OPERATION AND MAINTENANCE MANUAL FOR BIOWALLS

NWIRP McGREGOR
McGREGOR, TEXAS

CTO-0168

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1.0 INTRODUCTION

The purpose of this manual is to provide operation and maintenance (O&M) guidelines for the biological permeable reactive barriers (biowalls) that have been installed at the Naval Weapons Industrial Reserve Plant (NWIRP) McGregor. Although the Response Action Plans (RAPs) refer to these barriers as biotrenches, this document will refer to them as biowalls, which is the standard industry term for this technology. This document includes an overview of the biowall system, a summary of system objectives, a review of the biowall optimization study, and a description of the O&M protocol, including monitoring procedures, regular system maintenance, and triggers and procedures for injecting carbon substrate into the biowalls. This manual has been completed through Contract Task Order 0168 to the Naval Facilities Engineering Field Division South (NAVFAC EFD SOUTH), North Charleston, South Carolina, under contract N6246789-D-0318 and is organized as follows:

- **Section 1.0, Introduction:** This section introduces the objective of the manual, provides a technical overview of the biowalls, and presents manual organization.

- **Section 2.0, Summary of Biowall Optimization Study:** This section summarizes the results from the biowall optimization study conducted in Areas F and S.

- **Section 3.0, Full-Scale Implementation of Biowalls:** This section summarizes the details and locations of the full-scale biowalls that have been installed in Areas E, F, M, and S at NWIRP McGregor.

- **Section 4.0, Biowall Operation and Maintenance:** This section discusses effectiveness monitoring sampling, analysis, and data management and describes the general activities, processes, and equipment required to effectively operate the biowalls. It also provides specific criteria for initiating carbon substrate injection and assessing whether biowall maintenance activities are required.

- **Section 5.0, References**

1.1 Biowall Description

A biowall consists of a trench that is installed across the flow path of a groundwater plume. The biowalls at NWIRP McGregor were backfilled with a mixture of mushroom compost, three-quarter-inch pine wood chips, soybean oil, and 1-inch washed, crushed limestone aggregate. Two-inch diameter polyvinyl chlorinde (PVC) diffuser pipes were installed on the bottom of each trench to allow for future injections of carbon substrates as needed. The diffuser pipes were fitted with Cam-lock connections to facilitate carbon substrate injection. In addition to these injection ports, multiple trench ports were installed in the biowalls for monitoring and sampling purposes.

The trenches were capped with a compacted clay layer to limit seeps and surface infiltration. Biowall cross-sections are provided in the as-built diagrams located in Appendix A. The biowalls were designed to allow groundwater to flow through and promote reducing conditions in the aquifer so that perchlorate, trichloroethylene (TCE), and 1,1-dichloroethylene (DCE) would be biodegraded in situ.

Rows of bioborings, which comprise 12-inch diameter soil borings backfilled with the biowall media, were installed where biowall construction was difficult. The bioborings were typically installed on 10-foot centers. No O&M activities are required for bioborings since they are installed and supplemented on a one-time basis; therefore, no additional operational discussions of these bioborings are presented in this manual.

1.2 Biowall Objectives

Nearly two miles of biowalls have been installed in shallow weathered limestone at NWIRP McGregor to (1) reduce source area perchlorate plume mass, (2) remediate perchlorate-contaminated groundwater before it seeps into streams, and (3) expedite offsite property cleanup. The data indicate that after nearly three years of operation, the biowalls are still effectively treating perchlorate-contaminated groundwater from 1,000 micrograms per liter (µg/L) to below the laboratory detection limit (0.043 µg/L). As discussed in this manual, carbon substrate injections will likely be required to sustain the reducing conditions that facilitate perchlorate biodegradation.

2.0 SUMMARY OF BIOWALL OPTIMIZATION STUDY

A biowall optimization study was conducted to assess geochemistry data within and downgradient of the biowalls. The data were collected to optimize biowall performance and develop this manual. Details of the study, results, and conclusions are presented below.

2.1 Optimization Study Components

Four biowalls were chosen for the study, based on several criteria:

- Position relative to the perchlorate and chlorinated volatile organic compounds (CVOC) plumes
- Magnitude of contaminant concentrations
- Backfill design
- Duration of operation

Two Area F pilot study biowalls were selected. Biowall F-1 is 100 feet long and was installed in June 2002 in a commingled perchlorate and TCE groundwater plume. Its backfill consists of gravel and wood chips saturated with soybean oil. Biowall F-2 is 75 feet long and was installed in June 2002 in a groundwater perchlorate plume. Its backfill consists of gravel, mushroom compost, and wood chips saturated with soybean oil (EnSafe, August 2003). Both of these biowalls are shown in Figure 2-1.

The third and fourth biowalls evaluated during this study are in Area S. Biowall S-1b was installed in the fall of 2002 in a commingled perchlorate and TCE plume just downgradient of the suspected source area. Its backfill consists of gravel, mushroom compost, and wood chips saturated with soybean oil. The fourth biowall, S-3e, was installed in September 2004 and is at the eastern Area S property line. The locations of these biowalls can be found in Figure 3-5.

As part of this study, samples were collected from 16 monitoring wells and nine trench ports, which were installed within the biowalls. Field parameter measurements, such as dissolved oxygen (DO), pH, and oxidation reduction potential (ORP), were collected on a weekly basis throughout the optimization study. Groundwater samples were also collected in December 2004, March 2005, and June 2005, and analyzed for humic and fulvic acids, hydrogen, methane, nitrate, perchlorate, total organic carbon (TOC), and volatile fatty acids (VFAs).

In addition to groundwater sampling, samples were also collected from the organic and fill material of each of the four biowalls. These samples were collected by inserting a continuous sampler device into the biowalls.


N
S
E
W
PHYMW2S
PHYMW2D
AFT005N
Biowall 5
AFTMW09
PHYMW1S
PHYMW1D
AFT005S
Tributary F
AFT004W
AFT004E
AFTMW07
Biowall 4
GAF-7
AFTMW03
AFT003N
AFTMW04
AFTMW05
Biowall 3
AFTMW06
AFTMW08
AFT003S
AFTMW14
AFTMW13
AFT002W
AFTMW12
AFT002E
GAF-10
AFTMW11
Biowall 2
AFTMW10
AFTMW10B
AFTMW10A
GAF-8
AFTMW15
AFTMW02
AFT001E
AFT001W
AFTMW01
Biowall 1
Monitoring Well
Temporary Test Well Boring
Biowall
Road
Fence
Water
Ditch
Landfill
Building
Former Building
Berm
Current Boundary
50 25 0 50 100
Feet
Figure 2-1
Area F Parcel
Pilot-Scale Study Layout
NWIRP McGregor
McGregor, Texas
December 2005
gissafe://projects/mcgreg83/projects/area_f/f_trench_pilot_study_05.mxd

2.2 Optimization Study Results and Conclusions

The biowall optimization study sampling results for the four biowalls are provided in Tables 2-1 through 2-5. The major findings of the study are discussed below for key parameters that were analyzed during the optimization study.

2.2.1 Total Organic Carbon

TOC was deemed to be the most accurate parameter that reflects effective biodegradation of perchlorate as groundwater flows through the biowalls. Typically, TOC is strongly indicative of a source of useable carbon and the presence of reducing conditions in groundwater, both of which are essential to perchlorate biodegradation.

TOC concentrations appear to follow a first-order decrease over time. Typically, first- order decreases typify a rapid decrease soon after installation followed by a plateauing in concentration after an elapsed period if time. Perchlorate reduction seems to occur immediately following installation indicating that the TOC that gets rapidly depleted has the appropriate carbon substrate that induces its' bioreduction. Data that has been collected during the optimization study and from previous pilot studies and interim actions suggest that a minimum TOC concentration range is required to sustain reducing conditions that result in complete perchlorate degradation. Because TOC depletion appears to follow first-order kinetics, the carbon substrate renewal schedule can be developed based on sample results prior to perchlorate breakthrough. The minimum range at which perchlorate breakthrough generally occurs appears to be between 5,000 and 10,000 µg/L. Although there appears to be minimal risk in fixing the lower end of the range as the critical value, the higher value provides a safety factor that will allow corrective measures to be implemented prior to perchlorate breakthrough.

2.2.2 Humic and Fulvic Acids and VFAs

Measurement of humic and fulvic acids in groundwater and from the solid matrix in the biowalls indicate that these complex carbon substrates are produced very quickly from mushroom compost and wood chips. In other words, these are the first breakdown products from the solid-phase carbon that was incorporated into the biowalls. Concentrations of these acids were in the same range as TOC during the initial phases. Based on the rapid onset of perchlorate reduction immediately following biowall construction, the carbon substrate that was available from humic and fulvic acid formation and subsequent breakdown was a type that native microorganisms could directly use for this purpose.

Humic and fulvic acids also appear to induce and sustain reducing conditions for considerable periods of time both in the biowall vicinity and downgradient as they flow with the groundwater. However, because in all likelihood, humic and fulvic acids cannot be directly used by perchlorate degrading microorganisms, their mere longevity is not a surety for sustained perchlorate reduction even though they sustain reducing conditions. Based on the sampling results of the optimization study, as time elapses, concentrations of humic and fulvic acids appear to be higher than TOC concentrations at the same location but they are not able to prevent perchlorate breakthrough. Therefore, unlike TOC, they are not as effective an indicator parameter for breakthrough and biowall rejuvenation.

VFAs which are components and breakdown products of vegetable oils and humic and fulvic acids serve two purposes. They create reducing conditions and play a direct role in perchlorate biodegradation, the latter being the more useful purpose in biowalls. Because they appear to be rapidly created from vegetable oil following biowall construction, they make up the bulk of quick release useable carbon substrate that is essential for perchlorate biodegradation. However, they also are more easily degraded compared to humic and fulvic acids. Therefore, over a period of time their concentrations appears to diminish to the extent that they are no longer available for perchlorate biodegradation after the vegetable oil is consumed. At this time, the humic and fulvic acids continue to sustain reducing conditions but do not produce as much of the fatty acids that were created from the combination with vegetable oil. This is the reason why the biowalls will likely require multiple replenishments of emulsified vegetable oil during their life cycles.

Overall, the analysis of humic and fulvic acids has aided the understanding of the short term and long term roles of slow-release solid substrates such as compost and wood chips and that of liquid substrates such as vegetable oil. However, the data collected indicates that there appears to be no defining minimal ranges that can be used to predict perchlorate breakthrough and the need for biowall rejuvenation. What the results do indicate is that vegetable oil is the appropriate substrate for rejuvenation not only from an implementable and logistics viewpoint, but also from a biochemical standpoint. TOC as discussed earlier appears to be the appropriate carbon measurement for long term operations and maintenance of biowalls.

Table 2-1
Humic and Fulvic Acid Analyses
Trench Solids

Trench	Trench Port Location	Date	Soil	Rock	Chip	Total	Humic	Fulvic	Humic	Fulvic
			Dry Grams				mg/g soil		mg/g (total)	
F-1	AFTSF10101	Dec-04	118	2525	171	2814	1	10	0.042	0.42
		Mar-05	68	2343	223	2634	1	4	0.026	0.10
		Jun-05	155	1943	183	2281	4	3	0.272	0.20
	AFTSF10102	Dec-04	295	2102	136	2533	4	9	0.466	1.05
		Mar-05	89	2654	302	3045	6	8	0.175	0.23
		Jun-05	127	1763	122	2012	5	2	0.316	0.13
	AFTSF10103	Dec-04	391	1813	121	2325	4	54	0.673	9.08
		Mar-05	51	247	232	530	4	3	0.385	0.29
		Jun-05	45	3245	159	3449	4	10	0.052	0.13
F-2	AFTSF20101	Dec-04	382	1975	216	2573	3	7	0.445	1.04
		Mar-05	31	2547	200	2778	13	5	0.145	0.06
		Jun-05	2063	857	2	2922	3	11	2.118	7.77
	AFTSF20102	Dec-04	448	1781	157	2386	11	6	2.065	1.13
		Mar-05	112	273	408	793	2	5	0.282	0.71
		Jun-05	1661	823	0	2484	3	2	2.006	1.34
	AFTSF20103	Dec-04	270	2419	246	2935	9	6	0.828	0.55
		Mar-05	15	813	272	900	6	10	0.1	0.17
		Jun-05	24	2690	268	2982	16	3	0.129	0.02
S-1	TSTSS10101	Dec-04	1066	794	89	1949	10	210	5.469	114.86
		Mar-05	124	217	72	413	5	3	1.501	0.90
		Jun-05	698	1610	214	2522	13	3	3.598	0.83
	TSTSS10102	Dec-04	983	560	118	1661	25	207	14.795	122.51
		Mar-05	452	2018	42	2512	10	2	1.799	0.36
		Jun-05	1164	672	77	1913	13	3	7.910	1.83
	TSTSS10103	Dec-04	1147	846	106	2099	18	200	9.836	109.29
		Mar-05	204	957	198	1155	23	14	4.062	2.47
		Jun-05	291	366	23	680	5	6	2.140	2.57
S-3E	TSTSS30101	Dec-04	388	2490	136	3014	90	25	11.586	3.22
		Mar-05	119	78	33	230	23	10	11.9	5.17
		Jun-05	1262	795	55	2112	22	7	13.146	4.18
	TSTSS30202	Mar-05	26	939	86	1051	33	14	0.816	0.35
		Jun-05	516	477	45	1038	10	15	4.971	7.46
	TSTSS30203	Mar-05	160	830	33	823	27	3	5.249	0.58
		Jun-05	1232	487	60	1779	10	19	6.925	13.16

TABLE 2-2
Trench 1 Monitoring System Data

Sampling Location	Sample Date	Perchlorate (µg/L)	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	Methane (µg/L)	pH	Depth to Water (ft)	Nitrate (µg/L)	Total Organic Carbon (µg/L)	Humic Acid (mg/L)	Fulvic Acid (mg/L)	Volatile Fatty Acids (mg/L)								
												Acetic acid	n-Butric acid	Hexanoic acid	i-Hexanoic acid	i-Pentanoic acid	Lactic acid	n-Pentanoic acid	Propanoic acid	Pyruvic acid
AFTMW01 15 ft Upgradient	07/23/02	600	0.18	-9	NS	7.54	6.5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	09/23/02	670	11.21	17	NS	6.78	14.25	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/30/02	550	1.69	-12	NS	7.26	6.85	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/26/02	500	1.68	0	NS	7.11	6.88	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/19/02	310	1.74	5	NS	7.12	6.62	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/30/03	550	1.66	-24	NS	7.14	7.15	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/27/03	420	1.52	-30	NS	7.11	2.97	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/31/03	420	2.61	-48	NS	7.37	6.37	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	04/29/03	340	1.58	53	NS	7.29	9.96	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/29/03	480	1.49	57	NS	7.15	10.84	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/30/03	570	1.23	59	NS	7.14	11.66	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/03/03	490	2.21	11	NS	6.46	6.71	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/19/04	610	2.34	19	NS	6.49	5.64	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/11/04	570	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/10/04	380	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/02/04	450	NS	-7	5.8	NS	4.13	1,600 J	1,300	0.5	19	<0.2	<0.1	<0.2	<0.1	<0.07	<0.07	<0.07	<0.07	<0.07
	01/13/05	NS	1.64	-14	NS	6.92	4.18	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/20/05	NS	1.36	-16	NS	6.87	4.26	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/28/05	NS	1.06	-22	NS	6.85	3.84	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/11/05	NS	1.21	-22	NS	6.94	4.27	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/18/05	NS	1.31	-24	NS	7.01	4.31	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/25/05	NS	1.08	-31	NS	6.91	3.81	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/04/05	NS	0.94	-34	NS	6.87	3.64	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/10/05	120	1.63	64	2.4	7.3	5.33	140	1,300	1	11	0.048 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	03/20/05	NS	1.57	53	NS	7.21	5.36	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	9.47	23	NS	7.43	10.76	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/23/05	180	10.64	NS	0.48	6.98	12.1	1,300	670 J	1	9	0.048 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
AFTG001E East Trench Port Location	07/24/02	10	0.15	-174	NS	6.16	3.41	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	09/23/02	<2	5.37	-92	NS	6.52	6.87	36	890,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/30/02	<2	1.65	-83	NS	6.71	4.87	50	390,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/26/02	39	2.41	-89	NS	6.93	4.58	51	230,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/19/02	<2	2.16	-102	NS	7.05	4.42	NS	150,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/30/03	<0.43	2.15	-143	NS	6.98	5.4	25	140,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/27/03	<0.43	2.03	-141	NS	6.97	1.84	25	160,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/31/03	<0.43	0.00	-102	NS	6.78	3.48	25	130,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	04/29/03	<0.43	0.66	-71	NS	6.52	5.86	23	110,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/29/03	<0.43	0.58	-74	NS	6.74	6.21	25	90,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/30/03	<0.43	0.68	-71	NS	6.99	8.62	25	100,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/22/03	<0.43	0.72	-170	NS	6.88	3.72	25	51,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/19/04	<0.43	0.88	-166	NS	6.91	4.37	120	33,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/11/04	<0.43	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/10/04	<0.43	3.74	-84	NS	6.66	1.98	25	28,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/02/04	<0.43	NS	-136	6,000	NS	1.95	<25	18,000	6	51	0.472	<0.1	<0.2	<0.1	<0.07	0.879	<0.07	<0.07	<0.07
	01/13/05	NS	0.64	-138	NS	6.87	2.34	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/20/05	NS	0.94	-132	NS	6.82	2.41	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/28/05	NS	0.94	-124	NS	6.84	1.98	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/11/05	NS	0.79	-118	NS	6.78	2.55	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/18/05	NS	0.81	-124	NS	6.81	2.63	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/25/05	NS	0.89	-113	NS	6.74	1.94	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/04/05	NS	0.34	-134	NS	6.84	2.3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/10/05	<0.43	1.05	-121	12,000	6.75	2.97	<25	13,000	3	15	<0.07	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	03/20/05	NS	0.52	-118	NS	6.88	3.03	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	9.51	84	NS	7.66	8.1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/23/05	89	10.05	NS	7,700	6.65	9.39	<120	11,000	4	19	0.045 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07

