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Groundwater Flow Simulation of the Savannah River Site General Separations Area

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September 6, 2017

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REVIEWS AND APPROVALS

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REVISIONS

Revision 0	Issued May 2, 2017
Revision 1	In Section 6.0, moved discussion of a recommended model for baseline Performance Assessment analyses to new Section 7.5. In Section 7.0, included detailed information for all four final round models: PEST.47, 51, 52 and 53. Introduced alternative, descriptive, labels for the final models. In Section 7.4, added an explanation for slower groundwater speeds observed in GSA2016 flow models compared to the GSA2004 model. In Section 7.5, revised the recommended baseline model from PEST.47 to PEST.51, based on consideration of hydrogeologic conceptual models for the General Separations Area and groundwater trajectories inferred from contaminant plumes.

EXECUTIVE SUMMARY

The most recent groundwater flow model of the General Separations Area, Savannah River Site, is referred to as the "GSA/PORFLOW" model. GSA/PORFLOW was developed in 2004 by porting an existing General Separations Area groundwater flow model from the FACT code to the PORFLOW code. The preceding "GSA/FACT" model was developed in 1997 using characterization and monitoring data through the mid-1990's. Both models were manually calibrated to field data. Significantly more field data have been acquired since the 1990's and model calibration using mathematical optimization software has become routine and recommended practice. The current task involved updating the GSA/PORFLOW model using selected field data current through at least 2015, and use of the PEST code to calibrate the model and quantify parameter uncertainty. This new GSA groundwater flow model is named "GSA2016" in reference to the year in which most development occurred. The GSA2016 model update is intended to address issues raised by the DOE Low-Level Waste (LLW) Disposal Facility Federal Review Group (LFRG) in a 2008 review of the E-Area Performance Assessment, and by the Nuclear Regulatory Commission in reviews of tank closure and Saltstone Disposal Facility Performance Assessments.

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LIST OF ABBREVIATIONS

AAA	A and AA aquifer zones
CPT	Cone Penetration Testing
DOE	Department of Energy
ELLWF	E-Area Low Level Waste Facility
FMB	Fourmile Branch
GAU	Gordon aquifer unit
GCU	Gordon confining unit
GSA	General Separations Area
HSU	Hydrostratigraphic unit
LAZ	Lower aquifer zone
LFRG	Low- Level Waste Disposal Facility Federal Review Group
LLW	Low-Level Waste
NRC	Nuclear Regulatory Commission
PA	Performance Assessment
QA	Quality Assurance
SRR	Savannah River Remediation, LLC
SRS	Savannah River Site
TCCZ	Tan Clay Confining Zone
TZ	Transmissive Zone
UAZ	Upper aquifer zone
USGS	United States Geological Survey
WSRC	Westinghouse Savannah River Company (before September 2005) or Washington Savannah River Company (after September 2005)

1.0 Introduction

Numerical simulation of groundwater flow became routine practice in the 1980's and several studies of the Savannah River Site (SRS) General Separations Area (GSA) have been conducted since then, including Duffield et al. (1986), Parizek and Root (1986a, b), GeoTrans (1992), Flach and Harris (1999) and Flach (2004). Bagwell and Flach (2016) provide a brief history of GSA groundwater flow model development over these years.

Development of the 2004 "GSA/PORFLOW" model (Flach 2004) primarily involved porting the 1999 "GSA/FACT" model (Flach and Harris 1999) from the FACT code to the PORFLOW code; no updates were made to the characterization and monitoring data sets used to develop the 1999 model. Model re-calibration to address minor changes in gridding and different numerical algorithms between the FACT and PORFLOW codes was performed in a manual *ad hoc* approach, which was commonplace in that groundwater modeling era.

The GSA/PORFLOW model supported the 2008 E-Area Performance Assessment (PA) (WSRC 2008) and related Special Analyses (SAs), and was reviewed by the DOE Low-Level Waste (LLW) Disposal Facility Federal Review Group (LFRG) in 2008. Considering the significant amount of field data acquired since the mid-1990's and maturation of optimization software available for model calibration, the LFRG "recommended that the model be reevaluated with more current data and recalibrated using automated inverse procedures" (Bagwell and Flach 2016; LFRG 2008).

The GSA/PORFLOW model also supported recent F-Area Tank Farm, H-Area Tank Farm, and Saltstone PAs and SAs, for example, SRR Closure & Waste Disposal Authority (2009) and Savannah River Remediation, LLC (2010, 2012). In the course of reviewing these analyses, the Nuclear Regulatory Commission (NRC) "recommended that the model calibration and uncertainty estimation be improved" (Bagwell and Flach 2016; NRC 2014).

In response to these reviews and in preparation for a planned 2018 E-Area PA update, a program and execution plan (Bagwell and Flach 2016) was developed for GSA groundwater flow modeling with the goals to:

- Re-evaluate the model with selected new data acquired since 1997
- Recalibrate the GSA flow model using automated inverse modeling procedures
- Estimate uncertainty in model input and output parameters.

Under the program plan, PORFLOW (http://www.acricfd.com/software/porflow) was retained as the groundwater flow simulation code of choice, and the PEST code (http://www.pesthomepage.org) was adopted for model calibration / optimization / inverse modeling (Flach 2015b). At the request of SRNL, version 6.42.3 of PORFLOW incorporates a combined recharge-drain boundary condition option, and a velocity correction option for non-orthogonal computational meshes (Flach 2015a, b). PORFLOW version 6.42.3 and PEST version 13.6 have been placed under Software Quality Assurance (QA) control (Whiteside 2016a, b). PORFLOW 6.42.4 was also used toward the end of the project and has similarly been placed under QA control (Whiteside 2017).

The remainder of this report summarizes updates to the database of field information available for GSA flow model development, the capabilities of the PEST code and model calibration approach, calibration results, recommended groundwater flow models for transport simulation, and flow model parameter uncertainty.

1.1 Quality Assurance

Requirements for performing reviews of technical reports and the extent of review are established in Manual E7 Procedure 2.60. SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011, Rev. 2.

2.0 Field data updates

This section provides a brief summary of the updated monitoring and characterization data available for model redevelopment, and current information regarding land-use and cover system performance in the GSA.

2.1 Monitoring data

Hiergesell et al. (2015) developed new well-water level targets for GSA groundwater flow model calibration, and provided information to enable non-uniform weighting of these targets in the PEST optimization function using statistical uncertainty and spatial de-clustering concepts. The calibration targets were developed from data from 2004 through late 2014, a period of relatively stable hydrologic conditions that followed major remediation activities, such as pump-treat-reinjection at the F- and H-Area Seepage Basins. Average water levels were defined in 283 Upper aquifer zone (UAZ), 275 Lower aquifer zone (LAZ), and 81 Gordon aquifer unit (GAU) wells, for a total of 639 calibration targets. The standard error of the mean was computed for each target as a potential weighting factor in optimization software to be used for model calibration. Similarly, a polygonal de-clustering method was used to generate an additional weighting factor inversely proportional to spatial data density.

Baseflows in streams bordering the GSA were estimated by Flach and Harris (1997b) and used post-calibration to validate the GSA/FACT and GSA/PORFLOW models. United States Geological Survey (USGS) monitoring of GSA streams generally ended in 2002, providing no more than seven years of additional data beyond the 1973 to 1995 historical record used by Flach and Harris (1997b). The baseflow estimates were also based on hydrologic budget studies conducted by Parizek and Root (1986b) and baseflow measurements reported by WSRC (1992, 1994). No further studies of this nature have been identified. Thus no attempt was made to revise the stream baseflow estimates from 1997, which were judged to be adequate for validating an updated GSA groundwater flow model. Similarly, the previous recharge estimate of 15 in/yr from Flach and Harris (1997b) was retained in the current study, lacking any substantive new information for the 2004 to 2014 period associated with well targets. Away from seepage faces, recharge is assumed to be uniform; the adequacy of this assumption is discussed post-calibration. Table 2-1 summarizes the groundwater flow information adopted for this study. The range of uncertainty in recharge is 10 to 16 in/yr according to Flach et al. (1999). Uncertainties in the stream baseflow estimates have not been quantified. However, stream baseflows may be biased high relative to the head calibration targets, because rainfall and water levels were higher on average during the 1973-1995 period compared to 2004-2014 (Figure 3-1 or 3-2 in Hiergesell et al. 2015).

Table 2-1. Recharge and stream baseflow estimates.

Flow parameter	Estimate
Recharge	15 in/yr
Baseflow from GSA model domain:	
Upper Three Runs and tributaries excluding McQueen Branch	18.2 ft^3/s
Fourmile Branch and tributaries	2.6 ft^3/s
McQueen Branch	1.5 ft^3/s
Crouch Branch	1.8 ft^3/s

2.2 Characterization data

Characterization data in the form of large- and small-scale pumping tests, slug tests, laboratory permeability measurements, and visual descriptions of recovered sediment core were used to develop the GSA/FACT and GSA/PORFLOW model hydraulic conductivity fields (Flach and Harris 1999, Flach 2004). Approximately two decades ago, cone penetration testing (CPT) largely supplanted drilling in GSA field characterization efforts. As a result, relatively little borehole-based hydraulic conductivity characterization data have appeared since then. Recognizing that monitoring data play a more significant role in defining the calibrated model hydraulic conductivity field, no attempt was made to update the existing datasets related to permeability.

However, cone penetration testing over the past two decades has enabled delineation of hydrostratigraphic elevations at many more locations than available through the mid-1990's. Bagwell et al. (2017) recently revised hydrostratigraphic picks and generated detailed hydrostratigraphic surfaces for the GSA, per the GSA model update program plan (Bagwell and Flach 2016). These new hydrostratigraphic surfaces were adopted as-is for grid generation in the GSA flow model update.

2.3 Land-use and man-made features

Hiergesell et al. (2015, Appendix E) describe "GSA operations potentially enhancing or reducing infiltration adjacent to the ELLWF". The authors remark that "studies indicate that kaolin caps return to background infiltration within 2 to 4 years if they are not overlain by a geomembrane and at least six feet of soil in humid environments", which means that the Mixed Waste Management Facility, F-Area Seepage Basin, and H-Area Seepage Basin caps do not represent a low infiltration region in the 2004 to 2014 time period and beyond. However, the Low-Level Radioactive Waste Disposal Facility and Old Radioactive Waste Burial Ground / General Separations Area Consolidation Unit caps incorporate a geomembrane and significantly reduce infiltration. Considering cap degradation over time, cap infiltration for these units is set to 10% of 15 in/yr.

3.0 Model updates

The new GSA groundwater flow model will be referred to as "GSA2016" to distinguish it from its predecessors, "GSA/PORFLOW" (Flach 2004) and "GSA/FACT" (Flach and Harris 1999). The design of the GSA2016 model is the same as GSA/PORFLOW unless otherwise noted herein. Notable revisions include:

- Computational grid: Hydrostratigraphic surfaces were updated from Bagwell et al. (2017). Appendix A provides plots of the topographic and hydrostratigraphic surfaces used to build the PORFLOW computational grid.
- Hydraulic conductivity field: The vertical hydraulic conductivity of the Gordon confining unit (GCU) was increased from 1.e-5 to 7.5e-5 (0.75e-4) ft/d to achieve better agreement with hydraulic head targets, and to honor characterization data (Flach and Harris 1999) and regional groundwater flow modeling (Flach et al. 1999) that indicate $K_v \cong$ 1.e-4 ft/d for the GCU. The Upper Aquifer Zone was subdivided into a Transmissive Zone (TZ) and a combined A and AA zone (AAA) using the terms of Flach et al. (1999). Figure 3-1 is an example cross-section running north-south through E-Area showing GSA2016 hydrostratigraphy. Separate calibration adjustments are applied independently to the TZ and AAA zones. As defined, the TZ coincides with the first three UAZ grid layers above the Tan Clay Confining Zone (TCCZ), while the AAA occupies the remainder of the UAZ. Calibration of the hydraulic conductivity field was aided by

the PEST code using updated hydraulic head targets from Hiergesell et al. (2015), as described further below.

- Boundary conditions: A combined recharge-drain condition was applied to the top boundary using a new option in PORFLOW version 6.42.3 described by Flach (2015b). The equivalent condition was applied in the GSA/PORFLOW model in an indirect, less computationally efficient, manner. The local recharge rate is set to 15 in/yr based on the recharge estimates cited by Flach et al. (1999). The general head boundary applied to the bottom of the GSA/PORFLOW model used an unintended reference head around 195 ft. GSA2016 uses the intended 180 ft. Side boundary conditions were unaltered. In the Upper Three Runs aquifer, no-flow conditions are imposed on all sides (generally beneath streams), except the west end where hydraulic head is prescribed. In the Gordon aquifer, no-flow is prescribed beneath Upper Three Runs (northern boundary) and hydraulic head is prescribed along the remaining side boundaries.
- Vadose zone: Although the focus of the model simulation is saturated groundwater flow, the GSA model domain continues to include the vadose zone to enable varying seepline locations and recharge between and within optimization case iterations. The pseudo soil characteristic curves used in the GSA2016 model are

```
MULTiphase properties: (S,P) from TABLe with 4 sets:
0.4       10
0.7       5
0.9       2
1         0
MULTIphase properties: (S,COND) from TABLe with 4 sets:
0.4       1
0.6       1
0.8       1
1         1
```

  That is, relative permeability is assumed to be one for the purpose of transmitting water from the ground surface to the water table.

- Velocity field: Velocity components are computed using a new PORFLOW option described by Flach (2015a) which corrects for non-orthogonality in the computational mesh.
- PORFLOW file formatting: GSA/PORFLOW input files were formatted for PORFLOW version 5 whereas version 6 is used for the GSA2016 model. Some file formats changed between these versions and GSA2016 was made compatible with PORFLOW version 6.42.x.

PORFLOW versions 6.42.3 and 6.42.4 were subjected to an extensive suite of QA tests and produced acceptable results (Whiteside 2016b, 2017). PEST version 13.6 also passed SRNL internal QA testing (Whiteside 2016a).

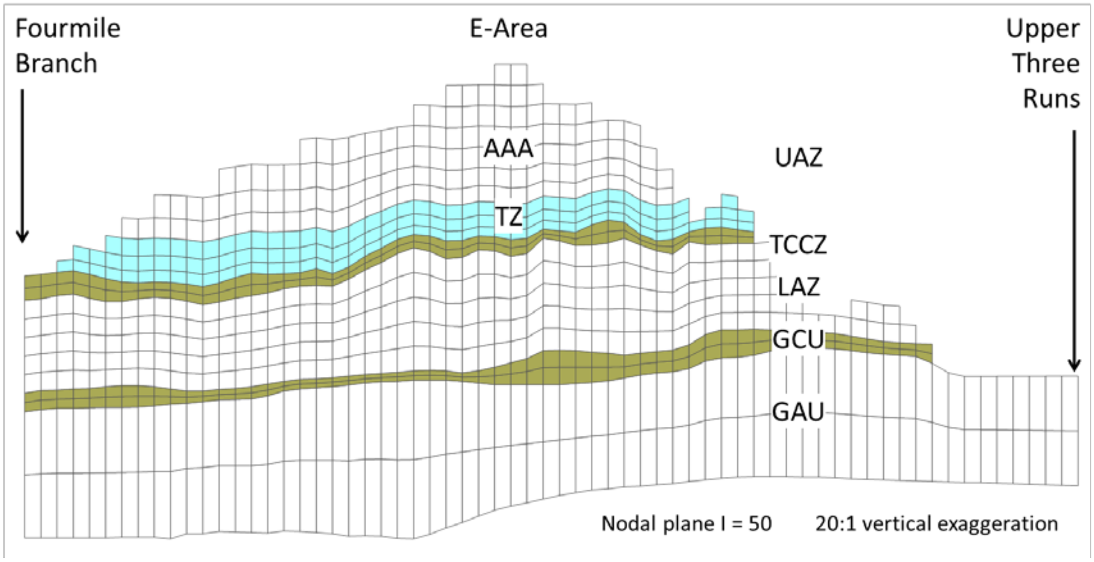


Figure 3-1. Stratigraphy and permeability zones in the GSA2016 computational grid.

4.0 Initial condition simulations

For the purpose of generating initial conditions for PEST optimization, the GSA2016 framework was crudely calibrated to the updated water level observations for two conceptual models of the hydraulic conductivity (K) field. The traditional "Layer-cake" concept views hydraulic conductivity as uniform within hydrostratigraphic units. The "Heterogeneous" concept views hydraulic conductivity as heterogeneous within hydrostratigraphic units, as defined by mud fraction and permeability data using the methods described by Flach and Harris (1999). These simulation cases are denoted PEST.0L (Layer-cake) and PEST.0H (Heterogeneous).

The hydraulic conductivity field for the PEST.0L Layer-cake model is defined through direct specification of the horizontal (K_h) and vertical hydraulic conductivity (K_v) in each hydrostratigraphic zone as indicated by Table 4-1. K_h for the Gordon aquifer unit (38 ft/d) is based on multiple well pumping test data and earlier GSA models (Flach and Harris 1999). K_v for the Gordon confining unit (1.0E-4 ft/d) is based on multiple well pumping test and laboratory permeability data summarized by Flach and Harris (1999) and well-supported by the CKLP reactor regional groundwater flow model (Flach et al. 1999). Selection of K_h in the remaining aquifer zones (LAZ, TZ, AAA) and K_v in the tan clay confining zone was guided by the earlier GSA models, preliminary application of the PEST code, and visual observation of residuals between simulated hydraulic head and measured well water level targets. The remaining conductivities were defined based on assumed anisotropy ratios of 100, 10 and 30 in the GAU, GCU and remaining zones, respectively. Groundwater flow simulations are mildly sensitive to these values. Anisotropy is typically assumed to lie within the range $1 = 10^0$ to $1000 = 10^3$ (Anderson and Woessner 1992, p. 70) and the geometric midpoint of this range is $10^{1.5} \approx 30$. Phifer et al. (2006, Tables 5-7 and 5-8) indicate anisotropy ratios for Savannah River sediments on this order of magnitude. An anisotropy ratio higher than 30 is used in the GAU because of its thicker model layers (such that a greater range of heterogeneity may be encountered). A lower ratio is assumed for the GCU because the unit is believed to be relatively uniform compared to other hydrostratigraphic units (as evidenced by its hydraulic competence). Simulation results for the PEST.0L case are summarized by Figure 4-1, where a positive residual value indicates the simulated head is above the measured head. Although not fully calibrated, the PEST.0L case generally produces good agreement with monitoring data. However, the model under-predicts hydraulic conductivity significantly in H-Area and moderately in Z-Area, indicating an opportunity for further calibration.

The hydraulic conductivity field for the PEST.0H Heterogeneous model is defined through direct specification in the Gordon aquifer and confining units, and multiplication factors to the baseline heterogeneous K field in the overlying hydrostratigraphic units (Table 4-2). The baseline K field was adopted from the GSA/FACT and GSA/PORFLOW models (Flach and Harris 1999; Flach 2004) as previously noted. A multiplication factor of 1.4 was selected based on visual inspection of hydraulic head residuals. Minimum and maximum value limits were also placed on K to avoid extreme values from small-scale characterization data that are not likely to reflect conditions over larger-scales (Table 4-3). The chosen limits generally create a one-order of magnitude range around the nominal values in Table 4-1. One notable exception is the AAA horizon. Simulation results are shown in Figure 4-2 and observed to be similar to the PEST.0L case. In particular, simulated head is biased low in H-Area and Z-Area, motivating further optimization of the K field. Appendix B provides plots of the PEST.0H conductivity field.

Table 4-1. Calibration parameters for PEST.0L case.

Calibration parameter	Value
Horizontal hydraulic conductivity of GAU, <GAUkh>	38 ft/d
Vertical hydraulic conductivity of GAU, <GAUkv>	0.38 ft/d
Horizontal hydraulic conductivity of GCU, <GCUkh>	1.0E-03 ft/d
Vertical hydraulic conductivity of GCU, <GCUkv>	1.0E-04 ft/d
Horizontal hydraulic conductivity of LAZ, <LAZkh>	12 ft/d
Vertical hydraulic conductivity of LAZ, <LAZkv>	0.4 ft/d
Horizontal hydraulic conductivity of TCCZ, <TCCZkh>	0.18 ft/d
Vertical hydraulic conductivity of TCCZ, <TCCZkv>	0.006 ft/d
Horizontal hydraulic conductivity of TZ, <TZkh>	9 ft/d
Vertical hydraulic conductivity of TZ, <TZkv>	0.3 ft/d
Horizontal hydraulic conductivity of AAA, <AAAkh>	9 ft/d
Vertical hydraulic conductivity of AAA, <AAAkv>	0.3 ft/d

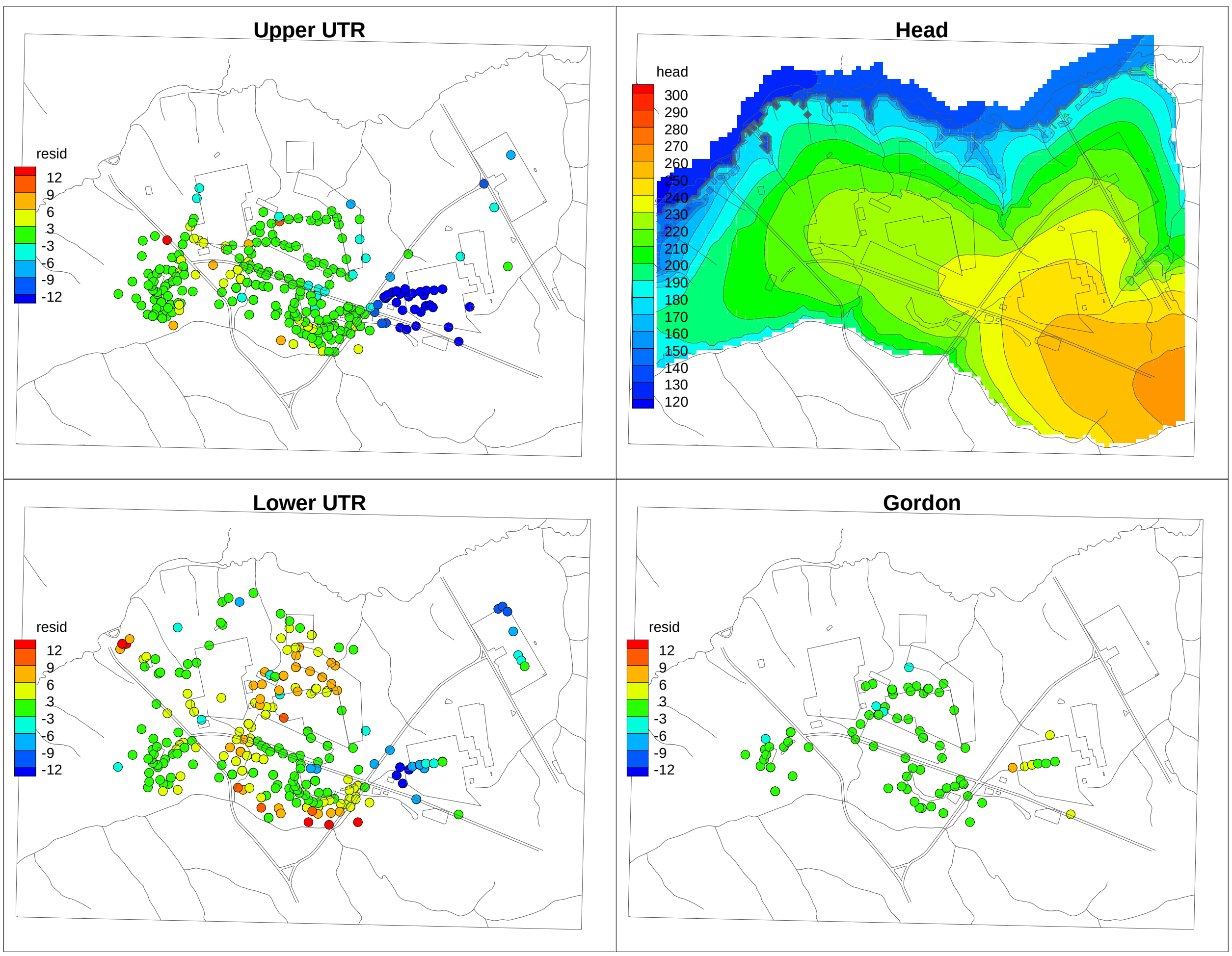


Figure 4-1. Hydraulic head residuals and water table surface for the Layer-cake K field (PEST.0L case).

Table 4-2. Calibration parameters for PEST.0H case.

Calibration parameter	Value
Horizontal hydraulic conductivity of GAU, <GAUkh>	38 ft/d
Vertical hydraulic conductivity of GAU, <GAUkv>	0.38 ft/d
Horizontal hydraulic conductivity of GCU, <GCUkh>	1.00E-03 ft/d
Vertical hydraulic conductivity of GCU, <GCUkv>	1.00E-04 ft/d
Horizontal hydraulic conductivity multiplier for LAZ, <LAZkhf>	1.4
Vertical hydraulic conductivity multiplier for LAZ, <LAZkvf>	1.4
Horizontal hydraulic conductivity multiplier for TCCZ, <TCCZkhf>	1.4
Vertical hydraulic conductivity multiplier for TCCZ, <TCCZkvf>	1.4
Horizontal hydraulic conductivity multiplier for TZ, <TZkhf>	1.4
Vertical hydraulic conductivity multiplier for TZ, <TZkvf>	1.4
Horizontal hydraulic conductivity multiplier for AAA, <AAAkhf>	1.4
Vertical hydraulic conductivity multiplier for AAA, <AAAkvf>	1.4

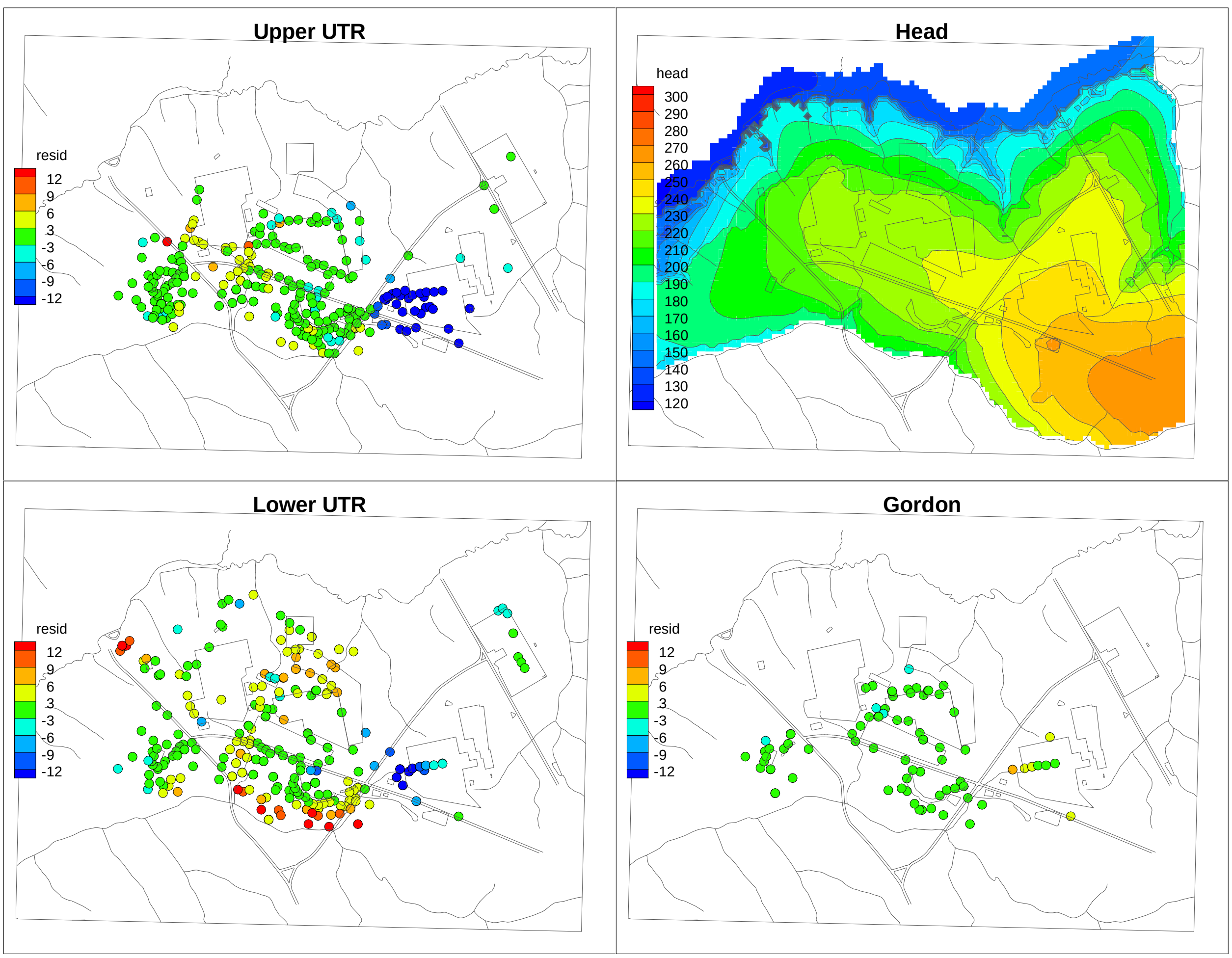


Figure 4-2. Hydraulic head residuals and water table surface for the Heterogeneous K field (PEST.0H case).

Table 4-3. Hydraulic conductivity limits for Heterogeneous K field.

Limits (ft/d)	K_h min	K_h max	K_v min	K_v max
LAZ	3.8	38	0.13	1.3
TCCZ	0.057	1.8	0.0019	0.06
TZ	3.2	32	0.11	1.1
AAA	0.1	3.2	0.0033	0.11

5.0 Calibration approach

PEST offers four modes of operation: "estimation", "predictive analysis", "regularisation" and "pareto". The basic "estimation" mode chosen for this study uses the Gauss-Marquardt-Levenberg method to iteratively adjust model parameters in a manner that ultimately minimizes a user-defined "objective function" (Watermark Numerical Computing 2016, Sections 3.3.2 and 3.7). Estimation of these optimal parameter values, parameter estimation in short, is also known as inverse modeling. Because no Tikhonov regularization (or similar scheme) is applied in the "estimation" mode, PEST requires a mathematically well-posed inverse problem. In layman's terms the number and type of model output targets (e.g. measured well water levels) must be sufficient such that a unique set of parameter values minimizes the objective function. For example, the number of calibration targets (knowns) must equal or exceed the number of parameters to be estimated (unknowns).

Use of the "regularisation" mode to conduct "highly parameterized inversion" (Watermark Numerical Computing 2016, Section 3.3.3) was considered but rejected because of PORFLOW license and computing resource limitations. Each PEST iteration requires at least one PORFLOW model simulation per parameter being estimated to generate the Jacobian matrix. Using four CPUs, each PORFLOW simulation takes roughly 10 minutes to complete. The number of concurrent PORFLOW runs is license limited to 15. Optimization requires several to many iterations, typically around a dozen using the basic "estimation" mode. The PEST wall-clock time can be reduced by running PORFLOW simulations in parallel using the parallel PEST code "ppest". PEST optimization running in the "estimation" mode with 7 parallel PORFLOW simulations typically required several hours to complete, as much as one day. Using 7 PORFLOW licenses per PEST run enabled two simultaneous optimization runs. "Highly parameterized inversion" using the "regularisation" mode would have involved many more parameters and required days if not weeks of wall-clock time for each PEST run.

The "predictive analysis" mode is designed to be used after a successful "estimation" or "regularisation" run to quantify uncertainty in a user-designated model output or "prediction" (Watermark Numerical Computing 2016, Section 3.3.4). The "pareto" mode is an advanced estimation mode involving multiple, competing, optimization functions (Watermark Numerical Computing 2016, Section 3.3.5).

5.1 PEST objective function and weights

The basic form of the objective function Φ minimized using the PEST "estimation" mode is:

$$\Phi = \sum_i (w_i r_i)^2 \quad (1)$$

where r_i is the i^{th} model - target residual and w_i is the weight given to the i^{th} residual. Thus PEST "estimation" constitutes a least-squares optimization. "Unweighted" optimization refers to the special case of uniform weights, or equivalently:

$$w_i = 1 \quad (2)$$

for all i. Otherwise the optimization is "Weighted". Weighting is used to give more or less emphasis to an individual target compared to its peers, and a generally recommended parameter inversion practice (Doherty and Hunt 2010, p. 14). Residuals are commonly given weights that are inversely proportional to their uncertainty, for example:

$$w_i^u = \frac{1}{(s_e)_i} = \frac{\sqrt{n}}{s_i} \quad (3)$$

where s_e is the "standard error of the mean" for a sample mean, n is the number of measurements, s is the standard deviation of the population (transient well record), and i indicates a particular calibration target. s_i in the denominator gives less weight to targets exhibiting more variability, and $\sqrt{n}$ in the numerator gives more weight to targets with more measurements (longer record). Appendix C of Hiergesell et al. (2015) provides s_e for the GSA2016 updated targets.

Weights can also be used to deal with data clustering / sparsity within and between hydrostratigraphic units. "Geographic" weights w_i^g are proposed in Appendix D of Hiergesell et al. (2015). These weighting factors account for differences in data density across the GSA footprint. Another consideration is the data density between hydrostratigraphic units (HSUs). Equal weight can be given to each unit by defining weighting factors that are the inverses of the fractions of targets within each HSU:

$$w^{GAU} = \frac{639}{81} = 7.9 \quad (4a)$$

$$w^{LAZ} = \frac{639}{275} = 2.3 \quad (4b)$$

$$w^{UAZ} = \frac{639}{283} = 2.3 \quad (4c)$$

For GSA2016 calibration using weighted PEST "estimation", the effects of data uncertainty and spatial density are combined by defining residual weights as:

$$w_i = w_i^u w_i^g w^{HSU} \quad (5)$$

where HSU = GAU, LAZ or UAZ (TZ + AAA) depending of the location of the target. Weights were also limited to a maximum value of 10, approximately 10 times the median value, to avoid excessive emphasis on isolated locations that may occur using the polygonal de-clustering algorithm of Hiergesell et al. (2015). Appendix C lists hydraulic head targets from Hiergesell et al. (2015) and associated weights computed from Equation (5). One well, "ZBG 1A", is suspected to reflect perched water, or water held up in the well sump, and was ignored during PEST "estimation" through an assigned weight of zero.

The objective function Φ differs by orders of magnitude for unweighted (Equation (2)) and weighted (Equation (5)) optimization, and relative goodness-of-fit cannot be directly assessed by comparing Φ for calibration runs using different weights. However, a more meaningful comparison can be achieved by normalizing the objective function for weighted optimization by the sum of the squared weights:

$$\Phi_{normalized} = \frac{\sum_i (w_i r_i)^2}{\sum_i (w_i)^2} \quad (6)$$

This normalized metric is similar in magnitude regardless of weighting, enabling approximate comparisons of unweighted and weighted optimization results. For the weights listed in Appendix C, $1/\sum_i (w_i)^2$ = 6.89E-4.

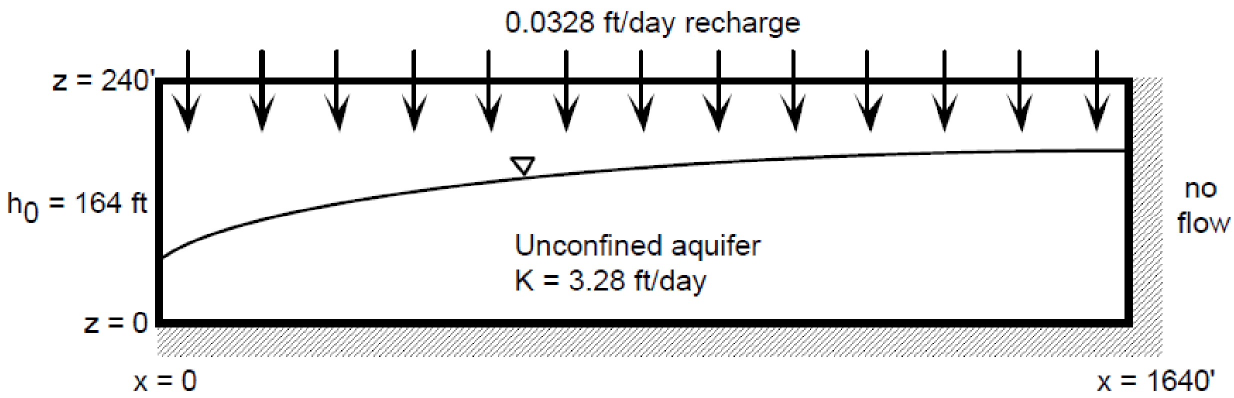
5.2 PEST parameterization strategy

The hydraulic properties of the GAU and GCU are moderately certain based on data and previous modeling studies. Thus these HSUs were not subjected to PEST optimization in order to improve mathematical well-posedness and reduce wall-clock time (PEST computational load is roughly proportional to the number of parameters to be estimated). However, the UAZ was subdivided into TZ and AAA zones as noted in Section 3.0, based on the work of Flach et al. (1999) and preliminary model calibration. The TZ zone is approximately 30 ft thick. The additional TZ and AAA HSUs increase the number of conductivity parameters that are candidates for PEST estimation.

Recharge was not estimated in order to limit calibration targets to well water levels and avoid mathematical non-uniqueness. Recharge and hydraulic conductivity cannot be independently estimated unless stream baseflow measurements are introduced to the set of calibration targets, because the former parameters are correlated with respect to hydraulic head. Figure 5-1 illustrates this general concept using two simple groundwater flow problems as examples; also indicated in the figure are the corresponding analytic solutions. Note that the flow rate (Q) and conductivity (K) parameters appear as the quotient Q/K. Thus only the quotient can be estimated using hydraulic head (h) data alone as calibration targets. In this study recharge is fixed so that conductivity can be estimated from head targets through the quotient. Omitting stream baseflows from the model calibration process also has the advantage making these data available for post-calibration model validation. Furthermore, limiting the number of parameters to be estimated significantly reduces PEST runtime, enabling consideration of more parameter sets.

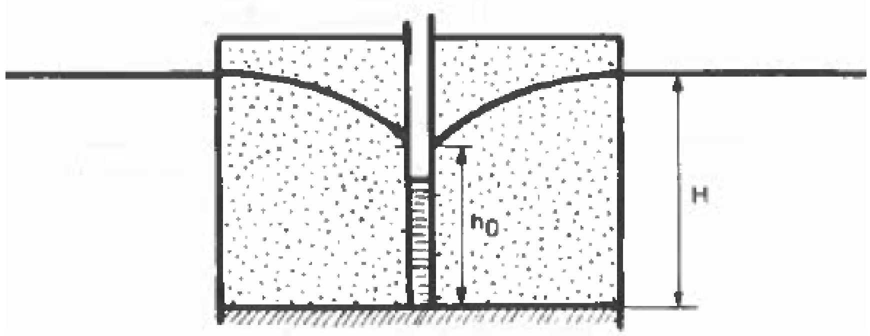
Table 5-1 summarizes the two initial condition PEST cases and a progression of optimization / calibration cases. Each round of PEST optimization generally considered a 2 by 2 matrix of four cases: Layer-cake versus Heterogeneous K field and Unweighted versus Weighted targets. Although four cases were defined for most rounds, some optimization cases were not run; these instances are indicated by grayed text in Table 5-1. Every optimization case (PEST.1 through PEST.53) included global multipliers to the LAZ, TCCZ, TZ and AAA baseline K_h and K_v fields, whether Layer-cake or Heterogeneous. These four global multipliers are denoted g01 (LAZ), g02 (TCCZ), g03 (TZ) and g04 (AAA) and were effectively unconstrained during optimization. PEST optimization for all cases was conducted using the parallel version of PEST ("ppest") with 7 slaves running up to 7 simultaneous model simulations. Unless otherwise noted the units of hydraulic conductivity are ft/d.

$$h^2 = h_0^2 - \frac{Q_{src}L^2}{K}\left(\frac{x}{L}\right)\left(\frac{x}{L} - 2\right)$$



(a)

$$h^2 = H^2 + \frac{Q}{\pi K} \ln \frac{r}{R}$$



(b)

Figure 5-1. Groundwater flow examples highlighting correlation between flow rate and hydraulic conductivity parameters: a) unconfined 2D flow in an unconfined aquifer with recharge (Aleman 2007, Figure 4.2.2), and, b) steady-state flow to a well in an unconfined aquifer (de Marsily 1986, Figure 7.5).

Table 5-1. PEST initial condition and optimization/calibration cases (grayed entries are placeholders).

PEST case	Base K field	Zonal K adjustments	Zonal K layers	Constraints	Targets
0L	Layer cake	None	N/A	N/A	N/A
0H	Heterogeneous	None	N/A	N/A	N/A
1	Layer cake	None	N/A	N/A	Unweighted
2	Heterogeneous	None	N/A	N/A	Unweighted
3	Layer cake	None	N/A	N/A	Weighted
4	Heterogeneous	None	N/A	N/A	Weighted
5	Layer cake	HareaCore.ply	TCCZ, TZ, AAA	>0.01, <100	Unweighted
6	Heterogeneous	HareaCore.ply	TCCZ, TZ, AAA	>0.01, <100	Unweighted
7	Layer cake	HareaCore.ply	TCCZ, TZ, AAA	>0.01, <100	Weighted
8	Heterogeneous	HareaCore.ply	TCCZ, TZ, AAA	>0.01, <100	Weighted
9	Layer cake	HareaCore.ply	TCCZ, TZ, AAA	>0.1, <10	Unweighted
10	Heterogeneous	HareaCore.ply	TCCZ, TZ, AAA	>0.1, <10	Unweighted
11	Layer cake	HareaCore.ply	TCCZ, TZ, AAA	>0.1, <10	Weighted
12	Heterogeneous	HareaCore.ply	TCCZ, TZ, AAA	>0.1, <10	Weighted
13	Layer cake	HareaCore.ply	TCCZ, TZ, AAA	>0.3162, <3.162	Unweighted
14	Heterogeneous	HareaCore.ply	TCCZ, TZ, AAA	>0.3162, <3.162	Unweighted
15	Layer cake	HareaCore.ply	TCCZ, TZ, AAA	>0.3162, <3.162	Weighted
16	Heterogeneous	HareaCore.ply	TCCZ, TZ, AAA	>0.3162, <3.162	Weighted
17	Layer cake	HSZarea.ply	TCCZ, TZ, AAA	>0.01, <100	Unweighted
18	Heterogeneous	HSZarea.ply	TCCZ, TZ, AAA	>0.01, <100	Unweighted
19	Layer cake	HSZarea.ply	TCCZ, TZ, AAA	>0.01, <100	Weighted
20	Heterogeneous	HSZarea.ply	TCCZ, TZ, AAA	>0.01, <100	Weighted
21	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	>0.3162, <3.162 AAAKh>3.e-4 AAAKv>1.e-5	Unweighted
22	Heterogeneous	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Unweighted
23	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Weighted
24	Heterogeneous	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Weighted

PEST case	Base K field	Zonal K adjustments	Zonal K layers	Constraints	Targets
25	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	limits+alluvium factor	Unweighted
26	Heterogeneous	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Unweighted
27	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Weighted
28	Heterogeneous	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Weighted
29	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	limits+root	Unweighted
30	Heterogeneous	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Unweighted
31	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Weighted
32	Heterogeneous	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Weighted
33	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	limits+FMBkmin	Unweighted
34	Heterogeneous	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Unweighted
35	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Weighted
36	Heterogeneous	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Weighted
37	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	new polygons	Unweighted
38	Heterogeneous	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Unweighted
39	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Weighted
40	Heterogeneous	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	"	Weighted
41	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU=1.e-4	Unweighted
42	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU=1.e-5	Unweighted
43†	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU optimized + vadoseFlag off	Unweighted
44†	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU optimized + vadoseFlag off + noConstraints	Unweighted
45†	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU = 0.75e-4 + vadoseFlag off + half order of magnitude	Unweighted
46†	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU = 0.75e-4 + vadoseFlag off + one order of magnitude	Unweighted
47	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU = 0.75e-4 + vadoseFlag off + one order of magnitude + 4	Unweighted

PEST case	Base K field	Zonal K adjustments	Zonal K layers	Constraints	Targets
				iterations	
48	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU = 0.75e-4 + vadoseFlag on + one order of magnitude + 4 iterations	Unweighted
49	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU = 1.e-4 + vadoseFlag off + one order of magnitude + 4 iterations	Unweighted
50	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU = 1.e-5 + vadoseFlag off + one order of magnitude + 4 iterations	Unweighted
51	Layer cake	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU = 0.75e-4 + vadoseFlag off + one order of magnitude + 4 iterations	Weighted
52	Heterogeneous	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU = 0.75e-4 + vadoseFlag off + one order of magnitude + 4 iterations	Unweighted
53	Heterogeneous	HS&Zarea.ply	LAZ,TCCZ, TZ, AAA	kGCU = 0.75e-4 + vadoseFlag off + one order of magnitude + 4 iterations	Weighted

Notes: -- Grayed entries are placeholders and were not run
† poor convergence due to inadequate Newton iterations

6.0 Calibration results

Optimization results for PEST.1 through PEST.4 are summarized by Figure 6-1 through Figure 6-4 and Table 6-1 through Table 6-4. In the summary tables, “Net Kh” and “Net Kv” for Layer-cake cases denote net conductivities after multiplying the “Base Kh” and “Base Kv” values by the global multipliers (g01 through g04) indicated in the “PEST.xx” column. The four rightmost columns represent an independent calculation of average conductivity, where “Kv avg” is computed from the average “log10” value (geometric averaging). For the Heterogeneous cases, “Net Khf” and “Net Kvf” are the same as the global multiplication factors for PEST.2 and 4. “Ratio” is the ratio of “Kh avg” to “Kv avg”. Although the local anisotropy ratio is nominally 30x in the Upper Three Runs aquifer, the average ratio can deviate from 30 due to maximum and/or minimum conductivity cutoffs and spatial averaging.

Above the capillary fringe adjoining the water table, the hydraulic head gradient tends to be close to 1.0 (e.g. Wilson 1980 Figure 15; Nimmo et al. 2002 Figure 2), in which case Darcy velocity U and hydraulic conductivity are approximately equal according to Darcy’s law. Thus:

$$K = U = 15\,\frac{in}{yr} = 0.00342\,\frac{ft}{d} = 1.2 \times 10^{-6}\,\frac{cm}{s} \tag{6}$$

is the minimum saturated conductivity value that will allow the AAA zone to accept 15 in/yr of surface infiltration. In all four cases the optimized vertical conductivity of the AAA is very low, approaching 0.00342 ft/d. Around H-Area, where the water table resides in the AAA, K near 0.003 ft/d has the effect of raising the water table significantly compared to lower values of K. However, K approaching 10^{-6} cm/s (Equation (6)) is unrealistically low compared to average soil properties compiled by Phifer et al. (2006 Table 5-18), which range from approximately 10^{-5} to 10^{-4} cm/s for vertical conductivity. Furthermore, the water table east of H-Area is at or just below the ground surface, which would create wetland conditions inconsistent with casual field observations. Cases PEST.1 through PEST.4 suggest the need for perturbations to global K settings near H-Area. Alternatively, recharge could be increased near H-Area to achieve higher hydraulic heads. Because H-Area rainfall and topography are similar to other areas of the GSA, the hypothesis of higher recharge was deemed less likely than a conductivity perturbation and not pursued further.

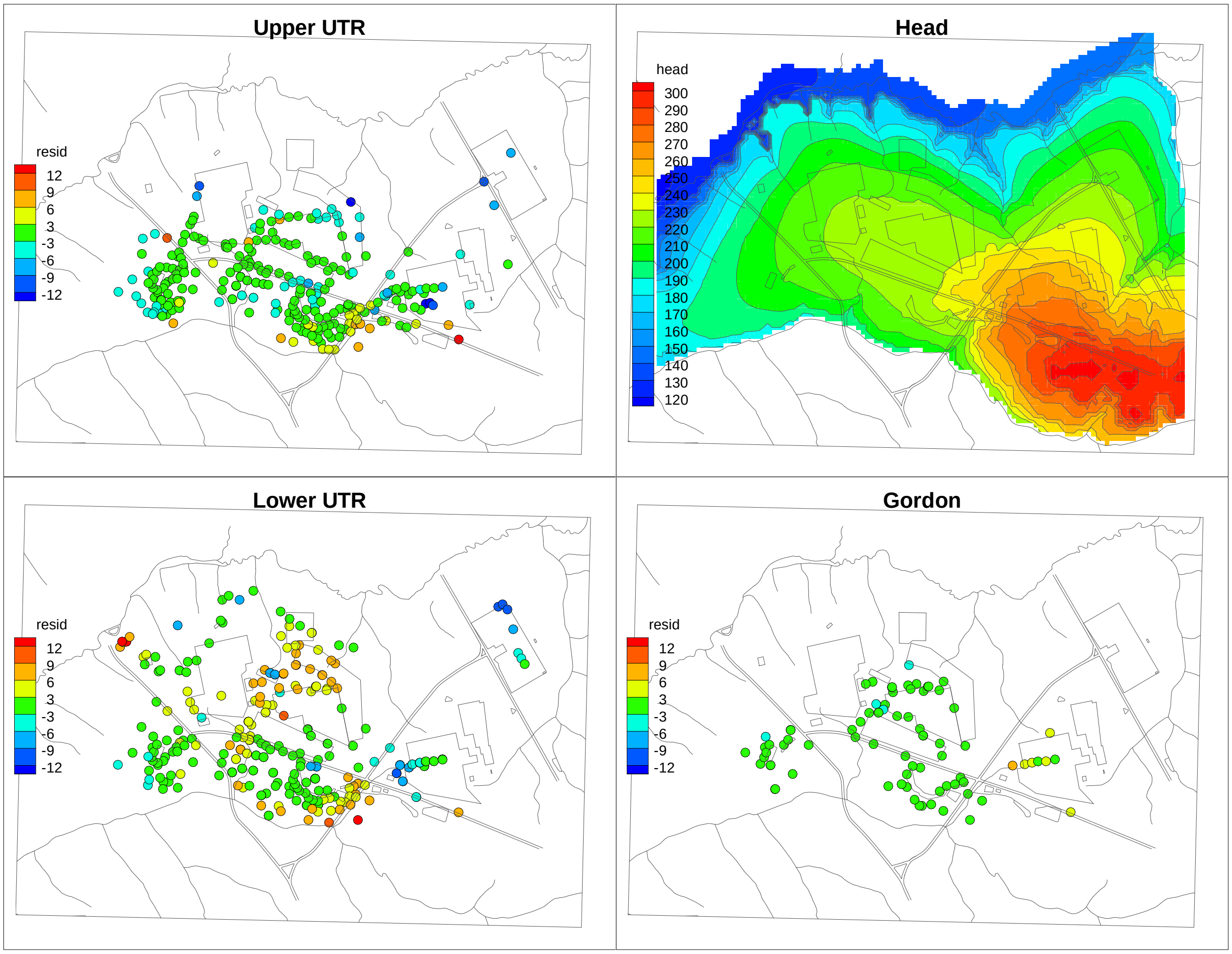


Figure 6-1. Hydraulic head residuals and water table surface for the PEST.1 case.

Table 6-1. Hydraulic conductivity summary for PEST.1 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.1a	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					10437								
g01	LAZ	Global	12	0.4	1.04924	12.6	0.42	4.4E-03	1.5E-04	12.6	0.420	-0.3771	30x
g02	TCCZ	Global	0.18	0.006	3.13369	0.56	0.019	2.0E-04	6.6E-06	0.56	0.019	-1.726	30x
g03	TZ	Global	9	0.3	0.671775	6.0	0.20	2.1E-03	7.1E-05	6.0	0.202	-0.6957	30x
g04	AAA	Global	9	0.3	1.84E-02	0.17	0.0055	5.8E-05	1.9E-06	0.17	0.006	-2.259	30x
h01	TCCZ	Local			1	0.56	0.019	2.0E-04	6.6E-06				
h02	TZ	Local			1	6.0	0.20	2.1E-03	7.1E-05				
h03	AAA	Local			1	0.17	0.0055	5.8E-05	1.9E-06				

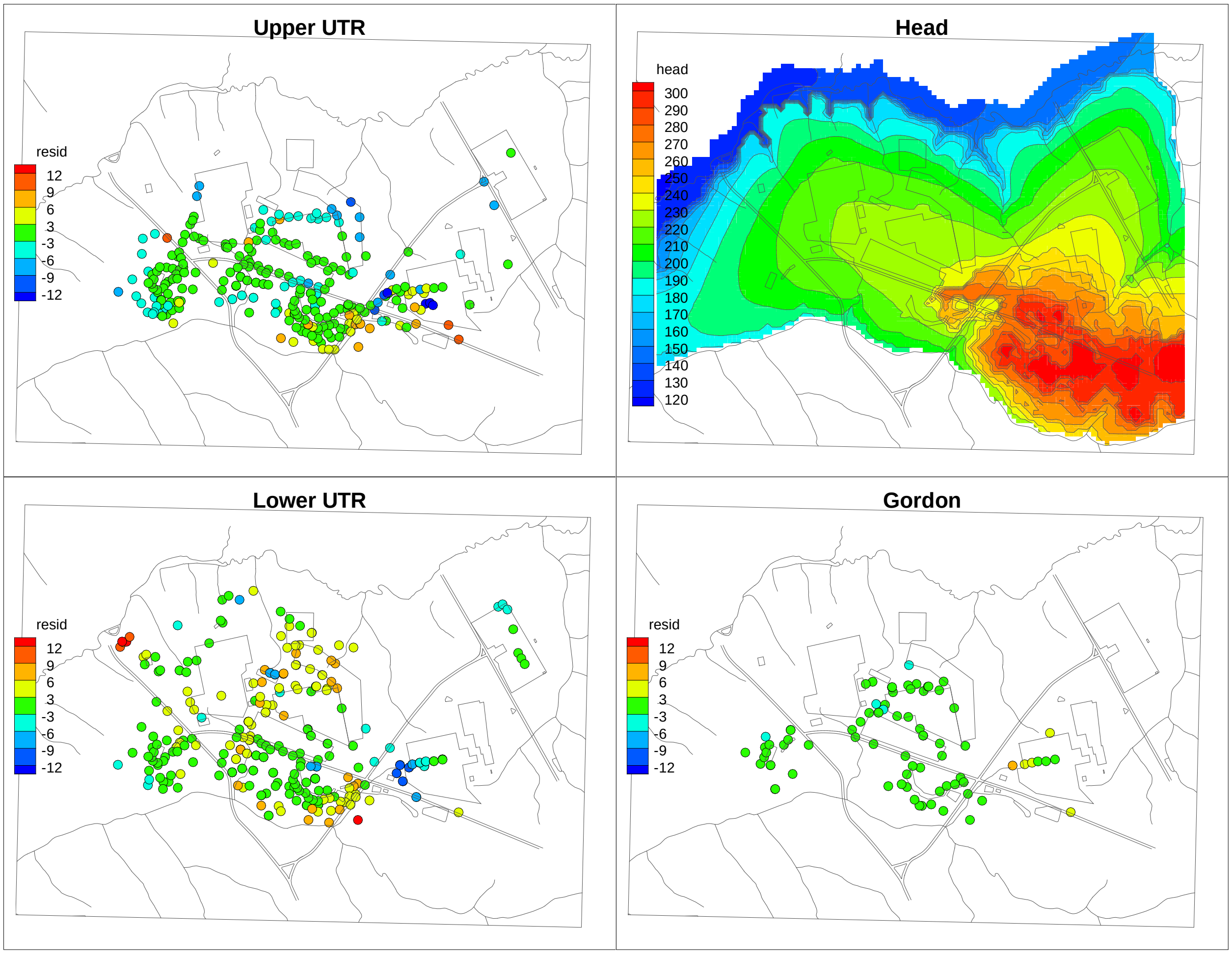


Figure 6-2. Hydraulic head residuals and water table surface for the PEST.2 case.

Table 6-2. Hydraulic conductivity summary for PEST.2 case.

Parameter	Unit	Region	Base Kh factor	Base Kv factor	PEST.2e	Net Kh factor	Net Kv factor	N/A	N/A	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					10852								
g01	LAZ	Global	1	1	1.49865	1.5	1.5			12.6	0.192	-0.7166	66x
g02	TCCZ	Global	1	1	*100*	100	100			*1.8*	0.046	-1.338	39x
g03	TZ	Global	1	1	0.303046	0.30	0.30			3.3	0.138	-0.8599	24x
g04	AAA	Global	1	1	1.88E-02	0.019	0.019			0.12	0.004	-2.451	35x
h01	TCCZ	Local			1	100	100						
h02	TZ	Local			1	0.30	0.30						
h03	AAA	Local			1	0.019	0.019						

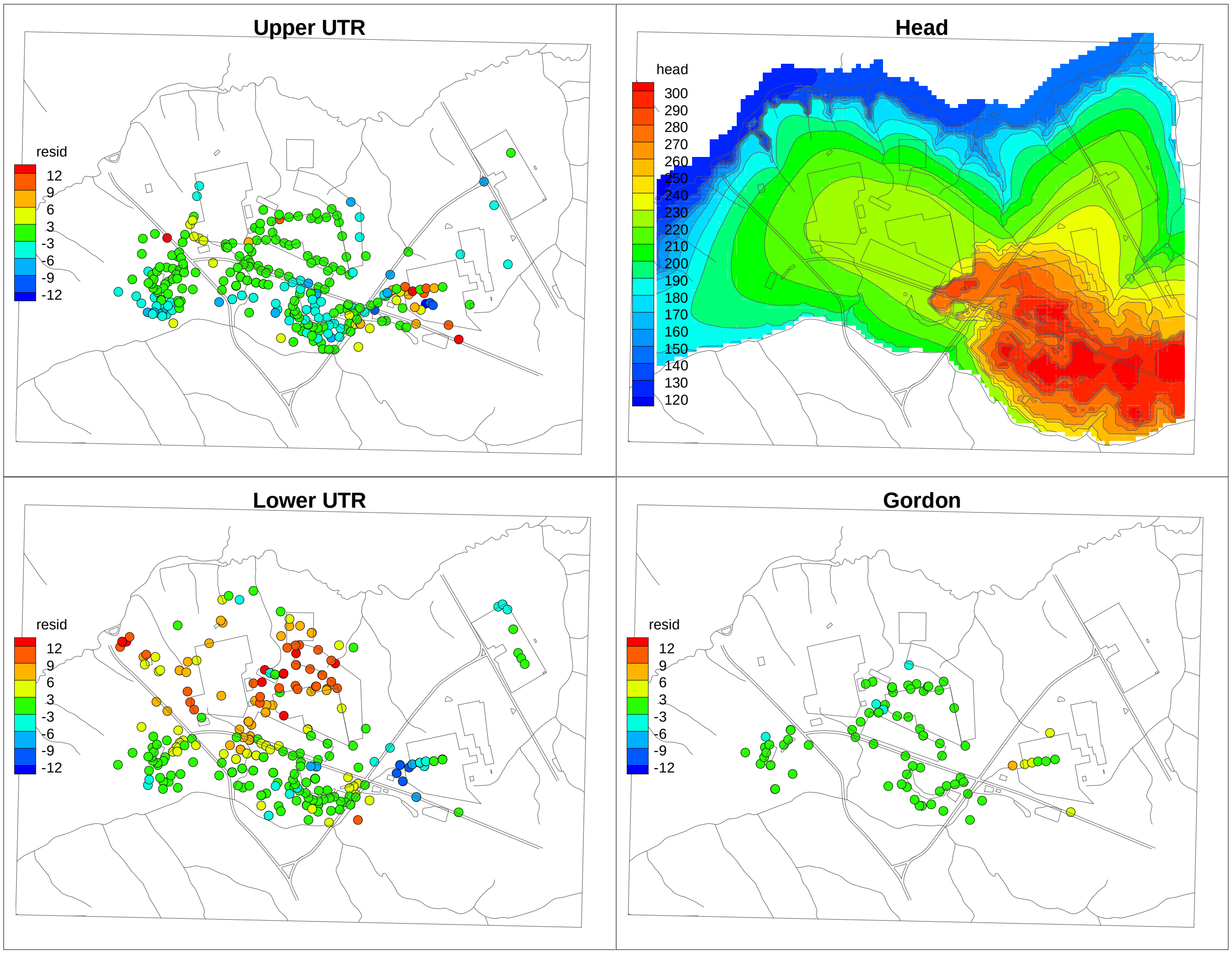


Figure 6-3. Hydraulic head residuals and water table surface for the PEST.3 case.

Table 6-3. Hydraulic conductivity summary for PEST.3 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.3a	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.17E+07								
g01	LAZ	Global	12	0.4	0.723788	8.7	0.29	3.1E-03	1.0E-04	8.7	0.290	-0.5383	30x
g02	TCCZ	Global	0.18	0.006	17.6766	3.2	0.11	1.1E-03	3.7E-05	3.2	0.106	-0.9744	30x
g03	TZ	Global	9	0.3	1.06805	9.6	0.32	3.4E-03	1.1E-04	9.6	0.320	-0.4943	30x
g04	AAA	Global	9	0.3	1.08E-02	0.10	0.0032	3.4E-05	1.1E-06	0.10	0.0033	-2.488	30x
h01	TCCZ	Local			1	3.2	0.11	1.1E-03	3.7E-05				
h02	TZ	Local			1	9.6	0.32	3.4E-03	1.1E-04				
h03	AAA	Local			1	0.10	0.0032	3.4E-05	1.1E-06				

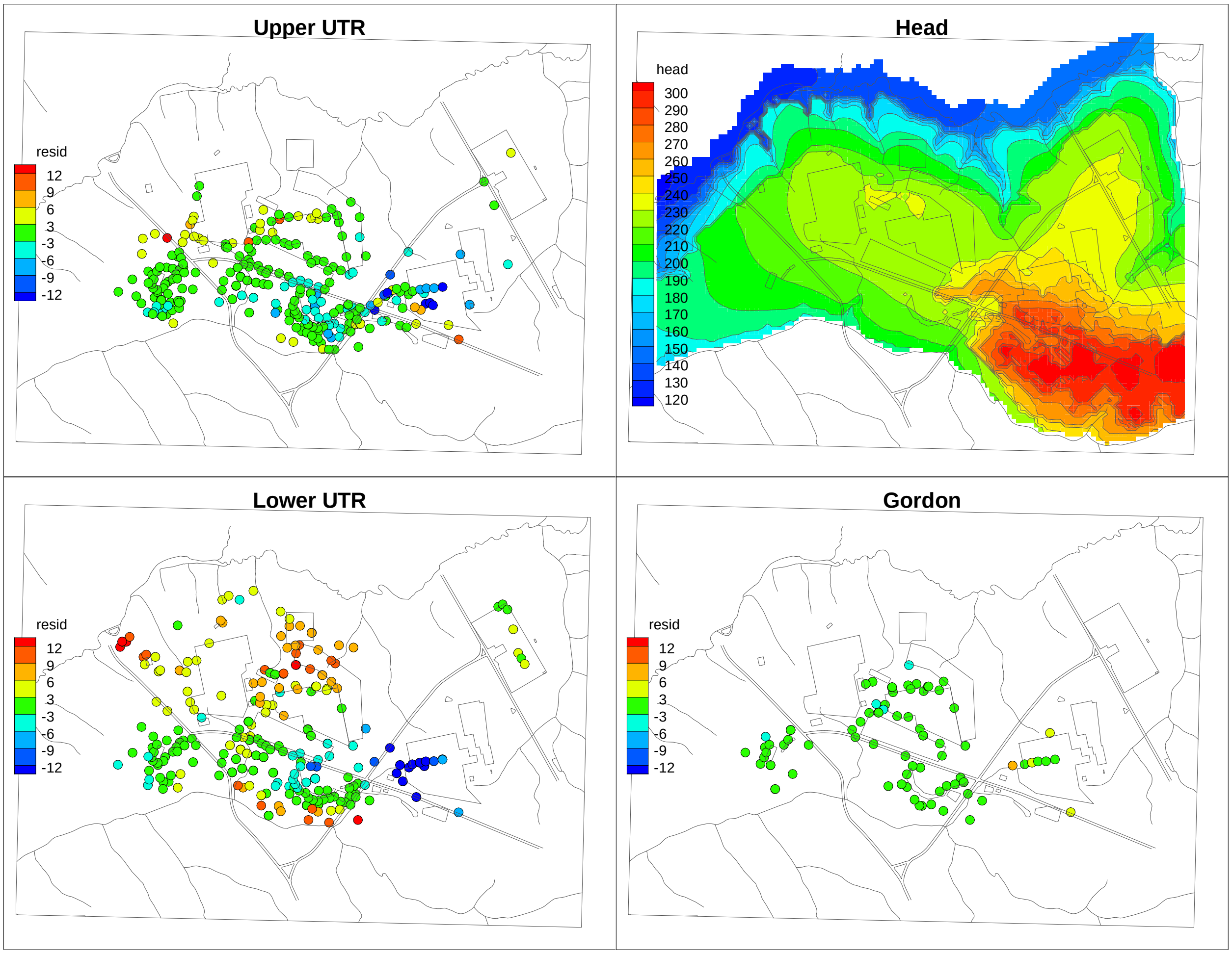


Figure 6-4. Hydraulic head residuals and water table surface for the PEST.4 case.

Table 6-4. Hydraulic conductivity summary for PEST.4 case.

Parameter	Unit	Region	Base Kh factor	Base Kv factor	PEST.4f	Net Kh factor	Net Kv factor	N/A	N/A	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.98E+07								
g01	LAZ	Global	1	1	0.888793	0.89	0.89			7.5	0.163	-0.788	46x
g02	TCCZ	Global	1	1	0.101618	0.10	0.10			0.19	0.0020	-2.705	98x
g03	TZ	Global	1	1	2.96986	3.0	3.0			27.2	0.536	-0.2708	51x
g04	AAA	Global	1	1	1.02E-02	0.010	0.010			0.11	0.0034	-2.469	33x
h01	TCCZ	Local			1	0.10	0.10						
h02	TZ	Local			1	3.0	3.0						
h03	AAA	Local			1	0.010	0.010						

Cases PEST.5 through PEST.16 involved three optimization rounds where TCCZ, TZ and AAA conductivities were allowed to deviate from the global specification within an elliptical region with variable location, orientation, size and shape. The initial ellipse is shown in Figure 6-5 through Figure 6-14 with a dashed line. Cases PEST.17 through PEST.20 allowed perturbations within a polygon capturing greater H, S and Z-Areas, indicated by the solid magenta line in Figure 6-15 through Figure 6-18. The parameters presented to PEST for optimization are defined in Table 6-5. With the ellipse or HSZ polygon, baseline hydraulic conductivity is multiplied by both the global and local factors, for example:

$$K_{TZ} = K_{TZ,baseline} \times g03 \times h02 \tag{7}$$

For Layer-cake simulations, the net conductivity value after such multiplication is indicated in summary tables under the headings "Net Kh" (ft/d), "Net Kv" (ft/d), "Kh cm/s" and "Kv cm/s". For the Heterogeneous K field simulations (which lack a single baseline K), the net multiplication factors (e.g. $g03 \times h02$) are indicated under the headings "Net Khf" and "Net Kvf".

Table 6-5. Calibration parameters for PEST.5 through 20.

Parameter description	PEST name
LAZ global K multiplier	g01
TCCZ global K multiplier	g02
TZ global K multiplier	g03
AAA global K multiplier	g04
TCCZ local K multiplier	h01
TZ local K multiplier	h02
AAA local K multiplier	h03
Ellipse easting	p01 (PEST.5 through 16)
Ellipse northing	p02 (PEST.5 through 16)
Ellipse major axis length	p03 (PEST.5 through 16)
Ellipse minor axis length	p04 (PEST.5 through 16)
Ellipse rotation angle	p05 (PEST.5 through 16)

To avoid an abrupt jump in hydraulic conductivity, the h0# factors are spatially smoothed with a digital filter. The number of calibration parameters is 12 for PEST.5 through PEST.16 and 7 for PEST.17 through PEST.20. As indicated in Table 5-1, the PEST.9 to 12 and PEST.13 to 16 rounds impose constraints on the local K multipliers h01, h02 and h03. For PEST.9 to 12, conductivity can deviate up to one order of magnitude from the global settings. For PEST.13 to 16, local perturbations are limited to half an order of magnitude ($10^{-0.5} = 0.3162, 10^{0.5} = 3.162$). The two order of magnitude bounds on PEST.5 to 8 and PEST.17 to 20 are sufficiently large to be non-limiting.

Optimization results for PEST.5 through PEST.20 (except PEST.10 and 12) are summarized by Figure 6-5 through Figure 6-18 and Table 6-6 through Table 6-19. For cases PEST.5 through PEST.16, the final optimized ellipse is indicated with a solid magenta line. All cases produced a significant reduction in the objective function compared to their PEST.1 to 4 counterparts, indicating much better agreement with hydraulic head targets. However, all 16 optimization results were deemed unsatisfactory for various reasons associated with some or all cases:

- The calibrated water table was excessively high east of H-Area
- The goodness-of-fit in Z-Area was marginal

- The local perturbations were excessively large
- The calibrated properties were questionable
- The calibrated ellipse created sharp changes within PA areas of interest

Therefore additional optimization cases were considered.

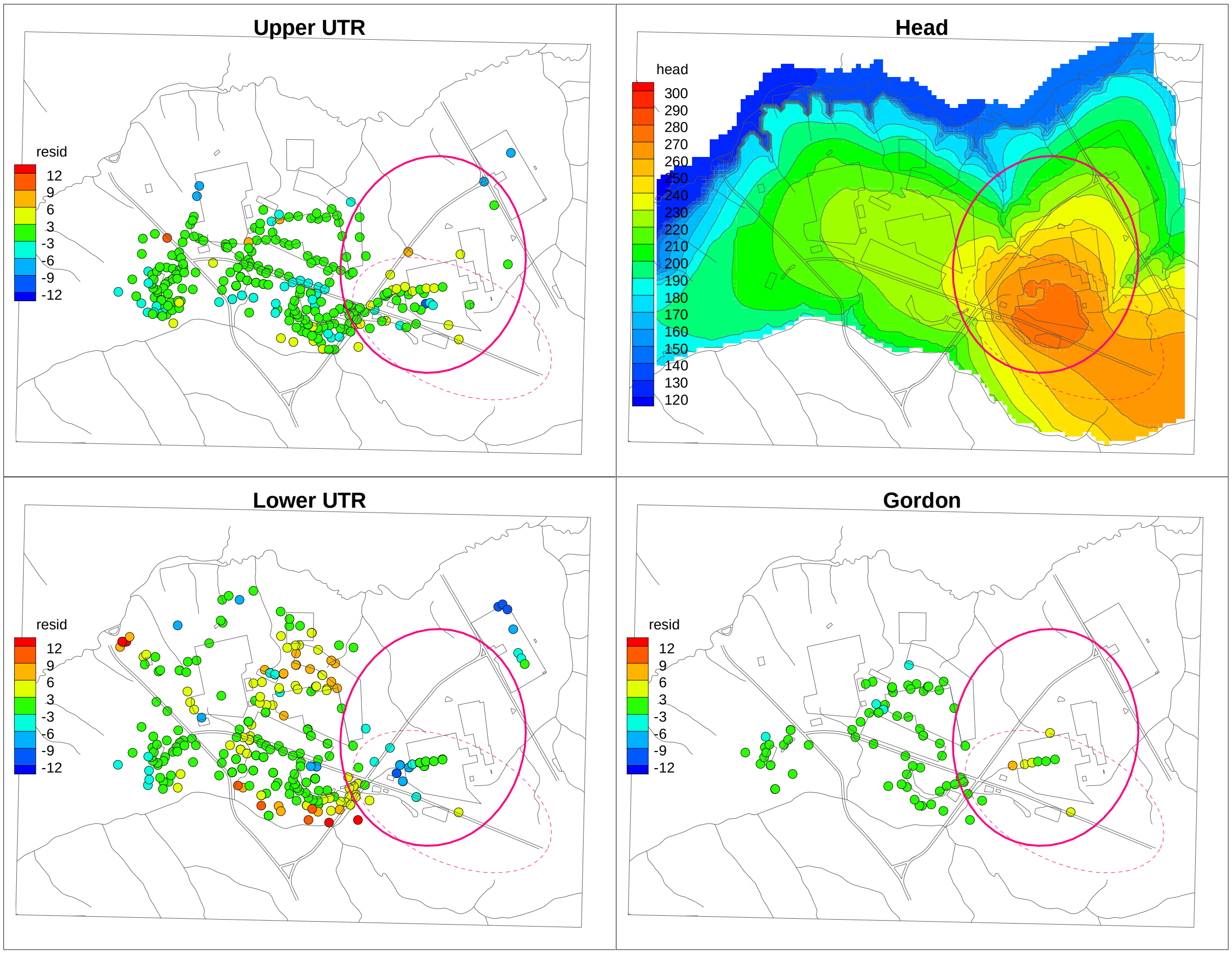


Figure 6-5. Hydraulic head residuals and water table surface for the PEST.5 case.

