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| Soil and Groundwater Remediation

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# ATHENS ROAD WELL FIELD MODELING REPORT

**Near BMI Industrial Complex  
Henderson, Nevada**

*Prepared for:*

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## CONTENTS

|       |  |    |
|-------|--|----|
| 1.    | INTRODUCTION.....                            | 1  |
| 1.1   | Background.....                              | 1  |
| 1.1.1 | Study Area Description.....                  | 1  |
| 1.1.2 | Remediation History.....                     | 2  |
| 1.2   | Objective and Scope of Services.....         | 2  |
| 2.    | DATA SET AND CONCEPTUAL MODEL.....           | 2  |
| 3.    | METHODS OF ANALYSES .....                    | 3  |
| 3.1   | Analog Capture Zone Analysis .....           | 3  |
| 3.2   | Numerical Modeling .....                     | 3  |
| 3.2.1 | Numerical Codes.....                         | 3  |
| 3.2.2 | General Modeling Techniques.....             | 4  |
| 3.2.3 | Domain and Grid.....                         | 4  |
| 3.2.4 | Boundary Conditions .....                    | 5  |
| 3.2.5 | Aquifer Parameters.....                      | 5  |
| 4.    | RESULTS OF ANALYSES AND MODELING.....        | 5  |
| 4.1   | Analog Capture Zone Analysis Results .....   | 5  |
| 4.2   | Groundwater Flow.....                        | 6  |
| 4.3   | Preliminary Solute Transport .....           | 6  |
| 5.    | DISCUSSION AND CONCLUSIONS.....              | 7  |
| 5.1   | Primary Capture Zone Lines of Evidence ..... | 7  |
| 5.2   | Calculated Well Field Efficiency.....        | 8  |
| 6.    | RECOMMENDATIONS.....                         | 8  |
| 7.    | REFERENCES.....                              | 9  |
| 8.    | LIMITATIONS.....                             | 11 |
| 9.    | CLOSING.....                                 | 12 |

### LIST OF TABLES

|         |  |  |
|---------|--|--|
| Table 1 | Data Locations for Qal-MCf Contact (Model Bottom) Elevation Contouring                               |  |
| Table 2 | Data Locations for Groundwater Elevation Contouring  |  |
| Table 3 | ART Well Pumping Rates, Perchlorate Concentrations, Reported and Calculated Hydraulic Conductivities |  |

### LIST OF FIGURES

|          |  |
|----------|--|
| Figure 1 | Project Location Map                               |
| Figure 2 | Numerical Model Boundary and Select Data Locations |
| Figure 3 | Hydrographs for Two Wells in Vicinity of COH RIBs  |
| Figure 4 | Model Grid and Boundary Conditions                 |
| Figure 5 | Model Bottom Elevation Contours                    |

- Figure 6 Model Constant Head Boundary Elevation Contours
- Figure 7 ART Well Extraction Rates for 2005 and 2006
- Figure 8 PEST (Final) Model Hydraulic Conductivity Array
- Figure 9 Vectors from Three Point Solutions for Select ARF Wells
- Figure 10 Predicted Groundwater Elevation Contours
- Figure 11 Predicted Groundwater Flow Paths
- Figure 12 Preliminary Predicted Perchlorate Isopleths
- Figure 13 Example Additional Well Locations

## **LIST OF APPENDICES**

- Appendix A Electronic Files:
  - Tronox Second Half 2006 Monitoring Report Figures,
  - Project Working Directory

# 1. INTRODUCTION

This report describes the methods and results of an evaluation of the Athens Road groundwater extraction system, near the BMI Industrial Complex in Henderson, Nevada (Figure 1). The groundwater extraction system is designed to capture chromium and perchlorate plumes which are largely contained within paleochannel alluvial deposits underlain by fine grained sedimentary deposits. The purpose of the evaluation was to establish the degree of observed well field capture with respect to the target capture zone, and to develop an estimate of well field efficiency for mass recovery.

The majority of data used for this evaluation were provided by Tronox LLC and its agents (Susan Crowley, Ed Krish, Bob Berry). Additional data were also contributed by Basic Remediation Company (BRC) and its agents.

## 1.1 Background

The history of perchlorate production at the BMI Industrial Complex has been summarized in several previous reports including Geraghty & Miller (1993) and NDEP (2003). Production of perchlorate compounds began within the BMI Industrial Complex in 1945. Initially, both the U.S. Navy and Western Electrochemical Company (WECCO) produced perchlorate compounds. In 1955, WECCO merged with American Potash and Chemical Company (AM&CC). The Navy ceased their operations in 1962 and sold that portion of the plant to AP&CC. Kerr-McGee purchased AP&CC in 1967 and continued perchlorate compound production until cessation of manufacturing in 1998. The majority of remaining perchlorate compounds were recovered from the on-site lined ponds and process equipment, and the perchlorate production process was dismantled by March 2002.

High concentrations of perchlorate are found dissolved in groundwater on-site. The presence of the perchlorate is a result of past industrial activities which occurred over a large area of the alluvial fan above the Las Vegas Wash, specifically, the BMI Industrial Complex and the BMI Ponds. The BMI Industrial Complex is still active; however, use of the Ponds for the disposal of process effluent was discontinued in 1976.

Groundwater characterization efforts in the vicinity have identified two perchlorate plumes south of the Wash. One plume originates from the former Pacific Engineering & Production Company of Nevada (PEPCON) facility and extends northeasterly towards the Wash. The second plume originates from the Tronox LLC (formerly Kerr-McGee) facility within the BMI Industrial Complex and extends north-north easterly towards the Wash.

Active remediation measures are currently being conducted for the Tronox plumes at three areas: the on-site Interceptor well field, the Athens Road well field, and the Seep Area well field. This study focuses on evaluation of the Athens Road well field area.

### 1.1.1 Study Area Description

The study area encompasses the vicinity of the Athens Road well field (ARF), as shown in Figure 1. The ARF is situated approximately one and a half miles down-gradient of the on-site Interceptor well field. The City of Henderson aeration ponds and Rapid Infiltration Basins (RIBs) are situated approximately 400 feet and 1,700 feet, respectively, further north of the ARF. No faulting or structures are known to exist in the vicinity of the ARF.

Land surface generally slopes from the BMI Industrial Complex to the north toward the Las Vegas Wash with an approximate gradient of 0.020. Groundwater flows generally north towards the Wash under an approximate gradient of 0.010.

Groundwater flow across the ARF occurs primarily within somewhat defined alluvium-filled paleochannels. The paleochannels are incised into underlying lower permeability, fine grained Tertiary sedimentary deposits, which are widely accepted as Muddy Creek Formation (Mcf). Quaternary Alluvium (Qal) comprised chiefly of gravels and sands with silt, overlies and fills the paleochannels. Chromium and perchlorate-impacted groundwater originating from the Tronox facility flows within a paleochannel which is further divided into two sub-channels with a higher mound of Mcf separating them, in the immediate vicinity of the ARF.

### 1.1.2 Remediation History

A line of eight extraction wells across the divided paleochannel was installed at the ARF, and pumping and treatment of perchlorate-impacted groundwater was initiated in July 2002. However, the wells did not operate on a continuous basis until October 2002. A separate ion exchange system (IX) was installed and became operational in mid-October 2002, allowing for continuous operation of the ARF in conjunction with an existing IX used to treat collected seep water. A ninth well was installed during the second half of 2006. Currently seven “buddy well” pairs (closely spaced wells designed for dual redundancy of pumping and monitoring) operate on a continuous basis.

## 1.2 Objective and Scope of Services

The overall project objective was to qualify the effectiveness, and quantify the efficiency, of remedial activities currently being implemented at the ARF. To achieve that objective, four specific project tasks were defined, as follows:

1. Evaluate combined data sets (well construction and completion records, lithologic logs, water level and perchlorate concentration monitoring data, extraction well meter data, recent monitoring report exhibits, and a prior numerical model),
2. Generate a conceptual site model (CSM),
3. Perform an analog capture zone analysis, and
4. Generate a numerical model to calculate the efficiency of the Athens Road well field.

## 2. DATA SET AND CONCEPTUAL MODEL

A relatively large data set was compiled, including well construction and lithologic logs, survey data, water level measurements, groundwater sample analytical results, and extraction well meter readings. Approximately 250 monitoring or characterization locations were selected for regional database population (within an approximate one-mile radius of the ARF), with either water level or perchlorate concentration data, or both (Tables 1 and 2). A local domain was identified within closer proximity of the ARF, containing approximately seventy data locations for target data (Figure 2).

In the vicinity of Athens Road, groundwater is observed to be flowing generally towards the north-northeast under a moderately low hydraulic gradient, and towards the Seep area and the Las Vegas Wash. Static groundwater levels in the ARF area have been measured an average of 25 feet below ground surface (bgs), within Qal. The Qal is underlain by the Mcf at an

average depth of 35 feet bgs. The paleochannel in the ARF area is defined by numerous lithologic logs in close proximity to the ARF (mostly ARP, ART and L series wells) and along Sunset Road (PC series wells), and by fewer logs at greater distance from the ARF.

The paleochannel topology at greater distances from the ARF is inferred based on the apparent correlation between calculated hydraulic conductivity from ART series wells, and paleochannel topology and perchlorate concentrations (plume geometry) in the ARF transect. Furthermore, the paleochannel appears to be separated into two sub-channels (west and east channel) with a localized high of MCf materials between them, and pumping field conditions have decreased water levels below the formations' contact in that immediate vicinity.

Given the large hydraulic conductivity contrast between the Qal and MCf, groundwater flow and solute transport are inferred to be largely dominant in the alluvium. However, some degree of communication is presumed to occur.

Large amounts of water are periodically infiltrated to the Qal at the City of Henderson RIBs, approximately 1,700 feet north of the ARF. Monitoring well hydrographs near the southeast corner of the RIBs indicate relatively large fluctuations in groundwater levels during the times of infiltration. However, monitoring wells closer to the ARF, near the lined aeration ponds indicate a far lesser degree of change, which may not be controlled by RIB infiltration (Figure 3). RIB infiltration is not considered hydraulically significant in the vicinity of the ARF.

### **3. METHODS OF ANALYSES**

#### **3.1 Analog Capture Zone Analysis**

A preliminary two-dimensional capture zone analysis was conducted using tabulated and exhibited data from the report entitled *Semi-Annual Performance Report for Chromium and Perchlorate, Tronox LLC, Henderson, Nevada, July – December 2006* (Tronox, 2007). These data will be referred to as “second half 2006” herein; data from December 2006 were used where available.

Water level elevation data from monitoring wells within the ARF were plotted for examination. Gradients were calculated using the standard three-point solution for well triplets in close proximity, across the ARF. The calculation was performed using the U.S. Environmental Protection Agency (EPA) on-line site assessment tool, On-Site [<http://www.epa.gov/athens/learn2model/part-two/onsite/gradient3ns.htm>]. Vectors were plotted for each well triplet, and the resulting map was reviewed for indications of inward flow to the pumping well field. Perchlorate concentration data from monitoring wells within the area of interest were examined, as a secondary line of evidence.

#### **3.2 Numerical Modeling**

##### **3.2.1 Numerical Codes**

The codes selected for groundwater flow and solute transport modeling, respectively, were MODFLOW2000 and MT3D. The U.S. Geological Survey modular finite-difference ground-water flow model, MODFLOW2000 (Harbaugh et al., 2000) was used for the purpose of simulating groundwater flow, which is the latest release of MODFLOW (McDonald and Harbaugh, 1988). MODFLOW2000 will be referred to as MODFLOW

herein. MODFLOW may be used to approximate the solution to the partial-differential equation for three-dimensional transient groundwater flow in heterogeneous and anisotropic media, assuming constant fluid density and alignment of the principal axes of hydraulic conductivity with the coordinate system (McDonald and Harbaugh, 1988; Harbaugh et al., 2000). MODFLOW is modular in structure: it uses a suite of subroutines for the solution of the groundwater flow problem and simulation of various hydrologic system components.

The PEST code (Watermark, 2004) was used to generate an independent model of the hydraulic conductivity array. The PEST code perturbs each estimated parameter and records model calibration changes, in an iterative fashion, and tends towards parameter values that improve the model agreement with the target data.

MT3D (Zheng, 1990) is a three-dimensional solute transport model for simulation of advection, dispersion and chemical reactions of contaminants in groundwater systems. MT3D was first developed by S.S. Papadopoulos & Associates, Inc. with partial support from the U.S. Environmental Protection Agency (USEPA). Since 1990, MT3D has been available as a public domain code from the USEPA. MT3D is based on a modular structure to simulate solute transport. MT3D interfaces directly with MODFLOW for the head solution, and supports all the hydrologic and discretization features of MODFLOW. MT3D has been widely accepted and applied in numerous field-scale modeling studies throughout the world.

### 3.2.2 General Modeling Techniques

The groundwater flow model was run using the deterministic technique. The models were run as two-dimensional steady-state simulations, using site data for boundary conditions and pumping rates. The hydraulic conductivity array was developed using site data, professional judgment and automated parameter estimation.

The preliminary solute transport model simulation time was set sufficiently long to generate essentially steady state conditions. Solute inputs for transport modeling were specified using site data and environmental interpretations. The solute transport model was not calibrated; however, final solute concentrations were found to be within acceptable ranges of observations for the purpose of this project.

### 3.2.3 Domain and Grid

The spatial dimensions of the model domain are shown on Figure 2. The spatial extents of the modeling domain were chosen to incorporate areas extending beyond the ARF area of influence. The southwest vertex of the model domain was chosen to coincide with the location of well PC-132 (Northing 26,726,723 feet, Easting 827,914 feet, State Plane Nevada East). The domain extends 2,600 feet north and 2,600 feet east from the southwest vertex. The northeast vertex of the model domain lies generally due north of the Athens Road/Pabco Road intersection, just north of a transect that includes the south-most lined aeration ponds.

The domain was discretized into a two-dimensional model grid with regular row and column spacing of 20 feet (130 rows and 130 columns; Figure 4). The grid spacing was chosen to provide sufficiently fine resolution to simulate flow nuances within the immediate vicinity of, and between, the extraction wells.

The bottom elevations of the model grid were calculated using site lithologic logs and a kriging method. The complete list of Qal-MCf contact elevations used for kriging is provided in Table 1, and a contour map of the model bottom is shown in Figure 5. The elevation of the top of the model is determined by calculation, since the aquifer is simulated as an unconfined aquifer.

