PARSONS

Technical Memorandum

To: Jeff Aston and Chris Beal, CSSA

From: Gary Cobb

CC: file (744223.04)

Date: September 9, 2005

Re: Location and Construction Information for the Proposed Injection Well at SWMU B-3

This Technical Memorandum presents location and construction recommendations for the planned injection well B3-MW01 at SWMU B-3. These recommendations for the injection well are submitted for your review and comment.

Parsons was contracted to perform a Pilot Study to evaluate enhanced anaerobic bioremediation as a remedial option for groundwater contaminants at SWMU B-3 at Camp Stanley Storage Activity. The Pilot Study will involve injection of an organic substrate into the Lower Glen Rose formation at SWMU B-3 and monitoring the effects of the substrate on anaerobic contaminant biodegradation rates. The location selected for the Pilot Study is the area between the suspected source area at the SWMU B-3 landfill and well CS-MW16 to the northwest where contaminants are present in the groundwater (see Figure 1, attached). An injection well (B3-MW01) will be installed along the migration pathway between the suspected source and well CS-MW16 to facilitate injection of the organic substrate. One of the Westbay monitoring wells (CS-WB-05) being installed to monitor SWMU B-3 will be utilized as the downgradient monitoring point for the study.

In selecting the location and depth for the injection well, the hydraulic properties, contaminant concentrations, and stratigraphic position for the injection zone were considered. The hydraulic properties influence the rate and direction of groundwater flow, contaminant migration, and migration of the substrate within the injection zone. Contaminant concentrations within the zone should be sufficiently high so changes in concentration due to increased biodegradation can be accurately measured and quantified. Stratigraphic considerations include adequate depth below the water table to ensure the zone will remain saturated during the study, and zone thickness is no more than 30 feet to minimize the volume of substrate required for the study.

To aid in determining location of the injection well and selection of the zone within the formation for injection of the substrate, geophysical and hydraulic testing was performed on the borehole drilled for Westbay well CS-WB05. Results of that testing were used to select potential injection zones and determine the necessary separation distance between the injection well and Westbay well CS-WB05, which will be used as a downgradient monitoring point for the study. Borehole testing included:

- Geophysical borehole logging: Caliper, electric, electromagnetic, natural gamma, video, and optical televiewer logging to determine physical properties of the rock material and identify stratigraphic zones within the formation;
- Hydrophysical testing: To identify the permeable zone within the saturated interval of the formation to provide preliminary estimates of groundwater flowrates within the permeable zones; and
- Hydraulic testing: Packer testing on selected intervals within the formation was done to assess hydraulic properties of the zones and to collect discrete interval groundwater samples

to determine contaminant concentrations within each zone. A 20-foot packer spacing was used for the hydraulic testing.

Injection Zone Selection

From Parsons' evaluation of the borehole geophysical logging, depths to the LGR(d), LGR(e), and LGR(f) hydrostratigraphic units were determined to be 153, 212, and 274 feet below ground surface (bgs), respectively (see attached geophysical log). As discussed in the Draft Work Plan for Enhanced Anaerobic Biodegradation Pilot Study at SWMU B-3 (Parsons, July 2005), the desired depth for the injection well is within the LGR(d) or LGR(e) hydrostratigraphic zone to ensure the zone would remain saturated for the duration of the study. As discussed in the Draft Work Plan, injection into the lower portion of the LGR(f) interval is not preferred because the thickness and high permeability of this interval would require large volumes of substrate to create conditions conducive to enhancing natural biodegradation processes. Therefore, in Parsons opinion, an injection zone within the LGR(d), LGR(e) and upper portions of the LGR(f) hydrostratigraphic intervals should be considered for the injection zone. Additionally, the zone selected for the injection should be separated from permeable zones immediately above or below so the substrate can be placed into the desired zone with minimal loss into adjacent layers.

Results of the hydrophysical testing identified four probable permeable zones above the lower LGR(f) interval, 168-173 feet,, 184-189 feet, 205-218 feet, and 278-287 feet (see attached preliminary hydrophysics results). Water level in the boring was at 169 feet bgs during hydrophysics testing; as a result, Parsons believes the upper interval in the hydrophysics data (168-173 feet) may be the result of water entering the borehole from minor saturated zones above the water table. Additionally, because of its proximity to the water table, there is a high probability that the 184-189-foot zone might not remain saturated for the entire study period and, therefore, would not be suitable as the injection zone. Parsons believes the 205-218 and 278-287-foot intervals represent the best options for the injection zone.

Injection packer tests were performed at four intervals in the CS-WB05 borehole: 162-182 feet, 198-218 feet, 230-250 feet, and 268-288 feet. Preliminary analysis of the recovery data for intervals at 198-218 feet and 268-288 feet indicates that the hydraulic conductivities of the 198-218 foot and 268-288 foot intervals are approximately 0.58 and 2.7 ft/day, respectively (see attached calculation sheets). Injection test results of the 230-250 foot interval indicate this interval is very impermeable, so additional analysis of this zone was not performed. Also, injection test results for the 162-182 foot zone were not analyzed since this zone is too close to the water table.

To establish hydraulic properties, discrete interval packer testing was performed on specific zones in the CS-WB05 borehole. Groundwater samples were collected from 268-288 foot, 290-310 foot, and 320-340 foot intervals and submitted for VOC analysis (see Table 1, attached). An attempt to collect a sample from the 198-218 foot depth, was not successful due to low groundwater yield for that interval. Results of the sample collected from 268-288 feet contained PCE (31.3 µg/L), TCE (152 µg/L), cis-1,2-DCE (286 µg/L), and toluene (4.18 µg/L). Although the concentrations are not as high as in deeper intervals, contaminant concentrations in the 268-288 foot interval appear adequate for the pilot study objectives.

Based on the stratigraphic position, hydraulic conductivity estimates, and contaminant concentrations, Parsons believes the 278-288 foot interval is best suited for the substrate injection. The 205-218 foot interval appears less suitable for injection due to its lower permeability and uncertainties in contaminant concentrations. Therefore, Parsons recommends the injection well be constructed with a 10-foot screen interval set from 277-287 feet bgs.

Injection Well Location

Location of the injection well involved evaluating the following criteria:

- Groundwater gradient: The injection well should be situated hydraulically upgradient of Westbay well CS-MW05 which will be used for monitoring purposes during the study; and

- Interwell spacing: A suitable distance between the injection well and downgradient monitoring well CS-WB05 should be determined to ensure that the desired results are obtained during the study.

One of the primary concerns of correctly locating the injection well is that the well must be hydraulically upgradient of the planned downgradient monitoring point, CS-WB05. Since natural groundwater gradients in the immediate area are not well defined and general knowledge about groundwater conditions at CSSA indicate that groundwater gradients may change with seasonal groundwater fluctuations, predictions of the natural gradients that will be present during the study are problematic. Pumping groundwater is one means of establishing and controlling local groundwater gradients. Monitoring well CS-MW16-LGR, located approximately 200 feet northwest of the planned pilot study, is cased to 200 feet and open hole from 200 to 325 and is equipped with a submersible pump. Therefore, Parsons recommends that well CS-MW16-LGR be pumped during the study to establish groundwater gradients within the aquifer and induce groundwater flow toward the pumping well. Also, since the gradient will be toward the pumping well, the injection well should be installed in line with well CS-WB05 and CS-MW16-LGR to ensure groundwater from the injection well will flow to the downgradient Westbay well.

Determining the well spacing between the injection well and Westbay well CS-WB05 requires consideration of the injection process and groundwater flow rates. The organic substrate injected into the formation will consist of a vegetable oil emulsion and water mixture. Parsons recommends the injection well be far enough away from the Westbay well to prevent the oil mixture from migrating to the Westbay well and potentially impacting the use of that well for monitoring purposes. The current plan is to inject the oil mixture at an approximate 15-foot radius from the injection well. Based on the planned substrate injection depth and allowing for uncertainties in aquifer hydraulic estimates, the interwell spacing should be no less than 25 feet to prevent potential impacts to the Westbay well.

The other consideration for interwell spacing is that the downgradient well should be within or on the fringe of the reaction zones that will be established downgradient of the substrate injection location. Based on experience, an appropriate interwell spacing can be established by estimating the distance groundwater will migrate in 30 days. The 30-day groundwater travel time estimate generally provides a reasonable means for establishing placement of downgradient monitoring points since size of the anaerobic biodegradation reaction zone is a function of groundwater migration rates. Estimates of groundwater velocity can be made using the hydraulic conductivity of the injection zone (2.7 ft/day) along groundwater gradients and a conservative porosity estimate of 5 percent. Estimating groundwater gradients that will be established during pumping of well CS-MW16-LGR are difficult without detailed groundwater modeling. Because groundwater gradients across the CSSA site generally range from 0.004 to 0.007, the gradients established by a pumping well at a distance of 200 feet could easily be 0.01 or greater. Using a gradient of 0.01, estimated groundwater velocities would be approximately 0.54 ft/day, which results in a 30-day travel time of 16.2 feet. Since this distance is less than the 25-foot recommended setback, Parsons believes this distance should be doubled to provide adequate safety to the Westbay well and allow for reasonable groundwater migration rates. Therefore, Parsons recommends injection well B3-MW01 be located approximately 35 feet upgradient of well CS-WB05 and in line with wells CS-WB05 and CS-MW16-LGR.

