D-AREA TREATMENT TRENCH (DTT-1) EVALUATION (U)

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D-AREA TREATMENT TRENCH (DTT-1) EVALUATION

1.0 EXECUTIVE SUMMARY

A limestone trench was installed adjacent to the D-Area Coal Pile Runoff Basin (DCPRB) on May 4, 1999. Since limestone is considered the most likely amendment to produce the optimal pH range for sulfate reduction in the D-Area low pH/metals/sulfate plume (Phifer, et al. 2001), the existing limestone trench has undergone a re-evaluation. The re-evaluation has been conducted to determine if the hydraulic and geochemical activity of the limestone trench is similar to its initial conditions upon installation and to determine the potential to promote sulfate reduction at the limestone trench with the addition of an organic carbon substrate.

The results of the re-evaluation indicate that the limestone trench is essentially as hydraulically active now as it was at its installation. Additionally it has been determined that the limestone trench remains an effective treatment for increasing the pH and removing aluminum as at its installation. Finally it has been determined that the limestone trench has increased sulfate reducing bacteria (SRB) activity and has in general improved conditions relative to optimal sulfate reduction conditions. Based upon this re-evaluation it has been determined that limestone could potentially be a viable component of an in-situ sulfate reduction remediation system, and the addition of soybean oil downgradient of the limestone trench should result in successful sulfate reduction remediation.

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List of Abbreviations

BHS = bottom horizontal screen
bls = below land surface
BOS = bottom of vertical screen
cfs/ft = specific capacity measured in cubic feet per second per foot
DCPRB = D-Area Coal Pile Runoff Basin
DIW-1 = D-Area Interceptor Well
DO = dissolved oxygen
DTT-1 = D-Area Treatment Trench
EBS = Environmental Biotechnology Section
Eh = redox potential
EPA = United States Environmental Protection Department
ft = feet
ft-msl = feet above mean sea level
gpm = gallons per minute
gpm/ft = specific capacity measured in gallons per minute per foot
IC = Ion Chromatography
ICP-AES = Inductively Coupled Plasma – Atomic Emission Spectroscopy
mg/L = milligram per liter
ml = milliliter
mV = millivolt
PVC = polyvinyl chloride
SRB = sulfate-reducing bacteria
SRTC = Savannah River Technology Center
THS = top horizontal screen
TOC = top of casing
TOC = total organic Carbon
TOS = top of vertical screen
μg/L = microgram per liter
μS/cm = microSiemens per centimeter
WSRC = Westinghouse Savannah River Company
XRD = x-ray diffraction
XRF = x-ray fluorescence

D-AREA TREATMENT TRENCH (DTT-1) EVALUATION

2.0 INTRODUCTION

A low pH/metals/sulfate, groundwater contaminant plume emanates from the D-Area Coal Pile Runoff Basin (DCPRB), due to the contaminated runoff the basin receives from the D-Area coal pile. A field study, to assess the potential of in situ sulfate reduction to serve as a remedial technology for this groundwater plume, is currently being conducted (WSRC 2001; Phifer et al. 2002a). In situ sulfate reduction entails the oxidation of an organic substrate by sulfate-reducing bacteria (SRB) for energy and growth, the use of sulfate as the terminal electron acceptor, the production of carbonates and hydrogen sulfide, an increase in pH, a decrease in Eh, and the precipitation of metal sulfides, hydroxides and carbonates. In addition to the need to add organic carbon substrates to promote in situ sulfate reduction, the pH optimally needs to be in the range of 5.5 to 9. (Phifer et al. 2001)

A limestone trench was installed as part of a Permeable Reactive Barrier/GeoSiphon treatment system that was evaluated for the treatment of metals contaminated groundwater (i.e. the D-Area low pH/metals/sulfate plume). The previous study is documented in Washburn et al. 1999. The limestone trench, D-Area Treatment Trench (DTT-1), is a 2 ft wide by 40 ft long by 15 to 16 ft deep trench filled with limestone which was installed adjacent to DCPRB on May 4, 1999. Since limestone is considered the most likely amendment to produce the optimal pH range for sulfate reduction in the D-Area low pH/metals/sulfate plume (Phifer, et al. 2001), the existing limestone trench has undergone a re-evaluation. The re-evaluation has been conducted to determine if the hydraulic and geochemical activity of the limestone trench is similar to its initial conditions upon installation and to determine the potential to promote sulfate reduction at the limestone trench with the addition of an organic carbon substrate.

To address the hydraulic activity of the limestone trench, the current specific capacity of the trench has been determined and compared to that previously determined at the same flow rates (Washburn et al. 1999). To address the geochemical activity of the limestone trench, current parameters such as calcium, magnesium, aluminum, and pH have been determined and compared to that previously determined (Washburn et al. 1999). In particular a comparison of the current and previous hydraulic and geochemical activity of the trench will address the potential for limestone armoring and formation/limestone pluggage, which is directly related to limestone longevity within the D-Area low pH/metals/sulfate plume environment. To address the existing sulfate reduction potential that exists within the trench the existing microbial activity within the trench and trench conditions versus optimal sulfate reduction conditions and the current sulfate reduction field study have been evaluated. All work was conducted in conformance with the *D-Area Treatment Trench (DTT-1) Evaluation Field Scoping Plan* (Phifer et al., 2002b).

3.0 D-AREA TREATMENT TRENCH (DTT-1) BACKGROUND INFORMATION

The D-Area Treatment Trench (DTT-1) was permitted as a well and installed adjacent to the D-Area Coal Pile Runoff Basin (DCPRB) on May 4, 1999. See Figures 1 and 2 for the location of DTT-1 relative to that of the DCPRB, and see Figures 3 and 4 for as-built diagrams of DTT-1. Table 1 and Figure 2 provide details associated with DTT-1 and adjacent monitoring wells, DCB-49 and DCB-50. The following description of DTT-1 is taken from Washburn et al. 1999:

> "The trench design called for a 2 foot wide by 40 foot long by 16.5 foot deep trench, with about a 10 foot vertical saturated thickness. Within the trench, four-inch-diameter Schedule 40 PVC piping was configured in three vertical risers connected by two horizontal pipes spaced 4 feet apart. The northern most riser was designated DTT-1A; the center riser was designated DTT-1, and the southern most riser was designated DTT-1B. One horizontal pipe was connected to the riser bottoms. A second horizontal pipe was connected to the risers about four feet above the bottom horizontal pipe. Both horizontal pipes had at least four rows of 3/8-inch diameter holes spaced about four inches apart to allow groundwater flow into the piping. All three risers extended to above the ground surface for access to the trench. The trench was backfilled around the piping with Number Four sized, limestone cobble aggregates. The center riser, DTT-1, transitioned from 4 inch polyvinyl chloride (PVC) to a 6 inch by 3 inch tee at approximately 2 feet bls, with the 6 inch piping extending to above the ground surface and with a 3 inch PVC siphon sleeve connecting to the tee. … "
>
> "The trench, subsurface piping, limestone-rock aggregate backfill, and the siphon sleeve were installed by Bechtel Savannah River, Inc. on May 4, 1999. The total as installed

> trench depth was approximately 15-16 feet below land surface (bls). The trench was excavated by backhoe, digging with a 2-foot-wide bucket. An approximate 1-2 foot layer of limestone aggregate was placed in the trench bottom. The piping system was placed atop the initial 1-2 foot layer of limestone, with the lower horizontal perforated piping set at about 14 feet bls. Limestone aggregate was then carefully placed around the piping system to a depth of about 2 feet bls. The trench was finished near the surface with two layers of non-woven geotextile material placed over the limestone rock aggregate backfill. The geotextile material was covered with native soil fill and mounded slightly to allow precipitation runoff and settling. … Each of the three PVC risers was finished with a 4 foot by 4 foot by 6-inch thick concrete pad and protective steel casing. ...”

Table 1. DTT-1, DCB-49, and DCB-50 Details

Trench Access	Coordinates (ft)		Diameter (inches)	Elevation (ft-msl)		
	North	South		TOC	THS	BHS
DTT-1A	63447.78	20000.97	4	124.7	112.47	108.47
DTT-1	63431.43	20007.49	4	122.64	112.47	108.47
DTT-1B	63415.08	20014.68	4	124.72	112.47	108.47
Well	Coordinates (ft)		Diameter (inches)	Elevation (ft-msl)		
	North	South		TOC	TOS	BOS
DCB-49	63429.96	20013.93	2	124.52	118.67	106.17
DCB-50	63426.58	20004.29	2	124.33	118.29	105.73

Notes to Table 1:
TOC = top of casing; THS = top horizontal screen; BHS = bottom horizontal screen; TOS = top of vertical screen; BOS = bottom of vertical screen

