Development of a Fully Three-Dimensional Groundwater Flow Model for the A/M Area Using Data Fusion

by

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DEVELOPMENT OF A FULLY THREE-DIMENSIONAL GROUNDWATER FLOW MODEL FOR THE A/M AREA USING DATA FUSION

Final Report

**Prime Contract No. DE-AC09-89SR18035
Subcontract No. AA82250N**

**Prepared for:
Westinghouse Savannah River Company
Aiken, SC 29808**

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November 18, 1996

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EXECUTIVE SUMMARY

SRS was established in the 1950's to produce plutonium, tritium, and other nuclear materials. The A/M Area contained fabrication facilities where assemblies were degreased using industrial solvents, primarily trichloroethylene (TCE) and tetrachloroethylene (PCE). From 1952 to 1982, about 3.5 million pounds of solvents were released to the environment as process waste. The DFM calibrated groundwater flow model will contribute to the cleanup and containment of the dissolved plume. The DFM delineation of clay layers has the potential to contribute to the cleanup of DNAPL's.

Data Fusion Modeling (DFM) was used in the A/M Area to provide the distribution of parameters that effect groundwater flow and to provide a calibrated model to be used for development of corrective action programs. DFM was developed by EM-50's Characterization Monitoring Sensor Technology Program and was demonstrated at the Savannah River Site (SRS) Old Burial Ground (Gibbs and Jones (1995)). DFM provided a better fit to the data in less time than conventional methods and also quantified parameter uncertainty.

In the A/M Area, lithological data on subsurface heterogeneity was incorporated into model calibration using DFM. Since DFM provides rapid model updates, alternative conceptual models were able to be considered in order to select the best model. Groundwater flow patterns were determined using particle tracking methods.

Prior to model calibration, DFM was used to delineate the hydrostratigraphy. A combination of picks from well data and cone penetrometer data were used by DFM to map the interfaces between clay layers and aquifers. The hydrostratigraphy was then used as input to model calibration.

SRS used previous models to aid in the siting of recovery wells. The DFM calibration effort builds on the results of previous model calibrations. The most recent model prior to the DFM calibration is the first fully three-dimensional model for the A/M Area using the FACT code. The model incorporates local discontinuities and regional variations of the aquifers and confining units. Hydraulic head data were used to calibrate the model. Hydraulic properties and boundary conditions were manually adjusted to reduce the residual difference between the measured head and the model predicted head. Modeling activities before the FACT model used a quasi-three-dimensional approach that restricted the horizontal flow to the aquifer zones and vertical flow to the confining zones.

DFM model calibration builds on the FACT model by incorporating lithological data on subsurface heterogeneities. Mud fraction data, aquifer pump tests, and laboratory permeability tests were used to determine local hydraulic conductivities treated as measured data by DFM. Head data were also used by DFM where the VAM3DF code (similar to the FACT code) was used to provide the groundwater numerical model. In addition, prior information was used on recharge/boundary conditions that were to be estimated by DFM. Conductivity data provide information on a local scale while head data provide information on a larger scale. DFM geostatistical random field models were used in each hydrostratigraphic unit in order to combine data on different scales.

The result is a model that uses conductivity data to provide a better distribution of hydraulic conductivity model while still fitting the hydraulic head data. In fact, the root-mean-squared (RMS) head residual for DFM is 1.0 ft. The heterogeneity in hydraulic conductivity is particularly evident in the "Lost Lake" Aquifer Zone as shown in the 2D visualization of hydraulic conductivity shown in Figure 6.12. Groundwater flow patterns for the "Lost Lake" Aquifer Zone are shown by the particle pathlines of Figure 6.23.

Because DFM processing is efficient, a number of conceptual models were considered in order to select the best. For example, boundary conditions were treated at different times as prescribed head, no flow, no accumulation, and head-dependent flux (HDF) boundary. It was ultimately decided that the best model was to use HDF boundary and to let DFM estimate the source head parameter in the HDF as part of calibration.

Data files were delivered for the calibrated model so that the model can be used by SRS investigators. The model was produced for the purpose of being employed by SRS investigators for development of corrective action programs for the Southern Sector, Western Sector, and the Northern Sector groundwater remediation activities. DFM software modifications made in the course of the work were delivered. The software modifications provide the capability to perform rapid model updates with additional data that becomes available, thus supporting remediation decisions and monitoring purposes.

Different combinations of parameters sometimes give nearly the same fit to the data, producing uncertainties in parameter estimates. DFM quantifies the uncertainties and computes the impact of the uncertainties on the variability in model predictions. For example, Figure 7.4 shows the variability in a particle pathline in the "Lost Lake" Aquifer Zone. The variability is displayed as Monte Carlo pathlines all starting from the same point, but each experiencing different random realizations of parameter estimate errors.

DFM delineation of the top of the "Green Clay" Confining Zone has been observed by SRS investigators to correlate better with the known distribution of DNAPL's than previous maps of clay surfaces. DFM estimates the clay surfaces as part of determining the hydrostratigraphic layers by interpolating picks using geostatistical models for the spatial variability of layer width. Due to the ability of DFM to incorporate physical models, it is possible to constrain the estimation to be consistent with the known distribution of DNAPL's. Potential future work would be to customize DFM software to estimate DNAPL target zones for remediation. Building on the success of groundwater model calibration, other potential areas of future work are to customize DFM software to incorporate contaminant data for the calibration of flow and transport parameters and to calibrate multi-phase models in the vadose zone.

1.0 INTRODUCTION

1.1 PURPOSE AND OBJECTIVES

The purpose of the work was to obtain the distribution of the parameters that effect groundwater flow and to calibrate a model for subsequent use in the development of corrective action programs in the A/M Area. This lead to the following objectives:

- Delineate hydrostratigraphy with DFM using picks from borehole data and cone penetrometer data and define numerical grid conformal with hydrostratigraphic layers.
- Incorporate mud fraction data, aquifer pump tests, and laboratory permeability tests into DFM with 1995 head data, VAM3DF, geostatistical models in each hydrostratigraphic layer for spatial variability of hydraulic conductivity, and recharge/boundary condition prior information.
- Calibrate model considering alternative conceptual models.
- Determine parameter uncertainties and impact of uncertainties on spatial variability of flow patterns.

1.2 DESCRIPTION OF MODELED SITE

The Savannah River Site (SRS) operated by Westinghouse Savannah River Company (WSRC) is located in South Carolina along the banks of the Savannah River. The A/M Area is located in the northern section of the SRS and consists of those facilities that fabricated reactor fuel and target assemblies for the SRS reactors (M-Area), Savannah River Technology Center (SRTC), and administrative and support facilities (A-Area). The vadose zone and aquifers beneath the A/M Area have been contaminated with tetrachloroethylene (PCE) and trichloroethylene (TCE). In order to remove the subsurface contamination, SRS has installed a groundwater recovery well network in the A/M Area. In 1985, pump-and-treat remediation began in the central A/M Area with eleven operating recovery wells, RWM-1 through RWM-11 (M1 system). Later, recovery well RWM-12 in the northern sector of the A/M Area began pumping. In 1996, remediation began at recovery wells, RWM-13B, RWM-13C, RWM-14B, RWM-14C, and RWM-15.

The modeled area is a 6.7 square mile rectangle which is aligned with the SRS plant coordinates. The rectangle covers an area from 43,500 (ft) to 56,000 (ft) SRS easting and from 95,000 (ft) to 110,000 (ft) SRS northing. Computational limitations preclude an areal extent similar to previous models of the A/M Area. SRS north is 36° to the west of true north. Figure 1.1 shows the modeled area with roads, buildings, sector boundaries, and recovery well in the A/M Area.

Figure 1.1 A/M Area recovery wells and sector boundaries.

1.3 PREVIOUS GROUNDWATER MODELING INVESTIGATIONS

SRS has continually supported the development of numerical models that simulate groundwater flow in the A/M Area. The numerical models have been used to determine the effectiveness of the existing and planned recovery well systems. Papadopoulos and Associates (1987) studied the effectiveness of the M1 system by applying the United States Geological Survey's groundwater flow model, MODFLOW, of McDonald and Harbaugh (1983). Beaudoin et al. (1991) updated the A/M Area MODFLOW model with new hydrologic information and calibrated to 1989-1990 groundwater levels. Intera (1993) extended the A/M Area MODFLOW model to include a transient flow model. The Intera model was calibrated both to steady-state heads before the M1 system was fully operational, and to transient heads from the fourth quarter of 1985 through the fourth quarter of 1991. Jackson (1994) developed the first fully three-dimensional groundwater flow model for the A/M Area using the WSRC flow and contaminant transport code, FACT (WSRC (1995a)).

2.0 HYDROGEOLOGICAL SETTING

The SRS is located on the Aiken Plateau in the Upper Atlantic Coastal Plain of South Carolina. The unconsolidated and semi-consolidated sediments underlying the SRS are part of a Tertiary to Late Cretaceous wedge that dips and thickens in a southeasterly direction. The sediments mainly consist of unconsolidated interbedded sands, silts, and clays. The Aiken Plateau is deeply incised by surface water drainage features. Even though the plateau is well drained, several depressions or poorly-drained areas exist (Carolina Bays). The topography in the model area ranges from 380 feet mean sea level (MSL) in the A/M Area to 200 feet (MSL) along Tim's Branch (Figure 2.1).

2.1 HYDROSTRATIGRAPHY

The hydrostratigraphic representation utilized in this report is presented in Aadland et al. (1995). Aadland and Bledsoe (1990) developed a hydrostratigraphic classification system for the SRS. The classification system is divided into 4 ranks: (1) hydrogeologic province, (2) system, (3) unit, and (4) zone. Figure 3 shows the hydrostratigraphic classification for the A/M Area as presented by Aadland et al. (1995). The SRS is within the southeastern Central Plain hydrogeologic province. Layers in this province tend to thin in the direction of the ancestral coastline to the northwest. The hydrostratigraphic units beneath the A/M Area are part of the Floridan-Midville Aquifer System and include the Steed Pond Aquifer Unit, the Crouch Branch Confining Unit, the Crouch Branch Aquifer, the McQueen Branch Confining Unit, and the McQueen Branch Aquifer. The Steed Pond Aquifer Unit is divided into upper and lower aquifer units, the "M-Area" Aquifer Zone and the "Lost Lake" Aquifer Zone by the "Green Clay" Confining Zone. In the underlying Crouch Branch Confining Unit, the transmissive "middle sand" zone splits the unit into an "upper clay" zone and a "lower clay" zone. The "green clay", "upper clay" and "lower clay" confining zones thin and eventual pinchout north of the A/M Area as indicated in Figure 2.2. One significant feature is not shown in Figure 2.2. The "Lost Lake" Aquifer Zone is divided into "upper" and "lower" subzones by a thin discontinuous clay in some parts of the A/M Area. The groundwater flow model presented in this report includes the Steed Pond Aquifer and the Crouch Branch Confining Unit.

2.2 GROUNDWATER FLOW

The major drainage divide in the model area is along the ridge on which the A/M Area is located (Figure 2.1). Surface water on the west side of the ridge drains into the wetlands to the west of the A/M Area, while surface water on the east side of the ridge drains into Tim's Branch which flows south into Upper Three Runs Creek. Since the water table elevation mimics the surface topography, water entering the "M-Area" Aquifer Zone from the vadose zone flows west towards the wetlands, or east towards Tim's Branch. Most of the recharge on the A/M Area ridge flows through the "M-Area" Aquifer Zone and "Green Clay" Confining Zone into the "Lost Lake" Aquifer Zone. Once water enters the "Lost Lake" Aquifer Zone, it ignores the drainage divide and flows southwest towards the Savannah River or south towards Upper Three Runs Creek. Water that flows through the Crouch Branch Confining Unit into the Crouch Branch Aquifer then flows southwest toward the Savannah River. The A/M Area ridge is a recharge area where hydraulic head decreases with increasing depth. Discharge areas along Tim's Branch and along the low, swampy area west of the A/M Area have hydraulic heads increasing with increasing depth.

A/M Area Topographic Contours in Feet (MSL)

Figure 2.1 A/M Area topography and drainage divide.

Figure 2.2 Schematic north-south hydrostratigraphic section of the A/M Area (Aadland et al. 1995).

Most of the recharge to the groundwater flow system is due to infiltration of precipitation. A large proportion of the precipitation runs off to drainageways and then flows out of the region or evaporates back into the atmosphere. Some of the precipitation is absorbed by plants and transpired back into the atmosphere. At the SRS, it was estimated by Looney et al. (1987) that the water table receives an average annual recharge rate of 15 in/yr. The actual recharge may vary significantly from this estimate since soil type, ground slope, vegetative cover and man-made structures will affect how water enters the subsurface.

Additional recharge to the groundwater flow system is due to the process water discharged at the A-1 and A-14 Outfalls. The drainageways lose water to the subsurface from the outfall point to the point where the drainageways reach a discharge area.

Natural discharge from the groundwater flow system occurs in low lying areas near streams and wetlands. Additional discharge is due to pumping in the A/M Area. Of the seven production wells which pump water from the Crouch Branch Aquifer and McQueen Branch Aquifer, only 905-53A and 905-20A were used in 1995. Twelve recovery wells pumped water from the Steed Pond Aquifer in 1995.

3.0 DATA DESCRIPTION

3.1 MONITORING WELL AND BOREHOLE

Since 1979, monitoring well water levels have been monitored on a quarterly basis in the A/M Area. The 1995 quarterly monitoring well data (WSRC (1995b), (1995c), (1995d), (1995e)) was used to compute an average 1995 water level of each monitoring well. The average 1995 water levels were calibration targets for the groundwater flow model. In an attempt to eliminate water levels that are resulting from perched water, monitoring wells that were pumped less than 50 gallons were discarded. Monitoring well AMB 10DD was discarded since it is located near a Carolina Bay and has a depth to water of six feet. Appendix A contains a list of the 348 accepted 1995 average water levels. The hydraulic head measurements were specified at the middle of the screens.

Hydrologic data was obtained from continuous drill cores at 103 boreholes in the A/M Area. The foot-by-foot description of mud fraction (silt and clay sized material) at 98 cores inside the model domain were used to produce conductivity measurements. Appendix B contains a list of the cores and hydrostratigraphic data modified from Aadland et al. (1995). Figure 3.1 shows the location of the monitoring well and borehole data along with a basemap of the modeled area. Notice lack of data in the northwest and southeast corners of the modeled area.

Appendix C contains plots of mud fraction (smoothed) versus elevation (ft) corresponding to the 103 cores. The dashed lines represent the hydrostratigraphic picks modified from Aadland et al. (1995). The raw mud fraction data was smoothed using the following filter which rejects frequencies in the upper half of the spectrum (Hamming):

$$h_k = \frac{f_{k-3} + 2f_{k-2} + 3f_{k-1} + 3f_k + 2f_{k+1} + f_{k+2}}{12},$$

where f_k is the raw mud fraction data and h_k is the smoothed mud fraction. The no recovery zones found in the raw mud fraction data are assumed to be sandy soils with an average mud fraction of 3%. The no recovery zones were replaced with a 3% mud fraction.

3.2 PUMP TEST

Geraghty and Miller (1987) analyzed recovery wells RWM-4 through RWM-11 in the central A/M Area. Step-drawdown and constant-rate pump tests were performed to estimate well efficiency, specific capacity, maximum potential pumping rates, and aquifer transmissivity. Since the pumping wells are screened across the "M-Area" and "Lost Lake" Aquifer Zones, transmissivity estimates for specific hydrostratigraphic units were not obtained. The total transmissivity of the "M-Area" and "Lost Lake" Aquifer Zones varied between 174 ft²/d near RWM-7 to over 14703 ft²/d near RWM-9.

Monitoring Well and Borehole Data for A/M Area

Figure 3.1 Monitoring well and borehole data.

An aquifer pumping test was performed on recovery well RWM-16 which is screened in the "Lost Lake" Aquifer Zone (Hiergesell (1993)). The horizontal hydraulic conductivity estimates ranged from 28 ft/d to 35.5 ft/d with an aquifer thickness of 40 ft. Estimates of the vertical hydraulic conductivity of the "Green Clay" Confining Zone ranged from 1.6×10^{-3} ft/day to 9.1×10^{-3} ft/day with an aquitard thickness of six feet.

An aquifer pumping test was also performed on recovery well RWM-12 which is screened in the "Upper Lost Lake" and "Lower Lost Lake" aquifer zones (Hiergesell (1994)). Since there was no response to pumping the "Upper Lost Lake" aquifer zone, all water flow was assumed to originate in the "Lower Lost Lake" aquifer zone. The horizontal hydraulic conductivity estimates for the "Lower Lost Lake" aquifer zone ranged from 43 ft/d to 82 ft/d with an aquifer thickness of 20.5 ft. The vertical hydraulic conductivity estimates for the aquitard dividing the "Lost Lake" Aquifer Zone ranged from 2.9×10^{-3} ft/d to 6.4×10^{-3} ft/d.

Hiergesell et al. (1994) performed aquifer pumping tests on recovery wells RWM-13B, RWM-13C, RWM-14B, RWM-14C, and RWM-15B which are screened in the "Lost Lake" Aquifer Zone. Estimates of horizontal hydraulic conductivity ranged from 17 ft/d near RWM-14C to 434 ft/d near RWM-15B.

Hiergesell and Pemberton (1995) performed aquifer pumping tests on five 2-inch monitoring wells in the Southern Sector of the A/M Area. The horizontal hydraulic conductivity estimates for the "Lost Lake" Aquifer Zone ranged from 21 ft/d to 119 ft/d. The horizontal hydraulic conductivity of the "M-Area" Aquifer Zone was estimated to be 53 ft/d.

3.3 LABORATORY

Riha (1993) presented laboratory permeability data from soil samples of the Integrated Demonstration Site (IDS), which is located immediately north of the M-Basin. The laboratory testing was performed by Law Environmental, Inc. under contract to O'Brien and Gere Engineers, Inc. Table 3.1 lists selected soil properties for 17 soil samples.

3.4 CONE PENETROMETER

Cone penetrometer tests were conducted adjacent to the M-Basin in order to delineate the geologic layering and determine the location of dense non-aqueous liquid-phase (DNAPL) contaminated soils (Shinn and Bratton (1992)). As the penetrometer probe is forced into the ground, the conical tip and friction sleeve independently measure vertical resistance beneath the tip as well as frictional resistance on the side of the probe as functions of depth. The penetrometer probe also has a pressure transducer in the cone that measures the pore water pressure and a resistivity module that measures variance in soil conductance. The tip resistance and friction ratio values from the cone penetrometer test were used to determine soil classification versus depth.

The cone penetrometer test (CPT) results presented by Shinn and Bratton (1992) were analyzed to determine the elevation of the top and bottom of the "Green Clay" Confining Zone. Figure 3.2 shows the location of the cone penetrometer tests and Table 3.2 lists the analysis results for 23 cone penetrometer tests. Only 12 of the cone penetrometer tests showed evidence of the "Green Clay" Confining Zone.

Table 3.1. Selected Soil Properties from the Integrated Demonstration Site (IDS) Data Set (modified from Riha (1993)).

Sample	% Sand	% Silt	% Clay	Mud Fraction	Porosity	Vertical K (ft/d)	Horizontal K (ft/d)
IDS 2	36.3	26.7	37.0	0.636	0.43	9.9×10^{-5}	1.19×10^{-4}
IDS 3	78.3	16.7	5.0	0.217	0.42	.94	0.22
IDS 4	91.4	3.6	5.0	0.086	0.37	4.3	NT
IDS 5	90.4	4.6	5.0	0.096	0.42	1.6	NT
IDS 6	30.1	31.9	38.0	0.699	0.43	1.1	NT
IDS 7	93.8	3.2	3.0	0.062	0.4	3.1	NT
IDS 8	44.0	28.0	28.0	0.56	0.39	1.1×10^{-3}	1.04×10^{-3}
IDS 9	80.3	8.1	7.0	0.151	0.39	1.6	NT
IDS 10	72.6	15.4	12.0	0.274	0.42	1.1×10^{-1}	5.38×10^{-2}
IDS 11	92.2	4.4	3.0	0.074	0.39	4.0	NT
IDS 12	48.1	24.9	27.0	0.519	0.7	1.6×10^{-5}	3.4×10^{-5}
IDS 13	80.8	14.2	5.0	0.192	0.36	9.6×10^{-4}	9.6×10^{-4}
IDS 14	68.2	21.8	10.0	0.318	0.35	1.1×10^{-3}	1.55×10^{-3}
IDS 15	93.3	3.7	3.0	0.067	0.39	0.12	0.127
IDS 16	50.8	32.9	16.0	0.489	0.37	5.4×10^{-4}	1.58×10^{-2}
IDS 17	93.1	3.9	3.0	0.069	0.39	0.71	0.24
IDS 18	95.6	4.4	0.0	0.044	0.37	1.1	0.34

NT = not tested

Figure 3.2 Location of the cone penetrometer tests.

Table 3.2 Cone Penetrometer Data

Name	SRS Easting (ft)	SRS Northing (ft)	Bottom of push (ft)	Top of "green clay" (ft)	Bottom of "green clay" (ft)
CPT-1	48761.45	104527.29	215.00		
CPT-2	47884.75	04243.57	180.00	192.	187.
CPT-3	45819.40	103251.70	180.00	187.	185.
CPT-4	45512.11	104120.50	192.00	205.	199.
CPT-5	47863.29	103874.72	174.00	195.	190.
CPT-6	48469.71	103064.78	207.00		
CPT-7	47586.21	102444.36	165.00	203.	200.
CPT-9	47696.68	100993.00	180.00	207.	200.
CPT-10	46714.64	100505.84	194.00	204.	202.
CPT-11	46114.51	101349.24	184.00	198.	195.
CPT-12	45036.43	103267.58	190.00		
CPT-13A	45297.14	103066.76	210.00		
CPT-13B	45312.23	103083.19	180.00		
CPT-14	46433.01	102736.28	190.00	198.	195.
CPT-15A	48778.89	102963.77	208.00		
CPT-17	50104.06	101955.15	190.00	206.	200.
CPT-19A	48785.38	102265.49	204.00		
CPT-20A	47921.33	102488.19	232.00		
CPT-20B	47906.81	102500.20	240.00		
CPT-21	48590.50	101383.04	192.00	209.	202.
CPT-22	48316.81	102495.85	238.00		
CPT-23A	46704.50	103862.03	230.00		
CPT-23B	46596.17	103812.47	184.00	205.	201.

4.0 NUMERICAL, GEOSTATISTICAL, AND MEASUREMENT MODEL S

4.1 GROUNDWATER FLOW

DFM incorporates a modified version of the HydroGeoLogic, Inc., variably saturated flow and transport code VAM3DCG (Huyakorn and Panday (1992)). The modified code, called VAM3DF (Huyakorn and Panday(1995)), was specifically developed for DFM. Enhanced features of VAM3DF include:

- Nodal hydraulic soil properties.
- More efficient assembly of the variably saturated flow equation.
- Head-dependent flux boundary conditions.

When used for steady-state flow modeling within DFM, VAM3DF does not invert the flow equation to compute the steady-state heads (since this is done by DFM). Thus, the Orthomin and PCG solvers are not used. Rather, VAM3DF only computes the steady-state flow error at each node. Partial derivatives of the flow error with respect to estimated parameters are computed numerically by repeated calls to VAM3DF.

Adopting the assumptions of Huyakorn et al. (1984) and using hydraulic head as the dependent variable, the governing equation for water flow in a variably saturated porous medium can be written as

$$\begin{aligned} \frac{\partial}{\partial x_i} \left[K_{ij} k_{rw} \frac{\partial h}{\partial x_j} \right] &= S_w S_s \frac{\partial h}{\partial t} + \phi \frac{\partial S_w}{\partial t} - q \quad i,j = 1,2,3 \\ &= \eta \frac{\partial h}{\partial t} - q \end{aligned} \quad (4.1)$$

where $\eta = S_w S_s + \phi \frac{\partial S_w}{\partial h}$ and h is the hydraulic head, K_{ij} is the saturated hydraulic conductivity tensor for the porous medium, k_{rw} is the relative permeability of water, x_i represents an orthogonal coordinate system, q is the volumetric flow rate (due to sources or sinks) per unit volume of the porous medium, S_w is the water saturation, S_s is the specific storage, and ϕ is the effective porosity.

The hydraulic head is related to the water saturation in the variably saturated zone by the moisture retention function

$$S_w = S_w(\psi)$$

where the pressure head ψ is given as

$$\psi = h - z$$

and z is the elevation above a given datum. The relative permeability of the unsaturated zone is a function of the water saturation [i.e., $k_{rw} = k_{rw}(S_w)$]. Appropriate initial and boundary conditions required to solve the governing equations, including evaporation, plant root uptake, and seepage faces, are discussed by Huyakorn et al. (1986).

When the soil retention and relative permeability functions of a soil are unknown and the saturated zone moisture behavior is unimportant to the simulated scenario, the pseudo-soil relations may be used to predict the water table levels. VAM3DF utilizes simple linear relations to account for changes in element saturated thickness and relative permeability due to the transient movement of the water table in the aquifer.

These linear pseudo-soil moisture relations are given by

$$S_w = 1 - (|\psi - \psi_s|) / b \geq 0.01$$

and

$$k_{rw} = S_w$$

where S_w is the saturation of the element defined such that $S_w = 1$ when the water table is above the top of the element, and $S_w \approx 0$ when the water table is below the bottom of the element. ψ is the pressure head at the element centroid, which governs the pseudo-relation; b is the average elemental thickness; and $\psi_s = b/2$ is the pressure head scaling parameter. The pseudo-relative permeability function ensures that the vertically integrated transmissivity of the element is adjusted to its saturated thickness as in done in the solution to the vertically integrated areal 2-D aquifer flow equations.

The flow equation (4.1) is approximated in three-dimensional space using the Galerkin finite-element method, resulting in a system of differential equations of the form

$$A_{IJ} h_J + B_{IJ} \frac{dh_J}{dt} - F_I = 0$$

The Galerkin approximation process is detailed in Huyakorn et al. (1984). The global coefficient matrices A_{IJ} , B_{IJ} , and F_I are assembled as a sum of the element matrices for a general 8 noded orthogonal curvilinear element. Influence coefficient techniques presented by Huyakorn et al. (1984) and Huyakorn et al. (1986) can be effectively used for assembling 8 noded prism elements in order to avoid integration of each of the element level matrices. They are presented here as

$$\begin{aligned} A_{IJ}^e &= \langle K'_{xx} k_{rw} \rangle \frac{mH}{2\ell} [A_{IJ}^{xx}]^e + \langle K'_{yy} k_{rw} \rangle \frac{\ell H}{2m} [A_{IJ}^{yy}]^e \\ &+ \langle K'_{zz} k_{rw} \rangle \frac{\ell m}{2H} [A_{IJ}^{zz}]^e + \langle K'_{xy} k_{rw} \rangle \frac{H}{2} [A_{IJ}^{xy}]^e \\ &= \langle K'_{yz} k_{rw} \rangle \frac{\ell}{2} [A_{IJ}^{yz}]^e + \langle K'_{zx} k_{rw} \rangle \frac{m}{2} [A_{IJ}^{zx}]^e \end{aligned} \quad (4.2)$$

$$B_{IJ}^e = \frac{\ell m H}{8} \langle \eta \rangle [M_{IJ}]^e \quad (4.3)$$

where A_{IJ}^e is the seepage influence matrix; B_{IJ}^e is the storage matrix; F^e represents all elemental sources, sinks and other boundary conditions; and η represents the storage term of equation (4.1), represented in the original mixed form of the equation. The superscript e in equations (4.2) and (4.3) represents an element level matrix; m , ℓ , and H are the mean lengths of the element in its local x_i' ($i=1,2,3$) coordinate system, and the absolute conductivities are represented in the local coordinate system. The quantities in angular brackets refer to centroidal values of the respective hydraulic properties and the seepage influence coefficient matrices $[A_{IJ}^{xx}]^e$, $[A_{IJ}^{yy}]^e$, $[A_{IJ}^{zz}]^e$, $[A_{IJ}^{xy}]^e$, $[A_{IJ}^{yz}]^e$, and $[A_{IJ}^{zx}]^e$ may have a 7-point, an 11-point, or a 27-point connectivity in three dimensions.

4.2 GEOSTATISTICAL

DFM uses geostatistical models for spatial variability in order to interpolate and to combine information on different scales of variability. For example, DFM uses geostatistical models in the A/M Area to delineate hydrostratigraphy and to perform model calibration. Well and cone penetrometer picks are interpreted as hydrostratigraphic layers using geostatistical models for interpolation. Hydraulic conductivity data on a local scale and hydraulic head data on a larger scale are combined using geostatistical models for the three-dimensional spatial variation of hydraulic conductivity within each hydrostratigraphic layer.

DFM uses nested structures for spatial variability at different scales as described by Gibbs and Hughes (1995). At the observational scale, measurement noise and microstructure appear as white noise. At intermediate scales larger than observational but smaller than the aquifer, spatial variability is modeled as a stationary process using the Markov Random Field (MRF). At the aquifer scale, nonstationary effects are taken into account with a deterministic trend having unknown coefficients that are estimated in DFM. The distinctions between scales are problem and objective dependent. If there are too few terms in the trend, then the Markov process will be forced to account for nonstationary behavior for which it is not well suited. On the other hand, too many terms in the trend leads to familiar problems with overparameterization. Our experience has been that decisions about problems of scale are a natural and reasonably straightforward part of modeling conceptual iteration.

Correlated spatial variability is modeled using state variables that are the sum of a spatial polynomial trend and an MRF. DFM estimates the trend polynomial coefficients as well as the random variation. For example, for a two-dimensional model using a first order autoregression and second order polynomial:

$$s_{ij} = p_{ij} + v_{ij} \quad (4.4)$$

$$p_{ij} = c_0 + c_1 x_i + c_2 y_j + c_3 x_i^2 + c_4 y_j^2 + c_5 x_i y_j \quad (4.5)$$

$$v_{ij} = a(v_{i+1,j} + v_{i-1,j}) + b(v_{i,j+1} + v_{i,j-1}) + w_{ij} \quad (4.6)$$

where s_{ij} is the state at position x_i, y_j ; p_{ij} is the trend evaluated at position x_i, y_j ; v_{ij} is the MRF at x_i, y_j ; c_i are the polynomial coefficients; and a, b are the autoregressive coefficients. If $a=b$, then this is isotropic; otherwise it is anisotropic. w_{ij} is the white noise input with zero mean and variance computed from specified variance on v_i .

The autoregressive coefficients (a and b) indicate the extent of the surrounding states influence on the value at a given state. As the grid points are taken closer together, the coefficients will be larger. In DFM, the autoregressive coefficients are computed internally from other inputs (Yancey (1994)).