Table 6-6. Hydraulic conductivity summary for PEST.5 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.5b	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					8640								
g01	LAZ	Global	12	0.4	1.01829	12.2	0.4	4.3E-03	1.4E-04	12.2	0.407	-0.3901	30x
g02	TCCZ	Global	0.18	0.006	0.881402	0.16	0.0053	5.6E-05	1.9E-06	0.1551	0.005	-2.287	30x
g03	TZ	Global	9	0.3	1.67956	15.1	0.50	5.3E-03	1.8E-04	13.1	0.358	-0.4457	36x
g04	AAA	Global	9	0.3	2.84E-01	2.55	0.085	9.0E-04	3.0E-05	2.2	0.065	-1.19	34x
h01	TCCZ	Local			0.84054	0.13	0.0043	4.7E-05	1.6E-06				
h02	TZ	Local			5.28E-02	0.80	0.027	2.8E-04	9.4E-06				
h03	AAA	Local			0.103724	0.26	0.0088	9.3E-05	3.1E-06				

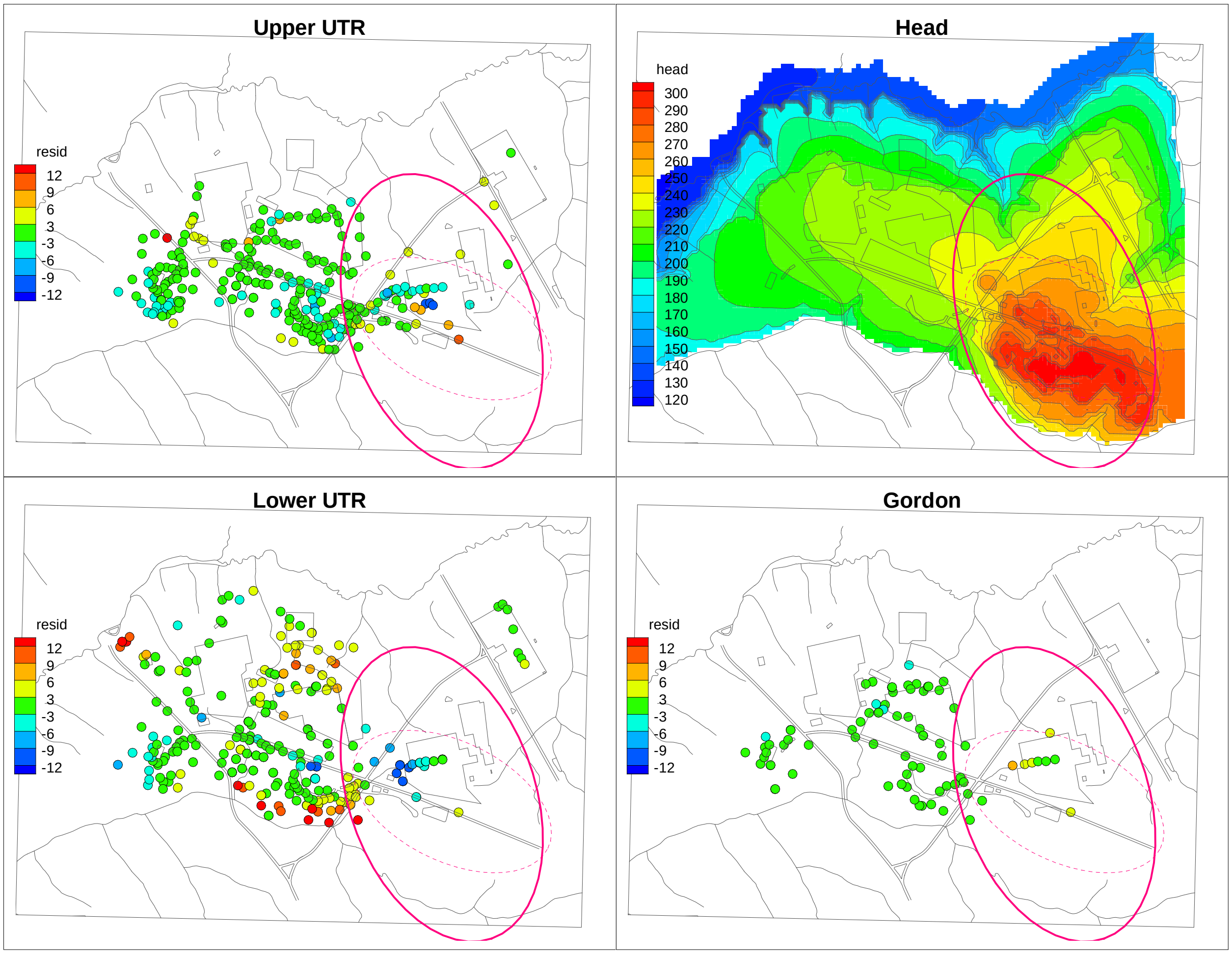


Figure 6-6. Hydraulic head residuals and water table surface for the PEST.6 case.

Table 6-7. Hydraulic conductivity summary for PEST.6 case.

Parameter	Unit	Region	Base Kh factor	Base Kv factor	PEST.6a	Net Kh factor	Net Kv factor	N/A	N/A	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					10440								
g01	LAZ	Global	1	1	1.31582	1.3	1.3			11.1	0.183	-0.737	60x
g02	TCCZ	Global	1	1	0.308147	0.31	0.31			0.5	0.002	-2.686	256x
g03	TZ	Global	1	1	2.42922	2.4	2.4			18.4	0.347	-0.46	53x
g04	AAA	Global	1	1	1.60E+00	1.6	1.6			2.3	0.018	-1.734	125x
h01	TCCZ	Local			0.697315	0.21	0.21						
h02	TZ	Local			1.09E-02	0.027	0.027						
h03	AAA	Local			0.120431	0.19	0.19						

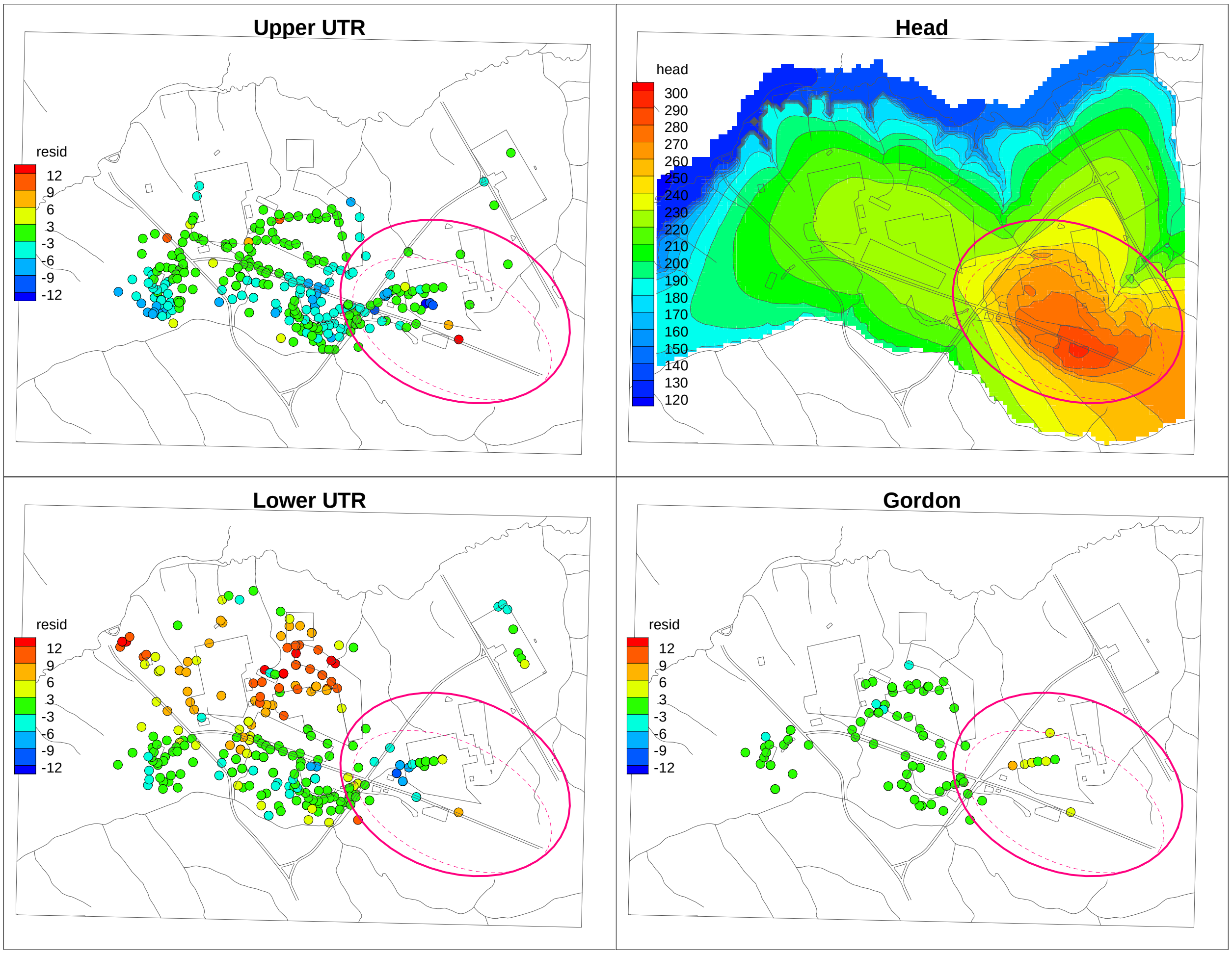


Figure 6-7. Hydraulic head residuals and water table surface for the PEST.7 case.

Table 6-8. Hydraulic conductivity summary for PEST.7 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.7b	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.12E+07								
g01	LAZ	Global	12	0.4	0.694194	8.3	0.28	2.9E-03	9.8E-05	8.3	0.278	-0.5565	30x
g02	TCCZ	Global	0.18	0.006	12.0348	2.17	0.072	7.6E-04	2.5E-05	1.9	0.052	-1.282	36x
g03	TZ	Global	9	0.3	1.80035	16.2	0.54	5.7E-03	1.9E-04	14.7	0.468	-0.3298	31x
g04	AAA	Global	9	0.3	1.73E+00	15.6	0.520	5.5E-03	1.8E-04	13.4	0.320	-0.4951	42x
h01	TCCZ	Local			9.05E-02	0.20	0.0065	6.9E-05	2.3E-06				
h02	TZ	Local			0.353224	5.7	0.19	2.0E-03	6.7E-05				
h03	AAA	Local			1.19E-02	0.19	0.0062	6.5E-05	2.2E-06				

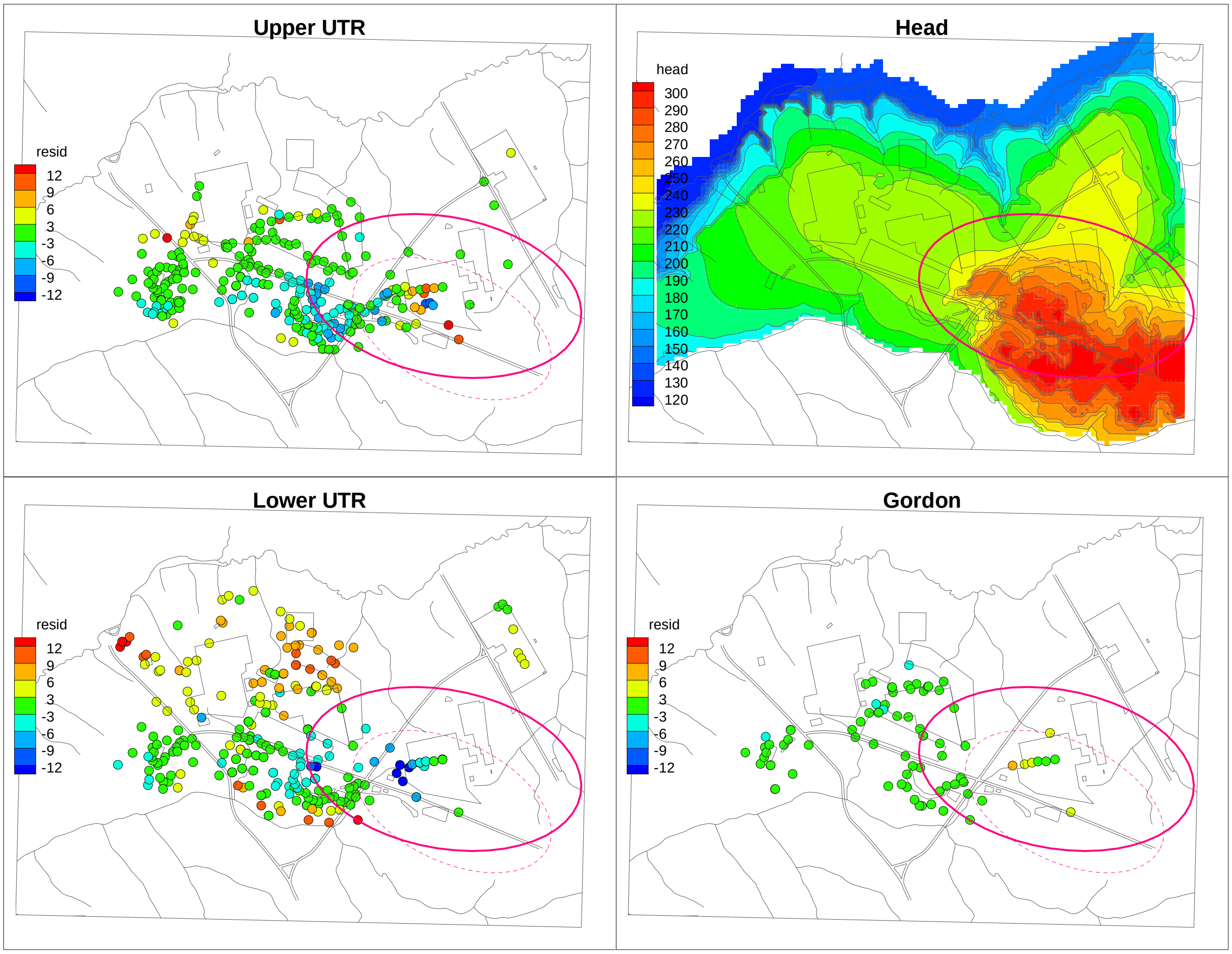


Figure 6-8. Hydraulic head residuals and water table surface for the PEST.8 case.

Table 6-9. Hydraulic conductivity summary for PEST.8 case.

Parameter	Unit	Region	Base Kh factor	Base Kv factor	PEST.8c	Net Kh factor	Net Kv factor	N/A	N/A	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.67E+07								
g01	LAZ	Global	1	1	0.876825	0.88	0.88			7.4	0.162	-0.7896	46x
g02	TCCZ	Global	1	1	4.30E-02	0.043	0.043			0.10	0.002	-2.713	51x
g03	TZ	Global	1	1	20.3992	20	20			29.0	0.793	-0.1005	37x
g04	AAA	Global	1	1	1.00E-02	0.010	0.010			0.13	0.0035	-2.456	38x
h01	TCCZ	Local			1.74292	0.075	0.075						
h02	TZ	Local			1.00E-02	0.20	0.20						
h03	AAA	Local			6.25299	0.063	0.063						

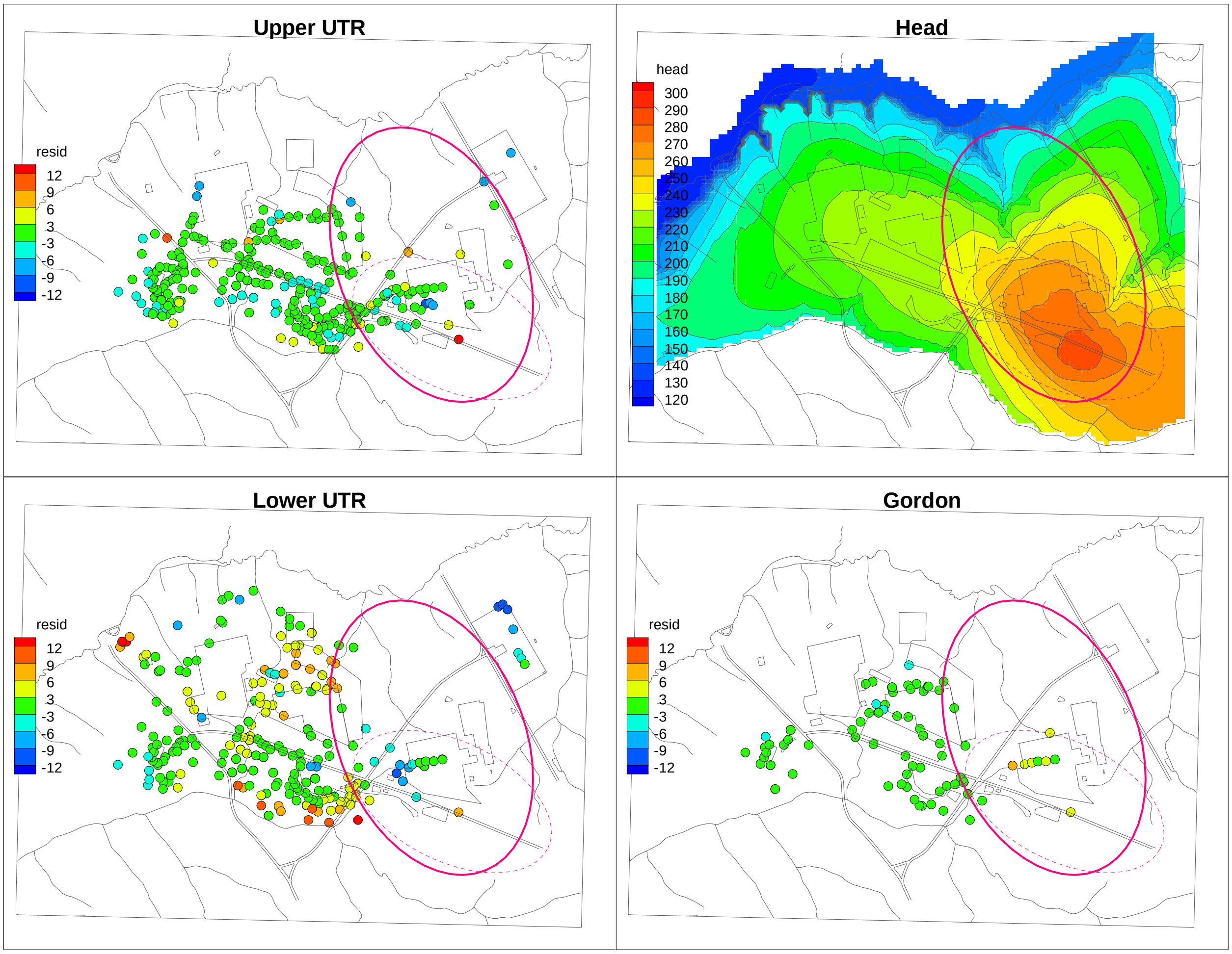


Figure 6-9. Hydraulic head residuals and water table surface for the PEST.9 case.

Table 6-10. Hydraulic conductivity summary for PEST.9 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.9a	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					8668.9								
g01	LAZ	Global	12	0.4	1.02961	12.4	0.41	4.4E-03	1.5E-04	12.3	0.408	-0.389	30x
g02	TCCZ	Global	0.18	0.006	1.13871	0.20	0.0068	7.2E-05	2.4E-06	0.1717	0.006	-2.251	31x
g03	TZ	Global	9	0.3	1.50277	14	0.45	4.8E-03	1.6E-04	11.8	0.328	-0.4845	36x
g04	AAA	Global	9	0.3	3.36E-01	3.0	0.10	1.1E-03	3.6E-05	1.7	0.048	-1.315	35x
h01	TCCZ	Local			0.564661	0.12	0.0039	4.1E-05	1.4E-06				
h02	TZ	Local			1.04E-01	1.4	0.047	5.0E-04	1.7E-05				
h03	AAA	Local			0.105843	0.32	0.011	1.1E-04	3.8E-06				

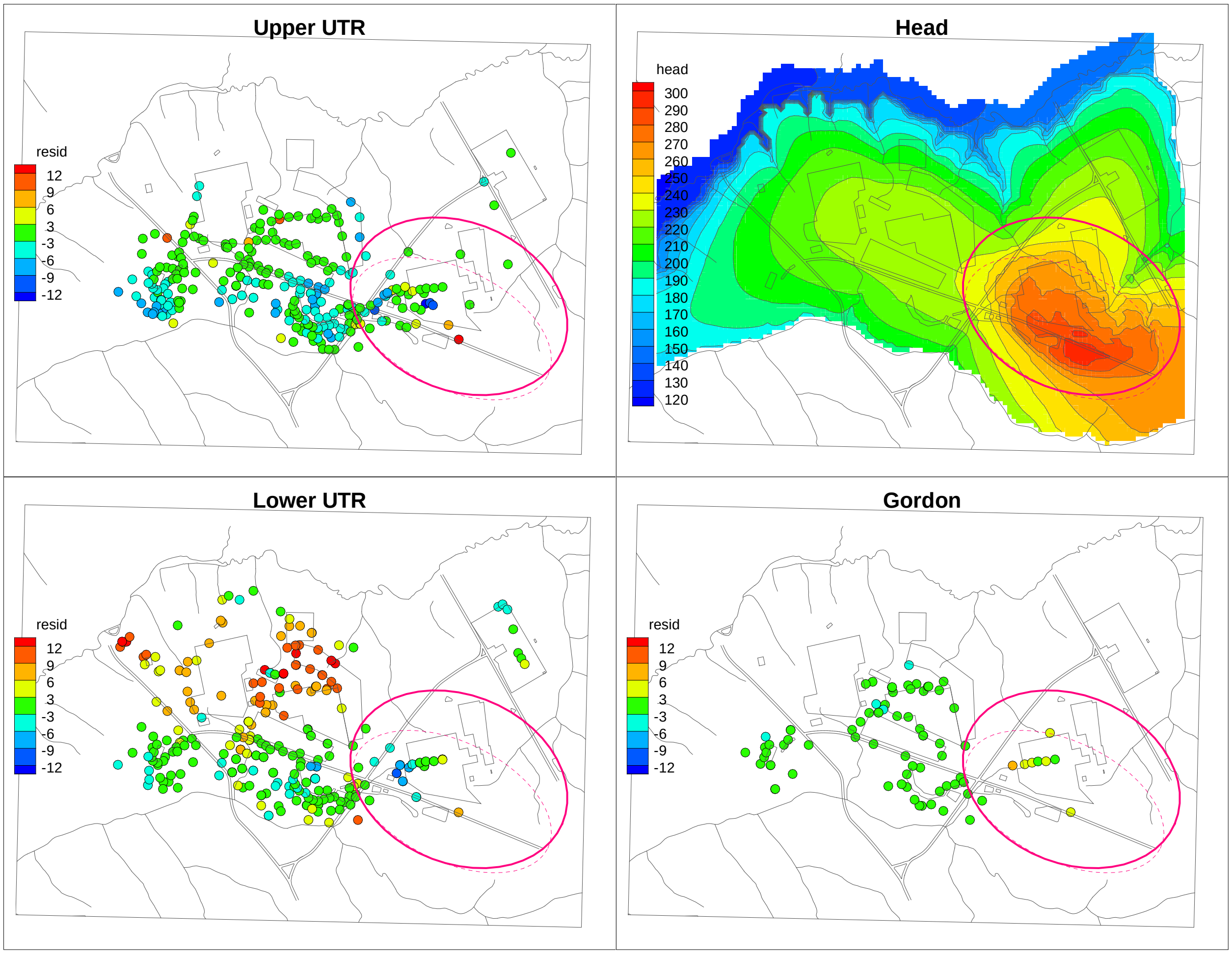


Figure 6-10. Hydraulic head residuals and water table surface for the PEST.11 case.

Table 6-11. Hydraulic conductivity summary for PEST.11 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.11c	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.28E+07								
g01	LAZ	Global	12	0.4	0.689544	8.3	0.28	2.9E-03	9.7E-05	8.3	0.276	-0.5594	30x
g02	TCCZ	Global	0.18	0.006	11.8158	2.1	0.071	7.5E-04	2.5E-05	1.9	0.054	-1.269	35x
g03	TZ	Global	9	0.3	1.9106	17	0.57	6.1E-03	2.0E-04	15.9	0.513	-0.2895	31x
g04	AAA	Global	9	0.3	1.83E-01	1.65	0.055	5.8E-04	1.9E-05	1.5	0.042	-1.372	34x
h01	TCCZ	Local			1.02E-01	0.22	0.0072	7.6E-05	2.5E-06				
h02	TZ	Local			0.41935	7.2	0.24	2.5E-03	8.5E-05				
h03	AAA	Local			1.03E-01	0.17	0.0056	6.0E-05	2.0E-06				

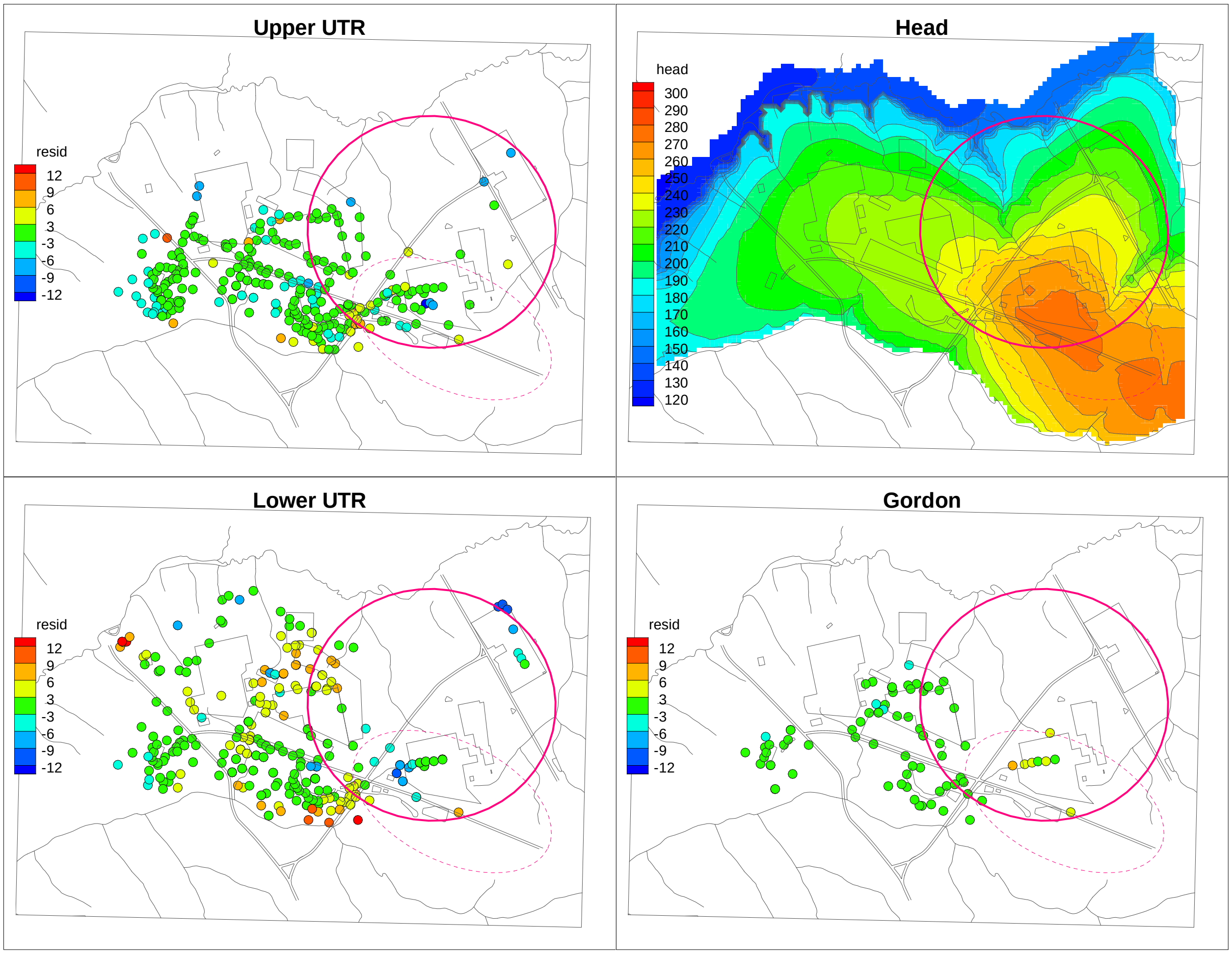


Figure 6-11. Hydraulic head residuals and water table surface for the PEST.13 case.

Table 6-12. Hydraulic conductivity summary for PEST.13 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.13g	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					8792.8								
g01	LAZ	Global	12	0.4	1.03884	12.5	0.42	4.4E-03	1.5E-04	12.5	0.416	-0.3814	30x
g02	TCCZ	Global	0.18	0.006	1.61016	0.29	0.010	1.0E-04	3.4E-06	0.2552	0.008	-2.084	31x
g03	TZ	Global	9	0.3	1.24414	11	0.37	4.0E-03	1.3E-04	9.6	0.302	-0.5195	32x
g04	AAA	Global	9	0.3	5.52E-02	0.50	0.017	1.8E-04	5.8E-06	0.4	0.014	-1.849	31x
h01	TCCZ	Local			0.41444	0.12	0.0040	4.2E-05	1.4E-06				
h02	TZ	Local			3.16E-01	3.5	0.12	1.2E-03	4.2E-05				
h03	AAA	Local			0.43331	0.22	0.0072	7.6E-05	2.5E-06				

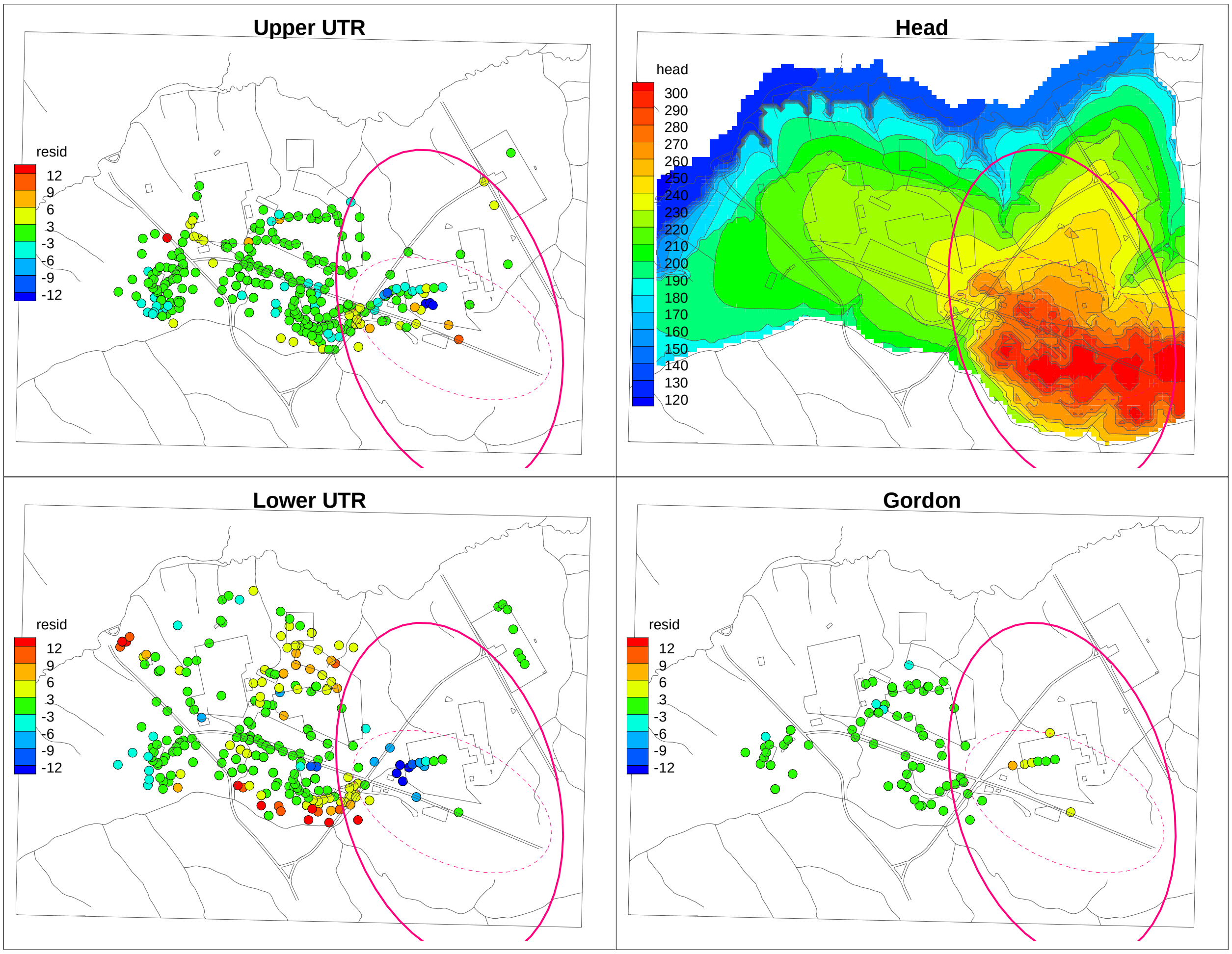


Figure 6-12. Hydraulic head residuals and water table surface for the PEST.14 case.

Table 6-13. Hydraulic conductivity summary for PEST.14 case.

Parameter	Unit	Region	Base Kh factor	Base Kv factor	PEST.14c	Net Kh factor	Net Kv factor	N/A	N/A	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					11294								
g01	LAZ	Global	1	1	1.35089	1.4	1.4			11.4	0.185	-0.733	61x
g02	TCCZ	Global	1	1	0.596704	0.60	0.60			0.8	0.002	-2.672	386x
g03	TZ	Global	1	1	2.04595	2.0	2.0			15.8	0.351	-0.4549	45x
g04	AAA	Global	1	1	1.83E-01	0.18	0.18			0.6	0.006	-2.233	99x
h01	TCCZ	Local			0.318444	0.19	0.19						
h02	TZ	Local			3.16E-01	0.65	0.65						
h03	AAA	Local			0.450396	0.082	0.082						

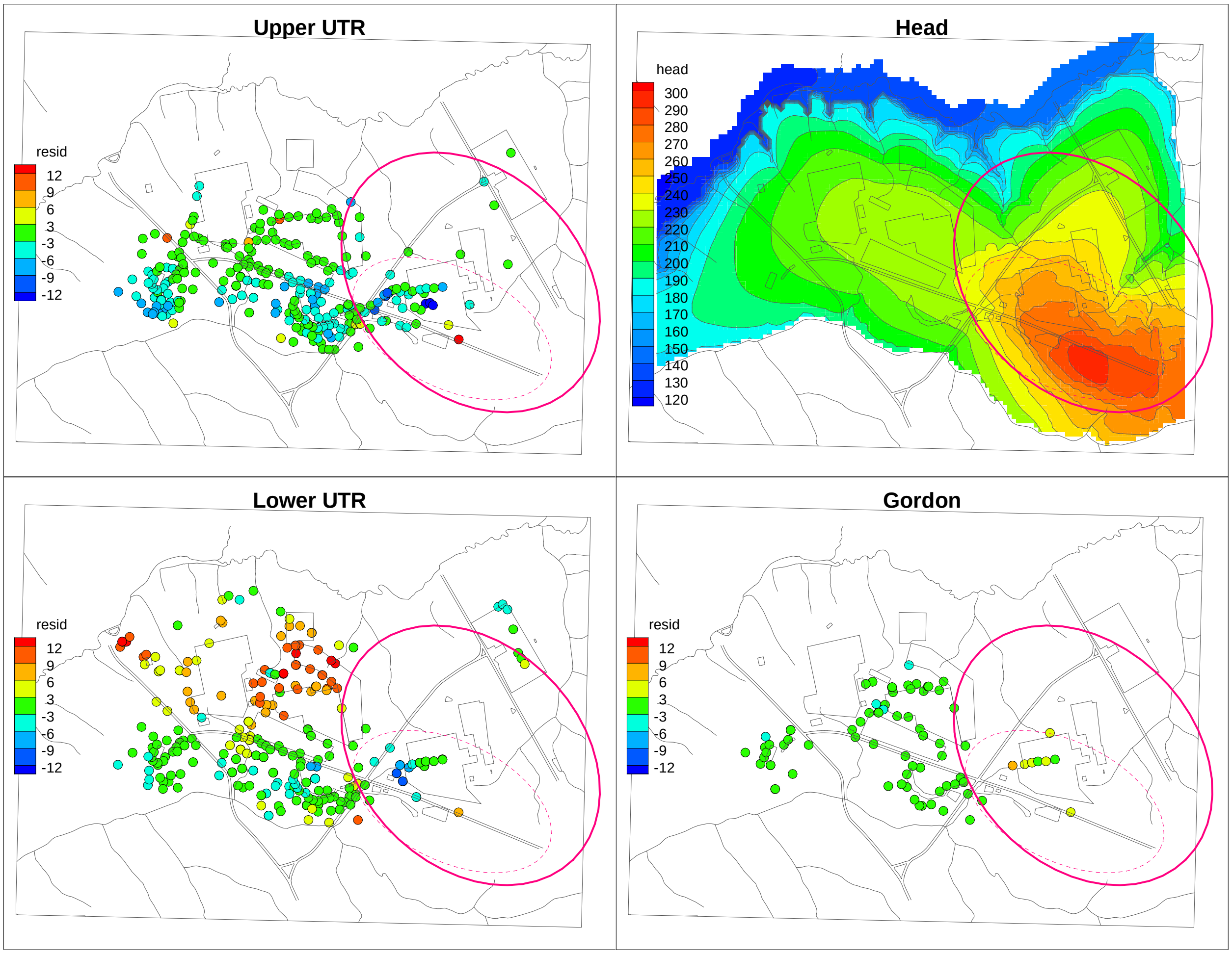


Figure 6-13. Hydraulic head residuals and water table surface for the PEST.15 case.

Table 6-14. Hydraulic conductivity summary for PEST.15 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.15a	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.12E+07								
g01	LAZ	Global	12	0.4	0.69631	8.4	0.28	2.9E-03	9.8E-05	8.4	0.279	-0.5551	30x
g02	TCCZ	Global	0.18	0.006	12.2042	2.2	0.073	7.7E-04	2.6E-05	1.9	0.058	-1.24	33x
g03	TZ	Global	9	0.3	2.02362	18	0.61	6.4E-03	2.1E-04	16.4	0.536	-0.271	31x
g04	AAA	Global	9	0.3	6.28E-02	0.56	0.019	2.0E-04	6.6E-06	0.5	0.015	-1.825	32x
h01	TCCZ	Local			3.16E-01	0.69	0.023	2.5E-04	8.2E-06				
h02	TZ	Local			0.546881	10	0.33	3.5E-03	1.2E-04				
h03	AAA	Local			3.18E-01	0.18	0.0060	6.3E-05	2.1E-06				

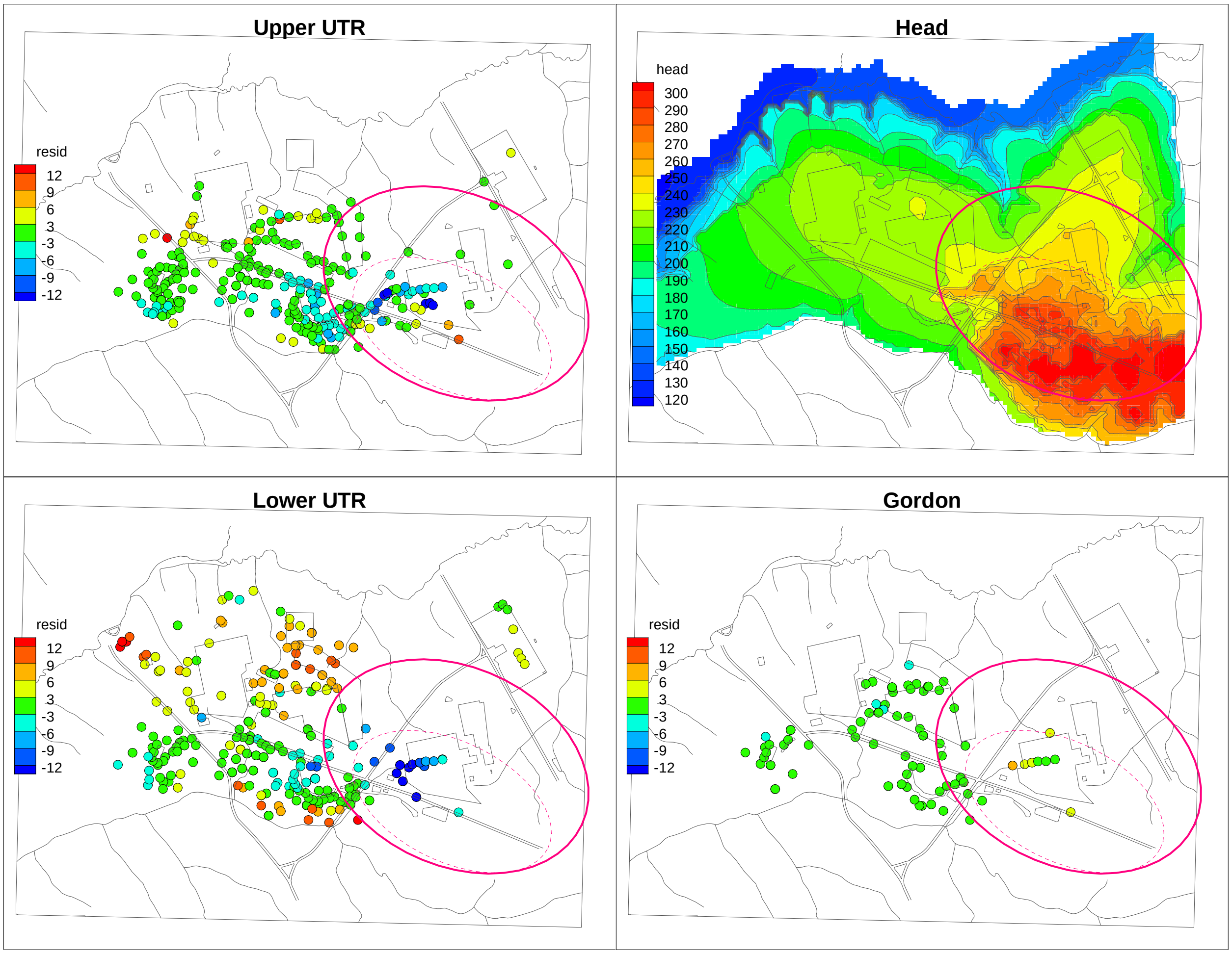


Figure 6-14. Hydraulic head residuals and water table surface for the PEST.16 case.

Table 6-15. Hydraulic conductivity summary for PEST.16 case.

Parameter	Unit	Region	Base Kh factor	Base Kv factor	PEST.16a	Net Kh factor	Net Kv factor	N/A	N/A	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.75E+07								
g01	LAZ	Global	1	1	0.917259	0.92	0.92			7.8	0.164	-0.7844	47x
g02	TCCZ	Global	1	1	5.10E-02	0.051	0.051			0.09	0.002	-2.714	45x
g03	TZ	Global	1	1	4.89443	4.9	4.9			28.4	0.620	-0.2079	46x
g04	AAA	Global	1	1	1.00E-02	0.010	0.010			0.12	0.003	-2.462	35x
h01	TCCZ	Local			0.3162	0.016	0.016						
h02	TZ	Local			0.3162	1.5	1.5						
h03	AAA	Local			3.162	0.032	0.032						

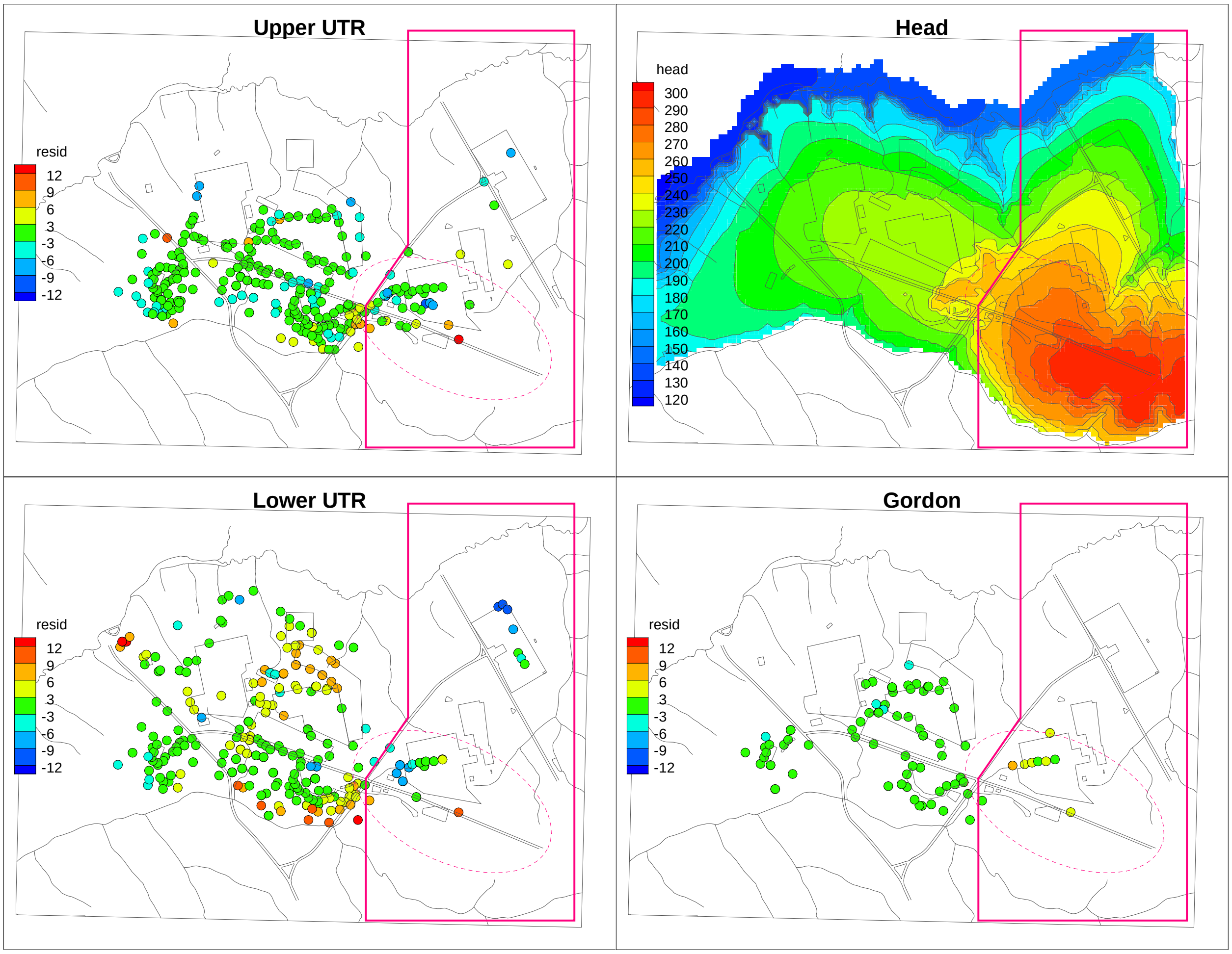


Figure 6-15. Hydraulic head residuals and water table surface for the PEST.17 case.

Table 6-16. Hydraulic conductivity summary for PEST.17 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.17a	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					9432.8								
g01	LAZ	Global	12	0.4	1.01075	12	0.40	4.3E-03	1.4E-04	12.1	0.404	-0.3933	30x
g02	TCCZ	Global	0.18	0.006	1.21617	0.22	0.0073	7.7E-05	2.6E-06	0.1798	0.006	-2.241	31x
g03	TZ	Global	9	0.3	1.46183	13	0.44	4.6E-03	1.5E-04	9.6	0.265	-0.5767	36x
g04	AAA	Global	9	0.3	1.25E-02	0.11	0.0038	4.0E-05	1.3E-06	0.16	0.005	-2.305	33x
h01	TCCZ	Local			0.478899	0.10	0.0035	3.7E-05	1.2E-06				
h02	TZ	Local			2.07E-01	2.7	0.091	9.6E-04	3.2E-05				
h03	AAA	Local			2.27561	0.26	0.0085	9.0E-05	3.0E-06				

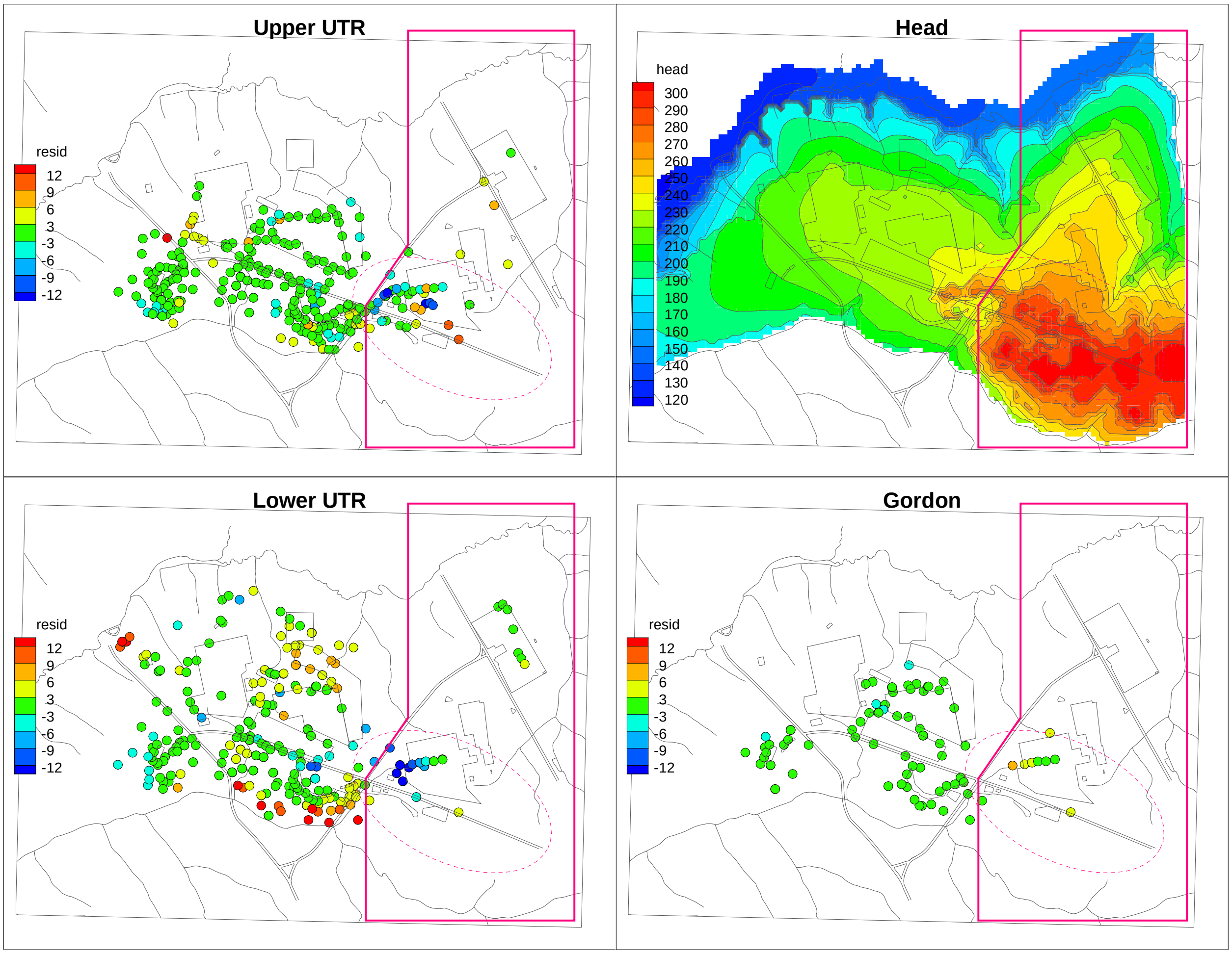


Figure 6-16. Hydraulic head residuals and water table surface for the PEST.18 case.

Table 6-17. Hydraulic conductivity summary for PEST.18 case.

Parameter	Unit	Region	Base Kh factor	Base Kv factor	PEST.18f	Net Kh factor	Net Kv factor	N/A	N/A	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					11617								
g01	LAZ	Global	1	1	1.3802	1.4	1.4			**11.6**	0.186	-0.7297	62x
g02	TCCZ	Global	1	1	0.318003	0.32	0.32			0.6	**0.002**	-2.684	268x
g03	TZ	Global	1	1	1.86959	1.9	1.9			**12.9**	0.288	-0.541	45x
g04	AAA	Global	1	1	2.09E-02	0.021	0.021			**0.2**	0.004	-2.421	49x
h01	TCCZ	Local			0.859467	0.27	0.27						
h02	TZ	Local			1.47E-02	0.027	0.027						
h03	AAA	Local			4.56707	0.095	0.095						

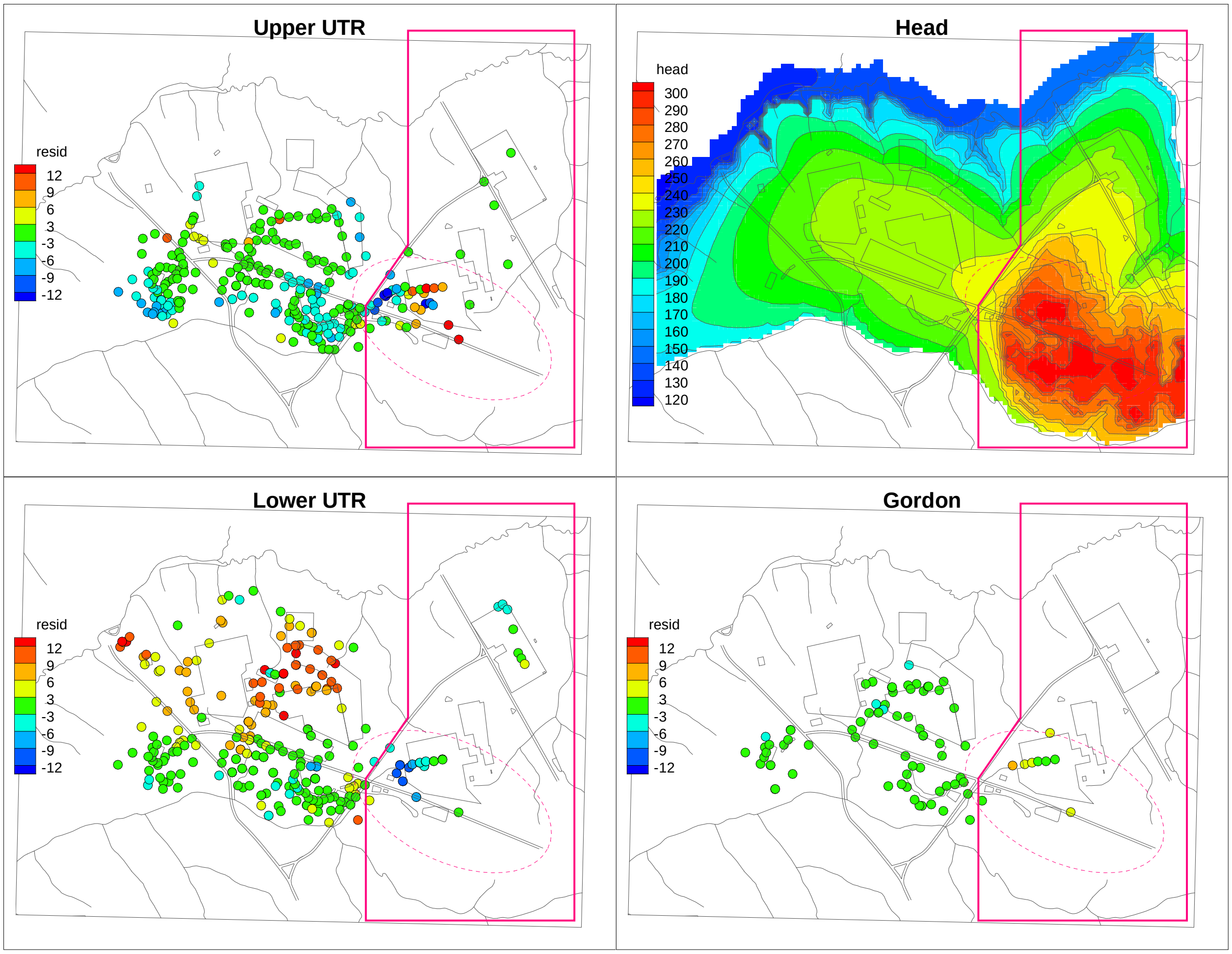


Figure 6-17. Hydraulic head residuals and water table surface for the PEST.19 case.

Table 6-18. Hydraulic conductivity summary for PEST.19 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.19b	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.13E+07								
g01	LAZ	Global	12	0.4	0.721216	8.7	0.29	3.1E-03	1.0E-04	8.7	0.288	-0.5399	30x
g02	TCCZ	Global	0.18	0.006	16.4347	3.0	0.099	1.0E-03	3.5E-05	2.0	0.039	-1.405	51x
g03	TZ	Global	9	0.3	1.3697	12	0.41	4.3E-03	1.4E-04	11.8	0.394	-0.4046	30x
g04	AAA	Global	9	0.3	9.92E-02	0.89	0.030	3.1E-04	1.0E-05	0.6	0.015	-1.825	41x
h01	TCCZ	Local			5.24E-02	0.16	0.0052	5.5E-05	1.8E-06				
h02	TZ	Local			0.879921	11	0.36	3.8E-03	1.3E-04				
h03	AAA	Local			1.13E-01	0.10	0.0034	3.6E-05	1.2E-06				

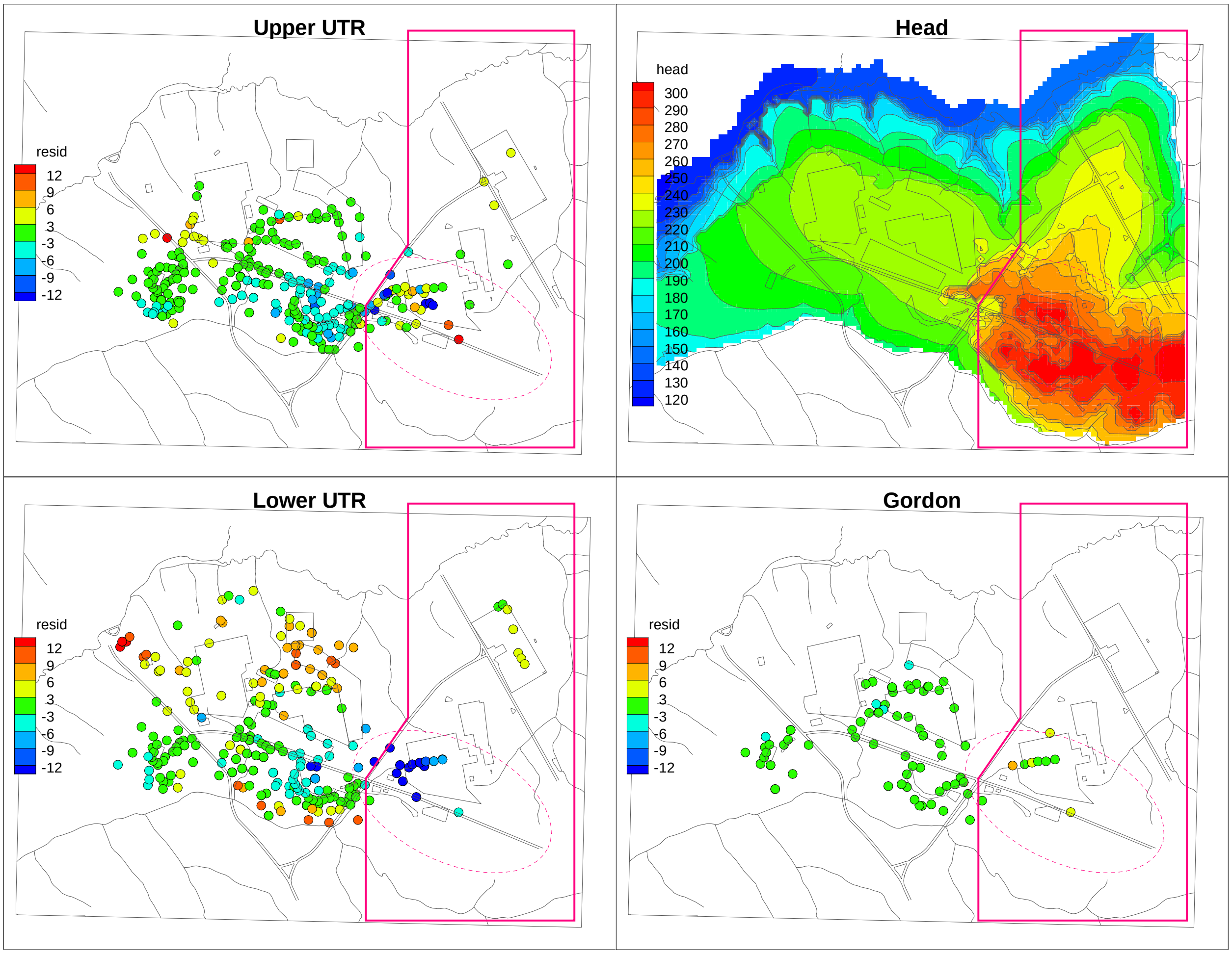


Figure 6-18. Hydraulic head residuals and water table surface for the PEST.20 case.

Table 6-19. Hydraulic conductivity summary for PEST.20 case.

Parameter	Unit	Region	Base Kh factor	Base Kv factor	PEST.20a	Net Kh factor	Net Kv factor	N/A	N/A	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.78E+07								
g01	LAZ	Global	1	1	0.910567	0.91	0.91			7.7	0.164	-0.7852	47x
g02	TCCZ	Global	1	1	1.75E-02	0.017	0.017			0.06	0.002	-2.718	32x
g03	TZ	Global	1	1	62.1597	62	62			26.6	0.708	-0.15	38x
g04	AAA	Global	1	1	1.07E-02	0.011	0.011			0.11	0.003	-2.469	33x
h01	TCCZ	Local			1.31868	0.023	0.023						
h02	TZ	Local			2.54E-02	1.6	1.6						
h03	AAA	Local			0.688092	0.0073	0.0073						

To address the above issues, the following adjustments were made (Table 5-1):

- The HSZ polygon was divided into HS-Area and Z-Area polygons
- Local perturbations were allowed in the LAZ in addition to the TCCZ, TZ and AAA
- Local perturbations were limited to a half order of magnitude range ($0.3162 < h0\# < 3.162$, $0.3162 < i0\# < 3.162$)
- Lower bounds were imposed on the AAA HSU: $K_h > 3 \times 10^{-4}$ cm.s and $K_v > 1 \times 10^{-5}$ cm/s.

PEST.21(Figure 6-19, Table 6-20) and PEST.23 (Figure 6-20, Table 6-21) produced a better match to Z-Area targets, and avoided excessively large perturbations, excessively low AAA K values, and sharp changes within PA areas of interest. However, large positive residuals were observed along Fourmile Branch (FMB), apparently due to an excessively low TCCZ conductivity along Fourmile Branch.

Three optimization rounds (PEST.25 & 27, 29 & 31, and 33 and 35) were conducted in response. All three rounds introduce a new optimization parameter, $j01$, that has a different meaning in each round. In PEST.25 and 27, $j01$ is a multiplier applied to conductivity along Fourmile Branch within 15 ft of the ground surface ($K = j01 \cdot K_{reference}$ for $z_{grd} - z < 15$ ft within `./Polygons/FMBrev2.ply`). In PEST.29 and 31, conductivity within 15 ft of the ground surface over the entire model domain was constrained by a lower bound $j01$ ($K = max[j01, K_{reference}]$ for $z_{grd} - z < 15$ ft). The preferred remedy implemented in PEST.33 and PEST.35 combines elements of the preceding two schemes: $K = max[j01, K_{reference}]$ for $z_{grd} - z < 15$ ft within `./Polygons/FMBrev2.ply`. The underlying conceptual model is that pine tree tap root penetration and/or other phenomena limit the competency of the TCCZ along FMB where it crops out or is very shallow depending on location. The results for PEST.33 and PEST.35 are presented in Figure 6-21 and Table 6-22, and Figure 6-22 and Table 6-23, respectively. These simulations still exhibit a high water table east of H-area.

To address this issue and limit the extent of Z-Area perturbations, the HS-Area and Z-Area polygons were replaced with the new polygons shown in Figure 6-23 through Figure 6-26. In addition, the two “Heterogeneous” K field cases were run in this round. Optimized parameter values for these four cases are provided by Table 6-24 through Table 6-27. Weighted optimization produced better agreement with the few isolated targets in Z-Area at the expense of denser targets, as expected. With the altered polygons, PEST.37 through PEST.40 produced more acceptable water table elevations east of H-Area.

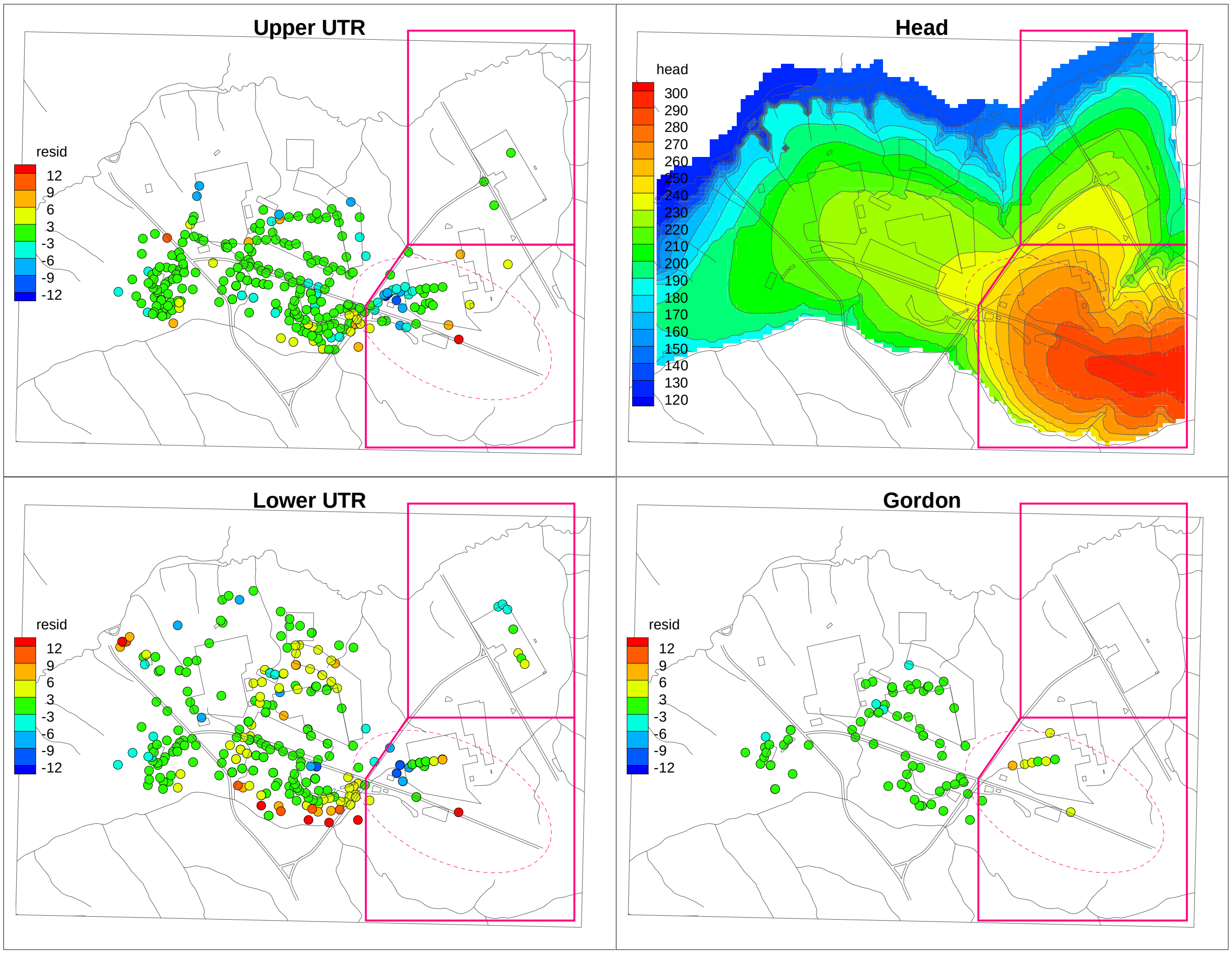


Figure 6-19. Hydraulic head residuals and water table surface for the PEST.21 case.

Table 6-20. Hydraulic conductivity summary for PEST.21 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.21d	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					9297.5								
g01	LAZ	Global	12	0.4	1.14581	14	0.46	4.9E-03	1.6E-04	11.6	0.366	-0.4365	32x
g02	TCCZ	Global	0.18	0.006	0.666019	0.12	0.0040	4.2E-05	1.4E-06	0.1454	0.004	-2.44	40x
g03	TZ	Global	9	0.3	1.34392	12	0.40	4.3E-03	1.4E-04	9.7	0.298	-0.5252	32x
g04	AAA	Global	9	0.3	0.061003	0.55	0.018	1.9E-04	6.5E-06	0.85	0.028	-1.548	30x
h01	LAZ	Harea			0.447684	6.2	0.21	2.2E-03	7.2E-05				
h02	TCCZ	Harea			0.3162	0.038	0.0013	1.3E-05	4.5E-07				
h03	TZ	Harea			0.3162	3.8	0.13	1.3E-03	4.5E-05				
h04	AAA	Harea			0.3162	0.17	0.0058	6.1E-05	2.0E-06				
i01	LAZ	Zarea			0.642163	8.8	0.29	3.1E-03	1.0E-04				
i02	TCCZ	Zarea			3.162	0.38	0.013	1.3E-04	4.5E-06				
i03	TZ	Zarea			0.528565	6.4	0.21	2.3E-03	7.5E-05				
i04	AAA	Zarea			0.818234	0.45	0.015	1.6E-04	5.3E-06				

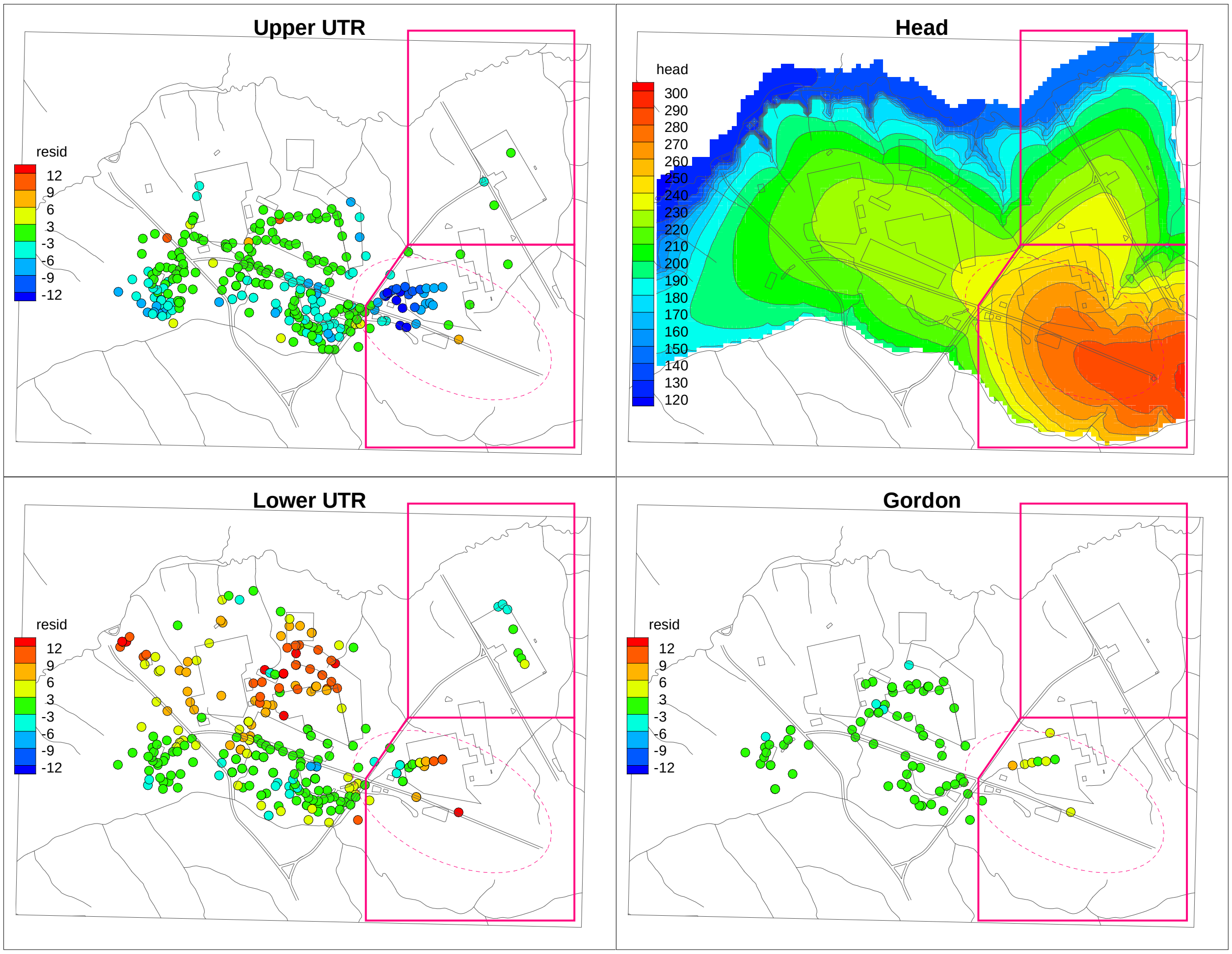


Figure 6-20. Hydraulic head residuals and water table surface for the PEST.23 case.