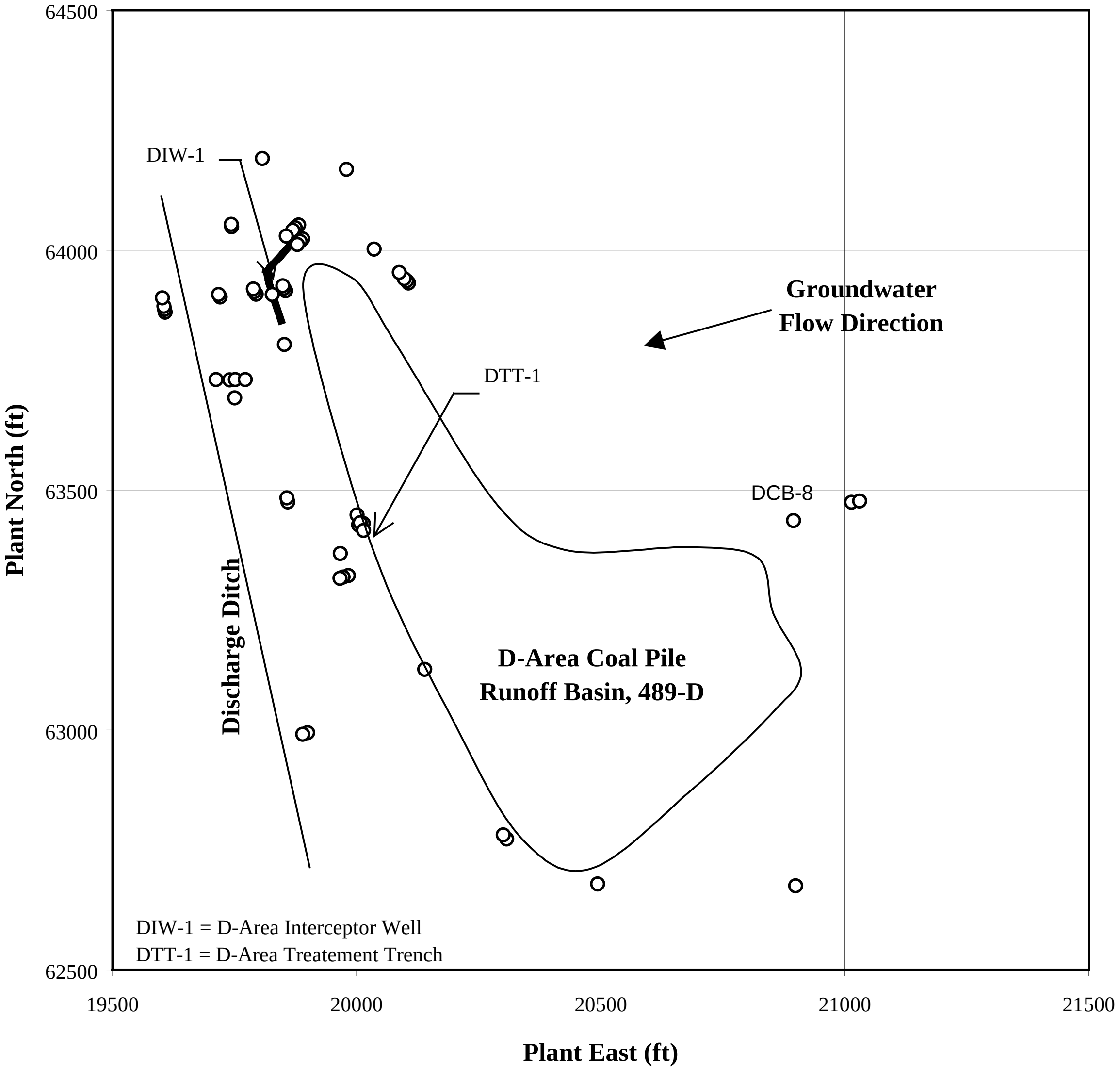


Figure 1. **DCPRB Location Map**

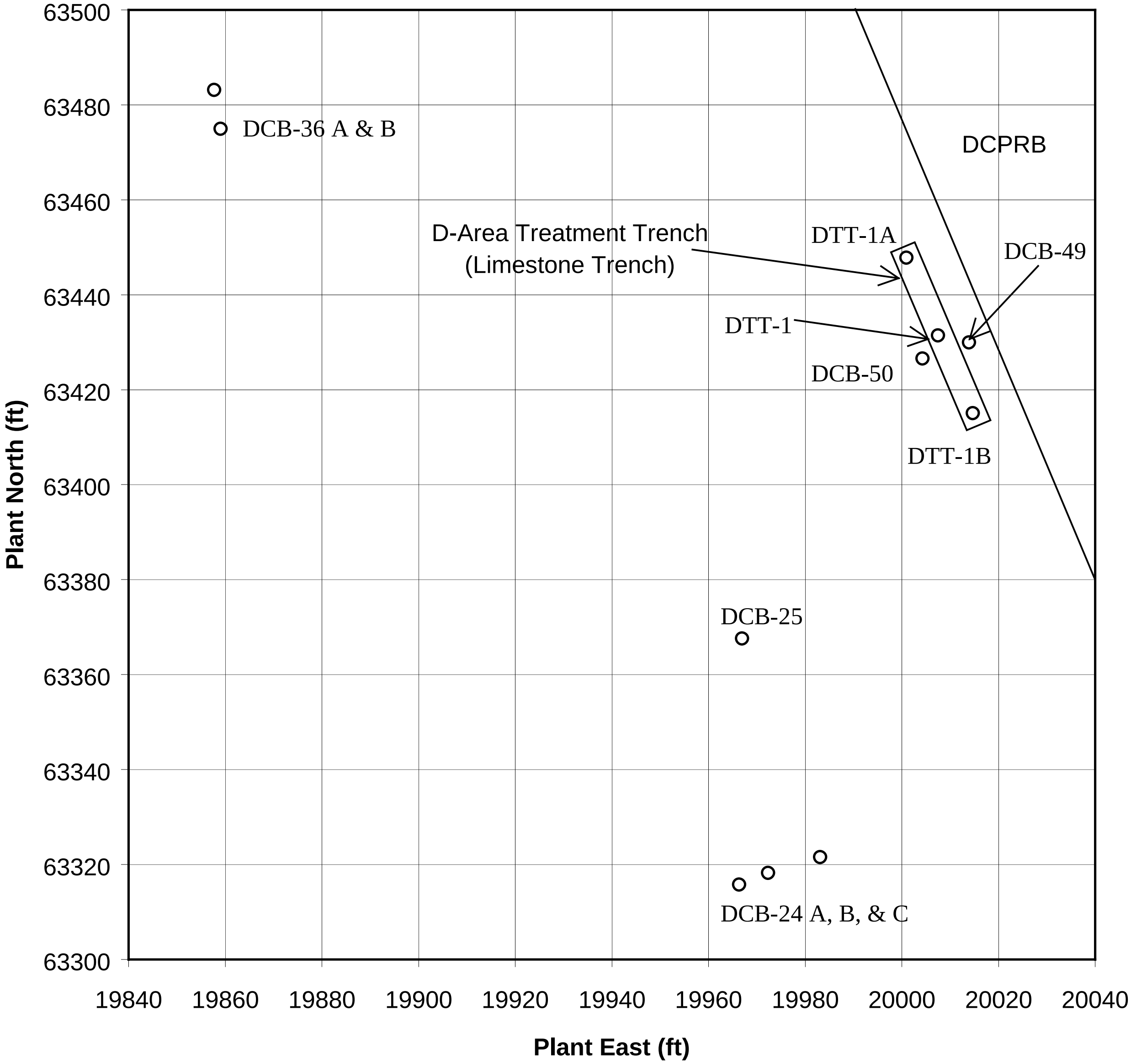
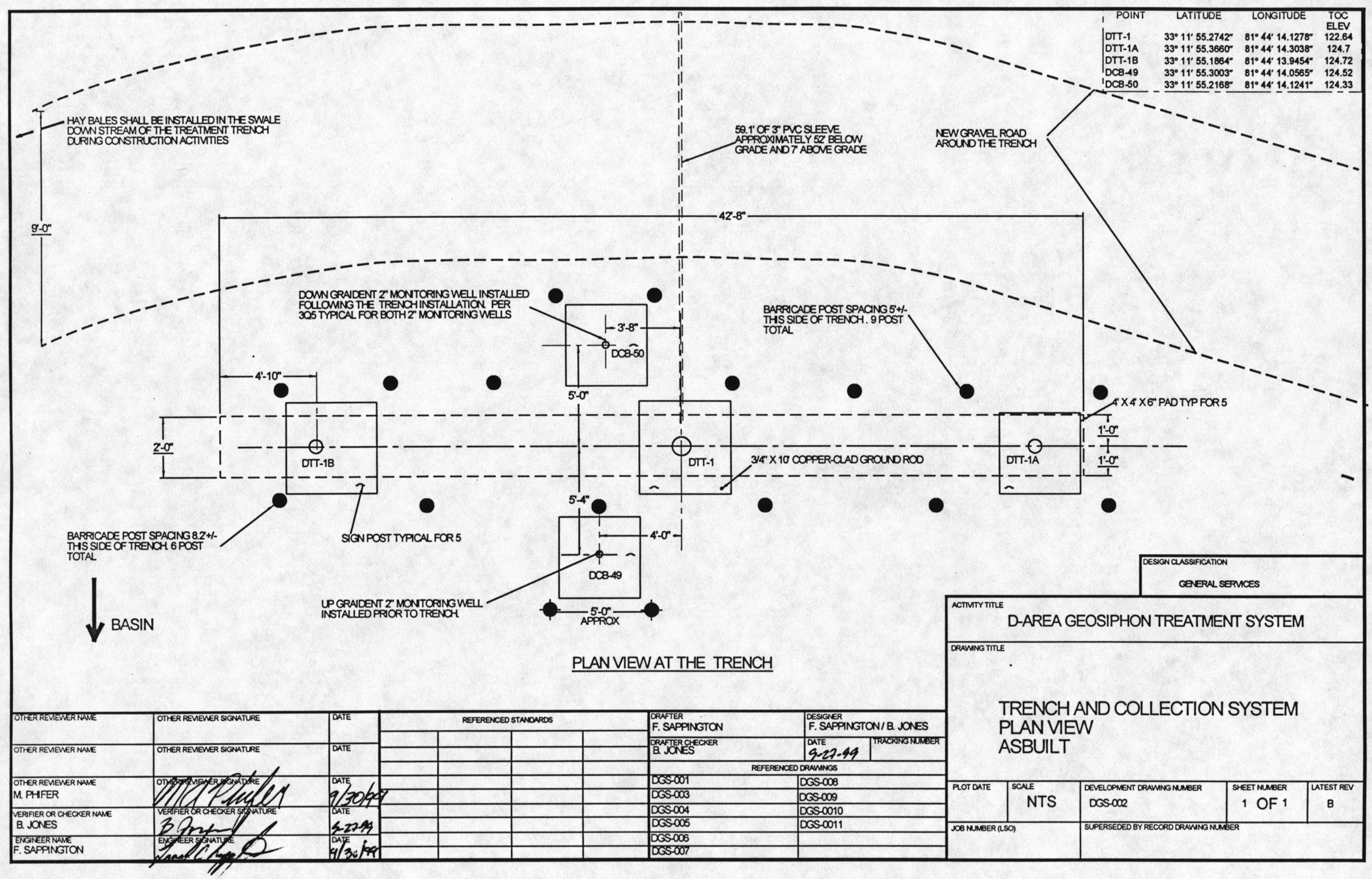


Figure 2. **DTT-1 and Adjacent Monitoring Wells Location Map**



POINT	LATITUDE	LONGITUDE	TOC ELEV
DTT-1	33° 11' 55.2742"	81° 44' 14.1278"	122.64
DTT-1A	33° 11' 55.3660"	81° 44' 14.3038"	124.7
DTT-1B	33° 11' 55.1864"	81° 44' 13.9454"	124.72
DCB-49	33° 11' 55.3003"	81° 44' 14.0565"	124.52
DCB-50	33° 11' 55.2168"	81° 44' 14.1241"	124.33

Figure 3. DTT-1 Plan View (Washburn et al. 1999)

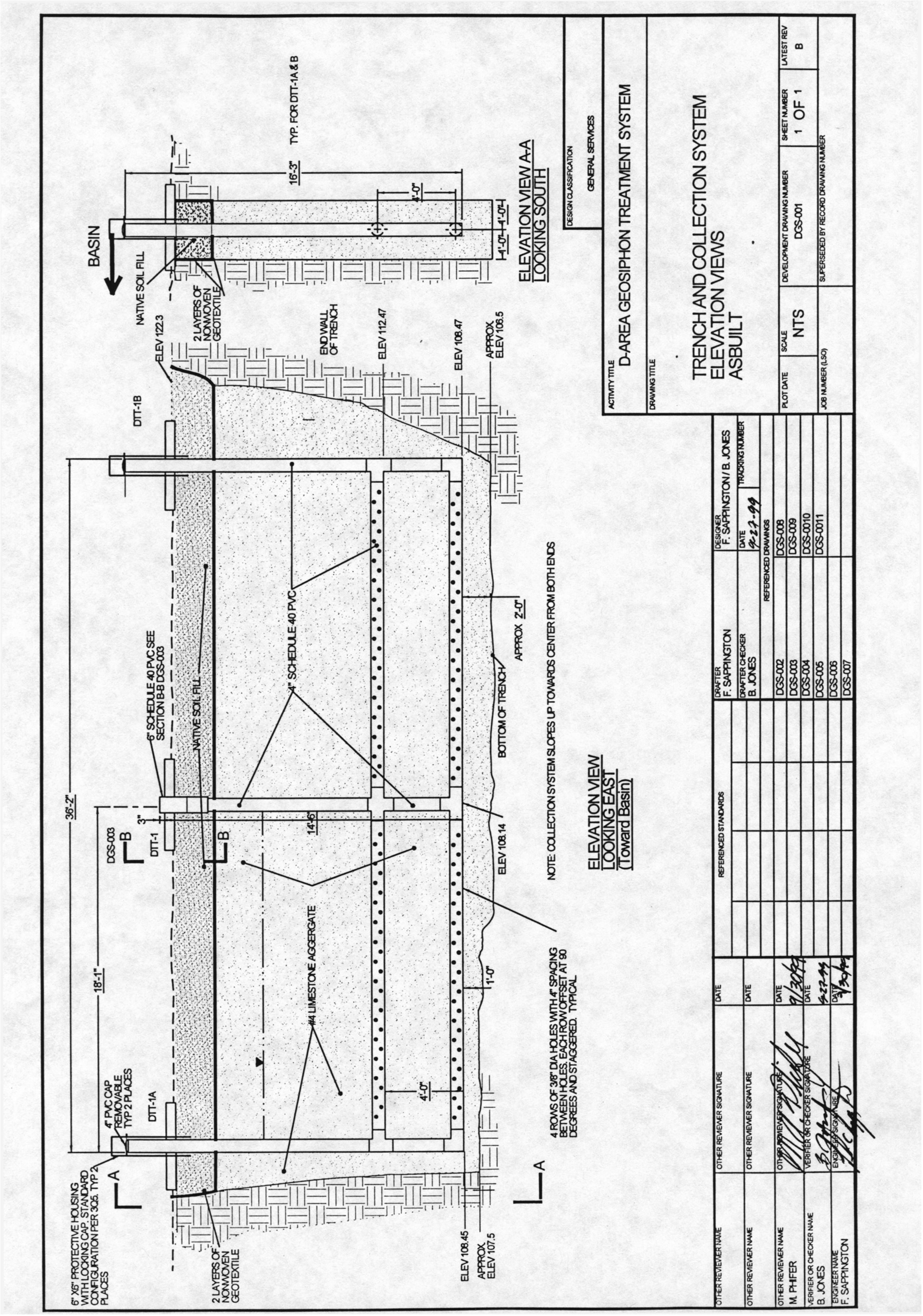


Figure 4. DTT-1 Cross-Section (Washburn et al. 1999)

4.0 DTT-1 HYDRAULIC EVALUATION

The hydraulic activity of the limestone trench has been addressed by determining the current specific capacity of the trench and comparing it to that previously determined following its installation in 1999. Table 2 provides the 1999 specific capacity estimates. The 1999 estimated specific capacities ranged from 0.402 to 0.562 gpm/ft with an average and standard deviation of 0.562 and 0.054 gpm/ft, respectively. (Washburn et al. 1999)

The current specific capacity estimates were obtained by pumping the trench, measuring drawdown and flow, and then calculating the specific capacity (flow rate divided by drawdown). Water level measurements, which were used to determine the drawdown, were taken continuously with pressure transducers and periodically with an electric water level tape. The periodic flow rate measurements were made using a known volume and stop watch. The current specific capacity estimates have been determined at approximately the same flow rates and durations since pumping began as those determined in 1999. The 1999 specific capacity estimates were made based upon flow rates ranging from approximately 0.4 to 1.2 gpm taken at durations of approximately 24 and 48 hours since pumping began. For the current testing water level measurements began approximately four days prior to initiating pumping and continued through completion of pumping. Two pumping episodes were conducted during December 2002 at flows of approximately 0.5 gpm and 1 gpm, respectively, with an approximately five-day recovery period in between. Additionally D-Area rainfall data for the testing period was also obtained. Figure 5 provides a summary of the 2002 data measured.

Data utilized to make the 2002 specific capacity estimates were obtained at approximately 24 and 48 hours since pumping began during periods like that of the 1999 estimates. The specific capacity data at these times was only utilized when the drawdown appeared to have stabilized as indicated by relatively constant elevations, rainfall did not appear to impact the water elevation, and the flow rate had not recently been adjusted (see Figure 5). The flow rates utilized to estimate the 2002 specific capacity are denoted by an “×” in Figure 5.

Table 3 presents the current specific capacity estimates based upon both drawdowns determined by electric water level tape (DTT-1) and pressure transducer (DTT-1B) measurements. The

December 2002 specific capacity estimates consist of three measurements ranging from 0.431 to 0.506 gpm/ft with an average of 0.459 gpm/ft for estimates based upon electric water level tape measurements. The same estimates range from 0.450 to 0.523 gpm/ft with an average of 0.481 gpm/ft for estimates based upon pressure transducer measurements. The estimates based upon pressure transducer measurements are on average 5% higher than those based upon electric water level tape measurement. Appendices A-1 and A-2 provide the detailed flow measurements and water elevations as determined from electric water level tape measurements, respectively.

As seen in Table 2 the 1999 specific capacity estimates consist of ten measurements ranging from 0.402 to 0.562 gpm/ft with an average of 0.489 gpm/ft and a standard deviation of 0.054 gpm/ft. The 1999 specific capacity estimates were based upon DTT-1 drawdown determined only by electric water level tape. While the 2002 averages are slightly less than the 1999 average (by less than 7%), the 2002 averages are based upon only three measurements versus ten in 1999. Additionally as seen in Figure 6 all of the 2002 data falls within the range of the 1999 data, and all but one of the 2002 data points lie within one standard deviation of the 1999 average. Therefore based upon this comparison it is concluded that little if any reduction in specific capacity has occurred between 1999 and 2002. That is the limestone trench appears to be essentially as hydraulically active now as it was at its installation. This indicates that precipitate accumulation has not significantly plugged the limestone or the formation.

