DEWATERING EVALUATION RAPTOR TWO RIVERS MINE

14822 396 HWY
EVANS, COLORADO
AWES PROJECT # 2022-RM-P124

August 31, 2022

Prepared for:
Raptor Materials, LLC.
8120 Gage Street
Frederick, CO 80516

Prepared by:
AWES, LLC
4809 Four Star Ct.
Fort Collins, CO 80524

Introduction

The following report presents the results of an updated hydrogeologic evaluation regarding a proposed dry mine gravel quarry operation to be operated by Raptor Materials, LLC (Raptor) near Evans, Colorado. The original evaluation was conducted in July 2020 by American Water Engineering Services, LLC. The original evaluation was modified due to changes in the mine pit configuration and questions raised by the Colorado Division of Reclamation, Mining and Safety. Raptor identifies the proposed mine as Pit 124.

This evaluation consisted of reviewing available hydrogeologic data and inputting those data into a numerical groundwater flow model. The model was then used to estimate the effects of dewatering operations on the surrounding groundwater hydrology. This report was prepared as part of an OMLR 112 permit application. The site location is depicted on Figure 1.

Background Information

The proposed gravel quarry is located in sections 3 and 4 of Township 4 North, Range 66 West and sections 33 and 34, Township 5 North, Range 66 West of the 6^{th} Principal Meridian. The surrounding land use consists of agricultural, rural residential and oil and gas gathering. The proposed mine area occupies an estimated 380 acres with an extraction area of 270 acres. The anticipated extraction depth will vary between 12 and 44 feet below grade.

Information provided by geotechnical investigations, monitoring well water level data and water resource evaluation reports document the local and regional hydrogeology. In January 2015, 12 soil borings were drilled from ground surface to bedrock to determine the potential aggregate mass within the proposed mine boundary. These borings were completed as groundwater monitoring wells. Bedrock elevations were also obtained from studies by Colton and Finch, 1974. The depth to bedrock within the proposed mine pit boundaries varied between 12 and 44 feet below ground surface. In general soil conditions consist of less than one to six feet of top soil and sandy clay underlain by sand and gravel with occasional clay and poorly graded sand lenses. The coarse alluvial deposits are underlain by bedrock which consists of siltstone, sandstone and claystone.

The average hydraulic conductivity of the sand and gravel deposits is estimated at 125 feet per day (Schneider, 1983) which is consistent with published values and pump test evaluations conducted by the author in similar geologic settings. In addition grain size analyses document the 90% passing (d_{10}) to vary between 0.2 and 0.3 millimeters. Freeze and Cherry 1979, present analytical solutions for saturated hydraulic conductivity estimations. Use of the equation $K=Ad^2_{10}$, where K is hydraulic conductivity in cm/s, d_{10} is in mm and A is a constant equal to one. Based on grain size curves the hydraulic conductivity is estimated to vary between 113 and 255 feet per day. The average effective porosity of the local sand and gravel deposits is estimated at 0.27.

The natural hydraulic gradient as documented by past water resource investigation reports is on the order of 0.002 feet per foot within the coarse alluvial deposits. The hydraulic gradient increases to 0.03 feet per foot within the fine sands that are present in the northern model area. The average depth to groundwater measured in the Raptor monitoring wells was nine feet below ground surface. The natural groundwater flow direction varies from southeast to northeast within the model and mine area. Seasonal water table fluctuations of between one and three feet are common for this area; however, fluctuations of greater than ten feet have been documented during drought conditions (Schneider, 1983).

The mine area is depicted on Figure 2. The water table in the pit will be drawn down to bedrock by allowing groundwater to flow from the side walls of the excavation into ditches excavated into the bedrock or pit bottom at the toe of the excavation walls. The ditches are sloped so water drains to predetermined pump locations. The water is then pumped from the excavation into irrigation ditches, which eventually outfall to the South Platte or Big Thompson Rivers.

Project Assumptions

The following are assumptions made in estimating the effects of mine dewatering operations.

- The aquifer within the model boundary is heterogeneous and anisotropic.
- The average water table altitude within the mine area varies between 4674 and 4681 feet above mean sea level.
- The average horizontal hydraulic conductivity (K) of the sand and gravel deposits is 125 feet per day and the vertical K value is 12.5 feet per day. Silty sands, which are predominant north of the Big Thompson River, were assigned a horizontal K of 50 feet per day and a vertical K of 5 feet per day.

- A 1.5 inch recharge rate from precipitation was assigned to the model area.
- The vertical hydraulic conductivity of the river beds is 4 feet per day.
- The hydraulic conductivity of the barrier wall material is 0.003 feet per day with a lining thickness of four feet.
- Other than dewatering associated with the Pit 124 mine operations no other aquifer stresses such as drought and surrounding well use were modeled.
- All groundwater solutions are steady state.
- The bedrock which underlies the coarse alluvial deposits is an impermeable barrier.

Model Parameters

The effects of dewatering on groundwater flow within the study area were evaluated by using the three dimensional groundwater flow model Visual ModFlow Pro. The general parameters used in the model are presented below. The model grid is depicted on Plate 1.

- The model boundary is 12800 feet (east-west) by 10050 feet (north-south);
- The model grid is 251 rows by 320 columns or 80,320 cells;
- Two layers were used in the model with the upper layer representing unconsolidated alluvial deposits and the lower layer representing bedrock (Plate 2);
- The thickness of the upper layer varied between 12 and 44 feet within the pit areas;
- Constant head boundaries were assigned for the dewatering line sinks;
- River boundaries were assigned for the South Platte and Big Thompson Rivers;
- Barrier walls were assigned to the excavation limits of central and northwest pits for shadow and mounding simulations;
- Constant head boundaries were assigned to the interior of the barrier walls to simulate reservoir storage; and,
- General head boundaries were assigned to the model perimeter.

A uniform flow field was defined in the model with an unconfined aquifer. Water levels obtained from published water level data and existing monitoring well data were used to generate water level contours unaffected by any pumping influences. Water level data within the mine boundaries were used to calibrate the model based on observed conditions. Ground surface and bedrock elevations were obtained from site surveys, drill hole data and USGS maps. The ground surface and bedrock elevations were input into the geo-statistical model Surfer®, which created surface and bedrock contour maps. These surface and bedrock elevation data were imported into Visual ModFlow (VMOD) to define the ground surface and bedrock elevations within the flow model. The river stage elevations were extrapolated from survey data. Water table contours generated from measured water levels (Raptor piezometers) are presented on Plate 3.

Water table elevations measured in on-site piezometers over a four year period were averaged and these elevations were used in the calibration process. A site survey also provided surface water elevations of the South Platte and Big Thompson Rivers. The model boundary was superimposed over a topographic map and the author generated hand drawn contours that best reflected measured groundwater and surface water elevations. In the extreme northwest model area the elevations of the intermittent stream beds were used as water table elevations. General head boundaries were assigned to the model perimeter and head elevations were assigned where hand drawn elevations intersected the model boundary. The model was then run and model predicted heads were compared to observed heads. This process took several iterations as water table gradients changed dramatically throughout the model boundary. After the calibration process was completed the "cell inspector" function was used to determine the predicted head elevation for model assigned wells. The head elevations at the model assigned wells prior to pumping or lining were used as a baseline to measure the effects of dewatering and mine wall lining. The calibration simulation included seepage from the river boundaries. The calibration simulation is depicted on Plate 4. The model calculated head values referenced above are depicted on Plates 5 and 5A. Plate 6 depicts calibration boundary conditions.