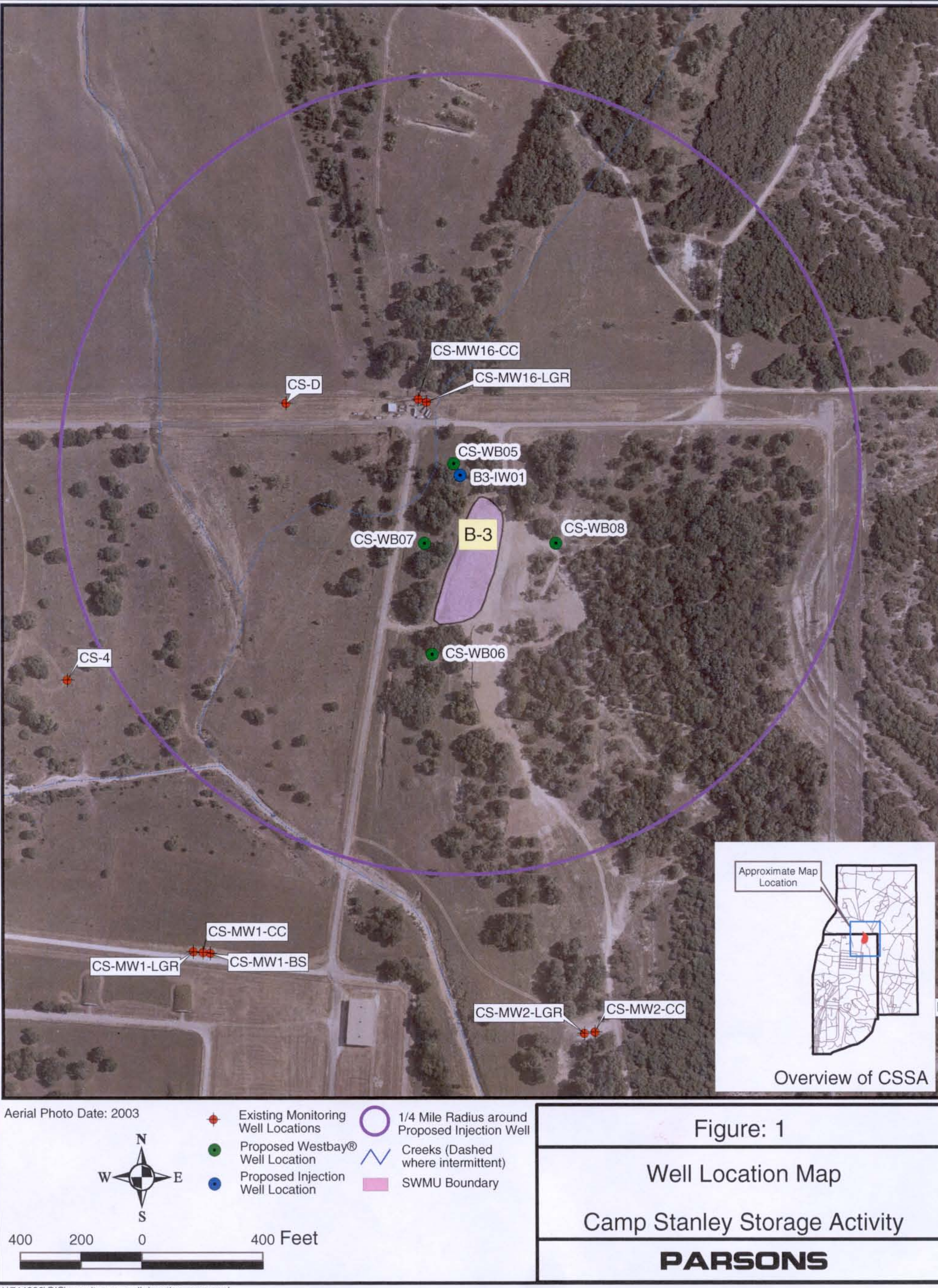


Figure: 1

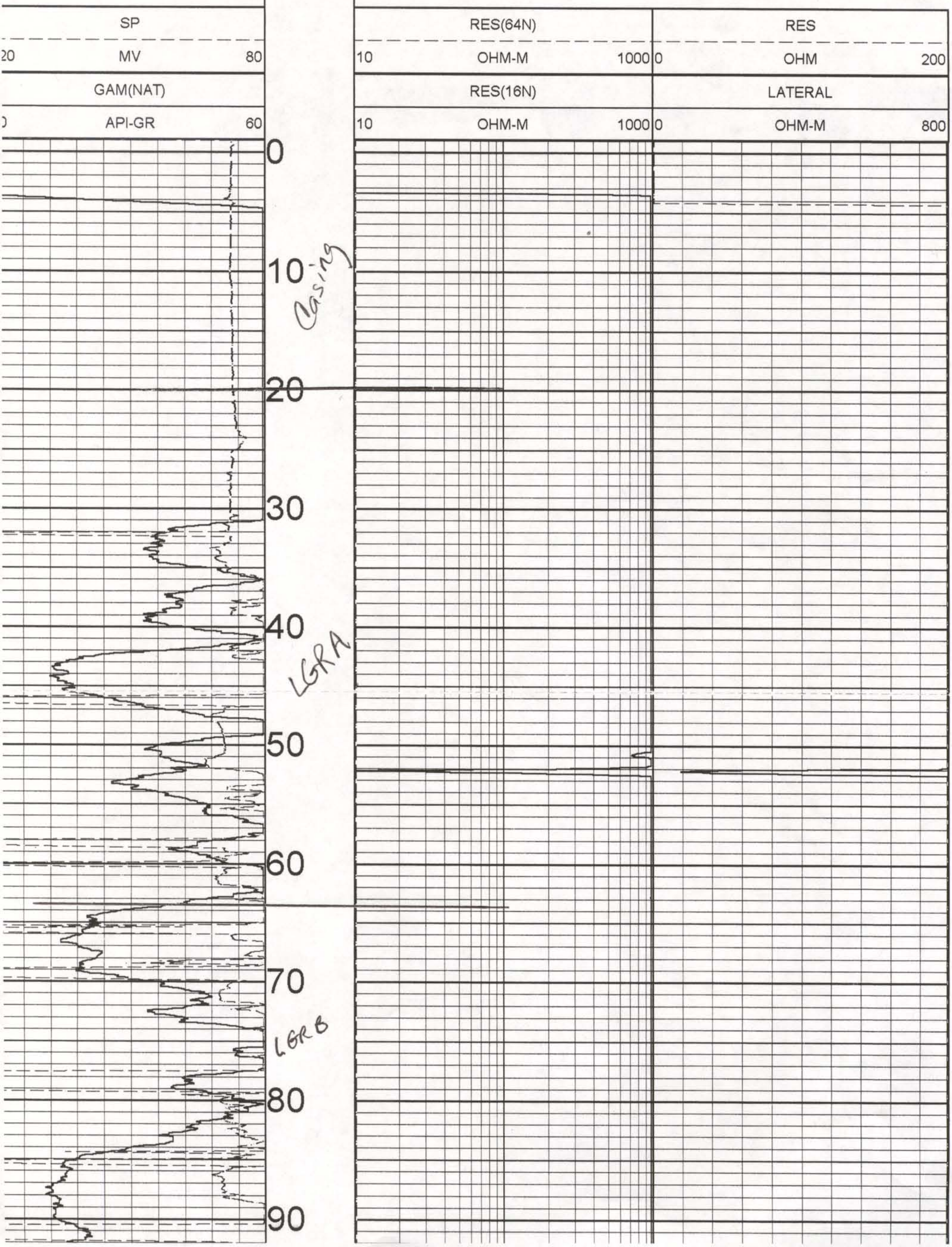
Well Location Map

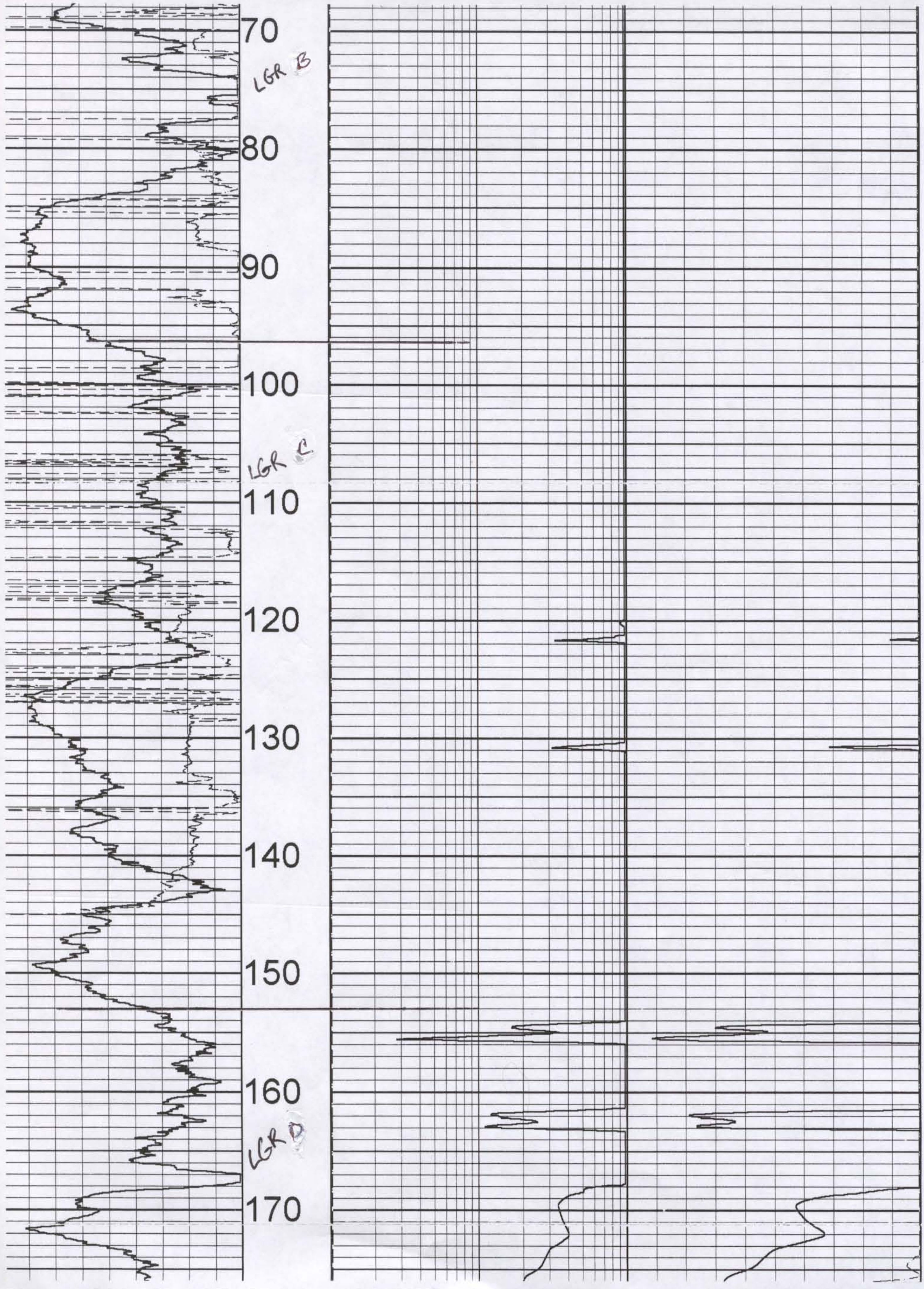
Camp Stanley Storage Activity

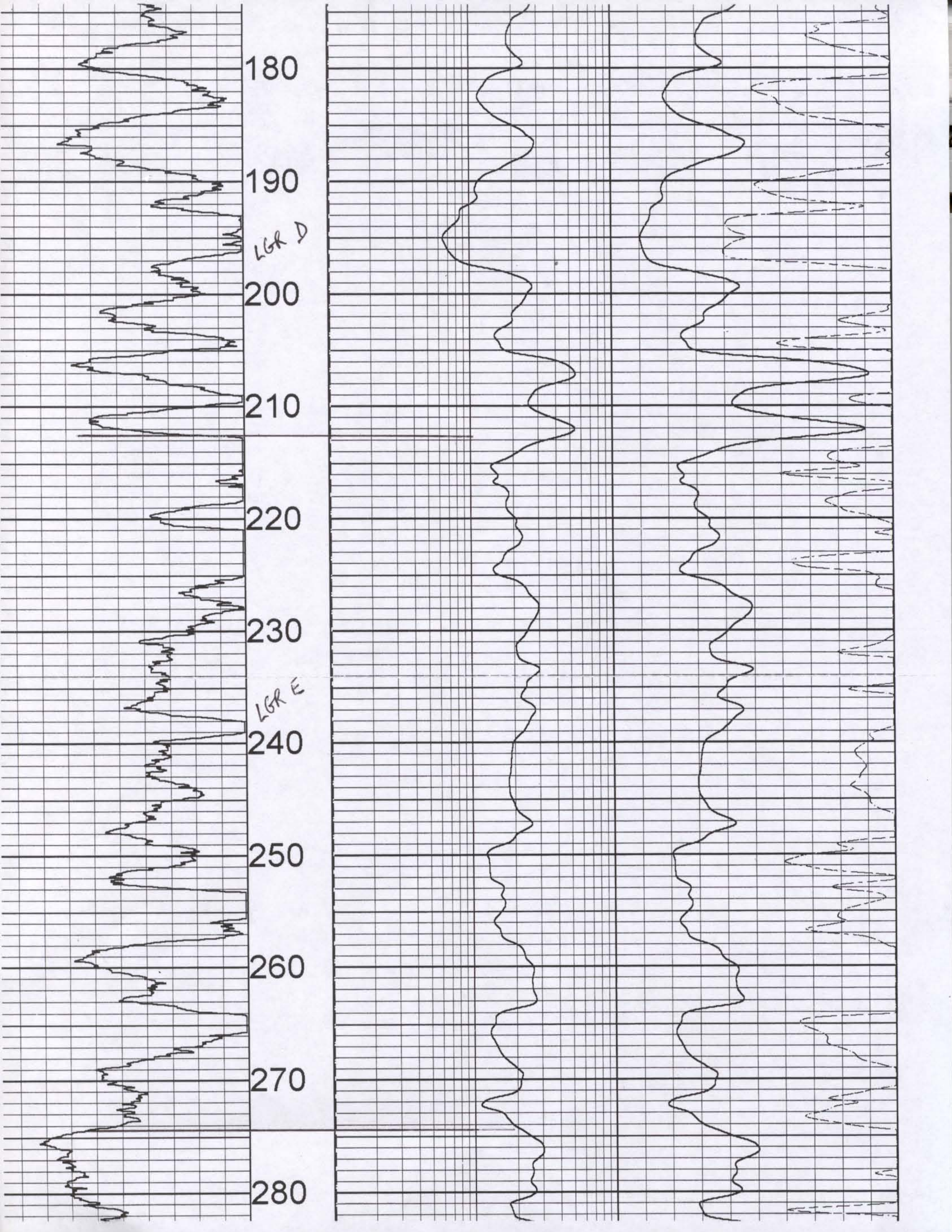
PARSONS

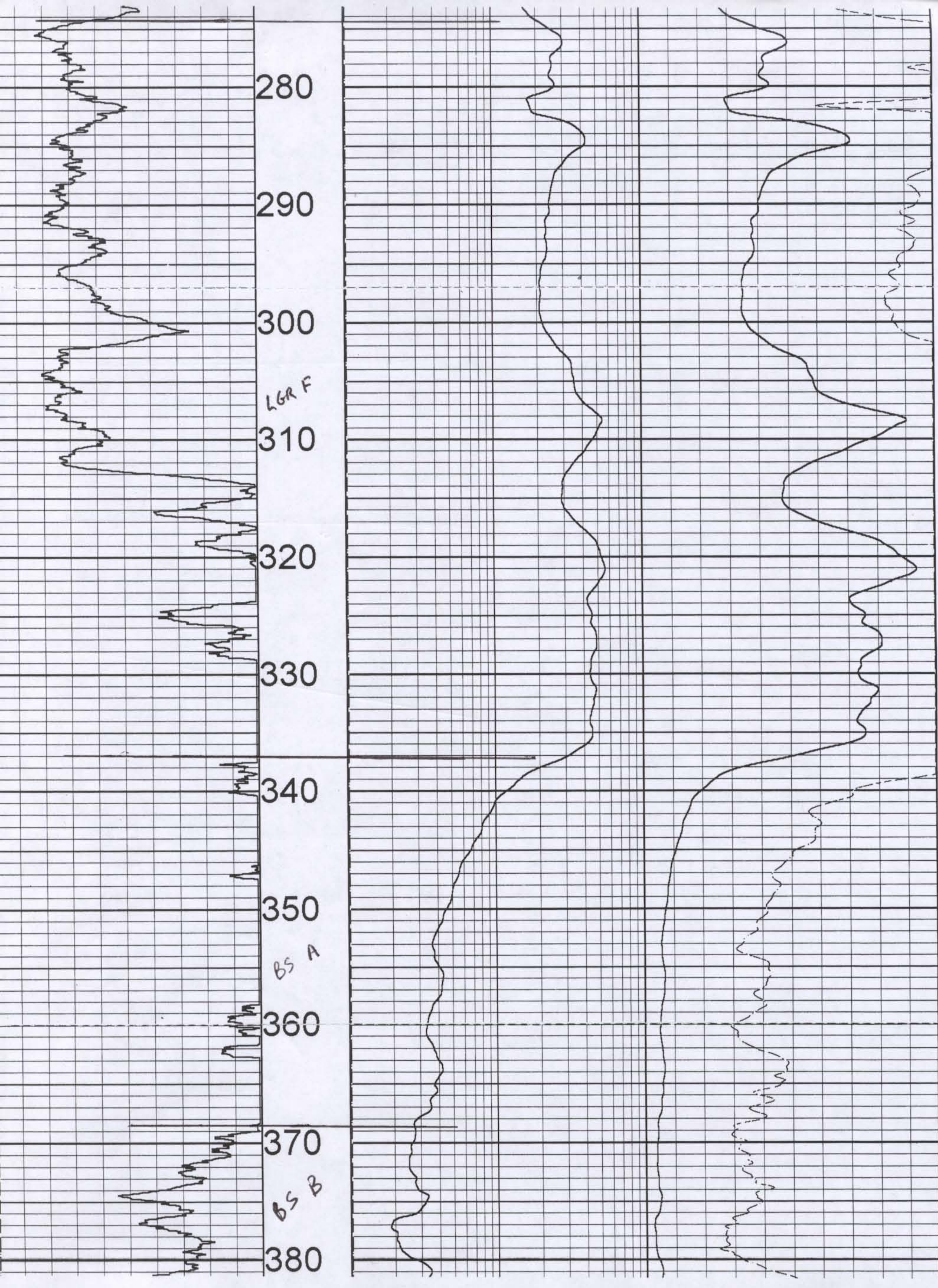
J:\744223\GIS\permit_app_well_location_map.mxd

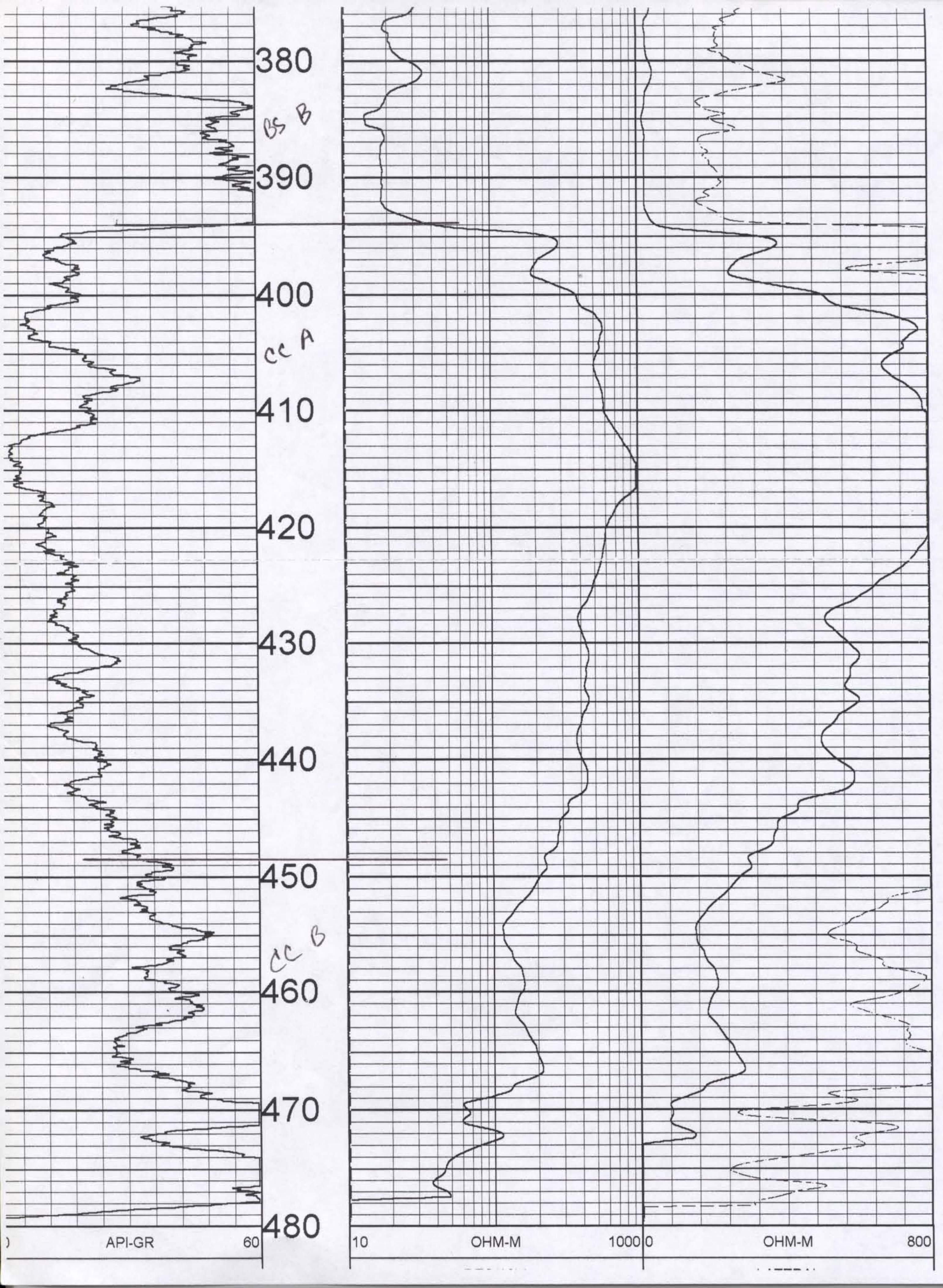
Well CS-WB05


SP
20 MV 80
GAM(NAT)
API-GR 60
RES(64N)
10 OHM-M 1000
RES
0 OHM 200
RES(16N)
10 OHM-M 1000
LATERAL
0 OHM-M 800
0
10
20
30
40
50
60
70
80
90
Casing
LGRA
LGRB


