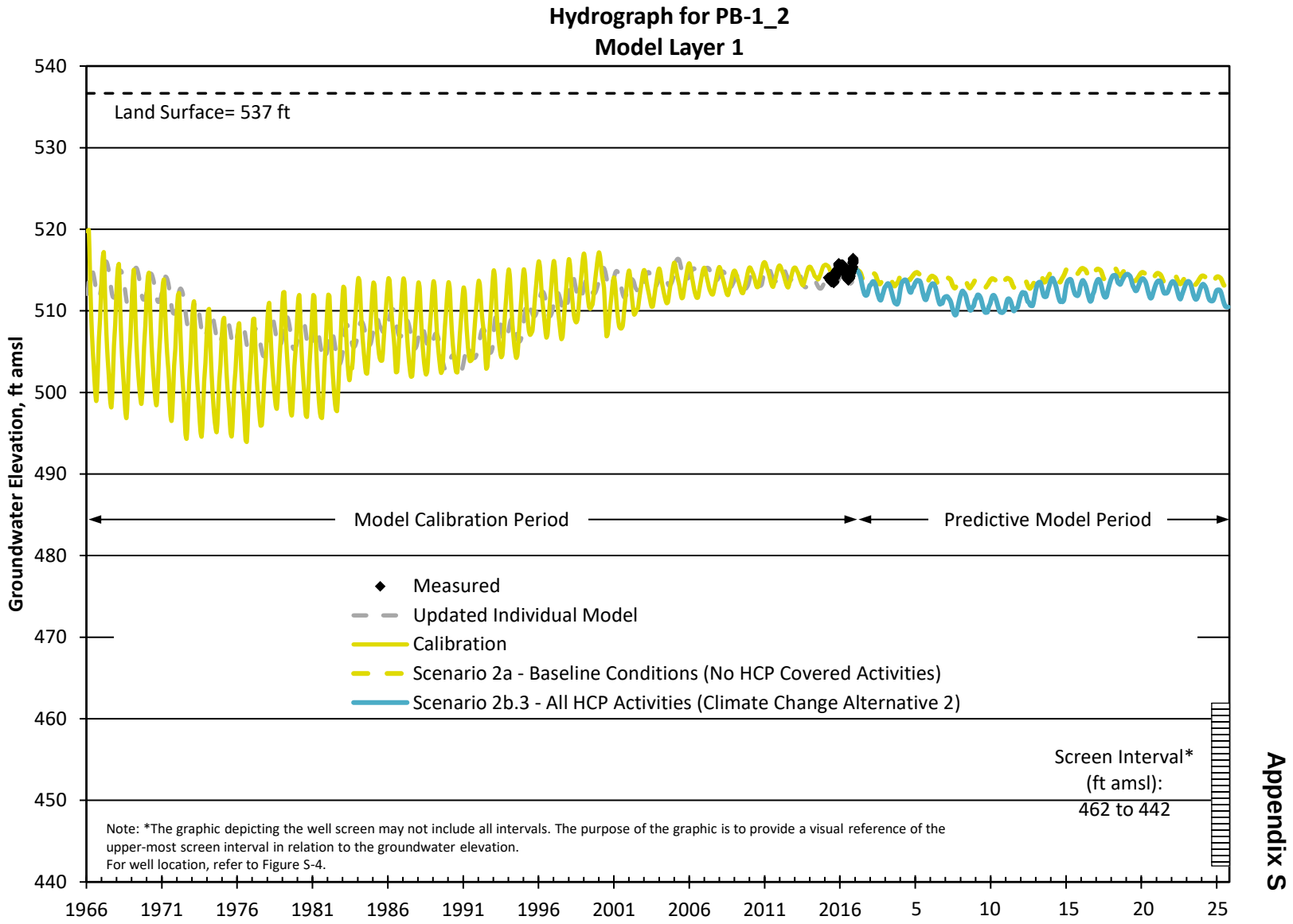
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.1 - All HCP Activities (Hydrology 1966-1990)
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
540
530
520
510
500
490
480
470
460
450
440
1966
1971
1976
1981
1986
1991
1996
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2006
2011
2016
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25

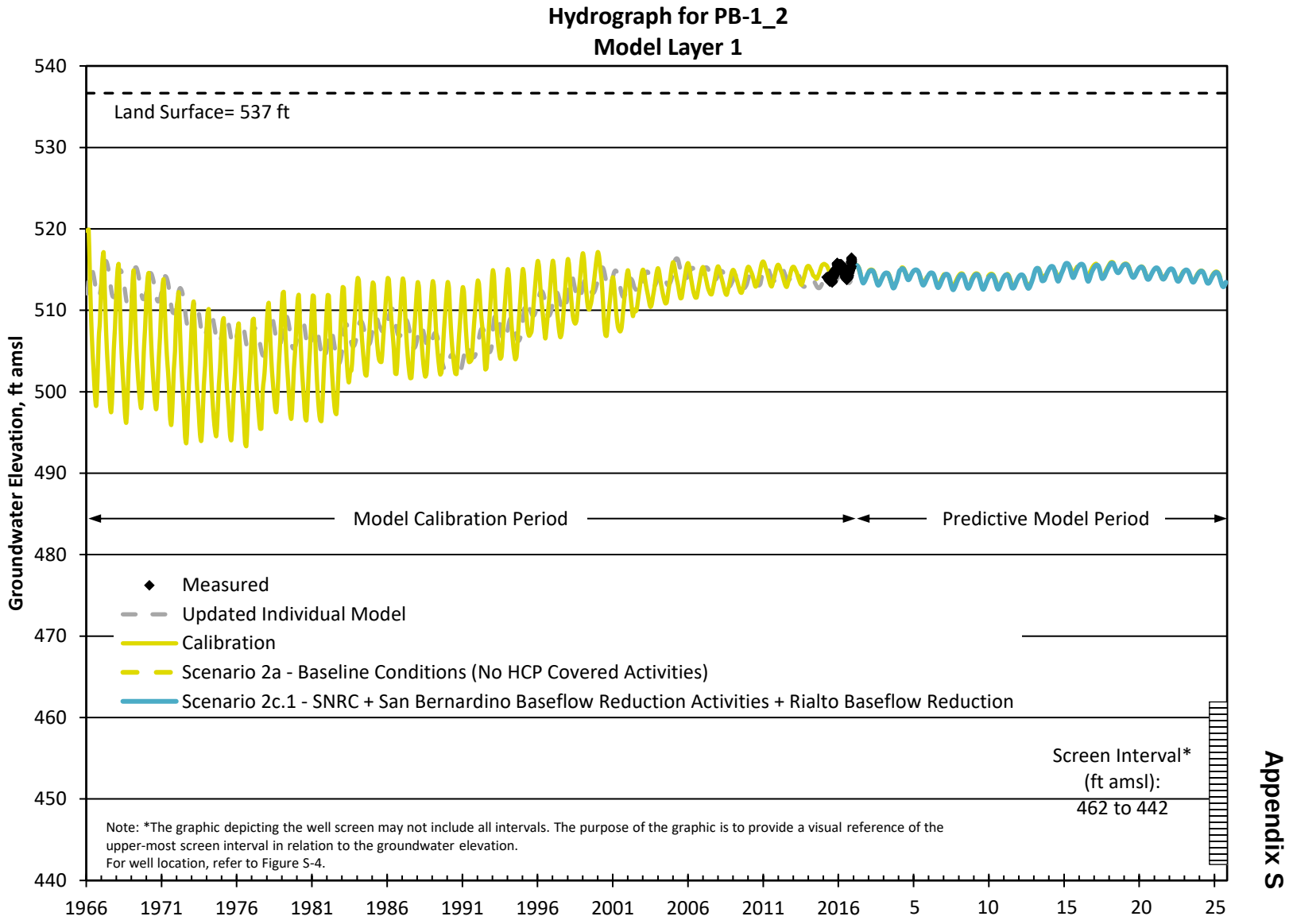
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.2 - All HCP Activities (Climate Change Alternative 1)
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
540
530
520
510
500
490
480
470
460
450
440
1966
1971
1976
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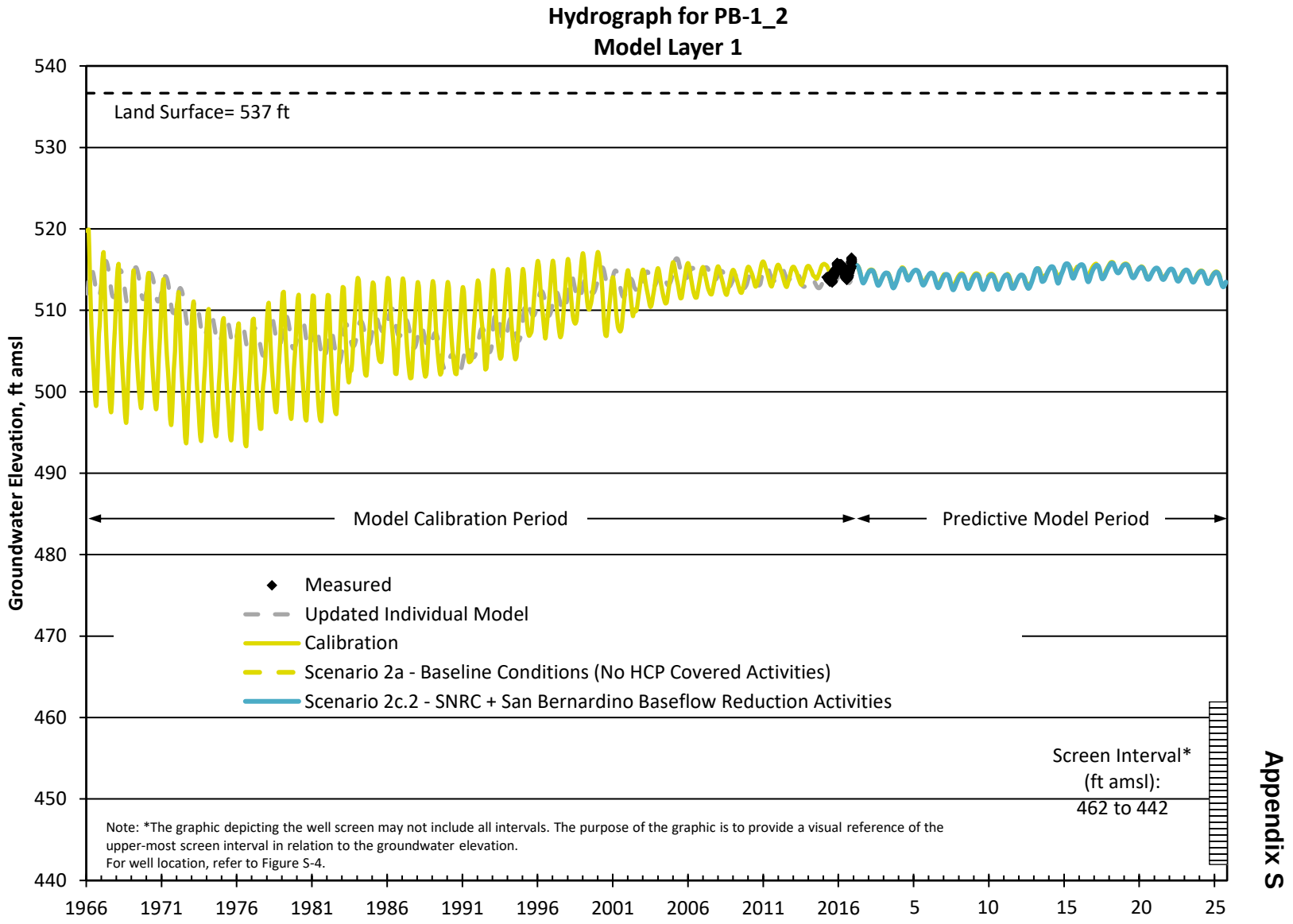
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.3 - All HCP Activities (Climate Change Alternative 2)
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
540
530
520
510
500
490
480
470
460
450
440
1966
1971
1976
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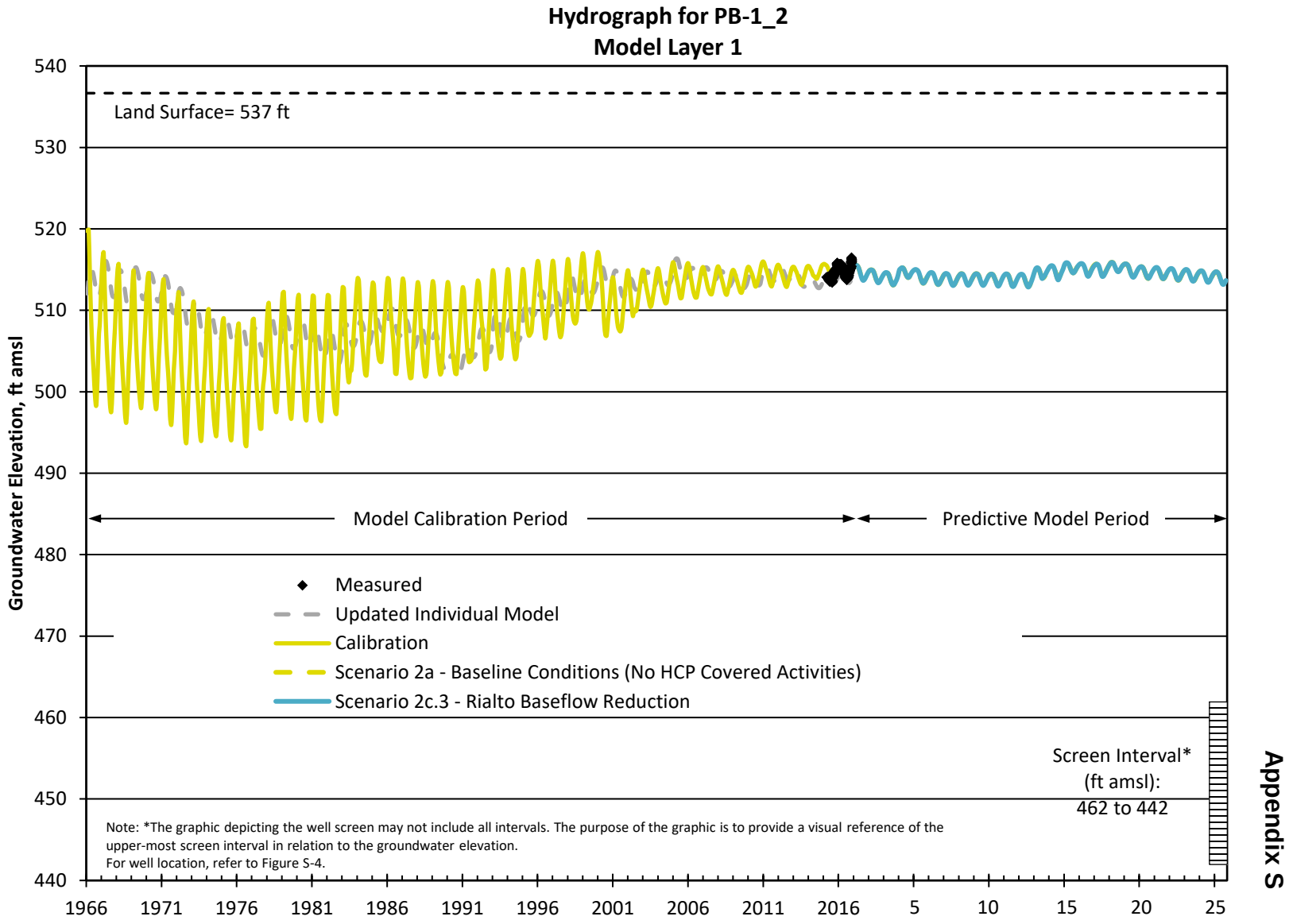
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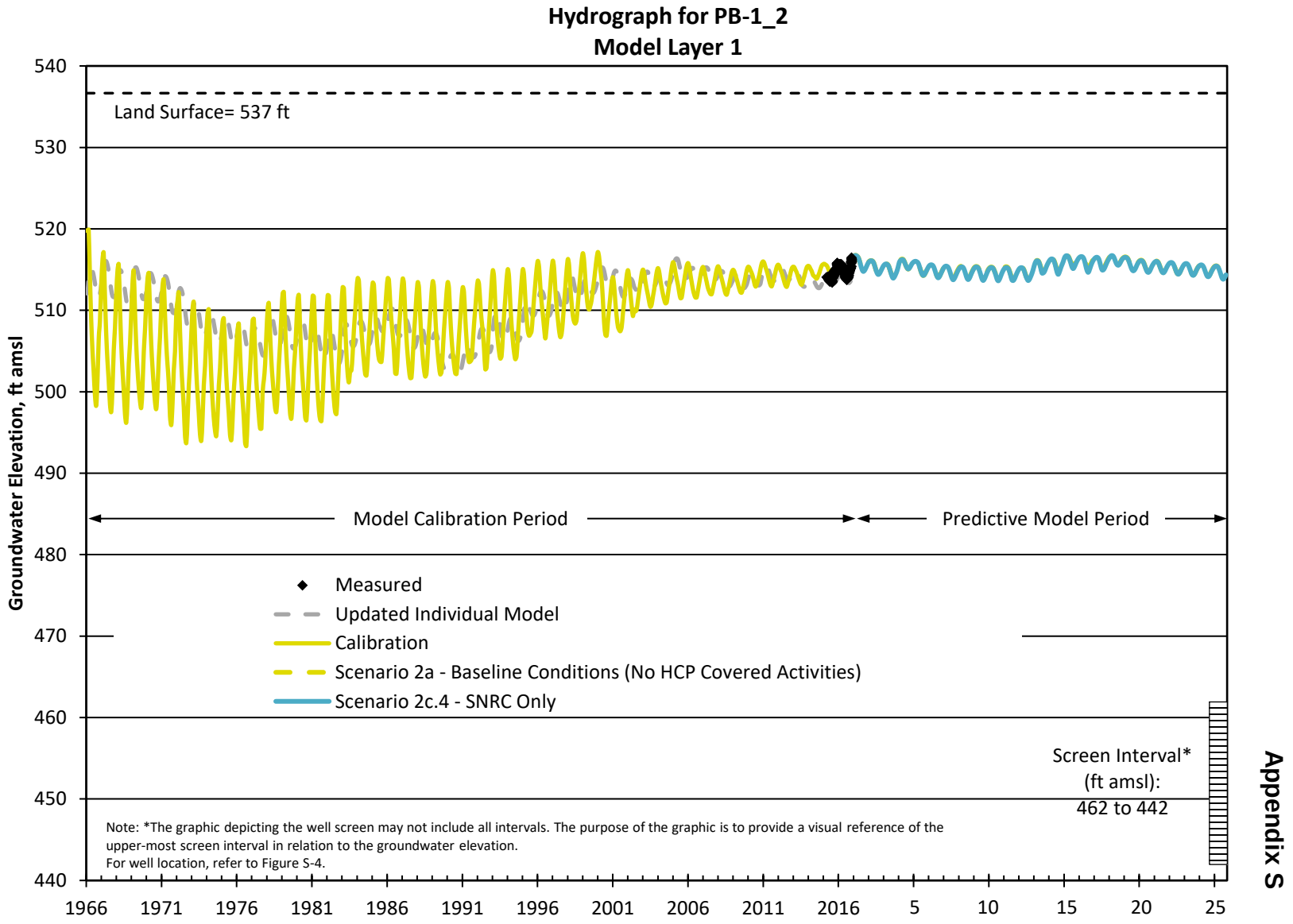

Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.1 - SNRC + San Bernardino Baseflow Reduction Activities + Rialto Baseflow Reduction
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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Appendix S

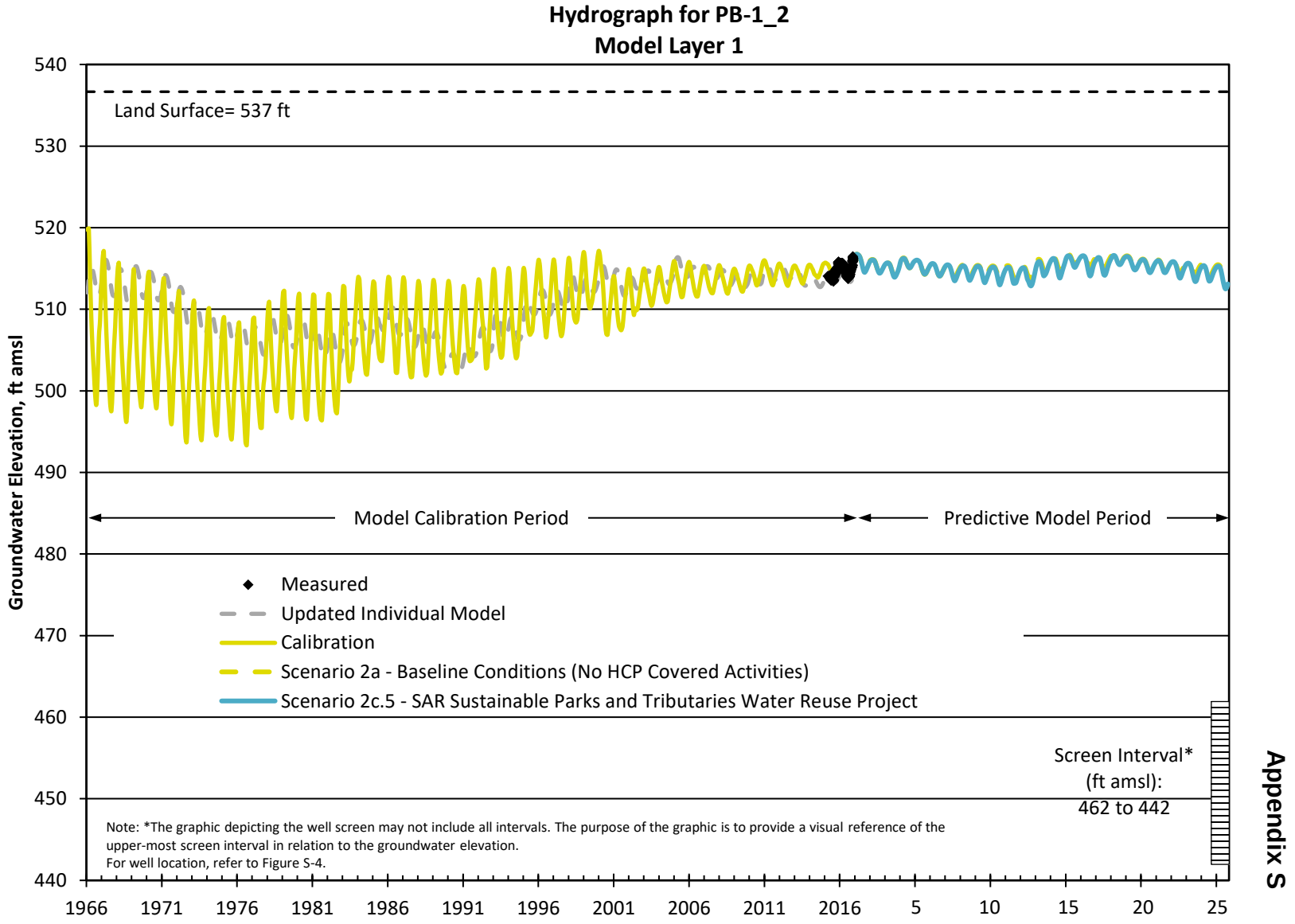

Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.2 - SNRC + San Bernardino Baseflow Reduction Activities
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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Appendix S

