Summary Report for
Updated Groundwater Flow Model Calibration
BMI Upper and Lower Ponds Area

Submitted to:

NDEP — Nevada Division of Environmental Protection
protecting the future for generations

November 2, 2009

Prepared for:

Basic Remediation Company

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Responsible CEM for this Project

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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Summary Report for Updated Groundwater Flow Model Calibration BMI Upper and Lower Ponds Area

1. Introduction

This report presents an update to the BRC Eastside groundwater flow model completed by Daniel B. Stephens & Associates, Inc. (DBS&A) on behalf of Basic Remediation Company (BRC) for submittal to the Nevada Division of Environmental Protection (NDEP). The BRC Eastside groundwater model, documented by DBS&A (2009a), was approved by NDEP on July 24, 2009, with the condition that simulated recharge beneath developed and undeveloped areas be adjusted prior to application of the model for additional purposes, such as solute transport. This report documents the implementation of the NDEP comments concerning recharge in the groundwater flow model. It is a summary report provided only to document the effects of changes in calibrated model recharge values, and it is not intended to be a comprehensive modeling report. Consequently, in order to review or use this report, the reader should also be familiar with or have available to them the previous groundwater modeling report (DBS&A, 2009a). The updated groundwater flow model documented in this report, once approved by NDEP, will serve as the basis for solute transport modeling as proposed in the solute transport modeling work plan (DBS&A, 2009b). A PDF file of this report and the updated groundwater flow modeling files are provided on DVD in Appendix A.

2. Groundwater Flow Model Update

NDEP requested that the current period simulation be updated to include different prescribed recharge values in the developed and undeveloped areas encompassed by the model (NDEP, 2009). Specifically, NDEP requested that prescribed recharge beneath undeveloped areas be reduced from 0.394 inch per year (in/yr), which is about 10 percent of the average annual precipitation of approximately 4 in/yr, to a maximum of about 2 percent of average annual precipitation (about 0.08 in/yr) or less. The results of previous simulations documented in DBS&A (2009a) indicate that this adjustment is feasible while maintaining a reasonable model calibration.

A series of Parameter ESTimation (PEST) (Watermark Numerical Computing, 2004) simulations were conducted for the current period simulation assuming a recharge value in the undeveloped areas of 0.08 in/yr (equivalent to 2 percent of average annual precipitation), reduced from the value of 0.394 in/yr in DBS&A (2009a). Assuming that the undeveloped area recharge was constant, PEST was used to estimate the recharge beneath developed areas required to maintain a reasonable model calibration. Once an updated developed area recharge was determined, PEST was then used to evaluate the undeveloped area recharge value. Final recharge values were selected for application after consideration of the updated model calibration results for each of these simulations in conjunction with the results of published recharge studies for arid environments. The remainder of this section presents a brief summary of the recharge literature identified and considered and the results of the model calibration update.

2.1 Summary Overview of Recharge Literature

A limited literature search was conducted to obtain references regarding the effects of urbanization (development) on groundwater recharge. The results of the literature search and reviews are summarized below. Although not exhaustive, it appears clear that in general, previous work indicates that urbanization tends to increase the groundwater recharge beneath the urbanized area relative to predevelopment recharge.

Lerner (1990) notes that urbanization alters all parts of the hydrological cycle such that no simple analysis of the effects on groundwater is possible. However, he suggests that many of the changes associated with urbanization will increase recharge where the development occurs over permeable ground. Lerner (1990) states that although this effect on the hydrologic system has been recognized in principle by many authors, the increases in groundwater recharge have rarely been quantified. Foster et al. (1994) estimated recharge in many cities around the world. They observed that in most cities the recharge that occurs beneath developed (urban) areas is about 2 to 10 times that which existed prior to urbanization.

Garcia-Fresca (2004) estimated recharge beneath the City of Austin, Texas, and found that recharge beneath the city under urbanized conditions was nearly double the estimated rate of recharge prior to development. Farther to the west in Texas, where the climate is more arid, recharge beneath the City of Lubbock was estimated to be about 16 times higher under urban conditions than it was under predevelopment conditions (DBS&A, 2007).

2.2 PEST Simulations

Six PEST simulations were conducted using different initial values of recharge in developed areas, ranging from 0.067 in/yr (as in the original model) to 3 in/yr. Three of the PEST simulations resulted in a developed area recharge of 0.57 in/yr, while the other three simulations resulted in an estimated developed area recharge of 1.87 in/yr. These results show that to a certain extent the PEST-identified recharge value is dependent on the initial value assumed, indicating that the posed optimization problem is nonlinear and that there are at least two local optimums in the parameter domain.

The developed recharge value of 1.87 in/yr provided slightly better calibration statistics for model layer 1 hydraulic heads than the 0.57 in/yr value. However, the developed area recharge rate of 0.57 in/yr provides a much better simulated extent of layer 1 dry areas than the 1.87 in/yr value. In addition, the developed area recharge value of 0.57 in/yr is approximately 7 times greater than the value used for recharge in undeveloped areas, which is in the approximate range of multipliers determined from published literature. The value of 1.87 in/yr is more than 20 times greater than the undeveloped area recharge of 0.08 in/yr, and is outside the range of differences between developed and undeveloped recharge determined in most of the existing case studies documented in the references reviewed in the previous section.

Another PEST simulation was performed in which developed area recharge was fixed at 0.57 in/yr and PEST was used to determine an optimum recharge value for undeveloped areas. This simulation resulted in an estimated undeveloped area recharge of 0.29 in/yr, which is equivalent to about 7 percent of average annual precipitation. Although this recharge value results in better model calibration statistics, it was rejected because it is higher than the maximum value required by NDEP (NDEP, 2009). This simulation does indicate, however, that in order to improve the existing model calibration, the PEST optimization code would increase (rather than decrease) recharge beneath undeveloped areas. For this reason, the initial value of approximately 2 percent of average annual precipitation was maintained.

As a result of all PEST simulations, it was found that a recharge value of 0.08 in/yr in undeveloped areas and 0.57 in/yr in the developed areas adequately addresses NDEP comments without compromising calibration statistics provided in DBS&A (2009a). The updated recharge distribution is illustrated in Figure 1. These results are consistent with DBS&A's previous PEST simulations (DBS&A, 2009a), in which we found a negative correlation between recharge values in both developed and undeveloped areas. This negative correlation between parameters led to similar calibration statistics with increasing developed areas recharge and decreasing undeveloped areas recharge. Details of the updated model calibration using the selected recharge rates for the developed and undeveloped areas are presented in the following section.

2.3 Updated Model Calibration Results

The details of the updated, recalibrated groundwater flow model are presented in this section. In order to present and document the update, a number of figures and tables presented in DBS&A (2009a) are reproduced based on the updated simulation results to (1) allow for detailed review of the groundwater flow model calibration, and (2) allow for easy comparison with prior simulation results. Table 1 provides the information required to cross-reference the tables and figures provided in this report with those provided in the previous groundwater flow model report (DBS&A, 2009a). Because this document is intended to be a brief report that presents the results of the updated model recharge, and because the updated model calibration results are generally very similar to those presented in DBS&A (2009a), detailed discussion on the model calibration is not included unless there is a noteworthy change in the revised model. For more detailed discussion of the model calibration results, see DBS&A (2009a).

The updated current period model calibration results were evaluated in terms of both observed hydraulic head and observed saturated thickness of the Quaternary alluvium (Qal), which is represented by model layer 1. A plot of simulated versus observed model layer 1 water levels for the updated model calibration is provided in Figure 2. Figure 2 shows a good agreement between simulated and observed water levels, with a mean absolute error (MAE) of 5.4 feet, a root mean squared error (RMSE) of 7.1 feet, and an RMSE divided by the range in observed water levels of 3 percent. In addition, the mean error (ME) is 1.9 feet, indicating that, on average, simulated water levels are 1.9 feet lower than observed water levels. The MAE, RMSE, and ME are all slightly greater than those reported in DBS&A (2009a). A complete listing of model calibration statistics is provided in Table 2, and observation well characteristics and model calibration results are listed in Table 3.

Figure 3 illustrates the distribution and magnitude of hydraulic head residuals (difference between simulated and observed values) for model layer 1, and Figure 4 illustrates the simulated model layer 1 hydraulic head field. As illustrated in Figure 4, significant portions of the model layer 1 are simulated as dry. At these locations, the simulated water table lies below the base of model layer 1 and is in model layer 2, the upper portion of the Upper Muddy Creek Formation (UMCf). Observation wells indicating dry Qal conditions are indicated on the figure, and there is a good correspondence between observed and simulated dry Qal zones at many locations, particularly in the eastern and southeastern portions of the model domain. At other locations, such as wells POD4, POD 7, AA-14, AA-15, and AA-19, saturated conditions are simulated where the Qal was observed to be dry in 2007 (Figure 4). As noted in Section 2.2, the extent of simulated dry cells was used to assist with the determination of the final assigned recharge value for developed area recharge.

The simulated current period saturated thickness, along with the distribution of saturated thickness residuals, is provided in Figure 5. The simulated saturated thickness ranges from 0 feet at dry cells up to 60 feet at portions of the northern boundary of the model domain. The comparison of simulated and observed saturated thickness provided in Figure 5 is based on the assumption that the bottom of the model cell is the base of the Qal for both simulated and observed values. The approach of using the base of the model cell to calculate both simulated and observed saturated thickness was followed to focus on the differences in saturated thickness attributable to differences between observed and simulated hydraulic head, rather than differences in discretization of the model layer 1 base elevation. This is the same approach followed in DBS&A (2009a).

A detailed listing of simulated and observed saturated thickness for the current period simulation is provided in Table 4. As indicated in the table, the mean observed and simulated saturated thickness values are very similar, at 22.3 feet and 20.7 feet, respectively. The ME of the saturated thickness is 1.6 feet, and the MAE of the saturated thickness is 7.5 feet, or about 34 percent of mean observed value. These values are nearly identical to those in DBS&A (2009a). Note that locations with zero saturated thickness are not included in the calculation.

A plot of simulated versus observed model layer 2 water levels for the updated current period model calibration is provided in Figure 6. Figure 6 shows good agreement between simulated and observed water levels, with an MAE of 8.7 feet, an RMSE of 12.4 feet, and an RMSE divided by the range in observed water levels of 5 percent. In addition, the ME is –0.8 foot, indicating that, on average, simulated water levels are very close to observed water levels. The MAE and RMSE are slightly greater than those reported in DBS&A (2009a), while the ME is significantly less than that reported in DBS&A (2009a). Additional calibration statistics for model layer 2 are provided in Table 2.

Figure 7 shows the spatial distribution of residuals for model layer 2, and Figure 8 shows the simulated hydraulic head field of model layer 2. Overall the simulated hydraulic head field for model layer 2 is similar to that presented in DBS&A (2009a). However, there is a concentration of monitor wells along the northern site boundary southwest of Tuscany and southeast of the Northern rapid infiltration basins (RIBs) where the difference in water levels increased significantly, from about 1 to 3 feet in DBS&A (2009a) to about 14 feet in the updated model. This limited area coincides with a local zone of dry cells in model layer 1 that did not occur in the previous model.

The updated current period simulation mass balance and the estimated range of values provided in the water balance technical memorandum (DBS&A, 2008) are summarized in Table 5. For the most part, the simulated mass balance is very similar to that of the previous model (DBS&A, 2009a, Table 6). As would be expected, the simulated recharge values for developed and undeveloped areas are significantly different, with the reduction in undeveloped area recharge of 10,851 cubic feet per day (ft^3/d) approximately offset by the increase in developed area recharge of 8,475 ft^3/d. The simulated mass balance error is very low, about 0.01 percent.

Figure 9 illustrates the simulated direction of groundwater flow between model layers 1 and 2, and Figure 10 illustrates the simulated direction of groundwater flow across the bottom of the model domain (bottom of model layer 2). Both of these figures are similar to those provided in DBS&A (2009a).

2.4 Comparison of Previous and Updated Model Simulation Results

Figure 11 presents a comparison of simulated dry cells for the previous and updated groundwater flow models. As indicated in the figure, the simulated distribution of dry cells between models is very similar, with the most significant difference being that the updated model has more simulated dry cells that occur along the margins of the zones of simulated dry cells in the previous model. This result makes sense because the undeveloped area recharge was decreased in the updated model.

Figure 12 is a plot of the simulated current period hydraulic head for the updated model minus the simulated hydraulic head for the previous model for model layer 1. With the exception of some limited areas, the simulated hydraulic head results for the updated model are within 2 feet of those simulated by the previous model. For the most part, the simulated hydraulic head is lower across the Upper Ponds area due to the reduction in recharge applied to the undeveloped areas.

Figure 13 is a plot of the simulated current period hydraulic head for the updated model minus the simulated hydraulic head for the previous model for model layer 2. As with model layer 1, across most of the model domain the difference in hydraulic head is less than 2 feet between the updated and previous models. The largest difference between models for model layer 2 is a decrease in simulated hydraulic head of more than 20 feet along the south-central portion of the Site boundary, approximately due north of the former spray wheel area. This local area corresponds with a region in model layer 1 where dry cells occur in the updated model, but did not occur in the previous model (Figure 11).

3. Updated Predictive Simulation Results

The base case predictive simulation was rerun using the updated groundwater flow model to estimate future water levels beneath the Site. Of particular interest is the potential for future water levels in the Qal (model layer 1) to intersect land surface. The predictive simulation is divided into three time periods as follows (DBS&A, 2009a):

- ***Period 1:*** January 2008 through July 2008. Assigned recharge is the same as that in the current period simulation, and evapotranspiration from phreatophytes is set to zero.

- ***Period 2:*** June 2008 through December 2011. Same conditions as Period 1, with the exception that use of the City of Henderson (CoH) Northern RIBs is stopped and the background recharge rate for undeveloped areas of 0.08 in/yr is applied over the area of the RIBs.

- ***Period 3:*** January 2012 through December 2107. Recharge prescribed according to the expected buildout conditions, including changes in land surface elevation across the Site.

The updated distribution of Period 2 and Period 3 recharge is illustrated in Figures 14 and 15, respectively. Figure 15 shows the assumed recharge for full buildout conditions of the BRC property. Most of the property is assigned a recharge rate of 0.57 in/yr, equivalent to the recharge determined during the current period model calibration for developed areas. Planned parks and green spaces (marked in green on the figure) are assigned a recharge of 8.67 in/yr, equivalent to that identified for the Tuscany golf course through model calibration. Birding Preserve recharge is maintained at 82.34 in/yr as was also identified during model calibration, although in the future, recharge from the Birding Preserve will likely decrease because less water will be sent there by the CoH. The recharge value of 82.34 in/yr is based on 1.6 million gallons per day (mgd) of water supplied to the Birding Preserve in 2005 and 2006 (DBS&A, 2009a), while future deliveries are expected to be approximately 1 mgd (Rakvica, 2009). If recharge were to decrease in direct proportion to water delivered (which may or may not be the case), future recharge from the Birding Preserve would be about 51.5 in/yr.

The amount of future pumping from the remediation well fields was allowed to vary during the predictive simulation in accordance with the saturated thickness in the model cell using the Fracture Well package in MODFLOW-SURFACT (HydroGeoLogic Inc., 1996). Using this option, the initial assigned total pumping for the AMPAC wells of 114 gallons per minute (gpm) was reduced in the simulation to 66 gpm, and the initial assigned total pumping for the Tronox wells of 191 gpm was reduced in the simulation to 175 gpm. Although the reduction in pumping occurs through time in accordance with the decrease in saturated thickness in the model cells that contain the pumping wells, most of the simulated reduction in pumping occurs during Period 2 of the predictive simulation, which has a duration of about 3.5 years. In addition, because the simulated pumping from the AMPAC well field is reduced by 48 gpm during the simulation, the assigned recharge from the AMPAC injection wells is also reduced by 48 gpm beginning at the start of Period 3.