70
LGR B
80
90
100
LGR C
110
120
130
140
150
160
LGR D
170

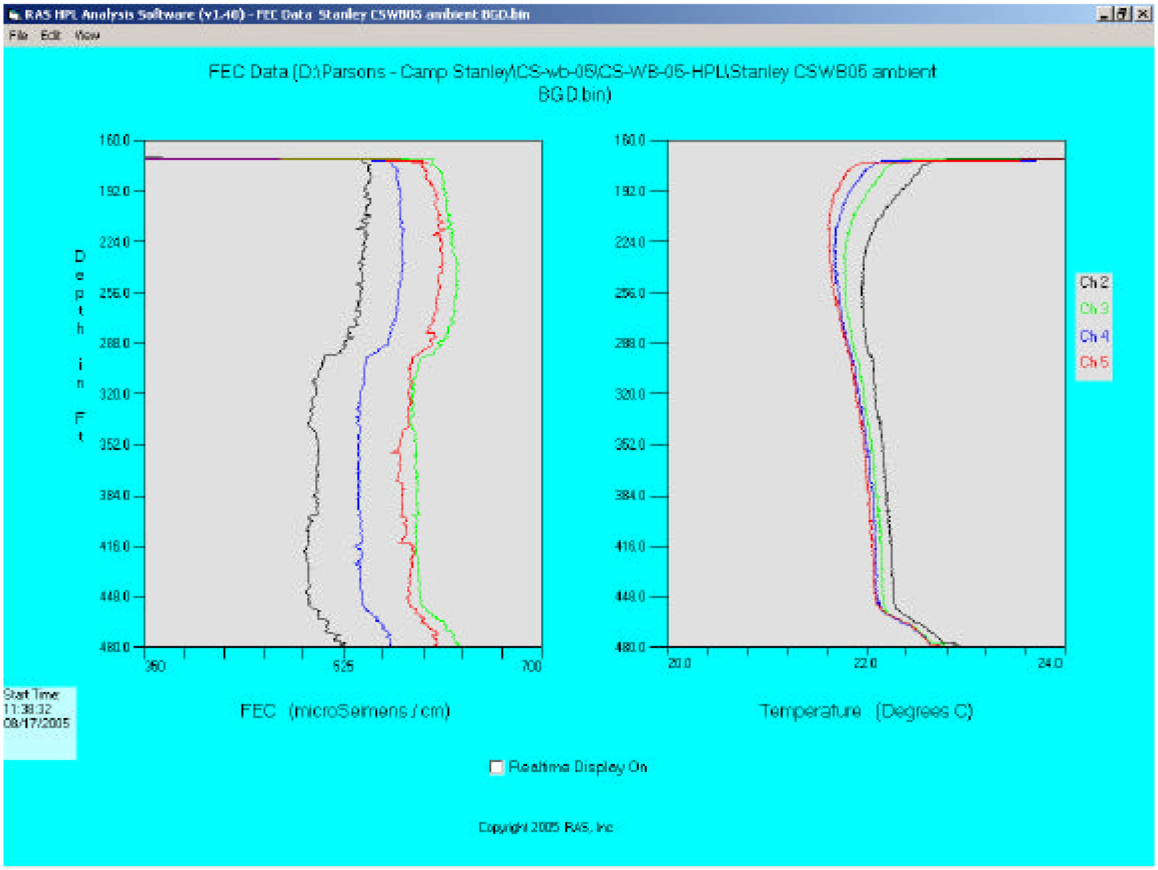

180
190
LGR D
200
210
220
230
LGR E
240
250
260
270
280


280
290
300
LGR F
310
320
330
340
350
BS A
360
370
BS B
380

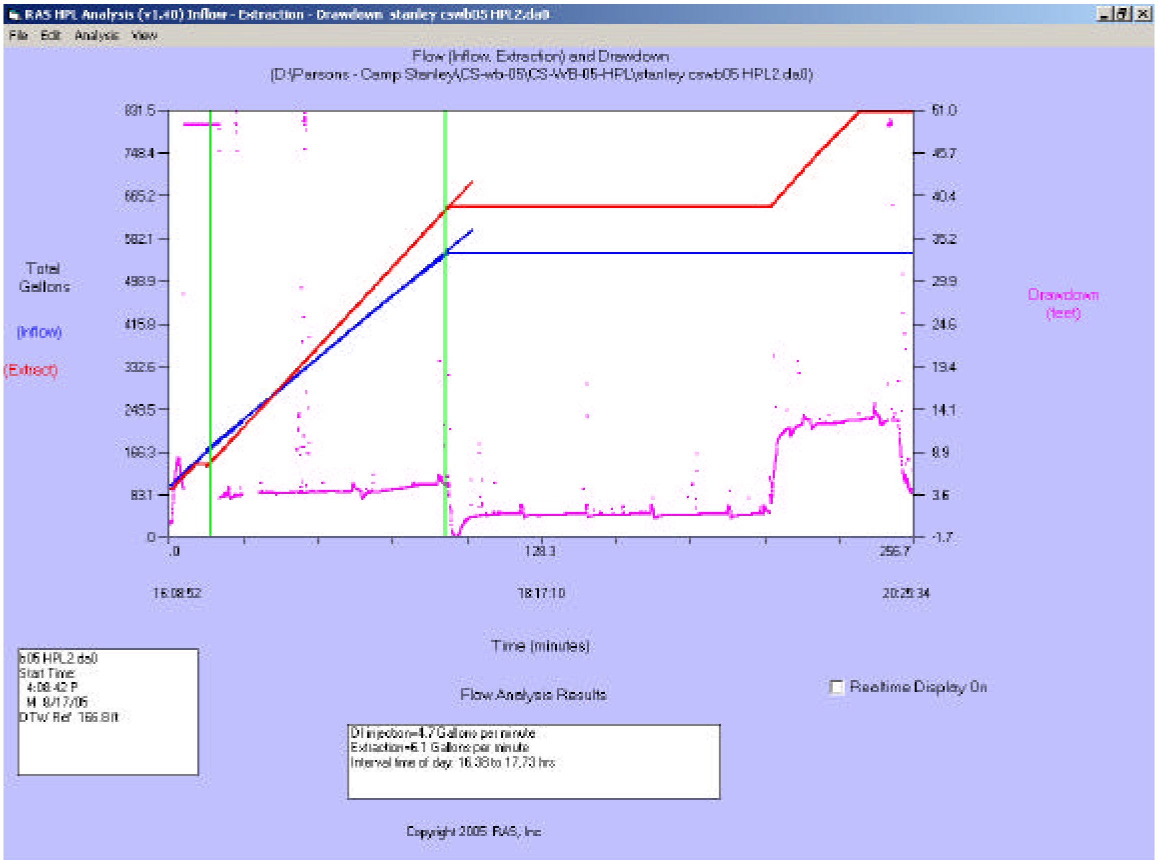

380
BS B
390
400
CC A
410
420
430
440
450
CC B
460
470
480
0
API-GR
60
10
OHM-M
1000
0
OHM-M
800

Camp Stanley – Preliminary Results

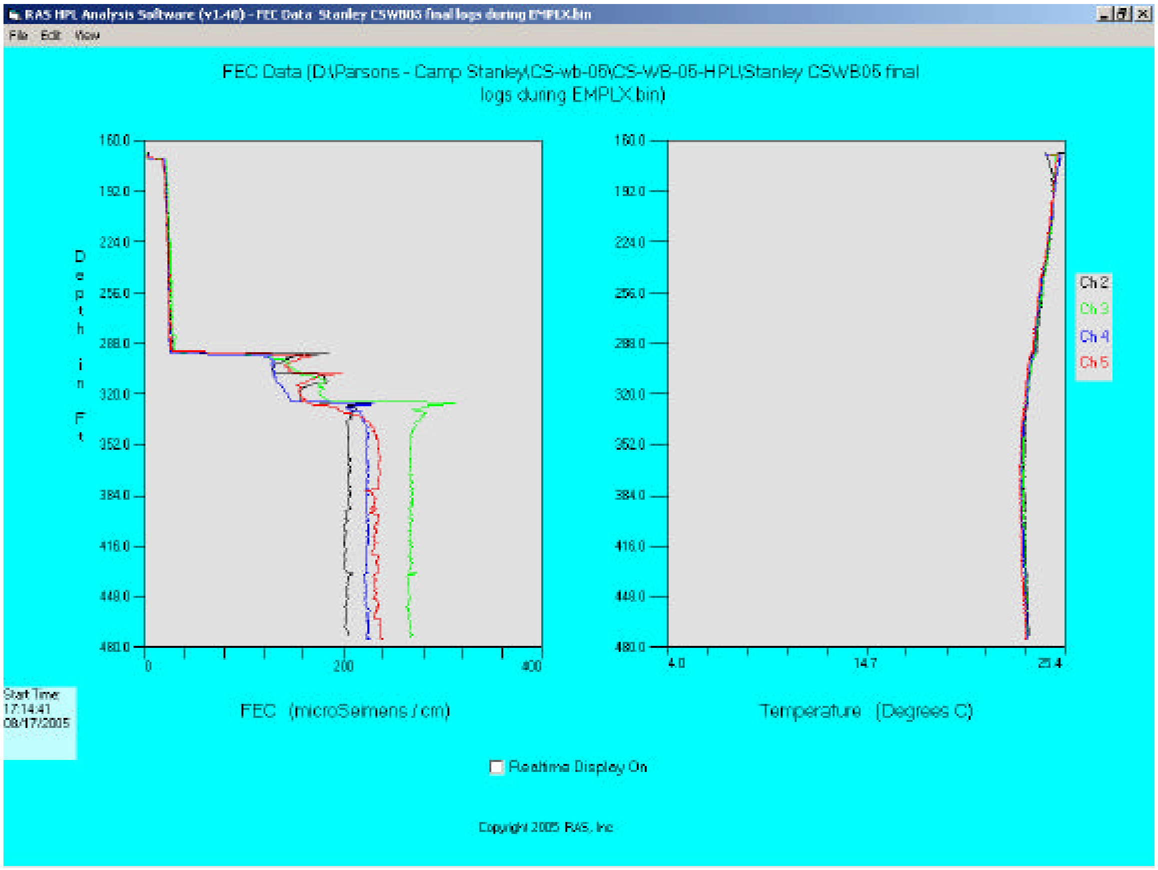
Well CS-WB-05



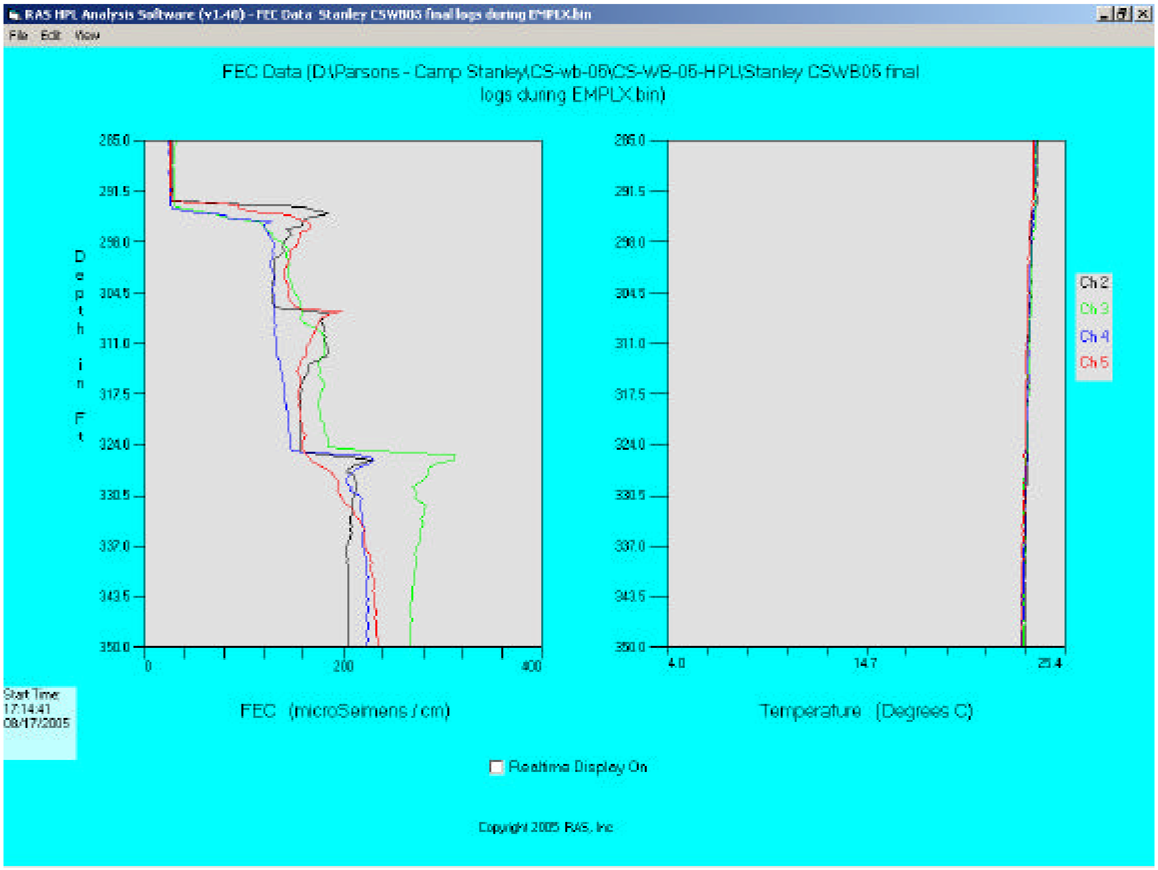
Ambient FEC and Temperature logs (pre emplx)

