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**Subject:** Draft Model Review Memo  
**Attachments:** ModelReview\_Vella\_DRAFT.pdf

Sylvan, Leslie, and Rob,

Please find attached the draft model review memo completed for the Vella Pit project. Please let me know if you have any questions or would like additional information or clarification on the points contained.

Thanks,

Lena Pappas  
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ATTACHMENT NAME:

ModelReview\_Vella\_DRAFT.pdf

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Adobe Portable Document Format (PDF) compound image

**MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY**

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**INTEROFFICE COMMUNICATION - DRAFT**

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TO: James Bales, Water Resources Division (WRD)

FROM: Lena Pappas, Geologic Resource Management Division (GRMD)

DATE: September 10, 2025

SUBJECT: Groundwater Model Review in Service of Part 301/303 Lake Creation Permit

On September 27, 2024, Haley & Aldrich of Michigan, Inc. (H&A) submitted a finite-difference numerical groundwater model (herein referred to as the Model) and Groundwater Model Development Report (Model Report) in service of completing a Part 301/303 Joint Permit Application (JPA) for lake creation on behalf of Mid-Michigan Materials, Inc. The groundwater model was created using United States Geologic Service (USGS) modular finite difference groundwater model MODFLOW-2005 dataset imported into Groundwater Vistas processing software version 9.0 for the purpose of evaluating the hydrologic effects of lake creation proposed in the vicinity of the Vella Pit. The model was developed as an initial steady state stress period to simulate pre-pumping conditions, a transient stress period simulated dewatering conditions, a transient stress period simulating conditions from the dewatering pump shutoff to present, as well as four transient state stress period for different phases of mine expansion. Phase 1 is current mining and pond extent, Phase 2 mine expansion to the west, Phase 3 mine expansion to the north, Phase 4 final conceptual reclamation conditions and pond extent.

In addition to the Model Report and Model, EGLE staff reviewed several key documents and resources. These included the Vella Pit Hydrogeological Investigation and the Wetland and Stream Delineation Report for Mid-Michigan Materials – Vella Pit (5/6/2024). Additional documentation supplied by Michael Watts on August 1<sup>st</sup>, 2025, were also reviewed. EGLE also consulted various state databases, including the Water Withdrawal Assessment Tool (WWAT), Geographic Information System (GIS) databases, Groundwater Inventory Mapping (GWIM) datasets, United States Geological Survey (USGS) topographic maps, National Agriculture Imagery Program (NAIP) aerial photographs owned by the State of Michigan, the Wellogic well log database, and the National Wetland Inventory (NWI) databases. The purpose of this memo is to summarize an evaluation of model construction in service of verifying model prediction reliability.

## **PROJECT DESIGN AND SITE SETTING**

The model report indicates the Vella Pit is located on the southeast corner of Earhart Road and Joy Road at 4984 Earhart Road in Ann Arbor Township comprising

approximately 142 acres (herein referred to as the site). The surrounding land use is primarily low density residential and agricultural. The current site elevation is reported as ranging between 882.0 and 965.6 feet above mean sea level (amsl) relative to North American Vertical Datum 1988 (NAVD88) generally sloping to the east. The site has been mined since 1956. The mine is proposed to be completed 15-20 years from the date of the report, with 487,000 cubic yard (cy) per year (7.3 million cy total) estimated removal. The final proposed lake is 59-acre pond approximately 50 feet deep with an estimated final elevation of 836 ft amsl.

Currently there are four ponds on site. Pond 1 is the northernmost pond which contains a permanent outfall into the wetlands to the north. Pond 2 provides water for the onsite wash plant and returns the water to Pond 3. Mining was previously completed in the dry from approximately March 1<sup>st</sup>, 2022, until October 2023 where the upper aquifer was dewatered and discharged into the stream and wetlands located north of the site. Mid-Michigan Materials had not been issued for a permit to dewater the upper aquifer; therefore, dewatering activities were ordered to stop in October 2023, and mining is now being completed in the wet. Future dewatering onsite is not planned, but limited pumping is occurring in a closed circuit to supply the wash plant.

GWIM datasets indicate the site sits atop the Coldwater Shale, underlain by the Berea Sandstone. Quaternary geology of the Model Area consists of medium-textured glacial tills, glacial outwash sand and gravel and postglacial alluvium, as well as end moraines of medium-textured till that range between 200 and 400 ft thick within the Model area. The site is situated atop the Fort Wayne Moraine, trending southwest to northeast locally, which acts as a hydrogeologic divide within glacial sediments present in the immediate vicinity of the site. Five soil borings were installed in 2023 and converted into groundwater monitoring wells onsite (well 1 through well 5), four around the perimeter and one in the center and logged for geologic descriptions. Geologic descriptions of soils encountered in these locations alongside geologic well log descriptions from approximately 500 Wellogic well logs were used by H&A to develop a geologic conceptual site model of the site. Clay with gravel and sand is observed from ground surface to approximately 15 feet bgs, which is underlain by interbedded sand and gravel observed at depths ranging from 15 to 90 bgs. Sand appears to taper out to the north and northeast near the wetlands; however, no further information was provided by H&A along this area to confirm this observation. Supplemental information was provided to EGLE which contained information on pump tests completed on residential wells closest to the eastern site boundary, installed in first quarter of 2021. Pump test results indicate the aquifer varies between confined and semi-confined. The description of regional geology provided in the report is consistent with reviewed state databases described above.

The NWI database indicates wetland soils and/or groundcover are present in the northern portions of the site and surrounding the site in the north, west, and east.

Figure 2 of the Report shows wetland areas have been identified by H&A in the northern and eastern portions of the site. Several wetlands are within the Model are onsite wetlands extending from the northern boundary to the east and moving southward along Dixboro Road. The site is observed to be within Fleming Creek water management area (WMA) 21292, which is identified as a cool stream within the Fleming Creek at Mouth sub-basin of the Huron watershed. The index flow for WMA 21292 is reported as 5.5 cfs with a total remaining balance of 538 gpm for the WMA. According to Special Report 55, an adverse resource impact (ARI) for a small cool stream is identified as a 25% decrease in streamflow<sup>1</sup>.

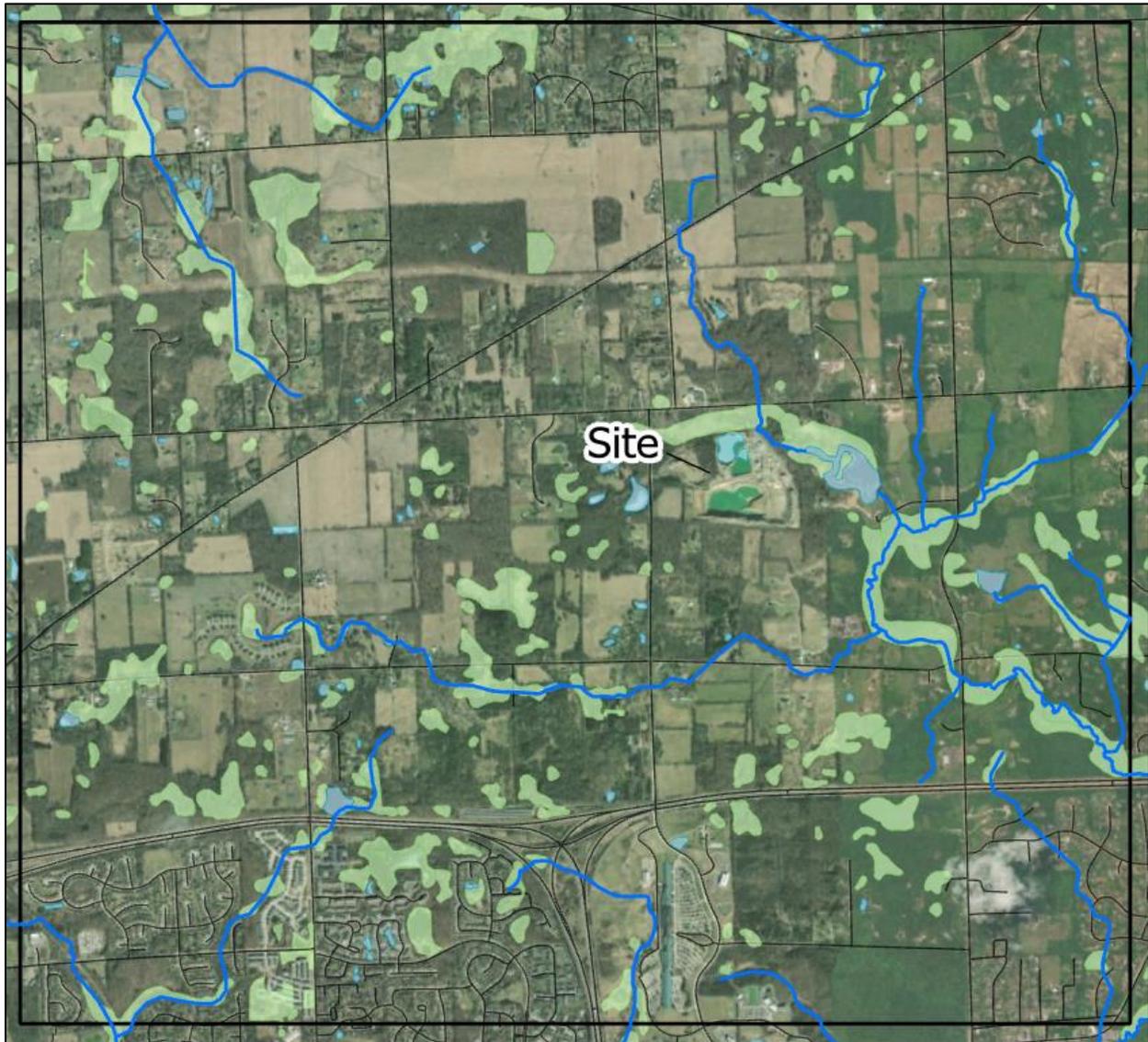
## **GRID**

The report indicates the model space is comprised of an area approximately 14.5-square miles in size divided into 381 rows and 423 columns for a total of 161,163 cells per layer and 483,489 cells in total. Model dimensions are 21,200 feet by 19,080 feet by 300 feet. The cell row and column dimensions are uniform across the model domain, 55.65 feet by 45.11 feet. NAD83 Michigan State Planes, South Zone, International Foot, was reported in C-106 to be the projection system in the Model. Models are observed to be constructed as a uniform grid without refinement consistent with the description provided above of grid dimensions. The model is observed to be constructed with three layers of variable thickness and elevation extending between 592.31 feet and 825.22 feet amsl. Layer 1 ranges in thickness between approximately 20 to 160 feet thick, layer 2 ranges between 10 and 100 feet thick, and layer 3 ranges between 100 and 200 feet thick.

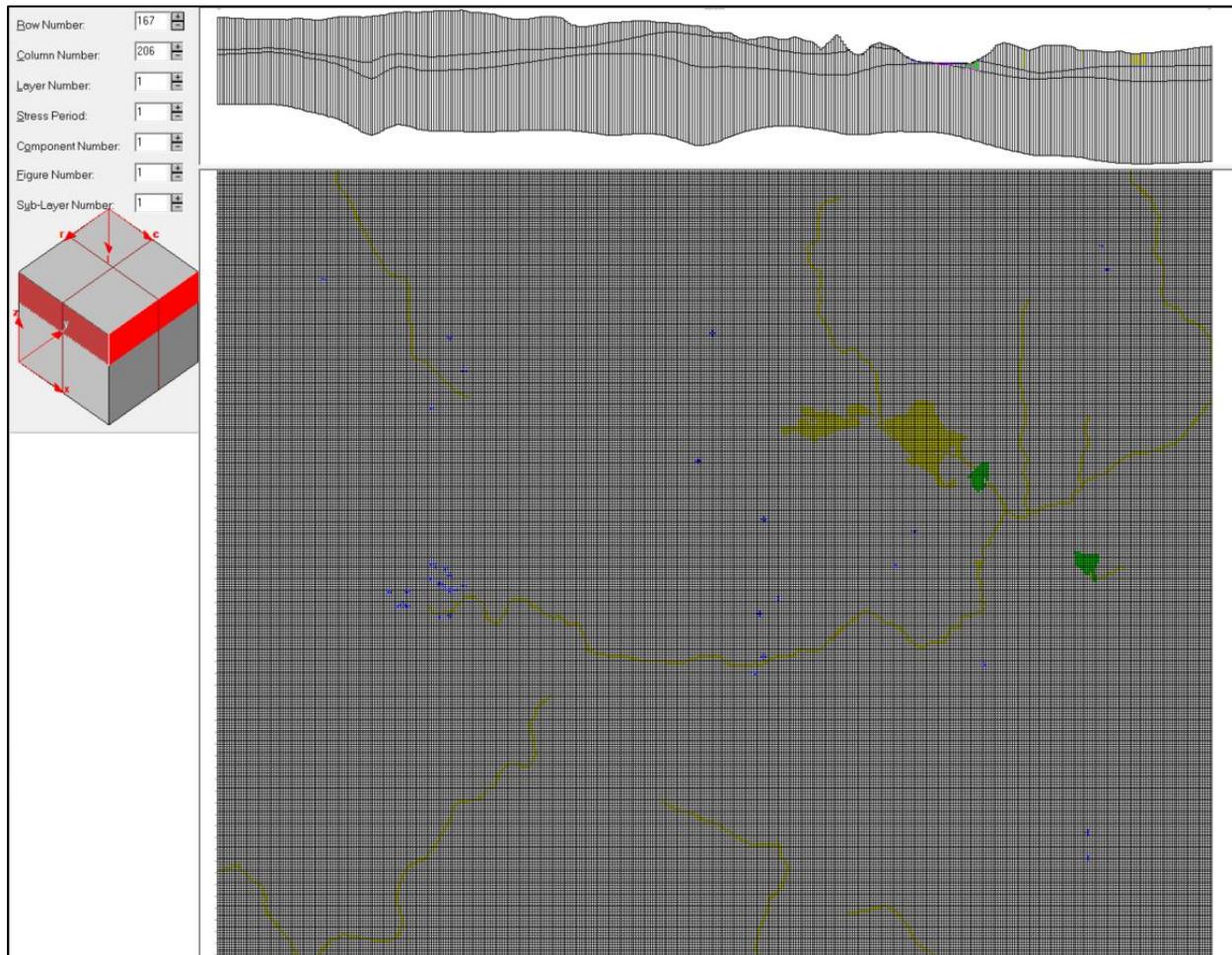
A base map was included in the model for site comparison. Additionally, the site layout observed in the model was compared to figures in the report and available state GIS data layers. The model origin appears to be located southwest of the intersection of East Joy Road and Earhart Road near 83.6837953°W 42.3454431°N. Given the model dimensions, the model space and distribution of observed features within the model is consistent with features observed in this area in aerial photographs and state databases. Model grid is shown below in Figure 2.

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<sup>1</sup> Hamilton, D. A., & Seelbach, P. W. (2011).



*Figure 1- Site location map showing area roadways, streamlines as blue lines, wetlands areas as green polygons, and bodies as water in blue polygons. The site is roughly in the center of the map. The thick black line represents the model boundary.*



*Figure 2 - layer 1 map and row 167 cross section showing the model grid for all three layers. Green cells represent river boundaries. Yellow cells represent drain boundaries. Blue markers represent target wells. North is oriented to the top of the page.*

## **PROPERTIES**

Model properties within Groundwater Vistas include conductivity, storativity, initial heads, porosity, specific yield, and recharge. The following is a summary of each compared to the information provided in the report.

According to the Model Report, hydraulic conductivity (K) has been assigned in 75 zones in the model. Hydraulic conductivity values were initially assigned values based on literature using a Thiessen interpretative approach starting with literature-based K values identified from 41 Wellogic wells, and then iteratively varied during model calibration to best fit observed data from water levels according to the report. The hydraulic conductivity zones numbers were duplicated resulting in the value ranges from Zones 1 to 75, however, Zones 22 through 46 were identical values for Kx, Ky, and Kz.