TABLE 2-2
Trench 1 Monitoring System Data

Sampling Location	Sample Date	Perchlorate (µg/L)	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	Methane (µg/L)	pH	Depth to Water (ft)	Nitrate (µg/L)	Total Organic Carbon (µg/L)	Humic Acid (mg/L)	Fulvic Acid (mg/L)	Volatile Fatty Acids (mg/L): Acetic acid	n-Butric acid	Hexanoic acid	i-Hexanoic acid	i-Pentanoic acid	Lactic acid	n-Pentanoic acid	Propanoic acid	Pyruvic acid
AFTG001W West Trench Port Location	12/02/04	<0.43	NS	-118	8,800	NS	NS	<25	18,000	9	147	0.093 J	<0.1	<0.2	<0.1	<0.07	<0.07	<0.07	<0.07	<0.07
	01/13/05	NS	0.52	-121	NS	6.89	2.84	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/20/05	NS	0.72	-128	NS	6.91	2.88	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/28/05	NS	1.24	-126	NS	6.88	2.48	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/11/05	NS	0.78	-134	NS	6.94	2.91	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/18/05	NS	0.62	-128	NS	6.95	3.01	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/25/05	NS	1.21	-122	NS	6.84	2.49	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/04/05	NS	0.61	-133	NS	6.82	2.89	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/10/05	<0.43	0.98	-116	10,000	6.98	3.29	25	6,900	4	9	0.056	0.07	0.1	0.1	0.07	0.1	0.07	0.07	0.07
	03/20/05	NS	0.64	-121	NS	7.02	3.41	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	9.54	-43	NS	6.96	8.9	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/23/05	180	9.86	NS	2,900	6.83	10.25	NS	8,100	6	16	0.08	0.07	0.1	0.1	0.07	0.1	0.07	0.07	0.07
	06/27/05	NS	NS	NS	NS	NS	NS	NS	18,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
AFTGMW02 15 ft Downgradient	07/23/02	410	0.16	10	NS	7.76	5.56	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	09/23/02	<2	3.42	-156	NS	6.65	13.88	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/30/02	<2	1.42	-141	NS	6.97	6.94	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/26/02	<2	2.14	-128	NS	7.04	7.04	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/19/02	<2	2.02	-134	NS	7.04	6.84	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/30/03	<0.43	1.98	-110	NS	7.07	7.93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/27/03	<0.43	1.74	-123	NS	7.05	3.02	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/31/03	<0.43	1.47	-114	NS	7.26	6	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	04/29/03	<0.43	0.87	-78	NS	7.10	8.91	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/29/03	<0.43	0.76	-66	NS	7.02	9.96	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/30/03	23	0.85	-66	NS	7.02	11.24	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/22/03	<0.43	0.59	-116	NS	6.28	6.21	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/19/04	78	0.66	-104	NS	6.57	5.15	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/11/04	90	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/10/04	30	1.26	-17	NS	6.99	4.26	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/02/04	99	NS	-113	65	NS	4.13	1,100	1,400	2	50	<0.2	<0.1	<0.2	<0.1	<0.07	<0.07	<0.07	<0.07	<0.07
	01/13/05	NS	1.52	-105	NS	6.92	4.18	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/20/05	NS	1.51	-111	NS	6.87	4.26	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/28/05	NS	1.14	-114	NS	6.85	3.84	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/11/05	NS	1.46	-106	NS	6.94	4.27	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/18/05	NS	1.42	-118	NS	7.01	4.31	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/25/05	NS	1.24	-123	NS	6.91	3.81	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/04/05	NS	1.12	1.2	NS	6.87	3.64	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/10/05	100	0.96	-104	20	7.3	5.33	610	1,800	8	61	0.042 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	03/20/05	NS	1.54	-106	NS	7.21	5.36	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	9.61	60	NS	7.43	10.76	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/23/05	180	10.28	NS	330	6.98	12.1	930	960 J	53	21	<0.07	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07

TABLE 2-2

Trench 1 Monitoring System Data

Sampling Location	Sample Date	Perchlorate (µg/L)	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	Methane (µg/L)	pH	Depth to Water (ft)	Nitrate (µg/L)	Total Organic Carbon (µg/L)	Humic Acid (mg/L)	Fulvic Acid (mg/L)	Volatile Fatty Acids (mg/L) Acetic acid	n-Butric acid	Hexanoic acid	i-Hexanoic acid	i-Pentanoic acid	Lactic acid	n-Pentanoic acid	Propanoic acid	Pyruvic acid
GAF-8 60 ft Downgradient	05/08/99	1200	NS	NS	NS	NS	NS	6,300	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/14/02	480	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	07/23/02	310	0.2	12	NS	7.34	6.9	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	09/23/02	<2	3.79	-108	NS	6.9	14.26	50	13,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/30/02	<2	1.84	-135	NS	6.92	7.24	50	230,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/26/02	<2	2.27	-121	NS	7.08	7.33	50	5,500	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/19/02	<2	2.34	-119	NS	7.16	7.18	NS	120,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/30/03	<0.43	2.02	-105	NS	7.11	6.88	25	5,800	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/27/03	<0.43	1.93	-98	NS	7.16	3.1	25	2,800	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/31/03	<0.43	0.00	-166	NS	7.14	6.33	25	4,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	04/29/03	<0.43	0.41	-57	NS	7.07	9.14	23	4,100	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/29/03	<0.43	0.3	-56	NS	7.00	10.24	25	2,800	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/30/03	<0.43	0.42	-58	NS	7.05	11.42	25	4,100	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/22/03	<0.43	0.53	-91	NS	6.44	6.6	25	51,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/27/04	1200	0.57	-101	NS	6.57	5.41	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/11/04	94	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/10/04	79	1.92	36.7	NS	6.67	4.58	430	2,300	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/02/04	29	NS	4	180	NS	4.43	290	2,300	5	28	<0.2	<0.1	<0.2	<0.1	<0.07	<0.07	<0.07	<0.07	<0.07
	01/13/05	NS	1.55	6	NS	6.99	4.49	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/20/05	NS	1.58	4	NS	7.03	4.53	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/28/05	NS	0.85	16	NS	7.11	4.12	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/11/05	NS	1.49	2	NS	7	4.56	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/18/05	NS	1.67	-11	NS	7.06	4.67	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/25/05	NS	1.2	-52	NS	7	2.34	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/04/05	NS	1.55	-24	NS	7	3.89	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/10/05	4.2	1.15	-10	15	7.33	5.36	70	2,600	7	18	<0.07	<0.07	<0.1	<0.1	<0.07	1.49	<0.07	<0.07	<0.07
	03/20/05	NS	1.38	-14	NS	7.22	5.38	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	9.65	81	NS	7.43	11.17	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/23/05	7.1	10.62	NS	750	5.18	12.8	470	1,400	16	17	0.06 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
AFTGMW10 200 ft Downgradient	02/27/03	48	1.84	3	NS	7.07	2.88	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/31/03	20	0.24	-20	NS	7.31	5.85	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	04/29/03	28	0.72	71	NS	7.32	8.66	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/29/03	55	0.68	84	NS	7.15	10.31	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/30/03	66	0.58	95	NS	7.09	11.04	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/22/03	47	4.66	18	NS	7.08	6.21	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/19/04	27	2.57	24	NS	7.12	5.04	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/11/04	12	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/10/04	6.9	1.21	-28.5	NS	7.14	4.23	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/13/05	28	3.24	-15	NS	6.78	3.87	440	1,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	9.54	84	NS	7.45	10.72	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/22/05	58	NS	NS	NS	NS	NS	930	840 J	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

TABLE 2-2
Trench 1 Monitoring System Data

												Volatile Fatty Acids (mg/L)								
Sampling Location	**Sample Date**	**Perchlorate (µg/L)**	**Dissolved Oxygen (mg/L)**	**Oxidation Reduction Potential (mV)**	**Methane (µg/L)**	**pH**	**Depth to Water (ft)**	**Nitrate (µg/L)**	**Total Organic Carbon (µg/L)**	**Humic Acid (mg/L)**	**Fulvic Acid (mg/L)**	**Acetic acid**	**n-Butric acid**	**Hexanoic acid**	**i-Hexanoic acid**	**i-Pentanoic acid**	**Lactic acid**	**n-Pentanoic acid**	**Propanoic acid**	**Pyruvic acid**
AFTGMW15	01/13/05	640	2.14	-15	NS	6.98	NS	3,500	720	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/20/05	NS	1.34	-21	NS	6.89	4.21	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/28/05	NS	1.32	-24	NS	6.91	3.86	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/11/05	NS	1.35	-26	NS	6.97	4.26	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/18/05	NS	1.37	-24	NS	7.01	4.28	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/25/05	NS	1.3	-31	NS	6.93	3.85	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/04/05	NS	1.24	-18	NS	6.89	3.68	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/10/05	630	0.98	27	0.5	7.28	5.51	4,100	910 J	3	10	0.051 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	03/20/05	NS	1.52	18	NS	7.16	5.67	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	9.56	73	NS	7.54	7.34	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/23/05	530	11.75	NS	0.55	7.62	8.7	4,700	<500	12	4	0.053 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07

Notes:

NS Not Sampled

< Undetected at the limit indicated

TABLE 2-3

Trench 2 Monitoring System

Sampling Location	Sample Date	Perchlorate (µg/L)	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	Methane (µg/L)	pH	Depth to Water (ft)	Nitrate (µg/L)	Total Organic Carbon (µg/L)	Humic Acid (mg/L)	Fulvic Acid (mg/L)	Volatile Fatty Acids (mg/L)								
												Acetic acid	n-Butric acid	Hexanoic acid	i-Hexanoic acid	i-Pentanoic acid	Lactic acid	n-Pentanoic acid	Propanoic acid	Pyruvic acid
GAF-10 30 ft Upgradient	04/16/00	690	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/14/02	980	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	07/23/02	910	0.27	62	NS	7.16	3.79	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	09/23/02	740	5.02	-17	NS	7.16	10.18	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/30/02	850	2.51	25	NS	7.12	3.74	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/26/02	910	2.28	-38	NS	7.12	3.8	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/19/02	820	2.21	-35	NS	7.15	3.45	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/30/03	740	2.04	-127	NS	7.03	4.36	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/27/03	580	2.10	-133	NS	7.05	3.04	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/31/03	490	1.49	34	NS	6.84	3.75	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	04/29/03	650	1.01	173	NS	7.23	5.68	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/29/03	610	1.10	167	NS	7.21	7.03	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/30/03	630	1.08	166	NS	7.2	7.67	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/03/03	740	0.53	10	NS	6.96	5.66	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/27/04	1800	0.69	18	NS	7.32	3.52	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/10/04	520	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/14/04	520	3.54	-8	NS	7.07	3.33	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/22/05	270	11.77	78	NS	7.34	8.97	8,500	500 J	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
AFTG002E East Trench Port Location	07/23/02	<10	0.22	-159	NS	6.1	6	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	09/23/02	<20	2.16	-138	NS	7.1	8.94	18	320,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/30/02	5.3	1.94	-174	NS	6.93	2.16	96	110,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	11/26/02	<2	1.04	-97	NS	6.97	3.47	75	84,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/19/02	<2	0.97	-102	NS	7.02	3.31	NS	49,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/30/03	<0.43	0.90	-98	NS	6.78	3.1	<25	26,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/27/03	<0.43	1.00	-102	NS	6.84	1.9	<25	33,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/31/03	<0.43	1.63	-127	NS	6.47	2.69	<25	15,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	04/29/03	<0.43	0.63	-129	NS	6.59	4.63	<23	21,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/29/03	<0.43	0.78	-115	NS	6.79	5.11	<25	25,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/30/03	<0.43	0.85	-121	NS	7.02	6.2	37	30,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/21/03	<0.86	0.79	-173	NS	6.42	3.41	<25	22,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/19/04	<0.43	1.10	-148	NS	7.1	2.28	<120	20,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/10/04	<1.7	NS	NS	NS	NS	NS	<25	13,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/01/04	<0.86	0.41	-147	4,900	6.43	1.27	52	6,900	13	33	0.076 J	<0.1	<0.2	<0.1	<0.07	<0.07	<0.07	<0.07	<0.07
	01/13/05	NS	0.41	-138	NS	6.54	1.24	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/20/05	NS	0.64	-116	NS	6.69	1.27	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/28/05	NS	0.64	-134	NS	6.81	1.06	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/11/05	NS	0.84	-124	NS	6.74	1.33	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/18/05	NS	1.02	-134	NS	6.82	1.42	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/25/05	NS	0.94	-124	NS	6.94	1.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/04/05	NS	1.06	-124	NS	6.81	1.24	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/11/05	<0.43	0.81	-127	4,700	7.17	1.62	30 J	3,600	10	14	0.045 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	03/20/05	NS	0.92	-130	NS	7.13	1.69	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	9.89	-70	NS	7.16	5.68	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/22/05	<2.2	12	118	3,900	6.95	7.64	<25	5,900	4	129	0.058 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07

TABLE 2-3

Trench 2 Monitoring System

Sampling Location	Sample Date	Perchlorate (μg/L)	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	Methane (μg/L)	pH	Depth to Water (ft)	Nitrate (μg/L)	Total Organic Carbon (μg/L)	Humic Acid (mg/L)	Fulvic Acid (mg/L)	Volatile Fatty Acids (mg/L) Acetic acid	n-Butric acid	Hexanoic acid	i-Hexanoic acid	i-Pentanoic acid	Lactic acid	n-Pentanoic acid	Propanoic acid	Pyruvic acid
AFTG002W West Trench Port Location	12/01/04	5.8	0.92	-127	230	6.91	NS	98	14,000	111	33	<0.2	<0.1	<0.2	<0.1	<0.07	<0.07	<0.07	<0.07	<0.07
	01/13/05	NS	0.92	-124	NS	6.84	1.36	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/20/05	NS	0.66	-128	NS	6.89	1.38	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/28/05	NS	1.02	-126	NS	6.84	1.08	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/11/05	NS	0.88	-117	NS	6.95	1.42	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/18/05	NS	1.06	-124	NS	6.97	1.51	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/25/05	NS	1.11	-61	NS	6.91	1.06	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/04/05	NS	1.04	-136	NS	6.89	1.36	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/11/05	48	0.86	-97	960	7.09	1.43	2,500	1,500	9	17	<0.07	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	03/20/05	NS	0.41	-99	NS	7.05	1.47	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	9.95	-50	NS	7.3	5.65	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/22/05	<0.43	12.4	145	4,600	7.05	7.35	<25	3,500	34	13	<0.07	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
AFTGMW11	12/01/04	250	1.51	-25	130	7.2	NS	5,600	1,300	43	25	<0.2	<0.1	<0.2	0.304	<0.07	<0.07	<0.07	<0.07	<0.07
	01/13/05	NS	1.51	-33	NS	7.15	2.63	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/20/05	NS	1.14	-40	NS	7.07	2.68	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/28/05	NS	1.3	-48	NS	7.03	2.46	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/11/05	NS	1.06	-51	NS	7.12	2.69	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/18/05	NS	1.01	-67	NS	7.15	2.75	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/25/05	NS	1.2	-52	NS	7	2.34	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/04/05	NS	0.68	-84	NS	7.05	2.64	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/11/05	290	0.91	64	13	7.19	1.91	6,300	1,200	9	7	0.047 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	03/20/05	NS	1.5	54	NS	7.09	2.01	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	10.18	66	NS	7.43	4.91	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/22/05	190	13.25	79	1.2	7.33	6.2	1,600	830 J	<1	6	0.059 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
AFTGMW12	12/01/04	94	1.05	31	620	7	NS	2,000	3,100	6	42	<0.2	<0.1	<0.2	<0.1	<0.07	<0.07	<0.07	<0.07	<0.07
	01/13/05	NS	1.05	18	NS	7.07	2.49	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/20/05	NS	1.01	16	NS	7.11	2.54	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/28/05	NS	0.91	9	NS	7.08	2.34	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/11/05	NS	1.16	7	NS	7.09	2.61	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/18/05	NS	0.99	-2	NS	7.11	2.68	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/25/05	NS	1.06	-2	NS	7	2.31	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/04/05	NS	0.67	-14	NS	7.06	2.35	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/10/05	0.68 J	1.06	117	1,700	7.22	1.08	52	2,800	8	4	<0.07	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	03/20/05	NS	1.15	86	NS	7.19	1.14	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	10.26	63	NS	7.35	5.06	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/22/05	360	9.98	87	82	6.68	6.79	2,700	1,100	13	5	<0.07	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
AFTGMW13	12/01/04	330	1.16	26	1.7	6.95	NS	4,000	2,900	32	23	<0.2	<0.1	<0.2	<0.1	<0.07	<0.07	<0.07	<0.07	<0.07
	01/13/05	NS	1.16	28	NS	7.1	2.15	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/20/05	NS	1.12	24	NS	7.08	2.21	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/28/05	NS	1.04	22	NS	7.05	2.04	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/11/05	NS	1.25	23	NS	7.14	2.34	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/18/05	NS	1.16	12	NS	7.08	2.42	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/25/05	NS	1.51	14	NS	7.01	2.02	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/04/05	NS	0.85	8	NS	7.11	2.34	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/10/05	340	0.96	61	27	7.07	0.43	3,100	1,900	2	7	<0.07	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	03/20/05	NS	1.47	62	NS	7.03	0.46	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	10.14	57	NS	7.27	4.75	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/22/05	<0.43	11.01	6.45	790	6.45	6.18	<25	1,700	13	4	0.057 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07

TABLE 2-3

Trench 2 Monitoring System

Sampling Location	Sample Date	Perchlorate (μg/L)	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	Methane (μg/L)	pH	Depth to Water (ft)	Nitrate (μg/L)	Total Organic Carbon (μg/L)	Humic Acid (mg/L)	Fulvic Acid (mg/L)	Volatile Fatty Acids (mg/L)								
												Acetic acid	n-Butric acid	Hexanoic acid	i-Hexanoic acid	i-Pentanoic acid	Lactic acid	n-Pentanoic acid	Propanoic acid	Pyruvic acid
AFTGMW14	12/01/04	390	1.70	44	3.8	7.1	NS	3,700	2,400	12	27	<0.2	<0.1	<0.2	<0.1	<0.07	<0.07	<0.07	<0.07	<0.07
	01/13/05	NS	1.7	32	NS	7.08	2.16	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/20/05	NS	1.43	34	NS	7.1	2.24	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	01/28/05	NS	1.52	36	NS	7.13	2.11	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/11/05	NS	1.24	29	NS	7.08	2.28	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/18/05	NS	1.46	18	NS	7.04	2.36	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/25/05	NS	1.24	28	NS	7.11	2.08	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/04/05	NS	1.12	16	NS	7.08	2.3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/10/05	140	0.6	64	0.63	7.33	0.17	1,500 J	1,300	1	17	0.048 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	03/20/05	NS	1.51	38	NS	7.24	0.21	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/07/05	NS	10.01	34	NS	7.42	5.1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/22/05	290	14.05	54	3.3	7.53	6.82	6,900	520	2	11	<0.07	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
AFTGMW08 60 ft Downgradient	01/30/03	33	1.14	17	NS	7.03	4.51	6,900	860	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/27/03	32	0.99	-2	NS	7.05	3.04	11,000	<500	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	03/31/03	29	0.00	-10	NS	6.48	4.03	13,000	<1000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	04/29/03	36	0.60	153	NS	7.16	5.57	12,000	730	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	05/29/03	46	0.39	143	NS	7.06	7.24	11,000	1,500	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/30/03	44	0.51	156	NS	7.11	7.23	8,800	980	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/21/03	6	0.49	32	NS	7.06	7.33	32	5,200	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	02/19/04	39	0.64	39	NS	7.04	3.81	6,100	860	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/10/04	61	3.06	157.3	NS	6.95	3.12	8,300	860	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	12/14/04	60	3.11	-3	NS	7.02	3.24	7,500	950	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	06/21/05	66	9.91	-1	NS	7.34	8.36	3,400	780 J	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Notes:

NS Not Sampled

< Undetected at the limit indicated

TABLE 2-4
Trench S-1B Monitoring System Data

Sampling Location	Sample Date	Perchlorate (μg/L)	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	Methane (μg/L)	pH	Depth to Water (ft)	Nitrate (μg/L)	Total Organic Carbon (μg/L)	Humic Acid (mg/L)	Fulvic Acid (mg/L)	Volatile Fatty Acids (mg/L): Acetic acid	n-Butric acid	Hexanoic acid	i-Hexanoic acid	i-Pentanoic acid	Lactic acid	n-Pentanoic acid	Propanoic acid	Pyruvic acid
	12/16/2004	THIS TRENCH COULD NOT BE SAMPLED DUE TO OIL INTERMINGLED WITH WATER																		
	1/13/2005	NS	NS	-115	NS	6.84	4.84	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	0.64	-141	NS	6.8	2.72	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/26/2005	1.1J	0.32	-134	NS	6.64	3.98	210	83,000	1512	93	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/11/2005	NS	0.79	-132	NS	6.79	2.84	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	0.94	-124	NS	6.84	2.9	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Trench Port S-1A	2/25/2005	NS	0.51	-124	NS	6.78	3.94	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	0.92	-134	NS	6.84	2.67	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	12	1.75	-111	2,400	6.87	1.72	120	27,000	34	38	<0.07	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	3/20/2005	NS	1.72	-106	NS	6.91	1.75	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/31/2005	2.3J	0.68	-118	NS	NS	2.73	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/5/2005	NS	10.14	-142	NS	6.88	5.47	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23/2005	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
	12/16/2004	THIS TRENCH COULD NOT BE SAMPLED DUE TO OIL INTERMINGLED WITH WATER																		
	1/13/2005	NS	NS	-123	NS	6.81	4.61	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	0.51	-147	NS	6.78	1.55	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/26/2005	4.4	0.37	-127	NS	6.71	2.56	160	64,000	171	75	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/11/2005	NS	0.61	-165	NS	6.78	1.61	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	0.76	-165	NS	6.86	1.68	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Trench Port S-1B	2/25/2005	NS	0.64	-134	NS	6.76	2.51	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	0.61	-152	NS	6.88	1.55	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	7	0.99	-102	14,000	6.89	1.36	75	53,000	6	55	0.059 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	3/20/2005	NS	0.67	-111	NS	6.94	1.48	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/31/2005	<2.2	0.91	-111	NS	NS	2.21	77	43000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/5/2005	THIS TRENCH COULD NOT BE SAMPLED DUE TO OIL INTERMINGLED WITH WATER																		
	6/23/2005	<0.43	10.08	NS	5,400	6.67	5.9	<25	64,000	62	51	0.068 J	0.282	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	12/16/2004	THIS TRENCH COULD NOT BE SAMPLED DUE TO OIL INTERMINGLED WITH WATER																		
	1/13/2005	NS	NS	-104	NS	6.78	4.67	160	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	0.38	-138	NS	6.84	1.27	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/26/2005	1.5	0.38	-138	NS	6.67	1.48	130	22,000	6	5	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/11/2005	NS	0.61	-124	NS	6.82	1.32	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	0.78	-134	NS	6.91	1.4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Trench Port S-1C	2/25/2005	NS	0.67	-133	NS	6.77	1.46	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	0.68	-134	NS	6.84	1.02	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	3.3	0.9	-116	0.096	6.97	0.37	47	20,000	2	103	<0.07	0.194	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	3/20/2005	NS	0.89	-104	NS	7.02	0.4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/31/2005	2.2U	0.94	-106	NS	NS	1.73	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/5/2005	NS	11.12	-117	NS	7.07	3.42	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23/2005	<0.43	10.05	NS	8,300	6.49	5.33	<25	27,000	35	31	<0.07	0.278	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	1/13/2005	NS	NS	8	NS	7.24	3.67	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	0.46	-164	NS	6.68	0.3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/26/2005	4,000	1.49	46	0.06	7.03	0.39	6,200	1,400	8	7	0.084 J	<0.07	<0.1	<0.1	<0.07	1	<0.07	<0.07	<0.07
	2/11/2005	NS	0.51	-149	NS	6.74	0.46	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	0.61	-144	NS	6.84	0.62	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
TSTMW28	2/25/2005	NS	1.52	41	NS	7.01	0.26	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	0.63	-166	NS	6.87	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	3,800	0.68	72	6.6	7.33	1.81	10,000 J	1,500	4	8	0.093	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	3/20/2005	NS	0.94	68	NS	7.21	1.86	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/6/2005	NS	10.58	63	NS	7.5	4.25	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23/2005	3,600	10.43	NS	130	7.14	6.16	9,500	1,000	3	28	0.044 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07

TABLE 2-4
Trench S-1B Monitoring System Data

												Volatile Fatty Acids (mg/L)								
Sampling Location	Sample Date	Perchlorate (µg/L)	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	Methane (µg/L)	pH	Depth to Water (ft)	Nitrate (µg/L)	Total Organic Carbon (µg/L)	Humic Acid (mg/L)	Fulvic Acid (mg/L)	Acetic acid	n-Butric acid	Hexanoic acid	i-Hexanoic acid	i-Pentanoic acid	Lactic acid	n-Pentanoic acid	Propanoic acid	Pyruvic acid
TSTMW29	1/13/2005	NS	NS	-12	NS	6.94	5.01	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	1.14	-18	NS	7.04	5.9	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/26/2005	4,400	1.57	37	0.072	7.11	5.23	10,000	850	3	5	0.089 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	2/11/2005	NS	1.24	-26	NS	7.08	6.12	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	1.3	-43	NS	7.02	6.19	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/25/2005	NS	1.24	26	NS	7.13	5.2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	1.14	-42	NS	6.95	4.26	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	3,400	0.98	52	65	7.51	3.57	4,700 J	2,100	2	7	0.086	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	3/20/2005	NS	1.24	56	NS	7.34	3.64	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/6/2005	NS	10.91	66	NS	7.5	7.11	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23/2005	3,400	11.02	NS	4.8	7.21	7.74	5,000	1,000	7	34	<0.07	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
TSTMW30	1/13/2005	NS	NS	-7	NS	6.96	5.13	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	1.2	24	NS	7.06	6.5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/26/2005	3500	1.37	58	0.065	7.14	5.59	6,900	<500	14	5	0.095 J	<0.07	<0.1	<0.1	<0.07	1	<0.07	<0.07	<0.07
	2/11/2005	NS	1.34	36	NS	7.11	6.59	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	1.22	17	NS	7	6.67	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/25/2005	NS	1.26	24	NS	7.08	5.41	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	0.98	11	NS	6.93	5.34	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	3,100	0.92	84	69	7.37	3.49	6,800 J	1,700	1	3	0.066 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	3/20/2005	NS	1.08	71	NS	7.26	3.61	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/6/2005	NS	11.8	73	NS	7.52	7.98	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23/2005	3,700	10	NS	0.19	7.06	8.7	7,700	1,000	1	20	0.043 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
TSTMW17	1/13/2005	NS	NS	12	NS	6.95	5.16	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	1.17	-28	NS	7.05	6.79	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/25/2005	2,100	NS	NS	NS	NS	NS	2,200	660	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/26/2005	4,600	1.81	42	0.064	7.09	18.3	13,000	1,200	NS	NS	0.071 J	<0.07	<0.1	<0.1	<0.07	1	<0.07	<0.07	<0.07
	2/11/2005	NS	1.42	-16	NS	7.06	6.84	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	1.34	-21	NS	7.04	6.92	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/25/2005	NS	1.57	31	NS	7.11	6.72	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	1.34	-33	NS	6.91	5.84	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	3,300	0.8	105	0.9	7.45	6.51	7,800 J	750 J	6	14	0.069 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	3/20/2005	NS	1.24	92	NS	7.31	6.68	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/7/2005	NS	9.83	68	NS	7.66	10.45	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23/2005	2,800	8.68	NS	0.088	7.03	10.94	7,900	<500	2	13	0.046 J	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07

Notes:

NS Not Sampled

< Undetected at the limit indicated

TABLE 2-5
Trench S-3E Monitoring System Data

Sampling Location	Sample Date	Perchlorate (mg/L)	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	Methane (mg/L)	pH	Depth to Water (ft)	Nitrate (mg/L)	Total Organic Carbon (mg/L)	Humic Acid (mg/L)	Fulvic Acid (mg/L)	Volatile Fatty Acids (mg/L)								
												Acetic acid	n-Butric acid	Hexanoic acid	i-Hexanoic acid	i-Pentanoic acid	Lactic acid	n-Pentanoic acid	Propanoic acid	Pyruvic acid
Trench Port S3E-F	12/17/2004	<22	2.03	-128.8	5,100	6.6	2.02	NS	1,900,000	294	844	68.1	55.9	<20	<10	9.09	1.86 J	29.9	2040	<7
	1/13/2005	NS	2.03	-128.8	NS	6.6	2.02	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	0.97	-123	NS	6.72	1.97	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/27/2005	NS	4.97	-156	NS	6.89	2.98	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/11/2005	43	0.85	-118	NS	6.78	2.12	NS	1,400,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	1.09	-129	NS	6.84	2.24	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/26/2005	NS	4.64	-133	NS	6.87	3.12	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	0.94	-119	NS	6.82	2.03	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	<22	0.55	-160.6	2,500	7.05	2.93	450 J	520,000	32	379	15.6	9.94	<0.1	<0.1	<0.7	<0.1	<0.07	1.48	<0.7
	3/20/2005	NS	1.01	-152	NS	7.01	2.97	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/31/2005	3.3J	0.93	-148	NS	NS	3.36	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/6/2005	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23/2005	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Trench Port S3E-D	12/17/2004	200 J	0.98	57.8	1,900	6.32	3.12	NS	21,000,000	522	1326	6610	423	45	0.1	0.07	748	287	5820	0.07
	1/13/2005	NS	0.98	57.8	NS	6.32	3.12	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	1.13	41	NS	6.68	2.93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/27/2005	NS	5.24	-108	NS	6.88	2.04	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/11/2005	43U	1.24	35	NS	6.84	3.05	NS	7,900,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	1.15	3	NS	6.86	3.18	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/26/2005	NS	4.31	-111	NS	6.94	2.01	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	0.99	-6	NS	6.84	2.81	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	<22	1.02	-140.7	14	6.97	1.19	440 J	2,000,000	NS	NS	121000	1520	<10	<10	<7	39500	1040	25600000	<7
	3/20/2005	NS	1.16	-132	NS	6.99	1.25	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/31/2005	2.2U	1.12	-135	NS	NS	2.09	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/6/2005	NS	9.33	-102	NS	7.25	7.65	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23/2005	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
TSTMW31	12/17/2004	8.2	0.66	-46.2	38	6.72	2.72	17,000	4,500	2	20	0.175 J	<0.1	<0.2	3.97	<0.07	<0.7	<0.07	<0.07	<0.07
	1/13/2005	NS	0.66	-46.2	NS	6.72	2.72	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	0.79	-38	NS	6.84	2.64	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/27/2005	NS	1.04	20	NS	7.02	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/11/2005	NS	1.02	-43	NS	6.89	2.74	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	1.34	-62	NS	6.86	2.86	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/26/2005	NS	0.91	-1	NS	6.97	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	1.06	-84	NS	6.83	2.74	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	8.2	2.43	128.1	2.2	6.99	3.33	12,000	2,700	6	20	<0.07	<0.07	<0.1	<0.1	<0.07	1.36	<0.07	<0.07	<0.07
	3/20/2005	NS	2.24	114	NS	7.06	3.38	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/7/2005	NS	9.44	118	NS	7.33	9.71	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23/2005	7.9	10.21	NS	85	6.85	9.4	9,600	2,400	4	65	0.046 J	0.139	<0.1	0.184	<0.07	<0.1	<0.07	<0.07	<0.07
TSTMW32	12/17/2004	<0.86	0.25	-108.7	31	6.76	6.73	41	73,000	7	48	69	5	<0.2	0.053 J	1.9	<3.5	0.419	<3.5	<3.5
	1/13/2005	NS	0.25	-108.7	NS	6.76	6.73	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	0.68	-79	NS	7.01	6.63	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/27/2005	NS	4.24	32	NS	7.15	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/11/2005	NS	0.74	-64	NS	7.05	6.78	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	1.35	-61	NS	7.04	6.89	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/26/2005	NS	3.28	16	NS	7.06	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	1.07	-56	NS	6.97	6.33	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	<0.43	1.1	-69.2	1.1	7.01	6.69	230	22,000	10	29	3.3	0.467	<0.1	<0.1	<0.07	<1	<0.07	<0.07	<0.07
	3/20/2005	NS	1.06	-78	NS	7.04	6.84	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/7/2005	NS	8.87	-25	NS	7.16	10.25	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23/2005	<0.43	10.74	NS	170	6.76	11.15	52	12,000	4	23	0.049 J	0.416	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07

TABLE 2-5
Trench S-3E Monitoring System Data

												Volatile Fatty Acids (mg/L)								
Sampling Location	**Sample Date**	**Perchlorate (mg/L)**	**Dissolved Oxygen (mg/L)**	**Oxidation Reduction Potential (mV)**	**Methane (mg/L)**	**pH**	**Depth to Water (ft)**	**Nitrate (mg/L)**	**Total Organic Carbon (mg/L)**	**Humic Acid (mg/L)**	**Fulvic Acid (mg/L)**	**Acetic acid**	**n-Butric acid**	**Hexanoic acid**	**i-Hexanoic acid**	**i-Pentanoic acid**	**Lactic acid**	**n-Pentanoic acid**	**Propanoic acid**	**Pyruvic acid**
TSTMW33	12/17/2004	23	2.17	26.7	1.7	7.48	5.5	21,000	2,500	1	51	<2	<0.1	<0.2	0.139 J	<0.07	0.164	<0.07	<0.07	<0.07
	1/13/2005	NS	2.17	26.7	NS	7.48	5.5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	2.04	18	NS	7.37	5.37	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/27/2005	NS	3.23	62	NS	7.04	1.01	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/11/2005	NS	1.76	22	NS	7.15	5.46	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	1.16	7	NS	7.13	5.67	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/26/2005	NS	3.42	45	NS	7.08	0.86	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	1.25	0	NS	6.95	5.48	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	23	3.82	32.5	12,000	7.16	4.07	14,000	2,200	9	28	<0.07	<0.07	<0.1	<0.1	<0.07	2.48	<0.07	<0.07	<0.07
	3/20/2005	NS	2.57	18	NS	7.14	4.21	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/7/2005	NS	9.03	51	NS	7.4	10.9	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23/2005	21	11.37	NS	0.085	7.11	12.1	17,000 J	820 J	7	15	<0.07	<0.07	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
TSTMW34	12/17/2004	1.6 J	0.3	-9.7	510	6.94	2.77	43 J	29,000	9	33	24.4	5	<0.2	0.078	0.586	3.5	0.162 J	4.75	<3.5
	1/13/2005	NS	0.3	-9.7	NS	6.94	2.77	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/20/2005	NS	1.11	-4	NS	7.04	2.64	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1/27/2005	NS	2.06	67	NS	7.06	0.22	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/11/2005	NS	1.2	-1	NS	7.06	2.71	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/18/2005	NS	1.32	-6	NS	7.08	2.88	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/26/2005	NS	2	42	NS	7.05	0.21	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/4/2005	NS	1.22	-5	NS	6.93	2.74	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3/11/2005	1.1J	0.32	51	27	6.95	3.12	1,300	5,700	8	14	<0.07	0.217	<0.1	<0.1	<0.07	<0.1	<0.07	<0.07	<0.07
	3/20/2005	NS	0.86	44	NS	6.97	3.21	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/7/2005	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	6/23/2005	5.3	10.53	NS	7.4	6.94	16.7	2,000	2,900	47	26	0.043 J	<0.07	<0.1	0.356	<0.07	<0.1	<0.07	<0.07	<0.07

Notes:

NS Not Sampled

< Undetected at the limit indicated

2.2.3 DO and ORP

Measurement of DO at this site does not seem to be a very useful or quantifiable indicator for perchlorate breakthrough. However, ORP appears to be useful as a long-term tool for biowall operation. An examination of DO and ORP values from the biowall optimization study and from previous remedial activities at the site have shown considerable fluctuation in DO readings, both in the trench ports as well as in downgradient monitoring well locations. While the general consensus is that reducing or anaerobic conditions are preferred for perchlorate biodegradation, measurement of this parameter at this site does not seem to be a very useful or quantifiable indicator for perchlorate breakthrough.

ORP appears to be a much better indicator of future perchlorate breakthrough. ORP values less than - 100 mVs are commonly observed soon after the biowalls have been installed. However, as the useable and easily biodegradable carbon is depleted, ORP values gradually increase. Nevertheless, despite nearly positive ORP values at some locations, complete perchlorate degradation is still achieved. At other locations, increases in ORP to greater than -50mV appear to be the first evidence of impending perchlorate breakthrough. Therefore, while ORP should not be used independently for assessing biowall effectiveness, it appears to be useful as a secondary parameter for biowall operation.