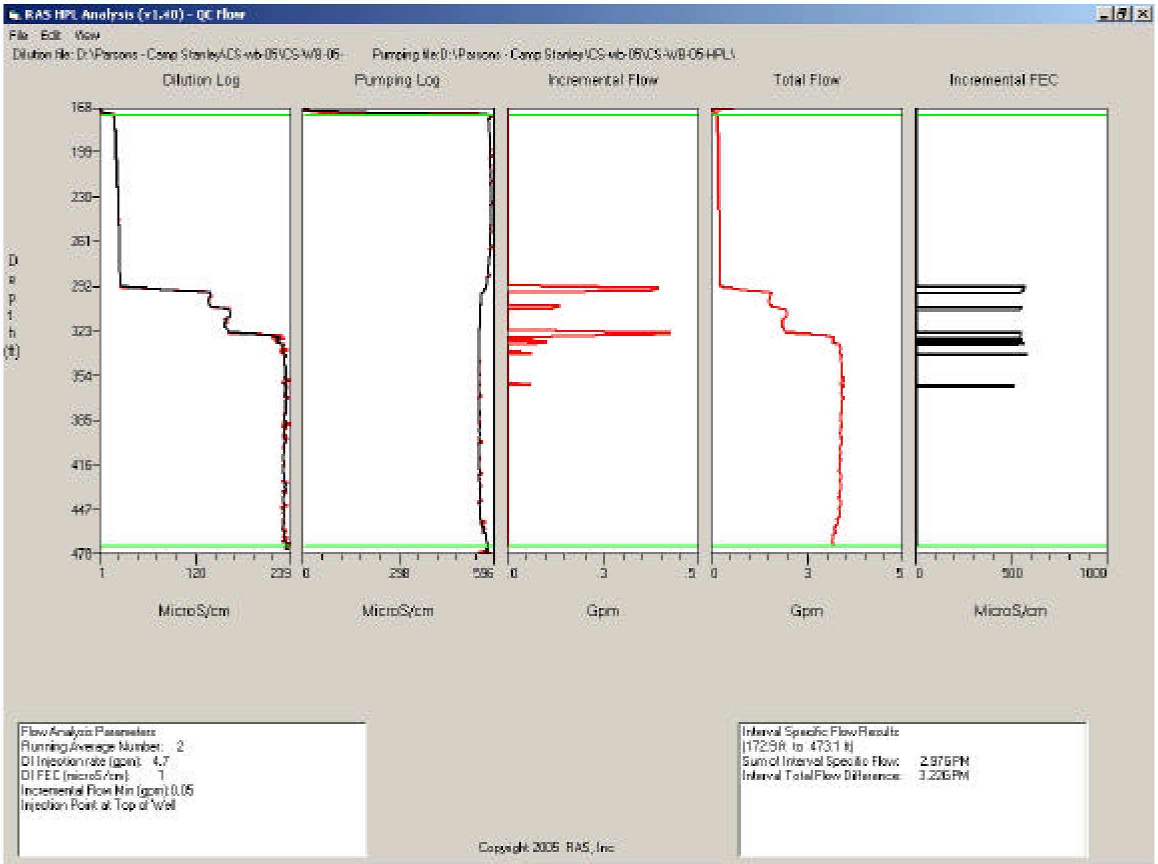


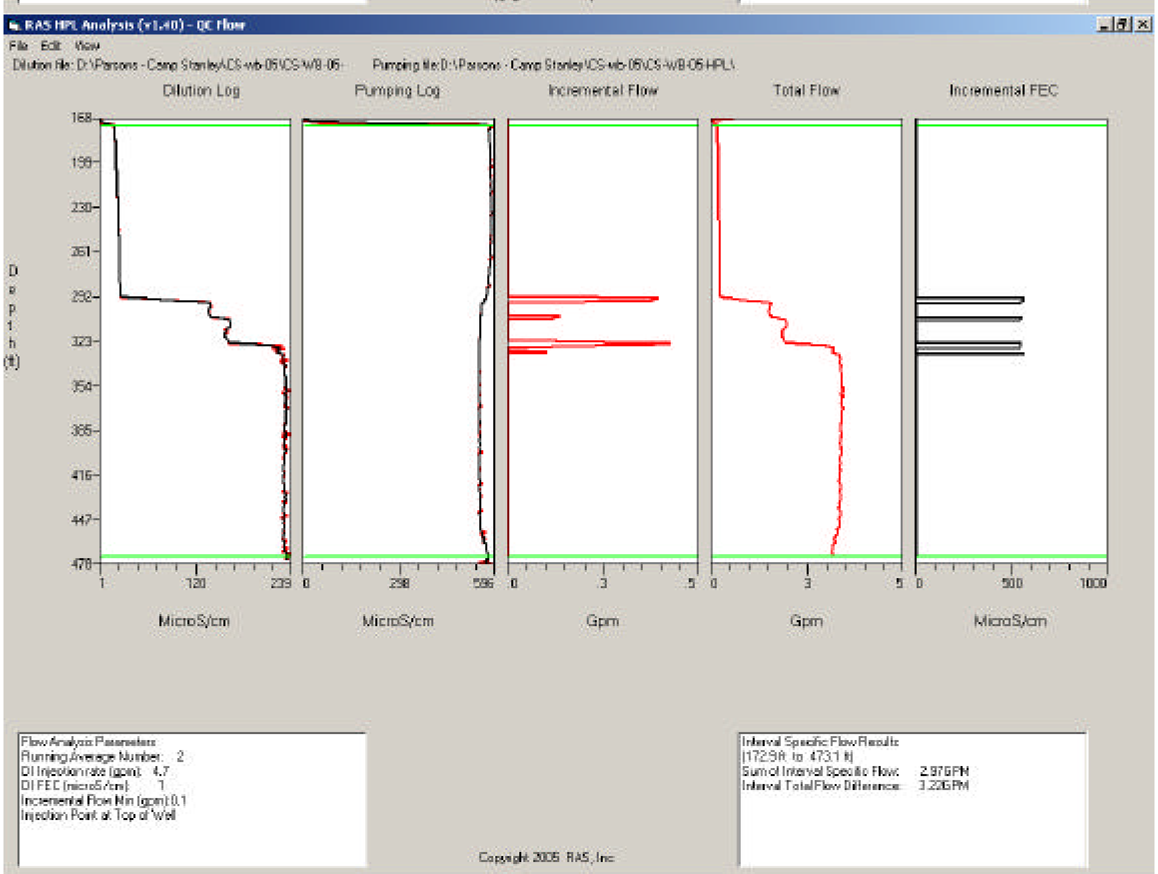
Pumping and drawdown data

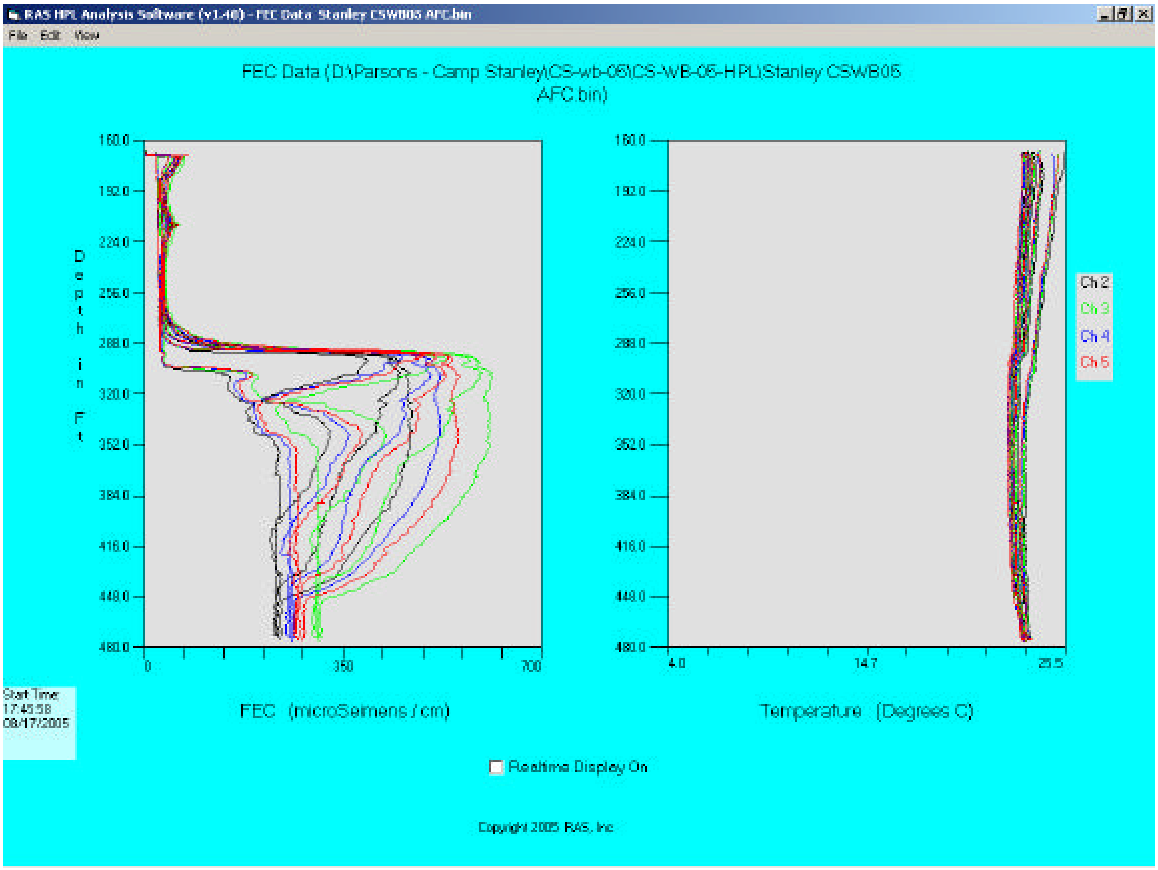


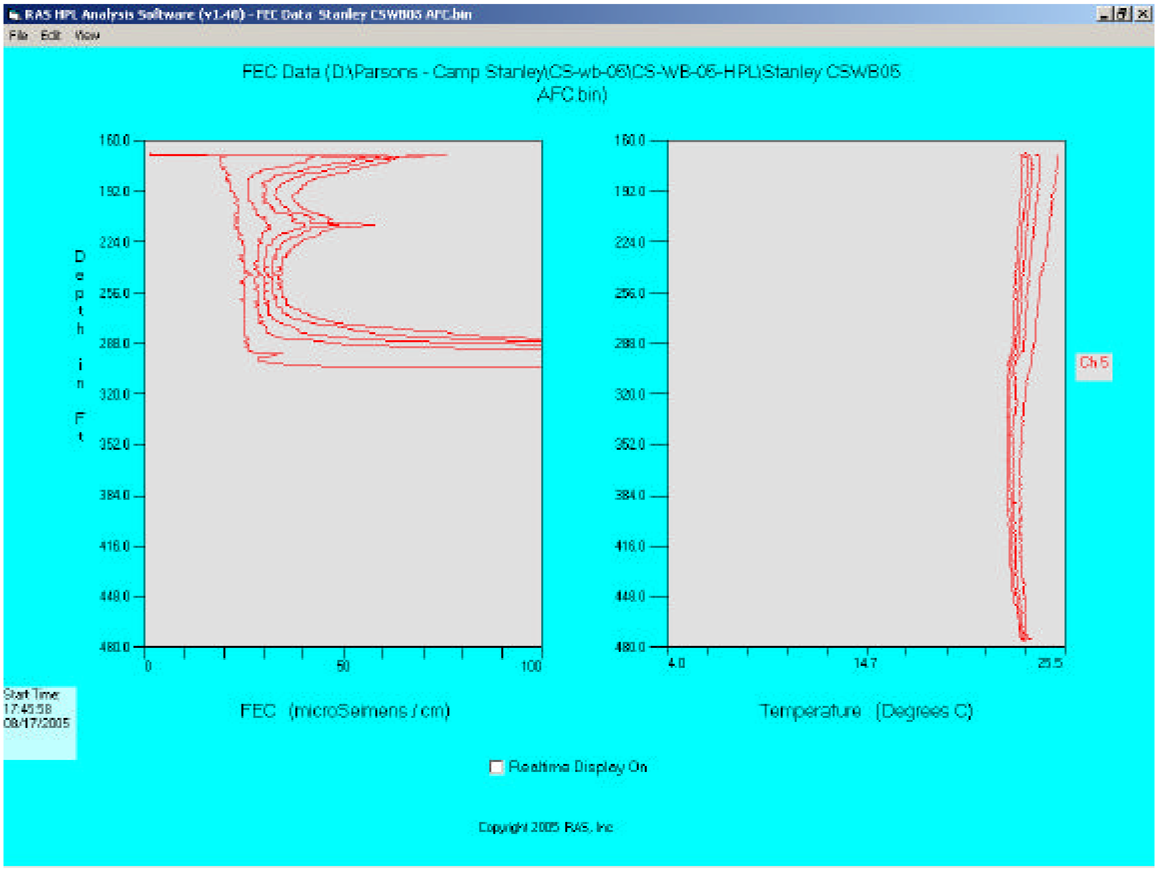
During Emplx – quasi PDI data set, processed below.

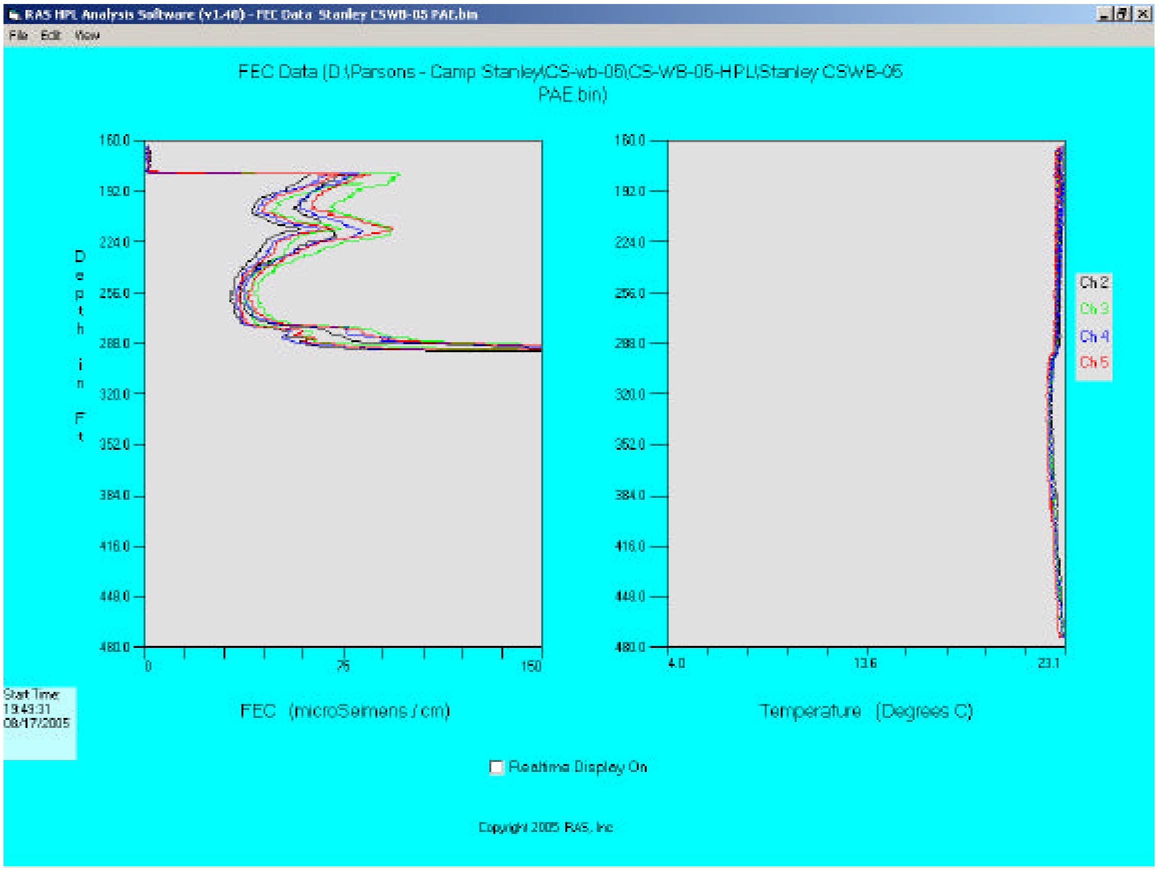

RAS HPL Analysis Software (v1.40) - FEC Data Stanley CSWB05 final logs during EMPLX.bin
File Edit View
FEC Data (D:\Parsons - Camp Stanley\CS-wb-05\CS-WB-05-HPL\Stanley CSWB05 final logs during EMPLX.bin)
Depth in Ft
285.0
291.5
298.0
304.5
311.0
317.5
324.0
330.5
337.0
343.5
350.0
0
200
400
FEC (microSeimens / cm)
4.0
14.7
25.4
Temperature (Degrees C)
Ch 2
Ch 3
Ch 4
Ch 5
Start Time:
17:14:41
08/17/2005
Realtime Display On
Copyright 2005 RAS, Inc