In addition to recharge and remediation well field pumping, the land surface elevation across the BRC property was adjusted at 2012 to represent planned buildout conditions. In general, changes in land surface elevation are not substantial. All other model inputs and boundary conditions are maintained at current period simulation values for the entire period of the predictive simulations. The initial conditions for the predictive simulation are the simulated hydraulic head values from the current period simulation.

The simulated hydraulic head at the end of the predictive simulation period (2107) is provided in Figure 16 for model layer 1. Although the predicted hydraulic heads at 100 years in the future are used in the figure, the simulated water levels at about 20 to 25 years in the future are nearly the same (within several feet) as those shown in Figure 16. Comparison of Figure 16 with Figure 4 indicates that simulated hydraulic heads in model layer 1 are predicted to increase in the Upper Ponds area due to increased applied recharge, but generally decrease in the Western Hook area and south of the Western Hook due to continued pumping at the Tronox Athens Road and AMPAC well fields. Note also the reduced number of dry cells in the Upper Ponds area indicated in Figure 16 relative to those indicated in Figure 4. .

Figure 17 illustrates the simulated hydraulic head for model layer 2 as of 2107. For the most part, simulated future water levels in model layer 2 are similar to those of the current period simulation (Figure 8). In the vicinity of the Tronox Athens Road well field, however, predicted hydraulic heads are significantly reduced, apparently due to continued extraction of groundwater from the well field, which is in model layer 1. Simulated hydraulic heads southwest of Tuscany along the northern Site boundary increase due to the increase in assigned recharge to model layer 1.

Figure 18 is a plot of flooded cells (model cells where the simulated water level is equal to or above land surface) for 2107. The only flooded cells that occur are in the northwest corner of Tuscany Village; none of the simulated flooded cells are on the BRC property.

Figure 19 is a plot of the predicted change in the water table from the current period simulation (2007) through the end of the predictive simulation in 2107. Because the plot represents simulated change in the water table, it is not necessarily representative of water levels exclusively in model layer 1 (Qal) or 2 (upper portion of the UMCf). Also indicated in the figure are cells where the Qal is dry in 2107; the plotted change in water table elevation at these cells occurs exclusively in the UMCf beneath the Qal.

As illustrated in Figure 19, changes of less than 5 feet are predicted in large portions of the model domain. Significant declines in the water table are predicted in the vicinity of the CoH Northern RIBs and the Tronox Athens road well field, as well as along the major paleochannel in which the well field is completed. This result is expected due to the elimination of enhanced infiltration at the RIBs and continued pumping at the well field. In the Upper Ponds area of the Site, the water table is predicted to rise about 4 to 8 feet north and east of the former TIMET Ponds, and larger rises up to 30 feet are simulated in local areas along the northern site boundary. Note that these regions of greatest simulated water table rise occur where the Qal is simulated as dry for the current period simulation (Figure 4); therefore, a portion of the rise occurs within the UMCf, and at some locations the rise is exclusively within the UMCf. The simulated rise in the water table occurs due to the higher prescribed recharge applied under site buildout conditions.

4. Summary and Conclusions

The BRC Eastside groundwater model was updated based on comments received from the NDEP. Specifically, the assigned recharge used for undeveloped areas in the current period simulation was adjusted to the maximum value requested by NDEP of 0.08 in/yr, and the recharge used for developed areas was adjusted to 0.57 in/yr in order to maintain model calibration. The feasibility of adjusting the recharge as described while maintaining a reasonable model calibration had already been identified and documented by DBS&A (2009a). The final adjusted values of recharge were identified and confirmed using PEST simulations, and the reasonableness of the identified recharge values and relative magnitude are supported by cited recharge studies.

The base-case predictive simulation presented by DBS&A (2009a) was re-run using the updated recharge values identified in this report. Some other adjustments, such as the determination of pumping from remediation well fields in accordance with simulated saturated thickness, were also incorporated into the predictive simulation. The updated predictive simulation results show continued water table declines in the Western Hook, the Tronox Athens Road well field, and the CoH Northern RIB areas and water table rises of more than 20 feet in some limited portions of the Upper Ponds area. The updated model and predictive simulation re-confirm DBS&A's previous conclusion (2009a) that flooding at the land surface due to changes in recharge resulting from development should not be a concern.

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Figures

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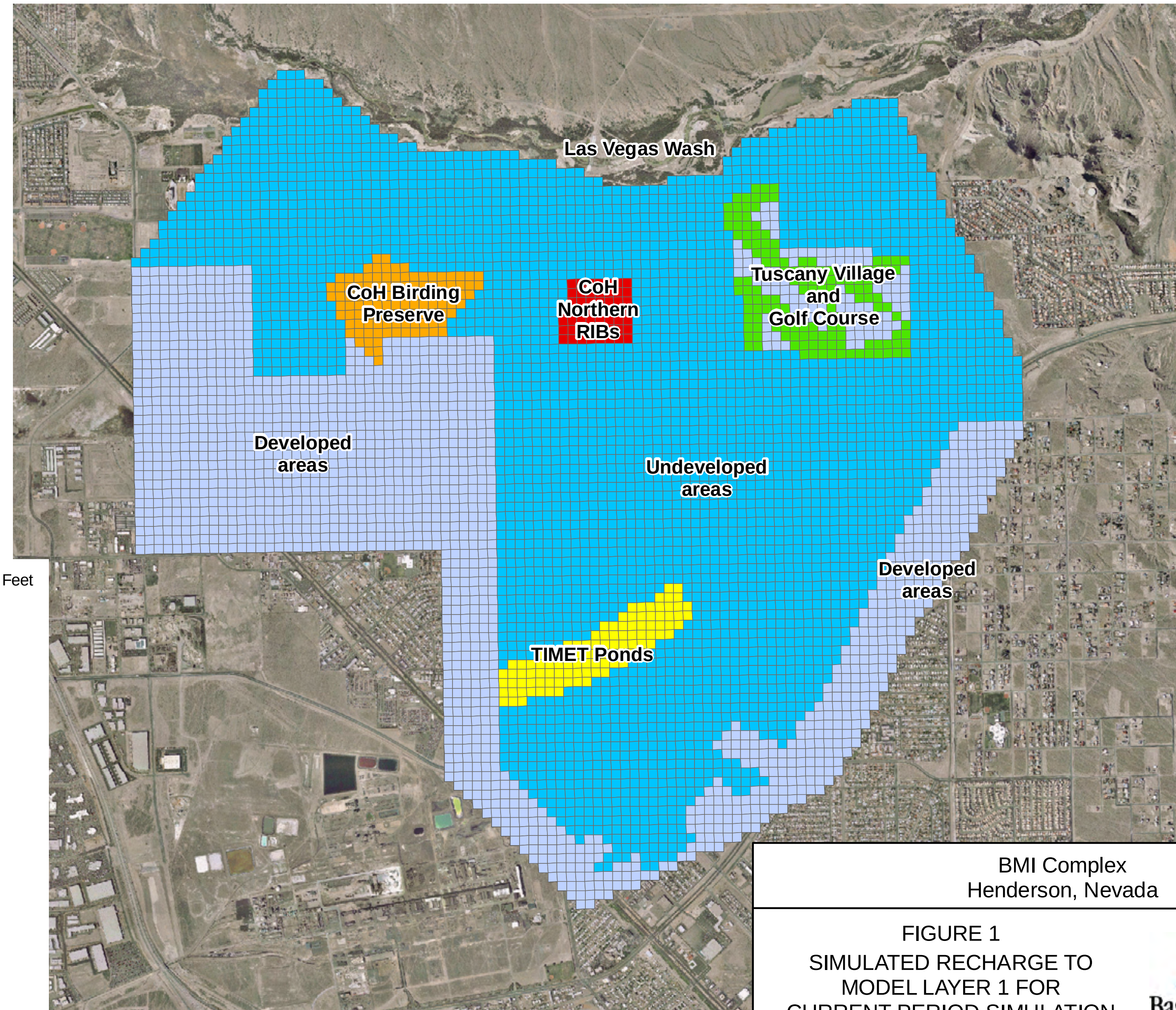

N

0 1,750 3,500 Feet

Explanation

Simulated recharge rate (in/yr)

- 0.08
- 0.57
- 2.475
- 8.672
- 82.344
- 291.270
- Model grid

Source: Aerial photograph, April 2004

BMI Complex
Henderson, Nevada

FIGURE 1
SIMULATED RECHARGE TO MODEL LAYER 1 FOR CURRENT PERIOD SIMULATION

Basic Remediation COMPANY

Prepared by: DBS&A GJ

Date 10/23/09

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Daniel B. Stephens & Associates, Inc.
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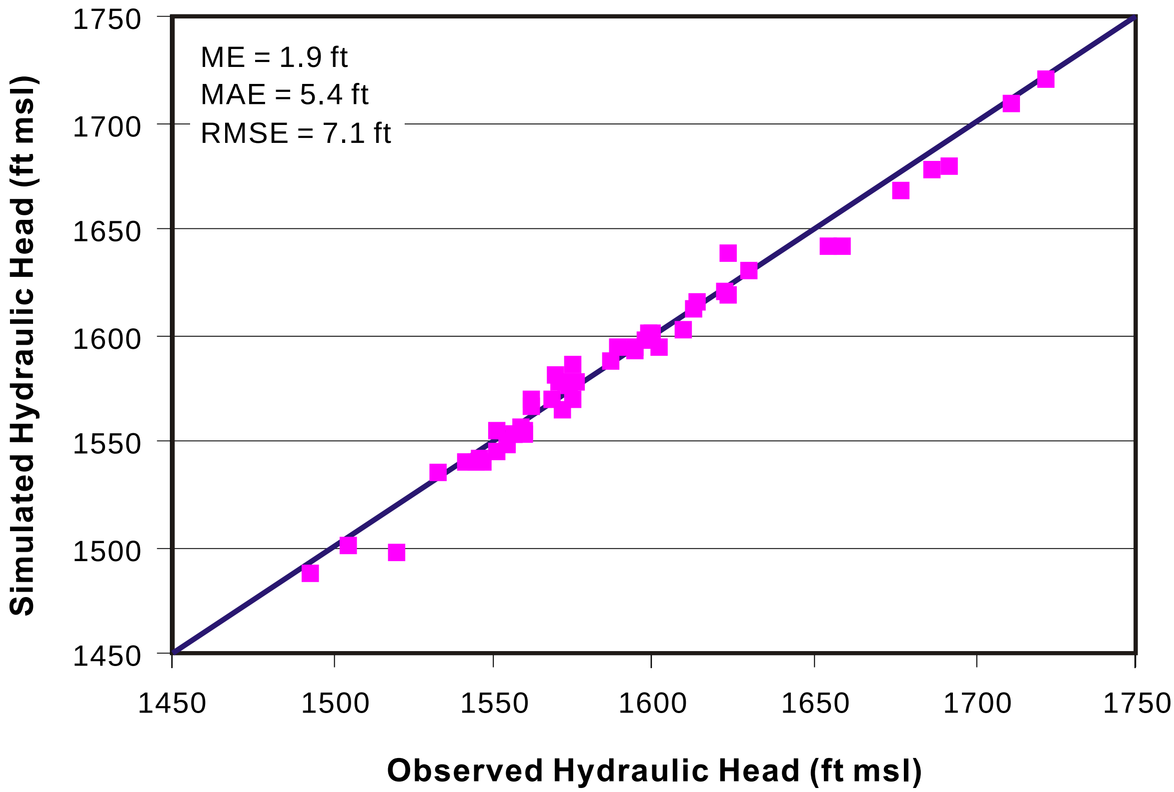
Figure 1



BMI Complex
Henderson, Nevada

FIGURE 2
SIMULATED VERSUS
OBSERVED HYDRAULIC HEADS
FOR MODEL LAYER 1 FOR
CURRENT PERIOD SIMULATION

Basic Remediation COMPANY

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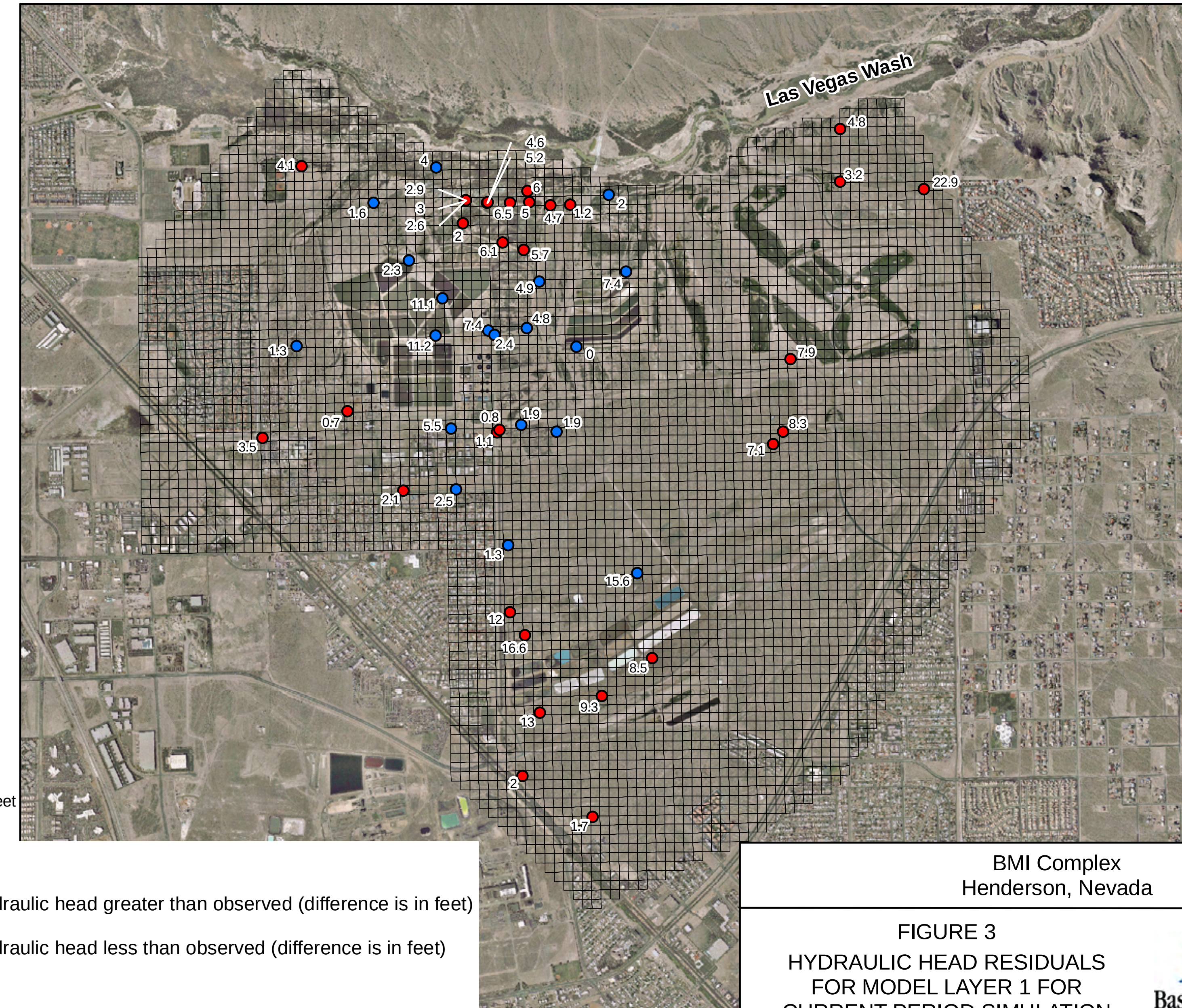