Table 2. 1999 Limestone Trench (DTT-1) Specific Capacity

Approximate Duration Since Pumping Began (hours)	Flow (gpm)	Specific Capacity (gpm/ft)	Specific Capacity (cfs/ft)
53	0.40	0.407	0.00091
47	0.41	0.466	0.00104
26	0.44	0.562	0.00125
24	0.58	0.521	0.00116
47	0.65	0.500	0.00111
25	0.69	0.552	0.00123
50	1.03	0.481	0.00107
24	1.14	0.402	0.00090
48	1.14	0.487	0.00109
25	1.17	0.515	0.00115
Average		0.489	0.00109
Standard Deviation		0.054	0.00012
Average - One Standard Deviation		0.436	0.00097
Average + One Standard Deviation		0.543	0.00121

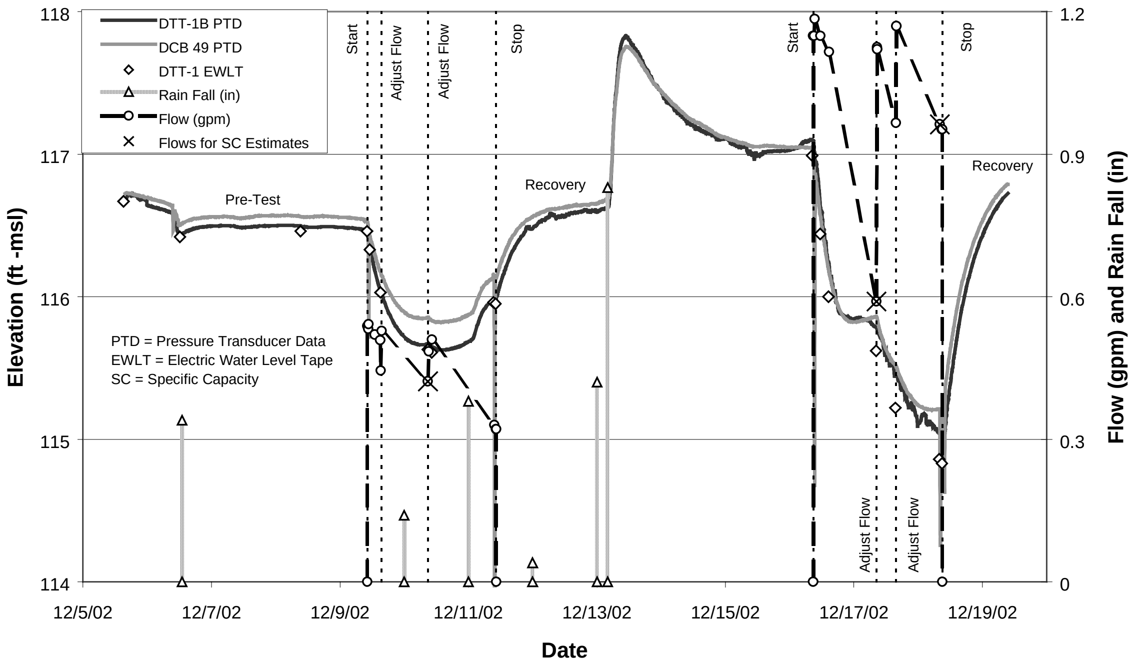


Figure 5. 2002 Data Measurement Summary

Table 3. 2002 Limestone Trench (DTT-1) Specific Capacity

Pre-pumping Water Elevation			Pumping Water Elevation			Approximate Duration Since Pumping Began (hours)	Flow			Specific Capacity (gpm/ft)	Specific Capacity (cfs/ft)
Date	Time	Water Elevation (ft-msl)	Date	Time	Water Elevation (ft-msl)		Date	Time	Flow (gpm)		
2002 Specific Capacity Estimates Based on Pressure Transducer Water Level Measurements in DTT-1B											
12/9/02	10:04	116.470	12/10/02	8:49	115.667	23	12/10/02	8:50	0.42	0.523	0.00117
12/16/02	8:49	117.095	12/17/02	8:19	115.785	24	12/17/02	8:24	0.59	0.450	0.00100
12/16/02	8:49	117.095	12/18/02	8:04	115.045	48	12/18/02	8:04	0.96	0.468	0.00104
									Average	0.481	0.00107
2002 Specific Capacity Estimates Based on Electric Water Level Tape Measurements in DTT-1											
12/9/02	10:07	116.46	12/10/02	8:44	115.63	23	12/10/02	8:50	0.42	0.506	0.00113
12/16/02	8:25	116.99	12/17/02	8:14	115.62	24	12/17/02	8:24	0.59	0.431	0.00096
12/16/02	8:25	116.99	12/18/02	7:50	114.86	48	12/18/02	8:04	0.96	0.451	0.00100
									Average	0.462	0.00103

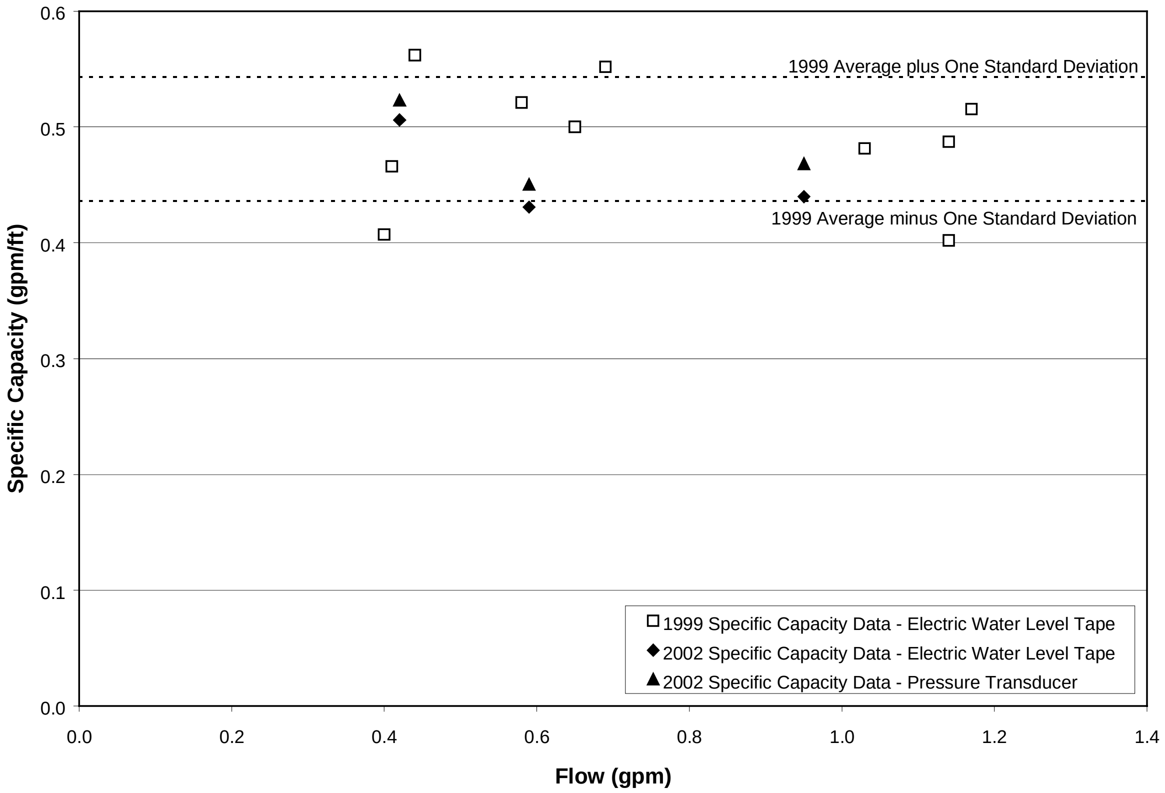


Figure 6. **1999 to 2002 Specific Capacity Comparison**

5.0 DTT-1 GEOCHEMICAL EVALUATION

To address the geochemical activity of the limestone trench, current parameters such as calcium, magnesium, aluminum, and pH have been determined and compared to that previously determined (Washburn et al. 1999). As also discovered in the earlier study, the heterogeneity of the waters entering the trench makes it difficult to assess the magnitude of the effects of the limestone trench. However, relationships among chemical constituents together with field parameter profiles and samples provide information regarding influent waters, their interaction with the limestone trench and the impact on downgradient waters. Appendices B-1 through B-6 provide the detailed data utilized in this geochemical discussion.

Compositional Heterogeneity

Field parameter profiles illustrate the compositional heterogeneity within DCB-49 and the trench (Figure 7). The upper six feet of the DCB-49 screen zone consists of waters with low conductivity (< 100 uS/cm) and pH's near 4. In the bottom two feet of the screen zone, the pH drops to 3.2 and conductivity increases to 3000 uS/cm reflecting higher concentrations of dissolved ions (e.g. sulfate, aluminum, iron, hydrogen). This change in the DCB-49 profile suggests that the plume emanating from the basin is stratified, with the lower portion of DCB-49 reflecting a more contaminated part of the plume. Waters with differing geochemistries are also found within the limestone trench. The upper portion of the trench (elevation 112.5–115.5 feet) consists of relatively low conductivity (500 uS/cm), pH neutral waters. Additionally, collected samples have low concentrations of sulfate, aluminum, and iron (Appendix B-3). However, with depth the pH decreases to 4 and conductivity increases to 1500 uS/cm. Collected samples have high concentrations of sulfate, aluminum, and ferrous iron. These findings are consistent with the stratification seen in the depth discrete samples collected in 1999, which showed that aluminum concentrations varied from <2 mg/L to 135 mg/L and pH varied from 5.33 to 3.87 over a 2-foot interval (Washburn et al. 1999).

Discrepancies found between the field parameter profiles and the field measurements of the samples collected for elemental analysis (represented as circles on Figure 7) most likely reflect artifacts of sampling. Purge rates and volumes during sample collection may have caused waters with differing geochemistries to mix and resulted in the collection of waters that are not representative of the heterogeneity present. In particular, the lower samples collected in DTT-1 and DTT-1B had field measurements and elemental concentrations more similar to the water in the upper part of the trench than the bottom water of the trench. Similarly, the sample collected from DCB-49 had field measurements representative of its lower, more contaminated water.

Calcium and Magnesium Concentrations

The relationship between calcium and magnesium concentrations is useful in evaluating the dissolution of limestone in the trench. In DCB-49 the concentrations of calcium and magnesium are linearly correlated and although their concentrations are higher than they were in 1999, their ratio is consistent with the ratio found in the earlier study (Figure 8). Limestone from the same batch as used in the trench was dissolved in acidic water and found to have a different ratio than that of DCB-49. More specifically, the dissolved limestone had a calcium concentration of 5.68 mg/L and a magnesium concentration of 0.69 mg/L (Washburn et al. 1999). This ratio can be used to plot the dissolution line of the limestone, which shows the calcium to magnesium ratio expected as limestone dissolves.

Samples collected from the trench in 1999 fall between the two lines (DCB-49 and the limestone dissolution line) indicating that their waters are a sum of the influent water concentrations and the limestone dissolution (Figure 8). Unlike the 1999 trench samples, most of the current trench samples plot on the limestone dissolution line suggesting that the calcium and magnesium come from limestone dissolution with very little influence from DCB-49 water. These samples include those collected from DTT-1, DTT-1B, and the shallow sample from DTT-1A. As discussed above, the lower samples collected from DTT-1 and DTT-1B appear to be more representative of the upper trench chemistry than the bottom chemistry and so plot on the limestone dissolution line as well. The lower DTT-1A sample is the only trench sample that does not fall on the limestone dissolution line and shows a calcium to magnesium ratio more similar to DCB-49 (the influent water). Samples collected from DTT-1 after the 48-hour pump tests also fall between the limestone dissolution line and DCB-49 and most likely represent the lower more contaminated influent water being pulled in to the trench (Figure 9). Samples collected from DCB-50 presumably reflect the mixing of waters exiting the trench (having interacted with the limestone) and waters that have not been impacted by the trench. The DCB-50 calcium and magnesium concentrations and ratio from this study are consistent with the values from the 1999 study (Figure 10).

Aluminum Concentrations

As in 1999, aluminum concentrations in DCB-49 are linearly correlated with calcium concentrations (Figure 11). Although their concentrations are higher than they were in 1999, their ratio is consistent with the ratio found in the earlier study. This relationship between calcium and aluminum can also be used to calculate the original concentration of aluminum of the waters entering the trench. Using mass balance, the equations relating calcium to magnesium for the limestone and DCB-49 can be applied to determine the original calcium concentration of the influent waters (Figure 12) and thereby the correlative aluminum concentrations. Based on these calculations, the upper influent waters currently entering the trench have little aluminum. However, the bottom influent waters, as represented by the lower sample of DTT-1A and the samples collected after the pump tests, have aluminum concentrations between 65 and 75 mg/L. DCB-49's field parameter profile and the 1999 DTT-1 depth discrete sampling (Washburn et al. 1999) also support this stratification of influent waters.

At the trench, white precipitates were observed during purging and were collected for x-ray diffraction and x-ray fluorescence analysis. These analyses indicate that an amorphous aluminum hydroxide is or has been precipitating in the trench (Appendix B-6). It is likely that the precipitation of aluminum hydroxides is occurring in the portions of the trench where aluminum concentrations and pH are elevated. Figure 13 shows a solubility curve for a potential aluminum hydroxide precipitate. It suggests that aluminum and pH conditions are favorable for aluminum hydroxide precipitation in portions of the trench. The acidic conditions (pH <5) of the bottom of the trench (as indicated by the field profile) would not be as conducive for aluminum precipitation despite the high concentration of aluminum in the influent waters. Since the upper influent waters of the trench have low calculated aluminum concentrations, aluminum hydroxide precipitation may be most favored in the middle of the trench where there is a blending of water chemistries.

Comparison of 1999 and 2002 samples collected from DCB-50 indicates a decrease in aluminum concentrations in the downgradient waters, which most likely reflect the impact of the limestone trench (Table 4). The field parameter profile also implies that for this study waters within DCB-50's screened elevation are less stratified than they are upgradient of the trench and therefore the low aluminum concentration in the sample collected may reflect the water throughout this screened interval. It is likely that DCB-50 currently reflects a mixture of waters that have reacted with the trench (consequently having relatively high pH and low aluminum concentrations) and waters that have not come into contact with the limestone (having low pH and high aluminum concentrations).

pH

Results from this study indicate that the limestone trench remains effective at raising the pH and suggest that its impact may now be seen in the pH of DCB-50. Based on field parameter profiles and collected water samples, the upper portion of the trench (elevation 111-115.5 feet) appears to be able to raise the pH of influent waters to 5 or greater (Figure 7). The upper 3 feet of this portion consists of waters that primarily reflect limestone dissolution as evidenced by the pH's of 7 and calcium to magnesium ratios of collected water samples. In contrast, the lower part of the trench (elevation 108.5-110.5) consists of more acidic waters with pH's near 4. In the downgradient well, DCB-50, pH remains constant near or above 5 throughout the screen zone. Additionally, samples collected after purging and the 48-hour pumps tests also had pH's above 5, which may reflect the extensive nature of these waters. These pH's are higher than those seen in DCB-50 in the 1999 study and are supporting evidence that the limestone trench is impacting downgradient waters (Table 4).

Geochemical Conclusions

The following are the primary geochemical conclusions associated with this evaluation:

- The geochemistries of upgradient plume waters and waters within the limestone trench are highly stratified as documented in the 1999 study.
- Overall, the limestone trench remains an effective treatment for increasing the pH and removing aluminum near the DCPRB. Analysis of collected precipitates indicates that aluminum removal is occurring through the precipitation of aluminum hydroxide

minerals. Iron armoring of the limestone (i.e. the precipitation of ferric hydroxide coatings) does not appear to be significant for the following reasons:

1) Waters within the upper part of the trench have low iron concentrations and have pH’s and calcium to magnesium ratios indicating that the limestone is still active, and
2) Waters within the lower part of the trench are dominated by ferrous iron as indicated by iron speciation analyses (see Appendix B-4).

- The impact of the limestone trench on downgradient waters is evident in the increase of pH and decrease of aluminum in DCB-50. In addition, a profile of field parameters within DCB-50’s screen zone suggests that waters downgradient of the trench may be less stratified.
- The longevity and effectiveness of the limestone trench may be impacted by the buildup of aluminum hydroxide precipitates. It is unclear whether aluminum hydroxide precipitation is contributing to the difference in reactivity of the limestone in the upper (more reactive) part versus the lower (less reactive) part of the trench. The stratification of the influent waters, differences in residence times, the buildup of aluminum hydroxide precipitates, or a combination of these factors may be contributing to the differences of limestone reactivity in the trench. Methods that could be used to determine the effects of aluminum hydroxide precipitation on limestone reactivity in the trench include:
    1) Field measurement profiles before and after heavy purging to elucidate whether the removal of aluminum precipitates increases the limestone reactivity, and
    2) Introducing retrievable pieces of limestone at various depths within the trench and evaluating the impacts from the stratified influent waters (e.g. dissolution, precipitation of aluminum hydroxides) on the limestone pieces.