The Model Report notes the Kx and Ky to have a minimum value of 0.007044 ft/day and maximum of 200 ft/day. Vertical hydraulic conductivity was estimated to be 1/10<sup>th</sup> of the horizontal value ranging from 0.0007 ft/day to 20 ft/day. The observations in the Model are consistent with what is in the Report with the exception of Zone 6 with an increase in from 200 ft/day to 1,000 ft/day in the Phase 1 through Phase 4 Models in 5-year increments. This was done to simulate the lake size increase.

Values selected are consistent with literature values for the sands, gravels, clays, and glacial tills seen and expected in the model area<sup>2</sup>; however, K zone classifications observed in the model assume uniform parameter extents within discrete lateral areas as a result of using a Thiessen polygon geostatistical estimate. Thiessen polygons are typically not used for the estimation of variable glaciated sediments, and are instead used for identification of catchment areas, weighting, or zone and network identification. Forcing matched uniform K zones creates non-realistic groundwater flow patterns and likely does not provide the estimate flexibility required to match the geologic heterogeneity observed in geologic data collected in the vicinity of the site. For comparison, EGLE created a kriged geostatistical estimate of K zones present within Model layer 1 which shows variation in estimated distribution of aquifer and confining materials by thickness throughout the model area (Figure 3), which shows conflicting.

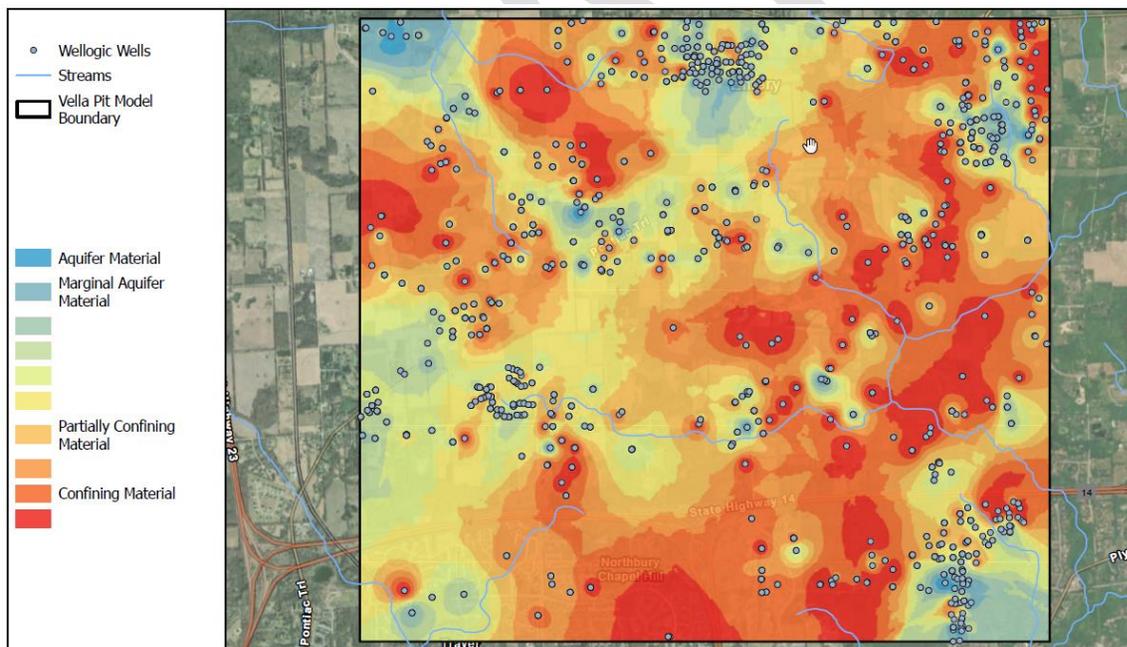


Figure 3 – Aquifer and confining material extents created by EGLE using a kriged geostatistical estimate from all Wellogic data available in the Model Area.

<sup>2</sup> Freeze, R. A., & Cherry, J. A. (1979)

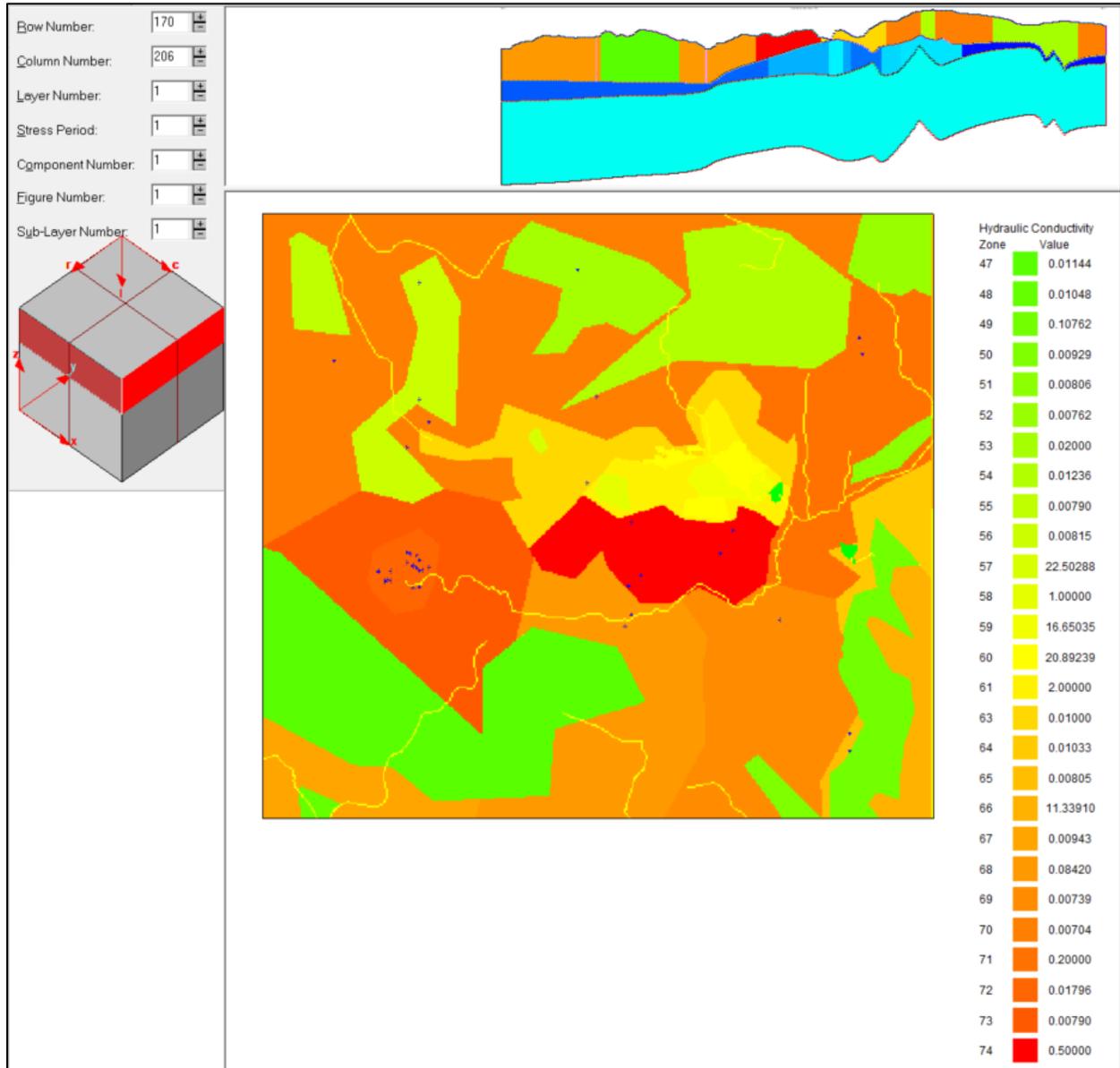


Figure 4 - K values reported in ft/d and displayed in zones. Image shows Steady State Model layer 1 and column 206 cross section.

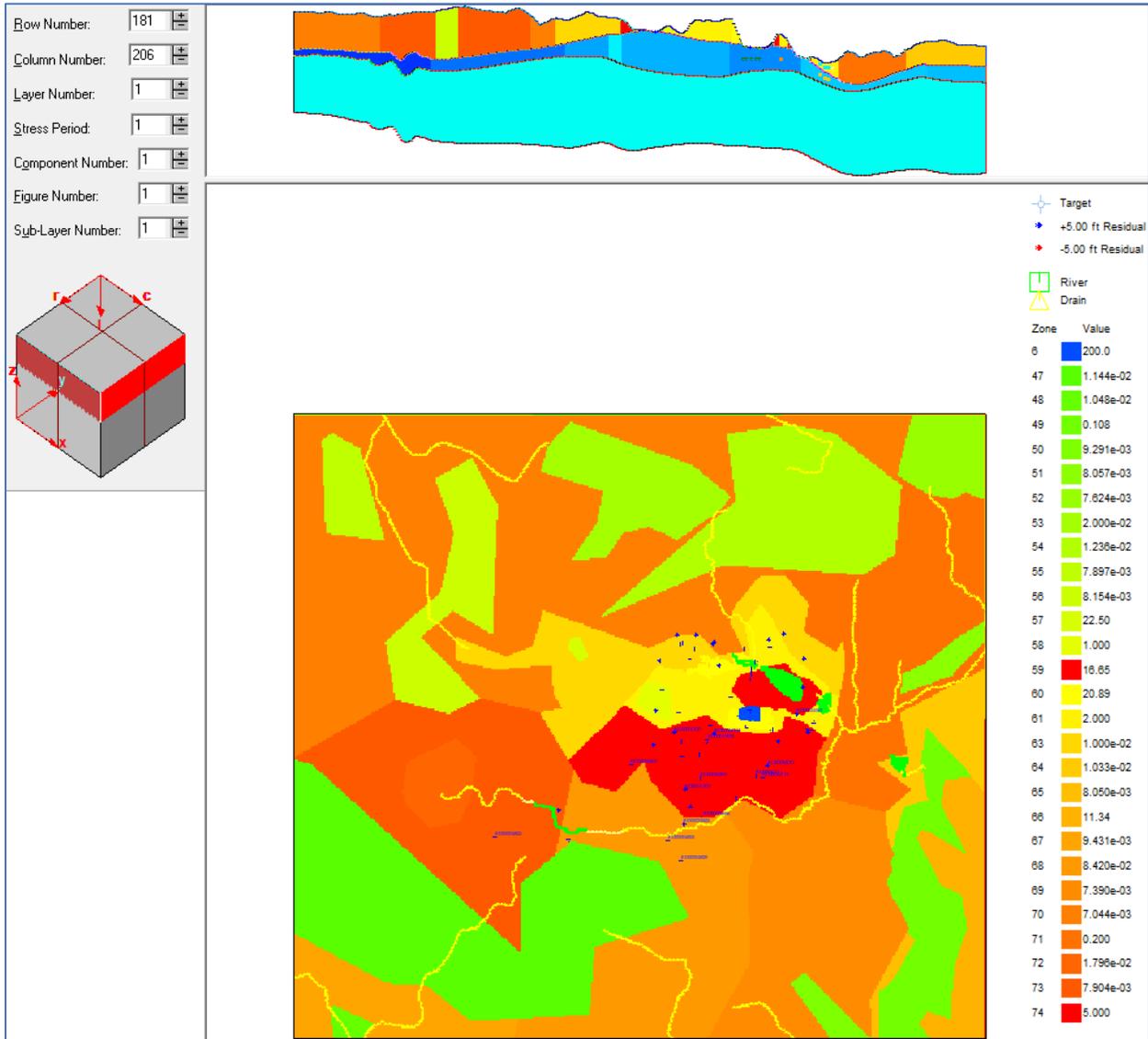


Figure 5 - K values displayed in zones. Image shows Transient Model layer 1 and column 206 section.

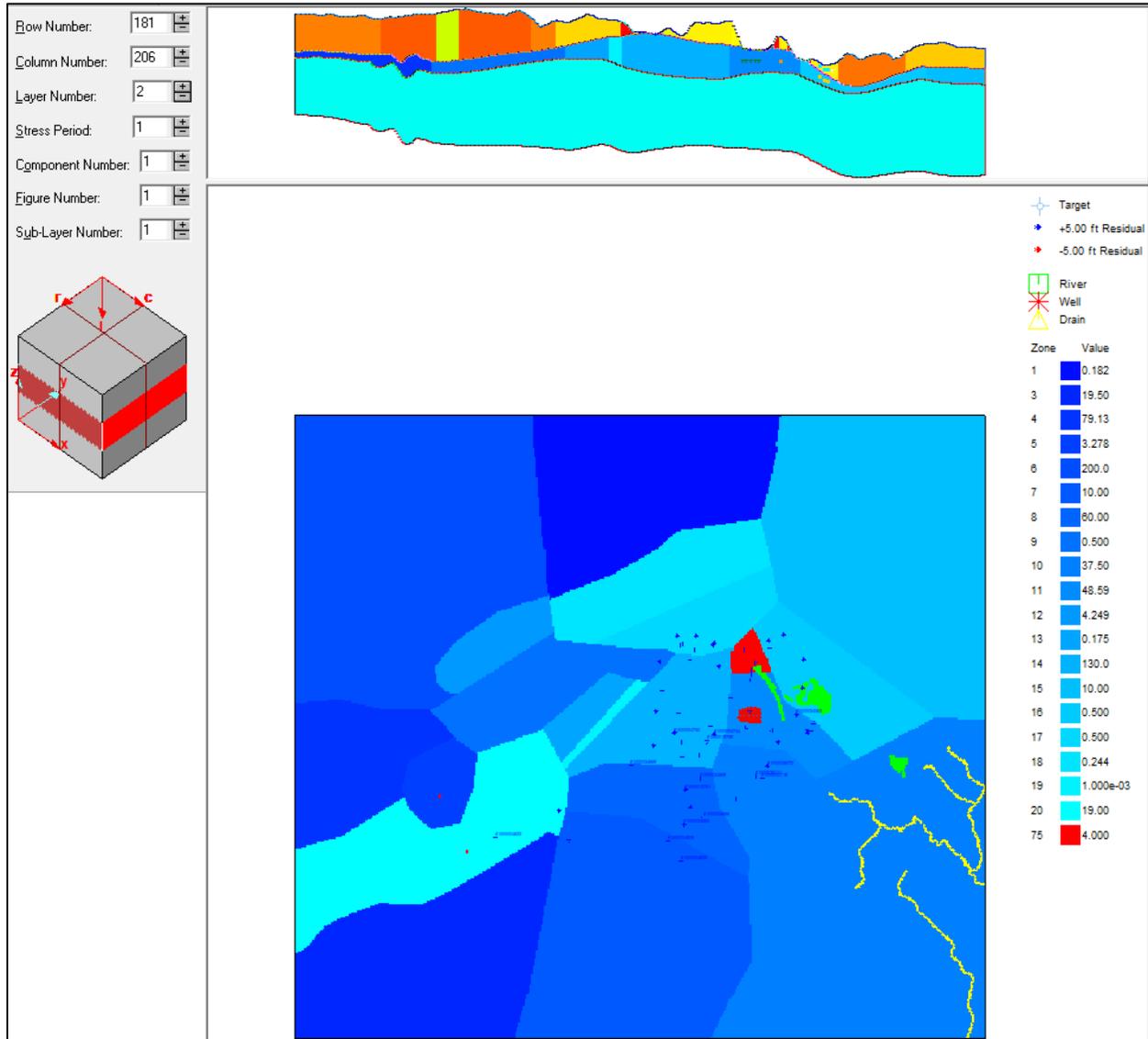


Figure 6 - K values displayed in zones. Image shows Transient Model layer 2 and column 206 cross section.