RAS HPL Analysis (v1.40) - QC Flow
File Edit View
Dilution file: D:\Parsons - Camp Stanley\CS-wb-05\CS-WB-05-
Pumping file: D:\Parsons - Camp Stanley\CS-wb-05\CS-WB-05-HPL\
Dilution Log
Pumping Log
Incremental Flow
Total Flow
Incremental FEC
Depth (ft)
168
199
230
261
292
323
354
385
416
447
478
1
120
239
0
298
596
0
.3
.5
0
3
5
0
500
1000
MicroS/cm
MicroS/cm
Gpm
Gpm
MicroS/cm
Flow Analysis Parameters
Running Average Number: 2
DI Injection rate (gpm): 4.7
DI FEC (microS/cm): 1
Incremental Flow Min (gpm): 0.05
Injection Point at Top of Well
Copyright 2005 RAS, Inc
Interval Specific Flow Results
(172.9 ft to 473.1 ft)
Sum of Interval Specific Flow: 2.97GPM
Interval Total Flow Difference: 3.22GPM


RAS HPL Analysis (v1.40) - QC Flow
File Edit View
Dilution file: D:\Parsons - Camp Stanley\CS-wb-05\CS-WB-05-
Pumping file: D:\Parsons - Camp Stanley\CS-wb-05\CS-WB-05-HPL\
Dilution Log
Pumping Log
Incremental Flow
Total Flow
Incremental FEC
Depth (ft)
168
199
230
261
292
323
354
385
416
447
478
1
120
239
0
298
596
0
.3
.5
0
3
5
0
500
1000
MicroS/cm
MicroS/cm
Gpm
Gpm
MicroS/cm
Flow Analysis Parameters
Running Average Number: 2
DI Injection rate (gpm): 4.7
DI FEC (microS/cm): 1
Incremental Flow Min (gpm): 0.1
Injection Point at Top of Well
Copyright 2005 RAS, Inc
Interval Specific Flow Results
(172.9 ft to 473.1 ft)
Sum of Interval Specific Flow: 2.97GPM
Interval Total Flow Difference: 3.22GPM


RAS HPL Analysis Software (v1.40) - FEC Data Stanley CSWB05 AFC.bin
File Edit View
FEC Data (D:\Parsons - Camp Stanley\CS-wb-05\CS-WB-05-HPL\Stanley CSWB05 AFC.bin)
Depth in Ft
160.0
192.0
224.0
256.0
288.0
320.0
352.0
384.0
416.0
448.0
480.0
0
350
700
4.0
14.7
25.5
Ch 2
Ch 3
Ch 4
Ch 5
Start Time:
17:45:58
08/17/2005
FEC (microSeimens / cm)
Temperature (Degrees C)
Realtime Display On
Copyright 2005 RAS, Inc


RAS HPL Analysis Software (v1.40) - FEC Data Stanley CSWB05 AFC.bin
File Edit View
FEC Data (D:\Parsons - Camp Stanley\CS-wb-05\CS-WB-05-HPL\Stanley CSWB05 AFC.bin)
Depth in Ft
160.0
192.0
224.0
256.0
288.0
320.0
352.0
384.0
416.0
448.0
480.0
0
50
100
FEC (microSeimens / cm)
4.0
14.7
25.5
Temperature (Degrees C)
Ch 5
Start Time:
17:45:58
08/17/2005
Realtime Display On
Copyright 2005 RAS, Inc



SUMMARY OF INFLOW POINTS

DEPTH (ref GS)	Data or analysis type	Comments
168-173	AFC	or above in unsat zone
184-189	PAE	
205-218	AFC	
278-287	PAE	
289-297	QCFLOW	
303-309	QCFLOW	
321-333	QCFLOW	
336-340	QCFLOW	
358-362	QCFLOW	(<0.1 gpm ?)
432-450	AFC	outflow zone-more?

Rev	Date	By	Ck	Title: Hydraluic Conductivity Estimate for 198' to 218' Depth Interval in Well CS-WB05 at CSSA

Falling Head Test Results for 198' to 218' Interval at Well CS-WB05

Test Data

T_0 (min) =	54.31	min
Static Water Level =	30.83	ft
Maximum Water Level =	255.93	ft
Maximum Water Level Change =	225.1	ft

T (min)	ΔT (min)	H (ft)	ΔH (ft)	H/H_0
54.31	0	255.93	225.1	1.00
55.37	1.06	212.80	181.97	0.81
57.71	3.4	180.64	149.81	0.67
60.48	6.17	148.48	117.65	0.52
64.73	10.42	114.48	83.65	0.37
70.48	16.17	84.95	54.12	0.24
77.08	22.77	63.77	32.94	0.15
83.25	28.94	56.71	25.88	0.11
89.42	35.11	51.22	20.39	0.09

Data Analysis

Hvorslev Method (From Fetter, 1988)

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

where:

K = hydraulic conductivity
r = radius of well casing
R = radius of well screen
L = length of well screen
T_0 = time for water level to fall to 37% of initial change

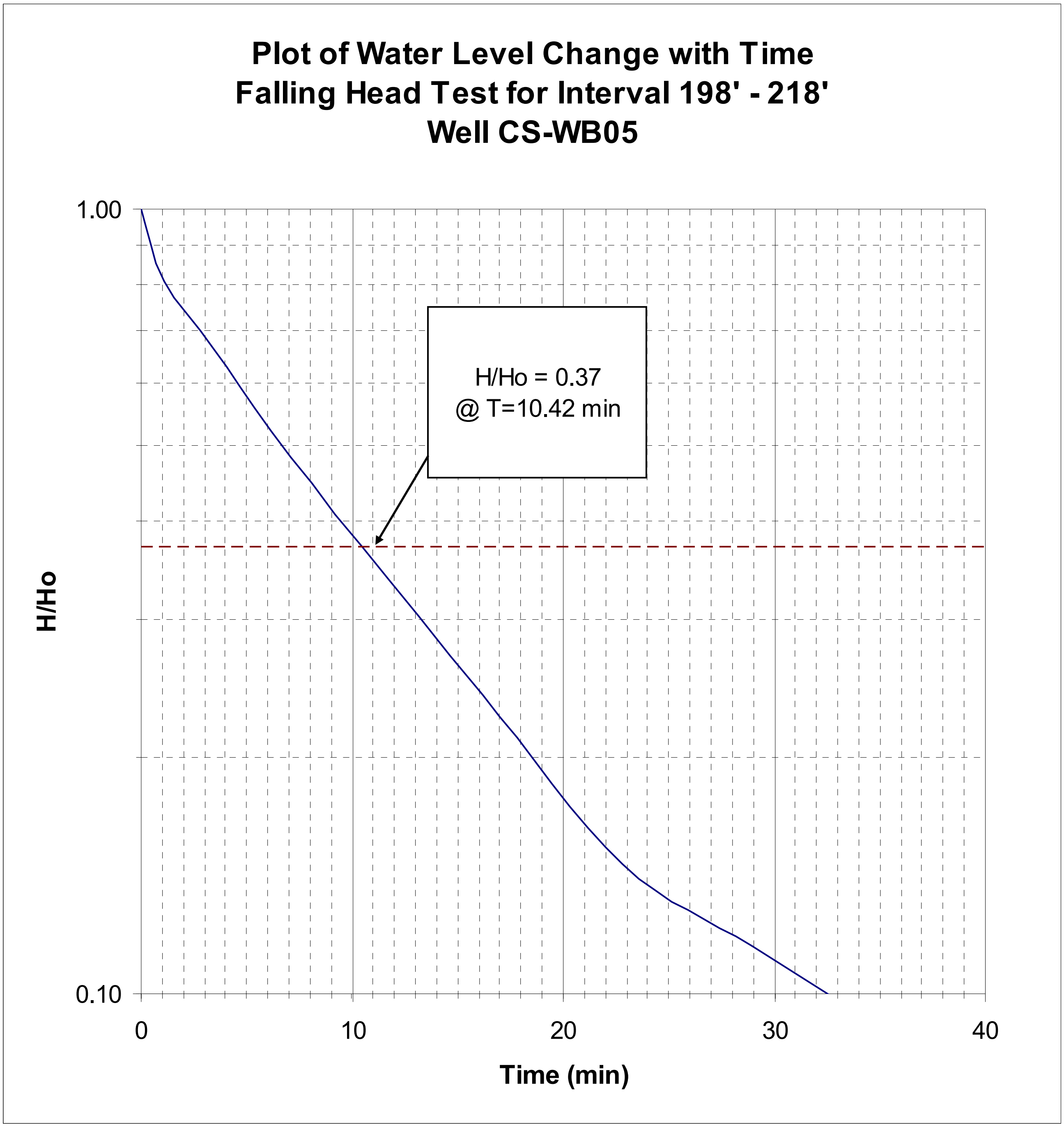
For well CS-WB05

r =	0.19	ft	ID = 4.25 in
R =	0.19	ft	ID = 4.25 in
L =	20.0	ft	Packer interval
T_0 =	10.42	min	from plot

K =	4.03E-04	ft/min
=	5.81E-01	ft/day
=	2.05E-04	cm/sec

PARSONS Calculation Sheet	Job Number 744223	WBS Number 04000	Page Number	Sheet 2 of 2

Rev	Date	By	Ck	Title Hydraluic Conductivity Estimate for 198' to 218' Depth Interval in Well CS-WB05 at CSSA



Rev	Date	By	Ck	Title: Hydraluic Conductivity Estimate for 268’ to 288’ Depth Interval in Well CS-WB05 at CSSA

Falling Head Test Results for 268' to 288' Interval at Well CS-WB05

Test Data

T_0 (min) =	115.32	min
Static Water Level =	104.81	ft
Maximum Water Level =	259.33	ft
Maximum Water Level Change =	154.52	ft

T (min)	ΔT (min)	H (ft)	ΔH (ft)	H/H_0
115.32	0	259.33	154.52	1.00
116.44	1.12	208.03	103.22	0.67
117.18	1.86	190.11	85.3	0.55
117.56	2.24	157.97	53.16	0.34
118.65	3.33	128.41	23.6	0.15
119.52	4.2	127.68	22.87	0.15
121.48	6.16	120.88	16.07	0.10
122.87	7.55	117.79	12.98	0.08
126.63	11.31	114.09	9.28	0.06

Data Analysis

Hvorslev Method (From Fetter, 1988)

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

where:

K = hydraulic conductivity
r = radius of well casing
R = radius of well screen
L = length of well screen
T_0 = time for water level to fall to 37% of initial change

For well CS-WB05

r =	0.19	ft	ID = 4.25 in
R =	0.19	ft	ID = 4.25 in
L =	20.0	ft	Packer interval
T_0 =	2.24	min	From plot
K =	1.88E-03	ft/min	
=	2.70E+00	ft/day	
=	9.54E-04	cm/sec	

Rev	Date	By	Ck	Title: Hydraluic Conductivity Estimate for 268' to 288' Depth Interval in Well CS-WB05 at CSSA

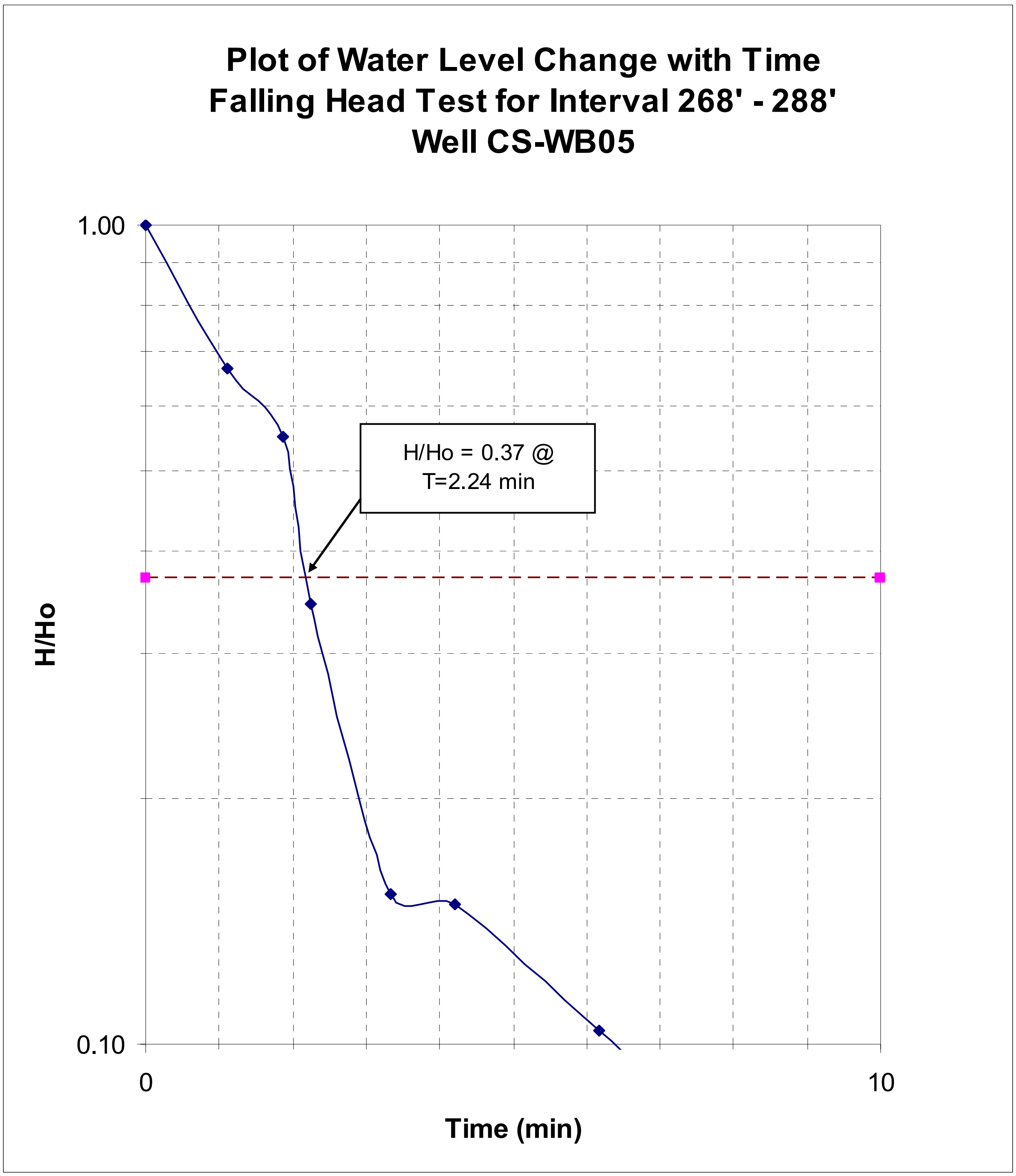


Table 1
Well CS-WB05 Discrete Interval Groundwater Sample Results
Camp Stanley Storage Activitiy, Texas

Packer Interval (ft bgs)	PCE	TCE	*cis* -1,2-DCE	*trans* -1,2-DCE	Toluene
268 to 288	31.3	152	286	ND	4.18
290 to 310	160	273	344	4.94	ND
320 to 340	319	427	533	ND	ND

Results presented in ug/L conentrations
ND - Analyte not detected

PARSONS

Technical Memorandum

To: Glaré Sanchez, Jeff Aston and Chris Beal, CSSA

From: Parsons Staff

CC: file (744223.07)

Date: November 1, 2005

Re: Construction Recommendations for proposed Westbay® MP38 System Wells at CSSA SWMU B-3

This Technical Memorandum presents construction information and recommendations for the new Westbay wells (WBs) WB05, WB06, WB07, and WB08 at SWMU B-3 located in Camp Stanley Storage Activity (CSSA). These recommendations for the new WBs are for your review and comment. For information on the scope of work beyond WB construction refer to the Draft TO-06 Work Plan and Draft TO-06 Sampling and Analysis Plan.