To simulate mine dewatering constant head line sinks were assigned to cells within the pit areas with head values approximately four feet above the bedrock elevation, which accounts for the predicted seepage face. To account for significant differences in bedrock elevations linear gradients were assigned to the line sinks where appropriate. Predicted groundwater contours resulting from mine dewatering are presented on Plate 7. Plate 8 depicts model boundary conditions used for dewatering simulations. The calibration graph for mine dewatering is presented as Plate 9. Two comparison points were used to determine the extent of drawdown and are depicted on Plate 8. The cell inspector function was used to determine heads at the comparison points prior to and during dewatering operations.

Raptor intends to line the mined out pits for water storage. To evaluate the effects of lining the mine cells on the local groundwater hydrology, barrier walls were assigned near the excavation limits of the two pits. Plate 10 depicts predicted groundwater contours for post lining conditions. As mentioned model assigned wells were used to obtain pre-mining model predicted water levels at four locations (MW-1 – MW-4). These predicted water levels were used for comparison to predicted groundwater levels in all simulations, including shadow and mounding effects. To simulate filled ponds, the interior of the reservoirs were assigned constant head values at an elevation slightly below ground surface elevations (4675 feet above mean sea level). A simulation was then run to predict the effects of the lined reservoirs on the groundwater hydrology. Table 1, presents the predicted water level changes as a result of lining the mined out pits. Plates 11 and 11A depict calibration graphs showing predicted groundwater elevations in assigned wells up and downgradient of the lined pits. Plate 12 depicts boundary conditions for the lined pit simulation.

Table 1 – Mining and Lined Pit Water Level Comparison Points

Point	Distance to Mine Wall (ft.)	Calibration Water Level (ft.)	Drawdown Water Level (ft.)	Post Lining Water Level (ft.)	Drawdown Elevation Difference (ft.)	Lining Elevation Difference (ft.)
MW-1	330	4680.39	4679.80	4680.64	-0.59	0.25
MW-2	187	4681.37	4661.39	4681.82	-19.98	0.45
MW-3	1220	4674.07	4670.03	4673.90	-4.04	-0.17
MW-4	488	4675.32	4665.83	4674.91	-9.49	-0.41
C-1	1378	4683.22	4679.26	4683.54	-3.96	0.32
C-2	4000	4686.19	4685.91	4686.30	-0.28	0.11

Results

A review of plate 7 shows that the groundwater hydrology north of the Big Thompson River and east and south of the South Platte River is unaffected by dewatering. The model predicts a drawdown of roughly four feet 1,378 feet west of Pit 124. The model predicted radius of influence is on the order of 4,000 feet – the predicted change in head is 0.11 feet.

A review of Table 1, shows that the lining of mined pits will have a de minimis effect on groundwater hydrology. Predicted post lining head levels immediately up and downgradient of the barrier walls are within the range of normal seasonal water table elevation changes.

Conclusions

The results of analytical and numerical solutions indicate that the proposed mine dewatering activities will not adversely affect the regional groundwater hydrology. Based on the location of registered water wells, the saturated aquifer thickness west of the mine is sufficient to provided adequate well yields. The predicted drawdown associated with the mine dewatering represents the worst case scenario and a substantial amount of time will be required before maximum drawdowns will occur.

In the author’s opinion one cannot reasonably differentiate the head differences of seasonal groundwater fluctuations and head differences possibly created by lining mined pits – they are both within expected seasonal head variations. The permeability of the aquifer materials are sufficient to mitigate pressure gradients created by the impermeable liners. This mine is bounded on three sides by rivers and the surface water gains and losses to and from the aquifer will mask any possible hydrology changes created by pit lining.

If there are unregistered domestic wells located within the area influenced by pumping, it may be advisable to conduct a physical well survey prior to the mine start-up. Though there is sufficient aquifer thickness to provide good well yields in most areas there may be partially penetrating wells that might be affected by mine dewatering.

This report was prepared by **AWES, LLC**

Date: 08/31/2022

Joby L. Adams, P.G., REM
Principal/Hydrogeologist

REFERENCES

Bear, J. 1979. Hydraulics of groundwater. McGraw-Hill Inc., New York, 569 pp.

Colton, R.B., and Fitch, H.R., 1974, Map showing potential sources of gravel and crushed-rock aggregate in the Boulder-Fort Collins-Greeley area, Front Range Urban Corridor, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-855-D.

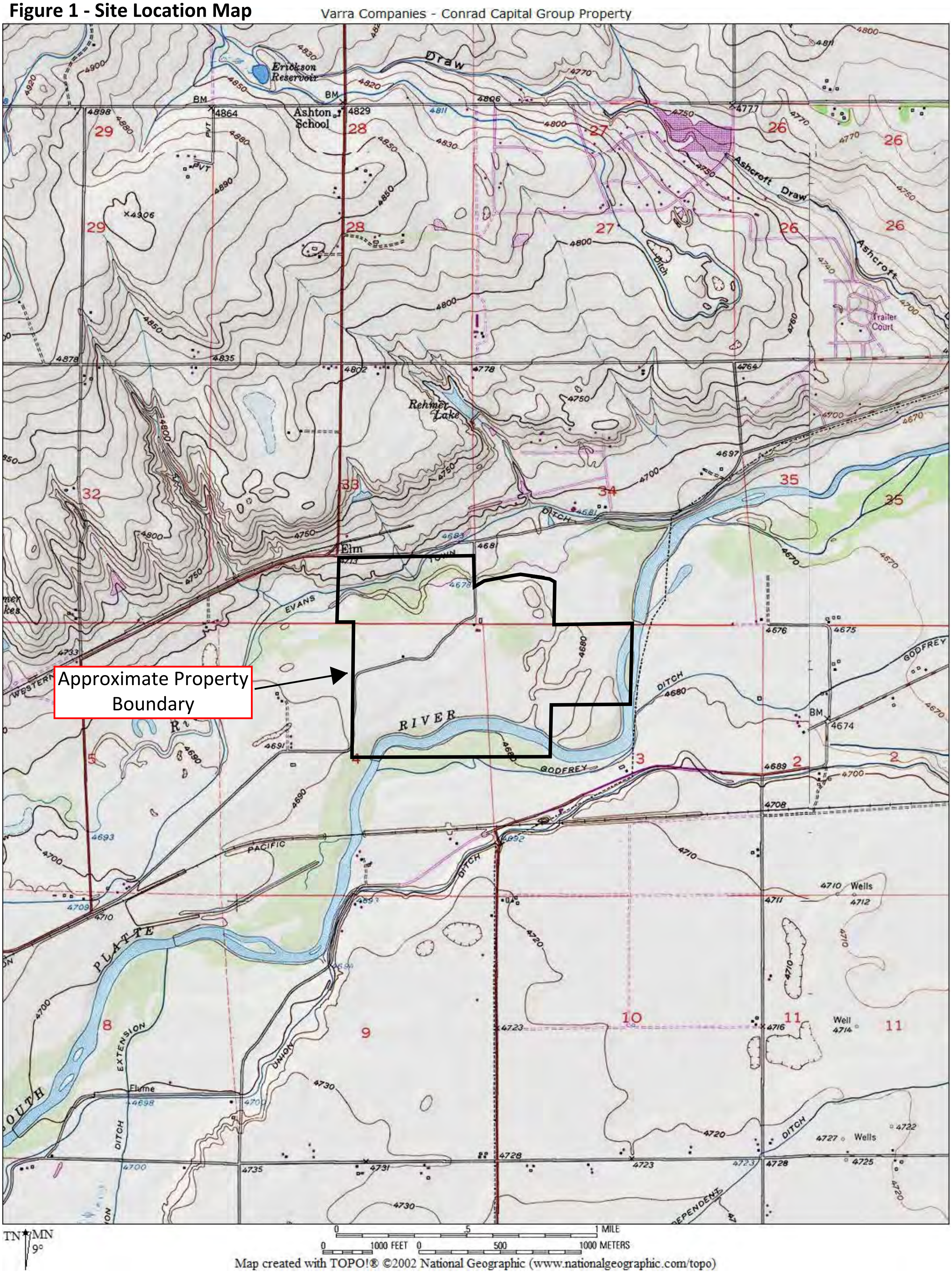
Freeze, A. R., and Cherry, J. A., 1979. Groundwater. Prentice-Hall, Inc., Englewood Cliffs, N.J., 604 pp.