There are two inputs relating to the spatial variability model that the user supplies. The spatial variability model has a spatial autocorrelation function which is exponential in three dimensions but deviates from exponential in one or two dimensions (see Figure 4.1). In two dimensions, except near zero, we have

$$E[(v(x_1, y_1) - \bar{v}(x_1, y_1))(v(x_2, y_2) - \bar{v}(x_2, y_2))] \approx \sigma^2 \exp \left\{ -\frac{\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}}{\tau} \right\}$$

where the average value $\bar{v}$ is obtained from the polynomial (4.5). The user must input τ which is the distance at which the correlation coefficient falls to $1/e=0.37$ (possibly different for different directions), and input σ which is the standard deviation of the output of (4.6).

Figure 4.1 Continuous autocorrelation functions in one, two, and three dimensions.

Ideally, the correlation distance τ and variance σ^2 should be chosen from statistical analysis of data. However, the data may not be initially available or may not be in a form suitable for easy interpretation. Thus the scientists' and engineers' prior insight and experience must often be used to select initial τ and σ^2 . As additional data are acquired, τ and σ^2 should be updated based on residuals. The statistical likelihood function is computed by fusion. Statistically optimal maximum likelihood parameter estimates are found by selecting τ and σ^2 to maximize the likelihood.

Grid spacing should be selected to accommodate the correlation distance. It is expected that the ratio of correlation distance to grid spacing should be greater than 1.0. Note that the fusion software internally computes the relationship between the output variance, the correlation distances, the autoregressive coefficients, and the white noise input variance.

The user should also note that very small σ 's can be used to constrain parameters in some situations. It might be easier to use a small σ in a test fusion run, rather than to change all the input required to delete the parameter from the estimated states.

4.3 DFM MEASUREMENT MODELS

The geological DFM measurement model used for 2D layered-earth models (e.g. section 5.0) is simply linear interpolation of the state values at the four nodes surrounding the measurement location and contained in the same model layer. This interpolation involves linearly interpolating in the y-direction at the two x-values, and then linearly interpolating in x. The appropriate layer is usually determined by the layer number specified on the measurement file, although other options are available for some measurement types. If the measurement type is "elevation" or "depth from the reference elevation" and the state at the specified layer is "layer thickness", the interpolations must be added across layers to obtain "elevation" or "depth".

The measurement model for 3D hydraulic conductivity is based on the same method. That is, it is basically a 2D interpolation. For log horizontal conductivity measurements $\ln(Kh)$, the model layer closest to the average well screen elevation (specified on the measurement file) is first calculated. Then the 2D interpolation described above is used to calculate the prediction of the measurement based on current model states. Since $\ln(Kh)$ is a nodal state in standard DFM, the interpolation is direct. Multi-grid DFM also stores $\ln(Kh)$ at each node, but this is interpolated from the coarse grid.

The computation is somewhat more complex for log vertical conductivity measurements $\ln(Kv)$, since this is not a nodal state in the model. Each of the four nodes surrounding the measurement are checked to determine if they lie within a zone in which $\ln(Kv)$ is directly specified. For nodes that are in $\ln(Kv)$ zones, those values are used. For other nodes, $\ln(Kv)$ is computed as $\ln(Kh) - \ln(Kh/Kv)$ where $\ln(Kh)$ at the node is used and $\ln(Kh/Kv)$ is evaluated from spatial polynomial coefficients. In all cases, the partial derivatives of the measurements with respect to the states are computed using a combination of analytic calculations plus the product rule (for the interpolation).

Calculation of the predicted head measurements is similar to that for the $\ln(Kh)$ measurements, since head is a nodal state, but involves interpolation in three dimensions. The average screen

elevation listed on the measurement file should be the average of the minimum (well screen top, head elevation) and the screen bottom. The model layers above and below this elevation are used to interpolate the nodal head values. More accurately, the model head should be computed by integrating from the well screen bottom to top (or water level) using 3D interpolation of values from nodes surrounding the well. It is believed that the error resulting from the use of linear interpolation is small compared to the random measurement error.

The DFM software also has the ability to estimate biases on the various measurement types. This bias is added to the computed value to generate the predicted measurement, i.e. it represents the measured value minus the true value.

4.4 MUD FRACTION TO LOG CONDUCTIVITY MAPPING

In order to produce conductivity data at the core locations, the foot-by-foot mud fraction data must be transformed into horizontal and vertical conductivity data at nodes of the numerical grid. A mud fraction to log conductivity mapping was constructed which takes in account the available pump tests and laboratory permeability tests.

The functional form of the mud fraction to log conductivity mapping is a continuous piecewise linear function given by:

$$f(x) = \begin{cases} P_1 & \text{for } 0 \leq x \leq x_1 \\ P_1 - P_2^2 (x - x_1) / \Delta x & \text{for } x_1 < x \leq x_2 \\ P_1 - P_2^2 - P_3^2 (x - x_2) / \Delta x & \text{for } x_2 < x \leq x_3 \\ P_1 - \sum_{i=2}^m P_i^2 & \text{for } x_m < x \leq 1 \end{cases}$$

where f is log conductivity, x is mud fraction, P_1 through P_m are parameters to be estimated, and $\Delta x = x_i - x_{i-1}$, $i=2, \dots, m$. The function f is a decreasing function with $f'(0.0) = f'(1.0) = 0.0$. The parameters P_1 to P_m are found by solving a nonlinear least squares problem which minimizes

$$\chi^2 = \sum_{i=1}^n (\log(K_i) - \log(\bar{K}_i))^2$$

where K_i is the conductivity derived from the i th pump test or laboratory permeability test, $\bar{K}_i$ is the average (arithmetic or harmonic) of $10^{f(x_1)}, \dots, 10^{f(x_j)}$, where $x_1 \dots x_j$ is the mud fraction data corresponding to the i th test. For a laboratory test, $j=1$, since laboratory tests are point data. Pump tests are integral data that estimates the transmissivity of an aquifer zone and the leakance of the overlying aquitard. For a pump test, mud fraction data $x_1, \dots, x_j$ corresponds to the aquifer zone where the test was performed or the overlying aquitard. An arithmetic average is used for transmissivity data and a harmonic average is used for leakance data.

The Hiergesell aquifer pumping test reports contain 14 pump test data. The reports contain transmissivity data at the following wells: ASB32C, MSB89B, RWM12, RWM13B, RWM14B, RWM16PA, and RWM16PB. The reports contain leakance data at the following wells: MSB32B, MSB32C, MSB89B, RWM12, RWM16PA, and RWM16PB. Riha (1993) presents 11 estimates of horizontal conductivity from IDS.

The Levenberg-Marquardt method (LMM) was used to minimize χ^2 with $m=6$, $x_1=0.08$, and $\Delta x=0.143$. The initial guess of the parameters was $(P_1, P_2, P_3, P_4, P_5, P_6) = (1.0, 0.1, 0.5, 0.5, 0.5, 0.1)$. The LMM needed 5 iterations to converge to $(P_1, P_2, P_3, P_4, P_5, P_6) = (0.99, 1.6, 0.89, 0.79, 0.48, 0.54)$ with $\chi^2 = 28.2$. Recall that the no recovery zones of the mud fraction data were replaced with a 3% mud fraction. Since $x_1 = 0.08$, the fit is not sensitive to any mud fraction less than or equal to 8%. Figure 4.2 shows the resulting fit and Figure 4.3 shows the residuals. Since the pump tests gave higher estimates of conductivity than laboratory tests, the fit is lower than most of the pump test conductivity data and higher than most of the laboratory conductivity data.

The process for translating mud fraction data into horizontal and vertical conductivity measurements is shown in Figure 4.4. The above mapping is used to convert foot-by-foot mud fraction data to foot-by-foot conductivity data, which is then scaled-up to the numerical grid.

A given core penetrates several numerical cells and the top and bottom of each cell divides the foot-by-foot conductivity data into sections along the core length. Each section of conductivity data is averaged arithmetic and harmonic to produce horizontal and vertical conductivity values, respectively. The horizontal and vertical conductivity values are used as conductivity measurements at the core location with an elevation equal to the average of the top and bottom of the numerical cell.

Figure 4.2 Mud fraction to log conductivity mapping.

Figure 4.3 Residual plot for mud fraction to log conductivity fit.

Figure 4.4 Process of translating mud fraction data to horizontal and vertical conductivity measurements.

5.0 DELINEATION OF HYDROSTRATIGRAPHIC UNITS USING DFM

The goal of this effort was to develop a fully 3D hydrological model of the A/M area where the hydraulic conductivity was treated as a heterogeneous field, computed from the core mud fraction data. This is in contrast to previous efforts which defined the model in hydrostratigraphic units. Although it would appear that there is no need to define any hydrostratigraphic units if conductivity is treated as a heterogeneous field, specification of these units can significantly improve the DFM estimates. If the entire domain is modeled as a single heterogeneous unit, the random field model must account for the significant discontinuities in conductivity which occur at the interfaces between the three "clays" ("green", "upper" and "lower") and the three "aquifers" ("M-Area", "Lost Lake" and "middle sand"). The first-order autoregressive model used in DFM will smooth these discontinuities. Thus the DFM process will be significantly aided if the conductivity is modeled as heterogeneous within each unit but independent between units. The trend models should also be modeled separately.

The primary disadvantage of this approach is the possible error introduced by incorrectly specifying the unit elevations, or in specifying unit locations where properties change (e.g. holes in clay layers, clay lenses within aquifers). However, this problem should not be great if the random field model is given enough flexibility to locally adjust the parameters where measurements indicate. In other words, it is better to give DFM an approximately correct structure (a framework for the model) rather than to give it no initial structure at all.

The data available for defining the unit top and bottom elevations consists of 341 layer picks as determined from borehole cores (modified from Aadland et al. (1995)), supplemented with 28 picks obtained from cone penetrometer picks for the "Green Clay" Confining Zone in the central region. This data is listed in Appendix B and Table 3.2. These layer elevations were input to the 2D geological DFM which models either layer depth, elevation or thickness as a random field plus trend. It was decided to estimate the top elevations of the "Green Clay" and "upper clay" zones, and the thicknesses of the "Green Clay", "upper clay", "middle sand" and "lower clay" zones. The choice of estimating layer elevations or thicknesses depends upon how the geologic unit was formed and on the thickness of the unit. Since the clay zones are relatively thin, it is better to estimate the unit thicknesses because DFM can constrain the thicknesses to be greater or equal to zero and because the zone top and bottom elevation will be highly correlated. Thus specification of the thickness as a trend plus spatially correlated random component is appropriate. The same argument also applies to the "middle sand" zone. However, the distances between the surface, the "Green Clay" top and the "upper clay" top are sufficiently large that these two zones are more probably independent than correlated. Thus the top elevations were estimated in DFM as a trend plus correlated random component. In all cases, the trend was specified as a bias plus linear x and y terms, because of the significant slope to the area.

Table 5.1 lists the a prior trend coefficients and 1-sigma uncertainty used in DFM while Table 5.2 lists the 1-sigma and x and y correlation distances which define the random component. All values are in feet.

Table 5.1 Prior Estimate and Uncertainty of Zone Trend Parameters

Parameter	Coefficient	Prior Value	Prior 1-sigma
green clay top elevation	bias	220	20
	linear x	0	10
	linear y	0	10
green clay thickness	bias	10	10
	linear x	0	3
	linear y	0	3
upper clay elevation	bias	140	20
	linear x	0	10
	linear y	0	10
upper clay thickness	bias	10	10
	linear x	0	3
	linear y	0	3
middle sand thickness	bias	20	10
	linear x	0	3
	linear y	0	3
lower clay thickness	bias	30	10
	linear x	0	3
	linear y	0	3

Table 5.2 Zone Parameters Random Model

Parameter	1-sigma	Correlation Distance - x	Correlation Distance - y
green clay top elevation	10	1500	1500
green clay thickness	4	1500	1500
upper clay top elevation	10	1500	1500
upper clay thickness	4	1500	1500
middle sand thickness	5	1500	1500
lower clay thickness	4	1500	1500

The model grid was 16000 feet in x and 15000 in y with a spacing of 250 feet (65 columns and 61 rows) where the origin was located at x=40000 and y=95000 in SRS site coordinates. The measurement standard deviation used to weight the measurements was 2 feet for well picks and 3 feet for CPT data. The model computes the predicted measurement by linearly interpolating the four nodes surrounding the measurement location, as explained in section 4.3.

Since the measurement and spatial continuity models are both linear, the DFM estimation should converge in one iteration. However, DFM required two iterations because one measurement was edited and the editing logic is nonlinear. In initial use of DFM, several measurements were edited, but it was found that these measurements were erroneous and were corrected.

The measurement residual RMS for the converged DFM estimate was 2.37 feet. The sum-of-squares for the three components of the cost function were 40 for the 18 prior trend coefficients, 443 for the 23790 spatial continuity nodes, and 476 for the 363 measurement residuals. Table 5.3 presents the residual RMS of each layer.

Figures 5.1 to 5.6 show the estimated unit surfaces and Tables 5.4-5.9 present measurements and residuals for each surface. Figure 5.7 shows the total thickness of the Crouch Branch Confining Unit. Figures 5.8 to 5.11 show several x-z slices with the measurements and grid lines within +/- 300 feet in y shown. Tables 5.10-5.13 present measurements and residuals for each x-z slice. The surfaces generally follow the data except that the CPT data consistently shows the "Green Clay" Confining Zone to be thinner than the well picks. Since the well data is thought to be the more accurate, this was given more weight. Note that the "Green Clay" Confining Zone never thins out in the north as some references suggest - the data used here seems to indicate a relatively constant thickness, although a distinct facies change occurs. Also note that the "middle sand" zone almost disappears in the west and at several locations in the middle.

SRS personnel have indicated that the "Green Clay" Confining Zone elevation shown in Figure 5.1 is the only computed surface they have seen for which a gradient descent along the surface will generate pathlines starting at a known DNAPL (TCE) source and reach a location at which the DNAPL is believed to be present.

To summarize, the computed lithological layer elevations and thicknesses are believed to be reasonable bounds for defining the hydrostratigraphic units.

Table 5.3 Total Residual RMS by Layer

Layer Number	Number of Data	RMS (ft)
1	99	3.0
2	100	1.7
3	73	1.6
4	41	2.5
5	33	3.2
6	17	1.9

Figure 5.1- DFM Estimated Top Elevation (ft) of the "green clay"

Figure 5.4- DFM Estimated Bottom Elevation (ft) of the "upper clay"

Figure 5.5- DFM Estimated Top Elevation (ft) of the "lower clay"

Figure 5.6 - DFM Estimated Bottom Elevation (ft) of the "lower clay"

Figure 5.7- DFM Estimated Thickness (ft) of "Crouch Branch confining unit"

Table 5.4 Geological Data for Layer 1 (Top of "Green Clay")

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Elevation (ft)	Residual (ft)
SRW__8BB	40464.9	103468.0	197.00	1.40
SRW_10BB	40940.5	103399.1	183.00	-1.00
SRW__4BB	41609.2	103347.9	186.00	-0.10
SRW__3BB	41845.6	103526.6	187.00	1.20
SRW_17BB	42463.8	103956.1	171.00	-1.30
MSB_70C_	45012.0	101785.2	201.00	1.20
__CPT-12	45036.4	103267.6	180.00	-1.20
__CPT-13B	45312.2	103083.2	180.00	-3.70
MSB_76C_	45344.0	103061.6	196.00	3.90
____CPT4	45512.1	104120.5	205.00	0.40
____CPT3	45819.4	103251.7	187.00	-0.90
MSB_49A_	45864.6	99759.0	210.00	-0.30
MSB_49B_	45868.2	99737.8	210.00	-0.40
__CPT-11	46114.5	101349.2	198.00	-2.30
MSB__6B_	46321.6	101148.5	215.00	2.70
__CPT-14	46433.0	102736.3	198.00	-0.30
MSB_64B_	46579.7	101831.0	193.00	-2.00
__CPT-23B	46596.2	103812.5	205.00	0.10
__CPT-10	46714.6	100505.8	204.00	-3.70
MSB__7B_	46718.1	100597.6	220.00	3.40
MSB__5B_	46983.6	101971.1	208.00	2.00
MSB__8B_	47281.9	100805.8	212.00	-0.90
MSB_79B_	47300.2	99296.9	228.00	1.00
MSB_13CC	47525.7	101728.8	217.00	1.00
____CPT7	47586.2	102444.4	203.00	-2.00
____CPT-9	47696.7	100993.0	207.00	-2.00
MSB_63B_	47861.0	101184.4	217.00	2.40
____CPT5	47863.3	103874.7	195.00	-0.80
____CPT2	47884.8	104243.6	192.00	-1.40
MSB_89B_	47889.9	98374.1	213.00	-0.60
MSB_62B_	47906.8	101865.3	215.00	0.70
RWM_16__	48244.8	97647.2	224.00	0.90
MSB_40A_	48279.4	97672.8	223.00	0.50
MSB__4C_	48313.6	101963.2	217.00	0.50
MSB_26A_	48440.7	104602.3	215.00	1.60
MSB__1C_	48512.7	101832.5	215.00	0.20
MSB__3B_	48568.0	102191.7	217.00	0.40
__CPT-21	48590.5	101383.0	209.00	-1.60
MSB__2B_	48748.2	101997.9	214.00	-1.00
MBC__7SB	48750.0	100850.0	212.00	0.30
MHT__1C_	48765.6	102706.8	219.00	1.30
MHT__2C_	48780.3	102747.1	221.00	2.10
MHT__3C_	48861.1	102704.3	206.00	-5.10

MHT_4C_	48863.5	102778.9	217.00	0.00
MSB_75B_	48875.5	98937.4	218.00	0.00
MHT_6C_	48900.0	102810.8	221.00	1.80
MHT_5C_	48905.9	102725.1	222.00	2.90
MHT_8C_	48970.2	102880.7	222.00	1.60
MHT_7C_	48977.5	102788.9	203.00	-7.00
MHT_10C_	49011.6	102892.3	217.00	-1.10
MHT_9C_	49015.6	102814.4	223.00	2.60
MHT_9B_	49031.8	102814.3	223.00	2.50
MSB_23TA	49225.8	104298.8	208.00	-0.10
MSB_38B_	49746.1	102360.8	220.00	1.00
_CPT-17	50104.1	101955.1	206.00	-1.80
MSB_74B_	50443.2	99197.4	223.00	1.10
MSB_88B_	50774.2	97013.0	200.00	-2.20
MSB_50B_	51053.5	96433.0	221.00	0.70
AMB_13AR	51396.0	103082.0	216.00	0.30
AMB_10A_	51410.0	103326.4	217.00	0.10
MBC_4SB	51445.0	105008.0	239.00	0.70
AMB_4A_	51469.8	104131.6	226.00	0.60
AMB_7A_	51591.0	103987.1	223.00	2.00
MSB_87B_	51607.0	101276.0	218.00	0.70
AMB_7_	51624.9	103920.0	223.00	2.50
MBC_5SB	51641.0	103983.0	206.00	-5.80
AMB_11B_	51919.5	103154.2	214.00	-0.10
MSB_82C_	51949.4	107521.9	236.00	0.40
MSB_82TA	51964.2	107525.7	236.00	0.40
MSB_84A_	51971.2	108982.1	234.00	-0.20
MSB_84C_	51973.7	108967.9	234.00	-0.30
MSB_55TA	52014.7	108322.8	236.00	-0.10
MSB_55C_	52029.7	108324.6	236.00	0.00
MSB_47TA	52219.0	106987.7	228.00	0.60
MSB_83C_	52384.7	108405.3	236.00	1.10
MSB_83TA	52410.9	108416.3	236.00	1.30
MSB_69TA	52418.4	107772.5	229.00	-0.80
ASB_6AA	52643.9	105727.0	201.00	-2.30
ASB_6TA	52671.3	105749.5	201.00	-1.70
MSB_32B_	52742.5	99676.0	218.00	0.00
MBC_1SB	52780.0	108450.0	222.00	-2.10
MSB_51B_	52818.0	96992.7	224.00	0.30
ASB_2CR	52862.7	105540.2	225.00	5.20
ASB_10C_	52965.5	105673.1	206.00	-0.80
MBC_2SB	52975.0	107750.0	226.00	-0.10
MSB_54TA	52985.8	108446.3	227.00	-0.40
RWM_14B_	53044.7	106362.1	206.00	0.00
MSB_85TA	53137.2	107831.2	230.00	1.20
MSB_85C_	53151.4	107835.2	230.00	1.20
MSB_52B_	53418.4	103077.7	232.00	1.00
RWM_13B_	53516.3	105803.3	203.00	-1.40
RWM_15B_	53849.0	107444.7	202.00	-1.10
MSB_48C_	54077.0	107917.5	207.00	-1.20
MSB_48TA	54089.2	107925.8	207.00	-1.20

ASB__9C_	54201.1	104568.1	218.00	-0.30
MSB_77TA	54208.9	107053.8	205.00	0.40
ASB__9__	54226.2	104589.2	218.00	-0.30
MSB_53C_	54540.5	106456.2	222.00	0.50
MSB_86C_	54560.5	108500.4	223.00	1.80
MSB_53B_	54574.3	106443.6	222.00	0.40
MSB_81B_	55230.4	103762.7	214.00	-0.40
MSB_61C_	55406.6	106091.1	222.00	-0.60

Table 5.5 Geological Data for Layer 2 (Bottom of "Green Clay")

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Elevation (ft)	Residual (ft)
SRW__8BB	40464.9	103468.0	177.00	-0.80
SRW_10BB	40940.5	103399.1	170.00	0.20
SRW__4BB	41609.2	103347.9	172.00	0.40
SRW__3BB	41845.6	103526.6	168.00	-1.00
SRW_17BB	42463.8	103956.1	164.00	0.70
MSB_70C_	45012.0	101785.2	182.00	-1.10
__CPT-12	45036.4	103267.6	179.00	0.70
__CPT-13B	45312.2	103083.2	179.00	-1.90
MSB_76C_	45344.0	103061.6	188.00	2.20
__CPT4	45512.1	104120.5	199.00	0.10
__CPT3	45819.4	103251.7	185.00	0.00
MSB_49A_	45864.6	99759.0	200.00	0.30
MSB_49B_	45868.2	99737.8	200.00	0.30
__CPT-11	46114.5	101349.2	195.00	1.60
MSB__6B_	46321.6	101148.5	194.00	-1.80
__CPT-14	46433.0	102736.3	195.00	0.60
MSB_64B_	46579.7	101831.0	189.00	1.20
__CPT-23B	46596.2	103812.5	201.00	0.30
__CPT-10	46714.6	100505.8	202.00	1.00
MSB__7B_	46718.1	100597.6	200.00	-0.80
MSB__5B_	46983.6	101971.1	187.00	-1.80
MSB__8B_	47281.9	100805.8	204.00	1.00
MSB_79B_	47300.2	99296.9	208.00	-0.40
MSB_13CC	47525.7	101728.8	198.00	-0.30
__CPT7	47586.2	102444.4	200.00	1.70
__CPT-9	47696.7	100993.0	200.00	1.50
MSB_63B_	47861.0	101184.4	192.00	-2.20
__CPT5	47863.3	103874.7	190.00	0.70
__CPT2	47884.8	104243.6	187.00	0.50
MSB_89B_	47889.9	98374.1	193.00	0.10
MSB_62B_	47906.8	101865.3	195.00	-1.20
RWM_16__	48244.8	97647.2	197.00	-0.50
MSB_40A_	48279.4	97672.8	197.00	-0.50
MSB__4C_	48313.6	101963.2	201.00	0.10
MSB_26A_	48440.7	104602.3	196.00	-0.70
MSB__1C_	48512.7	101832.5	199.00	-0.70
MSB__3B_	48568.0	102191.7	201.00	-0.10
__CPT-21	48590.5	101383.0	202.00	1.60
MSB__2B_	48748.2	101997.9	205.00	1.20
MBC__7SB	48750.0	100850.0	196.00	-0.40
MHT__2C_	48780.3	102747.1	196.00	-1.40
MHT__3C_	48861.1	102704.3	197.00	-0.80
MHT__4C_	48863.5	102778.9	200.00	0.40

MSB_75B_	48875.5	98937.4	198.00	0.10
MHT_6C_	48900.0	102810.8	201.00	0.60
MHT_5C_	48905.9	102725.1	198.00	-0.30
MHT_8C_	48970.2	102880.7	200.00	-0.50
MHT_7C_	48977.5	102788.9	200.00	0.40
MHT_10C_	49011.6	102892.3	202.00	0.20
MHT_9C_	49015.6	102814.4	200.00	0.00
MHT_9B_	49031.8	102814.3	200.00	-0.10
MSB_23TA	49225.8	104298.8	190.00	-0.40
MSB_38B_	49746.1	102360.8	202.00	-0.60
__CPT-17	50104.1	101955.1	200.00	1.30
MSB_74B_	50443.2	99197.4	196.00	-1.00
MSB_88B_	50774.2	97013.0	196.00	1.40
MSB_50B_	51053.5	96433.0	205.00	-0.20
AMB_13AR	51396.0	103082.0	197.00	-0.30
AMB_10A_	51410.0	103326.4	199.00	-0.20
AMB_4A_	51469.8	104131.6	211.00	0.30
AMB_7A_	51591.0	103987.1	204.00	-0.20
MSB_87B_	51607.0	101276.0	195.00	-0.60
AMB_7_	51624.9	103920.0	204.00	0.40
MBC_5SB	51641.0	103983.0	203.00	0.10
AMB_11B_	51919.5	103154.2	196.00	-0.10
MSB_82C_	51949.4	107521.9	219.00	-0.20
MSB_82TA	51964.2	107525.7	219.00	-0.20
MSB_84A_	51971.2	108982.1	226.00	0.40
MSB_84C_	51973.7	108967.9	226.00	0.40
MSB_55TA	52014.7	108322.8	223.00	0.00
MSB_55C_	52029.7	108324.6	223.00	0.00
MSB_47TA	52219.0	106987.7	210.00	-0.40
MSB_83C_	52384.7	108405.3	220.00	-0.70
MSB_83TA	52410.9	108416.3	220.00	-0.60
MSB_69TA	52418.4	107772.5	217.00	0.60
ASB_6AA	52643.9	105727.0	194.00	0.80
ASB_6TA	52671.3	105749.5	194.00	1.40
MSB_32B_	52742.5	99676.0	199.00	0.00
MBC_1SB	52780.0	108450.0	217.00	0.40
MSB_51B_	52818.0	96992.7	204.00	-0.30
ASB_2CR	52862.7	105540.2	195.00	-2.30
ASB_10C_	52965.5	105673.1	192.00	-0.70
MBC_2SB	52975.0	107750.0	210.00	-1.10
MSB_54TA	52985.8	108446.3	221.00	1.10
RWM_14B_	53044.7	106362.1	194.00	0.20
MSB_85TA	53137.2	107831.2	215.00	-0.10
MSB_85C_	53151.4	107835.2	215.00	-0.20
MSB_52B_	53418.4	103077.7	210.00	-0.60
RWM_13B_	53516.3	105803.3	197.00	1.10
RWM_15B_	53849.0	107444.7	196.00	0.50
MSB_48C_	54077.0	107917.5	204.00	1.10
MSB_48TA	54089.2	107925.8	204.00	1.00
ASB_9C_	54201.1	104568.1	208.00	0.30
MSB_77TA	54208.9	107053.8	191.00	-0.80

ASB__9__	54226.2	104589.2	208.00	0.30
MSB_53C_	54540.5	106456.2	209.00	0.00
MSB_86C_	54560.5	108500.4	202.00	-1.70
MSB_53B_	54574.3	106443.6	209.00	-0.20
MSB_81B_	55230.4	103762.7	201.00	0.00
MSB_61C_	55406.6	106091.1	213.00	0.50

Table 5.6 Geological Data for Layer 3 (Top of "upper clay")

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Elevation (ft)	Residual (ft)
SRW__8BB	40464.9	103468.0	118.00	0.70
SRW_10BB	40940.5	103399.1	111.00	-1.40
SRW__4BB	41609.2	103347.9	115.00	0.00
SRW__3BB	41845.6	103526.6	115.00	0.10
SRW_17BB	42463.8	103956.1	114.00	-0.40
MSB_76C_	45344.0	103061.6	115.00	-0.20
MSB_49A_	45864.6	99759.0	128.00	0.00
MSB_49B_	45868.2	99737.8	128.00	0.00
MSB__6B_	46321.6	101148.5	132.00	0.40
MSB_64B_	46579.7	101831.0	113.00	-0.70
MSB__7B_	46718.1	100597.6	138.00	0.10
MSB__5B_	46983.6	101971.1	117.00	-0.20
MSB__8B_	47281.9	100805.8	140.00	0.20
MSB_79B_	47300.2	99296.9	130.00	-0.30
MSB_13CC	47525.7	101728.8	131.00	0.20
MSB_89B_	47889.9	98374.1	142.00	0.20
MSB_62B_	47906.8	101865.3	133.00	0.10
RWM_16__	48244.8	97647.2	139.00	-1.30
MSB_40A_	48279.4	97672.8	145.00	1.50
MSB__4C_	48313.6	101963.2	135.00	0.30
MSB_26A_	48440.7	104602.3	140.00	1.20
MSB__1C_	48512.7	101832.5	135.00	-0.60
MSB__3B_	48568.0	102191.7	133.00	-0.70
MSB__2B_	48748.2	101997.9	139.00	-0.80
MBC__7SB	48750.0	100850.0	146.00	1.80
MSB_75B_	48875.5	98937.4	145.00	0.10
MSB_38B_	49746.1	102360.8	142.00	2.10
MSB_74B_	50443.2	99197.4	140.00	0.20
MSB_88B_	50774.2	97013.0	117.00	-1.20
MSB_50B_	51053.5	96433.0	132.00	0.50
AMB_13AR	51396.0	103082.0	150.00	2.60
AMB_10A_	51410.0	103326.4	144.00	-0.50
MBC__4SB	51445.0	105008.0	157.00	0.80
AMB__4A_	51469.8	104131.6	144.00	-2.30
AMB__7A_	51591.0	103987.1	144.00	0.20
MSB_87B_	51607.0	101276.0	132.00	-1.80
AMB__7__	51624.9	103920.0	144.00	0.50
MBC__5SB	51641.0	103983.0	142.00	-0.10
AMB_11B_	51919.5	103154.2	140.00	-0.20
MSB_82C_	51949.4	107521.9	160.00	-0.40
MSB_82TA	51964.2	107525.7	160.00	-0.40
MSB_84A_	51971.2	108982.1	150.00	-0.10
MSB_84C_	51973.7	108967.9	150.00	-0.10
MSB_55TA	52014.7	108322.8	148.00	-0.30