Table 6-21. Hydraulic conductivity summary for PEST.23 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.23g	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.29E+07								
g01	LAZ	Global	12	0.4	0.713309	8.6	0.29	3.0E-03	1.0E-04	7.5	0.228	-0.6424	33x
g02	TCCZ	Global	0.18	0.006	11.0482	1.99	0.066	7.0E-04	2.3E-05	1.522	0.046	-1.34	33x
g03	TZ	Global	9	0.3	1.63855	14.7	0.49	5.2E-03	1.7E-04	14.3	0.447	-0.3499	32x
g04	AAA	Global	9	0.3	0.157777	1.42	0.047	5.0E-04	1.7E-05	1.53	0.047	-1.324	32x
h01	LAZ	Harea			0.3162	4.3	0.14	1.5E-03	5.1E-05				
h02	TCCZ	Harea			0.3162	0.038	0.0013	1.3E-05	4.5E-07				
h03	TZ	Harea			0.429922	5.2	0.17	1.8E-03	6.1E-05				
h04	AAA	Harea			0.3162	0.17	0.0058	6.1E-05	2.0E-06				
i01	LAZ	Zarea			1.00246	13.8	0.46	4.9E-03	1.6E-04				
i02	TCCZ	Zarea			0.3162	0.038	0.0013	1.3E-05	4.5E-07				
i03	TZ	Zarea			1.48022	17.9	0.60	6.3E-03	2.1E-04				
i04	AAA	Zarea			2.03162	1.12	0.037	3.9E-04	1.3E-05				

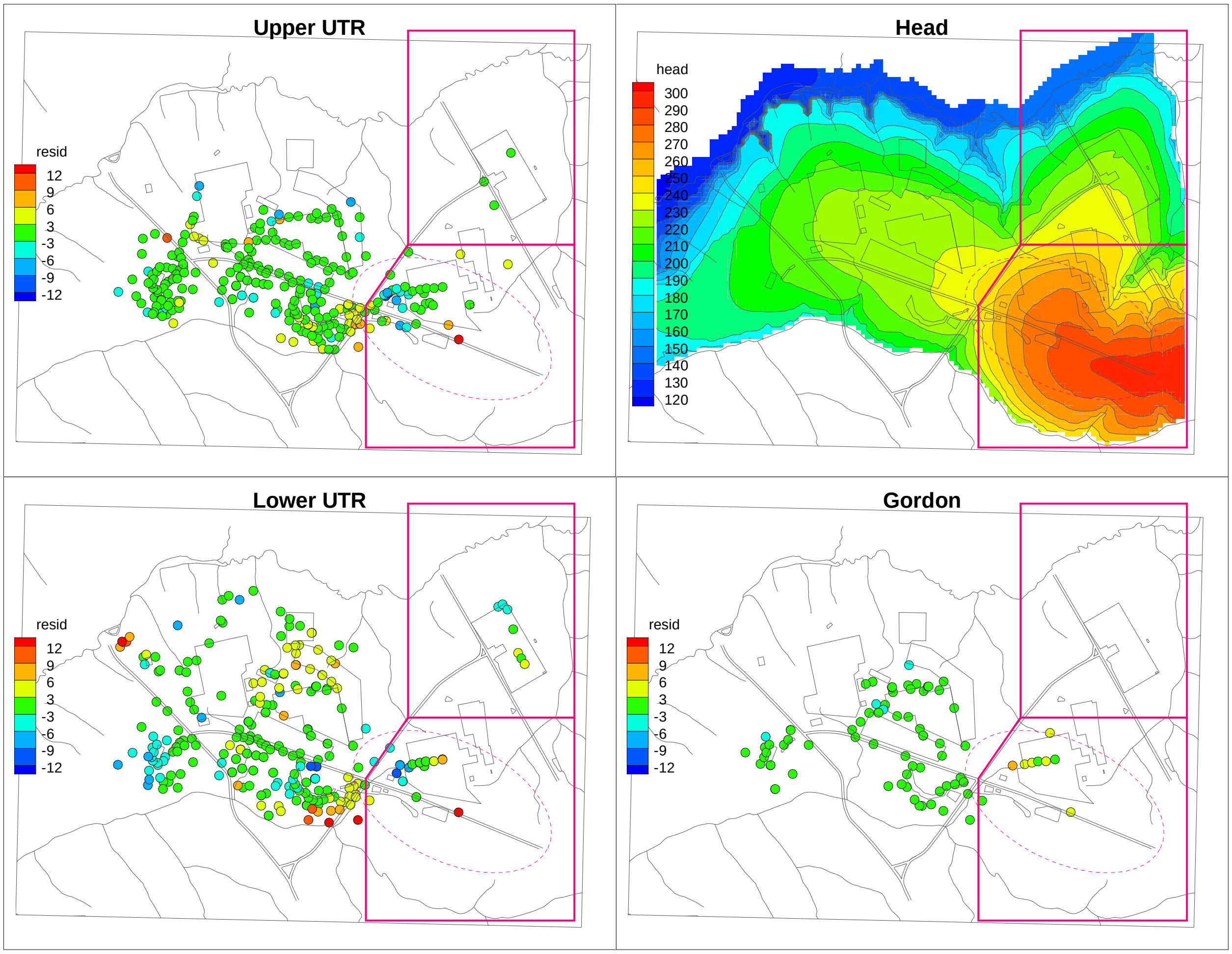


Figure 6-21. Hydraulic head residuals and water table surface for the PEST.33 case.

Table 6-22. Hydraulic conductivity summary for PEST.33 case.

Param.	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.33g	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					8397.2								
g01	LAZ	Global	12	0.4	1.12405	13	0.45	4.8E-03	1.6E-04	11.2	0.350	-0.4562	32x
g02	TCCZ	Global	0.18	0.006	0.591813	0.11	0.0036	3.8E-05	1.3E-06	0.1292	0.003	-2.471	38x
g03	TZ	Global	9	0.3	0.924514	8.3	0.28	2.9E-03	9.8E-05	8.2	0.263	-0.5797	31x
g04	AAA	Global	9	0.3	8.90E-02	0.80	0.027	2.8E-04	9.4E-06	0.9	0.029	-1.531	29x
h01	LAZ	Harea			0.390342	5.3	0.18	1.9E-03	6.2E-05				
h02	TCCZ	Harea			0.3162	0.034	0.0011	1.2E-05	4.0E-07				
h03	TZ	Harea			0.5822	4.8	0.16	1.7E-03	5.7E-05				
h04	AAA	Harea			0.350509	0.28	0.0094	9.9E-05	3.3E-06				
i01	LAZ	Zarea			0.644619	8.7	0.29	3.1E-03	1.0E-04				
i02	TCCZ	Zarea			3.162	0.34	0.011	1.2E-04	4.0E-06				
i03	TZ	Zarea			1.38236	11.5	0.38	4.1E-03	1.4E-04				
i04	AAA	Zarea			0.356546	0.29	0.010	1.0E-04	3.4E-06				
j01	FMB				3.62E-02								

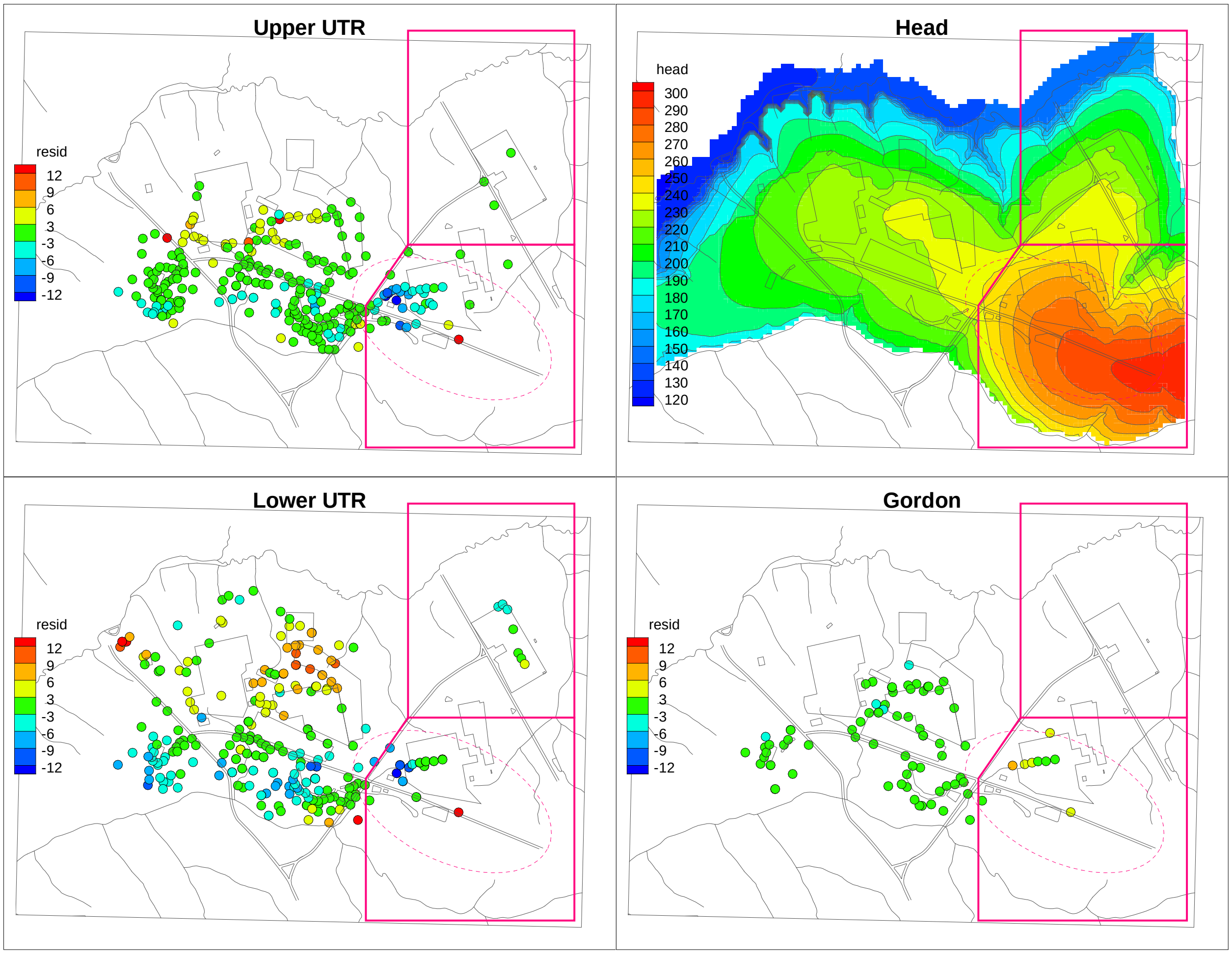


Figure 6-22. Hydraulic head residuals and water table surface for the PEST.35 case.

Table 6-23. Hydraulic conductivity summary for PEST.35 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.35a	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.06E+07								
g01	LAZ	Global	12	0.4	0.820305	9.8	0.33	3.5E-03	1.2E-04	8.3	0.255	-0.5941	33x
g02	TCCZ	Global	0.18	0.006	0.438248	0.079	0.0026	2.8E-05	9.3E-07	0.0945	0.002	-2.607	38x
g03	TZ	Global	9	0.3	1.5857	14	0.48	5.0E-03	1.7E-04	15.3	0.492	-0.3078	31x
g04	AAA	Global	9	0.3	0.244525	2.2	0.073	7.8E-04	2.6E-05	2.0	0.093	-1.033	21x
h01	LAZ	Harea			0.3162	4.3	0.14	1.5E-03	5.0E-05				
h02	TCCZ	Harea			0.3162	0.034	0.0011	1.2E-05	4.0E-07				
h03	TZ	Harea			0.609503	5.1	0.17	1.8E-03	6.0E-05				
h04	AAA	Harea			0.3162	0.25	0.0084	8.9E-05	3.0E-06				
i01	LAZ	Zarea			0.924896	12	0.42	4.4E-03	1.5E-04				
i02	TCCZ	Zarea			1.40547	0.15	0.0050	5.3E-05	1.8E-06				
i03	TZ	Zarea			1.82115	15	0.51	5.3E-03	1.8E-04				
i04	AAA	Zarea			3.162	2.5	0.084	8.9E-04	3.0E-05				
j01	FMB				2.07333								

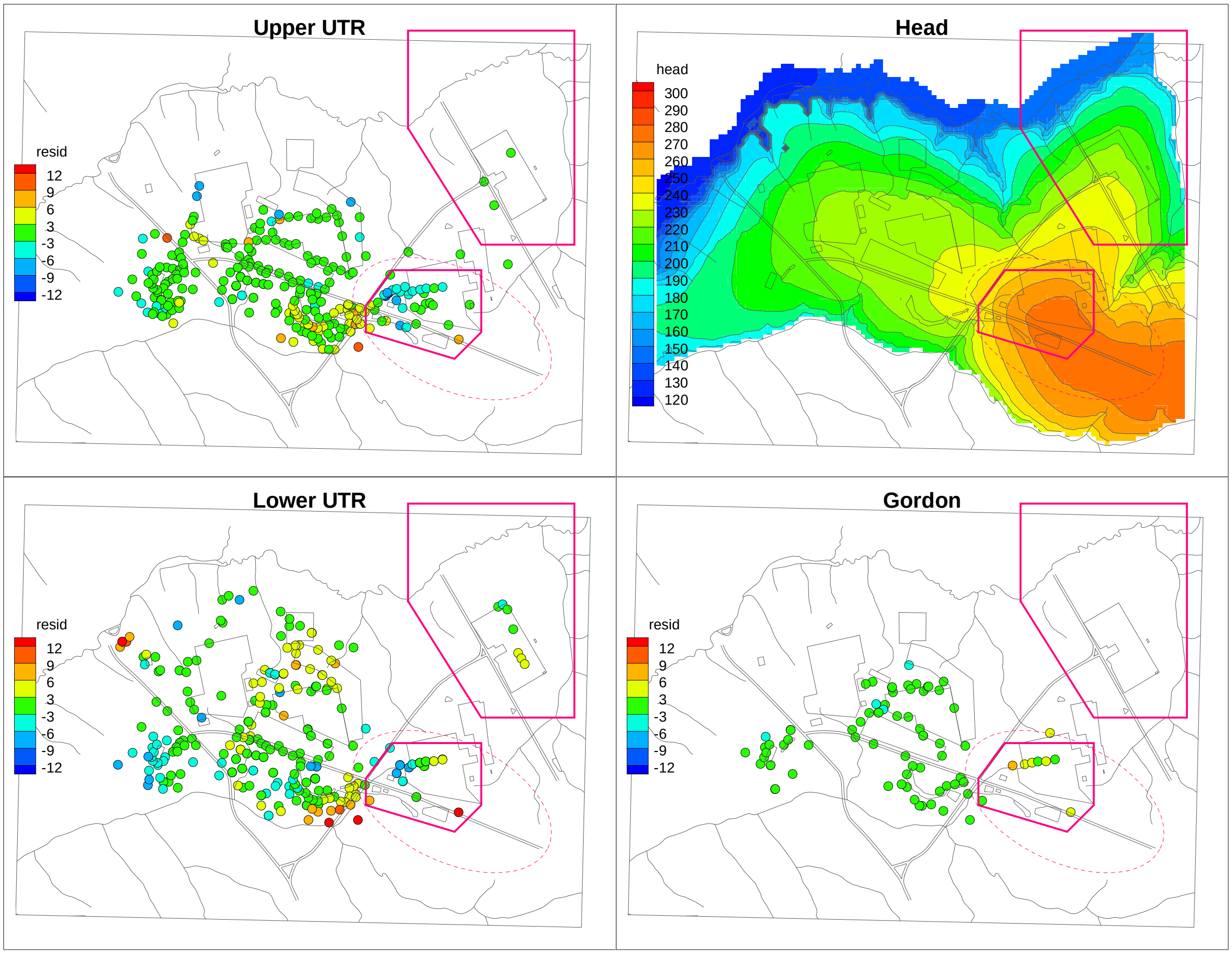


Figure 6-23. Hydraulic head residuals and water table surface for the PEST.37 case.

Table 6-24. Hydraulic conductivity summary for PEST.37 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.37b	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					8616.3								
g01	LAZ	Global	12	0.4	1.12004	13	0.45	4.7E-03	1.6E-04	12.5	0.410	-0.3876	30x
g02	TCCZ	Global	0.18	0.006	0.709066	0.13	0.0043	4.5E-05	1.5E-06	0.1385	0.005	-2.328	29x
g03	TZ	Global	9	0.3	0.581938	5.2	0.17	1.8E-03	6.2E-05	5.1	0.168	-0.7759	30x
g04	AAA	Global	9	0.3	7.90E-02	0.71	0.024	2.5E-04	8.4E-06	0.9	0.034	-1.466	25x
h01	LAZ	Harea			0.3162	4.2	0.14	1.5E-03	5.0E-05				
h02	TCCZ	Harea			0.3162	0.040	0.0013	1.4E-05	4.7E-07				
h03	TZ	Harea			0.3162	1.7	0.055	5.8E-04	1.9E-05				
h04	AAA	Harea			0.800022	0.57	0.019	2.0E-04	6.7E-06				
i01	LAZ	Zarea			0.609092	8.2	0.27	2.9E-03	9.6E-05				
i02	TCCZ	Zarea			1.52823	0.20	0.0065	6.9E-05	2.3E-06				
i03	TZ	Zarea			0.81411	4.3	0.14	1.5E-03	5.0E-05				
i04	AAA	Zarea			0.990094	0.70	0.023	2.5E-04	8.3E-06				
j01	FMB				1.22E-01								

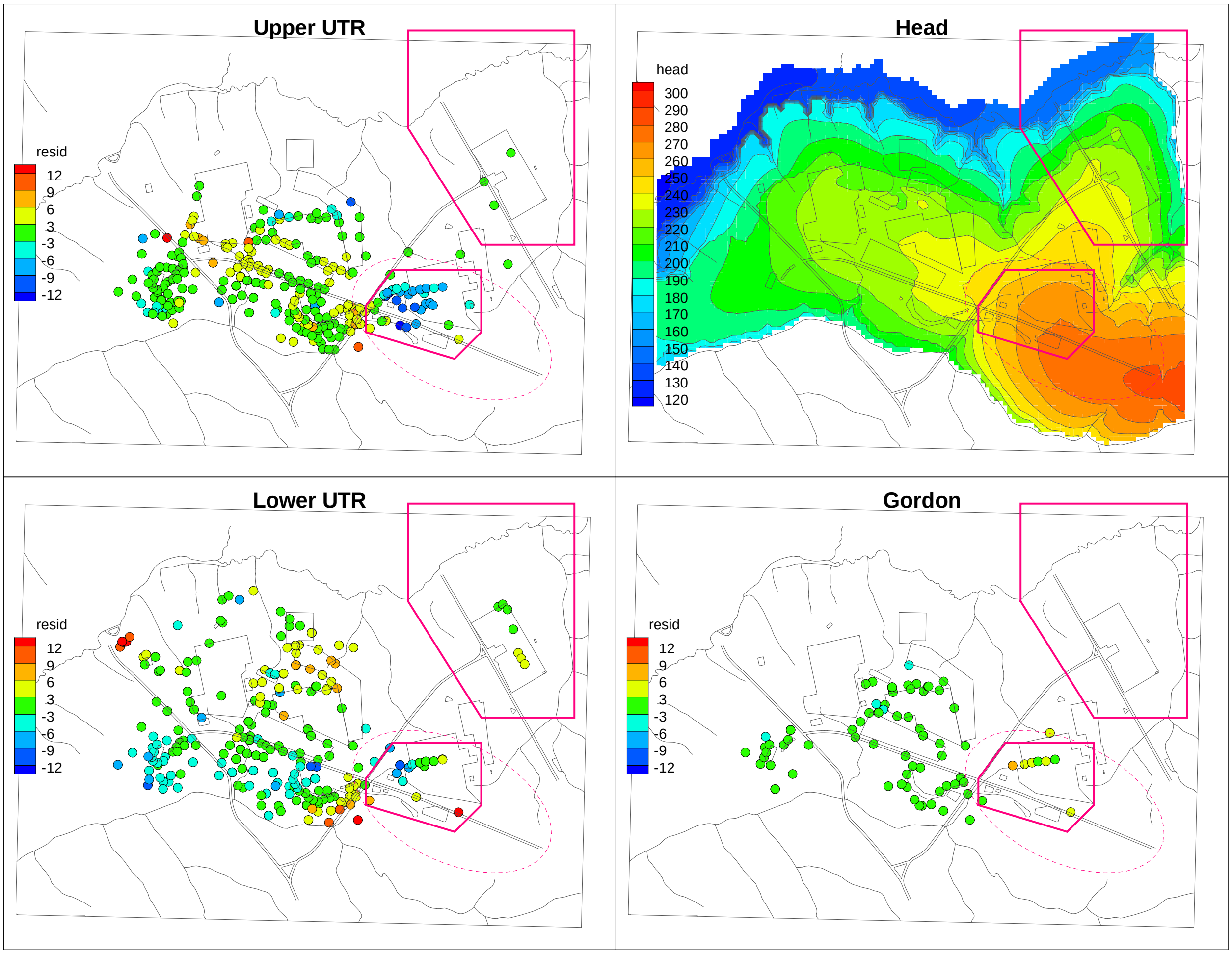


Figure 6-24. Hydraulic head residuals and water table surface for the PEST.38 case.

Table 6-25. Hydraulic conductivity summary for PEST.38 case.

Parameter	Unit	Region	Base Kh factor	Base Kv factor	PEST.38c	Net Kh factor	Net Kv factor	N/A	N/A	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					11003								
g01	LAZ	Global	1	1	1.50862	1.5	1.5			12.1	0.189	-0.7238	64x
g02	TCCZ	Global	1	1	1.48153	1.5	1.5			1.645	0.003	-2.515	538x
g03	TZ	Global	1	1	0.517016	0.52	0.52			4.7	0.179	-0.7483	26x
g04	AAA	Global	1	1	1.09E-02	0.011	0.011			0.9	0.046	-1.339	19x
h01	LAZ	Harea			0.3162	0.48	0.48						
h02	TCCZ	Harea			0.3162	0.47	0.47						
h03	TZ	Harea			0.3162	0.16	0.16						
h04	AAA	Harea			0.352466	0.0038	0.0038						
i01	LAZ	Zarea			0.827146	1.2	1.2						
i02	TCCZ	Zarea			2.09124	3.1	3.1						
i03	TZ	Zarea			0.3162	0.16	0.16						
i04	AAA	Zarea			2.15951	0.024	0.024						
j01	FMB				5.38E-01								

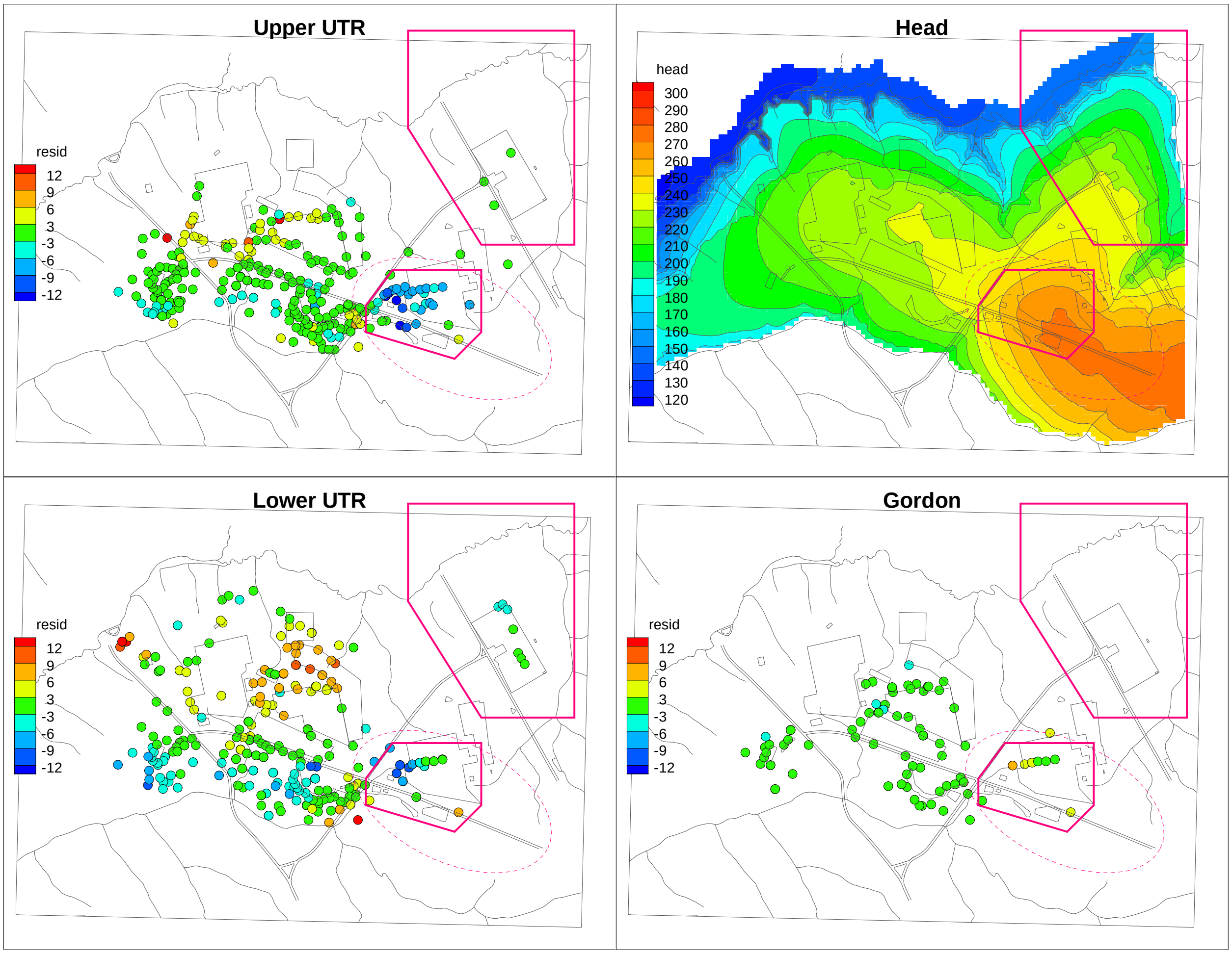


Figure 6-25. Hydraulic head residuals and water table surface for the PEST.39 case.

Table 6-26. Hydraulic conductivity summary for PEST.39 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.39g	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.13E+07								
g01	LAZ	Global	12	0.4	0.856909	10	0.34	3.6E-03	1.2E-04	9.8	0.325	-0.4885	30x
g02	TCCZ	Global	0.18	0.006	0.528448	0.10	0.0032	3.4E-05	1.1E-06	0.142	0.003	-2.457	41x
g03	TZ	Global	9	0.3	1.2047	11	0.36	3.8E-03	1.3E-04	12.8	0.429	-0.3673	30x
g04	AAA	Global	9	0.3	5.18E-02	0.47	0.016	1.6E-04	5.5E-06	1.2	0.061	-1.218	19x
h01	LAZ	Harea			0.3162	4.2	0.14	1.5E-03	5.0E-05				
h02	TCCZ	Harea			0.3162	0.040	0.0013	1.4E-05	4.7E-07				
h03	TZ	Harea			0.3162	1.7	0.055	5.8E-04	1.9E-05				
h04	AAA	Harea			0.624326	0.44	0.015	1.6E-04	5.2E-06				
i01	LAZ	Zarea			0.861659	12	0.39	4.1E-03	1.4E-04				
i02	TCCZ	Zarea			0.941789	0.12	0.0040	4.2E-05	1.4E-06				
i03	TZ	Zarea			2.49123	13	0.43	4.6E-03	1.5E-04				
i04	AAA	Zarea			0.977687	0.69	0.023	2.5E-04	8.2E-06				
j01	FMB				3								

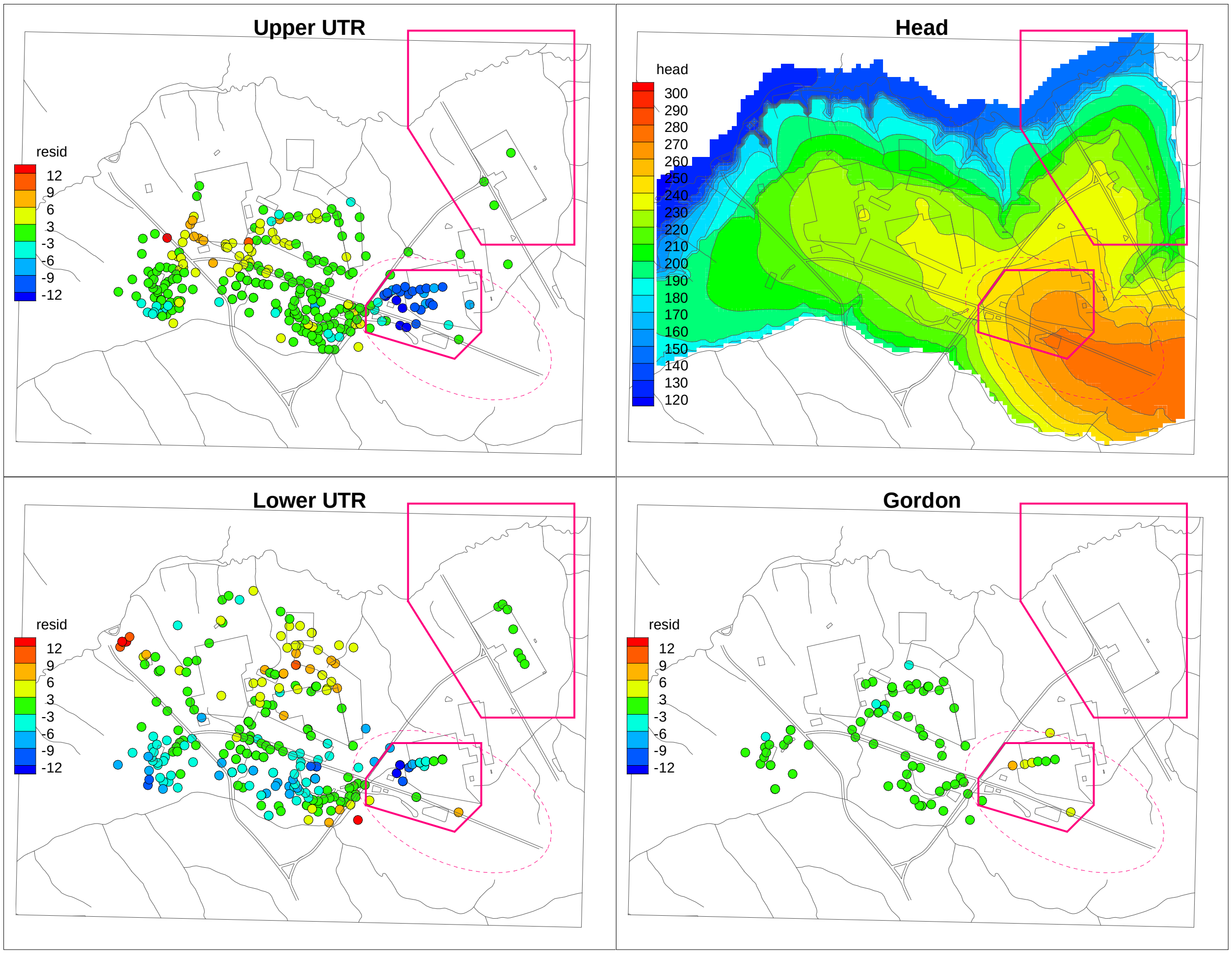


Figure 6-26. Hydraulic head residuals and water table surface for the PEST.40 case.

Table 6-27. Hydraulic conductivity summary for PEST.40 case.

Parameter	Unit	Region	Base Kh factor	Base Kv factor	PEST.40e	Net Kh factor	Net Kv factor	N/A	N/A	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.28E+07								
g01	LAZ	Global	1	1	1.2785	1.3	1.3			10.6	0.179	-0.7466	59x
g02	TCCZ	Global	1	1	0.241772	0.24	0.24			0.5664	0.002	-2.62	236x
g03	TZ	Global	1	1	1.05464	1.1	1.1			11.0	0.310	-0.5093	36x
g04	AAA	Global	1	1	1.00E-02	0.010	0.010			1.2	0.061	-1.218	19x
h01	LAZ	Harea			0.3162	0.48	0.48						
h02	TCCZ	Harea			0.3162	0.47	0.47						
h03	TZ	Harea			0.3162	0.16	0.16						
h04	AAA	Harea			0.906317	0.010	0.010						
i01	LAZ	Zarea			1.05104	1.6	1.6						
i02	TCCZ	Zarea			3.162	4.7	4.7						
i03	TZ	Zarea			2.33728	1.2	1.2						
i04	AAA	Zarea			0.918279	0.010	0.010						
j01	FMB				3								

Optimization results obtained through case PEST.40 were informally critiqued by Savannah River PA colleagues, which led to the following changes:

- The constraint $0.3162 < h0\# < 3.162$ was replaced with $0.1 < h0\# < 10$ to allow further adaptation of the hydraulic conductivity field around the H-Tank Farm.
- Material property averaging at computational cell interfaces within PORFLOW was changed from geometric averaging weighted by proximity to adjoining nodes (PROP GEOM) to harmonic averaging weighted by node to interface distance (PROP HARM TRAV). The latter option is a new feature available in PORFLOW 6.42.4 that more accurately simulates flow perpendicular to layers, notably the Gordon confining unit. Thus PORFLOW 6.42.4 was subsequently used instead of 6.42.3.
- The vertical conductivity of the Gordon confining unit was varied between 1.0e-5 and 1.0e-4 ft/d in sensitivity and optimization runs, rather than held fixed at 1.0e-4 ft/d.
- The option to set the vadose zone hydraulic conductivity to 0.1 ft/d, used in optimization cases through PEST.40 following Flach (2004), was determined to be unnecessary with implementation of the implicit recharge-drain boundary condition in PORFLOW 6.42.3 and turned off except as noted.

PEST.41 through PEST.50 were diagnostic cases investigating the effects of varying GCU K_v, vadose zone conductivity, and PORFLOW Newton iterations. These cases indicated that:

- the optimal GCU K_v is close to 0.75e-4 ft/d based on PEST optimization (PEST.43, 44) and a sensitivity study (PEST.47, 49, 50)
- no alteration to vadose zone conductivity is required for numerical stability (PEST.43-47, 49-50)
- 400 PORFLOW steady-state iterations (4 outer and 100 inner loop iterations) will produce an adequately converged solution (PEST.47-50).

Selected cases in the PEST.41 through PEST.50 series are further discussed below.

PEST.47, PEST.49 and PEST.50 involve a layer-cake conductivity field and unweighted targets, and are identical except for GCU K_v:

- PEST.47→ 0.75e-4 ft/d
- PEST.49→ 1.0e-4 ft/d
- PEST.50→ 1.0e-5 ft/d

These three parametric cases were run to confirm preliminary indications from PEST.41 through PEST.44 that the optimal value of GCU K_v is close to 0.75e-4 ft/d. Optimization results for these cases are given in Figure 6-27 through Figure 6-29 and Table 6-28 through Table 6-30. PEST.47 produced the lowest value of the objective function, Φ = 7581 compared to 7598 for PEST.49 and 7923 for PEST.50. Results from PEST.41-44 are not documented herein because an inadequate number of Newton iterations led to poor numerical convergence. PEST.48 was identical to PEST.47 except that vadose zone hydraulic conductivity was set to 0.1 ft/d. The latter was demonstrated to be unnecessary by a successful PEST.47 run, so PEST.48 is not documented herein.

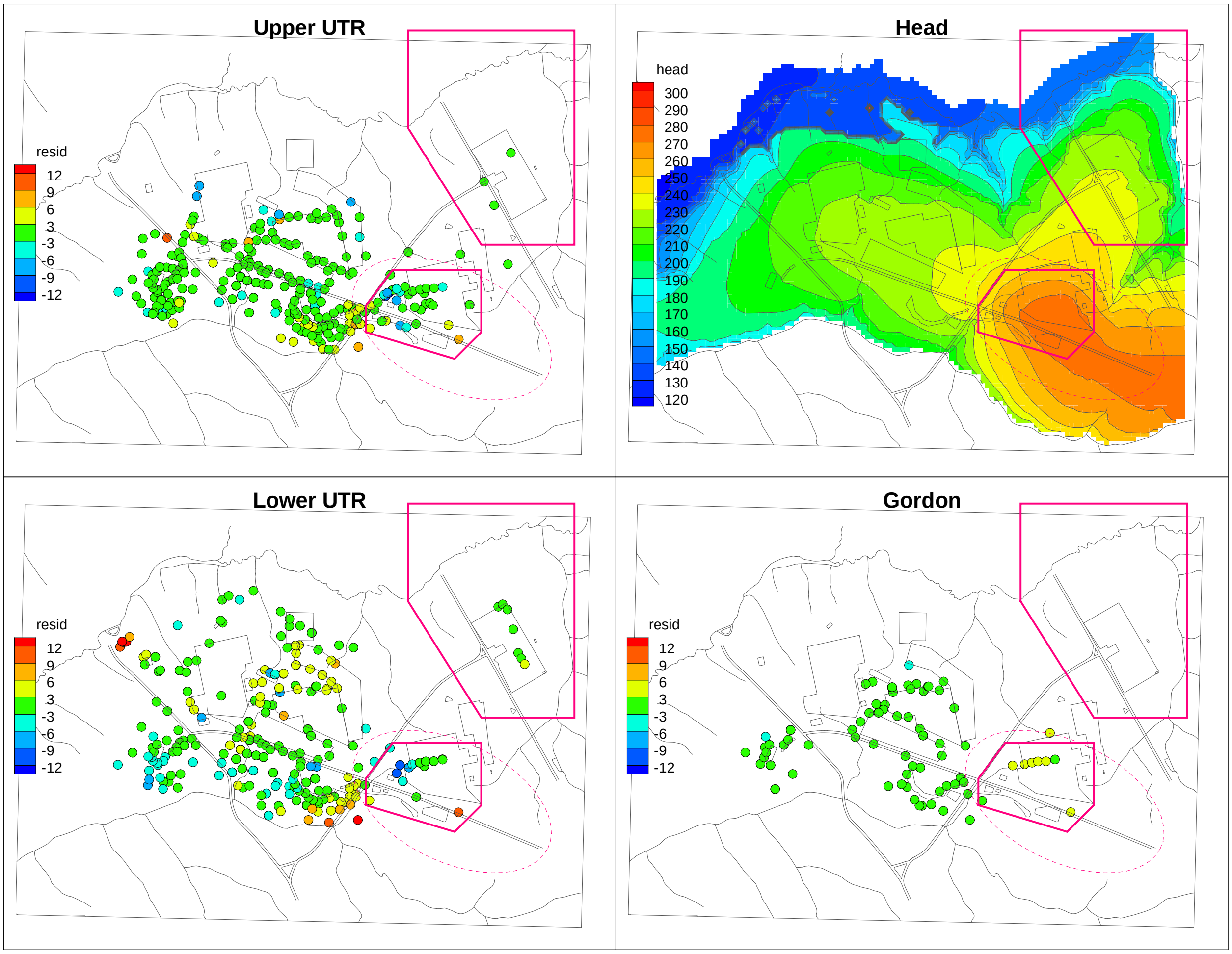


Figure 6-27. Hydraulic head residuals and water table surface for the PEST.47 case.

Table 6-28. Hydraulic conductivity summary for PEST.47 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.47a	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					7580.6								
g01	LAZ	Global	12	0.4	0.883144	11	0.35	3.7E-03	1.2E-04	9.6	0.314	-0.5034	31x
g02	TCCZ	Global	0.18	0.006	0.920123	0.17	0.0055	5.8E-05	1.9E-06	0.1491	0.005	-2.282	29x
g03	TZ	Global	9	0.3	0.687671	6.2	0.21	2.2E-03	7.3E-05	6.7	0.210	-0.6784	32x
g04	AAA	Global	9	0.3	2.00E-01	1.8	0.060	6.3E-04	2.1E-05	1.6	0.058	-1.233	28x
h01	LAZ	Harea			0.252574	2.7	0.089	9.4E-04	3.1E-05				
h02	TCCZ	Harea			0.224673	0.037	0.0012	1.3E-05	4.4E-07				
h03	TZ	Harea			0.103513	0.64	0.021	2.3E-04	7.5E-06				
h04	AAA	Harea			0.1	0.18	0.0060	6.3E-05	2.1E-06				
i01	LAZ	Zarea			0.539903	5.7	0.19	2.0E-03	6.7E-05				
i02	TCCZ	Zarea			0.493579	0.082	0.0027	2.9E-05	9.6E-07				
i03	TZ	Zarea			1.81306	11.2	0.37	4.0E-03	1.3E-04				
i04	AAA	Zarea			0.48422	0.87	0.029	3.1E-04	1.0E-05				
j01	FMB				1.13E-01								

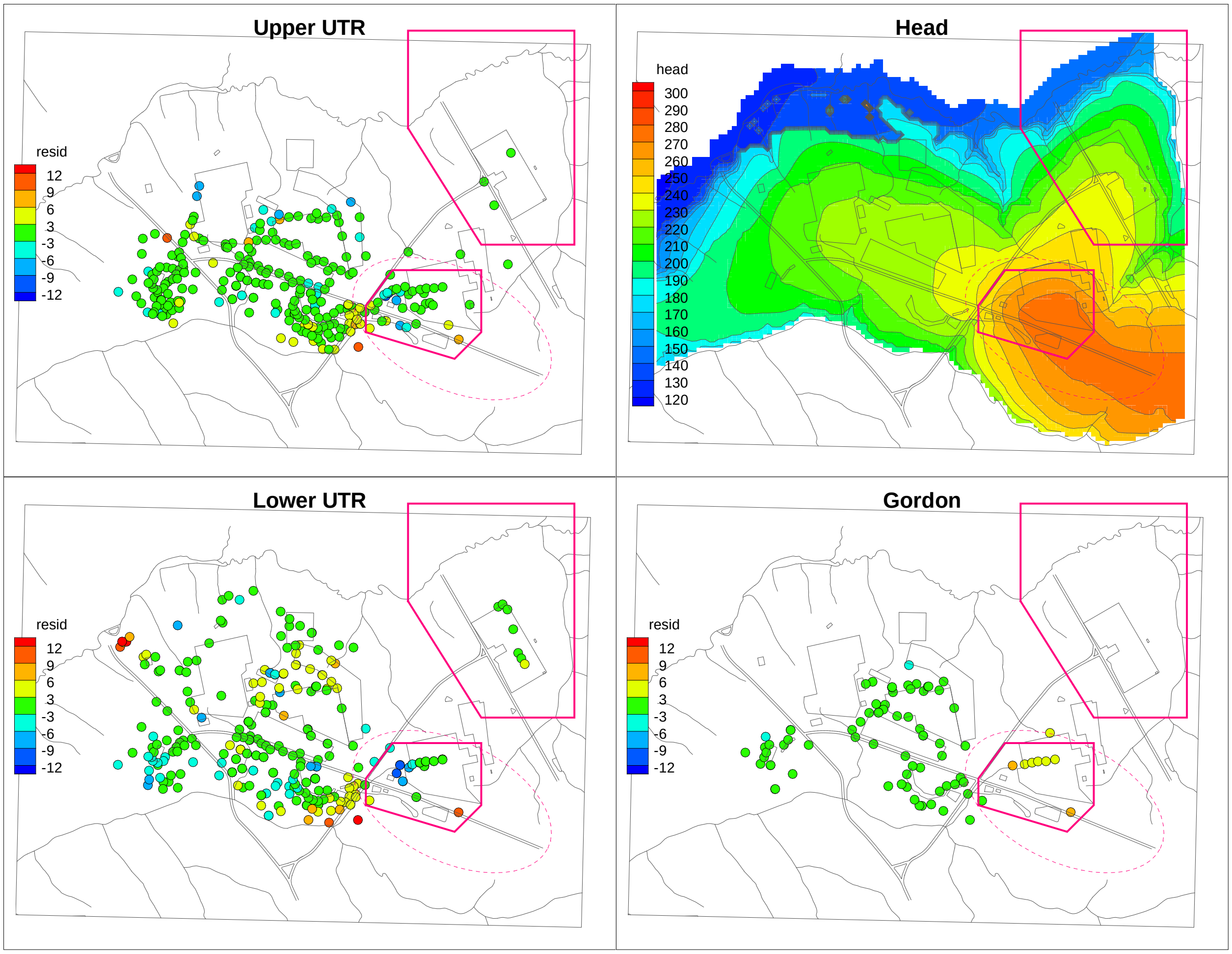


Figure 6-28. Hydraulic head residuals and water table surface for the PEST.49 case.

Table 6-29. Hydraulic conductivity summary for PEST.49 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.49f	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					7598.1								
g01	LAZ	Global	12	0.4	0.857175	10	0.34	3.6E-03	1.2E-04	9.4	0.309	-0.5098	31x
g02	TCCZ	Global	0.18	0.006	0.957887	0.17	0.0057	6.1E-05	2.0E-06	0.1663	0.006	-2.24	29x
g03	TZ	Global	9	0.3	0.628866	5.7	0.19	2.0E-03	6.7E-05	5.0	0.157	-0.8038	32x
g04	AAA	Global	9	0.3	1.50E-01	1.4	0.045	4.8E-04	1.6E-05	1.3	0.048	-1.322	27x
h01	LAZ	Harea			0.240845	2.5	0.083	8.7E-04	2.9E-05				
h02	TCCZ	Harea			0.208775	0.036	0.0012	1.3E-05	4.2E-07				
h03	TZ	Harea			0.1	0.57	0.019	2.0E-04	6.7E-06				
h04	AAA	Harea			0.13033	0.18	0.0059	6.2E-05	2.1E-06				
i01	LAZ	Zarea			0.615704	6.3	0.21	2.2E-03	7.4E-05				
i02	TCCZ	Zarea			0.954399	0.16	0.0055	5.8E-05	1.9E-06				
i03	TZ	Zarea			0.368239	2.1	0.069	7.4E-04	2.5E-05				
i04	AAA	Zarea			0.887835	1.2	0.040	4.2E-04	1.4E-05				
j01	FMB				8.28E-02								

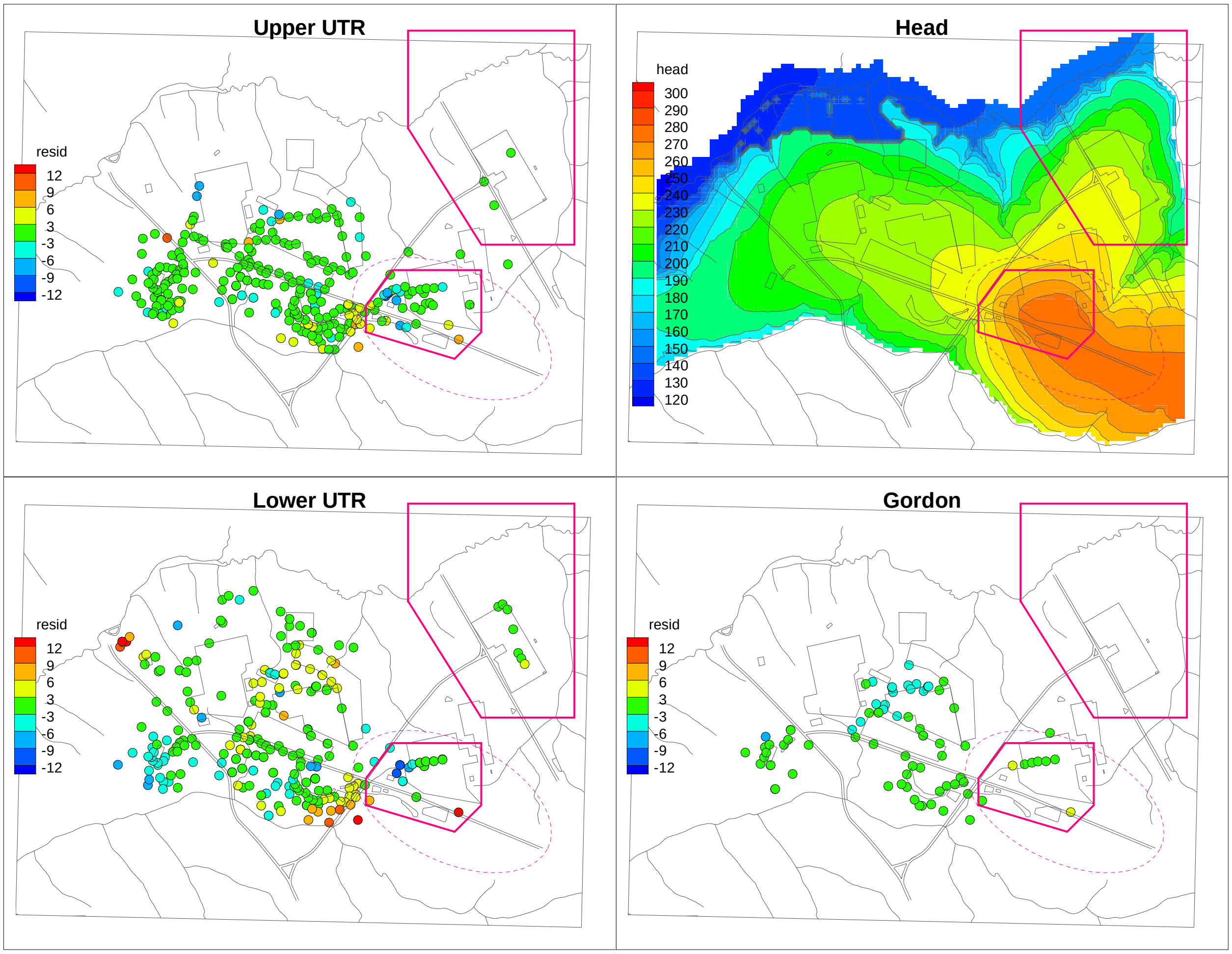


Figure 6-29. Hydraulic head residuals and water table surface for the PEST.50 case.

Table 6-30. Hydraulic conductivity summary for PEST.50 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.50d	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					7922.7								
g01	LAZ	Global	12	0.4	1.02489	12	0.41	4.3E-03	1.4E-04	11.1	0.360	-0.444	31x
g02	TCCZ	Global	0.18	0.006	0.782354	0.14	0.0047	5.0E-05	1.7E-06	0.1268	0.004	-2.354	29x
g03	TZ	Global	9	0.3	0.985068	8.9	0.30	3.1E-03	1.0E-04	9.0	0.289	-0.5393	31x
g04	AAA	Global	9	0.3	1.91E-01	1.7	0.057	6.1E-04	2.0E-05	1.6	0.058	-1.237	28x
h01	LAZ	Harea			0.225013	2.3	0.077	8.2E-04	2.7E-05				
h02	TCCZ	Harea			0.198997	0.034	0.0011	1.2E-05	4.0E-07				
h03	TZ	Harea			0.1	0.57	0.019	2.0E-04	6.7E-06				
h04	AAA	Harea			1.00E-01	0.14	0.0045	4.8E-05	1.6E-06				
i01	LAZ	Zarea			0.499895	5.1	0.17	1.8E-03	6.0E-05				
i02	TCCZ	Zarea			0.50148	0.086	0.0029	3.1E-05	1.0E-06				
i03	TZ	Zarea			1.35481	7.7	0.26	2.7E-03	9.0E-05				
i04	AAA	Zarea			0.787105	1.1	0.035	3.8E-04	1.3E-05				
j01	FMB				9.23E-02								

With PEST.47 embodying the preferred settings for a layer-cake conductivity field and unweighted optimization, three additional optimization cases were run to extend this configuration to a heterogeneous conductivity field and/or weighted optimization:

- PEST.47→ Layer-cake K field, unweighted optimization
- PEST.51→ Layer-cake K field, weighted optimization
- PEST.52→ Heterogeneous K field, unweighted optimization
- PEST.53→ Heterogeneous K field, weighted optimization

Calibration results for PEST.51 through PEST.53 are presented in Figure 6-30 through Figure 6-32 and Table 6-31 through Table 6-33. PEST.47, 51, 52 and 53 were accepted as the final round of model calibration.

Table 6-34 presents hydraulic head statistics for the final optimization round. Unweighted optimization produced lower (unweighted) root-mean-square values than weighted optimization, as expected. The goodness-of-fit measures in Table 6-34 are similar to the 2004 GSA/PORFLOW model (Flach 2004 Table 4-4). Table 6-35 compares simulated stream baseflows to estimated baseflows, which were not used to optimize / calibrate the model. Excellent agreement is observed for the Fourmile Branch and McQueen Branch validation targets, which are considered the more reliable estimates due to the measurement locations and period of record. Larger discrepancies are observed for Upper Three Runs and Crouch Branch, but these estimates are less certain. The Crouch Branch estimate is based on only two measurements. The Upper Three Runs estimate is uncertain because of a) the large distance between gaging stations such that the average rate of gain may not accurately reflect gain along the reach adjoining the model, and b) uncertainty in the fraction of groundwater discharge coming from the north and south sides of the Upper Three Runs (the estimate is based on a 50-50 split). In Section 3.0 the likelihood that stream baseflow estimates are biased high relative to 2004-2014 well water levels was mentioned. This suspected bias is not obvious from Table 6-35, apparently due to inadequate precision in the baseflow estimates.

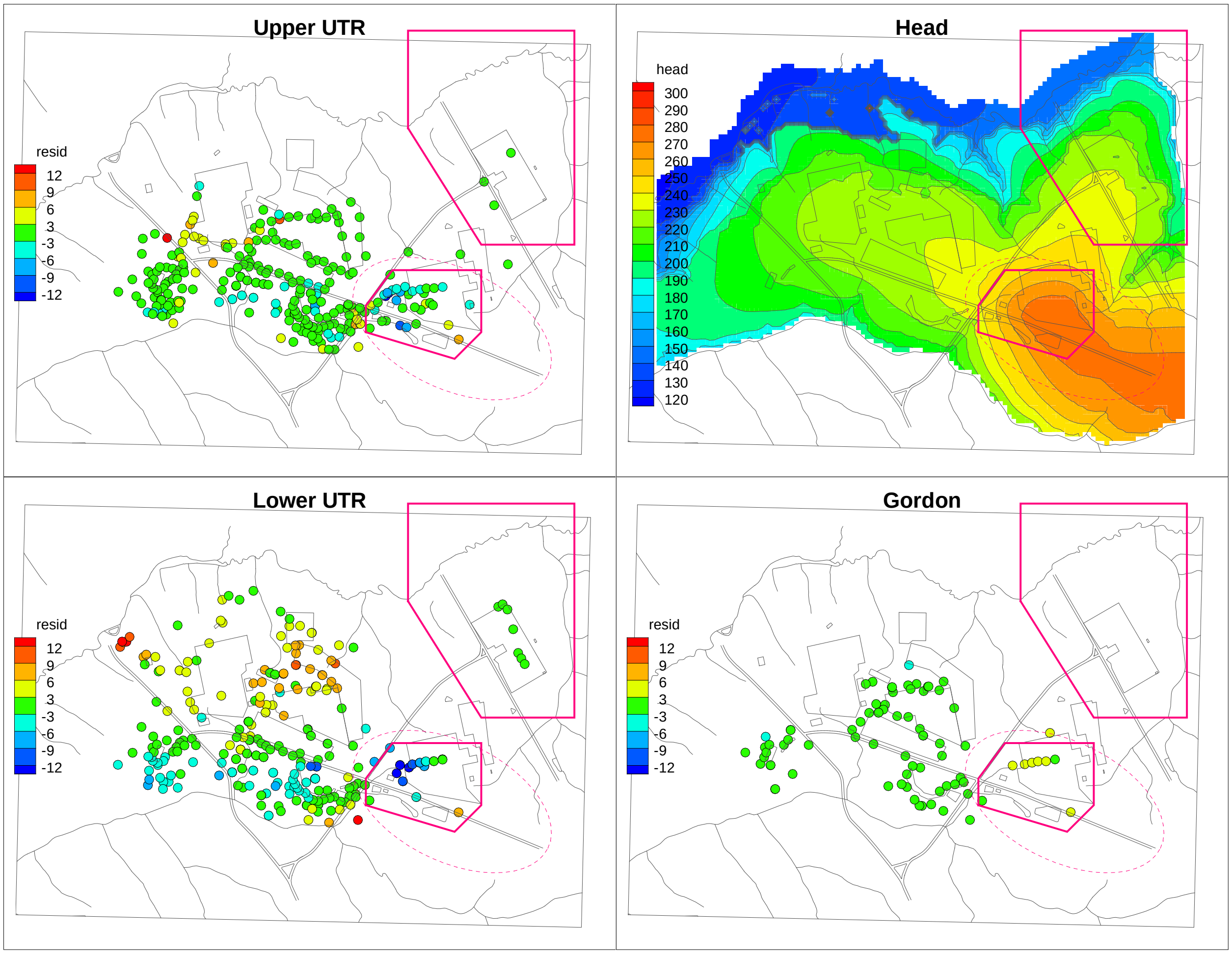


Figure 6-30. Hydraulic head residuals and water table surface for the PEST.51 case.

Table 6-31. Hydraulic conductivity summary for PEST.51 case.

Parameter	Unit	Region	Base Kh (ft/d)	Base Kv (ft/d)	PEST.51a	Net Kh (ft/d)	Net Kv (ft/d)	Kh (cm/s)	Kv (cm/s)	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.02E+07								
g01	LAZ	Global	12	0.4	0.661616	7.9	0.26	2.8E-03	9.3E-05	7.4	0.242	-0.6161	31x
g02	TCCZ	Global	0.18	0.006	0.623232	0.11	0.0037	4.0E-05	1.3E-06	0.1304	0.004	-2.417	34x
g03	TZ	Global	9	0.3	1.44508	13.0	0.43	4.6E-03	1.5E-04	12.2	0.419	-0.3777	29x
g04	AAA	Global	9	0.3	1.01E-01	0.91	0.030	3.2E-04	1.1E-05	1.0	0.057	-1.241	17x
h01	LAZ	Harea			0.120234	1.3	0.042	4.5E-04	1.5E-05				
h02	TCCZ	Harea			0.100547	0.017	0.0006	5.9E-06	2.0E-07				
h03	TZ	Harea			0.1	0.62	0.021	2.2E-04	7.3E-06				
h04	AAA	Harea			2.34E-01	0.42	0.014	1.5E-04	5.0E-06				
i01	LAZ	Zarea			0.768128	8.1	0.27	2.9E-03	9.6E-05				
i02	TCCZ	Zarea			0.692103	0.11	0.0038	4.0E-05	1.3E-06				
i03	TZ	Zarea			0.794679	4.9	0.16	1.7E-03	5.8E-05				
i04	AAA	Zarea			0.742783	1.3	0.044	4.7E-04	1.6E-05				
j01	FMB				1.67E+00								

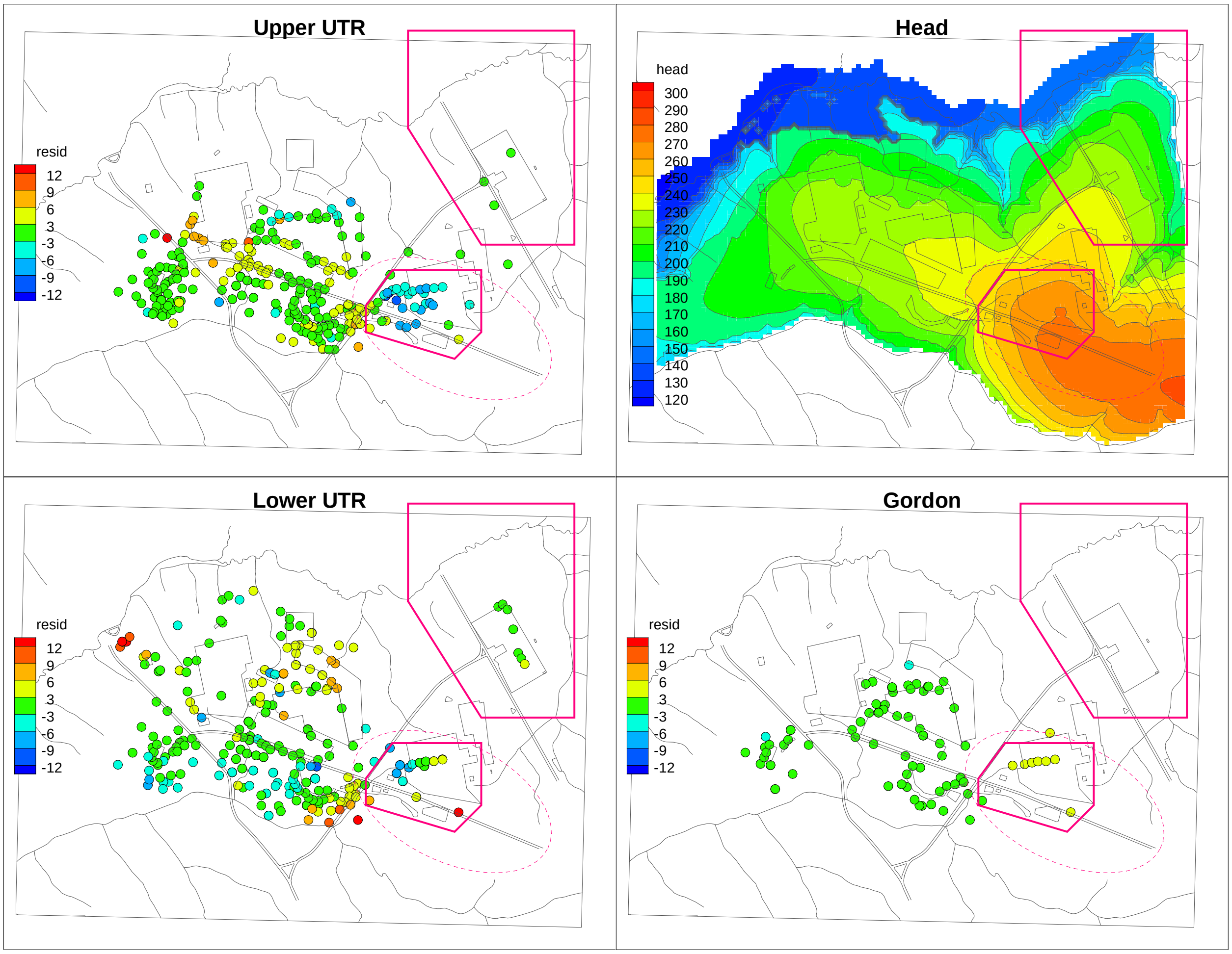


Figure 6-31. Hydraulic head residuals and water table surface for the PEST.52 case.

Table 6-32. Hydraulic conductivity summary for PEST.52 case.

Parameter	Unit	Region	Base Kh factor	Base Kv factor	PEST.52b	Net Kh factor	Net Kv factor	N/A	N/A	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					9634.2								
g01	LAZ	Global	1	1	1.21309	1.2	1.2			9.7	0.174	-0.7598	56x
g02	TCCZ	Global	1	1	3.37058	3.4	3.4			1.717	0.005	-2.34	376x
g03	TZ	Global	1	1	0.673831	0.67	0.67			5.9	0.198	-0.7029	30x
g04	AAA	Global	1	1	1.23E-01	0.12	0.12			0.9	0.043	-1.364	21x
h01	LAZ	Harea			0.104521	0.13	0.13						
h02	TCCZ	Harea			0.1	0.34	0.34						
h03	TZ	Harea			0.1	0.067	0.067						
h04	AAA	Harea			0.1	0.012	0.012						
i01	LAZ	Zarea			0.794928	1.0	1.0						
i02	TCCZ	Zarea			2.45528	8.28	8.28						
i03	TZ	Zarea			0.1	0.067	0.067						
i04	AAA	Zarea			2.36717	0.29	0.29						
j01	FMB				3.01E-01								

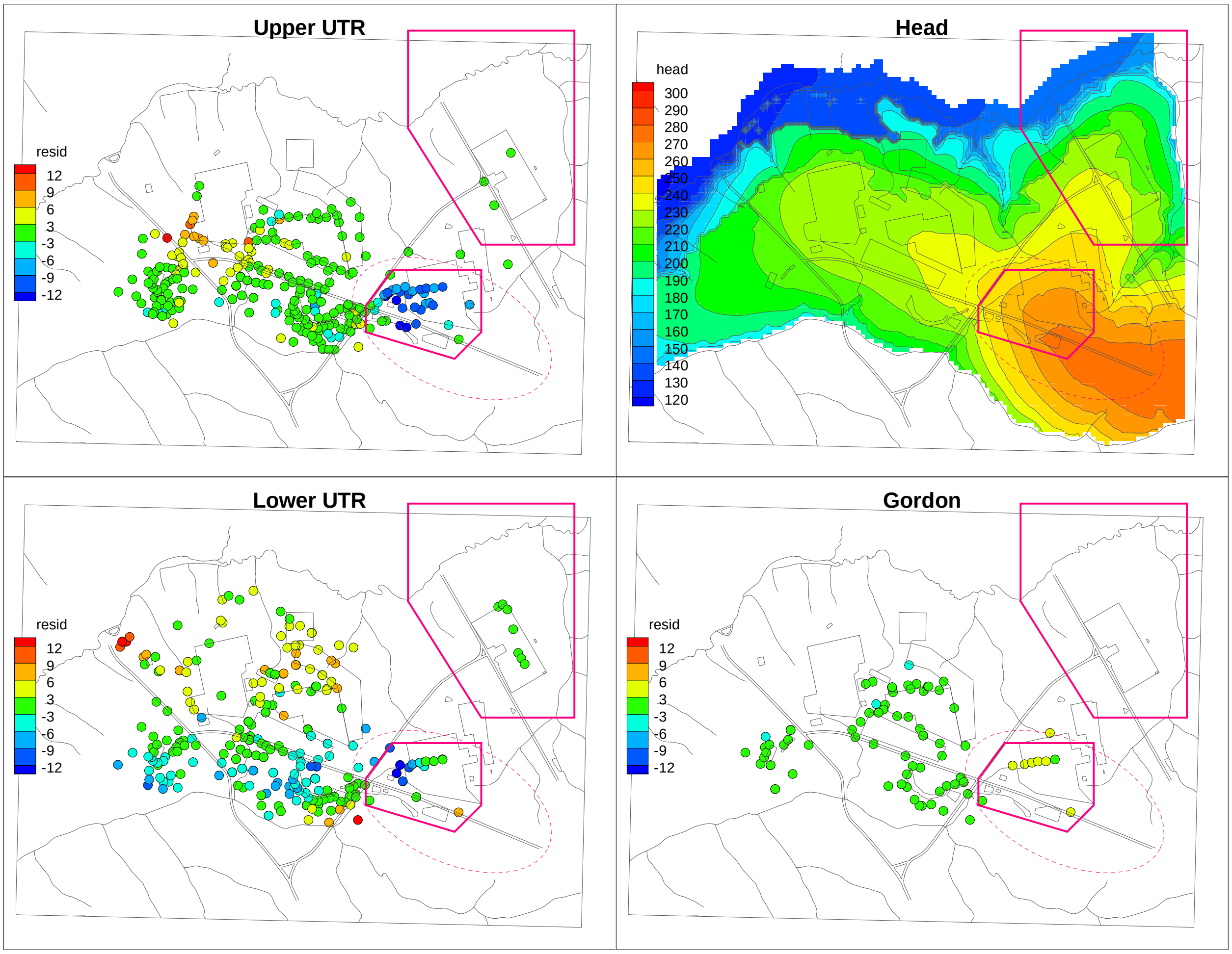


Figure 6-32. Hydraulic head residuals and water table surface for the PEST.53 case.

Table 6-33. Hydraulic conductivity summary for PEST.53 case.

Parameter	Unit	Region	Base Kh factor	Base Kv factor	PEST.53a	Net Kh factor	Net Kv factor	N/A	N/A	Kh avg (ft/d)	Kv avg (ft/d)	log10 Kv	Kh,v ratio
Phi					1.19E+07								
g01	LAZ	Global	1	1	1.02647	1.0	1.0			8.5	0.166	-0.7793	51x
g02	TCCZ	Global	1	1	0.533816	0.53	0.53			1.006	0.003	-2.594	395x
g03	TZ	Global	1	1	1.23316	1.2	1.2			10.6	0.313	-0.5049	34x
g04	AAA	Global	1	1	7.97E-02	0.080	0.080			1.2	0.062	-1.209	19x
h01	LAZ	Harea			0.1	0.12	0.12						
h02	TCCZ	Harea			0.1	0.34	0.34						
h03	TZ	Harea			0.1	0.067	0.067						
h04	AAA	Harea			3.95E-01	0.048	0.048						
i01	LAZ	Zarea			1.03638	1.3	1.3						
i02	TCCZ	Zarea			2.35201	7.9	7.9						
i03	TZ	Zarea			0.48211	0.32	0.32						
i04	AAA	Zarea			1.37764	0.17	0.17						
j01	FMB				3.00E+00								

Table 6-34. Hydraulic head residual statistics for PEST.47, 51, 52 and 53.

Case	number	median	average	root-mean-square	minimum	maximum
PEST.47						
GAU	79	0.3578	0.2164	1.9996	-5.1905	5.4197
LAZ	271	0.2628	0.463	4.1961	-9.4724	19.0612
UAZ	278	0.1209	0.0866	2.9947	-12.005	11.3281
PEST.51						
GAU	79	0.3836	0.2036	1.9593	-5.1606	5.3118
LAZ	271	-0.272	0.0029	5.2508	-14.5862	19.4421
UAZ	278	0.3143	0.0404	3.2295	-13.6501	14.7023
PEST.52						
GAU	79	0.3639	0.2208	2.0068	-5.1829	5.4701
LAZ	271	0.5704	0.5361	4.4711	-9.1071	19.6796
UAZ	278	1.1217	0.7551	3.7462	-12.512	12.8674
PEST.53						
GAU	79	0.358	0.174	1.9722	-5.1878	5.3123
LAZ	271	-1.1656	-0.6728	5.0052	-12.2174	19.7422
UAZ	278	0.674	-0.0051	4.3273	-16.2931	16.5871

Table 6-35. Stream baseflow validation targets.

Parameter	Target	PEST.47	PEST.51	PEST.52	PEST.53
Average recharge (in/yr)†	N/A	12.0	12.1	11.9	12.0
Stream baseflow (ft^3/s)					
Upper Three Runs and tributaries excluding McQueen Branch	18.2	10.6	10.4	10.4	10.3
Fourmile Branch and tributaries	2.6	2.4	2.8	2.5	2.8
McQueen Branch	1.5	1.6	1.6	1.6	1.6
Crouch Branch	1.8	1.2	1.2	1.2	1.2

† Surface infiltration divided by total surface area including seepage faces.

7.0 Groundwater flow simulation results

This section presents further validation information for the final optimization round models (PEST.47, 51, 52 and 53), additional groundwater flow simulation results, and information on simulation uncertainty. To avoid the need to refer to Table 5-1 for two key model attributes, the following shorthand notation is introduced

- "L" = Layer-cake conductivity field
- "H" = Heterogeneous conductivity field
- "U" = Unweighted calibration targets
- "W" = Weighted calibration targets

Using these abbreviations, the final round models are alternatively identified with these descriptive labels:

- "GSA2016.LU" ≡ PEST.47
- "GSA2016.LW" ≡ PEST.51
- "GSA2016.HU" ≡ PEST.52
- "GSA2016.HW" ≡ PEST.53

7.1 Simulation validation

Table 7-1 lists inflows and outflows for boundary face normal vectors grouped by coordinate direction. Cumulative inflow and outflow differ by only a few tenths of one percent, which indicates that the models conserve mass on a global basis. Table 7-2 through Table 7-5 provide the same information for various sub-regions of each model, where "GAU" includes the Gordon aquifer and confining units and "LAZ" includes the Lower Aquifer Zone and Tan Clay Confining Zone. Table 7-6 provides mass balance information broken out by boundary condition type. In all cases the flow discrepancy is no more than a few tenths of a percent, an indication that mass is conserved throughout the model domain. Table 7-7 summarizes an independent calculation to confirm that PORFLOW results satisfy Darcy's Law in the saturated zone. The calculation was performed by systematically searching the grid for saturated cells and computing Darcy velocity for each cell face that adjoins another saturated cell. Figure 7-1 through Figure 7-4 compare simulated seepage faces to surveyed seeplines where available. Good agreement is observed.

Appendix D provides a listing of hydraulic head targets, simulated head, and residuals. Figure 7-5 through Figure 7-8 plot hydraulic head residuals for the original set of Flach and Harris (1997b, 1999) targets. Residuals are biased toward negative values (simulated head biased low) in these figures because the water table targets from the 1990's are about 3.5 ft higher compared to those from the 2004-2014 period used to calibrate the current model. Figure 7-9 through Figure 7-12 show residuals for the 2004-2014 time frame, including any wells culled by Hiergesell et al. (2015) because of fewer than 4 records or other reason. Figure 7-13 through Figure 7-16 show crossplots of simulated hydraulic head versus hydraulic head targets for the UAZ, LAZ and GAU hydrostratigraphic units. Also shown are coefficient of determination (R^2) values, which range from 0.85 to 0.97. R^2 is the fraction of the observed hydraulic head variability that is captured by the model simulation.