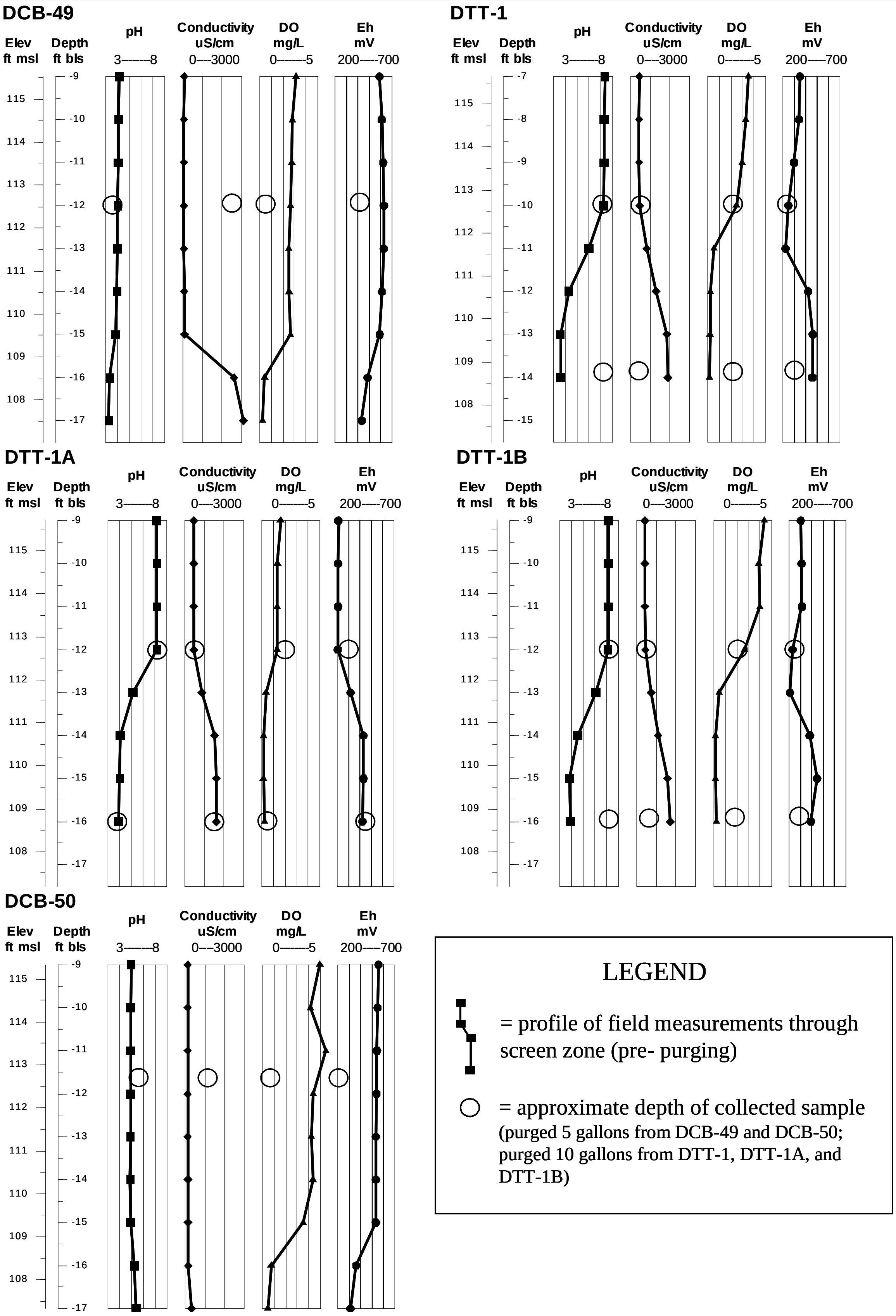


Figure 7. Field Measurement Profiles and Collected Samples

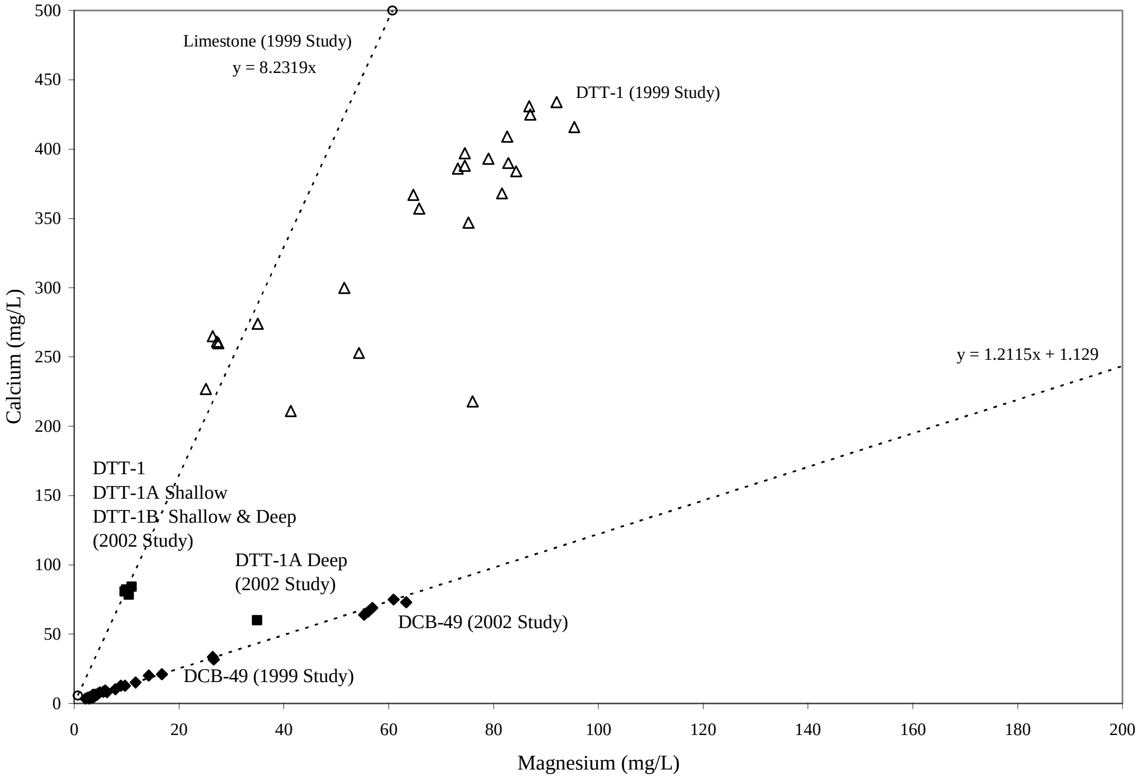


Figure 8. DCB-49 and DTT-1 Calcium Versus Magnesium Concentrations

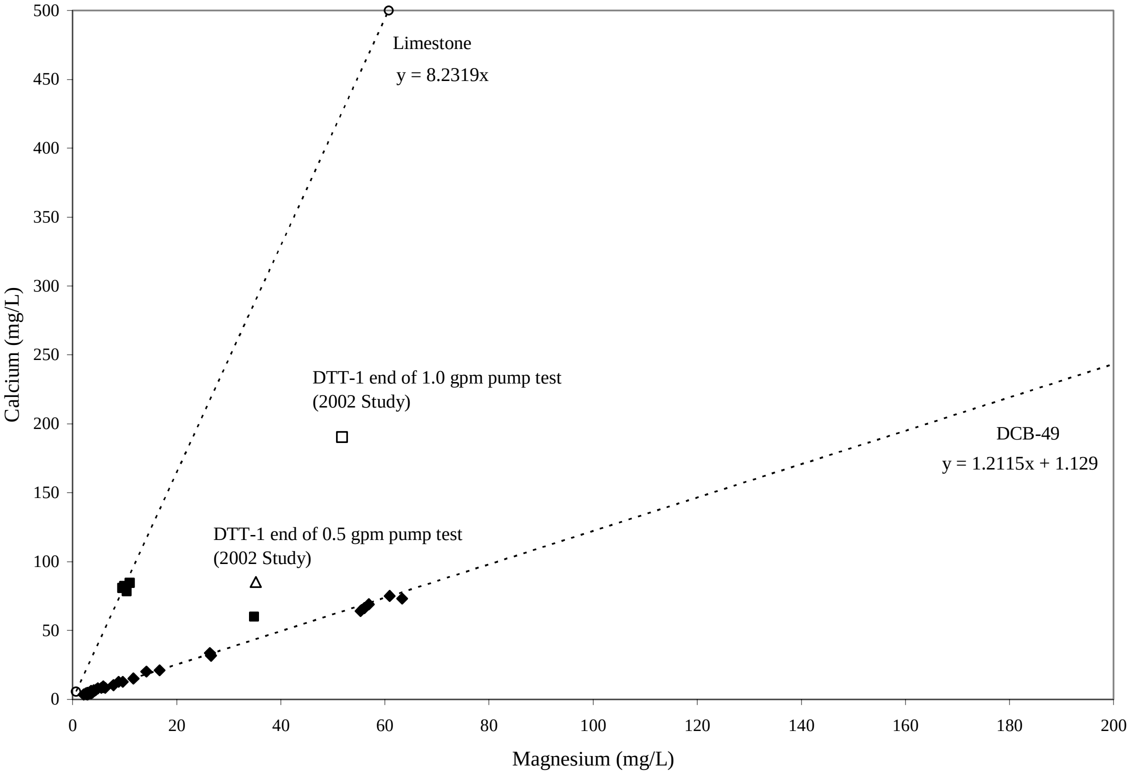


Figure 9. DTT-1 Post Pump Tests Calcium Versus Magnesium Concentrations

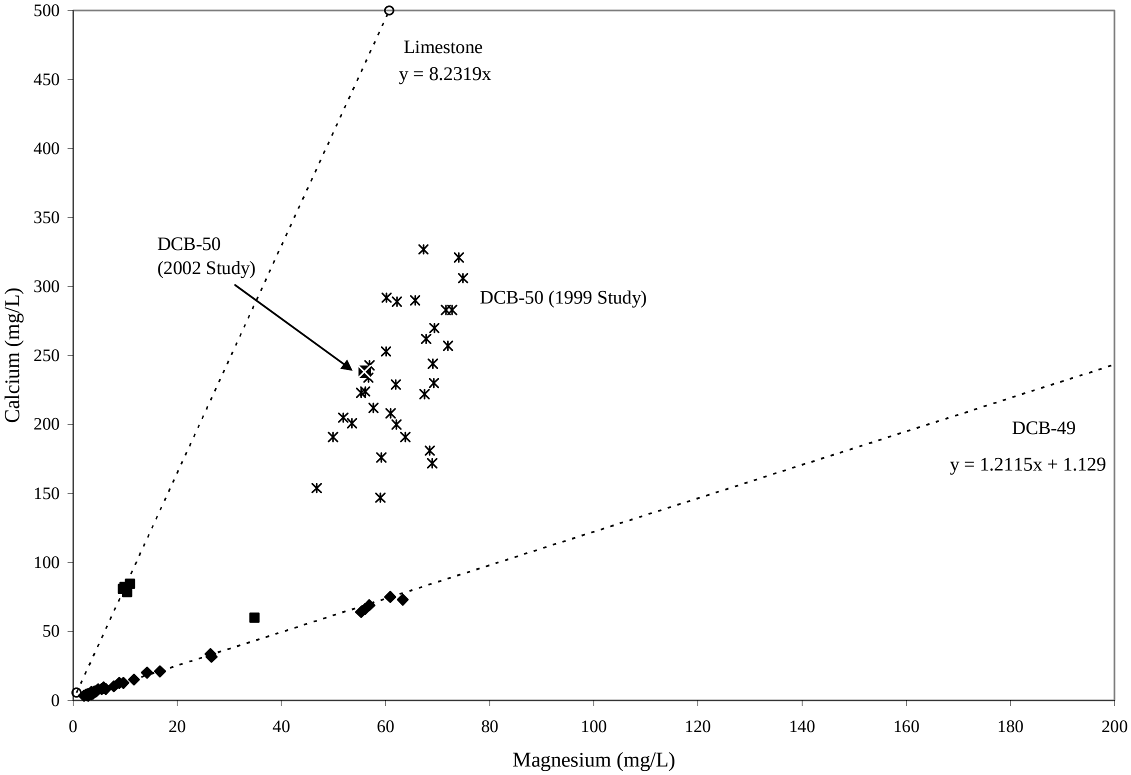


Figure 10. DCB-50 Calcium Versus Magnesium Concentrations

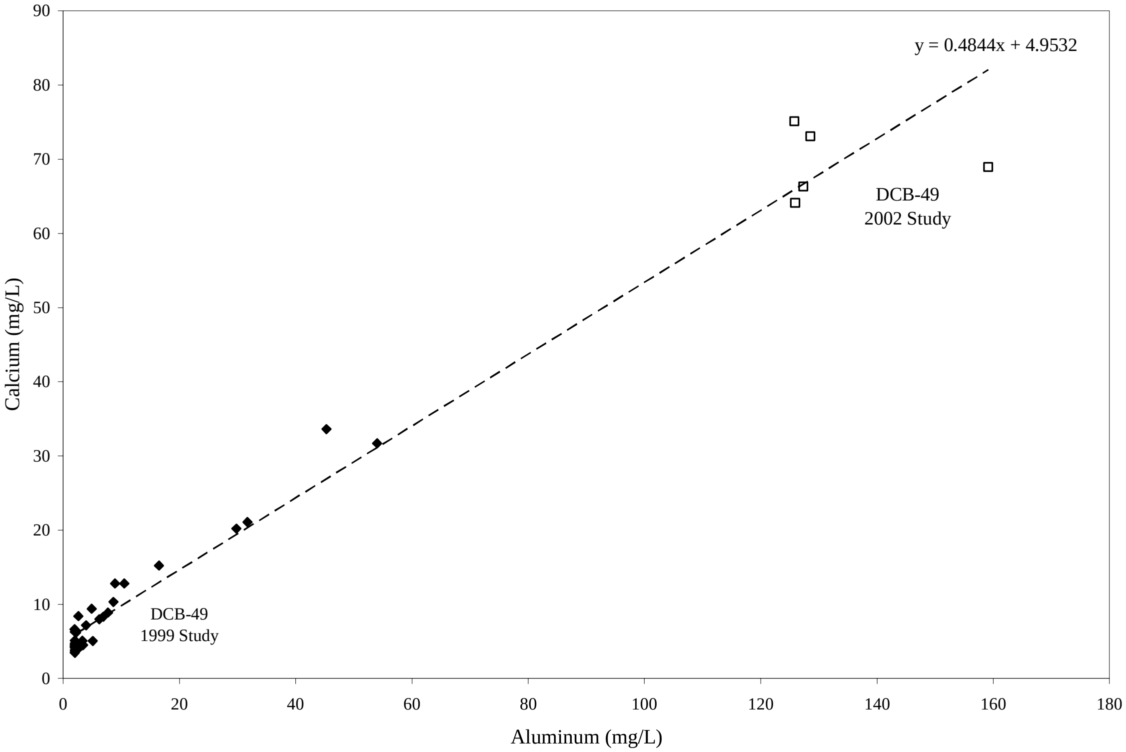


Figure 11. DCB-49 Calcium Versus Aluminum Concentrations

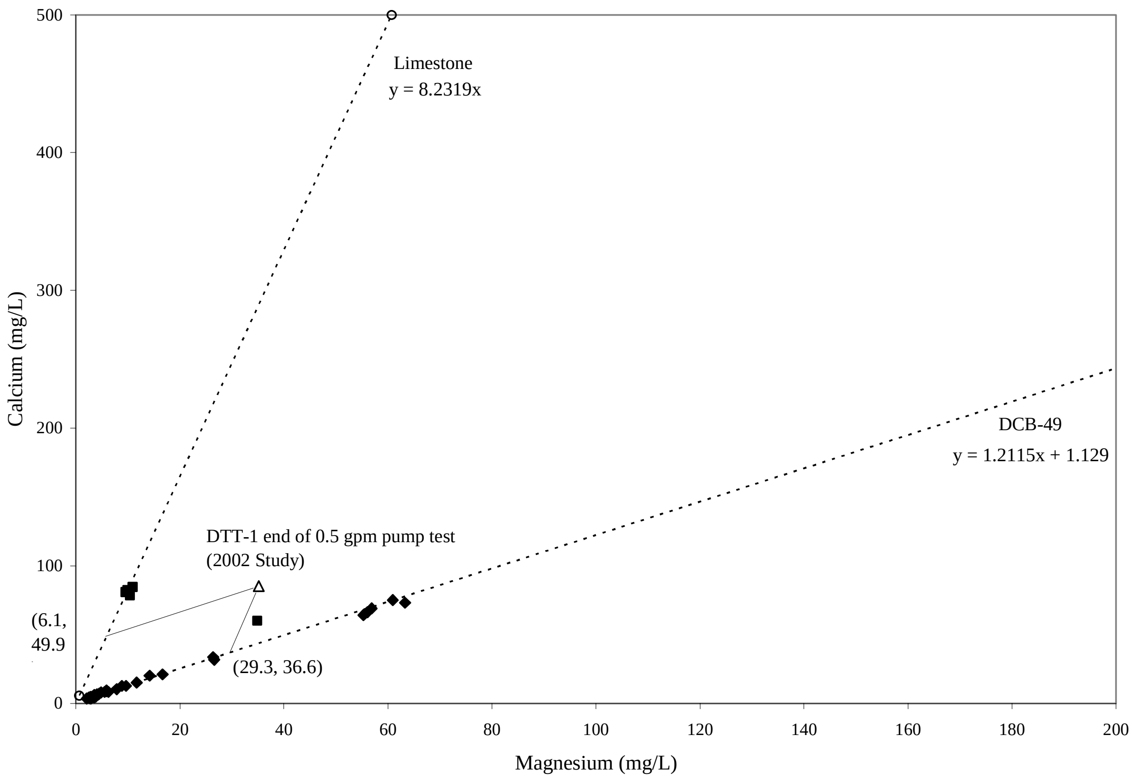


Figure 12. **Method of Calculation of Calcium and Magnesium Concentrations in Influent Water**

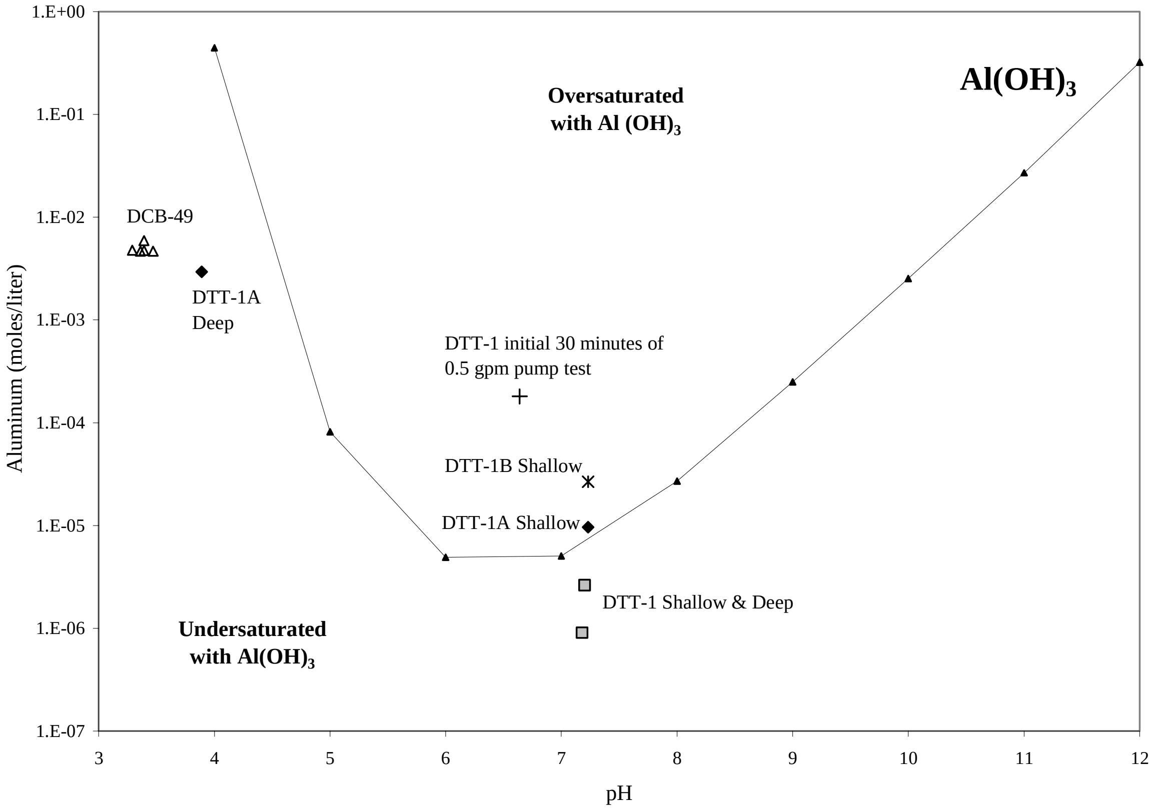


Figure 13. **$Al(OH)_3$ Solubility Diagram**

Table 4. DCB-50 Aluminum and pH Concentrations

Parameter	Statistical Parameter	1999 Value	2002 Value [1]
Aluminum (mg/L)	Minimum	28.8	0.648
	Maximum	100	
	Median	51.35	
	# of samples	32	1
pH	Minimum	3.38	5.68
	Maximum	5.04	6.04
	Median	3.88	5.89
	# of samples	32	3

[1] One sample collected for Al analysis on 12/6/02; pH data from 12/6/02 during and after sample collection and 12/18/02 at the end of the 48-hour 1 gpm pump test

6.0 DTT-1 SULFATE REDUCTION POTENTIAL EVALUATION

To address the existing sulfate reduction potential that exists within the trench the following evaluations have been performed:

- The existing limestone trench SRB and general microbial activity have been evaluated, and
- Existing limestone trench conditions have been compared to both optimal sulfate reduction conditions and the current sulfate reduction, field study (i.e. pre and post soybean oil injection conditions at the D-Area Interceptor Well (DIW-1)).

Sulfate Reducing Bacteria (SRB)

Microorganisms that couple the oxidation of carbon substrates to the reduction of sulfate for energy production and growth are known as sulfate reducing bacteria (SRB). In this process sulfate serves the same function as oxygen does for aerobic respiration (i.e. terminal electron acceptor). However SRB cannot use oxygen as terminal electron acceptors. In fact oxygen is toxic to SRB above trace levels.

During growth of SRB carbon is oxidized and sulfate is reduced to hydrogen sulfide (H_2S). Hydrogen sulfide can also react with metals in the environment and result in their immobilization via the formation of reduced minerals. When SRB oxidize a carbon source the resulting bicarbonate (HCO_3^-) serves to buffer the system (i.e. HCO_3^- can combine with additional hydrogen ions to form H_2CO_3). This in turn can react with metals to form carbonate minerals. The reduction of sulfate consumes electrons and results in an increased pH of the system. The increased pH can also result in metal immobilization through metal hydroxide formation. The ubiquity of SRB in the environment and their ability to catalyze biogeochemical transformation of minerals has been exploited for use in bioremediation.

Optimal Sulfate Reduction Conditions

SRB are widespread in the environment and grow best in a pH range from 5.5 – 9.0. However sulfate reduction has been recorded from acid mine drainage and a fresh water peat bog with pH values as low as 2.5. This may be due to the formation of biofilms of SRB around geologic substrates that provide a more alkaline microenvironment and therefore allow sulfate reduction to occur under otherwise harsh conditions.

Lactate and pyruvate are almost universally used as an organic carbon substrate and electron donor by SRB. Lactate is ideal for increasing SRB activity, however concentrations above 6 g/L may be inhibitory to SRB (Turick et al. 2002). Vegetable oil has been used in the bioremediation industry as a slow release carbon source for primarily chlorinated organic degradation and based on results to date is viewed favorably. Vegetable oil can provide a significant amount of carbon to SRB as a result of its breakdown by fermentative bacteria.

SRB compete for organic carbon substrates and micronutrients (nitrogen and phosphate) with both aerobic bacteria (i.e. use O_2 as the terminal electron acceptor) and other anaerobic bacteria that can utilize terminal electron acceptors other than sulfate. The major anaerobic competitors use the following as terminal electron acceptors: NO_3^- (nitrate reducers), Mn^{+4} (manganese reducers), Fe^{+3} (iron reducers) and CO_2 (methanogens). When sulfate concentrations are high relative to O_2, NO_3^-, Mn^{+4}, and Fe^{+3}, SRB are expected to predominate. Sulfate reduction is more thermodynamically favorable than methanogenesis and will therefore predominate so long as significant sulfate is available regardless of the CO_2 concentrations.

Existing Microbial Activity within and Downgradient of the Limestone Trench

Existing microbial activity including SRB within and downgradient of the limestone trench can be evaluated by comparing the upgradient values of total organic carbon (TOC), total microbes, sulfate/hydrogen sulfide, SRBs, pH, Eh (redox potential), and dissolved oxygen (DO) to that within and downgradient of the trench. Table 5 provides these parameters for monitoring well DCB-49 (upgradient), the trench itself (DTT-1A, DTT-1, and DTT-1B), and monitoring well DCB-50 (downgradient). However the following parameters can not be used as evidence of increased microbial activity within and downgradient of the trench for the following reasons:

- TOC can not be used, due to the very low TOC levels, and
- pH can not be used, due to the presence of the limestone, which increases the pH abiotically.