MSB_55C_	52029.7	108324.6	148.00	-0.60
MSB_47TA	52219.0	106987.7	146.00	0.60
MSB_83C_	52384.7	108405.3	165.00	1.30
MSB_83TA	52410.9	108416.3	165.00	0.90
MSB_69TA	52418.4	107772.5	160.00	0.70
ASB_6AA	52643.9	105727.0	142.00	0.00
ASB_6TA	52671.3	105749.5	142.00	-0.20
MSB_32B_	52742.5	99676.0	117.00	-0.50
MBC_1SB	52780.0	108450.0	160.00	-1.40
MSB_51B_	52818.0	96992.7	132.00	0.00
ASB_2CR	52862.7	105540.2	138.00	-0.80
ASB_10C_	52965.5	105673.1	142.00	-0.80
MBC_2SB	52975.0	107750.0	160.00	-0.60
MSB_54TA	52985.8	108446.3	160.00	-0.50
RWM_14B_	53044.7	106362.1	148.00	0.60
MSB_85TA	53137.2	107831.2	163.00	0.80
MSB_85C_	53151.4	107835.2	163.00	0.80
MSB_52B_	53418.4	103077.7	148.00	0.20
RWM_13B_	53516.3	105803.3	151.00	0.90
RWM_15B_	53849.0	107444.7	138.00	-0.20
MSB_48C_	54077.0	107917.5	139.00	-0.40
MSB_48TA	54089.2	107925.8	139.00	-0.40
ASB_9C_	54201.1	104568.1	150.00	0.20
MSB_77TA	54208.9	107053.8	132.00	-0.40
ASB_9_	54226.2	104589.2	150.00	0.20
MSB_53C_	54540.5	106456.2	139.00	-0.20
MSB_86C_	54560.5	108500.4	159.00	0.60
MSB_53B_	54574.3	106443.6	139.00	-0.40
MSB_81B_	55230.4	103762.7	140.00	-0.30

Table 5.7 Geological Data for Layer 4 (Bottom of "upper clay")

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Elevation (ft)	Residual (ft)
SRW__8BB	40464.9	103468.0	99.00	0.00
SRW__10BB	40940.5	103399.1	99.00	0.20
SRW__4BB	41609.2	103347.9	99.00	-0.30
SRW__3BB	41845.6	103526.6	99.00	0.00
SRW__17BB	42463.8	103956.1	99.00	0.10
MSB__40A_	48279.4	97672.8	122.00	-0.50
MSB__26A_	48440.7	104602.3	110.00	-0.40
MSB__2B_	48748.2	101997.9	121.00	0.30
MBC__7SB	48750.0	100850.0	114.00	-0.20
MSB__38B_	49746.1	102360.8	101.00	-2.90
MSB__88B_	50774.2	97013.0	110.00	2.20
AMB__13AR	51396.0	103082.0	116.00	-1.80
AMB__10A_	51410.0	103326.4	123.00	0.50
MBC__4SB	51445.0	105008.0	140.00	-0.70
AMB__4A_	51469.8	104131.6	138.00	1.30
AMB__7A_	51591.0	103987.1	131.00	1.10
MSB__87B_	51607.0	101276.0	128.00	1.20
AMB__7_	51624.9	103920.0	131.00	1.90
MBC__5SB	51641.0	103983.0	123.00	-2.00
MSB__82C_	51949.4	107521.9	145.00	-1.20
MSB__82TA	51964.2	107525.7	145.00	-1.30
MSB__84A_	51971.2	108982.1	136.00	-0.10
MSB__84C_	51973.7	108967.9	136.00	-0.10
MSB__55TA	52014.7	108322.8	132.00	-0.60
MSB__55C_	52029.7	108324.6	132.00	-0.90
MSB__47TA	52219.0	106987.7	132.00	2.10
MSB__69TA	52418.4	107772.5	146.00	1.40
ASB__6AA	52643.9	105727.0	132.00	0.50
ASB__6TA	52671.3	105749.5	132.00	0.30
MSB__32B_	52742.5	99676.0	102.00	-1.20
MBC__1SB	52780.0	108450.0	149.00	-0.80
ASB__2CR	52862.7	105540.2	125.00	-2.00
ASB__10C_	52965.5	105673.1	137.00	1.90
MBC__2SB	52975.0	107750.0	147.00	0.10
MSB__54TA	52985.8	108446.3	155.00	2.90
RWM__14B_	53044.7	106362.1	130.00	-1.40
RWM__13B_	53516.3	105803.3	135.00	-0.60
ASB__9C_	54201.1	104568.1	135.00	0.00
ASB__9_	54226.2	104589.2	135.00	-0.10
MSB__53C_	54540.5	106456.2	129.00	0.40
MSB__53B_	54574.3	106443.6	129.00	0.20

Table 5.8 Geological Data for Layer 5 (Top of "lower clay")

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Elevation (ft)	Residual (ft)
SRW__8BB	40464.9	103468.0	98.00	1.40
SRW_10BB	40940.5	103399.1	98.00	-0.10
SRW__4BB	41609.2	103347.9	98.00	-0.60
SRW__3BB	41845.6	103526.6	98.00	0.10
SRW_17BB	42463.8	103956.1	98.00	1.40
MSB_40A_	48279.4	97672.8	110.00	1.70
MSB_26A_	48440.7	104602.3	90.00	-0.20
MSB__2B_	48748.2	101997.9	120.00	2.00
MBC__7SB	48750.0	100850.0	85.00	-2.90
MSB_38B_	49746.1	102360.8	100.00	0.20
MSB_88B_	50774.2	97013.0	63.00	-1.70
AMB_13AR	51396.0	103082.0	94.00	-0.50
AMB_10A_	51410.0	103326.4	96.00	-0.20
MBC__4SB	51445.0	105008.0	127.00	0.30
AMB__4A_	51469.8	104131.6	117.00	1.90
MSB_87B_	51607.0	101276.0	115.00	0.50
MBC__5SB	51641.0	103983.0	96.00	-2.60
MSB_82C_	51949.4	107521.9	144.00	2.90
MSB_82TA	51964.2	107525.7	144.00	3.00
MSB_84A_	51971.2	108982.1	125.00	0.20
MSB_84C_	51973.7	108967.9	125.00	0.20
MSB_55TA	52014.7	108322.8	120.00	-0.60
MSB_55C_	52029.7	108324.6	120.00	-0.80
MSB_47TA	52219.0	106987.7	94.00	-3.50
MSB_69TA	52418.4	107772.5	114.00	-2.50
ASB__6AA	52643.9	105727.0	118.00	0.00
ASB__6TA	52671.3	105749.5	118.00	-0.30
MSB_32B_	52742.5	99676.0	98.00	0.20
MBC__1SB	52780.0	108450.0	128.00	1.70
ASB__2CR	52862.7	105540.2	120.00	1.10
MBC__2SB	52975.0	107750.0	116.00	-0.10
MSB_54TA	52985.8	108446.3	114.00	-2.60
RWM_14B_	53044.7	106362.1	118.00	0.90

Table 5.9 Geological Data for Layer 6 (Bottom of "lower clay")

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Elevation (ft)	Residual (ft)
SRW__8BB	40464.9	103468.0	20.00	-1.90
SRW_10BB	40940.5	103399.1	33.00	1.00
SRW__4BB	41609.2	103347.9	37.00	1.00
SRW__3BB	41845.6	103526.6	32.00	-0.30
SRW_17BB	42463.8	103956.1	25.00	-1.20
MSB_40A_	48279.4	97672.8	50.00	-1.30
MSB_26A_	48440.7	104602.3	45.00	-0.50
MSB__2B_	48748.2	101997.9	76.00	-0.50
MBC__7SB	48750.0	100850.0	60.00	1.30
MSB_38B_	49746.1	102360.8	67.00	0.50
MSB_82C_	51949.4	107521.9	109.00	-0.60
MSB_82TA	51964.2	107525.7	109.00	-0.60
MSB_84A_	51971.2	108932.1	104.00	0.00
MSB_84C_	51973.7	108967.9	104.00	0.00
MSB_55TA	52014.7	108322.8	104.00	1.10
MSB_55C_	52029.7	108324.6	104.00	0.90
MSB_32B_	52742.5	99676.0	77.00	1.00

Figure 5.8 - DFM Estimated Layers at y=99,500 ft (+/- 300)

Figure 5.9 - DFM Estimated Layers at y=102,000 ft (+/- 300)

Figure 5.10 - DFM Estimated Layers at y=105,500 ft (+/- 300)

Figure 5.11 - DFM Estimated Layers at y=108,500 ft (+/- 300)

Table 5.10 Geological Data at y = 99500 (ft)

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Data Type	Elevation (ft)	Residual (ft)
MSB_49A_	45864.6	99759.0	GREEN_CLAY_TOP	210.00	-.62
MSB_49A_	45864.6	99759.0	GREEN_CLAY_BOTTOM	200.00	.66
MSB_49A_	45864.6	99759.0	UPPER_CLAY_TOP	128.00	.07
MSB_49B_	45868.2	99737.8	GREEN_CLAY_TOP	210.00	-.71
MSB_49B_	45868.2	99737.8	GREEN_CLAY_BOTTOM	200.00	.61
MSB_49B_	45868.2	99737.8	UPPER_CLAY_TOP	128.00	.00
MSB_79B_	47300.2	99296.9	GREEN_CLAY_TOP	228.00	2.05
MSB_79B_	47300.2	99296.9	GREEN_CLAY_BOTTOM	208.00	-.79
MSB_79B_	47300.2	99296.9	UPPER_CLAY_TOP	130.00	-.59
MSB_32B_	52742.5	99676.0	LOWER_CLAY_BOTTOM	77.00	1.91
MSB_32B_	52742.5	99676.0	UPPER_CLAY_TOP	117.00	-.96
MSB_32B_	52742.5	99676.0	UPPER_CLAY_BOTTOM	102.00	-2.33
MSB_32B_	52742.5	99676.0	LOWER_CLAY_TOP	98.00	.49
MSB_32B_	52742.5	99676.0	GREEN_CLAY_BOTTOM	199.00	-.06
MSB_32B_	52742.5	99676.0	GREEN_CLAY_TOP	218.00	-.07

Table 5.11 Geological Data at y = 102000 (ft)

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Data Type	Elevation (ft)	Residual (ft)
MSB_70C_	45012.0	101785.2	GREEN_CLAY_TOP	201.00	2.42
MSB_70C_	45012.0	101785.2	GREEN_CLAY_BOTTOM	182.00	-2.18
MSB_64B_	46579.7	101831.0	GREEN_CLAY_TOP	193.00	-4.02
MSB_64B_	46579.7	101831.0	GREEN_CLAY_BOTTOM	189.00	2.33
MSB_64B_	46579.7	101831.0	UPPER_CLAY_TOP	113.00	-1.44
MSB_5B_	46983.6	101971.1	GREEN_CLAY_TOP	208.00	3.93
MSB_5B_	46983.6	101971.1	GREEN_CLAY_BOTTOM	187.00	-3.67
MSB_5B_	46983.6	101971.1	UPPER_CLAY_TOP	117.00	-.31
MSB_13CC	47525.7	101728.8	GREEN_CLAY_TOP	217.00	2.06
MSB_13CC	47525.7	101728.8	GREEN_CLAY_BOTTOM	198.00	-.69
MSB_13CC	47525.7	101728.8	UPPER_CLAY_TOP	131.00	.34
MSB_62B_	47906.8	101865.3	GREEN_CLAY_TOP	215.00	1.38
MSB_62B_	47906.8	101865.3	GREEN_CLAY_BOTTOM	195.00	-2.31
MSB_62B_	47906.8	101865.3	UPPER_CLAY_TOP	133.00	.18
MSB_4C_	48313.6	101963.2	GREEN_CLAY_TOP	217.00	1.00
MSB_4C_	48313.6	101963.2	GREEN_CLAY_BOTTOM	201.00	.18
MSB_4C_	48313.6	101963.2	UPPER_CLAY_TOP	135.00	.52
MSB_1C_	48512.7	101832.5	GREEN_CLAY_TOP	215.00	.38
MSB_1C_	48512.7	101832.5	GREEN_CLAY_BOTTOM	199.00	-1.35
MSB_1C_	48512.7	101832.5	UPPER_CLAY_TOP	135.00	-1.16
MSB_3B_	48568.0	102191.7	GREEN_CLAY_TOP	217.00	.81
MSB_3B_	48568.0	102191.7	GREEN_CLAY_BOTTOM	201.00	-.26
MSB_3B_	48568.0	102191.7	UPPER_CLAY_TOP	133.00	-1.30
MSB_2B_	48748.2	101997.9	LOWER_CLAY_TOP	120.00	3.97
MSB_2B_	48748.2	101997.9	LOWER_CLAY_BOTTOM	76.00	-1.08
MSB_2B_	48748.2	101997.9	GREEN_CLAY_BOTTOM	205.00	2.39
MSB_2B_	48748.2	101997.9	UPPER_CLAY_TOP	139.00	-1.57
MSB_2B_	48748.2	101997.9	UPPER_CLAY_BOTTOM	121.00	.60
MSB_2B_	48748.2	101997.9	GREEN_CLAY_TOP	214.00	-1.99
__CPT-17	50104.1	101955.1	GREEN_CLAY_TOP	206.00	-3.68
__CPT-17	50104.1	101955.1	GREEN_CLAY_BOTTOM	200.00	2.67

Table 5.12 Geological Data at y = 105500 (ft)

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Data Type	Elevation (ft)	Residual (ft)
ASB__6AA	52643.9	105727.0	GREEN_CLAY_TOP	201.00	-4.65
ASB__6AA	52643.9	105727.0	GREEN_CLAY_BOTTOM	194.00	1.59
ASB__6AA	52643.9	105727.0	UPPER_CLAY_TOP	142.00	-.06
ASB__6AA	52643.9	105727.0	UPPER_CLAY_BOTTOM	132.00	.98
ASB__6AA	52643.9	105727.0	LOWER_CLAY_TOP	118.00	-.03
ASB__6TA	52671.3	105749.5	UPPER_CLAY_TOP	142.00	-.43
ASB__6TA	52671.3	105749.5	GREEN_CLAY_TOP	201.00	-3.38
ASB__6TA	52671.3	105749.5	GREEN_CLAY_BOTTOM	194.00	2.75
ASB__6TA	52671.3	105749.5	UPPER_CLAY_BOTTOM	132.00	.52
ASB__6TA	52671.3	105749.5	LOWER_CLAY_TOP	118.00	-.54
ASB__2CR	52862.7	105540.2	GREEN_CLAY_TOP	225.00	10.48
ASB__2CR	52862.7	105540.2	GREEN_CLAY_BOTTOM	195.00	-4.57
ASB__2CR	52862.7	105540.2	UPPER_CLAY_TOP	138.00	-1.65
ASB__2CR	52862.7	105540.2	UPPER_CLAY_BOTTOM	125.00	-3.91
ASB__2CR	52862.7	105540.2	LOWER_CLAY_TOP	120.00	2.27
ASB_10C_	52965.5	105673.1	UPPER_CLAY_TOP	142.00	-1.68
ASB_10C_	52965.5	105673.1	GREEN_CLAY_TOP	206.00	-1.64
ASB_10C_	52965.5	105673.1	GREEN_CLAY_BOTTOM	192.00	-1.42
ASB_10C_	52965.5	105673.1	UPPER_CLAY_BOTTOM	137.00	3.88

Table 5.13 Geological Data at y = 108500 (ft)

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Data Type	Elevation (ft)	Residual (ft)
MSB_55TA	52014.7	108322.8	GREEN_CLAY_TOP	236.00	-.12
MSB_55TA	52014.7	108322.8	GREEN_CLAY_BOTTOM	223.00	-.04
MSB_55TA	52014.7	108322.8	UPPER_CLAY_TOP	148.00	-.51
MSB_55TA	52014.7	108322.8	UPPER_CLAY_BOTTOM	132.00	-1.10
MSB_55TA	52014.7	108322.8	LOWER_CLAY_TOP	120.00	-1.28
MSB_55TA	52014.7	108322.8	LOWER_CLAY_BOTTOM	104.00	2.11
MSB_55C_	52029.7	108324.6	UPPER_CLAY_TOP	148.00	-1.16
MSB_55C_	52029.7	108324.6	GREEN_CLAY_TOP	236.00	-.10
MSB_55C_	52029.7	108324.6	GREEN_CLAY_BOTTOM	223.00	-.02
MSB_55C_	52029.7	108324.6	UPPER_CLAY_BOTTOM	132.00	-1.79
MSB_55C_	52029.7	108324.6	LOWER_CLAY_TOP	120.00	-1.66
MSB_55C_	52029.7	108324.6	LOWER_CLAY_BOTTOM	104.00	1.72
MSB_83C_	52384.7	108405.3	GREEN_CLAY_TOP	236.00	2.14
MSB_83C_	52384.7	108405.3	GREEN_CLAY_BOTTOM	220.00	-1.48
MSB_83C_	52384.7	108405.3	UPPER_CLAY_TOP	165.00	2.55
MSB_83TA	52410.9	108416.3	UPPER_CLAY_TOP	165.00	1.83
MSB_83TA	52410.9	108416.3	GREEN_CLAY_TOP	236.00	2.53
MSB_83TA	52410.9	108416.3	GREEN_CLAY_BOTTOM	220.00	-1.22
MBC__1SB	52780.0	108450.0	LOWER_CLAY_TOP	128.00	3.33
MBC__1SB	52780.0	108450.0	UPPER_CLAY_BOTTOM	149.00	-1.64
MBC__1SB	52780.0	108450.0	GREEN_CLAY_BOTTOM	217.00	.89
MBC__1SB	52780.0	108450.0	UPPER_CLAY_TOP	160.00	-2.75
MBC__1SB	52780.0	108450.0	GREEN_CLAY_TOP	222.00	-4.19
MSB_54TA	52985.8	108446.3	UPPER_CLAY_TOP	160.00	-1.00
MSB_54TA	52985.8	108446.3	UPPER_CLAY_BOTTOM	155.00	5.77
MSB_54TA	52985.8	108446.3	LOWER_CLAY_TOP	114.00	-5.29
MSB_54TA	52985.8	108446.3	GREEN_CLAY_TOP	227.00	-.81
MSB_54TA	52985.8	108446.3	GREEN_CLAY_BOTTOM	221.00	2.23
MSB_86C_	54560.5	108500.4	UPPER_CLAY_TOP	159.00	1.27
MSB_86C_	54560.5	108500.4	GREEN_CLAY_TOP	223.00	3.61
MSB_86C_	54560.5	108500.4	GREEN_CLAY_BOTTOM	202.00	-3.30

6.0 GROUNDWATER MODEL CALIBRATION USING DFM

6.1 DATA FUSION MODELING METHODOLOGY

Details of the data fusion modeling (DFM) approach are given by Gibbs and Hughes (1995). Basically DFM is a Bayesian least squares estimation method which combines information from the measurements, prior information on model parameters, stochastic descriptions of the random variability (heterogeneity) of the hydraulic conductivity field, and the steady-state groundwater flow equations to compute a flow model which best fits all this information. Each source of information is weighted in the solution according to the expected accuracy of the data model. The groundwater flow model and stochastic model of conductivity heterogeneity are incorporated in the solution by treating these models as pseudo-measurements. That is, the output of these models at each node is treated somewhat like an ordinary measurement in that it has an expected value and random error for which the variance is known. Using this approach, all measurements and pseudo-measurements are processed as ordinary measurements in the data equation representation developed by Bierman (1977). Further details of the measurement processing are given by Gibbs and Hughes (1995).

DFM attempts to minimize the residuals (difference between the data and the model output) for all four sources of information described above by minimizing a nonlinear least squares cost function representing the weighted sum of residuals. i.e.

$$J = \frac{1}{2} \sum_i \left[\frac{z_i - h_i(x)}{w_{zi}} \right]^2 + \frac{1}{2} \sum_i \left[\frac{0 - f_i(x)}{w_{fi}} \right]^2 + \frac{1}{2} \sum_i \left[\frac{0 - g_i(x)}{w_{gi}} \right]^2 + \frac{1}{2} \sum_i \left[\frac{x_{pi} - x_i}{w_{xi}} \right]^2 \quad (6.1)$$

where z_i is the measurement i ; x is the state vector containing all model parameters to be estimated (nodal head and $\ln(Kh)$, anisotropy, recharge, source/drain heads of head-dependent flux boundary conditions, etc.); $h_i(x)$ is the nonlinear function which computes the expected value of measurement based on the state; w_{zi} is the weighting of the measurement (standard deviation of measurement noise); $f_i(x)$ is the nonlinear function which computes the steady-state flow error based on x ; w_{fi} is the weighting of the flow measurement (standard deviation of model error set = 0.0002 ft/day); $g_i(x)$ is the linear function which computes the expected value of the stochastic variability model based on state x ; w_{gi} is the weighting of the spatial variability model (standard deviation of model error); x_{pi} is the prior expected value of component i of x ; w_{xi} is the weighting of the prior estimate (standard deviation of prior error).

The models represented by $h_i(x)$, $f_i(x)$, and $g_i(x)$ were described in Section 4.

J can be minimized using an iterative Gauss-Newton method which re-linearizes about the current estimate at each iteration, using an approximate Hessian of the cost function. The linearized problem can be expressed in the information array form due to Bierman (1977).

Unfortunately, full Gauss-Newton steps may greatly exceed the linear region of the partial derivatives and thus the method may not converge. It is therefore necessary to restrict the

Gauss-Newton steps. While many methods have been used for this purpose (e.g. Levenberg-Marquardt), we prefer either the trust-region methods (Vandergraft (1977)) or backtracking (Press (1992)). The trust region method may be the most robust, but it can also be computationally expensive. We have found that backtracking is quite robust and satisfactory for most applications.

The DFM software has several options for computing the step at each iteration: direct matrix solution (matrix triangularization), an iterative preconditioned conjugate gradient solution using iterative solutions of the flow and stochastic models, a conjugate gradient solution using the gradient only, or a quasi-Newton method based on the gradient only. The last option is restricted to the multi-grid DFM (described later) and the third option has not been overly successful. The direct solution is practical because all four sources of information can be formulated as finite-difference-like equations involving only nearest neighbor nodes. Thus the information array is extremely sparse and the direct method can be coded to take advantage of that sparseness. However, the direct method becomes increasingly impractical in terms of computer memory, disk space and computations as the number of nodes increases beyond about 15000 to 20000. Thus the second method, referred to as the "fast solver", is the preferred method for large problems. Unfortunately, while it computes the Gauss-Newton step, it does not compute the covariance: the direct method must be used to compute this for medium-sized problems or the multi-grid method (described later) for large problems.

One other important refinement of the basic Gauss-Newton iteration is the inclusion of automated data editing logic. While one hopes that the measurement data is accurate within about three times the specified standard deviation, real data sets always seem to include a few anomalous measurements which deviate significantly from the surrounding data. Often this is due to transcription errors in recording or transforming the data, or in specifying the location of the measurement. In other cases it is due to a local effect which cannot be modeled on the granularity of the numerical model (such as local drawdown near a pumping well). Thus the DFM software tests the residuals from each measurement set normalized by the specified standard deviation and by the overall residual RMS from the previous iteration. If that residual sum-of-squares exceeds at user specified threshold, the measurement set is edited. Since the residual RMS from the previous iteration is included in the test, large residuals on early iterations (caused by inaccurate initial estimates of the states) will not cause excessive editing. While this automated editing procedure cannot be based on rigorous statistical analysis, it has been used for many years in a variety of applications ranging from satellite orbit determination (Chin, et al. (1972)) to power plant modeling (Gibbs(1995)), and has proved satisfactory.

Most of the above DFM description refers to the standard DFM software. There is also an alternate version referred to as multi-grid. While standard hydrological DFM estimates hydraulic head and natural log y-direction conductivity ($\ln(Kh)$) at each node in the numerical model, the multi-grid DFM uses a fine grid for the flow numerical model and a much coarser grid (e.g. less than 2000 nodes) for the random field model of $\ln(Kh)$. The basis for this approach is the belief that a fine numerical flow grid is necessary to accurately model flow (especially near pumping wells and other discontinuities), but even if the earth is truly heterogeneous on the scale of the numerical grid, a sufficient number of conductivity measurements is not available to estimate the conductivity at this scale. Thus the "standard DFM" user will specify a correlation distance for $\ln(Kh)$ much larger than the flow model grid spacing. In multi-grid DFM the conductivity is

specified on a coarser grid where the spacing between nodes is comparable to the correlation distances which would be specified for standard DFM. Then interpolation (e.g. linear) can be used to compute the conductivity at the flow model nodes. Note that this approach is not simply a zonal specification of conductivity as is often used. Rather, $\ln(Kh)$ is modeled as a random field where $\ln(Kh)$ will differ at each node of the flow model.

While the multi-grid approach potentially suffers from the coarser specification of conductivity than standard DFM, it has several advantages. First, it is implemented using an exact solution to the steady-state flow equation so that some of the linearization problems encountered in standard DFM are minimized. Thus it tends to converge in fewer iterations than standard DFM and may be more robust. Secondly, it can be implemented using either a direct method or the quasi-Newton method: the computational requirements are approximately equal for the A/M area model. Thus it is possible to compute the state error covariance matrix for much flow larger grids than for standard DFM. Furthermore, the method can be easily extended to include transient flow or contaminant transport measurements. Unfortunately, it suffers from one disadvantage which was not obvious. For small to medium sized grids, the computational burden is usually larger for multi-grid than standard DFM. However, the computations do not increase as rapidly with the number of grid nodes as for standard DFM, so that multi-grid will be more efficient for large grids. Most of the results in this section are based on standard DFM. The flow pattern variability analysis in section 7.0 used multi-grid DFM because of the requirement to compute the state error covariance matrix.

6.2 APPLICATION OF DFM TO SRS A/M AREA

As previously noted, the flow numerical model covers a horizontal area of 12,500 (ft) by 15,000 (ft). Numerical horizontal grid cell sizes of both 250 feet (fine grid) and 500 feet (coarse grid) were used in this study. The numerical model used 22 nodal layers distributed by hydrostratigraphic unit as follows:

Table 6.1 Model Layers per Hydrostratigraphic Unit

Hydrostratigraphic Unit	Model Layers
"M-Area" Aquifer Zone	7
"Green Clay" Confining plus "Lost Lake" Aquifer Zones	8
"Crouch Branch" Confining Zone	7

We initially used 6 hydrostratigraphic unit for the A/M Area: "M-Area" Aquifer Zone, "Green Clay" Confining Zone, "Lost Lake" Aquifer Zone, "upper clay" zone, "middle sand" zone, and "lower clay" zone. However, the poor definition and discontinuity of some clay layers made modeling difficult. It was found that DFM could better fit the measurements and produced more reasonable flow estimates using the three hydrostratigraphic units listed above. We also tried modeling the area as a single hydrostratigraphic unit, but the lack of a model structure caused convergence problems for DFM.

The elevation of each layer node was determined by using a fixed ratio of the hydrostratigraphic unit upper and lower elevation. For example, the top layer was set to the surface elevation and layer 7 was set to the "Green Clay" top elevation plus 4 % of the "M-Area" Aquifer Zone thickness. Layers 2 to 6 were computed as fixed ratios between layers 1 and 7. Figure 6.1 shows the nodal layers for the y-z slice at $x = 50000$.

The resulting numerical grids were 17732 nodes (coarse) and 68442 nodes (fine). Most of the initial results were obtained using the coarse grid because of the much shorter computational time. This allowed determination of significant modeling issues and resolution of problems. When satisfactory results were obtained, the fine grid was used to compute final results.

As noted previously, "standard DFM" estimates hydraulic head and $\ln(Kh)$ at each numerical node. In addition to the random component of $\ln(Kh)$, the trend was modeled as a constant bias for each hydrostratigraphic unit, which was estimated with an a priori uncertainty of 0.2 to 0.3. Although the software is capable of estimating up to 4th-order spatial polynomials, there was no reason to expect significant trends in the conductivities so that only a bias was modeled. The log vertical anisotropy was treated as an unknown bias to be estimated (a priori value = 5.0 with uncertainty = 0.5). Again this could have been estimated as a higher order spatial polynomial but was not believed to be necessary. The horizontal anisotropy was fixed at 1.0.

The calculation of hydraulic conductivity from mud fraction data as described in section 4.4 is subject to both systematic and random errors. Calculation of vertical conductivity is believed to be particularly subject to errors. Biases on log horizontal and vertical conductivity were estimated in the DFM to allow for adjustments to average conductivity and recharge. The prior values were assumed to be zero with a 1-sigma uncertainty of 0.3. (Note that a bias in log is equivalent to a multiplicative error, i.e. scale factor error: $e^{0.3} = 1.35$).

Recharge is another modeling parameter potentially subject to errors. In the A/M Area, recharge was modeled in four separate zones (Figure 6.1): the general area (16 inches/year), paved areas (3 inches/year), the A-14 outfall (30 inches/year) and the A-1 outfall (21 inches/year). While the two outfalls have high recharge, the area is small and there are few wells nearby, so that the model is not sensitive to these recharge values (i.e. the observability of the recharges is poor). Thus these two values were fixed in DFM while the general and paved area recharge values were estimated using a 1-sigma uncertainty of 1 inch/year.

Boundary conditions (BC) for the modeled area are poorly known because of a lack of wells outside the area. There are no monitoring wells north and east of the model boundaries and only a limited number of wells to the south and west (and these are not close). In this report, north, south, east and west refer to the SRS site coordinate. Following the methods used in previous studies, we initially assumed that the eastern boundary was no-flow for all three aquifers. Because some head data was available to the northwest of the site, we initially fit contours to all the data for each aquifer and used the interpolated values at the western boundaries as fixed head boundary conditions. For the north and south boundaries, we tried both no-accumulation (second derivative of head perpendicular to boundary is zero) and head-dependent flux (HDF) conditions where DFM estimated the source heads. Both methods produced satisfactory results. Since the no-accumulation BC is uncommon in groundwater modeling and use of the HDF gives DFM more

Figure 6.1 Fine grid at SRS Easting 50,000 (ft)

control of the model, the HDF was selected as the preferred model. As will be explained later, the HDF was eventually used for all four model sides for all three aquifers.

The bottom layer of the model grid was defined as a fixed head BC using the interpolated heads (Figure 6.3) computed from fitting head data from the Crouch Branch Aquifer, which is listed in Table 6.2. Although the well information in this aquifer is sparse and thus the computed heads may not be accurate, the sensitivity of our model to those boundary conditions is small (because the bottom unit is mostly clay).

The HDF for each boundary and aquifer was defined in zones of about 2000 to 6000 feet horizontally where the extent of the zone was determined by the variation of head in the zone. All zones used the same leakance (0.07 for an area of 3800 ft²) but the source heads for each zone were different. Since these were not known accurately, they were estimated in DFM using an a prior value determined from fits to the data. The assumed 1-sigma uncertainty was 2 feet.

To summarize, the prior information used for the 67 estimated common parameters is (units of ft/d) is listed in Tables 6.3 to 6.8.