N

0 1,750 3,500 Feet

Explanation

15.6 Simulated hydraulic head greater than observed (difference is in feet)

7.1 Simulated hydraulic head less than observed (difference is in feet)

Model grid

Source: Aerial photograph, April 2004

Daniel B. Stephens & Associates, Inc.
JN ES09.0057

BMI Complex
Henderson, Nevada

FIGURE 3
HYDRAULIC HEAD RESIDUALS
FOR MODEL LAYER 1 FOR
CURRENT PERIOD SIMULATION

Basic Remediation
COMPANY

Prepared by: DBS&A MK

Date 10/23/09

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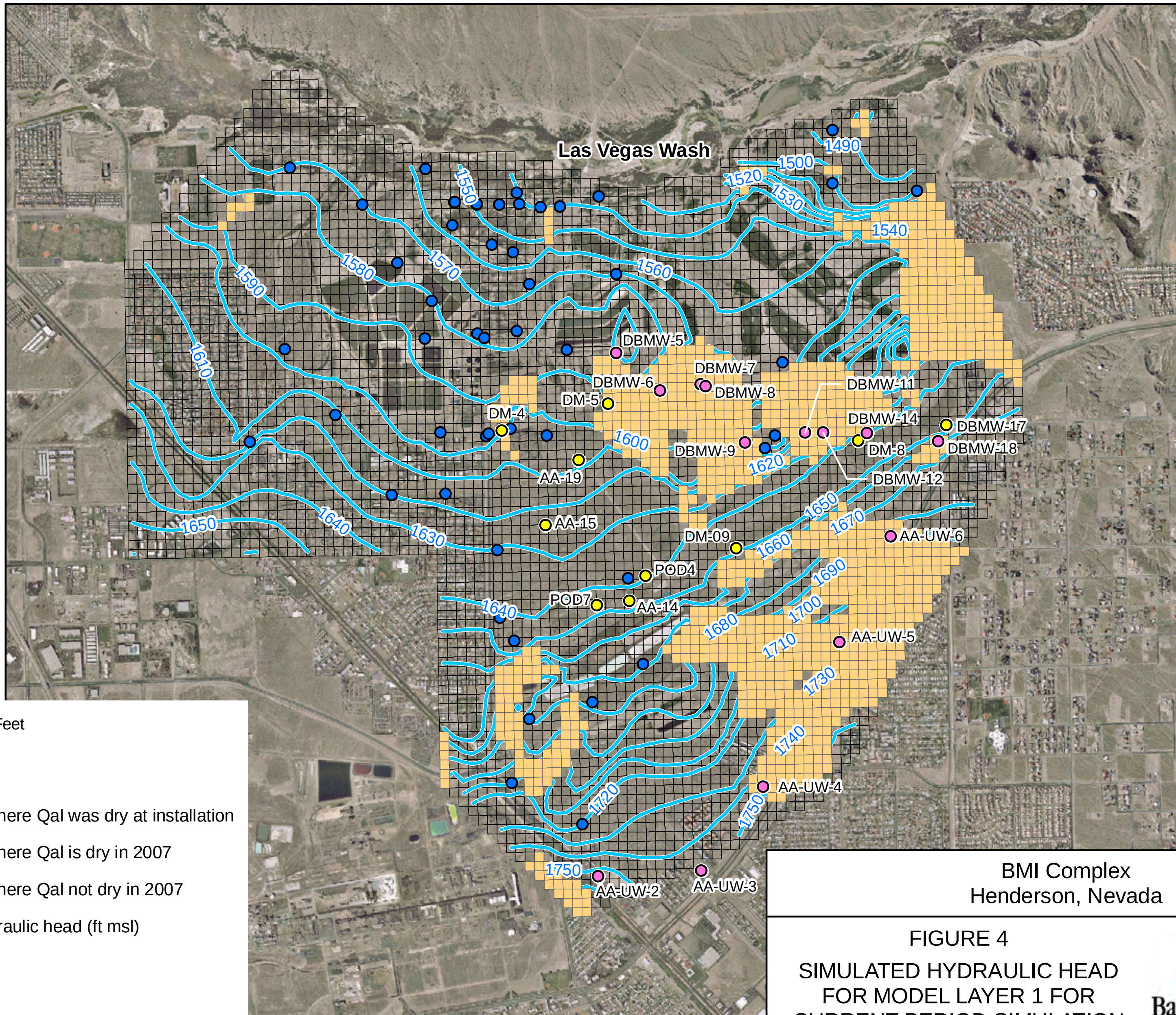
Figure 3



Explanation

- Monitor well where Qal was dry at installation
- Monitor well where Qal is dry in 2007
- Monitor well where Qal not dry in 2007
- Simulated hydraulic head (ft msl)
- Dry cells
- Model grid

Source: Aerial photograph, April 2004

BMI Complex
Henderson, Nevada

FIGURE 4

SIMULATED HYDRAULIC HEAD FOR MODEL LAYER 1 FOR CURRENT PERIOD SIMULATION

Basic Remediation COMPANY

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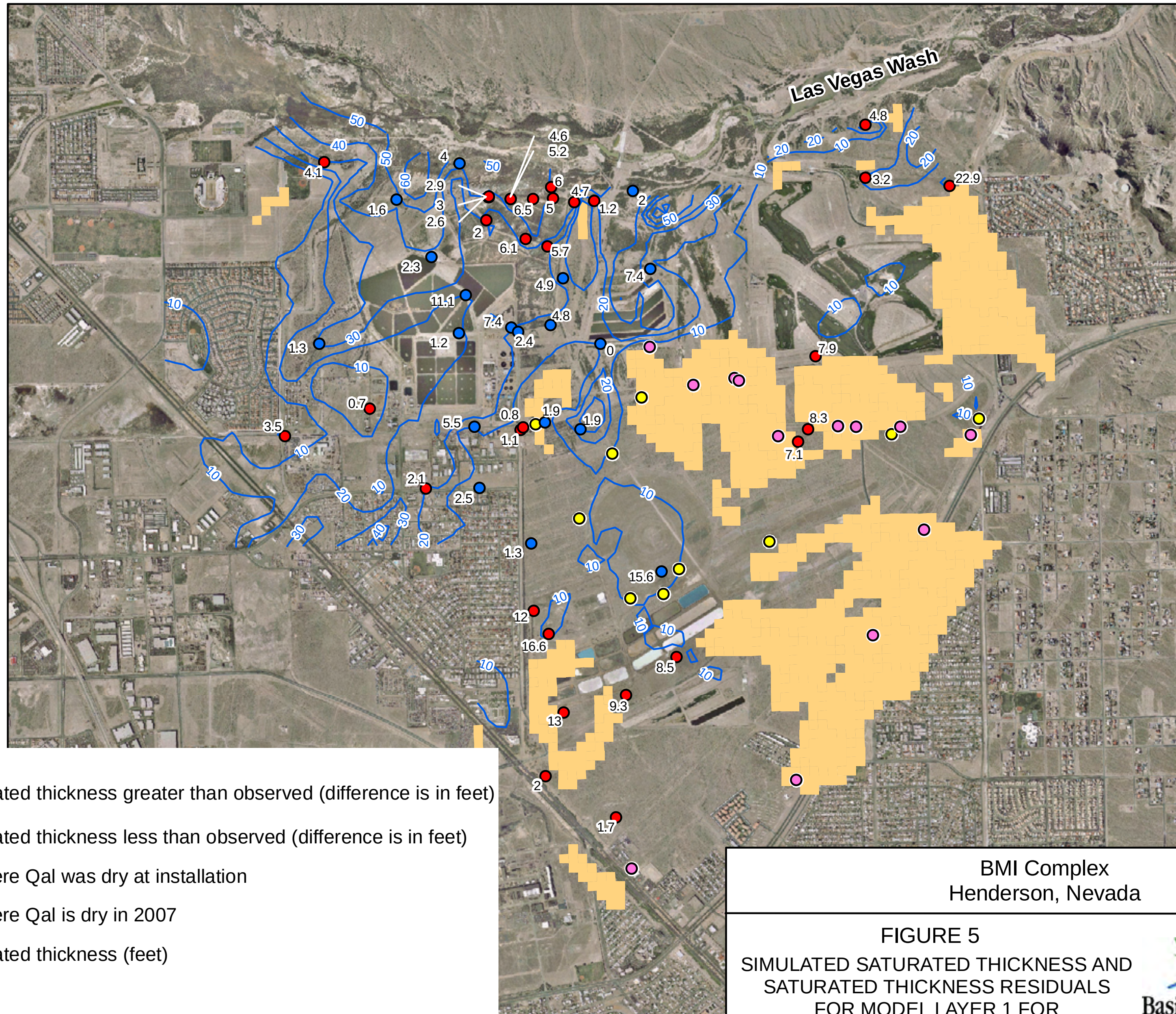
DBS&A MK	10/23/09	S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG04_SIM_HYD_HEAD_MODEL_LAYER_1_CUR_PER_SIM.MXD 903201

Figure 4

Daniel B. Stephens & Associates, Inc.
JN ES09.0057



N

0 1,750 3,500 Feet

Explanation

- 15.6 Simulated saturated thickness greater than observed (difference is in feet)
- 7.1 Simulated saturated thickness less than observed (difference is in feet)
- Monitor well where Qal was dry at installation
- Monitor well where Qal is dry in 2007
- Simulated saturated thickness (feet)
- Dry cells

Source: Aerial photograph, April 2004

BMI Complex
Henderson, Nevada

FIGURE 5

SIMULATED SATURATED THICKNESS AND SATURATED THICKNESS RESIDUALS FOR MODEL LAYER 1 FOR CURRENT PERIOD SIMULATION

Basic Remediation COMPANY

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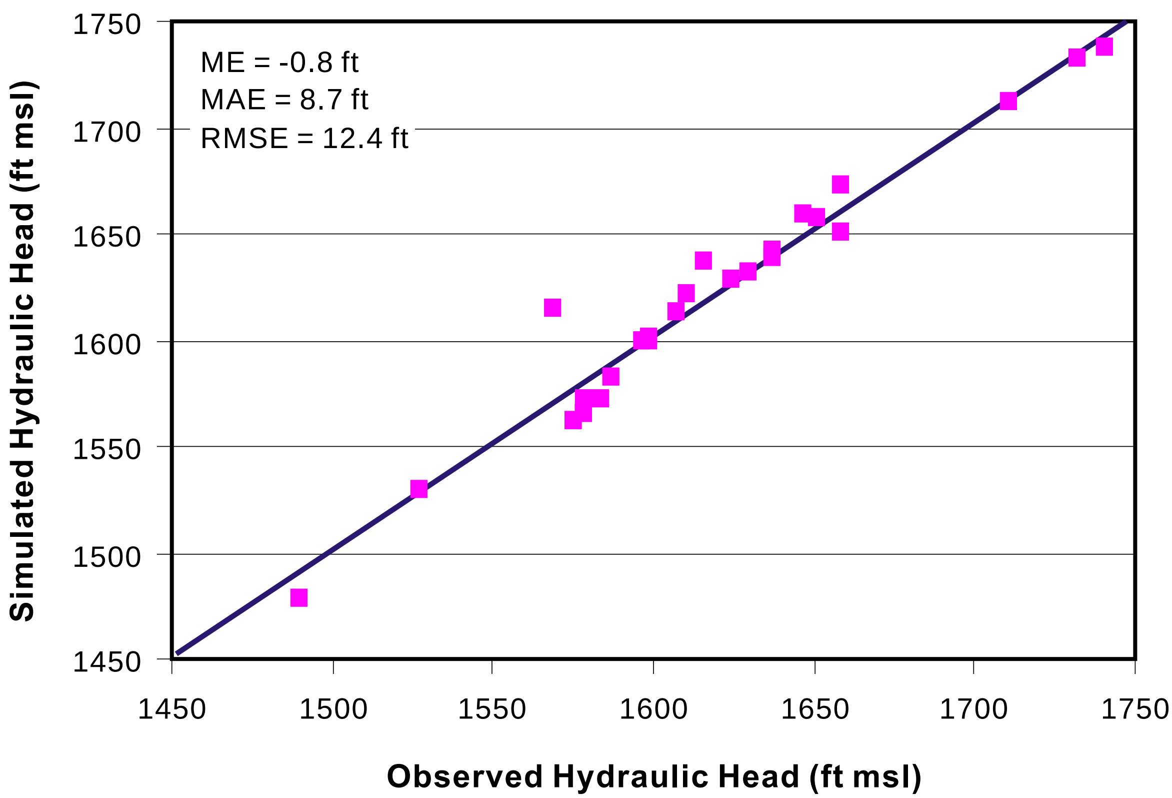
JN ES09.0057



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BMI Complex
Henderson, Nevada

FIGURE 6
SIMULATED VERSUS
OBSERVED HYDRAULIC HEADS
FOR MODEL LAYER 2 FOR
CURRENT PERIOD SIMULATION

Basic Remediation COMPANY

Prepared by: DBS&A MNW	Date 10/23/09	S:/PROJECTS/BRC/ES09.0057_BRC_GROUNDWATER_MODELING/VDR_DRAWINGS\FIG06_SIM_VS_OBSER_MOD_LAYER_1_CUR_PER_SIM.CDR