2.2.4 Nitrate

Nitrate is a parameter that can be useful in the determination of biowall effectiveness. Nitrate, perhaps more than any other electron acceptor, competes with perchlorate for carbon resources in the aquifer. General native bacterial species in groundwater sometime appear to have a preference for nitrate over perchlorate in the energy-generation metabolic process. However, when useable carbon is present in high quantities, particularly soon after biowall installation or substrate replenishment, competition may be insignificant. At later stages of the biowall life cycle, when carbon substrate gets depleted, nitrate in groundwater may inhibit complete perchlorate biodegradation. Temporal nitrate measurements indicate the sensitivity of perchlorate biodegradation to the presence of nitrate. In groundwater at this site, this sensitivity appears to be critical at fairly low nitrate concentrations (100 to 500 µg/L). Therefore, if nitrate monitoring over time results in detections or increases that are above 100 µg/L, substrate replenishment may be required.

2.2.5 Methane

Methane has revealed itself as a useful parameter for determination of biowall effectiveness. Methane is often produced in aquifers where biowalls with mixed carbon substrates have been used. The presence of methane sometimes suggests the presence of extremely reducing conditions. However, in biowalls where considerable quantities of slow release substrates such as vegetable oil, wood chips, and compost have been used, methane concentrations tend to remain high even in moderately reducing conditions. Methane measurements in this aquifer actually seem to indicate that this parameter may be a critical one that could signal impending perchlorate breakthrough. At locations where concentrations of methane have dropped below 2,000 µg/L in the biowalls, perchlorate biodegradation appears hindered. Therefore, methane can be useful in the long-term O&M of biowalls, primarily because it reflects on the presence or absence of useable carbon for perchlorate biotreatment. Therefore, if methane monitoring over time results in decreases that are below 2,000 µg/L, substrate replenishment may be required.

3.0 FULL-SCALE IMPLEMENTATION OF BIOWALLS

Thirty-three full-scale biowalls have been installed at NWIRP McGregor as part of site restoration. The Areas E, F, M, and S biowalls were constructed from 2002 to September 2005. Area-specific details are provided below. A comprehensive figure showing all biowall locations is provided in Figure 3-1. All biowall as-builts are provided in Appendix A.

Area E

TCE and 1,1-DCE contaminant plumes in Area E and have migrated to the east-southeast onto offsite property. As a result, a low permeability soil cap was installed over the Area E landfill. Bioborings and a single biowall were also installed along the southeast property line (just south of the Area E landfill) to prevent any further offsite migration. The biowall and bioborings are shown on Figure 3-2.

Area F

A commingled perchlorate and TCE plume extends from the Area F industrial area to the north-northeast in the direction of surface water (Tributary F) and groundwater flow. The perchlorate plume extends onto offsite property. To limit further migration, a total of 11 biowalls and 330 bioborings were installed at locations along Tributary F. Of these 11 biowalls, nine were installed onsite within Area F, and the remaining two were installed northeast of NWIRP McGregor to remediate groundwater in this area. Offsite property ownership information for these biowalls is provided in Appendix C. While biowall construction was occurring, perchlorate regulatory values changed. As a result, two of the onsite biowalls, namely Biowalls F-1 and F-5, were no longer needed to achieve remedial objectives. Therefore, no O&M activities are required for either of these biowalls. Biowall dimensions and objectives are listed in Table 3-1. Figure 3-3 shows the locations of the biowalls and bioborings.

Table 3-1
Area F Biowall Summary

ID	Length (ft)	General Location	Objective
F-2	800	Approximately 1,500 feet upgradient of biowall F-3B.	Cleanup offsite groundwater within 15 years. Groundwater in the western portion of the offsite protective concentration level (PCL) exceedance (PCLE) zone flows through biowall F-2. Groundwater east of F-2 flows towards Tributary F and biowall F-3B.
F-3B	600	Approximately 200 feet from the downgradient edge of the PCLE zone.	
F-4B	300	Approximately 2,000 feet southwest of the eastern property line.	Reduce the migration of perchlorate to Tributary F and the perchlorate load reaching the property line biowall.
F-4C	400		
F-6A	300	Approximately 1,000 feet southwest of the eastern property line.	
F-6B	300		
F-7	500		
F-8A	300	Along NWIRP McGregor property line.	Form a virtually continuous remediation barrier across the eastern property line.
F-8B	300		
Bioborings	1,000		

Figure 3-1
Sitewide Biowall
and Bioborings Locations
NWIRP McGregor
McGregor, Texas

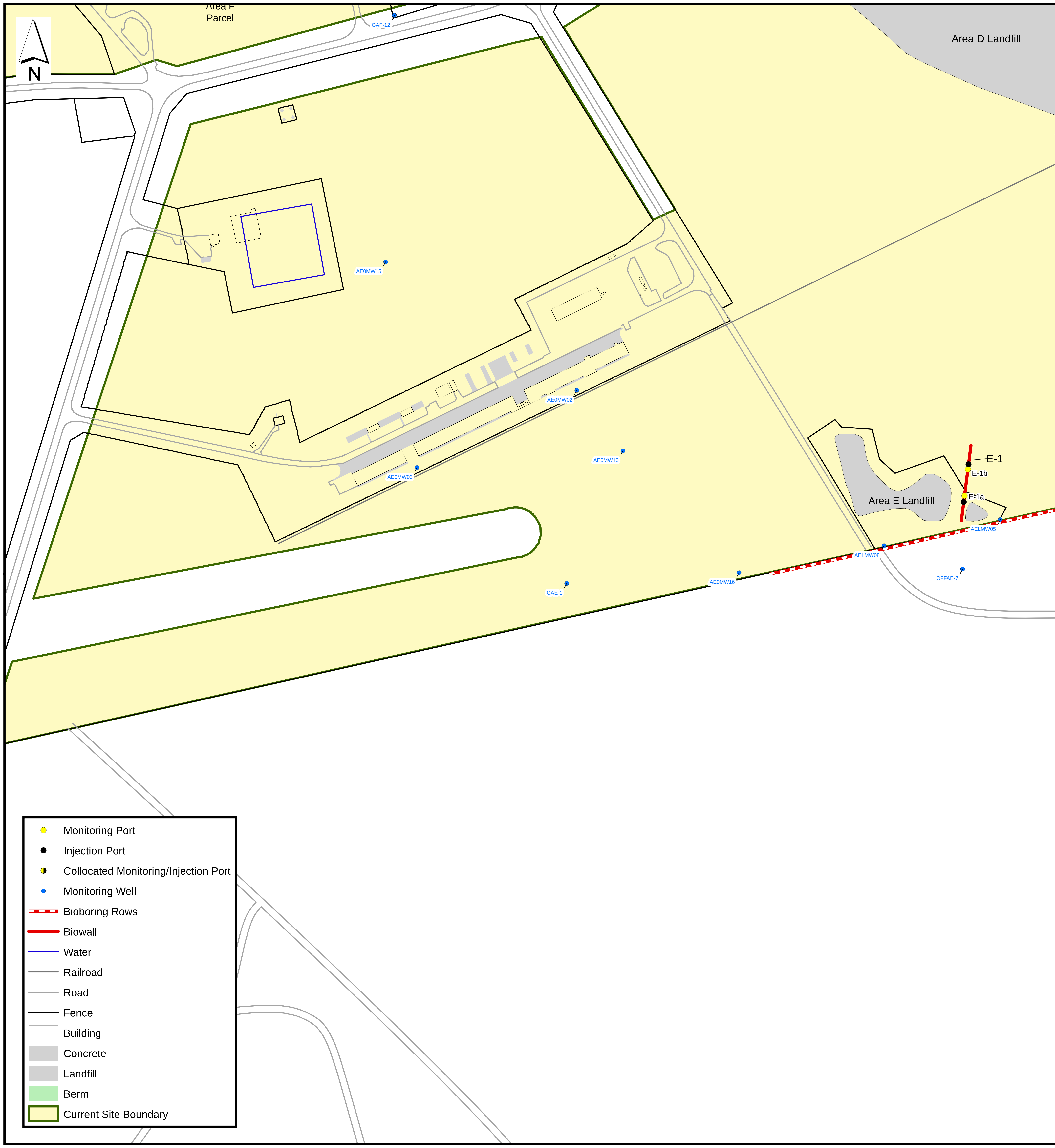

Figure 3-2
Area E Parcel
Biowall and Bioborings
Location Map
NWIRP McGregor
McGregor, Texas

November 2005

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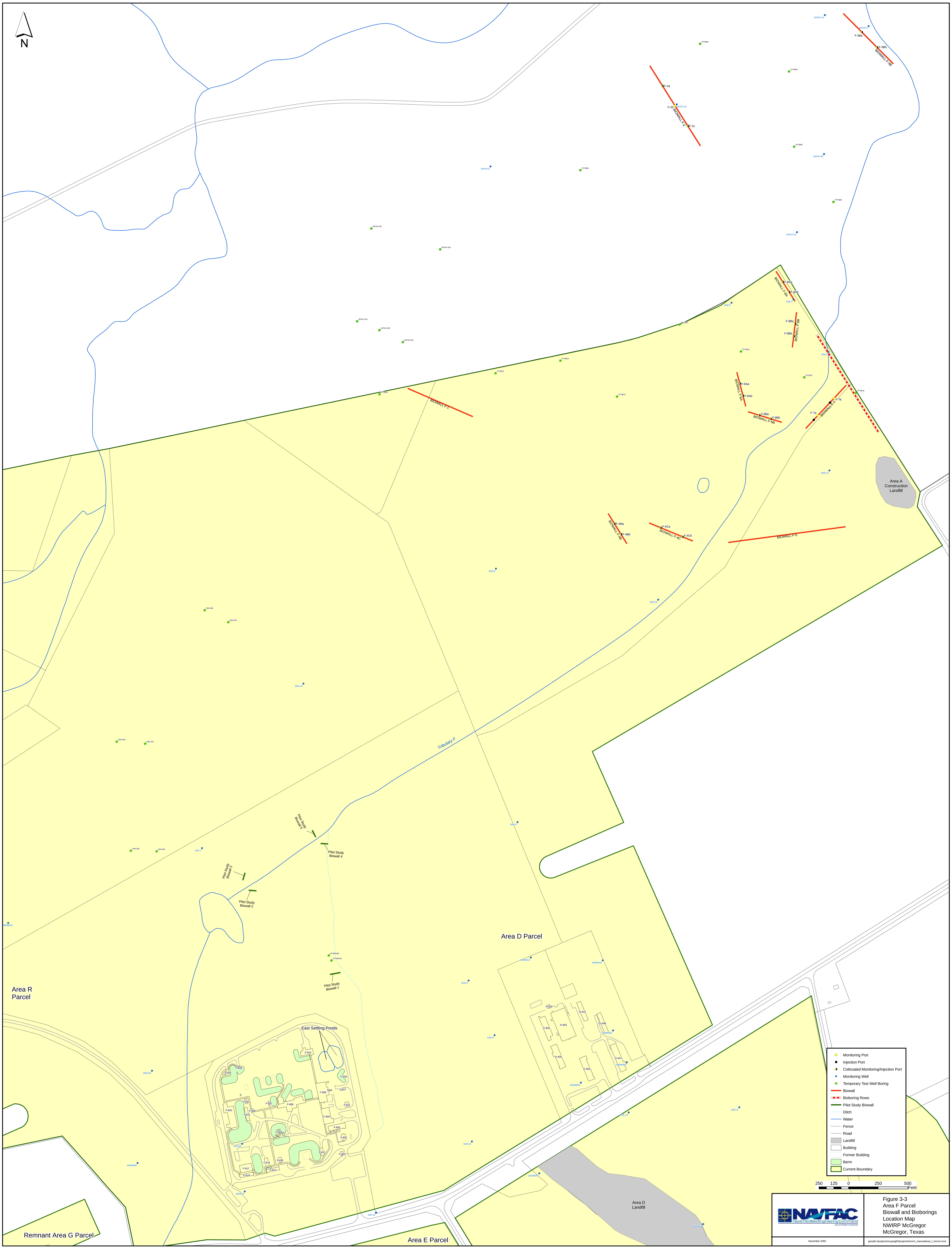

N
BIOWALL F-1
BIOWALL F-2
BIOWALL F-3B
BIOWALL F-4B
BIOWALL F-4C
BIOWALL F-5
BIOWALL F-6A
BIOWALL F-6B
BIOWALL F-7
BIOWALL F-8A
BIOWALL F-8B
Area A Construction Landfill
Tributary F
Pilot Study Biowall 1
Pilot Study Biowall 2
Pilot Study Biowall 3
Pilot Study Biowall 4
Pilot Study Biowall 5
East Settling Ponds
Area D Parcel
Area R Parcel
Remnant Area G Parcel
Area E Parcel
Area D Landfill
Monitoring Port
Injection Port
Collocated Monitoring/Injection Port
Monitoring Well
Temporary Test Well Boring
Biowall
Bioboring Rows
Pilot Study Biowall
Ditch
Water
Fence
Road
Landfill
Building
Former Building
Berm
Current Boundary
250 125 0 250 500
Feet
Naval Facilities Engineering Command
SOUTHERN DIVISION
Figure 3-3
Area F Parcel
Biowall and Bioborings
Location Map
NWIRP McGregor
McGregor, Texas
November 2005
gissafe://projects/mcgreg83/projects/trench_manual/area_f_trench.mxd

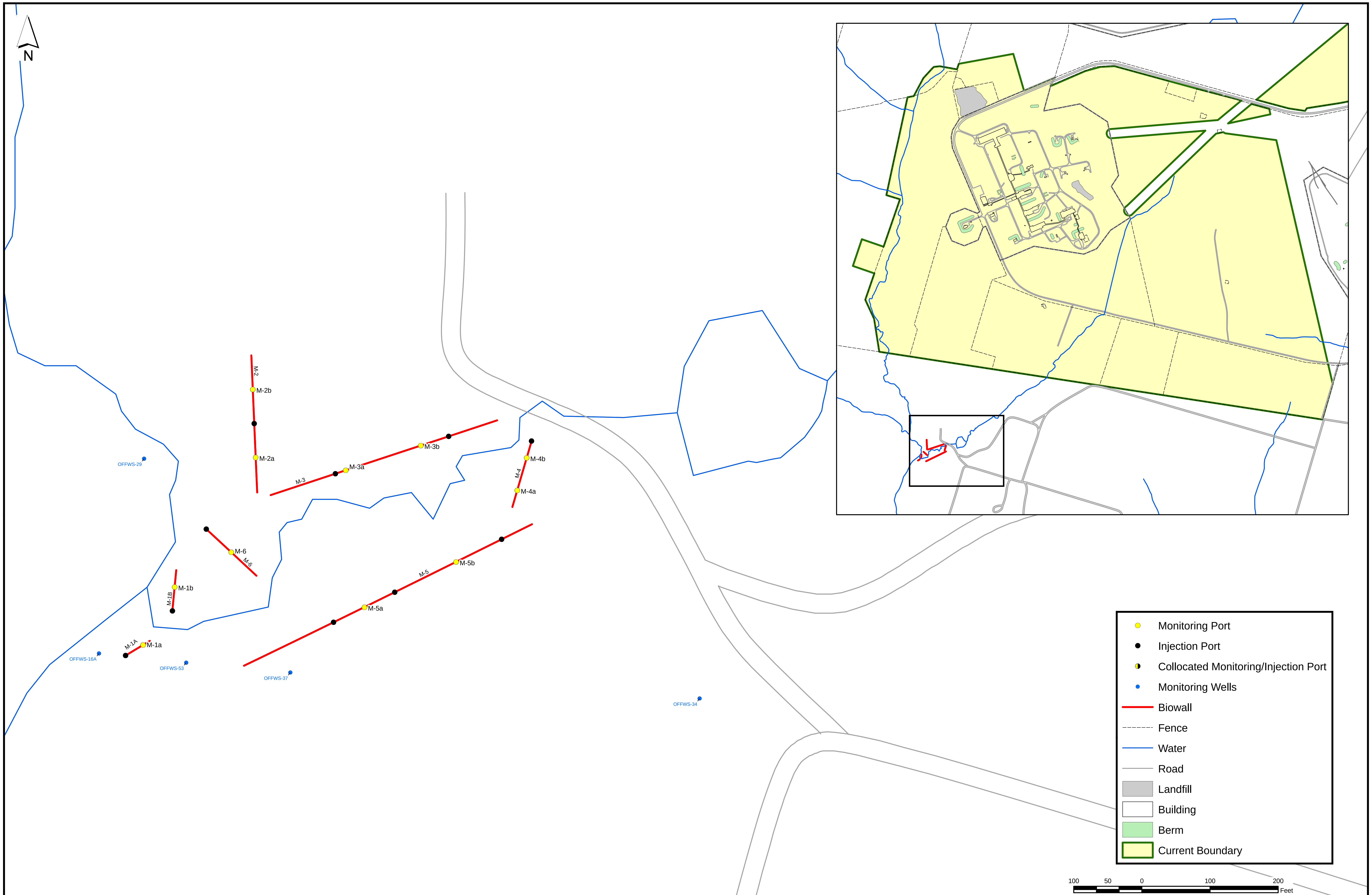
Area M

Eight biowalls (M-1A, M-1B, and M-2 to M-7) were constructed offsite at the confluence of Tributary M and Station Creek to limit perchlorate-contaminated groundwater exceeding the perchlorate residential PCL of 17.1 μg/L from migrating beyond the Texas A&M property boundary. Figure 3-4 shows the locations of the Area M biowalls.

Area S

Fifteen biowalls were originally installed onsite and offsite of Area S to address perchlorate- and CVOC-impacted groundwater (Figure 3-5). Biowalls S-1 (installed in 2 segments) and S-2 were installed for perchlorate mass reduction just downgradient of the suspected Area S source area. Biowalls S-3A and S-3C (2 segments) were installed as a chevron pair bracketing Tributary S at the southeast property boundary. Biowall S-3B parallels the property line downgradient of the chevron pair. Biowalls S-4 and S-5 were also installed offsite as chevron pairs bracketing Tributary S further downgradient. Biowalls S-6 (two segments) and S-7 were installed offsite on the north side of Tributary S.

The *Response Action Effectiveness Report* — Area S (EnSafe, July 2004) recommended the extension of Biowalls S-3A and S-3C. As a result, two additional segments were installed (Biowalls S-3D and S-3E). An Area S Response Action Plan (RAP) Addendum was submitted in February 2005 that detailed the corrective action proposed for perchlorate migration north of Area S toward offsite property. As a result, two more biowalls (S-8 and S-9) were installed near the northern property line.