Schneider, P. A., 1983, Shallow groundwater in the Boulder—Fort Collins—Greeley area, Colorado, 1975-77: U.S. Geological Survey Water Resources Investigation Report 83-4058.

WesTest, Inc., 2015. Geotechnical Investigation, Two Rivers Property, Weld County, Colorado. Prepared for Varra Companies, Inc., February 12, 2015.

FIGURES

Figure 1 - Site Location Map



VARRA COMPANIES, INC. 8120 GAGE STREET FREDERICK, COLORADO 80534 TELEPHONE: (303) 666-6657	PROJECT: Two Rivers Sand, Gravel and Reservoir Project DRAWING: Exhibit C-2: Extraction Plan Map	NOTES: 234.06±Acres Basins Total + 5.60±Acre Wash Pond R.O.W & Easements not shown from Exhibit C-1: Existing Conditions Map, are obsolete or vacated.	Drawn by: BL Janes SCALE: 1 inch = 200 feet DATE: 22 February 2022 REVISION: PAGE: 1 OF 1

PLATES

Plate 1 - Model Grid

Two Rivers Model Grid
Drawdown - Shadow/Mounding Simulations

AWES, LLC Fort Collins, CO 970-590-3807	Varra Companies Pit 124

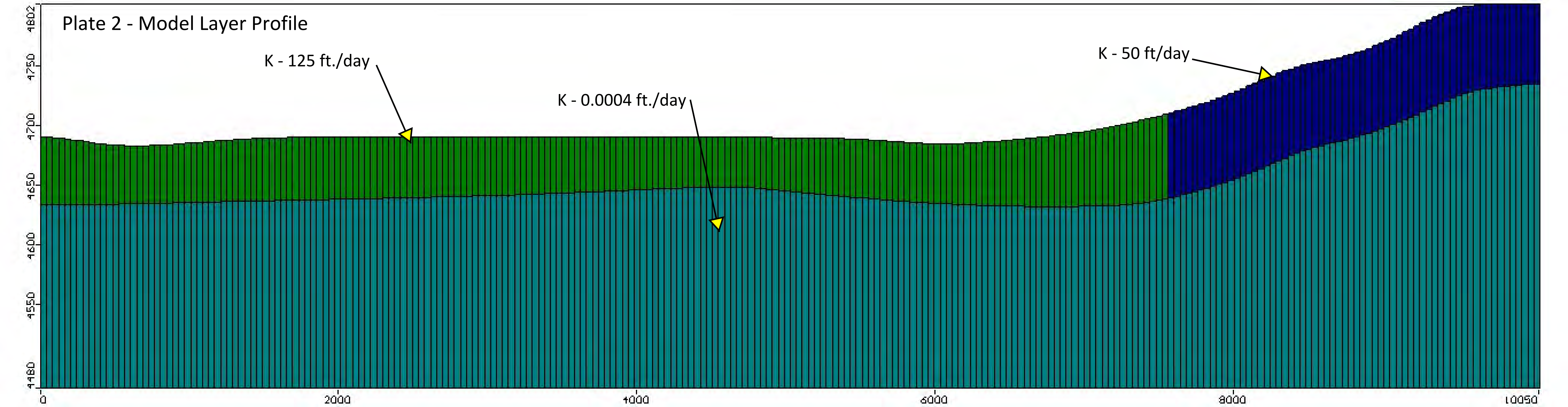
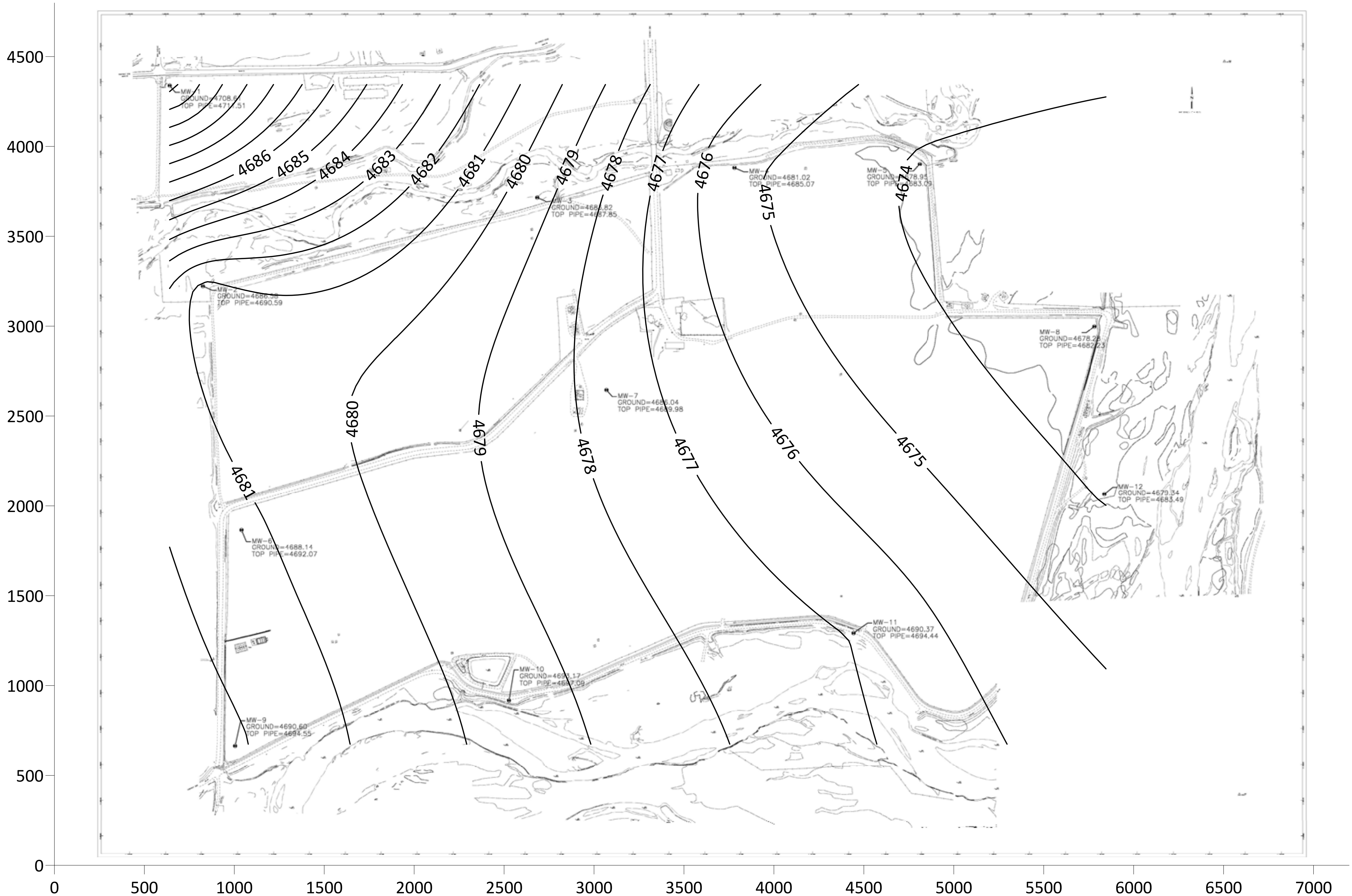