Daniel B. Stephens & Associates, Inc.
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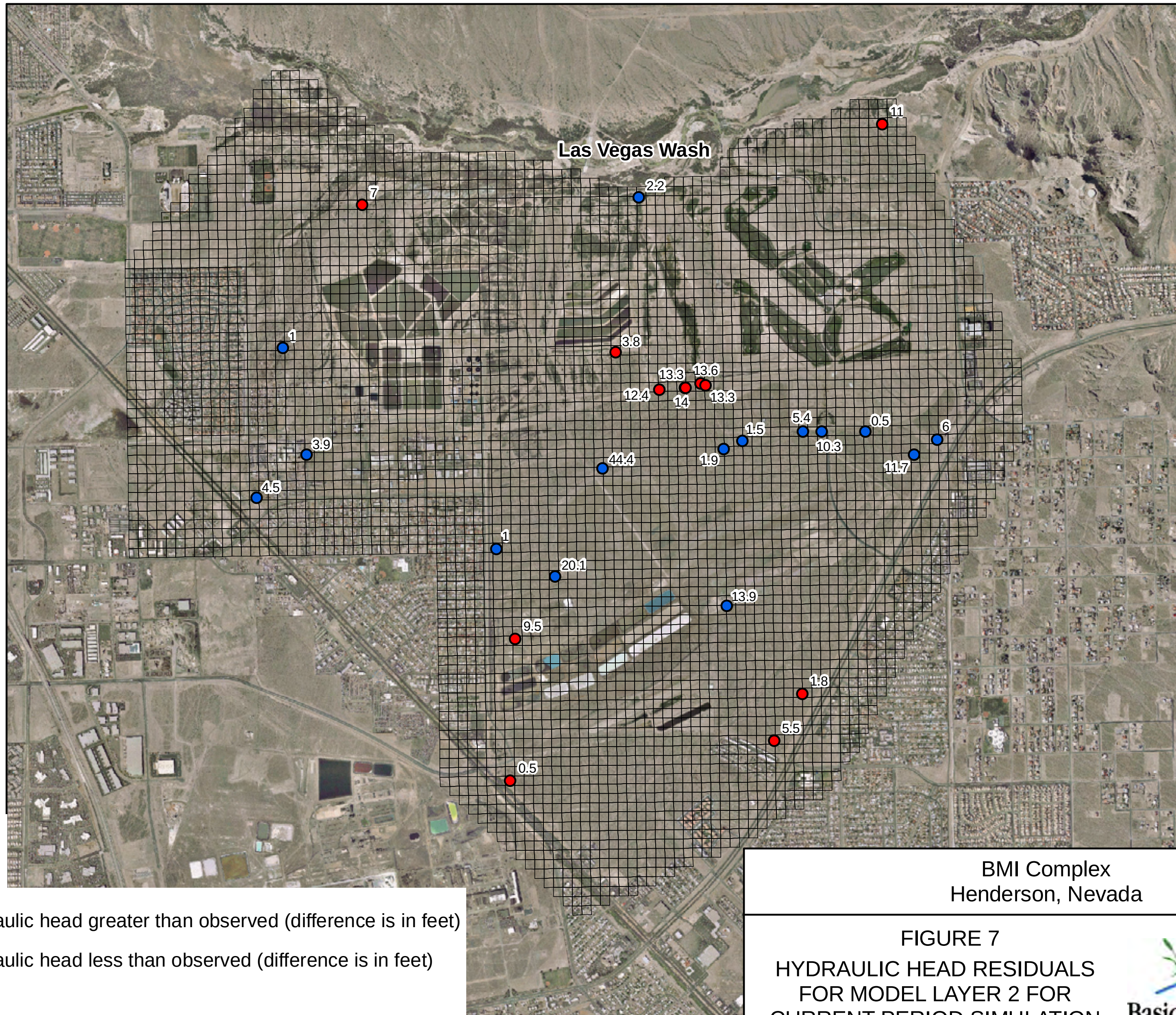


N

0 1,750 3,500 Feet

Explanation

- 1 Simulated hydraulic head greater than observed (difference is in feet)
- 0.5 Simulated hydraulic head less than observed (difference is in feet)
- Model grid

Source: Aerial photograph, April 2004

Daniel B. Stephens & Associates, Inc.
JN ES09.0057

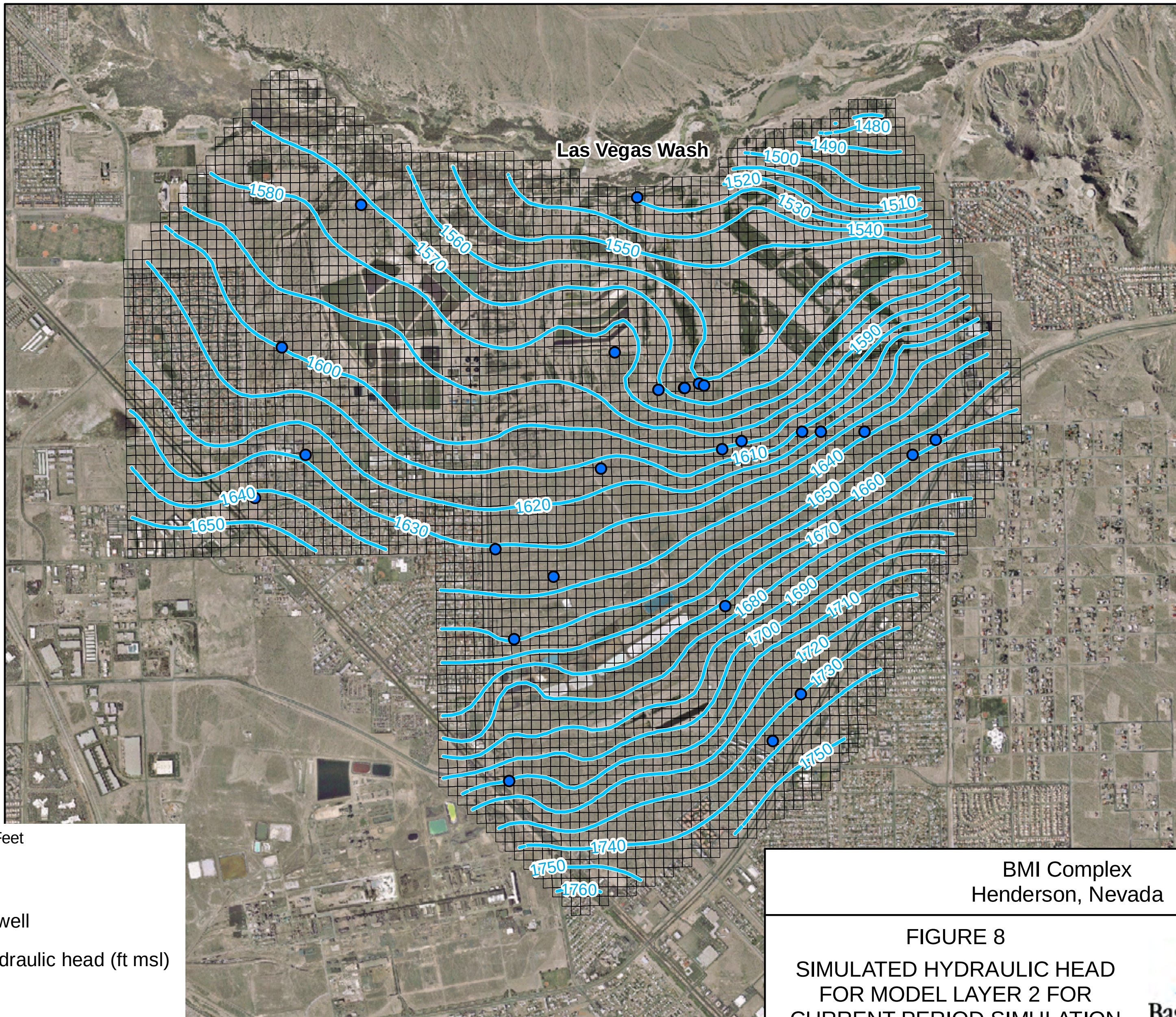
BMI Complex
Henderson, Nevada

FIGURE 7
HYDRAULIC HEAD RESIDUALS FOR MODEL LAYER 2 FOR CURRENT PERIOD SIMULATION

Basic Remediation COMPANY

Prepared by:		Date	
DBS&A	MW	10/27/09	S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/ REPORT_FIGURES_10-09/FIG23_LOC_OBSER_MODEL_LAYER _2_HYD_HEAD_RESIDUALS_DATA_CUR_PER_SIM.MXD 907201

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG08_SIM_HYD_HEAD_MODEL_LAYER_2_CUR_PER_SIM.MXD 903201



N

0 1,750 3,500 Feet

Explanation

- Observation well
- Simulated hydraulic head (ft msl)
- Model grid

Source: Aerial photograph, April 2004

BMI Complex
Henderson, Nevada

FIGURE 8

SIMULATED HYDRAULIC HEAD FOR MODEL LAYER 2 FOR CURRENT PERIOD SIMULATION

Basic Remediation COMPANY

Prepared by:	Date	
DBS&A GJ	10/23/09	S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG08_SIM_HYD_HEAD_MODEL_LAYER_2_CUR_PER_SIM.MXD 903201

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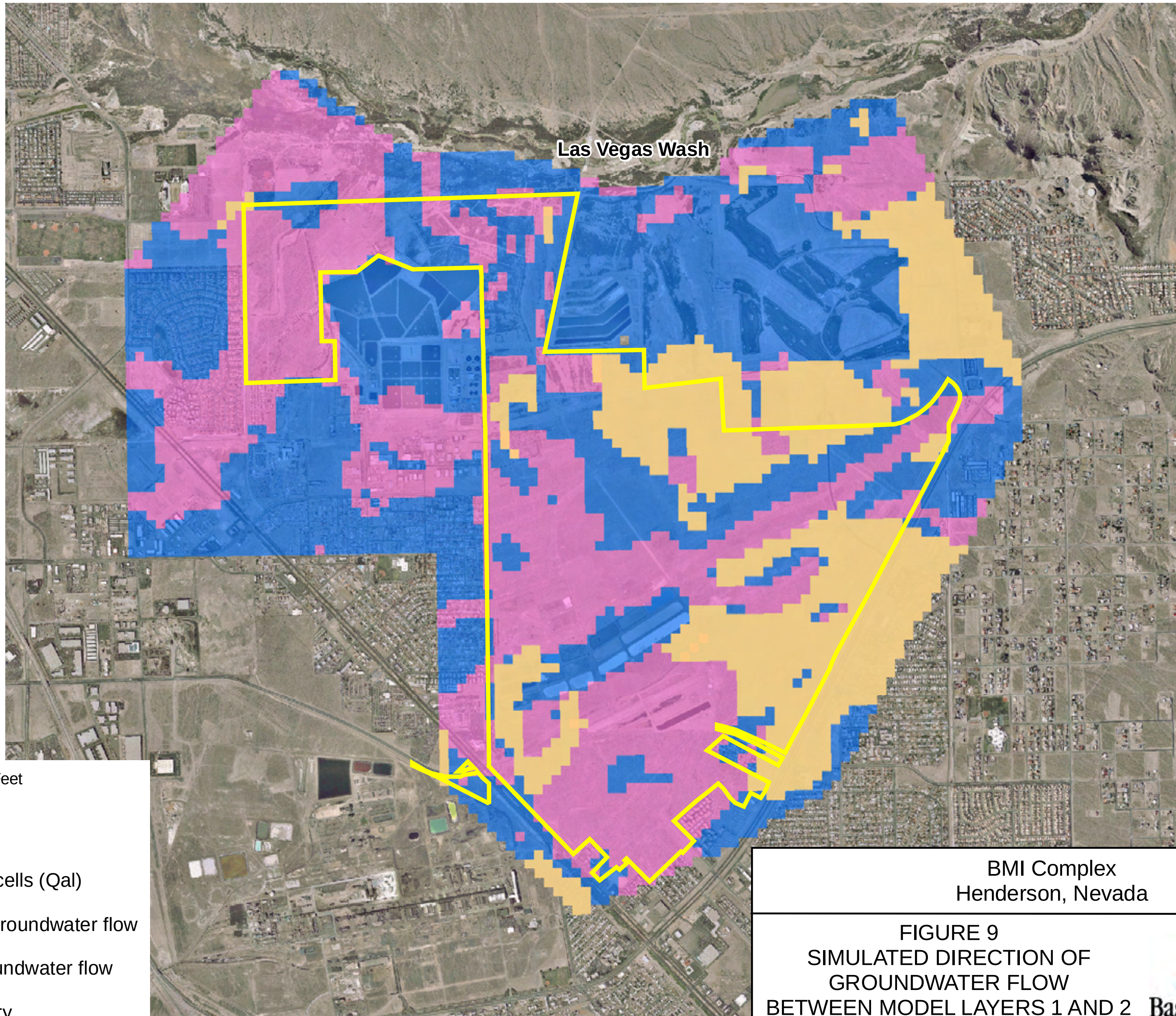
Figure 8

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG09_SIM_DIR_GW_FLOW_MOD_LAYERS_1-2.MXD 903201



Explanation

- Layer 1 dry cells (Qal)
- Downward groundwater flow
- Upward groundwater flow
- Site boundary

Source: Aerial photograph, April 2004

BMI Complex
Henderson, Nevada

FIGURE 9
SIMULATED DIRECTION OF GROUNDWATER FLOW BETWEEN MODEL LAYERS 1 AND 2 FOR CURRENT PERIOD SIMULATION

Basic Remediation COMPANY

Prepared by: DBS&A MK

Date 10/23/09

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG09_SIM_DIR_GW_FLOW_MOD_LAYERS_1-2.MXD 903201

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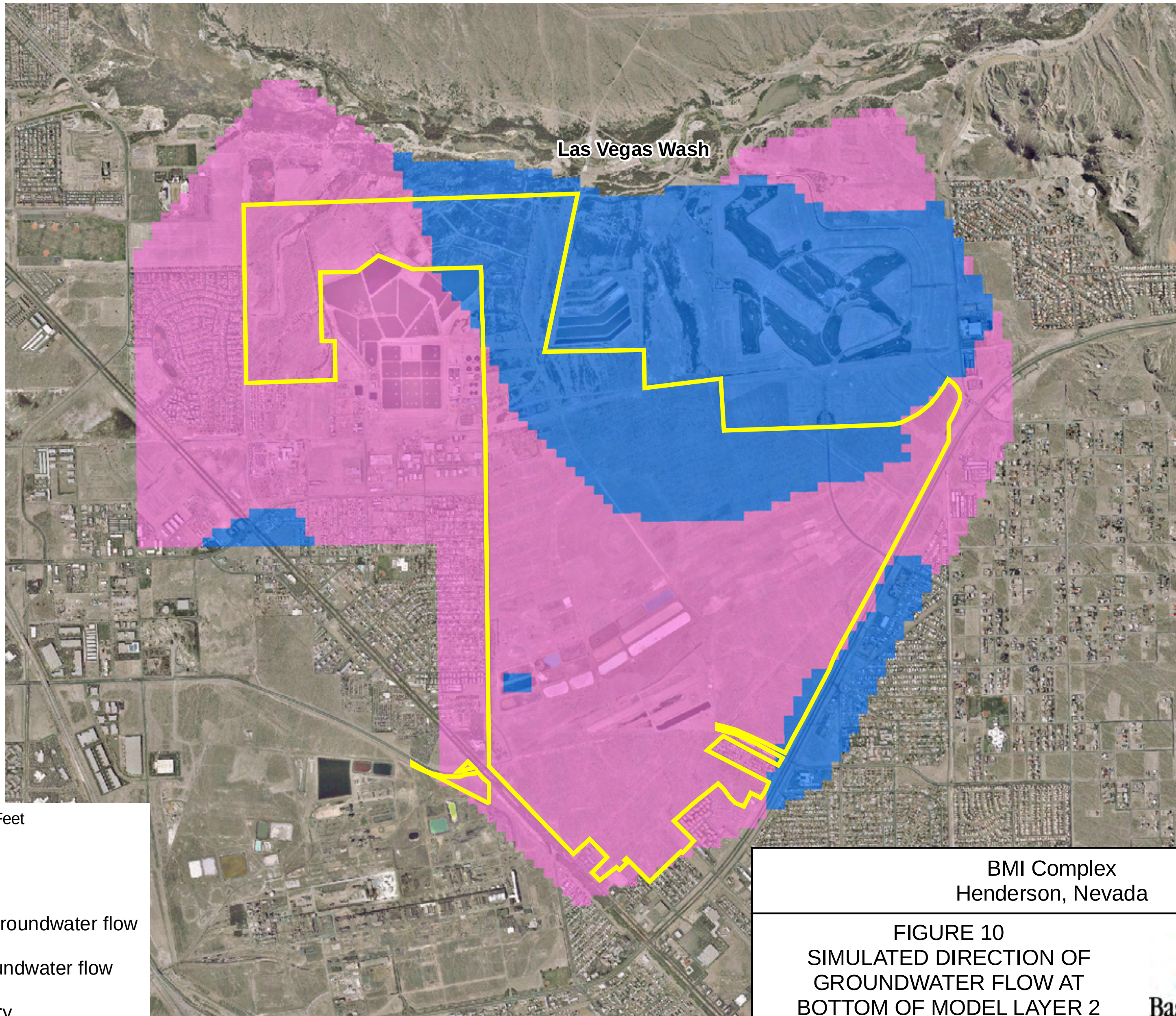
Figure 9