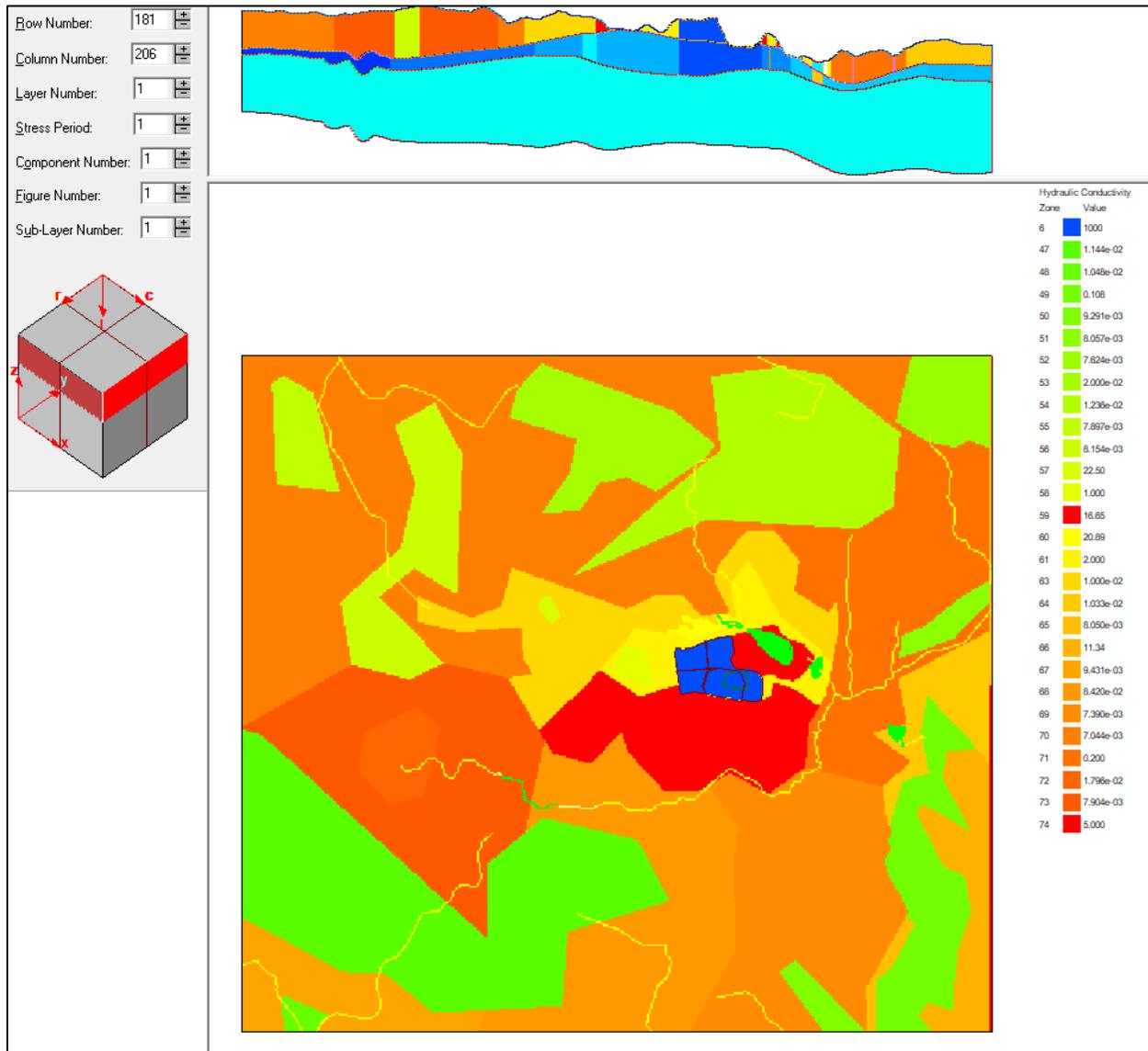


Figure 7 - K values displayed in zones for Phase 4. Image shows model layer 1. Dark blue represents the hydraulic conductivity values assigned to the ponds.

As described above, Geo Trans, Inc. completed pump tests on two residential wells located immediately east of the site. Test values indicate hydraulic conductivity for the area range from 233 ft/d to 780 ft/d, with an average hydraulic conductivity of 509 ft/d. The hydraulic conductivity for the polygon applied to this area of the model was 60 ft/d, which is inconsistent with the observed value at this location. H&A revised their model to include the low estimated hydraulic conductivity of 300 ft/d for the area. Results of the amended Model is provided below in the Results section.

While the K field update provided by H&A addressed the documented variance in estimated, variability in the hydraulic conductivity within the Model are likely not well represented due to the flattening of values within each polygon. While locations which have direct observation or testing completed can be well represented, areas between known datapoints do not represent probable estimates of the K parameter distribution, as evidenced by the supplemental data submitted by external parties.

The report indicates an effective porosity of 0.3, a specific storage of 0.0001, and a specific yield of 0.05 were used in the model. Areas that were generally clay were assigned a specific storage of 0.00001 and a specific yield of 0.01. These values were then calibrated to match observed responses to dewater and recovery. The storage values in the model after calibration, observed in the Model are summarized in Table 1.

<b>Ss Min</b>	<b>Ss Max</b>	<b>Sy Min</b>	<b>Sy Max</b>	<b>Porosity Min</b>	<b>Porosity Max</b>
0.00005	0.0331522	0.0001	0.2	0	0.3

*Table 1: Specific yield, specific storage, and effective porosity summary table for the Transient model.*

The model report includes two tables, Table 1A and Table 1B which discusses displays the values per zone of Ss, Sy, and Porosity. When compared to table exported from the model it appears that three zones: Zone 2, Zone 3, and Zone 37, are missing from the report table. Zone 2 and Zone 3 are the middle and bottom Zones of the Steady State model that were calibrated and adjusted to different Zones. Zone 37 is added to the Phase 1 through 4 models to simulate the increasing lake and its increasing size. This Zone has a Ss of 0.1, Sy of 1, and Porosity of 1.

The value ranges are appropriate for the expected geology on site; however, Thiessen polygons used to calibrate Storage values. As with the K field estimate, this has likely resulted in both underestimation and overestimation of values as a result of applying uniform estimates to highly variable geologic materials. Areas which have not been directly observed are likely not well represented by the estimation method.

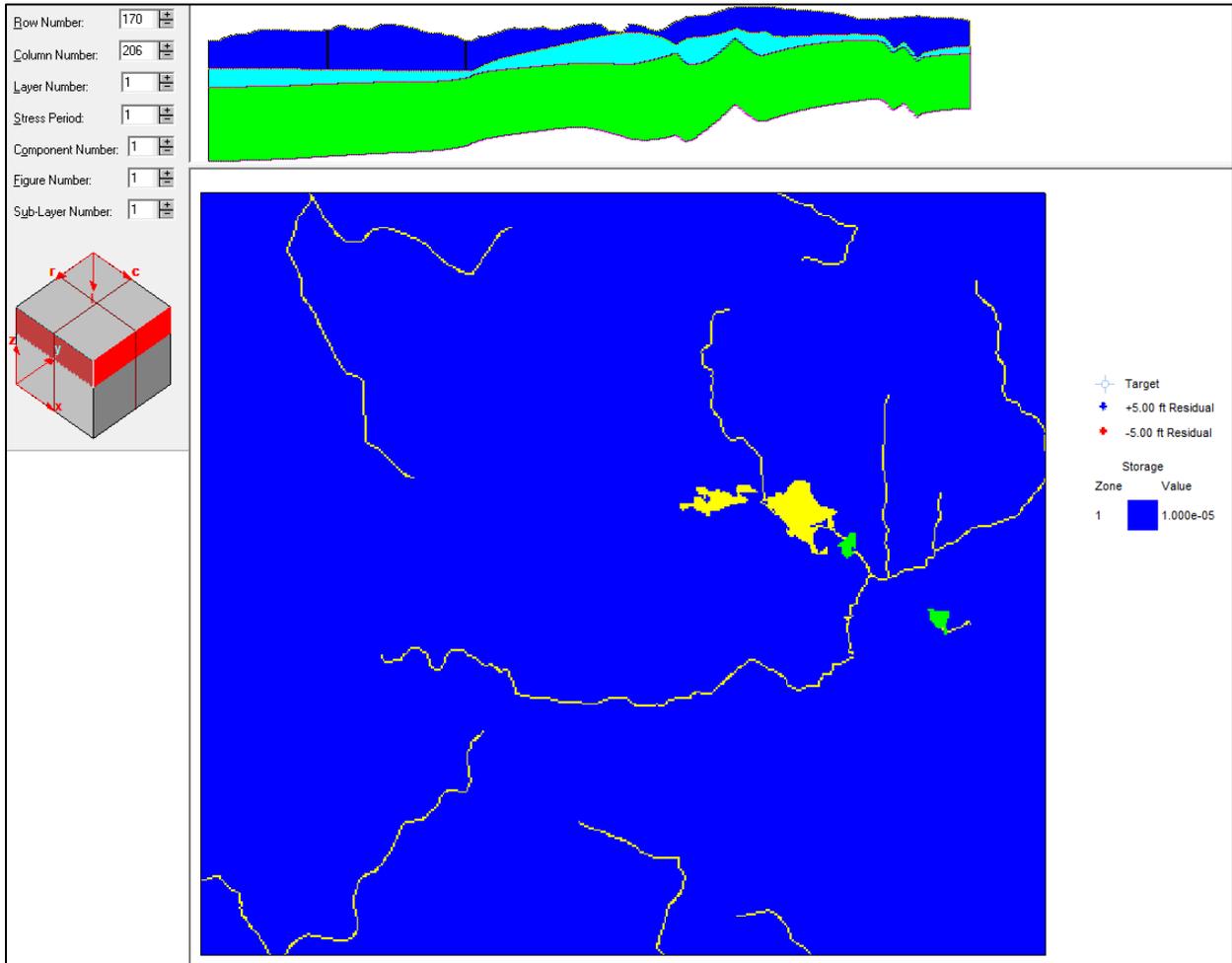


Figure 8 - Storage of the Steady State Model values displayed in three zones. Zone 1 in dark blue Zone 2 in teal, Zone 3 in lime green.

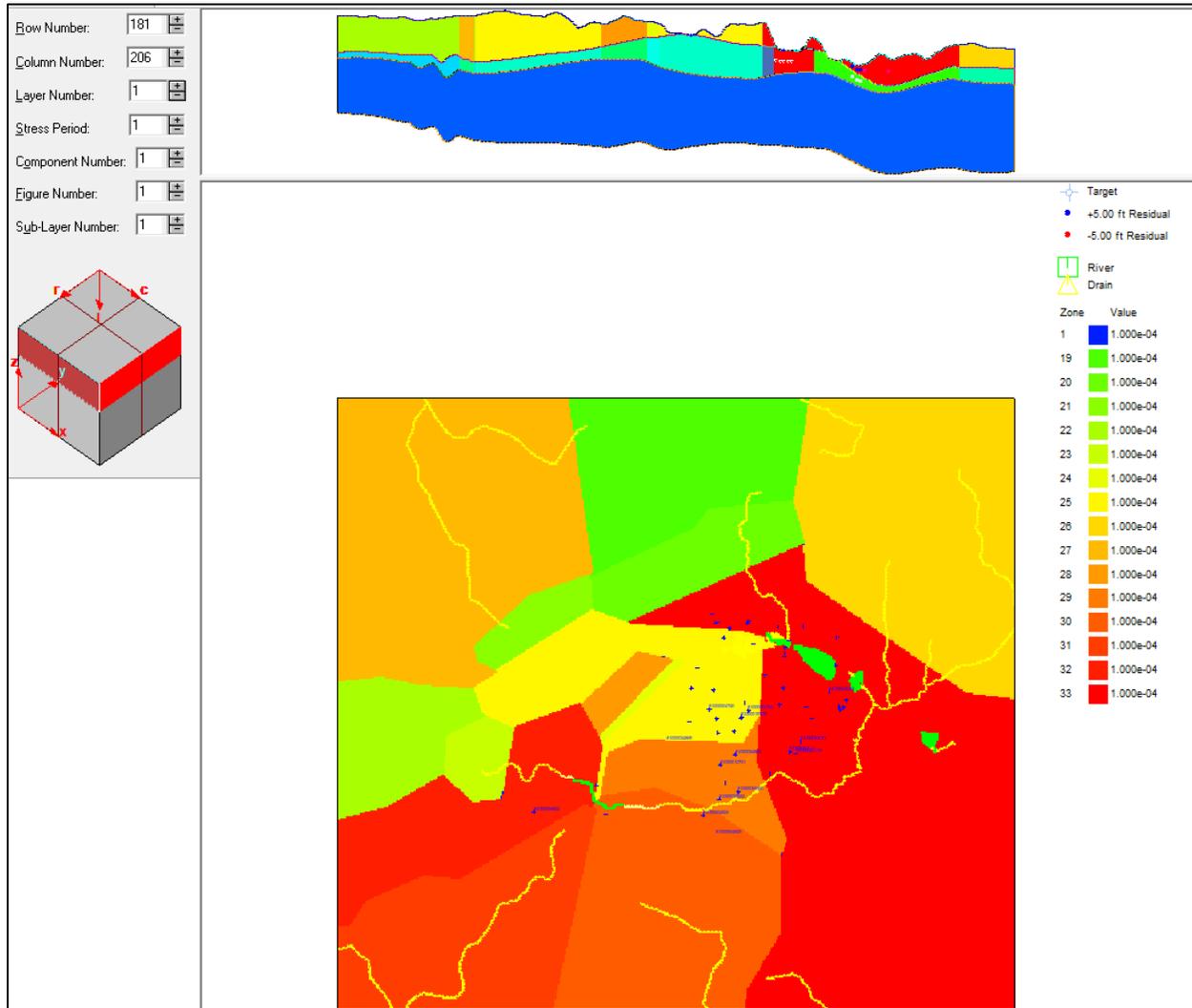


Figure 9 - Storage of the Transient Model values displayed for layer 1. Top cross section of column 181 displays variant storage values of the three model layers.

Table 2 from the Model Report lists the initial head values used for the steady state model and the year the wells were constructed. Initial heads observed in the model for the steady state range from 840.118 ft amsl to 949.559 ft amsl. Initial head values for the Steady State Model were set to top layer elevation altered during the calibration process to groundwater head values presented in the Model Report's Table 2 from Wellogic data. The heads output from the Steady State run was then used as the initial heads value for the Transient model. Each run utilized the simulated output head file of the previous run as an initial heads file for the remaining runs.

Recharge was calibrated to 34 zones within the Model. The report indicates that offsite values range from 0.05 in/year to approximately 205 in/year, or roughly 0.000011

feet/day to 0.04566 ft/day. Onsite recharge was set to 205 in/year to account for areas where mining had already occurred and surface till had been removed, exposing the upper aquifer. Recharge values were assigned in zones extents estimated by Thiessen polygons which are not representative of the material onsite. GWIM recharge estimates range between 6 to 10 in/year, which is consistent with the values observed outside the site boundaries within the model space, with the exception of zone 30 which assigns a recharge value of 20.49 to an area immediately west of the site. Recharge values observed in the model are shown below.