Table 6.2 Crouch Branch Aquifer Head Data

Well ID	SRS Easting (ft)	SRS Northing (ft)	Head (ft)
ASB 8TA	53124.69	106375.79	217.0
MSB 12TA	47127.30	102266.70	193.7
MSB 12TB	47133.00	102260.10	193.6
MSB 21TA	47218.19	103980.89	165.2
MSB 27TA	49486.80	104951.39	202.3
MSB 29TA	51245.69	107330.39	213.5
MSB 30A	48004.10	105727.39	199.5
MSB 31A	50100.19	101979.29	199.1
MSB 33TA	51734.00	98018.20	195.6
MSB 34TA	50536.60	104905.79	202.5
MSB 34TB	50537.89	104891.60	203.8
MSB 35TA	50919.60	102101.60	201.9
MSB 36TA	49503.00	100507.70	195.5
MSB 37A	51439.80	105295.00	208.5
MSB 37TA	514499.80	105301.29	208.3
MSB 38TA	49810.39	102434.89	199.2
MSB 39TA	48357.69	100830.60	193.6
MSB 40TA	48277.19	97660.39	190.2
MSB 41TA	53429.69	102176.50	207.4
MSB 42TA	54581.69	104545.60	206.9
MSB 43TA	49281.80	107275.79	204.2

MSB 47TA	52219.00	106987.70	217.9
MSB 54TA	52985.80	108446.29	220.8
MSB 55TA	52014.69	108322.79	215.3
MSB 66TA	51096.69	105842.60	207.6
MSB 69TA	52418.39	107772.50	216.8
MSB 82TA	51964.19	107525.70	215.7
MSB 83TA	52410.89	108416.29	216.8

Table 6.3 Prior Estimate and Uncertainty of Trend Log Conductivity States

Parameter	Unit	Prior Value	Prior 1-sigma
mean ln(Kh)	"M-Area" Aquifer	2.0	1.0
mean ln(Kh)	"Lost Lake"/"Green Clay"	2.0	1.0
mean ln(Kh)	CB Confining Unit	2.0	1.0
mean ln(Kh/Kv)	"M-Area" Aquifer	5.0	0.5
mean ln(Kh/Kv)	"Lost Lake"/"Green Clay"	5.0	0.5
mean ln(Kh/Kv)	CB Confining Unit	5.0	0.5

Table 6.4 Prior Estimate and Uncertainty of Measurement Bias and Recharge States

Parameter	Prior Value	Prior 1-sigma
meas. bias - ln(Kh)	0.0	0.3
meas. bias - ln(Kv)	0.0	0.3
recharge - general area	0.00342	0.00023
recharge - paved areas	0.00068	0.00023

Table 6.5 Prior Estimate and Uncertainty of North Boundary Source Head States

Aquifer	Grid Columns	Prior Value	Prior 1-sigma
M-area	2-10	225.	2.0
M-area	11-40	230.	2.0
M-area	41-50	230.	2.0
Lost Lake	2-10	220.	2.0
Lost Lake	11-20	224.	2.0
Lost Lake	21-28	230.	2.0
Lost Lake	29-36	230.	2.0
Lost Lake	37-44	225.	2.0
Lost Lake	45-50	222.	2.0
middle sand	2-10	220.	2.0
middle sand	11-40	220.	2.0
middle sand	41-50	220.	2.0

Table 6.6 Prior Estimate and Uncertainty of South Boundary Source Head States

Aquifer	Grid Columns	Prior Value	Prior 1-sigma
M-area	2-10	195.	2.0
M-area	11-40	195.	2.0
M-area	41-50	195.	2.0
Lost Lake	2-14	195.	2.0
Lost Lake	15-30	195.	2.0
Lost Lake	31-50	195.	2.0
middle sand	2-10	195.	2.0
middle sand	11-40	195.	2.0
middle sand	41-50	195.	2.0

Table 6.7 Prior Estimate and Uncertainty of East Boundary Source Head States

Aquifer	Grid Rows	Prior Value	Prior 1-sigma
M-area	1-10	215.	2.0
M-area	11-20	227.	2.0
M-area	21-30	235.	2.0
M-area	31-40	235.	2.0
M-area	41-50	235.	2.0
M-area	51-61	235.	2.0
Lost Lake	1-10	203.	2.0
Lost Lake	11-20	215.	2.0
Lost Lake	21-30	220.	2.0
Lost Lake	31-40	220.	2.0
Lost Lake	41-50	220.	2.0

Lost Lake	51-61	220.	2.0
middle sand	1-10	197.0	2.0
middle sand	11-20	210.0	2.0
middle sand	21-30	213.0	2.0
middle sand	31-40	213.0	2.0
middle sand	41-50	213.0	2.0
middle sand	51-61	212.0	2.0

Table 6.8 Prior Estimate and Uncertainty of West Boundary Source Head States

Aquifer	Grid Rows	Prior Value	Prior 1-sigma
M-area	1-10	210.	2.0
M-area	11-20	215.	2.0
M-area	21-30	215.	2.0
M-area	31-40	215.	2.0
M-area	41-50	220.	2.0
M-area	51-61	220.	2.0
Lost Lake	1-10	197.	2.0
Lost Lake	11-20	202.	2.0
Lost Lake	21-30	210.	2.0
Lost Lake	31-40	215.	2.0
Lost Lake	41-50	215.	2.0
Lost Lake	51-61	220.	2.0
middle sand	1-10	199.0	2.0
middle sand	11-20	198.0	2.0
middle sand	21-30	198.0	2.0
middle sand	31-40	199.0	2.0
middle sand	41-50	199.0	2.0
middle sand	51-61	200.0	2.0

Figure 6.2 Prior estimate of surface recharge.

Head Contours (ft) and Data for Crouch Branch Aquifer

Figure 6.3 Head contours and data for Crouch Branch Aquifer.

The 12 remediation pumping wells (RWM-1 to RWM-12) were modeled in DFM as fractured flow along a vertical column from the well screen top to bottom. This fractured flow is implemented in VAM3DF by multiplying the finite element geometric factor between the nodes by a "large number" such that the difference in head between the nodes is about 0.10 feet. The pumping was modeled in DFM as a flow from the grid node corresponding to the bottom-of-screen. Modeling the flow at the bottom-of-screen does create a minor problem in that the pathline will continue below the well bottom because of the downward head gradient in the aquifers. Thus it was necessary to stop the pathlines at the screen bottom. Table 6.9 lists the well node locations (fine grid) and average pumping rates (cu-ft/day) for 1994 (Note that the head data used in the analysis was for 1995 and it is assumed that the pumping rates for 1995 are not substantially different from 1994). The bottom of the "M-Area" Aquifer Zone is layer 7 in our model grid, so that 4 of the wells draw some water from the "M-Area" Aquifer Zone. However, most of drawdown is from the "Lost Lake" Aquifer Zone.

Table 6.9 Location and Pumping Rates (cu-ft/day) of Recovery Wells

Well	grid column	grid row	top layer	bottom layer	pumping rate
RWM-1	21	31	5	11	3471
RWM-2	24	39	8	15	4277
RWM-3	26	40	8	15	11279
RWM-4	23	36	7	16	7624
RWM-5	26	35	8	16	9352
RWM-6	27	29	6	15	12517
RWM-7	25	29	7	14	7246
RWM-8	16	29	10	19	6588
RWM-9	29	37	8	17	5686
RWM-10	20	29	8	18	3347
RWM-11	29	41	10	16	17028
RWM-12	37	49	10	14	9193

As explained in section 4.2, the value of $\ln(Kh)$ at each node is assumed to consist of a trend (bias) component and a random field component which is different at each node. As shown above, the bias is defined separately for each hydrostratigraphic unit. Likewise, the random component is assumed to be spatially correlated within each hydrostratigraphic unit but uncorrelated between units. The random field model is defined by the process standard deviation and correlation distances (distance at which the correlation falls to $1/e$) in each orthogonal direction. The statistics of the random field model used for the A/M Area is given in Table 6.10. Note that random variation in the "green clay/Lost Lake" unit was assumed to be slightly larger than in the other units, and the correlation distances were slightly shorter to allow for possible holes in the clay.

Table 6.10 Statistics of Random Field Model for $\ln(Kh)$

Hydrostratigraphic Unit	1-sigma	Correlation x (ft)	Correlation y (ft)	Correlation z (ft)
"M-Area" aquifer	1.0	1000	1000	15
"Green Clay"/"Lost Lake"	1.2	800	800	10
CB Confining Unit	1.0	1000	1000	15

Preprocessing of the head and conductivity measurements was described in Sections 3.1 and 4.4. The error standard deviation assumed for the head measurements was 0.9 feet, which is believed to be a reasonable estimate of the errors in calibration plus the temporal variability in the measurement. The error standard deviations assigned for the log conductivity measurements is dependent upon the number of individual mud fraction measurements averaged to compute the value at the grid node. Since the $\ln(Kh)$ measurements are computed as the log of the arithmetic average of the Kh values near the node, the variance should decrease as the log of the inverse of the number of measurements averaged if all individual Kh values have random errors of equal variance. That assumption will not be strictly true, but it is sufficiently close that we computed the standard deviation of the log average as $\sigma = 6.32/\sqrt{n}$ where n is the number of 1-foot conductivity measurements in the average. This gives a 1-sigma error of 2 (in log ft/day) for a typical 10 sample average. The log vertical conductivity measurements were computed as a harmonic average of the 1-foot conductivity measurements. We also used the same formula for computing the standard deviation even though it should be more heavily weighted by the low conductivity samples.

6.3 DFM ESTIMATION

All groundwater modeling is an iterative process in which the analyst makes assumptions about the model and adjusts parameters until the resulting model heads, conductivities and other flow parameters match the given measurement data. The analyst must also check that the behavior of the model is "reasonable". For example, it should show some flow path between known contaminant sources and the observed groundwater contamination. While the general process of groundwater modeling using DFM is conceptually similar to the conventional trial-and-error process, it differs significantly in the mechanism. Most importantly, it allows the analyst to think about modeling issues at a much higher level than has been previously possible. Using trial-and-error modeling, the analyst must adjust individual values of boundary conditions, recharge values, conductivities (or transmissivities) and leakances until the model output matches the measurements. It is virtually impossible for the analyst to keep track of the model sensitivity and interactions for hundreds of parameters. Thus the number of parameters varied in the analysis is usually very limited (e.g. conductivity is specified in a small number of zones) and the trial-and-error continues until the available time or funds are exhausted.

In contrast, DFM modeling automates the process of finding the set of parameters which best fit the available measurements. Thus the analyst can think about the model at the conceptual level and decide whether the results are reasonable. The burden of finding the best set of model parameters is replaced with the alternate task of determining the appropriate parameters to

estimate and the appropriate error model for those parameters and the measurement data. That is, the cost function (Equation 6.1) to be minimized involves a weighted sum of squared residual errors involving measurements, prior information, spatial continuity, and steady-state flow errors. Thus the results are dependent upon choosing the correct weighting for these terms. Ideally the weights should be chosen so that they are equal to the standard deviation of the error for that model, i.e., the measurement weights should be equal to the standard deviation of the random error in the measurement, the prior weight should reflect the expected error in the prior estimate, the spatial continuity weight should be a function of the average randomness of the field, and the flow weighting should be the expected error in the steady-state flow numerics. If all terms are weighted appropriately, the computed least squares error covariance should accurately represent the error in the estimates.

The measurement error standard deviation can usually be determined by analyzing the method used to obtain the measurement and by computing the effect of individual error sources. In some cases, it can also be determined simply by examining the scatter in repeat measurements. The spatial continuity model weighting can be computed (Yancey (1994)) if the process standard deviation and correlation distances are known. These can usually be estimated by examining the variability in the geological and hydrogeological structures from well and geophysical data. However, these parameters are perhaps the least certain, and are prime candidates to be used as tuning parameters if the resulting DFM estimates exhibit more or less variability than thought likely. The uncertainty in prior estimates can also be guessed from knowing the source of the information (e.g. recharge estimates usually include a range). Finally, the error in the steady-state flow model must be defined. We have usually used weighting equal to about 3 to 10 % of the recharge (since the DFM flow error is computed in units of head change per time). Ideally this flow error should be zero, and the final RMS residual error is always much smaller than the specified weighting. However, use of a weighting value much smaller than 3% of the recharge usually results in numerical instabilities in the nonlinear iterations.

The preceding discussion was given to help explain the sequence of DFM runs that were made in modeling the A/M Area. Initially we used the no-flow (east) and fixed-head (west) boundary conditions and 6 hydrostratigraphic unit model as described previously, with no allowance for measurement biases. The resulting DFM estimate of recharge was unreasonably high (e.g. 30 inches/year) and produced a relatively poor fit to the 250 unedited head measurements (RMS=2.4 feet). Convergence of the nonlinear iterations was poor, which is another indication of fundamental conceptual problems with the model. The high recharge estimate suggested that the measurements of conductivity may have been biased high. Thus biases on $\ln(Kh)$ and $\ln(Kv)$ were estimated in DFM: the resulting estimates were in the range 0.4 to 1.1 (scale factors of 1.5 to 3.0). This led us to re-examine the method used to compute conductivity from mud fraction. It was noted that the calibration curve was very sensitive to the values assigned for missing mud fraction data. The calibration curve was changed to piecewise linear, which was somewhat less sensitive to the assumption for missing data because conductivity was assumed to be constant for mud fractions below 8%. We also computed the vertical averaging of the mud fraction samples at the elevations of our grid nodes, and used the variable weighting formula described above (constant weighting was previously used). Large head residuals from a few wells suggested anomalous data, which led to the discovery of errors which were corrected.

These changes produced considerably improved DFM results with average recharge estimates of about 21 to 24 inches/year and estimated measurement biases of 0.2 to 0.6. However, convergence of the iterations and the fit to the data were not as good as desired. It was noted that the estimated "M-Area" and "Lost Lake" Aquifer Zone source heads on the eastern part of the north boundary were lower than the head, so that there was considerable flow to the north-east corner. This suggested that there might be flow across the northern section of the east boundary, and thus three HDF zones were created in the northern section of the east boundary. At the same time, the recharge model was changed from uniform recharge across the entire model area to four zones (as described above). This produced faster convergence and a much better fit to the data with considerable flow through the eastern boundary in both the "M-Area" and "Lost Lake" Aquifer Zones. We then extended the HDF model to the rest of the eastern boundary and to the western boundary. Only the "middle sand" zone was retained as no-flow on the east, and fixed head on the west. The "middle sand" zone was not modeled as HDF because less head data was available in this unit than in the others. At this point, a total of 58 "common" flow parameters were being estimated, in addition to the head and $\ln(Kh)$ at each node. These changes produced more reasonable estimates of recharge (19 inches/year overall and 10 inches/year in the paved areas).

It was next noted that the estimates of source heads for the two "Lost Lake" zones in the middle of the northern boundary had increased more than 5 feet above the prior estimate of 225 feet. This provided a source of water flowing southward through the middle of the "Lost Lake" Aquifer Zone. To allow the model greater flexibility, the prior estimate of these source heads were increased to 230 feet, the prior 1-sigma uncertainty was increased from 1.0 to 2.0 feet, and the 1-sigma on the random variation of $\ln(Kh)$ in the "green clay" unit was increased from 0.5 to 1.0 ($\ln$ ft/day). The standard deviation for the "Green Clay" Confining Zone was increased because it was thought that the high flow from the northern boundary might actually be the result of a "hole" in the "Green Clay" (There are few wells in that area that would allow the model to determine the better of the two possibilities). These changes resulted in an RMS fit to the head data of 1.7 feet with only three head measurements edited. A slightly lower head residual RMS (1.5 feet) was also obtained using somewhat different parameters, but the resulting conductivities were unrealistically high in the region north of the central pumping wells.

Finally we examined alternate model structures including three and single hydrostratigraphic unit models, and a no-flow boundary condition on the bottom. Surprisingly the bottom no-flow condition did not significantly change the flow in the "Lost lake" Aquifer Zone, and the fit to the data was only slightly worse. The convergence of the single unit model was a problem, and the three unit model produced the best fit to the measurements. We concluded that the three unit model with a fixed-head bottom boundary condition was the best model structure. The head residual RMS for this model was 1.0 feet.

All the above results were obtained using the coarse grid (500 foot horizontal spacing) because of the much shorter computational times. When the results using this grid were thought to be satisfactory, the final DFM results were obtained using the fine grid (250 foot spacing). The results were similar to those of the coarse grid, but provided better detail.

In addition to the described results obtained using standard DFM, multi-grid DFM results were also obtained using both the quasi-Newton and direct methods. The conductivity grid was defined

with 1000 foot horizontal spacing in the central region and 1500 foot spacing near the perimeter, giving 168 nodes per layer. Eleven conductivity layers were used as follows: "M-Area" Aquifer - 3, "Green Clay/Lost Lake" - 4, Crouch Branch Confining Unit - 4. This conductivity grid has a total of 1848 nodes. As noted, somewhat longer clock times were required for multi-grid DFM runs than standard DFM for the coarse grid flow models, but were about 50% shorter for the fine grid models. The resulting data fit and the estimated parameters were about the same as for standard DFM.

6.4 DFM ESTIMATES

The final estimates of the common parameters computed using standard DFM are listed in Tables 6.11 to 6.16. As explained before, the a posteriori standard deviations were obtained from the comparable multi-grid DFM. Figures 6.4 to 6.7 show the estimated heads and head measurement locations for several layers corresponding to the "M-Area", "Upper Lost Lake", "Lower Lost Lake", and "middle sand" aquifers and Tables 6.17 to 6.20 list the head measurements. Figure 6.8 shows the pore velocity vectors for the "Upper Lost Lake" aquifer and Figure 6.9 shows the pore velocity vectors for the "Lower Lost Lake" aquifer. Note that there is a region of high north-south flow within the upper layers of the "Upper Lost Lake" zone starting near the northern region of the "Green Clay" and running to six pumping wells (RWM-2,3,4,5,9,11) in the central M-Area. Surprisingly, there is very little horizontal flow within the "Lost Lake" Aquifer Zone at the east, west and south perimeters of the M-Area. Also note that there are significant differences in the flow between the upper and lower layers within the "Lost Lake". Figure 6.10 shows the estimated heads, head measurements and pore velocities at the y-z slice through the middle of the grid at $x=49,750$ (ft). Table 6.21 lists the head measurements. Figures 6.11 and 6.12 show the estimated K_v for the "Green Clay" Confining Zone and "upper clay" zone. Figures 6.13 to 6.15 show the estimated K_h for the "M-Area" Aquifer Zone, "Upper Lost Lake" aquifer, and "Lower Lost Lake" aquifer. Notice the large variation in conductivity within the "Lost Lake" Aquifer Zone: the region of low conductivity near the "Lost Lake" and the high conductivity region north of the pumping wells. Since there are no well cores in the north central region, DFM increased the conductivity in order to allow the large flow to the extraction wells. Also note that the vertical conductivity in the "Green Clay" Confining Zone (Figure 6.11) is somewhat higher in this same region, thus allowing more water to flow directly from the "M-Area" to "Lost Lake" Aquifer Zone. Again these high conductivity estimates were not caused by the presence of conductivity measurements, but rather by the need to fit the head data. Thus it cannot be determined by direct measurement if the regions actually have high conductivity, although the small drop in head across the "Green Clay" Confining Zone at certain locations certainly suggests higher conductivity. Also note the lower "Green Clay" vertical conductivity near the pumping wells RWM-2,3,4 and 5. There are no cores near these locations. Apparently a reduction in conductivity was required to match the measured head gradient across the unit, which was larger than initially modeled. However, the error may be partly due to the lack of detail in modeling the drawdown near the well. Figure 6.15 shows the estimated K_h and measurements for the y-z slice at $x = 53,000$ (ft) and Table 6.22 list the measurements.

Table 6.11 Posterior Estimate and Uncertainty of Mean Log Conductivity States

Parameter	Unit	Estimate	1-sigma
mean $\ln(Kh)$	M-area aquifer	1.99	0.13
mean $\ln(Kh)$	green clay/Lost Lake	2.31	0.09
mean $\ln(Kh)$	CB confining	0.46	0.17
mean $\ln(Kh/Kv)$	M-area aquifer	6.50	0.13
mean $\ln(Kh/Kv)$	green clay/Lost Lake	5.92	0.10
mean $\ln(Kh/Kv)$	CB confining	5.79	0.17

Table 6.12 Posterior Estimate and Uncertainty of Measurement Bias and Recharge States

Parameter	Estimate	1-sigma
meas. Bias $-\ln(Kh)$	-0.28	0.10
meas. bias $-\ln(Kv)$	1.29	0.10
recharge - general area	0.00413	0.00021
recharge - paved areas	0.00120	0.00022

Table 6.13 Posterior Estimate and Uncertainty of North Boundary Source Head States

Aquifer	Grid Columns	Estimate	1-sigma
M-area	2-10	221.7	2.00
M-area	11-40	230.0	1.98
M-area	41-50	229.8	2.00
Lost lake	2-10	219.0	1.98
Lost Lake	11-20	224.0	1.99
Lost Lake	21-28	230.5	1.97
Lost Lake	29-36	228.5	1.83
Lost Lake	37-44	223.1	1.80
Lost Lake	45-50	221.4	1.96
middle sand	2-10	220.0	2.00
middle sand	11-40	219.7	2.00
middle sand	41-50	219.9	2.00

Table 6.14 Posterior Estimate and Uncertainty of South Boundary Source Head States

Aquifer	Grid Columns	Estimate	1-sigma
M-area	2-10	195.0	2.00
M-area	11-40	195.0	2.00
M-area	41-50	195.0	2.00
Lost Lake	2-14	191.2	1.84
Lost Lake	15-30	190.6	1.68
Lost Lake	31-50	192.8	1.81
middle sand	2-10	194.8	2.00
middle sand	11-40	194.6	2.00
middle sand	41-50	195.0	2.00

Table 6.15 Posterior Estimate and Uncertainty of East Boundary Source Head States

Aquifer	Grid Rows	Estimate	1-sigma
M-area	1-10	215.0	2.00
M-area	11-20	227.0	2.00
M-area	21-30	235.0	2.00
M-area	31-40	235.1	2.00
M-area	41-50	235.0	2.00
M-area	51-61	234.8	2.00
Lost Lake	1-10	202.8	1.99
Lost Lake	11-20	214.8	1.99
Lost Lake	21-30	219.9	1.98
Lost Lake	31-40	221.0	1.49
Lost Lake	41-50	221.8	1.28
Lost Lake	51-61	218.0	1.78
middle sand	1-10	197.0	2.00
middle sand	11-20	210.0	2.00
middle sand	21-30	213.0	2.00
middle sand	31-40	213.0	2.00
middle sand	41-50	213.0	2.00
middle sand	51-61	211.9	2.00

Table 6.16 Posterior Estimate and Uncertainty of West Boundary Source Head States

Aquifer	Grid Rows	Estimate	1-sigma
M-area	1-10	210.7	1.99
M-area	11-20	215.4	1.95
M-area	21-30	214.8	2.00
M-area	31-40	214.9	2.00
M-area	41-50	219.8	2.00
M-area	51-61	219.3	1.98
Lost Lake	1-10	195.4	1.93
Lost Lake	11-20	200.1	1.82
Lost Lake	21-30	209.1	1.85
Lost Lake	31-40	216.5	1.52
Lost Lake	41-50	214.2	1.97
Lost Lake	51-61	217.2	1.83
middle sand	1-10	198.8	2.00
middle sand	11-20	197.7	2.00
middle sand	21-30	198.0	2.00
middle sand	31-40	199.1	2.00
middle sand	41-50	199.0	2.00
middle sand	50-61	199.9	2.00

Figure 6.4 - Estimated Heads (ft) and Measurement Locations for "M-area" aquifer

Figure 6.5 - Estimated Heads (ft) and Measurement Locations for "Upper Lost Lake" aquifer

Figure 6.6 - Estimated Heads (ft) and Measurement Locations for "Lower Lost Lake" aquifer

Figure 6.7 - Estimated Heads (ft) and Measurement Locations for "middle sand" aquifer

Table 6.17 M-Area Aquifer Hydraulic Head Data

Well ID	SRS Easting (ft)	SRS Northing (ft)	Layer	Head Data (ft)
-----	-----	-----	-----	-----
ABP__7D	43930.1	97449.7	5	224.41
ABP__8D	43984.1	97854.9	5	223.02
ABP__4DD	44101.3	97495.5	6	230.83
ABP__6D	44101.4	97889.7	6	223.32
ABP__2DD	44126.7	97753.7	6	223.34
ARP__1A	44317.4	99102.9	7	217.09
ARP__4	44374.8	98567.7	6	219.57
ABP__1DD	44433.6	97511.4	5	226.44
ABP__3	44509.3	97794.1	5	225.25
MCB__8D	44769.9	97180.6	5	226.42
MCB__9D	44858.8	97605.8	5	224.01
MCB__5	44863.9	97335.6	5	225.95
MSB__78D	45482.2	103643.8	5	224.86
MSB__6A	46319.9	101133.8	5	227.96
MSB__64D	46598.5	101854.8	5	227.59
MSB__7A	46726.1	100585.7	5	228.79
MSB__5A	46998.7	101971.5	5	228.60
MSB__12D	47139.7	102262.2	5	234.08
MSB__21C	47234.6	103973.0	5	229.77
MSB__8A	47293.2	100815.1	6	230.18
MSB__13C	47521.9	101745.7	5	229.73
MSB__89C	47881.6	98379.4	6	229.53
MSB__30C	48013.7	105731.1	5	231.48
MSB__9C	48273.0	102245.6	5	231.28
MSB__4D	48311.7	102007.5	6	230.85
MSB__4A	48313.0	101933.4	5	231.61
MSB__39D	48396.0	100858.7	5	232.95
MSB__1A	48467.3	101833.7	5	232.35
MSB__22	48508.8	102186.5	5	231.74
MSB__28	48517.3	104941.8	6	231.27
MSB__3D	48524.6	102188.6	6	231.08
MSB__3A	48553.7	102189.9	5	232.71
MSB__11F	48577.0	102629.3	5	231.27
MSB__2A	48746.4	102028.3	5	233.82
MSB__26	48941.7	104612.8	5	237.24
MSB__43DD	49341.2	107273.0	5	232.26
MSB__27	49487.7	104972.8	5	237.04
MSB__25	49668.9	103498.8	5	237.01
MSB__31C	50089.9	101979.6	5	235.85

AOB__1	50485.9	101910.7	5	237.73
AOB__2	50724.7	102009.8	5	237.63
MSB_35D	50949.7	102122.4	4	243.48
ACB__4A	51116.2	102343.9	5	239.74
MSB_29DD	51191.3	107311.4	7	233.55
AMB__9D	51263.0	103585.2	6	235.40
ACB__3A	51313.3	102154.3	6	239.57
ACB__1A	51369.9	102622.9	5	238.68
AMB__8D	51400.5	103874.7	6	234.96
AMB_10D	51456.0	103293.4	5	236.64
AMB__5	51467.2	104083.4	6	234.93
ACB__2A	51561.3	102367.4	5	239.78
AMB_12D	51901.6	103602.4	5	235.98
AMB_11D	51932.6	103132.3	5	237.31
MSB_47D	52184.0	106960.1	6	234.36
MSB_68D	52293.6	106741.4	6	234.34
ASB__1A	52614.0	105535.0	5	238.35
ASB__6A	52675.9	105716.0	5	237.87
ASB__2AR	52881.7	105550.5	5	239.65
MSB_54D	52984.5	108461.5	7	233.96
MSB_85D	53108.8	107822.8	7	233.68
ASB__3AR	53115.0	105605.1	5	240.25
ASB__8	53136.6	106381.6	5	235.32
ASB__4	53177.2	105935.7	4	239.47
ASB__9	54226.2	104589.2	5	242.98
MSB_53D	54553.1	106448.2	5	234.46

Table 6.18 Upper Lost Lake Aquifer Hydraulic Head Data

Well ID	SRS Easting (ft)	SRS Northing (ft)	Layer	Head Data (ft)
-----	-----	-----	-----	-----
ABP__3C	44506.3	97778.2	12	198.23
MSB_70C	45012.0	101785.2	11	218.54
MCB__6C	45207.7	97413.1	12	196.63
MSB_18B	46115.7	100424.1	10	222.63
MSB_64C	46589.2	101842.9	11	223.90
MSB_12C	47138.4	102274.4	11	224.56
MSB__8C	47264.6	100793.2	10	221.51
MSB_79C	47286.8	99290.2	10	211.01
MSB_63C	47849.2	101174.6	10	222.35
MSB_62C	47895.0	101857.2	10	224.84
MSB_40C	48283.5	97697.8	10	205.34
MSB_26A	48440.7	104602.3	12	226.35
MSB_14B	48519.1	101639.0	10	220.16
MSB_11C	48579.4	102658.6	11	223.36
MSB_23B	49286.4	104336.6	12	225.70
MSB_27A	49487.8	104962.8	10	230.25
MSB_36C	49537.2	100518.3	10	216.16
MSB_24A	49845.3	104625.3	12	227.79
MSB_31CC	50067.9	101983.1	11	220.65
MSB_34B	50534.9	104944.7	12	228.60
MSB_45B	50555.3	103987.9	12	228.17
MSB_46B	50557.5	103102.4	11	227.09
MSB_44B	51096.4	103296.2	12	226.48
MSB_42C	51582.8	104581.9	11	231.90
MSB_33C	51746.7	97984.8	12	211.15
AMB_11B	51919.5	103154.2	11	224.72
MSB_84C	51973.7	108967.9	12	230.52
MSB_55C	52029.7	108324.6	12	230.44
MSB_47C	52195.5	106969.2	10	233.51
ASB__6C	52655.9	105736.8	11	225.53
ASB__5C	52837.8	105884.8	12	224.37
ASB__2CR	52862.7	105540.2	12	224.66
ASB_10CR	52969.7	105655.4	11	224.63
RWM_14C	53051.5	106380.8	11	225.52
ASB__8C	53101.0	106354.4	10	224.97
ASB__3CR	53130.4	105614.5	12	224.25
MSB_48C	54077.0	107917.5	12	225.66
ASB__9C	54201.1	104568.1	12	222.13
MSB_77C	54225.9	107078.3	12	225.26

MSB_53C	54540.5	106456.2	11	224.53
ABW__1	55016.4	105939.9	11	226.92

Table 6.19 Lower Lost Lake Aquifer Hydraulic Head Data

Well ID	SRS Easting (ft)	SRS Northing (ft)	Layer	Head Data (ft)
-----	-----	-----	-----	-----
MSB_20A	46060.5	103545.1	15	220.06
MSB_18A	46110.4	100416.1	15	213.87
MSB_17A	46245.7	101976.6	15	218.00
AC__2A	46428.6	105636.4	15	221.99
MSB_21A	47217.2	103967.0	14	222.61
MSB_21B	47271.8	104000.1	15	222.04
MSB__8B	47281.9	100805.8	15	211.00
MSB_79B	47300.2	99296.9	15	208.93
MSB_13A	47525.4	101725.7	15	211.61
MSB_63B	47861.0	101184.4	15	211.55
MSB_62B	47906.8	101865.3	15	212.37
MSB_10B	47943.1	102488.2	14	217.16
MSB_30CC	47993.3	105724.2	13	226.67
RWM_16	48244.8	97647.2	13	204.32
MSB_40B	48281.6	97685.0	14	205.47
MSB_72B	48350.3	96387.6	14	200.57
MSB_39B	48376.9	100844.6	15	213.76
MSB__1B	48483.2	101833.0	15	213.01
MSB_14A	48521.9	101629.5	14	218.42
MSB_28A	48521.9	104947.7	14	225.36
MSB__3B	48568.0	102191.7	15	216.32
MSB_11B	48578.5	102648.9	13	221.39
MSB_15AA	48818.5	102953.2	15	216.96
MSB_15A	48827.0	102983.5	13	223.54
MSB_75B	48875.5	98937.4	14	211.03
MSB_16A	48965.1	103693.9	13	224.40
MSB_43B	49311.8	107274.6	13	230.42
MSB_27B	49486.4	104940.3	13	227.78
MSB_36B	49526.3	100514.9	13	216.06
MSB_25A	49657.9	103504.8	13	219.58
MSB_38B	49746.1	102360.8	15	218.61
MSB_38C	49762.0	102373.1	13	221.98
MSB_31B	50078.7	101981.3	14	220.51
MSB_74B	50443.2	99197.4	15	211.92
MSB_19B	50934.8	100999.3	15	218.56
MSB_35B	50947.9	102110.8	13	221.97
MSB_50B	51053.5	96433.0	13	202.36
MSB_66C	51053.5	105842.1	14	229.84
MSB_29C	51206.6	107315.0	13	231.47

AMB_10B	51418.3	103337.3	15	225.08
MSB_37C	51439.8	105283.2	13	229.64
AMB_4B	51482.7	104145.6	15	226.09
MSB_42B	51582.8	104569.8	14	227.54
AMB_7B	51590.3	103972.0	14	226.57
MSB_82C	51949.4	107521.9	14	229.61
MSB_67C	51988.6	106819.8	13	228.39
MSB_55B	52006.2	108342.4	15	223.19
MSB_47B	52207.2	106978.5	13	226.78
MSB_68C	52304.9	106730.5	13	226.60
MSB_83C	52384.7	108405.3	14	228.76
MSB_51B	52818.0	96992.7	13	205.19
MSB_54C	52955.7	108447.4	14	228.55
MSB_85C	53151.4	107835.2	14	225.99
MSB_41C	53410.6	102203.9	15	219.03
MSB_52B	53418.4	103077.7	14	220.09
RWM_13C	53502.2	105809.7	14	223.49
MSB_48B	54112.2	107945.0	14	225.18
ASB_9B	54215.3	104564.7	14	221.75
MSB_77B	54217.4	107065.8	14	223.23
MSB_86C	54560.5	108500.4	15	226.17
MSB_53B	54574.3	106443.6	15	223.64
MSB_81B	55230.4	103762.7	15	222.16
MSB_61C	55406.6	106091.1	13	224.97

Table 6.20 Middle Sand Aquifer Hydraulic Head Data

Well ID	SRS Easting (ft)	SRS Northing (ft)	Layer	Head Data (ft)
-----	-----	-----	-----	-----
MSB_71B	44054.7	103801.6	16	218.05
MSB_73B	45694.0	99270.3	17	202.75
MSB__7B	46718.1	100597.6	16	208.90
MSB_30B	47981.8	105719.9	17	226.59
MSB__9A	48242.5	102236.7	16	213.26
MSB__4B	48312.8	101978.3	17	213.53
MSB_11A	48577.6	102638.9	16	215.70
MSB_26B	48944.6	104646.7	16	221.25
MSB_43A	49293.7	107275.3	16	230.14
MSB_35A	50945.2	102098.0	17	218.11
MSB_66B	51064.6	105842.0	17	220.91
MSB_44A	51106.9	103296.5	17	219.56
MSB_29B	51217.5	107319.3	16	225.75
AMB_18A	51418.8	103988.8	17	220.43
MSB_33B	51741.9	97995.9	17	208.20
MSB_67B	51989.6	106842.0	17	220.50
MSB_68B	52308.5	106744.9	17	220.83
MSB_69B	52432.9	107776.1	17	222.38
RWM_14B	53044.7	106362.1	17	221.52
RWM_15B	53849.0	107444.7	16	223.95
MSB_48A	54099.8	107936.6	17	223.88

Figure 6.8 - Estimated Pore Velocity for "Upper Lost Lake" aquifer

Figure 6.9 - Estimated Pore Velocity for "Lower Lost Lake" aquifer

Figure 6.10 Head estimates, head measurements, and pore velocities at $x = 49,750$ (ft).