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG10_SIM_DIR_GW_FLOW_MOD_BOT_LAYER_2.MXD 903201



Explanation

- Downward groundwater flow
- Upward groundwater flow
- Site boundary

Source: Aerial photograph, April 2004

BMI Complex
Henderson, Nevada

FIGURE 10
SIMULATED DIRECTION OF GROUNDWATER FLOW AT BOTTOM OF MODEL LAYER 2 FOR CURRENT PERIOD SIMULATION

Basic Remediation COMPANY

Prepared by:		Date	
DBS&A	MK	10/23/09	S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG10_SIM_DIR_GW_FLOW_MOD_BOT_LAYER_2.MXD 903201

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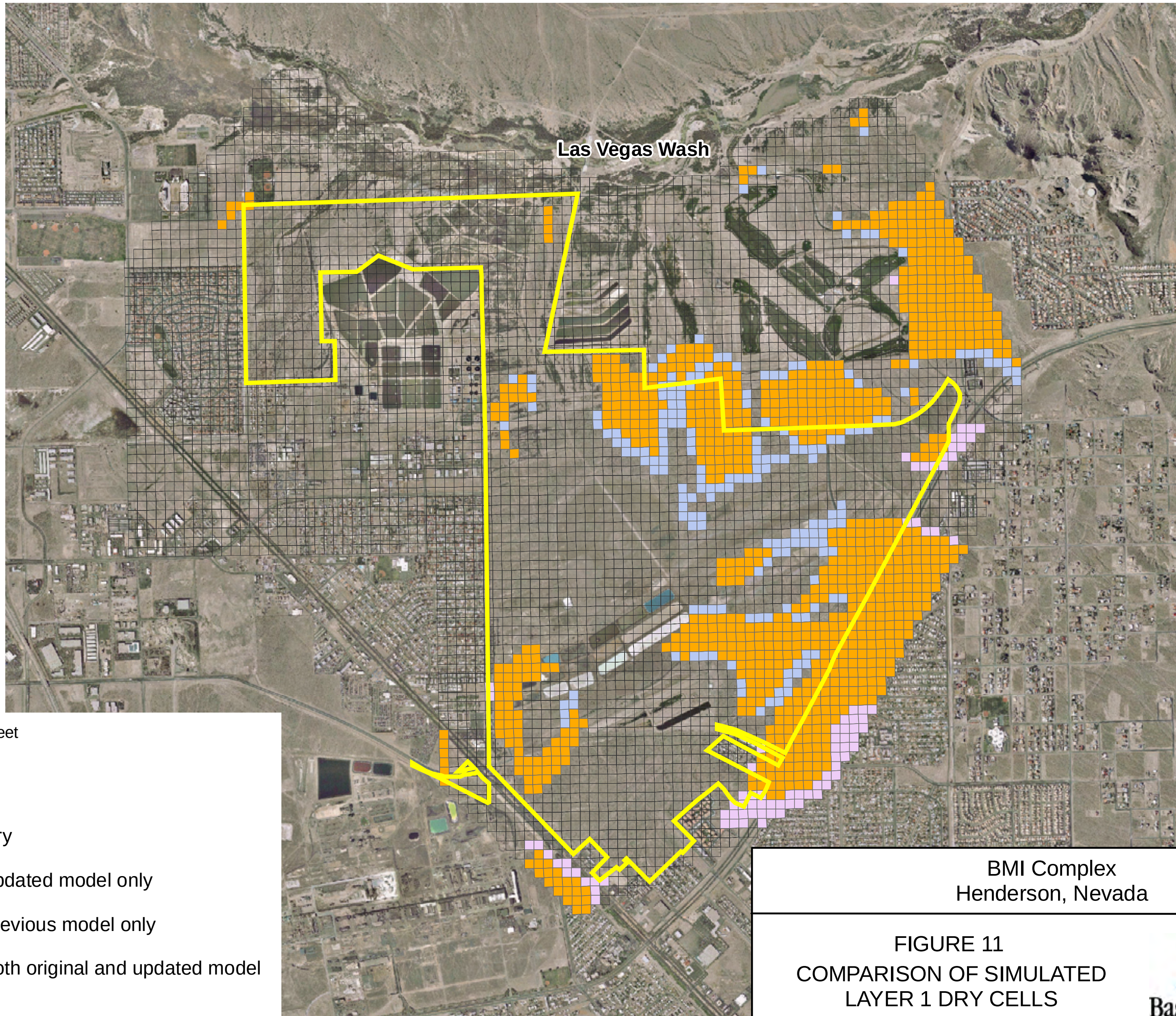
JN ES09.0057

Figure 10

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG11_ORIGINAL_UPDATED_MODELS_COMPARISON_DRYCELLS_LAYER_.MXD 907201



Source: Aerial photograph, April 2004

Explanation

- Site boundary
- Dry cell in updated model only
- Dry cell in previous model only
- Dry cell in both original and updated model
- Model grid

BMI Complex
Henderson, Nevada

FIGURE 11
COMPARISON OF SIMULATED
LAYER 1 DRY CELLS

Basic Remediation
COMPANY

Prepared by: DBS&A MK

Date 10/27/09

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG11_ORIGINAL_UPDATED_MODELS_COMPARISON_DRYCELLS_LAYER_.MXD 907201

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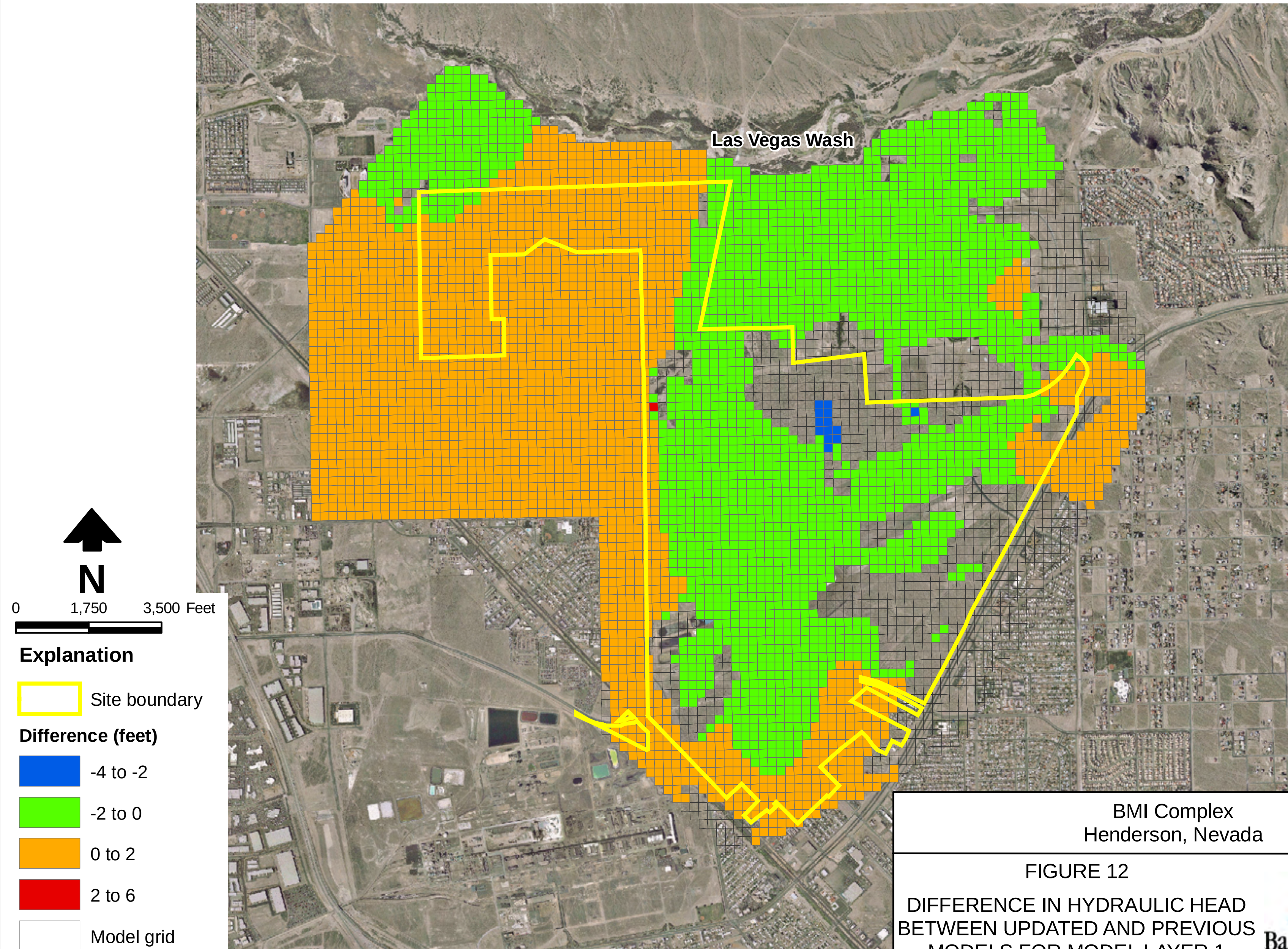
JN ES09.0057

Figure 11

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG12_ORIGINAL_UPDATED_MODELS_COMPARISON_LAYER_1.MXD 907201



Source: Aerial photograph, April 2004

BMI Complex
Henderson, Nevada

FIGURE 12

DIFFERENCE IN HYDRAULIC HEAD BETWEEN UPDATED AND PREVIOUS MODELS FOR MODEL LAYER 1

Basic Remediation COMPANY

Prepared by: DBS&A MK

Date 10/27/09

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG12_ORIGINAL_UPDATED_MODELS_COMPARISON_LAYER_1.MXD 907201

Daniel B. Stephens & Associates, Inc.
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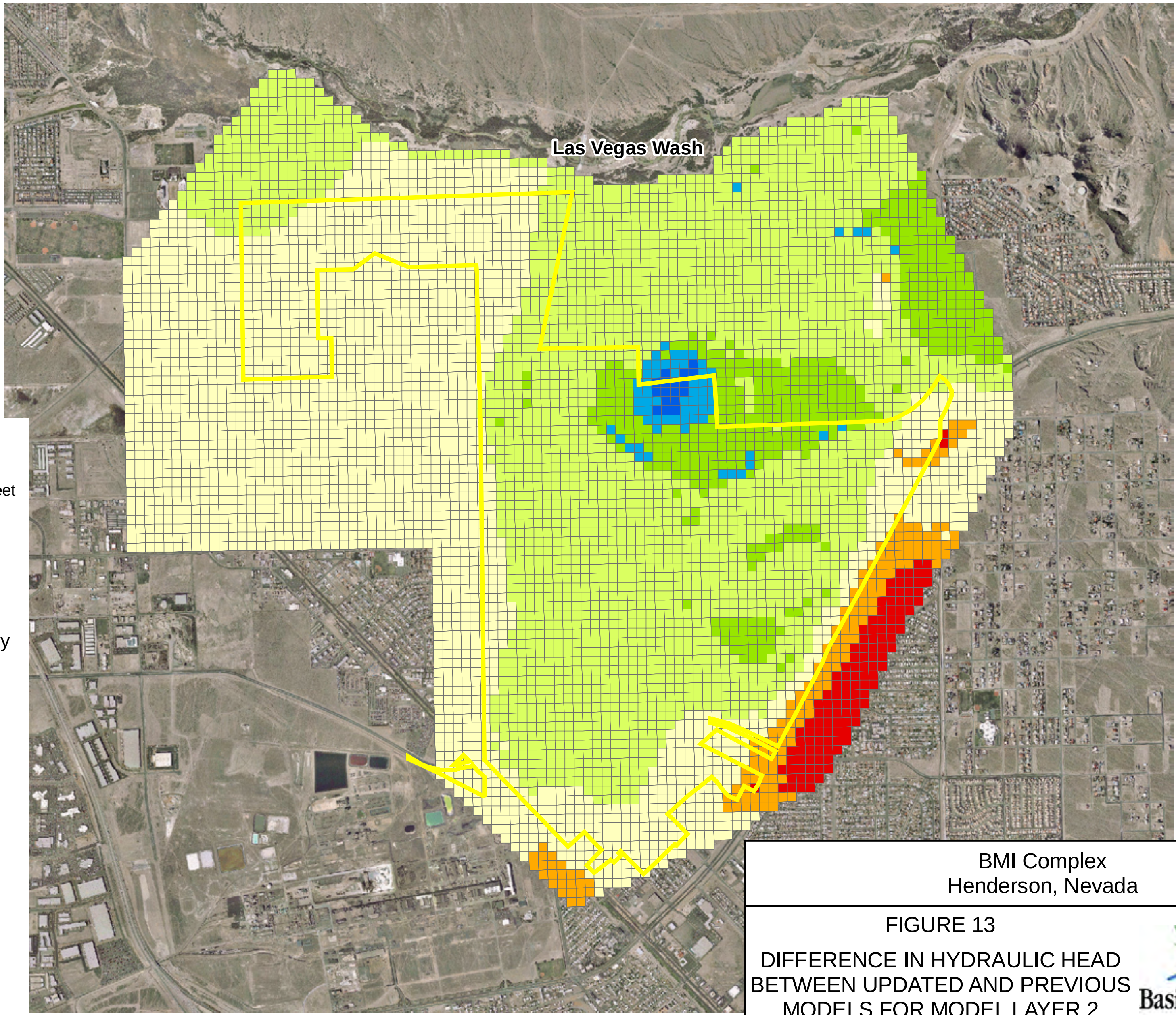


Explanation

Site boundary

Difference (feet)