PROJECT BACKGROUND AND OBJECTIVES

In July and August 2005, Parsons drilled four open boreholes around SWMU B-3 to be completed with Westbay MP38 Systems as part of Task Order 0006. The locations of the existing well boreholes are shown on Attachment 1 to this memorandum. The Westbay systems are multi-port wells capable of monitoring several vertically distinct and separate hydrogeologic zones within one borehole. During the interim design phase of the WB wells, the boreholes have been sealed against vertical groundwater and contaminant migration by FLUTe™ borehole liners. Parsons has, and will, monitor and maintain the appropriate interstitial head levels within the FLUTe liners until the actual WB installations scheduled to begin on 7 November 2005.

The WB wells are intended to monitor volatile organic compound (VOC) contamination and other subsurface conditions in various geologic layers beneath SWMU B-3 as part of a substrate injection pilot study, a bioreactor treatability study, subsequent O&M periods, groundwater pumping tests, and other ancillary groundwater monitoring needs. Well WB05 is completed to the base of the Cow Creek (CC) formation in support of a groundwater pumping test to be performed in December 2005. The focus of the pumping test is to assess the vertical leakage potential of the Bexar Shale (BS) in the vicinity of SWMU B-3 and the CS-16 well cluster, and general aquifer characterization. The pumping tests will also help assess the groundwater flow paths that ultimately led to the contamination discovered in 1991 at Well 16. The remaining wells (WB06, WB07, and WB08) are not specifically tied to the pumping tests, but to SWMU B-3 bioreactor monitoring, and therefore are completed to the base of the Lower Glen Rose (LGR) formation only. A design image of the wells is shown on Attachment 2.

The CC and the bottom of the LGR contain the two main water-bearing zones of the Middle Trinity aquifer and are separated by the Bexar Shale aquitard. Previous work at the CS-MW16 well cluster has demonstrated that contamination in excess of maximum contaminant levels (MCLs) is present within the major water-bearing units of the LGR and CC members. The design of WB05 and implementation of the MW16 pumping test will help determine the nature of how contamination is distributed downward into underlying strata.

Part of the SWMU B-3 Enhanced Anaerobic Bioremediation (EAB) Pilot Study involves injection of an organic substrate into a portion of the LGR formation at SWMU B-3 at the location and depth interval described in the technical memorandum recommending injection well location and injection intervals (see *Parsons Technical Memo* from Gary Cobb, September 2005). WB05 will facilitate monitoring the effects that the substrate has on geochemistry and associated biological activities related to anaerobic dechlorination of PCE and TCE. A conventional monitoring well also suitable for injection purposes (CS_B3-MW01) was installed along the presumed migration pathway between the VOC source area and the MW16 well pair to facilitate injection of the organic substrate. It is believed that prolonged pumping activities associated with groundwater production at the former Well 16 induced groundwater gradient reversals that literally pulled contamination within its sphere of influence toward the pumping well, rather than traveling along its natural flow paths southward and southwestward, and significantly influenced the shape of the resultant VOC plume. Data from groundwater monitoring suggests that absent the continuous pumping activities previously performed at Well 16 groundwater flow would trend more southward rather than northwesterly toward Wells D and 16. Renewing pumping operations at MW16 wells during the EAB injection pilot study will partially recreate the past conditions that originally contributed to the spread of SWMU B-3 contamination and should provide a hydraulic gradient that increases the probability that WB05 will be located ideally between the injection well and Well 16, and thus able to provide appropriate and significant data regarding the performance of the substrate injection. The injected substrate is expected to follow the same general groundwater flow paths under the recreated conditions as the original contamination, enhancing contaminant degradation along the way. The remaining WBs completed into the LGR will complement WB05 primarily in the monitoring of the formation during operation of bioreactor treatment cells planned for construction in the SWMU B-3 excavation scheduled for early 2006.

Drilling locations for the four monitoring wells were selected with the objective of optimizing observations of recharge and flow pathways from SWMU B-3. The possible recharge pathways are intended to represent the flow paths followed by the contaminants when they initially impacted the aquifer. Monitoring in areas of higher contamination, such as those closer to SWMU B-3, should also provide sufficient quantities of data to assess the effects of the enhanced biodegradation resulting from the operation and maintenance of the bioreactor cells throughout the vertical profile of the formation. Well WB08 was drilled in the apparent upgradient location east of SWMU B-3. CS-WB05 was installed between the SWMU B-3 'injection well' and the pilot study's pumping wells (MW16-LGR & -CC). It will be utilized as the main downgradient monitoring point for the substrate injection test and the main observation well for MW16 pumping tests (local aquifer characterization). WBs 06 and 07 will monitor the study's effects in the southward and westward downgradient directions from SWMU B-3, respectively.

SITE CHARACTERIZATION

Geophysical, optical, and Hydrophysical logging (HpL) was conducted by RAS, Inc. following the installation of the boreholes in August 2005. Geophysical and video logs were used to correlate the stratigraphy of individual boreholes and establish a site model, and compare/contrast these results to other geophysical work conducted throughout CSSA. The HpL testing conducted at WB05 primarily identified zones of groundwater flow and potential injection zones within the saturated interval of the formation. The data from this testing was also evaluated to assist in selecting appropriate WB sample port depths. Analysis of the HpL testing completed at WB05 identified the optimum injection zone for CS_B-3_MW01 (see *Parsons Technical Memo* from Gary Cobb, September 2005) at the 278 to 287-foot interval.

Parsons and its subcontractors collected discrete soil-gas and groundwater samples initially from each borehole to screen the subsurface for any VOC contamination emanating from SWMU B-3. In short, every aqueous and air sample collected from the SWMU B-3 boreholes exhibited VOC contamination. From the data it is reasonable to assume that the entire horizon from ground surface to the base of the LGR at SWMU B-3 is contaminated by VOCs. Detected constituents in both the soil-gas and groundwater samples typically included PCE, TCE, and *cis*-1,2,-DCE. To a lesser extent, *trans*-1,2-DCE, 1,1,1-TCA, 1,1-DCE, benzene, chloroform, methylene chloride, and vinyl chloride were reported in some samples. For the purposes of this memorandum, PCE will be used as the indicator constituent when discussing the subsurface contamination, even though multiple organic compounds were detected in each sample. A full tabulation of the sampling results by borehole is provided in Attachment 4.

At WB05, PCE soil-gas concentrations ranged from 120 to 479 parts per billion by volume (ppbv) between the depths of 30 and 176 feet below ground surface (bgs), with the greatest concentrations occurring between 116 to 136 feet bgs. Likewise, PCE soil-gas levels ranged between 540 and 1,570 ppbv between the depths of 10 and 150 feet bgs, with the highest concentration occurring at 150 feet bgs. The least amount of soil-gas contamination was found at WB07, where PCE concentrations were reported between 4.57 and 83.3 ppbv from 10 to 130 feet bgs. At WB07, the highest concentration occurred within the upper 30 feet of strata. The greatest soil-gas contamination was detected at WB08, which is located adjacent to the former SWMU B-3 east trench. PCE concentrations in soil gas ranged from 3,310 to 12,200 ppbv between 10 and 150 feet bgs, with the greatest concentration occurring within the same strata as the landfill (and former east trench) between 10 and 30 feet bgs.

In groundwater, VOCs were ubiquitously reported in all 14 samples (Attachment 4). At WB05, PCE concentrations ranged from 31.3 to 392 micrograms per liter (µg/L) between depths of 268 and 436 feet bgs. At WB05, the VOC concentrations increased with depth, and contamination was found to extend down through the BS into the CC, where the highest concentrations were detected. Likewise, at WB06, reported PCE concentrations in groundwater increased between the depths of 260 and 328 feet bgs, with concentrations ranging between 151 and 337 µg/L. WB07 results indicate that throughout the water column, PCE concentrations ranged between 34.7 and 293 µg/L at depths from 200 to 330 feet bgs. At WB08, while soil-gas results are indicative of the wells proximity to the landfill, the groundwater results suggest that the well is slightly hydraulically upgradient. WB08 PCE concentrations ranged from 38.6 to 53.7 µg/L, and increased with depth between 280 and 351 feet bgs.

DESIGN METHODOLOGY

Multiple factors were considered when designing WB well construction including water-bearing strata, zones of hydraulic distinction, site-specific characterization results in terms of hydrogeology and contaminant distribution, and optimal placement for well components (packer seals and monitoring ports). Finally, the observations and experiences gained from operating similar WB wells located at AOC-65 were also considered during the design phase.

Following prior work performed by the USGS with respect to the Upper Glen Rose (UGR) formation at Camp Bullis and CSSA, the basewide Hydrogeologic Conceptual Site Model (HCSM) has divided the Middle Trinity aquifer into 10 definable zones based upon both stratigraphic and hydrologic character (Parsons, 2005). Six of these zones are in the LGR (A-F), and 4 remaining zones are split equally between the BS and CC members.

At AOC-65, the HCSM model was further subdivided into 17 intervals (1 UGR, 11 LGR, 2 BS, and 3 CC) as monitored by the AOC-65 WB network. While those designs were comprehensive, several years of monthly data from those WB intervals has indicated that some of these individual zones behave in a similar fashion as a group, both from hydraulic and contaminant concentration standpoints. The insight gathered from this monitoring has indicated that combining discrete zones which behave in similar fashion is prudent and economical for future monitoring and generation of meaningful data. Therefore, this approach has been adopted for the WB effort at SWMU B-3.

Site-specific data germane to SWMU B-3 were obtained and reviewed to develop a conceptual monitoring network to meet the goals of the study, which included the EAB Pilot Study and the groundwater pumping tests. The geophysical logging that was performed in each borehole was used to correlate the SWMU B-3 subsurface features with the established HCSM. While some units varied locally with respect to elevation or thickness, the general hydrostratigraphy at SWMU B-3 is consistent with the basewide HCSM and AOC-65 WB observations.

Next, direct measurements of hydraulic properties via HpL, hydraulic profiling (via FLUTe system), straddle packer injection tests, and discrete interval soil-gas and groundwater sampling were reviewed. The findings of these data sets were evaluated with respect to the site hydrogeology. Typical results indicated that soil-gas contamination was present throughout the vadose zone, decreasing in concentration with depth below the SWMU B-3 landfill. Conversely, contaminant concentrations were detected throughout the groundwater column (LGR and CC, BS at SWMU B-3 not yet sampled) showing that concentrations increased with depth. Hydraulic characterization (HpL and FLUTe) confirmed the HCSM model of the primary water-bearing units of the Middle Trinity aquifer, occurring in the basal portion of the LGR and the upper portion of the CC. Very minor water-bearing units were identified above the basal unit, but were generally thin-bedded and very low yielding.

Based on the site-specific data, a conceptual monitoring network of WB intervals was established which addresses the hydrogeologic conditions, and considers locations of identified flow zones and the occurrence of contaminants. The next step was to select packer locations within the boreholes that would provide adequate seals between the intervals to keep them hydraulically separated. That task was accomplished by identifying suitable borehole wall conditions (smooth, narrow, and without cracks or sharp edges) on the geophysical caliper log. All potential packer locations were visually confirmed with data from the Optical Televiewer (OTV) and the downhole analog video. Based on the visual observations, some packer placements were ultimately adjusted from their ideal positions to avoid potentially interfering features and to increase the likelihood of a suitable hydraulic seal.

The final step was to place the sampling and purge ports of each WB well interval. In accordance with WBs standard design recommendation, all WB discrete intervals will have a purging/pumping port 5 feet up from the bottom of the zone (top of bottom packer). Also in accordance with WB recommendations, the intervals will have their sampling port 5 feet above the pumping port. The distance of 5 feet between packer top and the ports is the minimum necessary for proper operation of the WB probe and sampling equipment.

In the basal portion of the aquifer, the measurement/sampling ports were placed adjacent to identified flow paths (vugs, fractures, etc.). Since water levels are known to decline in many zones during dry periods, the sampling ports in upper intervals will be placed as low as feasible in the to minimize the potential for water levels falling below the port, which would preclude sample collection. At monitoring intervals where seasonally declining groundwater levels is less of a concern such as in the basal portion of the LGR, some sampling ports are planned at depths corresponding to a flow-zone identified through the HpL and packer testing.

The selected WB zones will be sufficiently distributed so monitored natural attenuation (MNA) parameters, and changes in contaminant concentrations in various hydrogeologic zones can be monitored and accurately measured and quantified. Contamination within the LGR appears to be ubiquitous around SWMU B-3; therefore contaminant concentrations played a minor role in interval selection, although it is important to note that the presence of contamination throughout the formation measured in the packer test samples suggests that the monitoring wells were properly located for their stated purpose, that of monitoring the effects of the bioreactor in the apparent core of the plume's source area.

WELL COMPLETION

Hydraulic properties of the different geologic layers exert a major influence on the rate and direction of groundwater flow through the formation. Corresponding SWMU B-3 WB intervals all include correlated geologic zones that contain significant permeable layers capable of facilitating groundwater and contaminant movement. While the zone selections are tailored to the site-specific conditions encountered at SWMU B-3, generally speaking, most intervals are assimilations of comparable zones that are discrete in the AOC-65 WBs. The recommended 23 sampling intervals are shown in Attachment 2, and are discussed below. The deeper WB well, WB05, will have 8 monitoring zones. The remaining shallower wells (WB06, WB07, and WB08) will have 5 zones each. Groundwater sampling by WB system is very low-flow and removes only a small amount of water (120 ml per sample). Samples can be collected by WB system from intervals where other conventional methods would fail (*e.g.*, bailer, submersible pump).

Table 1
Comparison of the B-3 Site-Specific Design with Respect to the HCSM and AOC-65 Design

<table>
<tr><th>HCSM Model Layer</th><th>AOC-65 WB Design</th><th>SMWU B-3 WB Design</th></tr>
<tr><td>UGR(D)
UGR(E)</td><td>UGR01</td><td>UGR01
(plus upper ~10’ of LGR[A])</td></tr>
<tr><td>LGR(A)</td><td>LGR01</td><td rowspan="3">LGR01</td></tr>
<tr><td rowspan="2">LGR(B)</td><td>LGR02</td></tr>
<tr><td>LGR03</td></tr>
<tr><td rowspan="2">LGR(C)</td><td>LGR04</td><td rowspan="3">LGR02</td></tr>
<tr><td>LGR05</td></tr>
<tr><td rowspan="2">LGR(D)</td><td>LGR06</td></tr>
<tr><td>LGR07</td><td rowspan="3">LGR03</td></tr>
<tr><td rowspan="2">LGR(E)</td><td>LGR08</td></tr>
<tr><td>LGR09</td></tr>
<tr><td rowspan="2">LGR(F)</td><td>LGR10</td><td rowspan="2">LGR04
(WB05 divided into 4A and 4B)</td></tr>
<tr><td>LGR11</td></tr>
<tr><td>BS(A)</td><td>BS01</td><td rowspan="2">BS01</td></tr>
<tr><td>BS(B)</td><td>BS02</td></tr>
<tr><td rowspan="2">CC(A)</td><td>CC01</td><td rowspan="2">CC01</td></tr>
<tr><td>CC02</td></tr>
<tr><td>CC(B)</td><td>CC03</td><td>CC02</td></tr>
</table>

For the overall WB design at SWMU B-3, the subsurface has been divided into single zone for the UGR, 4 monitoring zones in the LGR, 2 zones for the BS (WB05 only), and 2 zones for the CC (WB05 only). For reference, Table 1 provides an index of the SWMU B-3 zones with respect to the HCSM stratigraphy and equivalent zones at AOC-65. Table 2 summarizes the rationale for zone selections at SWMU B-3. Attachment 3 lists precise positions of all intervals. The paragraphs following summarize the reasoning for zone selections.