Plate 2 - Model Layer Profile
K - 125 ft./day
K - 0.0004 ft./day
K - 50 ft/day
1802
1750
1700
1650
1600
1550
0
2000
4000
6000
8000
10050

Plate 3 - Average VCI Measured Groundwater Elevations (9/2015 - 8/2019)



Note: Surfer Generated Contours

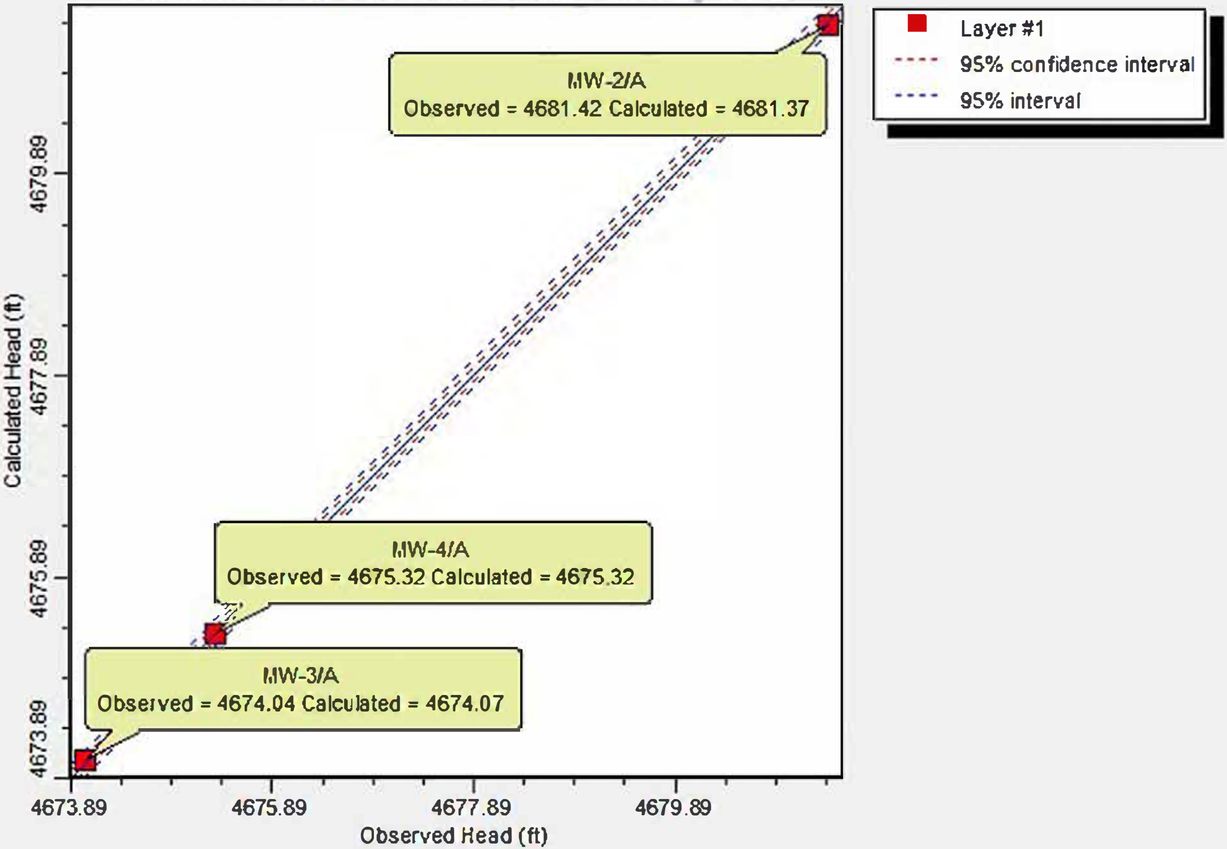
Plate 4- Groundwater Flow Calibration Simulation

Two Rivers Groundwater Flow Calibration
Drawdown - Shadow/Mounding Simulations

AWES, LLC
Fort Collins, CO
970-590-3807

Varra Companies
Pit 124

Plate 5 - Calculated vs. Observed Head Steady state

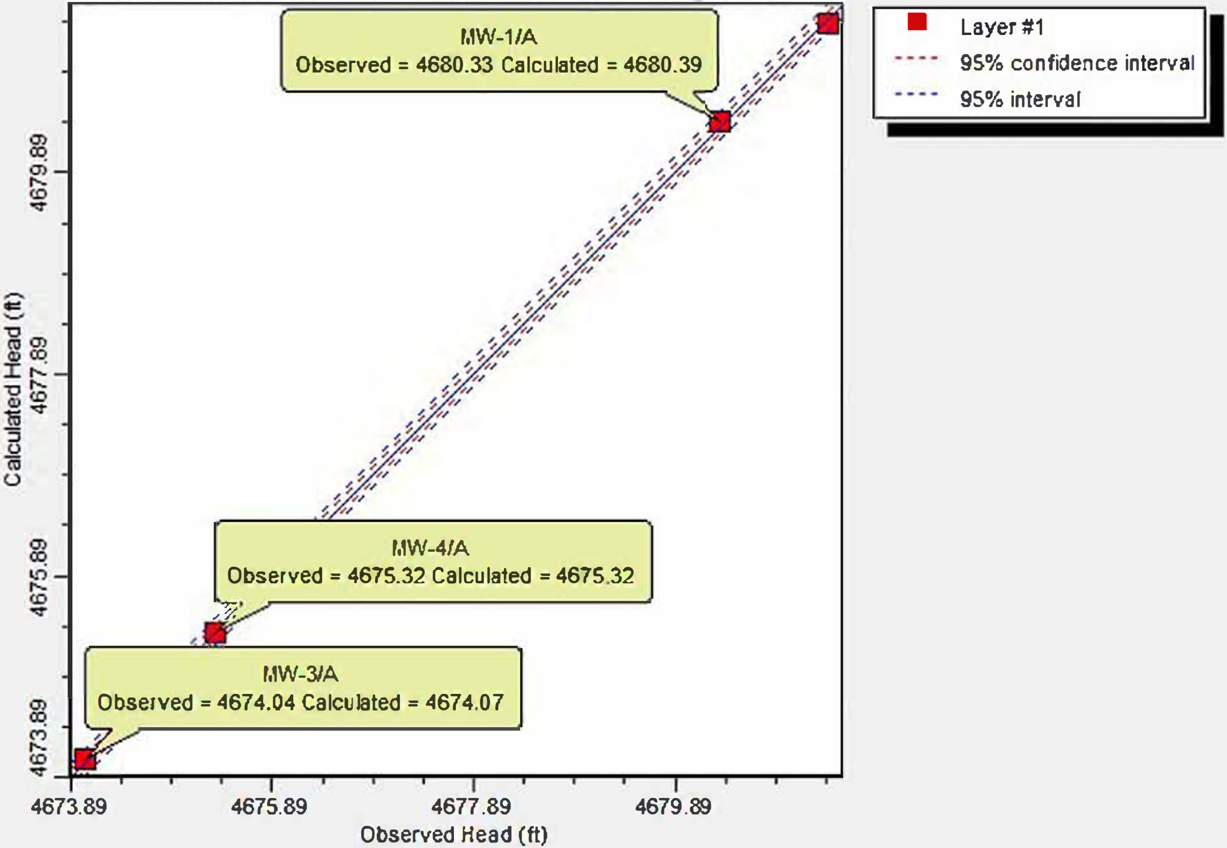


Num. of Data Points : 4

Max. Residual: 0.064 (ft) at MW-1/A
Min. Residual: 0.004 (ft) at MW-4/A
Residual Mean : 0.011 (ft)
Abs. Residual Mean : 0.038 (ft)