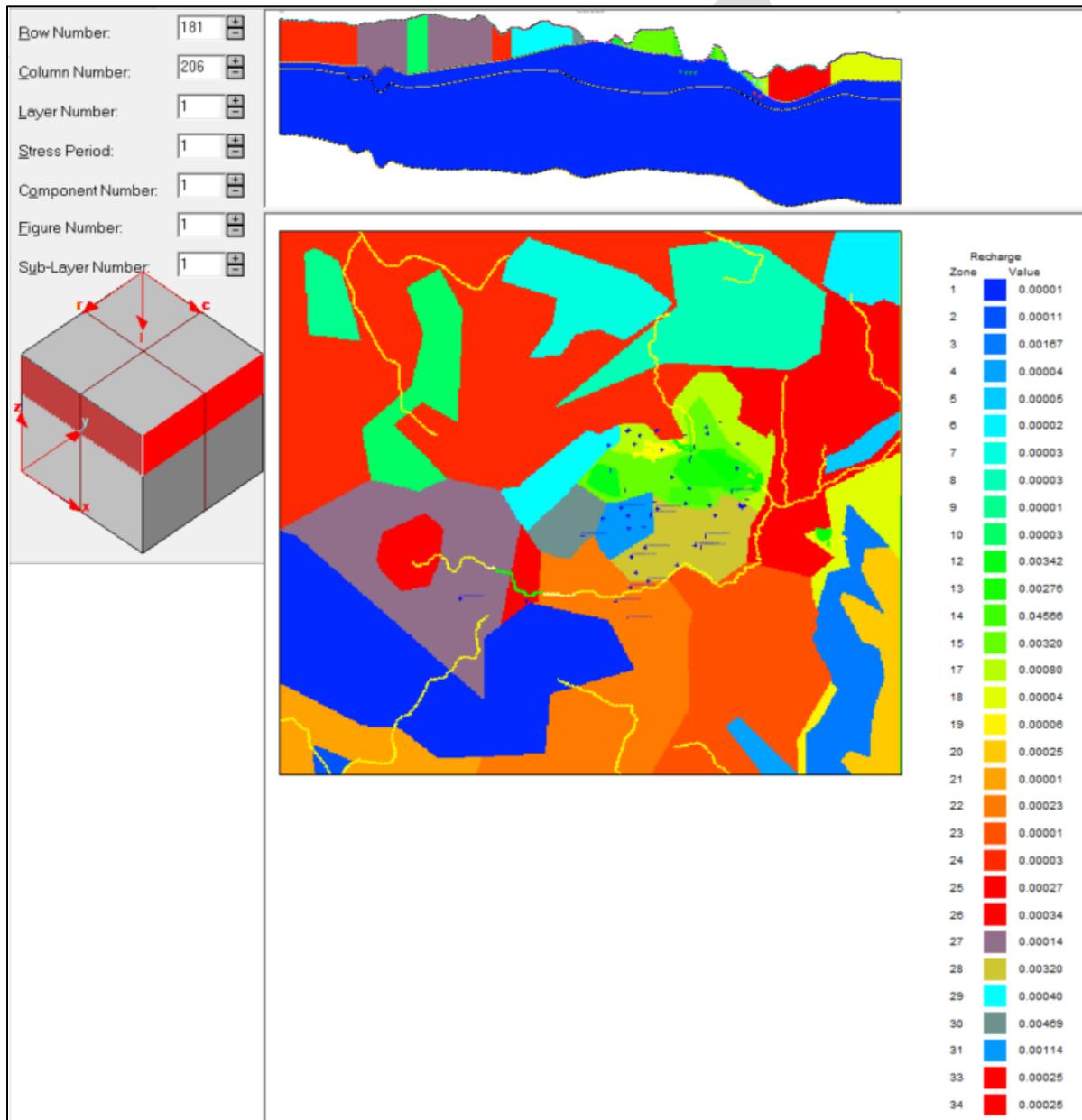


Figure 10 - Recharge values assigned to layer 1 for Transient Model.

Recharge values were confirmed in the Steady State Model, Transient Model, and Phases 1 through 3. Phase 4 uses a recharge value of 32 in/year, or 0.0073 ft/day, representing the ending of pumping and set to exclusively the average perception estimates for the model area. An evaporation value of 31.5 in/year, or 0.0072 ft/day, which indicates the total flux across layer 1 at the end of phase 4 is 0.5 in/year into the aquifer within the lake. No direct explanation for the application of recharge and evaporation is provided in the Report; however, previous text describes fine grained material accumulating within the lake bottom estimated at the end of 5 years past lake construction completion.

### **BOUNDARY CONDITIONS**

Three types of boundary conditions have been used to construct the model: river, drain, and well. Boundary conditions are shown below.

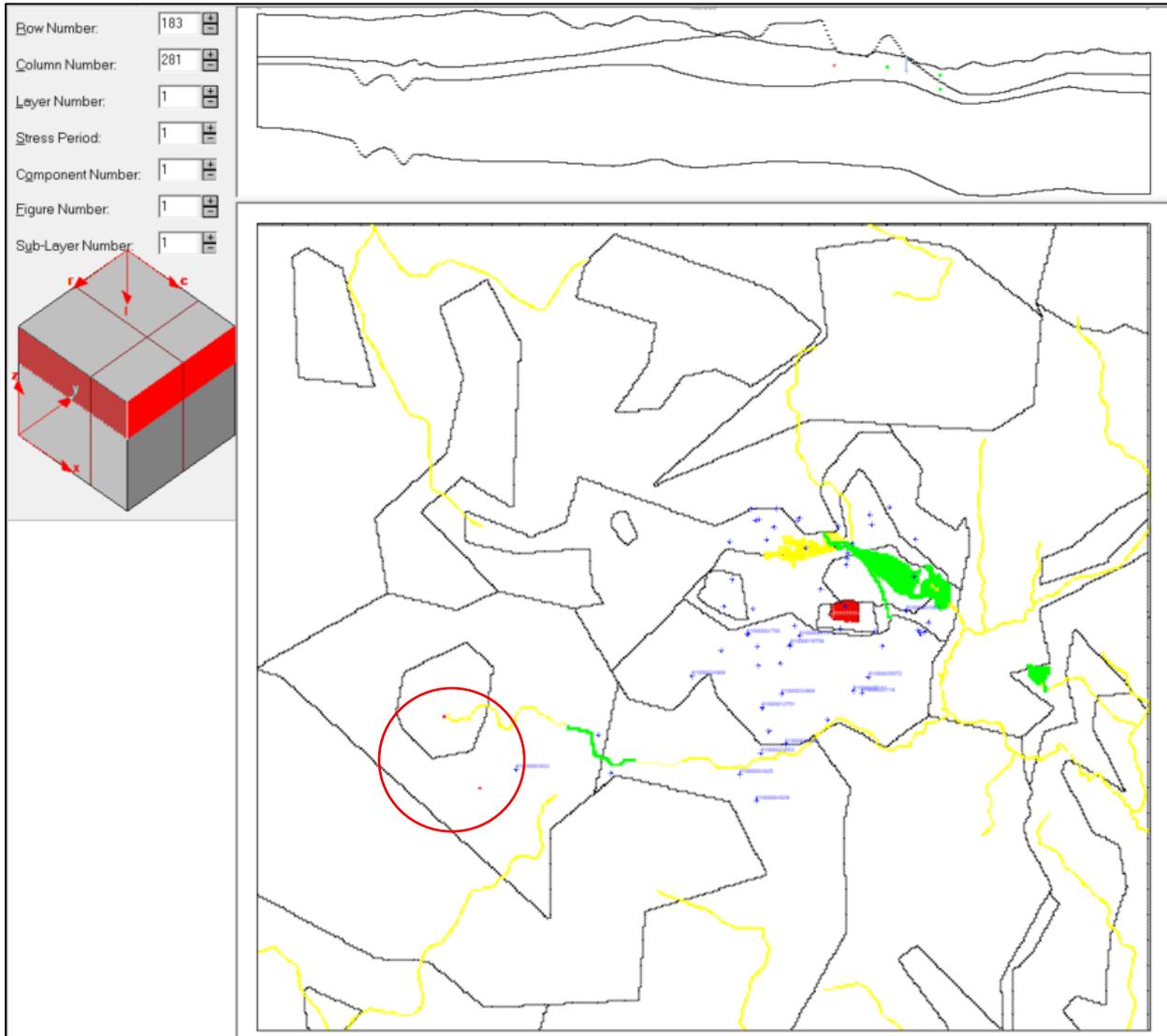
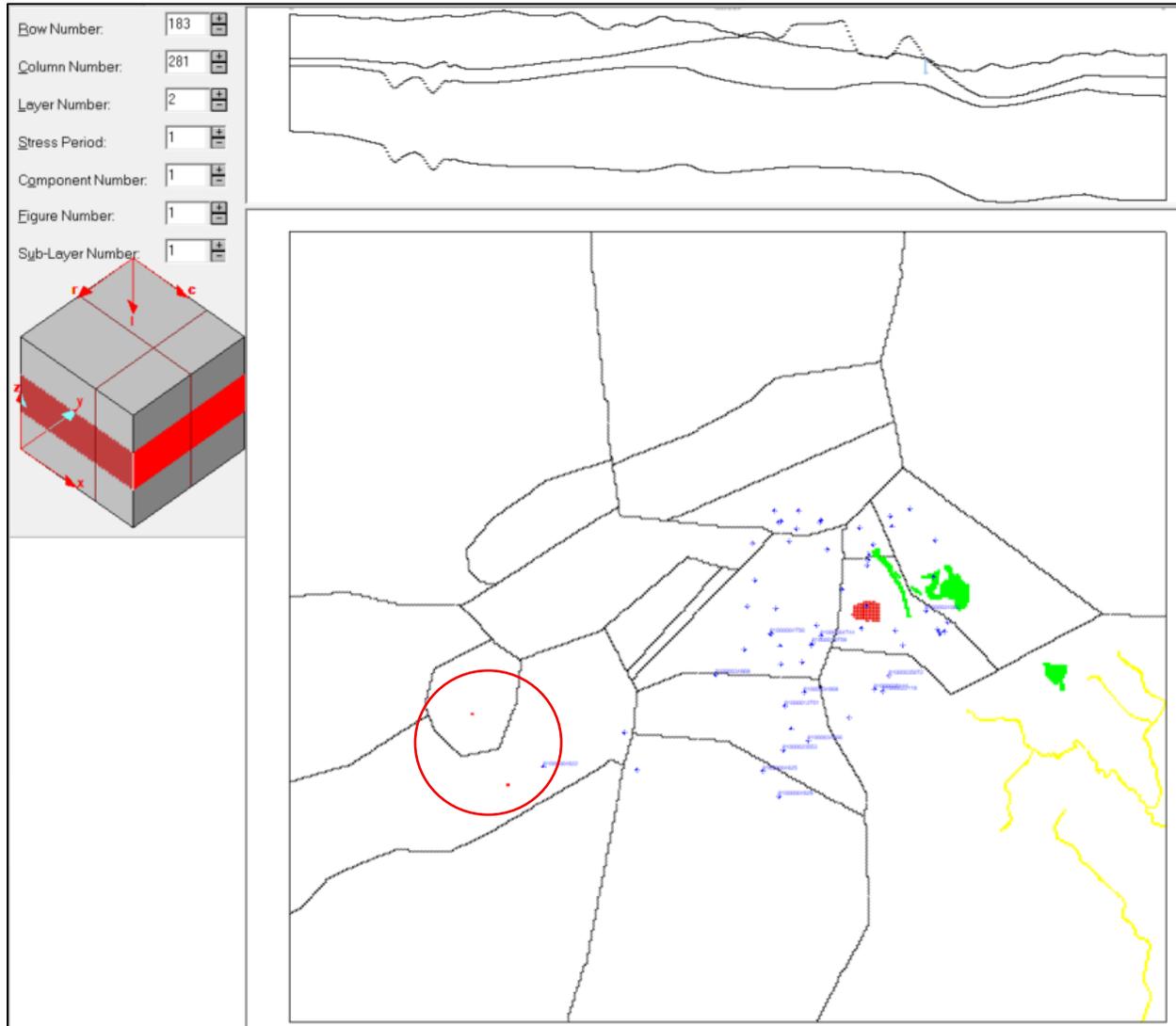


Figure 11 – Boundary Conditions of the Transient Model. River (green), DRN (yellow), and Well (red dots circled in red) boundary conditions in model layer 1. Blue markers represent the target wells.



*Figure 12 - Boundary Conditions of the Transient Model. River (green), DRN (yellow), and Well (red dots circled in red) boundary conditions assigned to model layer 2. Blue markers are the target wells.*

River boundaries (RIV) were used to simulate streams, ponds and lakes. A total of 916 river boundary cells are present in the model. According to the report, head values range from 865 to 875 feet in the eastern part of model and from 917-936 feet in the western area. The western river boundary has a hydraulic conductance of 19 ft<sup>2</sup>/day, and the eastern river boundary varies from 1-50 ft<sup>2</sup>/day. RIV boundary settings are summarized in Table 2 and cell assignments in model layers 1 and 2 relative to a site aerial are shown below.

RIV Boundaries				
Layer	River Stage (ft)	River Bottom (ft)	Conductance (ft <sup>2</sup> /day)	K
1	865 - 936.95	860 - 929.96	1 - 155,909.95	1 - 3,273.93
2	865 - 876	860 - 874.9	1 - 217,959.63	1 - 9,476.50

Table 2: RIV Boundaries in the Transient Model.

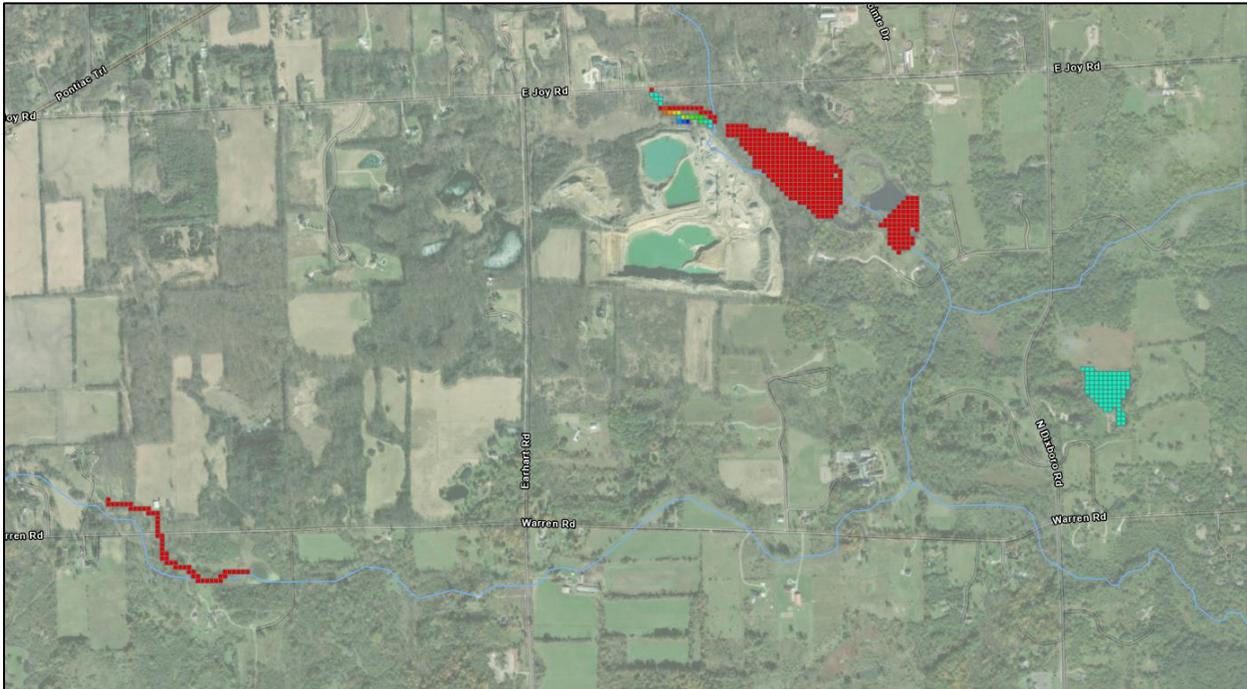


Figure 13 – RIV boundary cells shown relative to a site aerial present in Model layer 1.