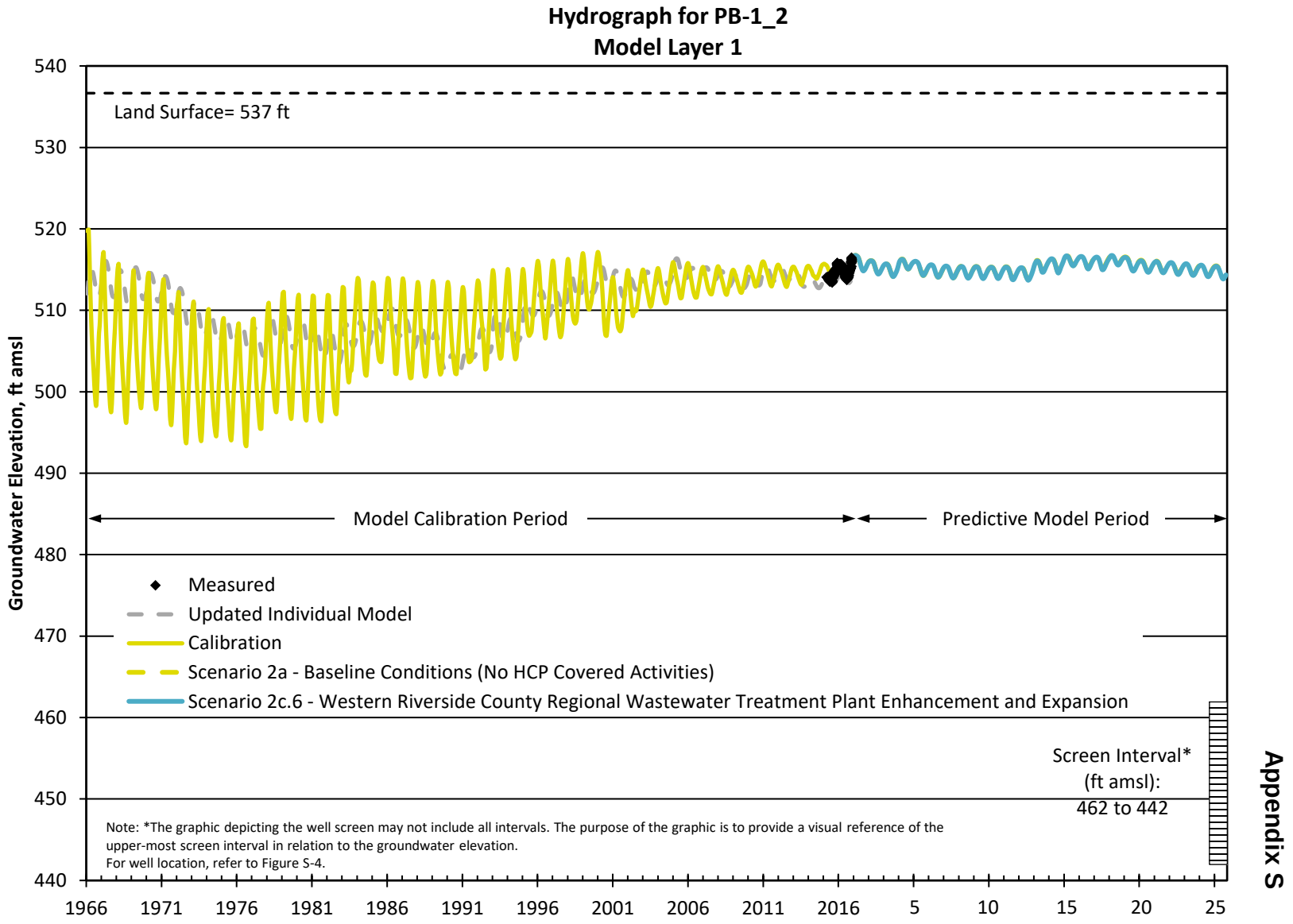

Hydrograph for PB-1_2
Model Layer 1
Land Surface= 537 ft
Groundwater Elevation, ft amsl
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.3 - Rialto Baseflow Reduction
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.4 - SNRC Only
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
1976
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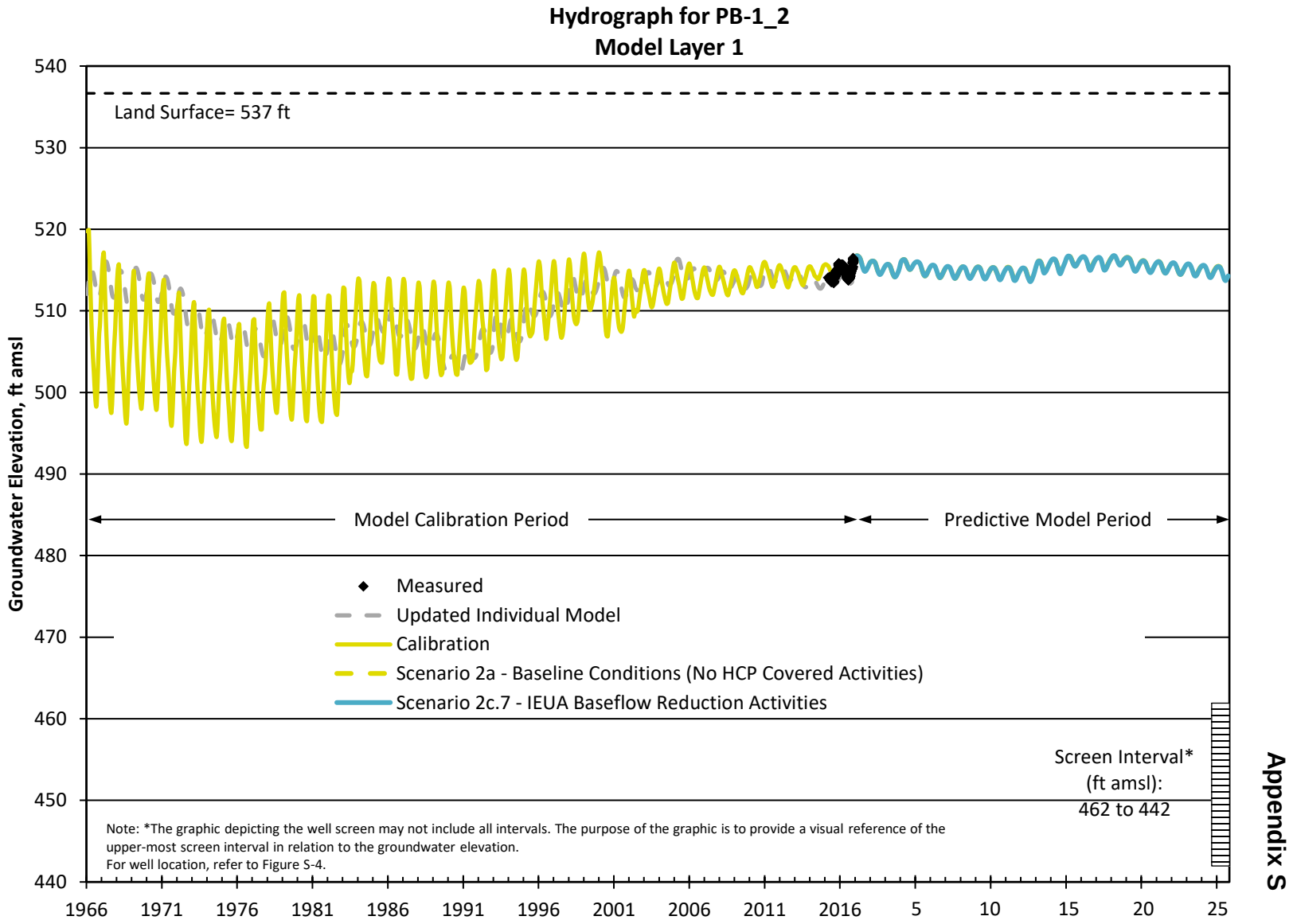
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.5 - SAR Sustainable Parks and Tributaries Water Reuse Project
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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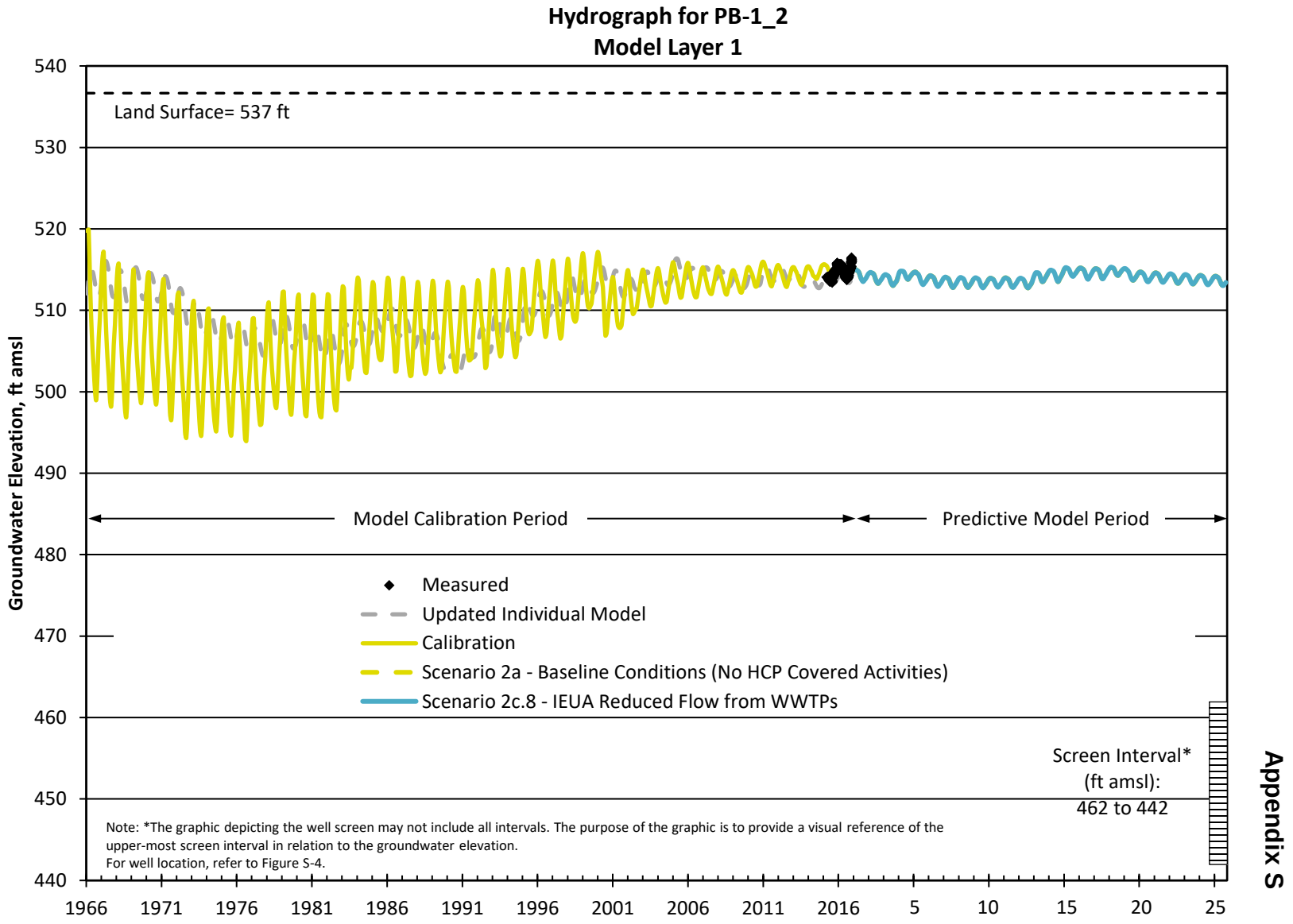
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.6 - Western Riverside County Regional Wastewater Treatment Plant Enhancement and Expansion
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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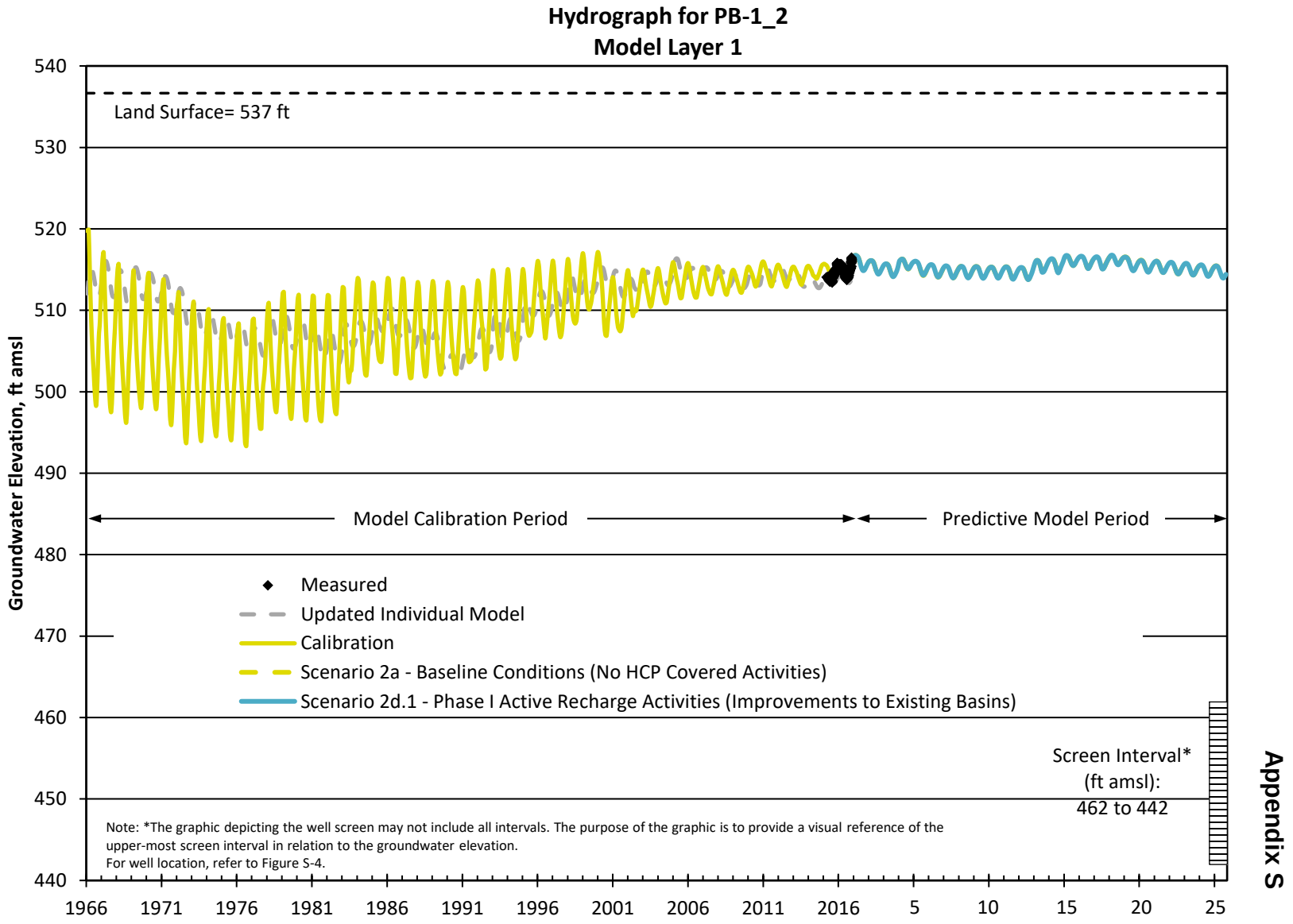
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.7 - IEUA Baseflow Reduction Activities
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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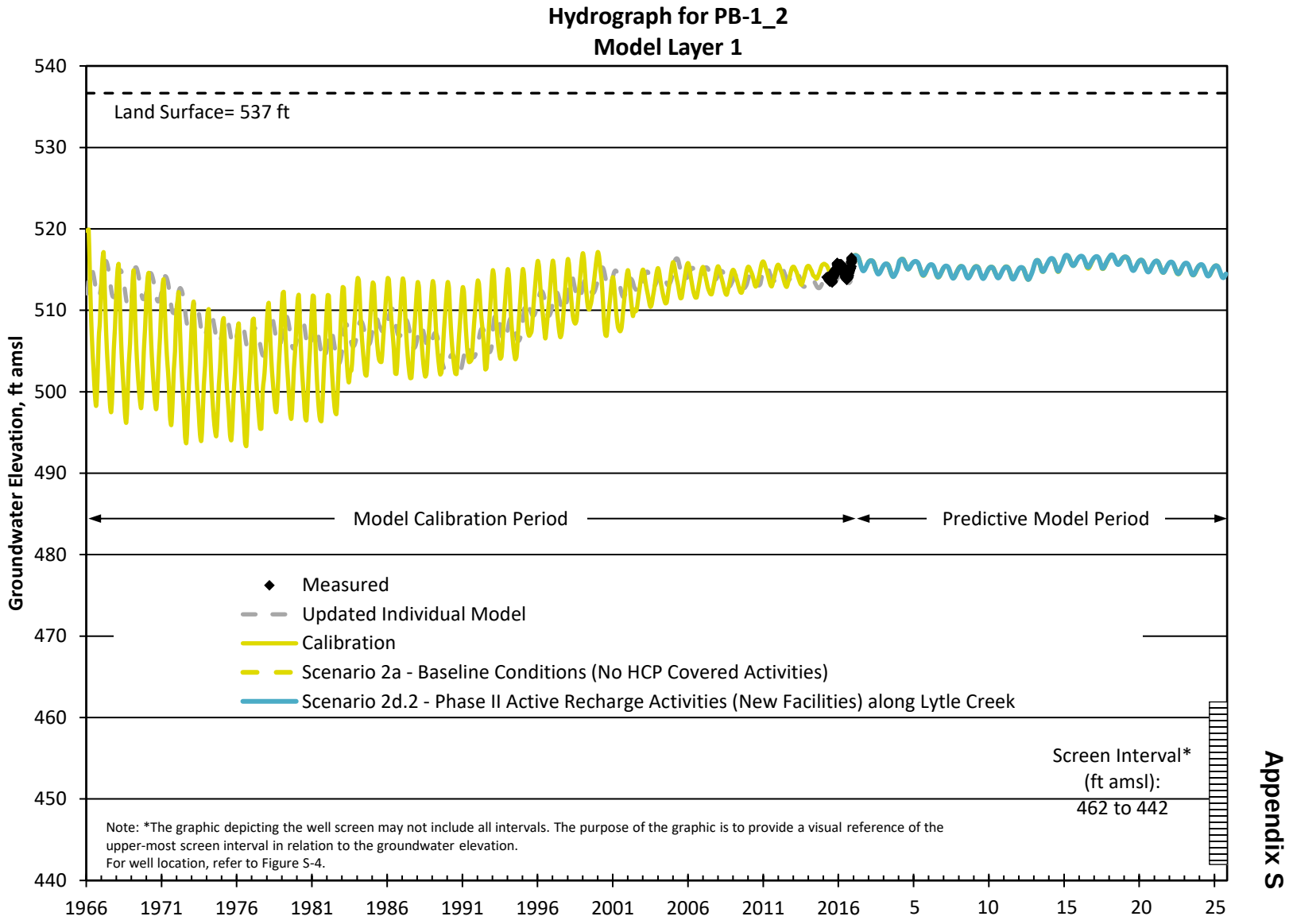
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.8 - IEUA Reduced Flow from WWTPs
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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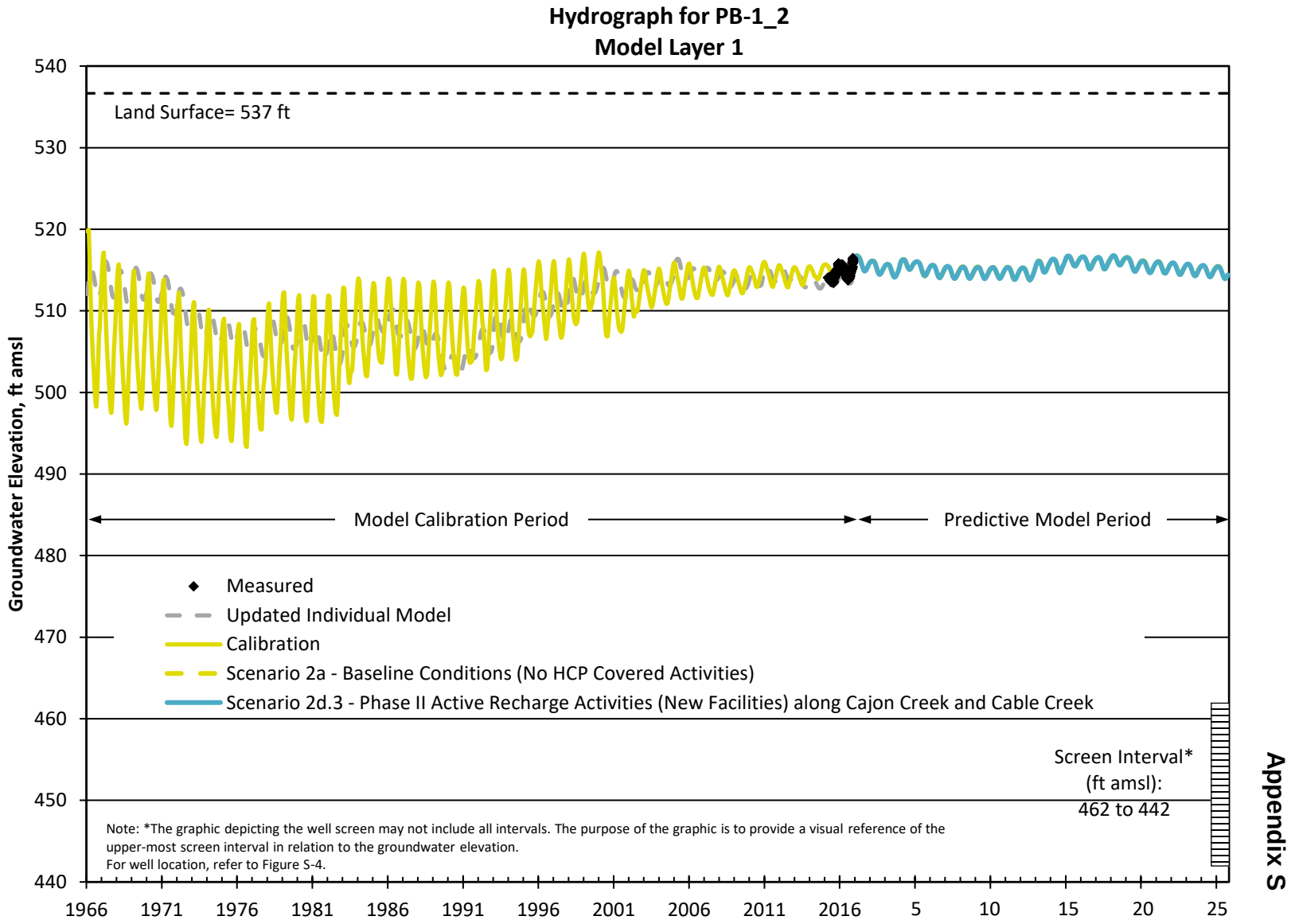
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.1 - Phase I Active Recharge Activities (Improvements to Existing Basins)
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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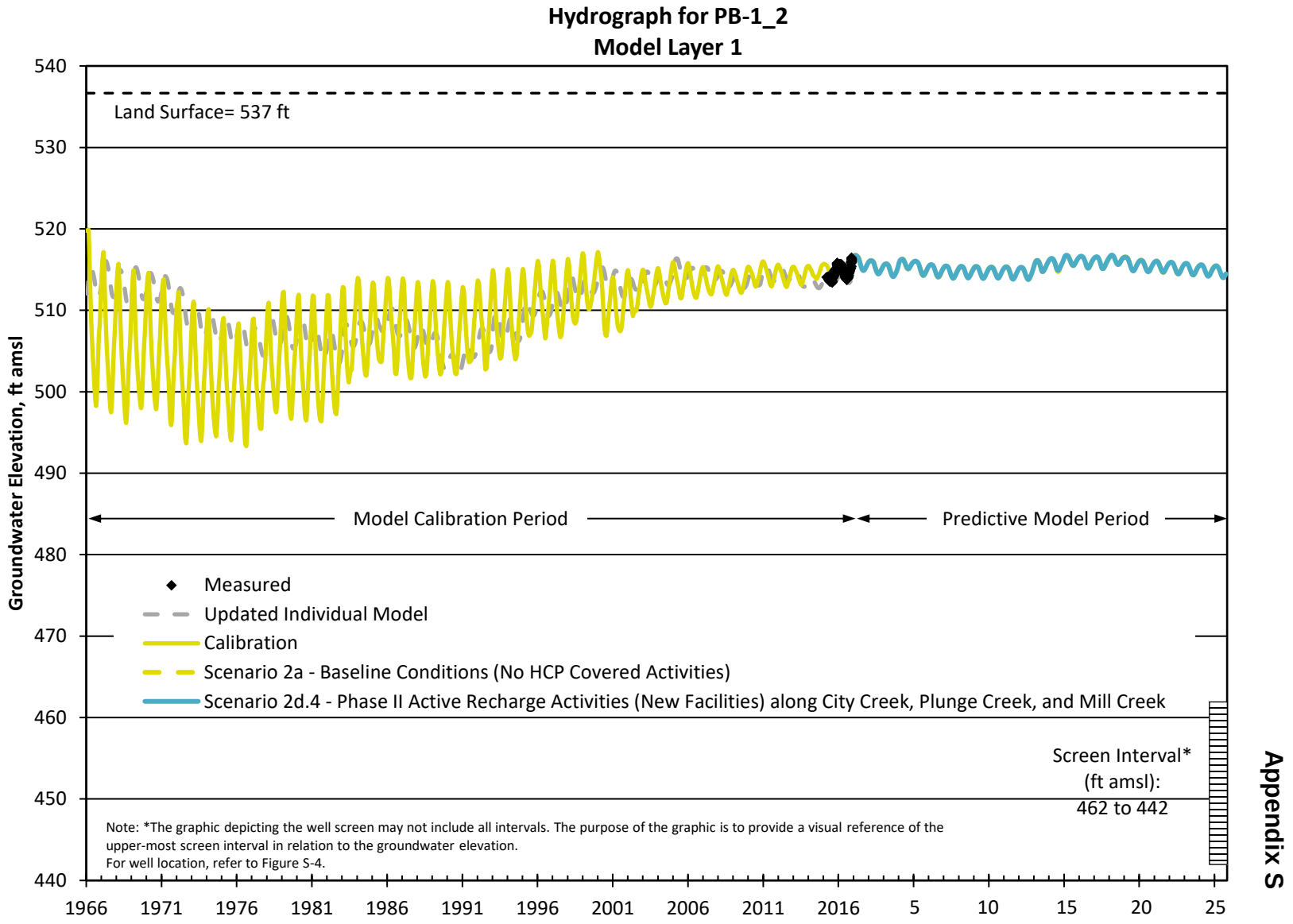
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.2 - Phase II Active Recharge Activities (New Facilities) along Lytle Creek
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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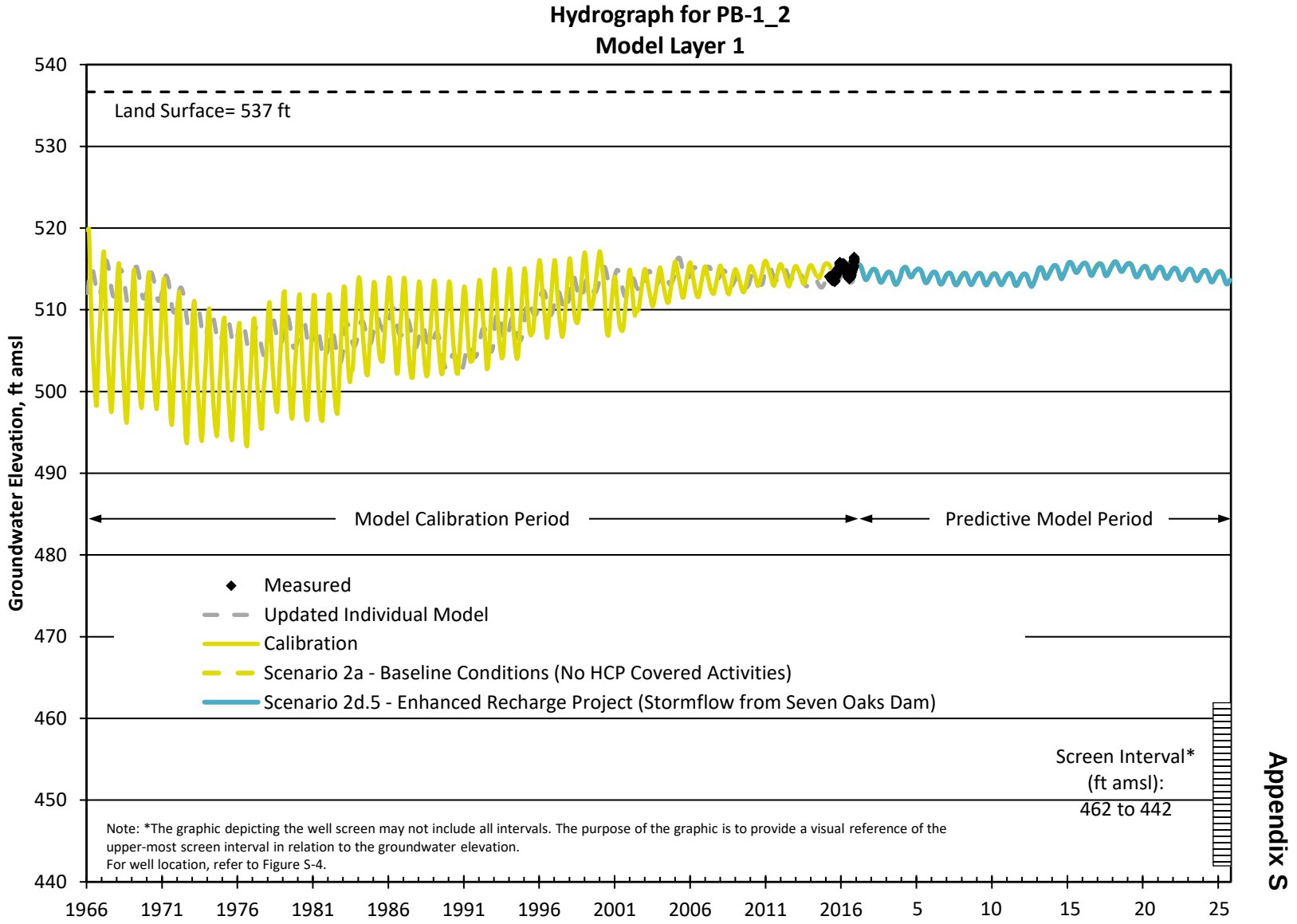
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.3 - Phase II Active Recharge Activities (New Facilities) along Cajon Creek and Cable Creek
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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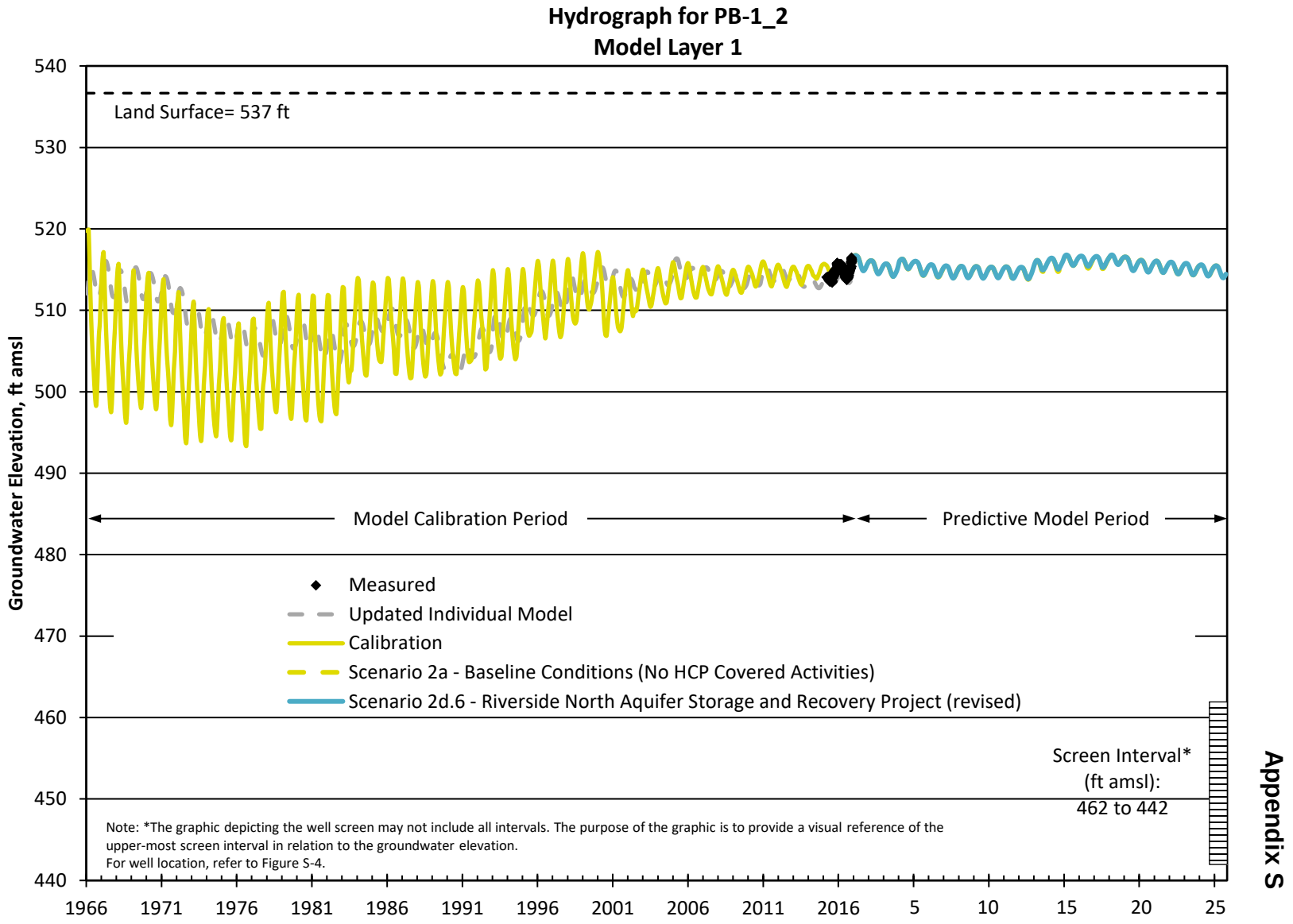
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.4 - Phase II Active Recharge Activities (New Facilities) along City Creek, Plunge Creek, and Mill Creek
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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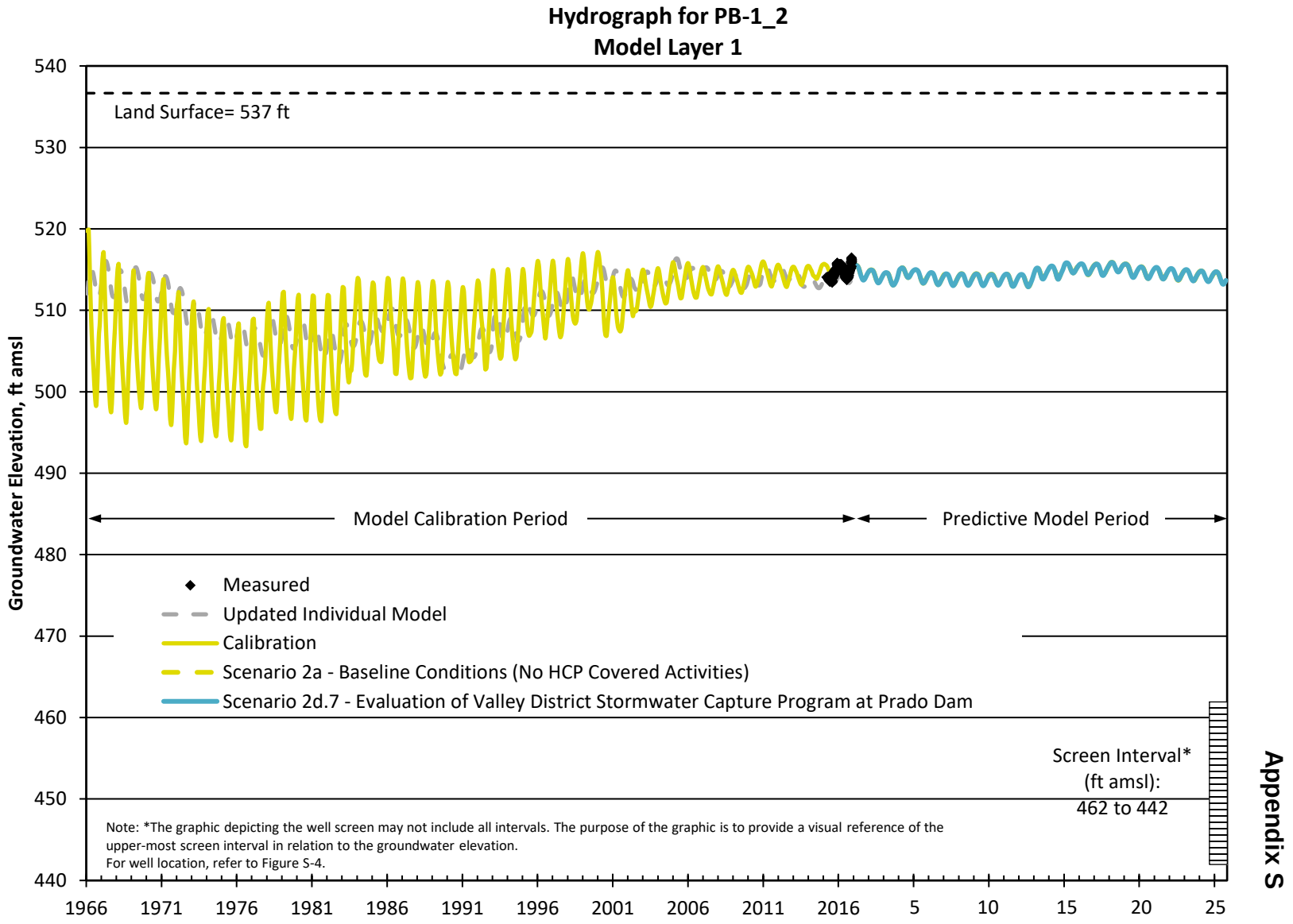
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.5 - Enhanced Recharge Project (Stormflow from Seven Oaks Dam)
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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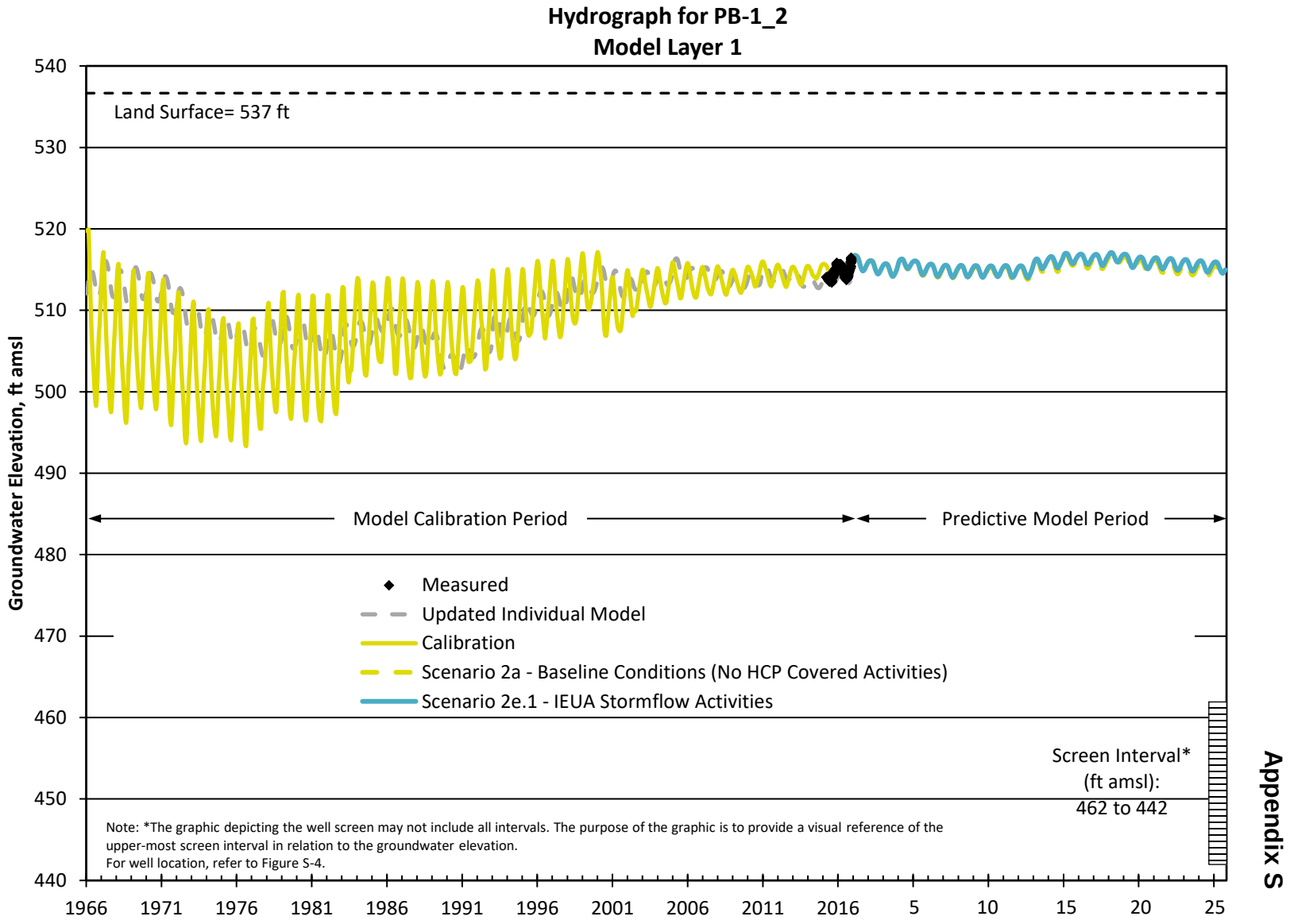
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.6 - Riverside North Aquifer Storage and Recovery Project (revised)
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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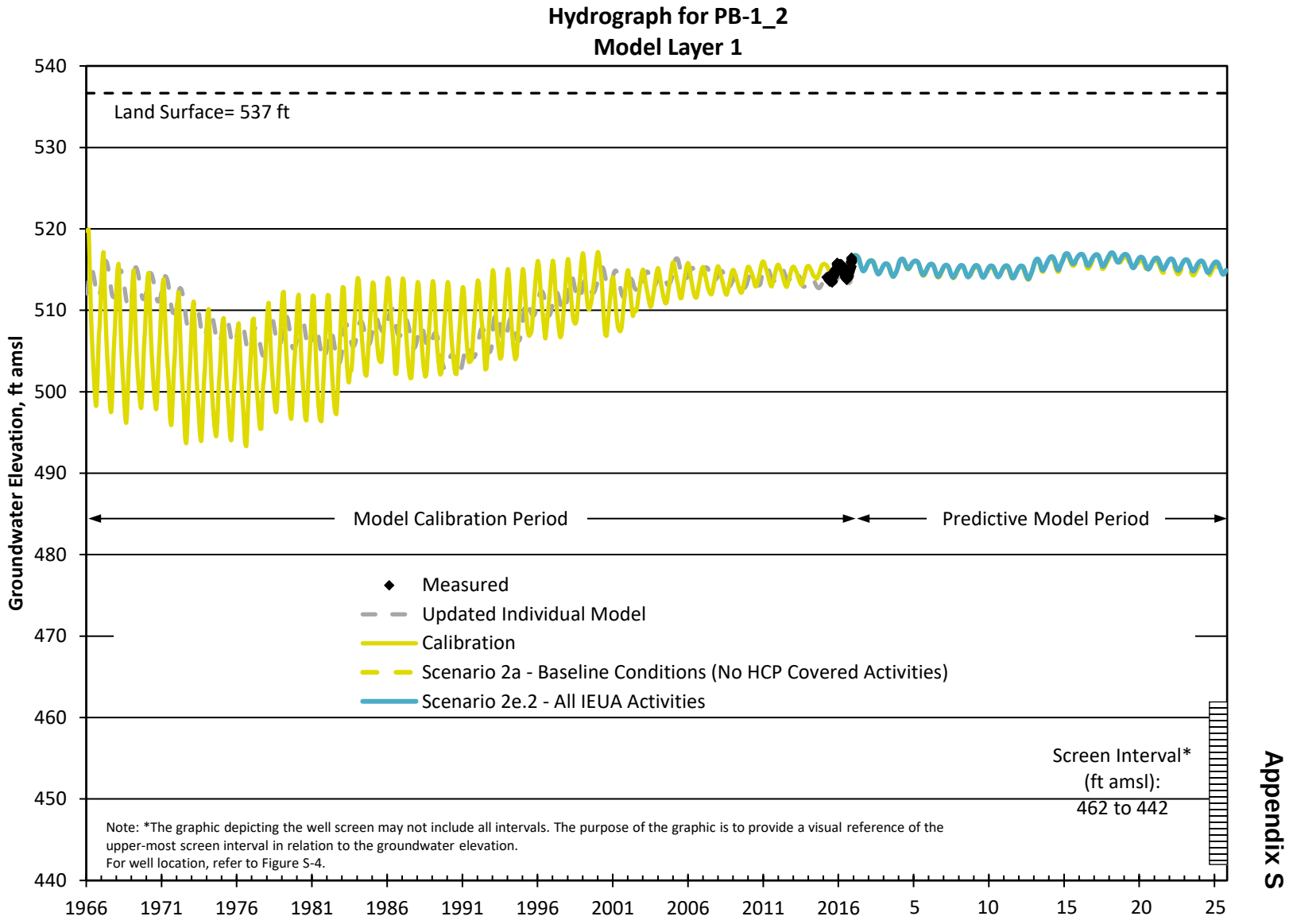
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.7 - Evaluation of Valley District Stormwater Capture Program at Prado Dam
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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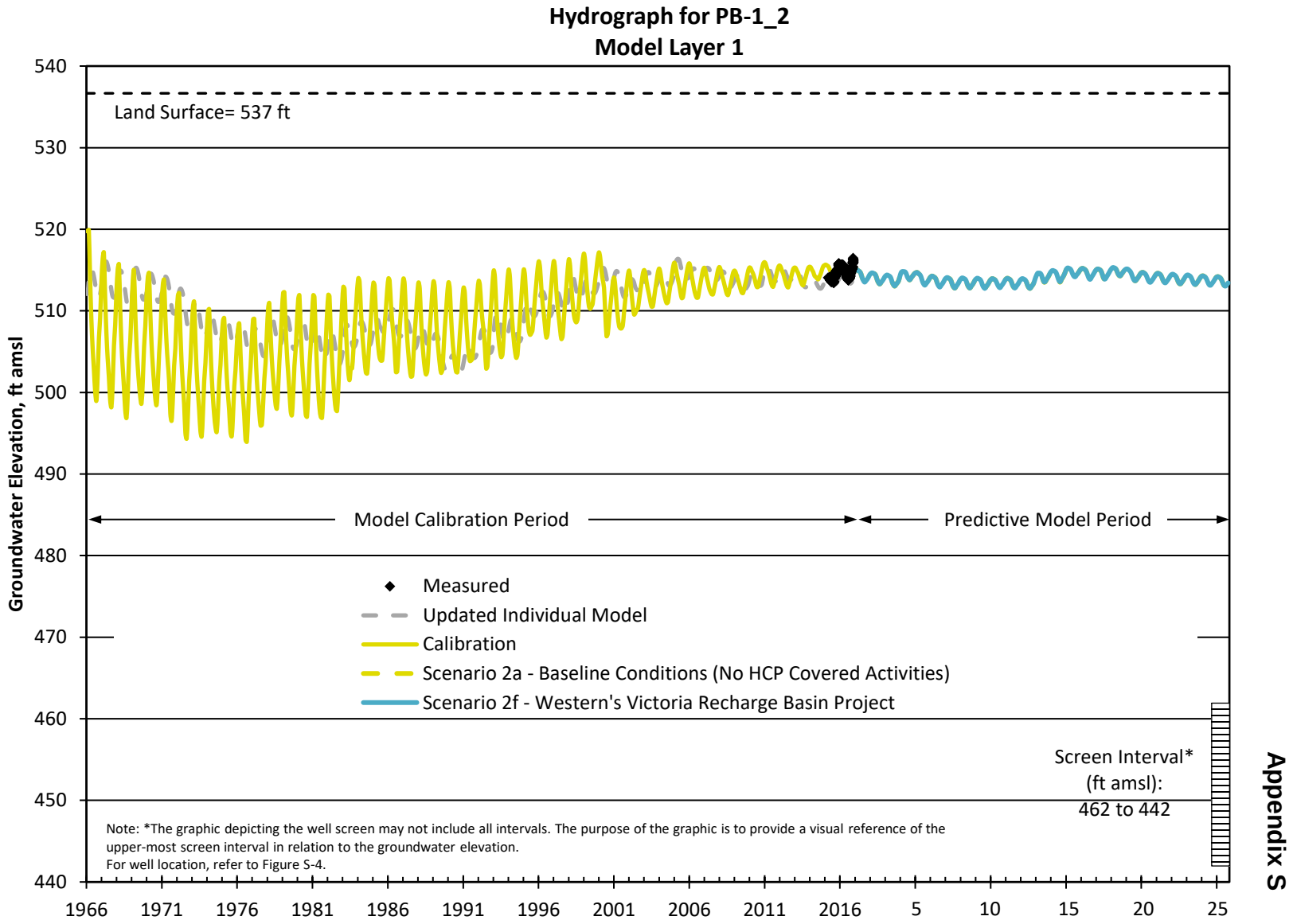
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2e.1 - IEUA Stormflow Activities
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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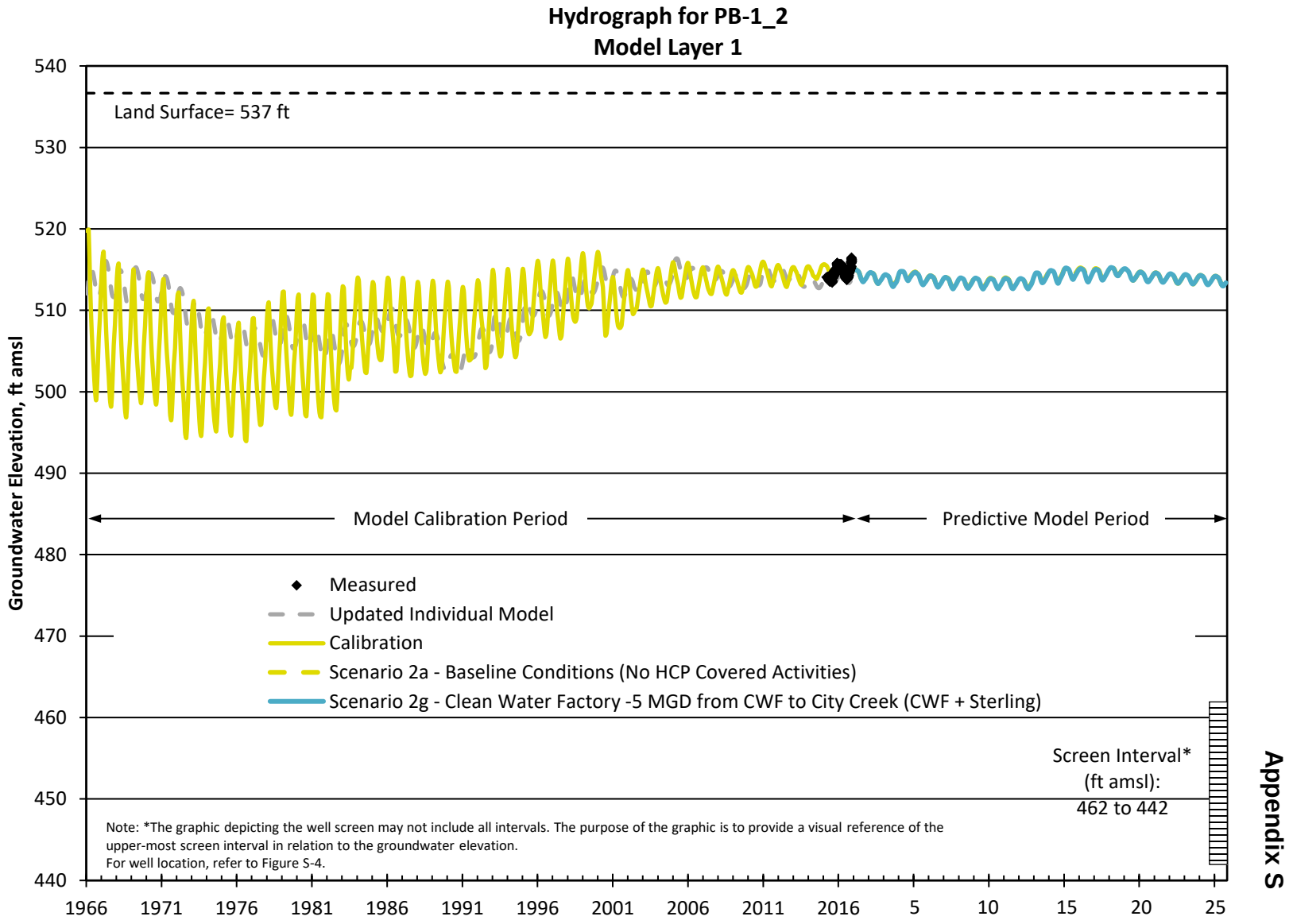
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2e.2 - All IEUA Activities
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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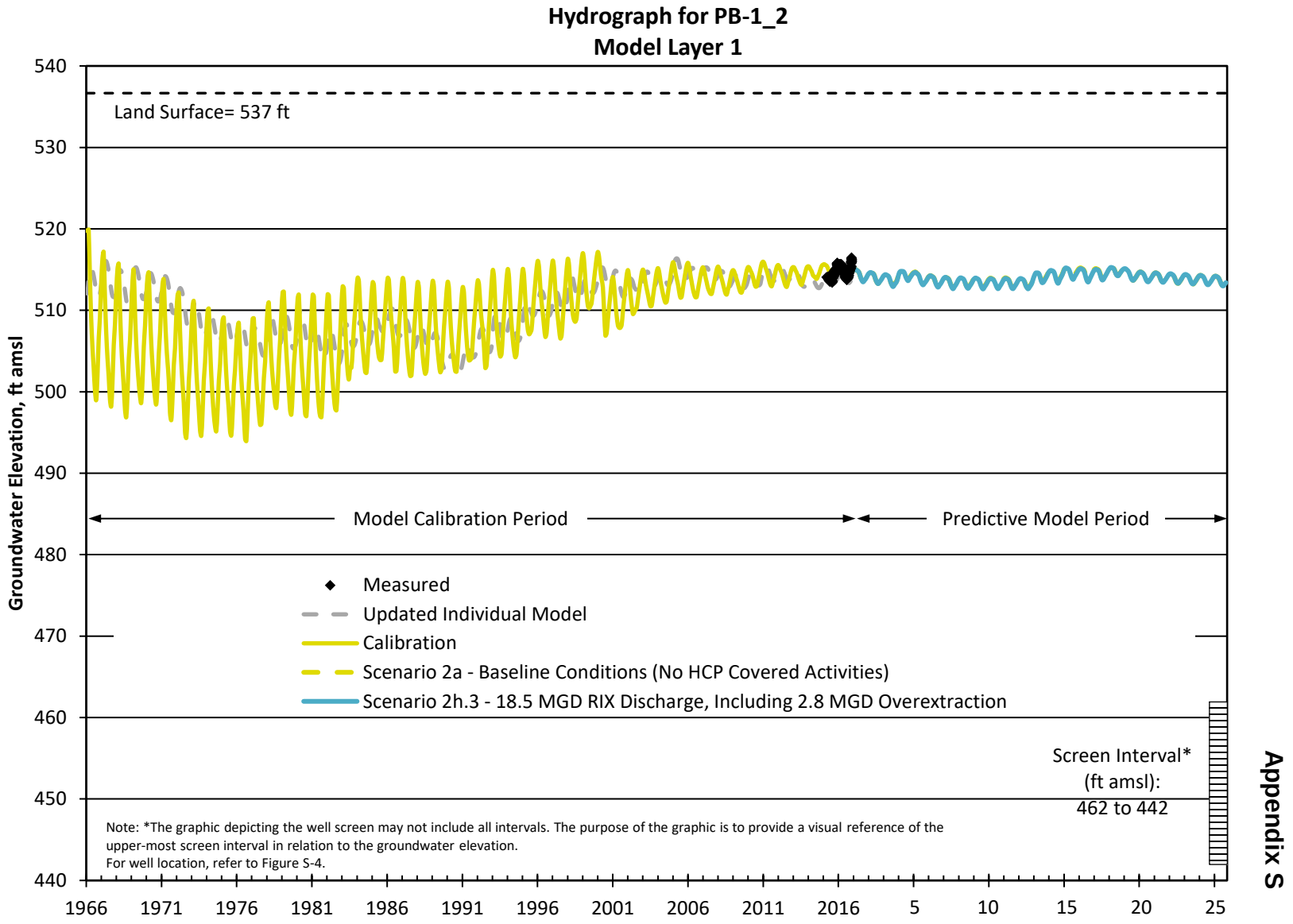
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2f - Western's Victoria Recharge Basin Project
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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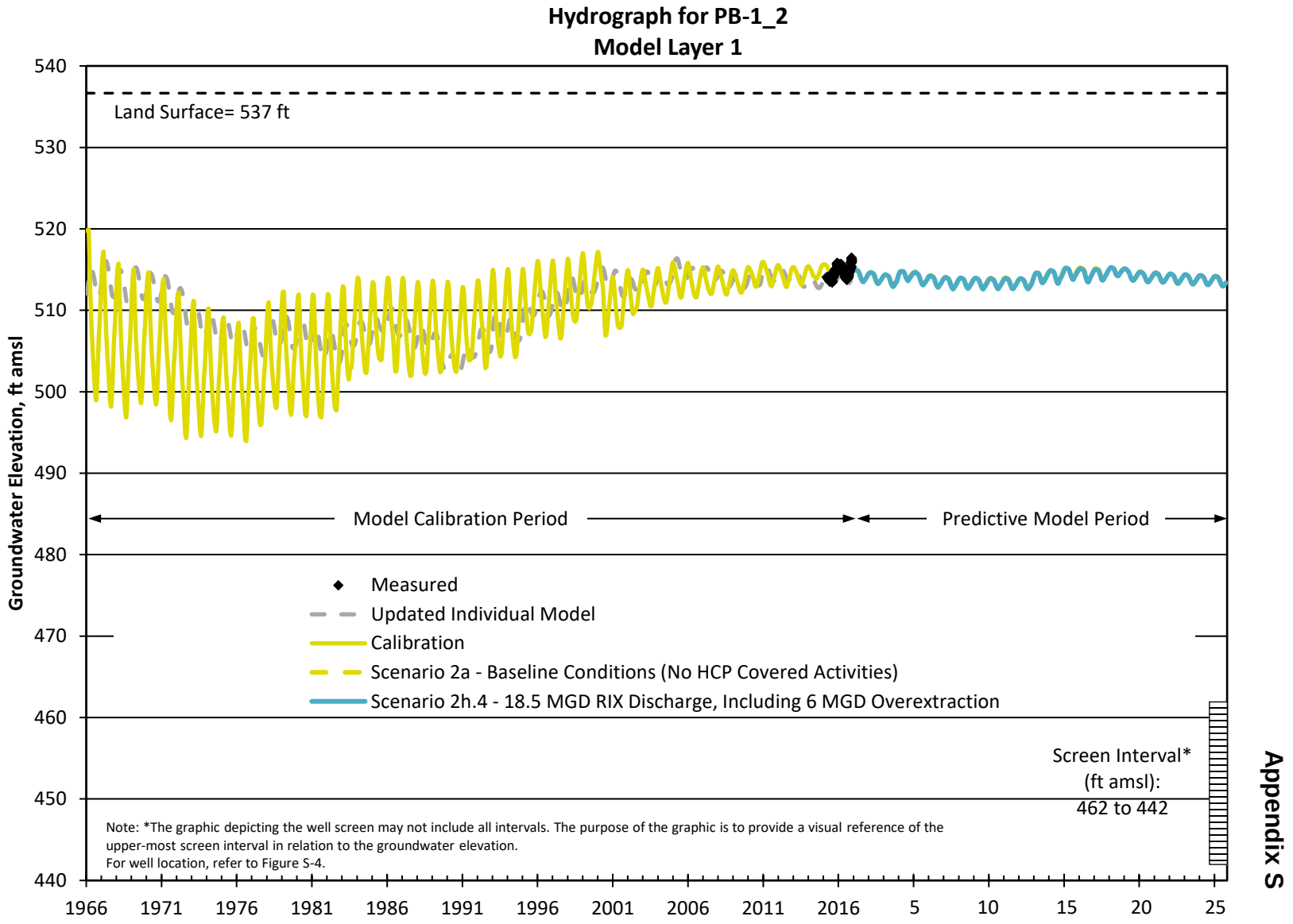
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
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510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2g - Clean Water Factory -5 MGD from CWF to City Creek (CWF + Sterling)
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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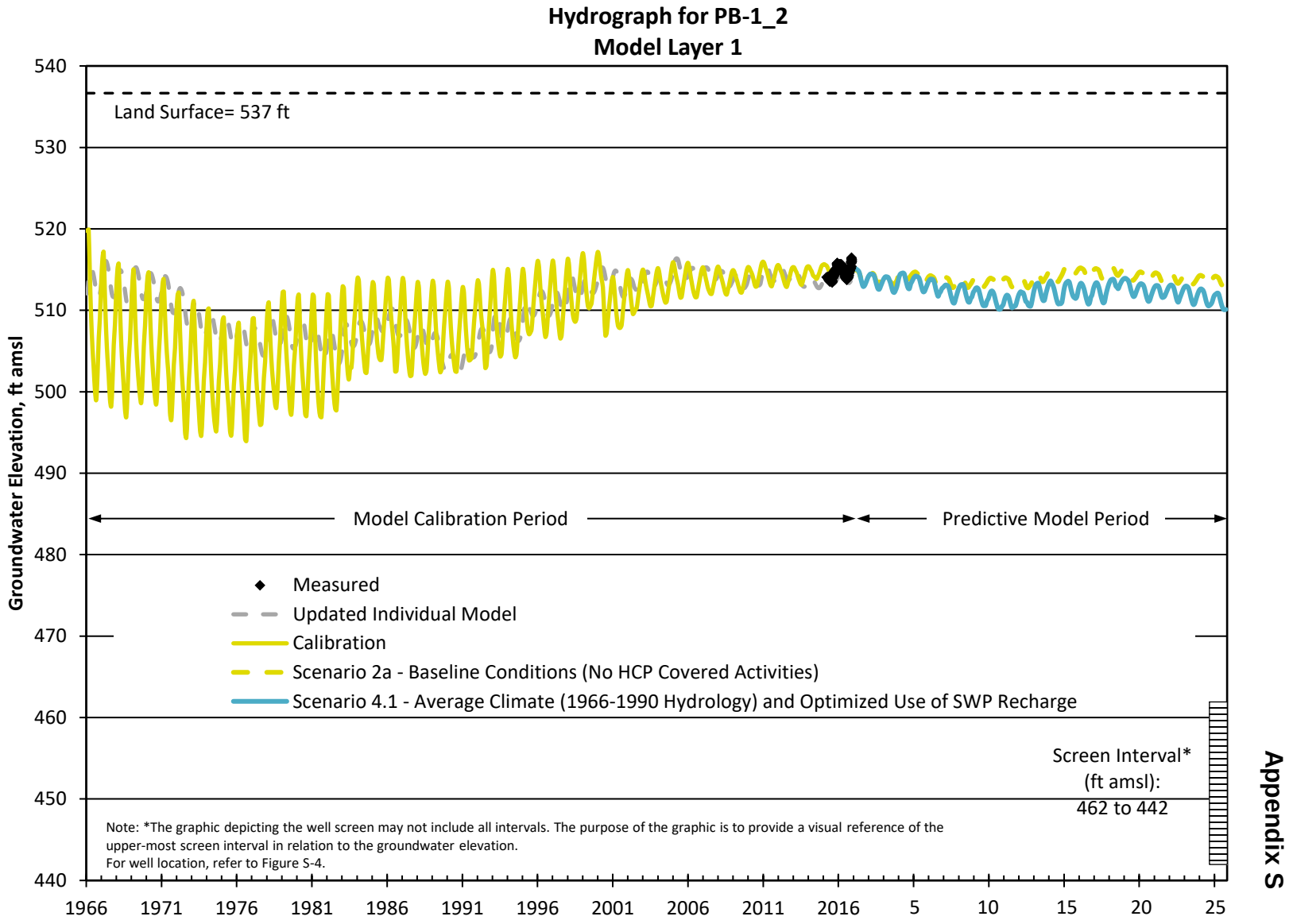
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
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510
500
490
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450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2h.3 - 18.5 MGD RIX Discharge, Including 2.8 MGD Overextraction
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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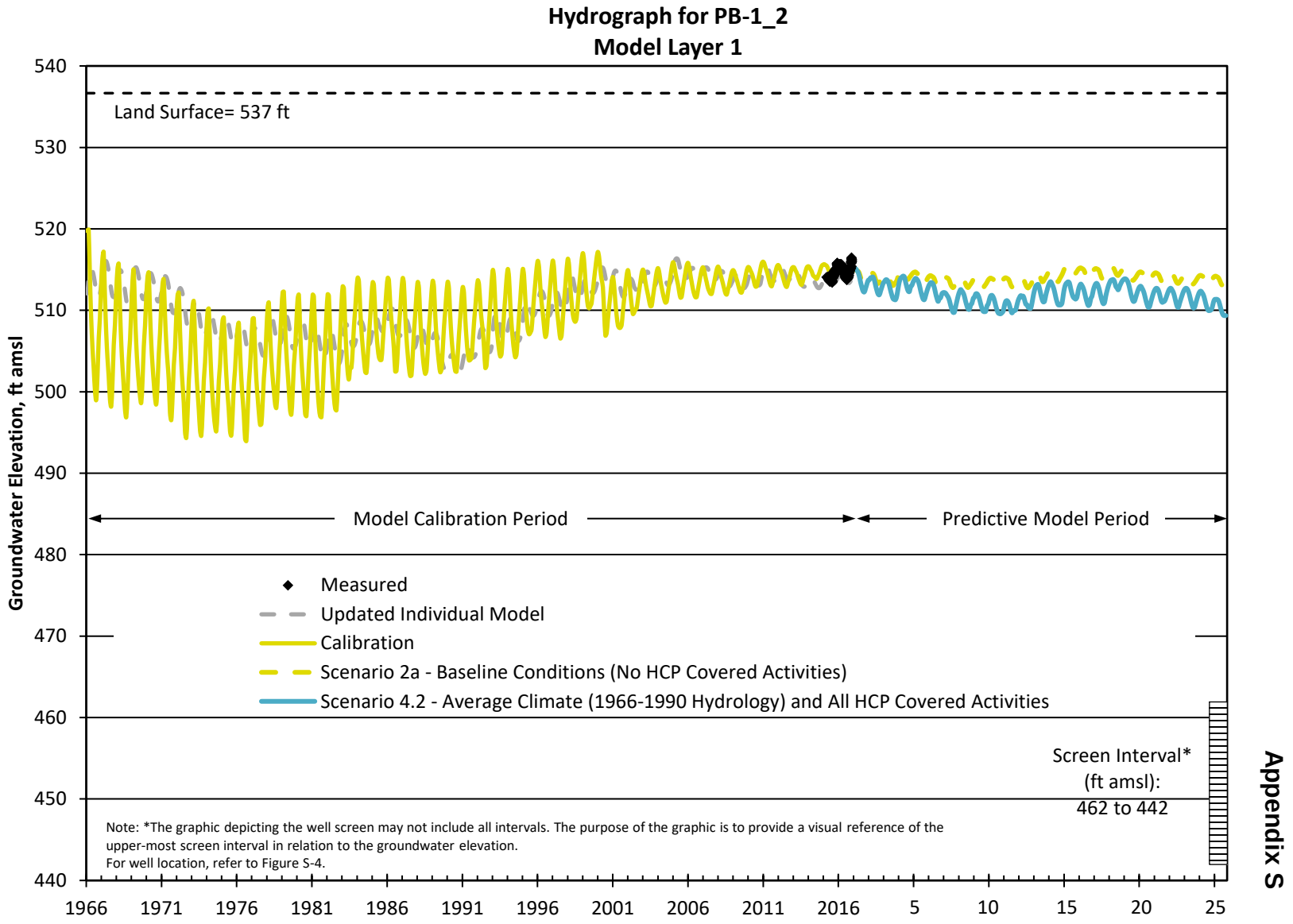
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
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510
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490
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450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2h.4 - 18.5 MGD RIX Discharge, Including 6 MGD Overextraction
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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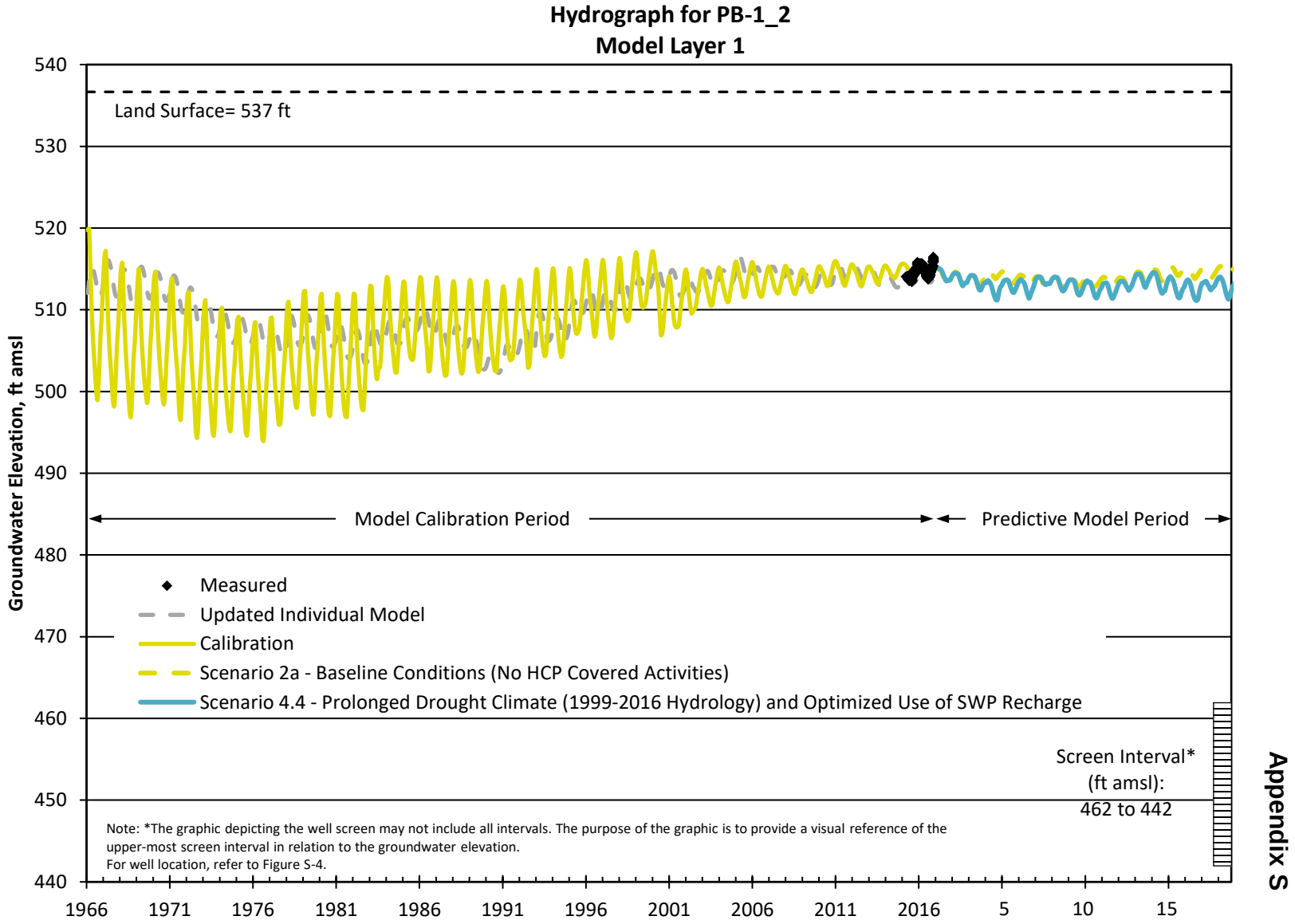
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
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490
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450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.1 - Average Climate (1966-1990 Hydrology) and Optimized Use of SWP Recharge
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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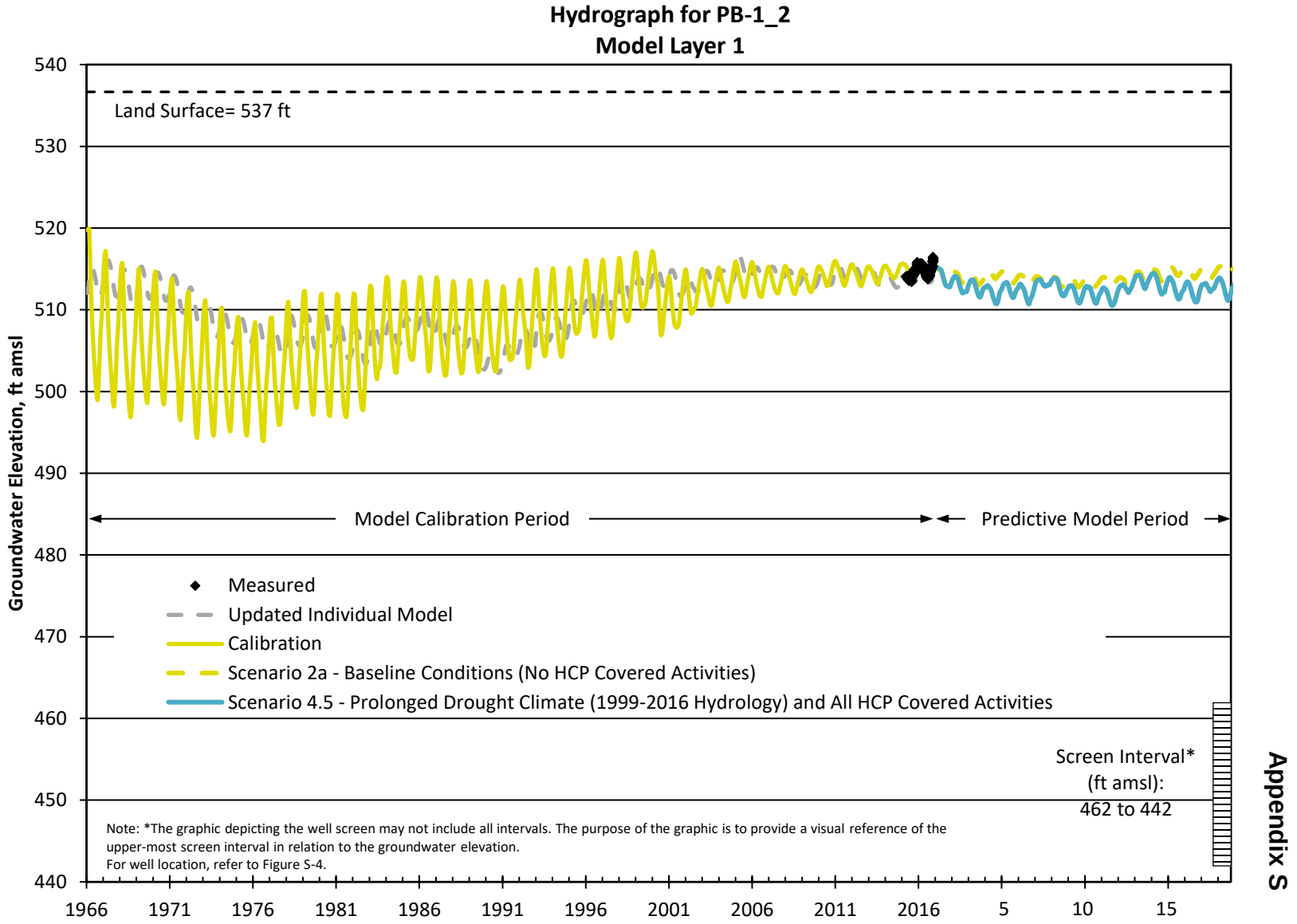
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.2 - Average Climate (1966-1990 Hydrology) and All HCP Covered Activities
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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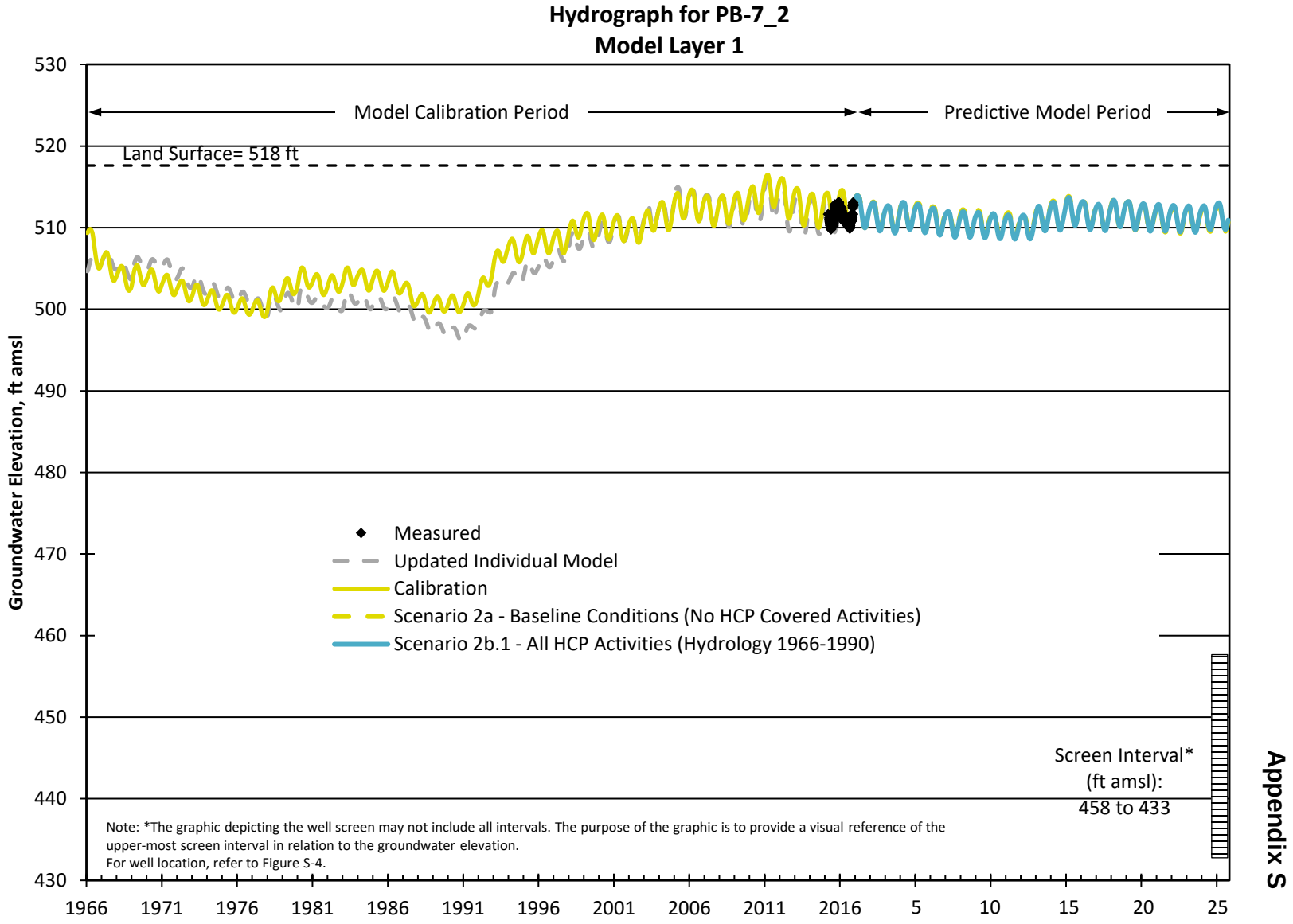
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.4 - Prolonged Drought Climate (1999-2016 Hydrology) and Optimized Use of SWP Recharge
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
1976
1981
1986
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1996
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10
15