### 3.2.4 Boundary Conditions

#### Groundwater Flow Model

A specified-head condition was used along the entire model boundary. The boundary head values were calculated using second half 2006 groundwater monitoring data and a kriging method. The complete list of groundwater elevations used for kriging is provided in Table 2, and a contour map of the groundwater elevations defining the boundary conditions is shown in Figure 6. Following initial model runs, a specified-flow boundary (no flow) was assigned to model cells within the Tronox-interpreted area of dewatered Qal and MCf between the sub-channels; this area is commonly referred to as “Muddy Creek high”.

Specified flow conditions were used to simulate pumping at the locations of ARF extraction wells. Extraction flow rate assignments were determined from average reported rates for 2005 and 2006, with the exception of wells ART-6 and ART-9 (Figure 7). ART-6 was not simulated for pumping, and the ART-9 pumping rate was designated based on the most recently reported pumping rates (39.6 gpm during first quarter 2007; personal communication, Todd Croft, NDEP). Simulated pumping rates are listed in Table 3.

#### Preliminary Solute Transport Model

Solute source concentrations were assigned to all cells along the southern (up-gradient) model boundary, and along a southern portion of the east boundary, based on the Tronox interpretation of perchlorate isopleths for the second half 2006 (Appendix A).

### 3.2.5 Aquifer Parameters

#### Groundwater Flow Model

The hydraulic conductivity array was developed using site data, professional judgment and automated parameter estimation. The initial hydraulic conductivity array was generated based on Tronox-provided values for each ARF extraction well, derived from pumping test conducted at the time of well construction (Table 3). Hydraulic conductivity zones were generated along the ARF transect based on the apparent direct correlation between historic and recent perchlorate concentrations for each extraction well, and Tronox-reported hydraulic conductivities (Appendix A, Table 3). Extrapolation of these zones to the north and south of the ARF transect was guided by the Qal-MCf contact surface and professional judgment. The final hydraulic conductivity array was calculated using parameter estimation, with target groundwater elevation data from second half 2007 (Figure 8).

#### Preliminary Solute Transport Model

A wide range of dispersivity values were tested, within expected ranges. The model appeared to be relatively insensitive to this parameter.

## 4. RESULTS OF ANALYSES AND MODELING

### 4.1 Analog Capture Zone Analysis Results

The results of the analog capture zone analysis are shown in Figure 9. Calculated groundwater gradient vectors do not indicate that capture was being achieved during the second half 2006.



## 4.2 Groundwater Flow

The results of parameter estimation for hydraulic conductivity are listed in Table 3. The difference between initial hydraulic conductivity values and the results of parameter estimation is relatively small (within low factors versus orders-of-magnitude). This result may be considered as a point of validation for modeled hydraulic conductivity, since the parameter estimation is based on observed groundwater elevations.

The groundwater flow model produced a mean absolute error (MAE) of 1.7 feet. The relative error, which is calculated by dividing the MAE by the total groundwater elevation relief throughout the model domain, was calculated to be approximately 4.2%. These degrees of error are deemed as low, and indicate a relatively high degree of performance for flow simulation, for the purpose of this project.

Initial model results indicated a limited degree of drying cells in the vicinity of ART-5. Drying cells were not produced throughout the entire area of the Muddy Creek high; however, the simulated saturated thickness in that area was relatively small. In order to preserve the effects of observed drying in that area, select cells were deactivated for subsequent model runs.

Initial model results appeared to indicate boundary effect (drawdown against a fixed head boundary, which may allow unlimited water input to the model) along a portion of the eastern model boundary. A boundary condition sensitivity test was performed by expanding the model boundary eastward by approximately 2,000 feet, and including data from the BRC AA series of wells. The results of this testing showed less apparent boundary effect, and also resulted in extensive cell drying throughout the expanded model domain area. The initial boundary extents were re-incorporated for subsequent model runs; however the AA series data (Qal-MCf contact elevation and groundwater elevation data) were also included in model input kriging. Inclusion of these model components resulted in preserving the unwrapped groundwater elevation contour results, without undue regional drying. The predicted groundwater elevation contours for the final flow model are shown in Figure 10.

A particle tracking exercise was performed using the results of the calibrated groundwater flow model (Figure 11). Two hundred and sixty particles were released uniformly along the southern model boundary. Some particles traveling along the western edge of the western sub-channel were simulated to pass the ARF extraction wells in that area; however, these particles were simulated to pass between wells ART-1 and ART-2, deflect towards the east and be captured by wells ART-3 and ART-4. All particles were captured using the final groundwater flow model.

## 4.3 Preliminary Solute Transport

The solute transport model was not strictly calibrated to observed perchlorate concentrations, and therefore serves only as a preliminary solute transport model. Despite the lack of calibration, calculated concentrations were generally simulated well within a factor of two compared with observed concentrations throughout the model domain.

The preliminary solute transport model results compare relatively well with observed concentration distributions through the western sub-channel (Figure 12). The results compare less favorably through the eastern sub-channel; specifically, the “tongue” of high concentrations extending through ARP-5 (264 mg/L) is not predicted by the preliminary transport model – the model predicts a high degree of capture through the eastern sub-

channel. Concentrations in the vicinity of ARP-3 and ARP-4 are predicted to be higher than observed.

Since the solute input concentrations were based generally on observed perchlorate concentrations, and the over-all concentration results generally agree with observed conditions, the mass budget for the solute transport model may be used for a limited calculation of ARF efficiency. A mass flux of 458 kg/day are simulated to be released into the model source boundary, approximately 456 kg/day are simulated to be extracted using the ARF, and approximately 2.2 kg/day (approximately 4.9 pounds per day) are simulated to escape the ARF. The mass balance calculations indicate the ARF to be 99.5% efficient, with 0.02% error.

## 5. DISCUSSION AND CONCLUSIONS

### 5.1 Primary Capture Zone Lines of Evidence

Industry-standard lines of evidence for plume capture include 1) potentiometric maps with sufficient contour detail to produce a reliable flow net, 2) inward flow demonstrated by hydraulic head data from appropriately located well pairs, and 3) decreasing temporal and spatial concentration data trends for key positioned wells.

The environmental interpretations presented for the second half 2006 (Appendix A, Plates 1 and 2) do not appear to demonstrate plume capture. The closed and inward-grading contour of 1590 feet above mean sea level (amsl) surrounding the ART series wells in the east sub-channel does not appear to be supported by plotted data; there are no data between the ART and ARP series wells through the east sub-channel to support the inclusion of that closed and inward graded contour. Neglecting the closed and inward graded 1590-foot contour, a flow net constructed on Plate 1 groundwater elevation contours does not result in flow paths that converge towards the ART wells. Also, none of the series of vectors based on well triplet groundwater elevation data across the ARF, from the analog capture zone analysis described herein, indicate inward flow. Recent groundwater elevation monitoring data do not indicate ARF capture is being achieved.

Perchlorate isopleth interpretations from second half 2006 appear to indicate relatively high concentrations extending down-gradient of the ART series wells, especially in the vicinity of ARP-5. Using a "ball-park" hydraulic conductivity value from the CSM (200 feet/day), an effective porosity of 0.20, and hydraulic gradient of 0.01, the average groundwater velocity in the vicinity of the paleochannel is estimated to be 10 feet/day. The elevated perchlorate concentration of 264 mg/L is shown for well ARP-5, which is located more than 300 feet down-gradient of the ART series wells in the east sub-channel. Given these calculations and observations, the center of a fresh water front which would be produced from complete ARF capture would have been anticipated to move past the position of ARP-5 within approximately 30 days of the commencement of pumping activities. A similar examination can be made for the west sub-channel. Perchlorate concentration data for key well positions do not appear to indicate complete ARF capture is being achieved.

The results of this analysis are not consistent with the results of the particle tracking exercise described above, which indicated that all particle pathways end at extraction well locations, and that "complete capture" is achieved.

## 5.2 Calculated Well Field Efficiency

In contrast to the inability to demonstrate plume capture using monitoring data and industry-standard methods, the preliminary solute transport model resulted in the prediction of a very high mass removal efficiency for the ARF. A similar degree of efficiency was also calculated for all preliminary models (previous to and during model refinement), indicating that the model's calculation of mass removal efficiency is generally insensitive to the main model elements, within their anticipated ranges. This observation appears to indicate that significant model performance gains are not possible for the current level of model complexity.

The high mass removal efficiency is due to more complete capture simulated for higher concentrations; only lower concentration groundwater is simulated to escape well field capture, due to dispersion along the plumes flanks and dispersion from higher concentration groundwater that passes through the western sub-channel and wraps towards the extraction wells of the eastern sub-channel (Figure 12).

The results of preliminary solute transport modeling are different, but not inconsistent, with the results of the particle tracking exercise described above. The different outcomes (complete capture for particle tracking versus incomplete capture for solute transport) stem from the inclusion of the effects of dispersion in the latter analysis, as described above.

The results of preliminary solute transport modeling are of limited use for site evaluation and decision support. The lack of well pairs to positively demonstrate capture impairs validation of the groundwater flow model, and hence any solute transport model (preliminary or otherwise). On the other hand, the high calculated efficiency for all stages of modeling suggests that high efficiency does actually exist, within the limitations of the CSM and its implementation herein. Validation or qualification of the groundwater flow and preliminary solute transport model described herein is recommended prior to its use for site evaluation and decision support. The disparity between observations and calculations presented herein underscores the need for model validation or further qualification.

## 6. RECOMMENDATIONS

Based on the results of analog capture zone analysis and numerical modeling described above, McGinley & Associates, Inc. provides the following recommendations:

1. a methodology and rationale for routine analog capture zone analysis should be developed and included as a standard operating procedure (SOP) attached to the document "Work Plan to Evaluate Effective Groundwater Capture at Tronox Extraction Systems, Henderson, NV,"
2. additional monitoring wells should be installed to support analog capture zone analysis, including nested or clustered wells for vertical definition, across the ARF,
3. characterization should be performed on newly installed wells, including detailed lithologic logging and aquifer testing,
4. data obtained from new wells, or new data from existing wells, should be compared with the CSM and numerical models presented herein, in order to validate or qualify these models.

Example locations for additional wells are shown in Figure 13. The actual location of proposed wells should be thoroughly considered in order to maximize the degree of assurance that may be derived from routine capture zone analysis. A well within the ARF area of influence will not necessarily also demonstrate inward flow – the water level in that well must also be lower than that of down-gradient wells in order to support the assertion of inward flow.

Well pair data which support the assertion of inward flow, alone, do not necessarily demonstrate capture. Multiple lines of evidence are typically required before inward flow, and plume capture, may be asserted. Development of the methodology for routine capture zone analysis, as a standard operating procedure (SOP), should consider widely available resources [e.g., <http://www.epa.gov/tio/download/remed/rse/factsheet.pdf> (Appendix A)]. The locations and rationale for additional wells, and the objective and data requirements of the SOP should be tightly integrated, and should be products of dialog and concurrence between the NDEP and Tronox.

Significant additional investments to the current model set described herein are not recommended, at this time. MGA believes, barring additional data which contrast the current CSM, that the model set presented herein represents the system as well as possible, for the purpose of this project, and that no significant change to numerical model results will be produced from the inclusion of additional data, within expected ranges.

Additional modeling efforts beyond those described herein, pending the discovery of significantly different data, may include expanding the model to three dimensions (e.g., simulating interaction between Qal and MCf or the Muddy Creek transition zone). Also, calibration of the current solute transport model may be warranted in the case of modified project objectives (e.g., more precise evaluation of mass removal efficiency is deemed necessary).

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## 8. LIMITATIONS

The conclusions and recommendations presented herein are based, in part, on analytical data, field measurements, survey data and results of previous environmental assessment and/or remediation activities conducted by others. MGA makes no warranties or guarantees as to the accuracy or completeness of information provided or compiled by others. Changes in site conditions may occur as a result of rainfall, water usage, or other factors.

It should be recognized that definition and evaluation of environmental conditions is a difficult and inexact science. Judgments and opinions leading to conclusions and recommendations are generally made with an incomplete knowledge of the conditions present. More extensive studies, including additional environmental investigations, can tend to reduce the inherent uncertainties associated with such studies. Additional information not found or available to MGA at the time of writing this report may result in a modification to the conclusions and recommendations contained herein.

The presentation of data in plots presented herein is intended for the purpose of the visualization of environmental conditions. A greater degree of spatial and temporal data density may result in a more accurate representation of environmental conditions. Although such data visualization techniques may aid in providing a conceptual understanding of environmental conditions, such presentations are not intended to completely depict environmental conditions.

This report is not a legal opinion. The services performed by MGA have been conducted in a manner consistent with the level of care ordinarily exercised by members of our profession currently practicing under similar conditions. No other warranty, expressed or implied, is made.

## 9. CLOSING

MGA anticipates that the information provided herein satisfies the NDEP at this time. Please do not hesitate to call the Project Manager, at (775) 829-2245, with any questions or concerns.

Respectfully submitted,

### **McGinley and Associates, Inc.**

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and to the best of my knowledge comply with all applicable federal, state and local statutes, regulations, and ordinances.