NAVFAC Naval Facilities Engineering Command SOUTHERN DIVISION

Figure 3-4
Area M Parcel
Biowall Location Map
NWIRP McGregor
McGregor, Texas

November 2005

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Figure 3-5
Area S Parcel
Biowall Location Map
NWIRP McGregor
McGregor, Texas

4.0 BIOWALL OPERATION AND MAINTENANCE

This section outlines required biowall effectiveness monitoring, describes monitoring data interpretation procedures, and provides details on biowall operation and maintenance activities. The effectiveness monitoring guidelines have been designed to determine when maintenance activities may be required (for example, carbon replenishment) so that the remedial objectives are met.

4.1 Biowall Effectiveness Monitoring

The biowall effectiveness monitoring program is based on the pilot and optimization study results discussed in Section 2. It was developed to assess the following key criteria:

- Perchlorate and VOC concentrations and distribution within and downgradient of the biowalls
- Carbon substrate concentrations and distribution within and downgradient of the biowalls
- Carbon substrate availability (current and long-term)
- Preferential groundwater flow pathways through or around the biowalls
- Indicator parameter concentrations
- Carbon replenishment schedule

4.1.1 Quarterly Groundwater Sampling

Quarterly groundwater samples will be collected from all biowall monitoring ports. The monitoring ports are shown on the area maps in Section 3.0. In the past, groundwater samples have been collected using a peristaltic pump and dedicated Teflon tubing or, as necessary, a decontaminated or disposable single use Teflon bailer. However, all samples should be collected according to the O&M contractor's Sampling and Analysis Plan (SAP) established for NWIRP McGregor.

4.1.2 Analysis

Effectiveness Parameters
Dissolved Oxygen
Oxidation Reduction Potential
pH
Perchlorate
Methane
VOCs (where commingled plumes exist)
TOC
Nitrate

Samples should be collected for both field and analytical parameters during each quarterly sampling event. The recommended parameters are listed in the table on the right. All laboratory groundwater parameters must be sent to a Navy-approved laboratory for analysis. All samples should be analyzed in accordance with *Test Methods for Evaluation of Solid Waste (Physical/Chemical Methods)*, (SW-846), United States Environmental Protection Agency Office of Solid Waste and Emergency Response, Third Edition; the most current revision or update of SW-846 should be used when applicable.

4.2 Biowall Monitoring Data Interpretation

Several parameters have been determined to be good indicators of biowall performance. TOC is the best parameter for deciding when carbon replenishments are required. Other parameters, including nitrate, methane, ORP, and perchlorate, can also be used as an indication that carbon replenishment is necessary. Critical ranges have been established for each of these parameters.

In order to determine when biowall replenishment is needed, a screening process has been developed. This screening process, which consists of three steps, assigns a weighted score to the various parameters, provides an interpretation of the meaning of the results, and gives guidance on when to replenish the biowalls factoring in the number of monitoring port locations where critical conditions exist. This three-step process is detailed below.

(1) **Step 1: Effectiveness Monitoring Screening Parameters and Weighting for Determination of Biowall Replenishment Needs** — Table 4-1 provides ranges of values for each effectiveness parameters and assigns a score to each range. After every quarterly sampling event, each monitoring port will be assigned a score for each effectiveness parameters based on the guidelines laid out in the table. Once all parameters have been assigned a score, results for each port should be totaled. A sample scoring sheet is provided in Appendix B.

(2) **Step 2: Interpretation of Score Awarded During Screening** — Table 4-2 designates the meaning of each total score. The total score for each port from Step 1 should be compared to this table to determine what action is recommended based on the results for that particular port.

(3) **Step 3: Final Determination of Biowall Replenishment** — Table 4-3 provides a tool to determine if biowall replenishment should occur taking into account the number of monitoring ports within an individual biowall that fall within the critical range. Although Step 2 recommends actions to be taken on a port by port basis, Table 4-3 is the final determination on whether or not a biowall should be replenished based on the entire biowall monitoring port network.

4.3 Carbon Replenishment of Biowalls

Once biowall rejuvenation has been deemed appropriate based on the biowall effectiveness monitoring results and operating criteria discussed in Sections 4.1 and 4.2, the appropriate carbon substrate must be selected. This subsection recommends the carbon substrate to be used for biowall carbon replenishment, as well as the activities, processes, and equipment required to inject the carbon substrate into the biowalls.

Table 4-1
Step 1: Effectiveness Monitoring Screening Parameters and Weighting for Determination of Biowall Replenishment Needs

Parameter	Concentration in Monitoring Port	Value
TOC	> 20,000 µg/L	5
	10,000 – 20,000 µg/L	3
	5,000 – 10,000 µg/L	1
	< 5,000 µg/L	-5
Nitrate	< 100 µg/L	2
	100 to 500 µg/L	0
	>500 µg/L	-2
Methane	>2,000 µg/L	1
	1,000 to 2,000 µg/L	0
	< 1,000 µg/L	-1
ORP	< -100 mV	3
	-100 mV to -50mV	2
	-50 mV to 0 mV	1
	> 0 mV	-1
Perchlorate	< PCL	3
	Between PCL and 100 µg/L	0
	> 100 µg/L	-3**

Note:

** Resample monitoring port in one month. Replenish biowall if resample has perchlorate > 100 µg/L and TOC < 10,000 µg/L. Otherwise, use Step 2 to conduct assessment.

Table 4-2
Step 2: Interpretation of Points Awarded During Screening

Score	Interpretation
> 10	Replenishment not needed.
5 - 10	If TOC is greater than 5,000 µg/L, then quarterly sampling should continue.
0 - 5	If TOC is greater than 5,000 µg/L and perchlorate is less than 100 µg/L, then sample one month later. If perchlorate concentrations remain below 100 µg/L in monthly sample, then continue quarterly sampling.
< 0	Replenishment required.

Table 4-3
Step 3: Final Determination of Biowall Replenishment

Number of Ports	Action
1	If results from this port indicate that replenishment is needed, then replenish biowall.
2	If one port indicates that replenishment is needed, then replenish biowall.
3	If two or more ports indicate that replenishment is needed, then replenish biowall.
4	If two or more ports indicate that replenishment is needed, then replenish biowall.

4.3.1 Substrate Selection

Several carbon substrates were evaluated for use at NWIRP McGregor, each of which is presented in more detail in Section 3 of the *Draft Carbon Substrate Injection Work Plan* (CH2M Hill, February 2005). As part of that evaluation, three specific carbon substrates, sodium lactate, HRC, and a commercial emulsified oil (EOS), were evaluated for use in the biowalls at NWIRP McGregor. Based on this evaluation, it was concluded that EOS is the preferred carbon substrate for rejuvenating the biowalls at NWIRP McGregor.

Once the carbon substrate was selected, the estimated amount of EOS required for replenishment of each individual biowall was calculated. Three different calculations were performed for each biowall and the lowest result was selected as the estimated amount for carbon replenishment. The lowest amount was selected as the initial recommendation because it has the lowest cost and requires the least amount of material to be handled. As discussed later, if future replenishments suggest this lowest calculated volume is insufficient; revisions to the methodology in this manual should be made.

The first calculation was based on a percentage recommendation made by EOS Remediation, the vendor that sells the EOS. This vendor typically uses a ratio of 0.1–0.4% of the mass of the solid media that is to be impacted. Therefore, the following calculations were made:

Example: Biowall S-1B

Length = 380 feet
Saturated thickness = 11 feet
Width = 2.5 feet
Volume = 10,450 ft^3
Assumed "soil" mass = 110 pounds per cubic foot (lb/ft^3)
Biowall soil mass = 10,450 ft^3 * 110 lb/ft^3 = 1,149,500 lbs
EOS mass = 0.2% * 1,149,500 lbs = 2,300 pounds

The second calculation was performed using spreadsheets supplied by EOS Remediation and was based on mass flux. The specifications for each biowall were entered into the spreadsheet and the results were produced. For Biowall S-1B, the EOS spreadsheets determined that approximately 3,780 lbs of EOS would be required for replenishment. This calculation assumed a two year effectiveness for the replenishment and a groundwater perchlorate concentration of 1,000 ug/L.

The final calculation was based on an assumption that was used initially when the biowalls were installed. This assumption was that 10 lbs of oil per cubic yard (yd^3) was needed for each biowall.

Based on this, the following calculation was performed for each biowall (calculation shown is for Biowall S-1B). Note that in the final step of this calculation the result is divided by 0.6 to account for the fact that EOS is only approximately 60% oil.

Length = 380 feet
Saturated thickness = 11 feet
Width = 2.5 feet
Volume = 10,450 ft^3 = 387 yd^3
EOS mass = (10 lbs/ yd^3 * 387 yd^3)/0.6 = 6,450 lbs

Therefore, comparing the results from the three calculations and using the lowest value, it was concluded that approximately 2,300 lbs of EOS would be needed for replenishment of Biowall S-1B. The lowest value was chosen, as it will be the most economical and logistically easiest quantity to inject.

These calculations were performed for all biowalls. Table 4-4 presents the recommended carbon replenishment amounts for each biowall at NWIRP McGregor. The volume of oil injected into a given biowall should be evenly divided between all of the injection ports. As actually field experience with carbon replenishment of biowalls is limited, all of the amounts presented in this table should be considered preliminary estimates. As more experience and knowledge is gained from future carbon substrate injections and subsequent post injection monitoring, these values may need to be revised. The O&M contractor should apply any new information that is learned from future events to verify that these initial estimates are adequate.

4.3.2 Injection Activities

Several activities are required for successful carbon replenishment of the biowalls. Each of these activities is discussed below.

Table 4-4
Approximate Dosage Amounts for Biowall Replenishment

Biowall	Length (ft)	Saturated Thickness (ft)	Width (ft)	Required Quantity of EOS (lbs)	Required Drums of EOS	Required Volume of EOS (gal)	Required Volume of Dilution Water (gal)	Required Total Volume to be Injected (gal)
E-1	300	15	3.5	3,465	8.3	413	1,650	2,063
F-2	800	16	3.5	9,856	23.5	1,173	4,693	5,867
F-3B	600	16	3.5	7,392	17.6	880	3,520	4,400
F-4B	300	16	3.5	3,696	8.8	440	1,760	2,200
F-4C	400	15	4	5,280	12.6	629	2,514	3,143
F-6A	300	16	3.25	3,432	8.2	409	1,634	2,043
F-6B	300	16	4.5	4,752	11.3	566	2,263	2,829
F-7	500	16	3.5	6,160	14.7	733	2,933	3,667
F-8A	300	16	3.5	3,696	8.8	440	1,760	2,200
F-8B	300	16	3.5	3,696	8.8	440	1,760	2,200
M-1A	42	8	3.5	259	0.6	31	123	154
M-1B	60	8	4.5	475	1.1	57	226	283
M-2	200	9	4	1,584	3.8	189	754	943
M-3	350	9	3.5	2,426	5.8	289	1,155	1,444
M-4	100	9	3.5	693	1.7	83	330	413
M-5	425	9	3.75	3,156	7.5	376	1,503	1,878
M-6	100	9	3.5	693	1.7	83	330	413
S-1A	235	10	2.5	1,293	3	154	615	769
S-1B	380	10	2.5	2,090	5	249	995	1,244
S-2	525	8	2.5	2,310	5.5	275	1,100	1,375
S-3A	200	11	2.5	1,210	2.9	144	576	720
S-3B	190	15	2.5	1,568	3.7	187	746	933
S-3C	225	11	2.5	1,361	3.2	162	648	810
S-3D	200	13	3.5	2,002	5	238	953	1,192
S-3E	200	11	4	1,936	5	230	922	1,152
S-4A	275	9	2.5	1,361	3	162	648	810
S-4B	275	9	2.5	1,361	3	162	648	810
S-5A	200	8	2.5	880	2	105	419	524
S-5B	300	8	2.5	1,320	3	157	629	786
S-6A	290	7	2.5	1,117	3	133	532	665
S-6B	240	7	2.5	924	2	110	440	550
S-7	250	5	2.5	688	2	82	327	409
S-8	300	15	3.5	3,465	8	413	1,650	2,063
S-9	500	15	3.5	5,775	14	688	2,750	3,438

4.3.2.1 Preliminary Activities

Preliminary activities associated with the carbon substrate injection process include the following:

- *Coordinate with offsite property owners.* Several biowalls associated with Areas F, M, and S were constructed on offsite, private property. Contact information for offsite property owners is presented in Appendix C.

- *Amend current underground injection control (UIC) permit* (Appendix D) as needed in accordance with the Injection Well Act, Texas Water Code, Chapter 27 and 30 Texas Administrative Code (TAC) 331.

- *Calculate final carbon substrate injection quantities* (as directed in Section 4.3.1) based on biowall effectiveness groundwater sampling results and order appropriate volume from vendor. Preliminary dosage estimates are provided in Table 4-4.

- *Address site-specific security and safety concerns*. Site-specific security and safety procedures for personnel and equipment should be reviewed before field activities commence. Relevant information should be included within the contractor's site-specific Health and Safety Plan.

4.3.2.2 Injection Process

The injection process consists of several elements which are summarized below. Additional details are provided in Appendix F; however, as with the exact quantity of substrate to be injected, field procedures may evolve as additional experience with biowall rejuvenation is gained.

4.3.2.2.1 Chemical Injection Trailer

A 6-foot by 12-foot chemical injection trailer was constructed with the initial intent of injecting soybean oil into the NWIRP McGregor biowalls. It may also be suitable for less viscous substances. The 6,000-pound gross-vehicle-weight–rated-trailer has a steel plate floor and a 5-inch steel kick plate. The trailer contains a 520-gallon polyethylene tank, a high pressure pump with a 5.5-horsepower motor, a flow meter, internal piping, 50 feet of 1.5-inch hose on a reel, and an oil spill response kit. The as-built drawings for the chemical injection trailer are provided in Appendix E.

4.3.3.2.2 Carbon Substrate Preparation

Potable water should be mixed with EOS in the chemical injection trailer tank at a ratio of 4 parts water to 1 part EOS.

4.3.3.2.3 Substrate Injection Method

The carbon substrate should be injected into the biowalls through the permanent injection ports. Locations of these injection ports are presented in Figures 3-3 through 3-6. Substrate injection procedures are provided in Appendix F. The procedures in Appendix F are general in nature and can be modified as necessary based on field conditions and the effectiveness of the initial supplemental injections.

4.3.3.2.4 Performance Verification Monitoring

Two to four weeks post-injection, groundwater samples should be collected from the biowall monitoring ports to verify carbon substrate injection effectiveness. Samples should be collected and analyzed for TOC to see if the post-injection biowall groundwater quality goals have been met. If concentrations are significantly elevated from pre-injection (i.e., TOC concentrations greater than 100,000 µg/L and <25% difference between trench ports), then the objectives have been met. If the post-injection biowall groundwater quality goals are not met, substrate re-injection <u>may</u> be required in selected injection ports.

4.3.3.2.5 Routine Injection Method Evaluation

The injection method should be evaluated during and at the completion of each injection event to optimize the process. At a minimum, the assessment should include the following:

- an evaluation of alternative carbon substrates that might be less expensive, longer-lasting, and easier to handle
- an evaluation of injection equipment limitations
- an assessment of the impact of the injection pressure on the biowall and surrounding formation by measuring water levels in the biowall and nearby monitoring wells during injection
- an assessment of the level of effort that was required based on injection duration, pressures, manpower, and vendor involvement

4.3.3.2.6 Other Routine Activities

In order to ensure continued functionality of biowall infrastructure, injection ports, monitoring ports, and well pads should be inspected quarterly. Any necessary repairs should be completed before or during the next quarterly effectiveness sampling event.

Appendix A

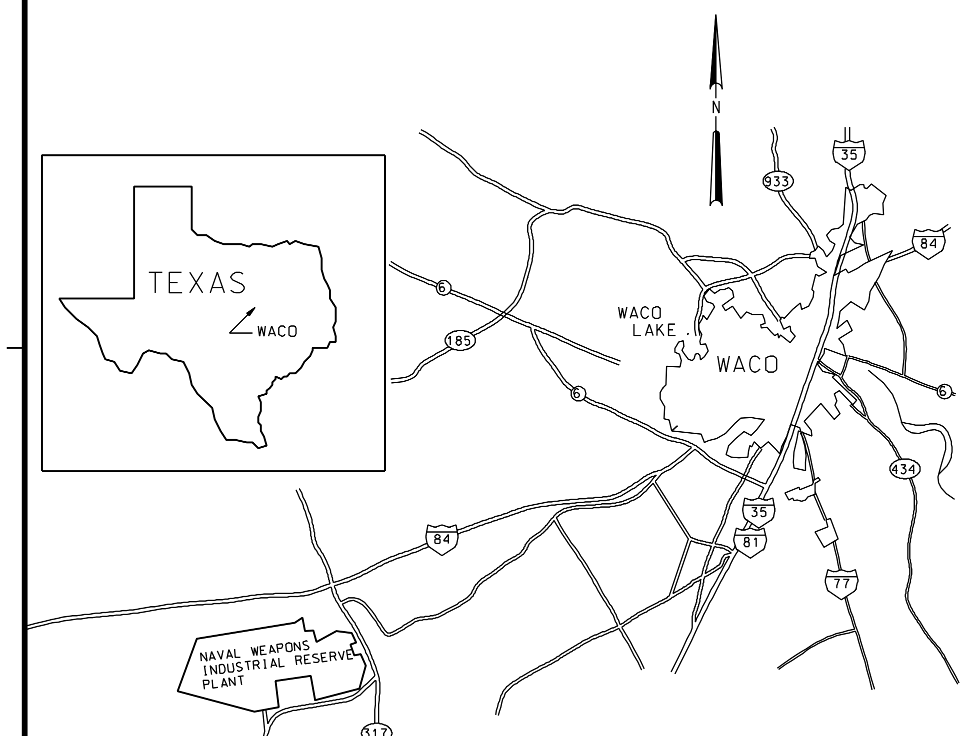
As-Built Drawings

BIOWALL AND BIOBORING AS-BUILTS

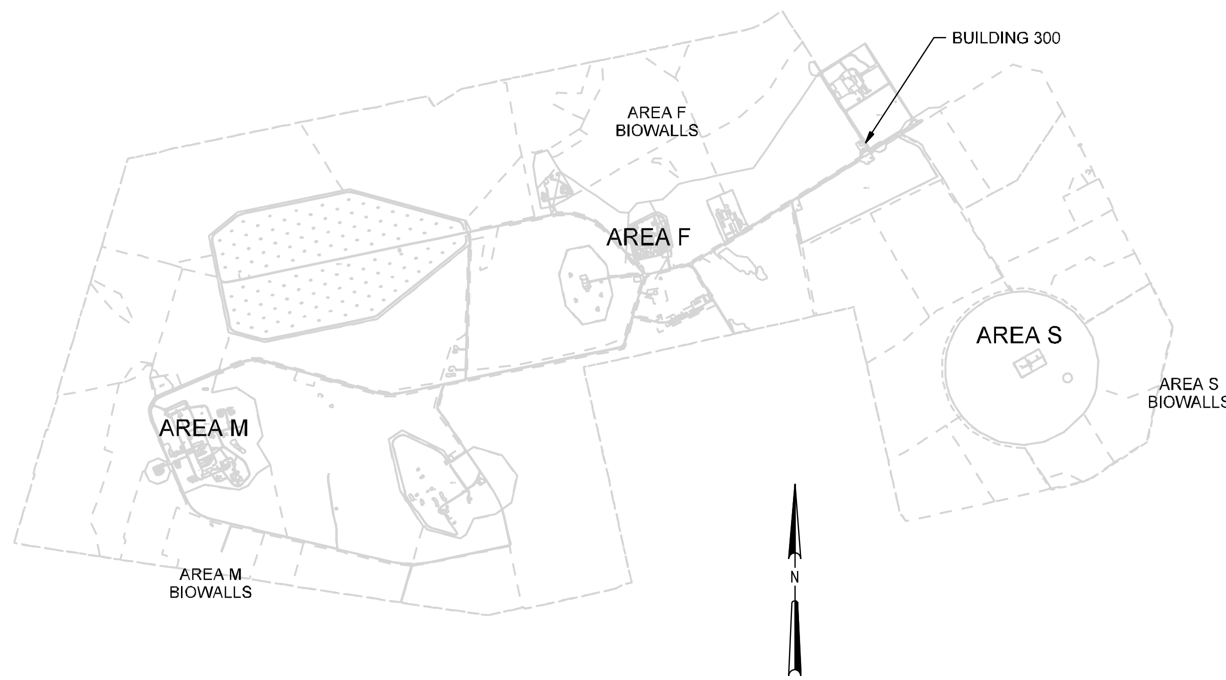
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT MCGREGOR