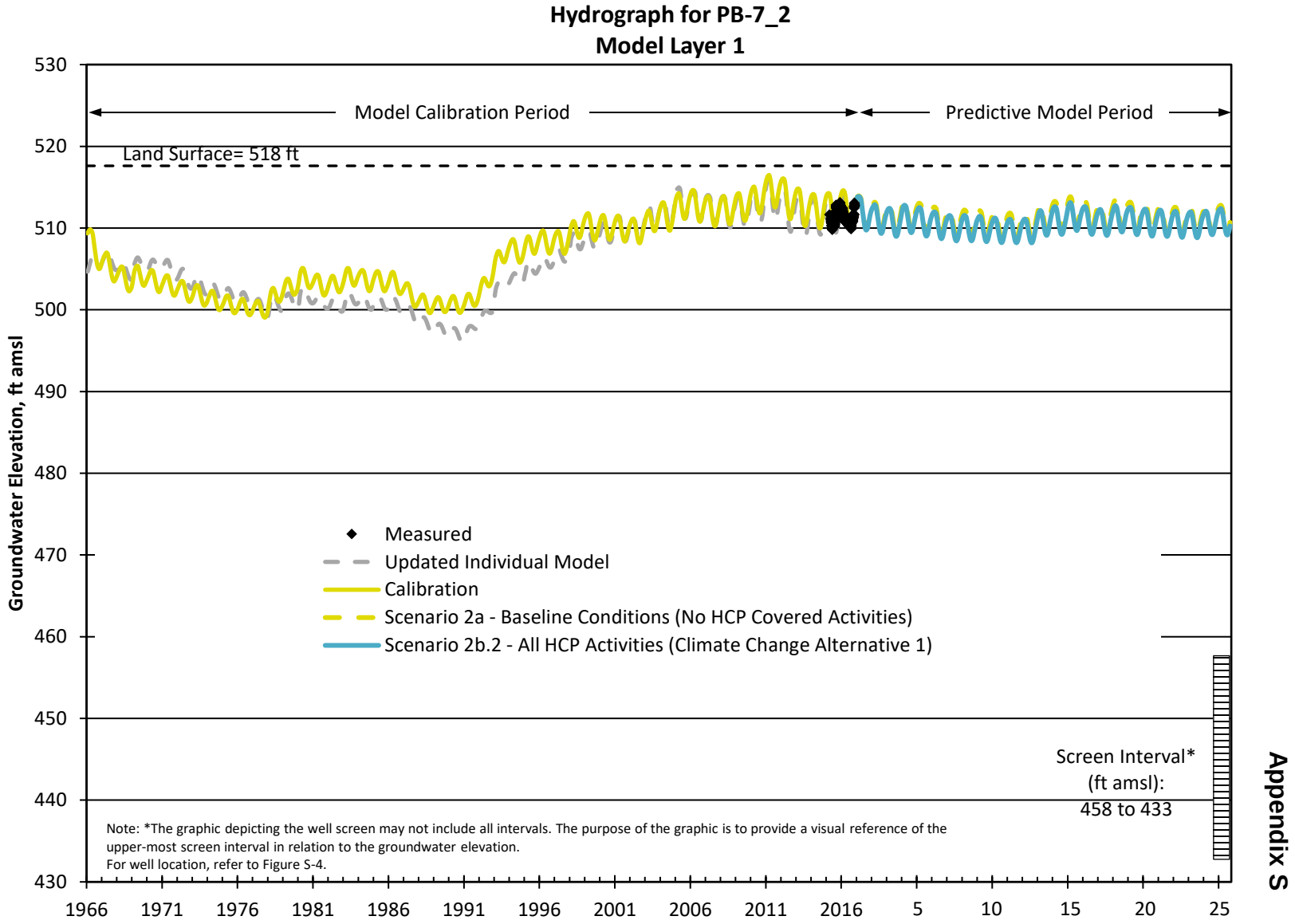
Appendix S


Hydrograph for PB-1_2
Model Layer 1
Groundwater Elevation, ft amsl
540
530
520
510
500
490
480
470
460
450
440
Land Surface= 537 ft
Model Calibration Period
Predictive Model Period
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.5 - Prolonged Drought Climate (1999-2016 Hydrology) and All HCP Covered Activities
Screen Interval*
(ft amsl):
462 to 442
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15

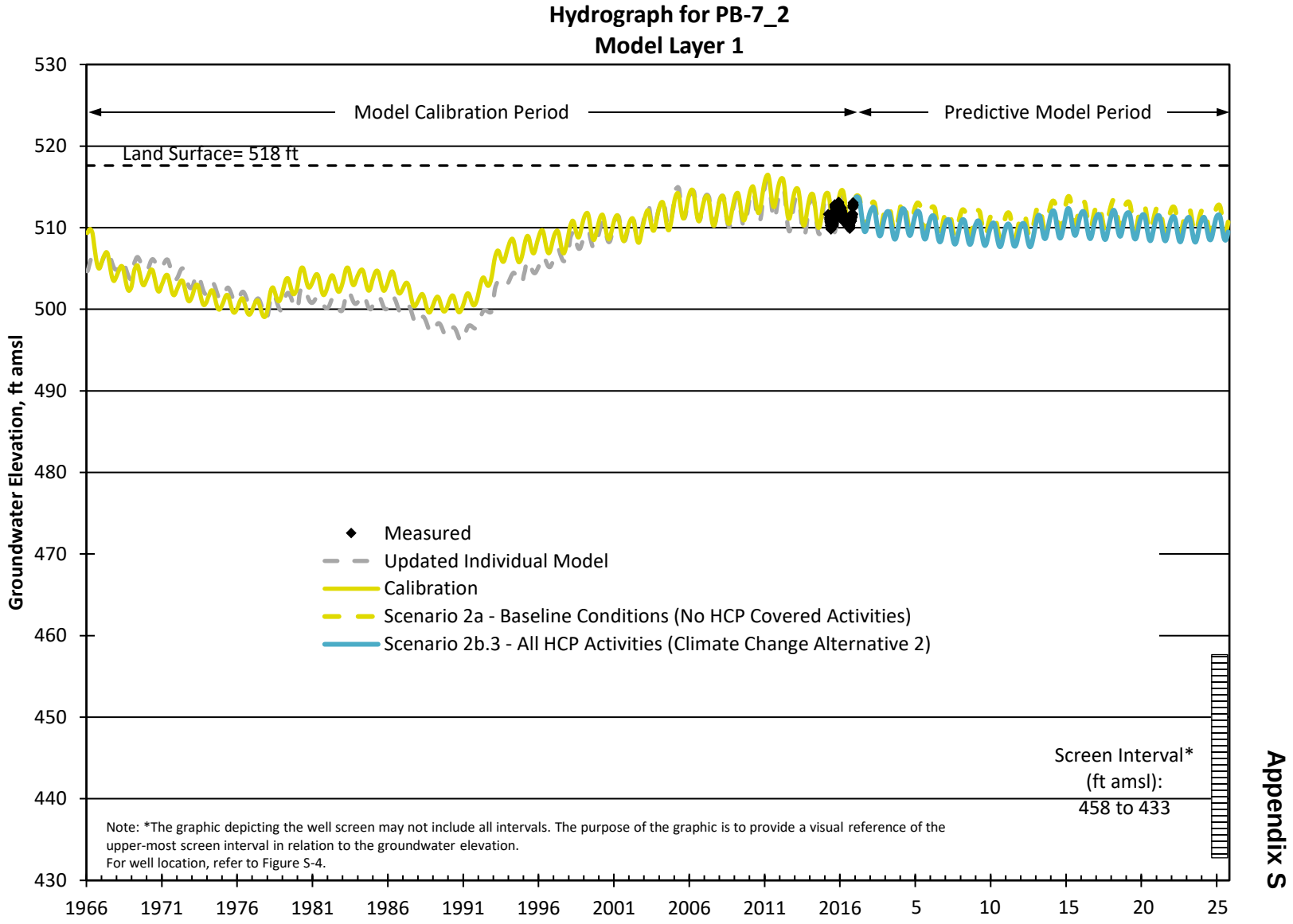
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.1 - All HCP Activities (Hydrology 1966-1990)
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

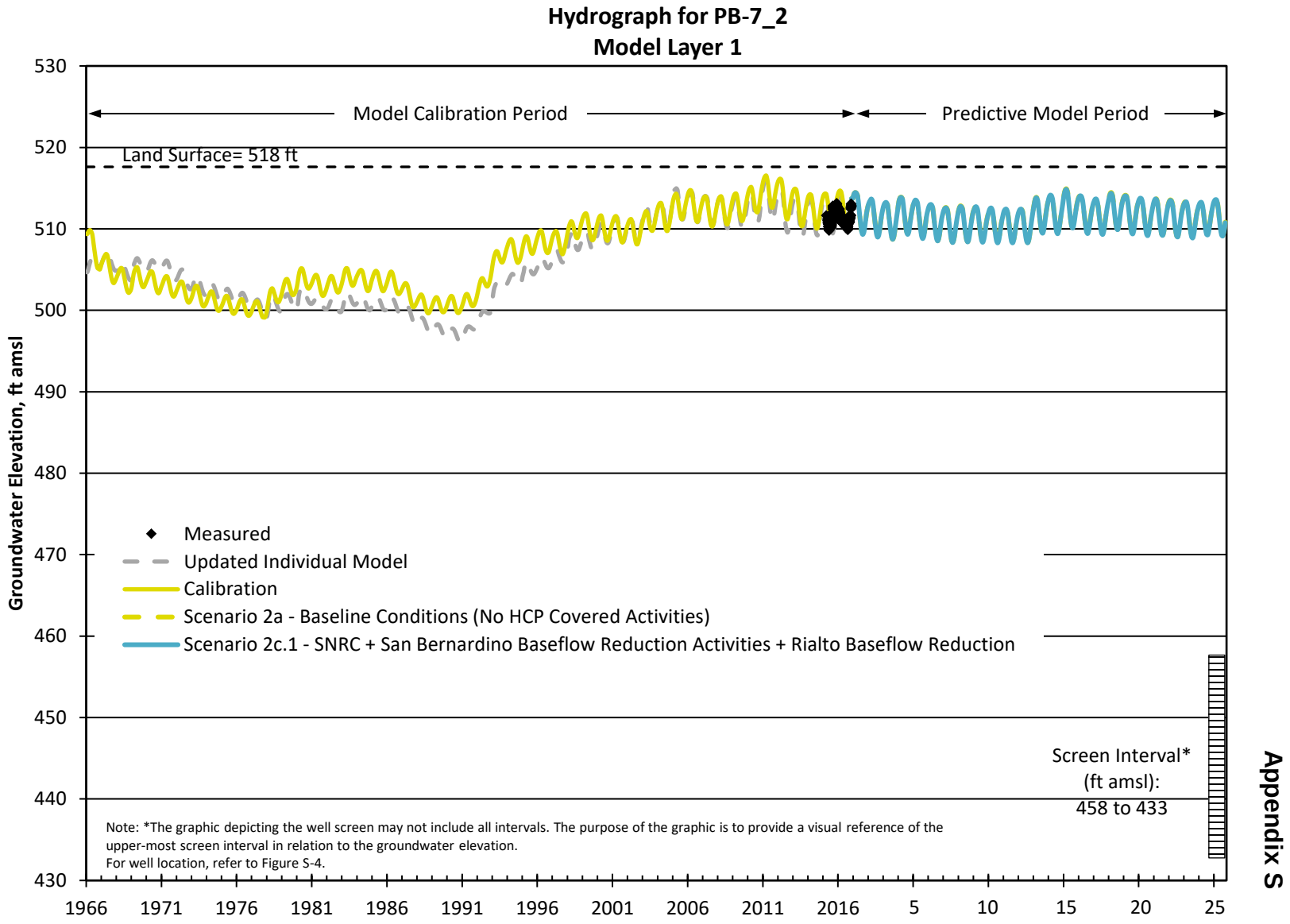
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.2 - All HCP Activities (Climate Change Alternative 1)
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

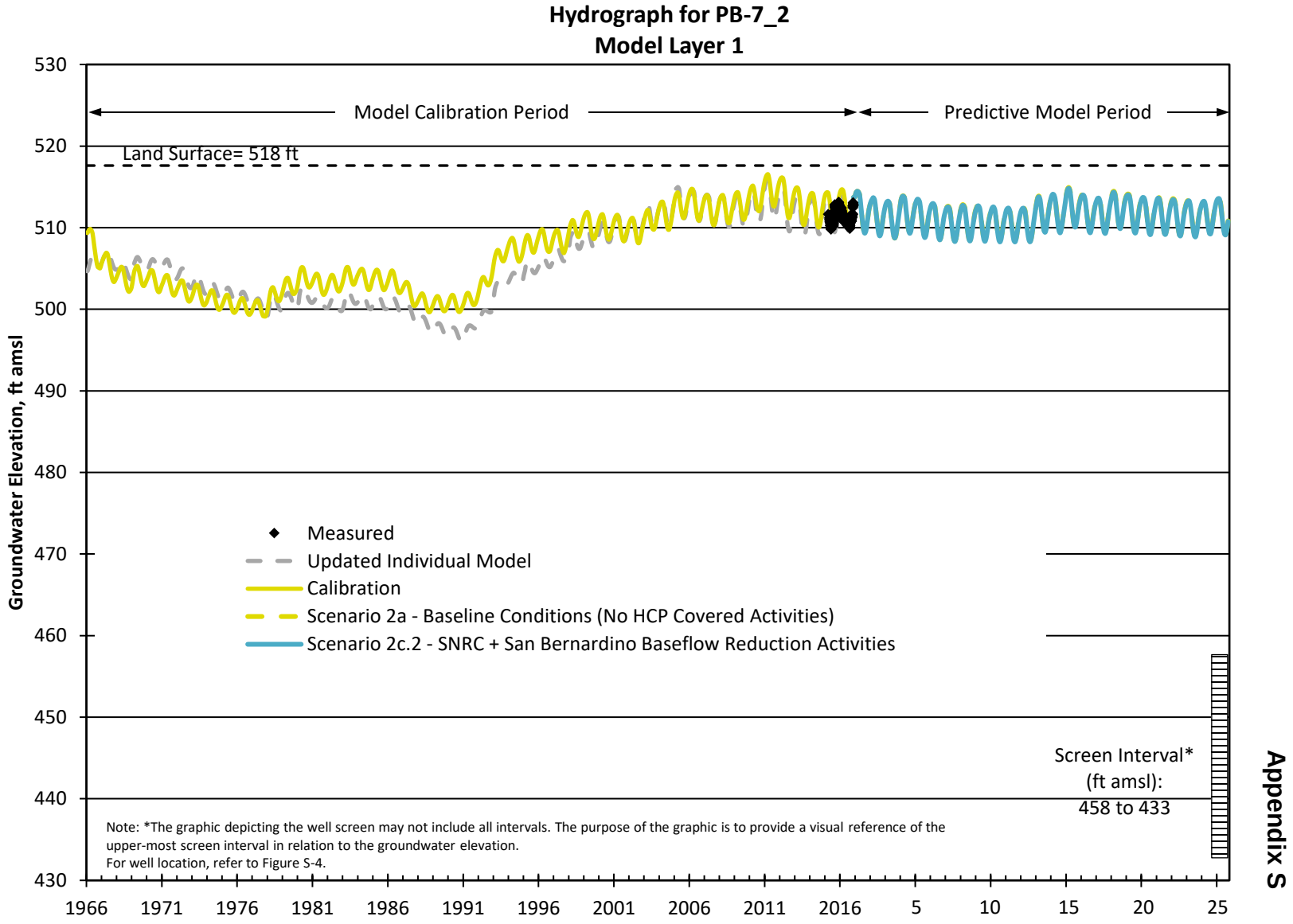
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
1971
1976
1981
1986
1991
1996
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2011
2016
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25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.3 - All HCP Activities (Climate Change Alternative 2)
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