Local recharge could potentially vary significantly with elevation, slope, and vegetation, whereas model simulations assumed uniform recharge over areas above seeplines. Smaller scale spatial perturbations would average-out and have little impact on the groundwater flow field. Of greater concern are potential variations at or approaching the scale of the model. For example, higher elevations in the center of the model tend to have smaller slopes, less tree cover, and more man-made features compared to outlying areas approaching the model boundaries. This large scale variation in topography could increase recharge in the center of the model and decrease recharge elsewhere. Hydraulic head residual plots were examined for spatial biases that might indicate non-uniform recharge. Figure 6-27, Figure 6-30, Figure 6-31, and Figure 6-32 do not provide compelling evidence for significant large scale variations in recharge. Thus, the model assumption of uniform recharge is deemed an adequate approximation of physical reality.

Table 7-1. Global mass balances (ft^3/s).

PEST.47 / GSA2016.LU

BOUNDARY:	IN	OUT	NET FLOW	
ALL x-	1.928E-01	8.930E-01	-7.002E-01	
ALL x+	1.960E+00	0.000E+00	1.960E+00	
ALL y-	1.622E+00	2.566E-03	1.619E+00	
ALL y+	0.000E+00	1.848E-01	-1.848E-01	
ALL z-	2.829E-01	2.139E-02	2.615E-01	
ALL z+	9.969E+00	1.297E+01	-3.006E+00	
TOTALS	1.403E+01	1.408E+01	-4.998E-02	-0.36%

PEST.51 / GSA2016.LW

BOUNDARY:	IN	OUT	NET FLOW	
ALL x-	1.720E-01	8.393E-01	-6.673E-01	
ALL x+	1.970E+00	0.000E+00	1.970E+00	
ALL y-	1.632E+00	2.221E-03	1.630E+00	
ALL y+	0.000E+00	1.846E-01	-1.846E-01	
ALL z-	2.832E-01	2.105E-02	2.622E-01	
ALL z+	1.002E+01	1.311E+01	-3.086E+00	
TOTALS	1.408E+01	1.416E+01	-7.599E-02	-0.54%

PEST.52 / GSA2016.HU

BOUNDARY:	IN	OUT	NET FLOW	
ALL x-	2.080E-01	8.800E-01	-6.720E-01	
ALL x+	1.957E+00	0.000E+00	1.957E+00	
ALL y-	1.620E+00	2.671E-03	1.618E+00	
ALL y+	0.000E+00	1.849E-01	-1.849E-01	
ALL z-	2.828E-01	2.148E-02	2.613E-01	
ALL z+	9.857E+00	1.289E+01	-3.028E+00	
TOTALS	1.392E+01	1.397E+01	-4.973E-02	-0.36%

PEST.53 / GSA2016.HW

BOUNDARY:	IN	OUT	NET FLOW	
ALL x-	2.039E-01	8.445E-01	-6.405E-01	
ALL x+	1.973E+00	0.000E+00	1.973E+00	
ALL y-	1.637E+00	2.169E-03	1.634E+00	
ALL y+	0.000E+00	1.846E-01	-1.846E-01	
ALL z-	2.835E-01	2.102E-02	2.625E-01	
ALL z+	9.911E+00	1.301E+01	-3.094E+00	
TOTALS	1.401E+01	1.406E+01	-4.874E-02	-0.35%

Table 7-2. Aquifer zone mass balances for PEST.47 / GSA2016.LU (ft^3/s).

BOUNDARY:	IN	OUT	NET FLOW	
GAU x-	9.486E-02	6.313E-01	-5.365E-01	
GAU x+	1.960E+00	0.000E+00	1.960E+00	
GAU y-	1.622E+00	2.566E-03	1.619E+00	
GAU y+	0.000E+00	1.848E-01	-1.848E-01	
GAU z-	2.829E-01	2.139E-02	2.615E-01	
GAU z+	1.600E+00	4.748E+00	-3.148E+00	
TOTALS	5.560E+00	5.588E+00	-2.841E-02	-0.51%

BOUNDARY:	IN	OUT	NET FLOW	
UTR x-	9.795E-02	2.617E-01	-1.637E-01	
UTR x+	0.000E+00	0.000E+00	0.000E+00	
UTR y-	0.000E+00	0.000E+00	0.000E+00	
UTR y+	0.000E+00	0.000E+00	0.000E+00	
UTR z-	6.222E-05	1.326E+00	-1.326E+00	
UTR z+	9.694E+00	8.226E+00	1.468E+00	
TOTALS	9.793E+00	9.814E+00	-2.157E-02	-0.22%

BOUNDARY:	IN	OUT	NET FLOW	
LAZ x-	9.795E-02	2.502E-01	-1.523E-01	
LAZ x+	0.000E+00	0.000E+00	0.000E+00	
LAZ y-	0.000E+00	0.000E+00	0.000E+00	
LAZ y+	0.000E+00	0.000E+00	0.000E+00	
LAZ z-	6.222E-05	1.326E+00	-1.326E+00	
LAZ z+	7.954E+00	6.484E+00	1.471E+00	
TOTALS	8.052E+00	8.060E+00	-7.734E-03	-0.10%

BOUNDARY:	IN	OUT	NET FLOW	
UAZ x-	0.000E+00	1.143E-02	-1.143E-02	
UAZ x+	0.000E+00	0.000E+00	0.000E+00	
UAZ y-	0.000E+00	0.000E+00	0.000E+00	
UAZ y+	0.000E+00	0.000E+00	0.000E+00	
UAZ z-	6.486E-01	7.224E+00	-6.575E+00	
UAZ z+	8.964E+00	2.391E+00	6.573E+00	
TOTALS	9.613E+00	9.626E+00	-1.384E-02	-0.14%

Table 7-3. Aquifer zone mass balances for PEST.51 / GSA2016.LW (ft^3/s).

BOUNDARY:	IN	OUT	NET	FLOW
GAU x-	9.445E-02	6.283E-01	-5.338E-01	
GAU x+	1.970E+00	0.000E+00	1.970E+00	
GAU y-	1.632E+00	2.221E-03	1.630E+00	
GAU y+	0.000E+00	1.846E-01	-1.846E-01	
GAU z-	2.832E-01	2.105E-02	2.622E-01	
GAU z+	1.584E+00	4.753E+00	-3.169E+00	
TOTALS	5.563E+00	5.589E+00	-2.607E-02	-0.47%

BOUNDARY:	IN	OUT	NET	FLOW
UTR x-	7.754E-02	2.110E-01	-1.335E-01	
UTR x+	0.000E+00	0.000E+00	0.000E+00	
UTR y-	0.000E+00	0.000E+00	0.000E+00	
UTR y+	0.000E+00	0.000E+00	0.000E+00	
UTR z-	6.246E-05	1.309E+00	-1.309E+00	
UTR z+	9.750E+00	8.358E+00	1.393E+00	
TOTALS	9.828E+00	9.878E+00	-4.992E-02	-0.51%

BOUNDARY:	IN	OUT	NET	FLOW
LAZ x-	7.754E-02	1.923E-01	-1.148E-01	
LAZ x+	0.000E+00	0.000E+00	0.000E+00	
LAZ y-	0.000E+00	0.000E+00	0.000E+00	
LAZ y+	0.000E+00	0.000E+00	0.000E+00	
LAZ z-	6.246E-05	1.309E+00	-1.309E+00	
LAZ z+	7.223E+00	5.834E+00	1.389E+00	
TOTALS	7.301E+00	7.336E+00	-3.469E-02	-0.48%

BOUNDARY:	IN	OUT	NET	FLOW
UAZ x-	0.000E+00	1.871E-02	-1.871E-02	
UAZ x+	0.000E+00	0.000E+00	0.000E+00	
UAZ y-	0.000E+00	0.000E+00	0.000E+00	
UAZ y+	0.000E+00	0.000E+00	0.000E+00	
UAZ z-	4.166E-01	6.513E+00	-6.096E+00	
UAZ z+	9.040E+00	2.940E+00	6.100E+00	
TOTALS	9.456E+00	9.471E+00	-1.523E-02	-0.16%

Table 7-4. Aquifer zone mass balances for PEST.52 / GSA2016.HU (ft^3/s).

BOUNDARY:	IN	OUT	NET	FLOW
GAU x-	9.464E-02	6.322E-01	-5.376E-01	
GAU x+	1.957E+00	0.000E+00	1.957E+00	
GAU y-	1.620E+00	2.671E-03	1.618E+00	
GAU y+	0.000E+00	1.849E-01	-1.849E-01	
GAU z-	2.828E-01	2.148E-02	2.613E-01	
GAU z+	1.614E+00	4.746E+00	-3.132E+00	
TOTALS	5.568E+00	5.587E+00	-1.845E-02	-0.33%

BOUNDARY:	IN	OUT	NET	FLOW
UTR x-	1.133E-01	2.477E-01	-1.344E-01	
UTR x+	0.000E+00	0.000E+00	0.000E+00	
UTR y-	0.000E+00	0.000E+00	0.000E+00	
UTR y+	0.000E+00	0.000E+00	0.000E+00	
UTR z-	6.018E-05	1.339E+00	-1.339E+00	
UTR z+	9.582E+00	8.140E+00	1.442E+00	
TOTALS	9.695E+00	9.726E+00	-3.127E-02	-0.32%

BOUNDARY:	IN	OUT	NET	FLOW
LAZ x-	1.133E-01	2.277E-01	-1.144E-01	
LAZ x+	0.000E+00	0.000E+00	0.000E+00	
LAZ y-	0.000E+00	0.000E+00	0.000E+00	
LAZ y+	0.000E+00	0.000E+00	0.000E+00	
LAZ z-	6.018E-05	1.339E+00	-1.339E+00	
LAZ z+	7.835E+00	6.389E+00	1.445E+00	
TOTALS	7.948E+00	7.956E+00	-7.447E-03	-0.09%

BOUNDARY:	IN	OUT	NET	FLOW
UAZ x-	0.000E+00	2.004E-02	-2.004E-02	
UAZ x+	0.000E+00	0.000E+00	0.000E+00	
UAZ y-	0.000E+00	0.000E+00	0.000E+00	
UAZ y+	0.000E+00	0.000E+00	0.000E+00	
UAZ z-	5.926E-01	7.190E+00	-6.597E+00	
UAZ z+	8.937E+00	2.343E+00	6.594E+00	
TOTALS	9.529E+00	9.553E+00	-2.383E-02	-0.25%

Table 7-5. Aquifer zone mass balances for PEST.53 / GSA2016.HW (ft^3/s).

BOUNDARY:	IN	OUT	NET	FLOW
GAU x-	9.459E-02	6.270E-01	-5.324E-01	
GAU x+	1.973E+00	0.000E+00	1.973E+00	
GAU y-	1.637E+00	2.169E-03	1.634E+00	
GAU y+	0.000E+00	1.846E-01	-1.846E-01	
GAU z-	2.835E-01	2.102E-02	2.625E-01	
GAU z+	1.570E+00	4.745E+00	-3.174E+00	
TOTALS	5.558E+00	5.579E+00	-2.132E-02	-0.38%

BOUNDARY:	IN	OUT	NET	FLOW
UTR x-	1.093E-01	2.175E-01	-1.081E-01	
UTR x+	0.000E+00	0.000E+00	0.000E+00	
UTR y-	0.000E+00	0.000E+00	0.000E+00	
UTR y+	0.000E+00	0.000E+00	0.000E+00	
UTR z-	5.908E-05	1.295E+00	-1.295E+00	
UTR z+	9.637E+00	8.260E+00	1.376E+00	
TOTALS	9.746E+00	9.773E+00	-2.741E-02	-0.28%

BOUNDARY:	IN	OUT	NET	FLOW
LAZ x-	1.093E-01	1.857E-01	-7.640E-02	
LAZ x+	0.000E+00	0.000E+00	0.000E+00	
LAZ y-	0.000E+00	0.000E+00	0.000E+00	
LAZ y+	0.000E+00	0.000E+00	0.000E+00	
LAZ z-	5.908E-05	1.295E+00	-1.295E+00	
LAZ z+	7.048E+00	5.682E+00	1.366E+00	
TOTALS	7.158E+00	7.163E+00	-5.606E-03	-0.08%

BOUNDARY:	IN	OUT	NET	FLOW
UAZ x-	0.000E+00	3.173E-02	-3.173E-02	
UAZ x+	0.000E+00	0.000E+00	0.000E+00	
UAZ y-	0.000E+00	0.000E+00	0.000E+00	
UAZ y+	0.000E+00	0.000E+00	0.000E+00	
UAZ z-	3.351E-01	6.411E+00	-6.076E+00	
UAZ z+	8.999E+00	2.913E+00	6.085E+00	
TOTALS	9.334E+00	9.356E+00	-2.181E-02	-0.23%

Table 7-6. Boundary condition mass balances (ft^3/s).

PEST.47 / GSA2016.LU

BOUNDARY:	IN	OUT	NET FLOW	IN	OUT	NET FLUX
RECH01:	9.788E+00	1.297E+01	-3.187E+00	1.196E+01	1.586E+01	-3.895E+00
RECH02:	1.124E-01	0.000E+00	1.124E-01	1.498E+01	0.000E+00	1.498E+01
RECH03:	1.536E-02	0.000E+00	1.536E-02	1.498E+00	0.000E+00	1.498E+00
GENH01:	2.451E-01	1.490E-02	2.302E-01	2.948E-01	1.792E-02	2.769E-01
GENH02:	1.423E-02	0.000E+00	1.423E-02	1.683E+01	0.000E+00	1.683E+01
GENH05:	1.652E-02	0.000E+00	1.652E-02	1.562E+02	0.000E+00	1.562E+02
GENH10:	2.238E-02	0.000E+00	2.238E-02	4.235E+01	0.000E+00	4.235E+01
HEAD01:	9.795E-02	2.617E-01	-1.637E-01	1.209E+02	3.231E+02	-2.022E+02
HEAD02:	3.715E+00	8.252E-01	2.889E+00	2.178E+02	4.838E+01	1.694E+02
TOTALS:	1.403E+01	1.408E+01	-5.011E-02	-0.36%		

PEST.51 / GSA2016.LW

BOUNDARY:	IN	OUT	NET FLOW	IN	OUT	NET FLUX
RECH01:	9.847E+00	1.311E+01	-3.263E+00	1.203E+01	1.602E+01	-3.988E+00
RECH02:	1.124E-01	0.000E+00	1.124E-01	1.498E+01	0.000E+00	1.498E+01
RECH03:	1.536E-02	0.000E+00	1.536E-02	1.498E+00	0.000E+00	1.498E+00
GENH01:	2.451E-01	1.480E-02	2.303E-01	2.949E-01	1.780E-02	2.771E-01
GENH02:	1.702E-02	0.000E+00	1.702E-02	2.012E+01	0.000E+00	2.012E+01
GENH05:	1.279E-02	0.000E+00	1.279E-02	1.210E+02	0.000E+00	1.210E+02
GENH10:	1.965E-02	0.000E+00	1.965E-02	3.717E+01	0.000E+00	3.717E+01
HEAD01:	7.754E-02	2.110E-01	-1.335E-01	9.574E+01	2.606E+02	-1.648E+02
HEAD02:	3.734E+00	8.214E-01	2.913E+00	2.189E+02	4.815E+01	1.708E+02
TOTALS:	1.408E+01	1.416E+01	-7.614E-02	-0.54%		

PEST.52 / GSA2016.HU

BOUNDARY:	IN	OUT	NET FLOW	IN	OUT	NET FLUX
RECH01:	9.680E+00	1.289E+01	-3.206E+00	1.183E+01	1.575E+01	-3.918E+00
RECH02:	1.124E-01	0.000E+00	1.124E-01	1.498E+01	0.000E+00	1.498E+01
RECH03:	1.536E-02	0.000E+00	1.536E-02	1.498E+00	0.000E+00	1.498E+00
GENH01:	2.450E-01	1.493E-02	2.301E-01	2.948E-01	1.796E-02	2.768E-01
GENH02:	1.693E-02	0.000E+00	1.693E-02	2.002E+01	0.000E+00	2.002E+01
GENH05:	1.168E-02	0.000E+00	1.168E-02	1.105E+02	0.000E+00	1.105E+02
GENH10:	2.061E-02	0.000E+00	2.061E-02	3.900E+01	0.000E+00	3.900E+01
HEAD01:	1.133E-01	2.477E-01	-1.344E-01	1.399E+02	3.059E+02	-1.660E+02
HEAD02:	3.709E+00	8.263E-01	2.883E+00	2.175E+02	4.845E+01	1.690E+02
TOTALS:	1.392E+01	1.397E+01	-4.981E-02	-0.36%		

PEST.53 / GSA2016.HW

BOUNDARY:	IN	OUT	NET FLOW	IN	OUT	NET FLUX
RECH01:	9.728E+00	1.301E+01	-3.277E+00	1.189E+01	1.589E+01	-4.005E+00
RECH02:	1.124E-01	0.000E+00	1.124E-01	1.498E+01	0.000E+00	1.498E+01
RECH03:	1.536E-02	0.000E+00	1.536E-02	1.498E+00	0.000E+00	1.498E+00
GENH01:	2.453E-01	1.479E-02	2.305E-01	2.950E-01	1.779E-02	2.773E-01
GENH02:	2.381E-02	0.000E+00	2.381E-02	2.816E+01	0.000E+00	2.816E+01
GENH05:	1.194E-02	0.000E+00	1.194E-02	1.130E+02	0.000E+00	1.130E+02
GENH10:	1.956E-02	0.000E+00	1.956E-02	3.701E+01	0.000E+00	3.701E+01
HEAD01:	1.093E-01	2.175E-01	-1.081E-01	1.350E+02	2.685E+02	-1.335E+02
HEAD02:	3.743E+00	8.200E-01	2.923E+00	2.194E+02	4.807E+01	1.713E+02
TOTALS:	1.401E+01	1.406E+01	-4.898E-02	-0.35%		

Table 7-7. Confirmation that Darcy's Law is satisfied.

PEST.47 / GSA2016.LU
```
252063 (  100%) Total number of unique saturated faces
1150   ( 0.46%) Darcy velocity difference exceeding 0.01d0,   local flow reference
5      (0.002%) Darcy velocity difference exceeding 0.01d0, average flow reference
0      (    0%) Darcy velocity difference exceeding 0.01d0, biggest flow reference
```

PEST.51 / GSA2016.LW
```
254408  (  100%) Total number of unique saturated faces
1185    ( 0.47%) Darcy velocity difference exceeding 0.01d0,   local flow reference
15      (0.006%) Darcy velocity difference exceeding 0.01d0, average flow reference
0       (    0%) Darcy velocity difference exceeding 0.01d0, biggest flow reference
```

PEST.52 / GSA2016.HU
```
258572  (  100%) Total number of unique saturated faces
6417    ( 2.48%) Darcy velocity difference exceeding 0.01d0,   local flow reference
4131    ( 1.60%) Darcy velocity difference exceeding 0.01d0, average flow reference
5       (0.002%) Darcy velocity difference exceeding 0.01d0, biggest flow reference
```

PEST.53 / GSA2016.HW
```
260304  (  100%) Total number of unique saturated faces
5462    ( 2.10%) Darcy velocity difference exceeding 0.01d0,   local flow reference
3206    ( 1.23%) Darcy velocity difference exceeding 0.01d0, average flow reference
5       (0.002%) Darcy velocity difference exceeding 0.01d0, biggest flow reference
```

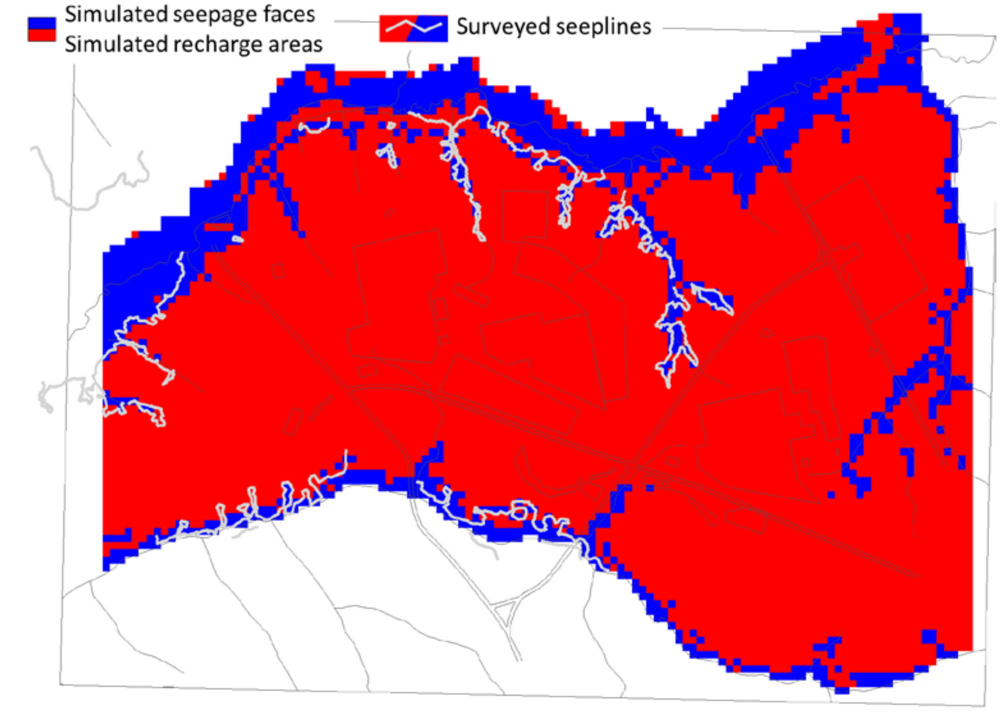


Figure 7-1. Simulated seepage faces compared to surveyed seeplines for PEST.47 / GSA2016.LU.

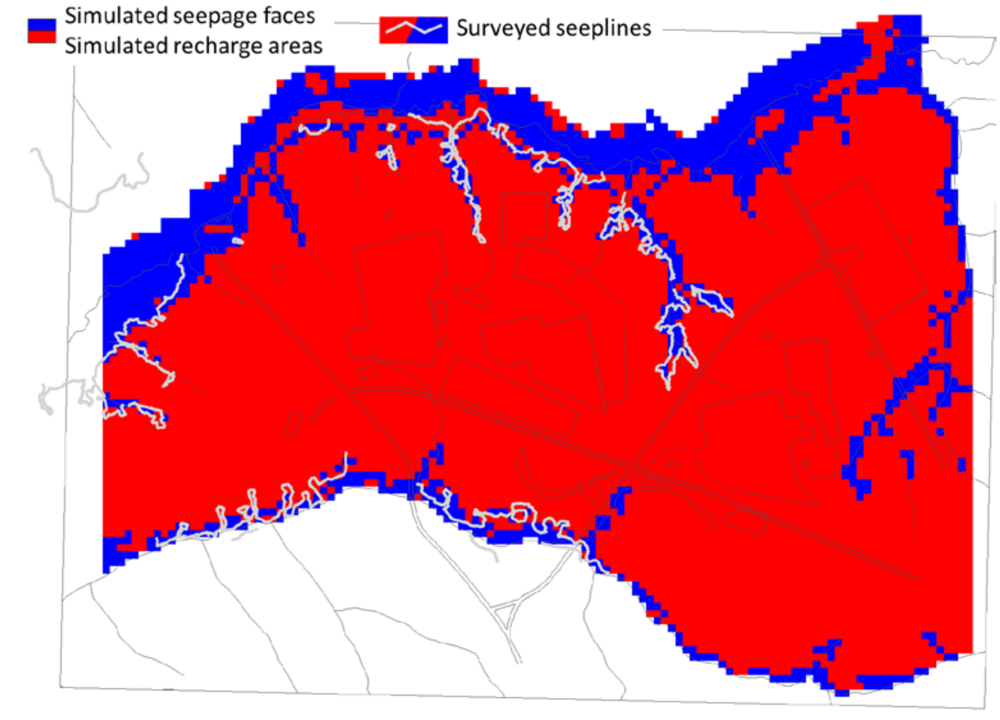


Figure 7-2. Simulated seepage faces compared to surveyed seeplines for PEST.51 / GSA2016.LW.

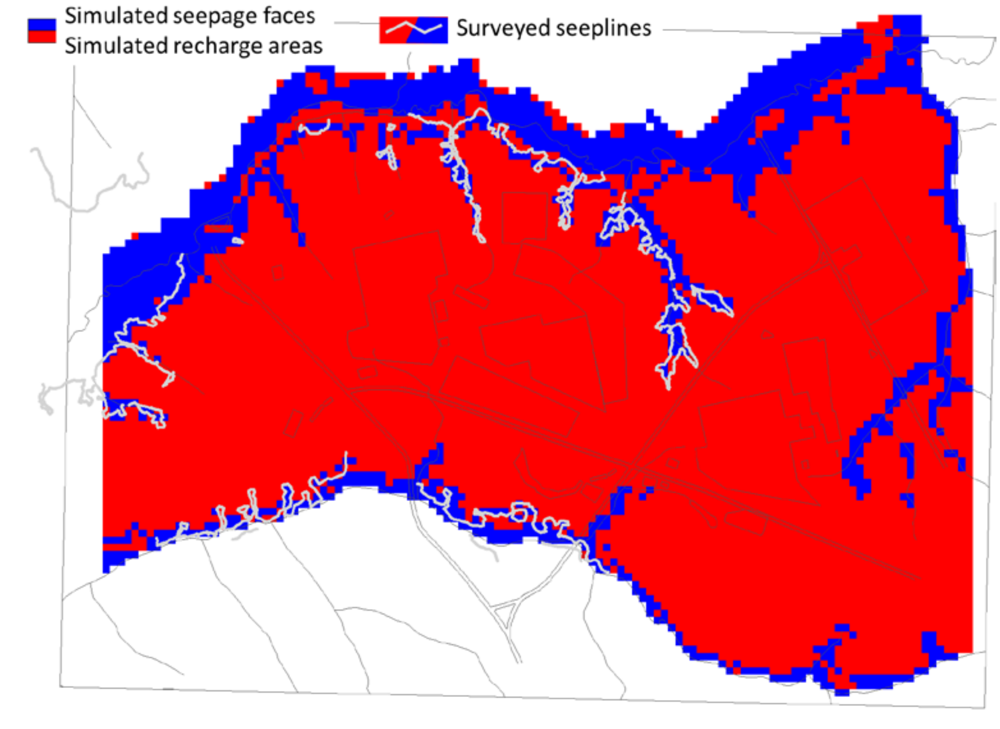


Figure 7-3. Simulated seepage faces compared to surveyed seeplines for PEST.52 / GSA2016.HU.

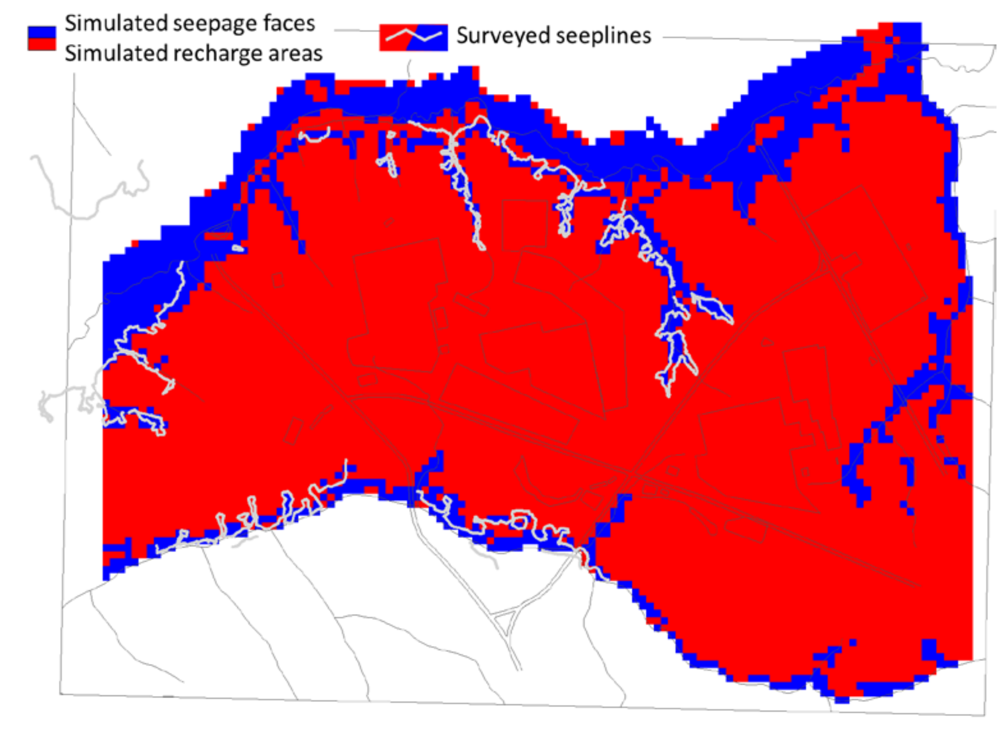


Figure 7-4. Simulated seepage faces compared to surveyed seeplines for PEST.53 / GSA2016.HW.

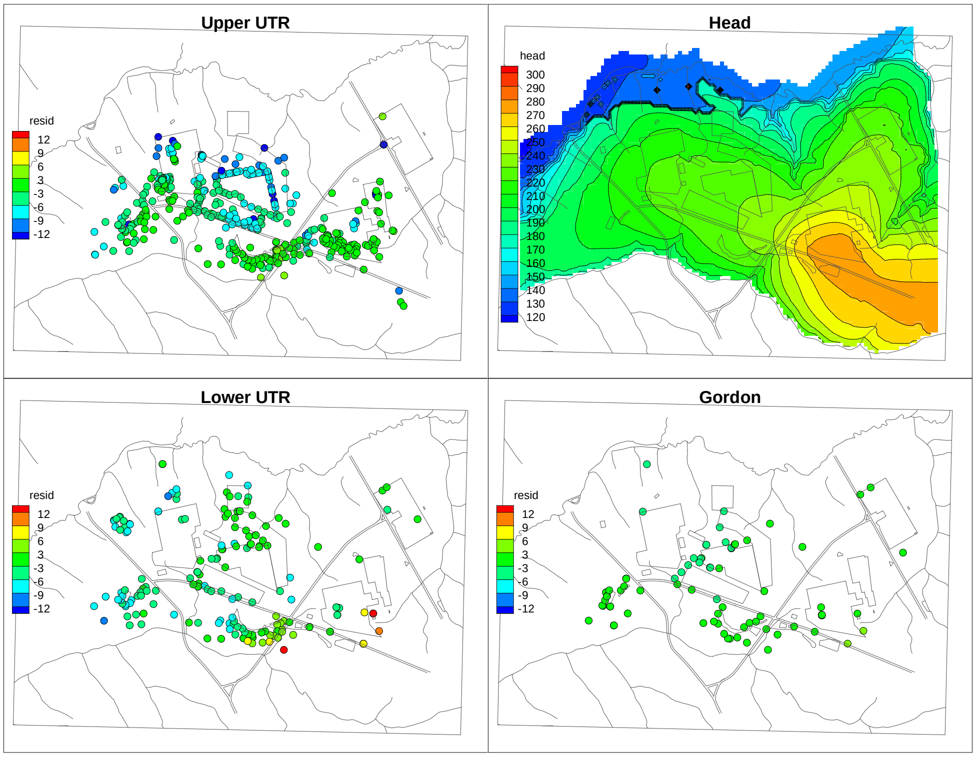


Figure 7-5. Hydraulic head residuals and water table surface for the PEST.47 / GSA2016.LU case for Flach and Harris (1997b, 1999) hydraulic head targets.

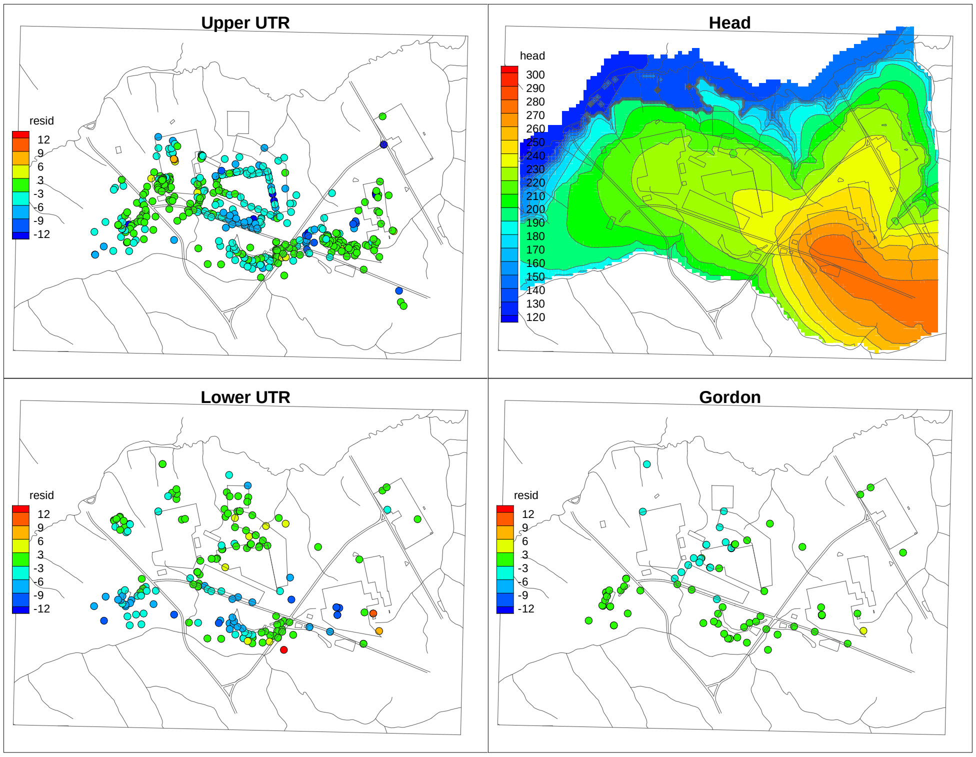


Figure 7-6. Hydraulic head residuals and water table surface for the PEST.51 / GSA2016.LW case for Flach and Harris (1997b, 1999) hydraulic head targets.

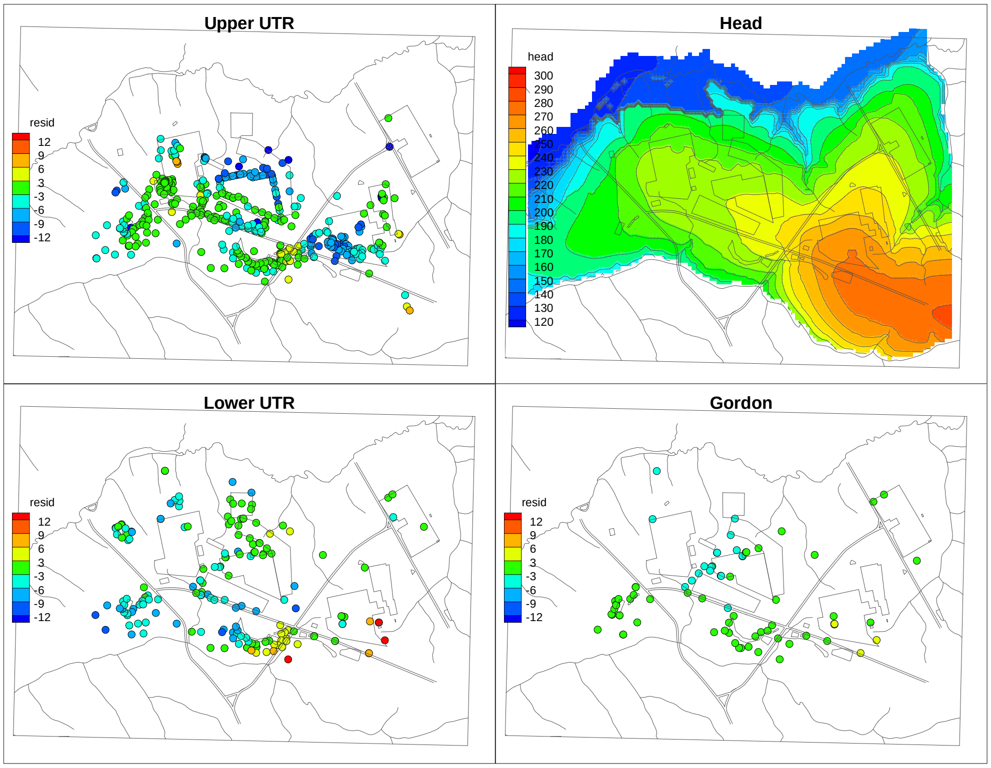


Figure 7-7. Hydraulic head residuals and water table surface for the PEST.52 / GSA2016.HU case for Flach and Harris (1997b, 1999) hydraulic head targets.

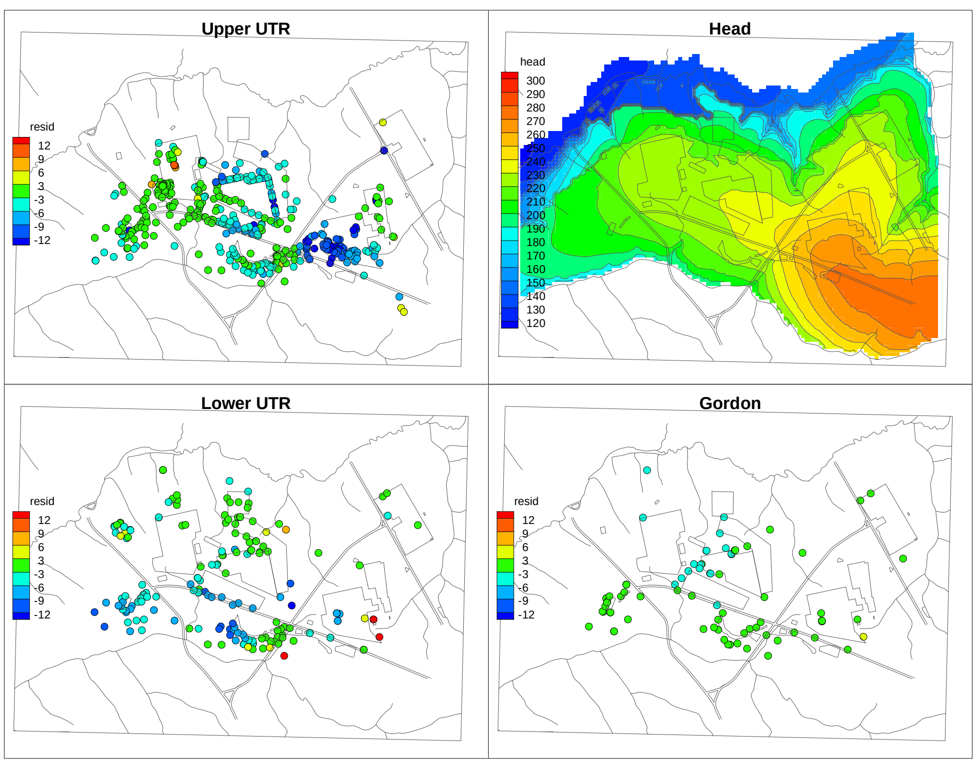


Figure 7-8. Hydraulic head residuals and water table surface for the PEST.53 / GSA2016.HW case for Flach and Harris (1997b, 1999) hydraulic head targets.

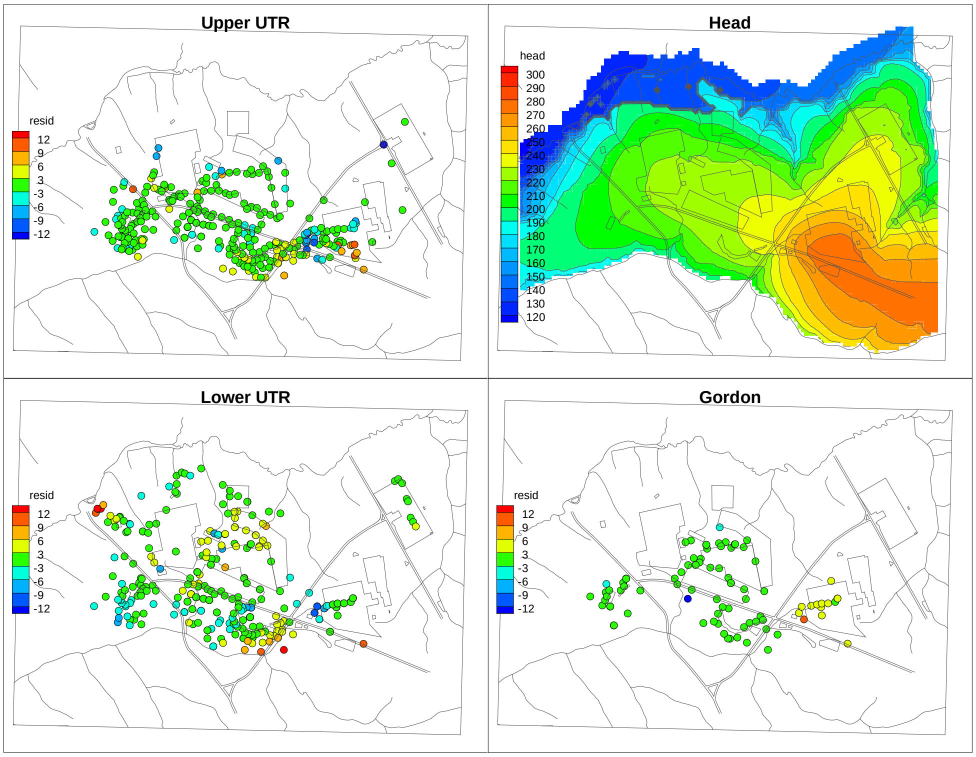


Figure 7-9. Hydraulic head residuals and water table surface for the PEST.47 / GSA2016.LU case for expanded "2004-2014" hydraulic head targets (no minimum records & no data cull).

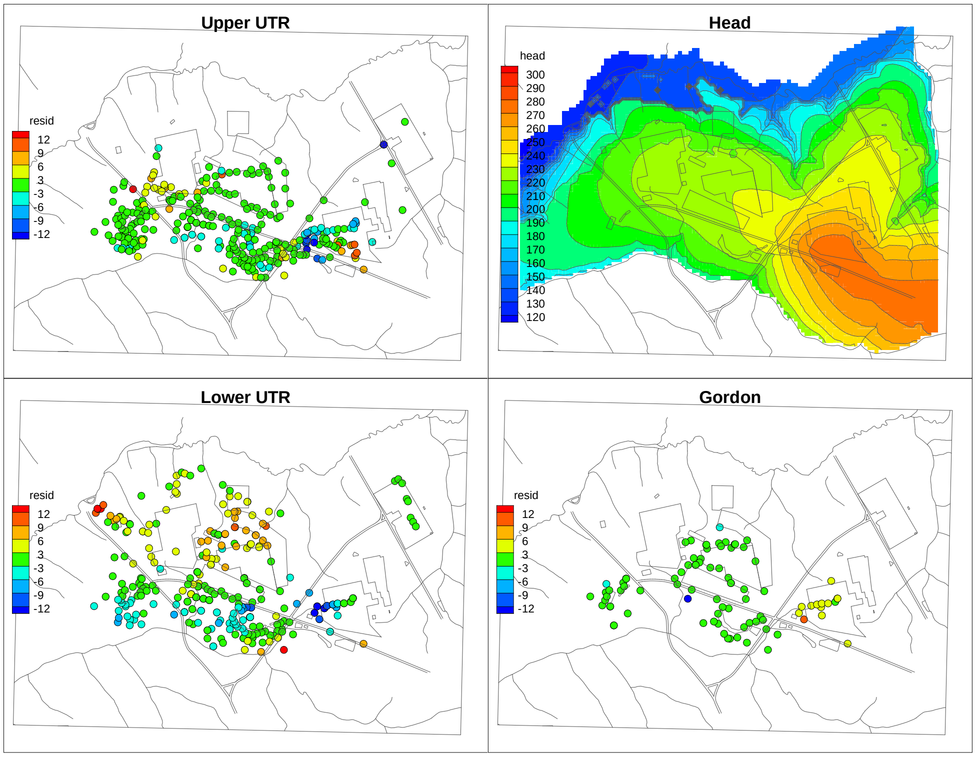


Figure 7-10. Hydraulic head residuals and water table surface for the PEST.51 / GSA2016.LW case for expanded "2004-2014" hydraulic head targets (no minimum records & no data cull).

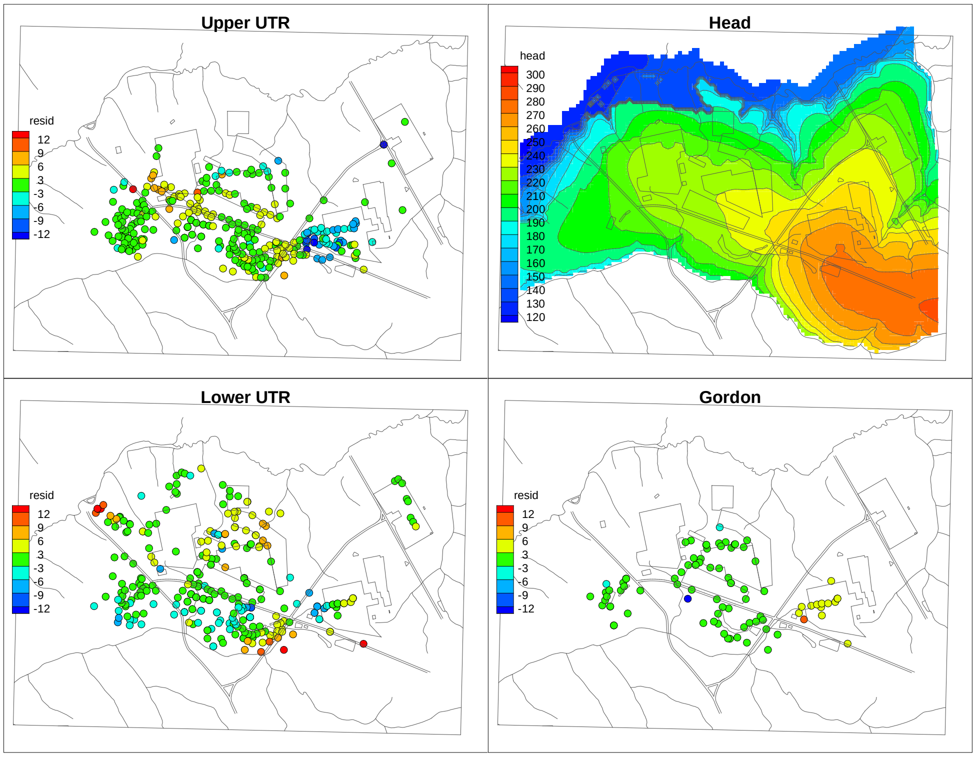


Figure 7-11. Hydraulic head residuals and water table surface for the PEST.52 / GSA2016.HU case for expanded "2004-2014" hydraulic head targets (no minimum records & no data cull).

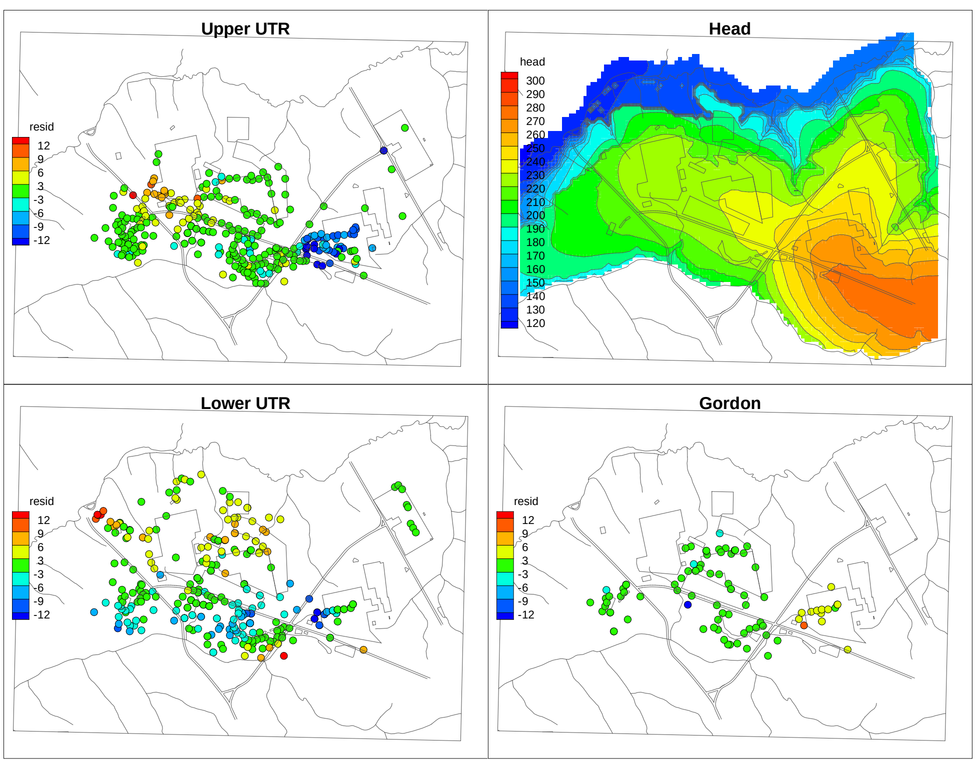


Figure 7-12. Hydraulic head residuals and water table surface for the PEST.53 / GSA2016.HW case for expanded "2004-2014" hydraulic head targets (no minimum records & no data cull).

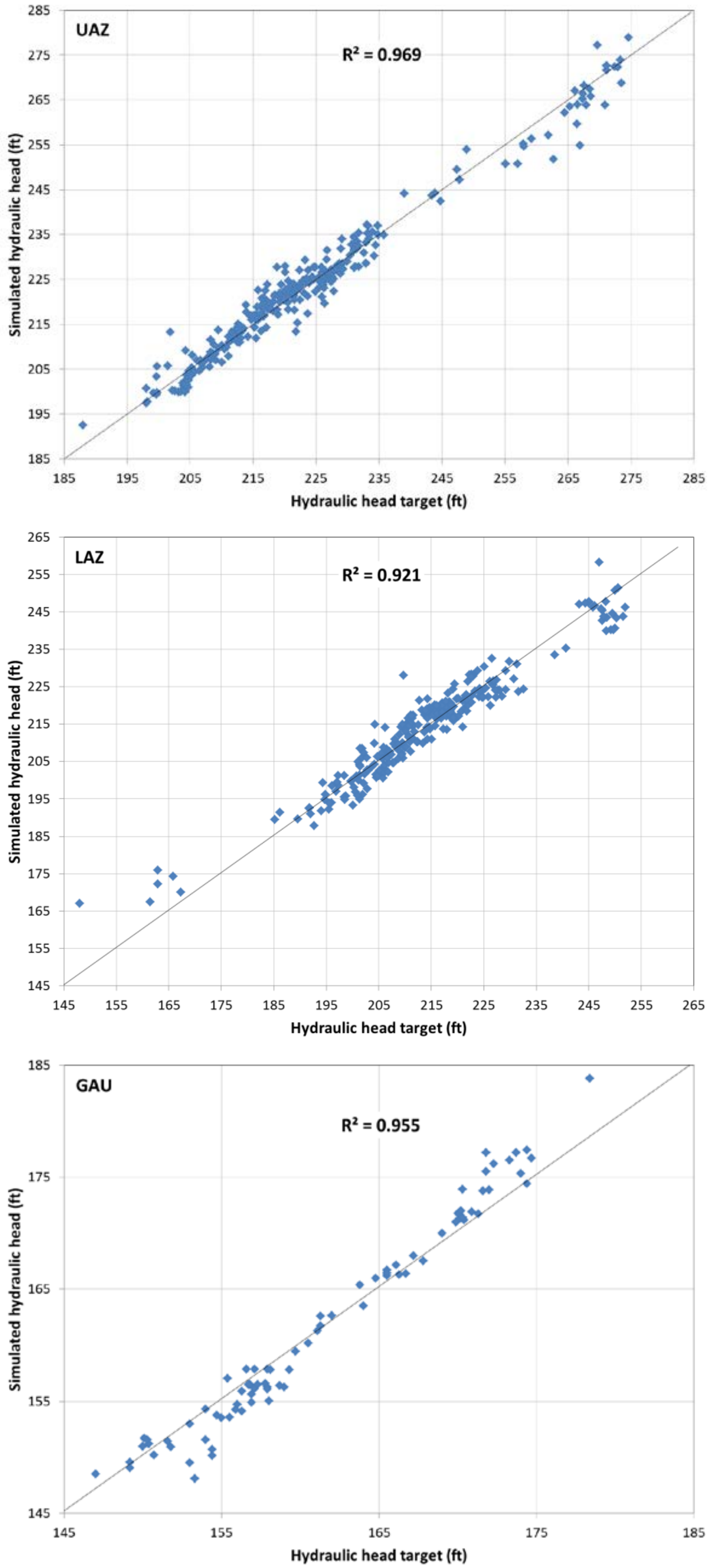


Figure 7-13. Hydraulic head crossplots for the PEST.47 / GSA2016.LU case.

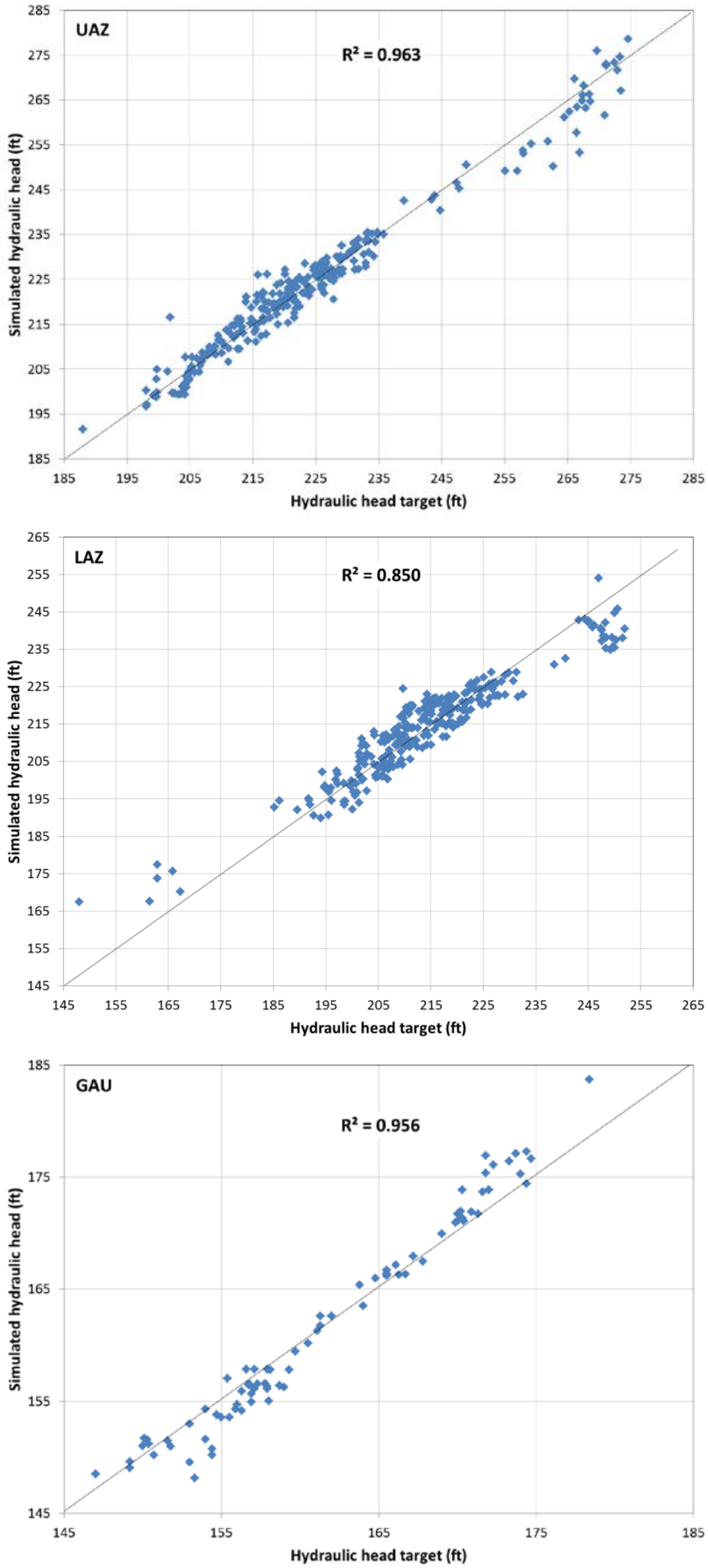


Figure 7-14. Hydraulic head crossplots for the PEST.51 / GSA2016.LW case.

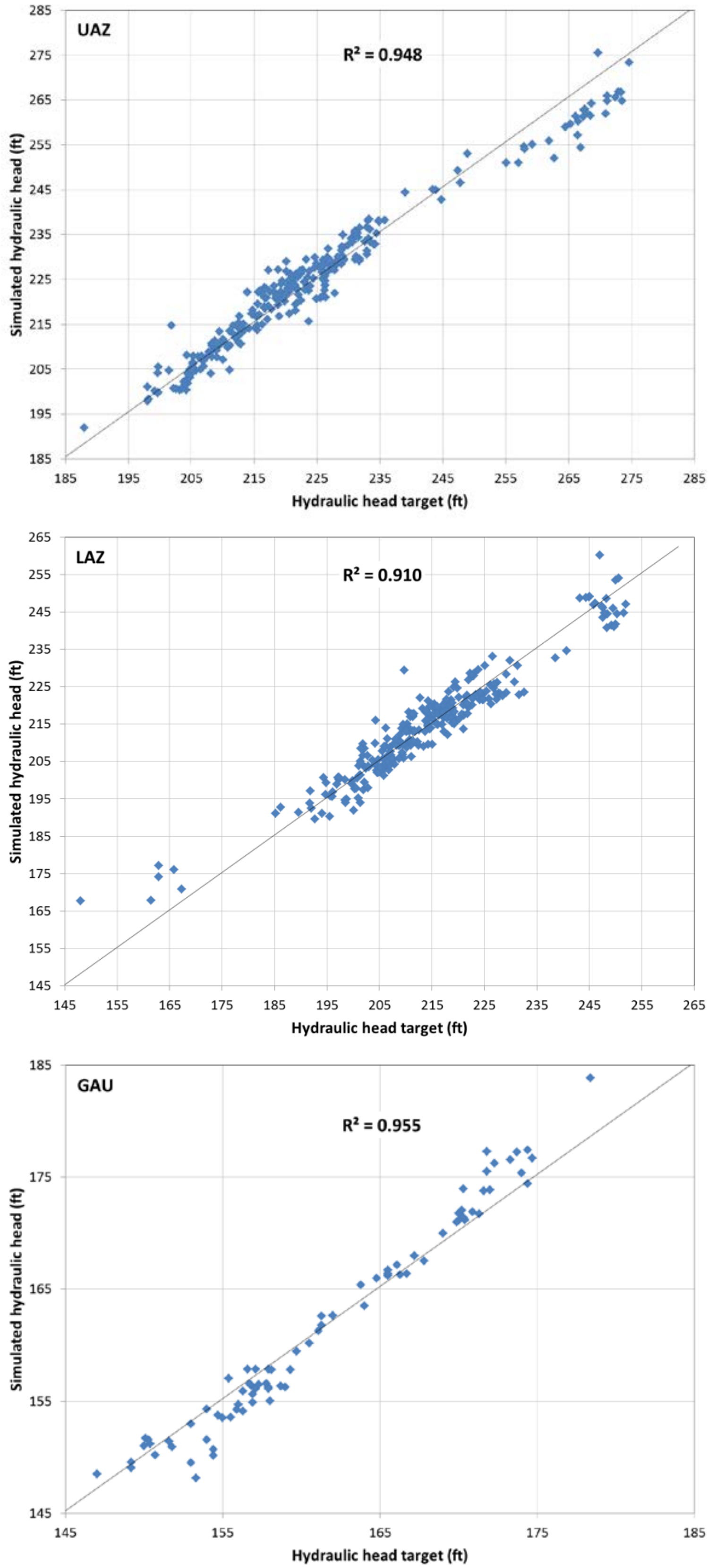


Figure 7-15. Hydraulic head crossplots for the PEST.52 / GSA2016.HU case.

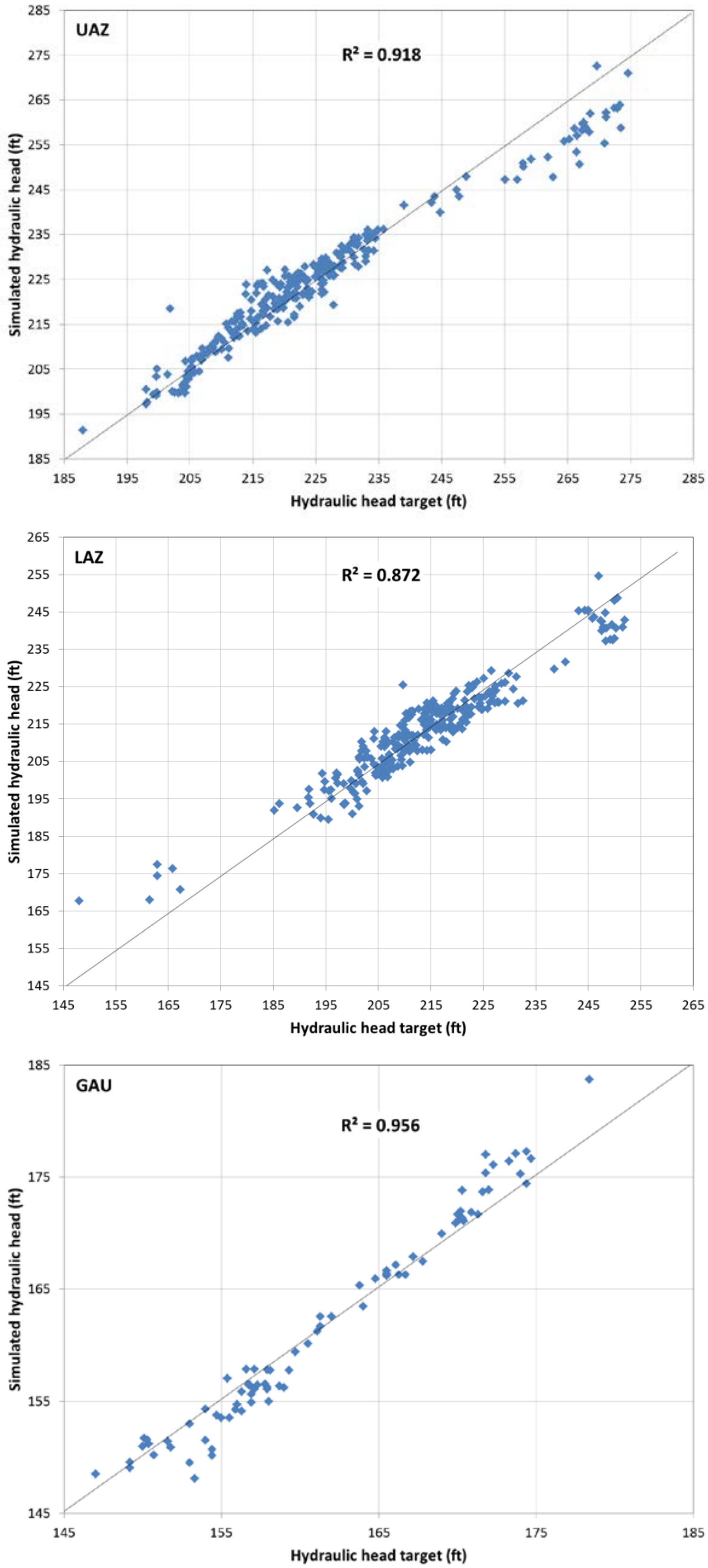


Figure 7-16. Hydraulic head crossplots for the PEST.53 / GSA2016.HW case.

7.2 Simulation results

The simulated water tables for the final round optimization cases are shown in Figure 7-17 through Figure 7-20. These figures can be compared to Figure 7-21, which is a kriging interpolation of measured water table elevations. Vertically-averaged hydraulic heads simulated for each aquifer zone are provided in Figure 7-22 through Figure 7-33. Figure 7-34 is a kriging interpolation of measured hydraulic head in the Gordon aquifer unit for comparison to simulated heads. Simulated surface flux is plotted in Figure 7-35 through Figure 7-38. These figures can be compared to the surveyed seeplines shown in Figure 7-1 through Figure 7-4.

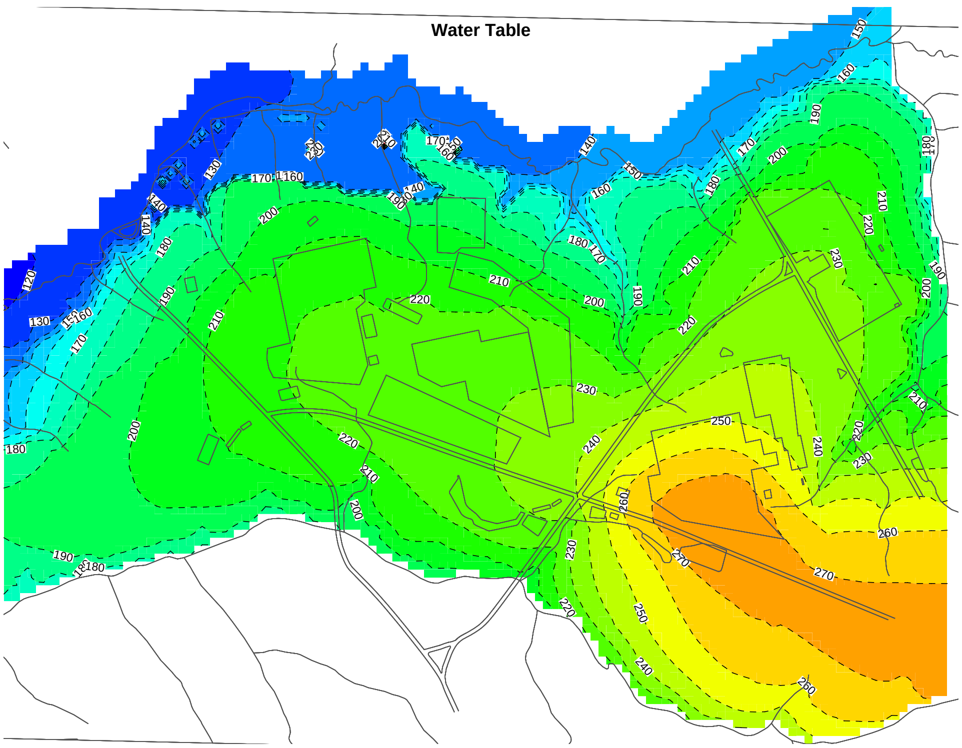


Figure 7-17. Simulated water table for the PEST.47 / GSA2016.LU case (ft).

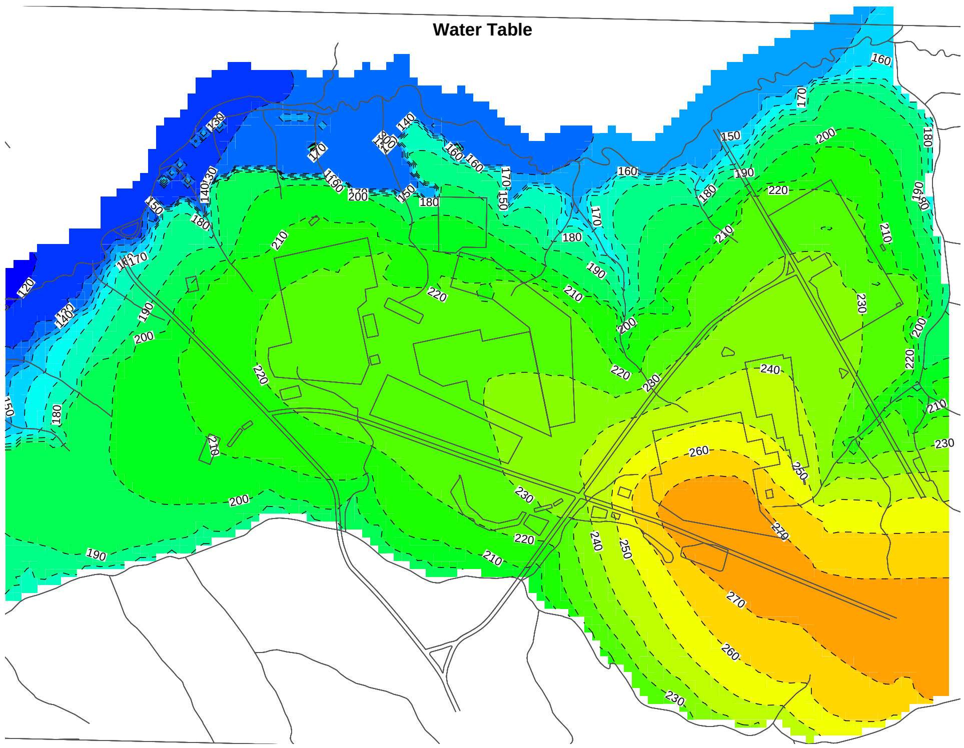


Figure 7-18. Simulated water table for the PEST.51 / GSA2016.LW case (ft).

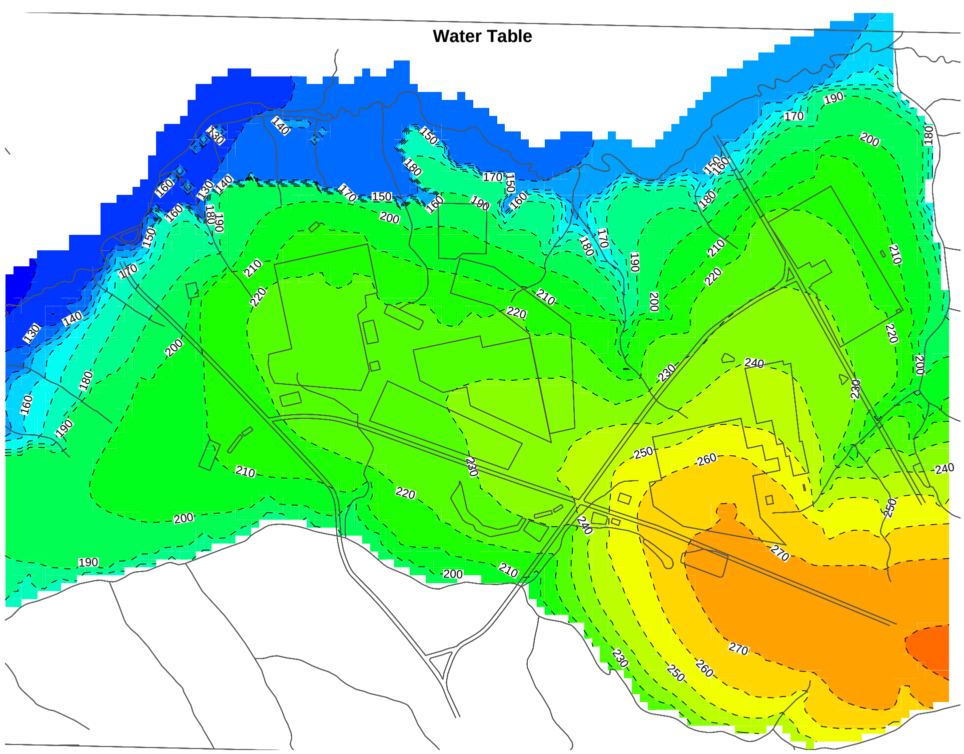


Figure 7-19. Simulated water table for the PEST.52 / GSA2016.HU case (ft).