MCGREGOR, TEXAS

VICINITY MAP



LOCATION MAP



INDEX TO DRAWINGS

SHT NO	TITLE
1	VICINITY MAP, LOCATION MAP, INDEX TO DRAWINGS AND LEGEND
2	AREA D BIOBORING LAYOUT
3	AREA E BIOWALL AND BIOBORING LAYOUT
4	AREA E BIOWALL E-1 PLAN AND PROFILE
5	AREA F BIOWALLS LAYOUT
6	AREA F BIOWALLS F-1 AND F-2 PLAN AND PROFILE
7	AREA F BIOWALL F-3B PLAN AND PROFILE
8	AREA F BIOWALLS F-4B AND F-4C PLAN AND PROFILE
9	AREA F BIOWALL F-5 PLAN AND PROFILE
10	AREA F BIOWALLS F-6A, F-6B, AND F-7 PLAN AND PROFILE
11	AREA F BIOWALLS F-8A AND F-8B PLAN AND PROFILE
12	AREA M BIOWALLS LOCATION
13	AREA M BIOWALLS LAYOUT
14	AREA M BIOWALLS M-1 AND M-4 PLAN AND PROFILE
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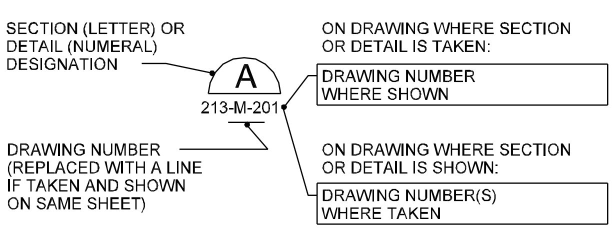
17	AREA M BIOWALL M-5 PLAN AND PROFILE
18	AREA S BIOWALL LOACATIONS
19	AREA S BIOWALL S-1 PLAN AND PROFILE
20	AREA S BIOWALL S-2 PLAN AND PROFILE
21	AREA S BIOWALLS S-3A AND S-3C PLAN AND PROFILE
22	AREA S BIOWALL S-3B PLAN AND PROFILE
23	AREA S BIOWALLS S-3D AND S-3E PLAN AND PROFILE
24	AREA S BIOWALL S-4 PLAN AND PROFILE
25	AREA S BIOWALL S-5 PLAN AND PROFILE
26	AREA S BIOWALL S-6 PLAN AND PROFILE
27	AREA S BIOWALL S-7 PLAN AND PROFILE
28	AREA S BIOWALLS S-6 AND S-7 PIPING
29	AREA S BIOWALLS S-8 AND S-9 LAYOUT
30	AREA S BIOWALL S-8 PLAN AND PROFILE
31	AREA S BIOWALL S-9 PLAN AND PROFILE
32	AREA S BIOBORING LAYOUT
33	BIOWALL DETAILS
34	INJECTION PUMPING SYSTEM DETAILS
35	MONITORING PORT AND BIOBORING DETAILS

LEGEND

DETAIL AND SECTION DESIGNATION



ABBREVIATIONS

EL	ELEVATION
HORIZ	HORIZONTAL
MIN	MINIMUM
TYP	TYPICAL
MW	MONITOR WELL

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN	M PERLMUTTER	NO.	DATE	REVISION	BY	APVD
DR	J BOOTH					
CHK	W THOMAS					
APVD	T BEISEL					

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL
Constructors, Inc.

ENSAFE
800-588-7962
MEMPHIS, TENNESSEE
CHARLESTON, SC • CINCINNATI, OH • DALLAS, TX • JACKSON, TN • KNOXVILLE, TN
LANCASTER, PA • NASHVILLE, TN • NORFOLK, VA • PADUCAH, KY • PENSACOLA, FL
RALEIGH, NC • COLOGNE, GERMANY

AS-BUILT
VICINITY MAP, LOCATION MAP,
INDEX TO DRAWINGS, AND LEGEND

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DWG GWAB-1
DATE SEPTEMBER 2005
PROJ 327014

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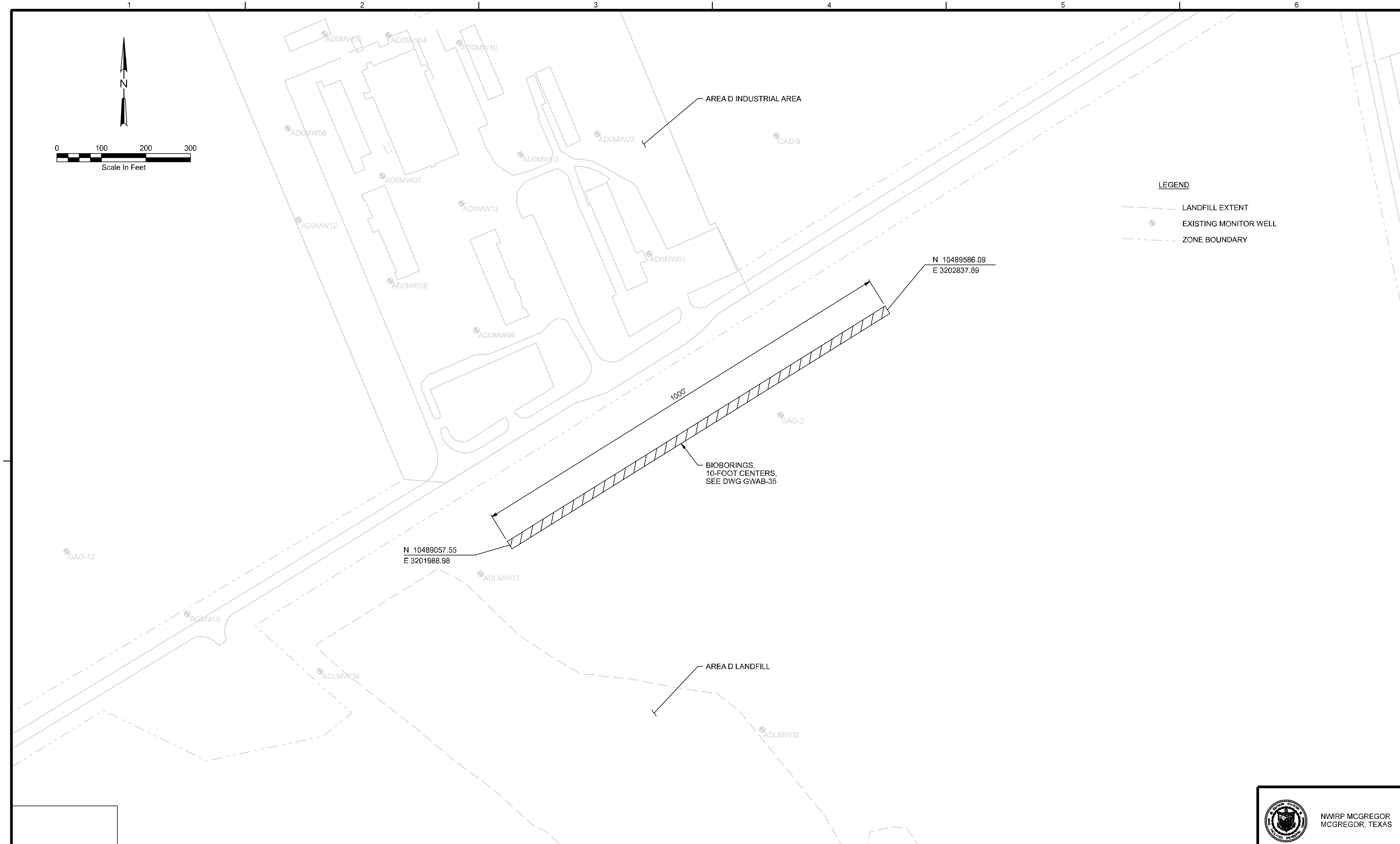

NWIRP MCGREGOR
MCGREGOR, TEXAS

PRELIMINARY

NOT FOR CONSTRUCTION

DSGN M PERLMUTTER					
DR J BOOTH					
CHK W THOMAS					
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL
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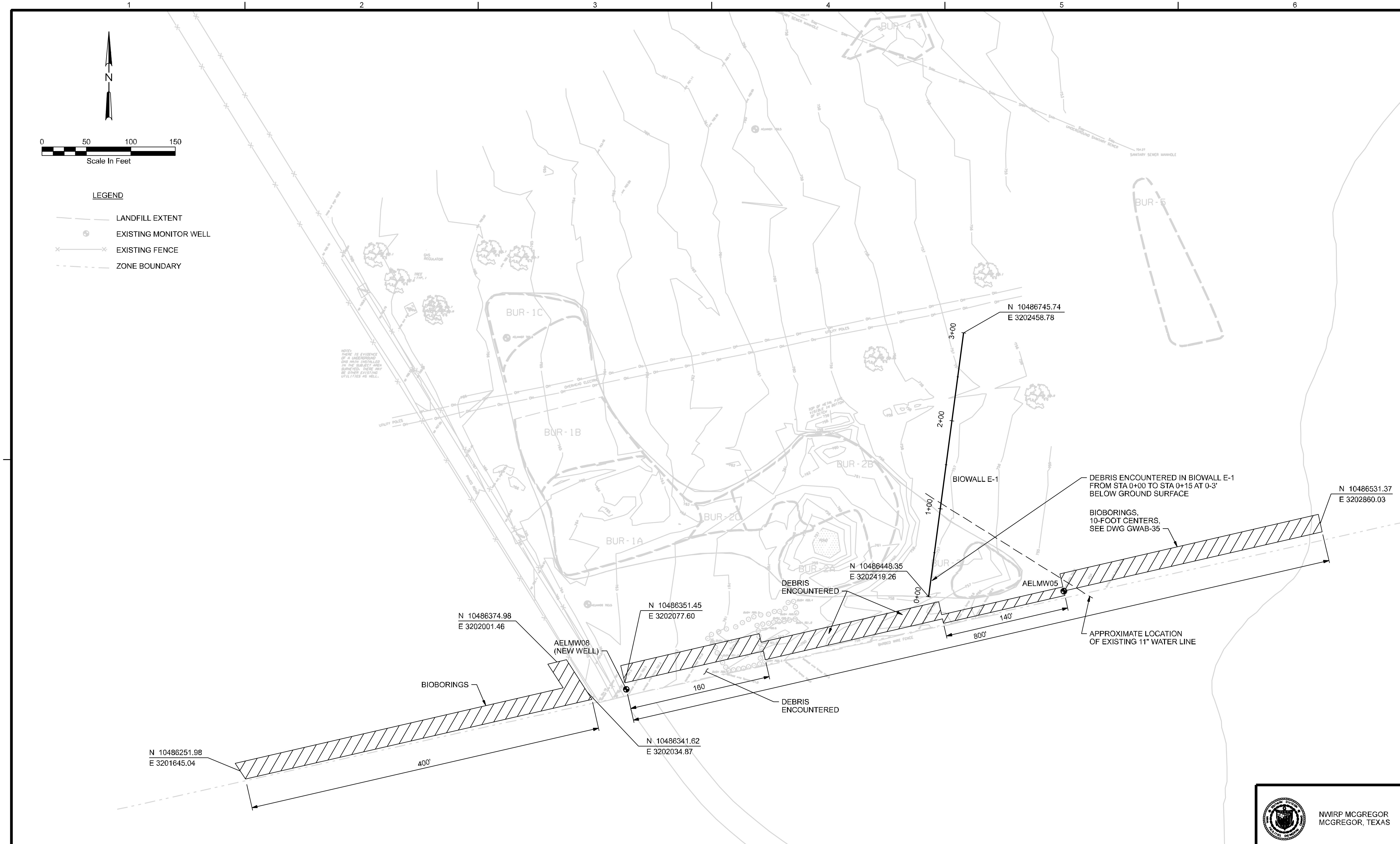
AS-BUILT
AREA D
BIOBORING LAYOUT

SHEET 2
DWG GWAB-2
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_d01.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 19:02:01



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DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

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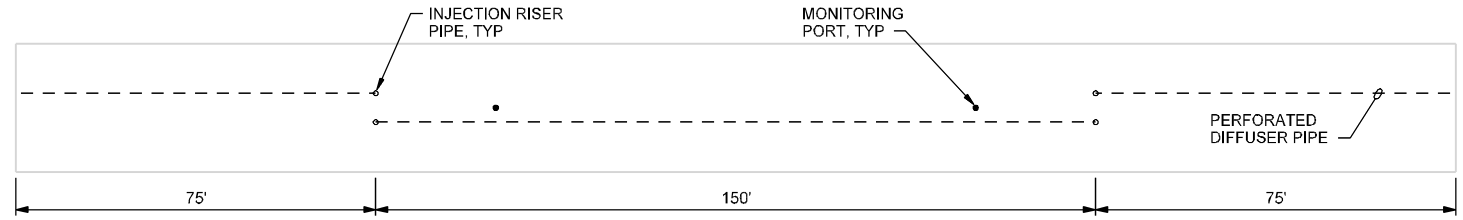
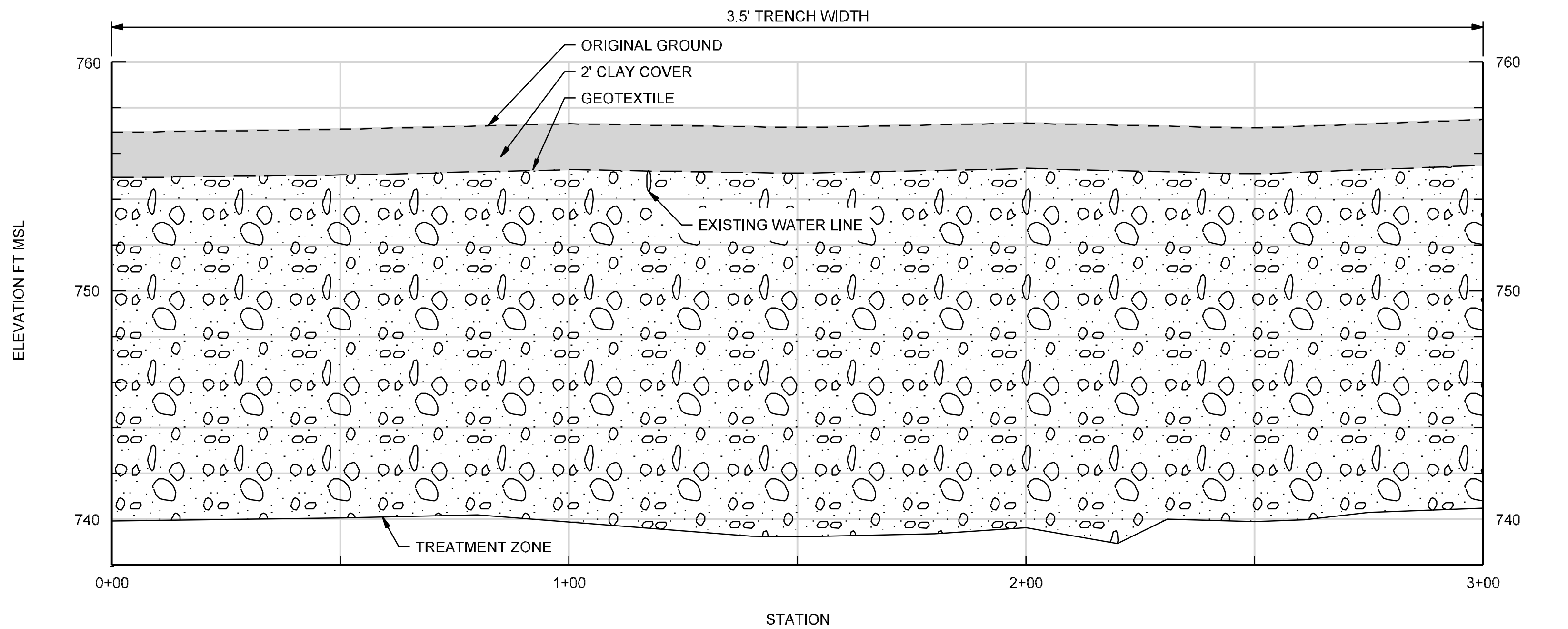
AS-BUILT
AREA E
BIOWALL AND BIOBORING LAYOUT