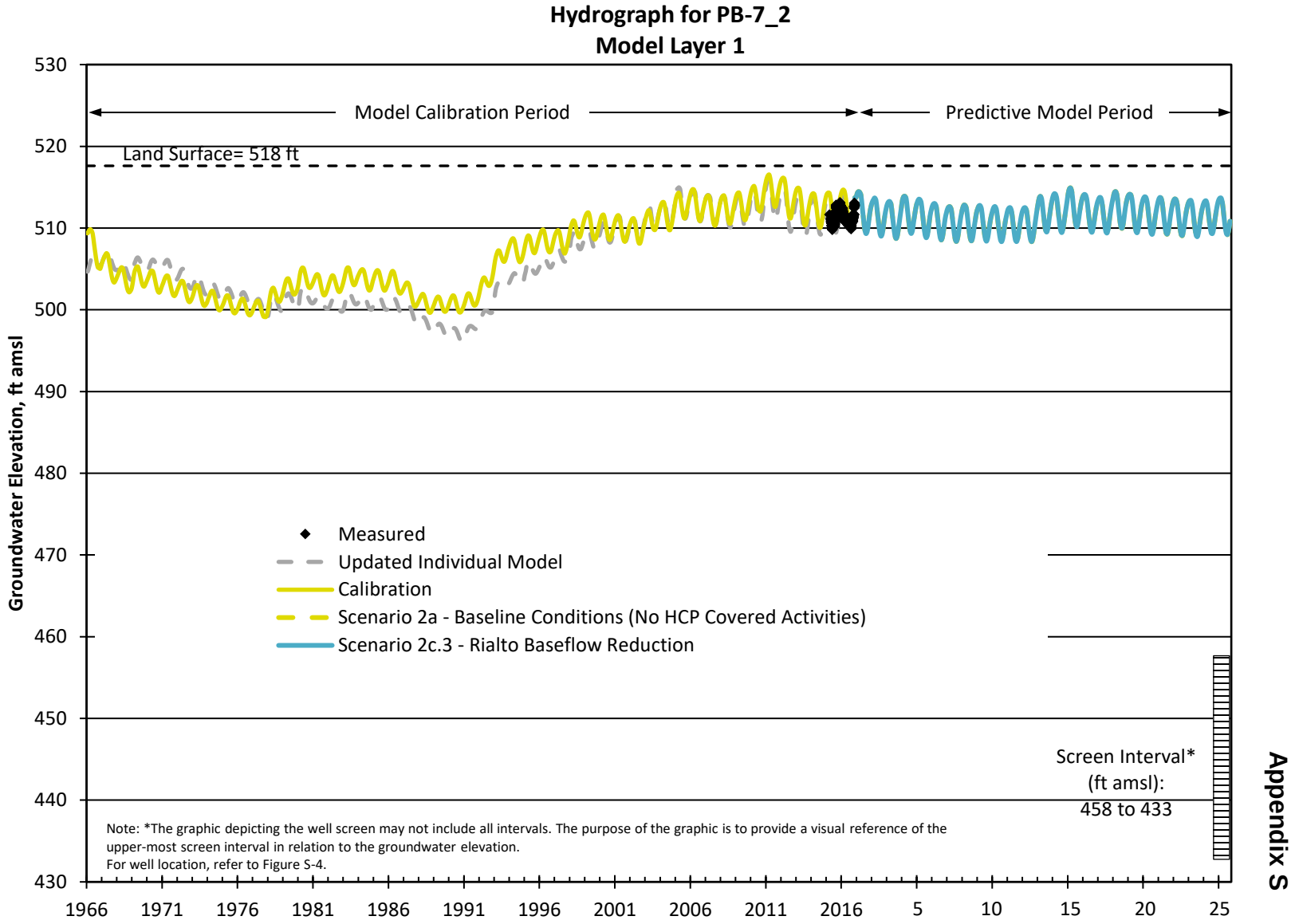
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
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2016
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25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.1 - SNRC + San Bernardino Baseflow Reduction Activities + Rialto Baseflow Reduction
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

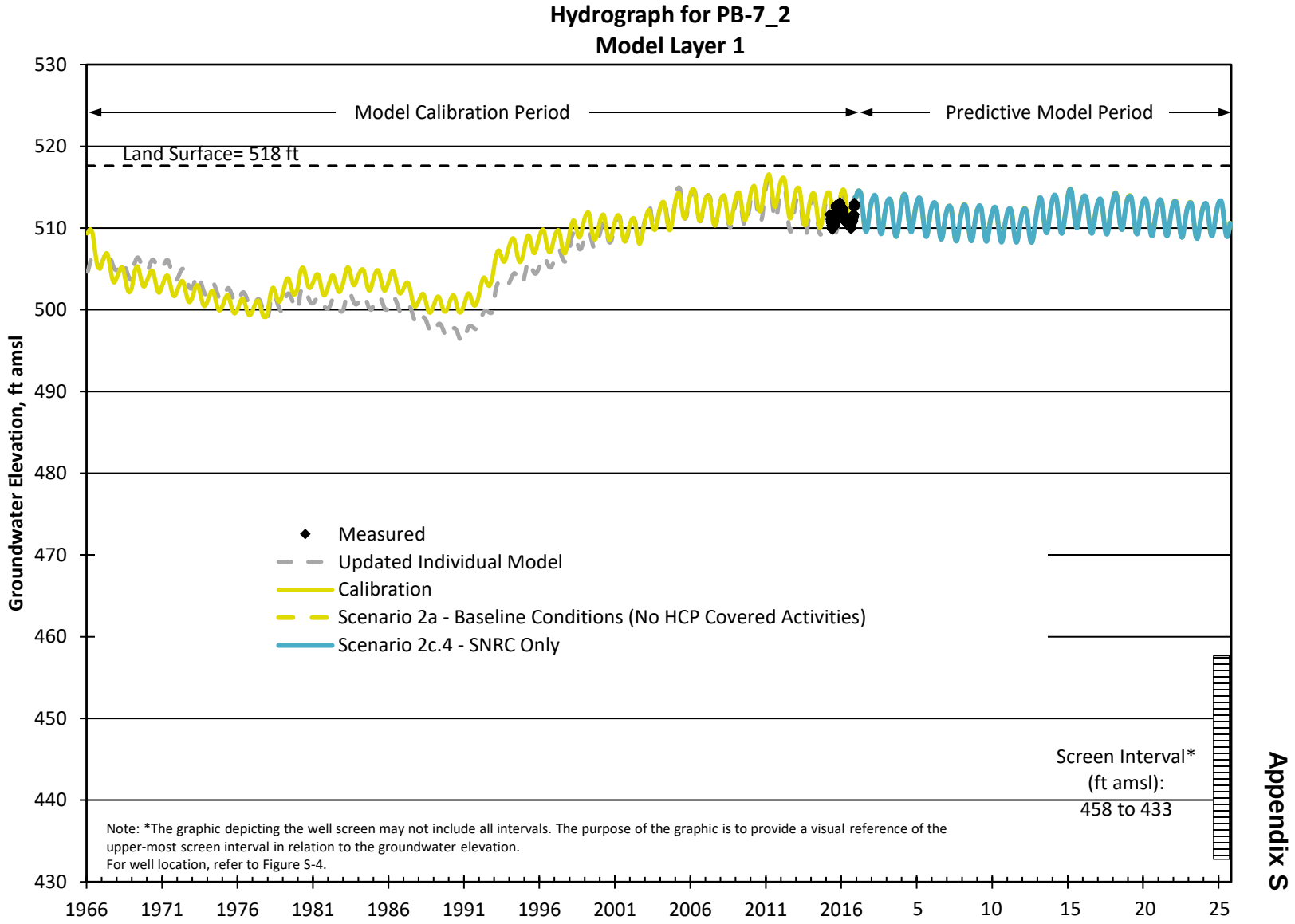
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
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2016
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25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.2 - SNRC + San Bernardino Baseflow Reduction Activities
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

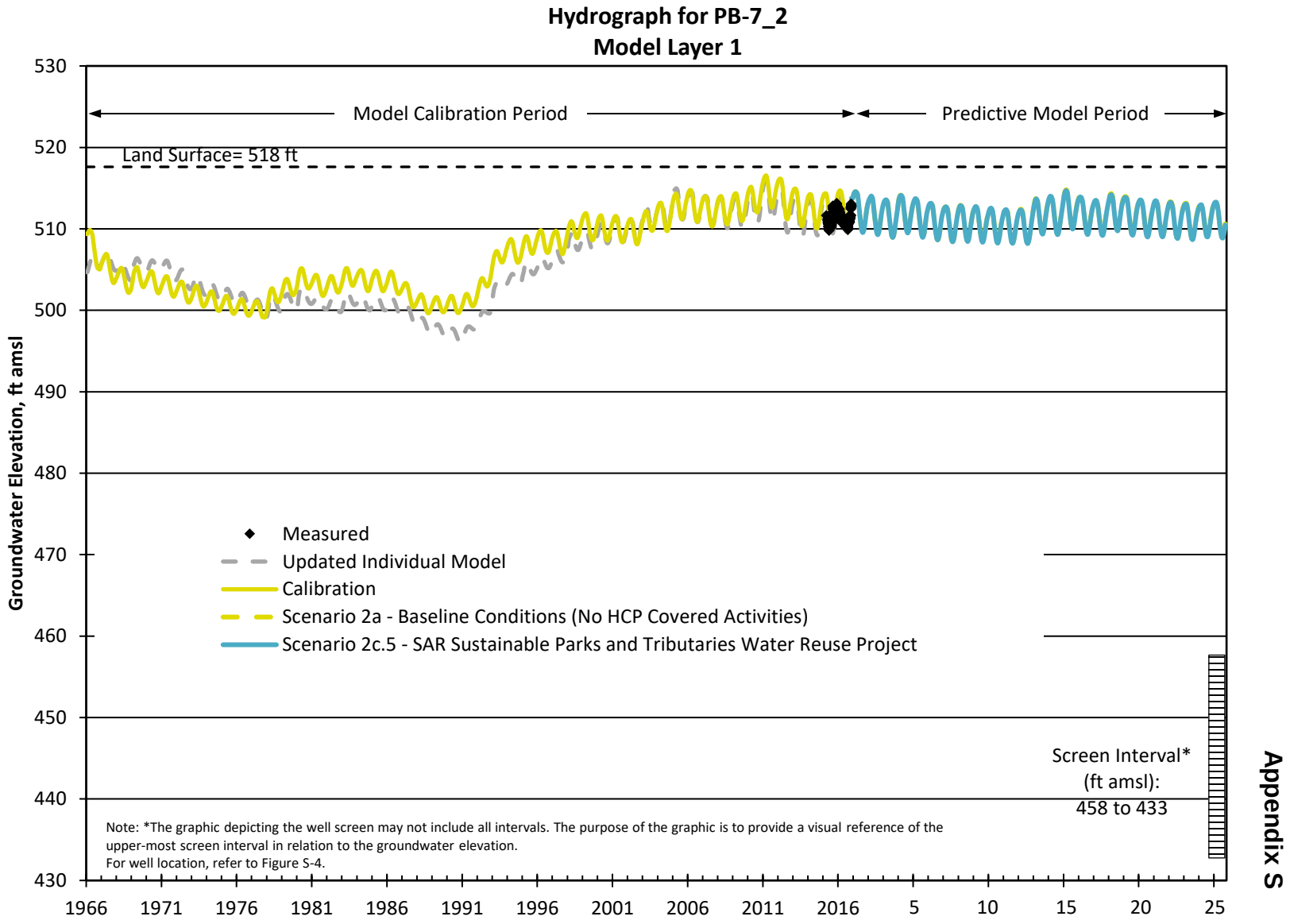
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
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430
1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.3 - Rialto Baseflow Reduction
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

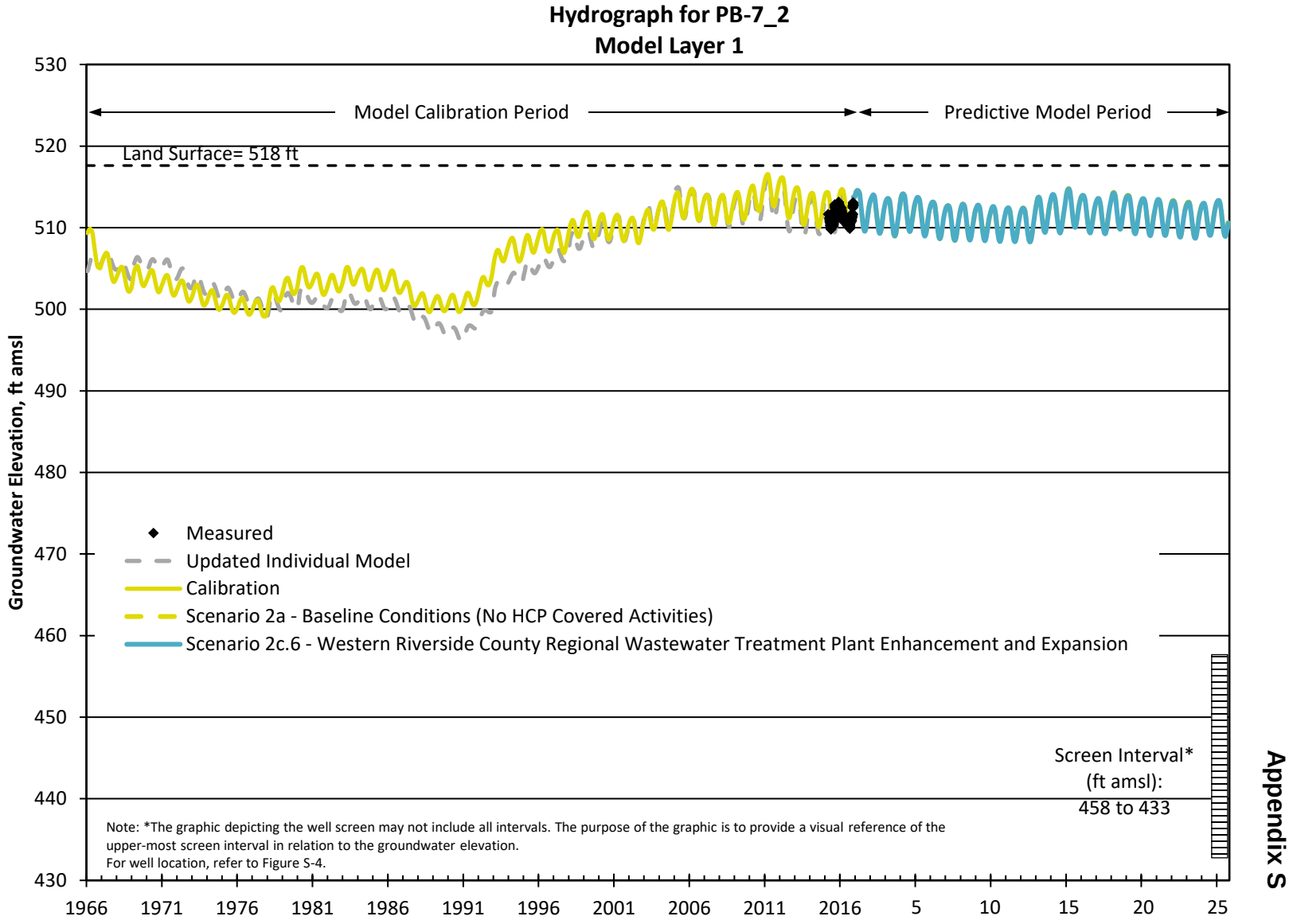
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
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460
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430
1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.4 - SNRC Only
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

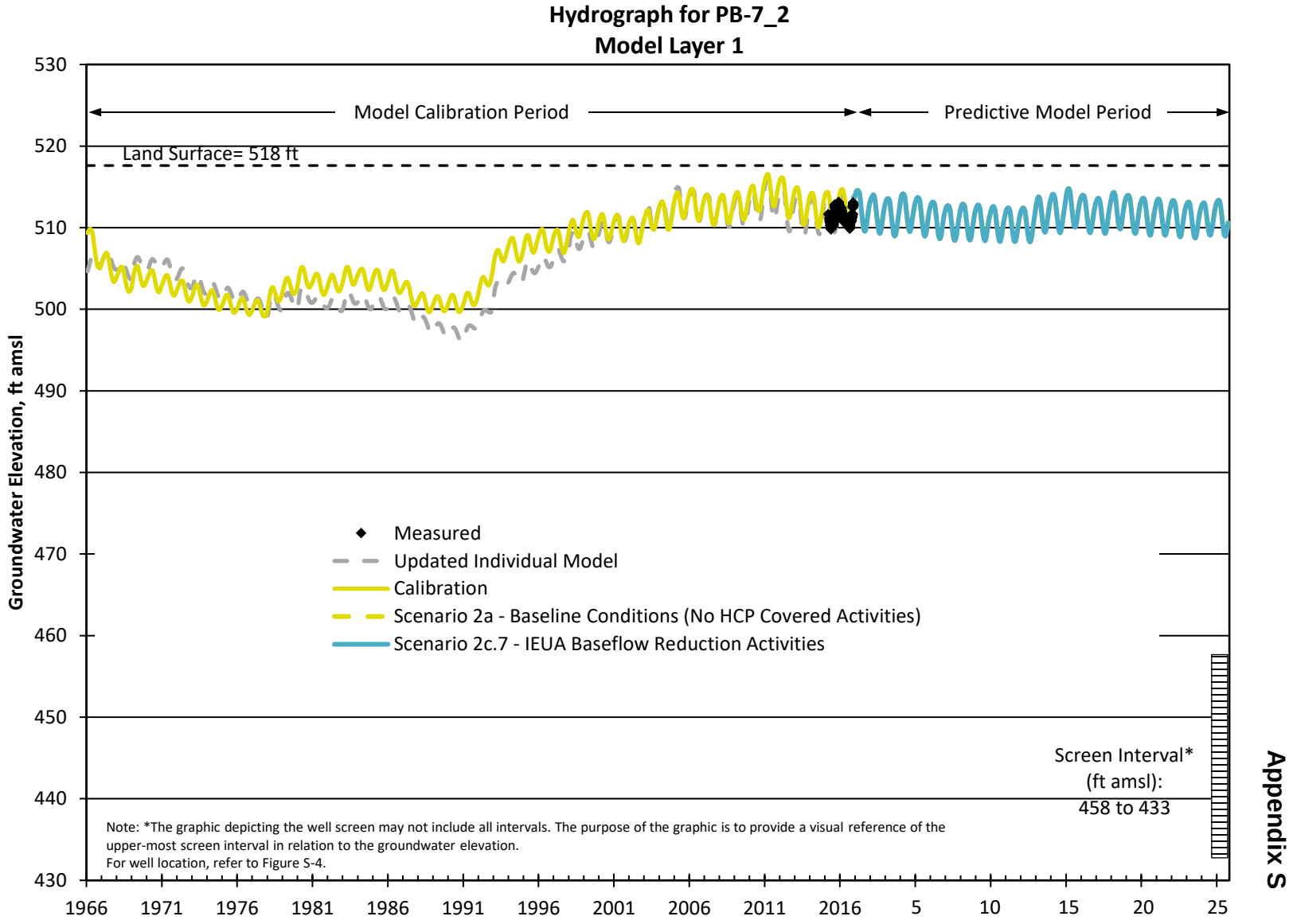
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
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510
500
490
480
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1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.5 - SAR Sustainable Parks and Tributaries Water Reuse Project
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

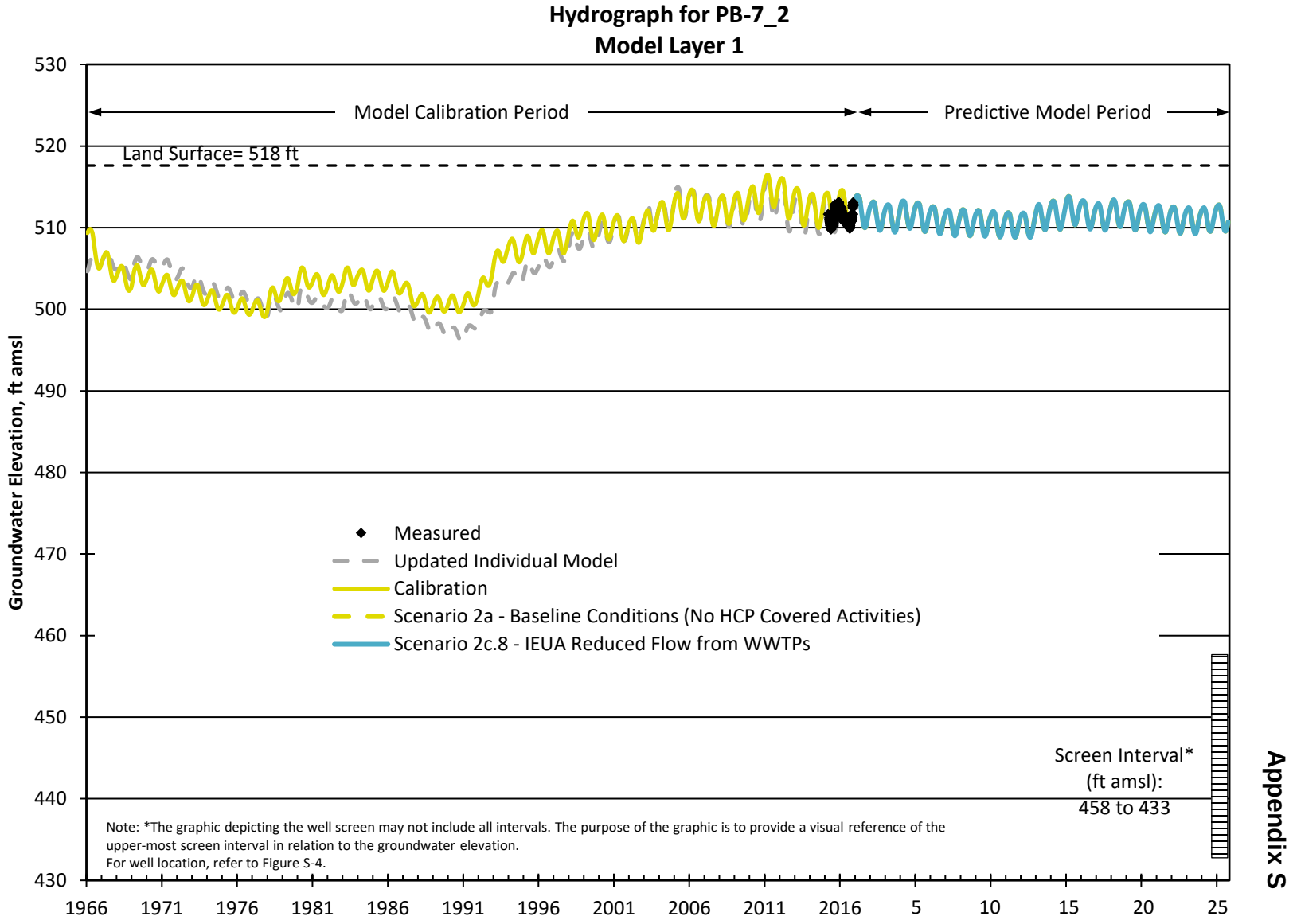
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
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1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.6 - Western Riverside County Regional Wastewater Treatment Plant Enhancement and Expansion
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

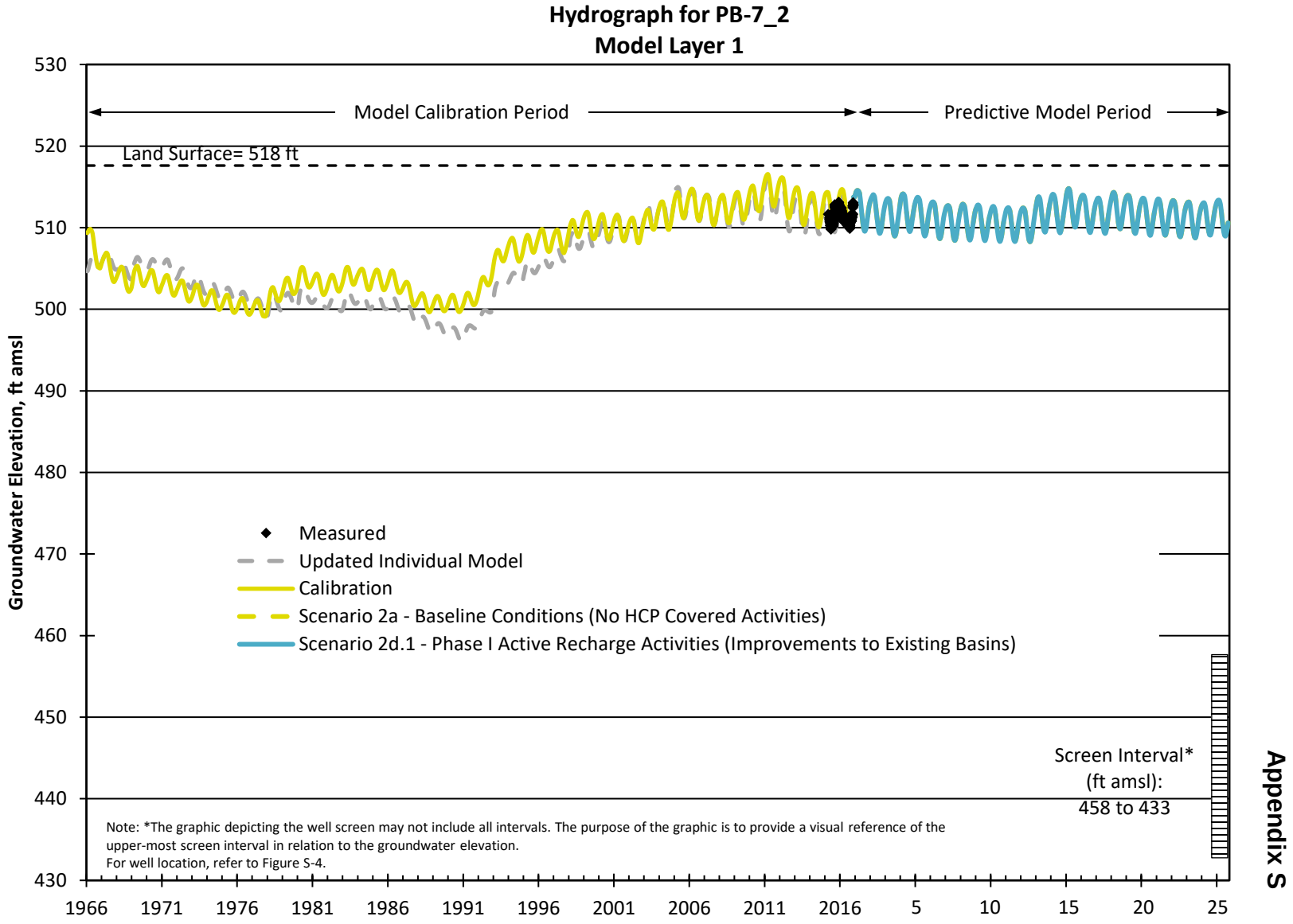
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
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440
430
1966
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2016
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.7 - IEUA Baseflow Reduction Activities
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

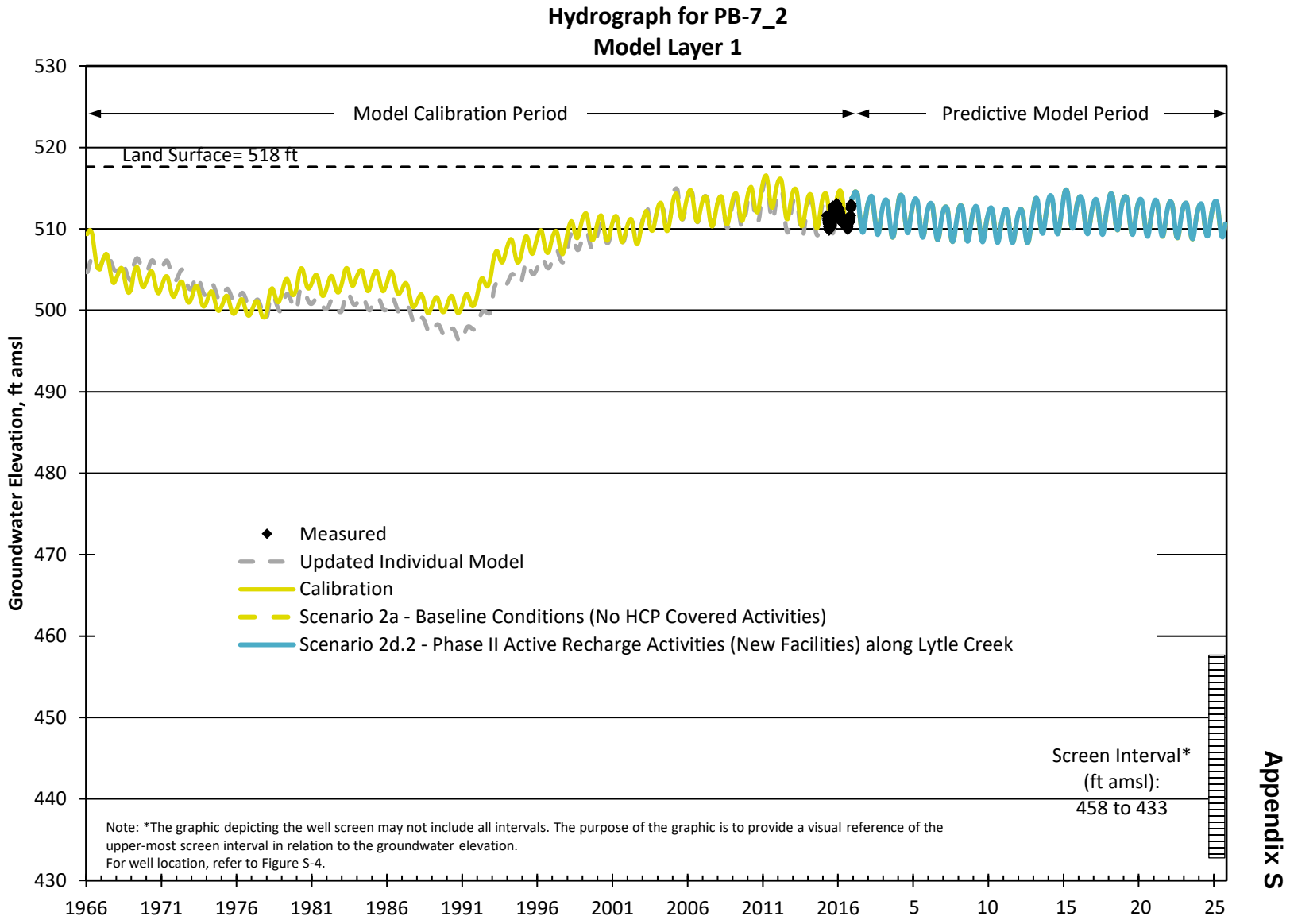
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
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2016
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.8 - IEUA Reduced Flow from WWTPs
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

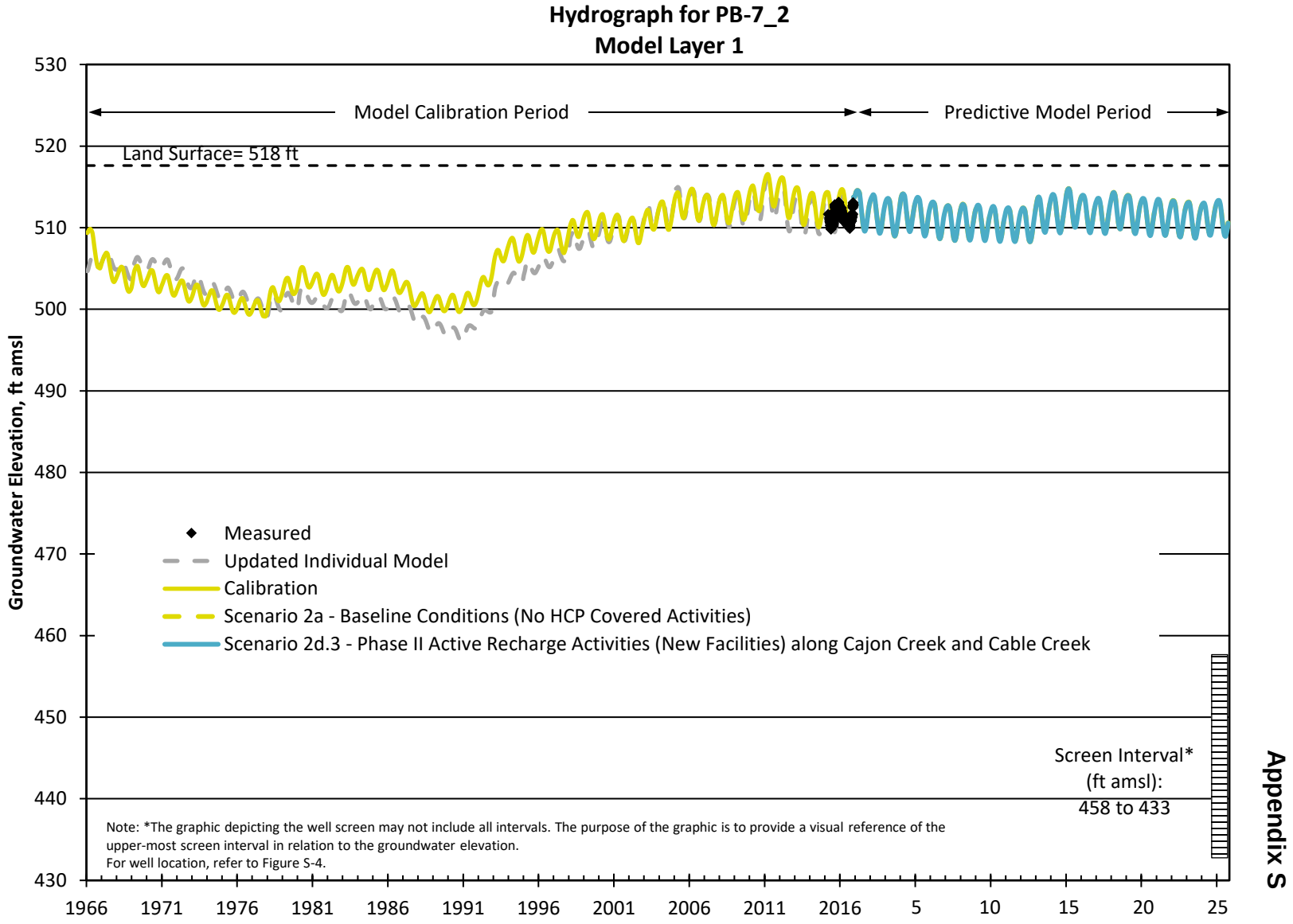
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.1 - Phase I Active Recharge Activities (Improvements to Existing Basins)
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

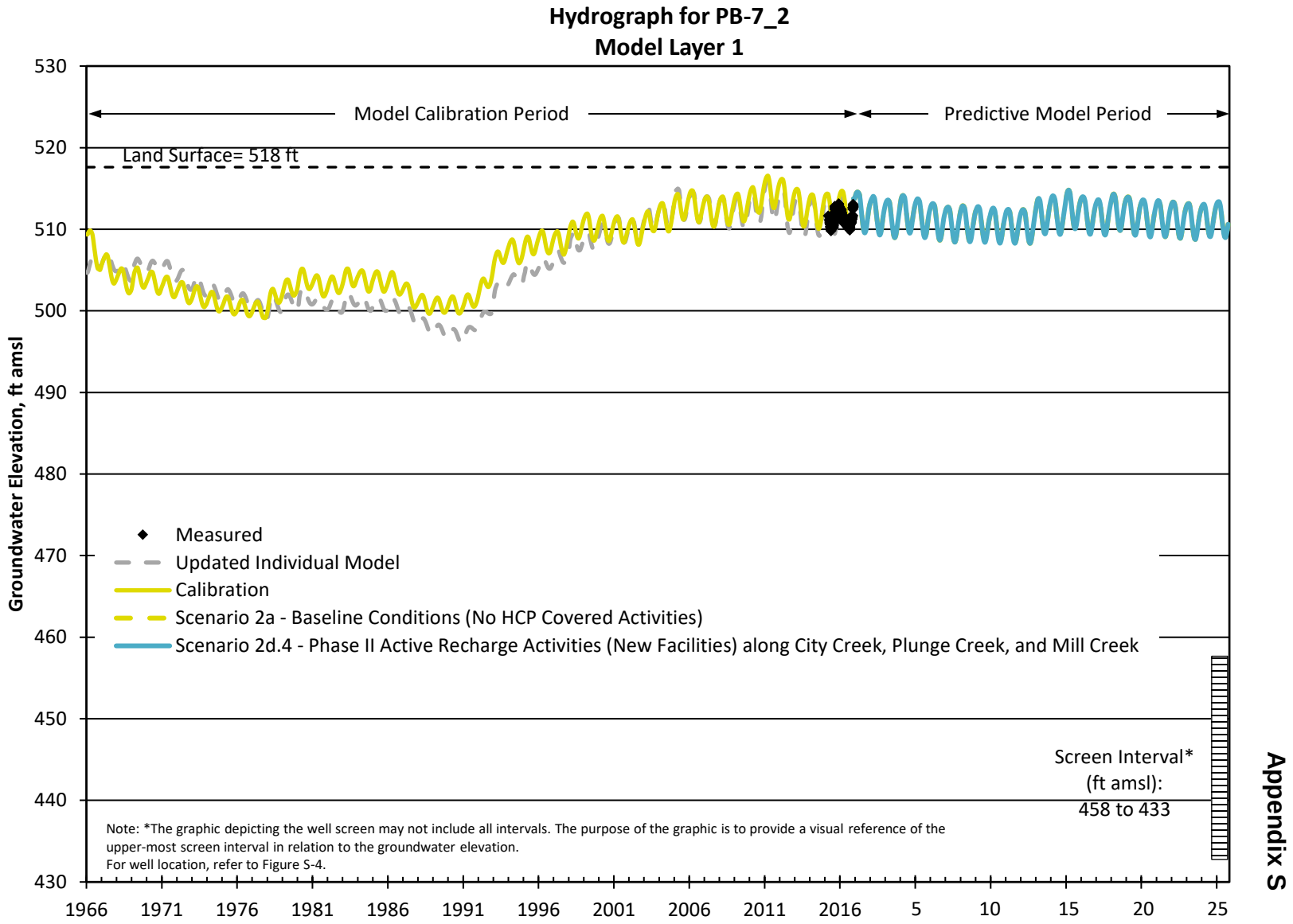
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
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2016
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.2 - Phase II Active Recharge Activities (New Facilities) along Lytle Creek
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