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| <b>Table 1. Data Locations for Qal-MCf Contact (Model Bottom) Elevation Contouring</b> |         |          |            |          |         |
|--|---------|----------|------------|----------|---------|
| Well ID  | Easting | Northing | Owner      | Type     | Qal-MCf |
| AA-15  | 831754  | 26726004 | BRC        | Mon      | 1606.96 |
| AA-19  | 832521  | 26727447 | BRC        | Mon      | 1575.34 |
| AA-20  | 831812  | 26728008 | BRC        | Mon      | 1574.57 |
| ARP-1  | 828593  | 26728366 | Kerr-McGee | Monitor  | 1573.33 |
| ARP-2  | 828726  | 26728364 | Kerr-McGee | Monitor  | 1562.03 |
| ARP-3  | 828861  | 26728365 | Kerr-McGee | Monitor  | 1570.38 |
| ARP-4  | 829172  | 26728364 | Kerr-McGee | Monitor  | 1576.13 |
| ARP-7  | 829668  | 26728501 | Kerr-McGee | Monitor  | 1571.39 |
| ART-1  | 828544  | 26728123 | Kerr-McGee | Recovery | 1562.57 |
| ART-1A   | 828537  | 26728122 | Kerr-McGee | Recovery | 1561.80 |
| ART-2  | 828625  | 26728085 | Kerr-McGee | Recovery | 1562.42 |
| ART-2A   | 828619  | 26728086 | Kerr-McGee | Recovery | 1561.33 |
| ART-3  | 828775  | 26728085 | Kerr-McGee | Recovery | 1574.18 |
| ART-3A   | 828769  | 26728085 | Kerr-McGee | Recovery | 1566.14 |
| ART-4  | 828851  | 26728085 | Kerr-McGee | Recovery | 1573.61 |
| ART-4A   | 828844  | 26728085 | Kerr-McGee | Recovery | 1574.91 |
| ART-5  | 829370  | 26728129 | Kerr-McGee | Recovery | 1589.18 |
| ART-6  | 829473  | 26728141 | Kerr-McGee | Recovery | 1582.25 |
| ART-6A   | 829479  | 26728141 | Kerr-McGee | Recovery | 1582.26 |
| ART-8  | 828698  | 26728084 | Kerr-McGee | Recovery | 1567.54 |
| ART-8A   | 828692  | 26728083 | Kerr-McGee | Recovery | 1566.53 |
| ART-9  | 829526  | 26728143 | Tronox     | Recovery | 1576.16 |
| AZ-1   | 832810  | 26730277 | Unknown    | Monitor  | 1571.00 |
| B-1  | 828418  | 26728050 | Kerr-McGee | Boring   | 1577.52 |
| B-2  | 828809  | 26728096 | Kerr-McGee | Boring   | 1572.10 |
| B-3  | 829210  | 26728103 | Kerr-McGee | Boring   | 1592.42 |
| B-4  | 829599  | 26728134 | Kerr-McGee | Boring   | 1573.94 |
| B-5  | 829210  | 26728071 | Kerr-McGee | Boring   | 1595.01 |
| B-6  | 829219  | 26728071 | Kerr-McGee | Boring   | 1595.09 |
| B-7  | 829448  | 26728078 | Kerr-McGee | Boring   | 1584.06 |
| B-8  | 829457  | 26728080 | Kerr-McGee | Boring   | 1583.53 |
| BEC-7  | 832696  | 26725924 | BMI        | Monitor  | 1615.32 |
| BEC-9  | 833050  | 26727222 | BMI        | Monitor  | 1598.27 |
| CMMW-1   | 824365  | 26728590 | Unknown    | Monitor  | 1588.00 |
| DM-4   | 830802  | 26728131 | COH/ D&M   | Monitor  | 1597.43 |
| DM-5   | 833187  | 26728699 | COH/ D&M   | Monitor  | 1600.82 |
| DW-1   | 831874  | 26728426 | Unknown    | Monitor  | 1575.00 |
| HMW-13   | 827711  | 26731740 | COH        | Monitor  | 1556.78 |
| HMW-15   | 827608  | 26729901 | COH        | Monitor  | 1591.33 |
| HMW-16   | 827090  | 26728531 | COH        | Monitor  | 1607.77 |
| HSC-1  | 829167  | 26733118 | COH        | Boring   | 1503.00 |
| HSC-2  | 830558  | 26733409 | COH        | Boring   | 1482.00 |
| HSW-1  | 832121  | 26730001 | COH        | Monitor  | 1577.90 |
| HSW-2  | 832608  | 26730008 | COH        | Monitor  | 1577.20 |
| HSW-3  | 833120  | 26731276 | COH        | Monitor  | 1561.10 |



| <b>Table 1. Data Locations for Qal-MCf Contact (Model Bottom) Elevation Contouring</b> |         |          |            |          |         |
|--|---------|----------|------------|----------|---------|
| Well ID  | Easting | Northing | Owner      | Type     | Qal-MCf |
| HSW-4  | 833677  | 26730298 | COH        | Monitor  | 1572.50 |
| HSW-5  | 832558  | 26731059 | COH        | Monitor  | 1561.30 |
| HSW-6  | 832832  | 26731107 | COH        | Monitor  | 1565.40 |
| I-Z  | 828468  | 26719923 | Kerr McGee | Recovery | 1717.19 |
| L-615  | 830280  | 26727857 | EPA        | Monitor  | 1597.40 |
| L-617  | 830105  | 26727862 | EPA        | Monitor  | 1584.10 |
| L-619  | 829913  | 26727855 | EPA        | Monitor  | 1587.50 |
| L-621  | 829705  | 26727855 | EPA        | Monitor  | 1585.30 |
| L-623  | 829535  | 26727856 | EPA        | Monitor  | 1583.10 |
| L-625  | 829352  | 26727855 | EPA        | Monitor  | 1589.10 |
| L-627  | 829147  | 26727855 | EPA        | Monitor  | 1591.70 |
| L-629  | 828965  | 26727851 | EPA        | Monitor  | 1590.70 |
| L-631  | 828744  | 26727841 | EPA        | Monitor  | 1575.00 |
| L-631T   | 828697  | 26727747 | EPA        | Monitor  | 1567.80 |
| L-633  | 828492  | 26727840 | EPA        | Monitor  | 1553.40 |
| L-635  | 828302  | 26727839 | EPA        | Monitor  | 1588.27 |
| L-637  | 828110  | 26727839 | EPA        | Monitor  | 1592.85 |
| L-639  | 827906  | 26727838 | EPA        | Monitor  | 1594.50 |
| L-641  | 827709  | 26727836 | EPA        | Monitor  | 1605.01 |
| L-643  | 827511  | 26727836 | EPA        | Monitor  | 1608.30 |
| L-643T   | 827473  | 26727731 | EPA        | Monitor  | 1605.60 |
| L-645  | 827310  | 26727833 | EPA        | Monitor  | 1611.55 |
| L-647  | 827106  | 26727830 | EPA        | Monitor  | 1604.80 |
| L-649  | 826903  | 26727825 | EPA        | Monitor  | 1604.20 |
| L-651  | 826709  | 26727828 | EPA        | Monitor  | 1612.63 |
| L-653  | 826511  | 26727825 | EPA        | Monitor  | 1612.15 |
| L-676  | 824195  | 26727815 | EPA        | Monitor  | 1602.10 |
| LG-17  | 833420  | 26732683 | USBR       | Monitor  | 1506.00 |
| LG-19  | 831713  | 26733098 | USBR       | Monitor  | 1507.00 |
| LG-21  | 831480  | 26728495 | USBR       | Monitor  | 1583.00 |
| LG-27  | 827263  | 26732993 | USBR       | Monitor  | 1530.61 |
| LK-1   | 827207  | 26727861 | DRI        | Monitor  | 1604.77 |
| LK-2   | 827202  | 26727869 | DRI        | Monitor  | 1603.83 |
| LK-3   | 827212  | 26727870 | DRI        | Monitor  | 1605.72 |
| LK-4   | 827216  | 26727863 | DRI        | Monitor  | 1600.78 |
| LK-5   | 827401  | 26727857 | DRI        | Monitor  | 1602.47 |
| LK-6   | 827410  | 26727848 | DRI        | Monitor  | 1612.24 |
| M-17A  | 828062  | 26719054 | Kerr McGee | Monitor  | 1724.95 |
| M-31A  | 828368  | 26718290 | Kerr McGee | Monitor  | 1753.94 |
| MW-AJ  | 826455  | 26726030 | AMPAC      | Monitor  | 1625.30 |
| MW-J   | 824962  | 26725010 | AMPAC      | Monitor  | 1647.76 |
| MW-K4  | 828994  | 26728411 | AMPAC      | Monitor  | 1571.21 |
| MW-K5  | 829617  | 26730252 | AMPAC      | Monitor  | 1557.62 |
| MW-O   | 824197  | 26727965 | AMPAC      | Monitor  | 1605.33 |
| MW-QD  | 826074  | 26727995 | AMPAC      | Monitor  | 1597.00 |
| MW-QS  | 826074  | 26727995 | AMPAC      | Monitor  | 1597.00 |

| <b>Table 1. Data Locations for Qal-MCf Contact (Model Bottom) Elevation Contouring</b> |         |          |            |          |         |
|--|---------|----------|------------|----------|---------|
| Well ID  | Easting | Northing | Owner      | Type     | Qal-MCf |
| MW-R   | 825423  | 26725016 | AMPAC      | Monitor  | 1645.72 |
| MW-S   | 826941  | 26730853 | AMPAC      | Monitor  | 1564.02 |
| MW-T   | 826645  | 26732347 | AMPAC      | Monitor  | 1553.02 |
| MW-TWB-140   | 825090  | 26726489 | AMPAC      | Monitor  | 1634.87 |
| MW-TWB-21  | 825254  | 26726461 | AMPAC      | Monitor  | 1630.57 |
| MW-TWB-36  | 825066  | 26726470 | AMPAC      | Monitor  | 1634.70 |
| MW-TWB-54  | 825080  | 26726478 | AMPAC      | Monitor  | 1634.86 |
| MW-TWBX-21   | 825215  | 26726338 | AMPAC      | Monitor  | 1636.40 |
| MW-TWBX-36   | 825224  | 26726346 | AMPAC      | Monitor  | 1639.06 |
| MW-TWBY-21   | 824977  | 26726538 | AMPAC      | Monitor  | 1638.08 |
| MW-TWBY-36   | 824988  | 26726540 | AMPAC      | Monitor  | 1634.79 |
| MW-TWC-126   | 825286  | 26726687 | AMPAC      | Monitor  | 1634.57 |
| MW-TWC-15  | 825244  | 26726761 | AMPAC      | Monitor  | 1633.47 |
| MW-TWC-28  | 825252  | 26726747 | AMPAC      | Monitor  | 1634.16 |
| MW-TWC-35  | 825270  | 26726726 | AMPAC      | Monitor  | 1634.30 |
| MW-TWC-48  | 825263  | 26726714 | AMPAC      | Monitor  | 1633.49 |
| MW-TWE-107   | 826428  | 26727637 | AMPAC      | Monitor  | 1611.95 |
| MW-TWE-15  | 826426  | 26727677 | AMPAC      | Monitor  | 1619.86 |
| MW-TWE-18  | 826427  | 26727666 | AMPAC      | Monitor  | 1610.66 |
| MW-TWE-33  | 826427  | 26727656 | AMPAC      | Monitor  | 1617.68 |
| MW-TWE-51  | 826427  | 26727647 | AMPAC      | Monitor  | 1595.76 |
| PB-104   | 832612  | 26733397 | Other      | Boring   | 1528.30 |
| PC-1   | 830925  | 26730309 | Kerr McGee | Monitor  | 1565.68 |
| PC-10  | 829891  | 26727968 | Kerr McGee | Monitor  | 1585.33 |
| PC-100R  | 829542  | 26730295 | Kerr McGee | Monitor  | 1552.51 |
| PC-101   | 828715  | 26728111 | Kerr McGee | Monitor  | 1567.86 |
| PC-101R  | 828712  | 26728108 | Kerr McGee | Monitor  | 1567.28 |
| PC-103   | 829111  | 26730206 | Kerr McGee | Monitor  | 1568.02 |
| PC-104   | 829277  | 26731050 | Kerr McGee | Monitor  | 1561.68 |
| PC-105   | 828827  | 26731426 | Kerr McGee | Monitor  | 1541.27 |
| PC-106   | 827110  | 26730248 | Kerr McGee | Monitor  | 1569.10 |
| PC-107   | 827136  | 26729288 | Kerr McGee | Monitor  | 1601.19 |
| PC-108   | 828527  | 26731913 | Kerr McGee | Monitor  | 1539.96 |
| PC-109   | 828117  | 26732064 | Kerr McGee | Monitor  | 1552.21 |
| PC-11  | 829542  | 26727966 | Kerr McGee | Boring   | 1581.98 |
| PC-111   | 826540  | 26732782 | Kerr McGee | Monitor  | 1550.79 |
| PC-112   | 828898  | 26732801 | Kerr McGee | Monitor  | 1525.24 |
| PC-113   | 829177  | 26732303 | Kerr McGee | Monitor  | 1543.71 |
| PC-114   | 829701  | 26732303 | Kerr McGee | Monitor  | 1544.83 |
| PC-115   | 831045  | 26733155 | Kerr McGee | Monitor  | 1505.00 |
| PC-115R  | 831149  | 26733131 | Kerr McGee | Recovery | 1504.79 |
| PC-116   | 831365  | 26733213 | Kerr McGee | Monitor  | 1505.50 |
| PC-116R  | 831348  | 26733203 | Kerr McGee | Recovery | 1503.04 |
| PC-117   | 831422  | 26733276 | Kerr McGee | Recovery | 1500.23 |
| PC-118   | 831052  | 26733167 | Kerr McGee | Recovery | 1504.15 |
| PC-119   | 830951  | 26733189 | Kerr McGee | Recovery | 1507.34 |