- -25 to -15
- -15 to -8
- -8 to -2
- -2 to 0
- 0 to 2
- 2 to 6
- 6 to 11

Source: Aerial photograph, April 2004

BMI Complex
Henderson, Nevada

FIGURE 13

DIFFERENCE IN HYDRAULIC HEAD BETWEEN UPDATED AND PREVIOUS MODELS FOR MODEL LAYER 2

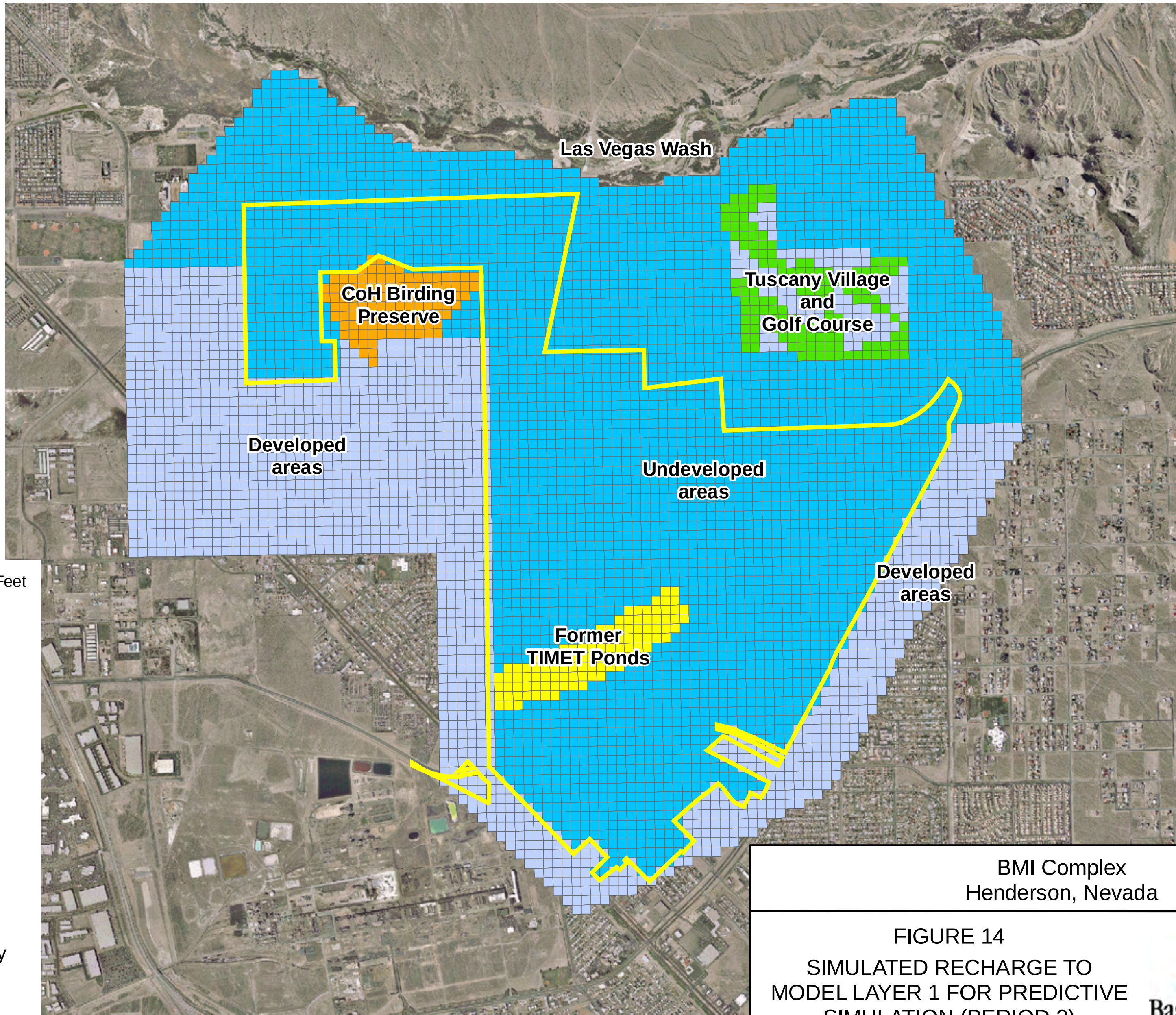
Basic Remediation COMPANY

Prepared by: DBS&A MK

Date 10/27/09

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG13_ORIGINAL_UPDATED_MODELS_COMPARISON_LAYER_2.MXD 907201

Daniel B. Stephens & Associates, Inc.
JN ES09.0057



Explanation

Simulated recharge rate (in/yr)

- 0.08
- 0.57
- 2.475
- 8.672
- 82.344
- Site boundary
- Model grid

Source: Aerial photograph, April 2004

BMI Complex
Henderson, Nevada

FIGURE 14
SIMULATED RECHARGE TO MODEL LAYER 1 FOR PREDICTIVE SIMULATION (PERIOD 2)

Basic Remediation COMPANY

Prepared by:		Date	
DBS&A	MK	10/23/09	S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG14_RECHARGE_PREDICTIVE_PHASE2.MXD 903201

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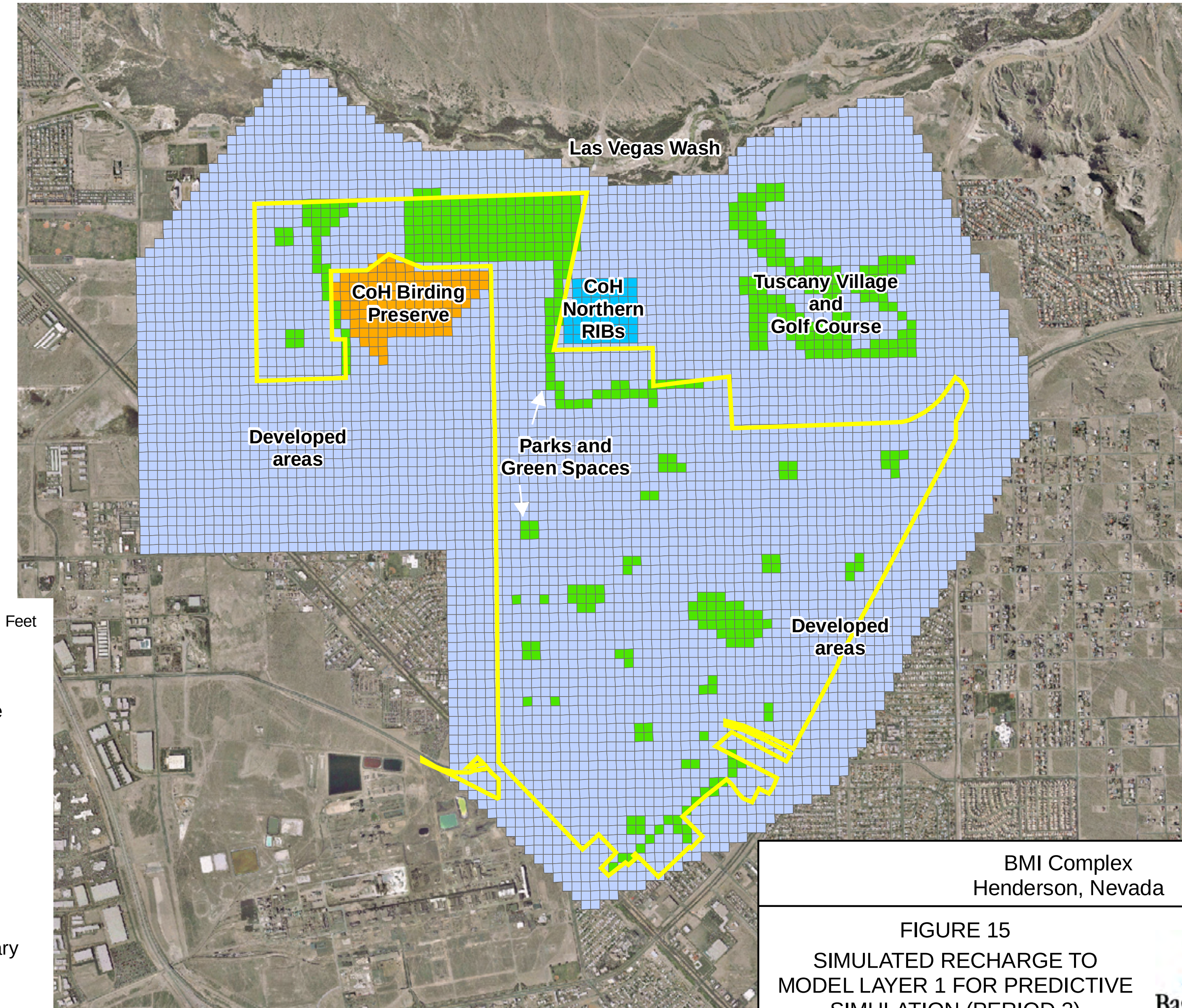
JN ES09.0057

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG15_RECHARGE_PREDICTIVE_PHASE3.MXD 903201



Explanation

Simulated recharge rate (in/yr)

- 0.08
- 0.57
- 8.672
- 82.344
- Site boundary
- Model grid

Source: Aerial photograph, April 2004

BMI Complex
Henderson, Nevada

FIGURE 15
SIMULATED RECHARGE TO MODEL LAYER 1 FOR PREDICTIVE SIMULATION (PERIOD 3)

Basic Remediation COMPANY

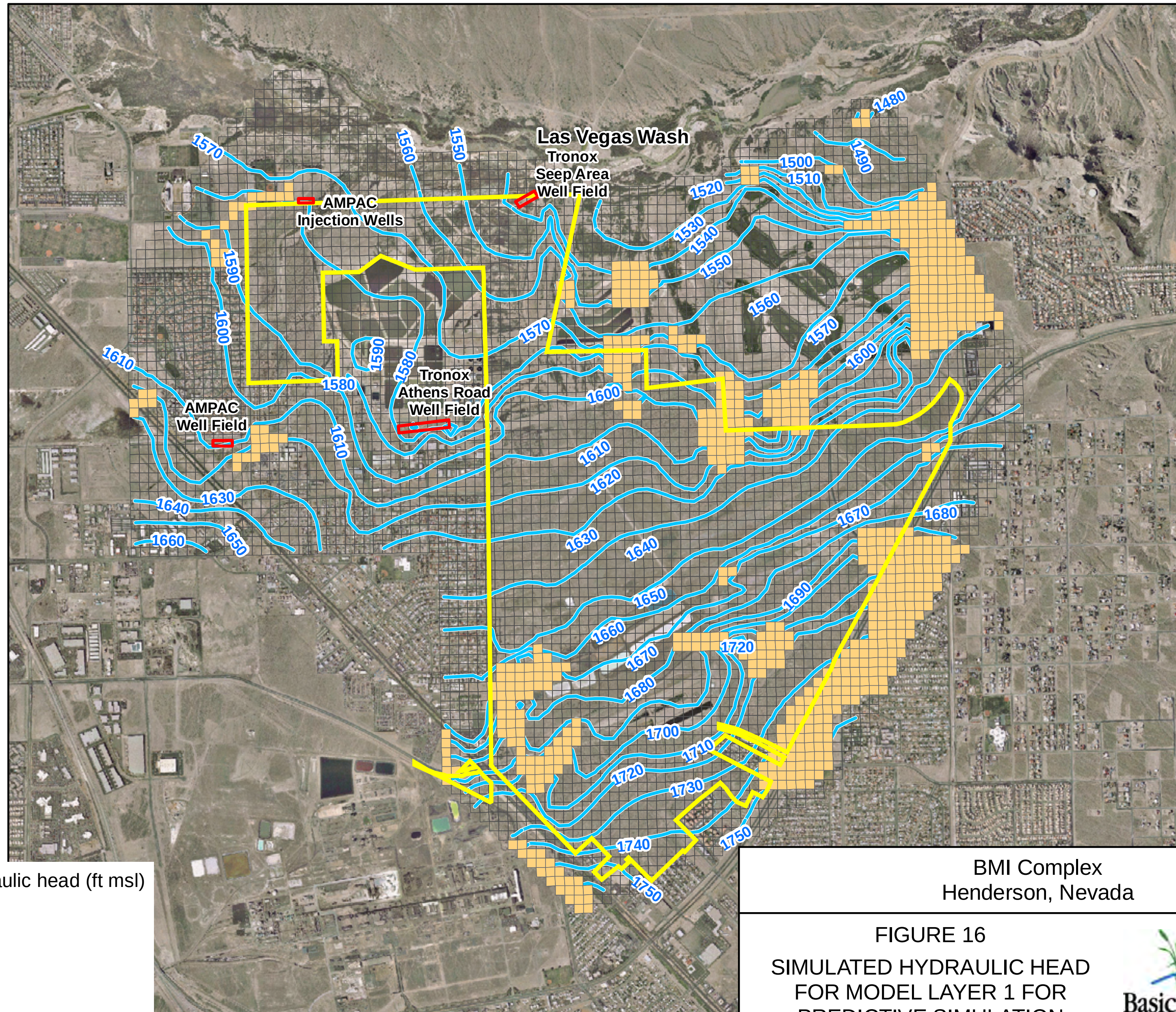
Prepared by: DBS&A MK

Date 10/23/09

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG15_RECHARGE_PREDICTIVE_PHASE3.MXD 903201

Daniel B. Stephens & Associates, Inc.
JN ES09.0057

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG16_SIMHEAD_PREDICTIVE_LAYER1.MXD 903201



N

0 1,750 3,500 Feet

Explanation

- Simulated hydraulic head (ft msl)
- Dry cells
- Site boundary
- Model grid

Source: Aerial photograph, April 2004

BMI Complex
Henderson, Nevada

FIGURE 16
SIMULATED HYDRAULIC HEAD FOR MODEL LAYER 1 FOR PREDICTIVE SIMULATION

Basic Remediation COMPANY

Prepared by: DBS&A MK

Date 10/23/09

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG16_SIMHEAD_PREDICTIVE_LAYER1.MXD 903201

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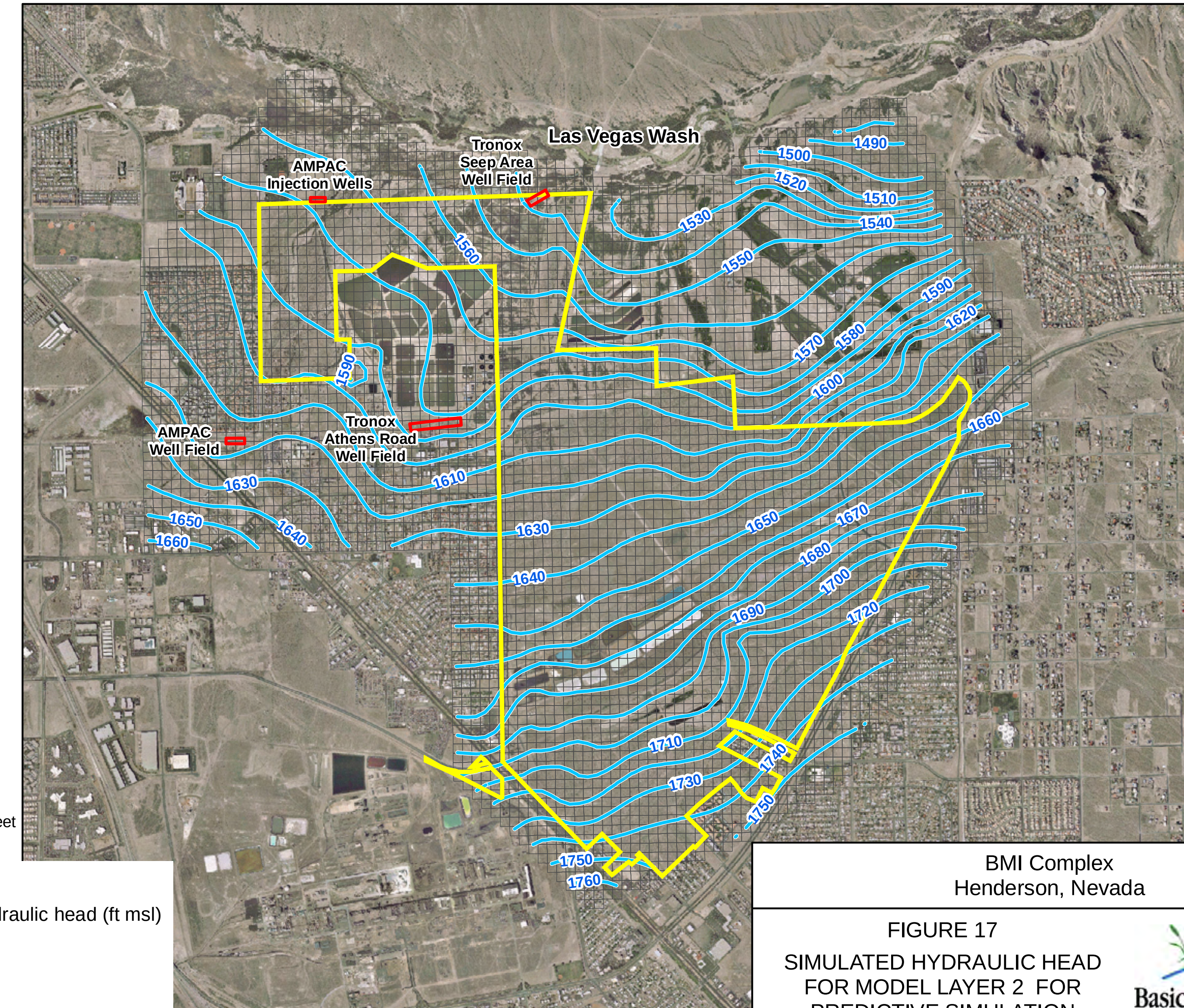
JN ES09.0057