SHEET 3
DWG GWAB-3
DATE SEPTEMBER 2005
PROJ 327014

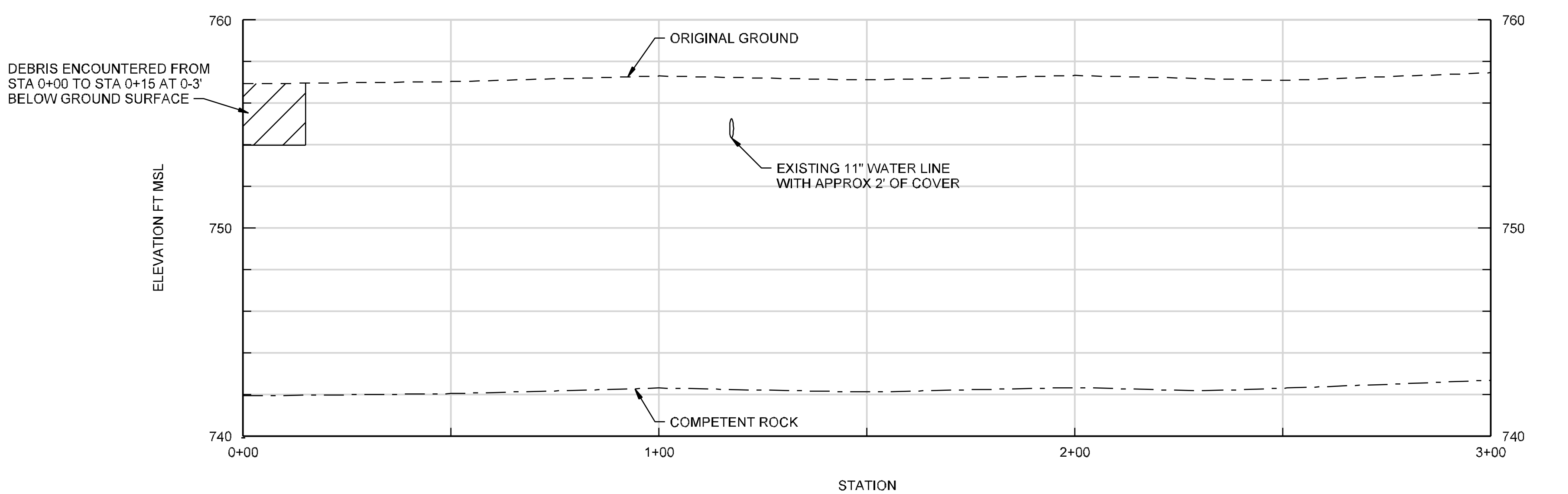
FILENAME: mc_gwab_e01.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:16:23



BIOWALL E-1 PIPING LAYOUT



BIOWALL E-1 CONSTRUCTED PROFILE



BIOWALL E-1 ORIGINAL PROFILE

NOTES:
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

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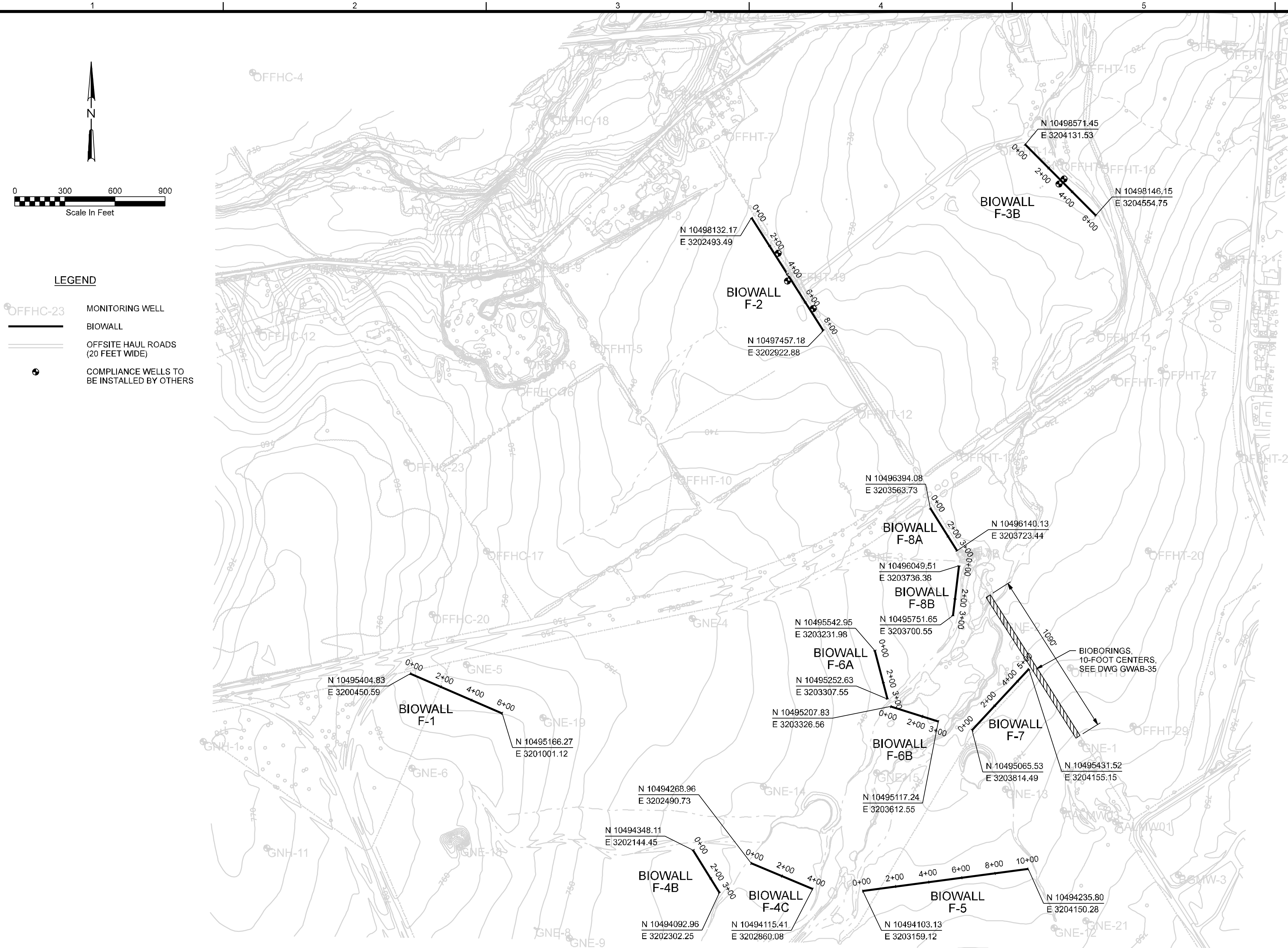
AS-BUILT
AREA E
BIOWALL E-1 PLAN AND PROFILE

SHEET 4
DWG GWAB-4
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_e02.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:14:51



LEGEND

- OFFHC-23 — MONITORING WELL
- BIOWALL
- OFFSITE HAUL ROADS (20 FEET WIDE)
- COMPLIANCE WELLS TO BE INSTALLED BY OTHERS

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

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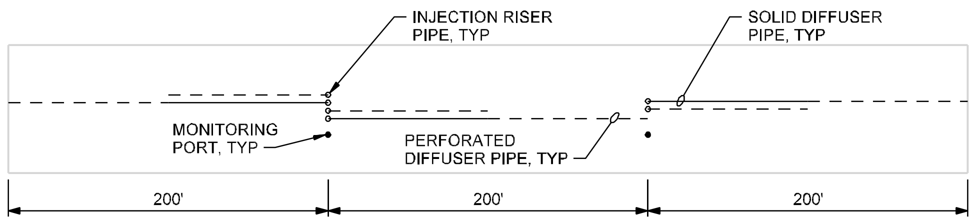
RALEIGH,NC COLOGNE, GERMANY

AS-BUILT

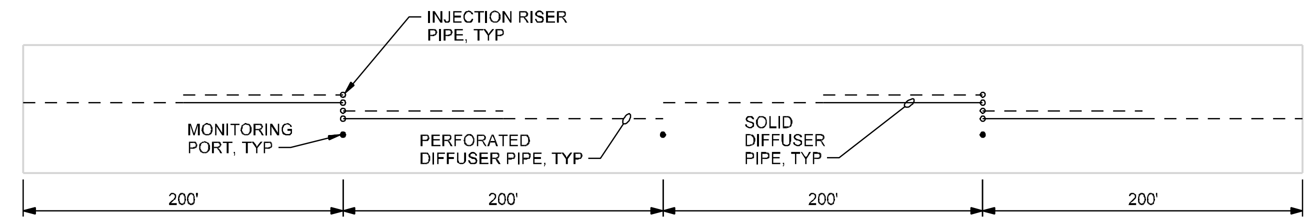
AREA F BIOWALLS LAYOUT

SHEET 5
DWG GWAB-5
DATE SEPTEMBER 2005
PROJ 327014

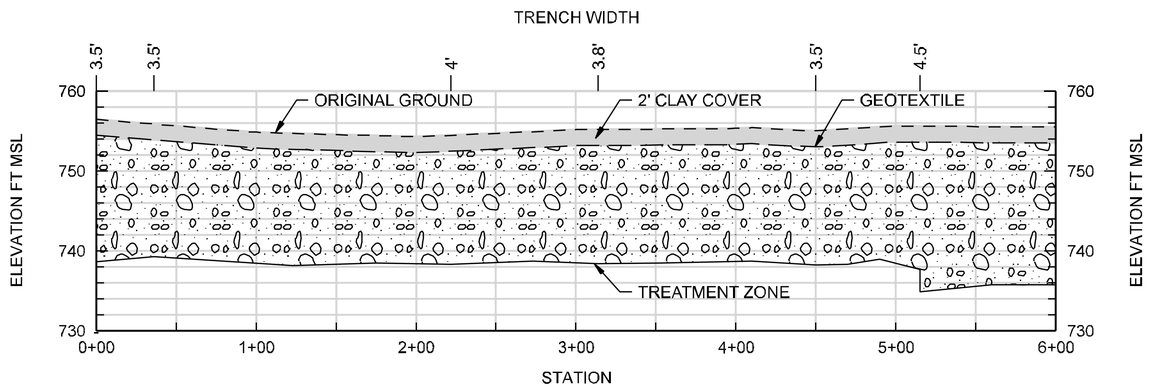
FILENAME: mc_gwab_f01.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:15:07



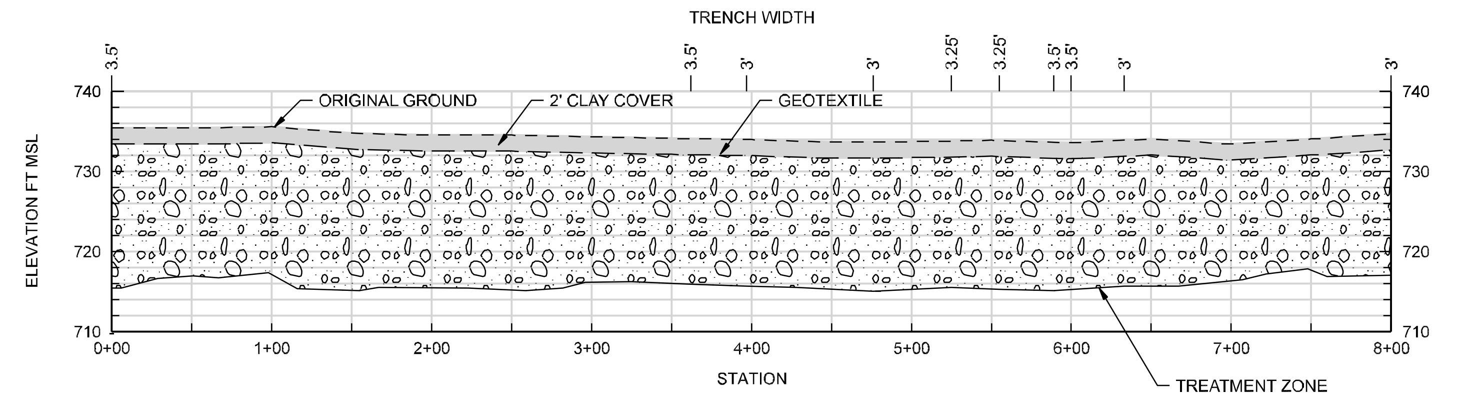
BIOWALL F-1 PIPING LAYOUT



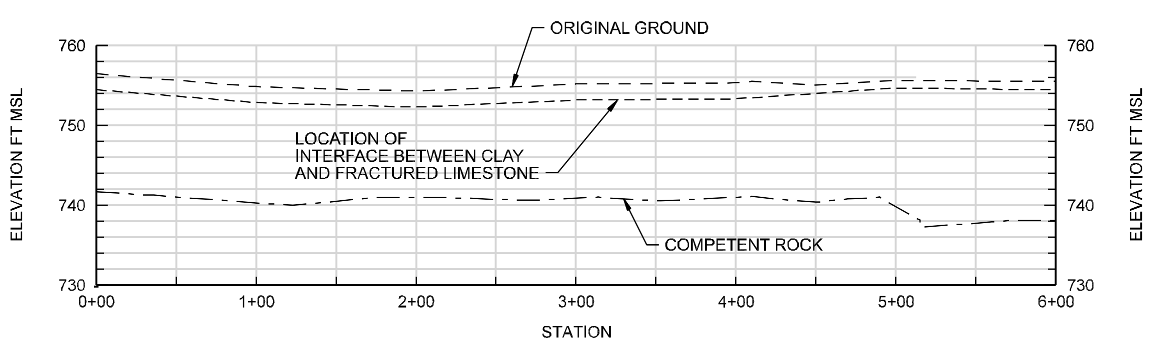
BIOWALL F-2 PIPING LAYOUT



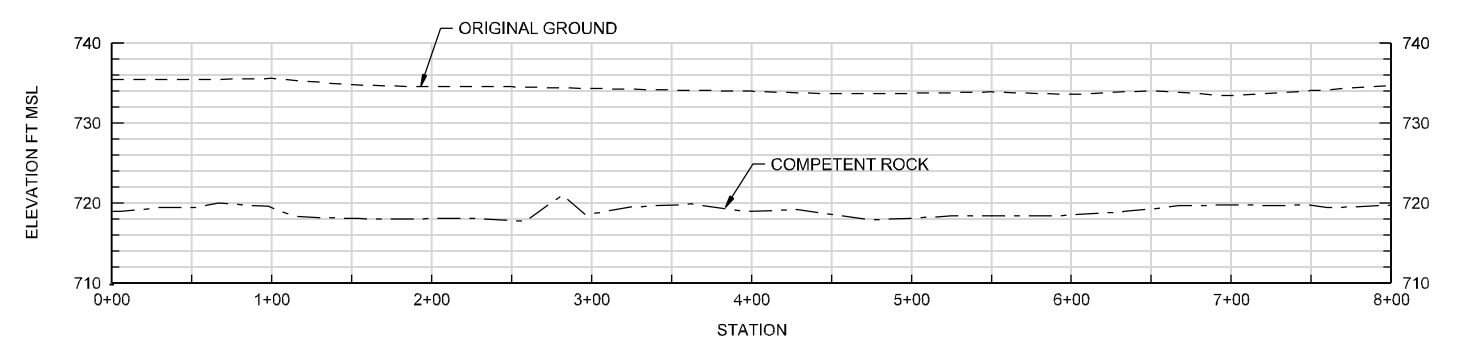
BIOWALL F-1 CONSTRUCTED PROFILE



BIOWALL F-2 CONSTRUCTED PROFILE



BIOWALL F-1 ORIGINAL PROFILE



BIOWALL F-2 ORIGINAL PROFILE

NOTES:
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER							
DR J BOOTH							
CHK W THOMAS							
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD		

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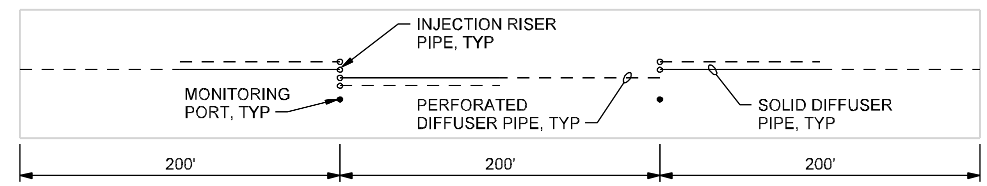
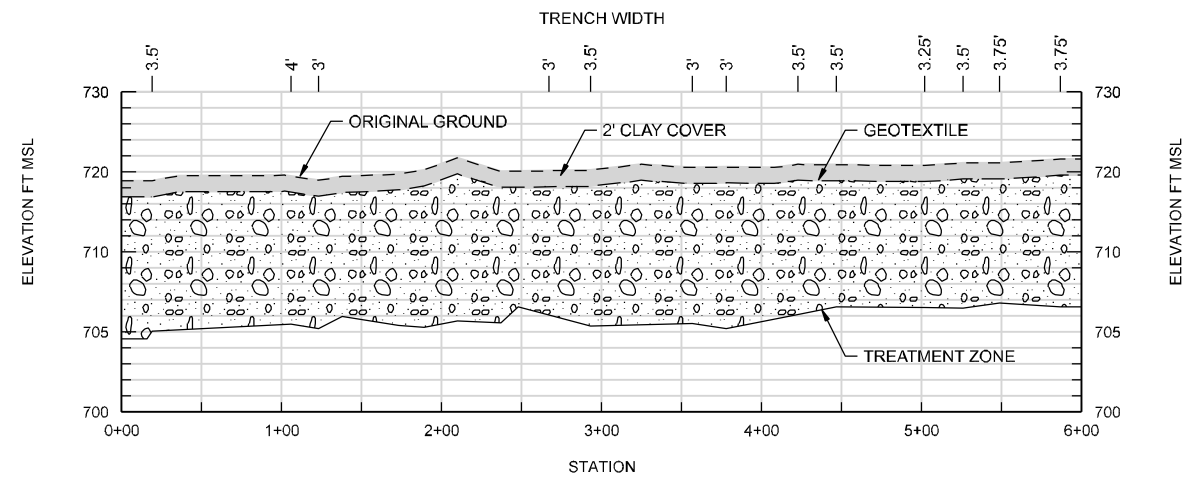
AS-BUILT
AREA F
BIOWALLS F-1 AND F-2 PLAN AND PROFILE