| <b>Table 1. Data Locations for Qal-MCf Contact (Model Bottom) Elevation Contouring</b> |         |          |            |          |         |
|--|---------|----------|------------|----------|---------|
| Well ID  | Easting | Northing | Owner      | Type     | Qal-MCf |
| PC-12  | 829430  | 26728103 | Kerr McGee | Monitor  | 1587.16 |
| PC-120   | 830851  | 26733186 | Kerr McGee | Recovery | 1509.41 |
| PC-122   | 829675  | 26728145 | Kerr McGee | Monitor  | 1580.39 |
| PC-123   | 829485  | 26727358 | Kerr McGee | Monitor  | 1593.44 |
| PC-124   | 830133  | 26726742 | Kerr McGee | Monitor  | 1603.73 |
| PC-125   | 829926  | 26726740 | Kerr McGee | Monitor  | 1603.06 |
| PC-127   | 829317  | 26726736 | Kerr McGee | Monitor  | 1599.42 |
| PC-128   | 828954  | 26726732 | Kerr McGee | Monitor  | 1601.36 |
| PC-13  | 829145  | 26728098 | Kerr McGee | Boring   | 1588.89 |
| PC-130   | 828538  | 26726729 | Kerr McGee | Monitor  | 1585.21 |
| PC-131   | 828123  | 26726725 | Kerr McGee | Monitor  | 1593.58 |
| PC-132   | 827914  | 26726723 | Kerr McGee | Monitor  | 1602.84 |
| PC-14  | 829037  | 26728096 | Kerr McGee | Boring   | 1590.27 |
| PC-15  | 828937  | 26728094 | Kerr McGee | Boring   | 1580.29 |
| PC-16  | 828837  | 26728091 | Kerr McGee | Boring   | 1571.48 |
| PC-17  | 828733  | 26728089 | Kerr McGee | Monitor  | 1569.28 |
| PC-18  | 828636  | 26728080 | Kerr McGee | Monitor  | 1566.69 |
| PC-19  | 828510  | 26728053 | Kerr McGee | Monitor  | 1560.46 |
| PC-2   | 830443  | 26730210 | Kerr McGee | Monitor  | 1562.79 |
| PC-20  | 828413  | 26728053 | Kerr McGee | Boring   | 1577.36 |
| PC-22  | 830321  | 26726737 | Kerr McGee | Boring   | 1610.15 |
| PC-23  | 829922  | 26726733 | Kerr McGee | Boring   | 1606.62 |
| PC-24  | 829524  | 26726730 | Kerr McGee | Monitor  | 1605.95 |
| PC-25  | 829124  | 26726727 | Kerr McGee | Boring   | 1611.84 |
| PC-27  | 829016  | 26725387 | Kerr McGee | Boring   | 1624.46 |
| PC-28  | 828531  | 26725376 | Kerr McGee | Monitor  | 1633.17 |
| PC-29  | 828014  | 26725373 | Kerr McGee | Boring   | 1618.66 |
| PC-3   | 830727  | 26730272 | Kerr McGee | Boring   | 1566.53 |
| PC-30  | 827269  | 26725198 | Kerr McGee | Boring   | 1618.29 |
| PC-31  | 826782  | 26725196 | Kerr McGee | Monitor  | 1608.13 |
| PC-32  | 826260  | 26725194 | Kerr McGee | Boring   | 1620.96 |
| PC-4   | 831172  | 26730353 | Kerr McGee | Monitor  | 1553.63 |
| PC-45  | 824003  | 26727056 | Kerr McGee | Boring   | 1612.39 |
| PC-46  | 824280  | 26726758 | Kerr McGee | Boring   | 1614.65 |
| PC-47  | 824593  | 26726430 | Kerr McGee | Boring   | 1619.66 |
| PC-48  | 824943  | 26726042 | Kerr McGee | Boring   | 1622.68 |
| PC-49  | 828727  | 26726726 | Kerr McGee | Boring   | 1596.48 |
| PC-5   | 830583  | 26730236 | Kerr McGee | Boring   | 1568.49 |
| PC-50  | 828327  | 26726722 | Kerr McGee | Monitor  | 1590.99 |
| PC-51  | 828027  | 26726719 | Kerr McGee | Boring   | 1601.96 |
| PC-52  | 830191  | 26730231 | Kerr McGee | Boring   | 1560.10 |
| PC-53  | 829942  | 26730225 | Kerr McGee | Monitor  | 1561.14 |
| PC-55  | 828530  | 26728057 | Kerr McGee | Monitor  | 1565.95 |
| PC-56  | 830645  | 26732289 | Kerr McGee | Monitor  | 1516.99 |
| PC-57  | 830831  | 26732239 | Kerr McGee | Boring   | 1518.21 |
| PC-58  | 831124  | 26732118 | Kerr McGee | Monitor  | 1536.79 |

| <b>Table 1. Data Locations for Qal-MCf Contact (Model Bottom) Elevation Contouring</b> |         |          |            |          |         |
|--|---------|----------|------------|----------|---------|
| Well ID  | Easting | Northing | Owner      | Type     | Qal-MCf |
| PC-59  | 830150  | 26732453 | Kerr McGee | Monitor  | 1536.34 |
| PC-6   | 831073  | 26730335 | Kerr McGee | Boring   | 1556.84 |
| PC-60  | 830405  | 26732359 | Kerr McGee | Monitor  | 1529.80 |
| PC-61  | 830525  | 26732323 | Kerr McGee | Boring   | 1523.70 |
| PC-62  | 829764  | 26732734 | Kerr McGee | Monitor  | 1533.45 |
| PC-63  | 829926  | 26732553 | Kerr McGee | Boring   | 1533.95 |
| PC-68  | 829617  | 26732907 | Kerr McGee | Monitor  | 1517.66 |
| PC-69  | 829478  | 26733074 | Kerr McGee | Boring   | 1516.19 |
| PC-7   | 831271  | 26730372 | Kerr McGee | Boring   | 1556.92 |
| PC-70  | 828700  | 26728085 | Kerr McGee | Monitor  | 1566.27 |
| PC-74  | 829204  | 26734004 | Kerr McGee | Monitor  | 1508.54 |
| PC-75  | 829195  | 26734005 | Kerr McGee | Boring   | 1508.48 |
| PC-76  | 829184  | 26734007 | Kerr McGee | Monitor  | 1508.51 |
| PC-79  | 829815  | 26733247 | Kerr McGee | Monitor  | 1519.33 |
| PC-8   | 831129  | 26730316 | Kerr McGee | Boring   | 1556.68 |
| PC-80  | 829824  | 26733250 | Kerr McGee | Monitor  | 1519.07 |
| PC-81  | 829833  | 26733255 | Kerr McGee | Monitor  | 1519.03 |
| PC-82  | 830317  | 26733195 | Kerr McGee | Monitor  | 1503.44 |
| PC-83  | 830326  | 26733201 | Kerr McGee | Monitor  | 1503.47 |
| PC-84  | 830333  | 26733209 | Kerr McGee | Monitor  | 1503.14 |
| PC-85  | 830816  | 26733186 | Kerr McGee | Monitor  | 1506.70 |
| PC-86  | 830827  | 26733186 | Kerr McGee | Monitor  | 1507.08 |
| PC-87  | 830838  | 26733185 | Kerr McGee | Monitor  | 1507.09 |
| PC-88  | 831259  | 26733178 | Kerr McGee | Monitor  | 1499.91 |
| PC-89  | 831265  | 26733184 | Kerr McGee | Monitor  | 1499.90 |
| PC-9   | 830329  | 26727966 | Kerr McGee | Boring   | 1598.02 |
| PC-90  | 831272  | 26733193 | Kerr McGee | Monitor  | 1499.53 |
| PC-91  | 831730  | 26733111 | Kerr McGee | Monitor  | 1512.42 |
| PC-92  | 831749  | 26733110 | Kerr McGee | Monitor  | 1512.12 |
| PC-93  | 832180  | 26733118 | Kerr McGee | Monitor  | 1508.86 |
| PC-94  | 832189  | 26733122 | Kerr McGee | Monitor  | 1508.84 |
| PC-95  | 831227  | 26733450 | Kerr McGee | Monitor  | 1507.61 |
| PC-96  | 830897  | 26733451 | Kerr McGee | Monitor  | 1505.69 |
| PC-97  | 831566  | 26733442 | Kerr McGee | Monitor  | 1505.78 |
| PC-98  | 829520  | 26730256 | Kerr McGee | Monitor  | 1552.35 |
| PC-98R   | 829523  | 26730261 | Kerr McGee | Monitor  | 1552.96 |
| PC-99R   | 831245  | 26733143 | Kerr McGee | Monitor  | 1500.17 |
| PC-99R2  | 831259  | 26733155 | Kerr McGee | Recovery | 1500.18 |
| PC-99R3  | 831256  | 26733160 | Kerr McGee | Recovery | 1499.90 |
| PG-101   | 824243  | 26725482 | USBR       | Monitor  | 1631.00 |
| PG-109   | 824917  | 26727734 | USBR       | Monitor  | 1616.70 |
| PG-110   | 826385  | 26727911 | USBR       | Monitor  | 1610.20 |
| PG-208   | 829919  | 26725374 | USBR       | Monitor  | 1623.40 |
| PG-209   | 830312  | 26725382 | USBR       | Monitor  | 1631.60 |
| PG-210   | 830735  | 26725542 | USBR       | Monitor  | 1626.50 |
| PG-211   | 831877  | 26725841 | USBR       | Monitor  | 1625.30 |

| <b>Table 1. Data Locations for Qal-MCf Contact (Model Bottom) Elevation Contouring</b> |         |          |       |         |         |
|--|---------|----------|-------|---------|---------|
| Well ID  | Easting | Northing | Owner | Type    | Qal-MCf |
| PG-212   | 830103  | 26727908 | USBR  | Monitor | 1585.80 |
| PG-213   | 830134  | 26728101 | USBR  | Monitor | 1594.70 |
| PG-214   | 830652  | 26727983 | USBR  | Monitor | 1600.60 |
| PG-222   | 832748  | 26725481 | USBR  | Monitor | 1619.40 |
| PG-224   | 828737  | 26730196 | USBR  | Monitor | 1565.10 |
| PG-225   | 831419  | 26730393 | USBR  | Monitor | 1558.60 |
| PG-226   | 828897  | 26731765 | USBR  | Monitor | 1551.90 |
| PG-227   | 830399  | 26731372 | USBR  | Monitor | 1550.30 |
| PG-228   | 830802  | 26731368 | USBR  | Monitor | 1535.40 |
| PG-229   | 830459  | 26732378 | USBR  | Monitor | 1531.50 |
| PG-230   | 828400  | 26732829 | USBR  | Monitor | 1563.40 |
| PG-231   | 832628  | 26728945 | USBR  | Monitor | 1595.50 |
| PG-232   | 833251  | 26729007 | USBR  | Monitor | 1599.50 |
| PG-233   | 833861  | 26728966 | USBR  | Monitor | 1596.10 |
| PG-235   | 826293  | 26725405 | USBR  | Monitor | 1612.80 |
| PG-237A  | 827249  | 26726757 | USBR  | Monitor | 1615.10 |
| PG-241   | 827674  | 26725964 | USBR  | Monitor | 1613.20 |
| PG-256   | 832118  | 26732045 | USBR  | Monitor | 1546.10 |
| PSW-6  | 827915  | 26727657 | Other | Boring  | 1587.00 |
| WW-1   | 825800  | 26727500 | USBR  | Boring  | 1622.00 |

| Well ID | Easting | Northing | TOC     | Sample Date | Depth to Water | Elevation |
|---------|---------|----------|---------|-------------|----------------|-----------|
| AA-15   | 831754  | 26726004 |         | 17-Nov-06   |                | 1615.87   |
| AA-19   | 832521  | 26727447 |         | 17-Nov-06   |                | 1599.85   |
| AA-20   | 831812  | 26728008 |         | 17-Nov-06   |                | 1600.68   |
| ARP-1   | 828593  | 26728366 | 1613.32 | 12-Dec-06   | 22.01          | 1591.31   |
| ARP-2   | 828726  | 26728364 | 1612.79 | 12-Dec-06   | 21.85          | 1590.94   |
| ARP-3   | 828861  | 26728365 | 1612.17 | 12-Dec-06   | 22.28          | 1589.89   |
| ARP-4   | 829172  | 26728364 | 1613.01 | 12-Dec-06   | 24.11          | 1588.90   |
| ARP-5   | 829395  | 26728453 | 1615.01 | 12-Dec-06   | 28.58          | 1586.43   |
| ARP-6A  | 829515  | 26728480 | 1614.11 | 12-Dec-06   | 27.82          | 1586.29   |
| ARP-7   | 829668  | 26728501 | 1613.20 | 12-Dec-06   | 26.88          | 1586.32   |
| ART-1   | 828544  | 26728123 | 1614.47 | 11-Dec-06   | 29.99          | 1584.48   |
| ART-1A  | 828537  | 26728122 | 1614.40 | 11-Dec-06   | 21.91          | 1592.49   |
| ART-2   | 828625  | 26728085 | 1617.10 | 11-Dec-06   | 25.69          | 1591.41   |
| ART-2A  | 828619  | 26728086 | 1616.81 | 11-Dec-06   | 24.74          | 1592.07   |
| ART-3   | 828775  | 26728085 | 1617.94 | 11-Dec-06   | 27.37          | 1590.57   |
| ART-3A  | 828769  | 26728085 | 1617.60 | 11-Dec-06   | 30.24          | 1587.36   |
| ART-4   | 828851  | 26728085 | 1617.46 | 11-Dec-06   | 37.74          | 1579.72   |
| ART-4A  | 828844  | 26728085 | 1617.46 | 11-Dec-06   | 26.73          | 1590.73   |
| ART-5   | 829370  | 26728129 | 1614.06 | 11-Dec-06   | 25.63          | 1588.43   |
| ART-6   | 829473  | 26728141 | 1615.31 | 11-Dec-06   | 27.72          | 1587.59   |
| ART-7   | 829577  | 26728146 | 1615.38 | 11-Dec-06   | 28.22          | 1587.16   |
| ART-7A  | 829583  | 26728143 | 1614.78 | 11-Dec-06   | 29.14          | 1585.64   |
| ART-8   | 828698  | 26728084 | 1617.69 | 11-Dec-06   | 26.26          | 1591.43   |
| ART-8A  | 828692  | 26728083 | 1617.10 | 11-Dec-06   | 27.73          | 1589.37   |
| ART-9   | 829526  | 26728143 | 1615.06 | 11-Dec-06   | 28.46          | 1586.60   |
| I-Z     | 828468  | 26719923 | 1743.78 | 01-Nov-06   | 34.00          | 1709.78   |
| L-635   | 828302  | 26727839 | 1620.94 | 12-Dec-06   | 15.12          | 1605.82   |
| L-637   | 828110  | 26727839 | 1621.60 | 12-Dec-06   | 10.41          | 1611.19   |
| M-17A   | 828062  | 26719054 | 1768.99 | 15-Dec-06   | 33.11          | 1735.88   |
| M-31A   | 828368  | 26718290 | 1796.87 | 15-Dec-06   | 46.37          | 1750.50   |
| MW-K4   | 828994  | 26728411 | 1614.96 | 12-Dec-06   | 26.02          | 1588.94   |
| MW-K5   | 829617  | 26730252 | 1598.87 | 12-Dec-06   | 26.11          | 1572.76   |
| PC-101R | 828712  | 26728108 | 1618.12 | 12-Dec-06   | 26.48          | 1591.64   |
| PC-103  | 829111  | 26730206 | 1599.49 | 12-Dec-06   | 21.62          | 1577.87   |
| PC-115R | 831149  | 26733131 | 1554.71 | 11-Dec-06   | 10.92          | 1543.79   |
| PC-116R | 831348  | 26733203 | 1552.10 | 11-Dec-06   | 19.02          | 1533.08   |
| PC-117  | 831422  | 26733276 | 1552.26 | 11-Dec-06   | 10.14          | 1542.12   |
| PC-118  | 831052  | 26733167 | 1554.53 | 11-Dec-06   | 6.23           | 1548.30   |
| PC-119  | 830951  | 26733189 | 1554.66 | 11-Dec-06   | 3.85           | 1550.81   |
| PC-12   | 829430  | 26728103 | 1616.37 | 12-Dec-06   | 28.12          | 1588.25   |
| PC-120  | 830851  | 26733186 | 1554.64 | 11-Dec-06   | 2.48           | 1552.16   |
| PC-121  | 830751  | 26733180 | 1554.10 | 11-Dec-06   | 2.56           | 1551.54   |