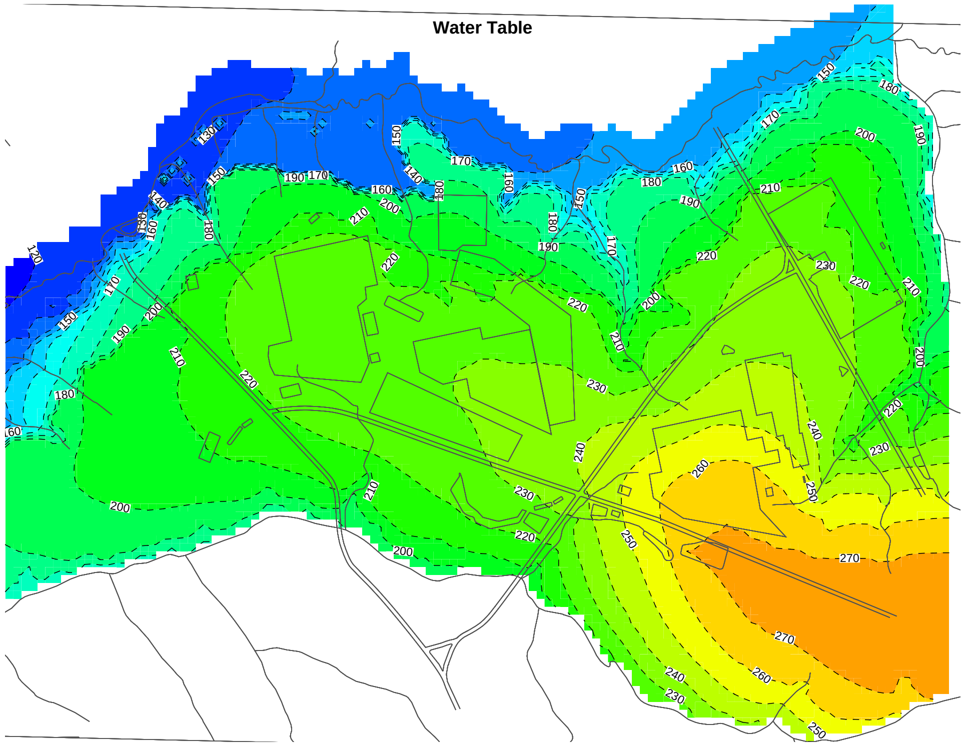
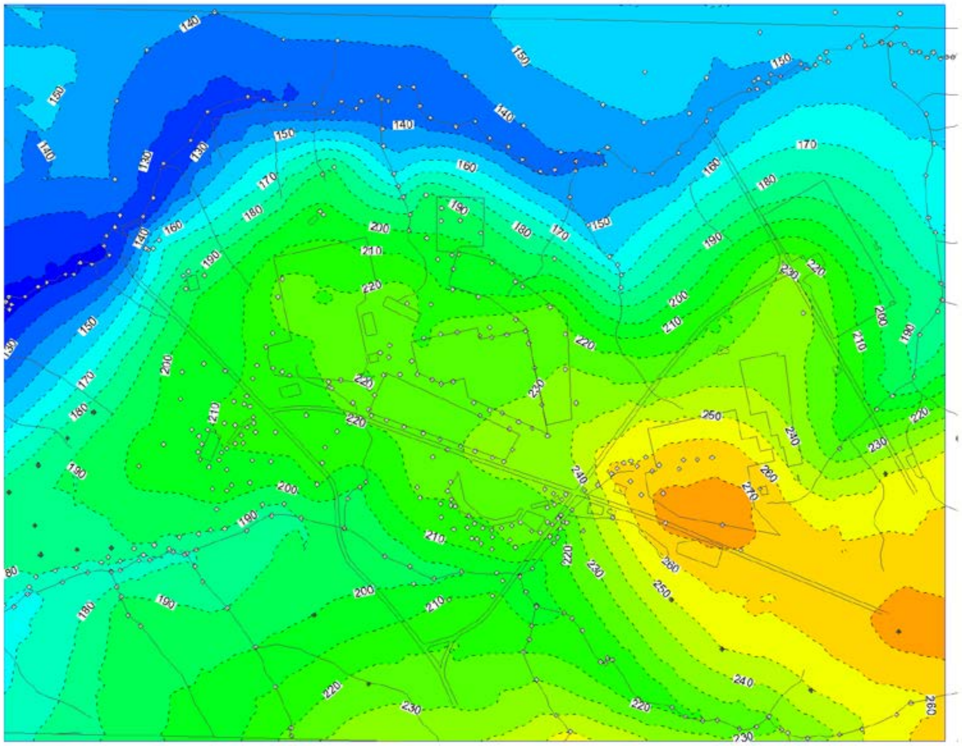


Figure 7-20. Simulated water table for the PEST.53 / GSA2016.HW case (ft).



Key: open diamonds = data; solid diamonds = control points

Figure 7-21. Kriging interpolation representation of water table measurements (ft).

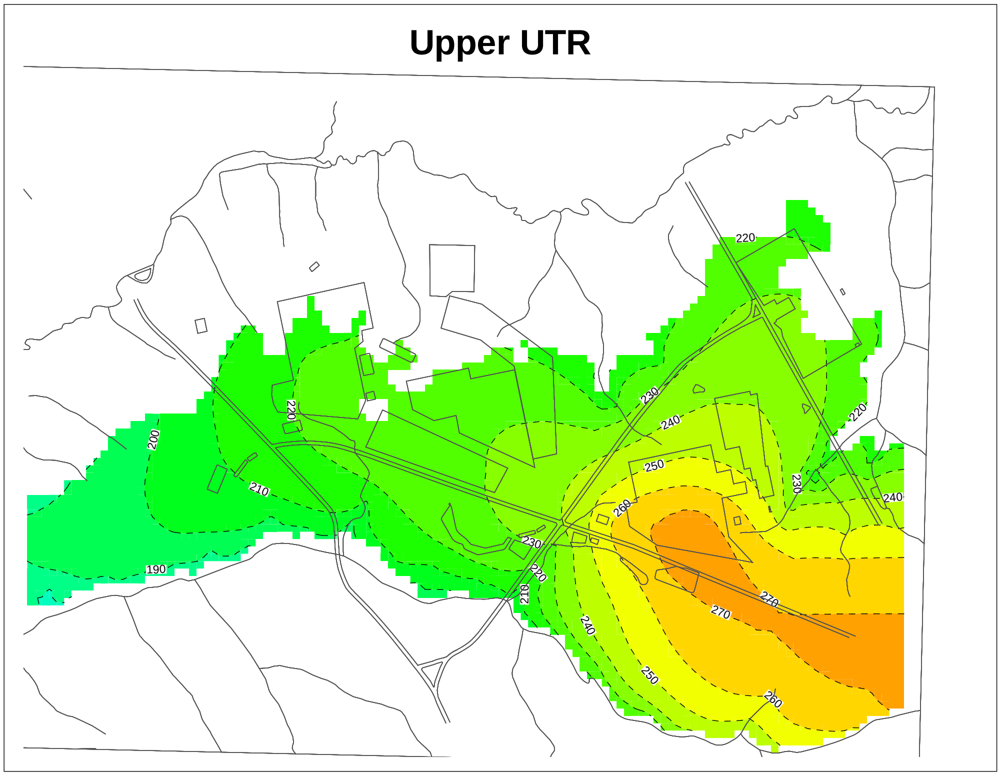


Figure 7-22. Simulated hydraulic head in the Upper Aquifer Zone for the PEST.47 / GSA2016.LU case (ft).

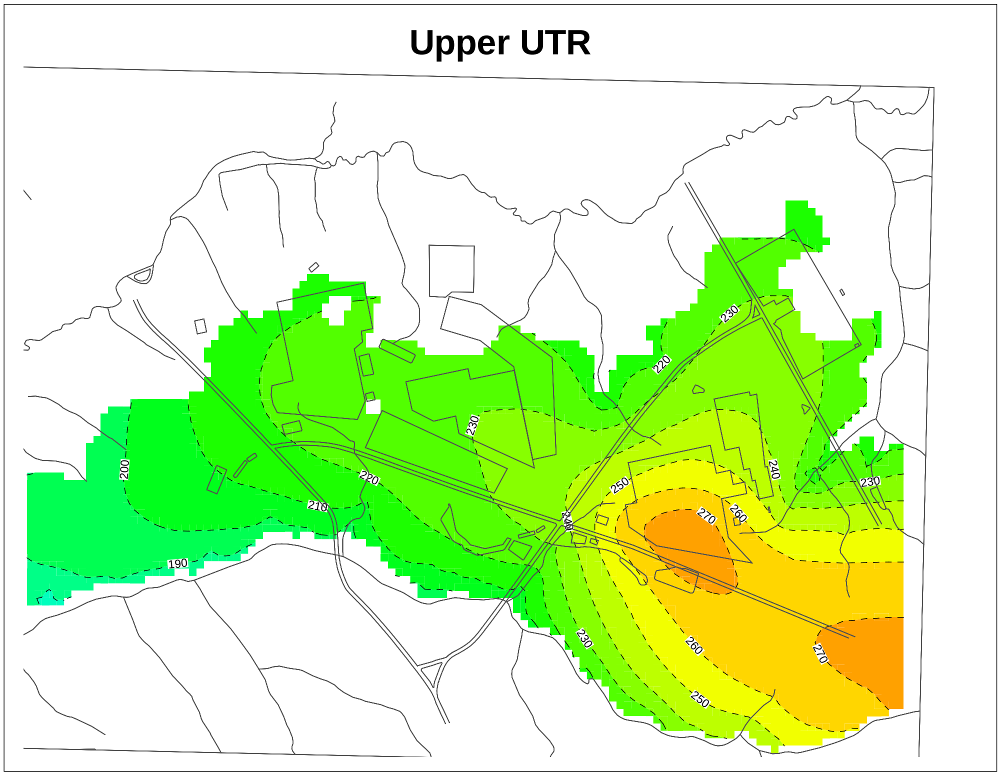


Figure 7-23. Simulated hydraulic head in the Upper Aquifer Zone for the PEST.51 / GSA2016.LW case (ft).

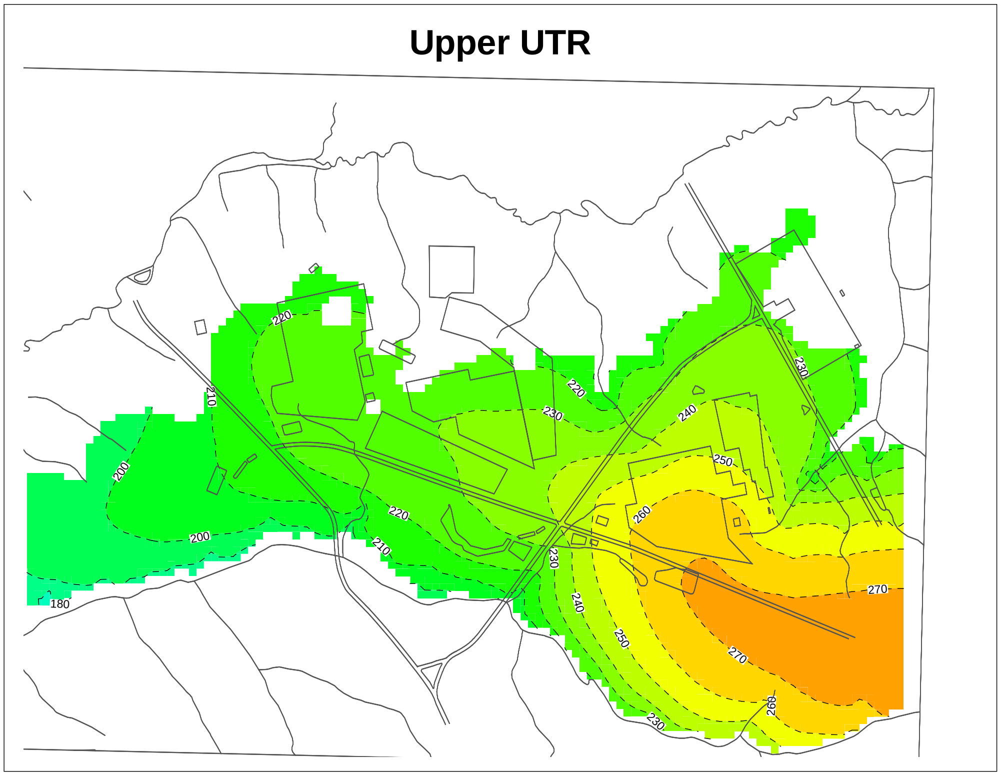


Figure 7-24. Simulated hydraulic head in the Upper Aquifer Zone for the PEST.52 / GSA2016.HU case (ft).

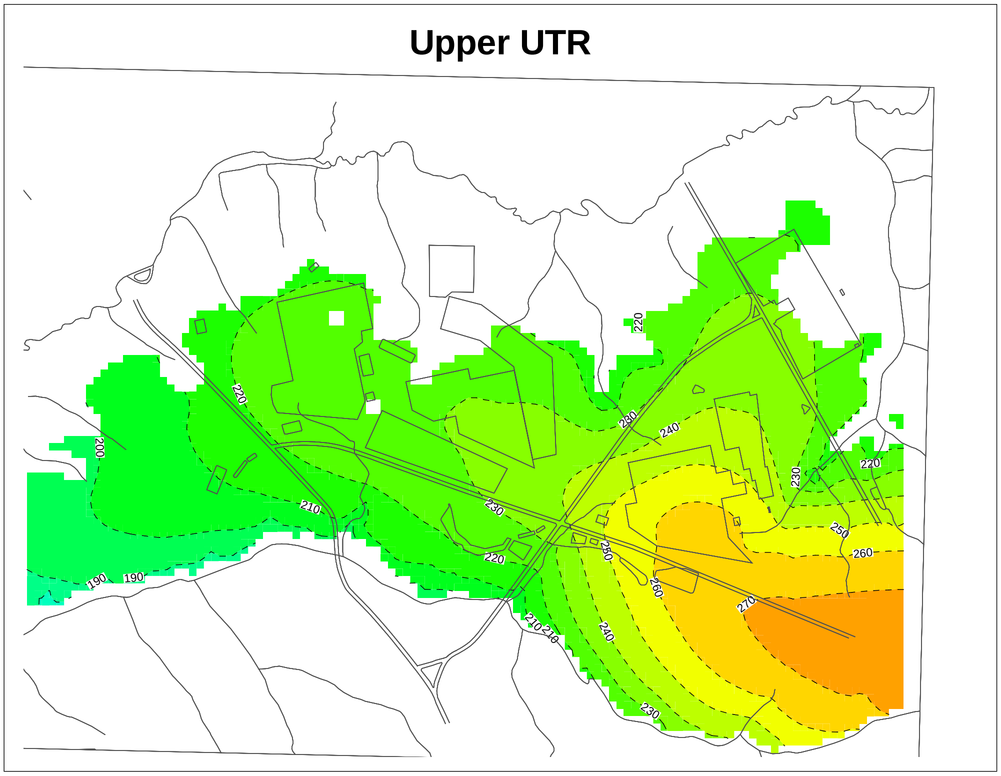


Figure 7-25. Simulated hydraulic head in the Upper Aquifer Zone for the PEST.53 / GSA2016.HW case (ft).

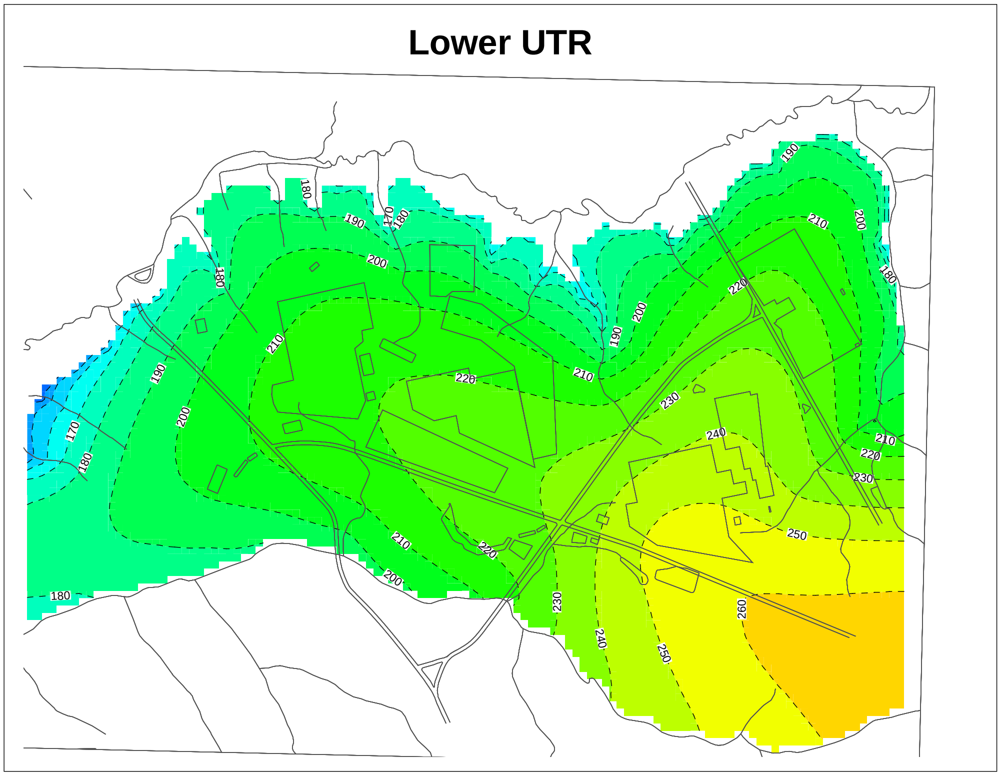


Figure 7-26. Simulated hydraulic head in the Lower Aquifer Zone for the PEST.47 / GSA2016.LU case (ft).

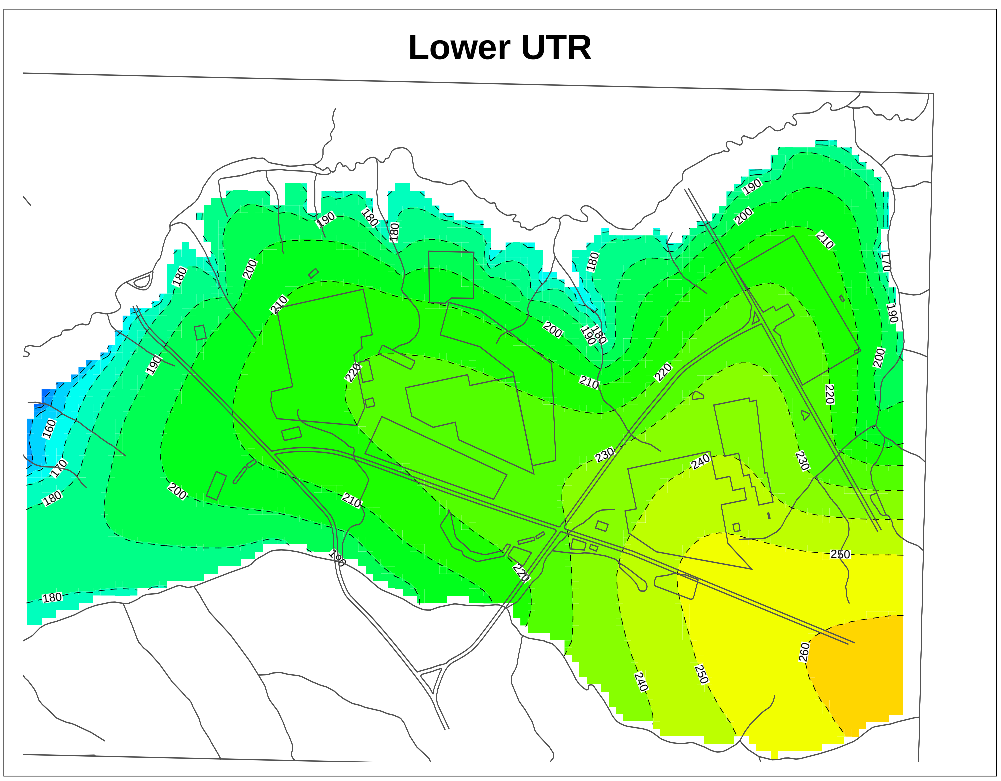


Figure 7-27. Simulated hydraulic head in the Lower Aquifer Zone for the PEST.51 / GSA2016.LW case (ft).

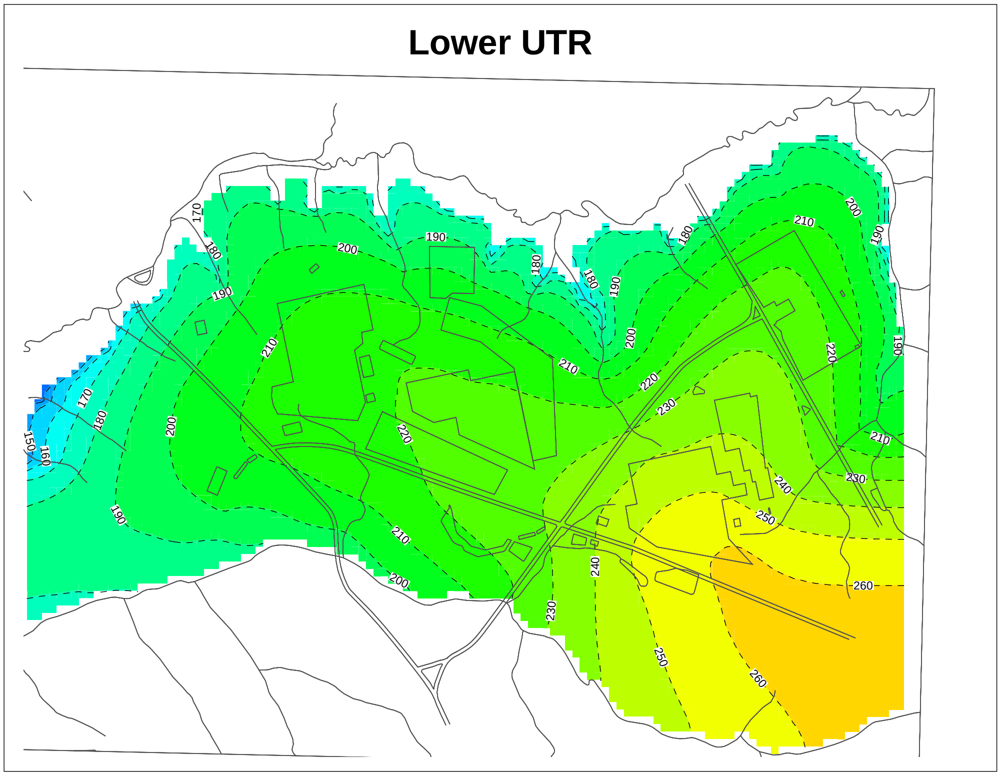


Figure 7-28. Simulated hydraulic head in the Lower Aquifer Zone for the PEST.52 / GSA2016.HU case (ft).

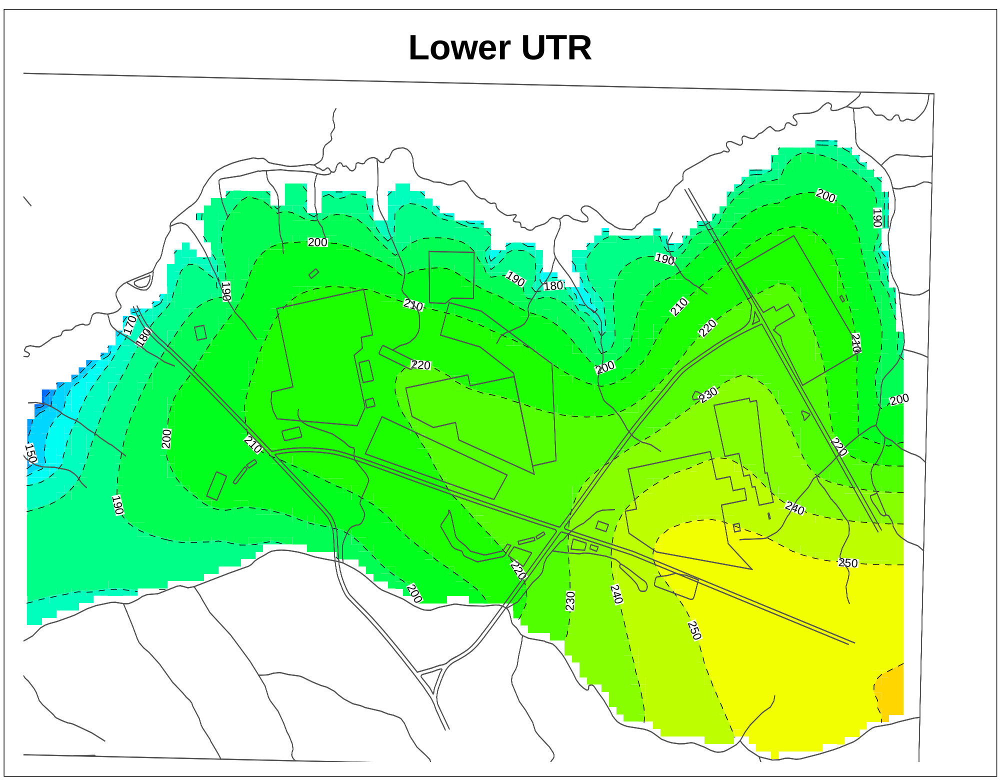


Figure 7-29. Simulated hydraulic head in the Lower Aquifer Zone for the PEST.53 / GSA2016.HW case (ft).

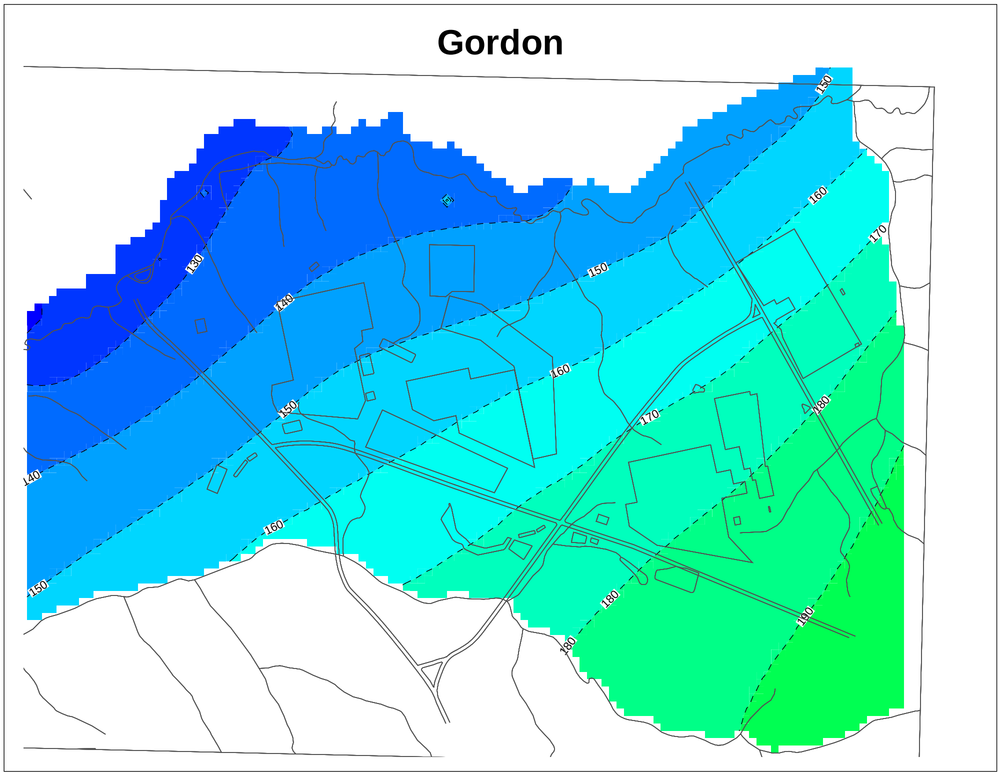


Figure 7-30. Simulated hydraulic head in the Gordon Aquifer Unit (ft) for the PEST.47 / GSA2016.LU case.

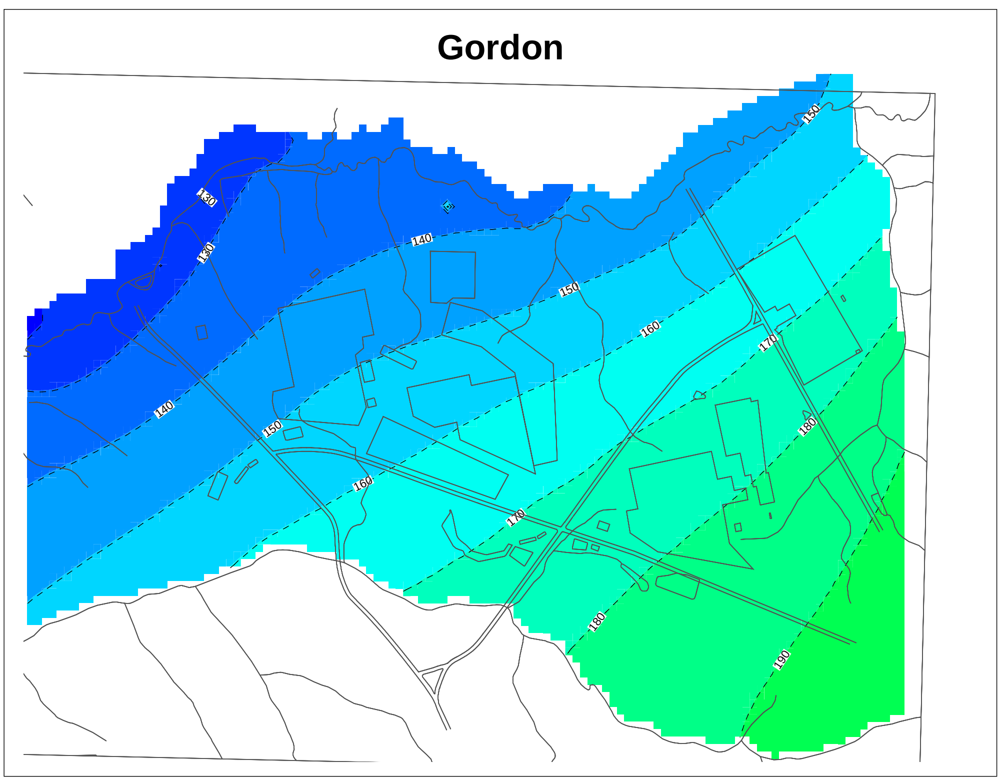


Figure 7-31. Simulated hydraulic head in the Gordon Aquifer Unit (ft) for the PEST.51 / GSA2016.LW case.

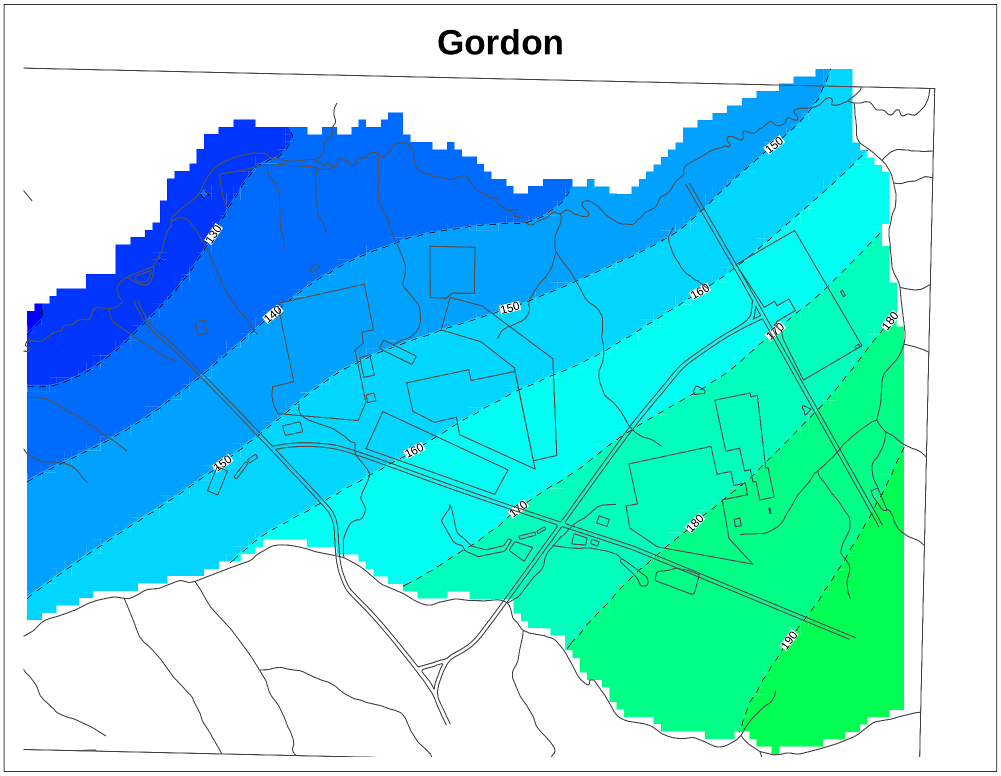


Figure 7-32. Simulated hydraulic head in the Gordon Aquifer Unit (ft) for the PEST.52 / GSA2016.HU case.

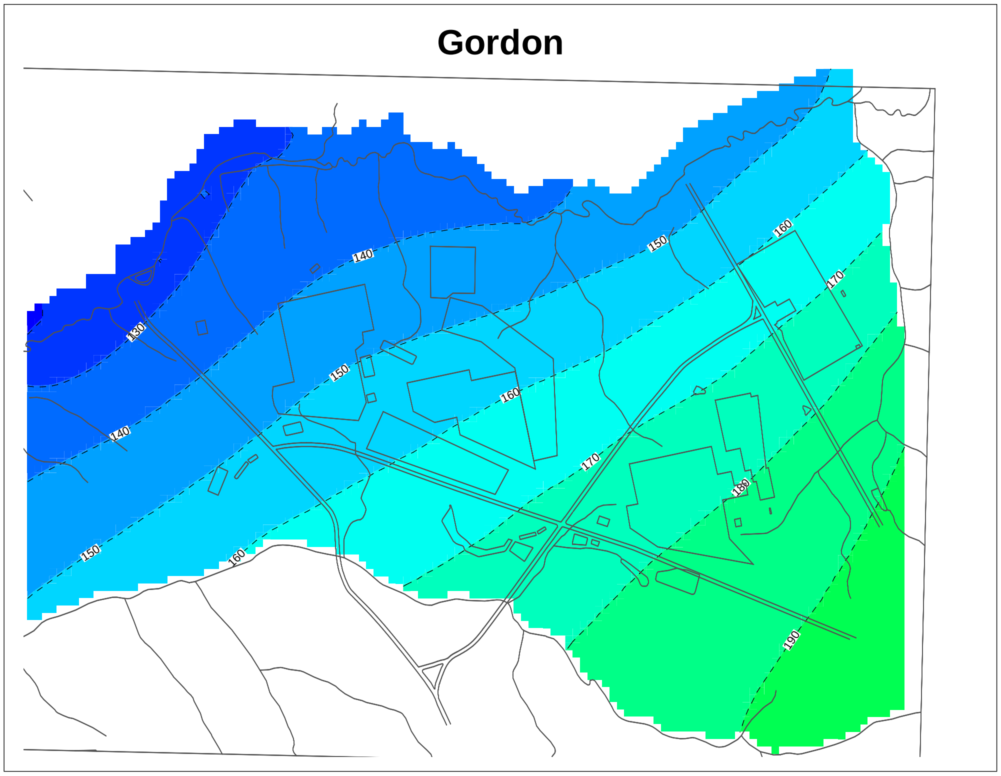
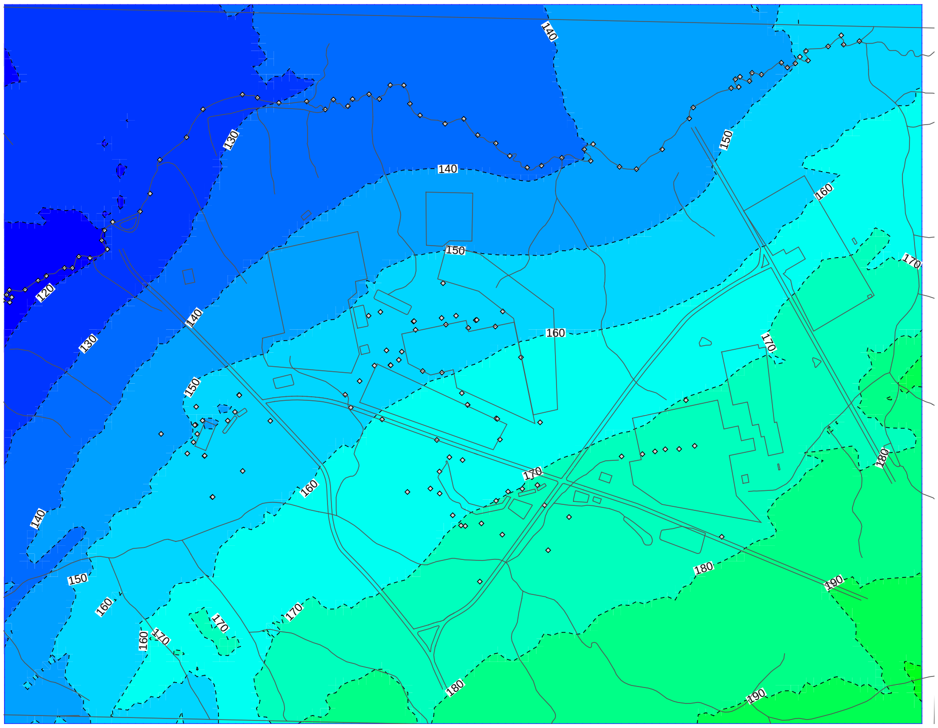
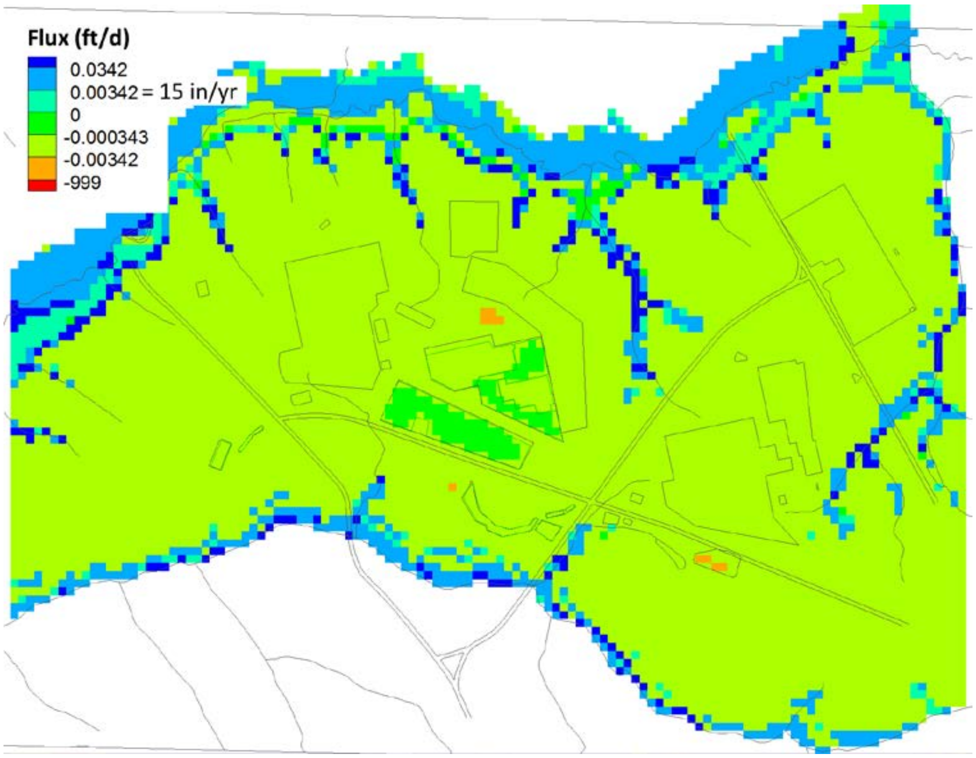


Figure 7-33. Simulated hydraulic head in the Gordon Aquifer Unit (ft) for the PEST.53 / GSA2016.HW case.



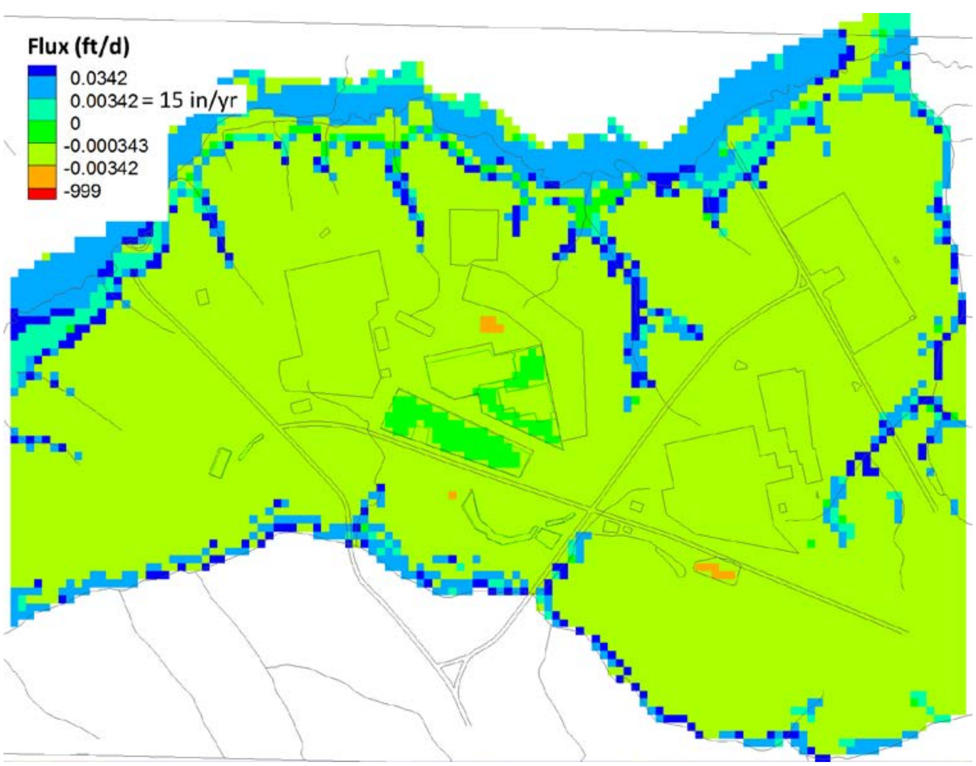
Key: open diamonds = data

Figure 7-34. Kriging interpolation representation of Gordon aquifer unit (GAU) measurements for the PEST.47 / GSA2016.LU case (ft).



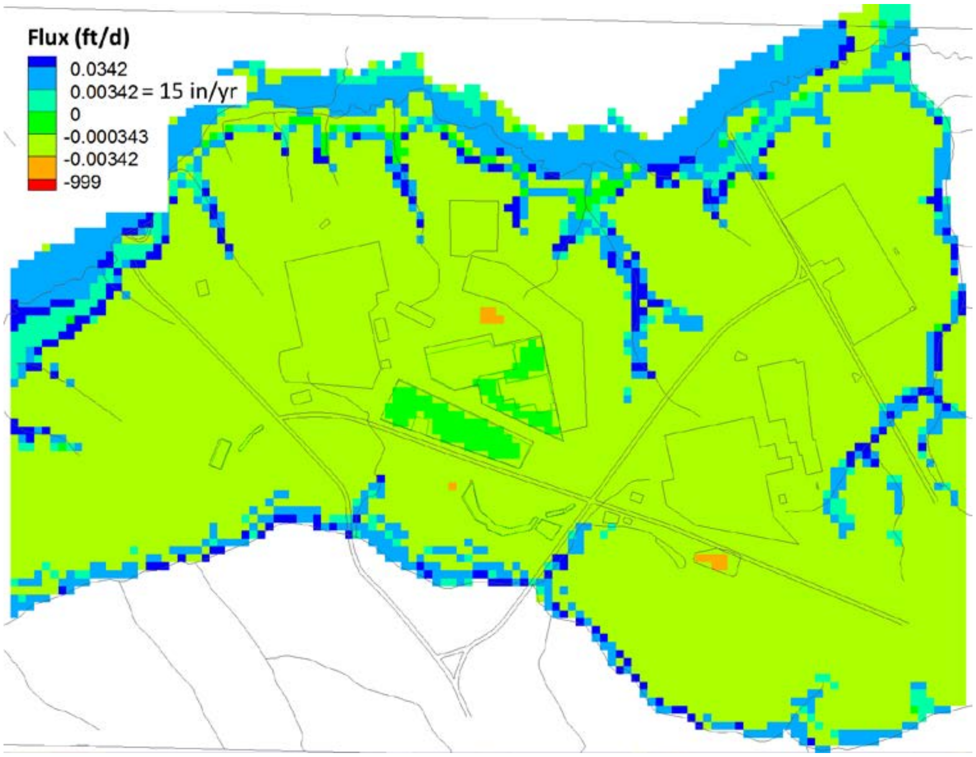
Note: negative values denote recharge, positive values discharge

Figure 7-35. Simulated surface flux for the PEST.47 / GSA2016.LU case (ft/d).



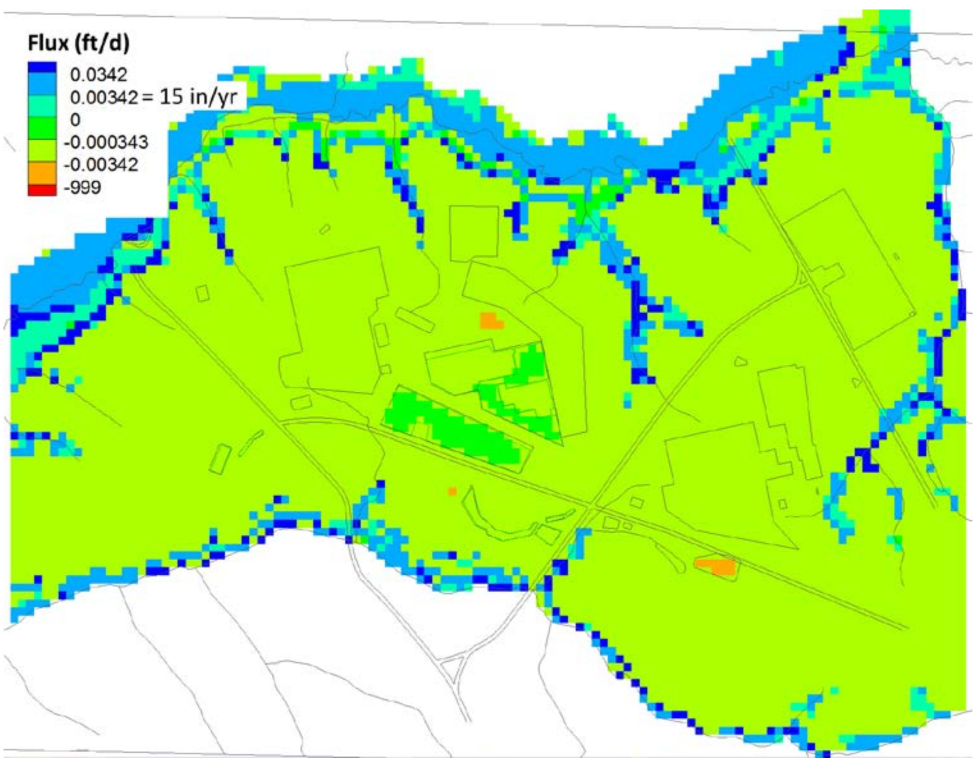
Note: negative values denote recharge, positive values discharge

Figure 7-36. Simulated surface flux for the PEST.51 / GSA2016.LW case (ft/d).



Note: negative values denote recharge, positive values discharge

Figure 7-37. Simulated surface flux for the PEST.52 / GSA2016.HU case (ft/d).



Note: negative values denote recharge, positive values discharge

Figure 7-38. Simulated surface flux for the PEST.53 / GSA2016.HW case (ft/d).

7.3 Simulation uncertainty

One measure of uncertainty in the final round simulations is provided by Table 7-8 through Table 7-11, which list 95% confidence limits for each estimated parameter. Parameter uncertainty increases from lower to higher HSUs. In particular, parameters associated with the LAZ are well defined, whereas those for the AAA are poorly defined. The latter is an indication of near non-uniqueness (ill-posedness) in the mathematical problem statement.

Another consideration is uncertainty in the conceptual model used to define the structure of the PORFLOW numerical model. Modeling biases result from choosing one conceptual model or design over another. Variability among the final round simulation cases and any other cases with similar degrees of fit to the field data is an indicator of conceptual model uncertainty.

Local surface recharge drives flow in the shallow aquifer zones and groundwater speed is roughly proportional to the surface recharge. Thus uncertainty in the applied rate of 15 in/yr (cf. Flach and Harris 1999; Flach et al. 1999 Section 2.4) produces a similar level of uncertainty in groundwater flow rates. This uncertainty could be reduced if recharge and/or stream baseflows were better known. Also, contaminant plume data could reduce model uncertainty.

For a given numerical model, the PEST "predictive analysis" mode can be used to quantify uncertainty in a particular flow model output, for example, Darcy velocity at a location of interest. "Predictive analysis" was beyond the scope of this study and not attempted.

Table 7-8. Parameter confidence limits for PEST.47 / GSA2016.LU case.

Parameter description	Parameter ID	Estimated value	95% percent confidence limits	
			lower limit	upper limit
Global multiplier to LAZ	g01	0.883144	0.842331	0.925934
Global multiplier to TCCZ	g02	0.920123	0.776307	1.09058
Global multiplier to TZ	g03	0.687671	0.519812	0.909736
Global multiplier to AAA	g04	0.199589	0.113154	0.352048
HS-Area multiplier to LAZ	h01	0.252574	9.353472E-02	0.682033
HS-Area multiplier to TCCZ	h02	0.224673	0.134594	0.375038
HS-Area multiplier to TZ	h03	0.103513	2.037518E-02	0.525878
HS-Area multiplier to AAA	h04	0.100000	1.912134E-02	0.522976
Z-Area multiplier to LAZ	i01	0.539903	0.410569	0.709979
Z-Area multiplier to TCCZ	i02	0.493579	0.128659	1.89354
Z-Area multiplier to TZ	i03	1.81306	0.178754	18.3894
Z-Area multiplier to AAA	i04	0.484220	1.980869E-05	11836.7
Minimum TCCZ K_v along Fourmile Branch	j01	0.113040	4.524966E-02	0.282388

Table 7-9. Parameter confidence limits for PEST.51 / GSA2016.LW case.

Parameter description	Parameter ID	Estimated value	95% percent confidence limits lower limit	upper limit
Global multiplier to LAZ	g01	0.661616	0.583593	0.750070
Global multiplier to TCCZ	g02	0.623232	0.501788	0.774068
Global multiplier to TZ	g03	1.44508	1.15725	1.80449
Global multiplier to AAA	g04	0.101316	1.016520E-02	1.00981
HS-Area multiplier to LAZ	h01	0.120234	4.892368E-03	2.95484
HS-Area multiplier to TCCZ	h02	0.100547	1.958583E-02	0.516178
HS-Area multiplier to TZ	h03	0.100000	8.222247E-03	1.21621
HS-Area multiplier to AAA	h04	0.234345	1.746601E-08	3.144243E+06
Z-Area multiplier to LAZ	i01	0.768128	0.517933	1.13918
Z-Area multiplier to TCCZ	i02	0.692103	0.188492	2.54126
Z-Area multiplier to TZ	i03	0.794679	6.984434E-02	9.04175
Z-Area multiplier to AAA	i04	0.742783	5.725424E-09	9.636425E+07
Minimum TCCZ K_v along Fourmile Branch	j01	1.66791	1.886210E-02	147.487

Table 7-10. Parameter confidence limits for PEST.52 / GSA2016.HU case.

Parameter description	Parameter ID	Estimated value	95% percent confidence limits lower limit	upper limit
Global multiplier to LAZ	g01	1.21309	1.08908	1.35121
Global multiplier to TCCZ	g02	3.37058	2.07317	5.47990
Global multiplier to TZ	g03	0.673831	0.539278	0.841957
Global multiplier to AAA	g04	0.122835	8.253746E-03	1.82807
HS-Area multiplier to LAZ	h01	0.104521	1.928398E-02	0.566513
HS-Area multiplier to TCCZ	h02	0.100000	1.480231E-02	0.675570
HS-Area multiplier to TZ	h03	0.100000	1.243052E-02	0.804472
HS-Area multiplier to AAA	h04	0.100000	2.379497E-05	420.257
Z-Area multiplier to LAZ	i01	0.794928	0.621814	1.01624
Z-Area multiplier to TCCZ	i02	2.45528	8.083708E-02	74.5746
Z-Area multiplier to TZ	i03	0.100000	1.418755E-09	7.048435E+06
Z-Area multiplier to AAA	i04	2.36717	1.784571E-04	31399.6
Minimum TCCZ K_v along Fourmile Branch	j01	0.300883	6.411210E-02	1.41207

Table 7-11. Parameter confidence limits for PEST.53 / GSA2016.HW case.

Parameter description	Parameter ID	Estimated value	95% percent confidence limits	
			lower limit	upper limit
Global multiplier to LAZ	g01	1.02647	0.908378	1.15992
Global multiplier to TCCZ	g02	0.533816	0.264857	1.07590
Global multiplier to TZ	g03	1.23316	1.01535	1.49769
Global multiplier to AAA	g04	7.965122E-02	4.179373E-04	15.1801
HS-Area multiplier to LAZ	h01	0.100000	4.413204E-04	22.6593
HS-Area multiplier to TCCZ	h02	0.100000	3.634794E-05	275.119
HS-Area multiplier to TZ	h03	0.100000	6.650765E-03	1.50359
HS-Area multiplier to AAA	h04	0.394662	3.064090E-05	5083.35
Z-Area multiplier to LAZ	i01	1.03638	0.708434	1.51613
Z-Area multiplier to TCCZ	i02	2.35201	1.750039E-02	316.104
Z-Area multiplier to TZ	i03	0.482110	3.240183E-03	71.7338
Z-Area multiplier to AAA	i04	1.37764	6.659415E-05	28499.2
Minimum TCCZ K_v along Fourmile Branch	j01	3.00000	0.216810	41.5110

7.4 Comparison to 2004 GSA/PORFLOW model

Figure 7-39 through Figure 7-43 provide particle tracking simulations with 10 year markers for the 2004 GSA/PORFLOW and GSA2016 models. The sharp kinks observed in some trajectories correspond to passage through the Gordon confining unit from the Upper Three Runs aquifer to the Gordon aquifer. The simulations use the same starting (seed) locations. Because the water table is about 3.5 ft lower in the GSA2016 model, some of the seeds are undoubtedly slightly above the water in the new model, leading to slower initial travel speed, although the impact to overall travel time is small. The GSA2016 particle tracks are based on the new PORFLOW velocity field correction described by Flach (2015a), which is also a difference in the GSA2004 and GSA2016 figures.

Time markers in the particle tracking figures indicate significantly slower groundwater travel times in the GSA2016 models compared to GSA2004. Slower speeds in the Upper Three Runs aquifer unit (UAZ and LAZ) are generally a result of reduced surface recharge (19 in/yr → 15 in/yr) and increased leakage through the Gordon confining unit (1.e-5 ft/d → 7.5e-5 ft/d K_v in GCU). The latter reduces lateral groundwater flow above the GCU. Another factor may be a drop in the water table of about 3.5 ft. Over much of the GSA, beneath topographic highs, the water table lies within (or above) the transmissive zone (TZ), a high conductivity preferential pathway. At lower elevations, closer to groundwater discharge locations, the water table resides in the lower aquifer zone (LAZ). A lower water table reduces the saturated thickness of the TZ in some areas and puts the water table below the TZ in other areas, which may decrease time spent traveling at faster groundwater speeds in the TZ.

Finally, differences in individual pathlines may reflect local model differences.

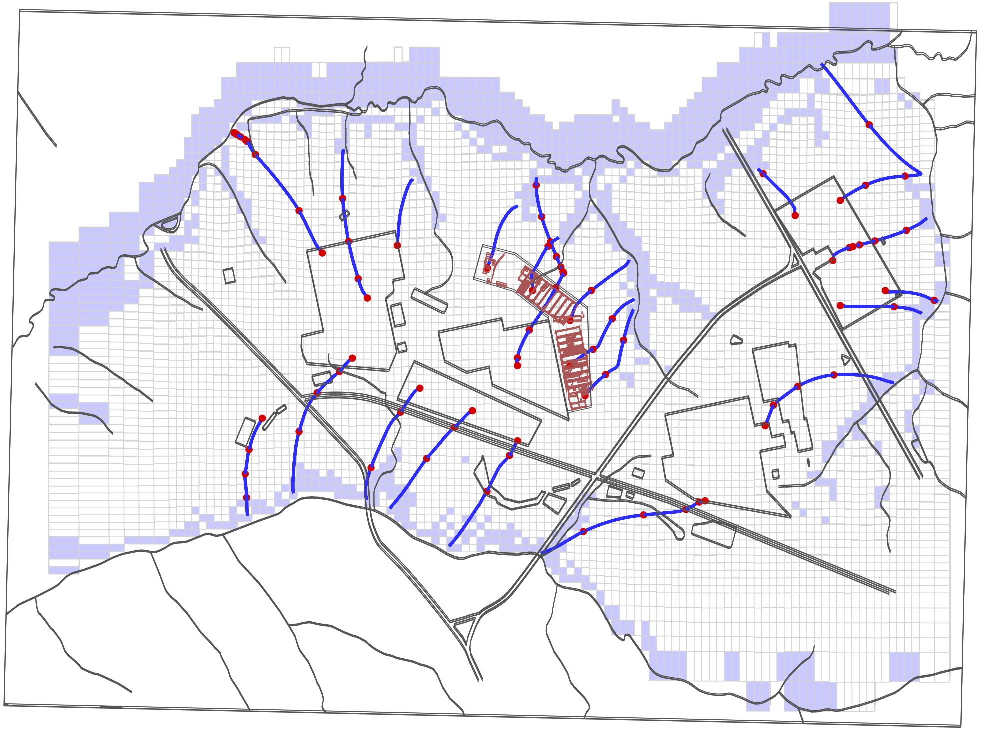


Figure 7-39. Particle tracking results for 2004 GSA/PORFLOW model.

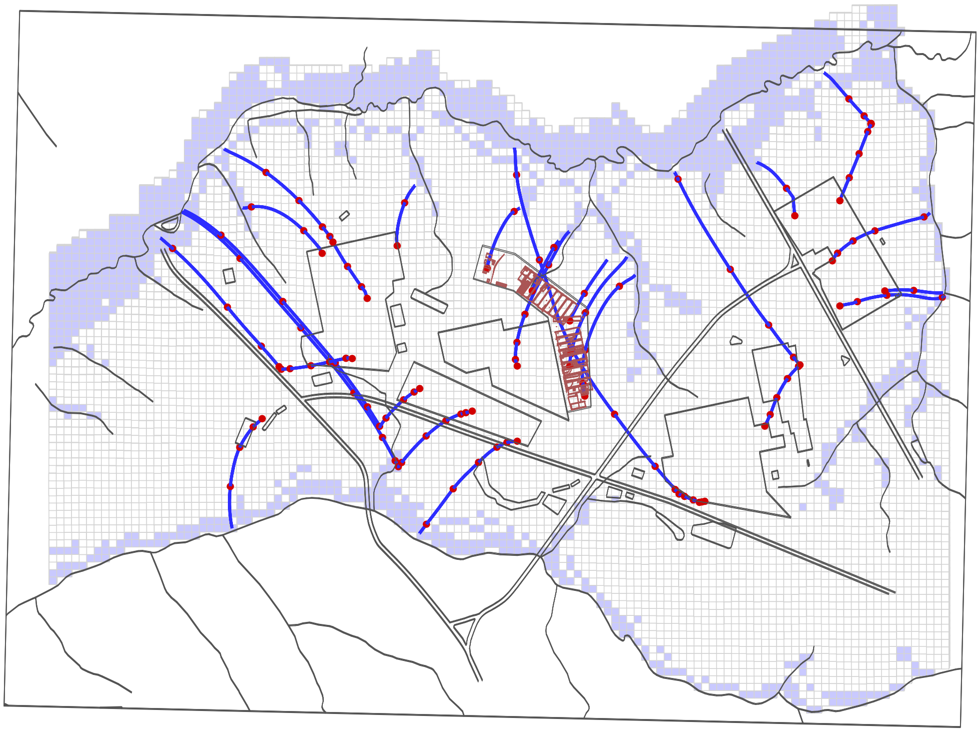


Figure 7-40. Particle tracking results for PEST.47 / GSA2016.LU model.

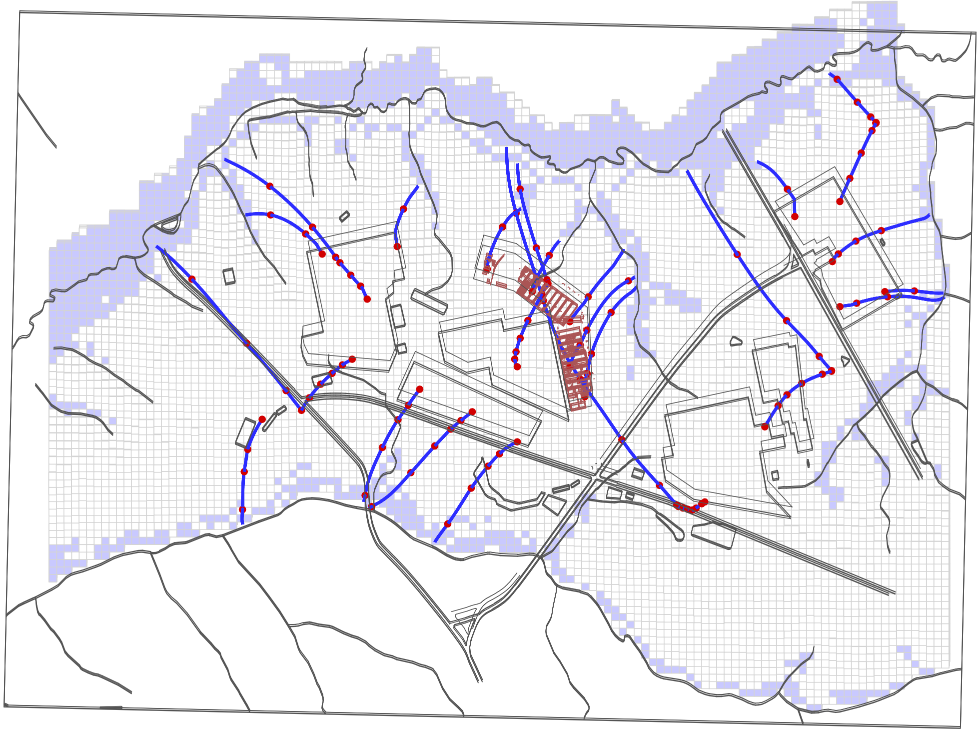


Figure 7-41. Particle tracking results for PEST.51 / GSA2016.LW model.

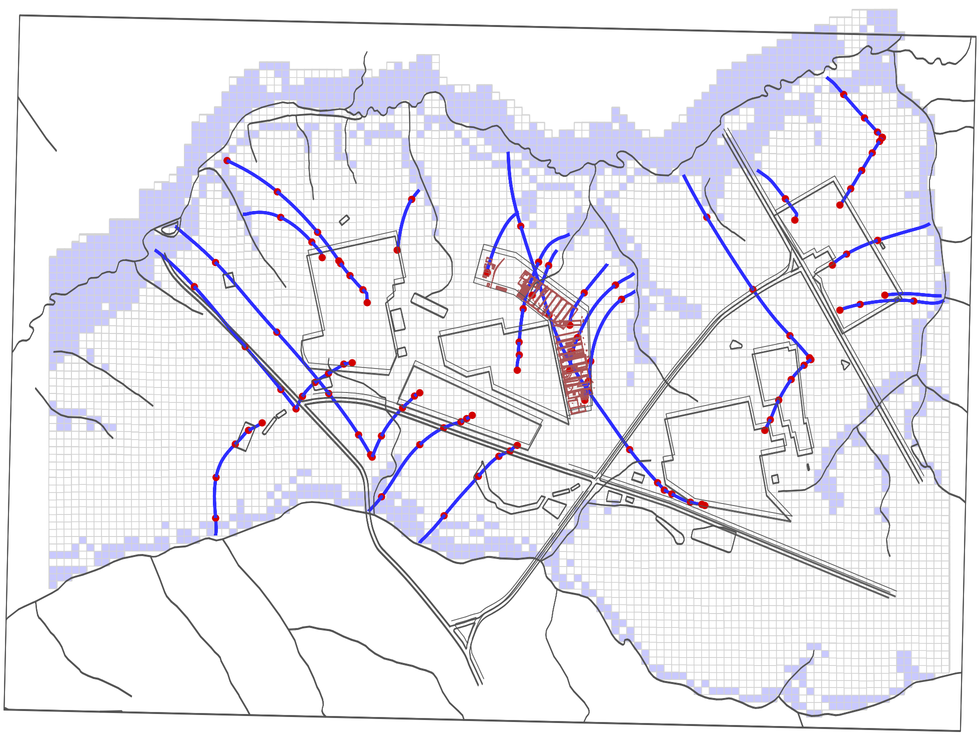


Figure 7-42. Particle tracking results for PEST.52 / GSA2016.HU model.

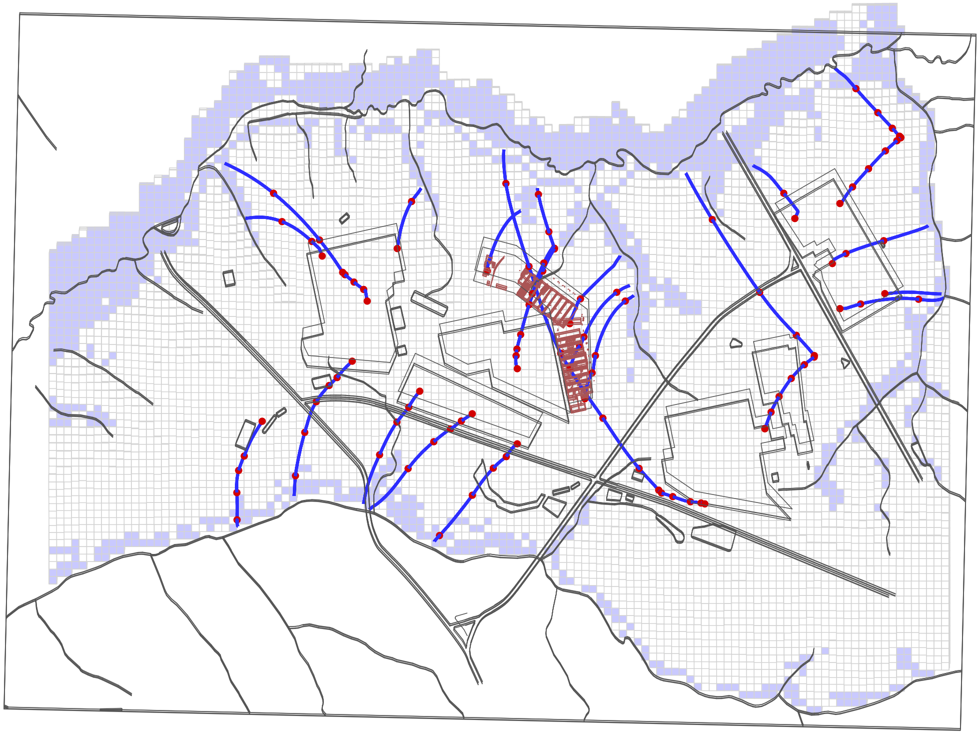


Figure 7-43. Particle tracking results for PEST.53 / GSA2016.HW model.

7.5 Recommended baseline model

Modeling studies are often focused on a “baseline” or “base case” simulation that best defines expected conditions (best-estimate case) and serves as a starting point for sensitivity analysis and uncertainty quantification. Among the four final round optimization cases, the PEST.51 / GSA2016.LW model is recommended as the baseline case for Performance Assessments and similar analyses going forward, for these reasons:

- The layer-cake conductivity field produces a better fit to data than the heterogeneous *K* field, for both unweighted and weighted optimization.
- The layer-case *K* field is more parsimonious; that is, it involves fewer assumptions and inputs while reproducing field observations to a degree similar to the alternative.
- Weighted optimization approximately accounts for data spatial density and uncertainty.
- Outside of the H-Area and Z-Area calibration zones, weighted optimization produces a transmissive zone (TZ) conductivity that is larger than those in the adjoining aquifer zones, consistent with hydrogeologic conceptual models associated with the F-Area seepage basins, Old Burial Ground, and H-Area seepage basins (e.g. WSRC 2000, SAIC 2000, SRNS 2017). The TZ corresponds to the Irwinton Sand member of the Dry Branch formation and is “believed to be the primary pathway for contaminant travel in the UAZ” (WSRC 2000).
- Weighted optimization produces particle tracks (Figure 7-41 and Figure 7-43) emanating from the Old Burial Ground (in the south-central GSA) that discharge to Fourmile Branch, consistent with tritium plume observations at that site (e.g. Flach and Harris 1997a, Flach et al. 1996). Figure 7-44 and Figure 7-45 illustrate the observed location and shape of the tritium plume leaving the southwest corner of the burial ground, inferred from a dense network of multi-depth sampling locations. The observed plume discharges to Fourmile Branch, whereas Figure 7-40 and

Figure 7-42 (unweighted optimization) show groundwater pathlines originating from the west end of the burial ground that cross the Gordon confining unit short of Fourmile Branch and enter the Gordon aquifer unit (kinks in pathlines).

Together these observations support selection of the model with a layer-cake K field and calibrated using weighted targets, that is, PEST.51 or GSA2016.LW.

Although GSA2016.LW is the recommended best-estimate / baseline / base case model, each of the remaining three models is a generally credible alternative and suitable for sensitivity analysis, and may out-perform GSA2016.LW in specific areas. For example, within the H- and Z-Area calibration zones, the calibrated conductivity of the TZ is lower than in the LAZ in the GSA2016.LW model, the reason for which is not clear. However, $K_{TZ} > K_{LAZ}$ in the GSA2016.LU model in H- and Z-Areas, which may be more accurate in those locations.

In Revision 0 of this report, PEST.47 / GSA2016.LU was recommended as the baseline model. This recommendation was changed based on the new reasons stated in the last two bullets above. That is, with the additional consideration of consistency with hydrogeologic conceptual models and plume data, GSA2016.LW is now judged to be the best choice for a baseline model.

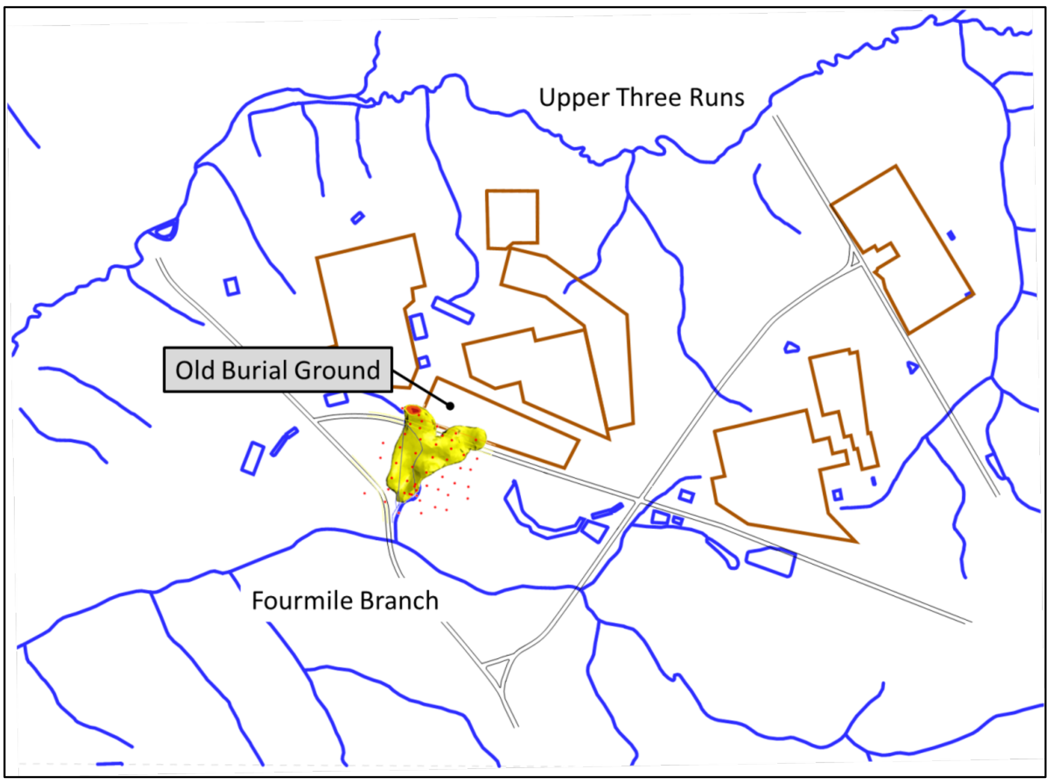


Figure 7-44. Tritium plume emanating from the southwest corner of the Old Radioactive Waste Burial Ground; location map (Flach and Harris 1997a).