Table 6.21 Head Data Near X = 49750 (ft)

Well ID	SRS Easting (ft)	SRS Northing (ft)	Elev. (ft)	Head Data (ft)
-----	-----	-----	-----	-----
MSB_36A	49514.9	100511.3	97.70	211.79
MSB_36B	49526.3	100514.9	160.90	216.06
MSB_36C	49537.2	100518.3	191.40	216.16
MSB_25A	49657.9	103504.8	164.70	219.58
MSB_25	49668.9	103498.8	230.85	237.01
MSB_38B	49746.1	102360.8	144.15	218.61
MSB_38C	49762.0	102373.1	166.65	221.98
MSB_24A	49845.3	104625.3	173.80	227.79

Figure 6.11 K_v(ft/d) estimates for "green clay."

K_v (ft/d) Estimates for Bottom of "upper clay"

K_v (ft/d) Estimates for Top of "upper clay"

Figure 6.12 K_v (ft/d) estimates for "upper clay."

K_h (ft/d) Estimates for "M-Area" Aquifer

Figure 6.13 K_h (ft/d) estimates for "M-area" aquifer.

K_h (ft/d) Estimates for "upper Lost Lake" Aquifer

Figure 6.14 K_h (ft/d) estimates for "Upper Lost Lake" aquifer.

K_h (ft/d) Estimates for "lower Lost Lake" Aquifer

Figure 6.15 K_h (ft/d) estimates for "Lower Lost Lake" aquifer.

Figure 6.16 K_h (ft/d) estimates and measurement locations at $x = 53,000$ (ft).

Table 6.22 Kh Data Near X = 53000 (ft)

Well ID	SRS Easting (ft)	SRS Northing (ft)	ln(Kh) Elev. Data (ft) ln(ft/d)	
-----	-----	-----	-----	-----
MBC__1SB	52780.0	108450.0	339.00	2.5118
MBC__1SB	52780.0	108450.0	291.50	8.6972
MBC__1SB	52780.0	108450.0	263.50	8.6538
MBC__1SB	52780.0	108450.0	243.50	9.6988
MBC__1SB	52780.0	108450.0	231.50	9.6988
MBC__1SB	52780.0	108450.0	226.00	9.6988
MBC__1SB	52780.0	108450.0	223.00	9.6988
MBC__1SB	52780.0	108450.0	218.50	1.6471
MBC__1SB	52780.0	108450.0	211.50	9.6988
MBC__1SB	52780.0	108450.0	203.00	9.6988
MBC__1SB	52780.0	108450.0	194.00	3.2544
MBC__1SB	52780.0	108450.0	185.00	6.9588
MBC__1SB	52780.0	108450.0	176.00	9.6988
MBC__1SB	52780.0	108450.0	167.50	9.6988
MBC__1SB	52780.0	108450.0	160.00	4.1579
MBC__1SB	52780.0	108450.0	152.50	.0006
MBC__1SB	52780.0	108450.0	143.00	7.0217
MBC__1SB	52780.0	108450.0	131.50	8.8906
MBC__1SB	52780.0	108450.0	121.00	.0164
MBC__1SB	52780.0	108450.0	113.00	1.3868
MBC__1SB	52780.0	108450.0	107.50	.0464
MSB_51B	52818.0	96992.7	251.10	2.6645
MSB_51B	52818.0	96992.7	238.10	3.2805
MSB_51B	52818.0	96992.7	231.60	1.7437
MSB_51B	52818.0	96992.7	227.10	6.1411
MSB_51B	52818.0	96992.7	224.60	4.3579
MSB_51B	52818.0	96992.7	222.10	1.4550
MSB_51B	52818.0	96992.7	217.10	.6427
MSB_51B	52818.0	96992.7	208.60	1.1537
MSB_51B	52818.0	96992.7	198.10	.0711
MSB_51B	52818.0	96992.7	186.60	4.4907
MSB_51B	52818.0	96992.7	174.60	2.6039
MSB_51B	52818.0	96992.7	162.60	5.2383
MSB_51B	52818.0	96992.7	150.60	7.2500
MSB_51B	52818.0	96992.7	139.10	3.8651
MSB_51B	52818.0	96992.7	129.10	.6332
MSB_51B	52818.0	96992.7	123.10	.0004
ASB__2CR	52862.7	105540.2	315.10	3.8806
ASB__2CR	52862.7	105540.2	273.10	7.4038

ASB__2CR	52862.7	105540.2	247.60	7.5534
ASB__2CR	52862.7	105540.2	229.60	6.9379
ASB__2CR	52862.7	105540.2	219.60	8.0849
ASB__2CR	52862.7	105540.2	214.60	9.6988
ASB__2CR	52862.7	105540.2	210.10	9.6988
ASB__2CR	52862.7	105540.2	203.10	8.6885
ASB__2CR	52862.7	105540.2	194.10	5.3925
ASB__2CR	52862.7	105540.2	184.60	8.7320
ASB__2CR	52862.7	105540.2	174.60	9.6988
ASB__2CR	52862.7	105540.2	164.60	9.6988
ASB__2CR	52862.7	105540.2	154.60	8.7320
ASB__2CR	52862.7	105540.2	145.10	6.9518
ASB__2CR	52862.7	105540.2	137.60	9.6988
ASB__2CR	52862.7	105540.2	131.60	4.8501
ASB__2CR	52862.7	105540.2	126.10	9.6988
ASB__2CR	52862.7	105540.2	120.10	6.9310
ASB__2CR	52862.7	105540.2	112.10	6.4689
ASB__2CR	52862.7	105540.2	102.10	7.5082
ASB__2CR	52862.7	105540.2	94.10	7.5610
ASB_10C	52965.5	105673.1	308.30	2.9922
ASB_10C	52965.5	105673.1	268.80	5.9003
ASB_10C	52965.5	105673.1	242.30	6.3726
ASB_10C	52965.5	105673.1	223.80	4.7588
ASB_10C	52965.5	105673.1	212.80	8.9352
ASB_10C	52965.5	105673.1	207.80	9.6988
ASB_10C	52965.5	105673.1	203.30	7.1994
ASB_10C	52965.5	105673.1	196.80	4.1620
ASB_10C	52965.5	105673.1	189.30	5.9417
ASB_10C	52965.5	105673.1	181.30	9.6988
ASB_10C	52965.5	105673.1	172.80	9.6988
ASB_10C	52965.5	105673.1	164.30	9.6988
ASB_10C	52965.5	105673.1	156.30	8.4909
ASB_10C	52965.5	105673.1	148.30	6.1411
ASB_10C	52965.5	105673.1	141.30	8.0849
ASB_10C	52965.5	105673.1	135.80	5.8183
ASB_10C	52965.5	105673.1	132.30	4.8501
MBC__2SB	52975.0	107750.0	346.20	2.4968
MBC__2SB	52975.0	107750.0	296.20	4.7922
MBC__2SB	52975.0	107750.0	265.70	8.1743
MBC__2SB	52975.0	107750.0	244.20	7.6523
MBC__2SB	52975.0	107750.0	231.70	9.6988
MBC__2SB	52975.0	107750.0	226.20	9.6988
MBC__2SB	52975.0	107750.0	222.20	6.0557
MBC__2SB	52975.0	107750.0	215.70	9.0340
MBC__2SB	52975.0	107750.0	207.70	9.0340
MBC__2SB	52975.0	107750.0	199.70	8.3645
MBC__2SB	52975.0	107750.0	191.20	8.5165

MBC__2SB	52975.0	107750.0	182.70	3.6510
MBC__2SB	52975.0	107750.0	174.20	7.5534
MBC__2SB	52975.0	107750.0	165.70	7.8932
MBC__2SB	52975.0	107750.0	157.70	9.6988
MBC__2SB	52975.0	107750.0	149.20	7.5459
MBC__2SB	52975.0	107750.0	138.20	8.2071
MBC__2SB	52975.0	107750.0	124.70	3.7886
MBC__2SB	52975.0	107750.0	112.70	1.4064
MBC__2SB	52975.0	107750.0	103.20	4.2845
MBC__2SB	52975.0	107750.0	96.20	6.4948
MSB_54TA	52985.8	108446.3	339.10	.5969
MSB_54TA	52985.8	108446.3	292.60	2.4522
MSB_54TA	52985.8	108446.3	264.60	3.3468
MSB_54TA	52985.8	108446.3	244.60	3.9118
MSB_54TA	52985.8	108446.3	233.10	4.3710
MSB_54TA	52985.8	108446.3	228.10	3.2674
MSB_54TA	52985.8	108446.3	225.10	.0361
MSB_54TA	52985.8	108446.3	220.60	3.9749
MSB_54TA	52985.8	108446.3	213.60	9.6988
MSB_54TA	52985.8	108446.3	204.60	6.3281
MSB_54TA	52985.8	108446.3	194.60	2.4449
MSB_54TA	52985.8	108446.3	185.10	4.3405
MSB_54TA	52985.8	108446.3	175.60	9.6988
MSB_54TA	52985.8	108446.3	166.10	7.6752
MSB_54TA	52985.8	108446.3	158.60	4.0593
MSB_54TA	52985.8	108446.3	151.10	5.8709
MSB_54TA	52985.8	108446.3	140.60	8.4486
MSB_54TA	52985.8	108446.3	127.60	8.2482
MSB_54TA	52985.8	108446.3	116.10	1.0800
MSB_54TA	52985.8	108446.3	107.60	2.4424
MSB_54TA	52985.8	108446.3	101.60	.3345
RWM_14B	53044.7	106362.1	312.00	1.2763
RWM_14B	53044.7	106362.1	270.00	5.1810
RWM_14B	53044.7	106362.1	242.00	3.4144
RWM_14B	53044.7	106362.1	222.50	3.5184
RWM_14B	53044.7	106362.1	211.50	5.3441
RWM_14B	53044.7	106362.1	206.00	3.8076
RWM_14B	53044.7	106362.1	202.00	2.4303
RWM_14B	53044.7	106362.1	196.50	.6288
RWM_14B	53044.7	106362.1	189.50	3.9630
RWM_14B	53044.7	106362.1	182.00	6.7666
RWM_14B	53044.7	106362.1	174.00	9.6988
RWM_14B	53044.7	106362.1	166.50	2.5702
RWM_14B	53044.7	106362.1	159.00	6.6792
RWM_14B	53044.7	106362.1	151.00	5.8241
RWM_14B	53044.7	106362.1	143.50	3.2674
RWM_14B	53044.7	106362.1	136.50	3.4144

RWM_14B	53044.7	106362.1	128.50	7.2066
RWM_14B	53044.7	106362.1	120.00	7.4187
RWM_14B	53044.7	106362.1	111.00	4.7541
RWM_14B	53044.7	106362.1	103.50	4.8695

Another prominent feature is the lower HDF source/drain heads on the western boundary and thus higher flow across the boundary, particularly in the northern region. As previously noted, the use of the HDF model on the east boundary of the "Lost Lake" Aquifer Zone results in significant flow across the northern portion of the boundary, which differs from previous models. As expected, the horizontal flow in the "M-Area" Aquifer Zone is relatively small, partly because of the lower conductivity. The higher head below the two outfall regions can be seen. The general flow is away from the A/M Areas.

Compared to the prior estimates, DFM has had decreased the average horizontal and vertical conductivity in the "M-Area" and "Lost Lake" Aquifer Zones slightly, increased the general area recharge slightly (from 15 to 18.2 inches/year), increased the "paved area" recharge significantly (from 3 to 5.3 inches/year), estimated respectively a large positive (+264%) and small negative (-24%) bias on the vertical and horizontal log conductivity measurements, and adjusted the HDF source/drain heads at a few locations. The estimated average horizontal conductivities in the "M-Area" and "Green Clay/Lost Lake" units were 7.3 and 10.0 feet/day respectively. The corresponding estimated average vertical conductivities were 0.011 and 0.027 feet/day. These horizontal values are slightly lower than the pump test data, but not unreasonable. The generally lower conductivity in the upper aquifers appears to be necessary to handle the nominal recharge. Note, however, that there is significant spatial variation in the estimated conductivity, particularly in the "Lost Lake" Aquifer Zone.

Since the low a prior estimate for the paved area recharge was only an educated guess, the slightly higher DFM estimate is reasonable. The method used to compute conductivity from mud fraction using pump and laboratory test data is subject to considerable uncertainty—much larger estimated biases would not be surprising. The primary locations in which the "Lost Lake" Aquifer Zone HDF source heads were adjusted from the prior were the middle north (lower), south (lower), north east (lower), and south west (lower). Thus there is slightly more water flow out the "Lost Lake" Aquifer Zone boundaries than initially expected. However, the estimated heads at the boundaries are not significantly different than expected. None of the HDF source heads for the "M-Area" Aquifer Zone were significantly altered. Also note that the a posteriori 1-sigma for the source heads was reduced below the prior 1-sigma of 2.00 at only a few locations. These were the same locations at which the a posteriori value deviated from the prior. The model is relatively insensitive to the source heads on much of the boundary, and thus the observability of the source heads at these locations is weak.

6.5 DATA FIT RESIDUALS

The least squares cost function for the final DFM estimate was 2576. The residual sum-of-squares contributions to the cost function are listed in Table 6.23. Note that the steady-state flow error contribution for standard DFM is slightly greater than zero. The total weighted residual RMS was 1.04 where the residual statistics for each measurement type and zone are listed in Table 6.24. The fit to head data is excellent, although 4 measurements were edited. The fit to the $\ln(Kh)$ measurements was very good, but the large variation in the $\ln(Kv)$ measurements could not be fit accurately with a model that attempts to fit both the horizontal and vertical conductivity measurements (with fixed anisotropy for each unit) and also performs spatial smoothing. Note that mean of the $\ln(Kv)$ residuals is positive in the upper two units but negative in the "Crouch Branch" Confining Unit. Since the residual is defined as the measured value minus

the computed value (including the estimated bias), a positive residual implies that the measurement is larger than the computed conductivity. The average $\ln(Kv)$ measurement is much lower in the "Crouch Branch" Confining Unit than in the upper zones, which may partially explain the bias in the residuals. Since DFM estimated a mean bias of 1.29 on all the $\ln(Kv)$ measurements, the average difference between measured and model computed $\ln(Kv)$ in the "Crouch Branch" Confining Unit is found to be $-0.64 + 1.29 = +0.65$. In other words, DFM has estimated $\ln(Kv)$ about 0.65 lower than the data.

Table 6.23 Residual Sum-of-Square Contributions

Residual Component	Number of Terms	Sum-of-squares
prior	67	70
spatial continuity	68442	913
steady-state flow error	68442	887
Measurements	3028	3282
Total		5152

Table 6.24 Measurement Residual Statistics

Type	zone	number	edited	mean	RMS
head	"M-Area"	66	1	-0.08	0.96
	"Green-Clay/ Lost lake"	134	1	-0.05	0.99
	CB Confining Unit	46	2	0.22	0.82
	total	246	4	-0.01	0.95
$\ln(Kh)$	"M-Area"	489	0	-0.45	1.38
	"Green-clay/ Lost Lake"	613	0	-0.25	1.38
	CB Confining Unit	289	0	-0.07	2.43
	total	1391	0	-0.27	1.65
$\ln(Kv)$	"M-Area"	489	0	0.58	2.45
	"Green-Clay/ Lost Lake"	613	0	0.64	2.84
	CB Confining Unit	289	0	-0.64	2.50
	total	1391	0	0.35	2.64

Figures 6.17 to 6.19 show the head residuals for the three aquifer zones. Note that most of the head residuals in the "M-Area" Aquifer Zone are small, but there is one large positive residual in the south west (which was edited) and one large positive residual in the southern central region. The first did not match those of nearby wells, and the second was very close to recovery well RWM-1. A positive residual indicates higher water levels than modeled.

Figure 6.18 shows the head residuals in the "Lost Lake" Aquifer Zone. There is one large negative residual which was edited near recovery well RWM-8. There is also a moderately positive residual in the north east which does not match other close wells. Most head residuals for the "Crouch Branch" Confining Unit are relatively small, as shown in Figure 6.19. Two positive residuals near the bottom did not match the boundary heads and were edited. Figure 6.20 shows the head residuals in a y-z slice, which better illustrates the vertical stratification of the errors.

Figures 6.21 and 6.22 show all the log conductivity residuals (ln feet/day) in y-z slices. (Residuals are not shown in plan view since they only display the top-most residual). From the y-z slice, it is seen that residual patterns appear in layers, but the effect is not pronounced. The many large positive vertical conductivity residuals near the "Green Clay" Confining Zone may suggest holes. There does not appear to be strong evidence of a continuous clay layer within the "Lost Lake" Aquifer Zone.

6.6 FLOW PATHLINES

Figures 6.23 and 6.24 show 50 3D pathlines with starting locations in the "M-Area" Aquifer Zone. The selected starting locations were based on potential sources of contaminants, and on capture zones shown in Jackson and Aleman (1994). Note that 23 of the 50 pathlines terminate in pumping wells. Another three were probably captured by pumping wells, but the integration did not model the pumping with sufficient accuracy, as discussed in Section 6.2. The pathlines which exit the bottom of the grid are mostly in the western part of the M-Area, or north of the A-area. Figure 6.8 and 6.9 show that the "Lost Lake" Aquifer Zone pore velocities near the perimeter of the M-Area are very small and the velocity in the northeast corner is more toward the east than presented by Jackson and Aleman (1995). Likewise, the velocity in the west is more toward the boundary than previously shown.

Figure 6.25 shows the capture zones for recovery wells RWM-1 through RWM-12. Most of the Central Sector is captured. The capture zones are similar to the results of Jackson and Aleman (1995) except on the west side of the Central Sector. Due to the low horizontal conductivity in the "Lost Lake" Aquifer Zone north of the Lost Lake (Figures 6.14 and 6.15), RWM-8 and RWM-10 have the smallest capture zones.

Note that the vertical velocities in the central area is very small, and that those particles which avoid the pumping wells will take from 60 to more than 100 years before exiting the bottom of the "Crouch Branch" Confining Unit. The DFM estimate of $\ln(K_v)$ in this unit is about 0.5 smaller than the average $\ln(K_v)$ measurement, so that model K_v is smaller than the measurements by about 40%. DFM is trying to reduce vertical conductivity, but the measurements are keeping this high. Thus the mud fraction to conductivity mapping must be modified if it is believed that the flow through the confining unit is too great.

Figure 6.17 - "M-Area" Aquifer Head Residuals

Figure 6.18 - "Lost Lake" Aquifer Head Residuals

Figure 6.19 - "Crouch Branch Confining Unit" Head Residuals

Figure 6.20 - Head Residuals - Y-Z View

Figure 6.21 - $\ln(K_h)$ Residuals - Y-Z View

Figure 6.22 - $\ln(K_v)$ Residuals - Y-Z View

**Figure 6.23 - 3D Pathlines for Standard DFM
Plan View (markers at 10 year intervals)**

**Figure 6.24 - 3D Pathlines for Standard DFM
Y-Z View (markers at 10 year intervals)**

Figure 6.25
Capture Zones for Recovery Wells RWM-1 through RWM-12

7.0 SPATIAL VARIABILITY IN FLOW PATTERNS

The flow pathlines shown in Section 6.0 were generated using the nominal flow model as computed by standard DFM. Since the parameters used for this flow model are estimates based on imperfect measurements, the parameters cannot be known with complete certainty. The covariance matrix computed in least squares estimation will provide an assessment of the parameter uncertainty if the model structure is correct. Unfortunately, it is not computationally practical to compute this covariance in standard DFM for models with more than about 20000 nodes. However, this can be computed in multi-grid DFM.

Figures 7.1 to 7.3 show the estimated head contours, velocity vectors and estimated log conductivity contours using multi-grid DFM. Figures 7.4 and 7.5 show the flow pathlines for the same starting locations used previously. Although there are some differences, these plots compare favorably with those in section 6 for standard DFM. Thus the variability in flow pathlines computed for multi-grid DFM should be representative of that for standard DFM.

The state error covariance matrix computed in multi-grid DFM can be used to compute the variation in pathlines which will result from errors in the measurements and prior information. The method used to compute the variation in the flow velocities from the state covariance matrix was documented in Gibbs and Jones (1995). Basically the square root of the information matrix is used with Gaussian random vectors to generate Monte Carlo samples of the states. Those samples will have a mean equal to the state estimate and covariance equal to the DFM computed covariance matrix. Those states (representing the flow model parameters) are used to compute steady-state flow solutions, from which the flow velocities are computed. Those velocities are then integrated to generate sample pathlines.

Figure 7.6 shows the plan view of 40 Monte Carlo pathline samples. Note that in the central region the distribution of pathlines is relatively tight, indicating that the flow model is known accurately. However, near the east and west boundaries and in the north east, the pathline distribution is much greater, indicating that flow model is subject to uncertainty. This is not surprising since the lack of data near the boundaries and unknown boundary conditions will result in uncertainty in the flow velocity.

A wide spread in pathlines near potential contaminant sources is an indication that more monitoring wells may be needed to properly determine flow directions. Design of successful remediation depends upon knowledge of the flow and the possible variation in that flow. Thus the flow pattern and variability may be used to analyze remediation alternatives.

Figure 7.1 - Estimated Head and Pore Velocity for the "Upper Lost Lake" Aquifer (Multi-Grid DFM)

**Figure 7.2 - Estimated Head and Pore Velocity
at x=50,000 ft (Multi-Grid DFM)**

**Figure 7.3 - Estimated $\text{Ln}(K_r)$ at $x=50,000$ ft
(Multi-Grid DFM)**

**Figure 7.4 - 3D Pathlines for Multi-grid DFM
Plan View, markers at 10 year intervals**

**Figure 7.5 - 3D Pathlines for Multi-grid DFM
Y-Z View, markers at 10 year intervals**

**Figure 7.6 - Variation in 3D Pathlines
10 Monte Carlo Samples, Plan View**

8.0 CONCLUSIONS

In the A/M Area, well and cone penetrometer picks were used by DFM to delineate the hydrostratigraphy and define the hydrostratigraphic units in a grid for numerical modeling. Local hydraulic conductivity data were combined with hydraulic head data and prior information on recharge/boundary conditions by DFM. Model calibration provided estimates for hydraulic conductivity fields in each hydrostratigraphic layer, different recharge values in the general area and the paved areas, and source heads in the head-dependent flux boundary conditions. DFM also quantified parameter uncertainties and determined the impact of the uncertainties on the model prediction of flow patterns. The following are specific conclusions:

- The "Lost Lake" Aquifer Zone displays the greatest heterogeneity in hydraulic conductivity.
- Flow pattern estimates were driven by pumping in the Central A/M Area. The model can be used to determine flow patterns for future pumping alternatives.
- The model matches the available data very well. In particular, the RMS residual difference between head data and model predicted head was 1.0ft.
- Recharge estimates were slightly higher than the prior estimates but not unreasonable.
- The model has significant flow through the "Green Clay" Confining Zone north of the M-Area which continues south through the "Lost Lake" Aquifer Zone towards the recovery wells.
- The computed capture zones for the recovery wells are consistent with Jackson and Aleman (1995), except in the western portion of the central sector.
- Different combinations of parameters such as conductivity, recharge, and source heads sometimes produce nearly the same data fit, producing parameter uncertainties. Parameter uncertainties were computed, and the impact of parameter uncertainties on flow patterns was determined. The flow uncertainty is greatest in the eastern part of the northern sector and along the western boundary of the central sector.
- Acquisition of monitoring well and borehole data from the General Administration Area (703-A) will improve the A/M Area flow model.

Areas of potential future work suggested by the current effort are the following:

- Customize DFM software to constrain the estimation of clay surfaces by the known distribution of DNAPL's to provide a tool to determine target zones for DNAPL remediation.
- Customize DFM software to incorporate contaminant data for flow and transport model calibration to support corrective action programs for the dissolved plume.
- Customize DFM software to calibrate multi-phase models for vadose zone remediation.