The following parameters (Table 5) are indicative of microbial growth as discussed:

- The total number of microbes is greater by about one order of magnitude within (DTT-1A, DTT-1, and DTT-1B) and downgradient (DCB-50) of the limestone trench from that upgradient (DCB-49) indicating that the limestone trench has been conducive to overall microbial growth. Since SRB often grow as part of complex microbial consortia, increased overall bacterial populations would be conducive to SRB activity, especially in environments that are not optimum to SRB. Additionally the total microbial count was even higher within sludge recovered from the trench (see Appendix C-1).
- The sulfate/hydrogen sulfide data, in particular, is indicative of SRB growth, since SRB decrease sulfate and increase hydrogen sulfide concentrations as a function of growth. As shown in Table 5 sulfate has decreased and hydrogen sulfide has increased within and downgradient of the limestone trench from that upgradient indicating that the limestone trench has been conducive to SRB growth. Hydrogen sulfide levels are temporal since it readily combines with many metals to form metal sulfide precipitates and it is transported as gas bubbles out of the groundwater. Therefore a direct one to one correlation between the reduction in sulfate levels and

increases in hydrogen sulfide levels is not possible. Additionally it is unlikely that the low sulfate levels generally found in the trench are entirely due to SRB growth. Plume stratification could also impact the level of sulfate within the trench.

- More directly the SRB concentration has slightly increased within and downgradient of the limestone trench from that upgradient again indicating that the limestone trench has been conducive to SRB growth. Additionally the SRB concentration was even higher within sludge recovered from the trench (see Appendix C-1).
- The Eh has decreased within and downgradient of the limestone trench from that upgradient which is indicative of anaerobic activity.

The dissolved oxygen levels within the limestone trench are higher than either the upgradient or downgradient levels. This may be due to the proximity of the limestone to the ground surface and the large void spaces of the limestone, which facilitates the transfer of atmospheric air (i.e. oxygen) into the trench water. However as shown in Figure 7 dissolved oxygen concentrations decrease as a function of depth in all the wells tested which is indicative of aerobic microbial activity.

Overall the data indicates that the limestone trench has resulted in increased microbial activity including SRB activity.

Limestone Trench Comparison to Optimal Sulfate Reduction Conditions and the Current Sulfate Reduction Field Study

Optimal sulfate reduction conditions are provided in Table 6 for comparison to the conditions upgradient (DCB-49), within (DTT-1A, DTT-1, and DTT-1B), and downgradient (DCB-50) of the limestone trench. The optimal conditions in this table are somewhat conservative because SRB activity can occur in microbial biofilms where conditions approach optimum for SRB even though the environment outside the biofilm is less than optimal. The ability to isolate SRB from environments as harsh as DCB-49 indicates that bacterial biofilms are present. As shown in the table the presence of the limestone trench has had the following beneficial impacts relative to approaching optimal sulfate reduction conditions from upgradient conditions (DCB-49):

- The pH has increased to within the optimal range within and downgradient of the trench.
- The Eh has decreased toward optimal conditions.
- The total SRB numbers have increased.
- The manganese, iron, and aluminum concentrations have all decreased.

While conditions have improved with flow through the limestone not all parameters are within the optimal range. However as shown in Table 7 the conditions downgradient (DCB-50) of the limestone trench are generally better than the pre-injection conditions at the D-Area Interceptor Well (DIW-1) as represented by data from piezometer DIW-P07A, where soybean oil was injected as an organic carbon substrate. The primary limiting factor to the promotion of sulfate reduction remediation at the limestone trench is the lack of available organic carbon substrate, since the rate of SRB growth is largely dependent on the type and amount of organic carbon entering the system. Due to the low organic carbon concentrations at the trench, SRB growth was expected to be slow as indicated by the data. Accelerated SRB growth and subsequent metals remediation could be accomplished through the addition of a suitable organic carbon substrate such as soybean oil similar to what has been accomplished at DIW-1. However injection of soybean oil within the limestone trench is not recommended for the following reasons:

- As seen in Table 5 the sulfate concentrations within the limestone trench are considerably less than downgradient of the trench. As outlined previously higher sulfate concentrations favor SRB dominance, since sulfate is the terminal electron acceptor.
- Also as seen in Table 5 the dissolved oxygen concentration with the limestone trench is higher than downgradient of the trench. As outlined previously oxygen is toxic to SRB and the downgradient concentrations are more favorable.
- Injection of soybean oil within the limestone will result in coating the limestone and may reduce its geochemical activity. Additionally sulfate reduction promoted within the limestone will result in the precipitation of metals on the limestone, which may also reduce its geochemical activity.