Well boundaries were used to simulate with pumping a recirculation of the wash plant, and to simulate two wells observed at an offsite property. The Model Report indicates that two wells were used onsite to simulate the pumping for the wash plant and the recirculation of the water back into the aquifer. These were set to an equal rate of withdrawal and injection at 2 million gallons per day (the upper limit for current pumping of Pond 3). The offsite wells were estimated by H&A to pump at approximately 48,623 gpm. These locations were added to the model to assist in calibration.

### **TRANSLATION SETTINGS**

The Model is set to utilize MODFLOW-NWT of the MODFLOW 2005 variants. The solver is observed set to 500 maximum outer iterations and 20 maximum inner iterations, with a head change criterion set to 0.0001 and residual criterion for convergence set to 1.1. These values are within recommended default settings.

### **CALIBRATION**

The report indicates the model was calibrated using 3 stress periods: initial steady state of pre-pumping conditions, transient stress for dewatering conditions, and transient stress for the recharge after pumping ceased; however, this appears to refer to the calibration of model parameters. Two methods were used to calibrate the model. The first was “trial and error” where values were manually changed to fit the observed data, and the second was the PEST (Doherty, 2016) using 41 target wells obtained from the Wellogic dataset. According to the report, hydraulic properties were not varied during calibration because it caused adverse impacts to other observation points.

Model calibration appears to have been achieved by simulating heads in the steady state model using Wellogic depth to water measurements. Calibration Statics for the Steady State run is shown below.

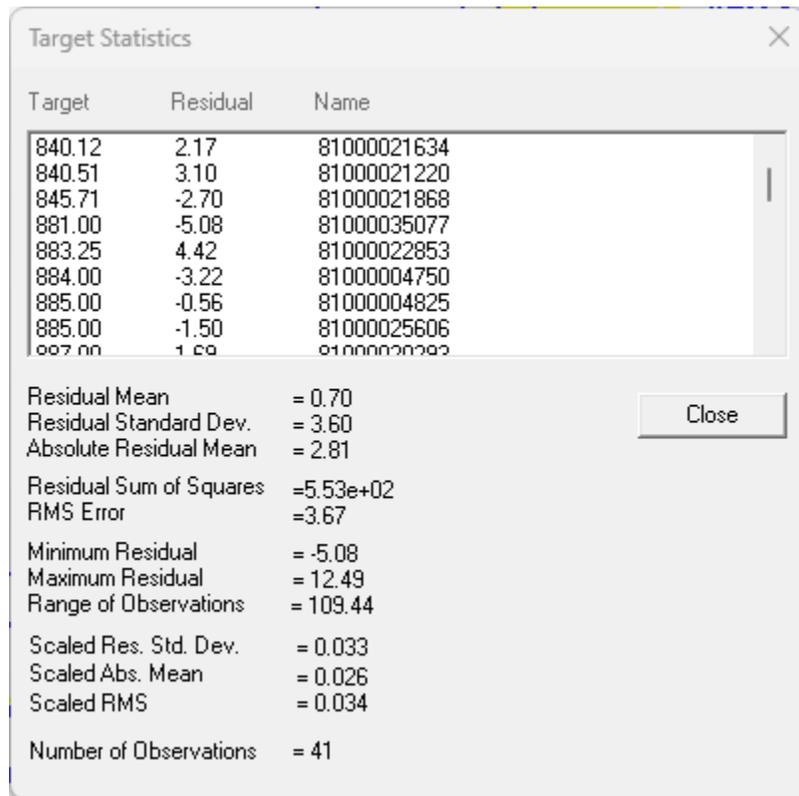


Figure 15 – Steady State Model Run Target Statics.

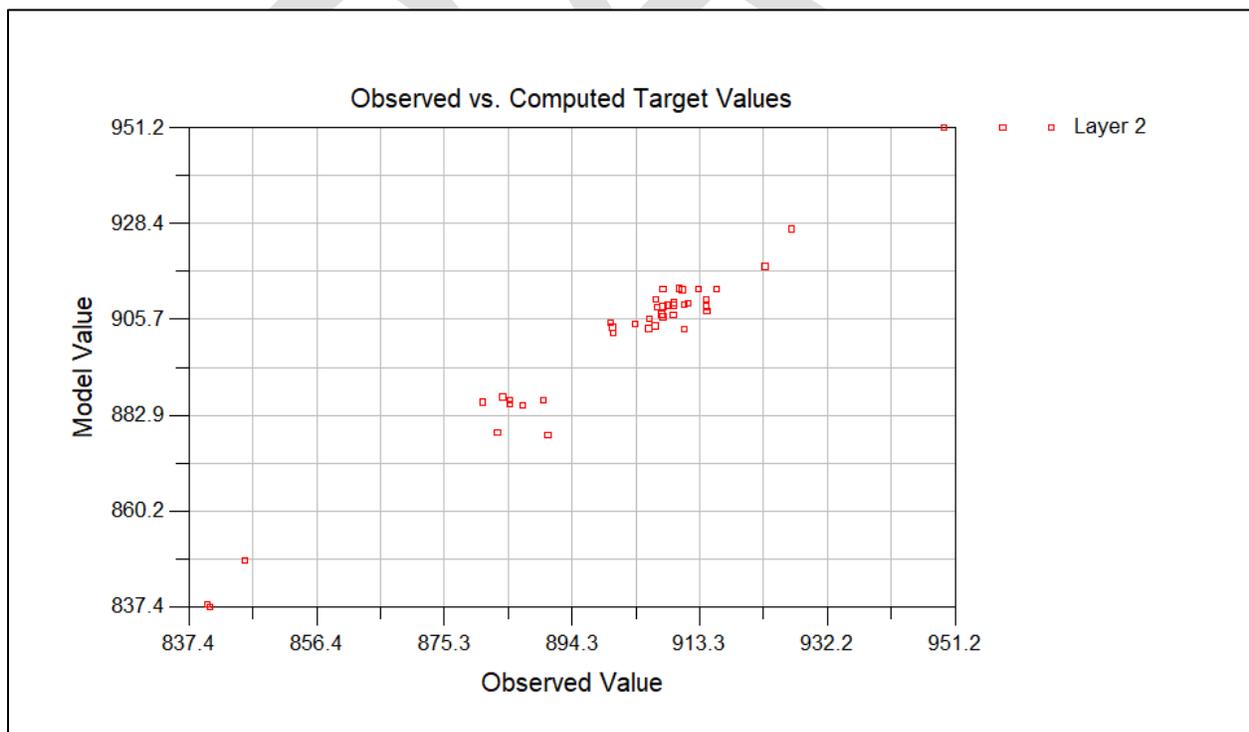


Figure 16 – Steady State Run Observed vs Simulated.

Calibration statistics for steady state simulation are consistent with reported values and are within acceptable correlation thresholds.

## **OUTPUT**

EGLE ran all simulations provided to verify reported output. The Model Report presents the figures of potentiometric heads for the models, however only the drawdown figure of Phase 4; therefore, EGLE independently produced drawdown contours for each model phase change. Simulation output for the final timestep in layer 1 for each simulation is provided below, alongside drawdown calculations for each individual phase change and the overall hydraulic change between the final conditions proposed in Phase 4 and the initial steady state estimate.

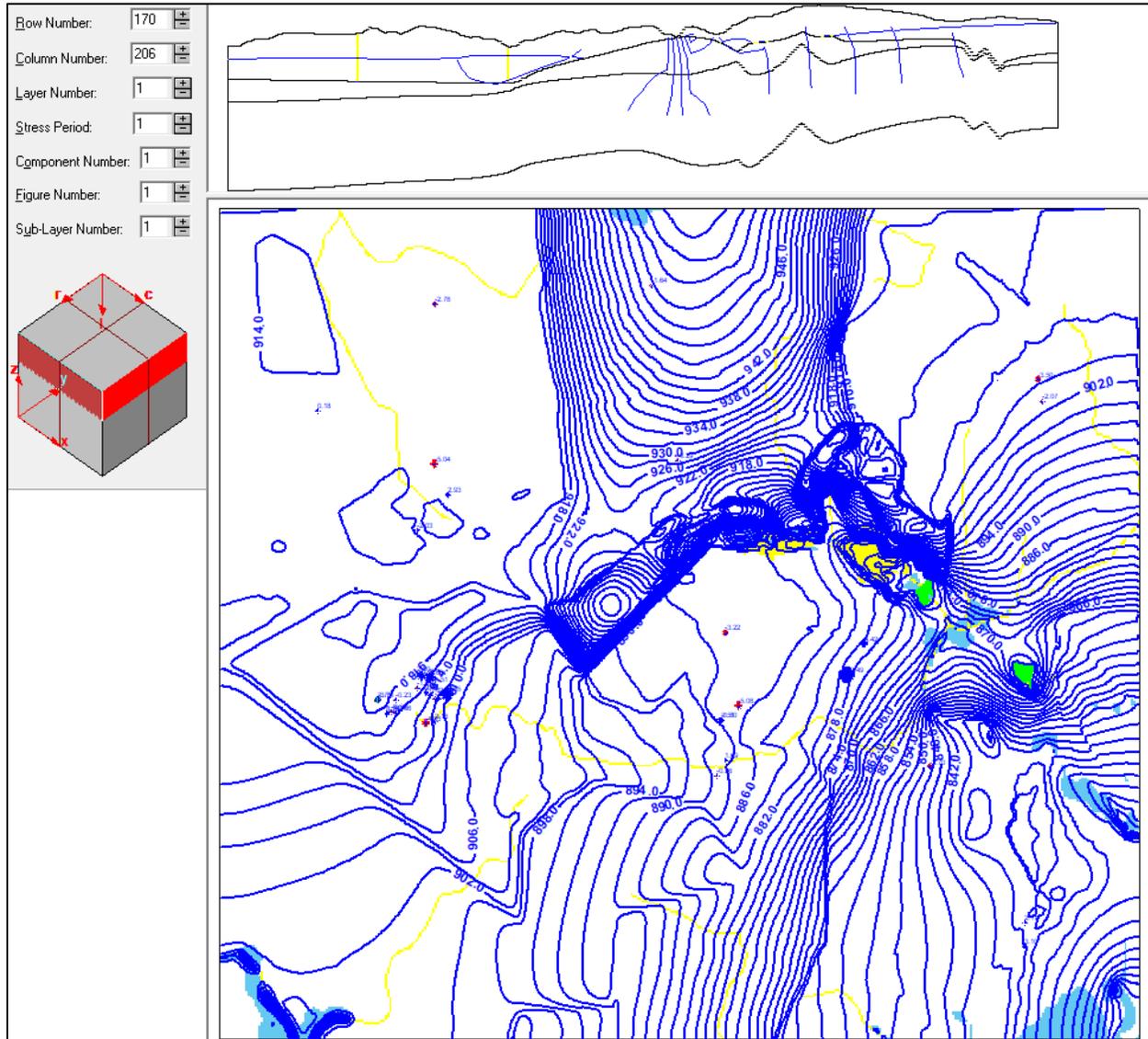


Figure 17 - Simulation of potentiometric head in Layer 1 of Steady State model run. Contours at 2-ft intervals represented in dark blue. Flooded cells in light blue. Drain boundaries in yellow. River boundaries in green.

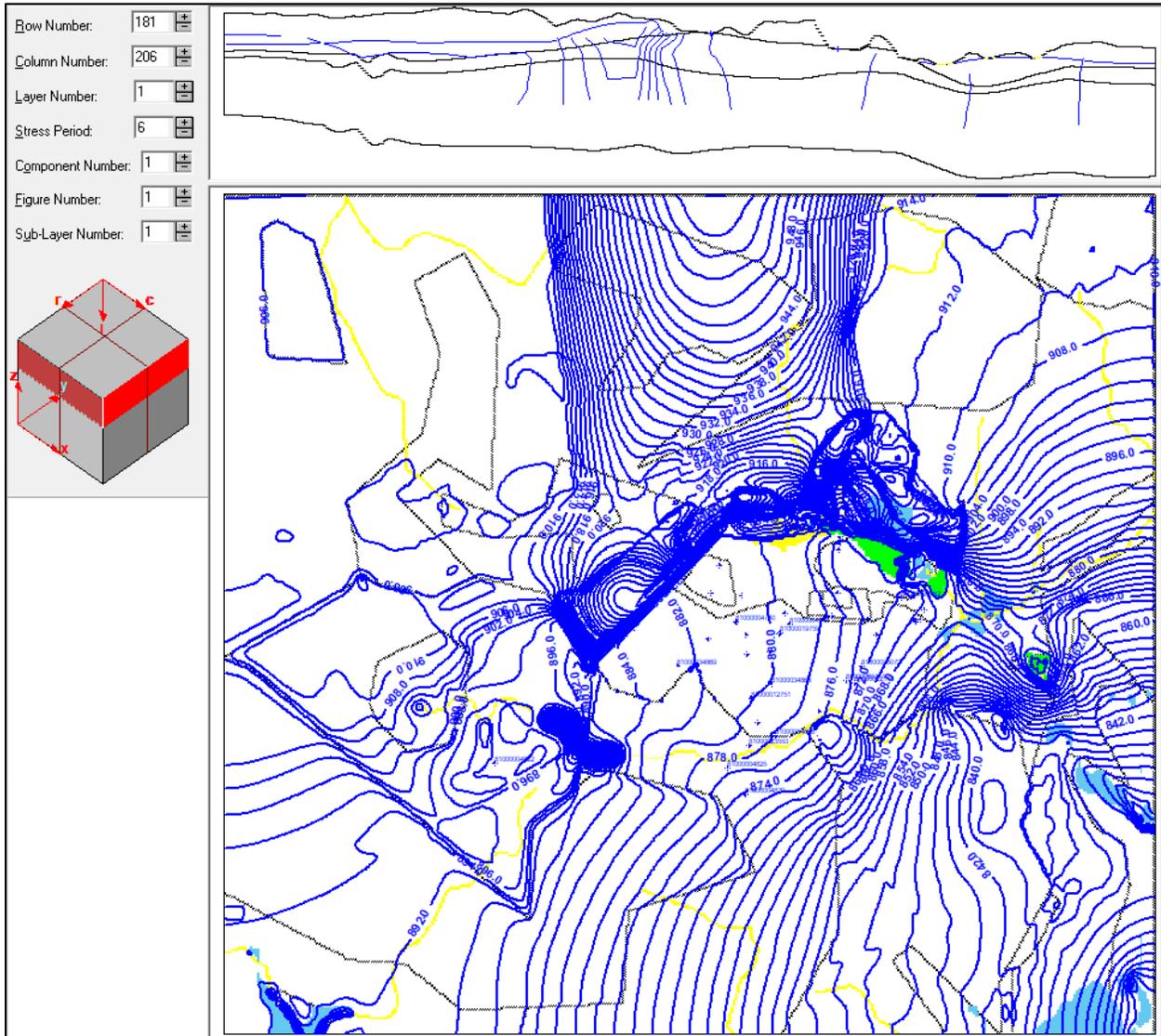
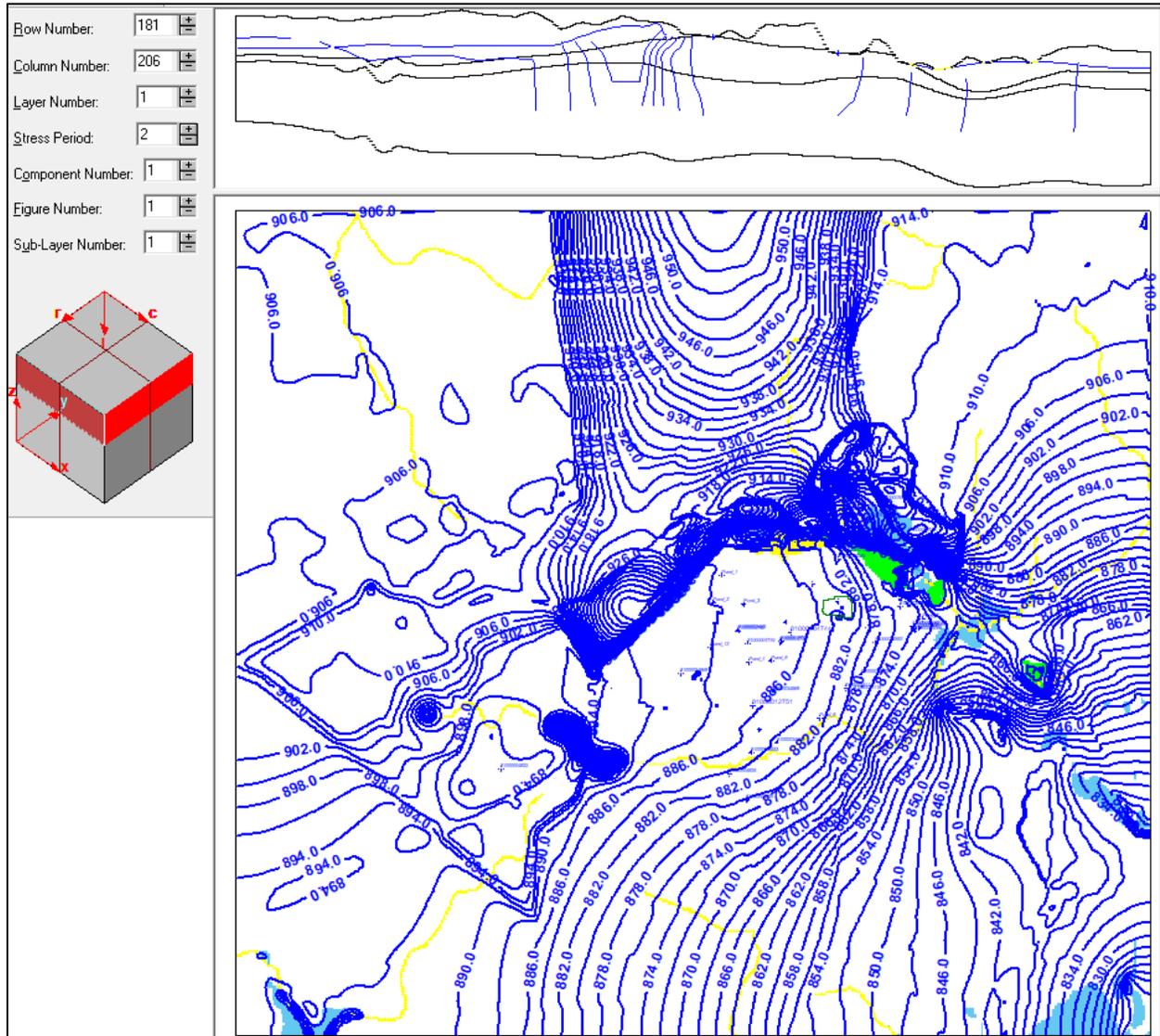