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Well ID	SRS East (ft)	SRS North (ft)	Middle of Screen Head (ft)	
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ABP 1A	44425.60	97501.60	187.90	225.07
ABP 1DD	44433.60	97511.40	226.44	226.44
ABP 2A	44118.80	97764.30	196.10	223.74
ABP 2DD	44126.70	97753.70	212.25	223.34
ABP 3	44509.30	97794.10	225.25	225.25
ABP 3C	44506.30	97778.20	162.80	198.23
ABP 4	44096.00	97489.70	197.50	223.55
ABP 4DD	44101.30	97495.50	213.20	230.83
ABP 6D	44101.40	97889.70	212.40	223.32
ABP 7D	43930.10	97449.70	224.41	224.41
ABP 8D	43984.10	97854.90	223.02	223.02
ABW 1	55016.40	105939.90	200.10	226.92
AC 1A	42238.80	105865.00	143.20	214.20
AC 1B	42250.50	105862.80	199.60	214.27
AC 2A	46428.60	105636.40	143.50	221.99
AC 3A	42119.80	100989.10	151.10	211.04
AC 3B	42113.60	100996.50	212.95	212.95
ACB 1A	51369.90	102622.90	238.68	238.68
ACB 2A	51561.30	102367.40	222.80	239.78
ACB 3A	51313.30	102154.30	221.30	239.57
ACB 4A	51116.20	102343.90	239.74	239.74
AMB 4A	51469.80	104131.60	123.80	220.56
AMB 4B	51482.70	104145.60	154.80	226.09
AMB 4D	51489.00	104154.70	223.40	234.52
AMB 5	51467.20	104083.40	234.93	234.93
AMB 7A	51591.00	103987.10	120.60	220.55
AMB 7B	51590.30	103972.00	157.90	226.57
AMB 8D	51400.50	103874.70	234.96	234.96
AMB 9D	51263.00	103585.20	235.40	235.40
AMB 10A	51410.00	103326.40	108.90	219.66
AMB 10B	51418.30	103337.30	151.80	225.08
AMB 10D	51456.00	103293.40	236.64	236.64
AMB 11B	51919.50	103154.20	179.50	224.72
AMB 11D	51932.60	103132.30	237.31	237.31
AMB 12D	51901.60	103602.40	235.98	235.98
AMB 13AR	51396.00	103082.00	105.90	220.56
AMB 17A	51465.40	104056.70	122.50	220.53
AMB 18A	51418.80	103988.80	133.90	220.43
AOB 1	50485.90	101910.70	237.73	237.73
AOB 2	50724.70	102009.80	237.63	237.63
ARP 1A	44317.40	99102.90	217.09	217.09
ARP 2	44876.10	99119.80	219.77	219.77
ARP 3	44903.70	98638.20	203.20	222.42
ARP 4	44374.80	98567.70	219.57	219.57
ASB 1A	52614.00	105535.00	238.35	238.35
ASB 2AR	52881.70	105550.50	239.65	239.65
ASB 2CR	52862.70	105540.20	178.10	224.66
ASB 3AR	53115.00	105605.10	240.25	240.25
ASB 3CR	53130.40	105614.50	179.00	224.25
ASB 4	53177.20	105935.70	239.47	239.47
ASB 5C	52837.80	105884.80	170.10	224.37
ASB 6A	52675.90	105716.00	237.87	237.87
ASB 6AA	52643.90	105727.00	80.45	219.84

Well ID	SRS East (ft)	SRS North (ft)	Middle of Screen Head (ft) (ft)	
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ASB 6C	52655.90	105736.80	176.15	225.53
ASB 6TA	52671.30	105749.50	37.25	215.54
ASB 8	53136.60	106381.60	216.60	235.32
ASB 8A	53117.50	106369.30	80.70	220.59
ASB 8B	53109.60	106362.30	125.60	221.89
ASB 8C	53101.00	106354.40	185.50	224.97
ASB 8TA	53124.70	106375.80	22.00	217.07
ASB 9	54226.20	104589.20	226.40	242.98
ASB 9B	54215.30	104564.70	161.60	221.75
ASB 9C	54201.10	104568.10	180.55	222.13
ASB 10CR	52969.70	105655.40	176.70	224.63
IDP 3A	37781.10	85104.30	-84.00	167.43
IDP 3B	37785.30	85119.50	98.20	158.65
LFW 20	45582.90	85262.60	159.67	159.67
LFW 26	45633.80	85654.60	162.31	162.31
LFW 27	45596.10	85839.10	162.99	162.99
LFW 29	45503.30	86372.70	154.40	165.92
LFW 30	45170.90	86318.40	152.20	165.81
LFW 31	44869.00	86262.20	155.50	167.95
LFW 32	44935.90	85836.80	163.29	163.29
LFW 33	44973.00	85633.80	162.14	162.14
LFW 34	45016.90	85409.50	160.87	160.87
LFW 35	45378.80	85237.40	159.88	159.88
LFW 43B	45240.50	86459.20	95.40	165.91
LFW 43C	45234.90	86480.60	133.50	166.20
LFW 43D	45244.50	86443.20	166.53	166.53
LFW 74C	45097.80	85813.80	108.50	163.29
LFW 74D	45098.00	85828.10	163.46	163.46
LFW 75C	45357.00	85856.80	108.10	163.19
LFW 75D	45355.60	85868.00	163.72	163.72
MCB 5	44863.90	97335.60	225.95	225.95
MCB 6C	45207.70	97413.10	167.50	196.63
MCB 8D	44769.90	97180.60	215.70	226.42
MCB 9D	44858.80	97605.80	224.01	224.01
MSB 1A	48467.30	101833.70	232.35	232.35
MSB 1B	48483.20	101833.00	140.25	213.01
MSB 2A	48746.40	102028.30	233.82	233.82
MSB 3A	48553.70	102189.90	232.71	232.71
MSB 3B	48568.00	102191.70	143.45	216.32
MSB 3D	48524.60	102188.60	220.95	231.08
MSB 4A	48313.00	101933.40	231.61	231.61
MSB 4B	48312.80	101978.30	140.75	213.53
MSB 4D	48311.70	102007.50	218.70	230.85
MSB 5A	46998.70	101971.50	228.60	228.60
MSB 5B	46983.60	101971.10	133.75	211.29
MSB 6A	46319.90	101133.80	227.96	227.96
MSB 6B	46321.60	101148.50	127.45	208.50
MSB 7A	46726.10	100585.70	228.79	228.79
MSB 7B	46718.10	100597.60	145.10	208.90
MSB 8A	47293.20	100815.10	230.18	230.18
MSB 8B	47281.90	100805.80	148.45	211.00
MSB 8C	47264.60	100793.20	193.55	221.51
MSB 9A	48242.50	102236.70	141.70	213.26

Well ID	SRS East (ft)	SRS North (ft)	Middle of Screen Head (ft)	
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MSB 9C	48273.00	102245.60	231.28	231.28
MSB 10A	47954.40	102451.80	122.70	214.66
MSB 10B	47943.10	102488.20	154.90	217.16
MSB 11A	48577.60	102638.90	133.30	215.70
MSB 11B	48578.50	102648.90	163.20	221.39
MSB 11C	48579.40	102658.60	180.40	223.36
MSB 11D	48579.70	102669.50	206.40	229.70
MSB 11E	48579.60	102678.50	239.73	239.73
MSB 11F	48577.00	102629.30	231.27	231.27
MSB 12A	47138.20	102283.20	119.00	212.38
MSB 12C	47138.40	102274.40	181.40	224.56
MSB 12D	47139.70	102262.20	234.08	234.08
MSB 12TA	47127.30	102266.70	-107.80	193.71
MSB 12TB	47133.00	102260.10	4.50	193.66
MSB 13A	47525.40	101725.70	133.90	211.61
MSB 13B	47523.50	101735.70	175.00	203.29
MSB 13C	47521.90	101745.70	229.73	229.73
MSB 14A	48521.90	101629.50	154.60	218.42
MSB 14B	48519.10	101639.00	191.40	220.16
MSB 15A	48827.00	102983.50	165.30	223.54
MSB 15AA	48818.50	102953.20	144.75	216.96
MSB 16A	48965.10	103693.90	164.30	224.40
MSB 17A	46245.70	101976.60	158.10	218.00
MSB 17B	46237.70	101994.60	188.30	226.43
MSB 17BB	46220.80	102009.50	134.95	214.33
MSB 18A	46110.40	100416.10	161.40	213.87
MSB 18B	46115.70	100424.10	196.00	222.63
MSB 19A	50934.40	100983.00	117.20	215.84
MSB 19B	50934.80	100999.30	145.20	218.56
MSB 19C	50942.40	100992.10	208.70	239.31
MSB 20A	46060.50	103545.10	160.10	220.06
MSB 21A	47217.20	103967.00	157.00	222.61
MSB 21B	47271.80	104000.10	144.85	222.04
MSB 21C	47234.60	103973.00	229.77	229.77
MSB 21TA	47218.20	103980.90	19.95	195.22
MSB 22	48508.80	102186.50	231.74	231.74
MSB 23B	49286.40	104336.60	173.60	225.70
MSB 23TA	49225.80	104298.80	62.90	202.75
MSB 24A	49845.30	104625.30	173.80	227.79
MSB 25	49668.90	103498.80	237.01	237.01
MSB 25A	49657.90	103504.80	164.70	219.58
MSB 26	48941.70	104612.80	237.24	237.24
MSB 26A	48440.70	104602.30	174.80	226.35
MSB 26B	48944.60	104646.70	134.50	221.25
MSB 27	49487.70	104972.80	237.04	237.04
MSB 27A	49487.80	104962.80	198.80	230.25
MSB 27B	49486.40	104940.30	167.15	227.78
MSB 27TA	49486.50	104951.40	53.25	202.32
MSB 28	48517.30	104941.80	220.60	231.27
MSB 28A	48521.90	104947.70	155.30	225.36
MSB 29A	51236.40	107326.80	120.10	221.56
MSB 29B	51217.50	107319.30	148.40	225.75
MSB 29C	51206.60	107315.00	176.90	231.47

Well ID	SRS East (ft)	SRS North (ft)	Middle of Screen Head (ft)	
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MSB 29D	51226.90	107323.30	217.30	233.26
MSB 29DD	51191.30	107311.40	233.55	233.55
MSB 29TA	51245.70	107330.40	61.25	213.52
MSB 30A	48004.10	105727.40	31.90	199.56
MSB 30AA	47970.50	105715.70	93.60	224.98
MSB 30B	47981.80	105719.90	125.90	226.59
MSB 30C	48013.70	105731.10	231.48	231.48
MSB 30CC	47993.30	105724.20	161.20	226.67
MSB 31A	50100.20	101979.30	17.00	199.13
MSB 31B	50078.70	101981.30	154.80	220.51
MSB 31C	50089.90	101979.60	235.85	235.85
MSB 31CC	50067.90	101983.10	179.05	220.65
MSB 32	52733.90	99655.60	208.10	224.47
MSB 33A	51738.00	98006.70	85.60	205.34
MSB 33B	51741.90	97995.90	123.50	208.20
MSB 33C	51746.70	97984.80	168.20	211.15
MSB 33TA	51734.00	98018.20	20.75	195.69
MSB 34A	50534.90	104954.90	116.10	220.51
MSB 34B	50534.90	104944.70	184.50	228.60
MSB 34TA	50536.60	104905.80	-96.90	202.57
MSB 34TB	50537.90	104891.60	70.80	203.88
MSB 35A	50945.20	102098.00	126.00	218.11
MSB 35B	50947.90	102110.80	166.50	221.97
MSB 35D	50949.70	102122.40	243.48	243.48
MSB 35TA	50919.60	102101.60	35.55	201.94
MSB 36A	49514.90	100511.30	97.70	211.79
MSB 36B	49526.30	100514.90	160.90	216.06
MSB 36C	49537.20	100518.30	191.40	216.16
MSB 36TA	49503.00	100507.70	50.90	195.53
MSB 37A	51439.80	105295.00	70.90	208.58
MSB 37B	51450.00	105289.50	139.50	220.91
MSB 37C	51439.80	105283.20	178.00	229.64
MSB 37TA	51449.80	105301.30	32.45	208.38
MSB 38B	49746.10	102360.80	144.15	218.61
MSB 38C	49762.00	102373.10	166.65	221.98
MSB 38TA	49810.40	102434.90	29.35	199.23
MSB 39A	48367.30	100837.60	108.90	211.05
MSB 39B	48376.90	100844.60	146.80	213.76
MSB 39C	48386.70	100852.10	196.80	217.15
MSB 39D	48396.00	100858.70	232.95	232.95
MSB 39TA	48357.70	100830.60	47.05	193.63
MSB 40A	48279.40	97672.80	113.40	203.65
MSB 40B	48281.60	97685.00	151.90	205.47
MSB 40C	48283.50	97697.80	189.60	205.34
MSB 40TA	48277.20	97660.40	26.35	190.29
MSB 41A	53424.10	102184.40	85.10	218.32
MSB 41B	53417.80	102194.50	111.40	218.57
MSB 41C	53410.60	102203.90	149.70	219.03
MSB 41TA	53429.70	102176.50	24.05	207.45
MSB 42A	51582.30	104557.90	126.60	220.89
MSB 42B	51582.80	104569.80	163.50	227.54
MSB 42C	51582.80	104581.90	201.50	231.90
MSB 42TA	51581.70	104545.60	43.15	206.93

Well ID	SRS East (ft)	SRS North (ft)	Middle of Screen Head (ft)	
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MSB 43A	49293.70	107275.30	137.70	230.14
MSB 43B	49311.80	107274.60	172.70	230.42
MSB 43D	49322.00	107274.20	210.50	232.35
MSB 43DD	49341.20	107273.00	232.26	232.26
MSB 43TA	49281.80	107275.80	37.65	204.28
MSB 44A	51106.90	103296.50	129.60	219.56
MSB 44B	51096.40	103296.20	179.60	226.48
MSB 45B	50555.30	103987.90	185.00	228.17
MSB 46B	50557.50	103102.40	184.80	227.09
MSB 47B	52207.20	106978.50	168.70	226.78
MSB 47BB	52234.40	106999.70	117.95	221.82
MSB 47C	52195.50	106969.20	199.80	233.51
MSB 47D	52184.00	106960.10	234.36	234.36
MSB 47TA	52219.00	106987.70	52.60	217.95
MSB 48A	54099.80	107936.60	127.05	223.88
MSB 48B	54112.20	107945.00	155.95	225.18
MSB 48C	54077.00	107917.50	177.80	225.66
MSB 48TA	54089.20	107925.80	105.15	223.67
MSB 49A	45864.60	99759.00	74.35	198.47
MSB 49B	45868.20	99737.80	113.50	204.19
MSB 50B	51053.50	96433.00	152.40	202.36
MSB 50D	51044.10	96416.70	202.37	202.37
MSB 51B	52818.00	96992.70	157.20	205.19
MSB 51DD	52830.30	97006.20	225.60	212.28
MSB 52B	53418.40	103077.70	168.60	220.09
MSB 53B	54574.30	106443.60	149.95	223.64
MSB 53C	54540.50	106456.20	190.20	224.53
MSB 53D	54553.10	106448.20	234.46	234.46
MSB 54B	52970.50	108446.80	133.60	223.46
MSB 54C	52955.70	108447.40	172.80	228.55
MSB 54D	52984.50	108461.50	233.96	233.96
MSB 54TA	52985.80	108446.30	78.10	220.81
MSB 55B	52006.20	108342.40	150.35	223.19
MSB 55C	52029.70	108324.60	186.95	230.44
MSB 55D	52032.50	108391.40	233.92	233.92
MSB 55TA	52014.70	108322.80	88.90	215.37
MSB 56D	44207.90	108463.50	221.73	221.73
MSB 61C	55406.60	106091.10	176.90	224.97
MSB 62B	47906.80	101865.30	138.65	212.37
MSB 62C	47895.00	101857.20	187.60	224.84
MSB 63B	47861.00	101184.40	138.55	211.55
MSB 63C	47849.20	101174.60	193.45	222.35
MSB 64B	46579.70	101831.00	121.95	210.49
MSB 64C	46589.20	101842.90	178.85	223.90
MSB 64D	46598.50	101854.80	227.59	227.59
MSB 66B	51064.60	105842.00	141.55	220.91
MSB 66C	51053.50	105842.10	168.55	229.84
MSB 66D	51044.00	105841.80	232.21	232.21
MSB 66TA	51096.70	105842.60	33.15	207.63
MSB 67B	51989.60	106842.00	132.50	220.50
MSB 67C	51988.60	106819.80	172.50	228.39
MSB 68B	52308.50	106744.90	130.65	220.83
MSB 68C	52304.90	106730.50	169.35	226.60

Well ID	SRS East (ft)	SRS North (ft)	Middle of Screen Head (ft)	
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MSB 68D	52293.60	106741.40	234.34	234.34
MSB 69B	52432.90	107776.10	142.15	222.38
MSB 69D	52462.00	107784.30	234.09	234.09
MSB 69TA	52418.40	107772.50	77.45	216.86
MSB 70C	45012.00	101785.20	176.45	218.54
MSB 71B	44054.70	103801.60	133.50	218.05
MSB 72B	48350.30	96387.60	154.35	200.57
MSB 73B	45694.00	99270.30	133.15	202.75
MSB 74B	50443.20	99197.40	145.15	211.92
MSB 75B	48875.50	98937.40	159.30	211.03
MSB 76C	45344.00	103061.60	183.65	221.69
MSB 77B	54217.40	107065.80	142.75	223.23
MSB 77C	54225.90	107078.30	170.85	225.26
MSB 77TA	54208.90	107053.80	80.25	222.84
MSB 78D	45482.20	103643.80	224.86	224.86
MSB 79B	47300.20	99296.90	138.45	208.93
MSB 79C	47286.80	99290.20	197.25	211.01
MSB 81B	55230.40	103762.70	143.75	222.16
MSB 82A	51978.40	107529.50	123.75	222.11
MSB 82B	51993.30	107533.40	145.85	221.76
MSB 82C	51949.40	107521.90	175.35	229.61
MSB 82D	51934.60	107518.10	233.85	233.85
MSB 82TA	51964.20	107525.70	91.10	215.72
MSB 83B	52421.40	108426.70	143.95	223.15
MSB 83C	52384.70	108405.30	180.40	228.76
MSB 83TA	52410.90	108416.30	72.95	216.87
MSB 84C	51973.70	108967.90	192.55	230.52
MSB 85B	53122.70	107827.00	134.95	222.96
MSB 85C	53151.40	107835.20	171.20	225.99
MSB 85D	53108.80	107822.80	233.68	233.68
MSB 86C	54560.50	108500.40	162.45	226.17
MSB 88D	50793.50	97012.30	205.16	205.16
MSB 89C	47881.60	98379.40	220.10	229.53
RWM 1	48575.10	102599.10	213.89	213.89
RWM 2	49205.50	104434.10	173.30	228.06
RWM 3	49680.00	104730.20	212.78	212.78
RWM 4	48948.20	103719.30	170.70	214.46
RWM 5	49628.00	103502.20	214.72	214.72
RWM 6	50107.40	102001.50	211.13	211.13
RWM 7	49449.50	101904.60	202.33	202.33
RWM 8	47353.30	101948.20	153.25	209.26
RWM 9	50400.00	104099.80	176.60	230.06
RWM 10	48244.10	102000.90	192.41	192.41
RWM 11	50400.20	104875.00	178.25	215.16
RWM 12	52500.10	106879.20	184.80	217.29
RWM 13B	53516.30	105803.30	125.60	221.67
RWM 13C	53502.20	105809.70	163.35	223.49
RWM 14B	53044.70	106362.10	135.85	221.52
RWM 14C	53051.50	106380.80	183.45	225.52
RWM 15B	53849.00	107444.70	138.35	223.95
RWM 16	48244.80	97647.20	167.80	204.32
RW 1	41407.00	103776.70	212.10	212.10
RW 1BB	41415.20	103772.20	124.30	208.55

Well ID	SRS East (ft)	SRS North (ft)	Middle of Screen (ft)	Head (ft)
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RW 2	41627.20	103721.80	214.35	214.35
RW 2A	41634.60	103720.80	93.50	207.71
RW 2B	41631.70	103729.70	157.70	208.79
RW 3A	41851.20	103516.40	178.10	214.06
RW 3BB	41845.60	103526.60	125.25	209.70
RW 4	41612.40	103359.90	213.71	213.71
RW 4BB	41609.20	103347.90	129.05	208.35
RW 5	41240.00	103418.20	211.99	211.99
RW 6	41243.90	103602.70	211.99	211.99
RW 8	40455.90	103470.00	209.41	209.41
RW 9	39688.40	103259.80	181.30	200.68
RW 9A	39692.90	103251.10	119.35	199.90
RW 9B	39697.60	103241.60	157.50	201.21
RW 10BB	40940.50	103399.10	121.65	206.71
RW 11	40874.20	103693.20	210.18	210.18
RW 11BB	40871.20	103703.40	124.50	206.84
RW 12A	39013.30	103710.30	108.80	195.45
RW 12B	39020.30	103702.70	151.20	190.63
RW 12C	39023.10	103712.50	198.00	198.00
RW 13A	40668.20	103001.00	98.70	202.56
RW 13B	40675.80	102993.60	158.25	204.52
RW 13C	40682.70	102986.50	210.30	210.30
RW 14A	41538.60	102831.30	118.80	204.52
RW 14B	41548.10	102836.10	158.00	206.42
RW 15A	41234.70	104778.00	102.70	210.39
RW 15B	41252.50	104772.90	156.70	210.46
RW 15C	41245.10	104774.90	213.30	213.30
RW 16B	42825.80	103772.00	165.00	215.47
RW 16C	42841.80	103772.40	215.87	215.87
RW 17BB	42463.80	103956.10	127.25	213.07

Core ID		SRS Northing (ft)	SRS Easting (ft)	Top of Core (ft)	"green clay"		"upper clay"		"lower clay"	
					Top (ft)	Bot (ft)	Top (ft)	Bot (ft)	Top (ft)	Bot (ft)
AMB	4A	51469.80	104131.60	377.30	226.	211.	144.	138.	117.	
AMB	7	51624.90	103920.0	367.10	223.	204.	144.	131.		
AMB	7A	51591.00	103987.10	370.60	223.	204.	144.	131.		
AMB	10A	51410.00	103326.40	363.40	217.	199.	144.	123.	96.	
AMB	11B	51919.50	103154.20	361.50	214.	196.	140.			
AMB	13AR	51396.00	103082.00	361.90	216.	197.	150.	116.	94.	
ASB	2CR	52862.70	105540.20	352.10	225.	195.	138.	125.	120.	110.
ASB	6AA	52643.90	105727.00	350.80	201.	194.	142.	132.	118.	106.
ASB	6TA	52671.30	105749.50	76.00	201.	194.	142.	132.	118.	106.
ASB	9	54226.20	104589.20	306.40	218.	208.	150.	135.	122.	115.
ASB	9C	54201.10	104568.10	156.90	218.	208.	150.	135.	122.	115.
ASB	10C	52965.50	105673.10	345.80	206.	192.	142.	137.		
MBC	1SB	52780.00	108450.0	371.00	222.	217.	160.	149.	128.	
MBC	2SB	52975.00	107750.0	379.20	226.	210.	160.	147.	116.	
MBC	3SB	52035.00	107178.00	366.20						
MBC	4SB	51445.00	105008.00	380.20	239.		157.	140.	127.	
MBC	5SB	51641.00	103983.00	369.50	206.	203.	142.	123.	96.	
MBC	6SB	50600.00	104750.0	381.00						
MBC	7SB	48750.00	100850.0	327.60	212.	196.	146.	114.	85.	60.
MCB	2	45129.00	97012.60	326.10						
MCB	4	44705.10	97532.50	348.20						
MCB	5	44863.90	97335.60	337.70						
MHT	1C	48765.60	102706.80	361.70	219.					
MHT	2C	48780.30	102747.10	363.10	221.	196.				
MHT	3C	48861.10	102704.30	361.60	206.	197.				
MHT	4C	48863.50	102778.90	366.40	217.	200.				
MHT	5C	48905.90	102725.10	363.10	222.	198.				
MHT	6C	48900.00	102810.80	368.60	221.	201.				
MHT	7C	48977.50	102788.90	367.00	203.	200.				
MHT	8C	48970.20	102880.70	368.30	222.	200.				
MHT	9B	49031.80	102814.30	366.30	223.	200.				
MHT	9C	49015.60	102814.40	366.70	223.	200.				
MHT	10C	49011.60	102892.30	367.90	217.	202.				
MHT	11C	48846.10	102854.00	365.20						
MHT	12C	49061.70	102844.80	366.90						
MHT	15C	48741.90	102520.70	356.70						
MHT	16C	48672.80	102430.90	358.50						
MHT	17C	48706.90	102394.60	356.70						
MHT	18C	48650.90	102486.10	359.30						
MHT	19C	48699.10	102502.70	357.90						
MHT	20C	48710.80	102589.30	359.30						
MHV	4A	48842.50	102841.70	365.10						
MHV	5A	48917.50	102878.80	368.20						
MSB	1C	48512.70	101832.50	352.00	215.	199.	135.			
MSB	2B	48748.20	101997.90	351.30	214.	205.	139.	121.	120.	76.
MSB	3B	48568.00	102191.70	357.80	217.	201.	133.			
MSB	4C	48313.60	101963.20	352.10	217.	201.	160.	135.		
MSB	5B	46983.60	101971.10	242.10	208.	187.	117.			
MSB	6B	46321.60	101148.50	240.80	215.	194.	132.			
MSB	7B	46718.10	100597.60	341.10	220.	200.	138.			
MSB	8B	47281.90	100805.80	340.80	212.	204.	140.			

Core ID	SRS Northing (ft)	SRS Easting (ft)	Top of Core (ft)	"green clay"		"upper clay"		"lower clay"	
				Top (ft)	Bot (ft)	Top (ft)	Bot (ft)	Top (ft)	Bot (ft)
MSB 13CC	47525.70	101728.80	243.80	217.	198.	131.			
MSB 23TA	49225.80	104298.80	84.40	208.	190.				
MSB 26A	48440.70	104602.30	158.80	215.	196.	140.	110.	90.	45.
MSB 32B	52742.50	99676.00	252.50	218.	199.	117.	102.	98.	77.
MSB 38B	49746.10	102360.80	213.00	220.	202.	142.	101.	100.	67.
MSB 40A	48279.40	97672.80	319.20	223.	197.	145.	122.	110.	50.
MSB 47TA	52219.00	106987.70	366.20	228.	210.	146.	132.	94.	
MSB 48C	54077.00	107917.50	359.20	207.	204.	139.			
MSB 48TA	54089.20	107925.80	358.80	207.	204.	139.			
MSB 49A	45864.60	99759.00	131.70	210.	200.	128.			
MSB 49B	45868.20	99737.80	330.80	210.	200.	128.			
MSB 50B	51053.50	96433.00	221.30	221.	205.	132.			
MSB 51B	52818.00	96992.70	261.10	224.	204.	132.			
MSB 52B	53418.40	103077.70	319.50	232.	210.	148.			
MSB 53B	54574.30	106443.60	191.30	222.	209.	139.	129.		
MSB 53C	54540.50	106456.20	343.20	222.	209.	139.	129.		
MSB 54TA	52985.80	108446.30	370.10	227.	221.	160.	155.	114.	
MSB 55C	52029.70	108324.60	256.30	236.	223.	148.	132.	120.	104.
MSB 55TA	52014.70	108322.80	365.60	236.	223.	148.	132.	120.	104.
MSB 61C	55406.60	106091.10	315.10	222.	213.				
MSB 62B	47906.80	101865.30	346.00	215.	195.	133.			
MSB 63B	47861.00	101184.40	343.90	217.	192.				
MSB 64B	46579.70	101831.00	345.30	193.	189.	113.			
MSB 69TA	52418.40	107772.50	378.30	229.	217.	160.	146.	114.	
MSB 70C	45012.00	101785.20	358.80	201.	182.				
MSB 74B	50443.20	99197.40	311.50	223.	196.	140.			
MSB 75B	48875.50	98937.40	323.70	218.	198.	145.			
MSB 76C	45344.00	103061.60	349.00	196.	188.	115.			
MSB 77TA	54208.90	107053.80	353.90	205.	191.	132.			
MSB 79B	47300.20	99296.90	344.80	228.	208.	130.			
MSB 81B	55230.40	103762.70	264.10	214.	201.	140.			
MSB 82C	51949.40	107521.90	370.70	236.	219.	160.	145.	144.	109.
MSB 82TA	51964.20	107525.70	170.80	236.	219.	160.	145.	144.	109.
MSB 83C	52384.70	108405.30	368.80	236.	220.	165.	148.	140.	112.
MSB 83TA	52410.90	108416.30	168.70	236.	220.	165.	148.	140.	112.
MSB 84A	51971.20	108982.10	358.40	234.	226.	150.	136.	125.	104.
MSB 84C	51973.70	108967.90	358.90	234.	226.	150.	136.	125.	104.
MSB 85C	53151.40	107835.20	377.60	230.	215.	163.			
MSB 85TA	53137.20	107831.20	377.40	230.	215.	163.			
MSB 86C	54560.50	108500.40	353.80	223.	202.	159.			
MSB 87B	51607.00	101276.00	333.00	218.	195.	132.	128.	115.	
MSB 88B	50774.20	97013.00	234.80	200.	196.	117.	110.	63.	
MSB 89B	47889.90	98374.10	336.30	213.	193.	142.			
RWM 13B	53516.30	105803.30	332.20	203.	197.	151.	135.		
RWM 14B	53044.70	106362.10	347.50	206.	194.	148.	130.	118.	102.
RWM 15B	53849.00	107444.70	364.90	202.	196.	138.			
RWM 16	48244.80	97647.20	317.40	224.	197.	139.			
SRW 3BB	41845.60	103526.60	329.30	187.	168.	115.	99.	98.	32.

Core ID	SRS Northing (ft)	SRS Easting (ft)	Top of Core (ft)	"green clay" Top (ft)	Bot (ft)	"upper clay" Top (ft)	Bot (ft)	"lower clay" Top (ft)	Bot (ft)
SRW 4BB	41609.20	103347.90	317.60	186.	172.	115.	99.	98.	37.
SRW 8BB	40464.90	103468.00	286.30	197.	177.	118.	99.	98.	20.
SRW 10BB	40940.50	103399.10	299.70	183.	170.	111.	99.	98.	33.
SRW 17BB	2463.80	103956.10	330.30	171.	164.	114.	99.	98.	25.