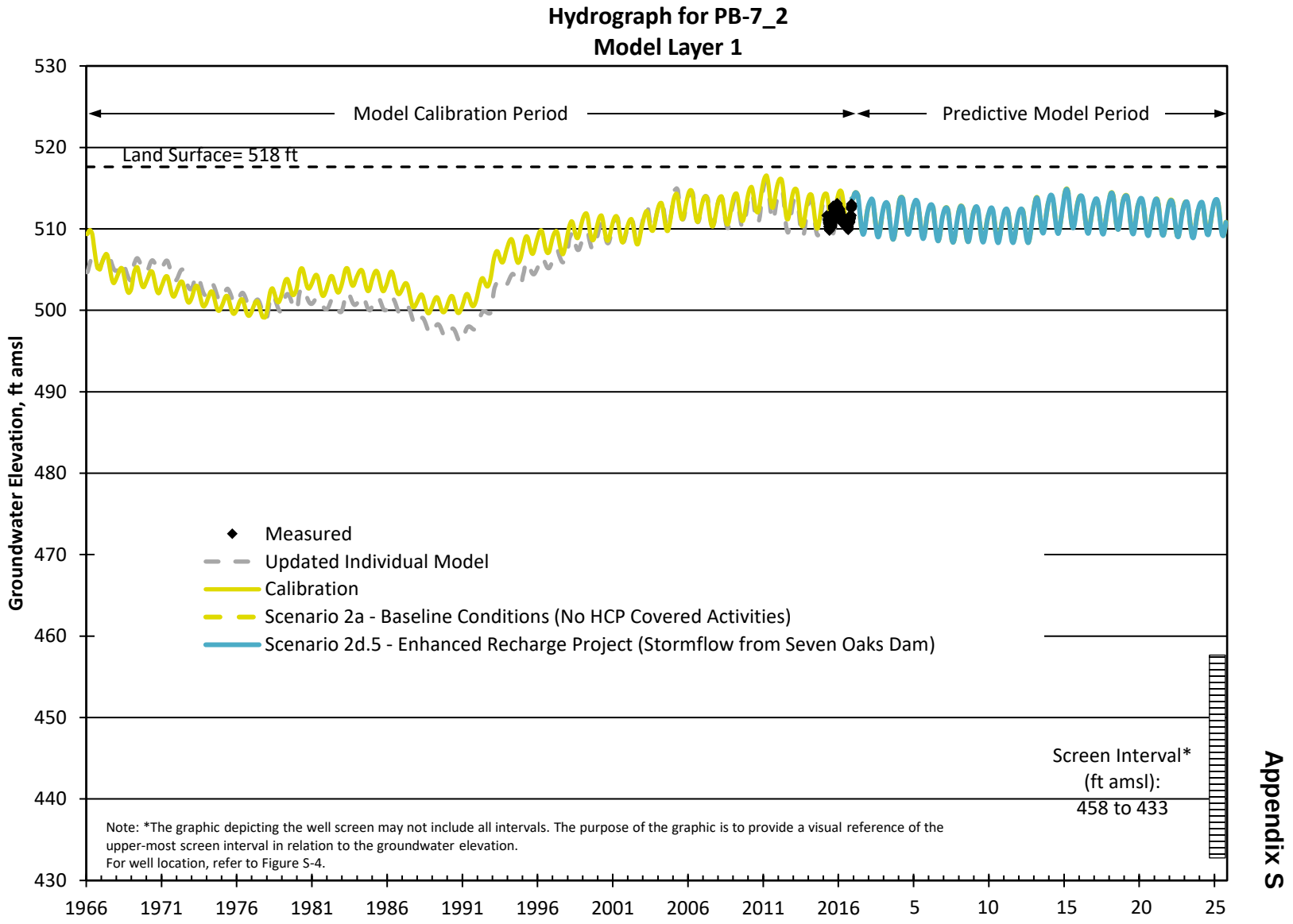
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.3 - Phase II Active Recharge Activities (New Facilities) along Cajon Creek and Cable Creek
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

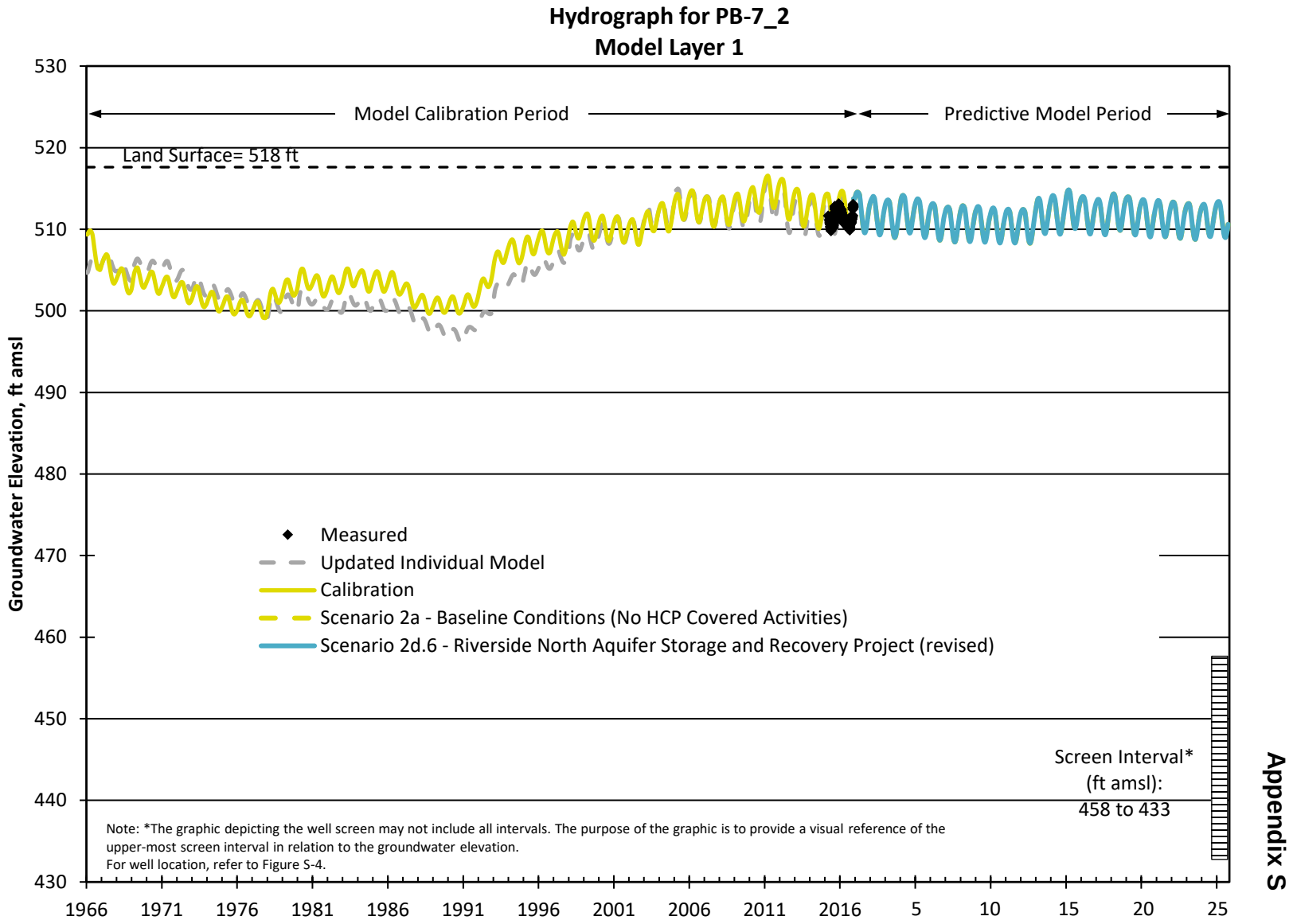
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
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2016
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.4 - Phase II Active Recharge Activities (New Facilities) along City Creek, Plunge Creek, and Mill Creek
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

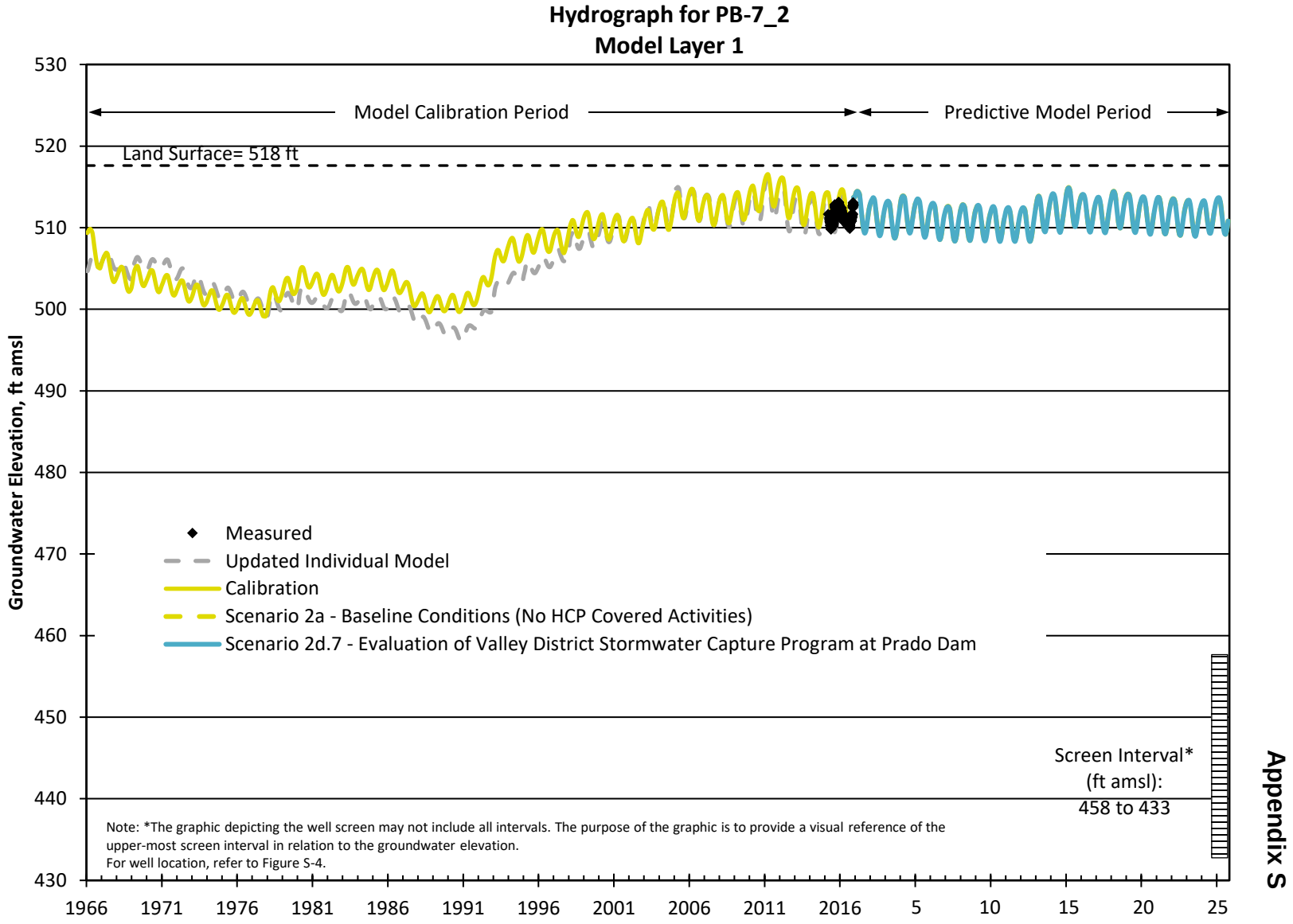
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
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430
1966
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.5 - Enhanced Recharge Project (Stormflow from Seven Oaks Dam)
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

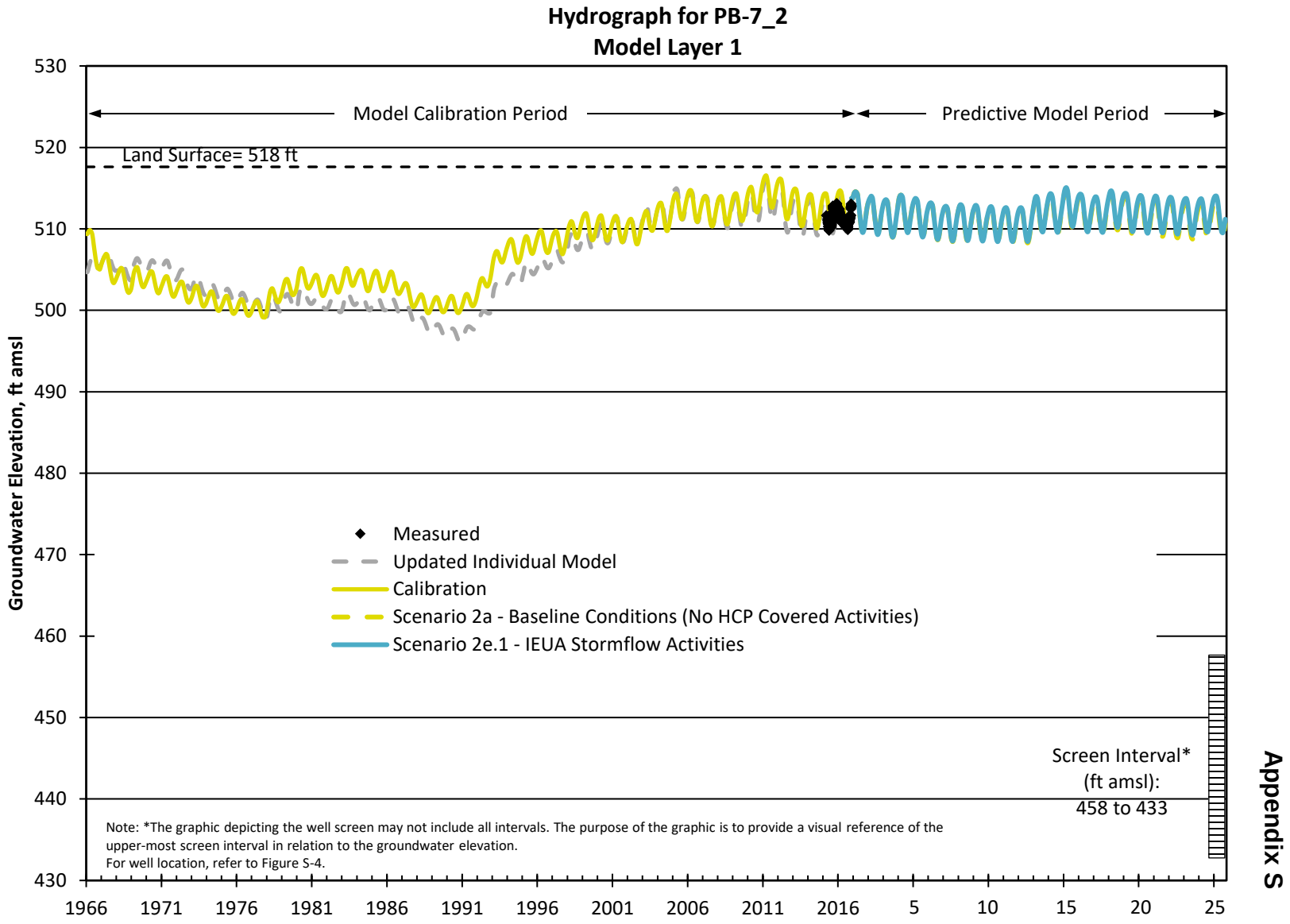
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
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510
500
490
480
470
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430
1966
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2016
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.6 - Riverside North Aquifer Storage and Recovery Project (revised)
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

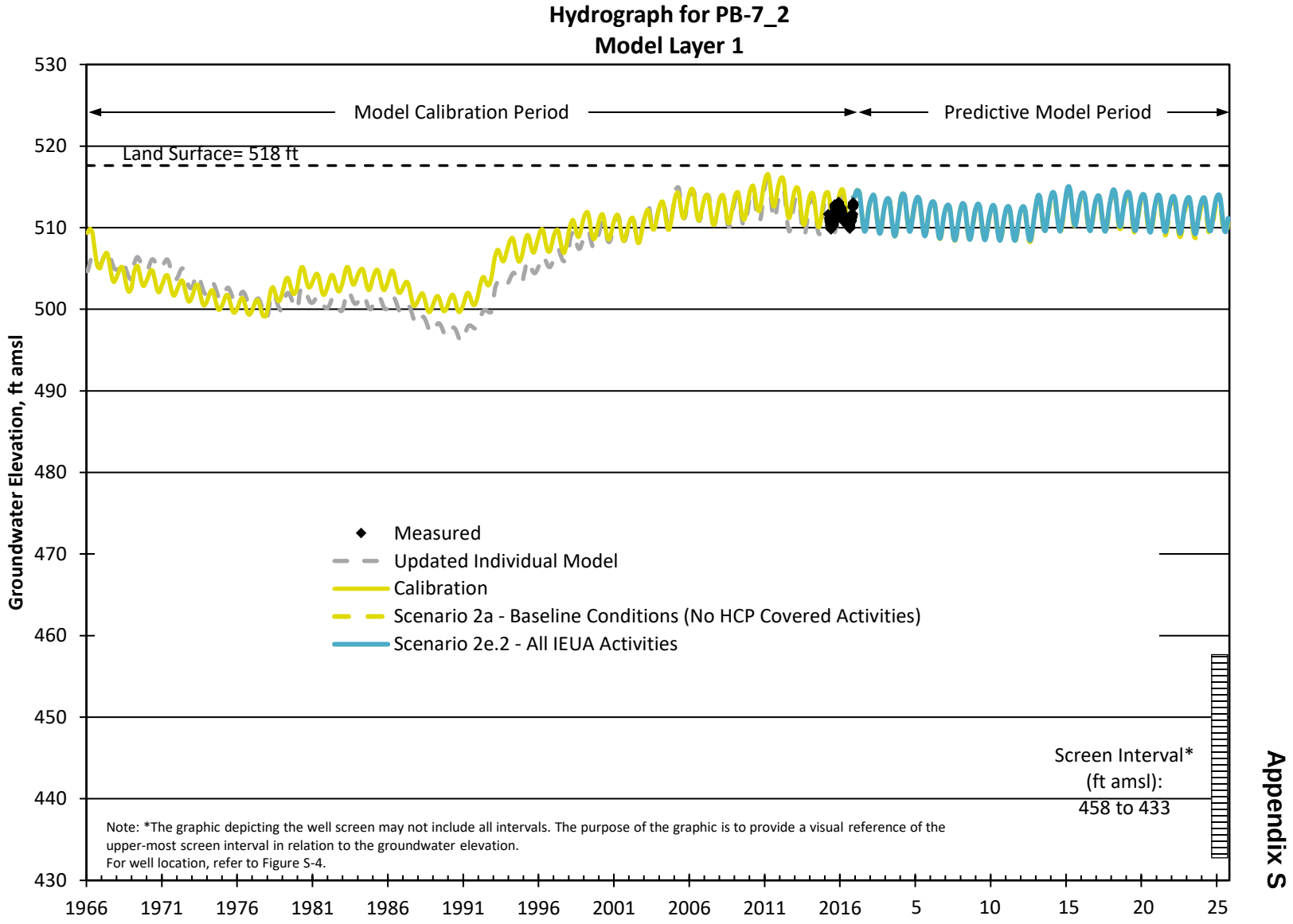
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.7 - Evaluation of Valley District Stormwater Capture Program at Prado Dam
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

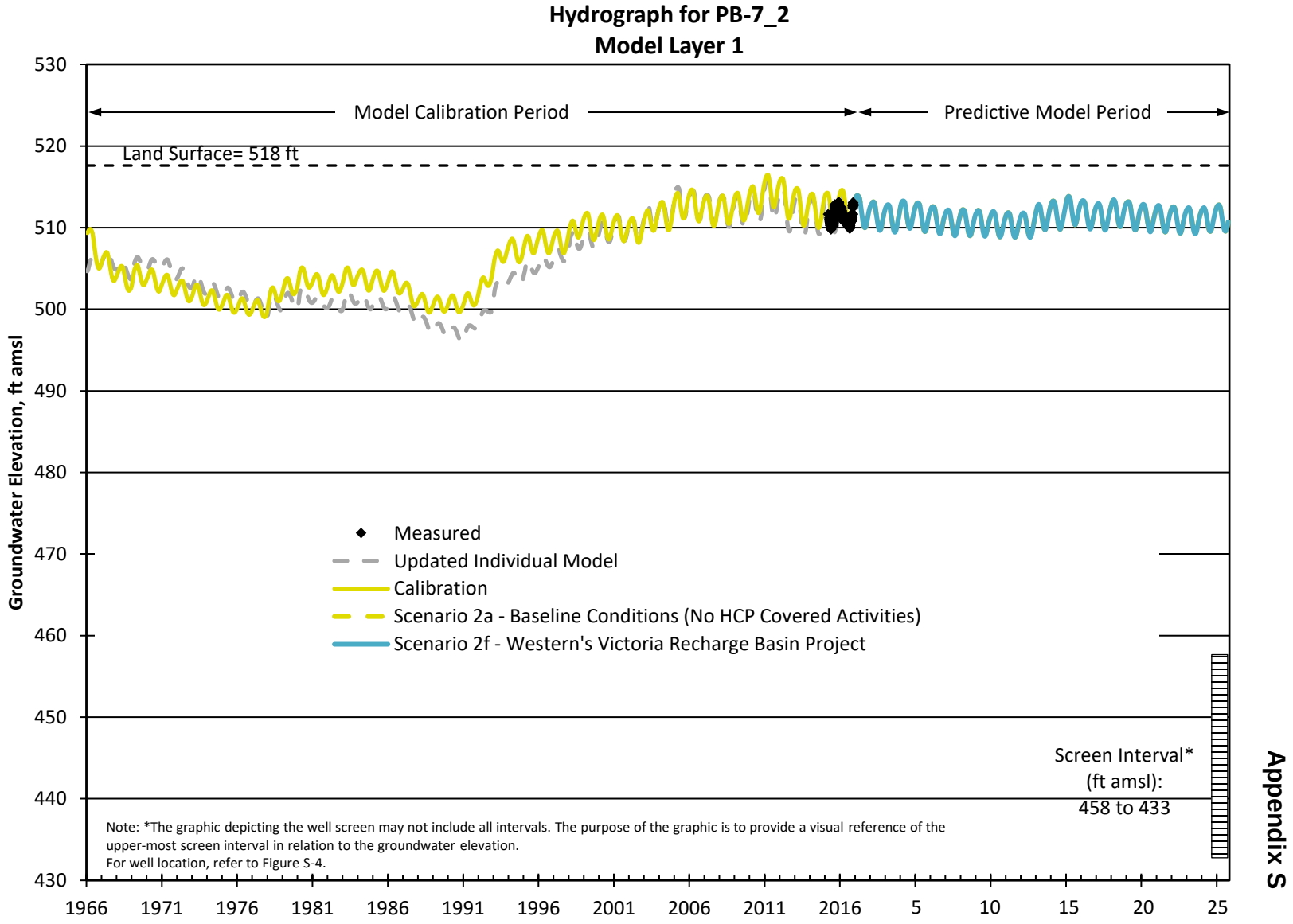
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
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510
500
490
480
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2016
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2e.1 - IEUA Stormflow Activities
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

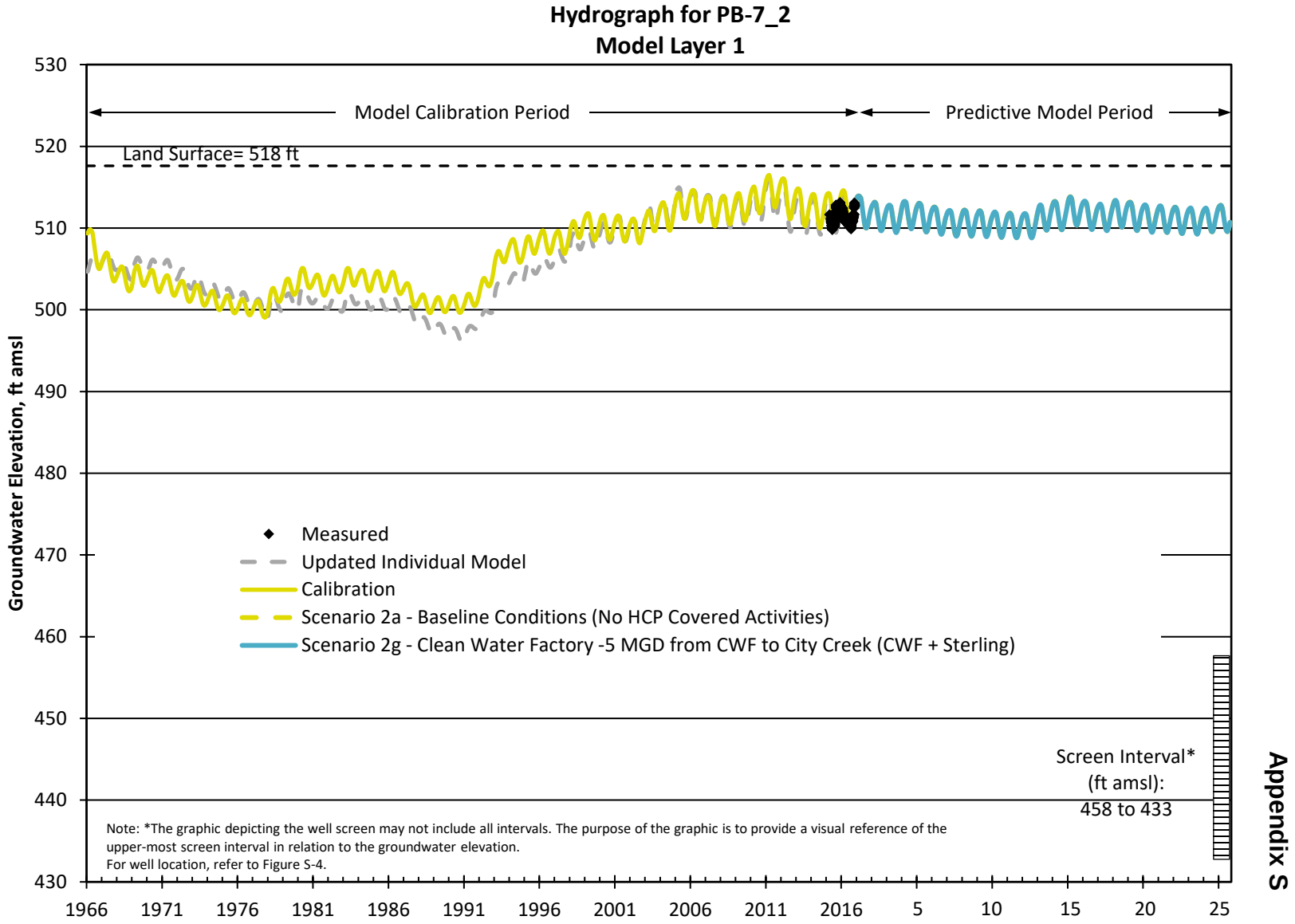
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
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Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2e.2 - All IEUA Activities
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

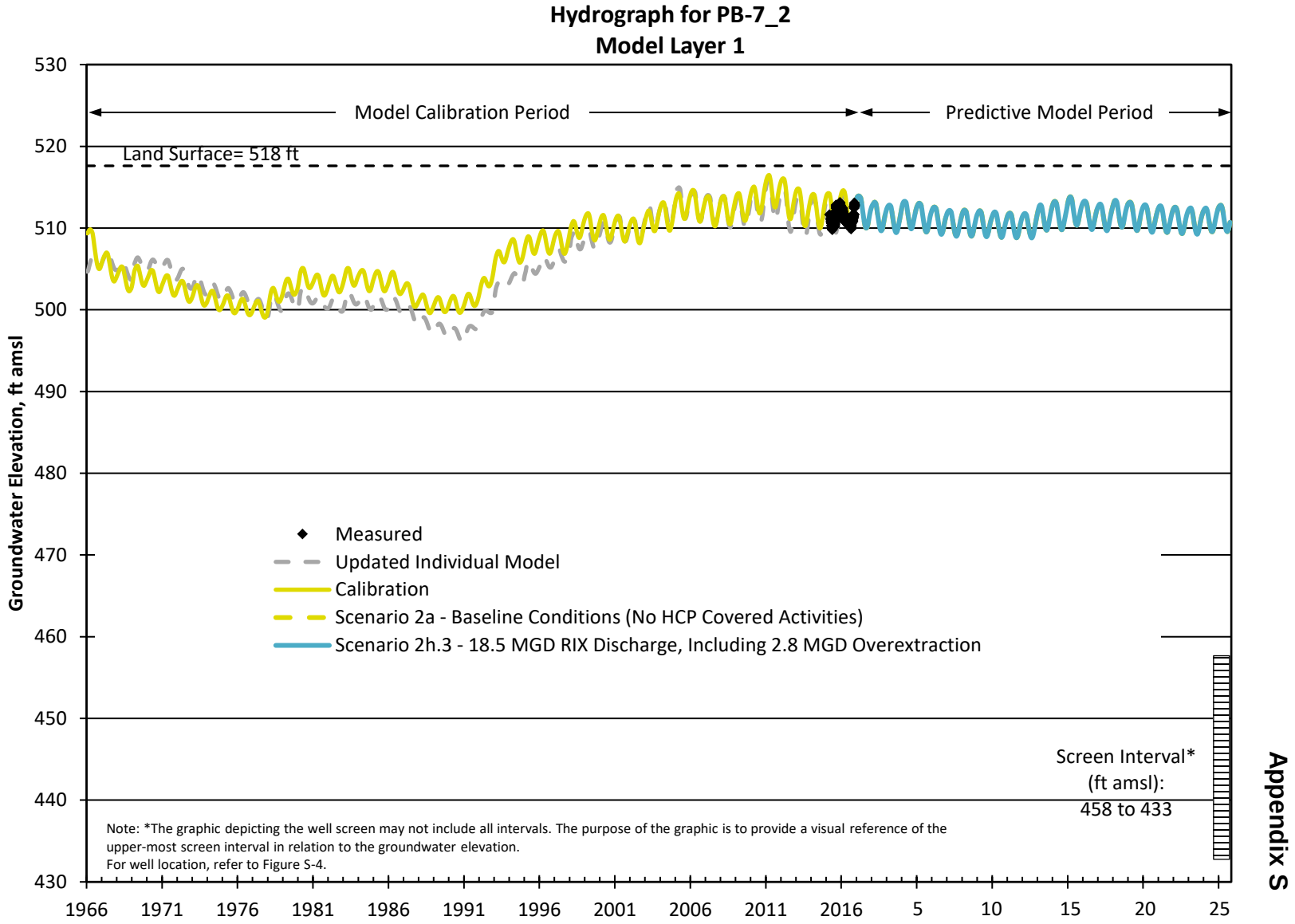
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2f - Western's Victoria Recharge Basin Project
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

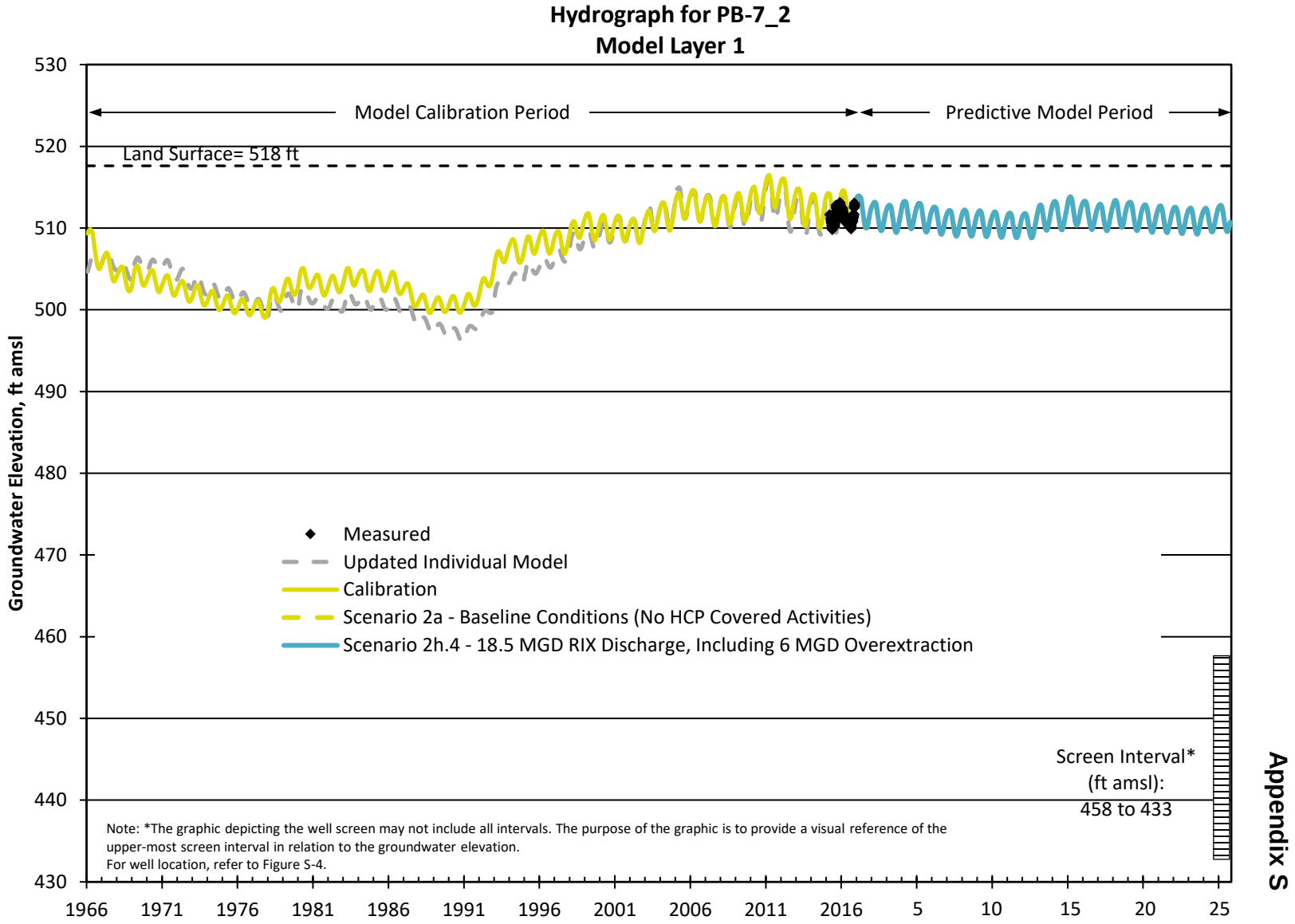
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2g - Clean Water Factory -5 MGD from CWF to City Creek (CWF + Sterling)
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

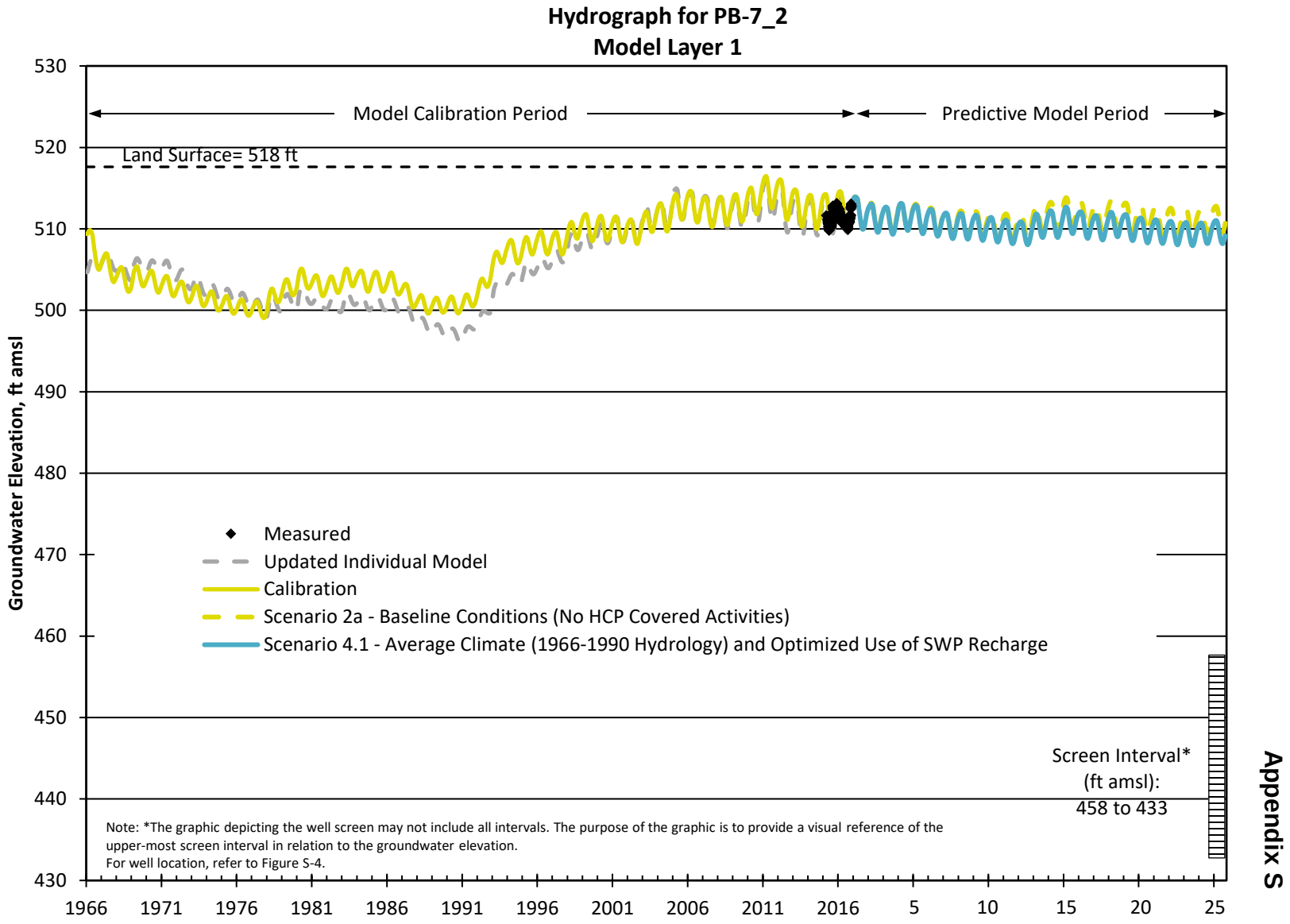
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
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20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2h.3 - 18.5 MGD RIX Discharge, Including 2.8 MGD Overextraction
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