Standard Error of the Estimate : 0.025 (ft)
Root Mean Squared : 0.044 (ft)
Normalized RMS : 0.599 (%)
Correlation Coefficient : 1

Plate 5 A - Calculated vs. Observed Head Steady state



Num. of Data Points : 4

Max. Residual: 0.064 (ft) at MW-1/A

Min. Residual: 0.004 (ft) at MW-4/A

Residual Mean : 0.011 (ft)

Abs. Residual Mean : 0.038 (ft)

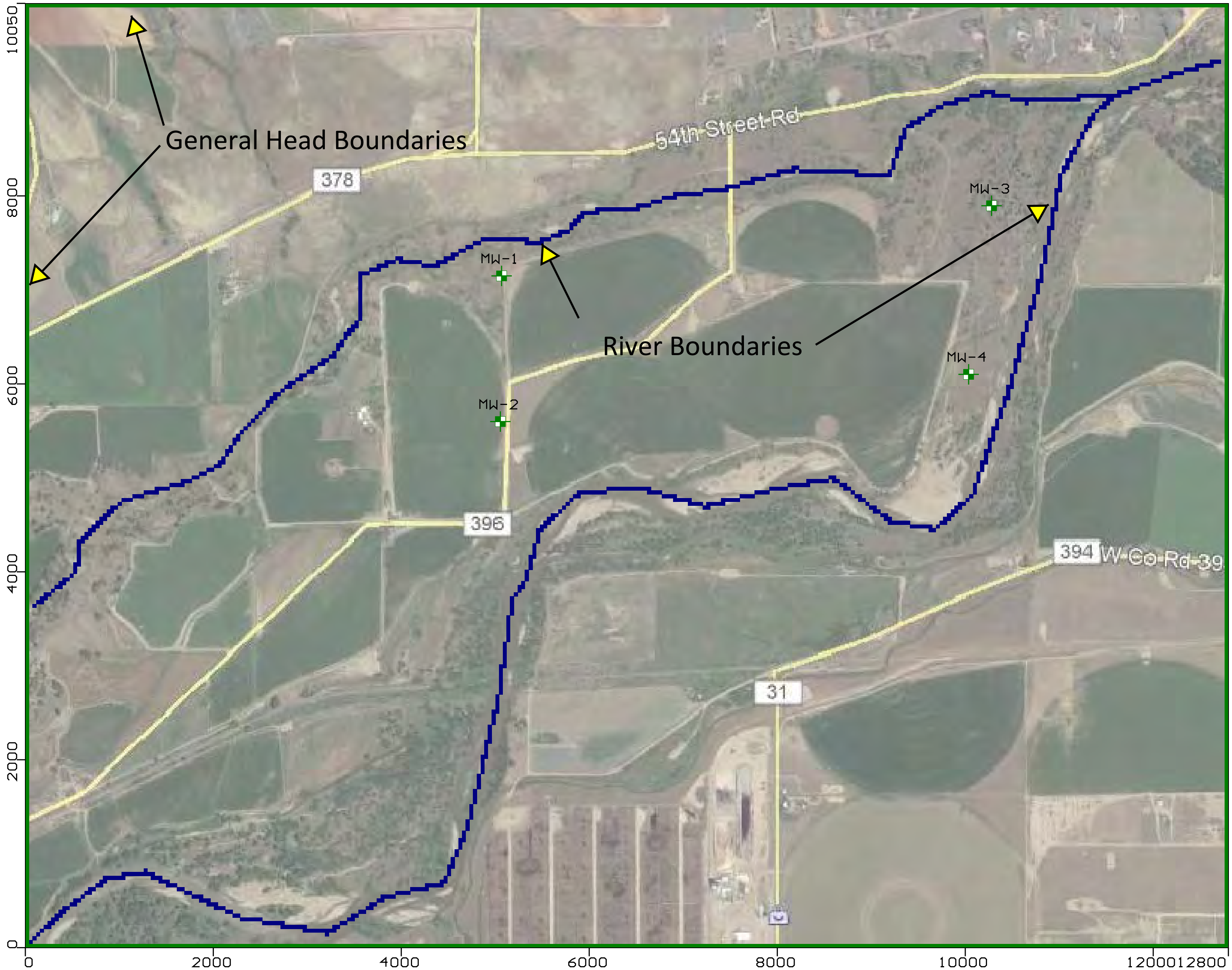
Standard Error of the Estimate : 0.025 (ft)

Root Mean Squared : 0.044 (ft)

Normalized RMS : 0.599 (%)