Figure 18 - Simulation of potentiometric head in Layer 1 of Transient model run. Contours at 2-ft intervals represented in dark blue. Flooded cells in light blue. Drain boundaries in yellow. River boundaries in green.



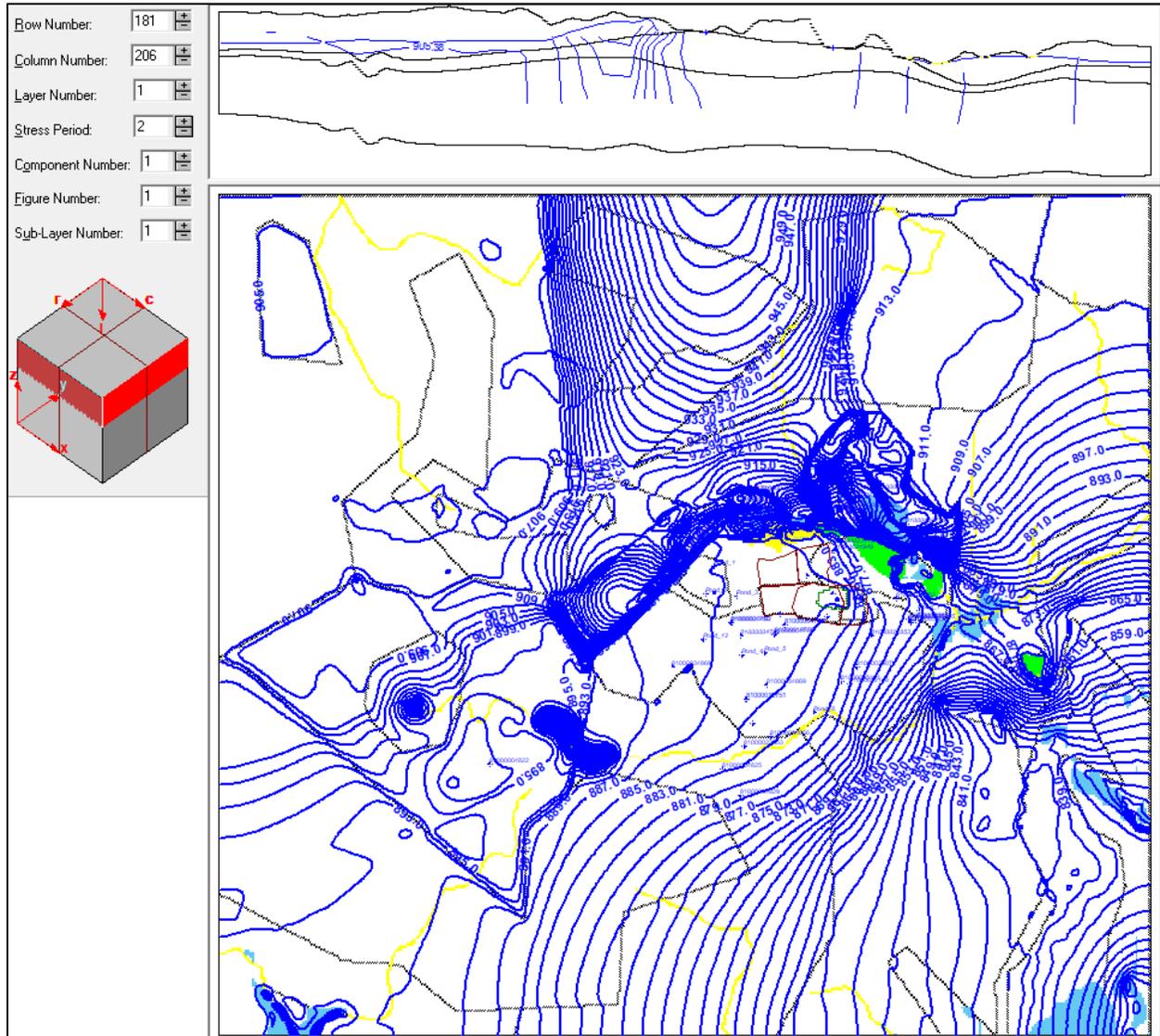


Figure 20 - Simulation of potentiometric head in Layer 1 of Phase 2 model run. Contours at 2-ft intervals represented in dark blue. Flooded cells in light blue. Drain boundaries in yellow. River boundaries in green.

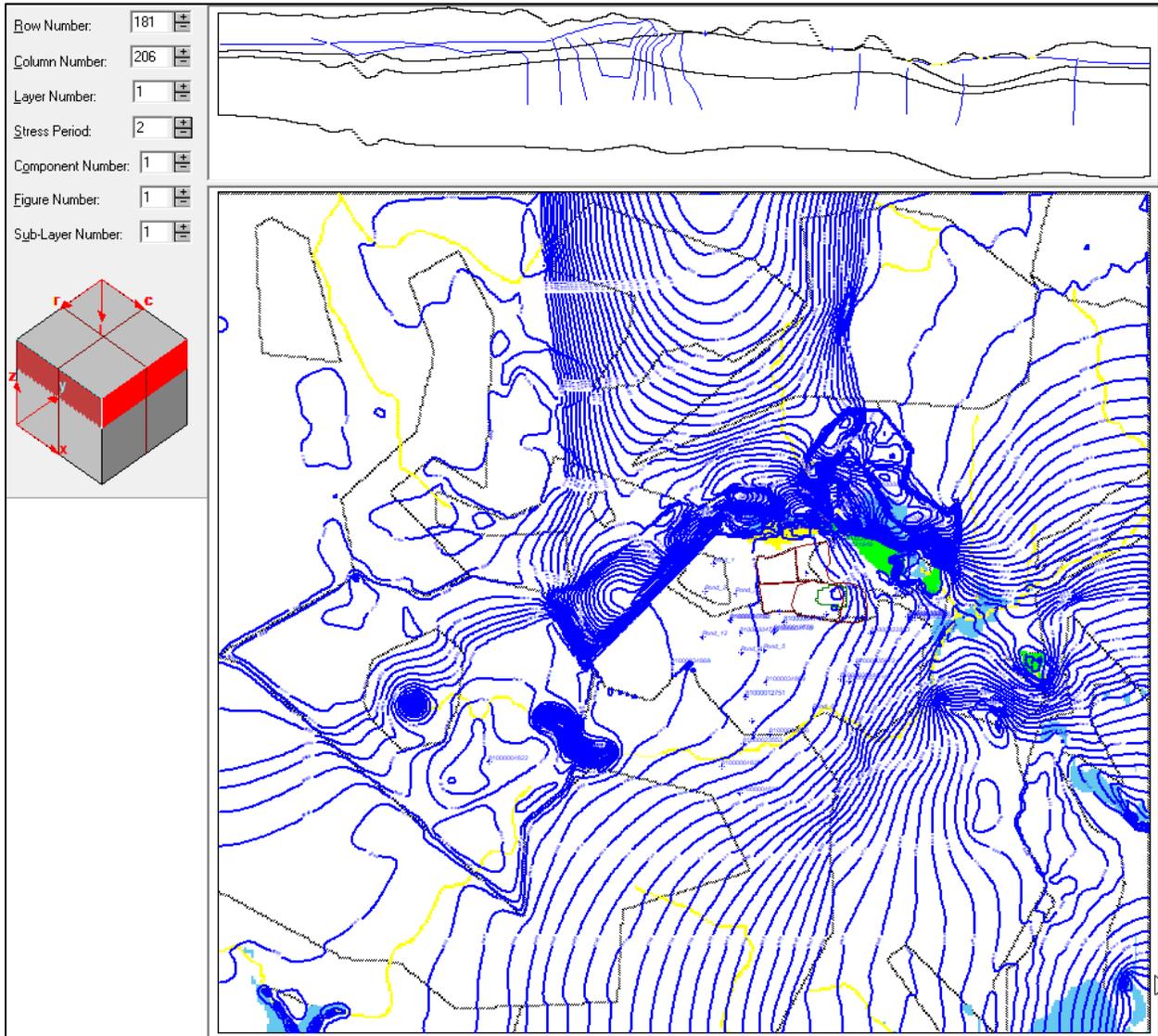
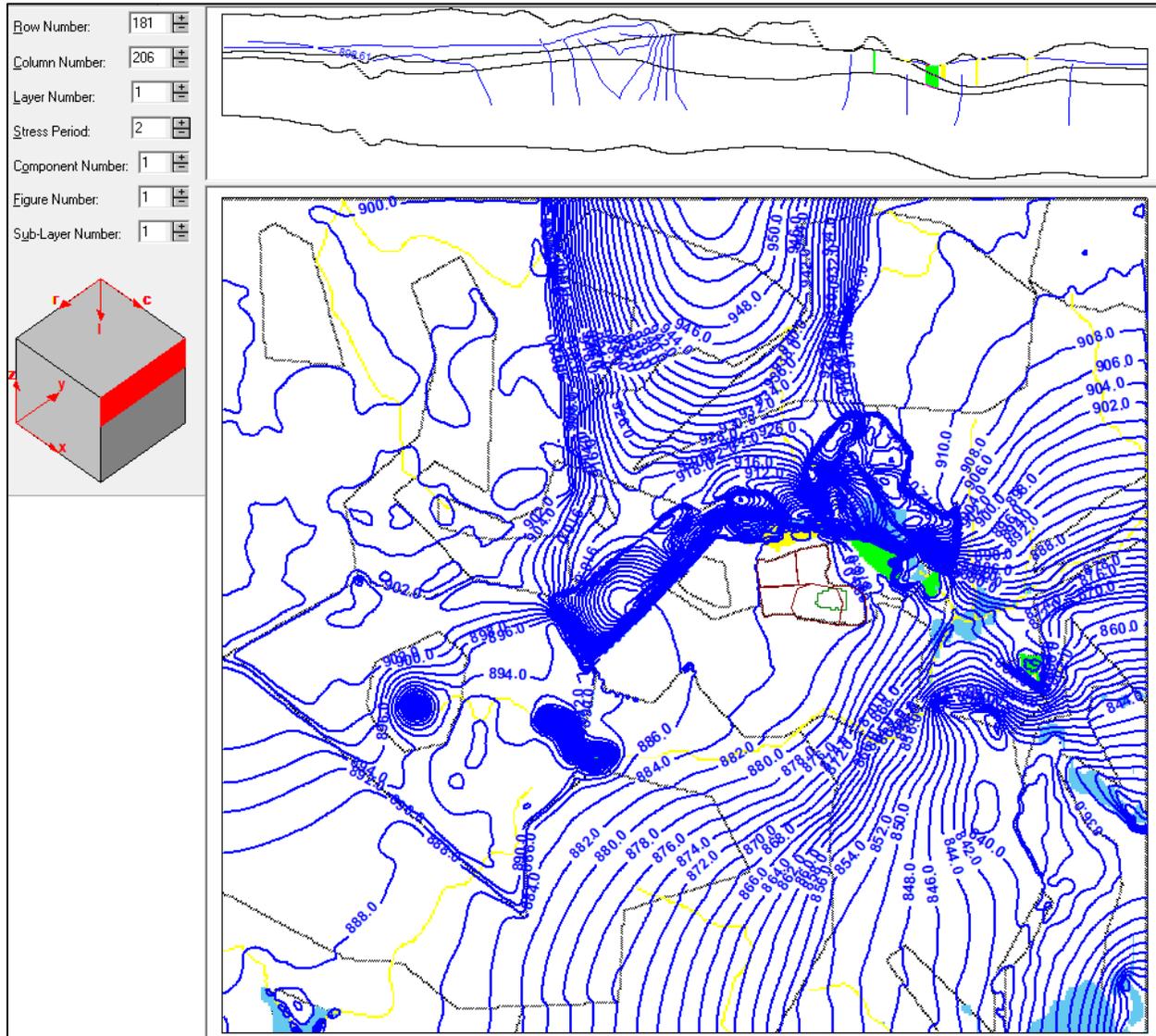


Figure 21 - Simulation of potentiometric head in Layer 1 of Phase 3 model run. Contours at 2-ft intervals represented in dark blue. Flooded cells in light blue. Drain boundaries in yellow. River boundaries in green.