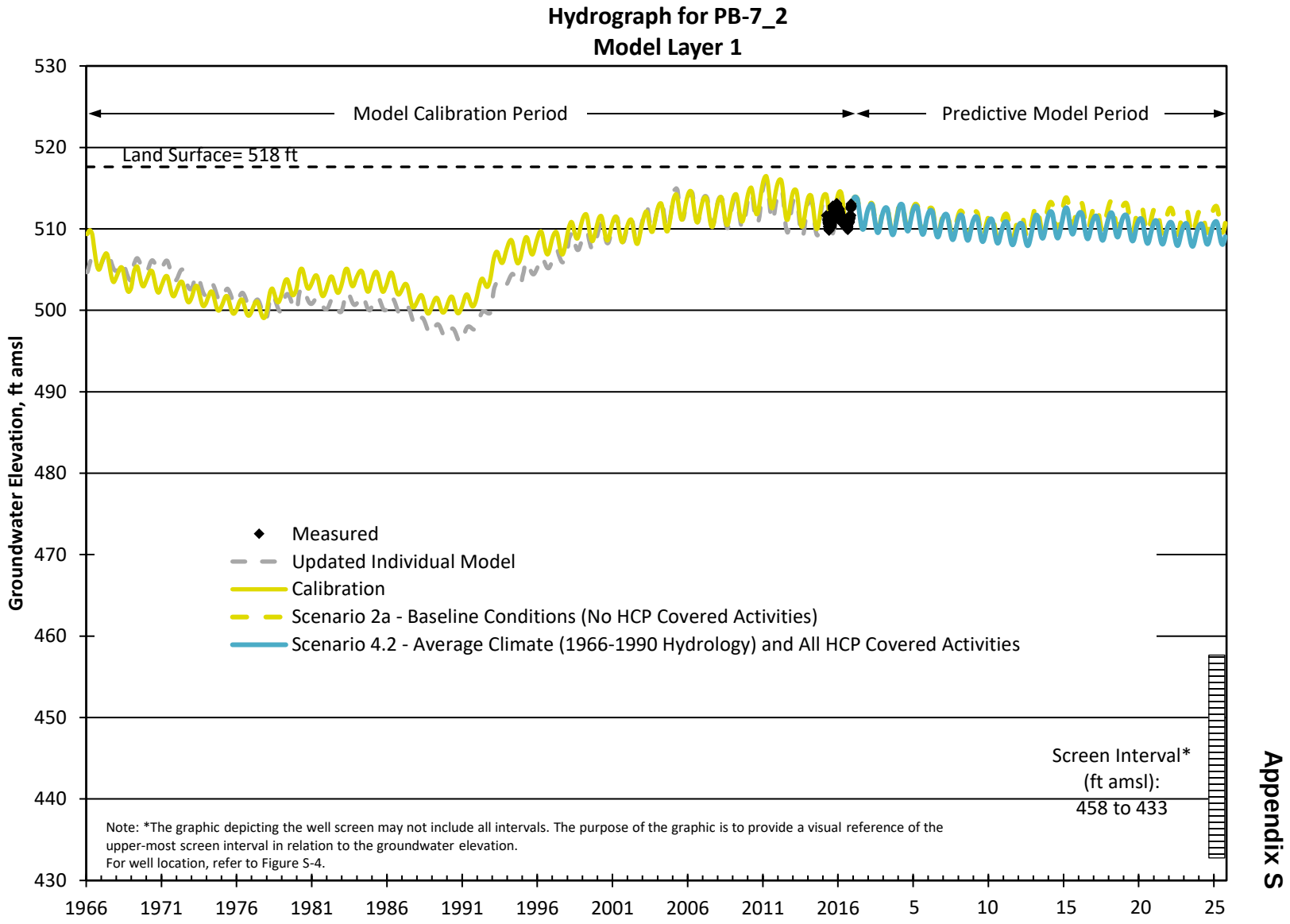
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2h.4 - 18.5 MGD RIX Discharge, Including 6 MGD Overextraction
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

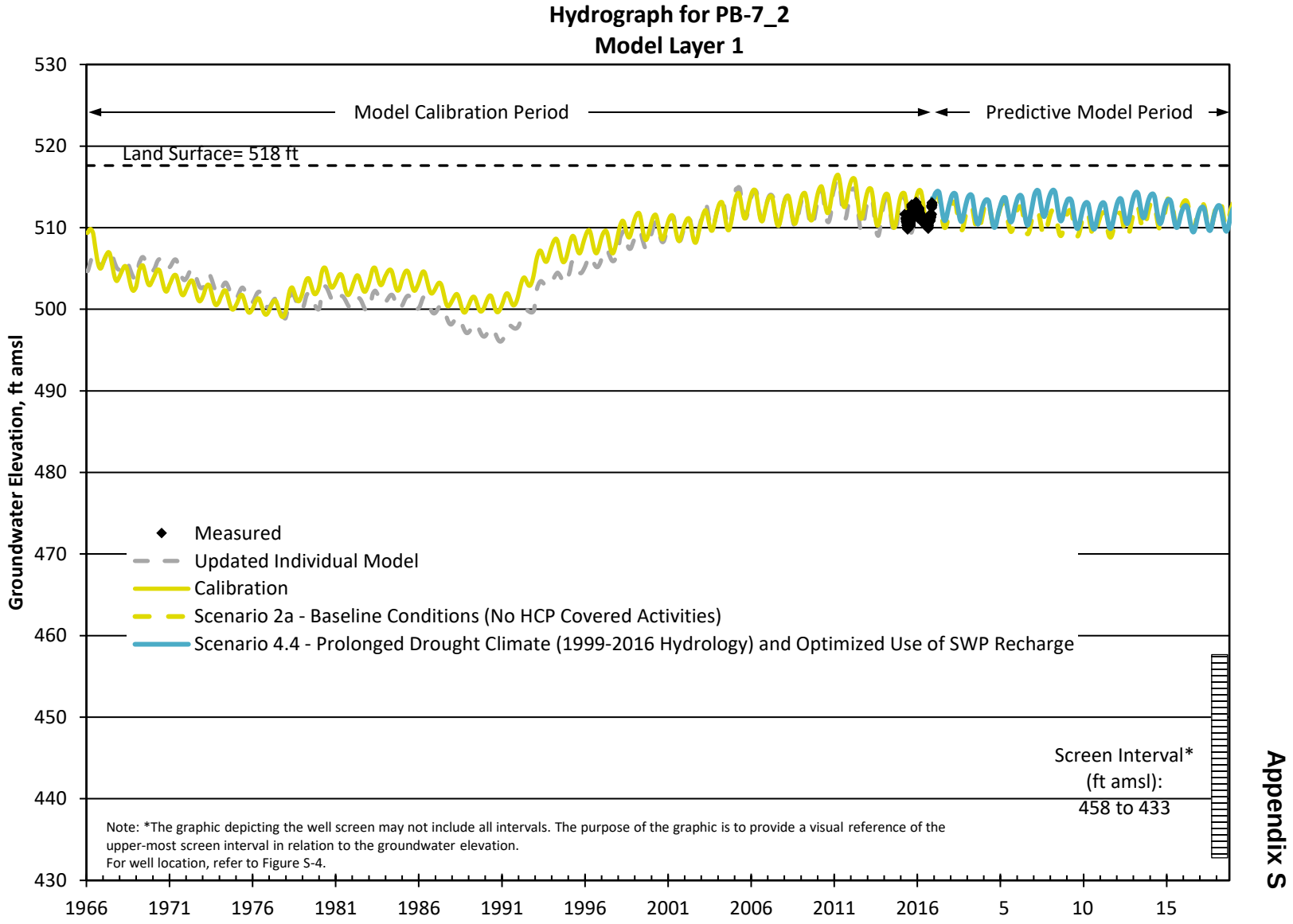
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
1971
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2016
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25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.1 - Average Climate (1966-1990 Hydrology) and Optimized Use of SWP Recharge
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

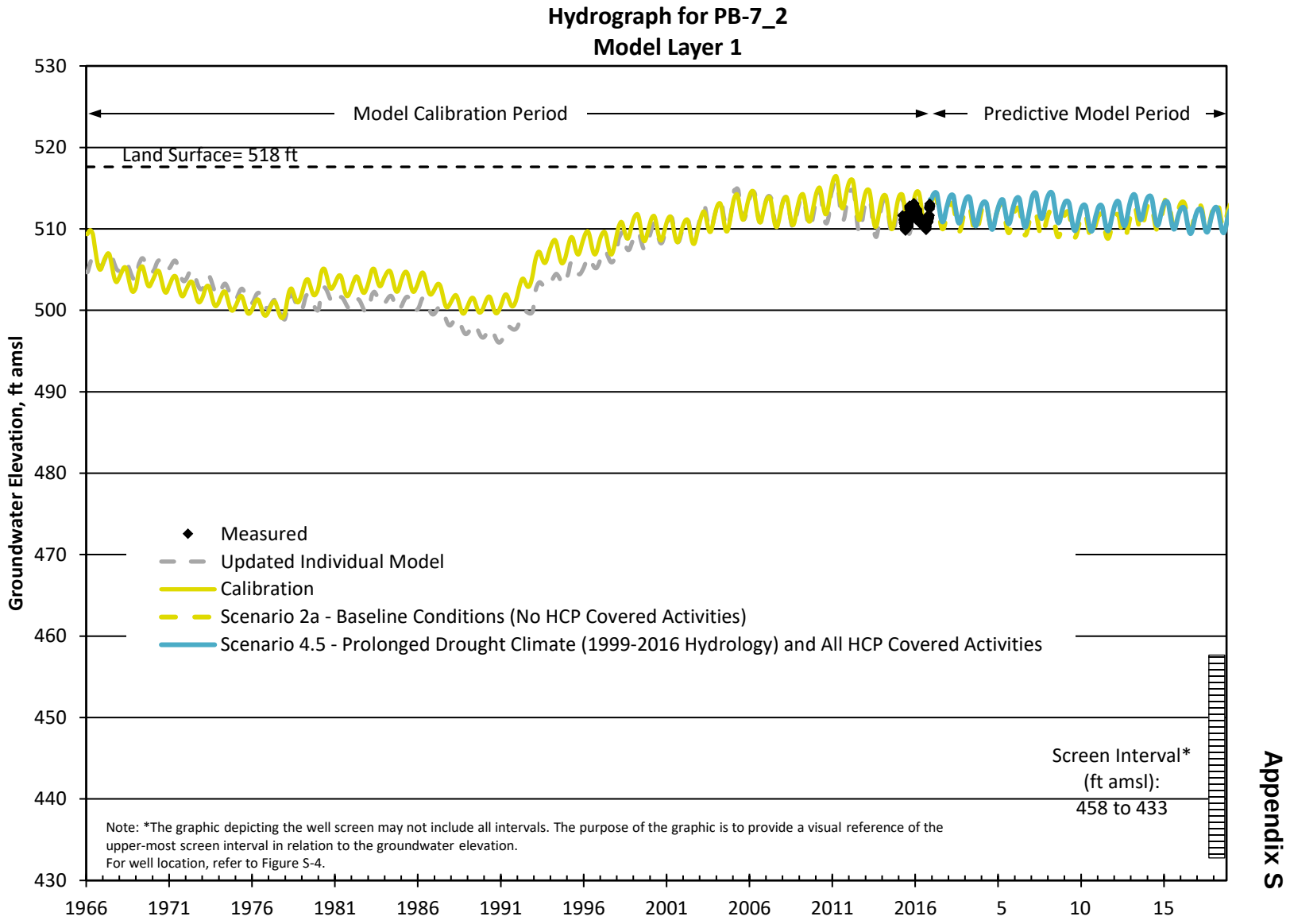
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
1971
1976
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2016
5
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20
25
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.2 - Average Climate (1966-1990 Hydrology) and All HCP Covered Activities
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

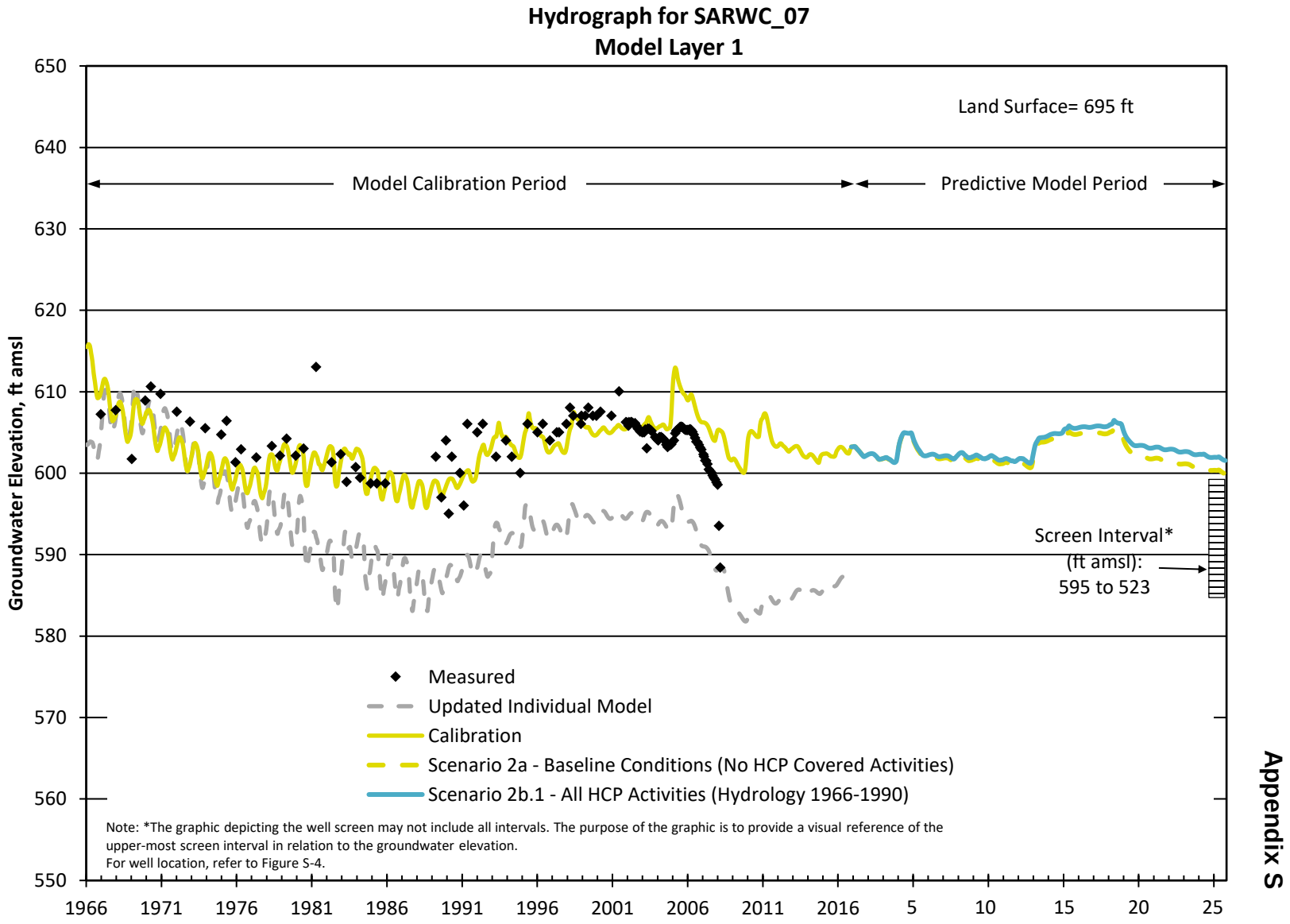
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
1971
1976
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1996
2001
2006
2011
2016
5
10
15
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.4 - Prolonged Drought Climate (1999-2016 Hydrology) and Optimized Use of SWP Recharge
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

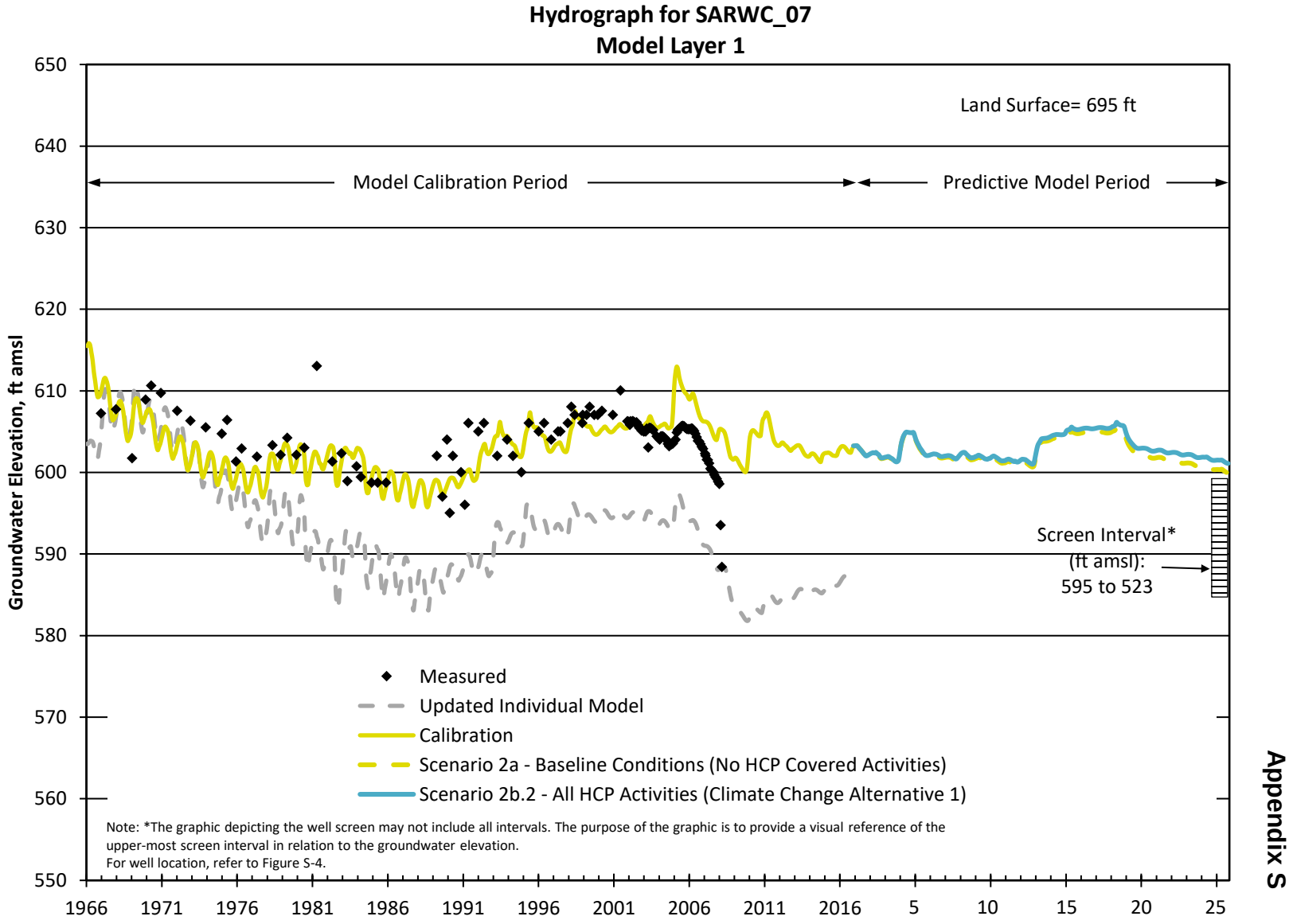
Appendix S


Hydrograph for PB-7_2
Model Layer 1
Model Calibration Period
Predictive Model Period
Land Surface= 518 ft
Groundwater Elevation, ft amsl
530
520
510
500
490
480
470
460
450
440
430
1966
1971
1976
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1996
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2006
2011
2016
5
10
15
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.5 - Prolonged Drought Climate (1999-2016 Hydrology) and All HCP Covered Activities
Screen Interval*
(ft amsl):
458 to 433
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

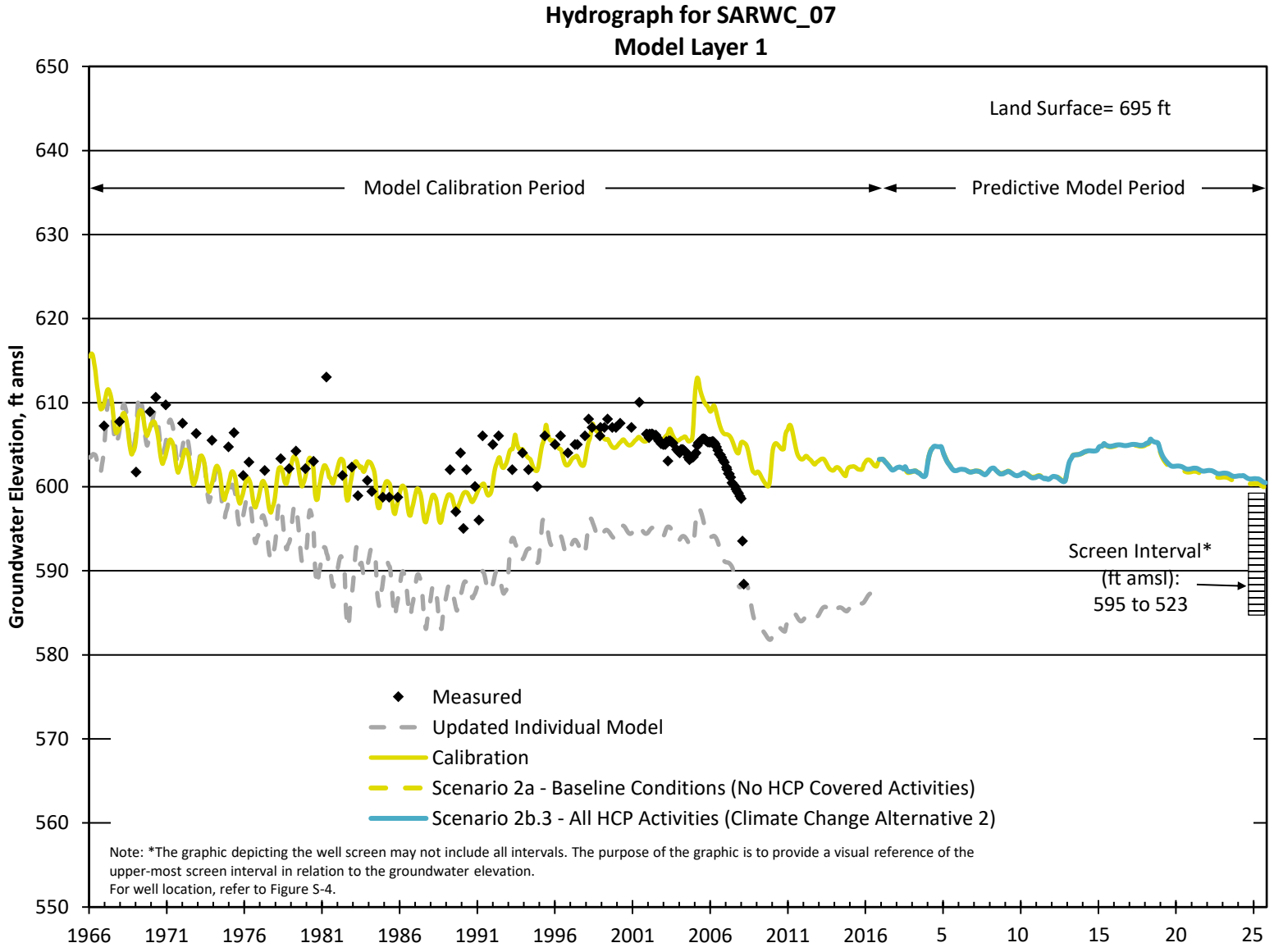
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
1966
1971
1976
1981
1986
1991
1996
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2006
2011
2016
5
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15
20
25
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.1 - All HCP Activities (Hydrology 1966-1990)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

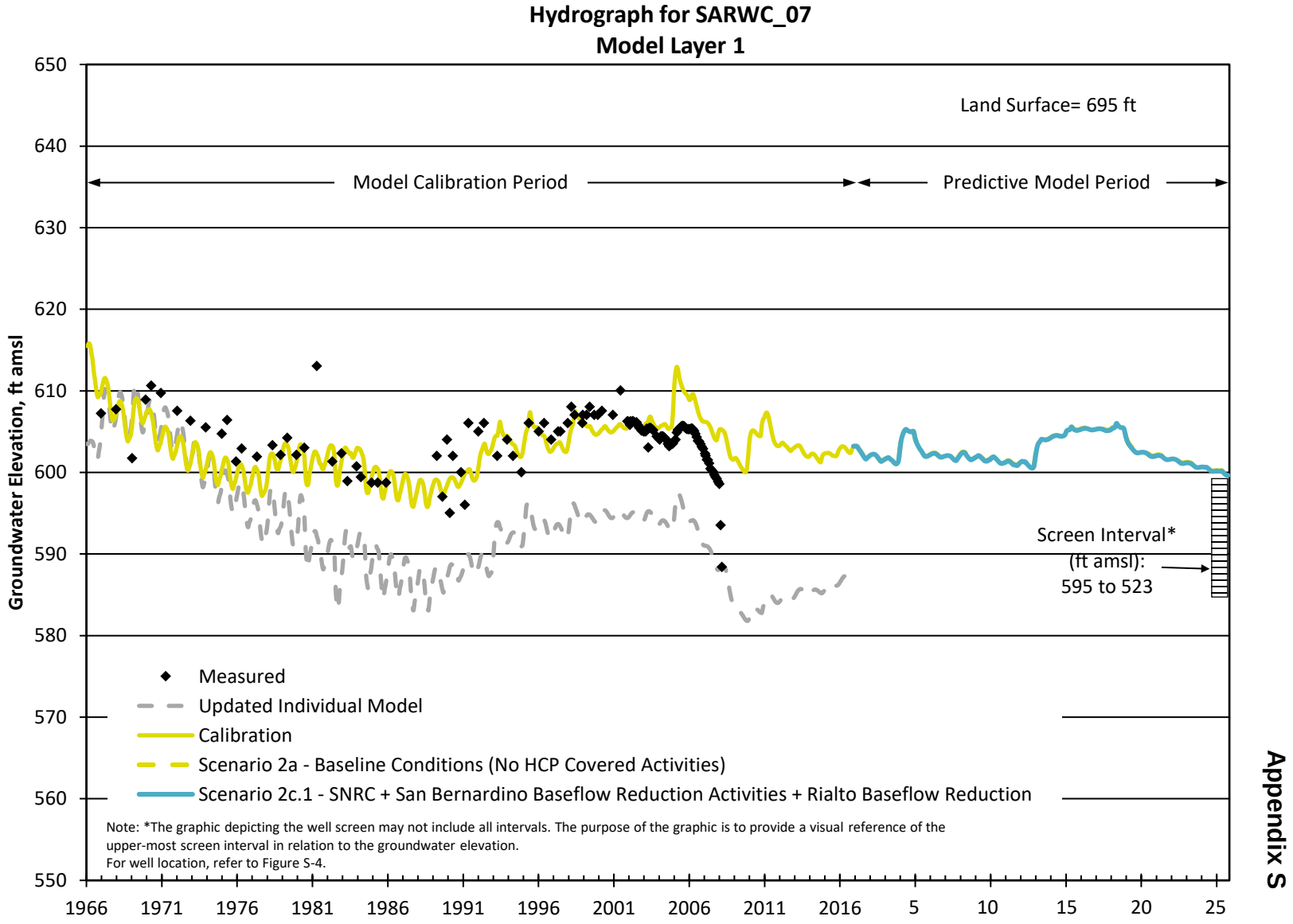
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.2 - All HCP Activities (Climate Change Alternative 1)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
1976
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1996
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2006
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2016
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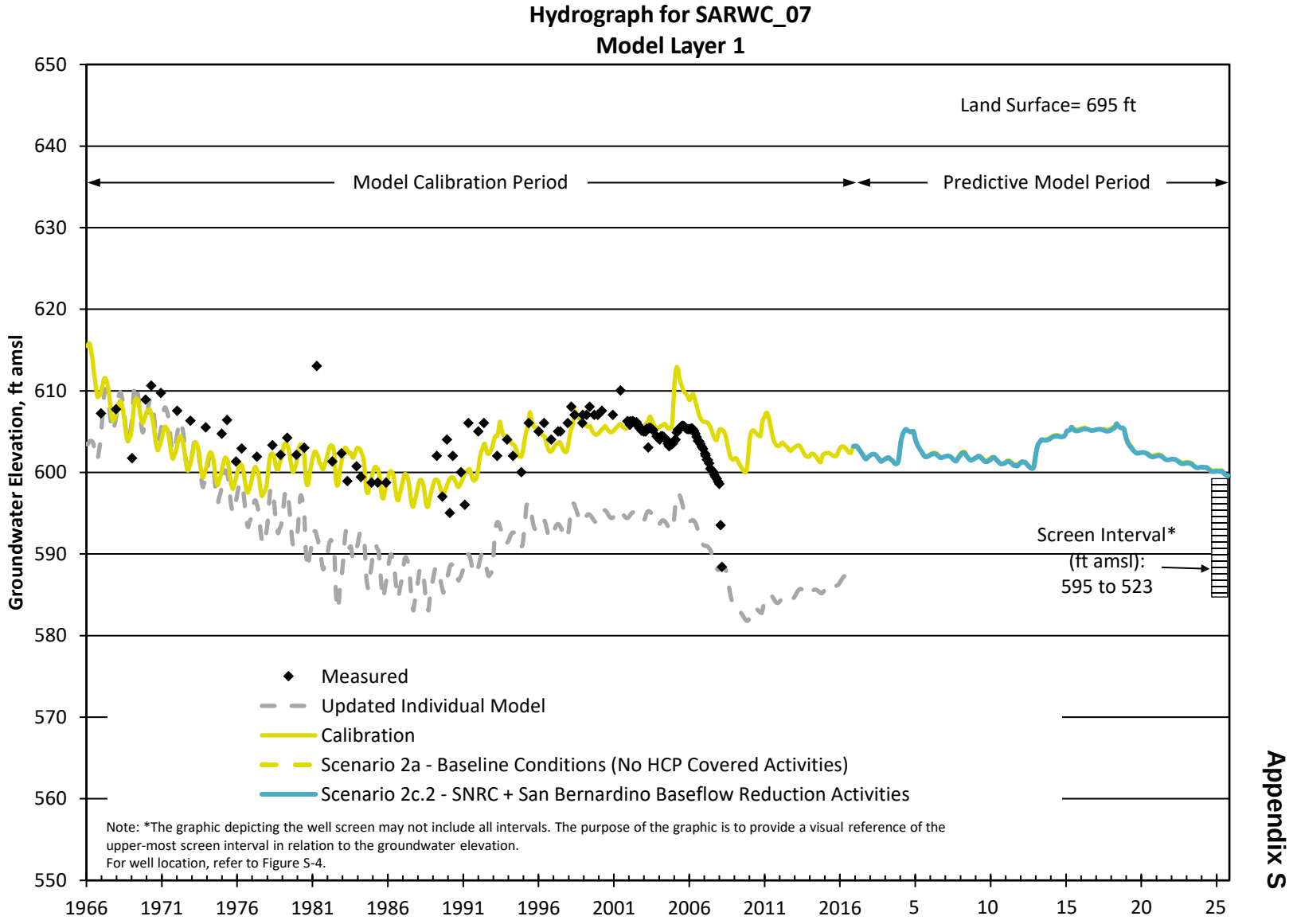
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2b.3 - All HCP Activities (Climate Change Alternative 2)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
1976
1981
1986
1991
1996
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2006
2011
2016
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15
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25

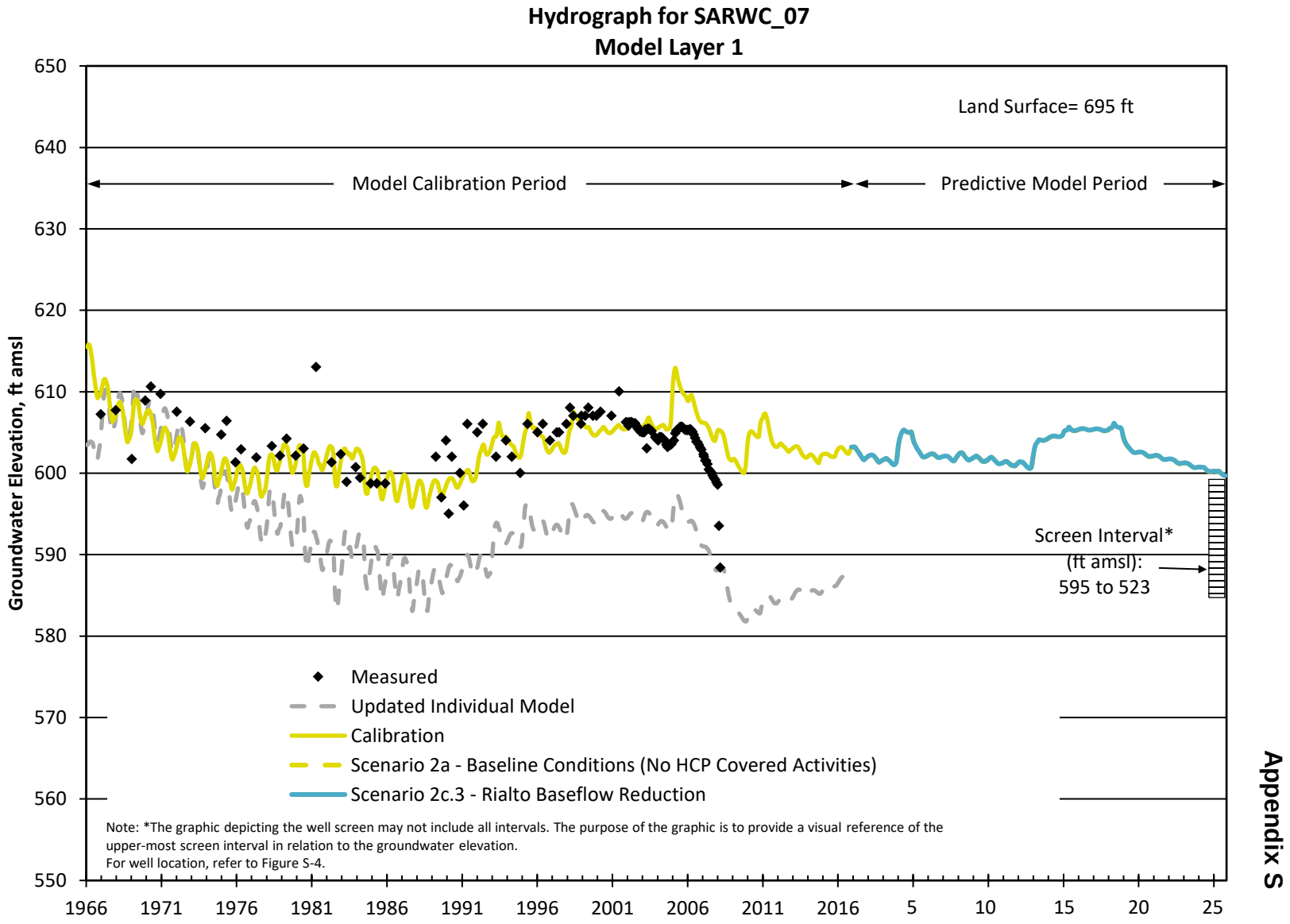
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.1 - SNRC + San Bernardino Baseflow Reduction Activities + Rialto Baseflow Reduction
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

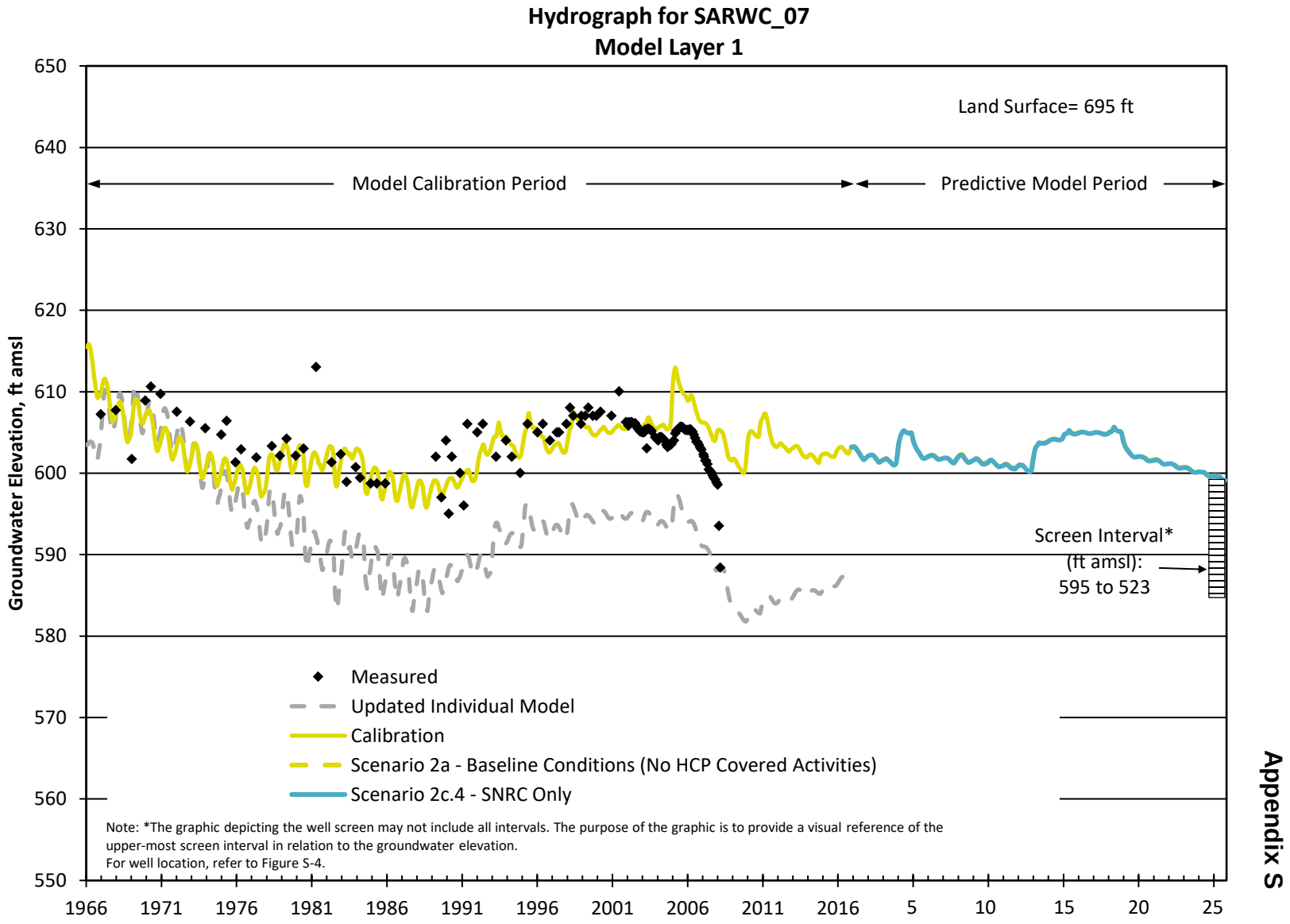
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.2 - SNRC + San Bernardino Baseflow Reduction Activities
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

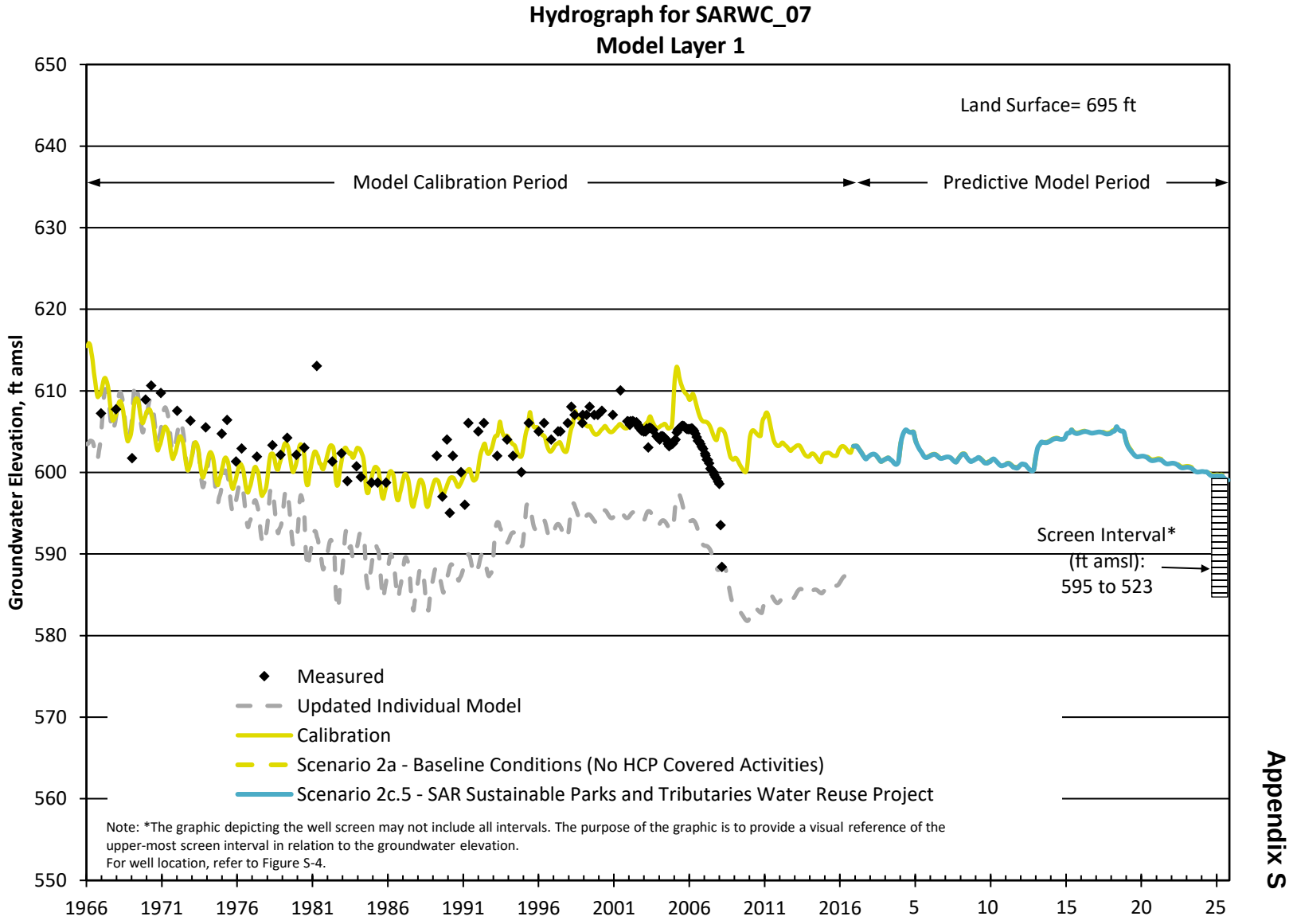
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.3 - Rialto Baseflow Reduction
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