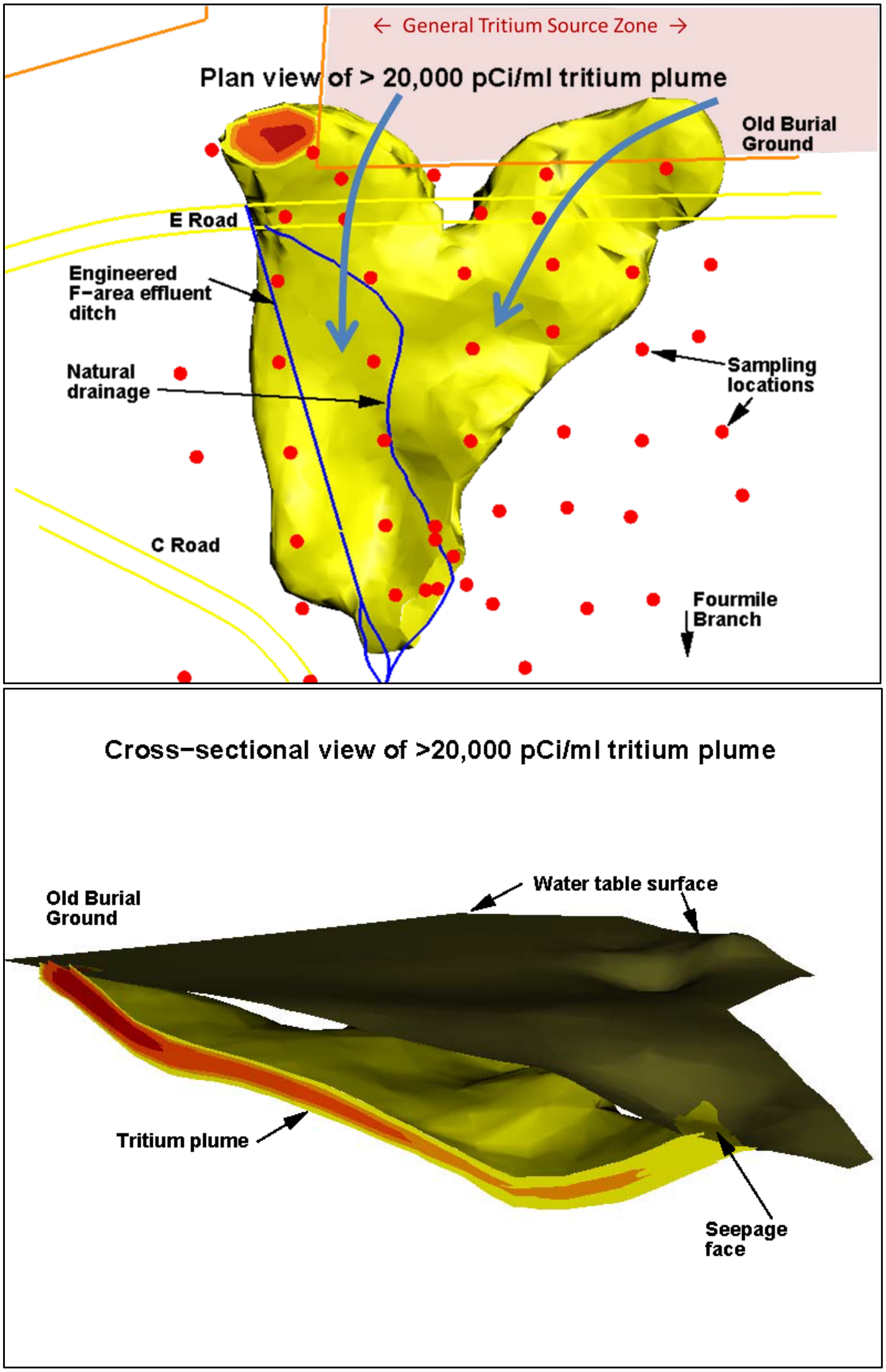


Figure 7-45. Tritium plume emanating from the southwest corner of the Old Radioactive Waste Burial Ground; plume detail (Flach and Harris 1997a).

8.0 Conclusions

The 2004 GSA/PORFLOW model has been updated to "GSA2016" using new monitoring data and recalibrated using the PEST optimization code. The recommended GSA2016 version is the optimization case identified as PEST.51 / GSA2016.LW (layer-cake *K* field and weighted calibration targets). Alternative models producing a similar goodness-of-fit to data are PEST.47, 52 and 53; these models are available for sensitivity analysis or other potential use. The recommended GSA2016 model exhibits good agreement with well water level, stream baseflow and seepline data, but has not been comprehensively validated against contaminant plume data in the GSA. Model uncertainty was briefly discussed and 95% confidence limits presented for model input parameters optimized by PEST. PEST "predictive analysis" can be used to quantify uncertainty in a specified model output.

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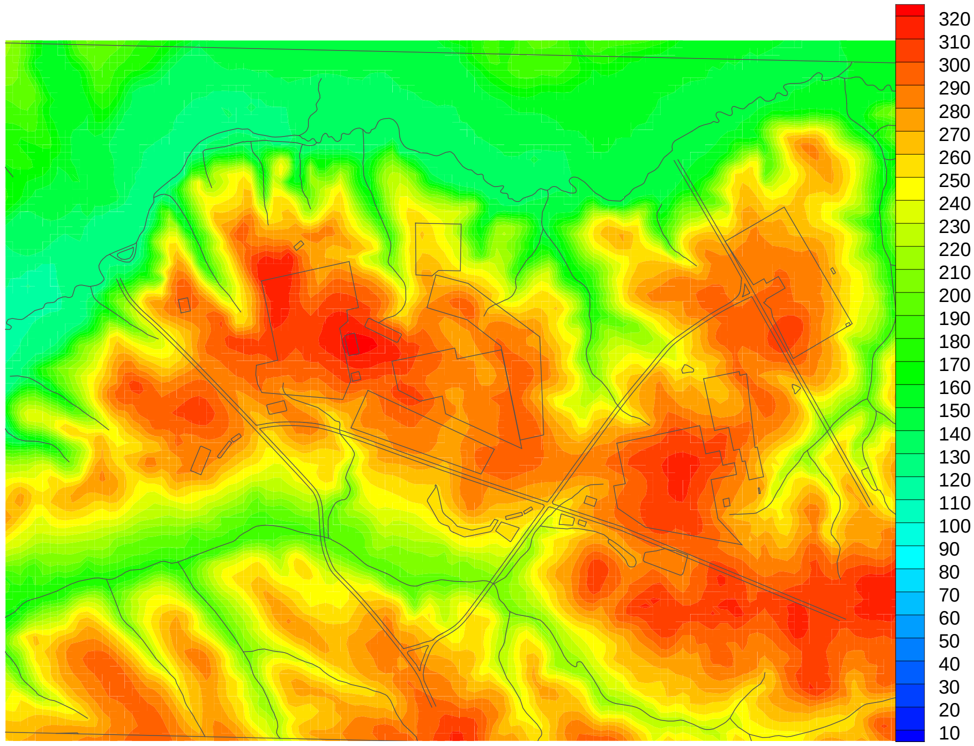
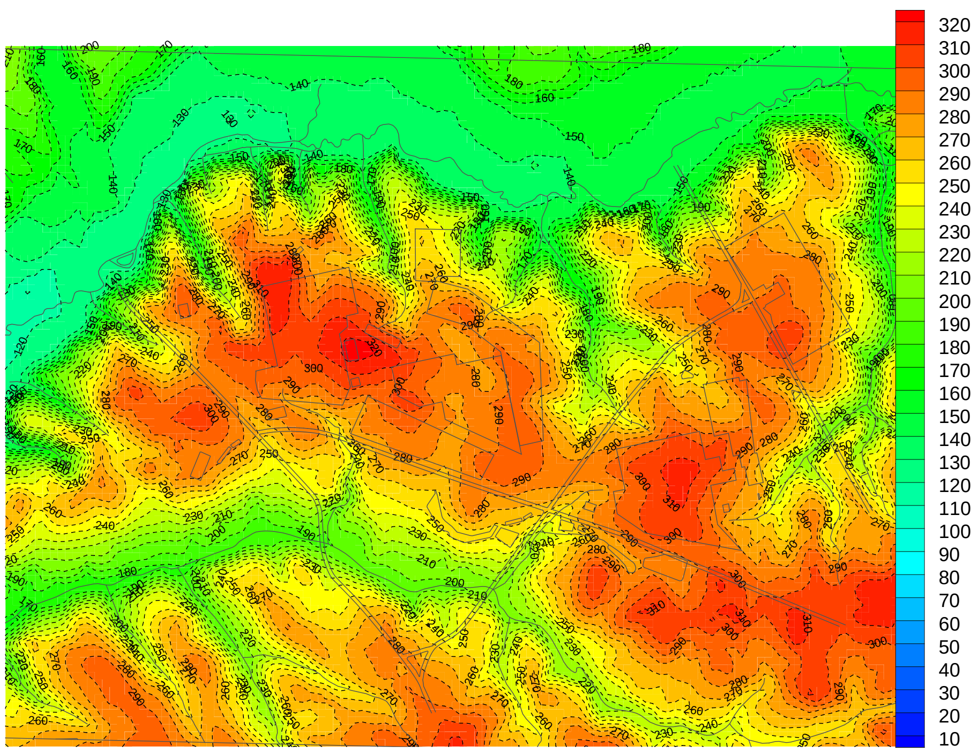
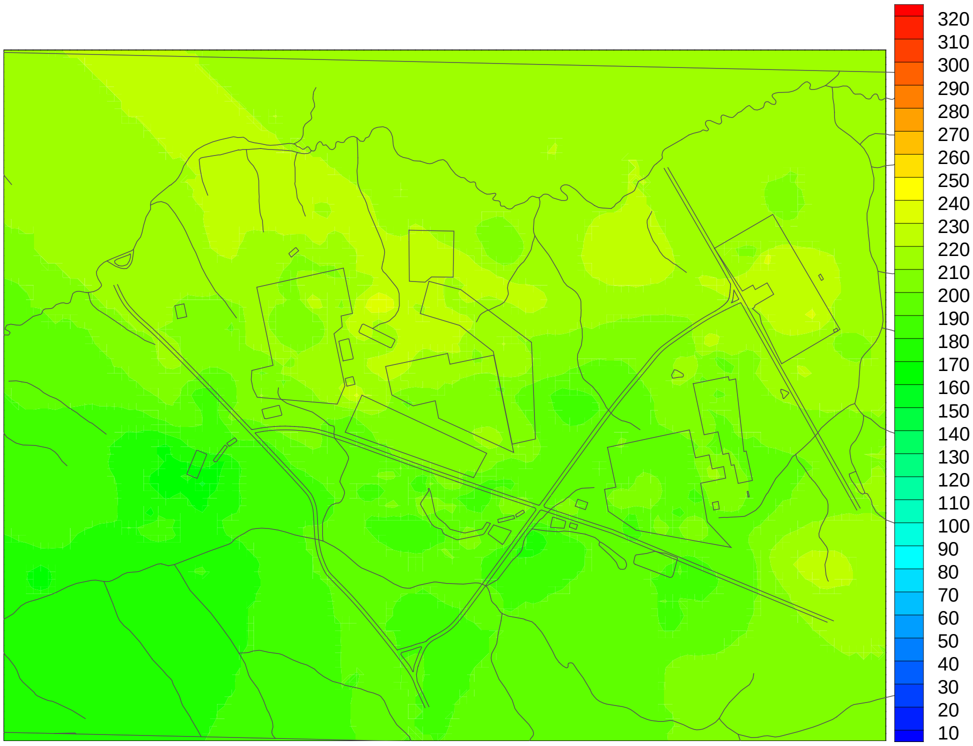
Appendix A. Topographic and hydrostratigraphic surfaces

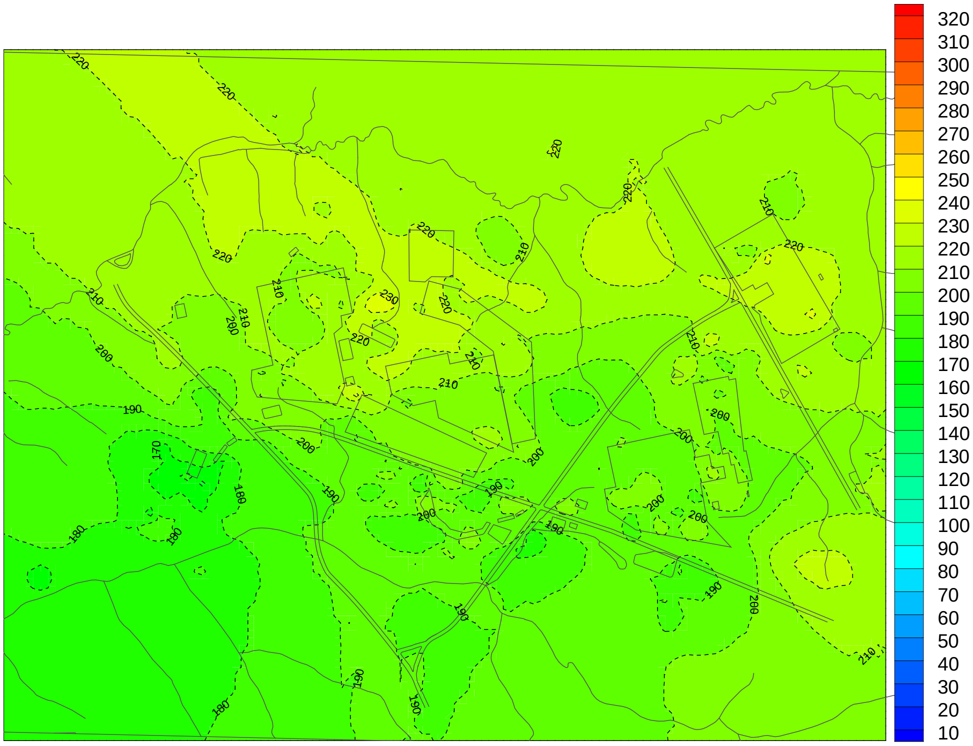
Topographic surface:



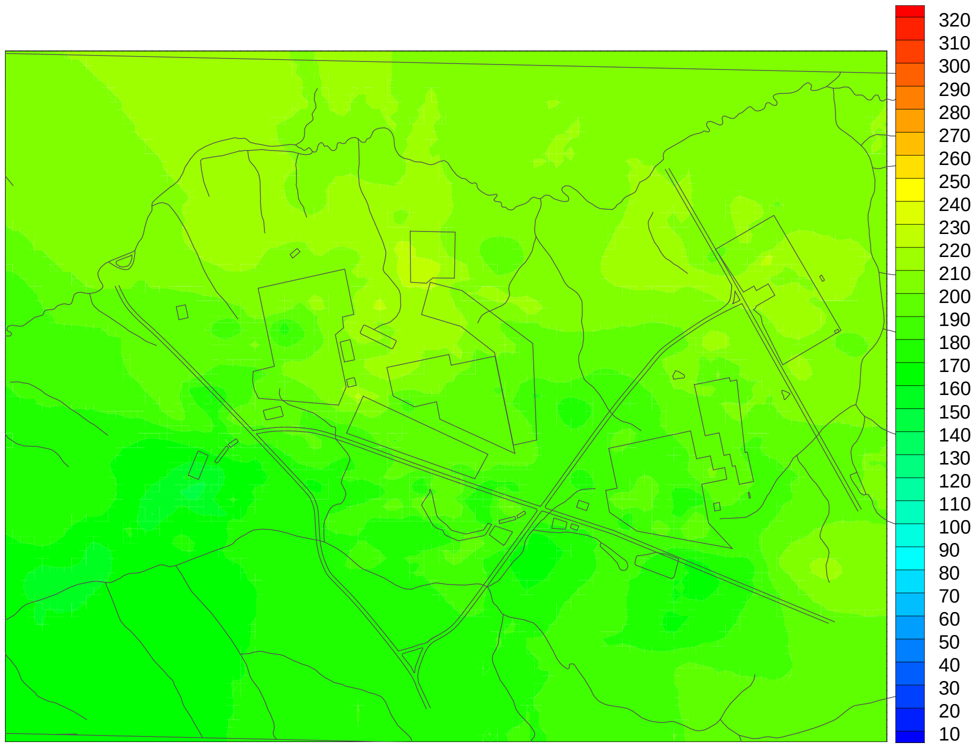


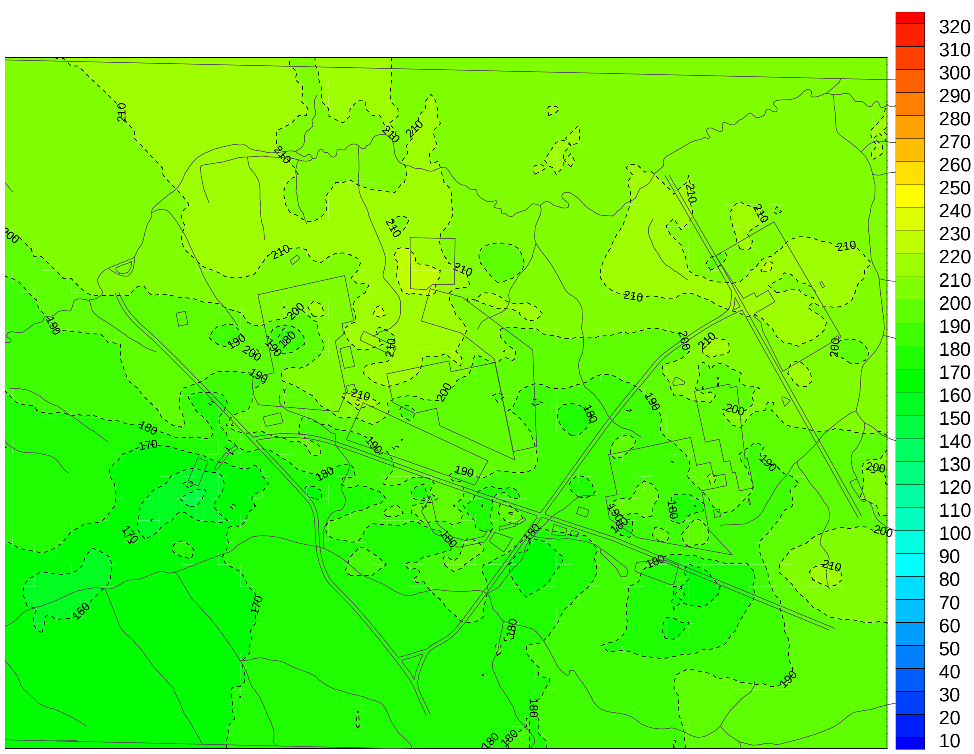
Top of the Tan Clay Confining Zone (TCCZ):



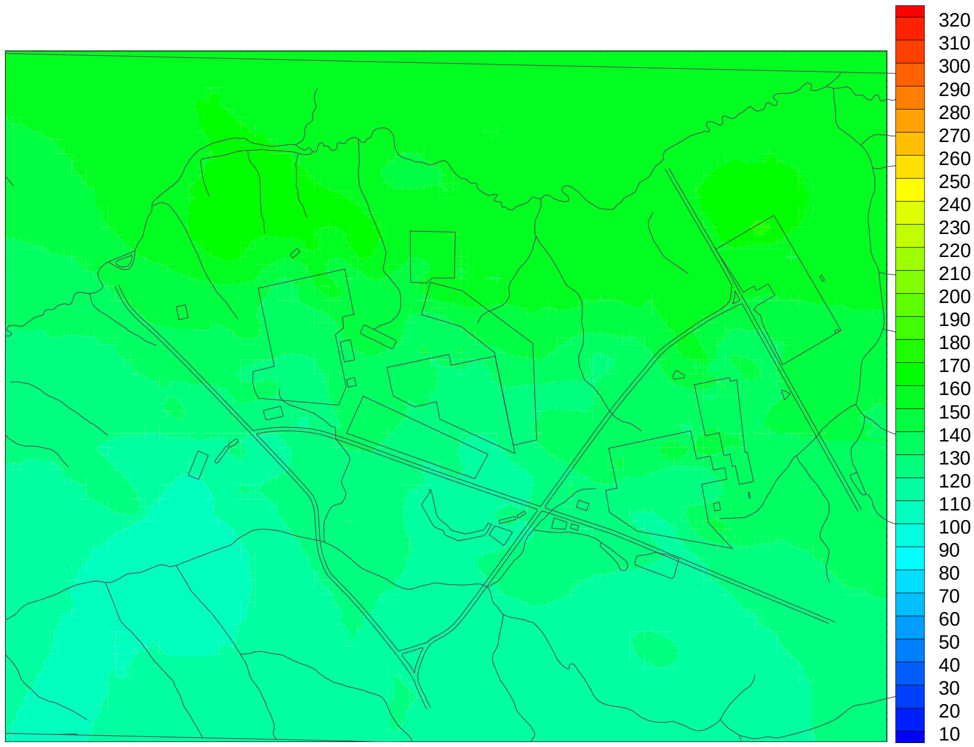


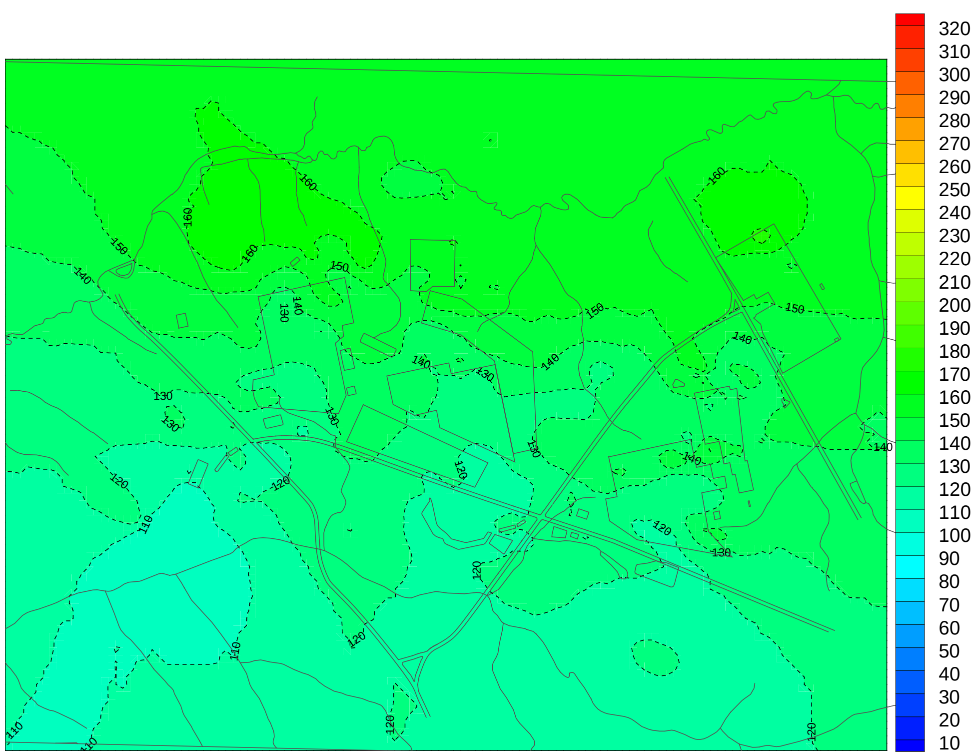
Top of the Lower Aquifer Zone (LAZ):



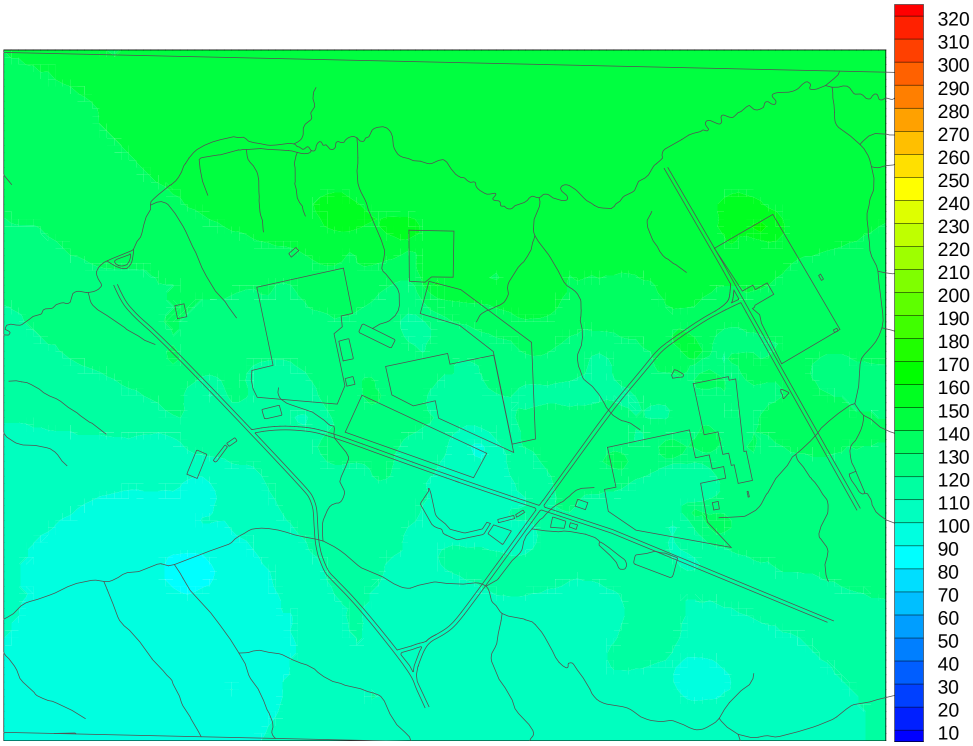


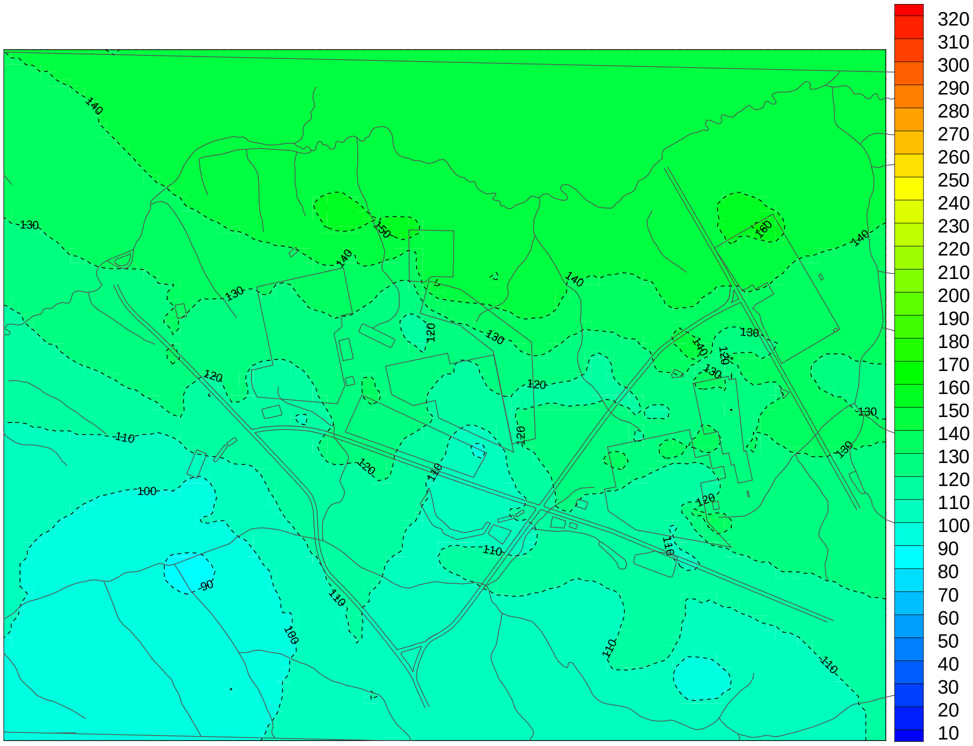
Top of the Gordon Confining Unit (GCU):



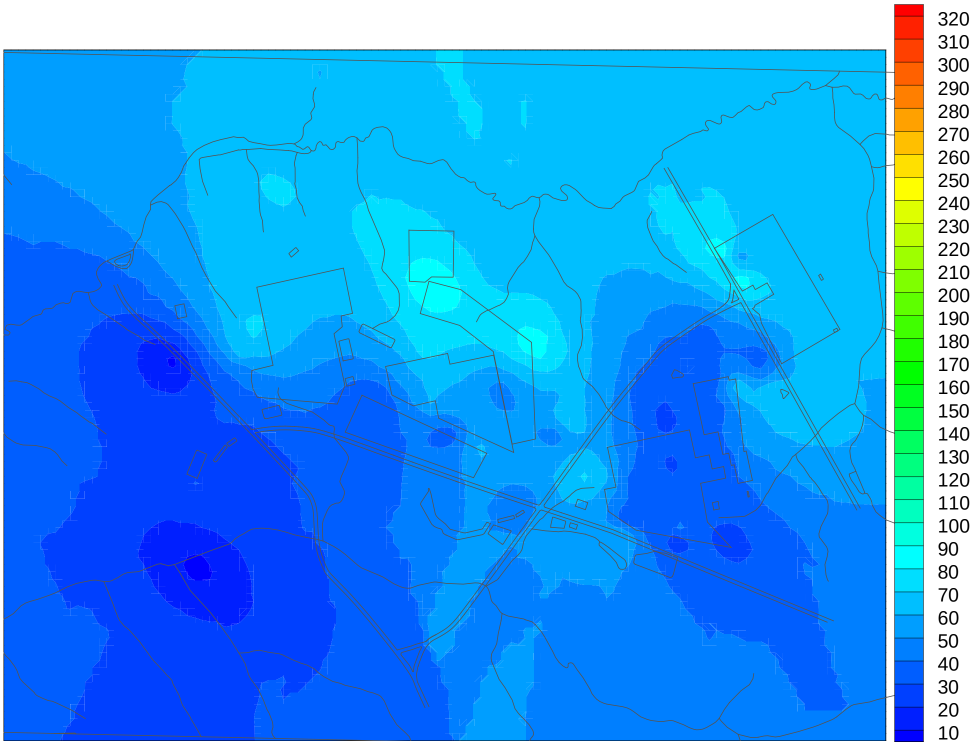


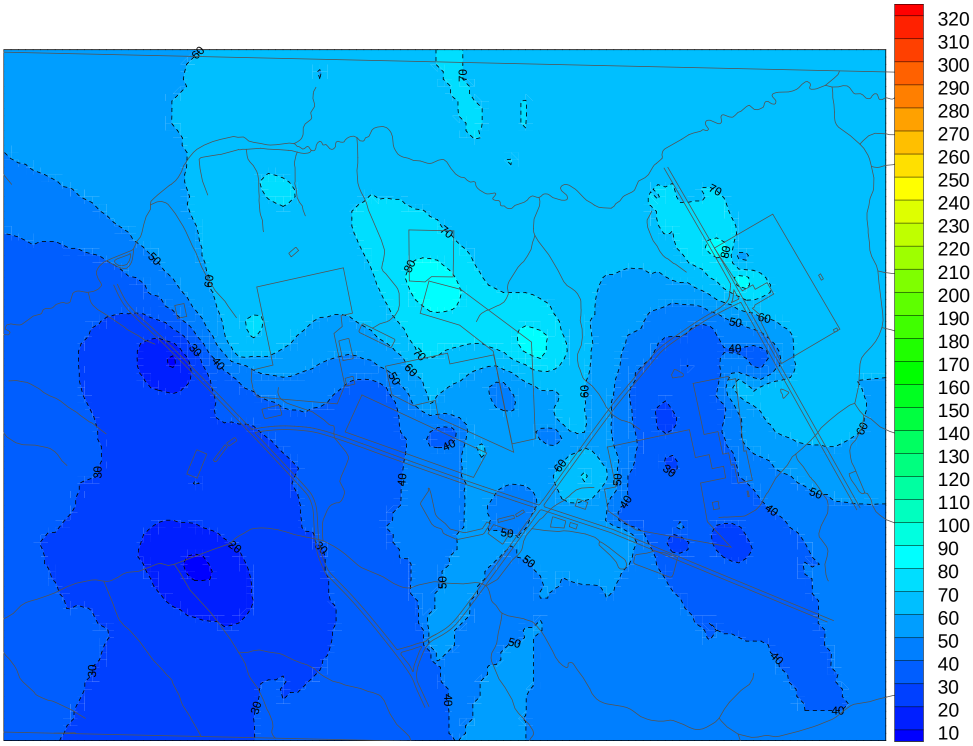
Top of the Gordon Aquifer Unit (GAU):





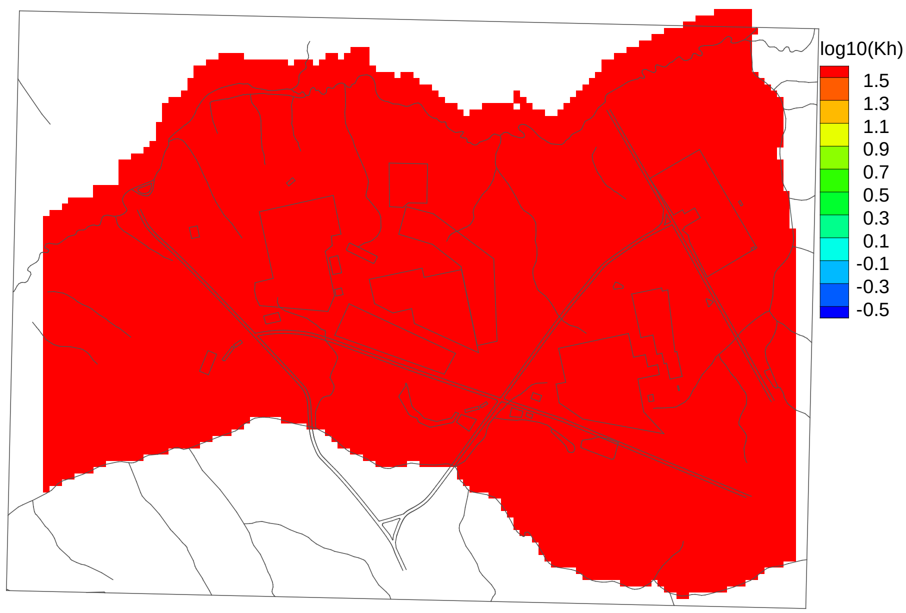
Top of the Crouch Branch Confining Unit:



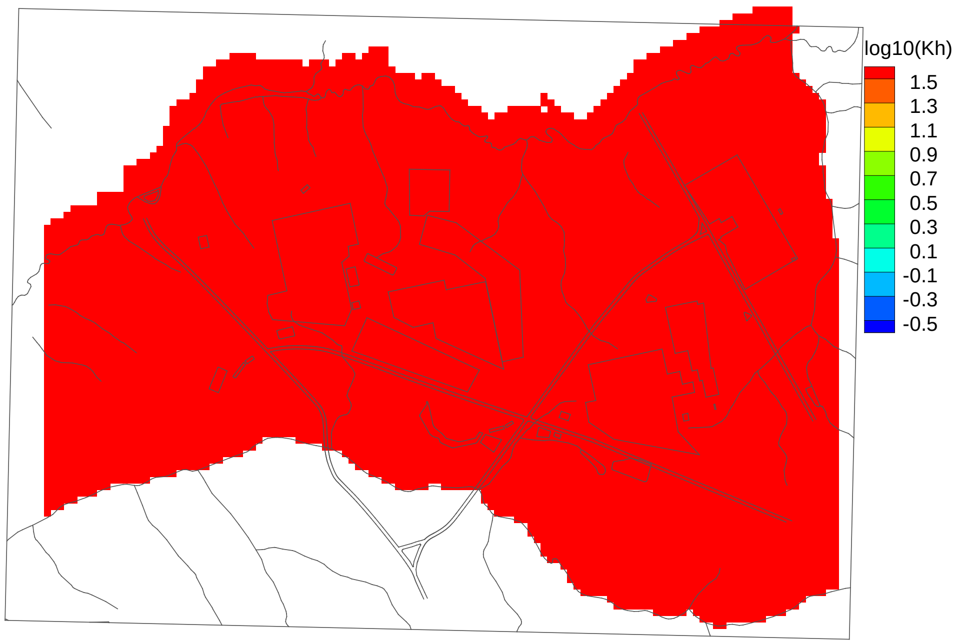


Appendix B. Heterogeneous hydraulic conductivity field for PEST.0H case

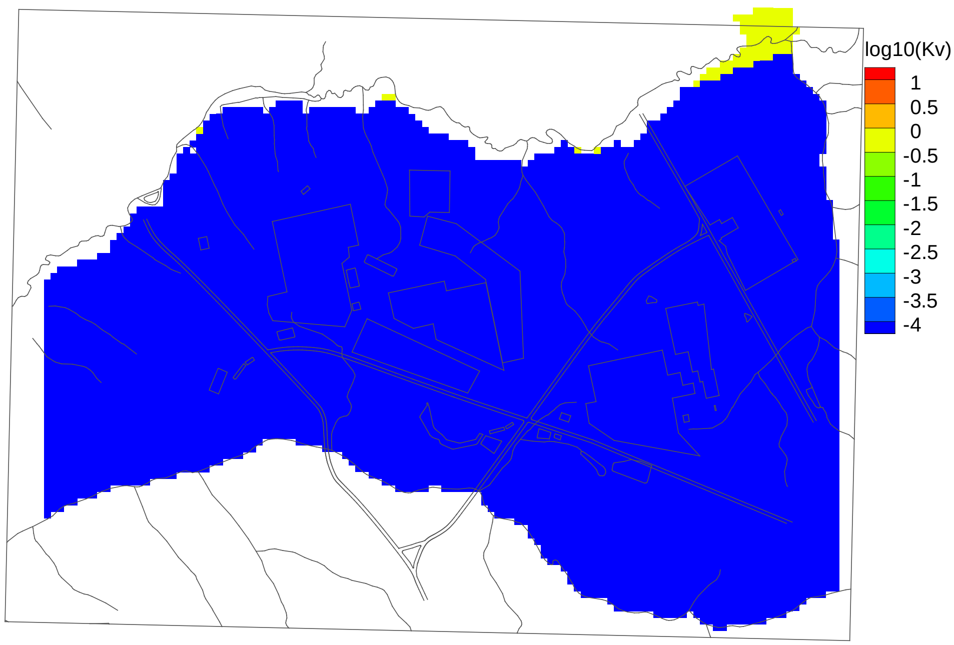
Grid layer 1 horizontal conductivity (GAU):



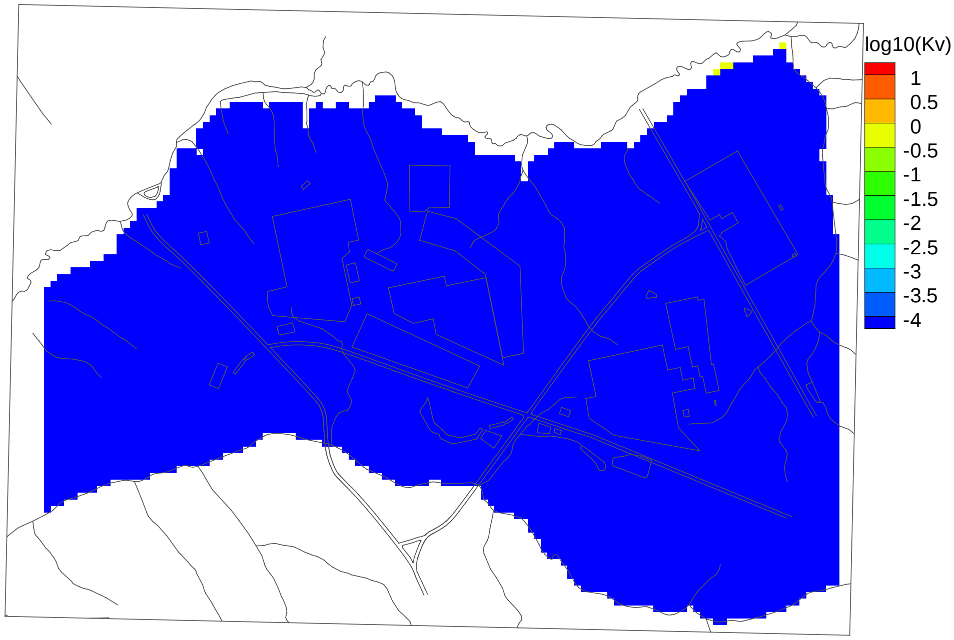
Grid layer 2 horizontal conductivity (GAU):



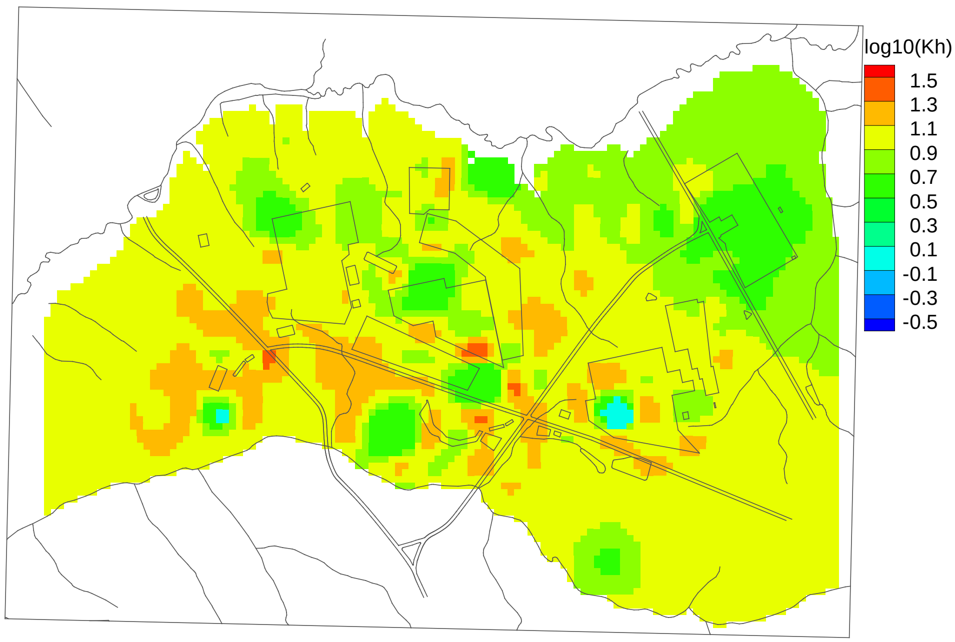
Grid layer 3 vertical conductivity (GCU):



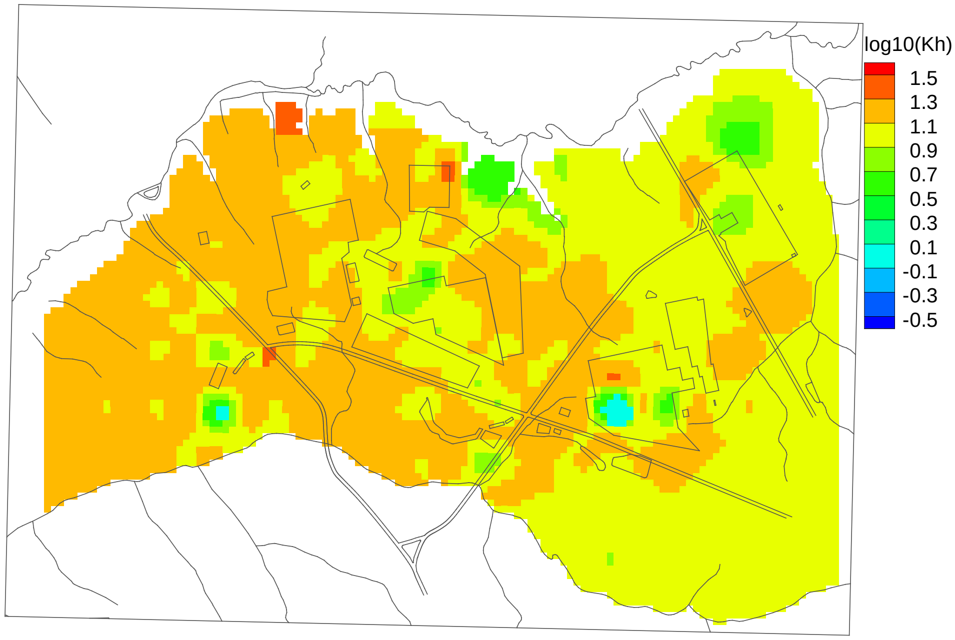
Grid layer 4 vertical conductivity (GCU):



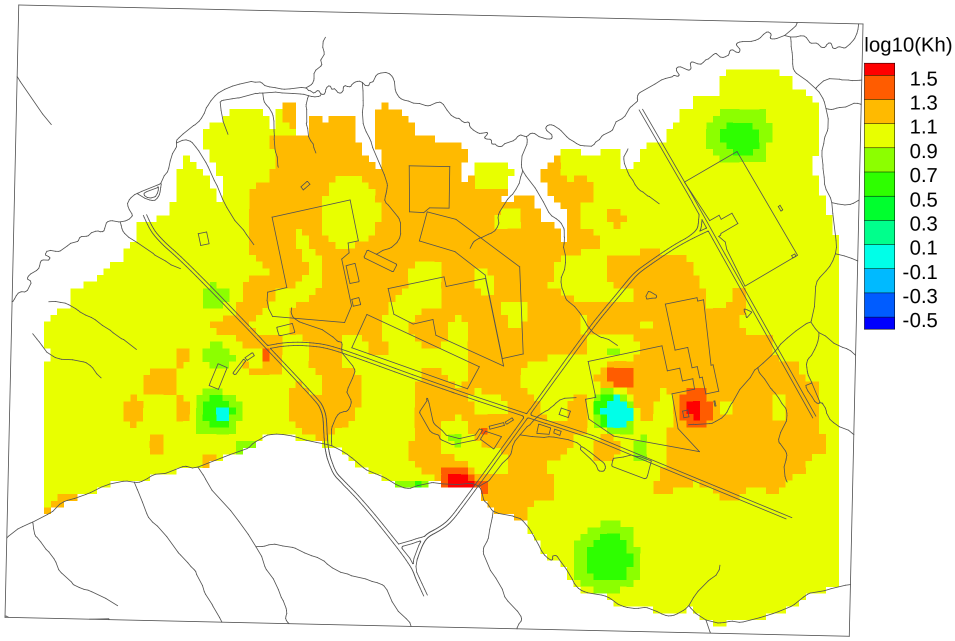
Grid layer 5 horizontal conductivity (LAZ):



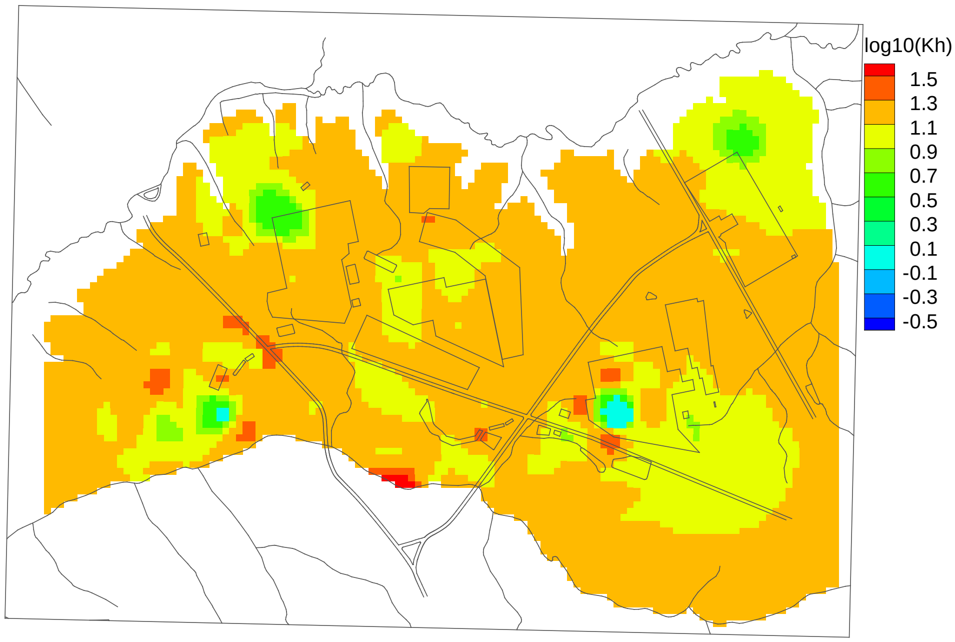
Grid layer 6 horizontal conductivity (LAZ):



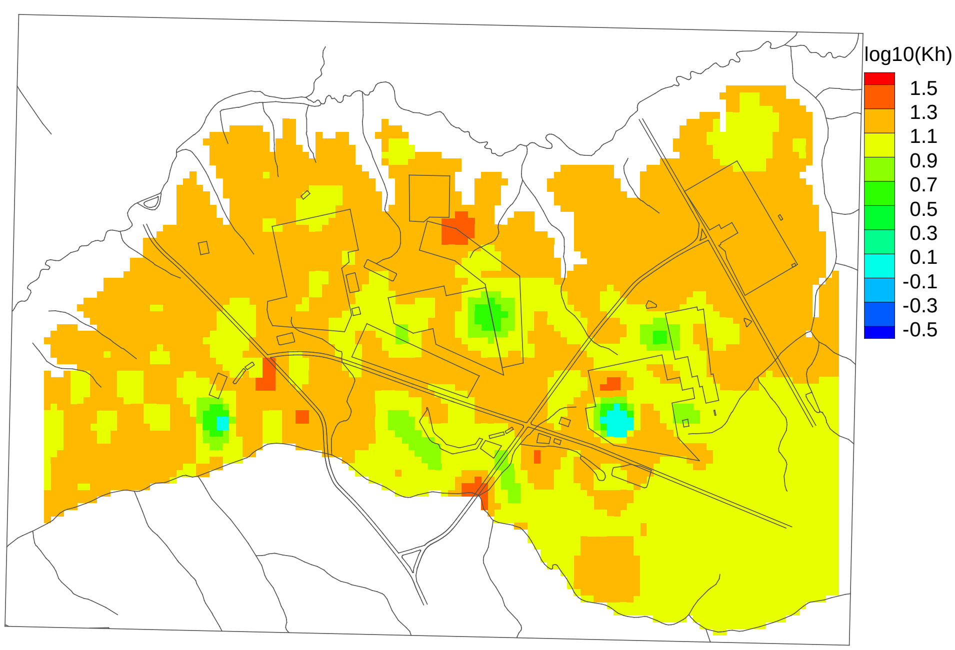
Grid layer 7 horizontal conductivity (LAZ):



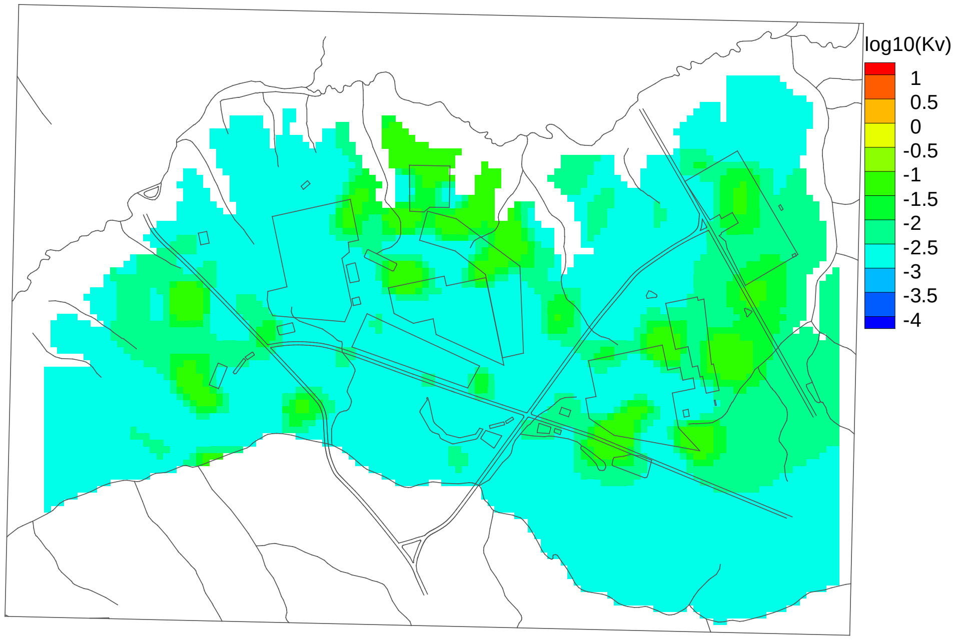
Grid layer 8 horizontal conductivity (LAZ):



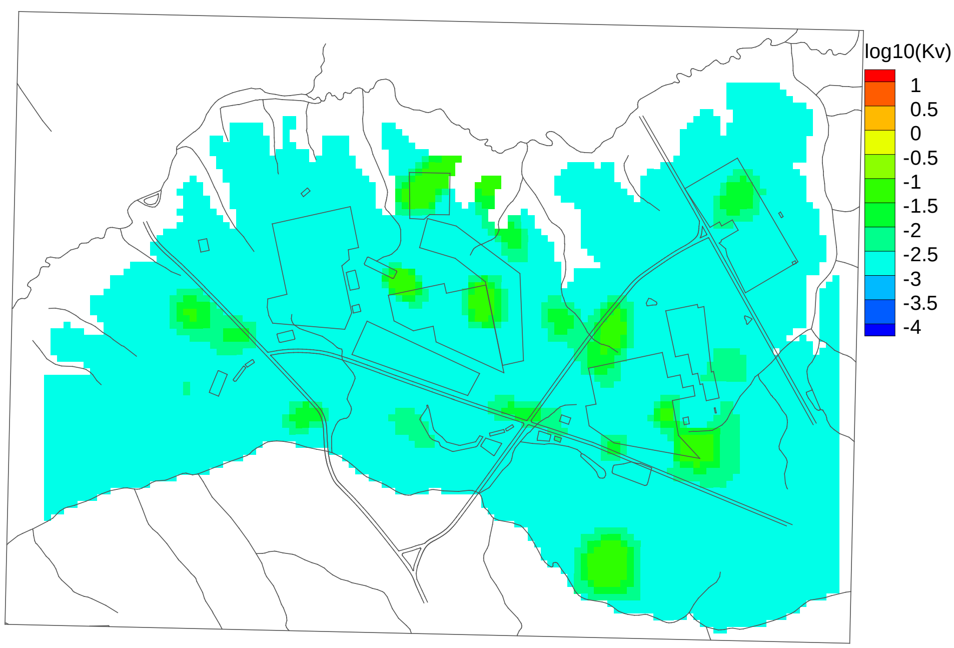
Grid layer 9 horizontal conductivity (LAZ):



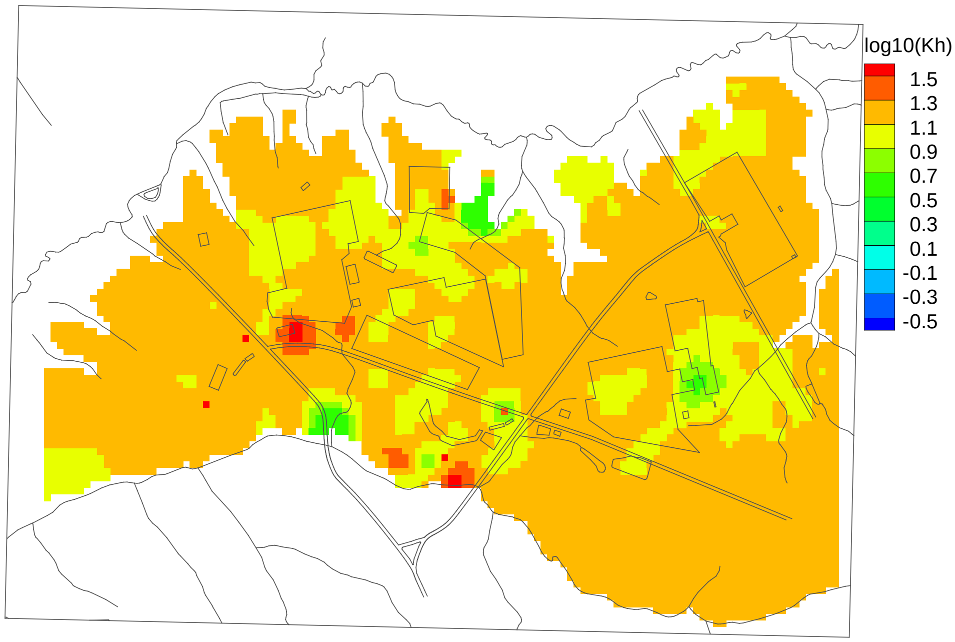
Grid layer 10 vertical conductivity (TCCZ):



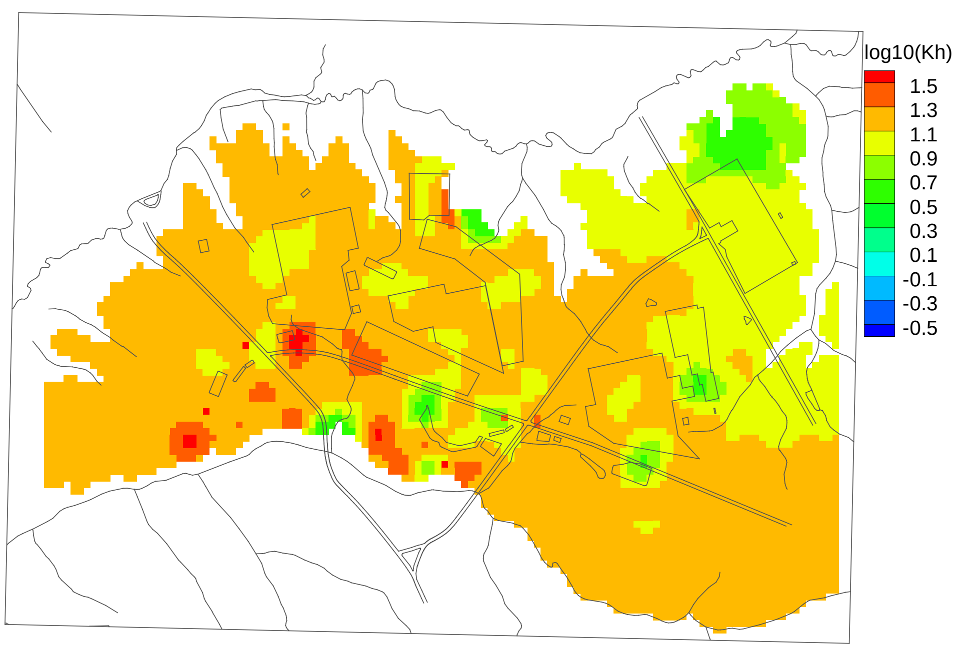
Grid layer 11 vertical conductivity (TCCZ):



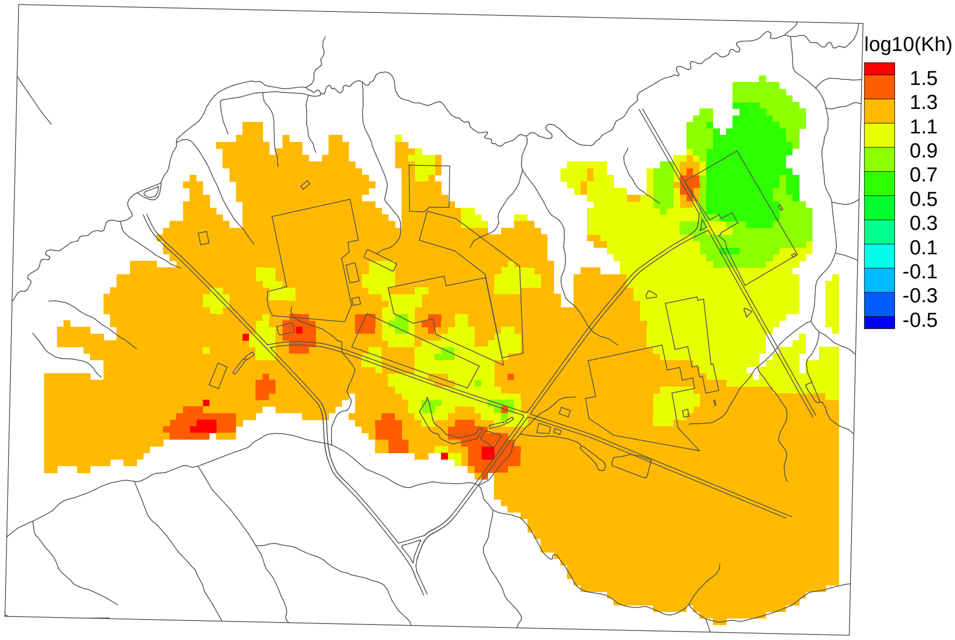
Grid layer 12 horizontal conductivity (UAZ):



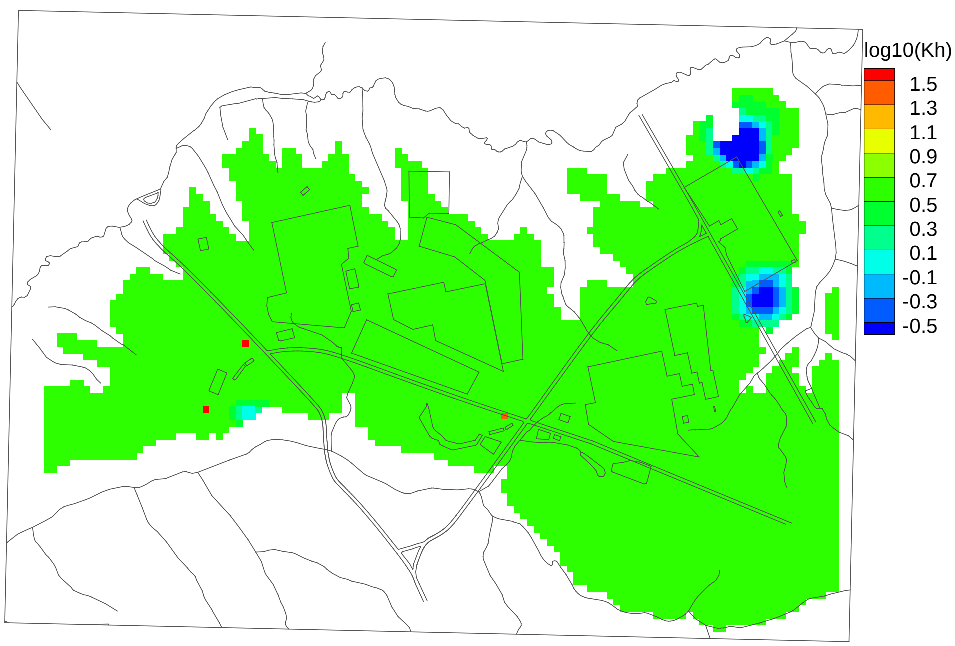
Grid layer 13 horizontal conductivity (UAZ):



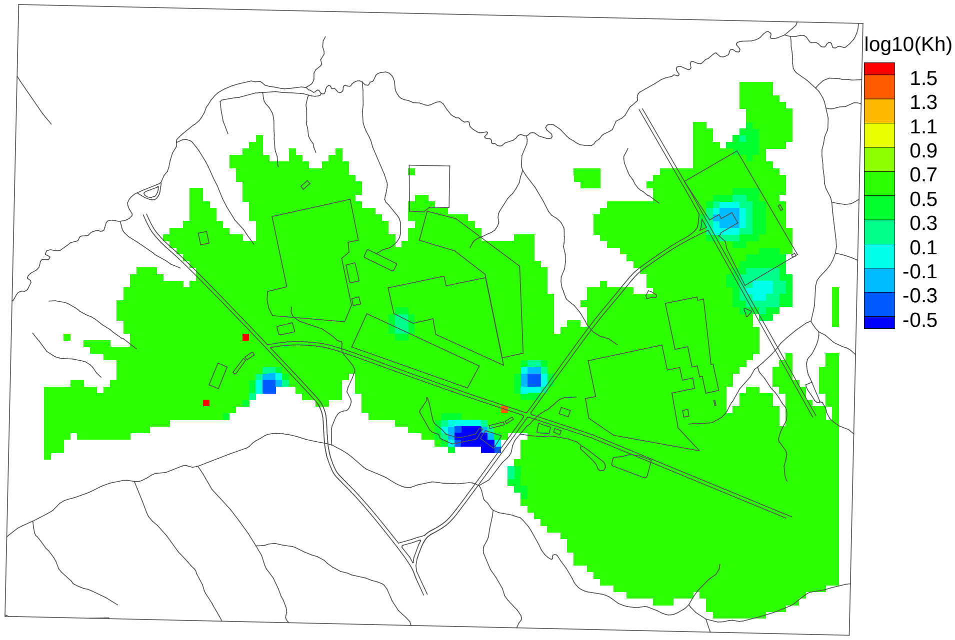
Grid layer 14 horizontal conductivity (UAZ):



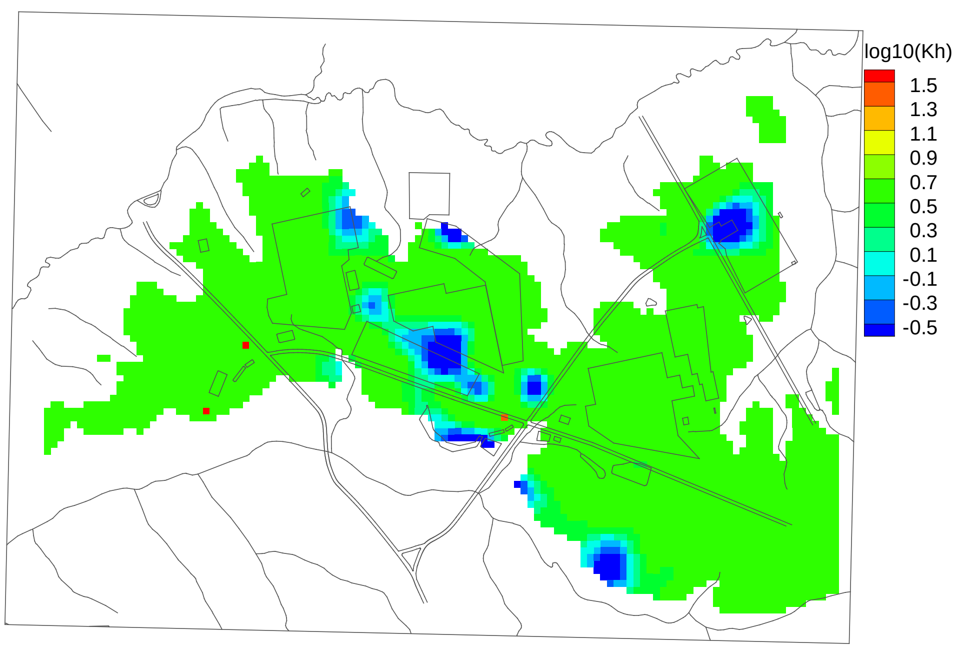
Grid layer 15 horizontal conductivity (UAZ):



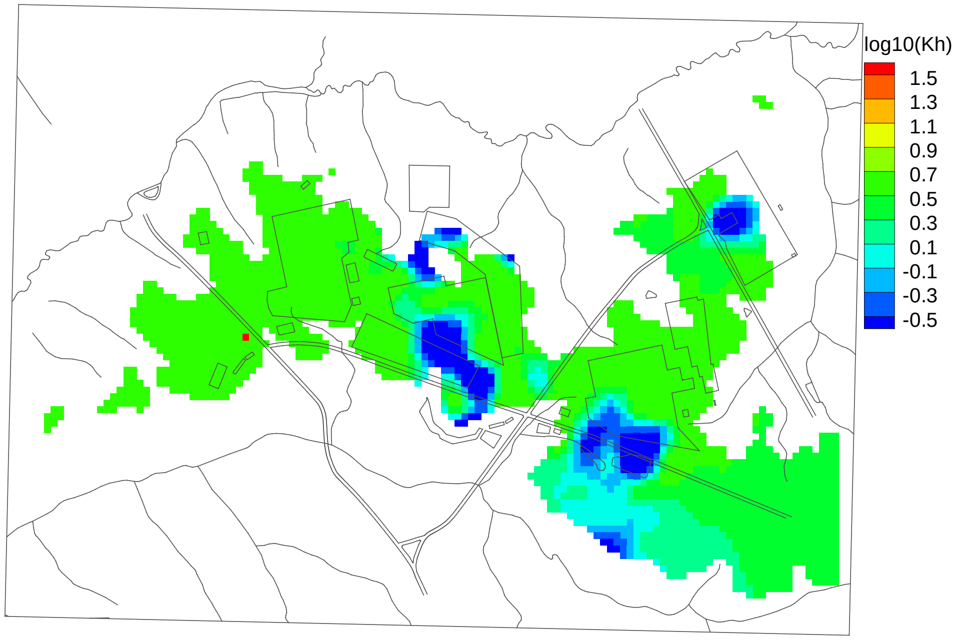
Grid layer 16 horizontal conductivity (UAZ):



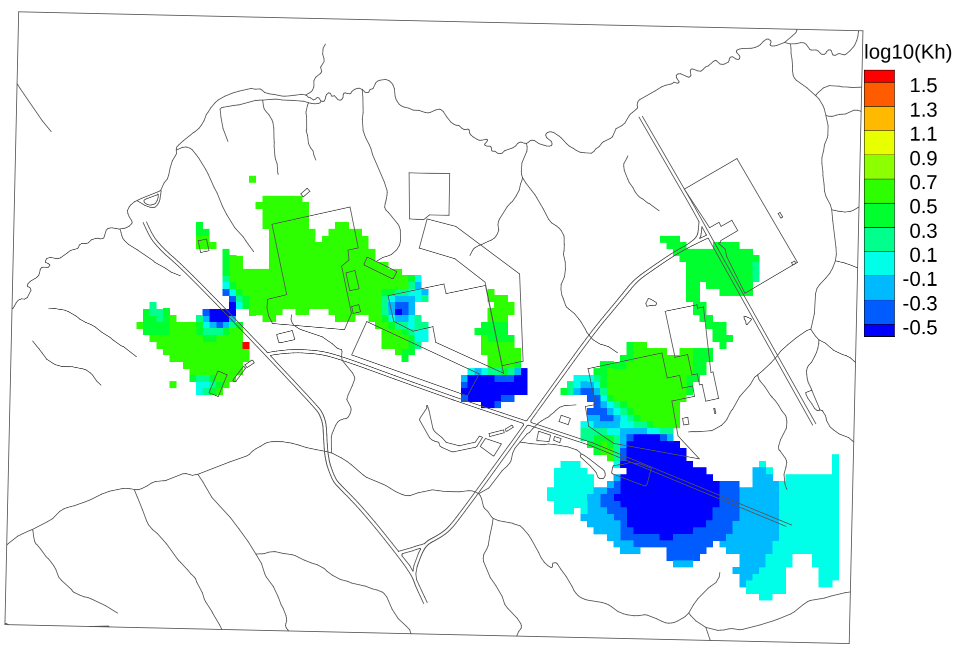
Grid layer 17 horizontal conductivity (UAZ):



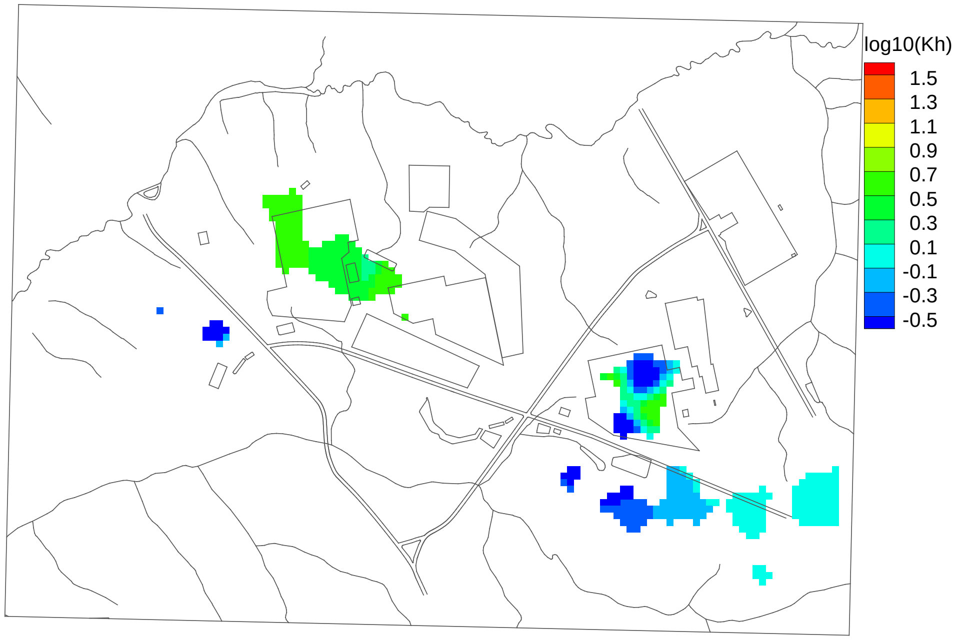
Grid layer 18 horizontal conductivity (UAZ):



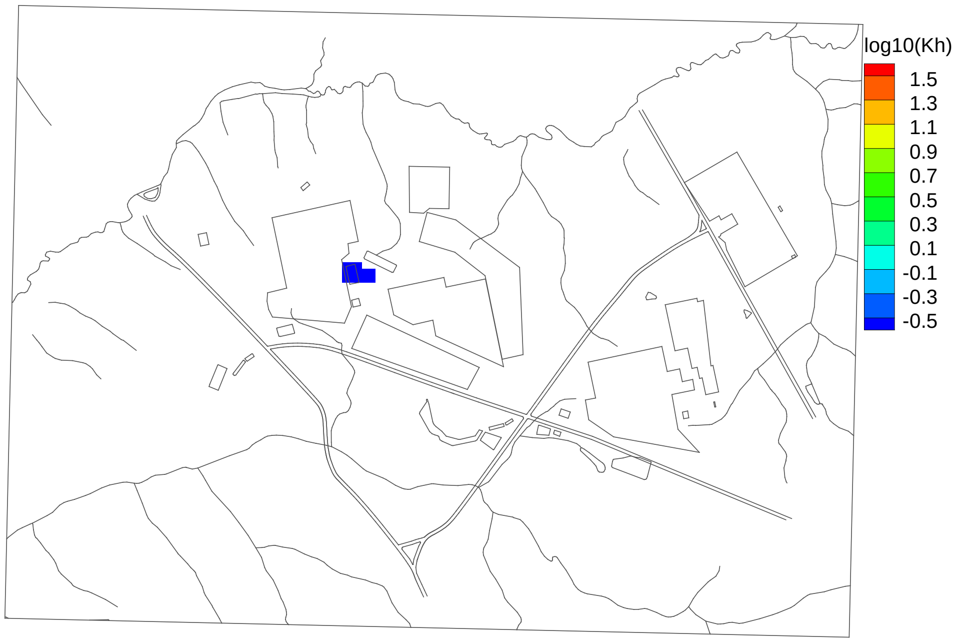
Grid layer 19 horizontal conductivity (UAZ):



Grid layer 20 horizontal conductivity (UAZ):



Grid layer 21 horizontal conductivity (UAZ):



Appendix C. Hydraulic head targets and weights

Targets values are taken as the "Mean" values from Appendix C of Hiergesell et al. (2015). The optimization function weights are defined by Equation (5) subject to a maximum value of 100, with the exception of target "o281". This well is suspected to reflect perched water, or water held up in the well sump, and was effectively removed from the PEST objective function by setting its weight to zero. The PEST observation groups are defined as: group3 = UAZ, group2 = LAZ, group1 = GAU.