Correlation Coefficient : 1

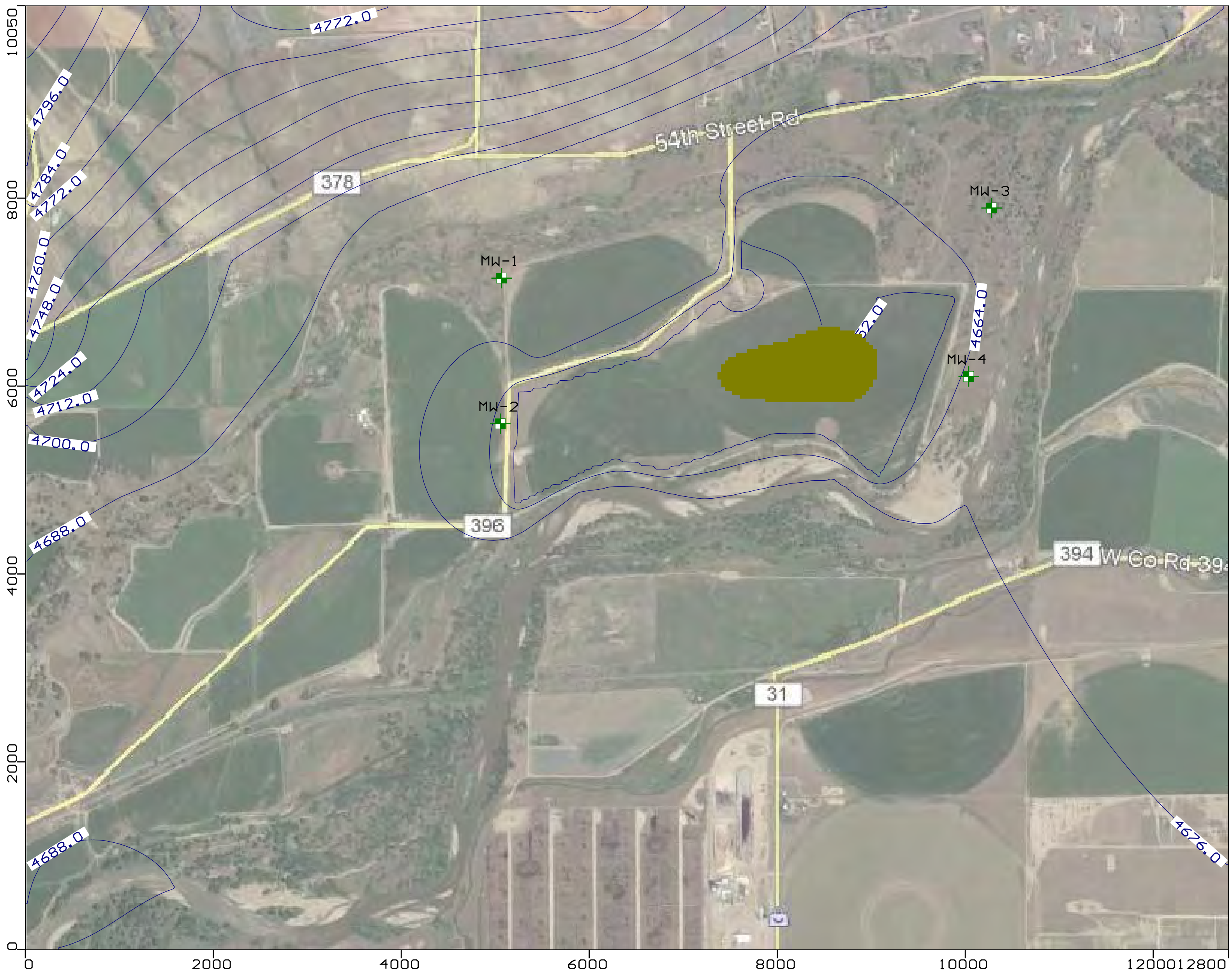
Plate 6 - Calibration Boundary Conditions



Two Rivers Boundary Conditions
Model Well Calibration
Drawdown - Shadow/Mounding Simulations