For these reasons it is recommended that if soybean oil is injected in conjunction with the limestone trench that it be injected downgradient of the trench.

DTT-1 Sulfate Reduction Potential Conclusions

Microbial activity, including SRBs, is greater within and downgradient of the trench than upgradient, primarily due to the increased pH produced by the limestone trench. Additionally the limestone trench has in general improved conditions both within and downgradient of the trench relative to optimal sulfate reduction conditions from that upgradient. In fact the conditions within and downgradient of the trench are markedly better relative to optimal sulfate reduction conditions than that of DIW-1 prior to injection of the soybean oil into it. The injection of soybean oil into DIW-1 has successfully promoted sulfate reduction remediation in that location. The primary limiting factor to the promotion of sulfate reduction remediation at the limestone trench is the lack of available organic carbon substrate therefore the addition of soybean oil should result in such remediation. However due primarily to the possibility of limestone deactivation with the injection of soybean oil into the limestone trench, it is recommended that if soybean oil at this location that it be done downgradient of the trench.

Table 5. Microbial Parameters

Sample Location	Sample Depth (ft)	TOC (mg/L)	Total Microbes (cells/ml)	SO_4 (mg/L)	H_2S (mg/L)	SRB (cells/ml)	pH	Eh (mV)	DO (mg/L)
DCB-49	11.7	3.1	3.95E+04	2556	< 0.05	1.84E+01	3.29	432	0.541
DTT-1A	11.9	8.3	3.29E+05	67.91	0.1	4.60E+01	7.23	304	2.012
DTT-1A	15.9	2.3	4.00E+05	1465	0.05	3.00E+01	3.89	449	0.490
DTT-1	9.8	9.4	2.72E+05	72.54	0.1	8.60E+01	7.18	255	2.114
DTT-1	13.8	8.5	3.29E+05	67.89	0.05	8.60E+01	7.2	292	2.277
DTT-1B	11.9	10.2	1.79E+05	78.62	0.08	4.60E+01	7.23	267	1.920
DTT-1B	15.9	7.4	1.14E+05	75.76	0.08	8.60E+01	7.28	284	1.822
DCB-50	11.5	7.6	2.37E+05	1262	0.14	8.60E+01	5.89	224	0.654

Note to Table 5:
TOC = total organic carbon; SRB = sulfate reducing bacteria; DO = dissolved oxygen
See Appendix C-1 for additional details concerning this data

Table 6. Limestone Trench Conditions Versus Optimal Sulfate Reduction Conditions

Parameter	Optimal Condition[1]	DCB-49	DTT-1A, DTT-1, and DTT-1B	DCB-50
pH	5.5 to 9	3.29	3.89 – 7.28 (6.67 average)	5.89
Eh	0 to –150 mV	432	255 – 449 (308 average)	224
Total SRBs	1.0E+5 – 1.0E+7 cells/ml	1.84E+01 cells/ml	3.0E+01 – 8.6E+01 cells/ml (6.3E+01 average)	8.6E+01 cells/ml
Organic Carbon Substrate	1000 – 3000 mg/L as Lactate (>6000 mg/L Lactate could be inhibitory) [2]	TOC = 3.1 mg/L	TOC = 2.3 – 10.2 (7.68 average)	TOC = 7.6 mg/L
Nitrogen: NO_3^-	mg/L range of soluble organic or inorganic nitrogen	<0.5 mg/L	<0.5 – 3.82 mg/L (2.68 average)	<0.5 mg/L
NO_2^-		10.13 mg/L	<0.5 - 6 mg/L (1.58 average)	<0.5 mg/L
NH_4^+		<0.5 mg/L	<0.5 mg/L	<0.5 mg/L
Phosphate (PO_4^{-3})	mg/L range of soluble organic or inorganic phosphate	<0.5 mg/L	<0.5 mg/L	<0.5 mg/L
Dissolved Oxygen (O_2)	<1 mg/L (toxic to SRB)	0.542 mg/L	0.49 – 2.28 mg/L (1.77 average)	0.654 mg/L
Nitrate (NO_3^-)	Small fraction of SO_4 concentration	<0.5 mg/L	<0.5 – 3.82 mg/L (2.68 average)	<0.5 mg/L
Manganese (Mn^{+4}) [3]	Small fraction of SO_4 concentration	Mn_{total} = 4.8 mg/L	Mn_{total} <0.001 – 3.277 mg/L (0.546 average)	Mn_{total} = 2.418 mg/L
Ferric Iron (Fe^{+3})	Small fraction of SO_4 concentration	Fe_{total} = 672.87 All Fe^{+2}	Fe_{total} <0.004 – 374.3 mg/L (62.4 average) All Fe^{+2}	Fe_{total} = 252.05 mg/L All Fe^{+2}
Sulfate (SO_4^{-2})	Significant SO_4 concentrations; <170 mg/L H_2S (higher concentrations may inhibit SRB)	SO_4^{-2} = 2556 mg/L H_2S <0.05 mg/L	SO_4^{-2} = 67.89 - 1465 mg/L (305 average) H_2S = 0.05 – 0.1 mg/L (0.08 average)	SO_4^{-2} = 1262 mg/L H_2S = 0.14 mg/L
Acetate CO_2 H_2	Eh > -150 mV; presence of significant sulfate	Eh = 432 mV SO_4^{-2} = 2556 mg/L	Eh = 255 – 449 mV (308 average) SO_4^{-2} = 67.89 - 1465 mg/L (305 average)	Eh = 224 mV SO_4^{-2} = 1262 mg/L
Aluminum	Low concentrations (toxic to SRB)	128.55 mg/L	0.024 – 79.31 mg/L (13.4 mg/L)	0.648 mg/L

[1] Sources for optimal sulfate reduction conditions: Benner et al. 1999; Chapelle 1993; EPA 1999; Fauque 1995; Fenchel et al. 1998; Thomas et al. 1999

[2] Turick et al. 2002

[3] Dissolved Mn data may include both $^{+2}$ and $^{+4}$ species; at the pH and Eh ranges given above, Mn^{+2} should be the dominant species present.

Table 7. D-Area Interceptor Well (DIW-1) Versus Limestone Trench Conditions

Parameter	Optimal Condition[1]	DCB-50	DIW-P07A [5] (Pre-Injection)	DIW-P07A [5] (Post-Injection)
pH	5.5 to 9	5.89	3.11	5.51
Eh	0 to –150 mV	224 mV	581 mV	129 mV
Total SRBs	1.0E+5 – 1.0E+7 cells/ml	8.6E+01 cells/ml	<7.20E+00 cells/ml	>2.20E+07 cells/ml [4]
Organic Carbon Substrate	1000 – 3000 mg/L as Lactate (>6000 mg/L Lactate could be inhibitory) [2]	TOC = 7.6 mg/L	TOC = 8.22 mg/L	TOC = 542 mg/L
Nitrogen: NO_3^-	mg/L range of soluble organic or inorganic nitrogen	<0.5 mg/L	<0.5 mg/L	<0.5 mg/L
NO_2^-		<0.5 mg/L	1.8 mg/L	<0.5 mg/L
NH_4^+		<0.5 mg/L	1.5 mg/L	<0.5 mg/L
Phosphate (PO_4^{-3})	mg/L range of soluble organic or inorganic phosphate	<0.5 mg/L	<0.5 mg/L	<0.5 mg/L
Dissolved Oxygen (O_2)	<1 mg/L (Toxic to SRB)	0.654 mg/L	0.255 mg/L	0.664 mg/L
Nitrate (NO_3^-)	Small fraction of SO_4 concentration	<0.5 mg/L	<0.5 mg/L	<0.5 mg/L
Manganese (Mn^{+4}) [3]	Small fraction of SO_4 concentration	Mn_{total} = 2.418 mg/L	Mn_{total} = 28.2 mg/L	Mn_{total} = 9.58 mg/L
Ferric Iron (Fe^{+3})	Small fraction of SO_4 concentration	Fe_{total} = 252.05 mg/L All Fe^{+2}	Fe_{total} = 181 mg/L Valance not known	Fe_{total} = 182 mg/L All Fe^{+2}
Sulfate (SO_4^{-2})	Significant SO_4 concentrations; <170 mg/L H_2S (higher concentrations may inhibit SRB)	SO_4^{-2} = 1262 mg/L H_2S = 0.14 mg/L	SO_4^{-2} = 2817.64 mg/L H_2S = 0.228 mg/L	SO_4^{-2} = 15.80 mg/L H_2S = 0.042 mg/L
Acetate CO_2 H_2	Eh > -150 mV; presence of significant sulfate	Eh = 224 mV SO_4^{-2} = 1262 mg/L	Eh = 581 mV SO_4^{-2} = 2817.64 mg/L	Eh = 129 mV SO_4^{-2} = 15.80 mg/L
Aluminum	Low concentrations (Toxic to SRB)	0.648 mg/L	196 mg/L	1.20 mg/L

[1] Sources for optimal sulfate reduction conditions: Benner et al. 1999; Chapelle 1993; EPA 1999; Fauque 1995; Fenchel et al. 1998; Thomas et al. 1999

[2] Turick et al. 2002

[3] Dissolved Mn data may include both $^{+2}$ and $^{+4}$ species; at the pH and Eh ranges given above, Mn^{+2} should be the dominant species present.

[4] Preliminary Data – Analysis still on-going

[5] Piezometer within the upgradient side of the DIW-1 north wing

7.0 CONCLUSIONS

A re-evaluation of the DTT-1 limestone trench has been conducted to determine if the hydraulic and geochemical activity of the trench is similar to its initial conditions upon installation three years ago. Additionally the potential to promote sulfate reduction at the limestone trench with the addition of an organic carbon substrate has been evaluated.

Based upon a comparison of specific capacity measurements the limestone trench appears to be essentially as hydraulically active now as it was at its installation. This indicates that precipitate accumulation has not significantly plugged the limestone or the formation. Additionally based upon analytical results it has been determined that the limestone trench remains an effective treatment for increasing the pH and removing aluminum both within and downgradient of the trench as at installation. Finally based upon the microbial results it has been determined that the limestone trench has increased microbial activity, including SRBs, both within and downgradient of the trench and has in general improved conditions relative to optimal sulfate reduction conditions from upgradient conditions. In fact the conditions within and downgradient of the trench are better relative to optimal sulfate reduction conditions than that of DIW-1 prior to injection of the soybean oil into it. Therefore the addition of soybean oil at the limestone trench should result in successful sulfate reduction remediation.

Based upon these conclusions the following recommendation are made:

- Since the possibility exists to deactivate the limestone with the injection of soybean oil into the limestone trench, it is recommended that if soybean oil is to be injected at this location it be done downgradient of the trench.
- Over the initial three-year period no significant hydraulic or geochemical degradation of the limestone was observed. However the buildup of aluminum hydroxide precipitates over time may impact the longevity and effectiveness of the limestone trench. Therefore it is recommended that the methods presented in section 4.0 be considered to determine the effects of aluminum hydroxide precipitation on limestone reactivity over longer time periods.

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APPENDICES

Appendix A-1, Flow Measurements

Date/Time	Cumulative Duration since Pumping Began (min)	Volume Collected (L)	Collection Duration (sec)	Flow (gpm)
12/9/02 10:14	0	0	0	0
12/9/02 10:15	1	1.00	29.5	0.54
12/9/02 10:30	16	1.00	29.5	0.54
12/9/02 10:35	21	1.00	29.8	0.53
12/9/02 10:45	31	1.00	29.3	0.54
12/9/02 13:05	171	0.95	29.0	0.52
12/9/02 15:04	290	0.98	30.6	0.51
12/9/02 15:15	301	16.80	600	0.44
12/9/02 15:40	326	16.80	505	0.53
12/10/02 8:50	1356	16.80	632	0.42
12/10/02 9:10	1376	16.80	550	0.48
12/10/02 10:24	1450	16.80	523	0.51
12/11/02 9:45	2851	16.80	809	0.33
12/11/02 10:15	2881	16.80	830	0.32
12/11/02 10:20	2886	16.80	830	0.32
12/11/02 10:21	2887	0	0	0
12/16/02 8:50	0	0	0	0
12/16/02 8:51	1	16.80	232	1.15
12/16/02 9:03	13	16.80	232	1.15
12/16/02 9:24	34	16.80	225	1.19
12/16/02 11:30	160	16.80	232	1.15
12/16/02 14:41	351	16.80	239	1.12
12/17/02 8:24	1414	16.80	452	0.59
12/17/02 8:40	1430	16.80	237	1.13
12/17/02 8:45	1435	16.80	238	1.12
12/17/02 15:43	1853	16.80	276	0.97
12/17/02 15:55	1865	16.80	228	1.17
12/18/02 8:04	2834	16.80	277	0.96
12/18/02 8:48	2878	16.80	280	0.95
12/18/02 9:01	2891	16.80	280	0.95
12/18/02 9:02	2892	16.80	0	0

Appendix A-2, Water Elevations (Determined from Electric Water Level Tape Measurement)

Sample Location	Date/Time	Top of Casing (ft-msl)	Depth to Water (ft)	Water Elevation (ft-msl)	Phase
DCB-49	12/2/02 14:18	124.52	7.97	116.55	1
DCB-49	12/5/02 15:09	124.52	7.78	116.74	1
DCB-49	12/6/02 12:11	124.52	8.05	116.47	1
DCB-49	12/8/02 9:17	124.52	7.99	116.53	1
DCB-49	12/9/02 10:06	124.52	7.98	116.54	1
DCB-49	12/9/02 11:07	124.52	8.11	116.41	2
DCB-49	12/9/02 15:09	124.52	8.37	116.15	2
DCB-49	12/10/02 8:43	124.52	8.68	115.84	2
DCB-49	12/10/02 10:17	124.52	8.72	115.80	2
DCB-49	12/11/02 9:19	124.52	8.4	116.12	2
DCB-49	12/11/02 10:11	124.52	8.43	116.09	2
DCB-49	12/16/02 8:26	124.52	7.46	117.06	1
DCB-49	12/16/02 11:22	124.52	7.93	116.59	3
DCB-49	12/16/02 14:28	124.52	8.31	116.21	3
DCB-49	12/17/02 8:12	124.52	8.64	115.88	3
DCB-49	12/17/02 15:33	124.52	9.01	115.51	3
DCB-49	12/18/02 7:50	124.52	9.31	115.21	3
DCB-49	12/18/02 8:58	124.52	9.36	115.16	3
DTT-1A	12/2/02 14:17	124.70	8.21	116.49	1
DTT-1A	12/5/02 15:05	124.70	8.03	116.67	1
DTT-1A	12/6/02 12:14	124.70	8.28	116.42	1
DTT-1A	12/8/02 9:21	124.70	8.23	116.47	1
DTT-1A	12/9/02 10:06	124.70	8.23	116.47	1
DTT-1A	12/9/02 11:10	124.70	8.37	116.33	2
DTT-1A	12/9/02 15:10	124.70	8.68	116.02	2
DTT-1A	12/10/02 8:44	124.70	9.06	115.64	2
DTT-1A	12/10/02 10:19	124.70	9.09	115.61	2
DTT-1A	12/11/02 9:20	124.70	8.73	115.97	2
DTT-1A	12/11/02 10:09	124.70	8.75	115.95	2
DTT-1A	12/16/02 8:29	124.70	7.71	116.99	1
DTT-1A	12/16/02 11:24	124.70	8.25	116.45	3
DTT-1A	12/16/02 14:29	124.70	8.71	115.99	3
DTT-1A	12/17/02 8:15	124.70	9.08	115.62	3
DTT-1A	12/17/02 15:34	124.70	9.49	115.21	3
DTT-1A	12/18/02 7:51	124.70	9.84	114.86	3
DTT-1A	12/18/02 8:56	124.70	9.87	114.83	3