Table 2
Summary and Rationale of Discrete Westbay Interval Selections at SWMU B-3

Monitoring Zone	General Description	Specific Results	Rationale
UGR-01	Weathered limestones and evaporites of the basal UGR and upper LGR that easily erode into large voids near the contact (contact approx. 13-17 feet bgs at SWMU B-3). This zone is typically dry through most of the year.	PCE in soil gas ranging between 83 ppbv and 12,200 ppbv at B-3.	Will almost always be dry except during heavy precipitation events, when high concentrations of contaminants will be expected. Thin segment of UGR available below surface casing precluded UGR-only monitoring. Measurement ports are located at the UGR/LGR contact. Lower packer of this zone is 10' below UGR/LGR contact because of large caliper openings. Design will allow for shallow vadose drainage and perched groundwater to sufficiently accumulate for sampling after heavy rainfall. Not monitored at WB05, cased off due to borehole instability.
LGR-01	Low permeable mudstones grading to periodically fossiliferous and moderately porous limestones.	PCE in soil gas ranging between 4.6 ppbv and 3,310 ppbv at B-3.	Monitor horizons containing flowpaths from contaminant source to the saturated zone, and effects of bioreactor on downward moving and perched water.
LGR-02	Low permeable mudstones grading into moderately fossiliferous, grainy limestones containing occasional thin, vuggy, permeable layers.	PCE in soil gas ranging between 21.5 ppbv and 5,010 ppbv at B-3.	As above, and to monitor minor water-bearing zones near base of interval. Zone is mostly to completely saturated during periods of high water levels. Monitoring port is between two of the most permeable layers through which shallow recharge water is transmitted.
LGR-03	Majority is tight, competent limestone, but with several laterally continuous intervals of more permeable, vuggy limestone that have shown to be low-yielding groundwater zones.	PCE > 30 ppb in groundwater. Little to no injection attained during straddle packer test of 20-foot "scissor-tail" resistivity marker zone.	HpL and injection tests showed low-yielding groundwater is available in a vuggy zone generally at an elevation of 1030' MSL. A monitoring port has been placed adjacent to that zone. This LGR-03 interval may partially dewater during droughts, therefore a secondary port has been placed at the base of the zone to ensure groundwater samples can still be obtained during low groundwater conditions.

Table 2
Summary and Rationale of Discrete Westbay Interval Selections at SWMU B-3

LGR-04	Very porous and permeable, fossiliferous limestone, more honey-combed with depth. Can yield high volumes of groundwater.	PCE ranging between 31.8 and 337 ppb in initial discrete water samples.	One of two main water-bearing zones in Middle Trinity Aquifer from which groundwater withdrawals are pumped; main source for local water supply wells. High potential for transmitting contamination. Sample port placed in most contaminated flow path.
BS-01	Poor hydraulic conductivity, shaley limestone and calcareous shale, with silty dolomitic and marl areas. Acts as an aquitard between the LGR and CC.	HpL indicates very low-flow zone. Nearby MW1-BS quarterly groundwater results show periodic TCE detections < lab RL and DCE 0.12-1.3 ppb.	Having very low permeability, the BS still has groundwater storage capabilities and over time exhibits leakage from/into the adjoining LGR and CC. Zone will monitor water in storage and what may be moving through BS via nearby fractures, and response to MW16 pumping test as part of aquifer characterization.
CC-01	High porosity and permeability, portions vuggy and honey-combed, fossiliferous limestone. Main water-bearing portion of the CC.	PCE detected at 392 ppb in initial discrete water sample.	One of two main water-bearing zones in Middle Trinity Aquifer from which groundwater withdrawals are pumped; a source for local water supply wells. Zone will be an important observation point for MW16 pumping test.
CC-02	Dolomitic to shaley limestone, contains permeable zones but generally less porous than CC-01. Permeability and porosity decrease with depth as CC transitions into underlying Hammett Shale.	Not yet sampled at B-3, but exhibits VOC contamination at wells downgradient (WB04) from other AOCs. Zone is expected to be contaminated at B-3.	Will be monitored as part of the CC, may have close interaction with above CC-01.

B3-UGR-01

Due to land surface elevation differences, the UGR at SWMU B-3 is much thinner than at AOC-65. Once the state-mandated minimum surface casing of 10 feet is installed, the remaining open UGR interval can be less than 10 feet. Generally speaking, the SWMU B-3 landfill is excavated into this stratum, thereby making it an important monitoring interval. The zone is characterized by sequences of weathered limestones that are fractured and easily erodible. In fact, borehole stability issues at WB05 made it necessary to use 30 feet of surface casing, effectively eliminating the B3-UGR-01 monitoring zone from that WB well. Under typical conditions, it is expected that this zone will be dry throughout most of the year. However, as a potentially important flow path during high precipitation events and from percolation from the saturated bioreactor cells, the UGR needs to be monitored. During drilling, the UGR interval is quite susceptible to erosion and washout by the rotary action, and often results in a borehole diameter that is too large for the standard WB packer. At SWMU B-3, the best location for UGR-01 packer seals actually does not occur until 10 feet below the UGR/LGR formation contact. The upper seal for this zone will consist of a packer inflated within the surface casing.

Soil-gas packer samples (see Attachment 4) collected from this approximate interval indicated near-surface VOC contamination, with PCE concentrations ranging between 83 and 12,200 ppbv. The vacuum pressures necessary to obtain the UGR-01 samples were generally one-third of the required vacuum needed at lower sampling intervals within B3-LGR-01 and B3-LGR-02. This indicates that the weathered nature of the UGR-01 can exhibit a higher permeability the upper zones of LGR-01 and -02. Below this interval, VOC concentrations in the soil-gas generally decrease with depth throughout the vadose zone. At the time of the investigation, no perched groundwater was encountered in this interval.

The thinness of the UGR coupled with eroded, enlarged borehole diameter made the singular monitoring of the UGR unattainable. The interval design will be open to the washed out portions the UGR and upper LGR. The monitoring port has been placed at the formational contact of the two units. Therefore, the UGR-01 intervals in the SWMU B-3 WBs include the basal portion of the UGR as well as the approximate top 10 feet of the LGR(A) subdivision to increase the likelihood of obtaining some data from this zone throughout the study and bioreactor O&M periods.

B3-LGR-01

The upper half of this unit is characterized by alternating layers of pale yellow mudstones. In contrast, the lower half of this monitoring interval can be fossiliferous, and subsequently exhibits some vuggy porosity. At the AOC-65 piezometers, this unit is known to perch groundwater on a seasonal basis. It is likely that this zone will be dry for part of the year. To maximize the ability to obtain samples from this zone, the monitoring port has been placed at the base of the interval to obtain water samples during depressed groundwater levels. A fracture system was noted at WB06 at a depth of approximately 100 feet below grade. The measurement port has been placed adjacent to this feature in anticipation that it may be a water-bearing structure.

At the time of drilling, no groundwater was encountered in this interval, precluding any HpL results. However, discrete interval soil-gas samples were collected by straddle packer system approximately every twenty feet in each WB borehole. During soil-gas sampling in the LGR-01 interval, some 20-foot sections maintained relatively low vacuum pressure (6 to 20 inches H_2O), indicating potentially high permeability. VOC contamination was detected, with PCE reported as ranging between 4.6 and 3,310 ppbv.

B3-LGR-02

The mudstones of the upper half of this interval can be described as alternating layers of tannish-brown and greenish-gray bioturbated muds with a low percentage allochemical constituents (*e.g.*, fossils). The rock is competent and highly styolitic (susceptible to diagenetic pressure solutioning). The lower half of this unit consists of a more grain-supported limestone, and contains a pervasive bed of permeable vuggy limestone near the bottom third of the interval. At the time of drilling, the static groundwater level at all boreholes was found to coincide with this vuggy permeable layer. The HpL findings indicated that two thin water-bearing zones, approximately 5 feet in thickness and separated by 11 feet, are present in the bottom third of this interval. The interval has been designed such that these low-yielding zones will be near the base of LGR-02 zone, and the monitoring port has been placed between the two intervals of saturation. This will allow for groundwater samples to be obtained to within 10 feet of this zone possibly becoming completely dewatered during droughts.

Multiple subsurface vapor samples were collected from the B3-LGR-02 interval. PCE concentrations ranging between 21.5 to 5,010 ppbv were reported within this interval below SWMU B-3. Because of the low-yielding groundwater characteristics, no samples were recovered using the standard investigation methodologies employed at CSSA.

B3-LGR-03

The HpL testing identified a low-yielding groundwater zone within the top third of interval B3-LGR-03. The identified zone is characterized by a unique geophysical marker, which has been referred to as the "scissor tail" by on-site geologists, referring to a scissor-tail-like resistivity graph pattern. This resistivity feature represents a short sequence of packstone/mudstone/packstone that is more or less uniformly present through most of CSSA. While optical logging indicates that this zone is somewhat vuggy, an injection test performed at this interval indicated very low permeability characteristics, meaning the void spaces are not well connected. Sample collection was attempted from this interval, but none could be obtained with the conventional packer apparatus. The remainder of the interval consists of a 55-foot layer of tan and light brown wackestones with intermittent thin fossiliferous layers and grain-supported rock. The unit is fairly unremarkable overall and does not appear to contain a significant groundwater flow path or permeability.

The design of this zone is unique relative to the other intervals such that 2 measurement ports have been included, rather than one. The rationale is that the "scissor-tail" packstone area is likely the only section in the interval that will produce a sufficient amount of sample quantity utilizing the WB sampling tools. Ideally, it is preferable to have the primary measurement port adjacent to the flowpath, even if it is very low-yielding. However, it is quite feasible that the aquifer will dewater below this elevation during drought periods, rendering that measurement port inoperable. Therefore, a secondary sampling port has been incorporated to the LGR-03 zone near the base of the unit. If the water table declines past the primary port, a groundwater sample can still be obtained from the lower port to characterize the zone for that sampling event. Though the water level may decline significantly in very dry seasons, smaller, multiple seams of groundwater seepage will continue to contribute to the total accumulation in the interval, thus assuring adequate sample quantities even when the ideal target flow zone cannot be directly sampled.

B3-LGR-04

B3-LGR-04 comprises the main groundwater production zone within the Middle Trinity aquifer throughout CSSA. It is composed of a 50 to 60-foot reef complex whose lateral extent appears to extend beneath the entire confines of CSSA. The occurrence of this reef has been well documented within boreholes drilled at CSSA and neighboring areas. The interval is described as a white to tan, very fossiliferous packstone/grainstone with a significant level of moldic porosity in the basal 40 feet. The interval is characterized by its relatively low gamma response and high resistivity response. The vuggy porosity left as a result of fossil dissolution has resulted in voids that range from several millimeters to 5 centimeters in size. Extensive basewide testing through packer tests indicate that the interval is capable of yielding groundwater in excess of 75 gallons per minute (gpm). Where fractures or karstic caverns exist, groundwater production can easily exceed 150, even 300 gpm.

HpL logging and FLUTe profiling has found that over 60 percent of the LGR-04 interval (40 feet, in 5 distinct beds) has a high groundwater yield relative to the rest of the borehole. VOC contamination in groundwater is present throughout the interval at SWMU B-3, and PCE was found in concentrations ranging from 31.8 to 337 µg/L. At each borehole, three discrete interval samples were collected from the B3-LGR-04 interval. The general trend appears to be that total VOC contamination slightly increases with depth in this unit. At each WB well, the measurement port has been placed adjacent to the lower flow path, which generally shows the greatest VOC concentration.

At WB05, the LGR-04 zone has been subdivided into an “A” and “B” interval to facilitate monitoring of the adjacent “injection” well, B-3_MW01 injection zone. The “A” zone is completed at an equivalent depth and length corresponding to the screened interval of the “injection” well. This approach will allow the affects of the substrate injection into the upper horizon of LGR-04 to be closely monitored. This distinction has not been made at the other WB locations because of their long distances from the injection point.

B3-BS-01 (WB05 only)

The BS forms a relatively impermeable aquitard for the overlying LGR water-bearing zones, effectively hampering the hydraulic communication between the LGR and underlying CC members. Otherwise, any significant vertical fluid movement in the BS would be anticipated to be through fractures and faults only. The upper 25 feet of the unit is a dolomitic wackestone that is dark gray in color. In terms of texture, this “dirty limestone” is very similar to the mudstones of interval LGR-03, including the presence of fossils and limited moldic porosity. The gamma count is high in comparison to the overlying LGR-04, and the resistivity of the entire layer is very low. The basal 30 feet of the BS is more characteristic of shale lithology with increasing mud content and a laminated, fissile bedding structure, and has an olive gray appearance.

In WB05 the BS is considered as one zone, BS-01. Data from AOC65-WB04 monitoring indicate only very slight differences between the two BS zones there, so only one monitoring interval is recommended for the BS at WB05. The measurement port was placed adjacent to an extremely low-flowing zone (less than 0.05 gpm) as identified by the HpL testing.

At WB05, the well has penetrated the BS and CC intervals to discretely monitor the response of these zones during the pumping tests, and will help assess the potential of vertical leakage or contaminated groundwater through the BS. During the drilling investigation, it was determined that groundwater production from this interval was too low to warrant an attempt at retrieving a groundwater sample. This monitoring interval will be able characterize the condition of this zone from a contaminant perspective.

B3-CC-01 (WB05 only)

Interval B3-CC-01 is characterized by alternating layers of white and light gray packstones and grainstones. On geophysical logs, the occurrence of the CC Limestone is easily identified by its geophysical signature relative to the BS. The large decrease in gamma count indicates the reduction in the amount of mudstone, and the sharp increase in overall resistivity supports the lithologic change, indicating the capability of increased groundwater storage. Moderate to large amounts of groundwater are expected to be produced from this interval. Both the HpL logging the FLUTe profiling also indicated lesser flow paths throughout this interval at WB05.

One groundwater sample was obtained from this interval at WB05. A PCE concentration of 392 ppb was reported within this interval, and was the highest reported concentration throughout the entire WB05 water column. This zone has also been designed to compliment the efforts of the pumping test. The lower packer has been placed at an elevation consistent with the total depth of the primary pumping well (CS-MW16-CC). The measurement port has been placed at an elevation proximal to the midpoint of the pumping well's screened interval.

B3-CC-02 (WB05 only)

The basal 20 feet of the CC Limestone represents a conformable transition with the underlying Hammett Shale. The grainstones and packstones of unit B3-CC-01 grade into a soft olive gray silty mudstone. Being that the contact is transitional, there are numerous interbeddings between soft shaley members and more competent limestone rock. The increase of shale content is reflected in the geophysical surveys with an increasing gamma count and decreasing resistivity. At this depth the unit is more characteristic of shale rather than limestone. The contact with the underlying Hammett Shale is interpretive due to the transitional nature of the contact.

The CC-02 interval appears to have low porosity and permeability, and will be qualified by the data collected at the measurement port. Hydraulic testing did not indicate any significant flow paths within this interval.