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
BGO 1D	58779	73738	225.0	245.0	o1	234.9	15.13	group3
BGO 2D	58810	74553	221.7	241.7	o2	231.1	24.58	group3
BGO 3DR	58820	75512	217.5	237.6	o3	228.3	49.81	group3
BGO 4D	58804	76150	220.2	240.2	o4	226.1	24.04	group3
BGO 5D	58785	76477	218.8	238.8	o5	225.6	17.16	group3
BGO 6D	58297	76487	217.2	237.2	o6	226.3	17.27	group3
BGO 7D	57917	76494	220.2	240.2	o7	226.3	22.10	group3
BGO 8D	57618	76589	220.6	240.6	o8	226.6	18.26	group3
BGO 10DR	57074	76805	218.3	238.3	o9	226.3	32.26	group3
BGO 11DR	56650	76849	213.1	233.0	o10	226.2	25.08	group3
BGO 12CX	56215	76835	212.7	232.8	o11	215.8	10.50	group3
BGO 13DR	55840	76825	210.3	220.3	o12	226.0	12.29	group3
BGO 14DR	55789	76322	218.1	238.1	o13	225.7	13.07	group3
BGO 15D	55859	75973	218.7	238.7	o14	225.7	13.66	group3
BGO 16D	56202	75751	217.3	237.3	o15	226.0	15.99	group3
BGO 17DR	56407	75604	216.9	236.9	o16	226.6	13.30	group3
BGO 18D	56711	75600	219.6	239.6	o17	229.0	38.39	group3
BGO 20D	57114	74962	216.3	236.3	o18	228.9	22.50	group3
BGO 21D	57471	74688	217.7	237.7	o19	229.9	10.73	group3
BGO 22DX	57771	74560	217.9	237.9	o20	230.4	15.97	group3
BGO 23D	58133	74238	222.0	242.0	o21	231.5	8.06	group3
BGO 24D	58439	74012	221.0	241.0	o22	232.9	9.68	group3
BGO 26D	55015	76128	213.4	233.5	o23	223.7	8.66	group3
BGO 27D	54680	75677	209.3	229.3	o24	222.5	9.03	group3
BGO 28D	54458	75348	210.1	230.1	o25	221.4	4.24	group3
BGO 29D	54099	75593	208.5	228.5	o26	221.6	9.56	group3
BGO 30D	54499	75188	207.8	227.8	o27	221.4	2.58	group3
BGO 31D	54842	74985	211.1	231.1	o28	222.0	9.70	group3
BGO 32D	55250	74727	214.5	234.5	o29	222.7	12.80	group3
BGO 33D	55695	74469	213.1	233.1	o30	225.4	16.73	group3
BGO 34D	56083	74229	212.7	232.7	o31	227.5	12.49	group3
BGO 35D	56557	73946	219.4	239.4	o32	229.3	9.95	group3
BGO 36D	56888	73744	223.3	243.3	o33	232.9	9.03	group3

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
BGO 37D	57293	73491	226.1	246.1	o34	234.2	5.29	group3
BGO 38D	57558	73329	222.3	242.3	o35	232.6	7.81	group3
BGO 39D	57831	73583	224.7	244.7	o36	231.1	14.07	group3
BGO 40D	54638	76126	216.6	226.5	o37	217.3	11.65	group3
BGO 43D	56239	77057	198.2	208.2	o38	226.4	18.99	group3
BGO 44D	57910	76759	223.4	233.4	o39	226.3	6.29	group3
BGO 45D	54585	75854	209.6	229.6	o40	222.5	5.30	group3
BGO 46D	54420	75034	202.1	212.1	o41	221.2	5.00	group3
BGO 47D	54923	74740	203.4	213.4	o42	222.0	5.02	group3
BGO 48D	55121	74586	202.0	212.0	o43	221.6	4.86	group3
BGO 49D	56199	73932	218.5	238.5	o44	228.9	4.52	group3
BGO 50D	54209	75181	208.0	228.0	o45	220.9	3.82	group3
BGO 51D	57861	74118	220.1	240.1	o46	231.1	10.04	group3
BGO 52D	57201	74617	219.4	239.4	o47	229.2	11.82	group3
BGO 53D	55426	76056	225.3	245.3	o48	227.4	19.26	group3
BGX 1D	58609	76809	214.7	234.7	o49	224.9	11.01	group3
BGX 9D	59522	76936	212.4	232.4	o50	223.7	60.26	group3
BGX 10D	59765	76183	216.2	236.2	o51	223.1	100.00	group3
BGX 11D	59581	75301	216.7	236.7	o52	231.1	41.85	group3
BGX 12D	59674	74411	223.7	243.7	o53	234.5	37.12	group3
BRR 1D	50588	77365	200.4	220.4	o54	210.8	33.67	group3
BRR 5D	50009	77267	202.1	222.1	o55	208.1	31.92	group3
BRR 6D	51088	77071	199.4	219.3	o56	201.9	20.59	group3
BSE 1D1	57156	73212	223.8	226.3	o57	232.9	1.13	group3
BSE 1D3	57156	73212	201.2	203.7	o58	231.8	0.70	group3
BSE 2D1	56898	73286	223.7	226.2	o59	231.2	0.56	group3
BSE 2D2	56898	73286	211.2	213.7	o60	224.7	0.63	group3
BSE 2D3	56898	73286	201.2	203.7	o61	227.4	0.44	group3
BSE 3D1	56973	72700	219.9	222.4	o62	228.0	1.13	group3
BSE 3D3	56973	72700	202.3	204.8	o63	227.2	0.58	group3
BSE 3D4	56973	72700	189.8	192.3	o64	227.8	0.72	group3
BSW 1D1	53958	74668	212.7	215.2	o65	218.3	1.83	group3
BSW 1D2	53958	74668	203.2	205.7	o66	218.2	1.54	group3
BSW 1D3	53958	74668	191.6	194.1	o67	217.3	0.90	group3
BSW 2D1	54219	74444	214.1	216.6	o68	219.2	4.18	group3
BSW 2D2	54219	74444	207.6	210.1	o69	220.5	2.89	group3
BSW 3D1	54586	74266	215.8	218.3	o70	220.4	4.03	group3
BSW 3D2	54586	74266	202.3	204.8	o71	221.5	2.17	group3
BSW 4D1	54898	74137	216.7	219.2	o72	221.4	3.39	group3

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
BSW 4D2	54898	74137	202.2	204.7	o73	220.4	2.38	group3
BSW 5D1	53678	74310	211.6	214.1	o74	216.8	2.69	group3
BSW 5D2	53678	74310	201.0	203.6	o75	216.6	1.52	group3
BSW 6D2	53385	73757	204.0	206.5	o76	212.6	8.55	group3
BSW 6D3	53385	73757	195.5	198.0	o77	212.9	6.65	group3
BSW 7D1	53845	73834	205.8	208.3	o78	214.2	5.32	group3
BSW 7D2	53845	73834	196.3	198.8	o79	215.5	2.04	group3
BSW 8D1	54328	73624	207.9	210.4	o80	217.1	7.72	group3
BSW 8D3	54328	73624	189.9	192.4	o81	216.3	7.98	group3
FBI 13D	50240	74166	162.1	172.1	o82	204.3	1.99	group3
FBI 15D	50346	73698	178.9	188.9	o83	198.1	5.71	group3
FBI 16D	50243	73992	168.1	178.1	o84	204.0	1.33	group3
FBI 17D	50169	73783	172.0	182.7	o85	199.2	1.19	group3
FCB 2D	55046	76698	224.9	235.0	o86	227.4	58.41	group3
FCB002DR	55243	76543	221.5	241.5	o87	224.7	9.31	group3
FGW012 D	49823	76603	189.0	209.0	o88	207.0	31.15	group3
FIB 1	50094	73908	176.5	186.5	o89	204.2	1.73	group3
FIB 8	50242	73963	169.5	179.5	o90	204.5	1.38	group3
FOB 1D	50027	73813	175.4	195.4	o91	203.2	0.82	group3
FOB 2D	49528	73974	175.5	195.5	o92	203.6	43.40	group3
FOB 4D	49338	74430	174.0	194.1	o93	204.8	30.54	group3
FOB 8D	49940	75772	191.4	211.4	o94	210.1	20.45	group3
FOB 9D	50783	75775	192.6	212.6	o95	212.4	9.66	group3
FOB 10D	51050	75661	195.6	215.5	o96	213.1	7.57	group3
FOB 13D	50630	73836	175.0	185.0	o97	199.7	6.90	group3
FOB 16D	49976	74565	163.6	183.7	o98	205.8	10.09	group3
FPZ008AR	50558	73249	174.3	176.3	o99	188.0	100.00	group3
FRB 1	53915	76229	212.2	232.2	o100	222.2	17.43	group3
FRB 2	53600	76250	213.6	228.6	o101	220.7	15.13	group3
FRB 3	53588	76117	216.2	231.2	o102	220.8	5.23	group3
FRB 4	53653	76076	214.6	229.6	o103	221.8	6.77	group3
FSB 76	51389	76141	197.0	227.0	o104	213.1	2.49	group3
FSB 77	50713	75129	186.4	216.4	o105	210.5	11.91	group3
FSB 78	50165	74764	187.7	217.7	o106	206.1	2.73	group3
FSB 79	50140	73663	174.1	204.1	o107	198.2	23.22	group3
FSB 87D	50081	75586	187.4	216.8	o108	208.3	2.59	group3
FSB 88D	51527	75622	202.1	222.1	o109	212.1	2.66	group3
FSB 89D	51336	75548	201.9	221.9	o110	211.7	2.42	group3
FSB 90D	51141	75377	205.1	225.1	o111	211.1	2.82	group3

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
FSB 91D	50946	75207	200.9	220.9	o112	210.1	3.91	group3
FSB 92D	50558	75046	201.7	221.7	o113	208.7	3.60	group3
FSB 93D	50452	74888	197.9	217.9	o114	207.8	3.25	group3
FSB 94DR	50163	74869	183.3	203.4	o115	207.0	2.46	group3
FSB 95DR	49996	74992	187.0	207.0	o116	206.8	5.20	group3
FSB 97D	49976	75189	196.9	216.9	o117	207.3	1.84	group3
FSB 98D	50112	75372	200.3	220.3	o118	208.1	3.79	group3
FSB 99D	50327	75692	198.1	218.1	o119	209.0	5.04	group3
FSB105DR	49841	75258	188.5	208.6	o120	209.1	21.45	group3
FSB106D	50637	74193	202.9	222.9	o121	205.0	9.03	group3
FSB107D	51150	75177	200.9	220.9	o122	211.7	9.97	group3
FSB108D	51142	76261	203.8	223.8	o123	212.6	11.89	group3
FSB109D	50489	75856	205.8	225.8	o124	209.6	11.12	group3
FSB110D	50142	74193	191.1	211.1	o125	204.5	3.08	group3
FSB111D	51516	75383	201.7	221.7	o126	213.3	12.85	group3
FSB113D	51098	74155	189.6	209.6	o127	205.3	27.32	group3
FSB114D	52019	75279	197.7	217.8	o128	212.7	21.57	group3
FSB117D	50487	74070	189.7	209.7	o129	203.8	4.69	group3
FSB118D	51276	74698	191.3	211.3	o130	208.3	12.62	group3
FSB119D	50600	74600	193.1	213.1	o131	206.7	15.24	group3
FSB120D	49164	75569	196.5	216.5	o132	205.3	39.81	group3
FSB121DR	48430	75152	191.3	211.3	o133	204.7	100.00	group3
FSB123D	51735	74563	194.1	214.1	o134	208.8	31.05	group3
FSB124D	49179	74791	180.3	190.3	o135	204.9	28.82	group3
FSB125D	50238	74400	176.0	186.0	o136	206.5	0.82	group3
FSB125DR	50246	74380	175.8	185.8	o137	204.8	1.51	group3
FSB126D	49977	74159	173.1	183.1	o138	204.1	6.62	group3
FSB127D	50961	73861	177.1	182.1	o139	198.1	37.59	group3
FSB130D	49813	73915	187.0	197.0	o140	202.6	4.72	group3
FSB131D	49736	73848	188.1	198.1	o141	202.2	41.55	group3
FSB139D	50972	74193	180.4	200.4	o142	205.3	4.87	group3
FSB141D	51010	74106	183.1	198.2	o143	199.7	1.64	group3
FSL 1D	52993	79063	208.5	228.6	o144	221.8	100.00	group3
FSL 2D	52791	78637	208.7	228.8	o145	222.1	100.00	group3
FSL 3D	52465	77765	205.9	226.0	o146	218.2	56.45	group3
FSL 4D	52230	77452	204.0	224.1	o147	214.0	15.22	group3
FSL 5D	51903	77048	203.5	223.7	o148	215.6	11.13	group3
FSL 6D	51728	76733	202.1	222.1	o149	214.8	10.16	group3
FSL 7D	51486	76328	199.5	219.6	o150	213.1	6.54	group3

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
FSL 8D	51513	76055	202.7	222.8	o151	212.6	7.18	group3
FSL 9D	51544	75768	201.4	221.5	o152	212.6	6.45	group3
FSS 2D	53919	75103	204.4	224.4	o153	219.3	7.59	group3
FSS 3D	53548	74961	205.8	225.8	o154	217.5	11.61	group3
FSS 4D	52876	75538	202.6	222.6	o155	213.9	19.50	group3
FTF 22	52495	76751	212.6	242.6	o156	216.6	3.88	group3
FTF 23	52660	76612	201.2	231.2	o157	216.7	11.71	group3
FTF009R	52370	77604	203.0	213.0	o158	216.3	3.26	group3
FTF030D	52287	76885	213.4	223.4	o159	215.7	3.04	group3
HAA 1D	62991	69859	261.8	281.8	o160	269.7	16.58	group3
HAA 2D	61251	70945	260.3	280.4	o161	272.9	8.22	group3
HAA 4D	61890	72223	255.7	275.7	o162	267.6	1.12	group3
HAA 5D	62673	70592	268.6	288.8	o163	274.6	19.11	group3
HAA 7D	60807	71771	252.0	272.1	o164	268.5	3.04	group3
HAA 8D	60609	72166	252.1	272.1	o165	266.4	2.03	group3
HAA 9D	60856	72511	247.7	267.8	o166	261.9	2.17	group3
HAA 10D	61205	72308	253.0	273.0	o167	265.3	1.47	group3
HAA 11D	61407	72421	254.8	274.8	o168	264.5	2.72	group3
HAA 12D	61759	72425	244.7	264.7	o169	266.5	4.91	group3
HAA 13D	62039	72419	259.4	278.6	o170	267.3	7.82	group3
HAA 14D	62386	72355	253.0	273.0	o171	267.4	8.81	group3
HAA 15D	62770	72327	255.9	275.9	o172	267.9	22.92	group3
HC 1D	61867	71746	206.5	211.5	o173	266.1	0.80	group3
HCB 2	63798	71290	239.9	269.9	o174	268.6	42.39	group3
HGW 1D	60574	73356	207.8	227.9	o175	243.4	17.82	group3
HGW 2D	61584	74197	208.4	228.5	o176	233.2	100.00	group3
HGW 4D	65861	72713	212.6	232.7	o177	233.4	100.00	group3
HHP 1D	60534	71027	260.4	270.4	o178	270.9	31.19	group3
HHP 2D	60803	70886	263.2	273.2	o179	273.5	47.56	group3
HOB 1D	56918	72993	204.2	224.2	o180	229.2	5.10	group3
HOB 2D	57274	72812	200.4	220.4	o181	228.7	11.57	group3
HOB 3D	58035	72326	207.7	227.7	o182	229.0	5.09	group3
HOB 4D	58370	72224	210.4	230.4	o183	230.7	1.49	group3
HOB 5D	58619	72273	214.0	234.0	o184	233.4	2.31	group3
HOB 6D	57421	70578	186.9	196.9	o185	208.3	31.05	group3
HOB 7D	56289	71880	197.4	217.4	o186	217.0	5.00	group3
HPZ 1A	55676	71301	186.0	192.5	o187	201.5	100.00	group3
HPZ 2A	56151	71692	207.2	212.2	o188	214.6	23.48	group3
HPZ 4A	56573	71155	197.0	199.5	o189	209.5	100.00	group3

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
HPZ 5A	56890	70995	204.3	206.8	o190	211.2	19.95	group3
HPZ 6AR	56904	70709	191.5	194.0	o191	204.3	57.20	group3
HR3 15DU	59962	71364	234.1	254.1	o192	248.9	32.83	group3
HR3 16DU	59772	71388	230.0	240.0	o193	247.4	25.59	group3
HR8 11	59560	71946	207.9	237.6	o194	244.8	8.76	group3
HSB 65	58432	72426	212.4	242.4	o195	231.6	2.35	group3
HSB 65C	58447	72440	207.8	218.6	o196	231.0	13.94	group3
HSB 66DR	56924	72441	188.6	208.6	o197	226.0	9.63	group3
HSB 67	58424	71505	200.7	230.7	o198	222.4	2.52	group3
HSB 68DR	56867	71511	205.7	225.8	o199	218.4	6.25	group3
HSB 69	56475	71547	199.0	229.0	o200	215.5	4.74	group3
HSB 70	55759	72607	205.7	235.7	o201	219.0	6.77	group3
HSB 71	55279	72876	204.8	234.8	o202	219.9	2.98	group3
HSB 83D	58602	71628	198.7	228.7	o203	223.3	2.01	group3
HSB 84D	56350	71584	199.5	219.5	o204	215.3	6.47	group3
HSB 85C	58947	73802	214.2	224.2	o205	235.8	26.14	group3
HSB 86C	55985	72530	189.4	199.4	o206	219.5	1.59	group3
HSB 86D	55997	72522	206.6	236.6	o207	220.1	1.13	group3
HSB100D	58797	72074	216.9	236.9	o208	231.8	2.02	group3
HSB101D	58595	71997	216.1	236.1	o209	229.1	2.26	group3
HSB102D	58393	71952	216.3	236.3	o210	226.8	4.69	group3
HSB103D	58316	71588	213.7	233.7	o211	223.8	4.62	group3
HSB104D	58076	71370	210.6	230.6	o212	223.4	3.83	group3
HSB105D	57877	71455	211.8	231.8	o213	223.9	5.69	group3
HSB106D	57645	71728	210.7	230.7	o214	224.4	6.12	group3
HSB107D	57412	71697	215.1	235.1	o215	223.0	6.45	group3
HSB108D	57146	71688	212.0	232.0	o216	221.5	6.94	group3
HSB109D	56885	71686	213.0	233.0	o217	219.0	5.04	group3
HSB110D	56672	71785	211.4	231.4	o218	217.0	6.25	group3
HSB111D	56495	71926	185.7	195.7	o219	216.7	3.16	group3
HSB111E	56487	71933	211.7	231.7	o220	216.4	1.83	group3
HSB112E	56400	72167	211.7	231.7	o221	221.9	7.83	group3
HSB113DR	56154	72324	194.4	214.4	o222	218.5	5.93	group3
HSB114D	56104	72474	212.8	232.8	o223	219.2	2.92	group3
HSB115D	56040	72662	213.9	233.9	o224	220.2	4.14	group3
HSB116D	55988	72898	214.5	234.5	o225	220.9	6.77	group3
HSB117D	55156	72748	200.3	220.3	o226	221.6	13.75	group3
HSB119D	56117	73104	204.9	224.8	o227	223.5	11.63	group3
HSB120D	56412	73377	213.0	223.0	o228	226.3	8.17	group3

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
HSB121D	57390	72069	205.1	215.1	o229	225.9	10.30	group3
HSB122D	57733	72194	204.6	214.6	o230	226.7	8.84	group3
HSB125D	58584	71498	199.4	219.4	o231	220.1	4.52	group3
HSB126D	57170	70633	190.5	200.5	o232	205.4	14.96	group3
HSB127D	56788	71219	197.8	217.8	o233	215.5	10.97	group3
HSB130D	54652	70757	182.1	202.1	o234	199.8	100.00	group3
HSB131D	56891	70365	195.7	205.7	o235	205.3	37.56	group3
HSB132C	58788	71472	168.6	178.6	o236	220.1	2.86	group3
HSB132D	58799	71469	206.5	226.5	o237	219.5	10.73	group3
HSB133D	59102	71943	208.5	228.5	o238	234.8	6.61	group3
HSB134D	58296	71217	205.8	225.8	o239	220.6	11.93	group3
HSB135D	56553	71397	199.9	219.9	o240	215.3	5.16	group3
HSB136D	55942	71906	200.2	220.2	o241	216.6	15.63	group3
HSB137D	55696	72279	205.3	225.3	o242	217.8	16.74	group3
HSB138D	55261	73160	208.1	228.1	o243	222.5	13.75	group3
HSB139D	57384	71133	206.7	226.7	o244	220.6	5.56	group3
HSB140D	56561	70036	194.1	214.1	o245	212.2	45.63	group3
HSB141D	59171	71184	217.8	237.8	o246	233.1	12.20	group3
HSB143D	52775	73754	196.9	216.9	o247	211.1	96.90	group3
HSB145D	57754	71088	184.2	194.2	o248	219.0	10.73	group3
HSB146D	58493	70470	204.0	224.1	o249	218.8	47.33	group3
HSB147D	55804	73828	215.2	235.2	o250	227.8	14.54	group3
HSB148D	55453	70174	198.1	218.1	o251	212.0	55.60	group3
HSB149D	57286	71339	207.0	227.0	o252	221.6	4.08	group3
HSB150D	58693	71693	206.9	226.9	o253	224.9	1.95	group3
HSB151DR	54003	73007	191.2	196.2	o254	206.7	100.00	group3
HSB153D	57019	72117	205.2	215.2	o255	225.9	8.53	group3
HSB154D	56549	72599	204.7	214.7	o256	226.3	12.09	group3
HSL 1D	58925	72180	219.8	239.8	o257	233.3	7.05	group3
HSL 2D	59423	72191	225.2	245.3	o258	239.0	8.73	group3
HSL 3D	59771	72251	233.7	253.8	o259	247.8	7.10	group3
HSL 4D	60172	72454	245.0	265.1	o260	262.7	1.79	group3
HSL 5D	60339	72562	247.8	267.7	o261	266.9	0.84	group3
HSL 6D	60531	72660	243.9	264.0	o262	257.9	2.89	group3
HSL 7D	60723	72674	242.3	262.4	o263	258.0	3.61	group3
HSL 8D	61117	72688	248.4	268.4	o264	259.2	14.18	group3
HSL004DR	60118	72525	237.3	247.2	o265	255.1	6.96	group3
HSL005DR	60280	72587	238.2	243.3	o266	257.0	2.06	group3
HSP 60B	55164	71583	193.2	198.2	o267	199.8	100.00	group3

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
HTF 1	62067	71745	236.9	256.9	o268	271.1	0.92	group3
HTF 2	62175	71610	237.0	257.0	o269	272.4	4.92	group3
HTF 12D	61593	71520	262.2	272.2	o270	273.3	4.31	group3
HTF 15D	61353	71694	264.6	274.6	o271	271.1	4.22	group3
NWP 3D	55324	76836	215.3	235.5	o272	225.8	10.90	group3
NWP101D	55589	77407	213.6	223.6	o273	226.3	86.40	group3
SBG 6	63860	73599	208.1	238.1	o274	243.9	82.99	group3
SEP001MD	56485	73562	205.8	225.8	o275	228.0	4.08	group3
SWP 3D	55107	74058	213.6	218.7	o276	220.5	12.83	group3
SWP005D	53172	74641	199.4	219.4	o277	214.8	5.76	group3
SWP006D	53014	74258	201.4	221.4	o278	213.5	5.86	group3
SWP04MD	53685	74321	187.4	197.4	o279	215.8	4.88	group3
ZBG 1	65584	76584	220.0	240.1	o280	231.7	63.79	group3
ZBG 1A	65599	76588	276.0	281.0	o281	275.8	0.00	group3
ZBG009D	67038	77602	197.7	212.7	o282	218.8	25.04	group3
ZBG015D	65809	75448	214.0	234.0	o283	234.0	60.03	group3
BGO 3C	58806	75550	178.7	188.7	o284	221.5	84.30	group2
BGO 5C	58794	76477	183.2	193.2	o285	210.6	64.93	group2
BGO 6B	58347	76553	139.7	149.7	o286	213.8	4.26	group2
BGO 6C	58307	76487	158.0	168.0	o287	215.4	17.04	group2
BGO 8C	57619	76579	174.3	184.3	o288	218.4	26.37	group2
BGO 10B	56979	76982	139.0	149.0	o289	214.8	11.62	group2
BGO 10C	57041	76805	157.3	167.3	o290	214.7	18.83	group2
BGO 12DR	56231	76834	141.2	151.2	o291	226.3	14.29	group2
BGO 14CR	55789	76338	190.1	200.1	o292	218.5	10.25	group2
BGO 16B	56184	75768	136.0	146.0	o293	214.3	40.28	group2
BGO 20B	57120	74952	131.0	141.0	o294	223.4	23.41	group2
BGO 20C	57106	74938	174.0	184.0	o295	224.7	10.97	group2
BGO 27C	54671	75666	154.9	163.9	o296	216.2	10.62	group2
BGO 29C	54099	75578	176.8	186.8	o297	217.3	18.50	group2
BGO 30C	54512	75181	178.4	188.4	o298	215.1	3.97	group2
BGO 31C	54816	74978	176.4	186.4	o299	221.1	8.94	group2
BGO 33C	55681	74480	177.8	187.8	o300	221.0	18.49	group2
BGO 35C	56546	73954	161.9	171.9	o301	224.4	13.48	group2
BGO 37C	57279	73498	168.8	178.8	o302	226.8	10.36	group2
BGO 39C	57816	73563	174.9	184.9	o303	227.4	20.26	group2
BGO 42C	55522	76405	185.9	195.9	o304	218.3	4.33	group2
BGO 43CR	56237	77035	178.4	188.4	o305	215.5	10.07	group2
BGO 44B	57866	76756	148.1	158.1	o306	216.6	4.43	group2

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
BGO 44C	57895	76758	190.6	200.6	o307	216.0	4.65	group2
BGO 45B	54564	75840	137.0	147.0	o308	214.2	13.03	group2
BGO 45C	54577	75835	190.5	200.5	o309	217.9	4.04	group2
BGO 46B	54445	75012	140.4	150.4	o310	213.8	3.07	group2
BGO 46C	54434	75022	178.0	188.0	o311	215.2	1.39	group2
BGO 47C	54933	74752	178.6	188.6	o312	218.8	3.90	group2
BGO 48C	55124	74600	176.7	186.7	o313	219.2	6.13	group2
BGO 49C	56202	73917	166.0	176.0	o314	224.1	9.20	group2
BGO 50C	54197	75190	162.5	172.5	o315	214.2	4.22	group2
BGO 51B	57848	74128	116.9	126.9	o316	226.2	15.56	group2
BGO 51C	57854	74123	175.1	185.1	o317	226.9	14.04	group2
BGO 52B	57190	74627	126.7	136.7	o318	224.2	5.00	group2
BGO 52C	57196	74622	178.7	188.7	o319	225.4	11.17	group2
BGO 53B	55416	76077	143.5	153.5	o320	217.1	9.76	group2
BGO 53C	55408	76082	183.2	193.2	o321	218.4	5.56	group2
BGX 1C	58600	76820	176.0	186.0	o322	210.9	12.52	group2
BGX 2B	58256	77203	137.2	147.2	o323	207.9	6.09	group2
BGX 2D	58265	77192	181.1	191.1	o324	209.8	4.88	group2
BGX 3D	57780	77577	201.6	221.6	o325	210.1	17.58	group2
BGX 4C	57202	77886	170.7	180.7	o326	209.2	7.46	group2
BGX 4D	57186	77894	203.8	223.8	o327	210.3	6.26	group2
BGX 5D	57309	78402	195.0	215.0	o328	204.2	11.27	group2
BGX 6D	57525	78740	191.0	211.0	o329	201.8	10.84	group2
BGX 7D	58313	78349	194.1	214.1	o330	201.4	22.71	group2
BGX 8DR	58943	77590	183.1	203.1	o331	201.8	28.37	group2
BGX 12C	59675	74428	174.1	184.1	o332	230.8	100.00	group2
BGX006DR	57358	78758	183.4	203.4	o333	202.7	2.05	group2
BGX013D	58795	77757	182.6	202.7	o334	202.1	11.04	group2
BRR 6C	51095	77063	156.0	166.0	o335	206.2	17.73	group2
BRR 7C	50698	77573	175.9	185.9	o336	203.7	38.79	group2
BSE 1C1	57147	73217	169.1	171.6	o337	229.2	0.04	group2
BSE 1C2	57147	73217	150.5	153.0	o338	227.7	0.07	group2
BSE 1C3	57147	73217	138.0	140.5	o339	228.0	0.07	group2
BSE 1C4	57147	73217	123.0	125.5	o340	227.2	0.15	group2
BSE 1D4	57156	73212	183.7	186.2	o341	232.6	2.98	group2
BSE 2CR1	56973	72700	175.7	178.2	o342	225.9	0.41	group2
BSE 2CR3	56973	72700	145.7	148.2	o343	224.7	0.85	group2
BSE 2D4	56898	73286	183.6	186.1	o344	231.6	1.28	group2
BSE 3C1	56980	72693	170.8	173.3	o345	224.7	1.68	group2

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BSE 3C2	56980	72693	150.7	153.2	o346	224.9	1.63	group2
BSE 3C3	56980	72693	138.2	140.7	o347	224.7	2.08	group2
BSW 1C1	53962	74676	178.0	180.5	o348	211.7	1.09	group2
BSW 1C2	53962	74676	168.5	171.0	o349	210.2	0.89	group2
BSW 1C3	53962	74676	151.0	153.5	o350	211.4	1.43	group2
BSW 1C4	53962	74676	143.5	146.0	o351	210.3	1.03	group2
BSW 2C2	54208	74442	141.2	143.7	o352	211.0	2.96	group2
BSW 2C3	54208	74442	133.7	136.2	o353	212.6	2.05	group2
BSW 3C2	54593	74274	159.5	162.0	o354	214.3	3.40	group2
BSW 3C4	54593	74274	132.6	135.1	o355	216.2	1.67	group2
BSW 4C2	54905	74129	153.1	155.6	o356	216.9	2.42	group2
BSW 4C3	54905	74129	138.5	141.1	o357	216.1	4.15	group2
BSW 5C1	53672	74301	172.0	174.5	o358	210.8	2.85	group2
BSW 5C4	53672	74301	131.5	134.0	o359	210.7	4.00	group2
BSW 6C1	53376	73753	172.3	174.8	o360	209.4	2.63	group2
BSW 6C2	53376	73753	160.8	163.3	o361	209.6	1.55	group2
BSW 6C3	53376	73753	154.3	156.8	o362	208.8	1.12	group2
BSW 6C4	53376	73753	134.8	137.3	o363	208.8	1.14	group2
BSW 7C1	53853	73825	168.6	171.1	o364	212.5	2.02	group2
BSW 7C3	53853	73825	142.6	145.1	o365	211.0	4.20	group2
BSW 8C1	54321	73633	173.3	175.8	o366	215.1	6.06	group2
BSW 8C3	54321	73633	137.3	139.8	o367	214.3	6.06	group2
FAB 2MC	55146	77482	186.8	196.8	o368	214.2	41.22	group2
FAB 5C	55774	77969	196.2	206.2	o369	211.4	20.03	group2
FAB 6C	55988	77782	167.8	177.8	o370	211.1	1.22	group2
FAB 6D	55978	77788	223.7	233.7	o371	228.5	1.07	group2
FAB 7C	56182	77658	183.9	193.9	o372	211.6	1.46	group2
FAB 7D	56181	77669	215.9	225.9	o373	227.3	1.83	group2
FBG001C	53617	77234	194.4	209.4	o374	215.4	10.51	group2
FBI 14C	50491	73930	148.8	158.8	o375	198.7	9.53	group2
FBI 16C	50255	73981	145.9	155.9	o376	198.4	6.34	group2
FBP 1A	51081	78893	161.8	191.8	o377	201.2	13.87	group2
FBP 6D	50547	79673	178.3	198.3	o378	185.2	5.42	group2
FBP 9D	51074	79565	177.9	197.9	o379	194.7	36.40	group2
FBP 10D	50536	79330	180.8	200.8	o380	196.0	39.95	group2
FBP 12D	51166	78932	182.1	202.1	o381	202.3	8.06	group2
FBP 13D	50694	79749	172.7	192.7	o382	186.2	8.08	group2
FBP 43C	52019	78740	154.2	164.2	o383	205.5	2.05	group2
FBP 43DL	52009	78742	184.3	194.3	o384	206.5	10.42	group2

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
FBP 44D	49614	80333	163.6	168.6	o385	162.9	51.92	group2
FBP 45D	49812	80506	160.6	165.6	o386	161.5	0.67	group2
FBP 46D	49940	80502	161.5	166.5	o387	162.9	4.10	group2
FBP 47D	50128	80689	165.8	170.8	o388	165.8	78.86	group2
FCB 2C	55055	76699	170.9	180.9	o389	219.0	22.38	group2
FCB002CR	55247	76551	175.2	185.2	o390	215.7	6.07	group2
FGW003 C	53574	79665	191.3	201.3	o391	208.9	38.31	group2
FGW005 C	52856	79020	167.0	182.0	o392	210.0	22.14	group2
FGW012 C	49808	76605	154.1	164.1	o393	202.4	60.54	group2
FGW019C	52354	80746	189.0	199.0	o394	201.9	63.30	group2
FGW022C	52457	79044	193.6	203.6	o395	207.0	14.67	group2
FHB 4D	53711	72977	142.4	147.4	o396	200.8	39.70	group2
FNB 2	54362	80442	180.8	210.8	o397	203.0	26.40	group2
FNB 5	54295	80556	193.5	203.5	o398	202.8	17.49	group2
FNB 12	54557	81456	164.6	194.6	o399	191.7	42.60	group2
FNB 13	54880	81572	167.2	197.2	o400	189.6	27.79	group2
FNB 15	55319	81294	149.4	179.4	o401	192.7	31.50	group2
FOB 2C	49543	73976	146.6	156.6	o402	200.1	69.54	group2
FOB 5C	49730	74607	129.3	149.3	o403	202.8	18.32	group2
FOB 7C	50236	76074	148.9	168.9	o404	207.7	28.78	group2
FOB 9C	50797	75773	155.5	175.5	o405	209.3	19.25	group2
FOB 11C	51921	75614	156.2	176.2	o406	212.3	18.59	group2
FSB 76C	51396	76112	154.8	165.3	o407	208.9	19.56	group2
FSB 78C	50170	74772	141.6	151.4	o408	204.5	4.34	group2
FSB 79C	50171	73668	149.8	159.6	o409	195.5	34.32	group2
FSB 87C	50093	75592	148.8	159.3	o410	205.4	6.58	group2
FSB 88C	51518	75620	158.4	168.4	o411	208.7	3.53	group2
FSB 89C	51345	75553	156.1	166.1	o412	208.3	3.20	group2
FSB 90C	51149	75383	158.1	168.1	o413	207.1	2.83	group2
FSB 91C	50953	75213	149.1	159.1	o414	206.4	4.73	group2
FSB 92C	50564	75053	147.6	157.6	o415	206.1	6.06	group2
FSB 93C	50458	74897	142.0	152.0	o416	205.8	4.87	group2
FSB 94C	50180	74869	139.8	149.8	o417	205.1	1.92	group2
FSB 95CR	49988	75002	151.9	161.9	o418	204.6	2.73	group2
FSB 97C	49970	75180	143.8	153.8	o419	204.8	1.49	group2
FSB 98C	50116	75381	148.4	158.4	o420	205.2	2.88	group2
FSB 99C	50321	75684	157.2	167.2	o421	206.1	5.13	group2
FSB102C	50835	73583	145.9	155.9	o422	194.1	84.28	group2
FSB103C	49651	74210	147.1	157.1	o423	201.4	16.65	group2

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
FSB105C	49828	75234	141.5	151.5	o424	205.8	20.65	group2
FSB106C	50651	74190	156.0	166.0	o425	200.3	20.14	group2
FSB107C	51158	75184	150.8	160.8	o426	207.2	7.27	group2
FSB110C	50151	74191	137.2	147.2	o427	200.6	14.41	group2
FSB111C	51526	75383	159.0	169.0	o428	210.2	14.20	group2
FSB113C	51084	74161	154.0	164.0	o429	199.7	20.17	group2
FSB114C	52034	75288	158.0	168.0	o430	209.5	20.53	group2
FSB120C	49171	75550	150.7	160.7	o431	202.1	41.83	group2
FSB121C	48413	75156	148.4	158.4	o432	201.0	66.34	group2
FSB123C	51750	74567	155.3	165.3	o433	207.9	25.84	group2
FSL 10C	52296	78599	179.0	199.0	o434	208.8	15.49	group2
FSS 1D	53898	75258	209.9	229.9	o435	219.9	8.43	group2
FSS003C	53536	74969	161.5	181.5	o436	210.7	7.01	group2
FTF 28	52185	77240	151.9	161.9	o437	209.0	12.22	group2
FTF 29	52166	77737	157.3	177.3	o438	208.1	12.56	group2
FTF030	52288	76874	183.6	193.6	o439	210.1	4.17	group2
FTF031	52543	76452	187.0	197.0	o440	221.0	4.24	group2
HAA 1C	62983	69866	147.4	157.4	o441	247.0	18.39	group2
HAA 2B	61267	70935	127.2	137.2	o442	250.0	11.00	group2
HAA 2C	61259	70940	171.9	181.9	o443	250.6	7.39	group2
HAA 4B	61910	72223	124.5	135.0	o444	247.6	2.12	group2
HAA 4C	61900	72223	158.3	168.3	o445	248.3	1.41	group2
HAA 7B	60818	71754	135.3	145.3	o446	249.5	3.82	group2
HAA 7C	60813	71763	177.2	187.2	o447	252.0	1.73	group2
HAA 8B	60623	72167	134.1	144.1	o448	249.2	0.68	group2
HAA 8C	60615	72173	172.1	182.1	o449	250.0	2.62	group2
HAA 9B	60846	72506	138.4	148.4	o450	248.4	1.97	group2
HAA 9C	60842	72496	172.4	181.5	o451	249.7	0.57	group2
HAA 10B	61225	72308	133.7	143.8	o452	250.3	1.12	group2
HAA 10C	61215	72308	167.5	177.5	o453	251.6	0.64	group2
HAA 11B	61395	72418	139.4	149.4	o454	248.5	1.22	group2
HAA 11C	61395	72418	170.7	180.7	o455	247.9	0.94	group2
HAA 12B	61733	72419	134.3	144.2	o456	247.6	0.74	group2
HAA 12C	61746	72422	169.5	179.5	o457	247.4	1.67	group2
HAA 13B	62007	72418	134.2	143.6	o458	245.8	0.37	group2
HAA 13C	62020	72421	167.2	176.6	o459	246.1	5.06	group2
HAA 14B	62366	72355	135.0	145.0	o460	245.0	1.36	group2
HAA 14C	62376	72355	161.1	171.1	o461	245.1	2.58	group2
HAA 15B	62770	72358	129.3	139.3	o462	243.2	58.55	group2

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
HAA 15C	62770	72341	161.3	171.3	o463	244.4	5.38	group2
HIW 5MC2	56499	73558	124.4	139.2	o464	222.8	4.65	group2
HMD 1D	56973	78732	199.7	219.7	o465	205.9	22.98	group2
HMD 2D	57269	79666	190.8	210.8	o466	197.3	12.39	group2
HMD 3D	57745	79579	187.7	207.7	o467	196.9	10.52	group2
HMD 4B	58199	79161	163.7	173.7	o468	194.4	11.31	group2
HMD 4D	58188	79160	188.9	208.9	o469	197.1	11.15	group2
HPZ 3A	56294	70938	183.2	185.7	o470	201.5	100.00	group2
HSB 65B	58439	72446	123.3	133.3	o471	222.7	21.69	group2
HSB 68B	56882	71525	123.5	134.5	o472	216.3	2.99	group2
HSB 68C	56873	71524	168.4	179.5	o473	216.2	1.78	group2
HSB 70C	55757	72597	164.9	174.9	o474	219.8	3.73	group2
HSB 71C	55282	72866	171.9	181.9	o475	219.3	4.51	group2
HSB 83B	58595	71640	121.2	132.1	o476	222.3	1.74	group2
HSB 83C	58615	71637	160.2	171.2	o477	223.1	2.99	group2
HSB 84B	56352	71603	121.8	132.9	o478	210.1	8.40	group2
HSB 84C	56360	71597	170.9	181.8	o479	211.8	3.93	group2
HSB 85B	58953	73789	133.2	143.2	o480	229.2	42.41	group2
HSB 86B	55977	72519	113.8	124.0	o481	218.6	0.93	group2
HSB100C	58806	72077	153.0	163.0	o482	225.1	5.39	group2
HSB101C	58604	72002	166.3	176.3	o483	223.8	2.85	group2
HSB102C	58400	71960	166.7	176.7	o484	223.0	7.44	group2
HSB103C	58323	71594	159.2	169.2	o485	222.0	4.41	group2
HSB104C	58083	71377	163.5	173.5	o486	219.2	3.42	group2
HSB105C	57884	71447	152.2	162.2	o487	218.2	5.29	group2
HSB106C	57652	71721	158.7	168.7	o488	220.1	7.70	group2
HSB107C	57432	71698	159.3	169.3	o489	217.7	7.60	group2
HSB108C	57155	71689	186.0	196.0	o490	217.0	7.82	group2
HSB109C	56895	71685	168.4	178.4	o491	217.1	4.44	group2
HSB110C	56681	71779	171.4	181.4	o492	217.1	4.45	group2
HSB111C	56502	71919	140.7	150.7	o493	217.9	5.90	group2
HSB112C	56418	72156	140.6	150.6	o494	219.2	8.04	group2
HSB113C	56160	72312	154.7	164.7	o495	218.7	4.80	group2
HSB114CR	56110	72453	146.8	156.8	o496	220.2	1.31	group2
HSB115CR	56045	72642	145.0	155.0	o497	220.7	3.14	group2
HSB116CR	55990	72871	141.2	151.2	o498	221.8	6.07	group2
HSB117C	55163	72741	165.1	175.1	o499	218.0	6.66	group2
HSB119C	56109	73095	149.8	159.8	o500	222.0	12.85	group2
HSB120C	56444	73377	155.3	165.3	o501	224.7	7.99	group2

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
HSB121C	57403	72066	159.6	169.6	o502	221.7	20.58	group2
HSB125C	58593	71504	145.6	155.6	o503	222.7	6.15	group2
HSB126C	57178	70628	176.3	181.3	o504	204.3	80.40	group2
HSB127C	56792	71210	148.4	158.4	o505	209.5	16.03	group2
HSB129C	55110	71830	147.8	157.8	o506	204.8	17.43	group2
HSB130C	54644	70762	159.9	169.9	o507	199.9	100.00	group2
HSB131C	56895	70375	148.5	158.5	o508	204.2	81.71	group2
HSB133C	59110	71949	173.3	183.3	o509	229.9	20.91	group2
HSB134C	58290	71210	149.1	159.1	o510	219.5	11.75	group2
HSB135C	56561	71390	147.3	157.3	o511	206.2	7.75	group2
HSB136C	55950	71900	160.5	170.5	o512	214.6	12.20	group2
HSB137CR	55705	72260	148.8	158.8	o513	217.3	7.34	group2
HSB139C	57374	71130	148.5	158.5	o514	213.2	13.11	group2
HSB140C	56552	70049	161.6	171.6	o515	205.7	81.99	group2
HSB141CR	59167	71227	152.1	162.1	o516	226.6	30.74	group2
HSB142C	53505	73119	161.6	171.6	o517	197.3	91.26	group2
HSB143C	52773	73738	169.1	179.1	o518	206.8	58.90	group2
HSB145C	57769	71099	164.7	174.7	o519	212.7	17.10	group2
HSB146C	58473	70472	152.3	162.3	o520	209.7	100.00	group2
HSB148C	55441	70165	158.9	168.9	o521	201.4	100.00	group2
HSB151C	54015	72998	170.6	180.6	o522	206.9	15.49	group2
HSB152C	54347	72012	173.1	183.1	o523	198.4	100.00	group2
HSB153C	57025	72132	164.5	174.5	o524	221.4	11.62	group2
HSB154C	56545	72612	147.5	157.5	o525	222.7	11.47	group2
HSB155C	54684	72503	159.8	169.8	o526	211.1	9.39	group2
HSL 9C	60561	73352	154.7	174.7	o527	240.7	88.75	group2
HSL 10C	59745	72886	150.0	170.0	o528	238.5	21.93	group2
HSL 11C	58987	72779	143.7	163.7	o529	231.3	17.18	group2
HSP 60A	55161	71581	182.0	184.5	o530	201.1	78.54	group2
HSP 76A	54580	71501	174.9	179.9	o531	196.1	100.00	group2
HSP 76B	54581	71503	185.9	190.9	o532	198.5	40.28	group2
NEP 1D	57021	80391	183.7	193.8	o533	192.0	60.80	group2
NEP 2D	57344	79983	190.3	200.4	o534	195.6	4.52	group2
NEP 3D	59278	78358	183.9	193.9	o535	194.8	18.18	group2
NEP 4D	59896	78122	186.7	196.7	o536	191.8	100.00	group2
NWP 1B	56559	77616	171.3	181.4	o537	211.4	4.16	group2
NWP 1D	56572	77632	202.6	212.7	o538	211.3	8.69	group2
NWP 2D	56810	79307	192.3	202.3	o539	201.5	67.82	group2
NWP 3C	55322	76823	189.2	199.2	o540	216.1	8.39	group2

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
NWP202C	55536	77451	173.5	183.5	o541	213.9	11.06	group2
SEP002B	54448	72463	145.8	155.8	o542	206.6	2.11	group2
SEP002D	54443	72467	172.5	182.5	o543	207.4	7.27	group2
SEP003CL	55185	73351	142.7	152.7	o544	218.9	5.77	group2
SEP003CU	55180	73356	166.6	176.6	o545	219.3	8.40	group2
SWP 1C	55268	74403	171.9	181.9	o546	219.3	6.26	group2
SWP 2C	55817	74196	171.0	181.1	o547	221.8	11.52	group2
SWP005C	53179	74644	164.6	174.6	o548	211.5	6.00	group2
SWP006C	53007	74266	170.6	180.6	o549	213.4	4.62	group2
UTR 6	56015	81561	160.7	165.7	o550	167.3	85.97	group2
UTR018R	49753	80552	145.5	150.5	o551	148.0	14.54	group2
ZBG 3	67104	76339	204.0	214.0	o552	218.7	57.84	group2
ZBG 4	67193	76069	205.4	215.4	o553	218.9	14.91	group2
ZBG 5	67287	75786	203.8	213.8	o554	217.8	44.58	group2
ZBG010D	67107	77431	199.5	214.5	o555	218.7	12.99	group2
ZBG012D	66659	78564	178.7	193.7	o556	214.2	40.92	group2
ZBG013D	66874	78632	179.7	194.7	o557	213.7	5.99	group2
ZBG014D	67038	78358	175.1	190.1	o558	215.8	7.12	group2
BGO 3A	58807	75562	103.7	113.7	o559	161.3	100.00	group1
BGO 6A	58317	76487	107.5	117.5	o560	157.9	100.00	group1
BGO 8AR	57618	76599	94.6	104.6	o561	157.8	86.78	group1
BGO 9AA	57372	76976	73.8	83.8	o562	156.0	34.84	group1
BGO 10AA	56990	76998	80.8	90.8	o563	156.3	48.32	group1
BGO 10AR	57064	76806	96.5	106.5	o564	156.9	56.21	group1
BGO 12AX	56258	76835	99.5	109.5	o565	155.9	67.62	group1
BGO 14AR	55789	76352	96.8	106.8	o566	156.9	36.81	group1
BGO 16AR	56217	75743	103.7	113.7	o567	159.3	100.00	group1
BGO 18A	56700	75600	99.5	109.5	o568	159.7	100.00	group1
BGO 20A	57100	74966	86.3	96.3	o569	161.1	100.00	group1
BGO 25A	55668	76158	104.1	114.1	o570	159.0	18.93	group1
BGO 26A	55014	76145	81.0	91.0	o571	156.3	67.84	group1
BGO 29A	54104	75560	102.5	112.5	o572	157.9	100.00	group1
BGO 39A	57822	73573	84.8	94.8	o573	165.5	100.00	group1
BGO 41A	55404	76469	103.3	113.3	o574	158.0	19.42	group1
BGO 43A	56253	77061	105.9	115.9	o575	155.5	16.27	group1
BGO 43AA	56269	77066	62.2	72.2	o576	155.0	60.15	group1
BGO 44A	57851	76755	98.0	108.0	o577	157.1	15.78	group1
BGO 44AA	57880	76757	61.2	71.3	o578	157.9	20.76	group1
BGO 45A	54550	75830	116.9	126.9	o579	158.7	100.00	group1

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BGO 47A	54914	74729	86.8	96.8	o580	160.5	100.00	group1
BGO 49A	56205	73903	75.1	85.1	o581	164.0	100.00	group1
BGO 50A	54180	75201	90.5	100.5	o582	158.1	100.00	group1
BGO 51A	57842	74133	75.1	85.1	o583	163.8	71.88	group1
BGO 51AA	57867	74113	29.2	39.2	o584	166.3	52.86	group1
BGO 52A	57184	74632	81.7	91.7	o585	162.0	63.99	group1
BGO 52AA	57178	74638	36.6	46.6	o586	161.3	32.43	group1
BGO 53A	55424	76071	78.7	88.7	o587	157.3	11.40	group1
BGO 53AA	55431	76065	38.9	48.9	o588	156.8	42.07	group1
BGX 1A	58590	76832	114.1	124.1	o589	156.7	100.00	group1
BGX 4A	57216	77879	106.8	116.8	o590	154.4	100.00	group1
FOB 7A	50228	76063	85.4	105.4	o591	153.3	59.05	group1
FSB 76A	51391	76132	36.9	47.4	o592	154.4	100.00	group1
FSB 76B	51394	76122	99.2	109.7	o593	150.7	64.24	group1
FSB 78A	50173	74758	28.3	38.7	o594	154.7	40.23	group1
FSB 78B	50179	74766	82.4	92.8	o595	153.0	36.29	group1
FSB 79A	50150	73665	25.4	35.9	o596	157.1	100.00	group1
FSB 79B	50159	73666	80.7	91.2	o597	156.6	71.72	group1
FSB 87A	50116	75602	33.1	43.6	o598	153.0	4.38	group1
FSB 87BR	50093	75602	86.2	96.3	o599	149.2	26.30	group1
FSB 96AR	49746	74915	79.0	89.0	o600	151.6	100.00	group1
FSB 97A	49966	75171	85.8	95.8	o601	150.4	19.36	group1
FSB 98AR	50106	75362	82.1	92.1	o602	150.0	18.65	group1
FSB 99A	50315	75675	92.9	102.9	o603	149.2	25.24	group1
FSB100A	50958	75534	95.8	105.8	o604	150.1	68.63	group1
FSB101A	51191	75719	92.9	102.9	o605	150.3	35.50	group1
FSB113A	51068	74167	81.0	91.3	o606	155.4	100.00	group1
FSB114A	52047	75297	95.2	105.0	o607	154.0	100.00	group1
FSB120AR	49182	75557	92.4	102.5	o608	147.0	100.00	group1
HAA 1A	62968	69879	94.9	104.9	o609	178.4	100.00	group1
HAA 9AR	60843	72478	113.3	123.3	o610	171.8	100.00	group1
HAA 11A	61388	72423	108.2	118.2	o611	171.8	73.74	group1
HAA 12A	61726	72424	109.0	119.0	o612	172.3	53.83	group1
HAA 13A	62000	72423	109.0	118.4	o613	173.3	21.12	group1
HAA 14A	62356	72355	90.2	100.2	o614	173.7	50.88	group1
HAA 15A	62770	72350	103.4	113.4	o615	174.4	100.00	group1
HGW 3A	62795	73565	101.1	111.2	o616	170.3	100.00	group1
HIW 2A	56753	73250	78.3	88.3	o617	166.7	24.63	group1
HSB 65A	58436	72436	62.5	73.2	o618	170.4	100.00	group1

Well ID	SRS E (ft)	SRS N (ft)	Screen bottom (ft)	Screen top (ft)	PEST ID	Target value (ft)	Weight (if used)	Observation group
HSB 68A	56892	71527	47.5	58.0	o619	170.9	58.73	group1
HSB 69A	56465	71549	83.1	93.1	o620	171.3	46.46	group1
HSB 83A	58606	71649	65.2	76.0	o621	171.6	71.00	group1
HSB 84A	56359	71586	64.7	75.9	o622	170.3	100.00	group1
HSB 85A	58943	73792	61.1	71.1	o623	167.2	100.00	group1
HSB 86A	55986	72520	63.1	73.9	o624	167.8	70.01	group1
HSB117A	55170	72734	84.8	94.8	o625	165.5	100.00	group1
HSB118A	55776	72696	91.0	101.0	o626	166.1	33.71	group1
HSB119A	56100	73082	93.3	103.3	o627	165.5	53.07	group1
HSB120A	56432	73395	91.0	101.0	o628	164.8	32.34	group1
HSB121A	57390	72025	88.3	98.3	o629	170.0	69.57	group1
HSB122A	57747	72196	85.4	95.4	o630	169.9	55.22	group1
HSB123A	58125	72190	93.6	103.6	o631	170.0	26.70	group1
HSB124AR	58532	72203	94.6	104.6	o632	170.2	71.72	group1
HSB139A	57365	71127	87.6	97.6	o633	172.0	100.00	group1
HSB140A	56535	70050	81.0	91.0	o634	174.4	100.00	group1
HSB141A	59169	71214	80.6	90.6	o635	174.0	100.00	group1
HSB144A	56201	71892	78.6	88.6	o636	169.0	100.00	group1
HSB146A	58454	70479	85.5	95.5	o637	174.7	100.00	group1
NWP302A	55457	77485	69.4	79.4	o638	154.0	100.00	group1
NWP303A	55134	77452	115.7	125.7	o639	151.8	100.00	group1

Appendix D. Hydraulic head targets and residuals for PEST.47, 51, 52 and 53

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
BGO 1D	58779	73738	225	245	3	234.9	234.9	0	235.07	0.17	237.91	3.01	236.08	1.18
BGO 2D	58810	74553	221.7	241.7	3	231.1	232.35	1.25	233.04	1.94	235.86	4.76	234.37	3.27
BGO 3DR	58820	75512	217.5	237.6	3	228.3	228.08	-0.22	230.08	1.78	230.05	1.75	230.95	2.65
BGO 4D	58804	76150	220.2	240.2	3	226.1	225.13	-0.97	227.91	1.81	224.78	-1.32	227.89	1.79
BGO 5D	58785	76477	218.8	238.8	3	225.6	223.13	-2.47	226.47	0.87	220.9	-4.7	225.67	0.07
BGO 6D	58297	76487	217.2	237.2	3	226.3	224.6	-1.7	227.73	1.43	223.71	-2.59	227.52	1.22
BGO 7D	57917	76494	220.2	240.2	3	226.3	225.06	-1.24	228.2	1.9	225.78	-0.52	228.35	2.05
BGO 8D	57618	76589	220.6	240.6	3	226.6	225.45	-1.15	228.54	1.94	226.65	0.05	228.65	2.05
BGO 10DR	57074	76805	218.3	238.3	3	226.3	224.58	-1.72	228.02	1.72	223.68	-2.62	226.71	0.41
BGO 11DR	56650	76849	213.1	233	3	226.2	223.74	-2.46	227.12	0.92	222.64	-3.56	224.77	-1.43
BGO 12CX	56215	76835	212.7	232.8	3	215.8	222.65	6.85	226	10.2	222.34	6.54	223.95	8.15
BGO 13DR	55840	76825	210.3	220.3	3	226	221.16	-4.84	223.33	-2.67	221.22	-4.78	221.77	-4.23
BGO 14DR	55789	76322	218.1	238.1	3	225.7	225.76	0.06	228.44	2.74	227.47	1.77	228.51	2.81
BGO 15D	55859	75973	218.7	238.7	3	225.7	225.82	0.12	228.03	2.33	228.21	2.51	228.61	2.91
BGO 16D	56202	75751	217.3	237.3	3	226	226.56	0.56	228.86	2.86	229.3	3.3	229.62	3.62
BGO 17DR	56407	75604	216.9	236.9	3	226.6	226.77	0.17	228.83	2.23	229.86	3.26	229.8	3.2
BGO 18D	56711	75600	219.6	239.6	3	229	227.26	-1.74	229.24	0.24	230.37	1.37	230.25	1.25
BGO 20D	57114	74962	216.3	236.3	3	228.9	228.08	-0.82	229.53	0.63	231.5	2.6	230.8	1.9
BGO 21D	57471	74688	217.7	237.7	3	229.9	229.03	-0.87	230.2	0.3	232.69	2.79	231.67	1.77
BGO 22DX	57771	74560	217.9	237.9	3	230.4	230.35	-0.05	231.15	0.75	234.07	3.67	232.7	2.3
BGO 23D	58133	74238	222	242	3	231.5	231.84	0.34	232.26	0.76	235.41	3.91	233.82	2.32
BGO 24D	58439	74012	221	241	3	232.9	233.25	0.35	233.44	0.54	236.63	3.73	234.9	2
BGO 26D	55015	76128	213.4	233.5	3	223.7	221.25	-2.45	223.6	-0.1	222.49	-1.21	222.99	-0.71
BGO 27D	54680	75677	209.3	229.3	3	222.5	223.47	0.97	225.31	2.81	226.32	3.82	226.31	3.81
BGO 28D	54458	75348	210.1	230.1	3	221.4	222.85	1.45	224.1	2.7	225.74	4.34	225.37	3.97
BGO 29D	54099	75593	208.5	228.5	3	221.6	222.91	1.31	224.29	2.69	226.11	4.51	225.54	3.94

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
BGO 30D	54499	75188	207.8	227.8	3	221.4	222.57	1.17	223.44	2.04	225.31	3.91	224.8	3.4
BGO 31D	54842	74985	211.1	231.1	3	222	222.86	0.86	223.41	1.41	225.68	3.68	224.85	2.85
BGO 32D	55250	74727	214.5	234.5	3	222.7	224.3	1.6	224.94	2.24	227.21	4.51	226.24	3.54
BGO 33D	55695	74469	213.1	233.1	3	225.4	224.93	-0.47	225.37	-0.03	227.67	2.27	226.56	1.16
BGO 34D	56083	74229	212.7	232.7	3	227.5	225.7	-1.8	225.99	-1.51	228.26	0.76	227.21	-0.29
BGO 35D	56557	73946	219.4	239.4	3	229.3	227.27	-2.03	227.29	-2.01	229.57	0.27	228.76	-0.54
BGO 36D	56888	73744	223.3	243.3	3	232.9	228.56	-4.34	228.63	-4.27	231.35	-1.55	230.12	-2.78
BGO 37D	57293	73491	226.1	246.1	3	234.2	230.28	-3.92	230.15	-4.05	232.83	-1.37	231.39	-2.81
BGO 38D	57558	73329	222.3	242.3	3	232.6	230.97	-1.63	230.6	-2	233.48	0.88	231.7	-0.9
BGO 39D	57831	73583	224.7	244.7	3	231.1	231.72	0.62	231.61	0.51	234.41	3.31	232.91	1.81
BGO 40D	54638	76126	216.6	226.5	3	217.3	223.84	6.54	226.11	8.81	227.11	9.81	227.11	9.81
BGO 43D	56239	77057	198.2	208.2	3	226.4	219.67	-6.73	221.93	-4.47	220.99	-5.41	222.2	-4.2
BGO 44D	57910	76759	223.4	233.4	3	226.3	224.57	-1.73	227.9	1.6	225.73	-0.57	228.03	1.73
BGO 45D	54585	75854	209.6	229.6	3	222.5	223.3	0.8	225.12	2.62	226.42	3.92	226.23	3.73
BGO 46D	54420	75034	202.1	212.1	3	221.2	222.04	0.84	222.48	1.28	224.53	3.33	223.86	2.66
BGO 47D	54923	74740	203.4	213.4	3	222	222.96	0.96	223.16	1.16	225.54	3.54	224.4	2.4
BGO 48D	55121	74586	202	212	3	221.6	223.46	1.86	223.74	2.14	226.05	4.45	224.89	3.29
BGO 49D	56199	73932	218.5	238.5	3	228.9	226.28	-2.62	226.29	-2.61	228.45	-0.45	227.57	-1.33
BGO 50D	54209	75181	208	228	3	220.9	222.32	1.42	223.09	2.19	225.06	4.16	224.46	3.56
BGO 51D	57861	74118	220.1	240.1	3	231.1	231.47	0.37	231.76	0.66	234.95	3.85	233.34	2.24
BGO 52D	57201	74617	219.4	239.4	3	229.2	228.51	-0.69	229.53	0.33	232.02	2.82	230.99	1.79
BGO 53D	55426	76056	225.3	245.3	3	227.4	224.97	-2.43	227.28	-0.12	227.33	-0.07	227.87	0.47
BGX 1D	58609	76809	214.7	234.7	3	224.9	222.29	-2.61	225.97	1.07	220.72	-4.18	225.54	0.64
BGX 9D	59522	76936	212.4	232.4	3	223.7	217.41	-6.29	221.94	-1.76	215.7	-8	221.98	-1.72
BGX 10D	59765	76183	216.2	236.2	3	223.1	221.92	-1.18	224.49	1.39	222.59	-0.51	225.58	2.48
BGX 11D	59581	75301	216.7	236.7	3	231.1	227.67	-3.43	229.08	-2.02	229.44	-1.66	229.94	-1.16
BGX 12D	59674	74411	223.7	243.7	3	234.5	232.69	-1.81	233.27	-1.23	235.22	0.72	234.08	-0.42
BRR 1D	50588	77365	200.4	220.4	3	210.8	209.82	-0.98	213.74	2.94	209.84	-0.96	215.04	4.24

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
BRR 5D	50009	77267	202.1	222.1	3	208.1	205.48	-2.62	209.92	1.82	204.08	-4.02	209.6	1.5
BRR 6D	51088	77071	199.4	219.3	3	201.9	213.23	11.33	216.6	14.7	214.77	12.87	218.49	16.59
BSE 1D1	57156	73212	223.8	226.3	3	232.9	228.61	-4.29	227.85	-5.05	230.63	-2.27	228.97	-3.93
BSE 1D3	57156	73212	201.2	203.7	3	231.8	227.91	-3.89	227.23	-4.57	229.51	-2.29	227.82	-3.98
BSE 2D1	56898	73286	223.7	226.2	3	231.2	227.9	-3.3	227.13	-4.07	230.08	-1.12	228.46	-2.74
BSE 2D2	56898	73286	211.2	213.7	3	224.7	227.75	3.05	227.07	2.37	229.86	5.16	228.28	3.58
BSE 2D3	56898	73286	201.2	203.7	3	227.4	227.19	-0.21	226.51	-0.89	228.93	1.53	227.3	-0.1
BSE 3D1	56973	72700	219.9	222.4	3	228	226.92	-1.08	225.36	-2.64	228.09	0.09	225.9	-2.1
BSE 3D3	56973	72700	202.3	204.8	3	227.2	226.63	-0.57	225.24	-1.96	227.86	0.66	225.76	-1.44
BSE 3D4	56973	72700	189.8	192.3	3	227.8	222.43	-5.37	220.51	-7.29	221.93	-5.87	219.33	-8.47
BSW 1D1	53958	74668	212.7	215.2	3	218.3	219.97	1.67	219.48	1.18	222.19	3.89	221.18	2.88
BSW 1D2	53958	74668	203.2	205.7	3	218.2	219.85	1.65	219.42	1.22	222.16	3.96	221.15	2.95
BSW 1D3	53958	74668	191.6	194.1	3	217.3	218.44	1.14	218.03	0.73	219.02	1.72	218.57	1.27
BSW 2D1	54219	74444	214.1	216.6	3	219.2	219.99	0.79	219.12	-0.08	222.26	3.06	220.83	1.63
BSW 2D2	54219	74444	207.6	210.1	3	220.5	219.91	-0.59	219.08	-1.42	222.18	1.68	220.77	0.27
BSW 3D1	54586	74266	215.8	218.3	3	220.4	221.45	1.05	220.69	0.29	223.72	3.32	222.15	1.75
BSW 3D2	54586	74266	202.3	204.8	3	221.5	221.32	-0.18	220.63	-0.87	223.52	2.02	221.97	0.47
BSW 4D1	54898	74137	216.7	219.2	3	221.4	221.36	-0.04	220.37	-1.03	223.34	1.94	221.64	0.24
BSW 4D2	54898	74137	202.2	204.7	3	220.4	221.16	0.76	220.29	-0.11	223.03	2.63	221.33	0.93
BSW 5D1	53678	74310	211.6	214.1	3	216.8	216.93	0.13	215.82	-0.98	218.66	1.86	218.02	1.22
BSW 5D2	53678	74310	201	203.6	3	216.6	216.8	0.2	215.77	-0.83	218.61	2.01	217.99	1.39
BSW 6D2	53385	73757	204	206.5	3	212.6	211.09	-1.51	209.54	-3.06	210.82	-1.78	212.43	-0.17
BSW 6D3	53385	73757	195.5	198	3	212.9	210.96	-1.94	209.48	-3.42	210.63	-2.27	212.35	-0.55
BSW 7D1	53845	73834	205.8	208.3	3	214.2	212.24	-1.96	211.28	-2.92	214.08	-0.12	213.51	-0.69
BSW 7D2	53845	73834	196.3	198.8	3	215.5	211.95	-3.55	211.07	-4.43	213.72	-1.78	213.21	-2.29
BSW 8D1	54328	73624	207.9	210.4	3	217.1	214.24	-2.86	212.83	-4.27	216.08	-1.02	214.74	-2.36
BSW 8D3	54328	73624	189.9	192.4	3	216.3	213.52	-2.78	212.32	-3.98	215.02	-1.28	213.89	-2.41
FBI 13D	50240	74166	162.1	172.1	3	204.3	202.46	-1.84	202.01	-2.29	202.68	-1.62	202.23	-2.07

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
FBI 15D	50346	73698	178.9	188.9	3	198.1	197.37	-0.73	196.71	-1.39	197.88	-0.22	197.21	-0.89
FBI 16D	50243	73992	168.1	178.1	3	204	201.33	-2.67	200.77	-3.23	201.65	-2.35	200.95	-3.05
FBI 17D	50169	73783	172	182.7	3	199.2	199.69	0.49	199.08	-0.12	200.17	0.97	199.41	0.21
FCB 2D	55046	76698	224.9	235	3	227.4	224.49	-2.91	227.41	0.01	227.91	0.51	228.35	0.95
FCB002DR	55243	76543	221.5	241.5	3	224.7	224.97	0.27	227.71	3.01	227.62	2.92	228.25	3.55
FGW012 D	49823	76603	189	209	3	207	205.35	-1.65	208.75	1.75	205.6	-1.4	209.62	2.62
FIB 1	50094	73908	176.5	186.5	3	204.2	199.91	-4.29	199.34	-4.86	200.36	-3.84	199.64	-4.56
FIB 8	50242	73963	169.5	179.5	3	204.5	201.49	-3.01	200.94	-3.56	201.83	-2.67	201.12	-3.38
FOB 1D	50027	73813	175.4	195.4	3	203.2	199.95	-3.25	199.35	-3.85	200.37	-2.83	199.64	-3.56
FOB 2D	49528	73974	175.5	195.5	3	203.6	199.99	-3.61	199.49	-4.11	200.57	-3.03	199.91	-3.69
FOB 4D	49338	74430	174	194.1	3	204.8	202.55	-2.25	202.44	-2.36	203.16	-1.64	202.73	-2.07
FOB 8D	49940	75772	191.4	211.4	3	210.1	206.54	-3.56	208.62	-1.48	207.16	-2.94	209.33	-0.77
FOB 9D	50783	75775	192.6	212.6	3	212.4	211.18	-1.22	212.74	0.34	212.28	-0.12	213.84	1.44
FOB 10D	51050	75661	195.6	215.5	3	213.1	211.92	-1.18	213.38	0.28	213.11	0.01	214.49	1.39
FOB 13D	50630	73836	175	185	3	199.7	199.34	-0.36	198.81	-0.89	199.64	-0.06	199.11	-0.59
FOB 16D	49976	74565	163.6	183.7	3	205.8	204.33	-1.47	204.21	-1.59	204.68	-1.12	204.31	-1.49
FPZ008AR	50558	73249	174.3	176.3	3	188	192.56	4.56	191.64	3.64	191.98	3.98	191.32	3.32
FRB 1	53915	76229	212.2	232.2	3	222.2	223.07	0.87	225.25	3.05	226.8	4.6	226.5	4.3
FRB 2	53600	76250	213.6	228.6	3	220.7	222.69	1.99	224.52	3.82	226.21	5.51	225.68	4.98
FRB 3	53588	76117	216.2	231.2	3	220.8	222.71	1.91	224.53	3.73	226.21	5.41	225.69	4.89
FRB 4	53653	76076	214.6	229.6	3	221.8	222.7	0.9	224.52	2.72	226.21	4.41	225.68	3.88
FSB 76	51389	76141	197	227	3	213.1	213.91	0.81	216.19	3.09	214.8	1.7	217.54	4.44
FSB 77	50713	75129	186.4	216.4	3	210.5	209.47	-1.03	210.25	-0.25	210.88	0.38	211.02	0.52
FSB 78	50165	74764	187.7	217.7	3	206.1	206.96	0.86	207.44	1.34	207.82	1.72	207.88	1.78
FSB 79	50140	73663	174.1	204.1	3	198.2	197.72	-0.48	197.06	-1.14	198.35	0.15	197.61	-0.59
FSB 87D	50081	75586	187.4	216.8	3	208.3	207.12	-1.18	208.7	0.4	207.83	-0.47	209.32	1.02
FSB 88D	51527	75622	202.1	222.1	3	212.1	213.4	1.3	214.63	2.53	214.73	2.63	215.59	3.49
FSB 89D	51336	75548	201.9	221.9	3	211.7	213.42	1.72	214.7	3	214.75	3.05	215.62	3.92

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
FSB 90D	51141	75377	205.1	225.1	3	211.1	212.23	1.13	213.45	2.35	213.45	2.35	214.15	3.05
FSB 91D	50946	75207	200.9	220.9	3	210.1	210.33	0.23	211.18	1.08	211.69	1.59	211.79	1.69
FSB 92D	50558	75046	201.7	221.7	3	208.7	208.45	-0.25	209.24	0.54	209.77	1.07	209.88	1.18
FSB 93D	50452	74888	197.9	217.9	3	207.8	207.58	-0.22	208.1	0.3	208.86	1.06	208.62	0.82
FSB 94DR	50163	74869	183.3	203.4	3	207	206.32	-0.68	206.79	-0.21	206.93	-0.07	207.11	0.11
FSB 95DR	49996	74992	187	207	3	206.8	206.24	-0.56	206.68	-0.12	206.85	0.05	207.01	0.21
FSB 97D	49976	75189	196.9	216.9	3	207.3	206.72	-0.58	207.87	0.57	207.45	0.15	208.28	0.98
FSB 98D	50112	75372	200.3	220.3	3	208.1	207.83	-0.27	209.13	1.03	208.82	0.72	209.69	1.59
FSB 99D	50327	75692	198.1	218.1	3	209	208.38	-0.62	210.05	1.05	209.21	0.21	210.86	1.86
FSB105DR	49841	75258	188.5	208.6	3	209.1	206.95	-2.15	208.28	-0.82	207.66	-1.44	208.79	-0.31
FSB106D	50637	74193	202.9	222.9	3	205	203.59	-1.41	202.92	-2.08	204.32	-0.68	203.49	-1.51
FSB107D	51150	75177	200.9	220.9	3	211.7	211.59	-0.11	212.53	0.83	212.87	1.17	213.11	1.41
FSB108D	51142	76261	203.8	223.8	3	212.6	213.2	0.6	215.52	2.92	214.09	1.49	216.93	4.33
FSB109D	50489	75856	205.8	225.8	3	209.6	209.67	0.07	211.4	1.8	210.46	0.86	212.4	2.8
FSB110D	50142	74193	191.1	211.1	3	204.5	203.65	-0.85	203.29	-1.21	204	-0.5	203.36	-1.14
FSB111D	51516	75383	201.7	221.7	3	213.3	213.58	0.28	214.42	1.12	215.05	1.75	215.19	1.89
FSB113D	51098	74155	189.6	209.6	3	205.3	205.29	-0.01	204.68	-0.62	206.49	1.19	205.63	0.33
FSB114D	52019	75279	197.7	217.8	3	212.7	215.09	2.39	215.71	3.01	216.75	4.05	216.6	3.9
FSB117D	50487	74070	189.7	209.7	3	203.8	201.9	-1.9	201.13	-2.67	202.25	-1.55	201.4	-2.4
FSB118D	51276	74698	191.3	211.3	3	208.3	208.85	0.55	208.56	0.26	210.29	1.99	209.49	1.19
FSB119D	50600	74600	193.1	213.1	3	206.7	206.73	0.03	206.73	0.03	207.96	1.26	207.33	0.63
FSB120D	49164	75569	196.5	216.5	3	205.3	203.66	-1.64	205.63	0.33	204.39	-0.91	206.78	1.48
FSB121DR	48430	75152	191.3	211.3	3	204.7	200.95	-3.75	202.49	-2.21	203.52	-1.18	204.52	-0.18
FSB123D	51735	74563	194.1	214.1	3	208.8	210.52	1.72	209.79	0.99	211.36	2.56	210.78	1.98
FSB124D	49179	74791	180.3	190.3	3	204.9	203.37	-1.53	204.01	-0.89	204.11	-0.79	204.66	-0.24
FSB125D	50238	74400	176	186	3	206.5	204.58	-1.92	204.37	-2.13	204.99	-1.51	204.54	-1.96
FSB125DR	50246	74380	175.8	185.8	3	204.8	204.58	-0.22	204.37	-0.43	204.98	0.18	204.54	-0.26
FSB126D	49977	74159	173.1	183.1	3	204.1	201.71	-2.39	201.24	-2.86	201.92	-2.18	201.32	-2.78