Figure 16

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG17_SIMHEAD_PREDICTIVE_LAYER2_REVISED.MXD 903201



N

0 1,750 3,500 Feet

Explanation

- Simulated hydraulic head (ft msl)
- Site boundary
- Model grid

Source: Aerial photograph, April 2004
Note: Labeled well fields are in model layer 1

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BMI Complex
Henderson, Nevada

FIGURE 17

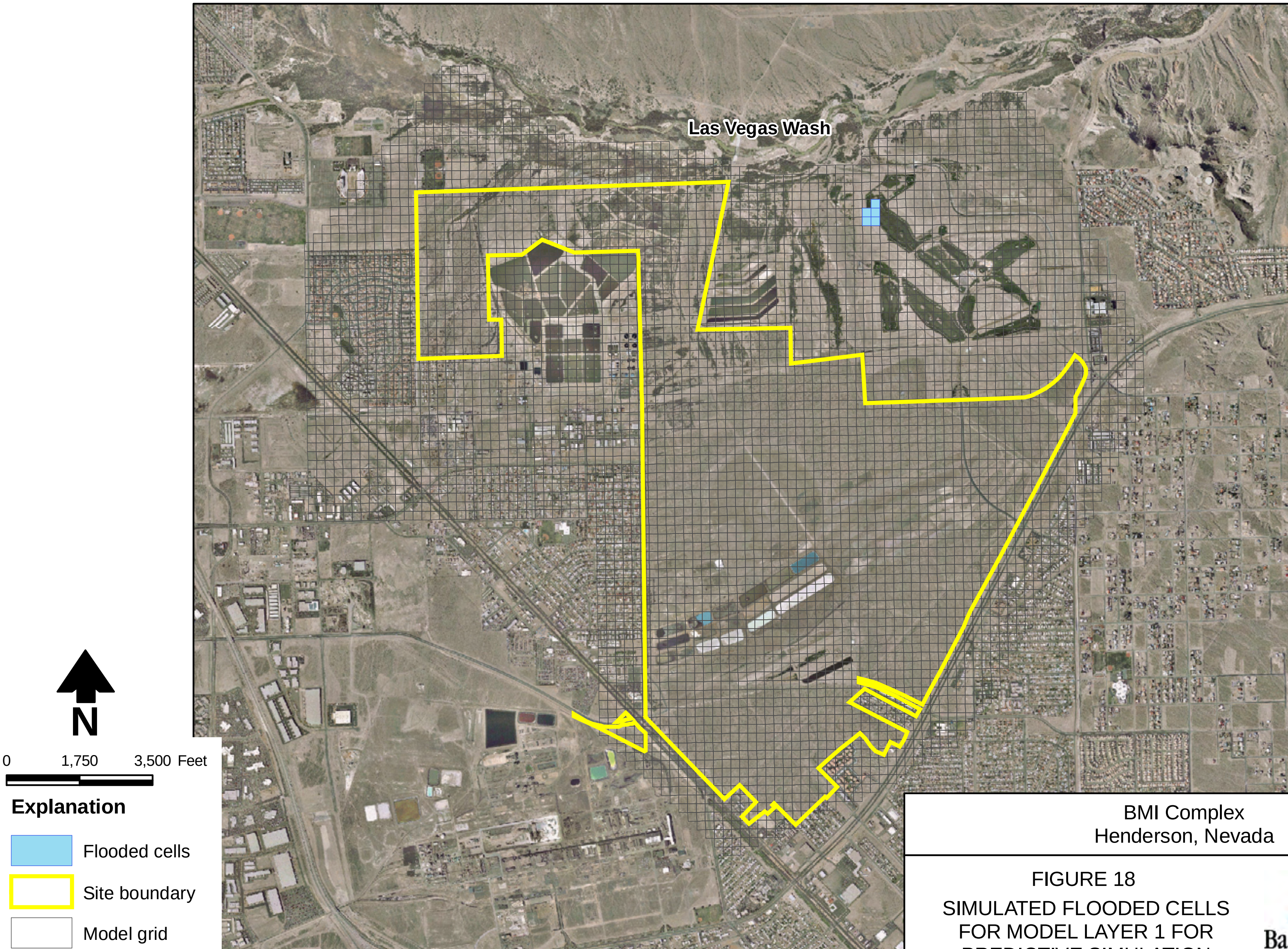
SIMULATED HYDRAULIC HEAD FOR MODEL LAYER 2 FOR PREDICTIVE SIMULATION

Basic Remediation COMPANY

Prepared by:		Date	
DBS&A	MK	10/23/09	S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG17_SIMHEAD_PREDICTIVE_LAYER2_REVISED.MXD 903201

Figure 17

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG18_SIMFLOODEDCELLS_PREDICTIVE_LAYER1.MXD 903201



Explanation

- Flooded cells
- Site boundary
- Model grid

Source: Aerial photograph, April 2004

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Henderson, Nevada

FIGURE 18

SIMULATED FLOODED CELLS FOR MODEL LAYER 1 FOR PREDICTIVE SIMULATION

Basic Remediation COMPANY

Prepared by: DBS&A MK

Date 10/23/09

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG18_SIMFLOODEDCELLS_PREDICTIVE_LAYER1.MXD 903201

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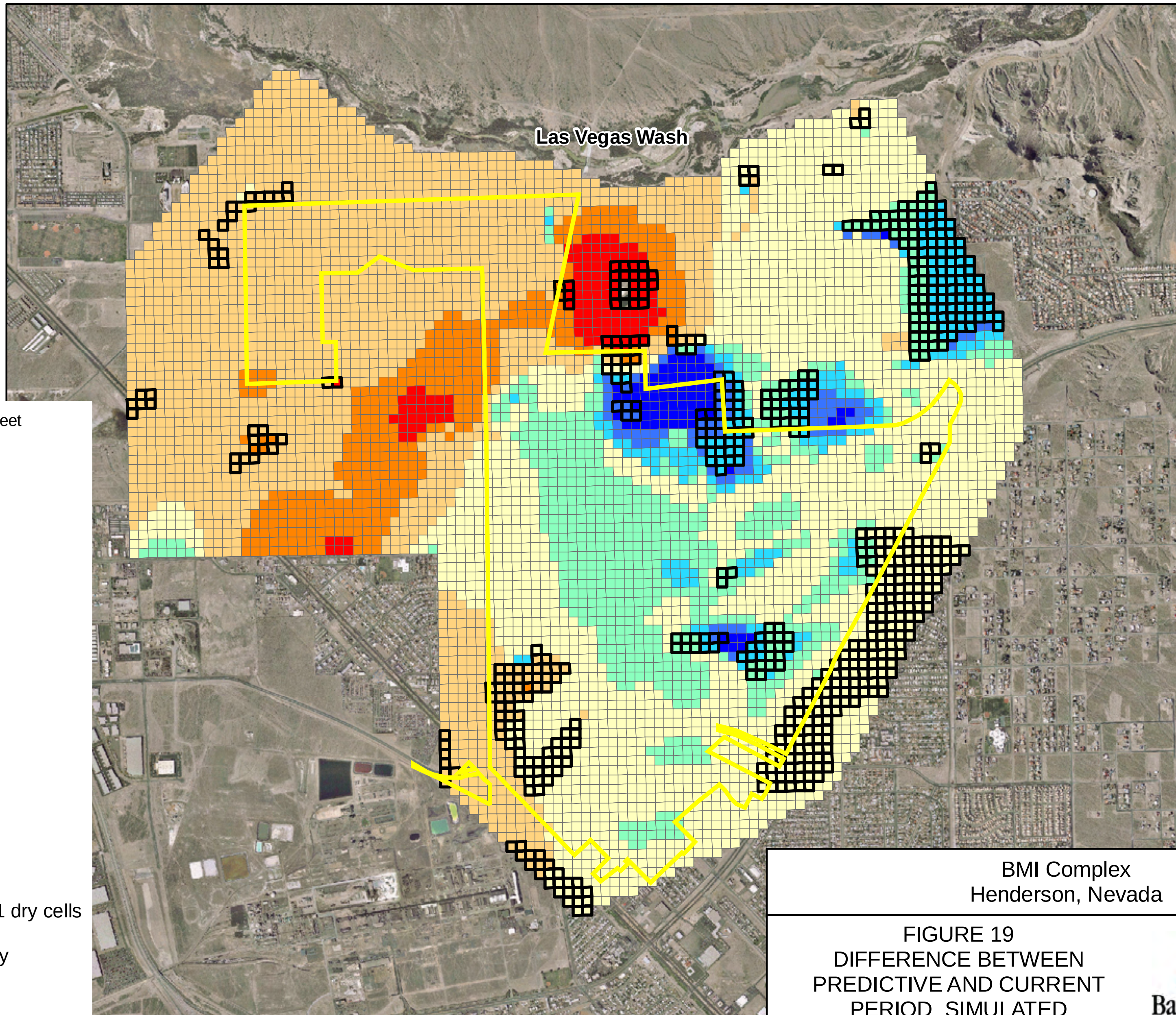
JN ES09.0057

Figure 18

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG19_CURRENT_PREDICTIVE_LAYER1.MXD 907201



N

0 1,750 3,500 Feet

Explanation

Difference (feet)

- -37 to -20
- -20 to -10
- -10 to 0
- 0 to 4
- 4 to 8
- 8 to 12
- 12 to 16
- 16 to 30
- Model layer 1 dry cells
- Site boundary
- Model grid

Source: Aerial photograph, April 2004

BMI Complex
Henderson, Nevada

FIGURE 19
DIFFERENCE BETWEEN
PREDICTIVE AND CURRENT
PERIOD SIMULATED
WATER TABLE

Basic Remediation
COMPANY

Prepared by: DBS&A MK

Date 10/23/09

S:/PROJECTS/BRC/ES09.0057_MODEL_UPDATE/GIS/MXDS/REPORT_FIGURES_10-09/FIG19_CURRENT_PREDICTIVE_LAYER1.MXD 907201

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JN ES09.0057

Figure 19

Tables

Table 1. Correspondence of Figure and Table Numbers Between This Report and DBS&A (2009a)

Figure or Table Number in this Report	Corresponding Figure or Table Number in DBS&A (2009a)
Figure 1	Figure 11
Figure 2	Figure 15
Figure 3	Figure 16
Figure 4	Figure 17
Figure 5	Figure 19
Figure 6	Figure 22
Figure 7	Figure 23
Figure 8	Figure 24
Figure 9	Figure 25
Figure 10	Figure 26
Figure 11	None
Figure 12	None
Figure 13	None
Figure 14	Figure 35
Figure 15	Figure 36
Figure 16	Figure 37
Figure 17	Figure 38
Figure 18	Figure 39
Figure 19	None
Table 1	None
Table 2	Table 3
Table 3	Table 4
Table 4	Table 5
Table 5	Table 6

Table 2. Model Calibration Statistics for Current Period Simulation

Statistic Index	Layer 1	Layer 2
Mean error (ME)	1.88	–0.84
Mean absolute error (MAE)	5.38	8.68
Root mean squared error (RMSE)	7.05	12.36
Minimum residual	–15.55	–44.42
Maximum residual	22.95	14.00
Range in target values	229.17	251.66
RMSE/range in target values	0.03	0.05

Table 3. Well Characteristics and Current Period Simulation Calibration Results

Well Name	TOC Elevation (ft msl)	Screen Depth (ft btoc)		Elevation of Qal - UMCf Contact	Bottom of Model Layer for Cell in Which Well Resides	Water Level (ft msl)		Residual (feet)	Well Located in Simulated Dry Cell?
		Top	Bottom			Observed	Simulated		
Model layer 1									
AA-01	1757.13	31	51	1706.93	1705	1711.45	1709.45	2.00	N
AA-07	1612.70	31	51	1558.62	1559	1572.01	1564.08	7.93	N
AA-08	1580.82	6	36	1525.46	1529	1568.72	1570.35	–1.63	N
AA-09	1695.87	34	69	1624.11	1629	1658.48	1641.85	16.63	N
AA-10	1615.12	13	43	1569.04	1560	1596.89	1598.21	–1.32	N
AA-11	1660.05	11	31	1630.50	1630	1629.87	1631.14	–1.27	N
AA-13	1724.69	42	62	1664.37	1666	1677.16	1668.64	8.52	N
AA-18	1669.00	49	69	1603.60	1606	1609.44	1602.38	7.06	N
AA-20	1628.49	13	33	1569.07	1581	1599.62	1601.56	–1.94	N
AA-21	1584.20	9	39	1544.13	1544	1574.37	1570.24	4.13	N
AA-22	1581.53	13	33	1548.88	1548	1562.19	1569.63	–7.44	N
AA-26	1566.67	38	58	1513.95	1475	1520.22	1497.27	22.95	N
AA-27	1789.43	64	84	1705.53	1718	1722.46	1720.76	1.70	N
BEC-4	1681.34 [a]	25	40	1645.35	1640	1653.85	1641.81	12.04	N
DBMW1	1626.46	21	51	1583.74	1591	1593.93	1593.17	0.76	N
DBMW10	1663.96	56	76	—	1591	1601.91	1593.61	8.30	N
DBMW19	1583.40	17	42	1550.41	1554	1562.24	1567.09	–4.85	N
DBMW2	1627.00	33	53	1580.66	1591	1594.60	1593.54	1.06	N
DBMW3	1625.86	21	41	1591.95	1594	1598.66	1600.52	–1.86	N
DBMW4	1605.81	23	43	1577.98	1574	1587.01	1587.01	0.00	N

[a] Assumed to be the same as the reference point elevation
[b] Survey data (elevation) are uncertain

TOC = Top of casing
ft msl = Feet above mean sea level
ft btoc = Feet below top of casing

Qal = Quaternary alluvium
UMCf = Upper Muddy Creek formation
— = Information not available

Table 3. Well Characteristics and Current Period Simulation Calibration Results
Page 2 of 4

Well Name	TOC Elevation (ft msl)	Screen Depth (ft btoc)		Elevation of Qal - UMCf Contact	Bottom of Model Layer for Cell in Which Well Resides	Water Level (ft msl)		Residual (feet)	Well Located in Simulated Dry Cell?
		Top	Bottom			Observed	Simulated		
Model layer 1 (cont.)									
DM1	1727.21 [b]	30	55	—	1675	1686.70	1677.43	9.27	N
HMW16	1622.10	8	23	—	1605	1612.55	1611.87	0.68	N
HMW9	1543.60	10	20	—	1512	1,532.74	1534.77	–2.03	N
MW04	1522.98	—	30	—	1494	1504.70	1501.46	3.24	N
MW13	1530.31	—	48	—	1461	1493.29	1488.46	4.83	N
PC1	1599.13	14.7	29.7	1568.13	1558	1575.36	1577.78	–2.42	N
PC103	1597.02	9	29	1570.49	1564	1574.61	1585.82	–11.21	N
PC104	1596.68	10	35	1561.68	1560	1569.66	1580.72	–11.06	N
PC108	1584.96 [a]	9.7	44.7	1539.81	1539	1574.07	1576.40	–2.33	N
PC12	1616.94	14.8	29.8	1587.50	1578	1588.23	1593.71	–5.48	N
PC2	1593.79 [a]	14	29	1566.07	1560	1570.95	1578.35	–7.40	N
PC24	1633.95	15	30	1605.95	1608	1612.95	1615.50	–2.55	N
PC4	1597.13 [a]	17.7	42.7	1556.92	1562	1572.32	1577.09	–4.77	N
PC50	1634.48	11.8	41.8	1599.48	1601	1622.05	1619.95	2.10	N
PC56	1568.99 [a]	48.0	54.8	1514.25	1531	1559.96	1553.81	6.15	N
PC58	1568.29 [a]	7.8	32.8	1533.96	1528	1559.91	1554.16	5.75	N
PC62	1568.45 [a]	7.6	37.6	1530.83	1530	1558.42	1556.45	1.97	N
PC76	1564.51 [a]	15	20	1509.10	1508	1551.34	1555.33	–3.99	N
PC79	1564.33	34.5	44.5	1519.16	1521	1556.66	1553.69	2.97	N
PC80	1564.07	19.5	29.5	1519.31	1521	1556.27	1553.63	2.64	N