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/AMB_10A.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/AMB_13AR.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/AMB_4A.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/AMB__7.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/AMB__7A.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/ASB_10C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/ASB_2CR.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/ASB_6AA.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/ASB_6TA.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/ASB__9.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/ASB_9C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MBC_1SB.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MBC_2SB.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MBC_3SB.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MBC_4SB.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MBC_6SB.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MBC_7SB.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MCB_2.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/Plots/CorePlots/MCB_4.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MCB_5.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_10C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_11C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_12C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_15C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_16C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_17C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_18C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_19C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_20C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_2C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_3C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_4C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_6C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_7C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_8C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT_9B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHT__9C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MHV_5A.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_13CC.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_23TA.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_26A.plt II

(2D) || Print || 27 Jan 1997 || msb_32b.plt ||

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_38B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_40A.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_47TA.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_48C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_48TA.plt II

(2D) || Print || 27 Jan 1997 || msb_49a.plt ||

(2D) II Print II 27 Jan 1997 II msb_49b.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_50B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_51B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_52B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PLCKS/CorePlots/MSB_53B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_53C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_54TA.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_55C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_55TA.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_61C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_62B.plt II

(2D) || Print || 27 Jan 1997 || msb_64b.plt ||

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_69TA.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_70C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_74B.plt II

(2D) II Print II 27 Jan 1997 II msb_76c.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_77TA.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_79B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_81B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_82C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_82TA.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_83TA.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_84A.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_84C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_85C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_85TA.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_86C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_87B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_88B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_89B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_1C.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_2B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/MSB_3B.plt II

(2D) II Print II 27 Jan 1997 II msb_4c.plt II

(2D) II Print II 27 Jan 1997 II msb__5b.plt II

(2D) II Print II 27 Jan 1997 II msb_6b.plt II

(2D) || Print || 27 Jan 1997 || msb_7b.plt ||

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/RWM_13B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/RWM_14B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/RWM_15B.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/RWM_16.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/SRW_10BB.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/SRW_17BB.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/walt/dennis/CoreData/PICKS/CorePlots/SRW__3BB.plt II

(2D) II Print II 7 Nov 1996 II /disk2/people/wait/dennis/CoreData/PICKS/CorePlots/SRW_4BB.plt II

Geological Modeling Residuals

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Data Type	Elev. (ft)	Residual (ft)	Status
SRW_8BB	40464.9	103468.0	GREEN_CLAY_TOP	197.00	2.87	ACCEPT
SRW_8BB	40464.9	103468.0	GREEN_CLAY_BOTTOM	177.00	-1.50	ACCEPT
SRW_8BB	40464.9	103468.0	UPPER_CLAY_TOP	118.00	1.39	ACCEPT
SRW_8BB	40464.9	103468.0	UPPER_CLAY_BOTTOM	99.00	0.00	ACCEPT
SRW_8BB	40464.9	103468.0	LOWER_CLAY_TOP	98.00	2.73	ACCEPT
SRW_8BB	40464.9	103468.0	LOWER_CLAY_BOTTOM	20.00	-3.81	ACCEPT
SRW_10BB	40940.5	103399.1	GREEN_CLAY_TOP	183.00	-2.05	ACCEPT
SRW_10BB	40940.5	103399.1	GREEN_CLAY_BOTTOM	170.00	0.34	ACCEPT
SRW_10BB	40940.5	103399.1	UPPER_CLAY_TOP	111.00	-2.72	ACCEPT
SRW_10BB	40940.5	103399.1	UPPER_CLAY_BOTTOM	99.00	0.43	ACCEPT
SRW_10BB	40940.5	103399.1	LOWER_CLAY_TOP	98.00	-0.24	ACCEPT
SRW_10BB	40940.5	103399.1	LOWER_CLAY_BOTTOM	33.00	1.96	ACCEPT
SRW_4BB	41609.2	103347.9	GREEN_CLAY_TOP	186.00	-0.29	ACCEPT
SRW_4BB	41609.2	103347.9	GREEN_CLAY_BOTTOM	172.00	0.71	ACCEPT
SRW_4BB	41609.2	103347.9	UPPER_CLAY_TOP	115.00	0.07	ACCEPT
SRW_4BB	41609.2	103347.9	UPPER_CLAY_BOTTOM	99.00	-0.60	ACCEPT
SRW_4BB	41609.2	103347.9	LOWER_CLAY_TOP	98.00	-1.21	ACCEPT
SRW_4BB	41609.2	103347.9	LOWER_CLAY_BOTTOM	37.00	2.03	ACCEPT
SRW_3BB	41845.6	103526.6	GREEN_CLAY_TOP	187.00	2.38	ACCEPT
SRW_3BB	41845.6	103526.6	GREEN_CLAY_BOTTOM	168.00	-1.90	ACCEPT
SRW_3BB	41845.6	103526.6	UPPER_CLAY_TOP	115.00	0.27	ACCEPT
SRW_3BB	41845.6	103526.6	UPPER_CLAY_BOTTOM	99.00	-0.05	ACCEPT
SRW_3BB	41845.6	103526.6	LOWER_CLAY_TOP	98.00	0.23	ACCEPT
SRW_3BB	41845.6	103526.6	LOWER_CLAY_BOTTOM	32.00	-0.61	ACCEPT
SRW_17BB	42463.8	103956.1	GREEN_CLAY_TOP	171.00	-2.61	ACCEPT
SRW_17BB	42463.8	103956.1	GREEN_CLAY_BOTTOM	164.00	1.31	ACCEPT
SRW_17BB	42463.8	103956.1	UPPER_CLAY_TOP	114.00	-0.77	ACCEPT
SRW_17BB	42463.8	103956.1	UPPER_CLAY_BOTTOM	99.00	0.21	ACCEPT
SRW_17BB	42463.8	103956.1	LOWER_CLAY_TOP	98.00	2.79	ACCEPT
SRW_17BB	42463.8	103956.1	LOWER_CLAY_BOTTOM	25.00	-2.49	ACCEPT
MSB_70C	45012.0	101785.2	GREEN_CLAY_TOP	201.00	2.42	ACCEPT
MSB_70C	45012.0	101785.2	GREEN_CLAY_BOTTOM	182.00	-2.18	ACCEPT
CPT-12	45036.4	103267.6	GREEN_CLAY_TOP	180.00	-2.39	ACCEPT
CPT-12	45036.4	103267.6	GREEN_CLAY_BOTTOM	179.00	1.39	ACCEPT
CPT-13B	45312.2	103083.2	GREEN_CLAY_TOP	180.00	-7.41	ACCEPT
CPT-13B	45312.2	103083.2	GREEN_CLAY_BOTTOM	179.00	-3.77	ACCEPT
MSB_76C	45344.0	103061.6	GREEN_CLAY_TOP	196.00	7.73	ACCEPT
MSB_76C	45344.0	103061.6	GREEN_CLAY_BOTTOM	188.00	4.35	ACCEPT
MSB_76C	45344.0	103061.6	UPPER_CLAY_TOP	115.00	-0.31	ACCEPT
CPT4	45512.1	104120.5	GREEN_CLAY_TOP	205.00	0.88	ACCEPT
CPT4	45512.1	104120.5	GREEN_CLAY_BOTTOM	199.00	0.20	ACCEPT
CPT3	45819.4	103251.7	GREEN_CLAY_TOP	187.00	-1.79	ACCEPT
CPT3	45819.4	103251.7	GREEN_CLAY_BOTTOM	185.00	-0.07	ACCEPT
MSB_49A	45864.6	99759.0	GREEN_CLAY_TOP	210.00	-0.62	ACCEPT
MSB_49A	45864.6	99759.0	GREEN_CLAY_BOTTOM	200.00	0.66	ACCEPT
MSB_49A	45864.6	99759.0	UPPER_CLAY_TOP	128.00	-0.07	ACCEPT
MSB_49B	45868.2	99737.8	GREEN_CLAY_TOP	210.00	-0.71	ACCEPT
MSB_49B	45868.2	99737.8	GREEN_CLAY_BOTTOM	200.00	0.61	ACCEPT
MSB_49B	45868.2	99737.8	UPPER_CLAY_TOP	128.00	0.00	ACCEPT
CPT-11	46114.5	101349.2	GREEN_CLAY_TOP	198.00	-4.57	ACCEPT

Geological Modeling Residuals

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Data Type	Elev. (ft)	Residual (ft)	Status
CPT-11	46114.5	101349.2	GREEN_CLAY_BOTTOM	195.00	3.23	ACCEPT
MSB_6B	46321.6	101148.5	GREEN_CLAY_TOP	215.00	5.37	ACCEPT
MSB_6B	46321.6	101148.5	GREEN_CLAY_BOTTOM	194.00	-3.60	ACCEPT
MSB_6B	46321.6	101148.5	UPPER_CLAY_TOP	132.00	0.89	ACCEPT
CPT-14	46433.0	102736.3	GREEN_CLAY_TOP	198.00	-0.66	ACCEPT
CPT-14	46433.0	102736.3	GREEN_CLAY_BOTTOM	195.00	1.21	ACCEPT
MSB_64B	46579.7	101831.0	GREEN_CLAY_TOP	193.00	-4.02	ACCEPT
MSB_64B	46579.7	101831.0	GREEN_CLAY_BOTTOM	189.00	2.33	ACCEPT
MSB_64B	46579.7	101831.0	UPPER_CLAY_TOP	113.00	-1.44	ACCEPT
CPT-23B	46596.2	103812.5	GREEN_CLAY_TOP	205.00	0.23	ACCEPT
CPT-23B	46596.2	103812.5	GREEN_CLAY_BOTTOM	201.00	0.55	ACCEPT
CPT-10	46714.6	100505.8	GREEN_CLAY_TOP	204.00	-7.35	ACCEPT
CPT-10	46714.6	100505.8	GREEN_CLAY_BOTTOM	202.00	2.07	ACCEPT
MSB_7B	46718.1	100597.6	GREEN_CLAY_TOP	220.00	6.76	ACCEPT
MSB_7B	46718.1	100597.6	GREEN_CLAY_BOTTOM	200.00	-1.63	ACCEPT
MSB_7B	46718.1	100597.6	UPPER_CLAY_TOP	138.00	0.27	ACCEPT
MSB_5B	46983.6	101971.1	GREEN_CLAY_TOP	208.00	3.93	ACCEPT
MSB_5B	46983.6	101971.1	GREEN_CLAY_BOTTOM	187.00	-3.67	ACCEPT
MSB_5B	46983.6	101971.1	UPPER_CLAY_TOP	117.00	-0.31	ACCEPT
MSB_8B	47281.9	100805.8	GREEN_CLAY_TOP	212.00	-1.82	ACCEPT
MSB_8B	47281.9	100805.8	GREEN_CLAY_BOTTOM	204.00	1.94	ACCEPT
MSB_8B	47281.9	100805.8	UPPER_CLAY_TOP	140.00	0.41	ACCEPT
MSB_79B	47300.2	99296.9	GREEN_CLAY_TOP	228.00	2.05	ACCEPT
MSB_79B	47300.2	99296.9	GREEN_CLAY_BOTTOM	208.00	-0.79	ACCEPT
MSB_79B	47300.2	99296.9	UPPER_CLAY_TOP	130.00	-0.59	ACCEPT
MSB_13CC	47525.7	101728.8	GREEN_CLAY_TOP	217.00	2.06	ACCEPT
MSB_13CC	47525.7	101728.8	GREEN_CLAY_BOTTOM	198.00	-0.69	ACCEPT
MSB_13CC	47525.7	101728.8	UPPER_CLAY_TOP	131.00	0.34	ACCEPT
CPT7	47586.2	102444.4	GREEN_CLAY_TOP	203.00	-3.91	ACCEPT
CPT7	47586.2	102444.4	GREEN_CLAY_BOTTOM	200.00	3.44	ACCEPT
CPT-9	47696.7	100993.0	GREEN_CLAY_TOP	207.00	-3.98	ACCEPT
CPT-9	47696.7	100993.0	GREEN_CLAY_BOTTOM	200.00	2.98	ACCEPT
MSB_63B	47861.0	101184.4	GREEN_CLAY_TOP	217.00	4.78	ACCEPT
MSB_63B	47861.0	101184.4	GREEN_CLAY_BOTTOM	192.00	-4.34	ACCEPT
CPT5	47863.3	103874.7	GREEN_CLAY_TOP	195.00	-1.63	ACCEPT
CPT5	47863.3	103874.7	GREEN_CLAY_BOTTOM	190.00	1.42	ACCEPT
CPT2	47884.8	104243.6	GREEN_CLAY_TOP	192.00	-2.78	ACCEPT
CPT2	47884.8	104243.6	GREEN_CLAY_BOTTOM	187.00	1.03	ACCEPT
MSB_89B	47889.9	98374.1	GREEN_CLAY_TOP	213.00	-1.19	ACCEPT
MSB_89B	47889.9	98374.1	GREEN_CLAY_BOTTOM	193.00	0.12	ACCEPT
MSB_89B	47889.9	98374.1	UPPER_CLAY_TOP	142.00	0.39	ACCEPT
MSB_62B	47906.8	101865.3	GREEN_CLAY_TOP	215.00	1.38	ACCEPT
MSB_62B	47906.8	101865.3	GREEN_CLAY_BOTTOM	195.00	-2.31	ACCEPT
MSB_62B	47906.8	101865.3	UPPER_CLAY_TOP	133.00	0.18	ACCEPT
RWM_16	48244.8	97647.2	GREEN_CLAY_TOP	224.00	1.90	ACCEPT
RWM_16	48244.8	97647.2	GREEN_CLAY_BOTTOM	197.00	-1.04	ACCEPT
RWM_16	48244.8	97647.2	UPPER_CLAY_TOP	139.00	-2.54	ACCEPT
MSB_40A	48279.4	97672.8	GREEN_CLAY_TOP	223.00	1.00	ACCEPT
MSB_40A	48279.4	97672.8	GREEN_CLAY_BOTTOM	197.00	-0.98	ACCEPT
MSB_40A	48279.4	97672.8	UPPER_CLAY_TOP	145.00	3.08	ACCEPT
MSB_40A	48279.4	97672.8	UPPER_CLAY_BOTTOM	122.00	-0.99	ACCEPT

Geological Modeling Residuals

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Data Type	Elev. (ft)	Residual (ft)	Status
MSB_40A	48279.4	97672.8	LOWER_CLAY_TOP	110.00	3.38	ACCEPT
MSB_40A	48279.4	97672.8	LOWER_CLAY_BOTTOM	50.00	-2.53	ACCEPT
MSB_4C	48313.6	101963.2	GREEN_CLAY_TOP	217.00	1.00	ACCEPT
MSB_4C	48313.6	101963.2	GREEN_CLAY_BOTTOM	201.00	0.18	ACCEPT
MSB_4C	48313.6	101963.2	UPPER_CLAY_TOP	135.00	0.52	ACCEPT
MSB_26A	48440.7	104602.3	GREEN_CLAY_TOP	215.00	3.13	ACCEPT
MSB_26A	48440.7	104602.3	GREEN_CLAY_BOTTOM	196.00	-1.44	ACCEPT
MSB_26A	48440.7	104602.3	UPPER_CLAY_TOP	140.00	2.47	ACCEPT
MSB_26A	48440.7	104602.3	UPPER_CLAY_BOTTOM	110.00	-0.86	ACCEPT
MSB_26A	48440.7	104602.3	LOWER_CLAY_TOP	90.00	-0.49	ACCEPT
MSB_26A	48440.7	104602.3	LOWER_CLAY_BOTTOM	45.00	-1.07	ACCEPT
MSB_1C	48512.7	101832.5	GREEN_CLAY_TOP	215.00	0.38	ACCEPT
MSB_1C	48512.7	101832.5	GREEN_CLAY_BOTTOM	199.00	-1.35	ACCEPT
MSB_1C	48512.7	101832.5	UPPER_CLAY_TOP	135.00	-1.16	ACCEPT
MSB_3B	48568.0	102191.7	GREEN_CLAY_TOP	217.00	0.81	ACCEPT
MSB_3B	48568.0	102191.7	GREEN_CLAY_BOTTOM	201.00	-0.26	ACCEPT
MSB_3B	48568.0	102191.7	UPPER_CLAY_TOP	133.00	-1.30	ACCEPT
CPT-21	48590.5	101383.0	GREEN_CLAY_TOP	209.00	-3.15	ACCEPT
CPT-21	48590.5	101383.0	GREEN_CLAY_BOTTOM	202.00	3.10	ACCEPT
MSB_2B	48748.2	101997.9	LOWER_CLAY_TOP	120.00	3.97	ACCEPT
MSB_2B	48748.2	101997.9	LOWER_CLAY_BOTTOM	76.00	-1.08	ACCEPT
MSB_2B	48748.2	101997.9	GREEN_CLAY_BOTTOM	205.00	2.39	ACCEPT
MSB_2B	48748.2	101997.9	UPPER_CLAY_TOP	139.00	-1.57	ACCEPT
MSB_2B	48748.2	101997.9	UPPER_CLAY_BOTTOM	121.00	0.60	ACCEPT
MSB_2B	48748.2	101997.9	GREEN_CLAY_TOP	214.00	-1.99	ACCEPT
MBC_7SB	48750.0	100850.0	UPPER_CLAY_BOTTOM	114.00	-0.32	ACCEPT
MBC_7SB	48750.0	100850.0	LOWER_CLAY_TOP	85.00	-5.77	ACCEPT
MBC_7SB	48750.0	100850.0	LOWER_CLAY_BOTTOM	60.00	2.70	ACCEPT
MBC_7SB	48750.0	100850.0	GREEN_CLAY_TOP	212.00	0.67	ACCEPT
MBC_7SB	48750.0	100850.0	GREEN_CLAY_BOTTOM	196.00	-0.79	ACCEPT
MBC_7SB	48750.0	100850.0	UPPER_CLAY_TOP	146.00	3.59	ACCEPT
MHT_1C	48765.6	102706.8	GREEN_CLAY_TOP	219.00	2.57	ACCEPT
MHT_2C	48780.3	102747.1	GREEN_CLAY_TOP	221.00	4.25	ACCEPT
MHT_2C	48780.3	102747.1	GREEN_CLAY_BOTTOM	196.00	-2.90	ACCEPT
MHT_3C	48861.1	102704.3	GREEN_CLAY_BOTTOM	197.00	-1.54	ACCEPT
MHT_3C	48861.1	102704.3	GREEN_CLAY_TOP	206.00	-10.19	ACCEPT
MHT_4C	48863.5	102778.9	GREEN_CLAY_TOP	217.00	0.00	ACCEPT
MHT_4C	48863.5	102778.9	GREEN_CLAY_BOTTOM	200.00	0.81	ACCEPT
MSB_75B	48875.5	98937.4	GREEN_CLAY_TOP	218.00	-0.01	ACCEPT
MSB_75B	48875.5	98937.4	GREEN_CLAY_BOTTOM	198.00	0.12	ACCEPT
MSB_75B	48875.5	98937.4	UPPER_CLAY_TOP	145.00	0.29	ACCEPT
MHT_6C	48900.0	102810.8	GREEN_CLAY_BOTTOM	201.00	1.29	ACCEPT
MHT_6C	48900.0	102810.8	GREEN_CLAY_TOP	221.00	3.52	ACCEPT
MHT_5C	48905.9	102725.1	GREEN_CLAY_BOTTOM	198.00	-0.52	ACCEPT
MHT_5C	48905.9	102725.1	GREEN_CLAY_TOP	222.00	5.74	ACCEPT
MHT_8C	48970.2	102880.7	GREEN_CLAY_TOP	222.00	3.16	ACCEPT
MHT_8C	48970.2	102880.7	GREEN_CLAY_BOTTOM	200.00	-1.10	ACCEPT
MHT_7C	48977.5	102788.9	GREEN_CLAY_TOP	203.00	-14.06	REJECT
MHT_7C	48977.5	102788.9	GREEN_CLAY_BOTTOM	200.00	0.75	ACCEPT
MHT_10C	49011.6	102892.3	GREEN_CLAY_BOTTOM	202.00	0.48	ACCEPT

Geological Modeling Residuals

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Data Type	Elev. (ft)	Residual (ft)	Status
MHT_10C	49011.6	102892.3	GREEN_CLAY_TOP	217.00	-2.28	ACCEPT
MHT_9C	49015.6	102814.4	GREEN_CLAY_TOP	223.00	5.24	ACCEPT
MHT_9C	49015.6	102814.4	GREEN_CLAY_BOTTOM	200.00	0.02	ACCEPT
MHT_9B	49031.8	102814.3	GREEN_CLAY_TOP	223.00	5.04	ACCEPT
MHT_9B	49031.8	102814.3	GREEN_CLAY_BOTTOM	200.00	-0.20	ACCEPT
MSB_23TA	49225.8	104298.8	GREEN_CLAY_TOP	208.00	-0.27	ACCEPT
MSB_23TA	49225.8	104298.8	GREEN_CLAY_BOTTOM	190.00	-0.87	ACCEPT
MSB_38B	49746.1	102360.8	UPPER_CLAY_BOTTOM	101.00	-5.77	ACCEPT
MSB_38B	49746.1	102360.8	LOWER_CLAY_TOP	100.00	0.32	ACCEPT
MSB_38B	49746.1	102360.8	LOWER_CLAY_BOTTOM	67.00	1.03	ACCEPT
MSB_38B	49746.1	102360.8	GREEN_CLAY_BOTTOM	202.00	-1.17	ACCEPT
MSB_38B	49746.1	102360.8	GREEN_CLAY_TOP	220.00	1.98	ACCEPT
MSB_38B	49746.1	102360.8	UPPER_CLAY_TOP	142.00	4.14	ACCEPT
CPT-17	50104.1	101955.1	GREEN_CLAY_TOP	206.00	-3.68	ACCEPT
CPT-17	50104.1	101955.1	GREEN_CLAY_BOTTOM	200.00	2.67	ACCEPT
MSB_74B	50443.2	99197.4	GREEN_CLAY_TOP	223.00	2.28	ACCEPT
MSB_74B	50443.2	99197.4	GREEN_CLAY_BOTTOM	196.00	-1.92	ACCEPT
MSB_74B	50443.2	99197.4	UPPER_CLAY_TOP	140.00	0.34	ACCEPT
MSB_88B	50774.2	97013.0	GREEN_CLAY_TOP	200.00	-4.35	ACCEPT
MSB_88B	50774.2	97013.0	GREEN_CLAY_BOTTOM	196.00	2.84	ACCEPT
MSB_88B	50774.2	97013.0	UPPER_CLAY_TOP	117.00	-2.30	ACCEPT
MSB_88B	50774.2	97013.0	UPPER_CLAY_BOTTOM	110.00	4.43	ACCEPT
MSB_88B	50774.2	97013.0	LOWER_CLAY_TOP	63.00	-3.40	ACCEPT
MSB_50B	51053.5	96433.0	UPPER_CLAY_TOP	132.00	0.92	ACCEPT
MSB_50B	51053.5	96433.0	GREEN_CLAY_TOP	221.00	1.49	ACCEPT
MSB_50B	51053.5	96433.0	GREEN_CLAY_BOTTOM	205.00	-0.39	ACCEPT
AMB_13AR	51396.0	103082.0	GREEN_CLAY_TOP	216.00	0.62	ACCEPT
AMB_13AR	51396.0	103082.0	GREEN_CLAY_BOTTOM	197.00	-0.56	ACCEPT
AMB_13AR	51396.0	103082.0	UPPER_CLAY_TOP	150.00	5.28	ACCEPT
AMB_13AR	51396.0	103082.0	UPPER_CLAY_BOTTOM	116.00	-3.60	ACCEPT
AMB_13AR	51396.0	103082.0	LOWER_CLAY_TOP	94.00	-0.99	ACCEPT
AMB_10A	51410.0	103326.4	GREEN_CLAY_TOP	217.00	0.25	ACCEPT
AMB_10A	51410.0	103326.4	GREEN_CLAY_BOTTOM	199.00	-0.48	ACCEPT
AMB_10A	51410.0	103326.4	UPPER_CLAY_TOP	144.00	-1.08	ACCEPT
AMB_10A	51410.0	103326.4	UPPER_CLAY_BOTTOM	123.00	1.01	ACCEPT
AMB_10A	51410.0	103326.4	LOWER_CLAY_TOP	96.00	-0.36	ACCEPT
MBC_4SB	51445.0	105008.0	GREEN_CLAY_TOP	239.00	1.34	ACCEPT
MBC_4SB	51445.0	105008.0	LOWER_CLAY_TOP	127.00	0.63	ACCEPT
MBC_4SB	51445.0	105008.0	UPPER_CLAY_TOP	157.00	1.65	ACCEPT
MBC_4SB	51445.0	105008.0	UPPER_CLAY_BOTTOM	140.00	-1.48	ACCEPT
AMB_4A	51469.8	104131.6	GREEN_CLAY_TOP	226.00	1.13	ACCEPT
AMB_4A	51469.8	104131.6	GREEN_CLAY_BOTTOM	211.00	0.50	ACCEPT
AMB_4A	51469.8	104131.6	UPPER_CLAY_TOP	144.00	-4.70	ACCEPT
AMB_4A	51469.8	104131.6	UPPER_CLAY_BOTTOM	138.00	2.60	ACCEPT
AMB_4A	51469.8	104131.6	LOWER_CLAY_TOP	117.00	3.90	ACCEPT
AMB_7A	51591.0	103987.1	UPPER_CLAY_BOTTOM	131.00	2.29	ACCEPT
AMB_7A	51591.0	103987.1	GREEN_CLAY_TOP	223.00	4.00	ACCEPT
AMB_7A	51591.0	103987.1	GREEN_CLAY_BOTTOM	204.00	-0.32	ACCEPT
AMB_7A	51591.0	103987.1	UPPER_CLAY_TOP	144.00	0.36	ACCEPT
MSB_87B	51607.0	101276.0	GREEN_CLAY_TOP	218.00	1.34	ACCEPT

Geological Modeling Residuals

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Data Type	Elev. (ft)	Residual (ft)	Status
MSB_87B	51607.0	101276.0	GREEN_CLAY_BOTTOM	195.00	-1.26	ACCEPT
MSB_87B	51607.0	101276.0	UPPER_CLAY_TOP	132.00	-3.54	ACCEPT
MSB_87B	51607.0	101276.0	UPPER_CLAY_BOTTOM	128.00	2.49	ACCEPT
MSB_87B	51607.0	101276.0	LOWER_CLAY_TOP	115.00	1.03	ACCEPT
AMB_7	51624.9	103920.0	GREEN_CLAY_TOP	223.00	4.95	ACCEPT
AMB_7	51624.9	103920.0	GREEN_CLAY_BOTTOM	204.00	0.89	ACCEPT
AMB_7	51624.9	103920.0	UPPER_CLAY_TOP	144.00	1.09	ACCEPT
AMB_7	51624.9	103920.0	UPPER_CLAY_BOTTOM	131.00	3.87	ACCEPT
MBC_5SB	51641.0	103983.0	LOWER_CLAY_TOP	96.00	-5.28	ACCEPT
MBC_5SB	51641.0	103983.0	UPPER_CLAY_TOP	142.00	-0.14	ACCEPT
MBC_5SB	51641.0	103983.0	UPPER_CLAY_BOTTOM	123.00	-3.92	ACCEPT
MBC_5SB	51641.0	103983.0	GREEN_CLAY_TOP	206.00	-11.53	REJECT
MBC_5SB	51641.0	103983.0	GREEN_CLAY_BOTTOM	203.00	0.19	ACCEPT
AMB_11B	51919.5	103154.2	GREEN_CLAY_TOP	214.00	-0.21	ACCEPT
AMB_11B	51919.5	103154.2	GREEN_CLAY_BOTTOM	196.00	-0.21	ACCEPT
AMB_11B	51919.5	103154.2	UPPER_CLAY_TOP	140.00	-0.42	ACCEPT
MSB_82C	51949.4	107521.9	GREEN_CLAY_TOP	236.00	0.79	ACCEPT
MSB_82C	51949.4	107521.9	GREEN_CLAY_BOTTOM	219.00	-0.41	ACCEPT
MSB_82C	51949.4	107521.9	UPPER_CLAY_TOP	160.00	-0.76	ACCEPT
MSB_82C	51949.4	107521.9	UPPER_CLAY_BOTTOM	145.00	-2.49	ACCEPT
MSB_82C	51949.4	107521.9	LOWER_CLAY_TOP	144.00	5.82	ACCEPT
MSB_82C	51949.4	107521.9	LOWER_CLAY_BOTTOM	109.00	-1.27	ACCEPT
MSB_82TA	51964.2	107525.7	GREEN_CLAY_TOP	236.00	0.79	ACCEPT
MSB_82TA	51964.2	107525.7	GREEN_CLAY_BOTTOM	219.00	-0.40	ACCEPT
MSB_82TA	51964.2	107525.7	UPPER_CLAY_TOP	160.00	-0.85	ACCEPT
MSB_82TA	51964.2	107525.7	UPPER_CLAY_BOTTOM	145.00	-2.55	ACCEPT
MSB_82TA	51964.2	107525.7	LOWER_CLAY_TOP	144.00	5.96	ACCEPT
MSB_82TA	51964.2	107525.7	LOWER_CLAY_BOTTOM	109.00	-1.21	ACCEPT
MSB_84A	51971.2	108982.1	GREEN_CLAY_TOP	234.00	-0.48	ACCEPT
MSB_84A	51971.2	108982.1	GREEN_CLAY_BOTTOM	226.00	0.80	ACCEPT
MSB_84A	51971.2	108982.1	UPPER_CLAY_TOP	150.00	-0.26	ACCEPT
MSB_84A	51971.2	108982.1	UPPER_CLAY_BOTTOM	136.00	-0.17	ACCEPT
MSB_84A	51971.2	108982.1	LOWER_CLAY_TOP	125.00	0.35	ACCEPT
MSB_84A	51971.2	108982.1	LOWER_CLAY_BOTTOM	104.00	0.06	ACCEPT
MSB_84C	51973.7	108967.9	GREEN_CLAY_TOP	234.00	-0.56	ACCEPT
MSB_84C	51973.7	108967.9	GREEN_CLAY_BOTTOM	226.00	0.79	ACCEPT
MSB_84C	51973.7	108967.9	UPPER_CLAY_TOP	150.00	-0.27	ACCEPT
MSB_84C	51973.7	108967.9	UPPER_CLAY_BOTTOM	136.00	-0.15	ACCEPT
MSB_84C	51973.7	108967.9	LOWER_CLAY_TOP	125.00	0.38	ACCEPT
MSB_84C	51973.7	108967.9	LOWER_CLAY_BOTTOM	104.00	0.02	ACCEPT
MSB_55TA	52014.7	108322.8	GREEN_CLAY_TOP	236.00	-0.12	ACCEPT
MSB_55TA	52014.7	108322.8	GREEN_CLAY_BOTTOM	223.00	-0.04	ACCEPT
MSB_55TA	52014.7	108322.8	UPPER_CLAY_TOP	148.00	-0.51	ACCEPT
MSB_55TA	52014.7	108322.8	UPPER_CLAY_BOTTOM	132.00	-1.10	ACCEPT
MSB_55TA	52014.7	108322.8	LOWER_CLAY_TOP	120.00	-1.28	ACCEPT
MSB_55TA	52014.7	108322.8	LOWER_CLAY_BOTTOM	104.00	2.11	ACCEPT
MSB_55C	52029.7	108324.6	UPPER_CLAY_TOP	148.00	-1.16	ACCEPT
MSB_55C	52029.7	108324.6	GREEN_CLAY_TOP	236.00	-0.10	ACCEPT
MSB_55C	52029.7	108324.6	GREEN_CLAY_BOTTOM	223.00	-0.02	ACCEPT
MSB_55C	52029.7	108324.6	UPPER_CLAY_BOTTOM	132.00	-1.79	ACCEPT