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
FSB127D	50961	73861	177.1	182.1	3	198.1	200.76	2.66	200.24	2.14	201.02	2.92	200.49	2.39
FSB130D	49813	73915	187	197	3	202.6	200.17	-2.43	199.57	-3.03	200.56	-2.04	199.84	-2.76
FSB131D	49736	73848	188.1	198.1	3	202.2	200.22	-1.98	199.66	-2.54	200.74	-1.46	200.02	-2.18
FSB139D	50972	74193	180.4	200.4	3	205.3	205.16	-0.14	204.67	-0.63	206.2	0.9	205.39	0.09
FSB141D	51010	74106	183.1	198.2	3	199.7	203.29	3.59	202.72	3.02	204.11	4.41	203.32	3.62
FSL 1D	52993	79063	208.5	228.6	3	221.8	213.33	-8.47	218.48	-3.32	219.73	-2.07	221.92	0.12
FSL 2D	52791	78637	208.7	228.8	3	222.1	215.3	-6.8	219.72	-2.38	221.6	-0.5	223.33	1.23
FSL 3D	52465	77765	205.9	226	3	218.2	218.06	-0.14	221.77	3.57	223.5	5.3	224.9	6.7
FSL 4D	52230	77452	204	224.1	3	214	217.76	3.76	221.18	7.18	222.19	8.19	223.82	9.82
FSL 5D	51903	77048	203.5	223.7	3	215.6	217.13	1.53	219.97	4.37	219.49	3.89	221.9	6.3
FSL 6D	51728	76733	202.1	222.1	3	214.8	215.99	1.19	218.75	3.95	217.3	2.5	220.45	5.65
FSL 7D	51486	76328	199.5	219.6	3	213.1	213.17	0.07	215.7	2.6	214.11	1.01	216.71	3.61
FSL 8D	51513	76055	202.7	222.8	3	212.6	214.36	1.76	216.24	3.64	215.32	2.72	217.35	4.75
FSL 9D	51544	75768	201.4	221.5	3	212.6	213.91	1.31	215.48	2.88	215.14	2.54	216.53	3.93
FSS 2D	53919	75103	204.4	224.4	3	219.3	221.43	2.13	221.77	2.47	224.02	4.72	223.26	3.96
FSS 3D	53548	74961	205.8	225.8	3	217.5	219.86	2.36	219.83	2.33	222.29	4.79	221.47	3.97
FSS 4D	52876	75538	202.6	222.6	3	213.9	219.27	5.37	220.03	6.13	222.16	8.26	221.71	7.81
FTF 22	52495	76751	212.6	242.6	3	216.6	219.53	2.93	222.15	5.55	223.13	6.53	224.1	7.5
FTF 23	52660	76612	201.2	231.2	3	216.7	219.64	2.94	221.95	5.25	222.82	6.12	223.44	6.74
FTF009R	52370	77604	203	213	3	216.3	217.49	1.19	221.11	4.81	222.43	6.13	224.04	7.74
FTF030D	52287	76885	213.4	223.4	3	215.7	218.84	3.14	221.49	5.79	222.1	6.4	223.5	7.8
HAA 1D	62991	69859	261.8	281.8	3	269.7	277.24	7.54	275.97	6.27	275.5	5.8	272.57	2.87
HAA 2D	61251	70945	260.3	280.4	3	272.9	272.35	-0.55	271.63	-1.27	266.82	-6.08	263.12	-9.78
HAA 4D	61890	72223	255.7	275.7	3	267.6	268.17	0.57	268.16	0.56	262.97	-4.63	260.02	-7.58
HAA 5D	62673	70592	268.6	288.8	3	274.6	278.94	4.34	278.64	4.04	273.29	-1.31	270.95	-3.65
HAA 7D	60807	71771	252	272.1	3	268.5	267.46	-1.04	266.22	-2.28	261.43	-7.07	257.82	-10.68
HAA 8D	60609	72166	252.1	272.1	3	266.4	259.62	-6.78	257.73	-8.67	257.19	-9.21	253.4	-13
HAA 9D	60856	72511	247.7	267.8	3	261.9	257.2	-4.7	255.78	-6.12	255.91	-5.99	252.22	-9.68

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
HAA 10D	61205	72308	253	273	3	265.3	263.51	-1.79	262.42	-2.88	259.63	-5.67	256.25	-9.05
HAA 11D	61407	72421	254.8	274.8	3	264.5	262.13	-2.37	261.19	-3.31	258.94	-5.56	255.75	-8.75
HAA 12D	61759	72425	244.7	264.7	3	266.5	263.95	-2.55	263.4	-3.1	260.2	-6.3	257	-9.5
HAA 13D	62039	72419	259.4	278.6	3	267.3	265.26	-2.04	264.78	-2.52	261.3	-6	258.23	-9.07
HAA 14D	62386	72355	253	273	3	267.4	266.44	-0.96	266.01	-1.39	262.76	-4.64	259.69	-7.7
HAA 15D	62770	72327	255.9	275.9	3	267.9	263.92	-3.98	263.2	-4.7	262.06	-5.84	258.9	-9
HC 1D	61867	71746	206.5	211.5	3	266.1	267.06	0.96	269.66	3.56	261.35	-4.75	258.68	-7.42
HCB 2	63798	71290	239.9	269.9	3	268.6	265.81	-2.79	264.65	-3.95	264.22	-4.38	261.9	-6.7
HGW 1D	60574	73356	207.8	227.9	3	243.4	243.67	0.27	242.77	-0.63	245.1	1.7	242.14	-1.26
HGW 2D	61584	74197	208.4	228.5	3	233.2	235.22	2.02	234.06	0.86	234.15	0.95	233.62	0.42
HGW 4D	65861	72713	212.6	232.7	3	233.4	234.18	0.78	231.05	-2.35	233.48	0.08	231.52	-1.88
HHP 1D	60534	71027	260.4	270.4	3	270.9	263.89	-7.01	261.59	-9.31	261.99	-8.91	255.32	-15.58
HHP 2D	60803	70886	263.2	273.2	3	273.5	268.78	-4.72	267.02	-6.48	264.77	-8.73	258.76	-14.74
HOB 1D	56918	72993	204.2	224.2	3	229.2	227.35	-1.85	226.42	-2.78	229.25	0.05	227.52	-1.68
HOB 2D	57274	72812	200.4	220.4	3	228.7	228.49	-0.21	227.32	-1.38	229.9	1.2	227.91	-0.79
HOB 3D	58035	72326	207.7	227.7	3	229	231.85	2.85	230.22	1.22	232.34	3.34	229.96	0.96
HOB 4D	58370	72224	210.4	230.4	3	230.7	232.7	2	231.13	0.43	233.34	2.64	231.05	0.35
HOB 5D	58619	72273	214	234	3	233.4	235.06	1.66	233.57	0.17	236.21	2.81	234	0.6
HOB 6D	57421	70578	186.9	196.9	3	208.3	211.53	3.23	209.77	1.47	210.71	2.41	209.5	1.2
HOB 7D	56289	71880	197.4	217.4	3	217	220.55	3.55	218.28	1.28	220.95	3.95	219.08	2.08
HPZ 1A	55676	71301	186	192.5	3	201.5	205.74	4.24	204.49	2.99	204.69	3.19	203.85	2.35
HPZ 2A	56151	71692	207.2	212.2	3	214.6	216.83	2.23	215.22	0.62	217.35	2.75	216.27	1.67
HPZ 4A	56573	71155	197	199.5	3	209.5	213.74	4.24	212.42	2.92	213.41	3.91	212.01	2.51
HPZ 5A	56890	70995	204.3	206.8	3	211.2	211.02	-0.18	209.67	-1.53	210.35	-0.85	209.62	-1.58
HPZ 6AR	56904	70709	191.5	194	3	204.3	209.15	4.85	207.63	3.33	208.1	3.8	206.73	2.43
HR3 15DU	59962	71364	234.1	254.1	3	248.9	253.95	5.05	250.51	1.61	253.09	4.19	247.87	-1.03
HR3 16DU	59772	71388	230	240	3	247.4	249.53	2.13	246.6	-0.8	249.24	1.84	244.94	-2.46
HR8 11	59560	71946	207.9	237.6	3	244.8	242.46	-2.34	240.35	-4.45	242.81	-1.99	239.89	-4.91

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
HSB 65	58432	72426	212.4	242.4	3	231.6	233.43	1.83	232.09	0.49	234.31	2.71	232.57	0.97
HSB 65C	58447	72440	207.8	218.6	3	231	234.42	3.42	233.1	2.1	235.47	4.47	233.66	2.66
HSB 66DR	56924	72441	188.6	208.6	3	226	224.64	-1.36	222.79	-3.21	225.19	-0.81	222.76	-3.24
HSB 67	58424	71505	200.7	230.7	3	222.4	227.02	4.62	225.38	2.98	226.79	4.39	224.82	2.42
HSB 68DR	56867	71511	205.7	225.8	3	218.4	221.22	2.82	218.57	0.17	220.76	2.36	218.4	0
HSB 69	56475	71547	199	229	3	215.5	217.02	1.52	215.04	-0.46	216.81	1.31	215.22	-0.28
HSB 70	55759	72607	205.7	235.7	3	219	221.43	2.43	219.65	0.65	221.09	2.09	219.51	0.51
HSB 71	55279	72876	204.8	234.8	3	219.9	220.48	0.58	218.8	-1.1	220.1	0.2	218.65	-1.25
HSB 83D	58602	71628	198.7	228.7	3	223.3	229.36	6.06	228.52	5.22	229.42	6.12	227.91	4.61
HSB 84D	56350	71584	199.5	219.5	3	215.3	214.3	-1	213.22	-2.08	214.34	-0.96	213.93	-1.37
HSB 85C	58947	73802	214.2	224.2	3	235.8	234.93	-0.87	234.98	-0.82	238.26	2.46	236.21	0.41
HSB 86C	55985	72530	189.4	199.4	3	219.5	221.75	2.25	219.97	0.47	221.05	1.55	219.53	0.03
HSB 86D	55997	72522	206.6	236.6	3	220.1	222.15	2.05	220.29	0.19	221.7	1.6	220.08	-0.02
HSB100D	58797	72074	216.9	236.9	3	231.8	235.33	3.53	233.98	2.18	236.52	4.72	234.19	2.39
HSB101D	58595	71997	216.1	236.1	3	229.1	233.96	4.86	232.48	3.38	234.97	5.87	232.47	3.37
HSB102D	58393	71952	216.3	236.3	3	226.8	231.45	4.65	229.78	2.98	231.84	5.04	229.19	2.39
HSB103D	58316	71588	213.7	233.7	3	223.8	227.08	3.28	225.44	1.64	226.86	3.06	224.87	1.07
HSB104D	58076	71370	210.6	230.6	3	223.4	224.32	0.92	221.94	-1.46	223.87	0.47	221.8	-1.6
HSB105D	57877	71455	211.8	231.8	3	223.9	224.17	0.27	221.34	-2.56	223.47	-0.43	221.06	-2.84
HSB106D	57645	71728	210.7	230.7	3	224.4	225.62	1.22	222.74	-1.66	225.21	0.81	222.26	-2.14
HSB107D	57412	71697	215.1	235.1	3	223	224.83	1.83	221.95	-1.05	224.43	1.43	221.61	-1.39
HSB108D	57146	71688	212	232	3	221.5	223.99	2.49	221.25	-0.25	223.73	2.23	220.95	-0.55
HSB109D	56885	71686	213	233	3	219	221.23	2.23	218.57	-0.43	220.76	1.76	218.38	-0.62
HSB110D	56672	71785	211.4	231.4	3	217	222.54	5.54	220	3	222.9	5.9	220.4	3.4
HSB111D	56495	71926	185.7	195.7	3	216.7	220.86	4.16	218.55	1.85	220.92	4.22	218.93	2.23
HSB111E	56487	71933	211.7	231.7	3	216.4	220.82	4.42	218.5	2.1	221.42	5.02	219.4	3
HSB112E	56400	72167	211.7	231.7	3	221.9	222.38	0.48	220.15	-1.75	222.87	0.97	220.73	-1.17
HSB113DR	56154	72324	194.4	214.4	3	218.5	221.59	3.09	219.57	1.07	221.39	2.89	219.62	1.12

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
HSB114D	56104	72474	212.8	232.8	3	219.2	221.89	2.69	219.89	0.69	221.76	2.56	219.95	0.75
HSB115D	56040	72662	213.9	233.9	3	220.2	222.78	2.58	220.93	0.73	222.45	2.25	220.73	0.53
HSB116D	55988	72898	214.5	234.5	3	220.9	223.21	2.31	221.5	0.6	222.9	2	221.37	0.47
HSB117D	55156	72748	200.3	220.3	3	221.6	218.22	-3.38	216.51	-5.09	218.04	-3.56	216.61	-4.99
HSB119D	56117	73104	204.9	224.8	3	223.5	225.21	1.71	223.77	0.27	225.47	1.97	224.4	0.9
HSB120D	56412	73377	213	223	3	226.3	226.73	0.43	225.85	-0.45	228.43	2.13	227.22	0.92
HSB121D	57390	72069	205.1	215.1	3	225.9	227.69	1.79	225.34	-0.56	227.95	2.05	225.01	-0.89
HSB122D	57733	72194	204.6	214.6	3	226.7	229.48	2.78	227.4	0.7	229.85	3.15	226.98	0.28
HSB125D	58584	71498	199.4	219.4	3	220.1	226.59	6.49	226.12	6.02	226.88	6.78	225.73	5.63
HSB126D	57170	70633	190.5	200.5	3	205.4	208.13	2.73	207.65	2.25	207.89	2.49	207.33	1.93
HSB127D	56788	71219	197.8	217.8	3	215.5	215.98	0.48	213.87	-1.63	214.73	-0.77	213.11	-2.39
HSB130D	54652	70757	182.1	202.1	3	199.8	199.8	-999	199.8	-999	199.8	-999	199.8	-999
HSB131D	56891	70365	195.7	205.7	3	205.3	205.3	-999	205.3	-999	205.3	-999	205.3	-999
HSB132C	58788	71472	168.6	178.6	3	220.1	228.02	7.92	227.22	7.12	228.97	8.87	227.14	7.04
HSB132D	58799	71469	206.5	226.5	3	219.5	223.81	4.31	224.22	4.72	224.63	5.13	223.96	4.46
HSB133D	59102	71943	208.5	228.5	3	234.8	236.96	2.16	235.54	0.74	238.13	3.33	235.84	1.04
HSB134D	58296	71217	205.8	225.8	3	220.6	224.63	4.03	223.1	2.5	224.62	4.02	223.04	2.44
HSB135D	56553	71397	199.9	219.9	3	215.3	217.07	1.77	215.09	-0.21	216.87	1.57	215.28	-0.02
HSB136D	55942	71906	200.2	220.2	3	216.6	218.36	1.76	216.43	-0.17	218.81	2.21	217.3	0.7
HSB137D	55696	72279	205.3	225.3	3	217.8	218.44	0.64	216.51	-1.29	218.37	0.57	216.69	-1.11
HSB138D	55261	73160	208.1	228.1	3	222.5	220.41	-2.09	218.98	-3.52	220.36	-2.14	218.99	-3.51
HSB139D	57384	71133	206.7	226.7	3	220.6	218.32	-2.28	215.31	-5.29	217.42	-3.18	215.39	-5.21
HSB140D	56561	70036	194.1	214.1	3	212.2	212.2	-999	212.2	-999	212.2	-999	212.2	-999
HSB141D	59171	71184	217.8	237.8	3	233.1	237.2	4.1	235.25	2.15	238.06	4.96	234.9	1.8
HSB143D	52775	73754	196.9	216.9	3	211.1	207.9	-3.2	206.65	-4.45	204.79	-6.31	207.6	-3.5
HSB145D	57754	71088	184.2	194.2	3	219	217.14	-1.86	214.95	-4.05	216.81	-2.19	215.63	-3.37
HSB146D	58493	70470	204	224.1	3	218.8	227.78	8.98	223.73	4.93	227.22	8.42	223.93	5.13
HSB147D	55804	73828	215.2	235.2	3	227.8	225.14	-2.66	224.69	-3.11	227.09	-0.71	225.74	-2.06

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
HSB148D	55453	70174	198.1	218.1	3	212	212	-999	212	-999	212	-999	212	-999
HSB149D	57286	71339	207	227	3	221.6	220.43	-1.17	217.46	-4.14	219.4	-2.2	217.09	-4.51
HSB150D	58693	71693	206.9	226.9	3	224.9	227.71	2.81	228.05	3.15	228.51	3.61	227.7	2.8
HSB151DR	54003	73007	191.2	196.2	3	206.7	206.94	0.24	205.88	-0.82	207.94	1.24	207.92	1.22
HSB153D	57019	72117	205.2	215.2	3	225.9	225.99	0.09	223.78	-2.12	226.63	0.73	223.94	-1.96
HSB154D	56549	72599	204.7	214.7	3	226.3	225.23	-1.07	223.73	-2.57	226.22	-0.08	224.16	-2.14
HSL 1D	58925	72180	219.8	239.8	3	233.3	236.83	3.53	235.45	2.15	238.42	5.12	236.06	2.76
HSL 2D	59423	72191	225.2	245.3	3	239	244.1	5.1	242.53	3.53	244.4	5.4	241.57	2.57
HSL 3D	59771	72251	233.7	253.8	3	247.8	247.2	-0.6	245.28	-2.52	246.59	-1.21	243.45	-4.35
HSL 4D	60172	72454	245	265.1	3	262.7	251.78	-10.92	250.15	-12.55	252.03	-10.67	247.85	-14.85
HSL 5D	60339	72562	247.8	267.7	3	266.9	254.9	-12	253.25	-13.65	254.39	-12.51	250.61	-16.29
HSL 6D	60531	72660	243.9	264	3	257.9	255.19	-2.71	253.73	-4.17	254.66	-3.24	250.88	-7.02
HSL 7D	60723	72674	242.3	262.4	3	258	254.64	-3.36	253.08	-4.92	254.09	-3.91	250.04	-7.96
HSL 8D	61117	72688	248.4	268.4	3	259.2	256.31	-2.89	255.16	-4.04	255.14	-4.06	251.79	-7.41
HSL004DR	60118	72525	237.3	247.2	3	255.1	250.79	-4.31	249.22	-5.88	250.96	-4.14	247.23	-7.87
HSL005DR	60280	72587	238.2	243.3	3	257	250.79	-6.21	249.22	-7.78	250.96	-6.04	247.23	-9.77
HSP 60B	55164	71583	193.2	198.2	3	199.8	205.61	5.81	204.91	5.11	205.55	5.75	205.1	5.3
HTF 1	62067	71745	236.9	256.9	3	271.1	271.64	0.54	272.68	1.58	264.74	-6.36	262.16	-8.94
HTF 2	62175	71610	237	257	3	272.4	272.44	0.04	273.34	0.94	265.62	-6.78	263.15	-9.25
HTF 12D	61593	71520	262.2	272.2	3	273.3	273.88	0.58	274.58	1.28	266.74	-6.56	263.93	-9.37
HTF 15D	61353	71694	264.6	274.6	3	271.1	272.66	1.56	273.01	1.91	265.89	-5.21	261.18	-9.92
NWP 3D	55324	76836	215.3	235.5	3	225.8	224.18	-1.62	227.42	1.62	226.58	0.78	227.66	1.86
NWP101D	55589	77407	213.6	223.6	3	226.3	223.12	-3.18	226.75	0.45	224.64	-1.66	226.79	0.49
SBG 6	63860	73599	208.1	238.1	3	243.9	244.32	0.42	243.67	-0.23	244.92	1.02	243.48	-0.42
SEP001MD	56485	73562	205.8	225.8	3	228	227.08	-0.92	226.54	-1.46	228.9	0.9	228	0
SWP 3D	55107	74058	213.6	218.7	3	220.5	222.92	2.42	222.2	1.7	224.73	4.23	223.14	2.64
SWP005D	53172	74641	199.4	219.4	3	214.8	216.86	2.06	216.2	1.4	218.22	3.42	217.93	3.13
SWP006D	53014	74258	201.4	221.4	3	213.5	214.21	0.71	212.98	-0.52	213.77	0.27	214.7	1.2

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
SWP04MD	53685	74321	187.4	197.4	3	215.8	216.04	0.24	215.06	-0.74	217.13	1.33	216.61	0.81
ZBG 1	65584	76584	220	240.1	3	231.7	232.48	0.78	232.44	0.74	229.16	-2.54	233.13	1.43
ZBG009D	67038	77602	197.7	212.7	3	218.8	218.23	-0.57	217.26	-1.54	219.35	0.55	218.37	-0.43
ZBG015D	65809	75448	214	234	3	234	235.55	1.55	235.14	1.14	232.82	-1.18	234.99	0.99
BGO 3C	58806	75550	178.7	188.7	2	221.5	222.49	0.99	223.19	1.69	222.26	0.76	221.28	-0.22
BGO 5C	58794	76477	183.2	193.2	2	210.6	216.59	5.99	218.31	7.71	218.14	7.54	217.66	7.06
BGO 6B	58347	76553	139.7	149.7	2	213.8	217.49	3.69	219.31	5.51	218.11	4.31	217.8	4
BGO 6C	58307	76487	158	168	2	215.4	218.7	3.3	220.36	4.96	219.26	3.86	218.75	3.35
BGO 8C	57619	76579	174.3	184.3	2	218.4	219.8	1.4	221.69	3.29	219.85	1.45	219.69	1.29
BGO 10B	56979	76982	139	149	2	214.8	213.63	-1.17	215.57	0.77	213.95	-0.85	214.17	-0.63
BGO 10C	57041	76805	157.3	167.3	2	214.7	219.38	4.68	221.53	6.83	219.83	5.13	220.06	5.36
BGO 12DR	56231	76834	141.2	151.2	2	226.3	219.97	-6.33	222.04	-4.26	220.3	-6	220.81	-5.49
BGO 14CR	55789	76338	190.1	200.1	2	218.5	220.87	2.37	222.49	3.99	220.62	2.12	220.44	1.94
BGO 16B	56184	75768	136	146	2	214.3	221.76	7.46	222.91	8.61	221.21	6.91	220.66	6.36
BGO 20B	57120	74952	131	141	2	223.4	223.74	0.34	224.13	0.73	222.89	-0.51	221.79	-1.61
BGO 20C	57106	74938	174	184	2	224.7	223.87	-0.83	224.28	-0.42	223.09	-1.61	222.01	-2.69
BGO 27C	54671	75666	154.9	163.9	2	216.2	219.58	3.38	220.44	4.24	218.37	2.17	217.76	1.56
BGO 29C	54099	75578	176.8	186.8	2	217.3	218.04	0.74	218.66	1.36	216.67	-0.63	215.97	-1.33
BGO 30C	54512	75181	178.4	188.4	2	215.1	218.38	3.28	218.56	3.46	216.99	1.89	216.12	1.02
BGO 31C	54816	74978	176.4	186.4	2	221.1	218.81	-2.29	218.72	-2.38	217.42	-3.68	216.31	-4.79
BGO 33C	55681	74480	177.8	187.8	2	221	221.2	0.2	220.9	-0.1	220.05	-0.95	218.7	-2.3
BGO 35C	56546	73954	161.9	171.9	2	224.4	223.36	-1.04	222.6	-1.8	222.49	-1.91	220.54	-3.86
BGO 37C	57279	73498	168.8	178.8	2	226.8	225.42	-1.38	224.34	-2.46	224.63	-2.17	222.48	-4.32
BGO 39C	57816	73563	174.9	184.9	2	227.4	226.73	-0.67	225.75	-1.65	226.16	-1.24	223.92	-3.48
BGO 42C	55522	76405	185.9	195.9	2	218.3	220.6	2.3	222.22	3.92	220.16	1.86	219.98	1.68
BGO 43CR	56237	77035	178.4	188.4	2	215.5	219.56	4.06	221.8	6.3	220.35	4.85	221.23	5.73
BGO 44B	57866	76756	148.1	158.1	2	216.6	218.55	1.95	220.53	3.93	218.59	1.99	218.53	1.93
BGO 44C	57895	76758	190.6	200.6	2	216	218.75	2.75	220.75	4.75	218.8	2.8	218.76	2.76

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
BGO 45B	54564	75840	137	147	2	214.2	219.06	4.86	219.89	5.69	217.72	3.52	217.13	2.93
BGO 45C	54577	75835	190.5	200.5	2	217.9	219.5	1.6	220.42	2.52	218.69	0.79	218.14	0.24
BGO 46B	54445	75012	140.4	150.4	2	213.8	217.39	3.59	217.25	3.45	215.88	2.08	214.74	0.94
BGO 46C	54434	75022	178	188	2	215.2	217.7	2.5	217.6	2.4	216.23	1.03	215.17	-0.03
BGO 47C	54933	74752	178.6	188.6	2	218.8	218.86	0.06	218.53	-0.27	217.45	-1.35	216.24	-2.56
BGO 48C	55124	74600	176.7	186.7	2	219.2	219.48	0.28	219.16	-0.04	218.13	-1.07	216.91	-2.29
BGO 49C	56202	73917	166	176	2	224.1	222.29	-1.81	221.56	-2.54	221.45	-2.65	219.6	-4.5
BGO 50C	54197	75190	162.5	172.5	2	214.2	217.51	3.31	217.63	3.43	216.11	1.91	215.04	0.84
BGO 51B	57848	74128	116.9	126.9	2	226.2	226.38	0.18	225.73	-0.47	225.42	-0.78	223.58	-2.62
BGO 51C	57854	74123	175.1	185.1	2	226.9	226.55	-0.35	225.93	-0.97	225.76	-1.14	223.87	-3.03
BGO 52B	57190	74627	126.7	136.7	2	224.2	224.42	0.22	224.37	0.17	223.51	-0.69	222.11	-2.09
BGO 52C	57196	74622	178.7	188.7	2	225.4	224.59	-0.81	224.57	-0.83	223.76	-1.64	222.37	-3.03
BGO 53B	55416	76077	143.5	153.5	2	217.1	220.62	3.52	221.82	4.72	219.68	2.58	219.22	2.12
BGO 53C	55408	76082	183.2	193.2	2	218.4	220.79	2.39	222.02	3.62	220.11	1.71	219.59	1.19
BGX 1C	58600	76820	176	186	2	210.9	215.77	4.87	217.73	6.83	216.92	6.02	216.65	5.75
BGX 2B	58256	77203	137.2	147.2	2	207.9	209.63	1.73	211.8	3.9	209.88	1.98	210.16	2.26
BGX 2D	58265	77192	181.1	191.1	2	209.8	214.17	4.37	216.53	6.73	214.43	4.63	214.74	4.94
BGX 3D	57780	77577	201.6	221.6	2	210.1	214.8	4.7	218.17	8.07	214.54	4.44	216.05	5.95
BGX 4C	57202	77886	170.7	180.7	2	209.2	214.24	5.04	217	7.8	213.8	4.6	214.66	5.46
BGX 4D	57186	77894	203.8	223.8	2	210.3	215.08	4.78	219.42	9.12	215.05	4.75	217.75	7.45
BGX 5D	57309	78402	195	215	2	204.2	209.81	5.61	212.91	8.71	209.89	5.69	211.04	6.84
BGX 6D	57525	78740	191	211	2	201.8	205.97	4.17	209.17	7.37	206.51	4.71	207.74	5.94
BGX 7D	58313	78349	194.1	214.1	2	201.4	204.02	2.62	207.19	5.79	205.06	3.66	206.16	4.76
BGX 8DR	58943	77590	183.1	203.1	2	201.8	208.5	6.7	211.03	9.23	209.63	7.83	210.21	8.41
BGX 12C	59675	74428	174.1	184.1	2	230.8	227.1	-3.7	226.52	-4.28	226.21	-4.59	224.35	-6.45
BGX006DR	57358	78758	183.4	203.4	2	202.7	205.95	3.25	209.13	6.43	206.5	3.8	207.73	5.03
BGX013D	58795	77757	182.6	202.7	2	202.1	207.37	5.27	210	7.9	208.4	6.3	209	6.9
BRR 6C	51095	77063	156	166	2	206.2	207.85	1.65	210.07	3.87	209.06	2.86	208.93	2.73

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
BRR 7C	50698	77573	175.9	185.9	2	203.7	203.52	-0.18	206.33	2.63	205.32	1.62	205.77	2.07
BSE 1C1	57147	73217	169.1	171.6	2	229.2	224.18	-5.02	222.79	-6.41	223.34	-5.86	221.02	-8.18
BSE 1C2	57147	73217	150.5	153	2	227.7	224.09	-3.61	222.69	-5.01	223.23	-4.47	220.91	-6.79
BSE 1C3	57147	73217	138	140.5	2	228	224.03	-3.97	222.62	-5.38	223.1	-4.9	220.78	-7.22
BSE 1C4	57147	73217	123	125.5	2	227.2	223.99	-3.21	222.57	-4.63	222.97	-4.23	220.66	-6.54
BSE 1D4	57156	73212	183.7	186.2	2	232.6	224.3	-8.3	222.91	-9.69	223.49	-9.11	221.16	-11.44
BSE 2CR1	56973	72700	175.7	178.2	2	225.9	222.31	-3.59	220.39	-5.51	221.74	-4.16	219.16	-6.74
BSE 2CR3	56973	72700	145.7	148.2	2	224.7	222.18	-2.52	220.25	-4.45	221.52	-3.18	218.97	-5.73
BSE 2D4	56898	73286	183.6	186.1	2	231.6	223.66	-7.94	222.3	-9.3	222.82	-8.78	220.54	-11.06
BSE 3C1	56980	72693	170.8	173.3	2	224.7	222.31	-2.39	220.39	-4.31	221.74	-2.96	219.16	-5.54
BSE 3C2	56980	72693	150.7	153.2	2	224.9	222.21	-2.69	220.29	-4.61	221.57	-3.33	219.02	-5.88
BSE 3C3	56980	72693	138.2	140.7	2	224.7	222.14	-2.56	220.21	-4.49	221.45	-3.25	218.91	-5.79
BSW 1C1	53962	74676	178	180.5	2	211.7	214.62	2.92	214.01	2.31	213.23	1.53	211.93	0.23
BSW 1C2	53962	74676	168.5	171	2	210.2	214.58	4.38	213.97	3.77	213.22	3.02	211.91	1.71
BSW 1C3	53962	74676	151	153.5	2	211.4	214.51	3.11	213.9	2.5	213.17	1.77	211.87	0.47
BSW 1C4	53962	74676	143.5	146	2	210.3	214.47	4.17	213.86	3.56	213.15	2.85	211.85	1.55
BSW 2C2	54208	74442	141.2	143.7	2	211	214.84	3.84	214.01	3.01	213.33	2.33	211.97	0.97
BSW 2C3	54208	74442	133.7	136.2	2	212.6	214.82	2.22	213.98	1.38	213.33	0.73	211.96	-0.64
BSW 3C2	54593	74274	159.5	162	2	214.3	216.57	2.27	215.77	1.47	214.95	0.65	213.59	-0.71
BSW 3C4	54593	74274	132.6	135.1	2	216.2	216.46	0.26	215.65	-0.55	214.84	-1.36	213.48	-2.72
BSW 4C2	54905	74129	153.1	155.6	2	216.9	216.5	-0.4	215.51	-1.39	214.89	-2.01	213.44	-3.46
BSW 4C3	54905	74129	138.5	141.1	2	216.1	216.46	0.36	215.47	-0.63	214.85	-1.25	213.4	-2.7
BSW 5C1	53672	74301	172	174.5	2	210.8	211.69	0.89	210.65	-0.15	210.72	-0.08	209.22	-1.58
BSW 5C4	53672	74301	131.5	134	2	210.7	211.54	0.84	210.5	-0.2	210.65	-0.05	209.13	-1.57
BSW 6C1	53376	73753	172.3	174.8	2	209.4	207.09	-2.31	205.49	-3.91	206.84	-2.56	205.52	-3.88
BSW 6C2	53376	73753	160.8	163.3	2	209.6	205.82	-3.78	204.14	-5.46	205.92	-3.68	203.77	-5.83
BSW 6C3	53376	73753	154.3	156.8	2	208.8	205.79	-3.01	204.11	-4.69	205.83	-2.97	203.74	-5.06
BSW 6C4	53376	73753	134.8	137.3	2	208.8	205.74	-3.06	204.06	-4.74	205.68	-3.12	203.67	-5.13

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
BSW 7C1	53853	73825	168.6	171.1	2	212.5	210.27	-2.23	208.91	-3.59	209.31	-3.19	207.73	-4.77
BSW 7C3	53853	73825	142.6	145.1	2	211	210.23	-0.77	208.86	-2.14	209.27	-1.73	207.69	-3.31
BSW 8C1	54321	73633	173.3	175.8	2	215.1	210.93	-4.17	209.45	-5.65	209.61	-5.49	208.04	-7.06
BSW 8C3	54321	73633	137.3	139.8	2	214.3	210.86	-3.44	209.37	-4.93	209.52	-4.78	207.95	-6.35
FAB 2MC	55146	77482	186.8	196.8	2	214.2	218.3	4.1	220.77	6.57	218.09	3.89	218.59	4.39
FAB 5C	55774	77969	196.2	206.2	2	211.4	216.54	5.14	219.36	7.96	216.9	5.5	217.54	6.14
FAB 6C	55988	77782	167.8	177.8	2	211.1	217.3	6.2	219.97	8.87	217.6	6.5	218.25	7.15
FAB 6D	55978	77788	223.7	233.7	2	228.5	222.46	-6.04	226.37	-2.13	222.49	-6.01	225.9	-2.6
FAB 7C	56182	77658	183.9	193.9	2	211.6	217.34	5.74	219.99	8.39	217.8	6.2	218.44	6.84
FAB 7D	56181	77669	215.9	225.9	2	227.3	222.16	-5.14	226.14	-1.16	221.57	-5.73	225.13	-2.17
FBG001C	53617	77234	194.4	209.4	2	215.4	217.5	2.1	219.72	4.32	217.6	2.2	218	2.6
FBI 14C	50491	73930	148.8	158.8	2	198.7	195.73	-2.97	194.38	-4.32	194.88	-3.82	193.76	-4.94
FBI 16C	50255	73981	145.9	155.9	2	198.4	195.53	-2.87	194.3	-4.1	194.67	-3.73	193.49	-4.91
FBP 1A	51081	78893	161.8	191.8	2	201.2	200.04	-1.16	203.3	2.1	201.15	-0.05	202.15	0.95
FBP 6D	50547	79673	178.3	198.3	2	185.2	189.5	4.3	192.73	7.53	191.05	5.85	191.95	6.75
FBP 9D	51074	79565	177.9	197.9	2	194.7	194.78	0.08	198.12	3.42	196.16	1.46	197.4	2.7
FBP 10D	50536	79330	180.8	200.8	2	196	193.99	-2.01	197.92	1.92	195.65	-0.35	197.45	1.45
FBP 12D	51166	78932	182.1	202.1	2	202.3	201.68	-0.62	205.47	3.17	203.45	1.15	205.84	3.54
FBP 13D	50694	79749	172.7	192.7	2	186.2	191.3	5.1	194.53	8.33	192.71	6.51	193.68	7.48
FBP 43C	52019	78740	154.2	164.2	2	205.5	207.1	1.6	210.27	4.77	207.83	2.33	209	3.5
FBP 43DL	52009	78742	184.3	194.3	2	206.5	208.31	1.81	212.12	5.62	211.05	4.55	213.04	6.54
FBP 44D	49614	80333	163.6	168.6	2	162.9	172.24	9.34	173.68	10.78	174.14	11.24	174.42	11.52
FBP 45D	49812	80506	160.6	165.6	2	161.5	167.38	5.88	167.59	6.09	167.88	6.38	167.92	6.42
FBP 46D	49940	80502	161.5	166.5	2	162.9	175.9	13	177.47	14.57	177.08	14.18	177.39	14.49
FBP 47D	50128	80689	165.8	170.8	2	165.8	174.31	8.51	175.68	9.88	176.02	10.22	176.31	10.51
FCB 2C	55055	76699	170.9	180.9	2	219	219.82	0.82	221.6	2.6	219.22	0.22	219.21	0.21
FCB002CR	55247	76551	175.2	185.2	2	215.7	220.12	4.42	221.91	6.21	219.64	3.94	219.63	3.93
FGW003 C	53574	79665	191.3	201.3	2	208.9	207.94	-0.96	211.95	3.05	209.23	0.33	211.28	2.38

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
FGW005 C	52856	79020	167	182	2	210	208.73	-1.27	212.2	2.2	209.55	-0.45	211.04	1.04
FGW012 C	49808	76605	154.1	164.1	2	202.4	201.94	-0.46	204.25	1.85	203.15	0.75	203.6	1.2
FGW019C	52354	80746	189	199	2	201.9	196.1	-5.8	199.92	-1.98	197.44	-4.46	199.53	-2.37
FGW022C	52457	79044	193.6	203.6	2	207	207.37	0.37	210.93	3.93	208.68	1.68	210.15	3.15
FHB 4D	53711	72977	142.4	147.4	2	200.8	201.05	0.25	198.96	-1.84	200.56	-0.24	199.05	-1.75
FNB 2	54362	80442	180.8	210.8	2	203	202.6	-0.4	206.87	3.87	203.6	0.6	206.13	3.13
FNB 5	54295	80556	193.5	203.5	2	202.8	202.65	-0.15	206.89	4.09	203.69	0.89	206.08	3.28
FNB 12	54557	81456	164.6	194.6	2	191.7	192.5	0.8	195.1	3.4	193.87	2.17	195.29	3.59
FNB 13	54880	81572	167.2	197.2	2	189.6	189.55	-0.05	192.03	2.43	191.41	1.81	192.58	2.98
FNB 15	55319	81294	149.4	179.4	2	192.7	187.84	-4.86	190.6	-2.1	189.52	-3.18	190.75	-1.95
FOB 2C	49543	73976	146.6	156.6	2	200.1	193.27	-6.83	192.18	-7.92	191.87	-8.23	190.99	-9.11
FOB 5C	49730	74607	129.3	149.3	2	202.8	197.6	-5.2	197.09	-5.71	197.96	-4.84	197.05	-5.75
FOB 7C	50236	76074	148.9	168.9	2	207.7	204.69	-3.01	206.15	-1.55	205.57	-2.13	205.27	-2.43
FOB 9C	50797	75773	155.5	175.5	2	209.3	206.73	-2.57	207.58	-1.72	207.38	-1.92	206.56	-2.74
FOB 11C	51921	75614	156.2	176.2	2	212.3	210.27	-2.03	210.64	-1.66	210.24	-2.06	209.3	-3
FSB 76C	51396	76112	154.8	165.3	2	208.9	209.23	0.33	210.32	1.42	210.22	1.32	209.26	0.36
FSB 78C	50170	74772	141.6	151.4	2	204.5	201.49	-3.01	201.35	-3.15	202.61	-1.89	201.91	-2.59
FSB 79C	50171	73668	149.8	159.6	2	195.5	192.22	-3.28	190.73	-4.77	190.29	-5.21	189.39	-6.11
FSB 87C	50093	75592	148.8	159.3	2	205.4	202.66	-2.74	203.52	-1.88	203.25	-2.15	202.89	-2.51
FSB 88C	51518	75620	158.4	168.4	2	208.7	208.94	0.24	209.49	0.79	209.27	0.57	208.36	-0.34
FSB 89C	51345	75553	156.1	166.1	2	208.3	208.92	0.62	209.48	1.18	209.24	0.94	208.33	0.03
FSB 90C	51149	75383	158.1	168.1	2	207.1	207.58	0.48	208	0.9	207.71	0.61	206.82	-0.28
FSB 91C	50953	75213	149.1	159.1	2	206.4	206.12	-0.28	206.4	0	206.24	-0.16	205.33	-1.07
FSB 92C	50564	75053	147.6	157.6	2	206.1	203.01	-3.09	203	-3.1	203.68	-2.42	202.94	-3.16
FSB 93C	50458	74897	142	152	2	205.8	201.63	-4.17	201.32	-4.48	202.68	-3.12	201.74	-4.06
FSB 94C	50180	74869	139.8	149.8	2	205.1	201.17	-3.93	200.99	-4.11	202.47	-2.63	201.6	-3.5
FSB 95CR	49988	75002	151.9	161.9	2	204.6	200.73	-3.87	200.68	-3.92	201.99	-2.61	201.26	-3.34
FSB 97C	49970	75180	143.8	153.8	2	204.8	201.13	-3.67	201.43	-3.37	202.06	-2.74	201.51	-3.29

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
FSB 98C	50116	75381	148.4	158.4	2	205.2	202.62	-2.58	203.09	-2.11	203.37	-1.83	202.77	-2.43
FSB 99C	50321	75684	157.2	167.2	2	206.1	203.94	-2.16	204.92	-1.18	204.51	-1.59	204.06	-2.04
FSB102C	50835	73583	145.9	155.9	2	194.1	191.81	-2.29	189.79	-4.31	191.05	-3.05	189.86	-4.24
FSB103C	49651	74210	147.1	157.1	2	201.4	194.86	-6.54	193.9	-7.5	193.98	-7.42	192.96	-8.44
FSB105C	49828	75234	141.5	151.5	2	205.8	200.55	-5.25	200.99	-4.81	201.23	-4.57	200.65	-5.15
FSB106C	50651	74190	156	166	2	200.3	198.13	-2.17	196.9	-3.4	197.68	-2.62	196.63	-3.67
FSB107C	51158	75184	150.8	160.8	2	207.2	206.72	-0.48	206.88	-0.32	206.66	-0.54	205.75	-1.45
FSB110C	50151	74191	137.2	147.2	2	200.6	196.82	-3.78	195.87	-4.73	197.82	-2.78	196.38	-4.22
FSB111C	51526	75383	159	169	2	210.2	208.83	-1.37	209.03	-1.17	208.74	-1.46	207.8	-2.4
FSB113C	51084	74161	154	164	2	199.7	199.64	-0.06	198.29	-1.41	199.05	-0.65	197.85	-1.85
FSB114C	52034	75288	158	168	2	209.5	210	0.5	210.03	0.53	209.57	0.07	208.6	-0.9
FSB120C	49171	75550	150.7	160.7	2	202.1	199.21	-2.89	200.29	-1.81	199.48	-2.62	198.99	-3.11
FSB121C	48413	75156	148.4	158.4	2	201	195.84	-5.16	196.65	-4.35	195.24	-5.76	194.96	-6.04
FSB123C	51750	74567	155.3	165.3	2	207.9	204.61	-3.29	203.53	-4.37	204.29	-3.61	202.98	-4.92
FSL 10C	52296	78599	179	199	2	208.8	209.62	0.82	212.77	3.97	210.61	1.81	211.83	3.03
FSS 1D	53898	75258	209.9	229.9	2	219.9	221.76	1.86	222.4	2.5	224.61	4.71	223.85	3.95
FSS003C	53536	74969	161.5	181.5	2	210.7	214.35	3.65	214	3.3	213.12	2.42	211.96	1.26
FTF 28	52185	77240	151.9	161.9	2	209	212.22	3.22	214.33	5.33	212.13	3.13	212.2	3.2
FTF 29	52166	77737	157.3	177.3	2	208.1	210.87	2.77	213.36	5.26	210.94	2.84	211.39	3.29
FTF030	52288	76874	183.6	193.6	2	210.1	213.56	3.46	215.32	5.22	213.35	3.25	213.37	3.27
FTF031	52543	76452	187	197	2	221	214.21	-6.79	215.54	-5.46	213.7	-7.3	213.65	-7.35
HAA 1C	62983	69866	147.4	157.4	2	247	258.22	11.22	254.05	7.05	260.12	13.12	254.55	7.55
HAA 2B	61267	70935	127.2	137.2	2	250	250.73	0.73	244.7	-5.3	253.42	3.42	248.01	-1.99
HAA 2C	61259	70940	171.9	181.9	2	250.6	251.47	0.87	245.81	-4.79	254.04	3.44	248.64	-1.96
HAA 4B	61910	72223	124.5	135	2	247.6	242.72	-4.88	237.18	-10.42	243.55	-4.05	239.97	-7.63
HAA 4C	61900	72223	158.3	168.3	2	248.3	247.74	-0.56	242.05	-6.25	248.53	0.23	244.71	-3.59
HAA 7B	60818	71754	135.3	145.3	2	249.5	244.56	-4.94	238.12	-11.38	245.9	-3.6	241.59	-7.91
HAA 7C	60813	71763	177.2	187.2	2	252	246.18	-5.82	240.44	-11.56	247.01	-4.99	242.76	-9.24

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
HAA 8B	60623	72167	134.1	144.1	2	249.2	240.18	-9.02	234.88	-14.32	241.43	-7.77	237.58	-11.62
HAA 8C	60615	72173	172.1	182.1	2	250	240.57	-9.43	235.41	-14.59	241.77	-8.23	237.88	-12.12
HAA 9B	60846	72506	138.4	148.4	2	248.4	239.92	-8.48	235.28	-13.12	240.73	-7.67	237.24	-11.16
HAA 9C	60842	72496	172.4	181.5	2	249.7	240.23	-9.47	235.67	-14.03	240.98	-8.72	237.48	-12.22
HAA 10B	61225	72308	133.7	143.8	2	250.3	243.3	-7	237.42	-12.88	244.4	-5.9	240.55	-9.75
HAA 10C	61215	72308	167.5	177.5	2	251.6	243.71	-7.89	238.07	-13.53	244.71	-6.89	240.86	-10.74
HAA 11B	61395	72418	139.4	149.4	2	248.5	243.45	-5.05	238.09	-10.41	244.41	-4.09	240.64	-7.86
HAA 11C	61395	72418	170.7	180.7	2	247.9	243.82	-4.08	238.62	-9.28	244.69	-3.21	240.94	-6.96
HAA 12B	61733	72419	134.3	144.2	2	247.6	245.43	-2.17	240.02	-7.58	246.12	-1.48	242.37	-5.23
HAA 12C	61746	72422	169.5	179.5	2	247.4	245.85	-1.55	240.64	-6.76	246.47	-0.93	242.73	-4.67
HAA 13B	62007	72418	134.2	143.6	2	245.8	246.24	0.44	240.9	-4.9	246.96	1.16	243.26	-2.54
HAA 13C	62020	72421	167.2	176.6	2	246.1	246.62	0.52	241.46	-4.64	247.26	1.16	243.57	-2.53
HAA 14B	62366	72355	135	145	2	245	247.45	2.45	242.32	-2.68	248.96	3.96	245.27	0.27
HAA 14C	62376	72355	161.1	171.1	2	245.1	247.71	2.61	242.7	-2.4	249.12	4.02	245.45	0.35
HAA 15B	62770	72358	129.3	139.3	2	243.2	247.08	3.88	242.78	-0.42	248.71	5.51	245.23	2.03
HAA 15C	62770	72341	161.3	171.3	2	244.4	247.33	2.93	243.13	-1.27	248.86	4.46	245.4	1
HIW 5MC2	56499	73558	124.4	139.2	2	222.8	222.59	-0.21	221.41	-1.39	221.75	-1.05	219.6	-3.2
HMD 1D	56973	78732	199.7	219.7	2	205.9	208.73	2.83	211.82	5.92	208.98	3.08	210.21	4.31
HMD 2D	57269	79666	190.8	210.8	2	197.3	198.64	1.34	201.64	4.34	200.05	2.75	201.44	4.14
HMD 3D	57745	79579	187.7	207.7	2	196.9	197.01	0.11	200.11	3.21	198.85	1.95	200.49	3.59
HMD 4B	58199	79161	163.7	173.7	2	194.4	199.27	4.87	202.21	7.81	200.62	6.22	201.76	7.36
HMD 4D	58188	79160	188.9	208.9	2	197.1	199.46	2.36	202.49	5.39	200.71	3.61	201.86	4.76
HPZ 3A	56294	70938	183.2	185.7	2	201.5	208.49	6.99	205.06	3.56	208.42	6.92	205.99	4.49
HSB 65B	58439	72446	123.3	133.3	2	222.7	228.25	5.55	226.04	3.34	227.83	5.13	224.81	2.11
HSB 68B	56882	71525	123.5	134.5	2	216.3	217.63	1.33	214.96	-1.34	217.38	1.08	214.62	-1.68
HSB 68C	56873	71524	168.4	179.5	2	216.2	217.77	1.57	215.1	-1.1	217.7	1.5	214.9	-1.3
HSB 70C	55757	72597	164.9	174.9	2	219.8	216.63	-3.17	214.71	-5.09	216.01	-3.79	213.65	-6.15
HSB 71C	55282	72866	171.9	181.9	2	219.3	215.83	-3.47	214.07	-5.23	214.97	-4.33	212.81	-6.49

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
HSB 83B	58595	71640	121.2	132.1	2	222.3	228.18	5.88	225.3	3	228.56	6.26	225.29	2.99
HSB 83C	58615	71637	160.2	171.2	2	223.1	228.23	5.13	225.4	2.3	228.62	5.52	225.38	2.28
HSB 84B	56352	71603	121.8	132.9	2	210.1	212.94	2.84	210.27	0.17	212.96	2.86	210.45	0.35
HSB 84C	56360	71597	170.9	181.8	2	211.8	213	1.2	210.37	-1.43	212.92	1.12	210.47	-1.33
HSB 85B	58953	73789	133.2	143.2	2	229.2	229.25	0.05	228.09	-1.11	228.34	-0.86	226.07	-3.13
HSB 86B	55977	72519	113.8	124	2	218.6	217.38	-1.22	215.44	-3.16	216.67	-1.93	214.32	-4.28
HSB100C	58806	72077	153	163	2	225.1	230.3	5.2	227.44	2.34	230.58	5.48	227.21	2.11
HSB101C	58604	72002	166.3	176.3	2	223.8	229.31	5.51	226.64	2.84	229.48	5.68	226.24	2.44
HSB102C	58400	71960	166.7	176.7	2	223	227.8	4.8	225.14	2.14	227.83	4.83	224.68	1.68
HSB103C	58323	71594	159.2	169.2	2	222	226.38	4.38	223.55	1.55	226.76	4.76	223.58	1.58
HSB104C	58083	71377	163.5	173.5	2	219.2	224.39	5.19	221.57	2.37	224.86	5.66	221.74	2.54
HSB105C	57884	71447	152.2	162.2	2	218.2	223.23	5.03	220.45	2.25	223.64	5.44	220.56	2.36
HSB106C	57652	71721	158.7	168.7	2	220.1	221.93	1.83	219.29	-0.81	222.1	2	219.16	-0.94
HSB107C	57432	71698	159.3	169.3	2	217.7	220.87	3.17	218.26	0.56	221	3.3	218.12	0.42
HSB108C	57155	71689	186	196	2	217	219.98	2.98	217.39	0.39	220	3	217.16	0.16
HSB109C	56895	71685	168.4	178.4	2	217.1	217.77	0.67	215.1	-2	217.7	0.6	214.9	-2.2
HSB110C	56681	71779	171.4	181.4	2	217.1	218.12	1.02	215.6	-1.5	217.98	0.88	215.22	-1.88
HSB111C	56502	71919	140.7	150.7	2	217.9	217.02	-0.88	214.55	-3.35	216.53	-1.37	213.93	-3.97
HSB112C	56418	72156	140.6	150.6	2	219.2	217.48	-1.72	215.19	-4.01	216.84	-2.36	214.33	-4.87
HSB113C	56160	72312	154.7	164.7	2	218.7	217.11	-1.59	215.03	-3.67	216.55	-2.15	214.11	-4.59
HSB114CR	56110	72453	146.8	156.8	2	220.2	217.08	-3.12	214.99	-5.21	216.45	-3.75	214.04	-6.16
HSB115CR	56045	72642	145	155	2	220.7	218.29	-2.41	216.33	-4.37	217.63	-3.07	215.21	-5.49
HSB116CR	55990	72871	141.2	151.2	2	221.8	218.43	-3.37	216.62	-5.18	217.74	-4.06	215.38	-6.42
HSB117C	55163	72741	165.1	175.1	2	218	213.5	-4.5	211.66	-6.34	212.22	-5.78	210.26	-7.74
HSB119C	56109	73095	149.8	159.8	2	222	219.98	-2.02	218.42	-3.58	219.44	-2.56	217.09	-4.91
HSB120C	56444	73377	155.3	165.3	2	224.7	222.22	-2.48	220.87	-3.83	221.53	-3.17	219.25	-5.45
HSB121C	57403	72066	159.6	169.6	2	221.7	222.86	1.16	220.48	-1.22	222.7	1	219.87	-1.83
HSB125C	58593	71504	145.6	155.6	2	222.7	227.64	4.94	224.71	2.01	228.21	5.51	224.92	2.22

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
HSB126C	57178	70628	176.3	181.3	2	204.3	214.96	10.66	212.07	7.77	215.97	11.67	212.98	8.68
HSB127C	56792	71210	148.4	158.4	2	209.5	214.83	5.33	211.91	2.41	214.88	5.38	212.08	2.58
HSB129C	55110	71830	147.8	157.8	2	204.8	206.33	1.53	203.99	-0.81	205.42	0.62	203.63	-1.17
HSB130C	54644	70762	159.9	169.9	2	199.9	199.9	-999	199.9	-999	199.9	-999	199.9	-999
HSB131C	56895	70375	148.5	158.5	2	204.2	204.2	-999	204.2	-999	204.2	-999	204.2	-999
HSB133C	59110	71949	173.3	183.3	2	229.9	231.7	1.8	228.66	-1.24	232.05	2.15	228.56	-1.34
HSB134C	58290	71210	149.1	159.1	2	219.5	225.66	6.16	222.77	3.27	226.29	6.79	223.07	3.57
HSB135C	56561	71390	147.3	157.3	2	206.2	214.03	7.83	211.3	5.1	213.9	7.7	211.3	5.1
HSB136C	55950	71900	160.5	170.5	2	214.6	214.18	-0.42	211.89	-2.71	213.72	-0.88	211.39	-3.21
HSB137CR	55705	72260	148.8	158.8	2	217.3	213.72	-3.58	211.6	-5.7	212.91	-4.39	210.73	-6.57
HSB139C	57374	71130	148.5	158.5	2	213.2	218.75	5.55	215.92	2.72	219.19	5.99	216.16	2.96
HSB140C	56552	70049	161.6	171.6	2	205.7	205.7	-999	205.7	-999	205.7	-999	205.7	-999
HSB141CR	59167	71227	152.1	162.1	2	226.6	232.52	5.92	228.82	2.22	233.02	6.42	229.24	2.64
HSB142C	53505	73119	161.6	171.6	2	197.3	201.16	3.86	199.01	1.71	200.76	3.46	199.13	1.83
HSB143C	52773	73738	169.1	179.1	2	206.8	202.11	-4.69	200.21	-6.59	202.75	-4.05	200.76	-6.04
HSB145C	57769	71099	164.7	174.7	2	212.7	221.29	8.59	218.48	5.78	222.07	9.37	218.93	6.23
HSB146C	58473	70472	152.3	162.3	2	209.7	228.03	18.33	224.4	14.7	229.34	19.64	225.45	15.75
HSB148C	55441	70165	158.9	168.9	2	201.4	201.4	-999	201.4	-999	201.4	-999	201.4	-999
HSB151C	54015	72998	170.6	180.6	2	206.9	204.68	-2.22	202.83	-4.07	203.82	-3.08	202.34	-4.56
HSB152C	54347	72012	173.1	183.1	2	198.4	201.19	2.79	199.14	0.74	200.09	1.69	199.06	0.66
HSB153C	57025	72132	164.5	174.5	2	221.4	221.2	-0.2	218.91	-2.49	220.93	-0.47	218.22	-3.18
HSB154C	56545	72612	147.5	157.5	2	222.7	220.76	-1.94	218.89	-3.81	220.03	-2.67	217.57	-5.13
HSB155C	54684	72503	159.8	169.8	2	211.1	207.62	-3.48	205.65	-5.45	206.34	-4.76	204.76	-6.34
HSL 9C	60561	73352	154.7	174.7	2	240.7	235.28	-5.42	232.55	-8.15	234.57	-6.13	231.59	-9.11
HSL 10C	59745	72886	150	170	2	238.5	233.47	-5.03	230.85	-7.65	232.69	-5.81	229.67	-8.83
HSL 11C	58987	72779	143.7	163.7	2	231.3	231.05	-0.25	228.79	-2.51	230.66	-0.64	227.62	-3.68
HSP 60A	55161	71581	182	184.5	2	201.1	204.89	3.79	202.88	1.78	203.8	2.7	202.58	1.48
HSP 76A	54580	71501	174.9	179.9	2	196.1	198.41	2.31	194.57	-1.53	196.87	0.77	195.12	-0.98

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
HSP 76B	54581	71503	185.9	190.9	2	198.5	194.8	-3.7	193.42	-5.08	193.97	-4.53	193.36	-5.14
NEP 1D	57021	80391	183.7	193.8	2	192	190.9	-1.1	193.43	1.43	192.52	0.52	193.62	1.62
NEP 2D	57344	79983	190.3	200.4	2	195.6	193.84	-1.76	196.84	1.24	195.73	0.13	197.16	1.56
NEP 3D	59278	78358	183.9	193.9	2	194.8	196.12	1.32	198.44	3.64	199.25	4.45	199.6	4.8
NEP 4D	59896	78122	186.7	196.7	2	191.8	192.66	0.86	194.71	2.91	197.11	5.31	197.55	5.75
NWP 1B	56559	77616	171.3	181.4	2	211.4	217.04	5.64	219.64	8.24	217.22	5.82	218.02	6.62
NWP 1D	56572	77632	202.6	212.7	2	211.3	217.21	5.91	219.84	8.54	217.68	6.38	218.35	7.05
NWP 2D	56810	79307	192.3	202.3	2	201.5	203.66	2.16	206.31	4.81	204.45	2.95	205.57	4.07
NWP 3C	55322	76823	189.2	199.2	2	216.1	219.96	3.86	221.94	5.84	219.66	3.56	219.8	3.7
NWP202C	55536	77451	173.5	183.5	2	213.9	218.61	4.71	221.05	7.15	218.62	4.72	219.09	5.19
SEP002B	54448	72463	145.8	155.8	2	206.6	206.06	-0.54	204.13	-2.47	204.84	-1.76	203.38	-3.22
SEP002D	54443	72467	172.5	182.5	2	207.4	206.81	-0.59	205	-2.4	205.57	-1.83	204.41	-2.99
SEP003CL	55185	73351	142.7	152.7	2	218.9	216.57	-2.33	215.06	-3.84	215.35	-3.55	213.46	-5.44
SEP003CU	55180	73356	166.6	176.6	2	219.3	216.69	-2.61	215.19	-4.11	215.62	-3.68	213.68	-5.62
SWP 1C	55268	74403	171.9	181.9	2	219.3	219.62	0.32	219.08	-0.22	218.37	-0.93	217	-2.3
SWP 2C	55817	74196	171	181.1	2	221.8	221.43	-0.37	220.91	-0.89	220.38	-1.42	218.86	-2.94
SWP005C	53179	74644	164.6	174.6	2	211.5	211.15	-0.35	210.36	-1.14	210.31	-1.19	208.86	-2.64
SWP006C	53007	74266	170.6	180.6	2	213.4	209.85	-3.55	208.63	-4.77	209.04	-4.36	208	-5.4
UTR 6	56015	81561	160.7	165.7	2	167.3	170.08	2.78	170.17	2.87	170.89	3.59	170.72	3.41
UTR018R	49753	80552	145.5	150.5	2	148	167.06	19.06	167.44	19.44	167.68	19.68	167.74	19.74
ZBG 3	67104	76339	204	214	2	218.7	220.61	1.91	219.56	0.86	221.5	2.8	219.11	0.41
ZBG 4	67193	76069	205.4	215.4	2	218.9	219.9	1	218.83	-0.07	220.6	1.7	218.2	-0.7
ZBG 5	67287	75786	203.8	213.8	2	217.8	221.04	3.24	219.94	2.14	221.56	3.76	219.19	1.39
ZBG010D	67107	77431	199.5	214.5	2	218.7	218.27	-0.43	217.3	-1.4	219.31	0.61	218.11	-0.59
ZBG012D	66659	78564	178.7	193.7	2	214.2	214.06	-0.14	213.15	-1.05	214.42	0.22	213.32	-0.88
ZBG013D	66874	78632	179.7	194.7	2	213.7	212.84	-0.86	211.9	-1.8	213.01	-0.69	212.17	-1.53
ZBG014D	67038	78358	175.1	190.1	2	215.8	214.45	-1.35	213.49	-2.31	215.14	-0.66	214.06	-1.74
BGO 3A	58807	75562	103.7	113.7	1	161.3	161.75	0.45	161.73	0.43	161.76	0.46	161.69	0.39

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
BGO 6A	58317	76487	107.5	117.5	1	157.9	157.86	-0.04	157.86	-0.04	157.87	-0.03	157.82	-0.08
BGO 8AR	57618	76599	94.6	104.6	1	157.8	156.56	-1.24	156.57	-1.23	156.56	-1.24	156.52	-1.28
BGO 9AA	57372	76976	73.8	83.8	1	156	154.72	-1.28	154.73	-1.27	154.72	-1.28	154.69	-1.31
BGO 10AA	56990	76998	80.8	90.8	1	156.3	154.12	-2.18	154.14	-2.16	154.13	-2.17	154.1	-2.2
BGO 10AR	57064	76806	96.5	106.5	1	156.9	154.91	-1.99	154.93	-1.97	154.91	-1.99	154.88	-2.02
BGO 12AX	56258	76835	99.5	109.5	1	155.9	154.26	-1.64	154.29	-1.61	154.26	-1.64	154.24	-1.66
BGO 14AR	55789	76352	96.8	106.8	1	156.9	155.64	-1.26	155.67	-1.23	155.64	-1.26	155.61	-1.29
BGO 16AR	56217	75743	103.7	113.7	1	159.3	157.81	-1.49	157.82	-1.48	157.81	-1.49	157.77	-1.53
BGO 18A	56700	75600	99.5	109.5	1	159.7	159.44	-0.26	159.45	-0.25	159.44	-0.26	159.39	-0.31
BGO 20A	57100	74966	86.3	96.3	1	161.1	161.28	0.18	161.28	0.18	161.28	0.18	161.23	0.13
BGO 25A	55668	76158	104.1	114.1	1	159	156.24	-2.76	156.26	-2.74	156.24	-2.76	156.21	-2.79
BGO 26A	55014	76145	81	91	1	156.3	155.88	-0.42	155.91	-0.39	155.88	-0.42	155.85	-0.45
BGO 29A	54104	75560	102.5	112.5	1	157.9	156.28	-1.62	156.3	-1.6	156.27	-1.63	156.25	-1.65
BGO 39A	57822	73573	84.8	94.8	1	165.5	166.71	1.21	166.68	1.18	166.71	1.21	166.64	1.14
BGO 41A	55404	76469	103.3	113.3	1	158	155.02	-2.98	155.05	-2.95	155.02	-2.98	154.99	-3.01
BGO 43A	56253	77061	105.9	115.9	1	155.5	153.56	-1.94	153.59	-1.91	153.56	-1.94	153.53	-1.97
BGO 43AA	56269	77066	62.2	72.2	1	155	153.54	-1.46	153.57	-1.43	153.54	-1.46	153.52	-1.48
BGO 44A	57851	76755	98	108	1	157.1	156.1	-1	156.11	-0.99	156.11	-0.99	156.07	-1.03
BGO 44AA	57880	76757	61.2	71.3	1	157.9	156.09	-1.81	156.1	-1.8	156.1	-1.8	156.06	-1.84
BGO 45A	54550	75830	116.9	126.9	1	158.7	156.38	-2.32	156.4	-2.3	156.37	-2.33	156.35	-2.35
BGO 47A	54914	74729	86.8	96.8	1	160.5	160.19	-0.31	160.19	-0.31	160.18	-0.32	160.14	-0.36
BGO 49A	56205	73903	75.1	85.1	1	164	163.52	-0.48	163.51	-0.49	163.51	-0.49	163.46	-0.54
BGO 50A	54180	75201	90.5	100.5	1	158.1	157.79	-0.31	157.81	-0.29	157.79	-0.31	157.76	-0.34
BGO 51A	57842	74133	75.1	85.1	1	163.8	165.39	1.59	165.36	1.56	165.39	1.59	165.32	1.52
BGO 51AA	57867	74113	29.2	39.2	1	166.3	166.3	-999	166.3	-999	166.3	-999	166.3	-999
BGO 52A	57184	74632	81.7	91.7	1	162	162.63	0.63	162.62	0.62	162.63	0.63	162.57	0.57
BGO 52AA	57178	74638	36.6	46.6	1	161.3	162.62	1.32	162.6	1.3	162.61	1.31	162.56	1.26
BGO 53A	55424	76071	78.7	88.7	1	157.3	156.5	-0.8	156.52	-0.78	156.49	-0.81	156.46	-0.84

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
BGO 53AA	55431	76065	38.9	48.9	1	156.8	156.47	-0.33	156.49	-0.31	156.46	-0.34	156.43	-0.37
BGX 1A	58590	76832	114.1	124.1	1	156.7	156.5	-0.2	156.5	-0.2	156.51	-0.19	156.47	-0.23
BGX 4A	57216	77879	106.8	116.8	1	154.4	150.7	-3.7	150.73	-3.67	150.71	-3.69	150.69	-3.71
FOB 7A	50228	76063	85.4	105.4	1	153.3	148.11	-5.19	148.14	-5.16	148.12	-5.18	148.11	-5.19
FSB 76A	51391	76132	36.9	47.4	1	154.4	150.15	-4.25	150.18	-4.22	150.16	-4.24	150.15	-4.25
FSB 76B	51394	76122	99.2	109.7	1	150.7	150.18	-0.52	150.21	-0.49	150.19	-0.51	150.18	-0.52
FSB 78A	50173	74758	28.3	38.7	1	154.7	153.76	-0.94	153.78	-0.92	153.77	-0.93	153.76	-0.94
FSB 78B	50179	74766	82.4	92.8	1	153	152.97	-0.03	152.99	-0.01	152.97	-0.03	152.97	-0.03
FSB 79A	50150	73665	25.4	35.9	1	157.1	157.85	0.75	157.86	0.76	157.85	0.75	157.85	0.75
FSB 79B	50159	73666	80.7	91.2	1	156.6	157.86	1.26	157.87	1.27	157.86	1.26	157.86	1.26
FSB 87A	50116	75602	33.1	43.6	1	153	149.52	-3.48	149.55	-3.45	149.53	-3.47	149.52	-3.48
FSB 87BR	50093	75602	86.2	96.3	1	149.2	149.04	-0.16	149.06	-0.14	149.04	-0.16	149.04	-0.16
FSB 96AR	49746	74915	79	89	1	151.6	151.43	-0.17	151.45	-0.15	151.43	-0.17	151.43	-0.17
FSB 97A	49966	75171	85.8	95.8	1	150.4	151.19	0.79	151.21	0.81	151.2	0.8	151.19	0.79
FSB 98AR	50106	75362	82.1	92.1	1	150	150.99	0.99	151.02	1.02	151	1	150.99	0.99
FSB 99A	50315	75675	92.9	102.9	1	149.2	149.56	0.36	149.58	0.38	149.56	0.36	149.56	0.36
FSB100A	50958	75534	95.8	105.8	1	150.1	151.7	1.6	151.72	1.62	151.7	1.6	151.69	1.59
FSB101A	51191	75719	92.9	102.9	1	150.3	151.55	1.25	151.57	1.27	151.55	1.25	151.54	1.24
FSB113A	51068	74167	81	91.3	1	155.4	157.04	1.64	157.05	1.65	157.04	1.64	157.03	1.63
FSB114A	52047	75297	95.2	105	1	154	154.29	0.29	154.31	0.31	154.29	0.29	154.28	0.28
FSB120AR	49182	75557	92.4	102.5	1	147	148.49	1.49	148.51	1.51	148.49	1.49	148.49	1.49
HAA 1A	62968	69879	94.9	104.9	1	178.4	183.82	5.42	183.71	5.31	183.85	5.45	183.71	5.31
HAA 9AR	60843	72478	113.3	123.3	1	171.8	177.21	5.41	176.91	5.11	177.27	5.47	177.01	5.21
HAA 11A	61388	72423	108.2	118.2	1	171.8	175.49	3.69	175.38	3.58	175.51	3.71	175.38	3.58
HAA 12A	61726	72424	109	119	1	172.3	176.19	3.89	176.08	3.78	176.21	3.91	176.08	3.78
HAA 13A	62000	72423	109	118.4	1	173.3	176.52	3.22	176.41	3.11	176.55	3.25	176.41	3.11
HAA 14A	62356	72355	90.2	100.2	1	173.7	177.2	3.5	177.09	3.39	177.23	3.53	177.1	3.4
HAA 15A	62770	72350	103.4	113.4	1	174.4	177.4	3	177.3	2.9	177.43	3.03	177.3	2.9

Well ID	SRS E	SRS N	Scr. Bot	Scr. Top	Zone	Target	PEST.47	Resid.	PEST.51	Resid.	PEST.52	Resid.	PEST.53	Resid.
HGW 3A	62795	73565	101.1	111.2	1	170.3	173.92	3.62	173.84	3.54	173.95	3.65	173.83	3.53
HIW 2A	56753	73250	78.3	88.3	1	166.7	166.37	-0.33	166.34	-0.36	166.36	-0.34	166.31	-0.39
HSB 65A	58436	72436	62.5	73.2	1	170.4	171.16	0.76	171.1	0.7	171.17	0.77	171.08	0.68
HSB 68A	56892	71527	47.5	58	1	170.9	171.91	1.01	171.88	0.98	171.91	1.01	171.87	0.97
HSB 69A	56465	71549	83.1	93.1	1	171.3	171.72	0.42	171.7	0.4	171.72	0.42	171.69	0.39
HSB 83A	58606	71649	65.2	76	1	171.6	173.75	2.15	173.69	2.09	173.76	2.16	173.68	2.08
HSB 84A	56359	71586	64.7	75.9	1	170.3	171.39	1.09	171.37	1.07	171.39	1.09	171.36	1.06
HSB 85A	58943	73792	61.1	71.1	1	167.2	167.98	0.78	167.93	0.73	167.99	0.79	167.9	0.7
HSB 86A	55986	72520	63.1	73.9	1	167.8	167.51	-0.29	167.49	-0.31	167.5	-0.3	167.46	-0.34
HSB117A	55170	72734	84.8	94.8	1	165.5	166.22	0.72	166.21	0.71	166.21	0.71	166.18	0.68
HSB118A	55776	72696	91	101	1	166.1	167.18	1.08	167.16	1.06	167.17	1.07	167.14	1.04
HSB119A	56100	73082	93.3	103.3	1	165.5	166.41	0.91	166.39	0.89	166.4	0.9	166.36	0.86
HSB120A	56432	73395	91	101	1	164.8	165.99	1.19	165.97	1.17	165.99	1.19	165.93	1.13
HSB121A	57390	72025	88.3	98.3	1	170	171.11	1.11	171.07	1.07	171.11	1.11	171.05	1.05
HSB122A	57747	72196	85.4	95.4	1	169.9	170.98	1.08	170.94	1.04	170.98	1.08	170.91	1.01
HSB123A	58125	72190	93.6	103.6	1	170	171.75	1.75	171.7	1.7	171.75	1.75	171.68	1.68
HSB124AR	58532	72203	94.6	104.6	1	170.2	172.01	1.81	171.95	1.75	172.02	1.82	171.93	1.73
HSB139A	57365	71127	87.6	97.6	1	172	173.88	1.88	173.85	1.85	173.88	1.88	173.84	1.84
HSB140A	56535	70050	81	91	1	174.4	174.4	-999	174.4	-999	174.4	-999	174.4	-999
HSB141A	59169	71214	80.6	90.6	1	174	175.34	1.34	175.26	1.26	175.35	1.35	175.26	1.26
HSB144A	56201	71892	78.6	88.6	1	169	169.98	0.98	169.96	0.96	169.97	0.97	169.94	0.94
HSB146A	58454	70479	85.5	95.5	1	174.7	176.68	1.98	176.63	1.93	176.68	1.98	176.63	1.93
NWP302A	55457	77485	69.4	79.4	1	154	151.55	-2.45	151.59	-2.41	151.55	-2.45	151.53	-2.47
NWP303A	55134	77452	115.7	125.7	1	151.8	150.92	-0.88	150.95	-0.85	150.91	-0.89	150.9	-0.9

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