| <b>Table 2. Data Locations for Groundwater Elevation Contouring</b> |         |          |         |             |                |           |
|---|---------|----------|---------|-------------|----------------|-----------|
| Well ID   | Easting | Northing | TOC     | Sample Date | Depth to Water | Elevation |
| PC-122  | 829675  | 26728145 | 1617.39 | 12-Dec-06   | 29.58          | 1587.81   |
| PC-123  | 829485  | 26727358 | 1626.44 | 30-Oct-06   | 23.00          | 1603.44   |
| PC-124  | 830133  | 26726742 | 1635.73 | 30-Oct-06   | 24.90          | 1610.83   |
| PC-125  | 829926  | 26726740 | 1635.06 | 30-Oct-06   | 23.45          | 1611.61   |
| PC-126  | 829725  | 26726738 | 1634.33 | 30-Oct-06   | 22.45          | 1611.88   |
| PC-127  | 829317  | 26726736 | 1632.42 | 30-Oct-06   | 19.21          | 1613.21   |
| PC-128  | 828954  | 26726732 | 1633.36 | 30-Oct-06   | 18.48          | 1614.88   |
| PC-129  | 828747  | 26726731 | 1633.99 | 30-Oct-06   | 18.55          | 1615.44   |
| PC-130  | 828538  | 26726729 | 1633.21 | 30-Oct-06   | 19.10          | 1614.11   |
| PC-131  | 828123  | 26726725 | 1633.58 | 30-Oct-06   | 11.10          | 1622.48   |
| PC-132  | 827914  | 26726723 | 1634.84 | 30-Oct-06   | 9.87           | 1624.97   |
| PC-133  | 831758  | 26733209 | 1553.00 | 11-Dec-06   | 5.33           | 1547.67   |
| PC-17   | 828733  | 26728089 | 1617.00 | 12-Dec-06   | 25.37          | 1591.63   |
| PC-18   | 828636  | 26728080 | 1618.47 | 12-Dec-06   | 26.42          | 1592.05   |
| PC-53   | 829942  | 26730225 | 1595.03 | 12-Dec-06   | 22.71          | 1572.32   |
| PC-55   | 828530  | 26728057 | 1617.19 | 12-Dec-06   | 24.25          | 1592.94   |
| PC-56   | 830645  | 26732289 | 1568.25 | 12-Dec-06   | 8.46           | 1559.79   |
| PC-58   | 831124  | 26732118 | 1567.96 | 12-Dec-06   | 7.83           | 1560.13   |
| PC-59   | 830150  | 26732453 | 1567.92 | 12-Dec-06   | 9.24           | 1558.68   |
| PC-60   | 830405  | 26732359 | 1568.38 | 12-Dec-06   | 8.42           | 1559.96   |
| PC-62   | 829764  | 26732734 | 1567.83 | 12-Dec-06   | 9.71           | 1558.12   |
| PC-68   | 829617  | 26732907 | 1566.97 | 12-Dec-06   | 8.48           | 1558.49   |
| PC-86   | 830827  | 26733186 | 1553.85 | 12-Dec-06   | 2.74           | 1551.11   |
| PC-90   | 831272  | 26733193 | 1550.46 | 12-Dec-06   | 4.28           | 1546.18   |
| PC-91   | 831730  | 26733111 | 1552.33 | 12-Dec-06   | 7.31           | 1545.02   |
| PC-95   | 831227  | 26733450 | 1550.62 | 12-Dec-06   | 4.03           | 1546.59   |
| PC-97   | 831566  | 26733442 | 1548.53 | 12-Dec-06   | 3.29           | 1545.24   |
| PC-98R  | 829523  | 26730261 | 1593.35 | 12-Dec-06   | 19.75          | 1573.60   |

| <b>Table 3. ART Well Pumping Rates, Perchlorate Concentrations, Reported and Calculated Hydraulic Conductivities</b> |          |           |            |            |           |           |         |
|--|----------|-----------|------------|------------|-----------|-----------|---------|
| Well ID  | FLOW1    | FLOW2     | Reported K | Early ClO4 | Late ClO4 | Initial K | Final K |
| ART-1  | 15.45753 | 2975.782  | 40         | (75)       | 0.2       | 1: 40     | 1: 25   |
| ART-2  | 70.73425 | 13617.29  | 278        | (368)      | 125       | 4: 300    | 4: 238  |
| ART-8  | 68.03973 | 13098.56  | 164        | (386)      | 325       | 3: 150    | 3: 178  |
| ART-3  | 32.50274 | 6257.212  | 53         | (386-130)  | 431       | 2: 70     | 2: 25   |
| ART-4  | 13.80822 | 2658.267  | 75         | (130)      | 379       | 1: 40     | 1: 25   |
| ART-5  | -        | -         | -          | (186)      | 74        | 3: 150    | 3: 178  |
| ART-6  | -        | -         | 150        | (186)      | 105       | 3: 150    | 3: 178  |
| ART-9  | 39.6*    | 7623.529* | 140        | (186-100)  | 349       | 3: 150    | 3: 178  |
| ART-7  | 29.83151 | 5742.964  | 325        | (100)      | 152       | 4: 300    | 4: 238  |

FLOW1 Average extraction well flow rate for 2005 and 2006 (gallons per minute)

\* Reported flow rate for first quarter 2007

FLOW2 Calculated flow rate for simulation (cubic feet per day)

Reported K Reported hydraulic conductivity calculated from pumping test data (feet per day)

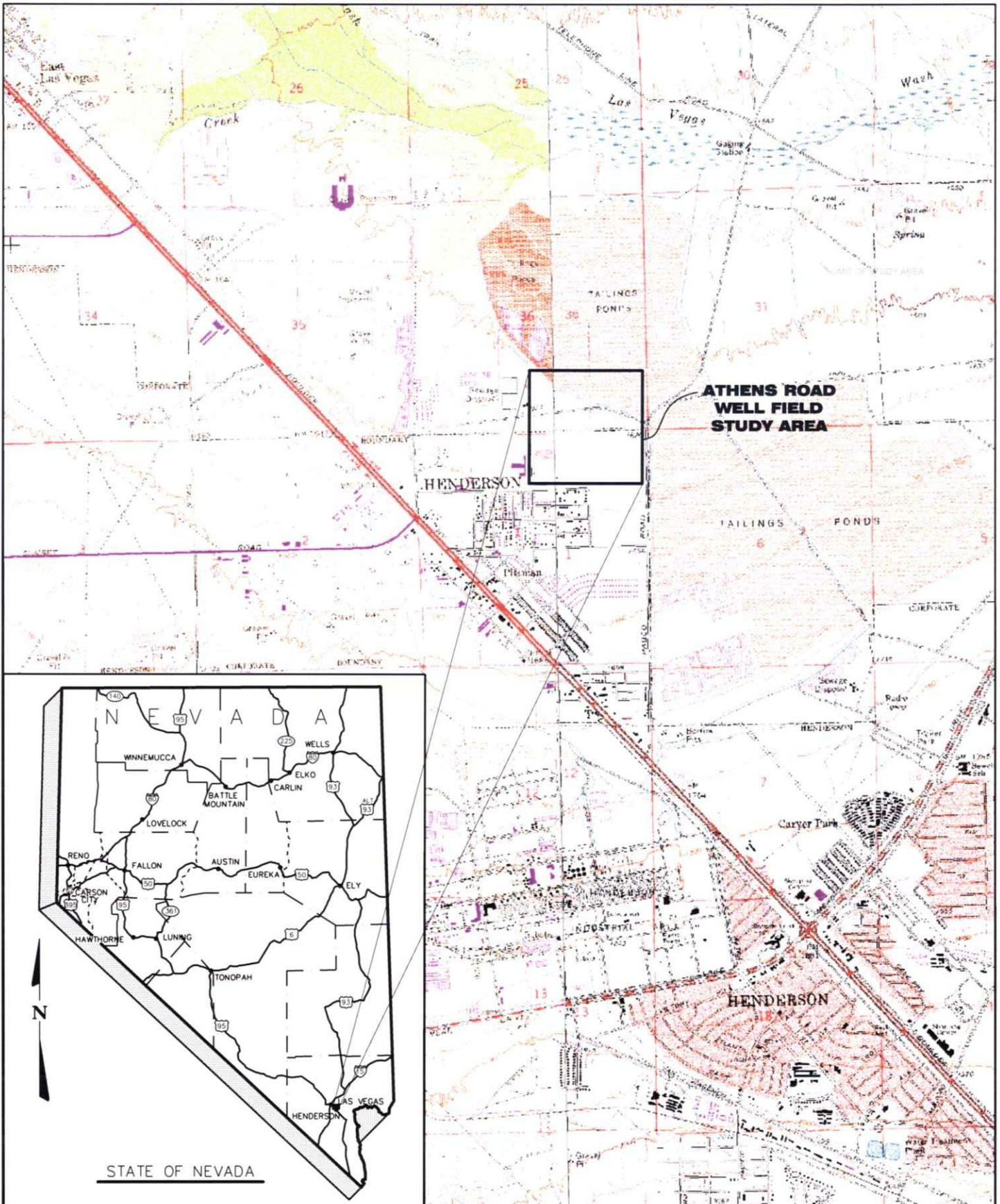
Early ClO4 May 1998 perchlorate concentrations (mg/L; parentheses indicates data projected from nearby wells)

Late ClO4 November 2006 perchlorate concentrations (mg/L)

Initial K Initial modeled hydraulic conductivity preceded by zone number (feet per day)

Final K Final (computed) hydraulic conductivity preceded by zone number (feet per day)





**ATHENS ROAD  
WELL FIELD  
STUDY AREA**

HENDERSON


TAILINGS POND

HENDERSON

STATE OF NEVADA

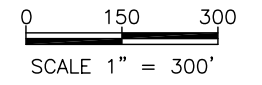
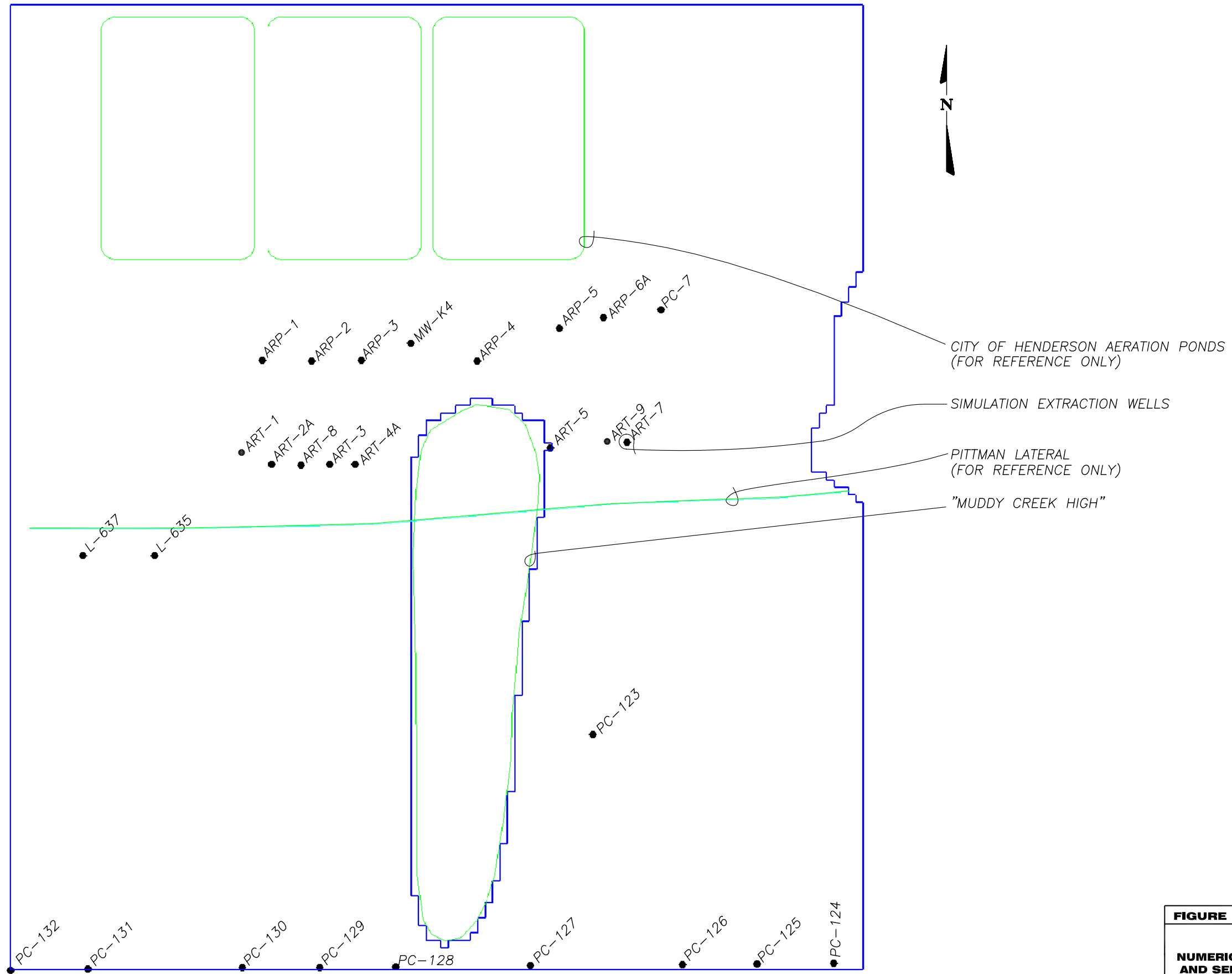
|           |          |             |         |
|-----------|----------|-------------|---------|
| REFERENCE | DESIGNED | BG          | 8/03    |
|           | DRAWN    | TAD         | 8/03    |
|           | CHECKED  |             |         |
| REVISIONS | APPROVED |             |         |
|           | No.      | DESCRIPTION | BY DATE |
|           |          |             |         |

**FIGURE 1**  
**PROJECT LOCATION MAP**  
**-SHOWING-**  
**ATHENS ROAD WELL FIELD**  
**NEAR HENDERSON, NEVADA**



McGinley & Associates

|                 |          |
|-----------------|----------|
| SCALE: AS SHOWN | REVISION |
| JOB NO. BMI-009 | A        |
| DWG NAME BASE   |          |