[a] Assumed to be the same as the reference point elevation
[b] Survey data (elevation) are uncertain

TOC = Top of casing
ft msl = Feet above mean sea level
ft btoc = Feet below top of casing

Qal = Quaternary alluvium
UMCf = Upper Muddy Creek formation
— = Information not available

Table 3. Well Characteristics and Current Period Simulation Calibration Results
Page 3 of 4

Well Name	TOC Elevation (ft msl)	Screen Depth (ft btoc)		Elevation of Qal - UMCf Contact	Bottom of Model Layer for Cell in Which Well Resides	Water Level (ft msl)		Residual (feet)	Well Located in Simulated Dry Cell?
		Top	Bottom			Observed	Simulated		
Model layer 1 (cont.)									
PC81	1564.03	9.5	14.5	1519.03	1521	1556.41	1553.55	2.86	N
PC82	1559.44 [a]	47	57	1503.31	1505	1553.85	1549.28	4.57	N
PC83	1559.47	20.5	30.5	1503.32	1505	1554.34	1549.17	5.17	N
PC86	1554.08 [a]	17.5	27.5	1506.85	1503	1550.89	1544.43	6.46	N
PC90	1550.90 [a]	4.5	14.5	1499.46	1500	1546.20	1541.17	5.03	N
PC92	1552.12 [a]	11.5	21.5	1512.05	1509	1544.59	1539.94	4.65	N
PC94	1548.84 [a]	9.5	19.5	1508.95	1517	1541.48	1540.24	1.24	N
PC95	1550.61	24.5	34.5	1507.62	1500	1546.28	1540.29	5.99	N
POD8	1691.33	42.5	72.5	1617.16	1618	1623.12	1638.67	–15.55	N
POU3	1728.51	35	65	1670	1676	1691.85	1678.81	13.04	N
PZ13	—	—	—	—	1620	1622.62	1619.13	3.49	N
Model layer 2									
BEC-6	1725.52 [a]	65	80	1670.52	1626	1658.83	1672.71	–13.88	N
BEC-9	1617.74 [a]	44	59	1611.24	1560	1569.15	1613.57	–44.42	N
BEC-10	1657.39 [a]	73	88	1629.39	1579	1599.31	1601.24	–1.93	N
DBMW5	1609.65	18	38	1594.55	1541	1586.69	1582.90	3.79	N
DBMW6	1632.63	32	52	1590.64	1539	1584.13	1571.71	12.42	N
DBMW7	1631.73	53	73	1587.65	1536	1574.87	1561.54	13.33	N
DBMW8	1632.05	49	69	1581.95	1535	1575.75	1562.13	13.62	N
DBMW9	1659.92	56	76	1616.83	1563	1596.80	1598.33	–1.53	N

[a] Assumed to be the same as the reference point elevation
[b] Survey data (elevation) are uncertain

TOC = Top of casing
ft msl = Feet above mean sea level
ft btoc = Feet below top of casing

Qal = Quaternary alluvium
UMCf = Upper Muddy Creek formation
— = Information not available

Table 3. Well Characteristics and Current Period Simulation Calibration Results

Well Name	TOC Elevation (ft msl)	Screen Depth (ft btoc)		Elevation of Qal - UMCf Contact	Bottom of Model Layer for Cell in Which Well Resides	Water Level (ft msl)		Residual (feet)	Well Located in Simulated Dry Cell?
		Top	Bottom			Observed	Simulated		
Model layer 2 (cont.)									
DBMW11	1667.96	45	75	1626.46	1580	1607.16	1612.58	–5.42	N
DBMW12	1669.68	49	79	1636.71	1585	1610.21	1620.55	–10.34	N
DBMW14	1675.96	38	68	1645.84	1593	1637.08	1637.60	–0.52	N
DBMW18	1717.15	48	68	1667.11	1606	1651.24	1657.21	–5.97	N
HMW8	—	21	41	—	1428	1526.90	1529.08	–2.18	N
HMWWT-6	1774.04	36	51	1744	1682	1732.39	1730.58	1.81	N
MCF-01B	1756.28	55	85	1701.45	1655	1711.28	1710.79	0.49	N
MCF-03B	1785.72	60	80	1743.46	1687	1741.61	1736.13	5.48	N
MCF-06B	1633.18	67	82	1587.40	1538	1578.79	1564.79	14.00	N
MCF-06C	1633.12	44	59	1587.42	1538	1578.09	1564.80	13.29	N
MCF-08B	1581.19	120.1	140.1	1525.43	1479	1578.59	1571.55	7.04	N
MCF-09B	1696.23	112	132	1623.00	1579	1659.09	1649.61	9.48	N
MCF-10B	1615.35	84	104	1568.88	1521	1598.85	1599.86	–1.01	N
MCF-11	1659.95	93.5	103.5	1625.75	1580	1630.11	1631.09	–0.98	N
MCF-12C	1715.27	155	175	1661.53	1615	1647.28	1659.03	–11.75	N
MW-01	1526.5	—	—	—	1417	1489.95	1478.94	11.01	N
POD2	1673.94	45	65	1623.94	1574	1616.37	1636.44	–20.07	N
TWC-126	1650.60	126	146	—	1581	1637.56	1642.07	–4.51	N
TWE107	1634.00	107	127	1612	1564	1624.50	1628.43	–3.93	N

[a] Assumed to be the same as the reference point elevation
[b] Survey data (elevation) are uncertain

TOC = Top of casing
ft msl = Feet above mean sea level
ft btoc = Feet below top of casing

Qal = Quaternary alluvium
UMCf = Upper Muddy Creek formation
— = Information not available

Table 4. Current Period Simulation Saturated Thickness Model Calibration Results

Well Name	Elevation of Qal - UMCf Contact	Bottom of Model Layer for Cell in Which Well Resides	Water Level (ft msl)		Saturated Thickness (feet)		Residual (ft)
			Observed	Simulated	Observed	Simulated	
Model layer 1							
AA-01	1706.93	1705.00	1711.45	1709.45	4.5	4.5	0.1
AA-07	1558.62	1559.00	1572.01	1564.08	13.4	5.1	8.3
AA-08	1525.46	1529.00	1568.72	1570.35	43.3	41.3	1.9
AA-09	1624.11	1629.00	1658.48	1641.85	34.4	12.8	21.5
AA-10	1569.04	1560.00	1596.89	1598.21	27.9	38.2	–10.4
AA-11	1630.50	1630.00	1629.87	1631.14	–0.6	1.1	–1.8
AA-13	1664.37	1666.00	1677.16	1668.64	12.8	2.6	10.1
AA-18	1603.60	1606.00	1609.44	1602.38	5.8	–3.6	9.5
AA-20	1569.07	1581.00	1599.62	1601.56	30.6	20.6	10.0
AA-21	1544.13	1544.00	1574.37	1570.24	30.2	26.2	4.0
AA-22	1548.88	1548.00	1562.19	1569.63	13.3	21.6	–8.3
AA-26	1513.95	1475.00	1520.22	1497.27	6.3	22.3	–16.0
AA-27	1705.53	1718.00	1722.46	1720.76	16.9	2.8	14.2
BEC-4	1645.35	1640.00	1653.85	1641.81	8.5	1.8	6.7
DBMW1	1583.74	1591.00	1593.93	1593.17	10.2	2.2	8.0
DBMW10	—	1591.00	1601.91	1593.61	—	—	—
DBMW19	1550.41	1554.00	1562.24	1567.09	11.8	13.1	–1.3
DBMW2	1580.66	1591.00	1594.60	1593.54	13.9	2.5	11.4
DBMW3	1591.95	1594.00	1598.66	1600.52	6.7	6.5	0.2
DBMW4	1577.98	1574.00	1587.01	1587.01	9.0	13.0	–4.0

[a] Assumed to be the same as the reference point elevation
[b] Survey data (elevation) are uncertain

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Qal = Quaternary alluvium
UMCf = Upper Muddy Creek formation
— = Information not available

Table 4. Current Period Simulation Saturated Thickness Model Calibration Results

Well Name	Elevation of Qal - UMCf Contact	Bottom of Model Layer for Cell in Which Well Resides	Water Level (ft msl)		Saturated Thickness (feet)		Residual (ft)
			Observed	Simulated	Observed	Simulated	
Model layer 1 (cont.)							
DM1	—	1675.00	1686.70	1677.43	—	—	—
HMW16	—	1605.00	1612.55	1611.87	—	—	—
HMW9	—	1512.00	1532.74	1534.77	—	—	—
MW04	—	1494.00	1504.70	1501.46	—	—	—
MW13	—	1457.00	1493.29	1488.46	—	—	—
PC1	1568.13	1558.00	1575.36	1577.78	7.2	19.8	–12.6
PC103	1570.49	1572.00	1574.61	1585.82	4.1	13.8	–9.7
PC104	1561.68	1560.00	1569.66	1580.72	8.0	20.7	–12.7
PC108	1539.81	1539.00	1574.07	1576.40	34.3	37.4	–3.1
PC12	1587.50	1578.00	1588.23	1593.71	0.7	15.7	–15.0
PC2	1566.07	1560.00	1570.95	1578.35	4.9	18.3	–13.5
PC24	1605.95	1608.00	1612.95	1615.50	7.0	7.5	–0.5
PC4	1556.92	1562.00	1572.32	1577.09	15.4	15.1	0.3
PC50	1599.48	1601.00	1622.05	1619.95	22.6	18.9	3.6
PC56	1514.25	1531.00	1559.96	1553.81	45.7	22.8	22.9
PC58	1533.96	1528.00	1559.91	1554.16	26.0	26.2	–0.2
PC62	1530.83	1530.00	1558.42	1556.45	27.6	26.5	1.1
PC76	1509.10	1508.00	1551.34	1555.33	42.2	47.3	–5.1
PC79	1519.16	1521.00	1556.66	1553.69	37.5	32.7	4.8
PC80	1519.31	1521.00	1556.27	1553.63	37.0	32.6	4.3

[a] Assumed to be the same as the reference point elevation
[b] Survey data (elevation) are uncertain

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Qal = Quaternary alluvium
UMCf = Upper Muddy Creek formation
— = Information not available

Table 4. Current Period Simulation Saturated Thickness Model Calibration Results

Well Name	Elevation of Qal - UMCf Contact	Bottom of Model Layer for Cell in Which Well Resides	Water Level (ft msl)		Saturated Thickness (feet)		Residual (ft)
			Observed	Simulated	Observed	Simulated	
Model layer 1 (cont.)							
PC81	1519.03	1521.00	1556.41	1553.55	37.4	32.6	4.8
PC83	1503.31	1505.00	1553.85	1549.28	50.5	44.3	6.3
PC82	1503.32	1505.00	1554.34	1549.17	51.0	44.2	6.8
PC86	1506.85	1503.00	1550.89	1544.43	44.0	41.4	2.6
PC90	1499.46	1500.00	1546.20	1541.17	46.7	41.2	5.6
PC92	1512.05	1509.00	1544.59	1539.94	32.5	30.9	1.6
PC94	1508.95	1517.00	1541.48	1540.24	32.5	23.2	9.3
PC95	1507.62	1500.00	1546.28	1540.29	38.7	40.3	-1.6
POD8	1617.16	1618.00	1623.12	1638.67	6.0	20.7	-14.7
POU3	1670.00	1676.00	1691.85	1678.81	21.8	2.8	19.0
PZ13	—	1620.00	1622.62	1619.13	—	—	—
				Mean	22.3	20.7	1.6

[a] Assumed to be the same as the reference point elevation
[b] Survey data (elevation) are uncertain

TOC = Top of casing
ft msl = Feet above mean sea level
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Qal = Quaternary alluvium
UMCf = Upper Muddy Creek formation
— = Information not available

Table 5. Current Period Simulation Mass Balance and Estimated Range of Inputs

Inflow/Outflow	Minimum Value	Maximum Value	Average Value	Simulated Value
Groundwater Inflows/Sources (ft^3/d)				
Lateral groundwater inflow-Qal	105	68,443	34,274	123,464
Lateral groundwater inflow-UMCf	2,722	22,686	12,704	2,981
City effluent pond seepage (RIBs plus Birding Preserve)	414,720	414,720	414,720	245,107
TIMET pond seepage	2,609	2,609	2,609	2,591
Recharge from precipitation/storm flow	277	13,844	7,060	2,751
Inflow from deep UMCf (upward vertical leakage)	399	4,868,983	2,434,691	15,423
Seepage from developed areas	253	1,265	759	9,580
Tuscany golf course irrigation return flow	18	89	53	12,368
AMPAC injection wells [a]	47,163	47,163	47,163	47,163
Total inflow	421,103	5,392,639	2,906,871	461,428
Groundwater Outflows/Sinks (ft^3/d)				
Lateral groundwater outflow-Qal	382	2,782,305	1,391,343	291,077
Lateral groundwater outflow-UMCf	1,794	14,952	8,373	4,594
Outflow to deep UMCf (downward vertical leakage)	209	2,546,439	1,273,324	12,946
Tronox seep pumping	62,208	129,600	95,904	62,208
Tronox pumping at Athens Road well field	50,112	50,112	50,112	43,254
AMPAC pumping [a]	44,467	44,467	44,467	22,908
Phreatophyte evapotranspiration	15,117	47,339	31,228	14,813
Western Hook drain	—	—	—	9,669
Total outflow	129,821	5,570,747	2,850,284	461,469

[a] Estimated value from AMPAC (2007)

ft^3/d = Cubic feet per day
Qal = Quaternary alluvium

UMCf = Upper Tertiary Muddy Creek formation
RIB = Rapid infiltration basin

Appendix A

Modeling Files

Description of Folder Structure for Modeling Files on Compact Disc

This DVD contains electronic files for the BRC Eastside groundwater model documented in the Daniel B. Stephens & Associates, Inc. report dated November 2, 2009. There are two main folders included on the disc, organized as follows. The files provided are consistent with the Groundwater Vistas (ESI, 2007) and MODFLOW-SURFACT (HydroGeoLogic, Inc., 1996) software packages as described in Section 3 of the report.

- *Current*: This folder has the modeling files for the current period simulation (Section 2.3 of the report).

- *Predictive:* This folder has the modeling files for the predictive scenario simulation (Section 3 of the report).

References

Environmental Simulations Inc. (ESI). 2007. *Guide to using Groundwater Vistas - Version 5.*

HydroGeoLogic, Inc. 1996. *MODFLOW-SURFACT Software (Version 3.0) Overview: Installation, Registration and Running Procedures.*

The modeling files are included on DVD in the hard copy report.