Appendix A-2 (continued)

Sample Location	Date/Time	Top of Casing (ft-msl)	Depth to Water (ft)	Water Elevation (ft-msl)	Phase
DTT-1	12/2/02 14:16	122.64	6.16	116.48	1
DTT-1	12/5/02 15:07	122.64	5.97	116.67	1
DTT-1	12/6/02 12:13	122.64	6.22	116.42	1
DTT-1	12/8/02 9:19	122.64	6.18	116.46	1
DTT-1	12/9/02 10:07	122.64	6.18	116.46	1
DTT-1	12/9/02 11:08	122.64	6.31	116.33	2
DTT-1	12/9/02 15:09	122.64	6.61	116.03	2
DTT-1	12/10/02 8:44	122.64	7.01	115.63	2
DTT-1	12/10/02 10:18	122.64	7.03	115.61	2
DTT-1	12/11/02 9:18	122.64	6.68	115.96	2
DTT-1	12/11/02 10:09	122.64	6.69	115.95	2
DTT-1	12/16/02 8:25	122.64	5.65	116.99	1
DTT-1	12/16/02 11:23	122.64	6.2	116.44	3
DTT-1	12/16/02 14:29	122.64	6.64	116.00	3
DTT-1	12/17/02 8:14	122.64	7.02	115.62	3
DTT-1	12/17/02 15:32	122.64	7.42	115.22	3
DTT-1	12/18/02 7:50	122.64	7.78	114.86	3
DTT-1	12/18/02 8:54	122.64	7.81	114.83	3
DTT-1B	12/2/02 14:20	124.72	8.23	116.49	1
DTT-1B	12/5/02 15:10	124.72	8.03	116.69	1
DTT-1B	12/6/02 12:14	124.72	8.29	116.43	1
DTT-1B	12/8/02 9:16	124.72	8.24	116.48	1
DTT-1B	12/9/02 10:05	124.72	8.25	116.47	1
DTT-1B	12/9/02 11:04	124.72	8.37	116.35	2
DTT-1B	12/9/02 15:07	124.72	8.68	116.04	2
DTT-1B	12/10/02 8:42	124.72	9.07	115.65	2
DTT-1B	12/10/02 10:15	124.72	9.1	115.62	2
DTT-1B	12/11/02 9:15	124.72	8.74	115.98	2
DTT-1B	12/11/02 10:07	124.72	8.76	115.96	2
DTT-1B	12/16/02 8:23	124.72	7.72	117.00	1
DTT-1B	12/16/02 11:21	124.72	8.26	116.46	3
DTT-1B	12/16/02 14:27	124.72	8.7	116.02	3
DTT-1B	12/17/02 8:11	124.72	9.09	115.63	3
DTT-1B	12/17/02 15:31	124.72	9.49	115.23	3
DTT-1B	12/18/02 7:48	124.72	9.85	114.87	3
DTT-1B	12/18/02 8:53	124.72	9.88	114.84	3

Appendix A-2 (continued)

Sample Location	Date/Time	Top of Casing (ft-msl)	Depth to Water (ft)	Water Elevation (ft-msl)	Phase
DCB-50	12/2/02 14:10	124.33	8.04	116.29	1
DCB-50	12/5/02 15:08	124.33	7.86	116.47	1
DCB-50	12/6/02 12:12	124.33	8.1	116.23	1
DCB-50	12/8/02 9:18	124.33	8.07	116.26	1
DCB-50	12/9/02 10:05	124.33	8.06	116.27	1
DCB-50	12/9/02 11:06	124.33	8.16	116.17	2
DCB-50	12/9/02 15:08	124.33	8.4	115.93	2
DCB-50	12/10/02 8:43	124.33	8.71	115.62	2
DCB-50	12/10/02 10:16	124.33	8.74	115.59	2
DCB-50	12/11/02 9:17	124.33	8.45	115.88	2
DCB-50	12/11/02 10:08	124.33	8.45	115.88	2
DCB-50	12/16/02 8:24	124.33	7.55	116.78	1
DCB-50	12/16/02 11:22	124.33	7.95	116.38	3
DCB-50	12/16/02 14:28	124.33	8.30	116.03	3
DCB-50	12/17/02 8:13	124.33	8.65	115.68	3
DCB-50	12/17/02 15:32	124.33	8.97	115.36	3
DCB-50	12/18/02 7:49	124.33	9.26	115.07	3
DCB-50	12/18/02 8:59	124.33	9.33	115.00	3
DCB-21A	12/9/02 13:15	128.22	10.45	117.77	
DCB-21A	12/10/02 10:31	128.22	10.44	117.78	
DCB-21A	12/11/02 10:30	128.22	10.47	117.75	
DCB-21A	12/16/02 11:16	128.22	9.95	118.27	
DCB-21A	12/17/02 7:58	128.22	9.99	118.23	
DCB-21A	12/17/02 16:03	128.22	9.95	118.27	
DCB-21A	12/18/02 7:42	128.22	10.00	118.22	
DCB-24A	12/9/02 11:13	124.17	7.91	116.26	
DCB-24A	12/10/02 9:03	124.17	7.92	116.25	
DCB-24A	12/10/02 10:34	124.17	7.91	116.26	
DCB-24A	12/11/02 10:24	124.17	7.68	116.49	
DCB-24A	12/16/02 11:33	124.17	7.22	116.95	
DCB-24A	12/17/02 8:10	124.17	7.35	116.82	
DCB-24A	12/17/02 15:36	124.17	7.39	116.78	
DCB-24A	12/18/02 7:47	124.17	7.45	116.72	

Phase 1 = Pre-pumping; Phase 2 = First pumping episode (~0.5 gpm); Phase 3 = second pumping episode (~1 gpm)

Appendix B-1, Pre-Pump Field Parameter Profile

Sample Location	Sample Date/Time	Top of Casing (ft-msl)	Probe Depth (ft)	Probe Elevation (ft-msl)	Temperature (°F)	Temperature (°C)	pH	Conducivity (µS/cm)	DO (µg/L)	ORP (mV)	Calculated Eh (mV)
DCB-49	12/2/02 15:07	124.52	9	115.52	68.03	20.02	4.18	72	3150	389	588.10
DCB-49	12/2/02 15:12	124.52	10	114.52	68.19	20.11	4.11	67	2825	410	609.03
DCB-49	12/2/02 15:15	124.52	11	113.52	69.97	21.09	4.07	67	2770	425	623.18
DCB-49	12/2/02 15:18	124.52	12	112.52	70.38	21.32	4.03	68	2645	431	628.98
DCB-49	12/2/02 15:22	124.52	13	111.52	70.79	21.55	4	69	2510	428	625.79
DCB-49	12/2/02 15:26	124.52	14	110.52	71.1	21.72	3.96	73	2530	412	609.64
DCB-49	12/2/02 15:31	124.52	15	109.52	71.25	21.81	3.84	84	2670	394	591.56
DCB-49	12/2/02 15:34	124.52	16	108.52	72.22	22.34	3.34	2613	420	288	485.10
DCB-49	12/2/02 15:36	124.52	17	107.52	72.47	22.48	3.26	3080	210	237	433.98
DTT-1A	12/3/02 10:26	124.7	9	115.7	68.15	20.08	7.18	446	1602	13	212.05
DTT-1A	12/3/02 10:32	124.7	10	114.7	68.24	20.13	7.19	447	1361	12	211.00
DTT-1A	12/3/02 10:37	124.7	11	113.7	68.29	20.16	7.19	447	1309	12	210.98
DTT-1A	12/3/02 10:42	124.7	12	112.7	68.31	20.17	7.19	446	1329	6	204.97
DTT-1A	12/3/02 10:47	124.7	13	111.7	69.17	20.65	5.15	894	360	121	319.56
DTT-1A	12/3/02 10:51	124.7	14	110.7	70.7	21.50	4.09	1534	137	232	429.83
DTT-1A	12/3/02 10:56	124.7	15	109.7	71.22	21.79	4.03	1630	129	234	431.58
DTT-1A	12/3/02 11:00	124.7	16	108.7	71.53	21.96	3.92	1604	226	225	422.43
DTT-1	12/3/02 8:45	122.64	7	115.64	68.4	20.22	7.35	440	3500	150	348.93
DTT-1	12/3/02 8:50	122.64	8	114.64	68.33	20.18	7.32	437	3300	142	340.96
DTT-1	12/3/02 8:55	122.64	9	113.64	68.6	20.33	7.28	438	2990	100	298.83
DTT-1	12/3/02 8:59	122.64	10	112.64	68.72	20.40	7.23	449	2468	50	248.77
DTT-1	12/3/02 9:05	122.64	11	111.64	69.15	20.64	6	812	528	24	222.57
DTT-1	12/3/02 9:10	122.64	12	110.64	69.52	20.84	4.27	1303	212	221	419.39
DTT-1	12/3/02 9:15	122.64	13	109.64	70.93	21.63	3.58	1844	202	264	461.72
DTT-1	12/3/02 9:20	122.64	14	108.64	71.26	21.81	3.6	1892	163	261	458.56

Appendix B-1 (continued)

Sample Location	Sample Date/Time	Top of Casing (ft-msl)	Probe Depth (ft)	Probe Elevation (ft-msl)	Temperature (^oF)	Temperature (^oC)	pH	Conducivity (µS/cm)	DO (µg/L)	ORP (mV)	Calculated Eh (mV)
DTT-1B	12/3/02 9:39	124.72	9	115.72	68.69	20.38	7.13	420	4379	106	304.79
DTT-1B	12/3/02 9:45	124.72	10	114.72	68.72	20.40	7.15	421	3872	114	312.77
DTT-1B	12/3/02 9:49	124.72	11	113.72	68.75	20.42	7.16	421	4002	116	314.76
DTT-1B	12/3/02 9:54	124.72	12	112.72	68.73	20.41	7.12	439	2660	32	230.77
DTT-1B	12/3/02 9:58	124.72	13	111.72	68.68	20.38	6.06	736	487	11	209.79
DTT-1B	12/3/02 10:03	124.72	14	110.72	68.69	20.38	4.56	1089	163	185	383.79
DTT-1B	12/3/02 10:08	124.72	15	109.72	69.36	20.76	3.86	1585	137	248	446.47
DTT-1B	12/3/02 10:14	124.72	16	108.72	70.1	21.17	3.92	1700	234	195	393.12
DCB-50	12/2/02 14:24	124.33	9	115.33	68.05	20.03	4.97	118	4950	356	555.09
DCB-50	12/2/02 14:29	124.33	10	114.33	68.33	20.18	4.95	117	4167	348	546.96
DCB-50	12/2/02 14:32	124.33	11	113.33	68.79	20.44	4.92	117	5454	344	542.74
DCB-50	12/2/02 14:36	124.33	12	112.33	69.25	20.69	4.91	118	4400	340	538.52
DCB-50	12/2/02 14:39	124.33	13	111.33	69.62	20.90	4.89	120	4200	336	534.35
DCB-50	12/2/02 14:42	124.33	14	110.33	69.92	21.07	4.88	122	4340	336	534.20
DCB-50	12/2/02 14:44	124.33	15	109.33	70.73	21.52	4.95	132	3490	334	531.81
DCB-50	12/2/02 14:49	124.33	16	108.33	71.46	21.92	5.24	157	750	164	361.46
DCB-50	12/2/02 14:52	124.33	17	107.33	71.81	22.12	5.36	338	480	114	311.30

Appendix B-2, Field Parameters

Phase	Sample ID	Sample Location	Sample Date	Sample Depth (ft)	Temperature (^oF)	Temperature (^oC)	pH	Conductivity (µS/cm)	DO (µg/L)	ORP (mV)	Calculated Eh (mv)	Turbidity (NTU)
1	DTT-00001	DCB-49	12/6/02	11.7	69.60	20.89	3.29	2540	541	234	432	4.0
1	DTT-00002	DTT-1A	12/6/02	11.9	66.28	19.04	7.23	432	2012	104	304	4.7
1	DTT-00014	DTT-1A	12/6/02	15.9	69.74	20.97	3.89	1655	490	251	449	37.0
1	DTT-00003	DTT-1	12/6/02	9.8	65.90	18.83	7.18	434	2114	55	255	15.2
1	DTT-00016	DTT-1	12/6/02	13.8	66.31	19.06	7.20	428	2277	92	292	41.9
1	DTT-00004	DTT-1B	12/6/02	11.9	66.96	19.42	7.23	460	1920	67	267	4.3
1	DTT-00015	DTT-1B	12/6/02	15.9	67.33	19.63	7.28	460	1822	85	284	4.6
1	DTT-00005	DCB-50	12/6/02	11.5	66.78	19.32	5.89	1325	654	24	224	Off scale
2a	DTT-00006	DCB-49	12/9/02	11.7	66.48	19.16	3.39	2615	418	256	456	0.6
2a	DTT-00007	DTT-1	12/9/02		63.64	17.58	6.64	540	1677	-24	177	6.4
2b	DTT-00008	DCB-49	12/11/02	11.7	66.36	19.09	3.39	2721	292	237	437	5.6
2b	DTT-00009	DTT-1	12/11/02		64.02	17.79	4.51	1373	1550	199	400	2.8
3a	DTT-00010	DCB-49	12/16/02	11.7	65.57	18.65	3.47	2590	535	249	449	0.4
3a	DTT-00011	DTT-1	12/16/02		62.51	16.95	7.25	439	2555	100	302	1.7
3b	DTT-00012	DCB-49	12/18/02	11.7	67.46	19.70	3.36	2761	636	237	436	0.2
3b	DTT-00013	DTT-1	12/18/02		65.90	18.83	4.88	1742	637	161	361	70.5

1 = Pre-pump tests
2a = Sample collected after first 30 min of pumping during 48-hour 0.5 gpm pump test
2b = Sample collected after last 30 min of pumping during 48-hour 0.5 gpm pump test
3a = Sample collected after first 30 min of pumping during 48-hour 1.0 gpm pump test
3b = Sample collected after last 30 min of pumping during 48-hour 1.0 gpm pump test

Appendix B-3, Anions and Cations (EBS Laboratory IC Results)

Sample ID	Sample Location	Sample Depth (ft)	Cl^- (mg/L)	NO_2^- (mg/L)	NO_3^- (mg/L)	NH_4^+ (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-2} (mg/L)	K^+ (mg/L)	Na^+ (mg/L)	Mg^{+2} (mg/L)	Ca^{+2} (mg/L)
DTT-00001	DCB-49	11.7	1.64	10.13	<0.5	<0.5	2556	<0.5	5.34	15.22	77.36	83.5
DTT-00002	DTT-1A	11.9	1.47	<0.5	3.73	<0.5	67.91	<0.5	5.73	2.59	13.96	94.26
DTT-00014	DTT-1A	15.9	1.09	6	<0.5	<0.5	1465	<0.5	4.3	8.22	45.85	68.71
DTT-00003	DTT-1	9.8	1.46	<0.5	<0.5	<0.5	72.54	<0.5	5.82	3.18	13.42	92.12
DTT-00016	DTT-1	13.8	1.35	1.5	3.73	<0.5	67.89	<0.5	5.63	2.95	13.51	92.93
DTT-00004	DTT-1B	11.9	1.32	<0.5	3.82	<0.5	78.62	<0.5	5.77	3.03	15.37	98.38
DTT-00015	DTT-1B	15.9	1.41	<0.5	3.77	<0.5	75.76	<0.5	5.91	2.06	15.23	99.68
DTT-00005	DCB-50	11.5	0.65	<0.5	<0.5	<0.5	1262	<0.5	6.31	8.2	63.33	267.72

See Appendix B-1 for phase and date information for corresponding sample ID.