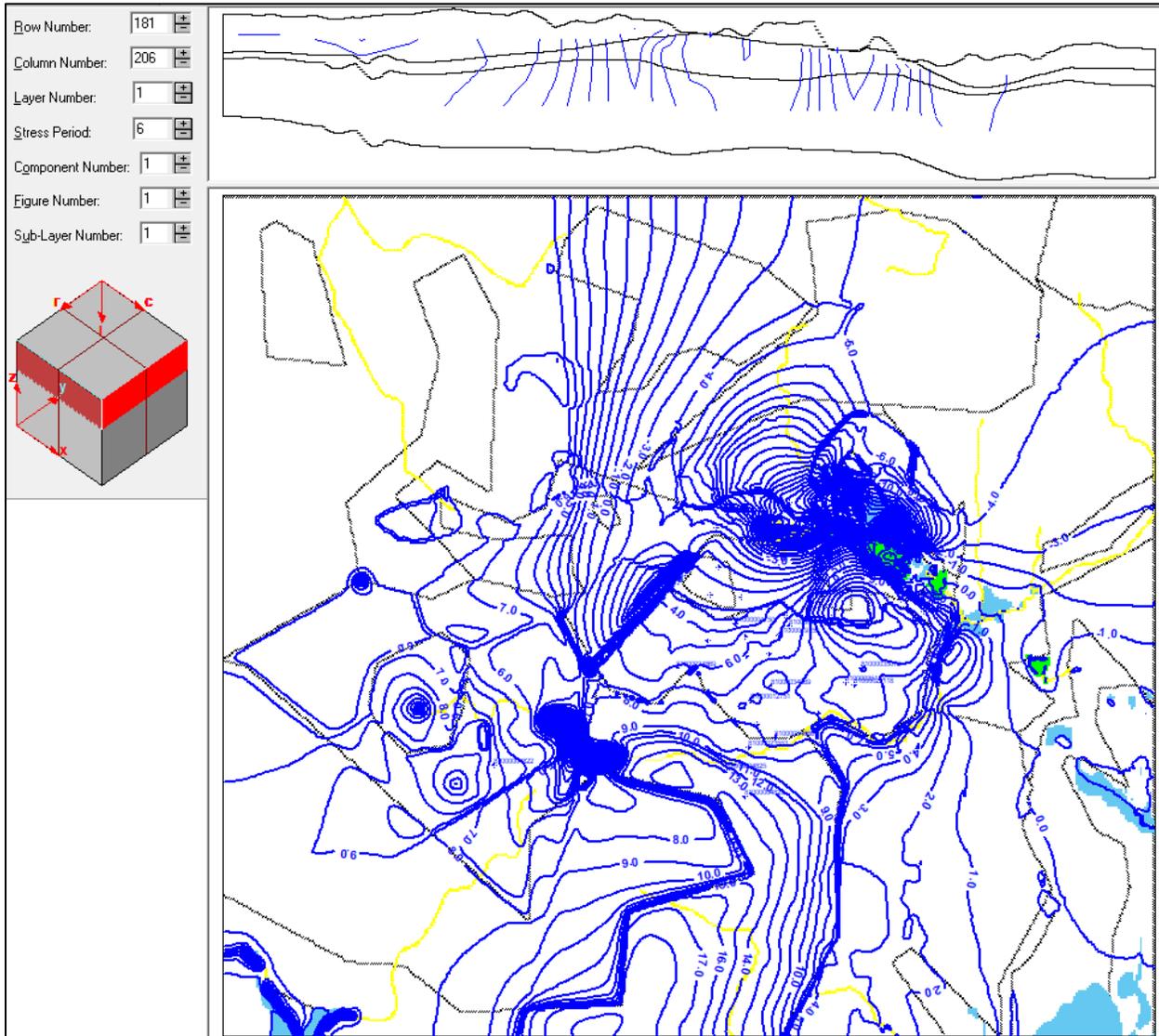


Figure 23 - Simulation of drawdown in Layer 1 of Transient model compared to the Steady State output. Drawdown contours at 1-ft represented by dark blue lines. Flooded cells in light blue. Drain boundaries in yellow. River boundaries in green.

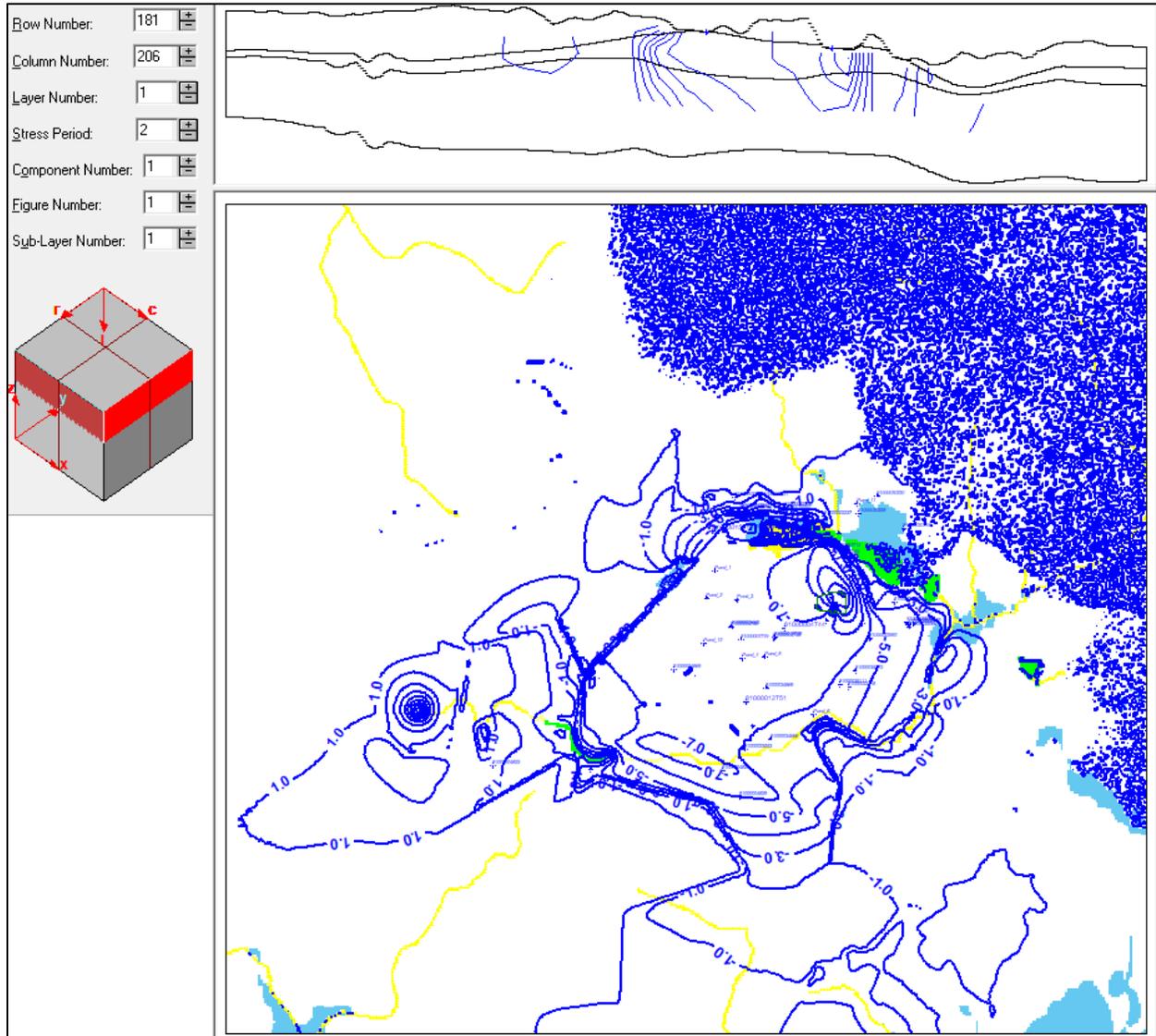


Figure 24 - Simulation of drawdown in Layer 1 of Phase 1 model run compared to the Transient model output. Drawdown contours at 1-ft represented by dark blue lines. Flooded cells in light blue. Drain boundaries in yellow. River boundaries in green.

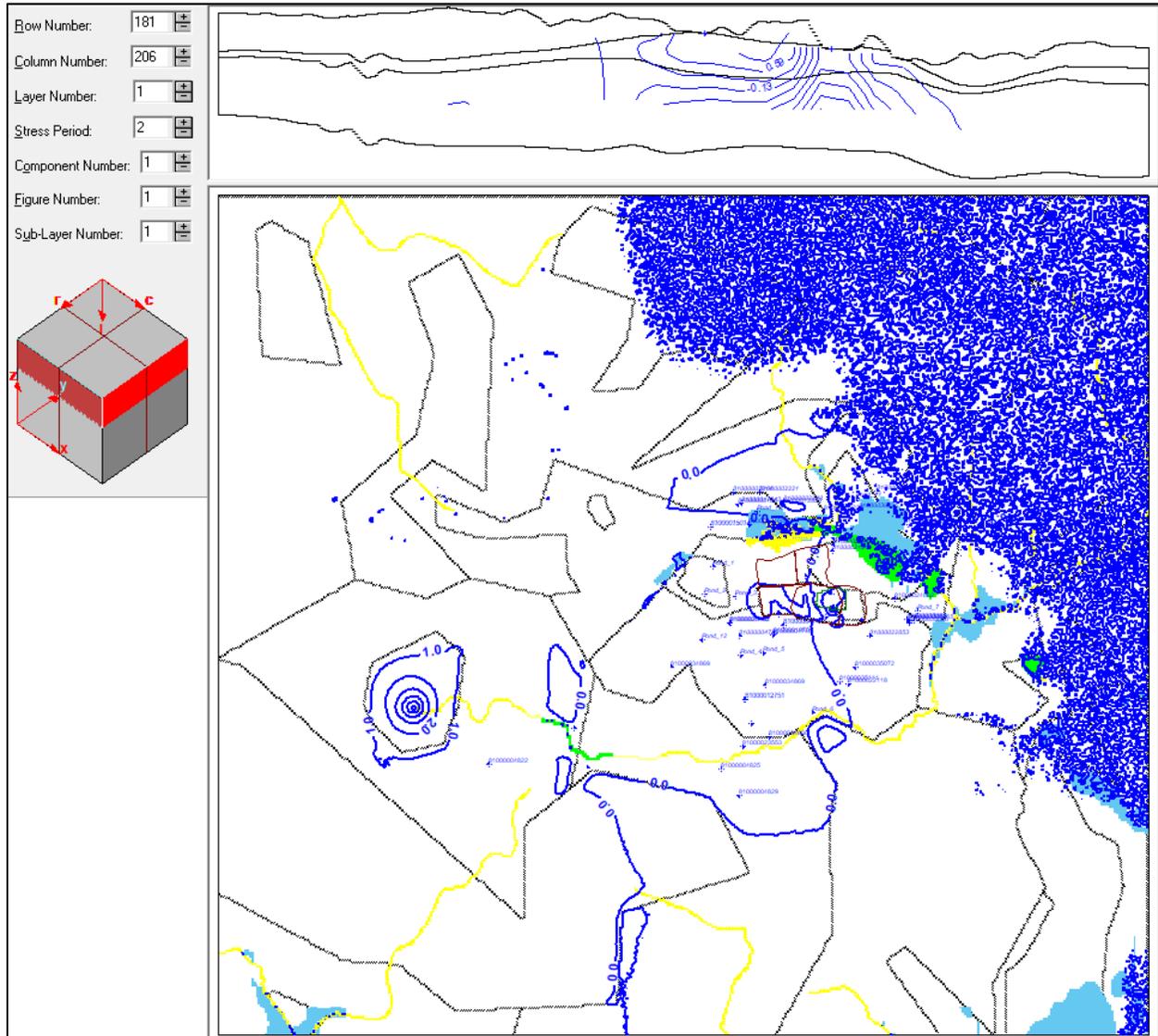


Figure 25 - Simulation of drawdown in Layer 1 of Phase 2 model run compared to Phase 1 model run output. Drawdown contours at 1-ft represented by dark blue lines. Flooded cells in light blue. Drain boundaries in yellow. River boundaries in green.

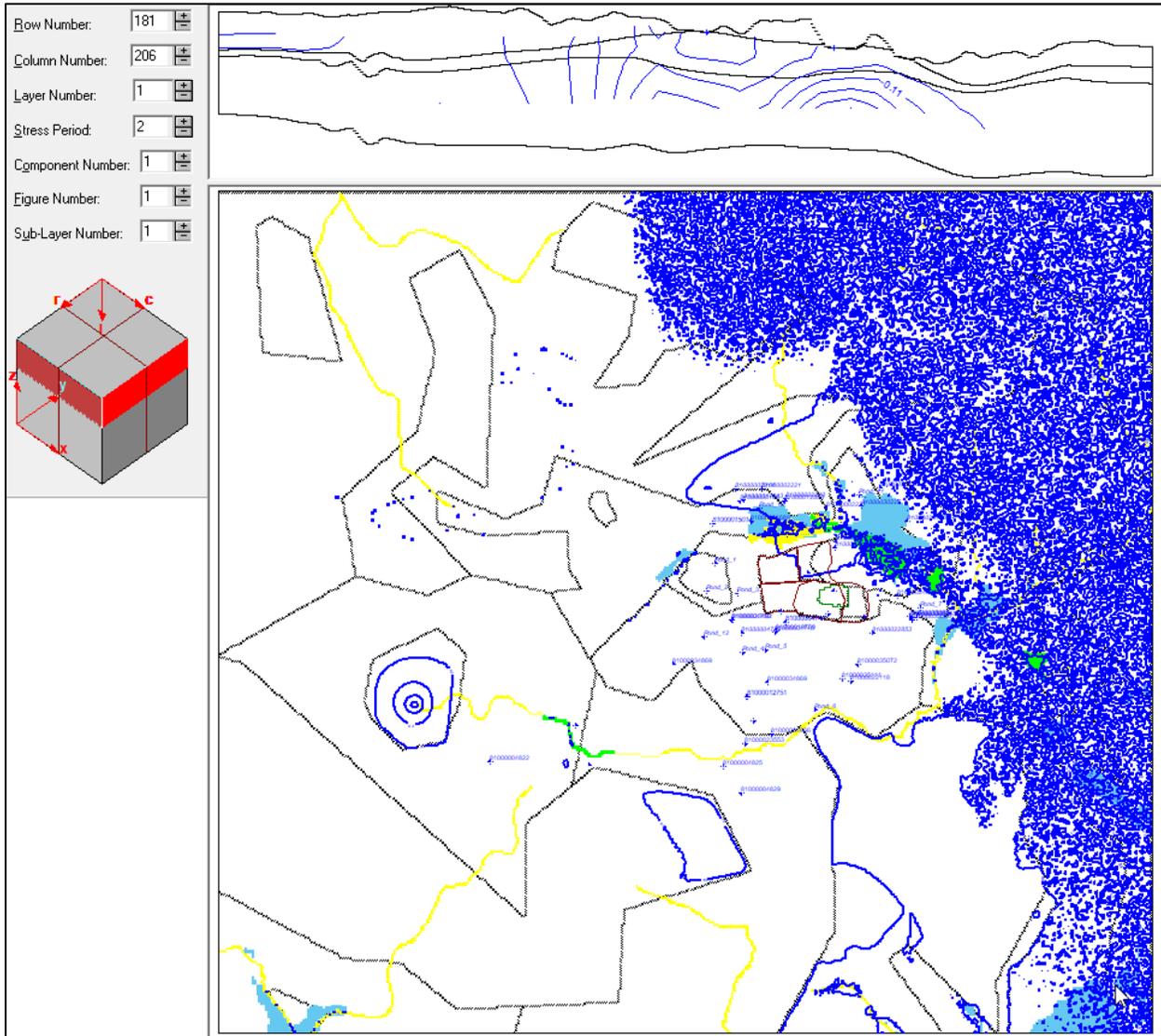


Figure 26 - Simulation of drawdown in Layer 1 of Phase 3 model run compared to the Phase 2 model run output. Drawdown contours at 1-ft represented by dark blue lines. Flooded cells in light blue. Drain boundaries in yellow. River boundaries in green.