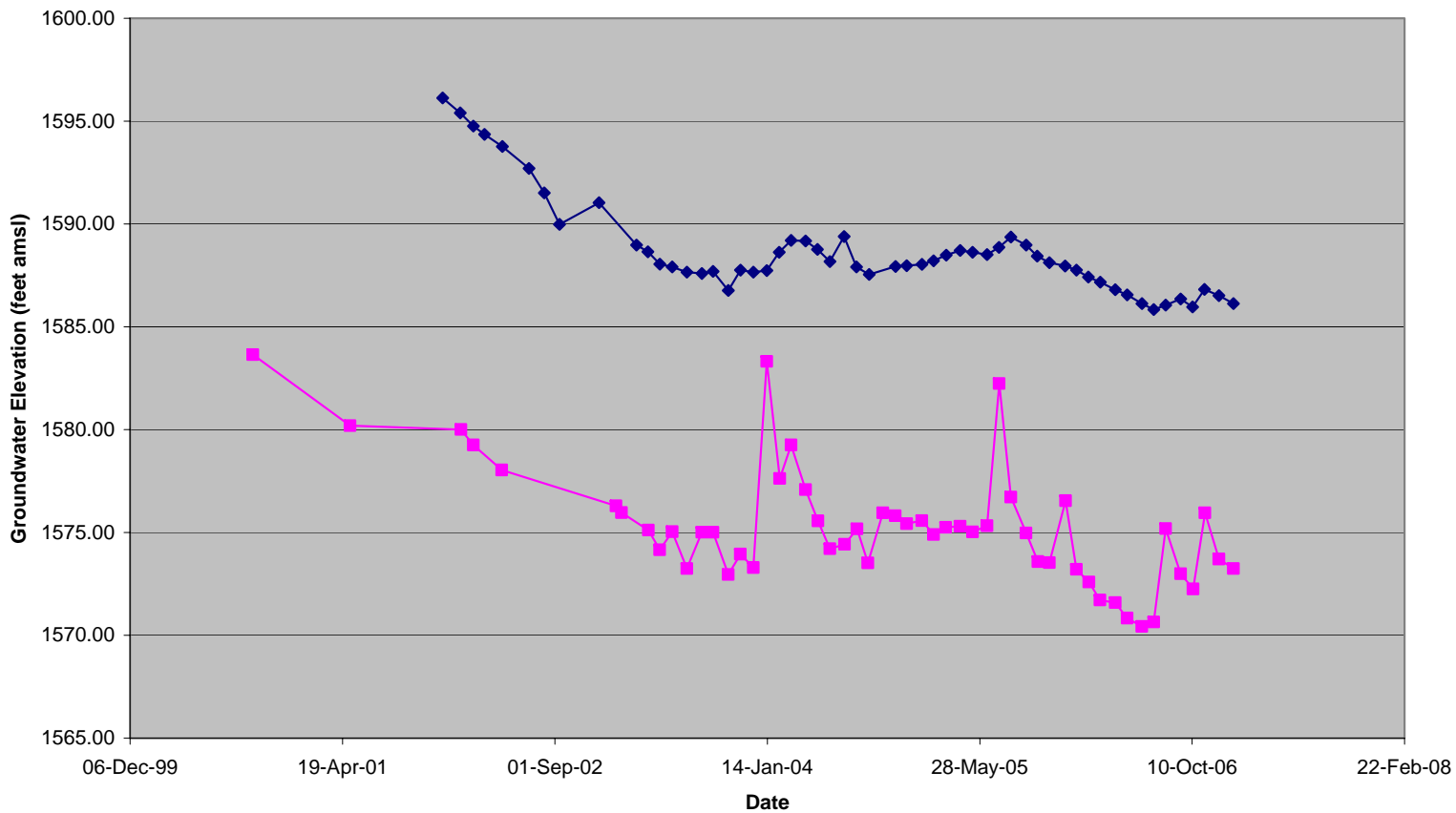
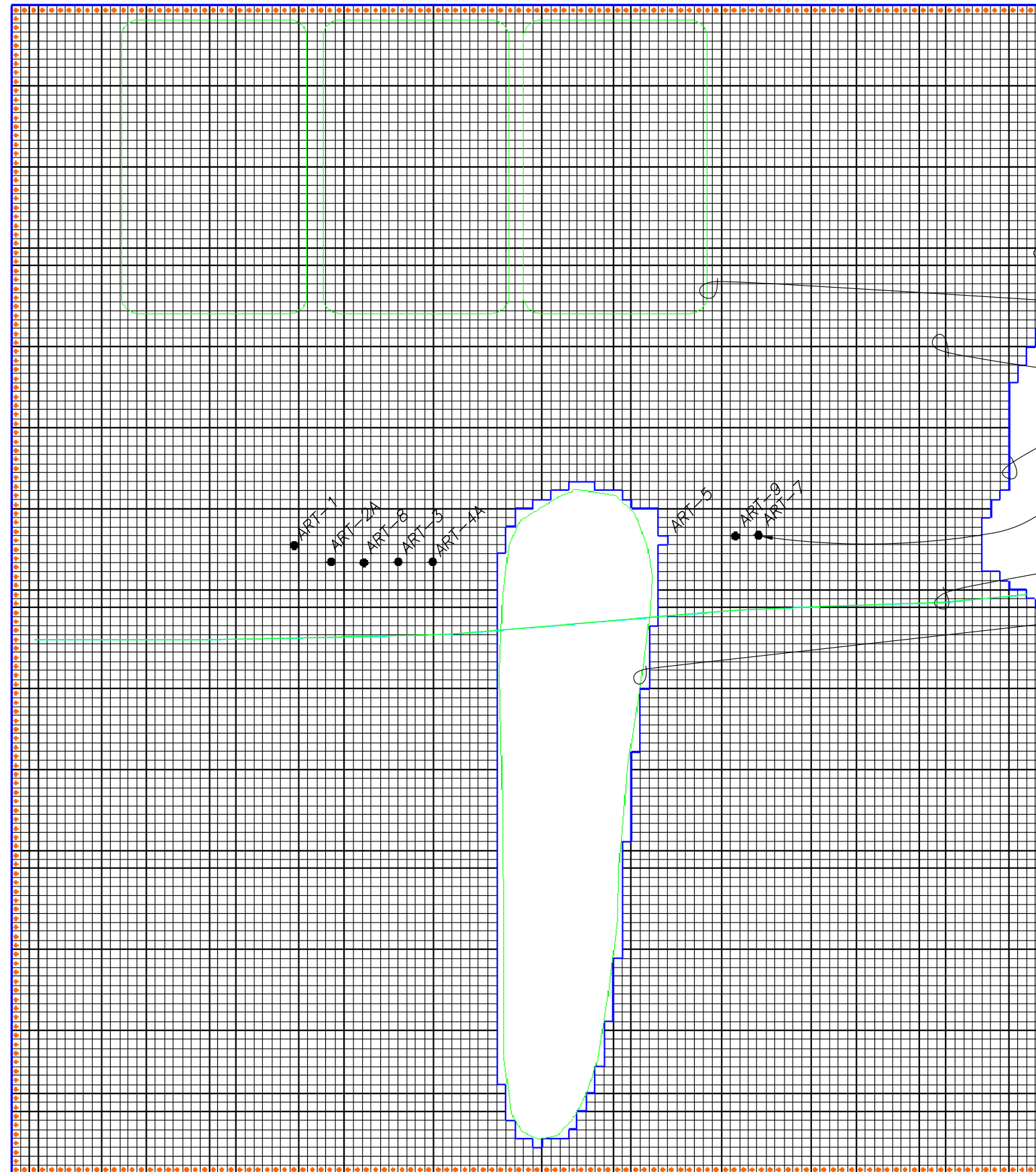
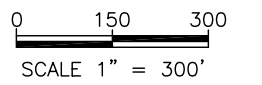
|  |  |                 |
|--|--|-----------------|
| <b>FIGURE 2</b><br><br><b>NUMERICAL MODEL BOUNDARY AND SELECT DATA LOCATIONS</b> | <br>McGinley & Associates |                 |
|  | SCALE: AS SHOWN  | <b>REVISION</b> |
|  | JOB NO. DEP-009  | A               |



Figure 3. Hydrographs for Two Wells in Vicinity of COH RIBs

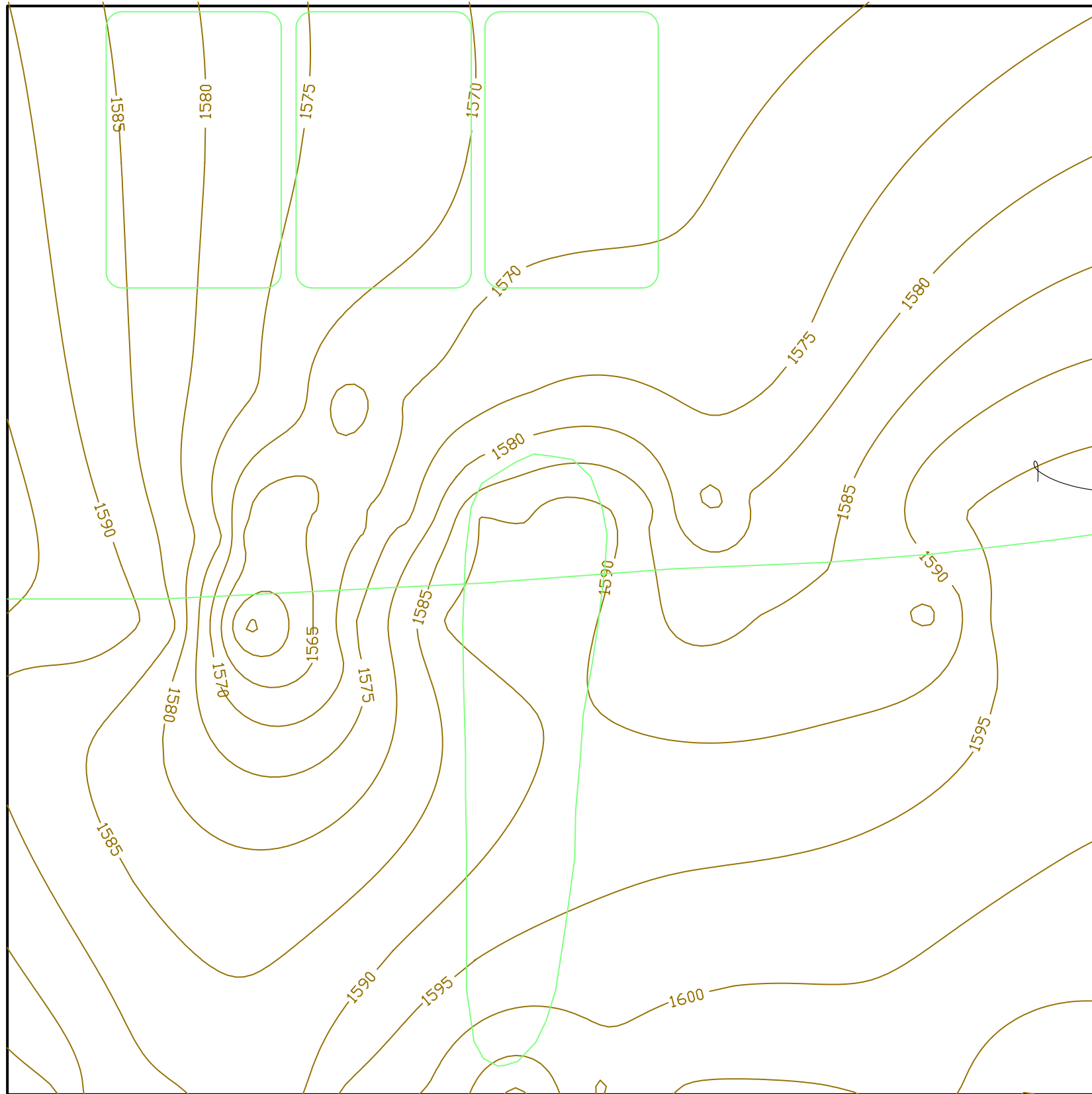




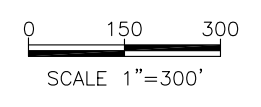
- CONSTANT HEAD BOUNDARY
- CITY OF HENDERSON AERATION PONDS  
(FOR REFERENCE ONLY)
- MODEL GRID
- NO FLOW BOUNDARY  
(DEACTIVATED CELLS)
- SIMULATION EXTRACTION WELLS
- PITTMAN LATERAL  
(FOR REFERENCE ONLY)
- "MUDDY CREEK HIGH"