Geological Modeling Residuals

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Data Type	Elev. (ft)	Residual (ft)	Status
MSB_55C	52029.7	108324.6	LOWER_CLAY_TOP	120.00	-1.66	ACCEPT
MSB_55C	52029.7	108324.6	LOWER_CLAY_BOTTOM	104.00	1.72	ACCEPT
MSB_47TA	52219.0	106987.7	GREEN_CLAY_BOTTOM	210.00	-0.89	ACCEPT
MSB_47TA	52219.0	106987.7	UPPER_CLAY_TOP	146.00	1.12	ACCEPT
MSB_47TA	52219.0	106987.7	LOWER_CLAY_TOP	94.00	-6.93	ACCEPT
MSB_47TA	52219.0	106987.7	GREEN_CLAY_TOP	228.00	1.28	ACCEPT
MSB_47TA	52219.0	106987.7	UPPER_CLAY_BOTTOM	132.00	4.14	ACCEPT
MSB_83C	52384.7	108405.3	GREEN_CLAY_TOP	236.00	2.14	ACCEPT
MSB_83C	52384.7	108405.3	GREEN_CLAY_BOTTOM	220.00	-1.48	ACCEPT
MSB_83C	52384.7	108405.3	UPPER_CLAY_TOP	165.00	2.55	ACCEPT
MSB_83TA	52410.9	108416.3	UPPER_CLAY_TOP	165.00	1.83	ACCEPT
MSB_83TA	52410.9	108416.3	GREEN_CLAY_TOP	236.00	2.53	ACCEPT
MSB_83TA	52410.9	108416.3	GREEN_CLAY_BOTTOM	220.00	-1.22	ACCEPT
MSB_69TA	52418.4	107772.5	GREEN_CLAY_BOTTOM	217.00	1.11	ACCEPT
MSB_69TA	52418.4	107772.5	UPPER_CLAY_TOP	160.00	1.34	ACCEPT
MSB_69TA	52418.4	107772.5	UPPER_CLAY_BOTTOM	146.00	2.85	ACCEPT
MSB_69TA	52418.4	107772.5	LOWER_CLAY_TOP	114.00	-5.07	ACCEPT
MSB_69TA	52418.4	107772.5	GREEN_CLAY_TOP	229.00	-1.53	ACCEPT
ASB_6AA	52643.9	105727.0	GREEN_CLAY_TOP	201.00	-4.65	ACCEPT
ASB_6AA	52643.9	105727.0	GREEN_CLAY_BOTTOM	194.00	1.59	ACCEPT
ASB_6AA	52643.9	105727.0	UPPER_CLAY_TOP	142.00	-0.06	ACCEPT
ASB_6AA	52643.9	105727.0	UPPER_CLAY_BOTTOM	132.00	0.98	ACCEPT
ASB_6AA	52643.9	105727.0	LOWER_CLAY_TOP	118.00	-0.03	ACCEPT
ASB_6TA	52671.3	105749.5	UPPER_CLAY_TOP	142.00	-0.43	ACCEPT
ASB_6TA	52671.3	105749.5	GREEN_CLAY_TOP	201.00	-3.38	ACCEPT
ASB_6TA	52671.3	105749.5	GREEN_CLAY_BOTTOM	194.00	2.75	ACCEPT
ASB_6TA	52671.3	105749.5	UPPER_CLAY_BOTTOM	132.00	0.52	ACCEPT
ASB_6TA	52671.3	105749.5	LOWER_CLAY_TOP	118.00	-0.54	ACCEPT
MSB_32B	52742.5	99676.0	LOWER_CLAY_BOTTOM	77.00	1.91	ACCEPT
MSB_32B	52742.5	99676.0	UPPER_CLAY_TOP	117.00	-0.96	ACCEPT
MSB_32B	52742.5	99676.0	UPPER_CLAY_BOTTOM	102.00	-2.33	ACCEPT
MSB_32B	52742.5	99676.0	LOWER_CLAY_TOP	98.00	0.49	ACCEPT
MSB_32B	52742.5	99676.0	GREEN_CLAY_BOTTOM	199.00	-0.06	ACCEPT
MSB_32B	52742.5	99676.0	GREEN_CLAY_TOP	218.00	-0.07	ACCEPT
MBC_1SB	52780.0	108450.0	LOWER_CLAY_TOP	128.00	3.33	ACCEPT
MBC_1SB	52780.0	108450.0	UPPER_CLAY_BOTTOM	149.00	-1.64	ACCEPT
MBC_1SB	52780.0	108450.0	GREEN_CLAY_BOTTOM	217.00	0.89	ACCEPT
MBC_1SB	52780.0	108450.0	UPPER_CLAY_TOP	160.00	-2.75	ACCEPT
MBC_1SB	52780.0	108450.0	GREEN_CLAY_TOP	222.00	-4.19	ACCEPT
MSB_51B	52818.0	96992.7	UPPER_CLAY_TOP	132.00	0.00	ACCEPT
MSB_51B	52818.0	96992.7	GREEN_CLAY_TOP	224.00	0.62	ACCEPT
MSB_51B	52818.0	96992.7	GREEN_CLAY_BOTTOM	204.00	-0.51	ACCEPT
ASB_2CR	52862.7	105540.2	GREEN_CLAY_TOP	225.00	10.48	REJECT
ASB_2CR	52862.7	105540.2	GREEN_CLAY_BOTTOM	195.00	-4.57	ACCEPT
ASB_2CR	52862.7	105540.2	UPPER_CLAY_TOP	138.00	-1.65	ACCEPT
ASB_2CR	52862.7	105540.2	UPPER_CLAY_BOTTOM	125.00	-3.91	ACCEPT
ASB_2CR	52862.7	105540.2	LOWER_CLAY_TOP	120.00	2.27	ACCEPT
ASB_10C	52965.5	105673.1	UPPER_CLAY_TOP	142.00	-1.68	ACCEPT
ASB_10C	52965.5	105673.1	GREEN_CLAY_TOP	206.00	-1.64	ACCEPT
ASB_10C	52965.5	105673.1	GREEN_CLAY_BOTTOM	192.00	-1.42	ACCEPT

Geological Modeling Residuals

Well or CPT ID	SRS Easting (ft)	SRS Northing (ft)	Data Type	Elev. (ft)	Residual (ft)	Status
ASB_10C	52965.5	105673.1	UPPER_CLAY_BOTTOM	137.00	3.88	ACCEPT
MBC_2SB	52975.0	107750.0	GREEN_CLAY_TOP	226.00	-0.14	ACCEPT
MBC_2SB	52975.0	107750.0	UPPER_CLAY_BOTTOM	147.00	0.26	ACCEPT
MBC_2SB	52975.0	107750.0	LOWER_CLAY_TOP	116.00	-0.16	ACCEPT
MBC_2SB	52975.0	107750.0	GREEN_CLAY_BOTTOM	210.00	-2.29	ACCEPT
MBC_2SB	52975.0	107750.0	UPPER_CLAY_TOP	160.00	-1.15	ACCEPT
MSB_54TA	52985.8	108446.3	UPPER_CLAY_TOP	160.00	-1.00	ACCEPT
MSB_54TA	52985.8	108446.3	UPPER_CLAY_BOTTOM	155.00	5.77	ACCEPT
MSB_54TA	52985.8	108446.3	LOWER_CLAY_TOP	114.00	-5.29	ACCEPT
MSB_54TA	52985.8	108446.3	GREEN_CLAY_TOP	227.00	-0.81	ACCEPT
MSB_54TA	52985.8	108446.3	GREEN_CLAY_BOTTOM	221.00	2.23	ACCEPT
RWM_14B	53044.7	106362.1	GREEN_CLAY_TOP	206.00	0.03	ACCEPT
RWM_14B	53044.7	106362.1	UPPER_CLAY_TOP	148.00	1.11	ACCEPT
RWM_14B	53044.7	106362.1	UPPER_CLAY_BOTTOM	130.00	-2.81	ACCEPT
RWM_14B	53044.7	106362.1	LOWER_CLAY_TOP	118.00	1.87	ACCEPT
RWM_14B	53044.7	106362.1	GREEN_CLAY_BOTTOM	194.00	0.34	ACCEPT
MSB_85TA	53137.2	107831.2	GREEN_CLAY_TOP	230.00	2.46	ACCEPT
MSB_85TA	53137.2	107831.2	GREEN_CLAY_BOTTOM	215.00	-0.23	ACCEPT
MSB_85TA	53137.2	107831.2	UPPER_CLAY_TOP	163.00	1.51	ACCEPT
MSB_85C	53151.4	107835.2	GREEN_CLAY_TOP	230.00	2.38	ACCEPT
MSB_85C	53151.4	107835.2	GREEN_CLAY_BOTTOM	215.00	-0.43	ACCEPT
MSB_85C	53151.4	107835.2	UPPER_CLAY_TOP	163.00	1.54	ACCEPT
MSB_52B	53418.4	103077.7	UPPER_CLAY_TOP	148.00	0.48	ACCEPT
MSB_52B	53418.4	103077.7	GREEN_CLAY_TOP	232.00	1.94	ACCEPT
MSB_52B	53418.4	103077.7	GREEN_CLAY_BOTTOM	210.00	-1.19	ACCEPT
RWM_13B	53516.3	105803.3	GREEN_CLAY_TOP	203.00	-2.87	ACCEPT
RWM_13B	53516.3	105803.3	GREEN_CLAY_BOTTOM	197.00	2.15	ACCEPT
RWM_13B	53516.3	105803.3	UPPER_CLAY_TOP	151.00	1.86	ACCEPT
RWM_13B	53516.3	105803.3	UPPER_CLAY_BOTTOM	135.00	-1.27	ACCEPT
RWM_15B	53849.0	107444.7	GREEN_CLAY_BOTTOM	196.00	0.96	ACCEPT
RWM_15B	53849.0	107444.7	UPPER_CLAY_TOP	138.00	-0.35	ACCEPT
RWM_15B	53849.0	107444.7	GREEN_CLAY_TOP	202.00	-2.24	ACCEPT
MSB_48C	54077.0	107917.5	GREEN_CLAY_BOTTOM	204.00	2.15	ACCEPT
MSB_48C	54077.0	107917.5	UPPER_CLAY_TOP	139.00	-0.79	ACCEPT
MSB_48C	54077.0	107917.5	GREEN_CLAY_TOP	207.00	-2.38	ACCEPT
MSB_48TA	54089.2	107925.8	GREEN_CLAY_TOP	207.00	-2.48	ACCEPT
MSB_48TA	54089.2	107925.8	GREEN_CLAY_BOTTOM	204.00	2.10	ACCEPT
MSB_48TA	54089.2	107925.8	UPPER_CLAY_TOP	139.00	-0.90	ACCEPT
ASB_9C	54201.1	104568.1	GREEN_CLAY_TOP	218.00	-0.69	ACCEPT
ASB_9C	54201.1	104568.1	UPPER_CLAY_TOP	150.00	0.39	ACCEPT
ASB_9C	54201.1	104568.1	GREEN_CLAY_BOTTOM	208.00	0.59	ACCEPT
ASB_9C	54201.1	104568.1	UPPER_CLAY_BOTTOM	135.00	-0.10	ACCEPT
MSB_77TA	54208.9	107053.8	GREEN_CLAY_BOTTOM	191.00	-1.69	ACCEPT
MSB_77TA	54208.9	107053.8	UPPER_CLAY_TOP	132.00	-0.77	ACCEPT
MSB_77TA	54208.9	107053.8	GREEN_CLAY_TOP	205.00	0.81	ACCEPT
ASB_9	54226.2	104589.2	GREEN_CLAY_TOP	218.00	-0.57	ACCEPT
ASB_9	54226.2	104589.2	UPPER_CLAY_TOP	150.00	0.32	ACCEPT
ASB_9	54226.2	104589.2	GREEN_CLAY_BOTTOM	208.00	0.61	ACCEPT
ASB_9	54226.2	104589.2	UPPER_CLAY_BOTTOM	135.00	-0.18	ACCEPT
MSB_53C	54540.5	106456.2	GREEN_CLAY_TOP	222.00	1.10	ACCEPT

Hydraulic Head Residuals

Well ID	SRS Easting (ft)	SRS Northing (ft)	Layer	Head Data (ft)	Residual (ft)	Status
ABP_7D	43930.1	97449.7	5	224.41	1.24	ACCEPT
ABP_8D	43984.1	97854.9	5	223.02	-.29	ACCEPT
MSB_71B	44054.7	103801.6	16	218.05	1.14	ACCEPT
ABP_4	44096.0	97489.7	8	223.55	.32	ACCEPT
ABP_4DD	44101.3	97495.5	6	230.83	6.85	REJECT
ABP_6D	44101.4	97889.7	6	223.32	.03	ACCEPT
ABP_2A	44118.8	97764.3	8	223.74	.93	ACCEPT
ABP_2DD	44126.7	97753.7	6	223.34	-.41	ACCEPT
MSB_56D	44207.9	108463.5	4	221.73	-1.56	ACCEPT
ARP_1A	44317.4	99102.9	7	217.09	.20	ACCEPT
ARP_4	44374.8	98567.7	6	219.57	-1.20	ACCEPT
ABP_1A	44425.6	97501.6	10	225.07	.37	ACCEPT
ABP_1DD	44433.6	97511.4	5	226.44	.71	ACCEPT
ABP_3C	44506.3	97778.2	12	198.23	-.50	ACCEPT
ABP_3	44509.3	97794.1	5	225.25	-.54	ACCEPT
MCB_8D	44769.9	97180.6	5	226.42	.93	ACCEPT
MCB_9D	44858.8	97605.8	5	224.01	-2.08	ACCEPT
MCB_5	44863.9	97335.6	5	225.95	.13	ACCEPT
ARP_2	44876.1	99119.8	8	219.77	-.22	ACCEPT
ARP_3	44903.7	98638.2	8	222.42	.52	ACCEPT
MSB_70C	45012.0	101785.2	11	218.54	.16	ACCEPT
MCB_6C	45207.7	97413.1	12	196.63	-2.45	ACCEPT
MSB_76C	45344.0	103061.6	9	221.69	-.07	ACCEPT
MSB_78D	45482.2	103643.8	5	224.86	-.75	ACCEPT
MSB_73B	45694.0	99270.3	17	202.75	-.75	ACCEPT
MSB_49A	45864.6	99759.0	21	198.47	.92	ACCEPT
MSB_49B	45868.2	99737.8	19	204.19	.18	ACCEPT
MSB_20A	46060.5	103545.1	15	220.06	-.28	ACCEPT
MSB_18A	46110.4	100416.1	15	213.87	.11	ACCEPT
MSB_18B	46115.7	100424.1	10	222.63	.11	ACCEPT
MSB_17BB	46220.8	102009.5	18	214.33	.14	ACCEPT
MSB_17B	46237.7	101994.6	9	226.43	.94	ACCEPT
MSB_17A	46245.7	101976.6	15	218.00	-.39	ACCEPT
MSB_6A	46319.9	101133.8	5	227.96	.19	ACCEPT
MSB_6B	46321.6	101148.5	19	208.50	.18	ACCEPT
AC_2A	46428.6	105636.4	15	221.99	-.09	ACCEPT
MSB_64B	46579.7	101831.0	19	210.49	-1.10	ACCEPT
MSB_64C	46589.2	101842.9	11	223.90	-.15	ACCEPT
MSB_64D	46598.5	101854.8	5	227.59	-1.67	ACCEPT
MSB_7B	46718.1	100597.6	16	208.90	-.67	ACCEPT
MSB_7A	46726.1	100585.7	5	228.79	-.30	ACCEPT
MSB_5B	46983.6	101971.1	18	211.29	.24	ACCEPT
MSB_5A	46998.7	101971.5	5	228.60	-1.32	ACCEPT
MSB_12A	47138.2	102283.2	19	212.38	.90	ACCEPT
MSB_12C	47138.4	102274.4	11	224.56	1.59	ACCEPT
MSB_12D	47139.7	102262.2	5	234.08	-.85	ACCEPT
MSB_21A	47217.2	103967.0	14	222.61	-.08	ACCEPT
MSB_21C	47234.6	103973.0	5	229.77	-1.27	ACCEPT
MSB_8C	47264.6	100793.2	10	221.51	.21	ACCEPT
MSB_21B	47271.8	104000.1	15	222.04	.14	ACCEPT

Hydraulic Head Residuals

Well ID	SRS Easting (ft)	SRS Northing (ft)	Layer	Head Data (ft)	Residual (ft)	Status
MSB_8B	47281.9	100805.8	15	211.00	-.17	ACCEPT
MSB_79C	47286.8	99290.2	10	211.01	-.56	ACCEPT
MSB_8A	47293.2	100815.1	6	230.18	-.02	ACCEPT
MSB_79B	47300.2	99296.9	15	208.93	.11	ACCEPT
MSB_13C	47521.9	101745.7	5	229.73	-.89	ACCEPT
MSB_13B	47523.5	101735.7	12	203.29	-15.42	REJECT
MSB_13A	47525.4	101725.7	15	211.61	.86	ACCEPT
MSB_63C	47849.2	101174.6	10	222.35	-.09	ACCEPT
MSB_63B	47861.0	101184.4	15	211.55	-.63	ACCEPT
MSB_89C	47881.6	98379.4	6	229.53	.36	ACCEPT
MSB_62C	47895.0	101857.2	10	224.84	2.13	ACCEPT
MSB_62B	47906.8	101865.3	15	212.37	-.43	ACCEPT
MSB_10B	47943.1	102488.2	14	217.16	-.33	ACCEPT
MSB_10A	47954.4	102451.8	18	214.66	1.15	ACCEPT
MSB_30AA	47970.5	105715.7	20	224.98	8.16	REJECT
MSB_30B	47981.8	105719.9	17	226.59	.65	ACCEPT
MSB_30CC	47993.3	105724.2	13	226.67	-1.02	ACCEPT
MSB_30C	48013.7	105731.1	5	231.48	-.46	ACCEPT
MSB_9A	48242.5	102236.7	16	213.26	-1.66	ACCEPT
RWM_16	48244.8	97647.2	13	204.32	-.51	ACCEPT
MSB_9C	48273.0	102245.6	5	231.28	-.35	ACCEPT
MSB_40A	48279.4	97672.8	19	203.65	.59	ACCEPT
MSB_40B	48281.6	97685.0	14	205.47	.59	ACCEPT
MSB_40C	48283.5	97697.8	10	205.34	-.23	ACCEPT
MSB_4D	48311.7	102007.5	6	230.85	.20	ACCEPT
MSB_4B	48312.8	101978.3	17	213.53	-.81	ACCEPT
MSB_4A	48313.0	101933.4	5	231.61	-.91	ACCEPT
MSB_72B	48350.3	96387.6	14	200.57	-.45	ACCEPT
MSB_39A	48367.3	100837.6	18	211.05	.81	ACCEPT
MSB_39B	48376.9	100844.6	15	213.76	-.93	ACCEPT
MSB_39C	48386.7	100852.1	9	217.15	-2.43	ACCEPT
MSB_39D	48396.0	100858.7	5	232.95	-.63	ACCEPT
MSB_26A	48440.7	104602.3	12	226.35	-.59	ACCEPT
MSB_1A	48467.3	101833.7	5	232.35	-.75	ACCEPT
MSB_1B	48483.2	101833.0	15	213.01	-2.14	ACCEPT
MSB_22	48508.8	102186.5	5	231.74	.00	ACCEPT
MSB_28	48517.3	104941.8	6	231.27	.20	ACCEPT
MSB_14B	48519.1	101639.0	10	220.16	-.09	ACCEPT
MSB_14A	48521.9	101629.5	14	218.42	1.74	ACCEPT
MSB_28A	48521.9	104947.7	14	225.36	-1.73	ACCEPT
MSB_3D	48524.6	102188.6	6	231.08	.19	ACCEPT
MSB_3A	48553.7	102189.9	5	232.71	.24	ACCEPT
MSB_3B	48568.0	102191.7	15	216.32	.03	ACCEPT
MSB_11F	48577.0	102629.3	5	231.27	.79	ACCEPT
MSB_11A	48577.6	102638.9	16	215.70	-.34	ACCEPT
MSB_11B	48578.5	102648.9	13	221.39	-1.29	ACCEPT
MSB_11C	48579.4	102658.6	11	223.36	4.24	ACCEPT
MSB_11E	48579.6	102678.5	5	239.73	1.59	ACCEPT
MSB_11D	48579.7	102669.5	8	229.70	.78	ACCEPT
MSB_2A	48746.4	102028.3	5	233.82	-2.08	ACCEPT
MSB_15AA	48818.5	102953.2	15	216.96	1.04	ACCEPT

Hydraulic Head Residuals

Well ID	SRS Easting (ft)	SRS Northing (ft)	Layer	Head Data (ft)	Residual (ft)	Status
MSB_15A	48827.0	102983.5	13	223.54	1.04	ACCEPT
MSB_75B	48875.5	98937.4	14	211.03	.45	ACCEPT
MSB_26	48941.7	104612.8	5	237.24	-.01	ACCEPT
MSB_26B	48944.6	104646.7	16	221.25	-.57	ACCEPT
MSB_16A	48965.1	103693.9	13	224.40	1.66	ACCEPT
MSB_23TA	49225.8	104298.8	22	202.75	.23	ACCEPT
MSB_23B	49286.4	104336.6	12	225.70	-.38	ACCEPT
MSB_43A	49293.7	107275.3	16	230.14	.42	ACCEPT
MSB_43B	49311.8	107274.6	13	230.42	-.97	ACCEPT
MSB_43D	49322.0	107274.2	8	232.35	.21	ACCEPT
MSB_43DD	49341.2	107273.0	5	232.26	-1.58	ACCEPT
MSB_27B	49486.4	104940.3	13	227.78	-.16	ACCEPT
MSB_27	49487.7	104972.8	5	237.04	-.12	ACCEPT
MSB_27A	49487.8	104962.8	10	230.25	1.79	ACCEPT
MSB_36A	49514.9	100511.3	19	211.79	.40	ACCEPT
MSB_36B	49526.3	100514.9	13	216.06	.46	ACCEPT
MSB_36C	49537.2	100518.3	10	216.16	-.96	ACCEPT
MSB_25A	49657.9	103504.8	13	219.58	-.37	ACCEPT
MSB_25	49668.9	103498.8	5	237.01	.74	ACCEPT
MSB_38B	49746.1	102360.8	15	218.61	-1.14	ACCEPT
MSB_38C	49762.0	102373.1	13	221.98	1.39	ACCEPT
MSB_24A	49845.3	104625.3	12	227.79	.61	ACCEPT
MSB_31CC	50067.9	101983.1	11	220.65	.65	ACCEPT
MSB_31B	50078.7	101981.3	14	220.51	.84	ACCEPT
MSB_31C	50089.9	101979.6	5	235.85	.71	ACCEPT
MSB_74B	50443.2	99197.4	15	211.92	-.26	ACCEPT
AOB_1	50485.9	101910.7	5	237.73	-.96	ACCEPT
MSB_34A	50534.9	104954.9	20	220.51	.92	ACCEPT
MSB_34B	50534.9	104944.7	12	228.60	.90	ACCEPT
MSB_45B	50555.3	103987.9	12	228.17	1.24	ACCEPT
MSB_46B	50557.5	103102.4	11	227.09	.77	ACCEPT
AOB_2	50724.7	102009.8	5	237.63	-1.64	ACCEPT
MSB_88D	50793.5	97012.3	8	205.16	-.29	ACCEPT
MSB_19A	50934.4	100983.0	18	215.84	.17	ACCEPT
MSB_19B	50934.8	100999.3	15	218.56	-.11	ACCEPT
MSB_19C	50942.4	100992.1	8	239.31	.92	ACCEPT
MSB_35A	50945.2	102098.0	17	218.11	-.51	ACCEPT
MSB_35B	50947.9	102110.8	13	221.97	-.64	ACCEPT
MSB_35D	50949.7	102122.4	4	243.48	1.20	ACCEPT
MSB_66D	51044.0	105841.8	8	232.21	1.08	ACCEPT
MSB_50D	51044.1	96416.7	9	202.37	-.56	ACCEPT
MSB_50B	51053.5	96433.0	13	202.36	-.07	ACCEPT
MSB_66C	51053.5	105842.1	14	229.84	.29	ACCEPT
MSB_66B	51064.6	105842.0	17	220.91	-1.02	ACCEPT
MSB_44B	51096.4	103296.2	12	226.48	-.39	ACCEPT
MSB_44A	51106.9	103296.5	17	219.56	-1.10	ACCEPT
ACB_4A	51116.2	102343.9	5	239.74	.79	ACCEPT
MSB_29DD	51191.3	107311.4	7	233.55	-.21	ACCEPT
MSB_29C	51206.6	107315.0	13	231.47	.44	ACCEPT
MSB_29B	51217.5	107319.3	16	225.75	-1.08	ACCEPT

Hydraulic Head Residuals

Well ID	SRS Easting (ft)	SRS Northing (ft)	Layer	Head Data (ft)	Residual (ft)	Status
MSB_29D	51226.9	107323.3	9	233.26	.73	ACCEPT
MSB_29A	51236.4	107326.8	20	221.56	.78	ACCEPT
AMB_9D	51263.0	103585.2	6	235.40	-.01	ACCEPT
ACB_3A	51313.3	102154.3	6	239.57	.43	ACCEPT
ACB_1A	51369.9	102622.9	5	238.68	-.51	ACCEPT
AMB_13AR	51396.0	103082.0	19	220.56	1.57	ACCEPT
AMB_8D	51400.5	103874.7	6	234.96	.20	ACCEPT
AMB_10A	51410.0	103326.4	18	219.66	.24	ACCEPT
AMB_10B	51418.3	103337.3	15	225.08	-.08	ACCEPT
AMB_18A	51418.8	103988.8	17	220.43	-1.48	ACCEPT
MSB_37C	51439.8	105283.2	13	229.64	.88	ACCEPT
MSB_37B	51450.0	105289.5	18	220.91	.15	ACCEPT
AMB_10D	51456.0	103293.4	5	236.64	-.35	ACCEPT
AMB_17A	51465.4	104056.7	18	220.53	-.05	ACCEPT
AMB_5	51467.2	104083.4	6	234.93	.57	ACCEPT
AMB_4A	51469.8	104131.6	19	220.56	-.04	ACCEPT
AMB_4B	51482.7	104145.6	15	226.09	-.08	ACCEPT
AMB_4D	51489.0	104154.7	8	234.52	.96	ACCEPT
ACB_2A	51561.3	102367.4	5	239.78	.45	ACCEPT
MSB_42A	51582.3	104557.9	19	220.89	.61	ACCEPT
MSB_42B	51582.8	104569.8	14	227.54	.83	ACCEPT
MSB_42C	51582.8	104581.9	11	231.90	1.31	ACCEPT
AMB_7B	51590.3	103972.0	14	226.57	.55	ACCEPT
AMB_7A	51591.0	103987.1	18	220.55	-.18	ACCEPT
MSB_33A	51738.0	98006.7	20	205.34	.50	ACCEPT
MSB_33B	51741.9	97995.9	17	208.20	.09	ACCEPT
MSB_33C	51746.7	97984.8	12	211.15	.88	ACCEPT
AMB_12D	51901.6	103602.4	5	235.98	-.94	ACCEPT
AMB_11B	51919.5	103154.2	11	224.72	-1.82	ACCEPT
AMB_11D	51932.6	103132.3	5	237.31	-1.33	ACCEPT
MSB_82D	51934.6	107518.1	9	233.85	.96	ACCEPT
MSB_82C	51949.4	107521.9	14	229.61	1.24	ACCEPT
MSB_84C	51973.7	108967.9	12	230.52	-.84	ACCEPT
MSB_82A	51978.4	107529.5	21	222.11	2.06	ACCEPT
MSB_67C	51988.6	106819.8	13	228.39	.13	ACCEPT
MSB_67B	51989.6	106842.0	17	220.50	-.91	ACCEPT
MSB_82B	51993.3	107533.4	18	221.76	-.51	ACCEPT
MSB_55B	52006.2	108342.4	15	223.19	-3.77	ACCEPT
MSB_55C	52029.7	108324.6	12	230.44	-.91	ACCEPT
MSB_55D	52032.5	108391.4	9	233.92	-.06	ACCEPT
MSB_47D	52184.0	106960.1	6	234.36	.37	ACCEPT
MSB_47C	52195.5	106969.2	10	233.51	3.29	ACCEPT
MSB_47B	52207.2	106978.5	13	226.78	.20	ACCEPT
MSB_47BB	52234.4	106999.7	18	221.82	1.16	ACCEPT
MSB_68D	52293.6	106741.4	6	234.34	-.08	ACCEPT
MSB_68C	52304.9	106730.5	13	226.60	.08	ACCEPT
MSB_68B	52308.5	106744.9	17	220.83	-.71	ACCEPT
MSB_83C	52384.7	108405.3	14	228.76	-.35	ACCEPT
MSB_83B	52421.4	108426.7	18	223.15	-.20	ACCEPT
MSB_69B	52432.9	107776.1	17	222.38	-.90	ACCEPT

Hydraulic Head Residuals

Well ID	SRS Easting (ft)	SRS Northing (ft)	Layer	Head Data (ft)	Residual (ft)	Status
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MSB_69D	52462.0	107784.3	8	234.09	.53	ACCEPT
ASB_1A	52614.0	105535.0	5	238.35	.39	ACCEPT
ASB_6C	52655.9	105736.8	11	225.53	-.56	ACCEPT
ASB_6A	52675.9	105716.0	5	237.87	-.39	ACCEPT
MSB_32	52733.9	99655.6	9	224.47	-.12	ACCEPT
MSB_51B	52818.0	96992.7	13	205.19	-.67	ACCEPT
MSB_51DD	52830.3	97006.2	8	212.28	-.37	ACCEPT
ASB_5C	52837.8	105884.8	12	224.37	-.82	ACCEPT
ASB_2CR	52862.7	105540.2	12	224.66	-.64	ACCEPT
ASB_2AR	52881.7	105550.5	5	239.65	.50	ACCEPT
MSB_54C	52955.7	108447.4	14	228.55	.93	ACCEPT
ASB_10CR	52969.7	105655.4	11	224.63	-.33	ACCEPT
MSB_54B	52970.5	108446.8	19	223.46	-.04	ACCEPT
MSB_54D	52984.5	108461.5	7	233.96	.15	ACCEPT
RWM_14B	53044.7	106362.1	17	221.52	-.03	ACCEPT
RWM_14C	53051.5	106380.8	11	225.52	-.55	ACCEPT
ASB_8C	53101.0	106354.4	10	224.97	-1.42	ACCEPT
MSB_85D	53108.8	107822.8	7	233.68	.58	ACCEPT
ASB_8B	53109.6	106362.3	19	221.89	.99	ACCEPT
ASB_3AR	53115.0	105605.1	5	240.25	.23	ACCEPT
MSB_85B	53122.7	107827.0	18	222.96	-.14	ACCEPT
ASB_3CR	53130.4	105614.5	12	224.25	-.42	ACCEPT
ASB_8	53136.6	106381.6	5	235.32	-.76	ACCEPT
MSB_85C	53151.4	107835.2	14	225.99	-.64	ACCEPT
ASB_4	53177.2	105935.7	4	239.47	-.62	ACCEPT
MSB_41C	53410.6	102203.9	15	219.03	-.99	ACCEPT
MSB_41B	53417.8	102194.5	19	218.57	1.10	ACCEPT
MSB_52B	53418.4	103077.7	14	220.09	-1.23	ACCEPT
MSB_41A	53424.1	102184.4	22	218.32	9.93	REJECT
RWM_13C	53502.2	105809.7	14	223.49	.07	ACCEPT
RWM_13B	53516.3	105803.3	19	221.67	1.73	ACCEPT
RWM_15B	53849.0	107444.7	16	223.95	-.37	ACCEPT
MSB_48C	54077.0	107917.5	12	225.66	-1.60	ACCEPT
MSB_48TA	54089.2	107925.8	19	223.67	.36	ACCEPT
MSB_48A	54099.8	107936.6	17	223.88	-.30	ACCEPT
MSB_48B	54112.2	107945.0	14	225.18	-.65	ACCEPT
ASB_9C	54201.1	104568.1	12	222.13	-.71	ACCEPT
MSB_77TA	54208.9	107053.8	22	222.84	1.38	ACCEPT
ASB_9B	54215.3	104564.7	14	221.75	-.22	ACCEPT
MSB_77B	54217.4	107065.8	14	223.23	-.95	ACCEPT
MSB_77C	54225.9	107078.3	12	225.26	-.91	ACCEPT
ASB_9	54226.2	104589.2	5	242.98	1.64	ACCEPT
MSB_53C	54540.5	106456.2	11	224.53	-.67	ACCEPT
MSB_53D	54553.1	106448.2	5	234.46	-.87	ACCEPT
MSB_86C	54560.5	108500.4	15	226.17	.96	ACCEPT
MSB_53B	54574.3	106443.6	15	223.64	.31	ACCEPT
ABW_1	55016.4	105939.9	11	226.92	1.17	ACCEPT
MSB_81B	55230.4	103762.7	15	222.16	.64	ACCEPT
MSB_61C	55406.6	106091.1	13	224.97	1.50	ACCEPT

APPENDIX A
HYDRAULIC HEAD MEASUREMENTS

APPENDIX B
CORES AND HYDROSTRATIGRAPHIC DATA

APPENDIX C
CORE MUD FRACTION PLOTS

APPENDIX D
GEOLOGICAL RESIDUALS

APPENDIX E
HYDRUALIC HEAD RESIDUALS