AWES, LLC Fort Collins, CO 970-590-3807	Raptor Materials, LLC Pit 124

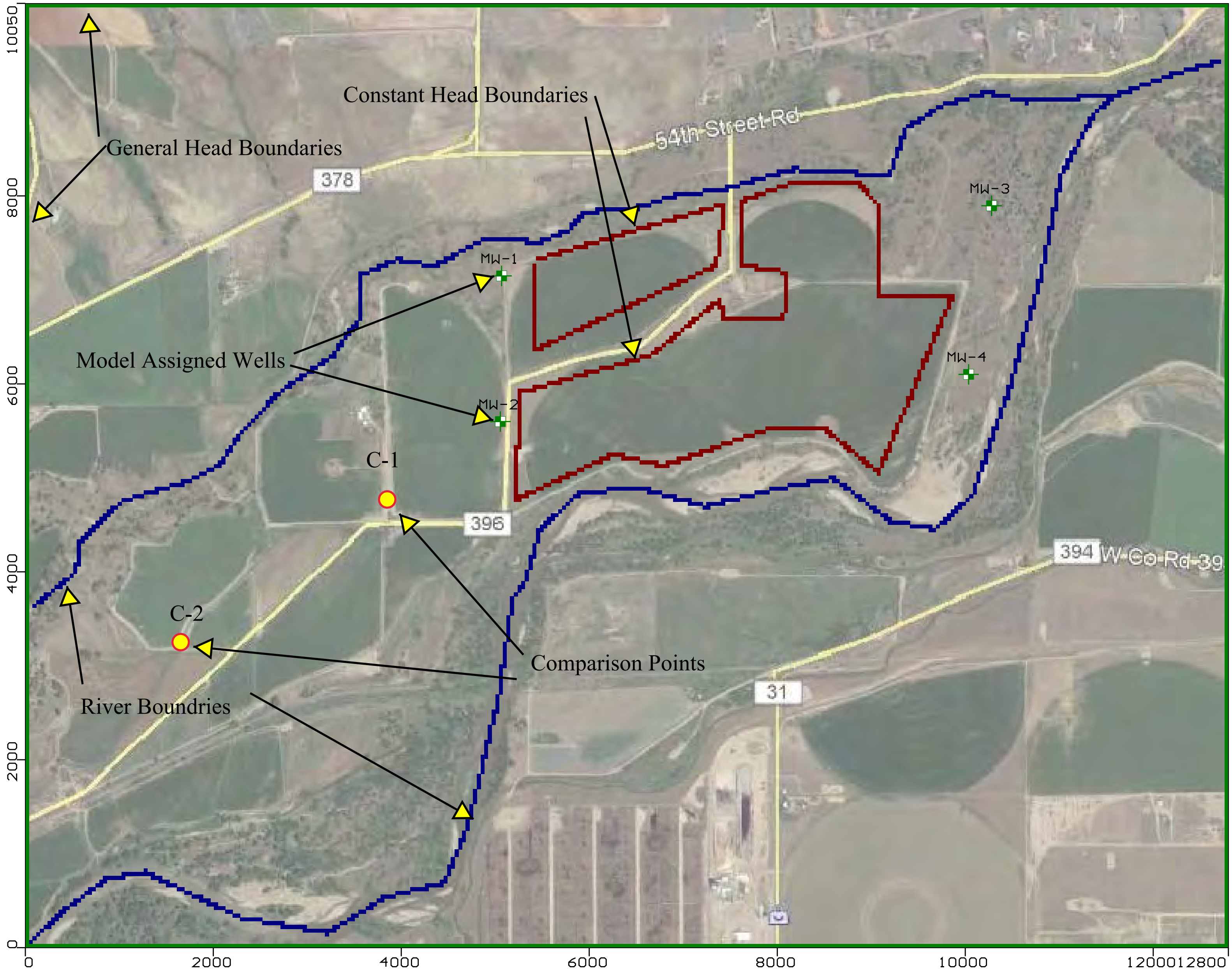
Plate 7 Drawdown Contours



Two Rivers Drawdown

AWES, LLC Fort Collins, CO 970-590-3807	Raptor Materials, LLC Pit 124

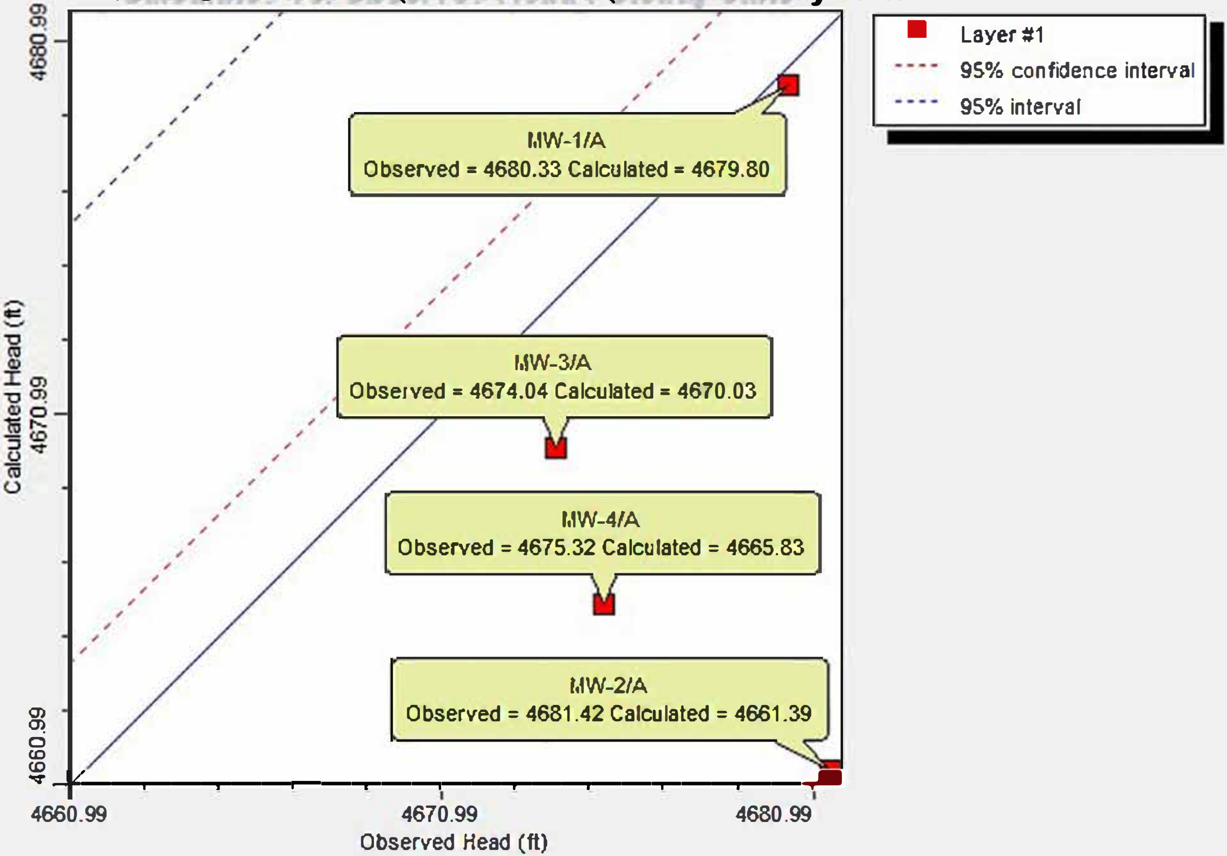
Plate 8 - Drawdown Boundary Conditions



Two Rivers Drawdown Boundary Conditions

AWES, LLC Fort Collins, CO 970-590-3807	Raptor Materials, LLC Pit 124

Plate 9 - Calculated vs. Observed Head : Steady state



Num. of Data Points : 4

Max. Residual: -20.028 (ft) at MW-2/A

Standard Error of the Estimate : 4.258 (ft)

Min. Residual: -0.532 (ft) at MW-1/A

Root Mean Squared : 11.264 (ft)

Residual Mean : -8.514 (ft)

Normalized RMS : 152.626 (%)

Abs. Residual Mean : 8.514 (ft)

Correlation Coefficient : 0.044

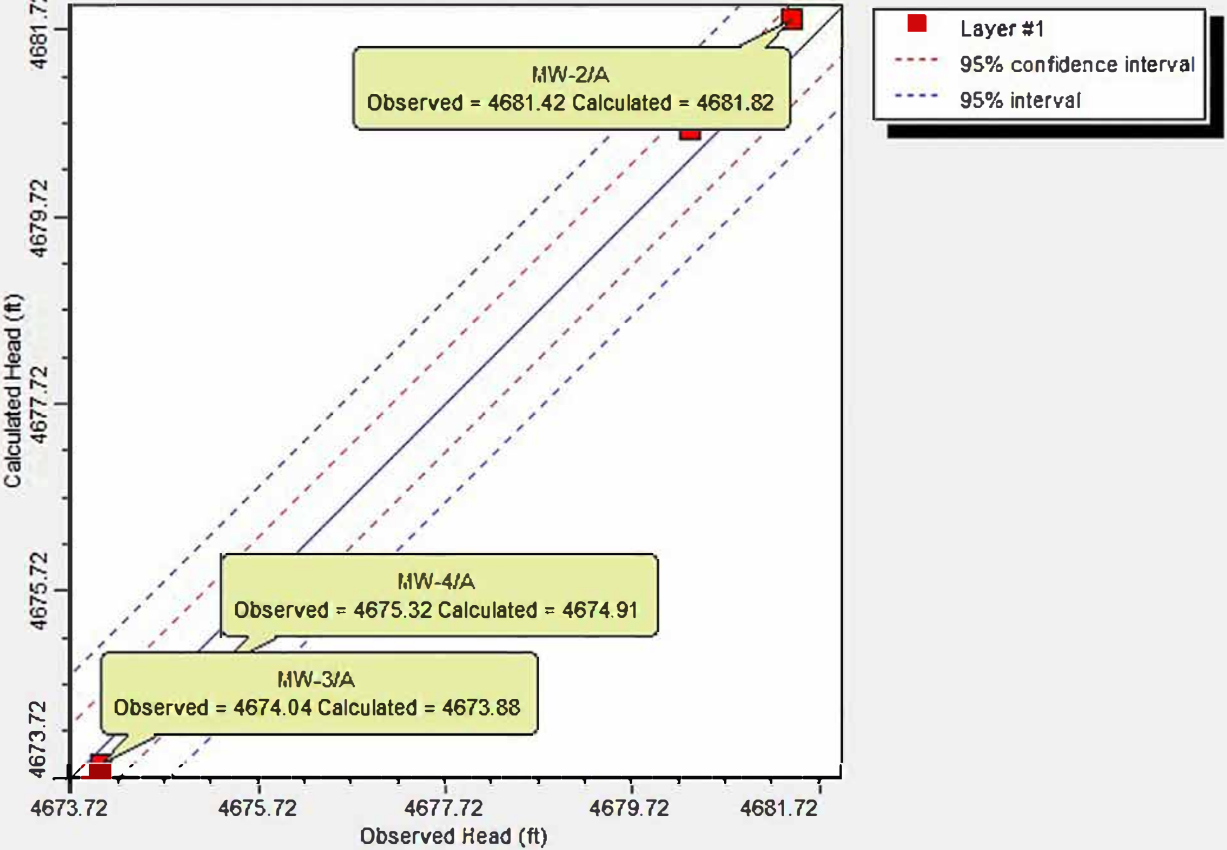
Plate 10 Lined Pond Groundwater Contours