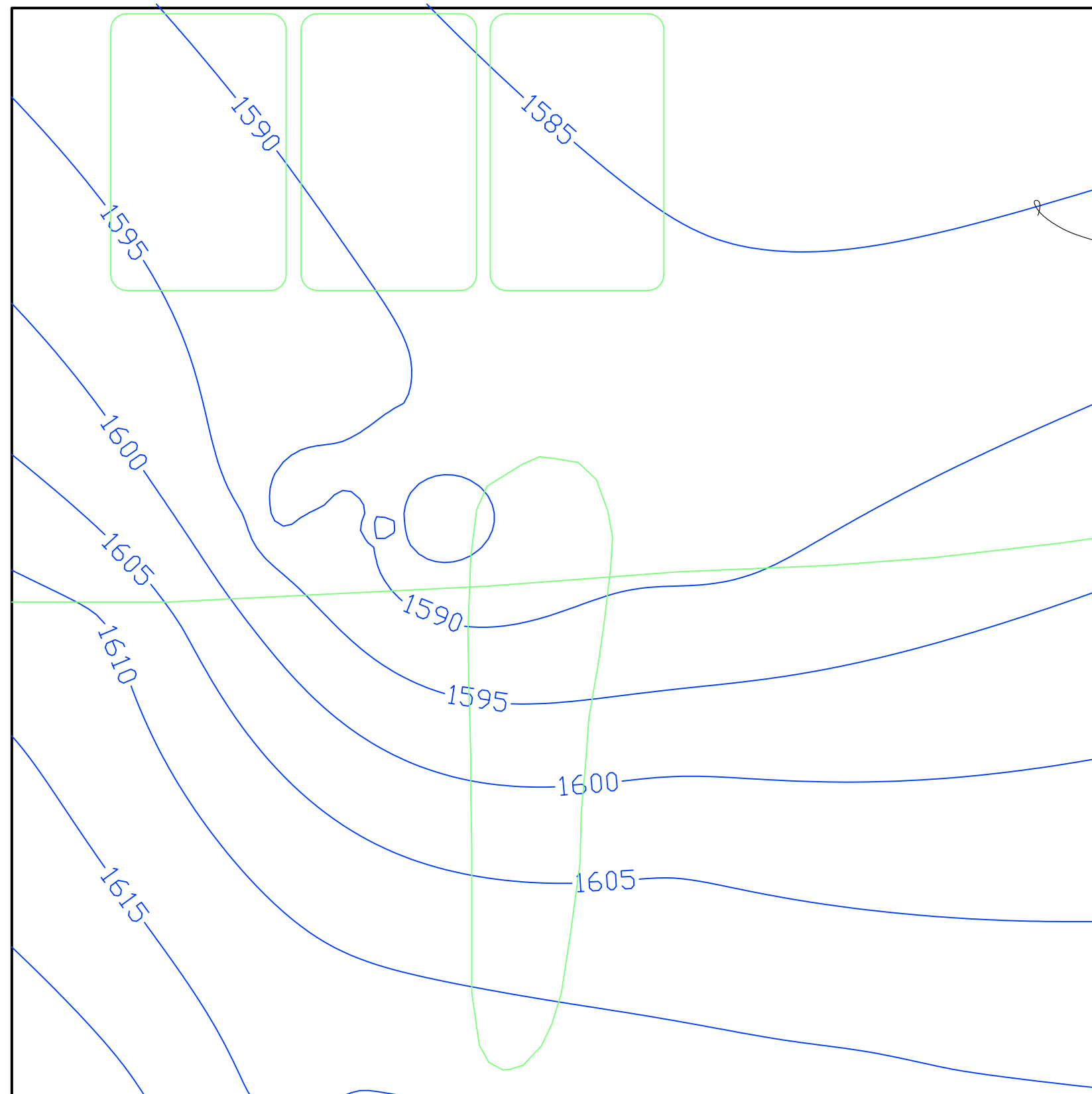
|  |  |
|--|--|
| <b>FIGURE 4</b><br><br><b>MODEL GRID AND BOUNDARY<br/>CONDITIONS</b>                                     | <br>McKinley & Associates |
|  | SCALE: AS SHOWN<br>JOB NO. DEP-009   |
| <b>REVISION</b><br> |  |



Qal-MCF Contact Elevation Contours (feet amsl)



|  |          |  |
|--|----------|--|
| <b>FIGURE 5</b>                        |          | <br>McGinley & Associates |
| <b>MODEL BOTTOM ELEVATION CONTOURS</b> |          |  |
| SCALE: AS SHOWN                        | REVISION |  |
| JOB NO. DEP-009                        |          | A  |



GROUNDWATER ELEVATION CONTOURS (feet amsl)

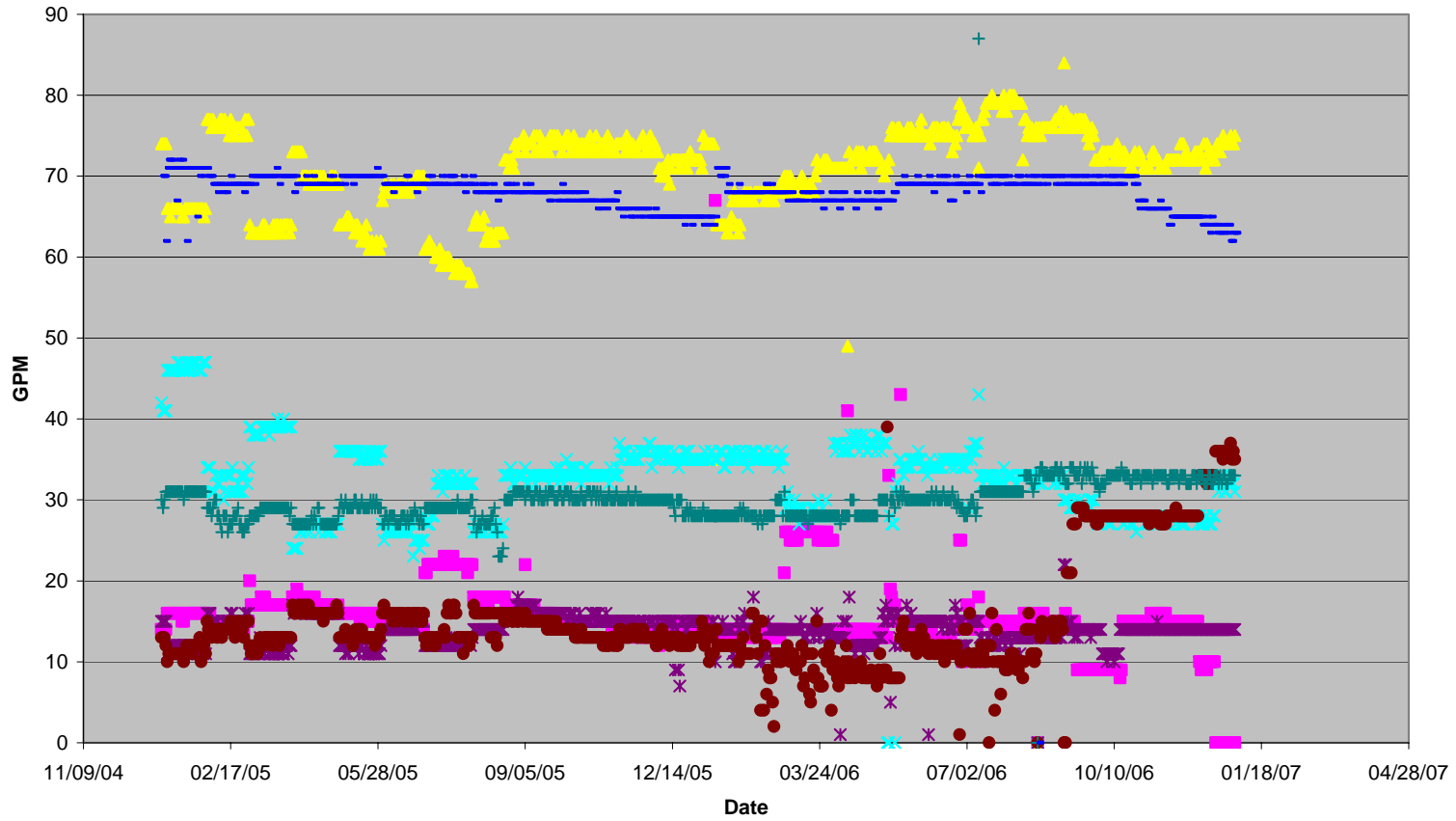
0 150 300  
SCALE 1"=300'

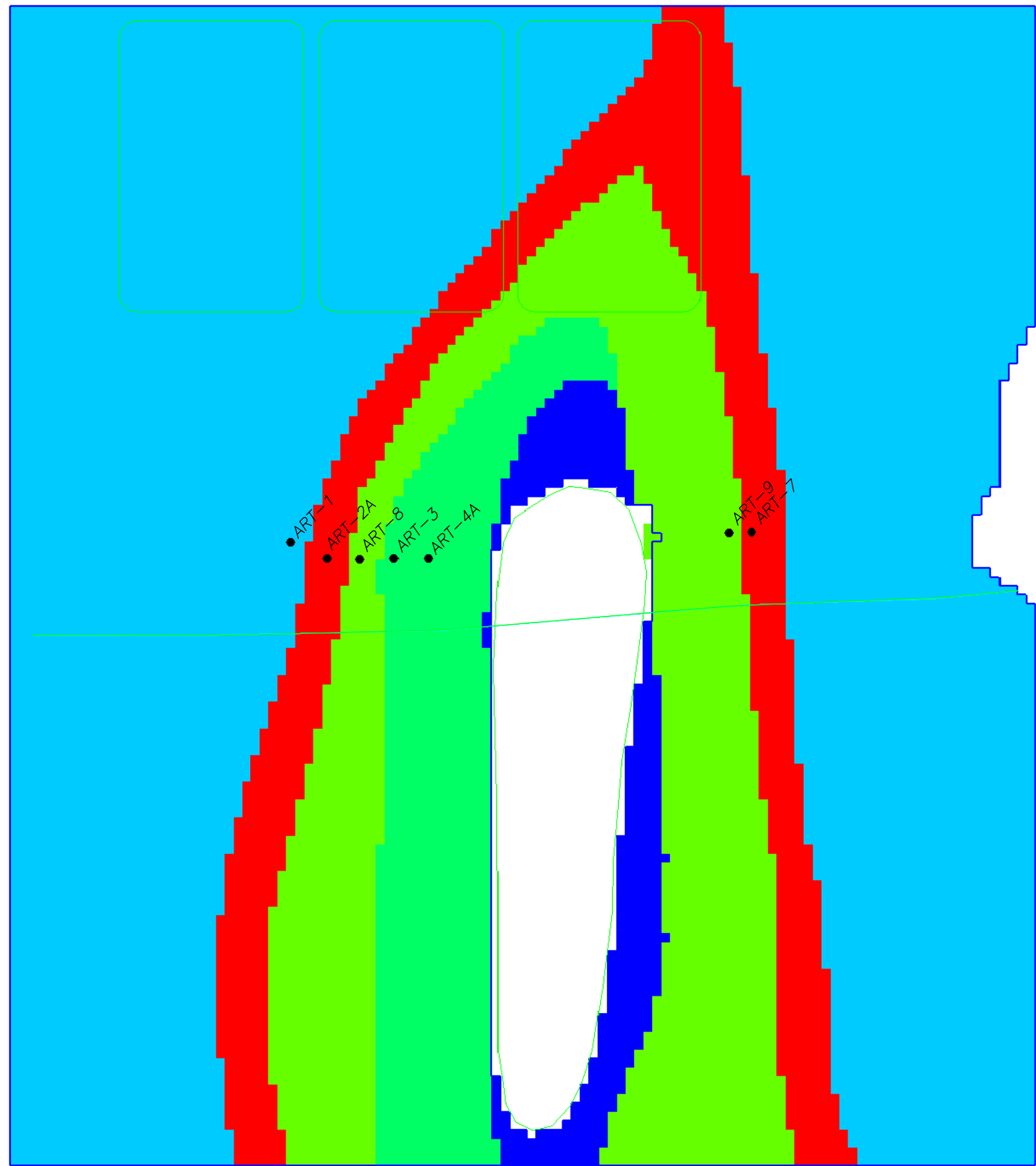
**FIGURE 6**  
**MODEL CONSTANT HEAD**  
**BOUNDARY ELEVATION CONTOURS**

McGinley & Associates

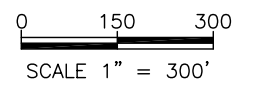
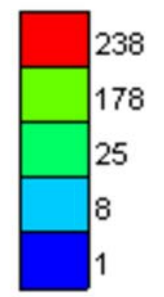
|                 |          |
|-----------------|----------|
| SCALE: AS SHOWN | REVISION |
| JOB NO. DEP-009 | A        |


Figure 7. ART Well Extraction Rates for 2005 and 2006





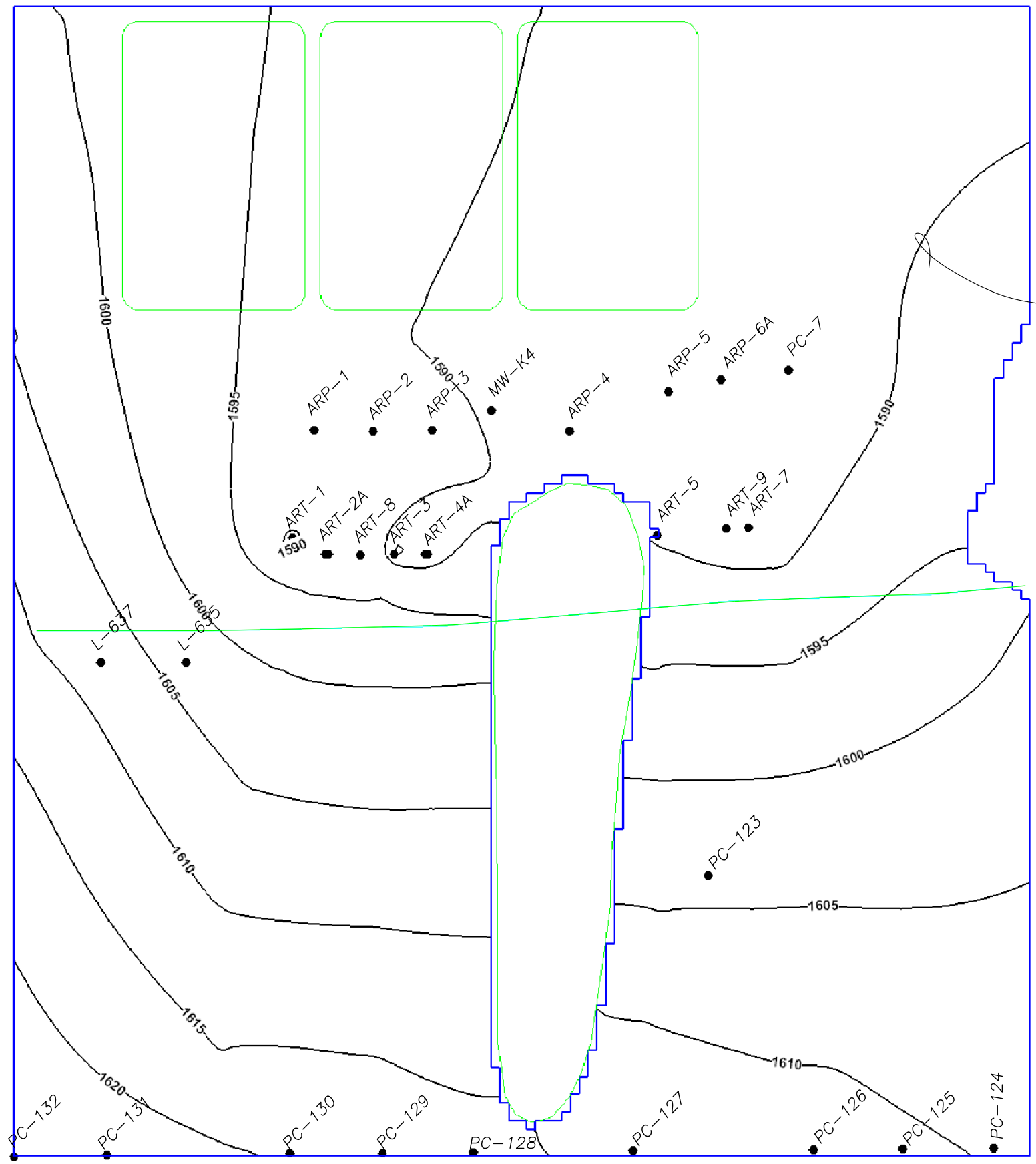
HYDRAULIC CONDUCTIVITY (ft/d)