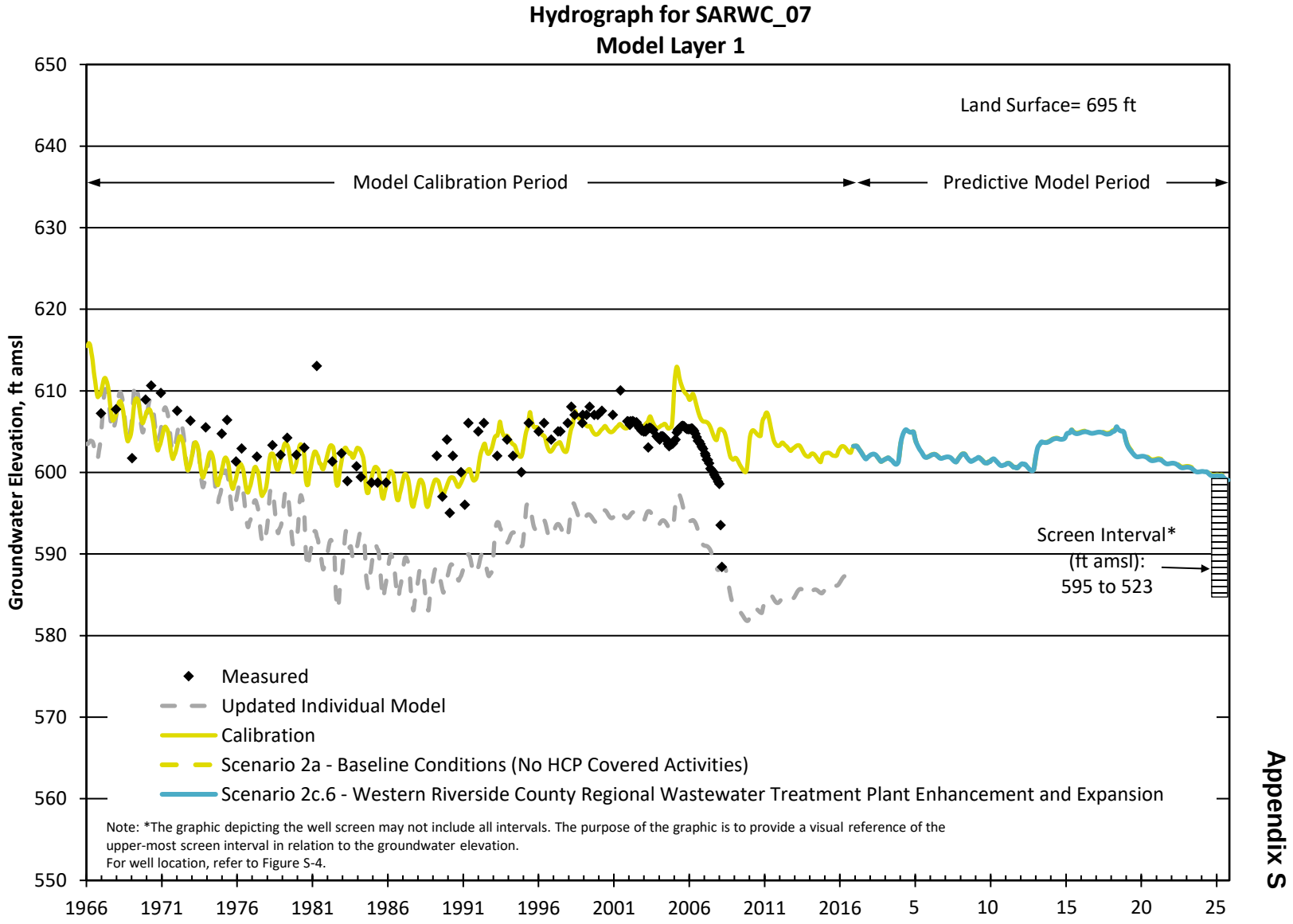
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.4 - SNRC Only
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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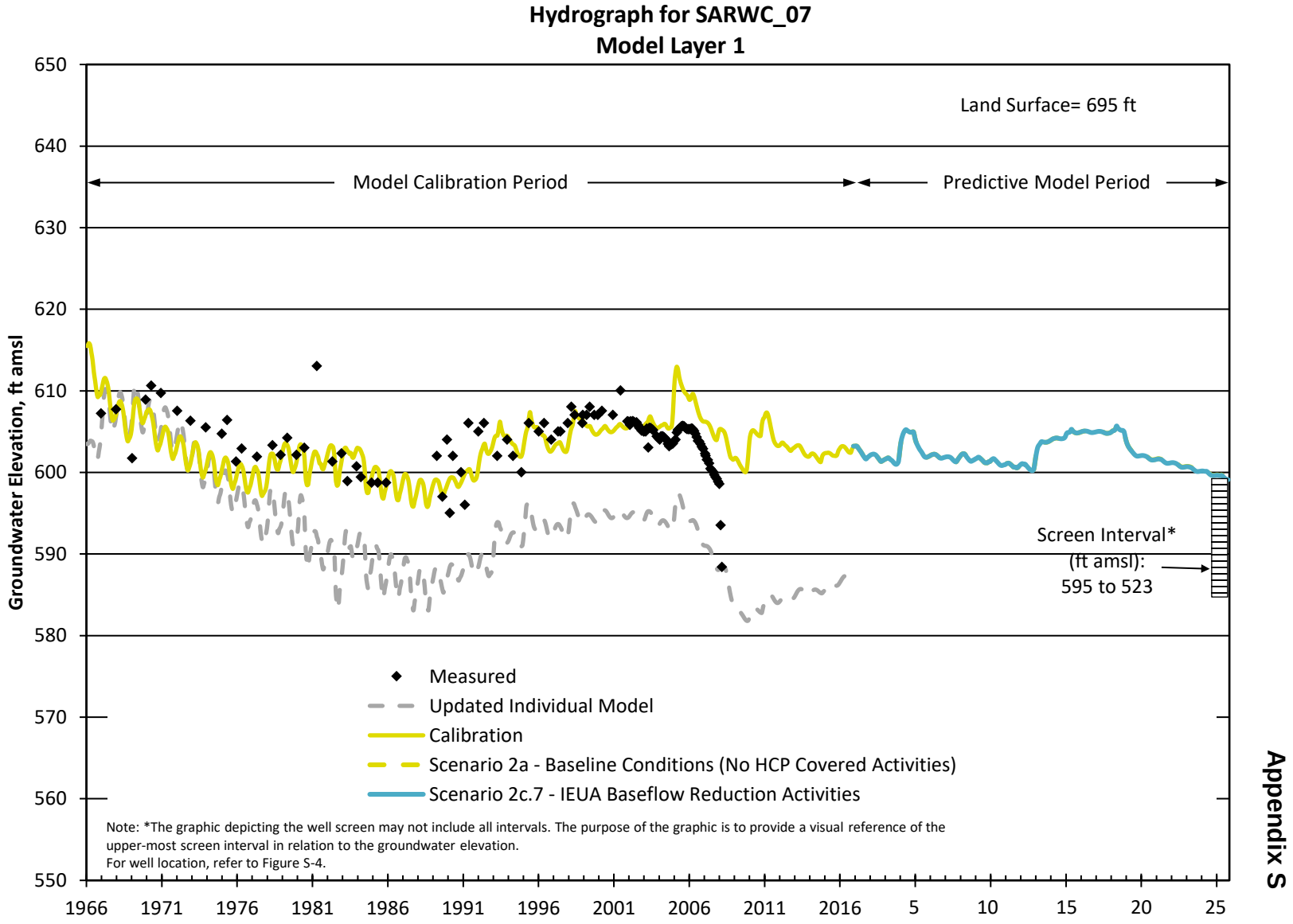
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
5
10
15
20
25
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.5 - SAR Sustainable Parks and Tributaries Water Reuse Project
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

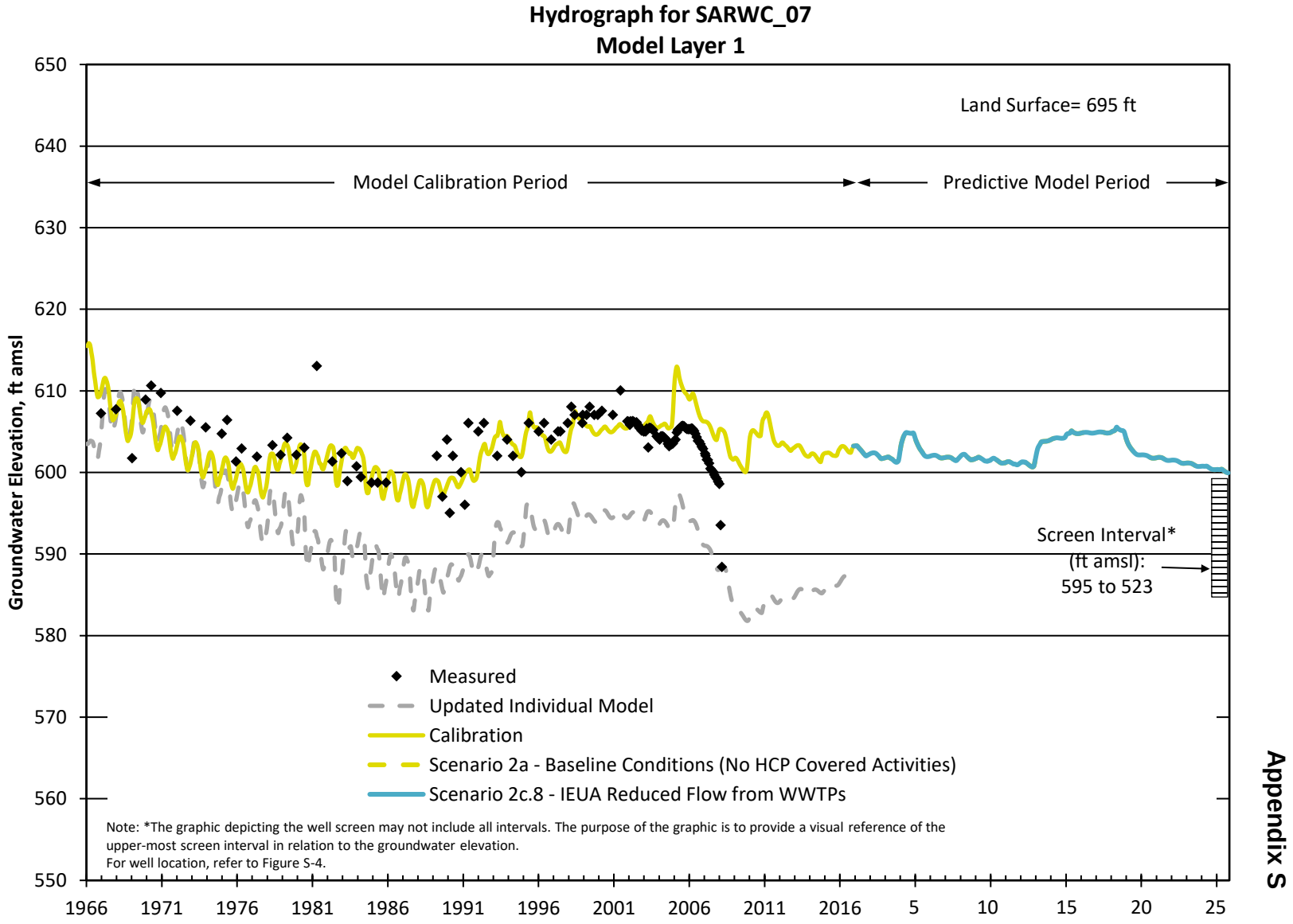
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.6 - Western Riverside County Regional Wastewater Treatment Plant Enhancement and Expansion
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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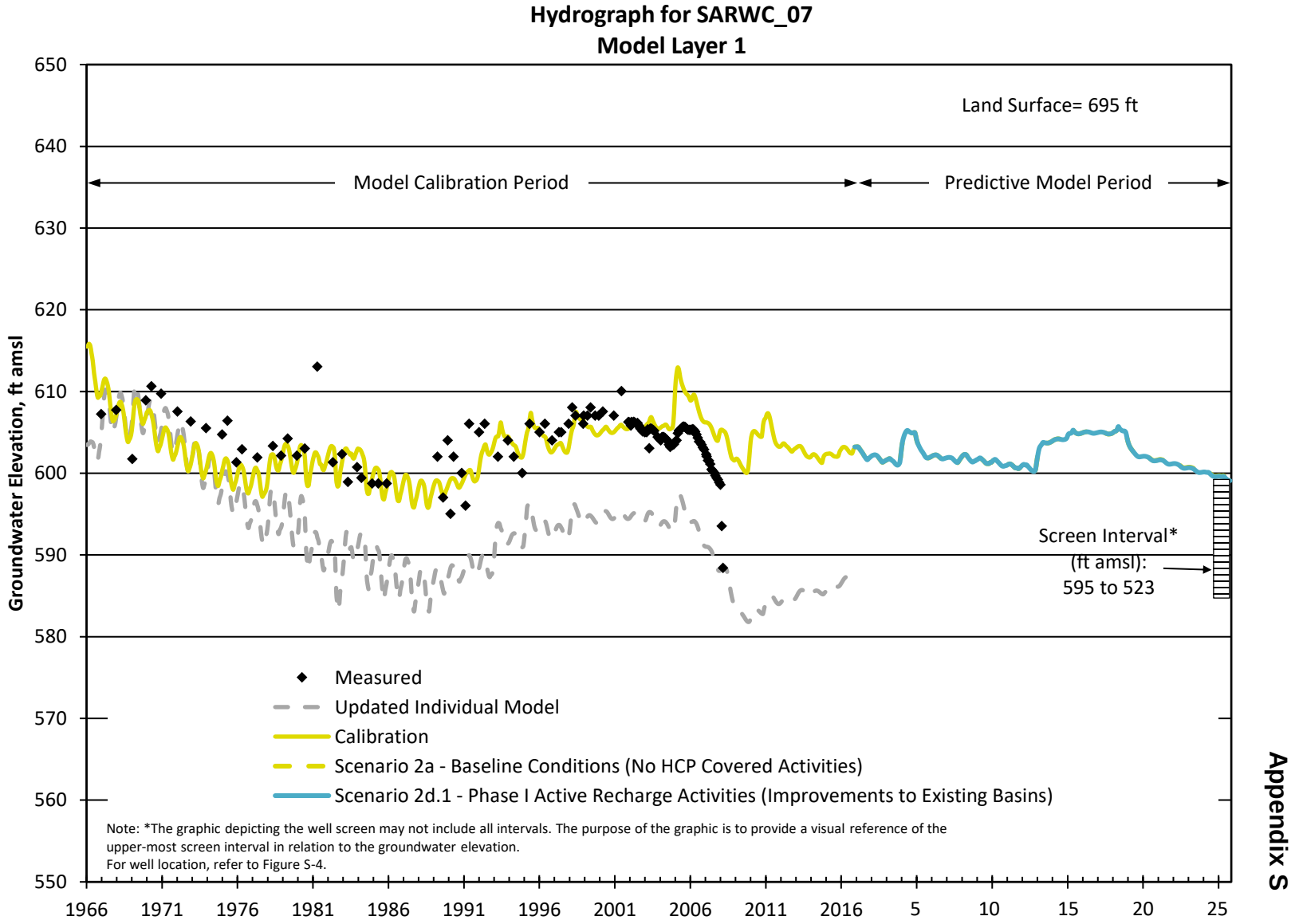
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.7 - IEUA Baseflow Reduction Activities
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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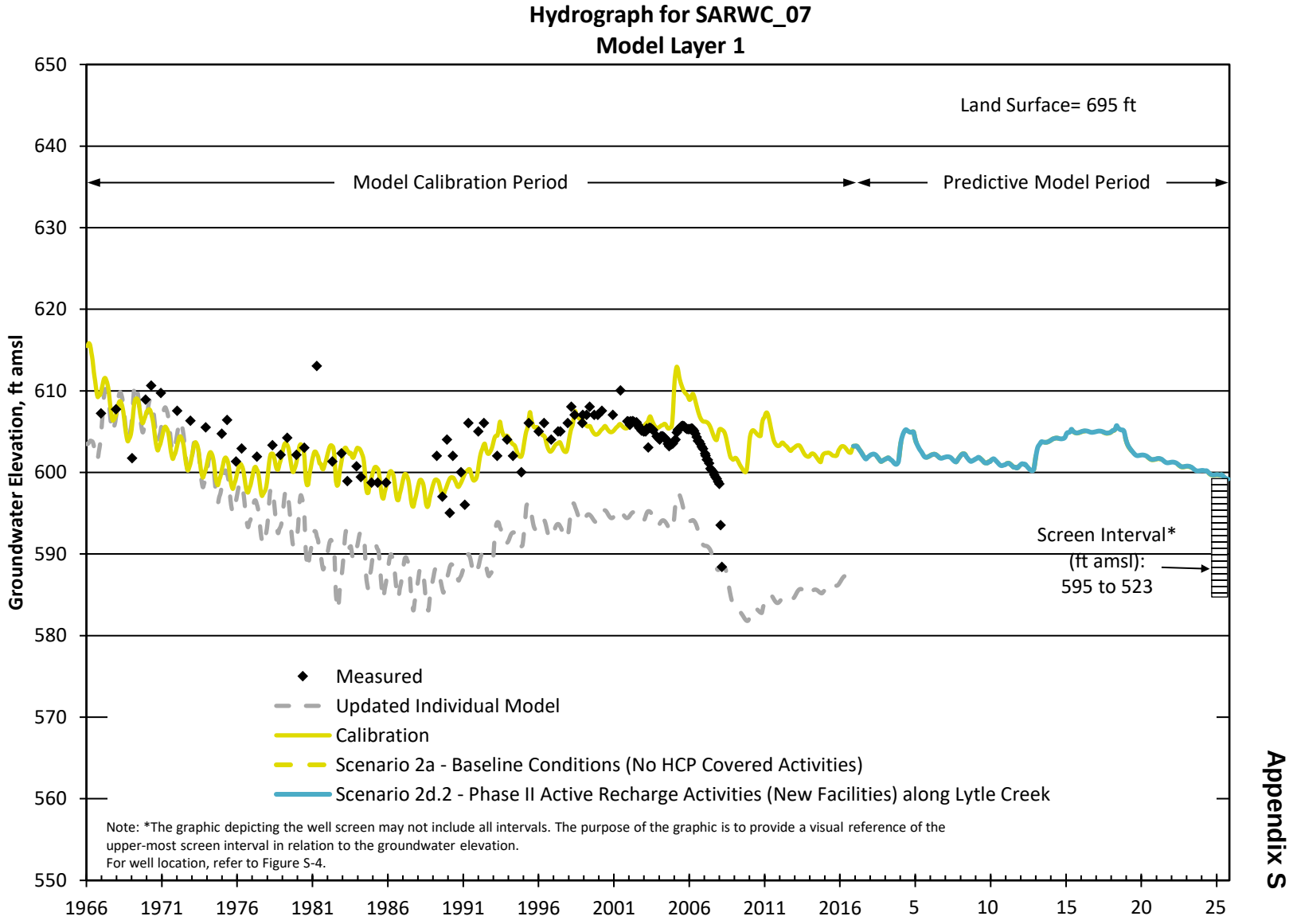
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2c.8 - IEUA Reduced Flow from WWTPs
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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2016
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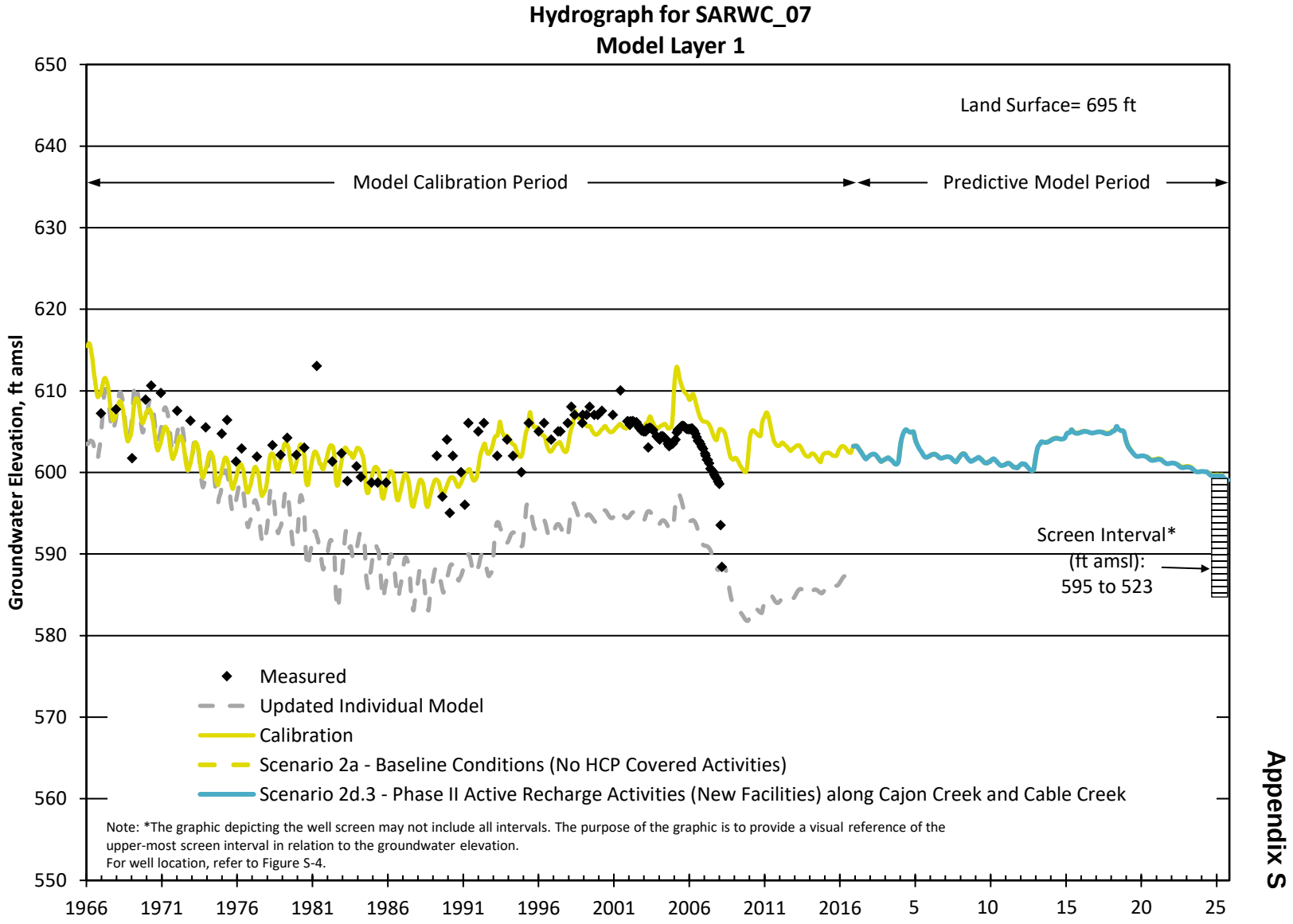
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.1 - Phase I Active Recharge Activities (Improvements to Existing Basins)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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2016
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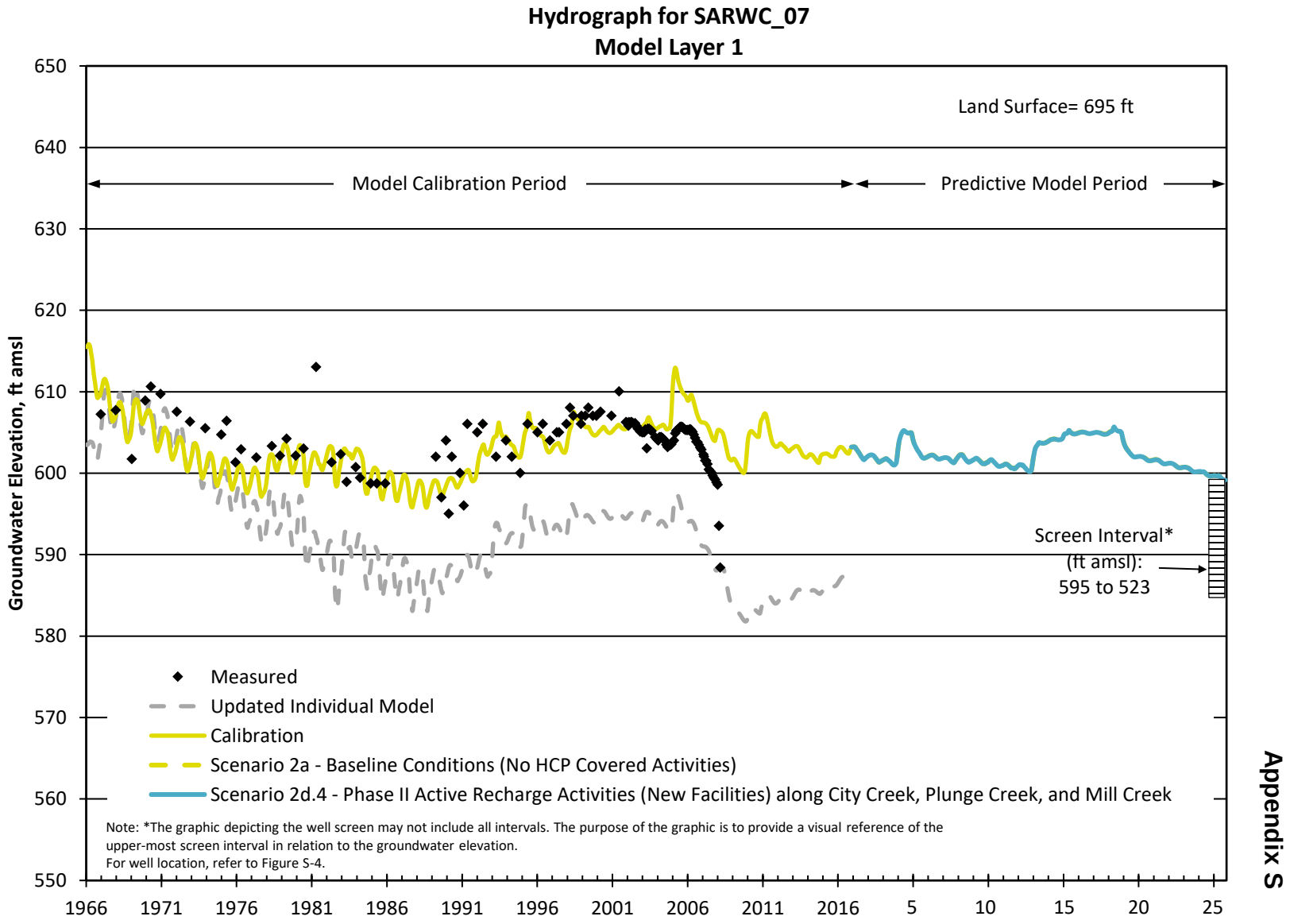
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
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Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.2 - Phase II Active Recharge Activities (New Facilities) along Lytle Creek
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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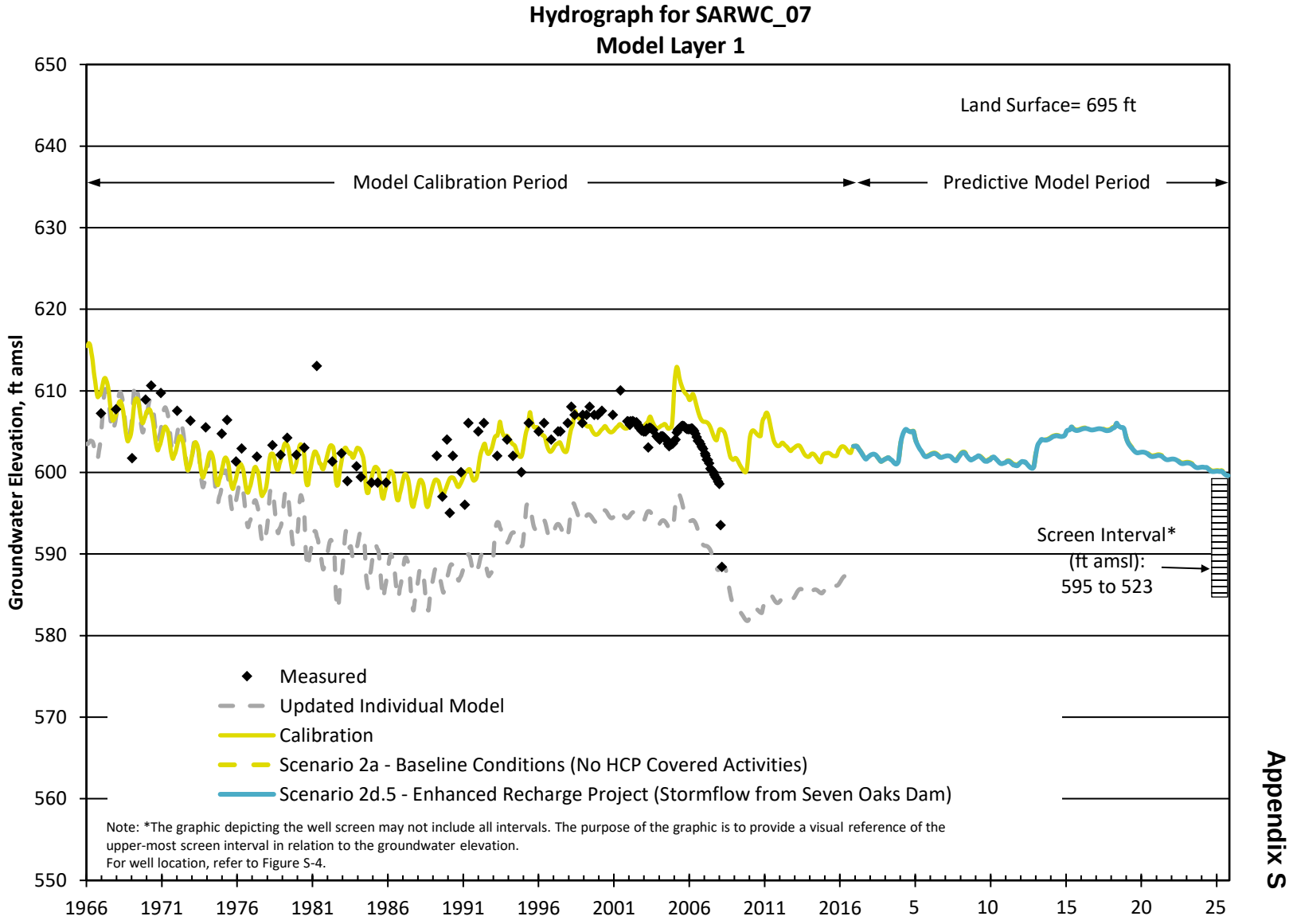
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.3 - Phase II Active Recharge Activities (New Facilities) along Cajon Creek and Cable Creek
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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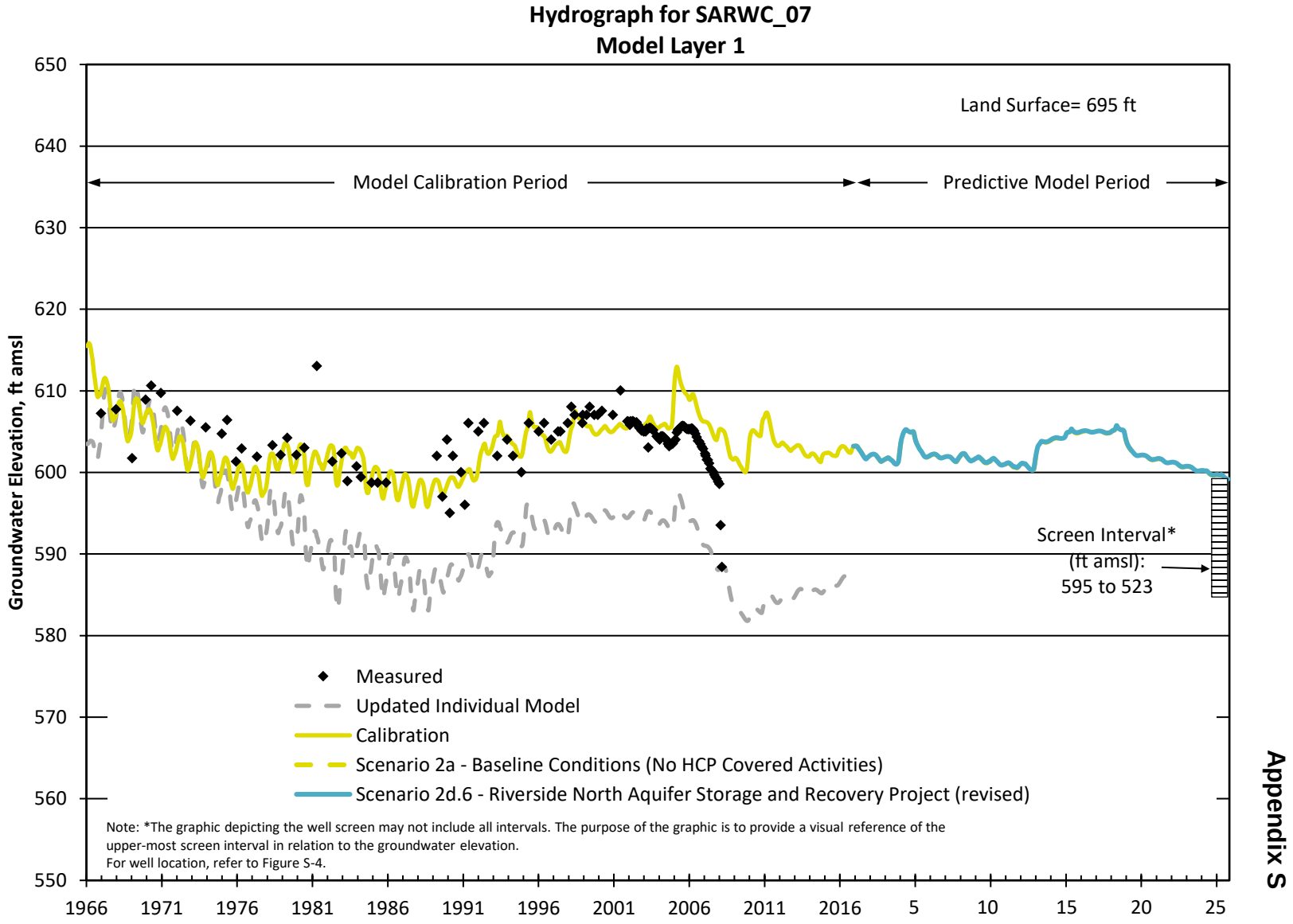
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
570
560
550
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.4 - Phase II Active Recharge Activities (New Facilities) along City Creek, Plunge Creek, and Mill Creek
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
1971
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Appendix S

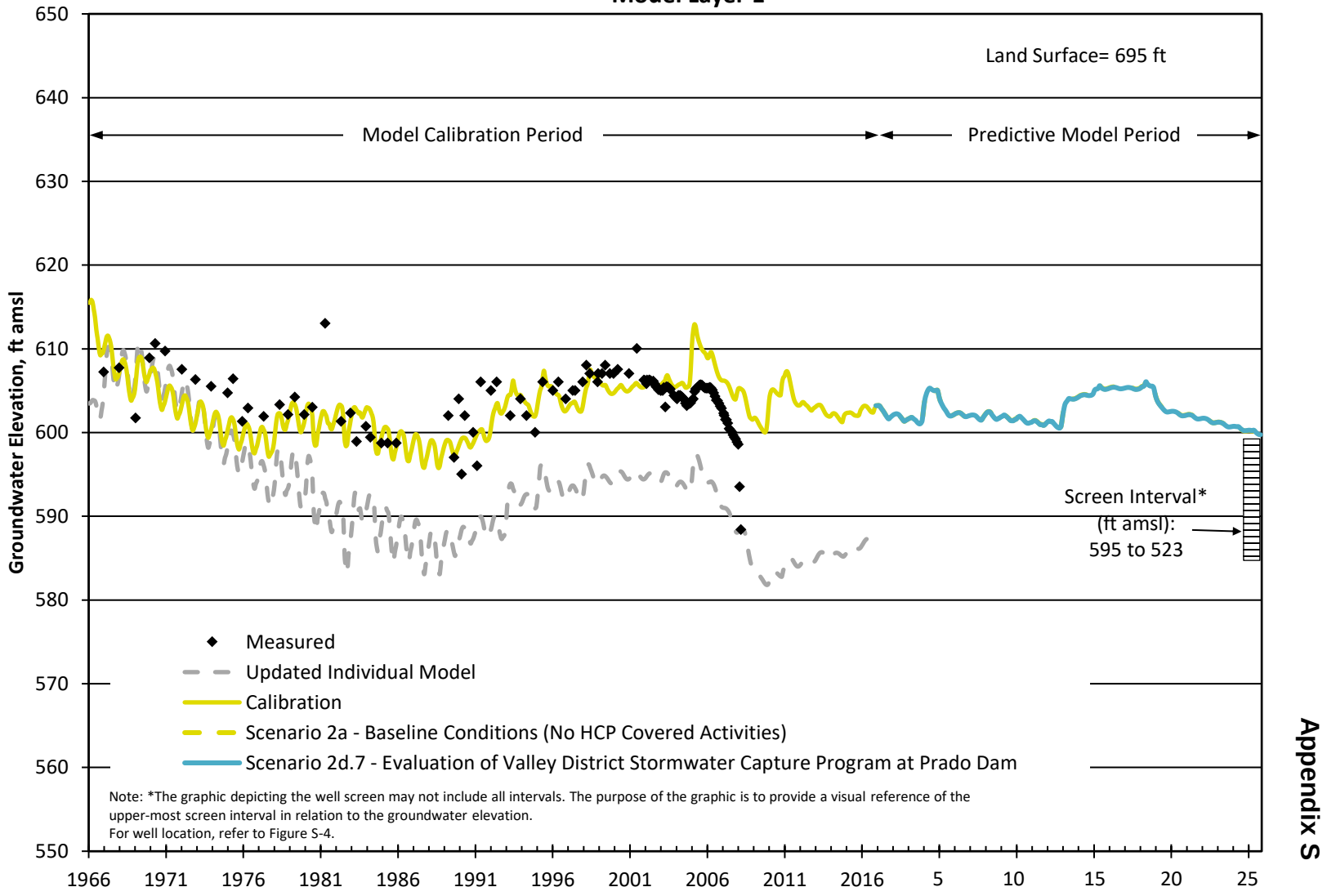

Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
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Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.5 - Enhanced Recharge Project (Stormflow from Seven Oaks Dam)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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Appendix S