Aerial Photo Date: 2003

N
W E
S

Feet
0 50 100 150 200

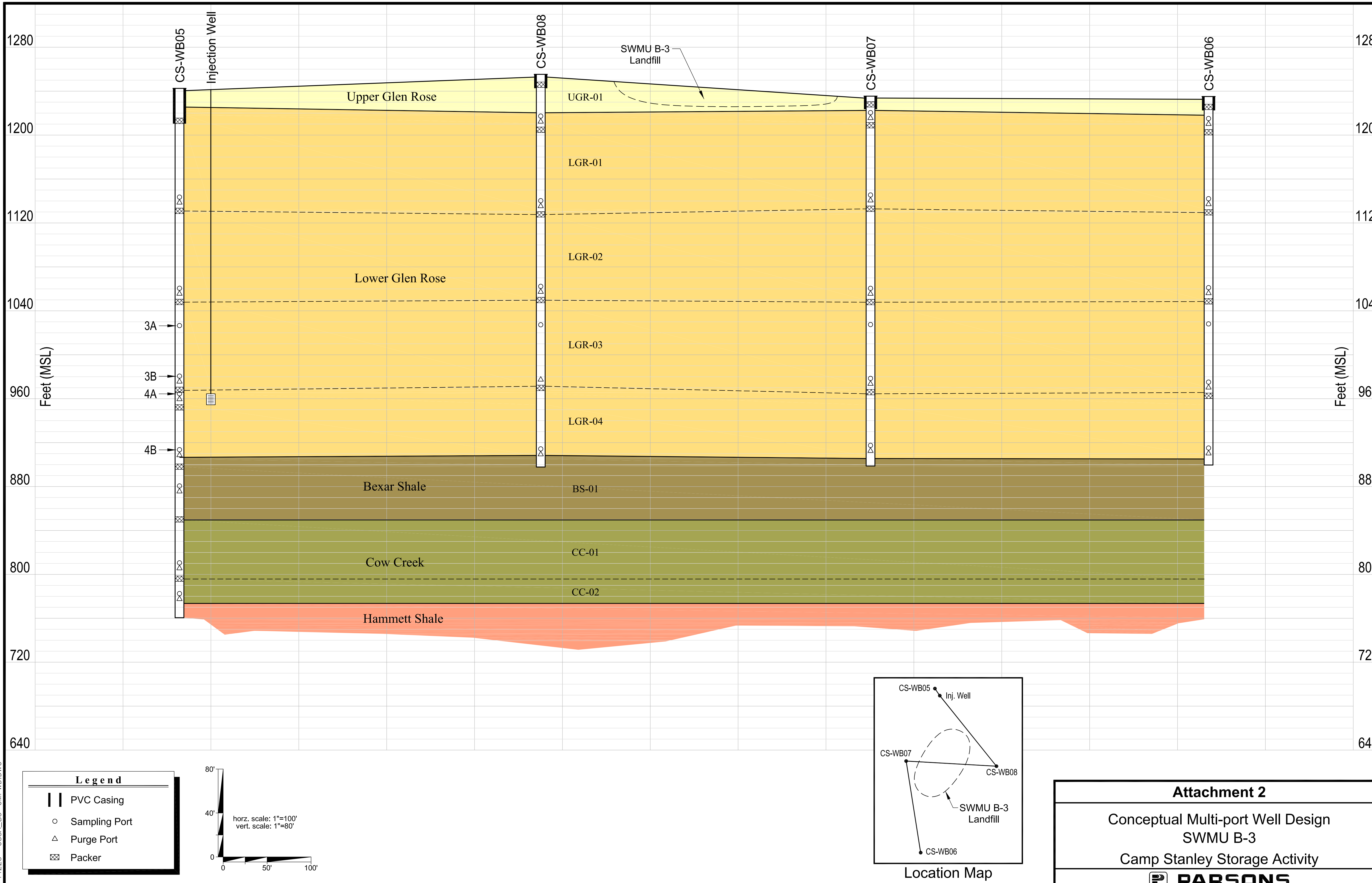
- Westbay® Well Location
- Injection Well Location
- Water Well Locations
- SWMU Boundary

Attachment 1

Locations of Westbay Wells at SWMU B-3
Camp Stanley Storage Activity, Texas

PARSONS

J:\744\744223 B3 & AOC65\gis\b3-well_location_map.mxd - 10/31/2005 @ 3:23:12 PM



Attachment 2

Conceptual Multi-port Well Design
SWMU B-3
Camp Stanley Storage Activity

PARSONS

Attachment 3
Westbay MP Monitoring Zones
SWMU B-3
Camp Stanley Storage Activity
October 2005

MP Well	Logger Casing Reference	Zone	Upper Packer	Lower Packer	Monitored Interval Length	Sampling Port		Pumping Port	Corresponding AOC-65 Westbay Zones
	(above grade)		*(feet BTOC)*	*(feet BTOC)*	*(feet)*	*(feet BTOC)*		*(feet BTOC)*	
						Primary	*Secondary*		
CS-WB05	**2**	LGR-01	27 - 32	109 - 114	77	99		104	UGR-01, LGR-01, 02, 03
		LGR-02	109 - 114	192 - 197	78	182		187	LGR-04, 05, 06
		LGR-03	192 - 197	272 - 277	75	216	262	267	LGR-07, 08, 09
		LGR-04A	272 - 277	286 - 291	9	277		282	top LGR-10
		LGR-04B	286 - 291	342 - 347	51	329		334	LGR-10, 11
		BS-01	342 - 347	390 - 395	43	362		367	BS-01, 02
		CC-01	390 - 395	444 - 449	49	432		437	CC-01
		CC-02	444 - 449	482	33	460		465	CC-02, 03
CS-WB06	**2.5**	UGR-01	7 - 12	30 - 35	18	20		25	UGR-01, top LGR-01
		LGR-01	30 - 35	103 - 108	68	93		98	LGR-01, 02, 03
		LGR-02	103 - 108	184 - 189	76	174		179	LGR-04, 05, 06
		LGR-03	184 - 189	270 - 275	81	207	260	265	LGR-07, 08, 09
		LGR-04	270 - 275	335.5	60.5	320		325	LGR-10, 11
CS-WB07	**1.75**	UGR-01	4 - 9	24 - 29	15	14		19	UGR-01, top LGR-01
		LGR-01	24 - 29	100 - 105	71	90		95	LGR-01, 02, 03
		LGR-02	100 - 105	185 - 190	80	175		180	LGR-04, 05, 06
		LGR-03	185 - 190	267 - 272	77	208	257	262	LGR-07, 08, 09
		LGR-04	267 - 272	336.75	64.75	318		323	LGR-10, 11
CS-WB08	**2.5**	UGR-01	7 - 12	48 - 53	36	38		43	UGR-01, top LGR-01
		LGR-01	48 - 53	125 - 130	72	115		120	LGR-01, 02, 03
		LGR-02	125 - 130	203 - 208	73	193		198	LGR-04, 05, 06
		LGR-03	203 - 208	283 - 288	75	228	273	278	LGR-07, 08, 09
		LGR-04	283 - 288	357.5	69.5	341		346	LGR-10, 11

Notes:

-All Depths are referenced from Below Top of Casing (BTOC), which is 4.5" ID PVC Surface Casing.

-The Total Depth of the borehole will serve as the lower isolation point for the bottom-most zones.

-Uppermost packers in each borehole will be inflated into the base of the PVC surface casing.

-CS-WB05 does not have a UGR zone due to borehole instability at that depth. Zone was subsequently cased off.

-Interval LGR-03 has an alternate sampling port at bottom of zone for when water level drops below primary port at scissor-tail vugs.

DRAFT

Attachment 4
Results of SWMU B-3 Soil Gas and Groundwater Packer Testing
Camp Stanley Storage Activity - Boerne, Texas
August/September 2005

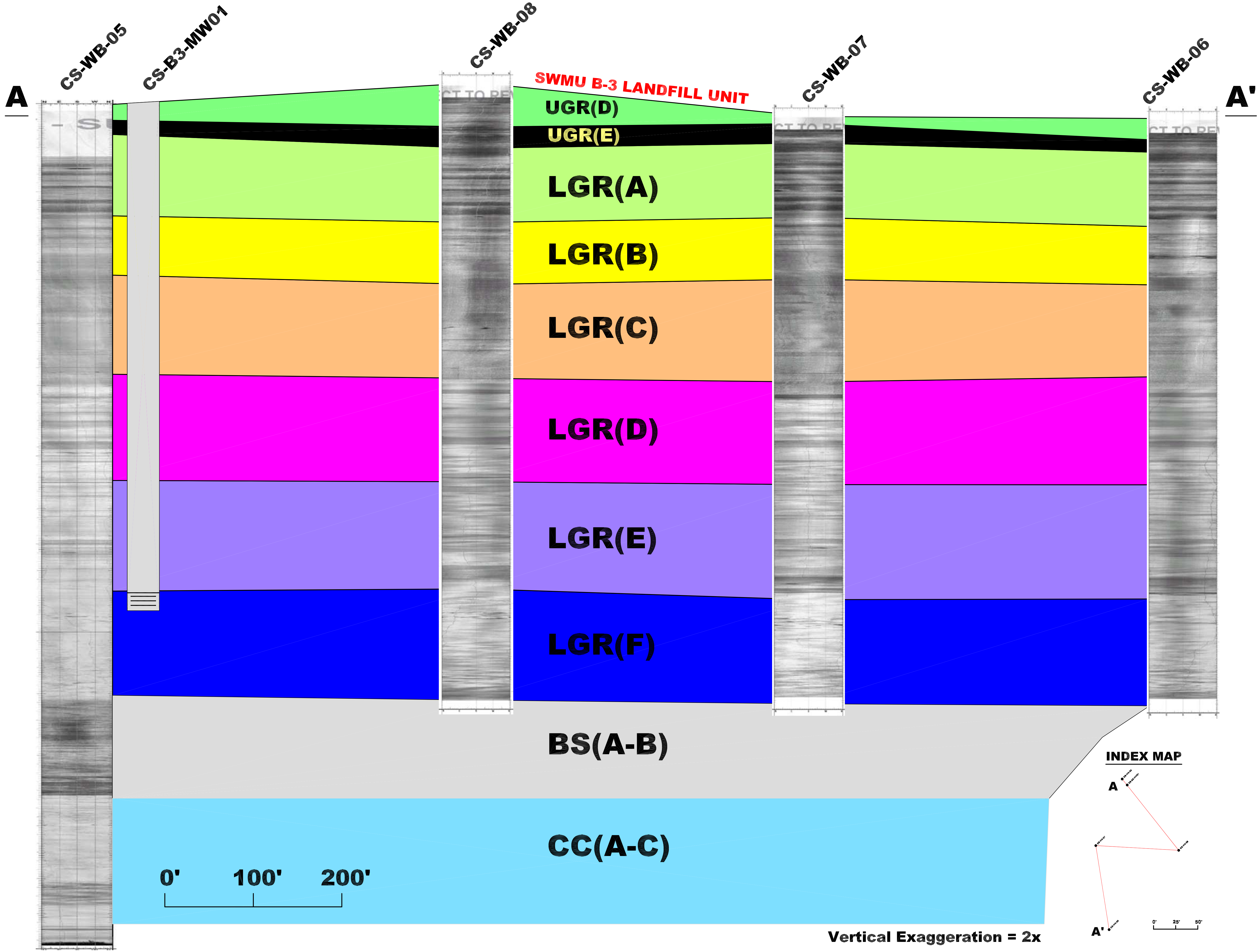
		Depth (feet bgs)	Analyte	Result	Unit
CS-WB05	Soil Gas	30-50	PCE	120	ppbv
			TCE	77.1	ppbv
			cis-1,2-DCE	17.8 J	ppbv
		71-91	PCE	204	ppbv
			TCE	167	ppbv
			cis-1,2-DCE	110	ppbv
		116-136	PCE	479	ppbv
			TCE	439	ppbv
			cis-1,2-DCE	368	ppbv
		156-176	1,1,1-TCA	0.732 J	ppbv
			1,1-DCE	1.23 J	ppbv
			Benzene	6.21 J	ppbv
			Chloroform	0.870 J	ppbv
			Methylene chloride	6.00 J	ppbv
			PCE	328	ppbv
			TCE	157	ppbv
			Vinyl chloride	1.22 J	ppbv
			cis-1,2-DCE	47.7	ppbv
	Groundwater	268-288	PCE	31.3	µg\L
			toluene	4.18	µg\L
			TCE	152	µg\L
			cis-1,2-DCE	286	µg\L
		290-310	PCE	160	µg\L
			TCE	273	µg\L
			cis-1,2-DCE	344	µg\L
			trans-1,2-DCE	4.94	µg\L
		320-340	PCE	319	µg\L
			TCE	427	µg\L
			cis-1,2-DCE	533	µg\L
		416-436	PCE	392	µg\L
			TCE	375	µg\L
			cis-1,2-DCE	465	µg\L
			trans-1,2-DCE	16.4	µg\L

		Depth (feet bgs)	Analyte	Result	Unit
CS-WB06	Soil Gas	10-30	PCE	1270	ppbv
			TCE	711	ppbv
			cis-1,2-DCE	856	ppbv
		50-70	PCE	1570	ppbv
			TCE	1270	ppbv
			cis-1,2-DCE	931	ppbv
		130-150	PCE	540	ppbv
			TCE	490	ppbv
			cis-1,2-DCE	520	ppbv
	Groundwater	260-280	PCE	151	µg\L
			TCE	159	µg\L
			cis-1,2-DCE	287	µg\L
		284-304	PCE	297	µg\L
			TCE	268	µg\L
			cis-1,2-DCE	413	µg\L
		308-328	PCE	337	µg\L
			TCE	268	µg\L
			cis-1,2-DCE	435	µg\L

Attachment 4
Results of SWMU B-3 Soil Gas and Groundwater Packer Testing
Camp Stanley Storage Activity - Boerne, Texas
August/September 2005

		Depth (feet bgs)	Analyte	Result	Unit
CS-WB07	Soil Gas	10-30	PCE	83.3	ppbv
			TCE	4160	ppbv
			cis-1,2-DCE	1340	ppbv
		30-50	PCE	25.7	ppbv
			TCE	937	ppbv
			cis-1,2-DCE	229	ppbv
		70-90	PCE	4.57	ppbv
			TCE	106	ppbv
			cis-1,2-DCE	27.1	ppbv
		110-130	PCE	21.5	ppbv
			TCE	94.3	ppbv
			cis-1,2-DCE	25.5	ppbv
	Groundwater	200-220	PCE	34.7	µg\L
			TCE	47.9	µg\L
			cis-1,2-DCE	56.1	µg\L
		265-285	PCE	293	µg\L
			TCE	322	µg\L
			cis-1,2-DCE	361	µg\L
		285-305	PCE	254	µg\L
			TCE	306	µg\L
			cis-1,2-DCE	322	µg\L
		310-330	PCE	221	µg\L
			TCE	277	µg\L
			cis-1,2-DCE	403	µg\L

CS-WB08	Soil Gas	10-30	PCE	12200	ppbv
			1,1-DCE	320	ppbv
			TCE	9520	ppbv
			Vinyl chloride	509	ppbv
			cis-1,2-DCE	2790	ppbv
		89-109	PCE	3310	ppbv
			TCE	2220	ppbv
			Vinyl chloride	73.6	ppbv
			cis-1,2-DCE	431	ppbv
		138-158	1,1-DCE	45.7 J	ppbv
			PCE	4270	ppbv
			TCE	2730	ppbv
			Vinyl chloride	69.3	ppbv
			cis-1,2-DCE	506	ppbv
		156-176	1,1-DCE	135	ppbv
			PCE	5010	ppbv
			TCE	3970	ppbv
			Vinyl chloride	234	ppbv
			cis-1,2-DCE	753	ppbv
	Groundwater	280-300	PCE	38.6	µg\L
			TCE	41.8	µg\L
			cis-1,2-DCE	108	µg\L
		305-325	PCE	50.9	µg\L
			TCE	57.3	µg\L
			cis-1,2-DCE	98.8	µg\L
		331.5-351.5	PCE	53.7	µg\L
			TCE	54.2	µg\L
			cis-1,2-DCE	115	µg\L
			trans-1,2-DCE	4.62 J	µg\L


A
CS-WB-05
CS-B3-MW01
CS-WB-08
SWMU B-3 LANDFILL UNIT
CS-WB-07
CS-WB-06
A'
UGR(D)
UGR(E)
LGR(A)
LGR(B)
LGR(C)
LGR(D)
LGR(E)
LGR(F)
BS(A-B)
CC(A-C)
0'
100'
200'
Vertical Exaggeration = 2x
INDEX MAP
A
A'