Lined Pond Groundwater Contours

AWES, LLC
Fort Collins, CO
970-590-3807

Raptor Materials, LLC
Pit 124

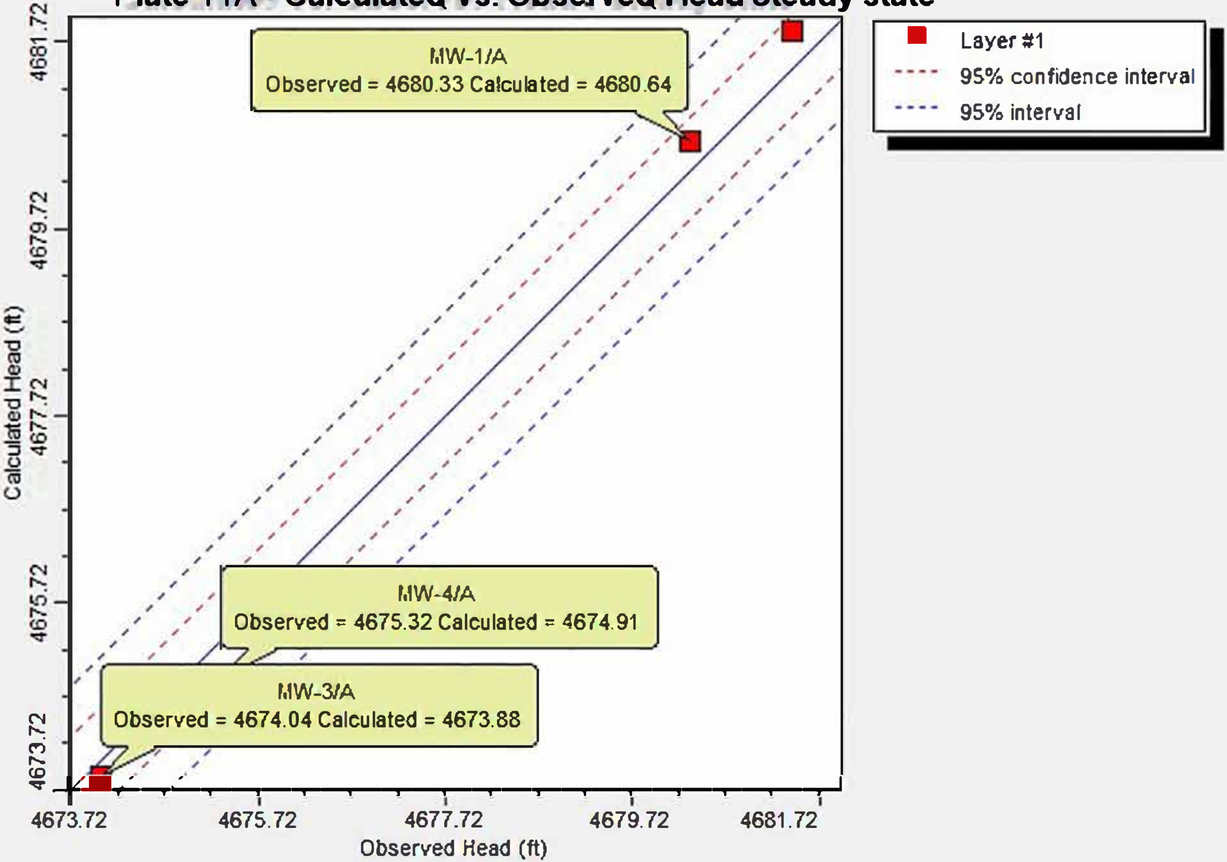
Plate 11 - Calculated vs. Observed Head Steady state



Num. of Data Points : 4
Standard Error of the Estimate : 0.194 (ft)
Root Mean Squared : 0.338 (ft)
Normalized RMS : 4.58 (%)
Correlation Coefficient : 0.999

Max. Residual: -0.412 (ft) at MW-4/A
Min. Residual: -0.165 (ft) at MW-3/A
Residual Mean : 0.035 (ft)
Abs. Residual Mean : 0.323 (ft)

Plate 11A - Calculated vs. Observed Head Steady state

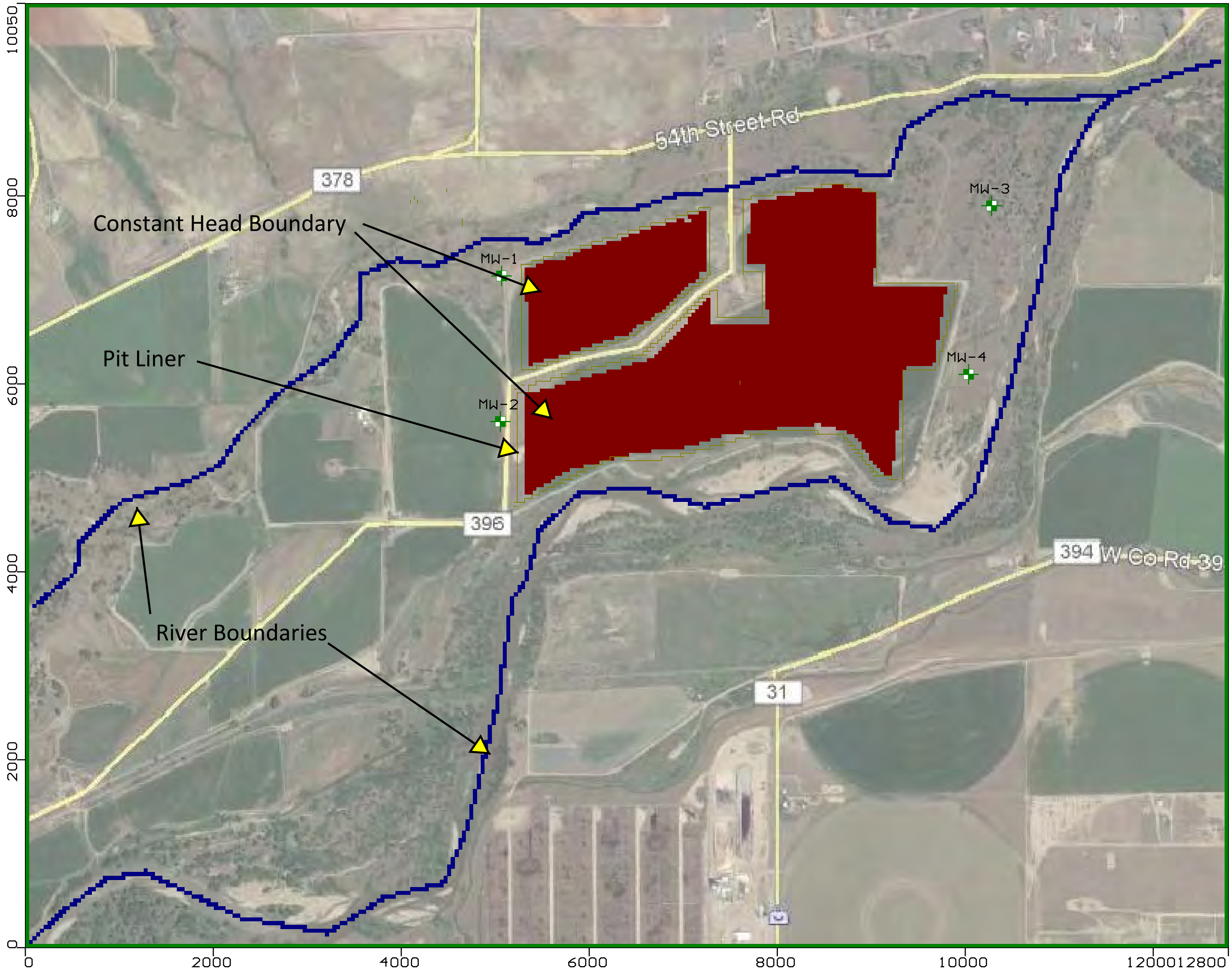


Num. of Data Points : 4

Max. Residual: -0.412 (ft) at MW-4/A
Min. Residual: -0.165 (ft) at MW-3/A
Residual Mean : 0.035 (ft)
Abs. Residual Mean : 0.323 (ft)

Standard Error of the Estimate : 0.194 (ft)
Root Mean Squared : 0.338 (ft)
Normalized RMS : 4.58 (%)
Correlation Coefficient : 0.999

Plate 12 Lined Pond Boundary Conditions



Lined Pond Boundarry Conditions

AWES, LLC Fort Collins, CO 970-590-3807	Raptor Materials, LLC Pit 124