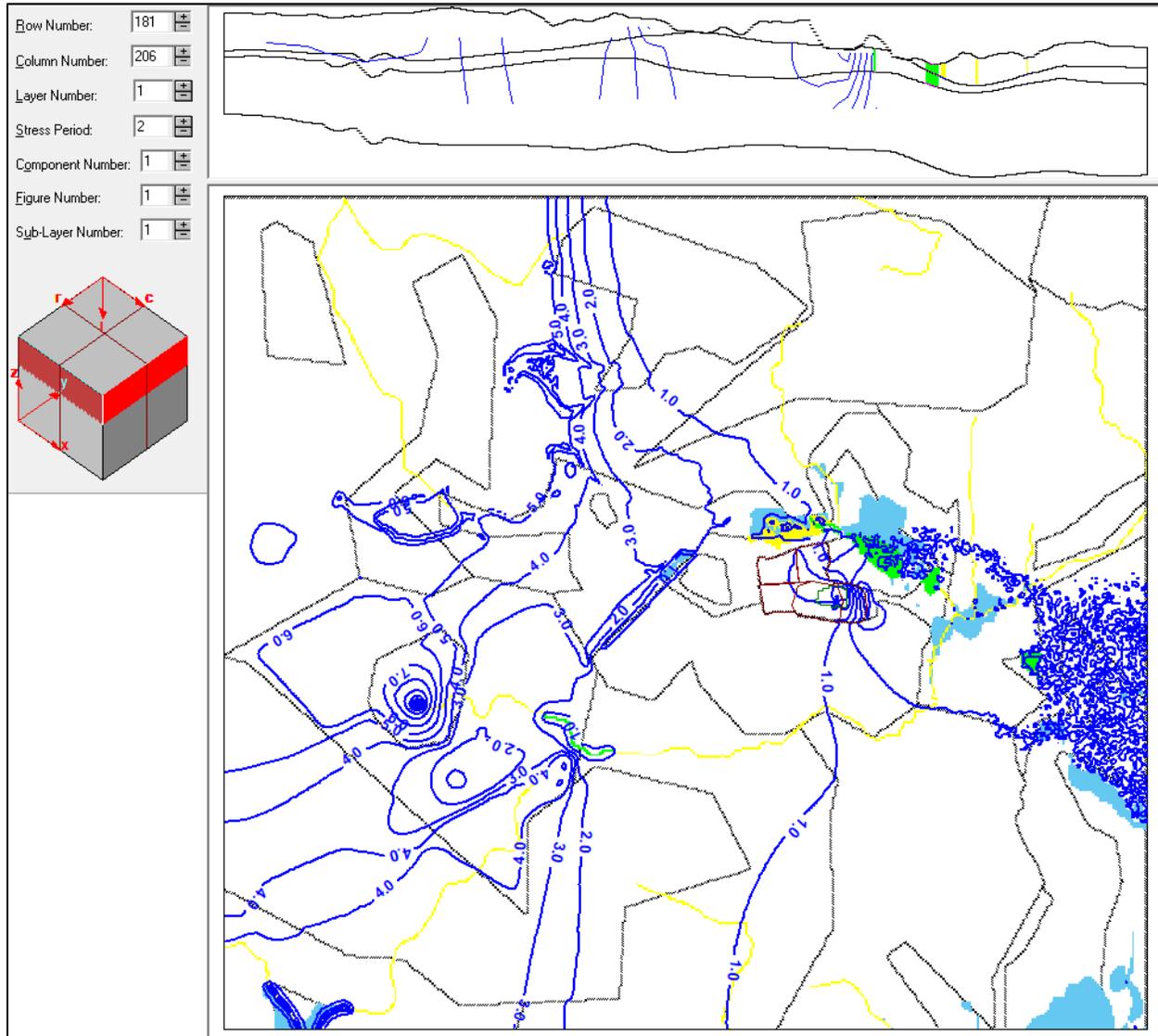


Figure 27 - Simulation of drawdown in Layer 1 of Phase 4 model run compared to the Phase 3 model run output. Drawdown contours at 1-ft represented by dark blue lines. Flooded cells in light blue. Drain boundaries in yellow. River boundaries in green.

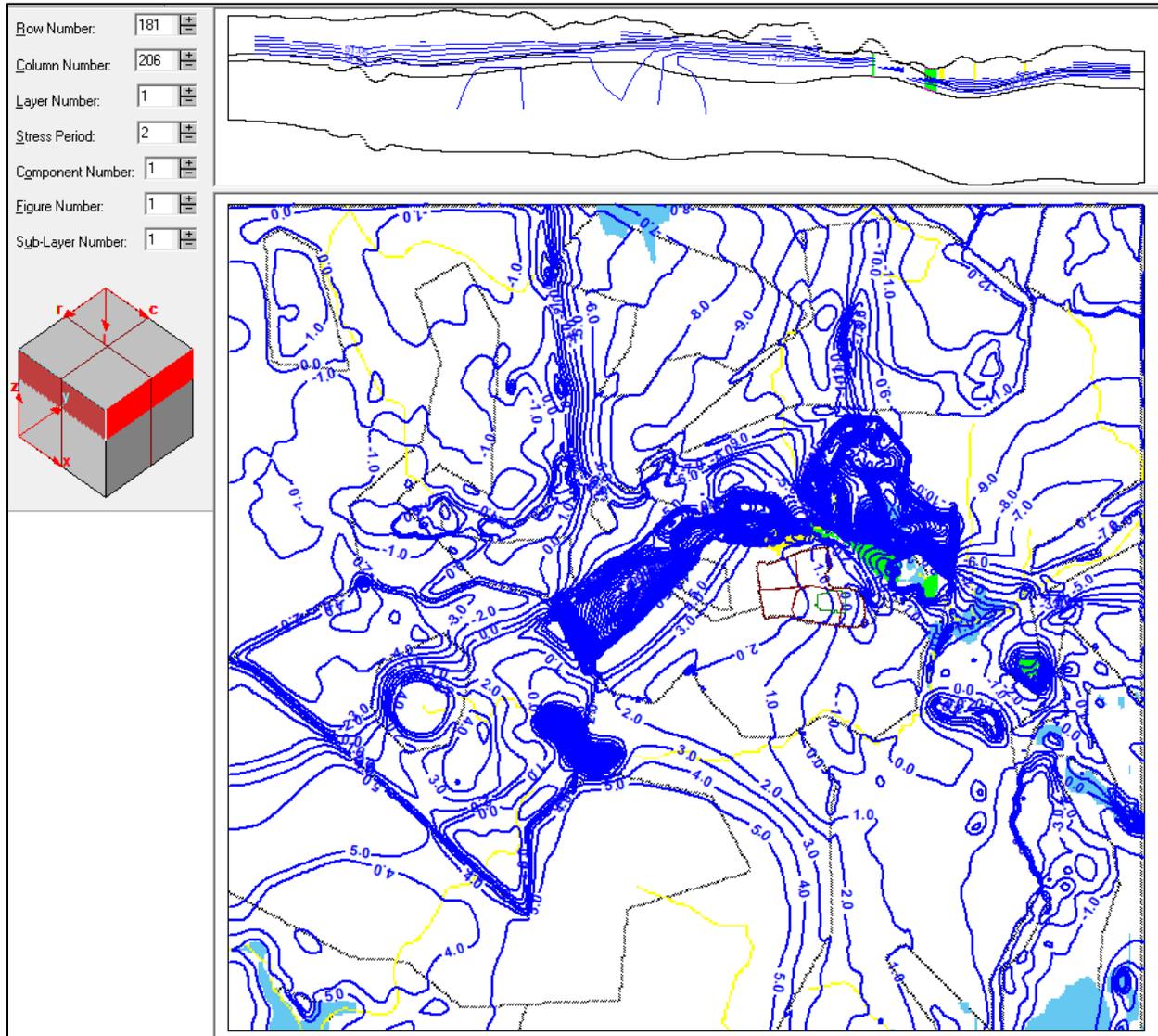
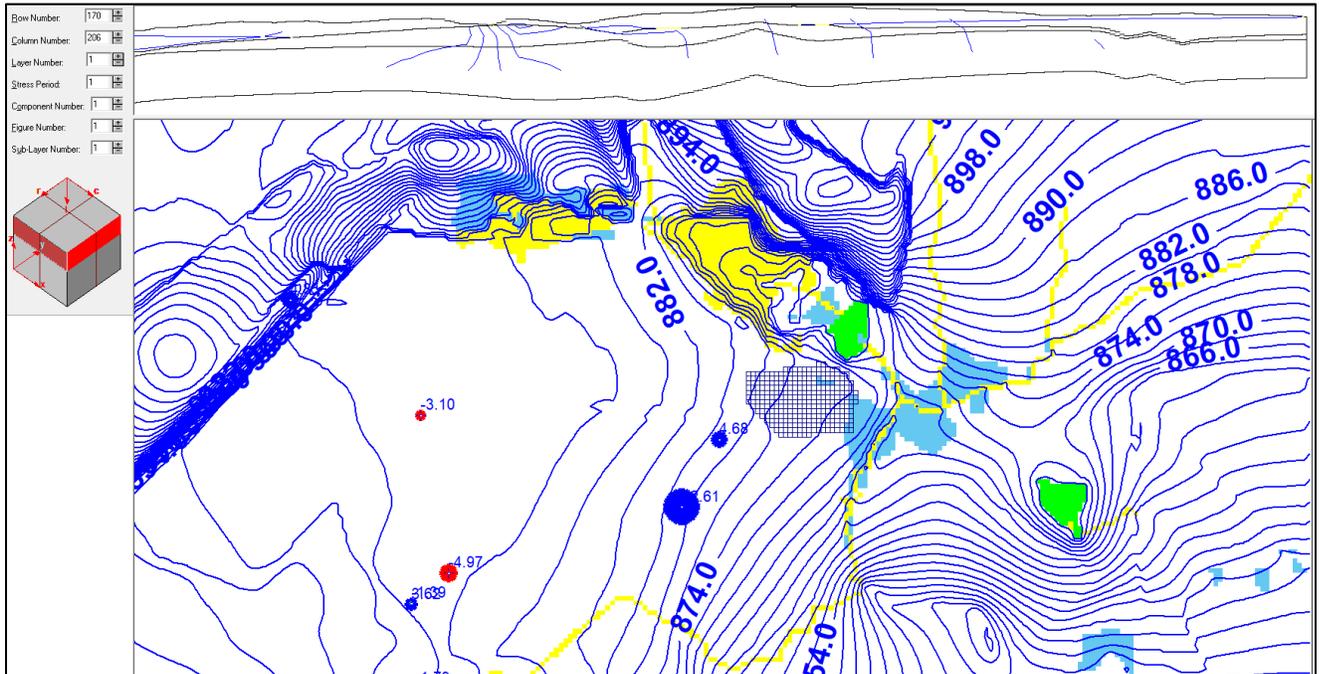


Figure 28 - Simulation of cumulative drawdown in Layer 1 of Phase 4 model run from Steady State. Drawdown contours at 1-ft represented by dark blue lines. Flooded cells in light blue. Drain boundaries in yellow. River boundaries in green.

EGLE reproduced the modified simulation of the Steady State model using the increased K values indicated to be present by the pump test conductivity values identified in supplemental data provided to EGLE. The observed output is shown below, and is consistent with the estimates provided by H&A. No further evaluation of the changes to overall water levels or drawdown effects was completed by EGLE of the other simulations.



*Figure 29 - Zoomed in sensitivity analysis simulation of potentiometric heads in Layer 1 of the Steady State model run. Contours at 2 ft interval represented in dark blue. Flooded cells in light blue. Residuals displayed as red (negative) and blue (positive) dots. Increased K value where gridded cells are displayed to 300ft/day.*

EGLE evaluated the flux occurring near the RIV boundary present along the eastern site boundary and identified impacts to predicted heads observable in both layer 1 and layer 2 head outputs, as visible in Figures 19, 20, 21, 28, and also in Figure 30 below. A cross-sectional view of head predictions at the RIV boundary is also presented below as Figure 31.

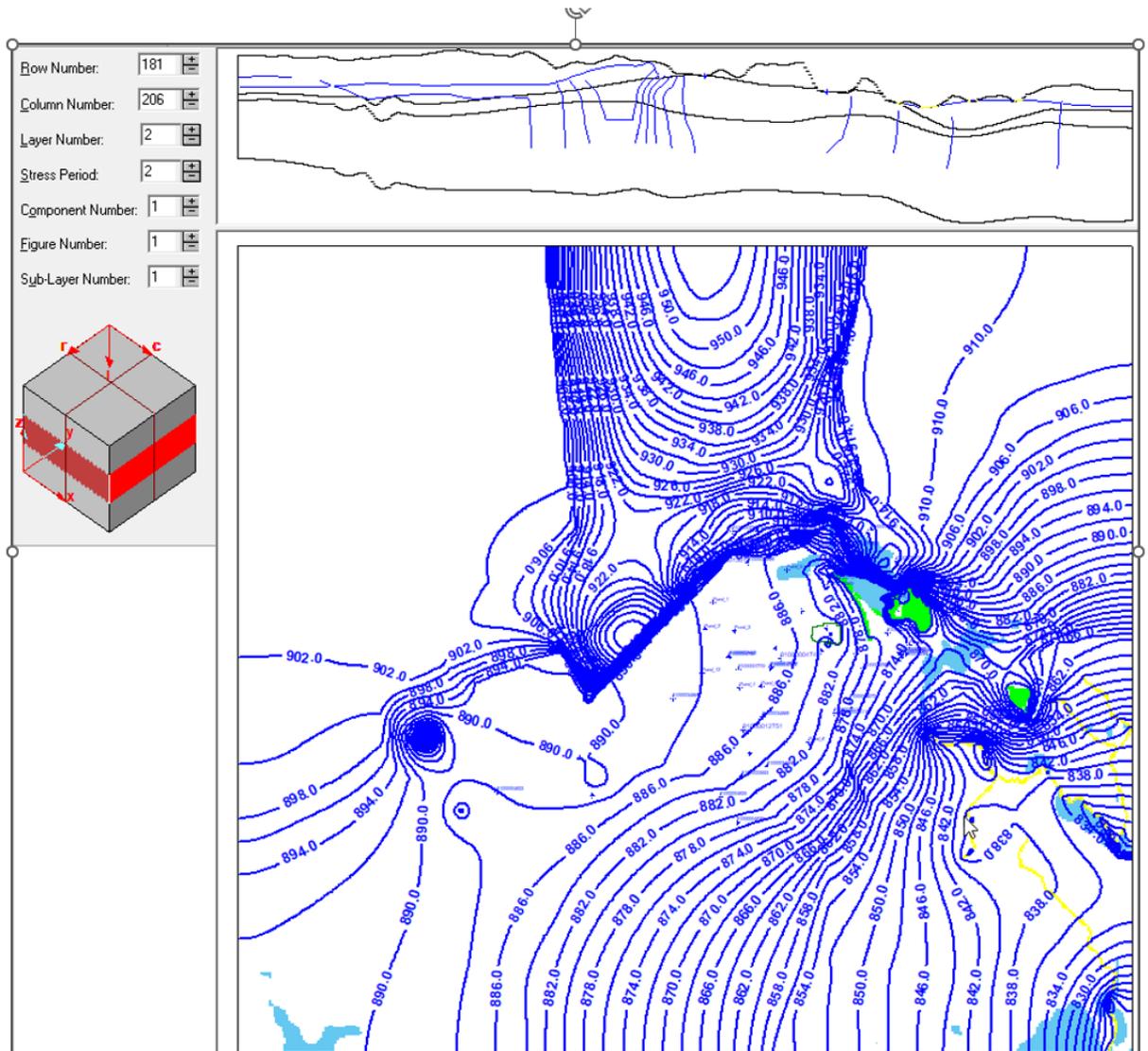


Figure 30 – Simulation of potentiometric head in Layer 2 of the Phase 1 model run. Contours at 2 ft interval represented in dark blue. Flooded cells in light blue. Drain boundaries in yellow. River boundaries in green.



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