Appendix B-4, Metals (SRTC Mobile Laboratory ICP-AES Results)

Phase	Sample ID	Sample Location	Sample Date	Sample Depth (ft)	Al (mg/L)	Ba (mg/L)	Be (mg/L)	Ca (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)
1	DTT-00001	DCB-49	12/6/02	11.7	128.550	<0.001	<0.005	73.070	<0.003	<0.002	0.070	672.870
1	DTT-00002	DTT-1A	12/6/02	11.9	0.259	<0.001	<0.005	80.893	<0.003	<0.002	<0.009	0.094
1	DTT-00014	DTT-1A	12/6/02	15.9	79.310	<0.001	<0.005	60.116	<0.003	<0.002	0.105	374.300
1	DTT-00003	DTT-1	12/6/02	9.8	0.024	<0.001	<0.005	81.260	<0.003	<0.002	<0.009	<0.004
1	DTT-00016	DTT-1	12/6/02	13.8	0.071	<0.001	<0.005	82.209	<0.003	<0.002	<0.009	0.025
1	DTT-00004	DTT-1B	12/6/02	11.9	0.716	<0.001	<0.005	78.479	<0.003	<0.002	<0.009	0.096
1	DTT-00015	DTT-1B	12/6/02	15.9	0.048	<0.001	<0.005	84.422	<0.003	<0.002	<0.009	<0.004
1	DTT-00005	DCB-50	12/6/02	11.5	0.648	<0.001	<0.005	238.190	<0.003	<0.002	<0.009	252.050
2a	DTT-00006	DCB-49	12/9/02	11.7	159.160	<0.001	<0.005	68.944	<0.003	<0.002	0.060	640.860
2a	DTT-00007	DTT-1	12/9/02		4.844	<0.001	<0.005	82.329	<0.003	<0.002	<0.009	21.360
2b	DTT-00008	DCB-49	12/11/02	11.7	127.360	<0.001	<0.005	66.318	<0.003	<0.002	0.091	733.380
2b	DTT-00009	DTT-1	12/11/02		51.661	<0.001	<0.005	85.263	<0.003	<0.002	0.035	284.380
3a	DTT-00010	DCB-49	12/16/02	11.7	125.800	<0.001	<0.005	75.087	<0.003	<0.002	0.068	644.640
3a	DTT-00011	DTT-1	12/16/02		0.397	<0.001	<0.005	86.850	<0.003	<0.002	<0.009	0.153
3b	DTT-00012	DCB-49	12/18/02	11.7	125.940	<0.001	<0.005	64.099	<0.003	<0.002	0.075	750.460
3b	DTT-00013	DTT-1	12/18/02		39.771	<0.001	<0.005	190.380	<0.003	<0.002	0.042	330.360

Appendix B-4 (continued)

Phase	Sample ID	Sample Location	Sample Date	Sample Depth (ft)	Mg (mg/L)	Mn (mg/L)	Na (mg/L)	Ni (mg/L)	Pb (mg/L)	Si (mg/L)	Zn (mg/L)
1	DTT-00001	DCB-49	12/6/02	11.7	63.319	4.800	14.484	0.828	<0.017	30.516	2.060
1	DTT-00002	DTT-1A	12/6/02	11.9	9.577	<0.001	2.256	<0.010	<0.017	1.771	<0.001
1	DTT-00014	DTT-1A	12/6/02	15.9	34.886	3.277	7.664	0.626	<0.017	43.578	1.418
1	DTT-00003	DTT-1	12/6/02	9.8	10.049	<0.001	2.267	<0.010	<0.017	1.720	<0.001
1	DTT-00016	DTT-1	12/6/02	13.8	9.923	<0.001	1.971	<0.010	<0.017	1.747	<0.001
1	DTT-00004	DTT-1B	12/6/02	11.9	10.404	<0.001	2.117	<0.010	<0.017	1.865	<0.001
1	DTT-00015	DTT-1B	12/6/02	15.9	10.951	<0.001	2.038	<0.010	<0.017	1.789	<0.001
1	DTT-00005	DCB-50	12/6/02	11.5	55.947	2.418	8.194	0.244	<0.017	5.371	0.469
2a	DTT-00006	DCB-49	12/9/02	11.7	56.878	4.758	13.765	0.814	<0.017	29.396	1.962
2a	DTT-00007	DTT-1	12/9/02		11.631	0.087	2.159	<0.010	<0.017	4.271	<0.001
2b	DTT-00008	DCB-49	12/11/02	11.7	56.083	4.935	16.362	0.877	<0.017	34.797	2.142
2b	DTT-00009	DTT-1	12/11/02		35.185	2.540	8.609	0.447	<0.017	24.472	0.947
3a	DTT-00010	DCB-49	12/16/02	11.7	60.915	4.983	14.213	0.823	<0.017	29.502	2.082
3a	DTT-00011	DTT-1	12/16/02		10.564	<0.001	2.262	<0.010	<0.017	1.841	<0.001
3b	DTT-00012	DCB-49	12/18/02	11.7	55.308	4.882	16.073	0.858	<0.017	35.690	2.066
3b	DTT-00013	DTT-1	12/18/02		51.782	3.572	9.622	0.484	<0.017	25.363	1.066

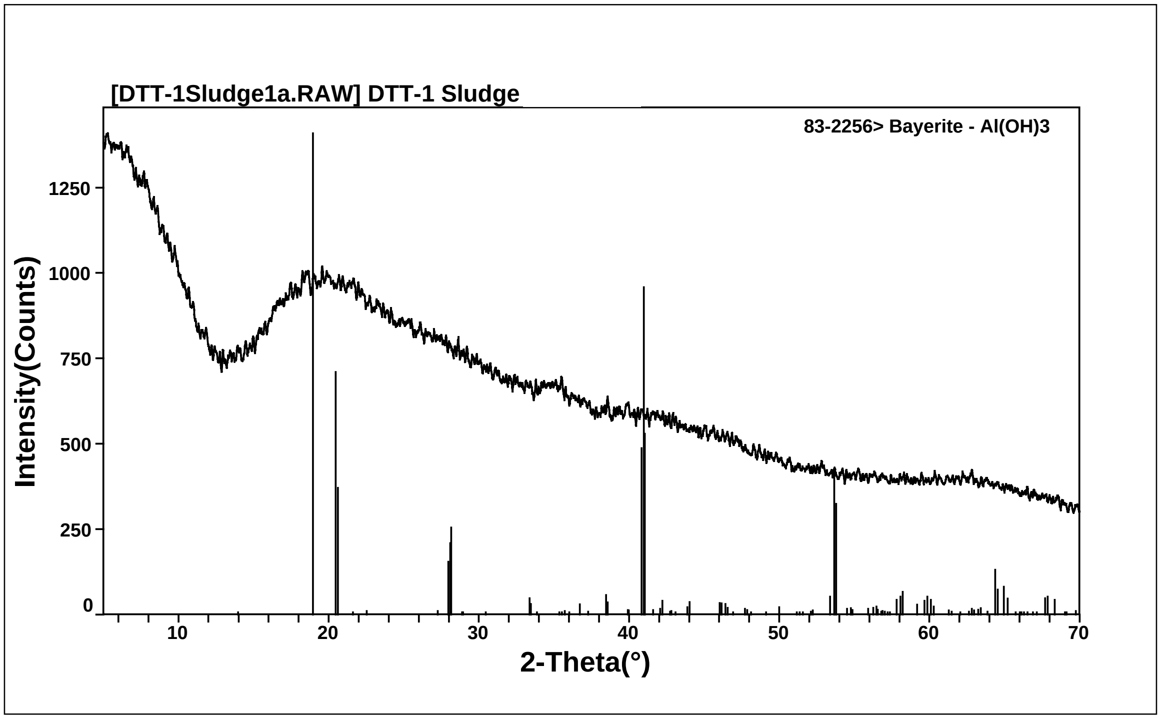
1 = Pre-pump tests
2a = Sample collected after first 30 min of pumping during 48-hour 0.5 gpm pump test
2b = Sample collected after last 30 min of pumping during 48-hour 0.5 gpm pump test
3a = Sample collected after first 30 min of pumping during 48-hour 1.0 gpm pump test
3b = Sample collected after last 30 min of pumping during 48-hour 1.0 gpm pump test

Appendix B-5, Iron Speciation (SRTC Mobile Laboratory)

Sample ID	Well	Fe^{+2}	Fe^{+3}	Fe$_{total}$	Fe^{+2}/Fe$_{total}$
DTT-00001	DCB-49	1.515	<0.010	1.523	all Fe^{+2}
		1.515	<0.010	1.521	
DTT-00002	DTT-1A	<0.010	<0.010	<0.010	no iron detected
		<0.010	<0.010	<0.010	
DTT-00014	DTT-1A	0.873	<0.010	0.877	all Fe^{+2}
		0.876	<0.010	0.875	
DTT-00003	DTT-1	<0.010	<0.010	<0.010	no iron detected
		<0.010	<0.010	<0.010	
DTT-00016	DTT-1	<0.010	<0.010	<0.010	no iron detected
		<0.010	<0.010	<0.010	
DTT-00004	DTT-1B	<0.010	<0.010	<0.010	no iron detected
		<0.010	<0.010	<0.010	
DTT-00015	DTT-1B	<0.010	<0.010	<0.010	no iron detected
		<0.010	<0.010	<0.010	
DTT-00005	DCB-50	0.544	<0.010	0.545	all Fe^{+2}
		0.545	<0.010	0.545	
DTT-00006	DCB-49	1.572	<0.010	1.572	all Fe^{+2}
		1.579	<0.010	1.582	
DTT-00007	DTT-1	0.016	<0.010	0.023	all Fe^{+2}
		0.017	<0.010	0.024	
DTT-00008	DCB-49	1.593	<0.010	1.59	all Fe^{+2}
		1.622	<0.010	1.624	
DTT-00009	DTT-1	0.629	<0.010	0.631	all Fe^{+2}
		0.643	<0.010	0.639	
DTT-00010	DCB-49	1.365	<0.010	1.377	all Fe^{+2}
		1.397	<0.010	1.389	
DTT-00011	DTT-1	<0.010	<0.010	<0.010	no iron detected
		<0.010	<0.010	<0.010	
DTT-00012	DCB-49	1.622	<0.010	1.626	all Fe^{+2}
		1.653	<0.010	1.660	
DTT-00013	DTT-1	0.718	<0.010	0.710	all Fe^{+2}
		0.712	<0.010	0.713	

See Appendix B-3 for phase and date information for corresponding sample ID.

Appendix B-6, XRD and XRF Results



XRD Results: Peaks in the x-ray diffraction spectrum suggest that the sludge is composed of an amorphous aluminum hydroxide mineral (similar to bayerite).

XRF Results:

SiO_2 wt%	Al_2O_3 wt%	Fe_2O_3 wt%	MgO wt%	CaO wt%	Na_2O wt%	K_2O wt%	P_2O_5 wt%	LOI wt%
8.47	53.15	4.89	0.47	3.32	0.01	0.09	0.38	29.15

LOI = loss on ignition (reflecting loss of water or other volatile componenets)

X-ray fluorescence on another similar sludge sample also indicates that the sludge consists predominantly of aluminum.

Appendix C-1, Microbial Parameters

Phase	Sample ID	Sample Location	Sample Depth (ft)	Date	TOC (mg/L)	Total Microbes (cells/ml)	SO_4 (mg/L)	H_2S (mg/L)	SRB (cells/ml)	pH	Eh (mV)	DO (mg/L)
1	DTT-00001	DCB-49	11.7	12/6/02	3.1	3.95E+04	2556	< 0.05	1.84E+01	3.29	432	0.541
1	DTT-00002	DTT-1A	11.9	12/6/02	8.3	3.29E+05	67.91	0.1	4.60E+01	7.23	304	2.012
1	DTT-00014	DTT-1A	15.9	12/6/02	2.3	4.00E+05	1465	0.05	3.00E+01	3.89	449	0.490
1	DTT-00003	DTT-1	9.8	12/6/02	9.4	2.72E+05	72.54	0.1	8.60E+01	7.18	255	2.114
1	DTT-00016	DTT-1	13.8	12/6/02	8.5	3.29E+05	67.89	0.05	8.60E+01	7.2	292	2.277
1	DTT-00004	DTT-1B	11.9	12/6/02	10.2	1.79E+05	78.62	0.08	4.60E+01	7.23	267	1.920
1	DTT-00015	DTT-1B	15.9	12/6/02	7.4	1.14E+05	75.76	0.08	8.60E+01	7.28	284	1.822
1	DTT-00005	DCB-50	11.5	12/6/02	7.6	2.37E+05	1262	0.14	8.60E+01	5.89	224	0.654

1 = Pre-pump tests

12/6/02 DTT-1 Sludge Sample	SRB (cells/ml)	Total Microbes (cells/ml)
Mixed Supernate and Precipitate	4.20E+02	3.59E+05
Supernate	-	1.63E+05
Precipitate	-	6.84E+07