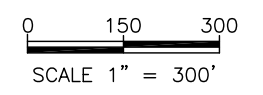
|   |  |   |
|---|--|---|
| <b>FIGURE 8</b><br><br><b>PEST (FINAL) MODEL HYDRAULIC CONDUCTIVITY ARRAY</b> | <br>McGinley & Associates |   |
|   | SCALE: AS SHOWN<br>JOB NO. DEP-009   | <b>REVISION</b><br><div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; margin: 0 auto;">A</div> |




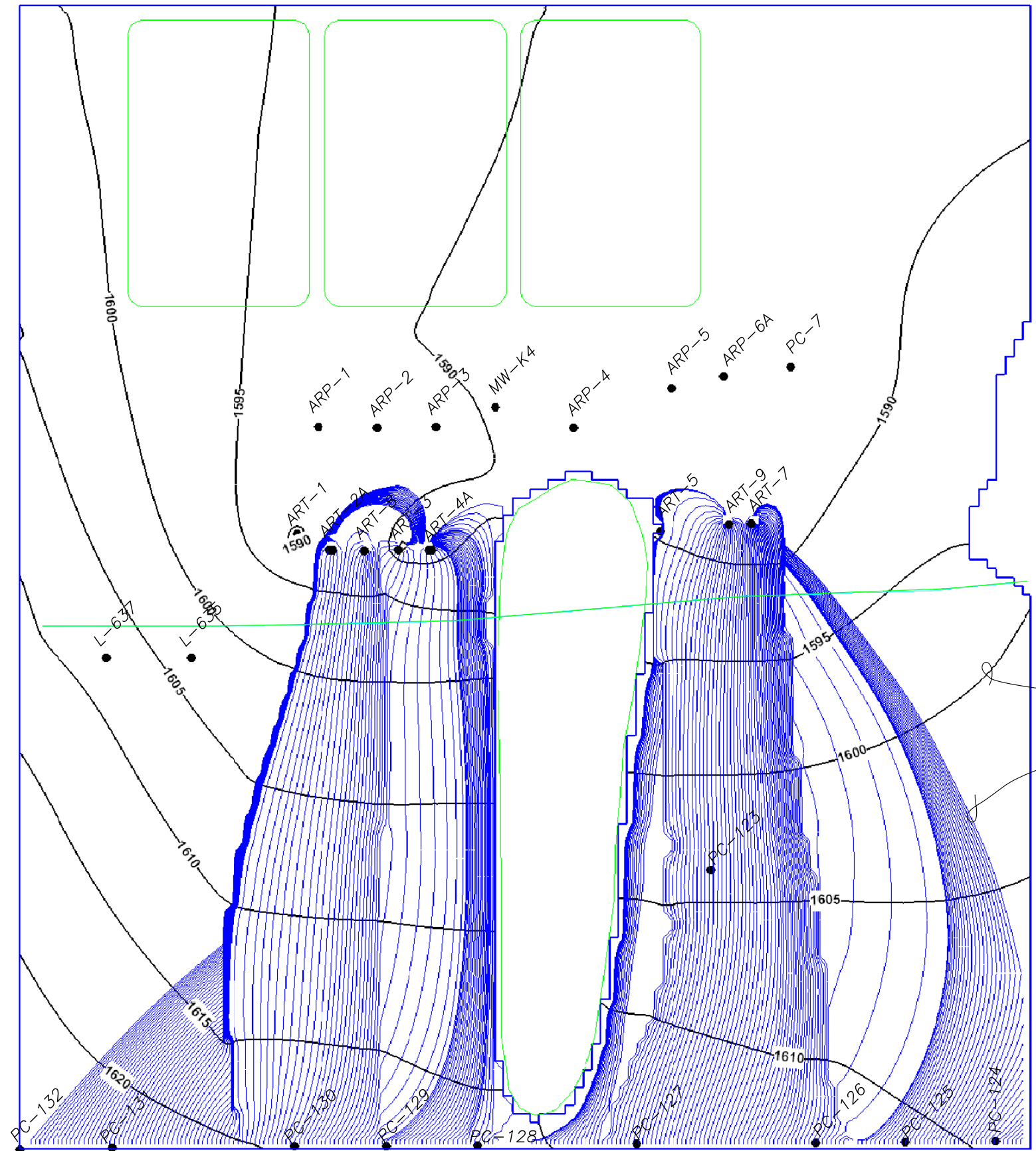




PREDICTED GROUNDWATER ELEVATION CONTOURS (feet amsl)

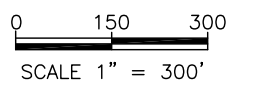



|   |  |                 |   |
|---|--|-----------------|---|
| <b>FIGURE 10</b><br><br><b>PREDICTED GROUNDWATER<br/>ELEVATION CONTOURS</b> | <br>McGinley & Associates | REVISION        |   |
|   | SCALE: AS SHOWN  | JOB NO. DEP-009 | A |
|   |  |                 |   |



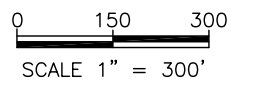
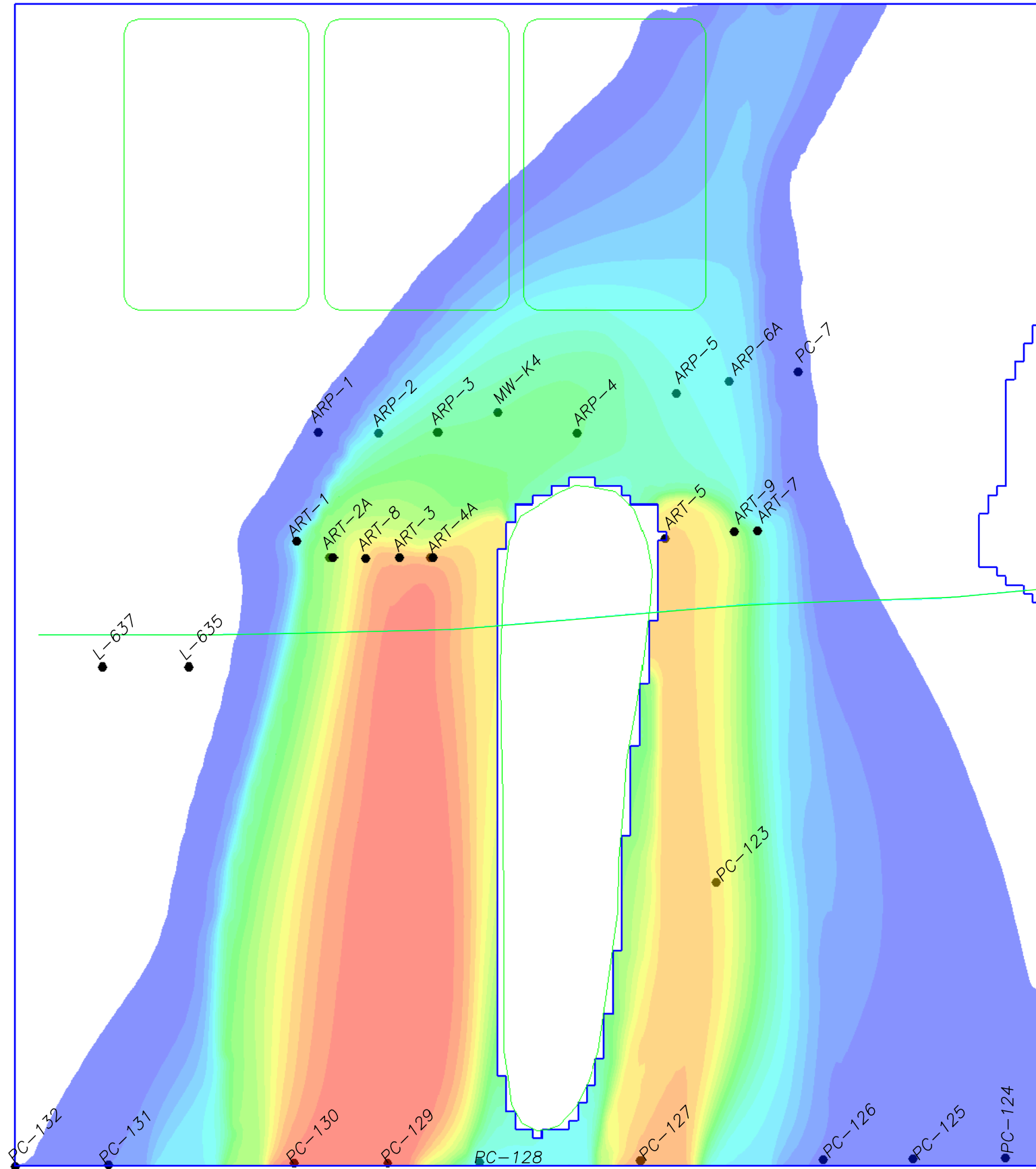
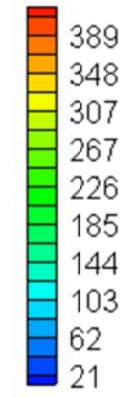
PREDICTED GROUNDWATER ELEVATION CONTOURS (feet amsl)

PREDICTED GROUNDWATER FLOW PATHS

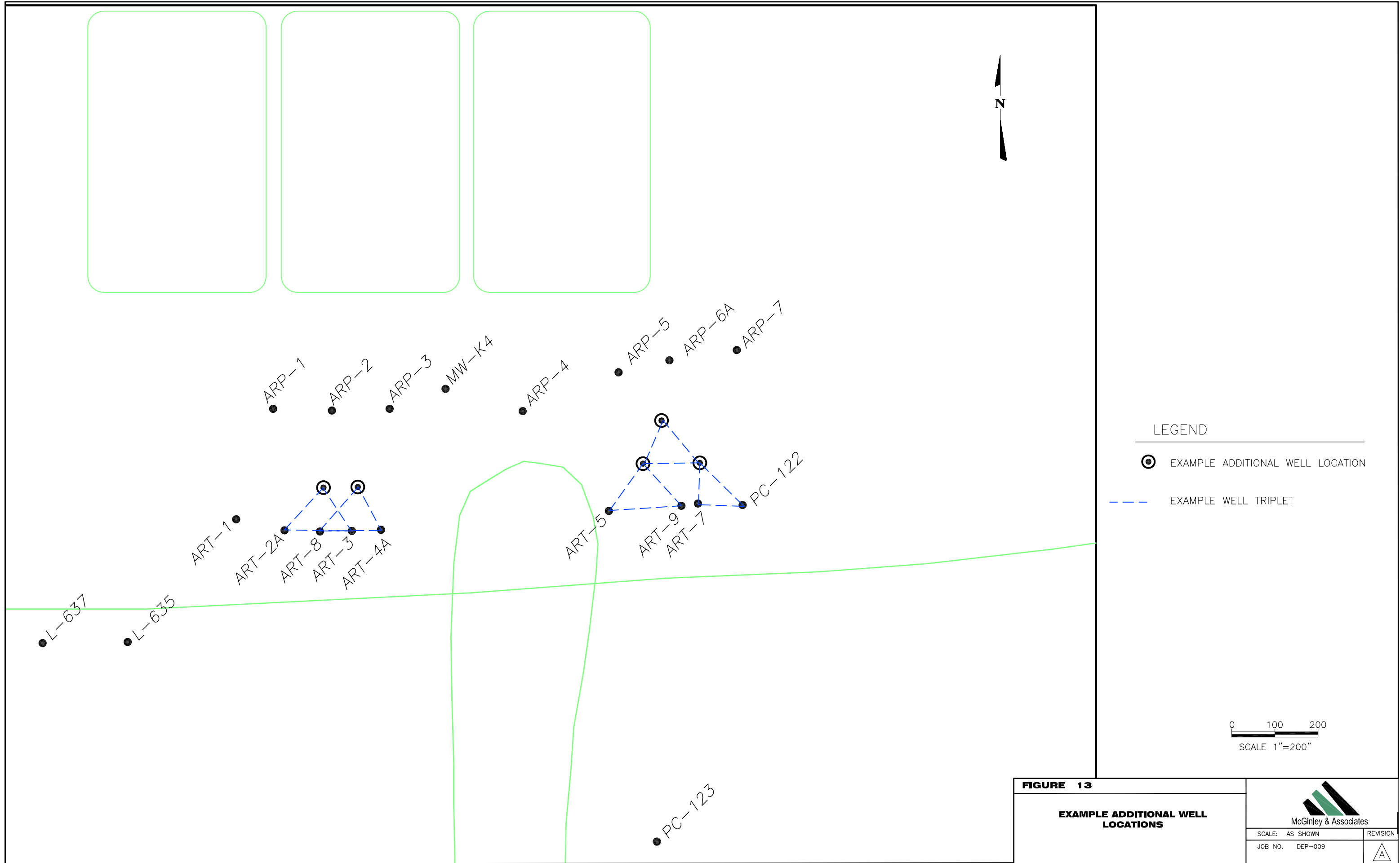


|   |          |  |
|---|----------|--|
| <b>FIGURE 11</b>                        |          | <br>McGinley & Associates |
| <b>PREDICTED GROUNDWATER FLOW PATHS</b> |          |  |
| SCALE: AS SHOWN                         | REVISION |  |
| JOB NO. DEP-009                         |          | A  |

PERCHLORATE CONCENTRATIONS (mg/L)



|   |                                  |                 |
|---|----------------------------------|-----------------|
| <p><b>FIGURE 12</b></p> <p><b>PRELIMINARY PREDICTED PERCHLORATE ISOPLETHS</b></p> | <p>McGinley &amp; Associates</p> |                 |
|   | SCALE: AS SHOWN                  | <b>REVISION</b> |
|   | JOB NO. DEP-009                  |                 |



**FIGURE 13**  
**EXAMPLE ADDITIONAL WELL LOCATIONS**

McGinley & Associates

|                 |          |
|-----------------|----------|
| SCALE: AS SHOWN | REVISION |
| JOB NO. DEP-009 | A        |

# **APPENDIX A**

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**Electronic Files:**

**Tronox Second Half 2006 Monitoring Report Figures,  
Project Working Directory**