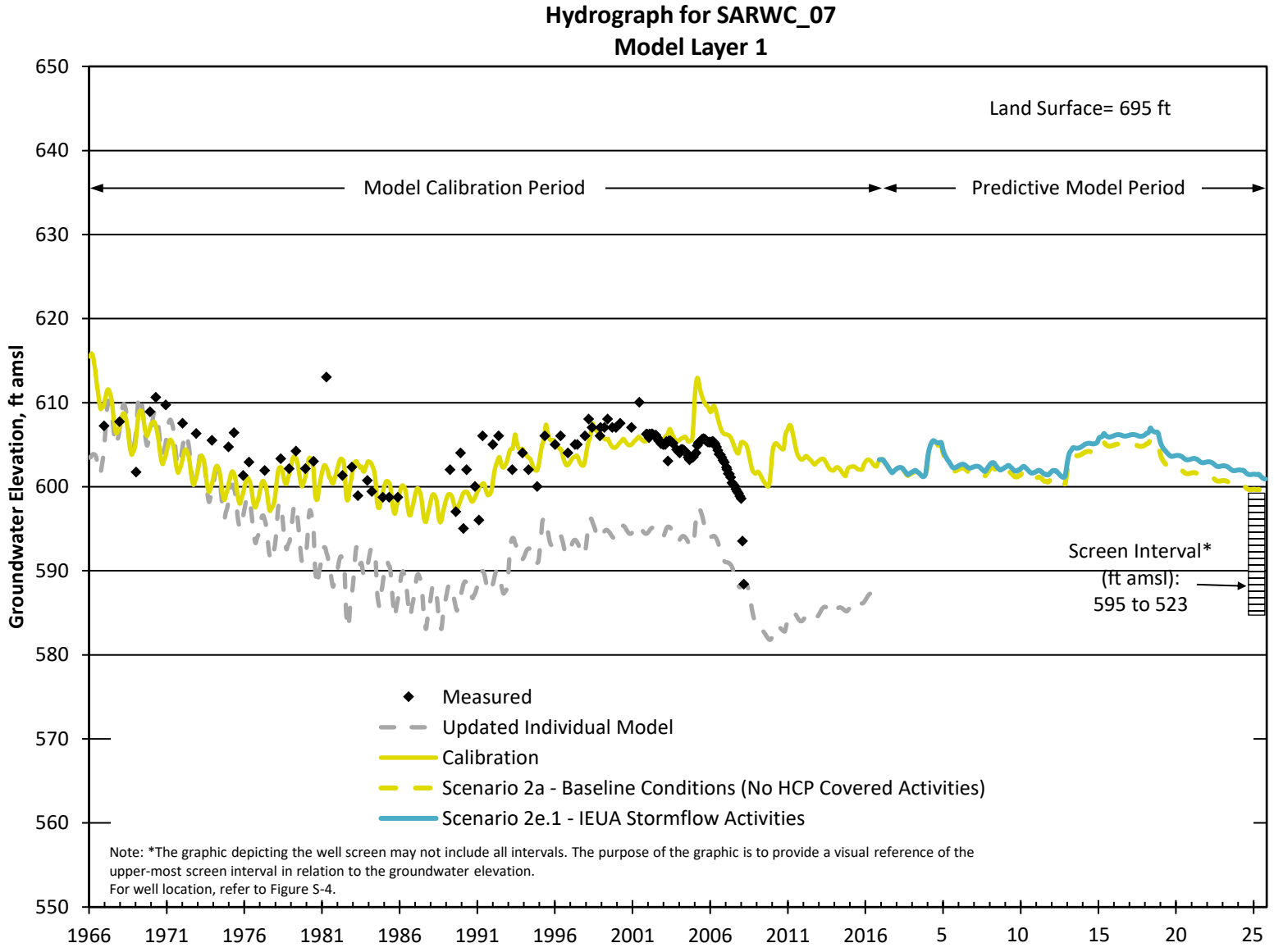

Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
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Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2d.6 - Riverside North Aquifer Storage and Recovery Project (revised)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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Appendix S

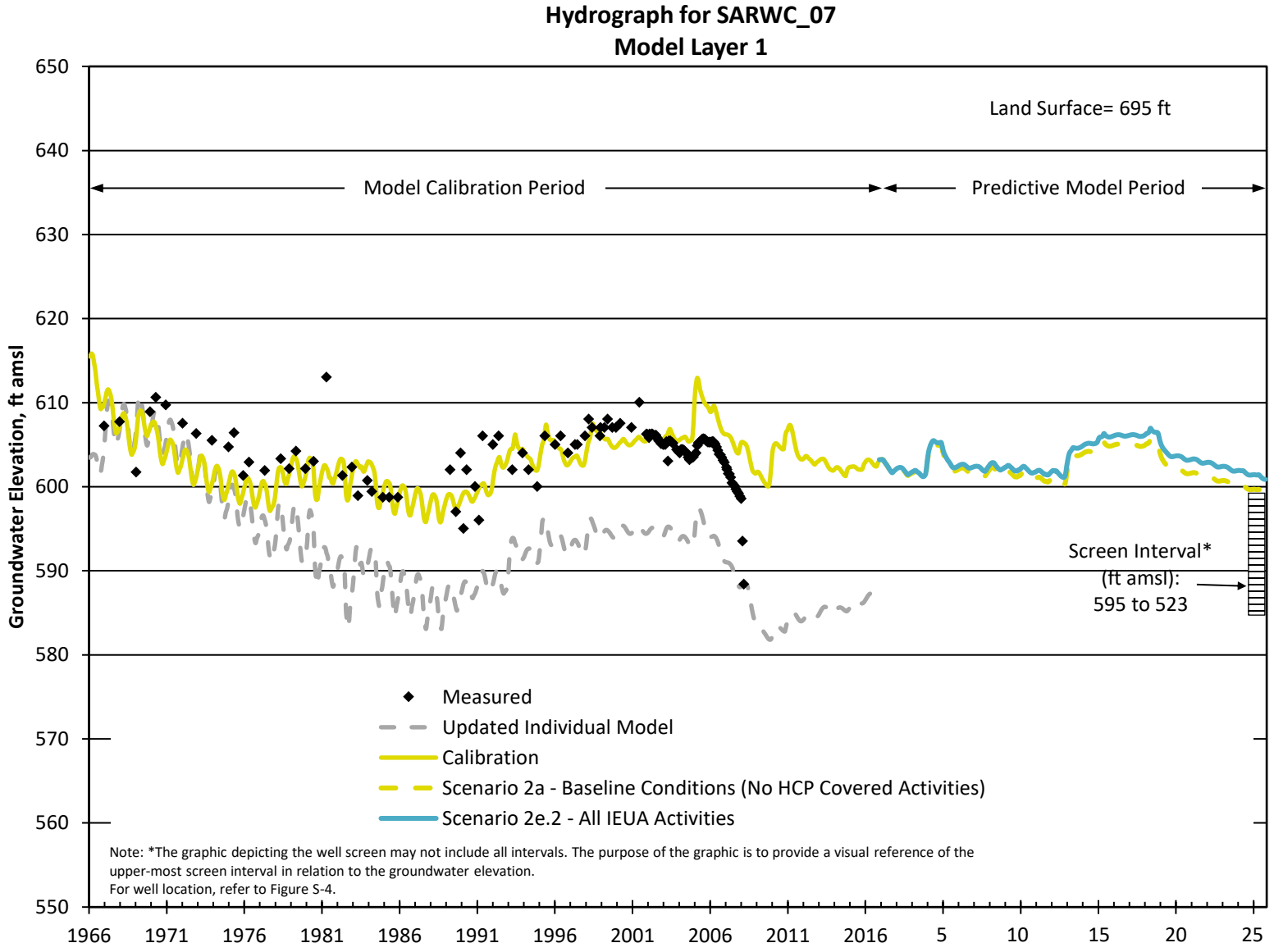
Hydrograph for SARWC_07
Model Layer 1



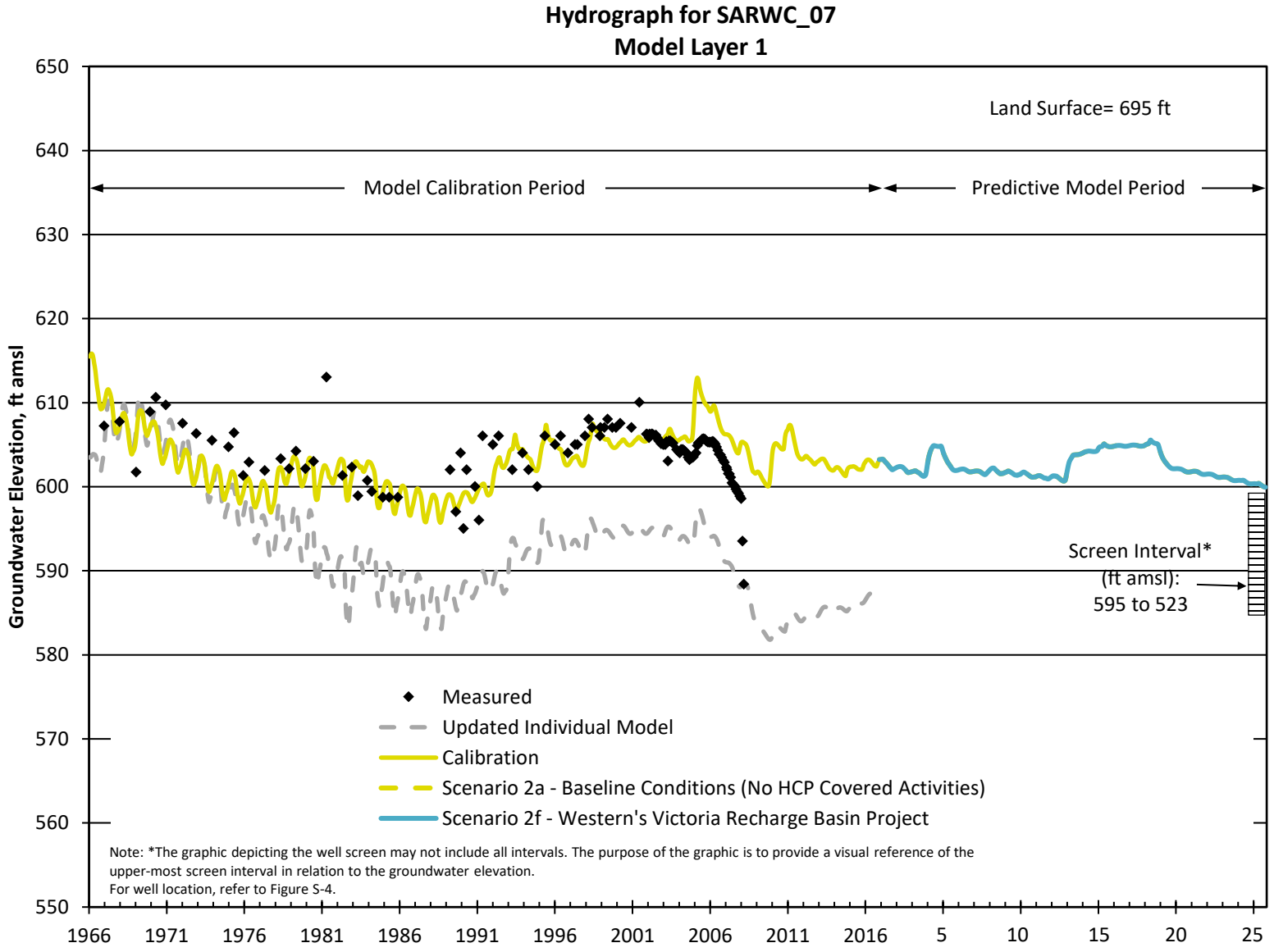
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Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
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Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2e.1 - IEUA Stormflow Activities
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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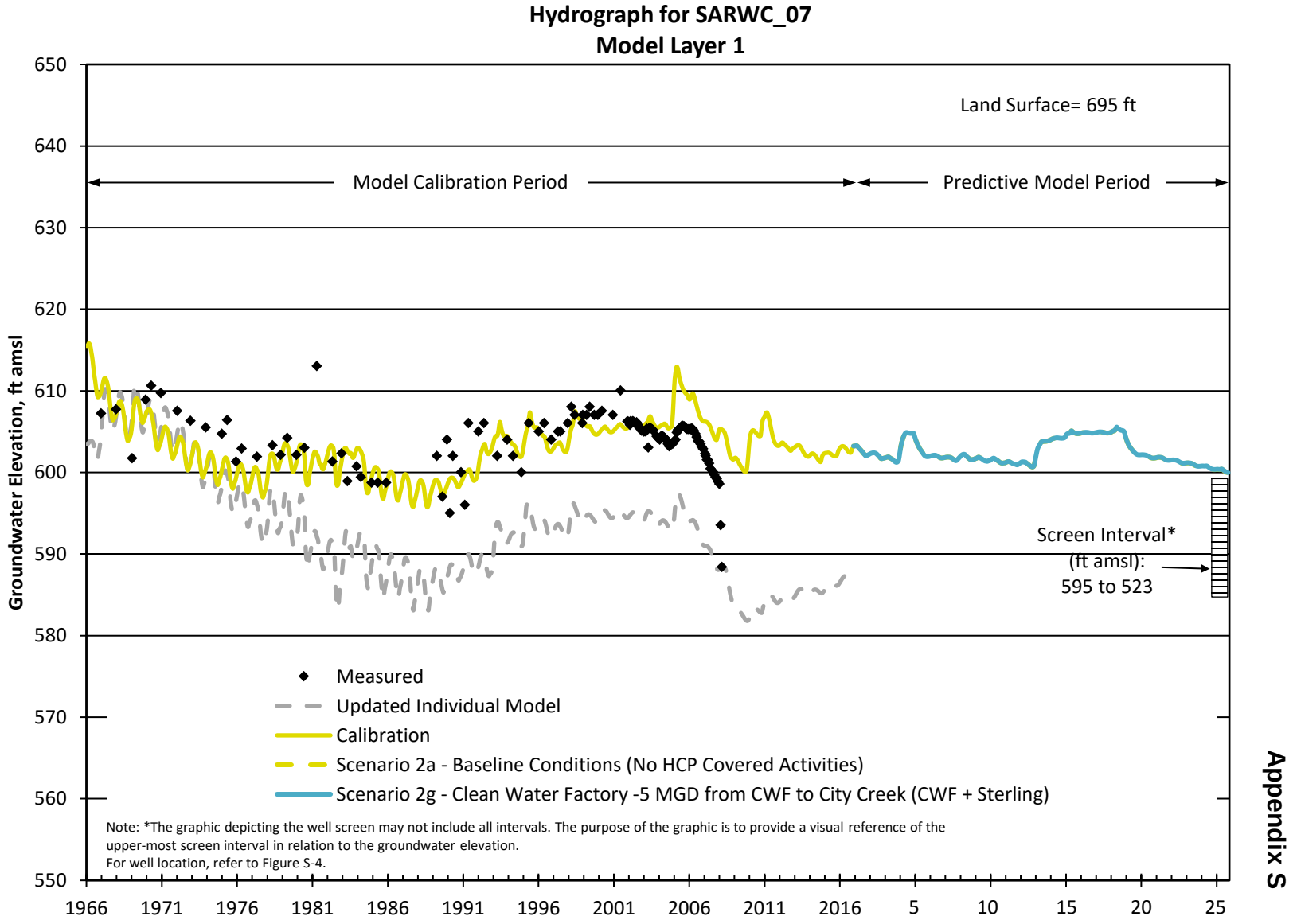
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Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
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Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2e.2 - All IEUA Activities
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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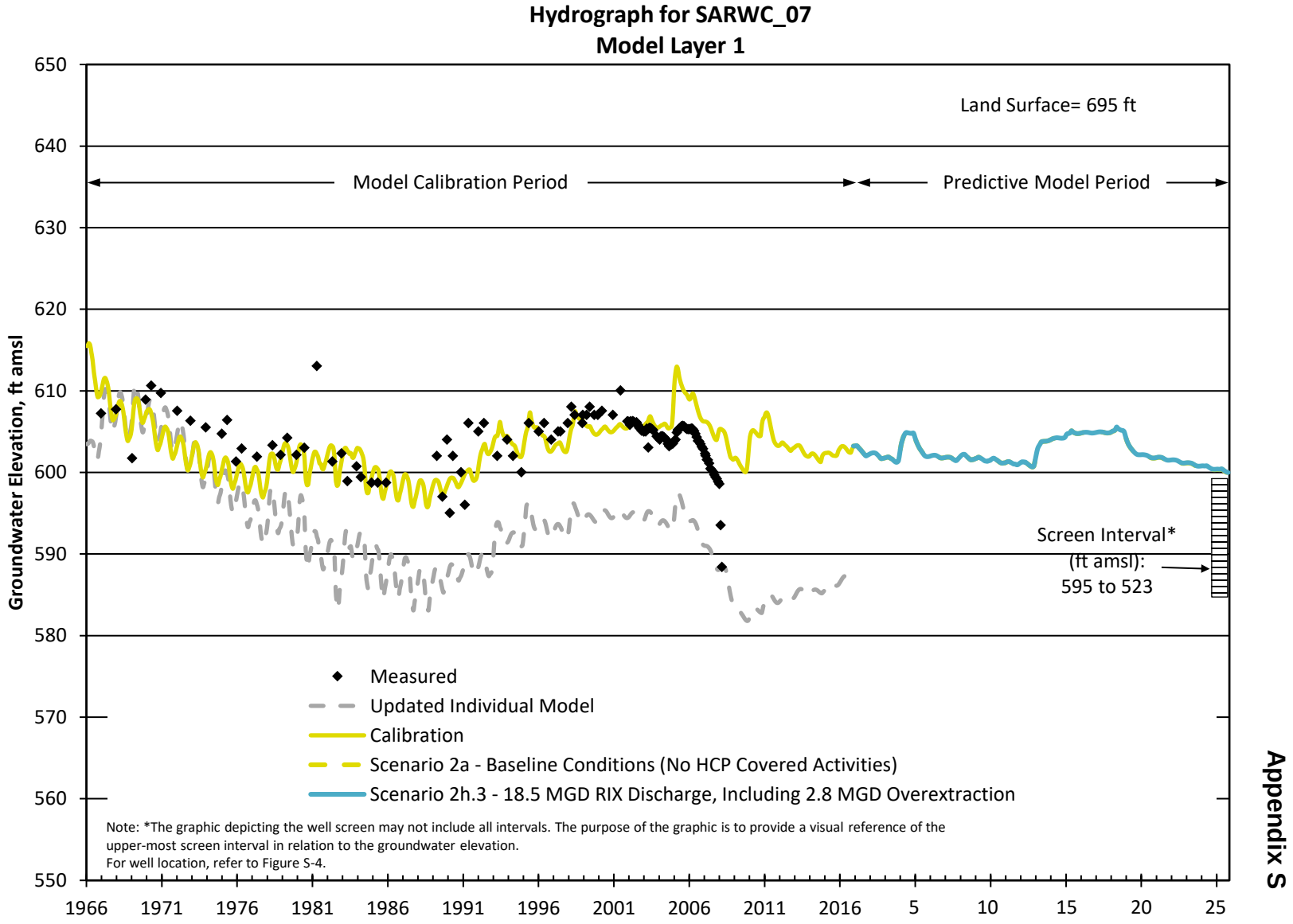
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
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Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2f - Western's Victoria Recharge Basin Project
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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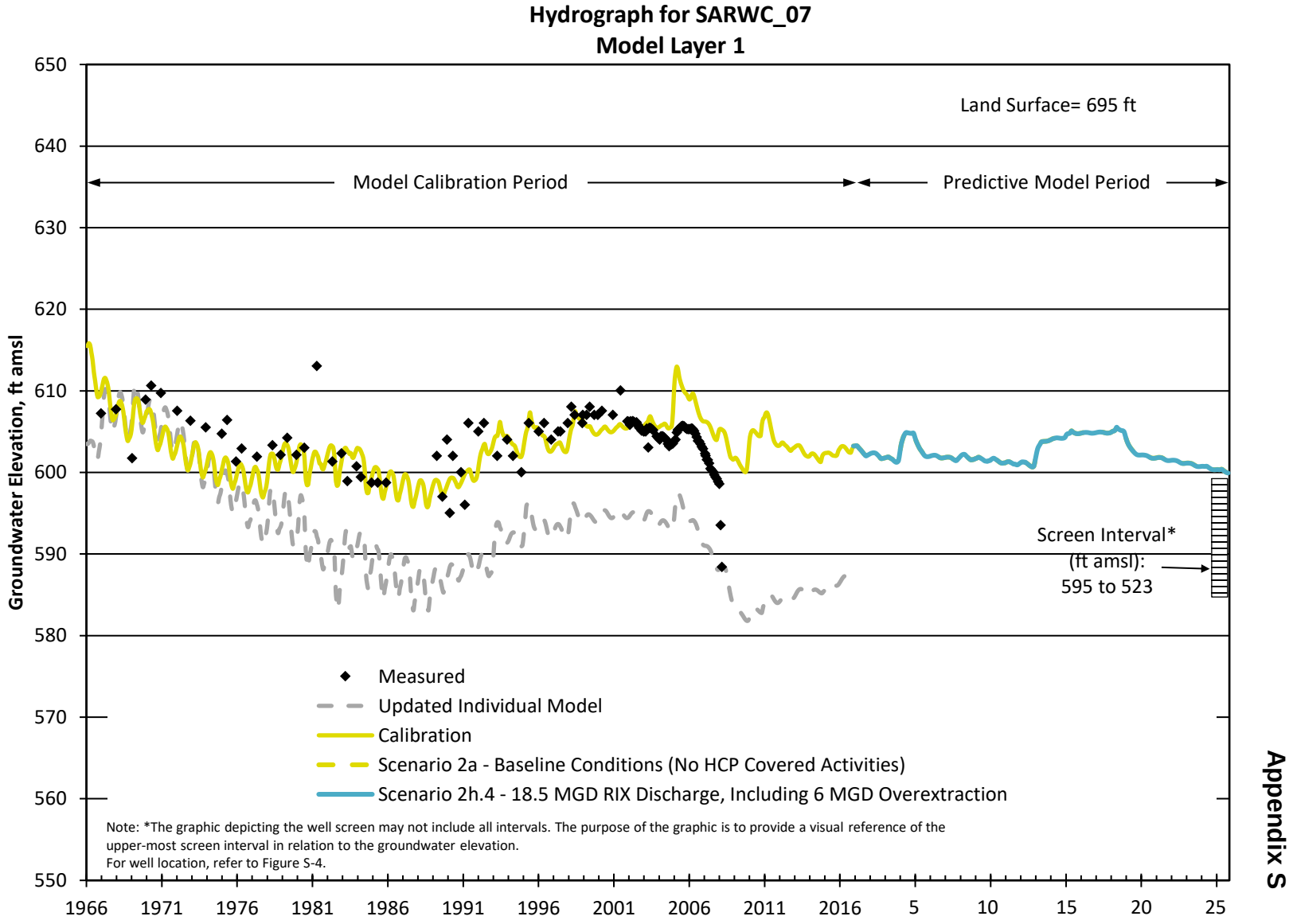
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
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Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2g - Clean Water Factory -5 MGD from CWF to City Creek (CWF + Sterling)
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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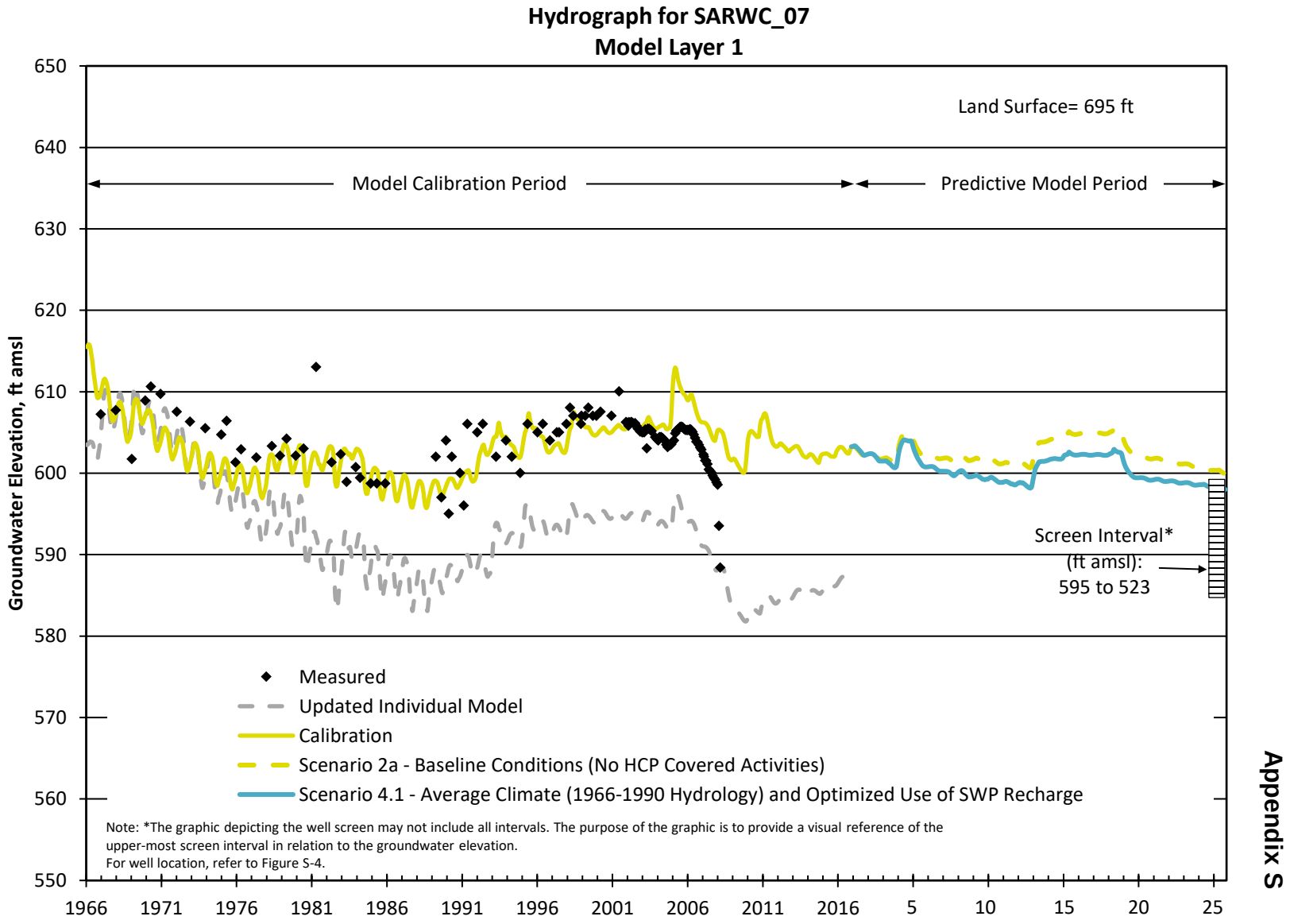
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
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Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2h.3 - 18.5 MGD RIX Discharge, Including 2.8 MGD Overextraction
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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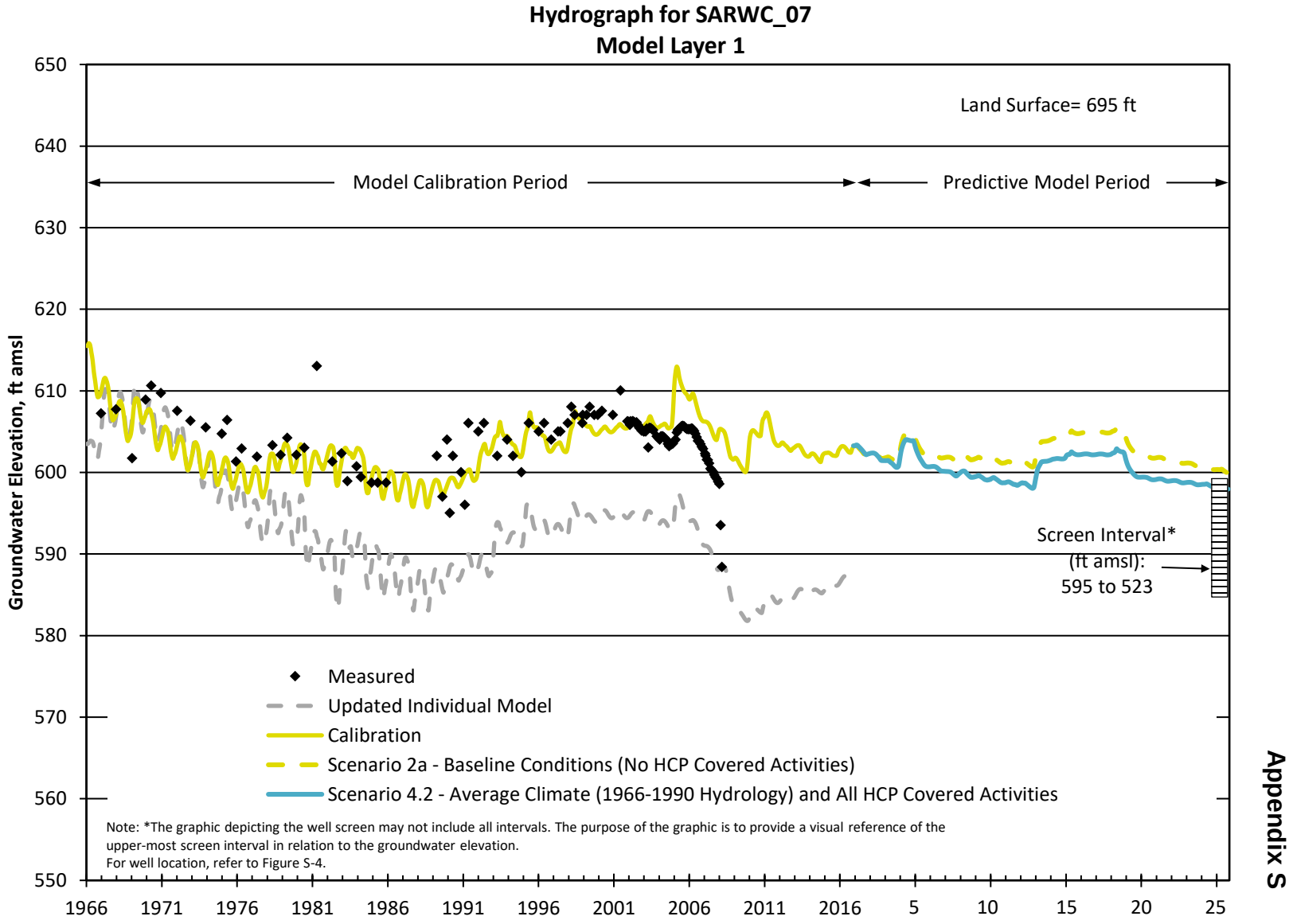
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
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Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 2h.4 - 18.5 MGD RIX Discharge, Including 6 MGD Overextraction
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.
1966
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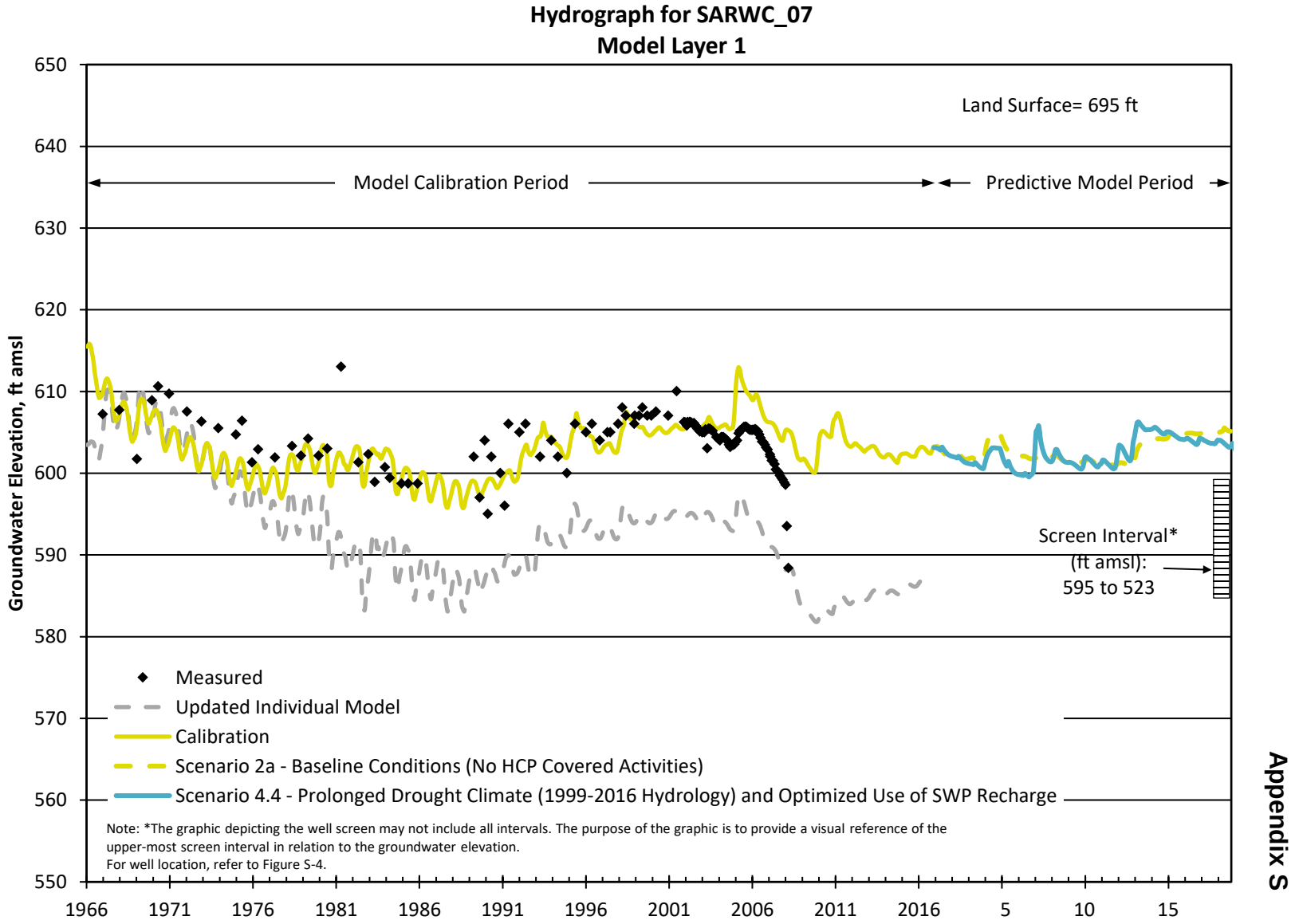
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
650
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1966
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Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.1 - Average Climate (1966-1990 Hydrology) and Optimized Use of SWP Recharge
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

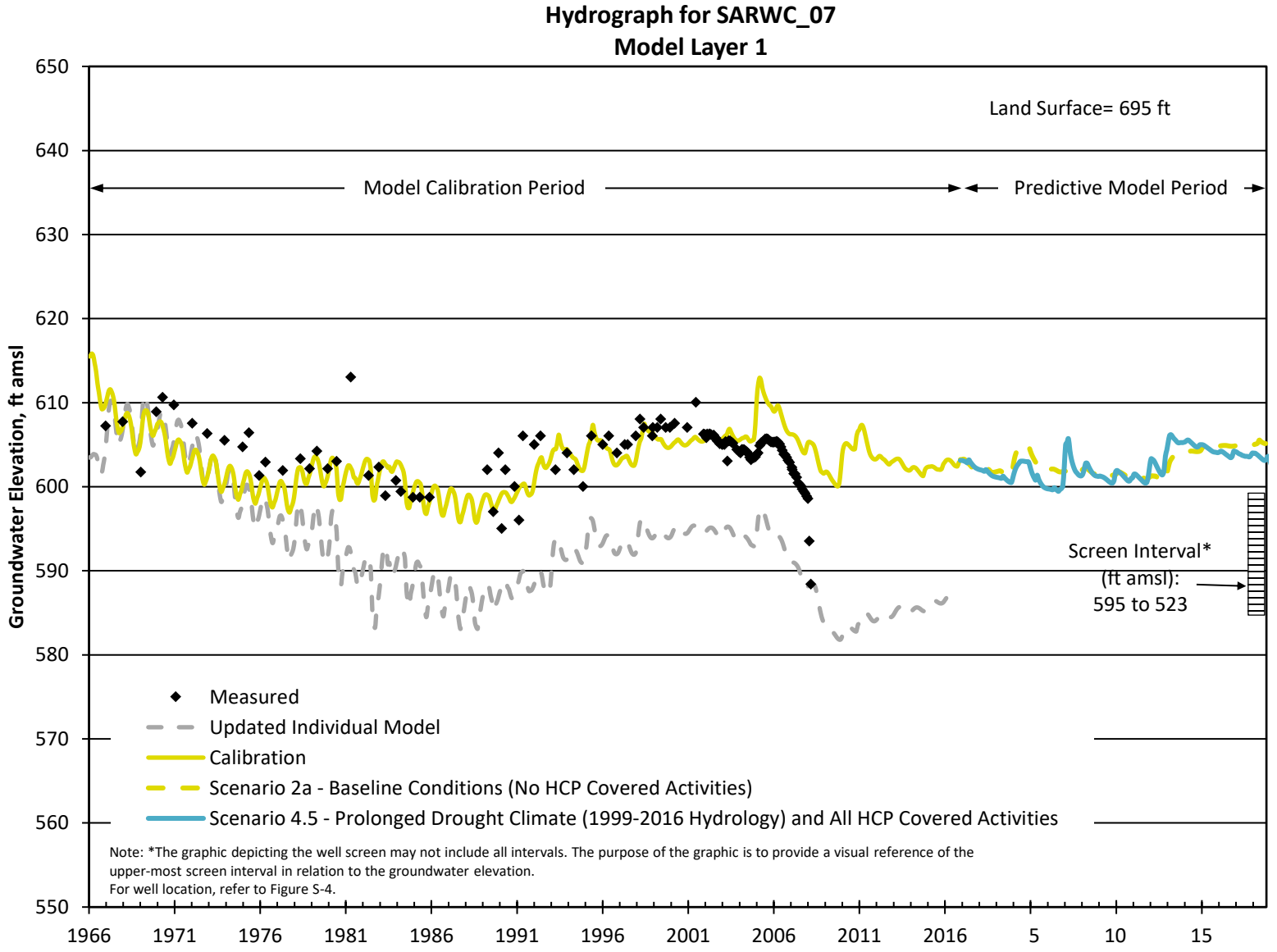
Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
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Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.2 - Average Climate (1966-1990 Hydrology) and All HCP Covered Activities
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

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Hydrograph for SARWC_07
Model Layer 1
Groundwater Elevation, ft amsl
650
640
630
620
610
600
590
580
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1966
1971
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2016
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15
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.4 - Prolonged Drought Climate (1999-2016 Hydrology) and Optimized Use of SWP Recharge
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

Appendix S


Hydrograph for SARWC_07
Model Layer 1
Land Surface= 695 ft
Model Calibration Period
Predictive Model Period
Groundwater Elevation, ft amsl
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1966
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15
Screen Interval*
(ft amsl):
595 to 523
Measured
Updated Individual Model
Calibration
Scenario 2a - Baseline Conditions (No HCP Covered Activities)
Scenario 4.5 - Prolonged Drought Climate (1999-2016 Hydrology) and All HCP Covered Activities
Note: *The graphic depicting the well screen may not include all intervals. The purpose of the graphic is to provide a visual reference of the upper-most screen interval in relation to the groundwater elevation.
For well location, refer to Figure S-4.

Appendix S



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