SHEET 6
DWG GWAB-6
DATE SEPTEMBER 2005
PROJ 327014

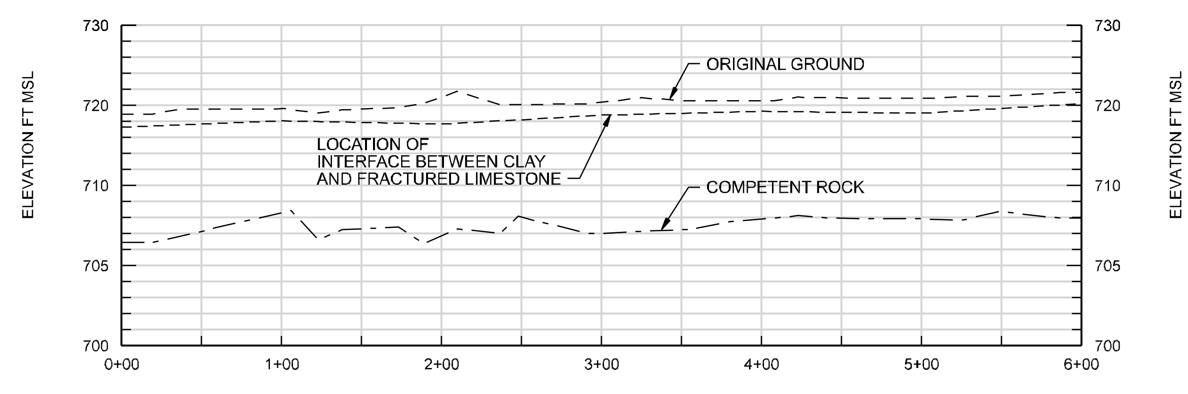
FILENAME: mc_gwab_f02.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:15:22



BIOWALL F-3B PIPING LAYOUT



BIOWALL F-3B CONSTRUCTED PROFILE



BIOWALL F-3B ORIGINAL PROFILE

NOTES:

1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

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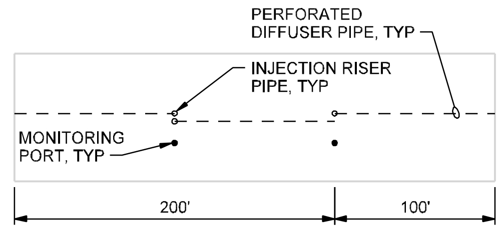
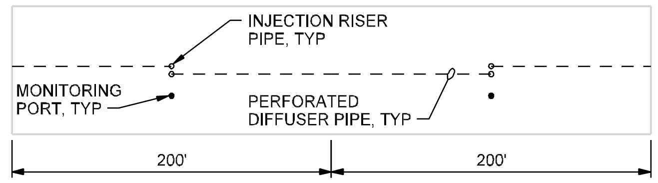
AS-BUILT
AREA F
BIOWALL F-3B PLAN AND PROFILE

SHEET 7
DWG GWAB-7
DATE SEPTEMBER 2005
PROJ 327014

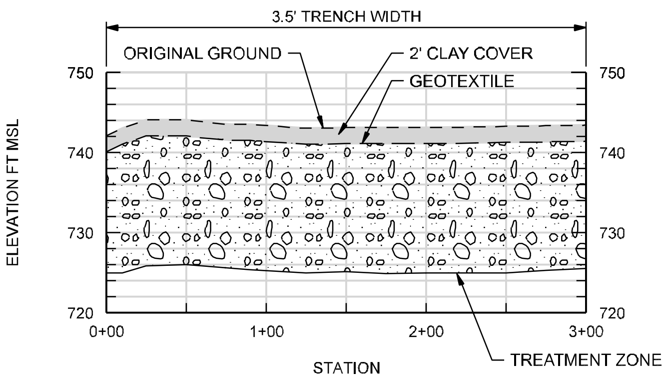
FILENAME: mc_gwab_f03.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:16:39



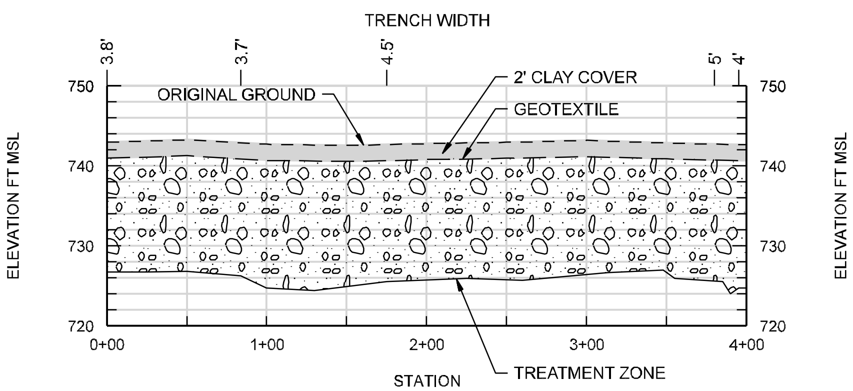
BIOWALL F-4B PIPING LAYOUT



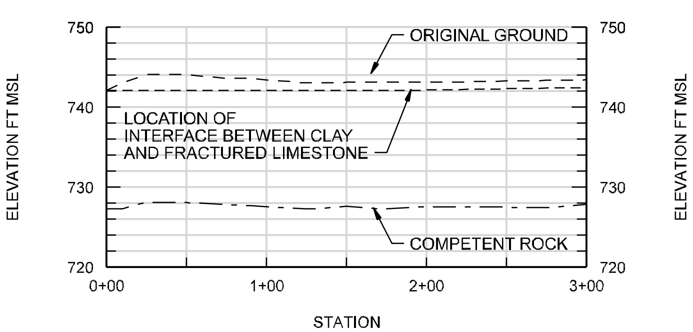
BIOWALL F-4C PIPING LAYOUT



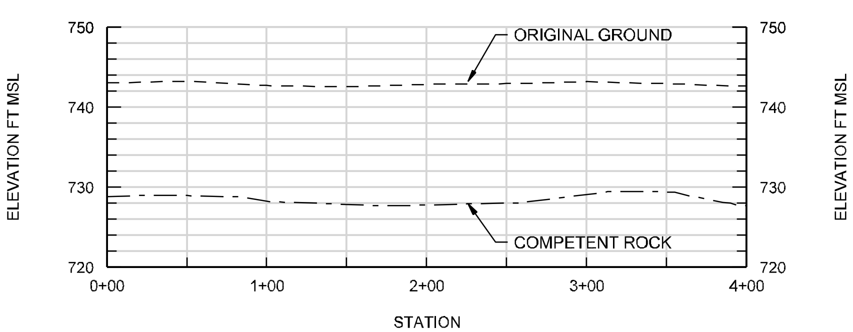
BIOWALL F-4B CONSTRUCTED PROFILE



BIOWALL F-4C CONSTRUCTED PROFILE



BIOWALL F-4B ORIGINAL PROFILE



BIOWALL F-4C ORIGINAL PROFILE

NOTES:

1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER							
DR J BOOTH							
CHK W THOMAS							
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD		

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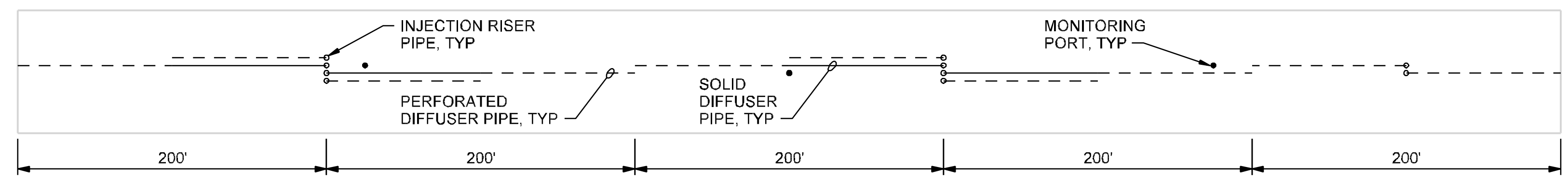
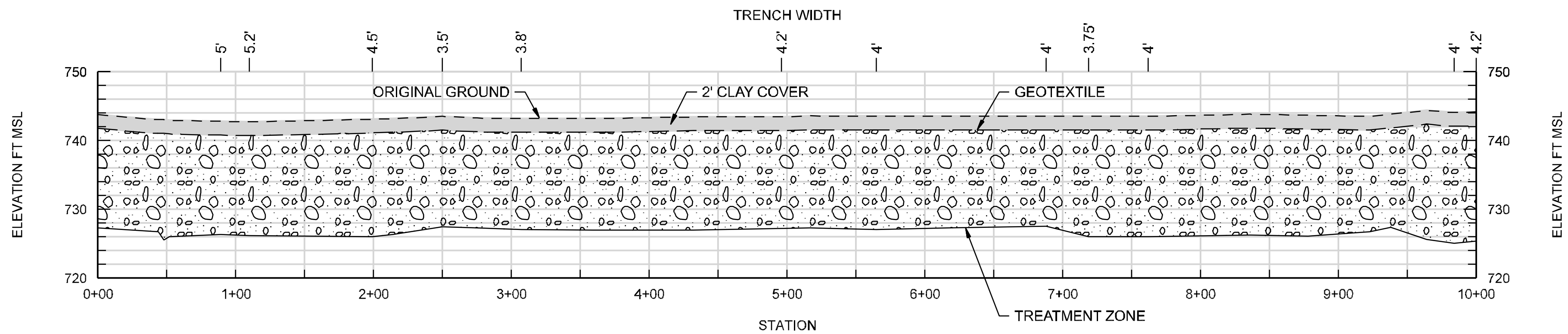
AS-BUILT
AREA F
BIOWALLS F-4B AND F-4C
PLAN AND PROFILE

SHEET 8
DWG GWAB-8
DATE SEPTEMBER 2005
PROJ 327014

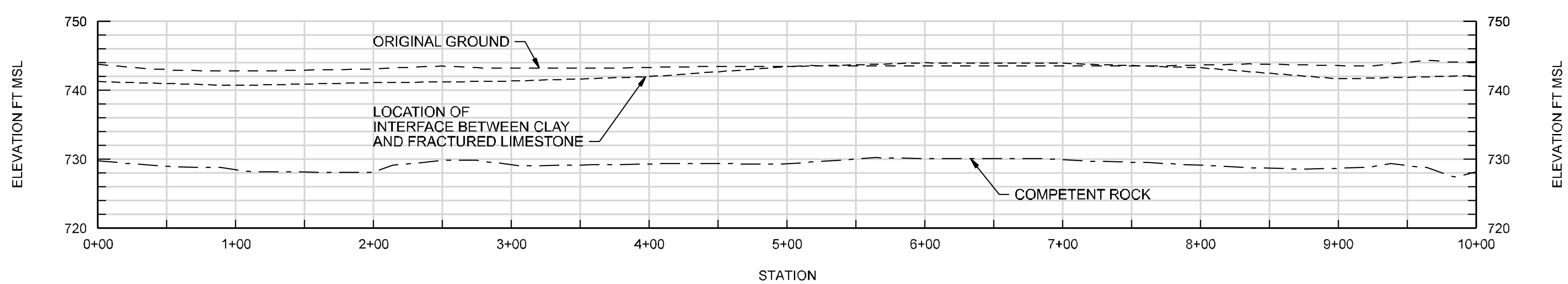
FILENAME: mc_gwab_f04.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:15:45



BIOWALL F-5 PIPING LAYOUT



BIOWALL F-5 CONSTRUCTED PROFILE



BIOWALL F-5 ORIGINAL PROFILE

NOTES:

1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

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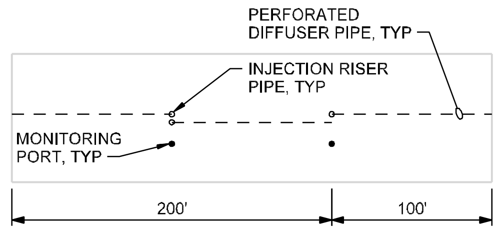
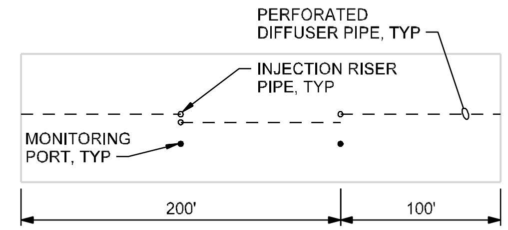
AREA F
BIOWALL F-5 PLAN AND PROFILE

SHEET 9
DWG GWAB-9
DATE SEPTEMBER 2005
PROJ 327014

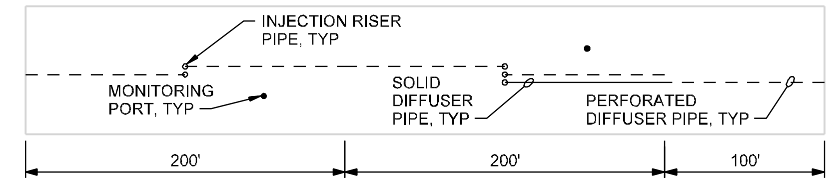
FILENAME: mc_gwab_f05.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:15:58



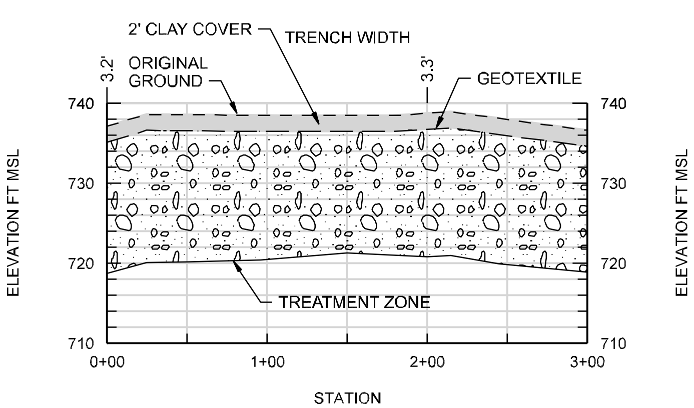
BIOWALL F-6A PIPING LAYOUT



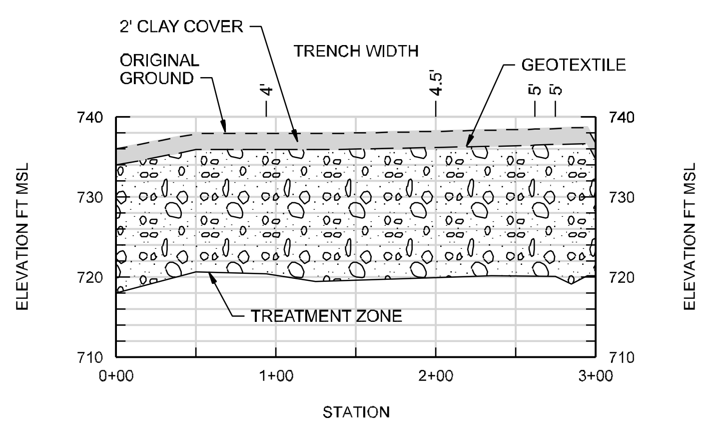
BIOWALL F-6B PIPING LAYOUT



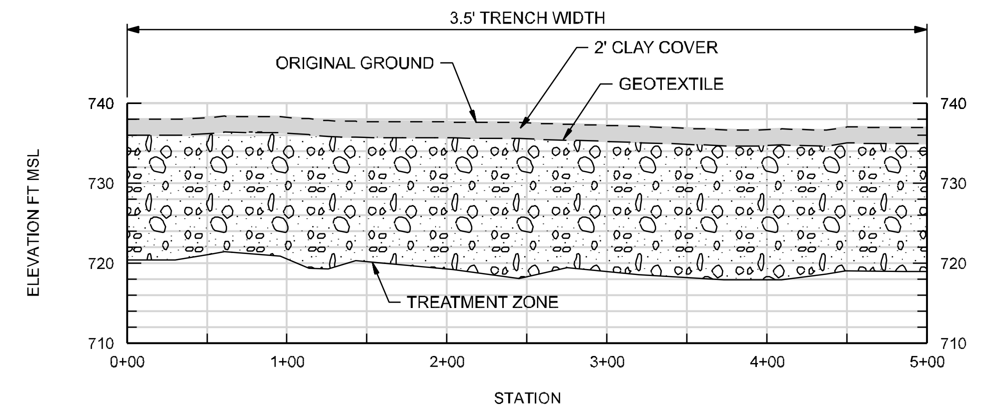
BIOWALL F-7 PIPING LAYOUT



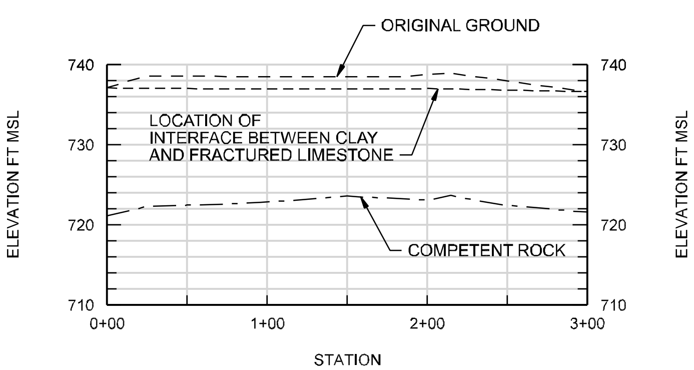
BIOWALL F-6A CONSTRUCTED PROFILE



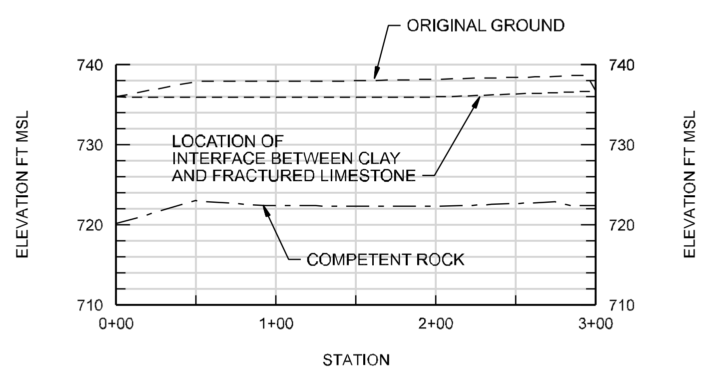
BIOWALL F-6B CONSTRUCTED PROFILE



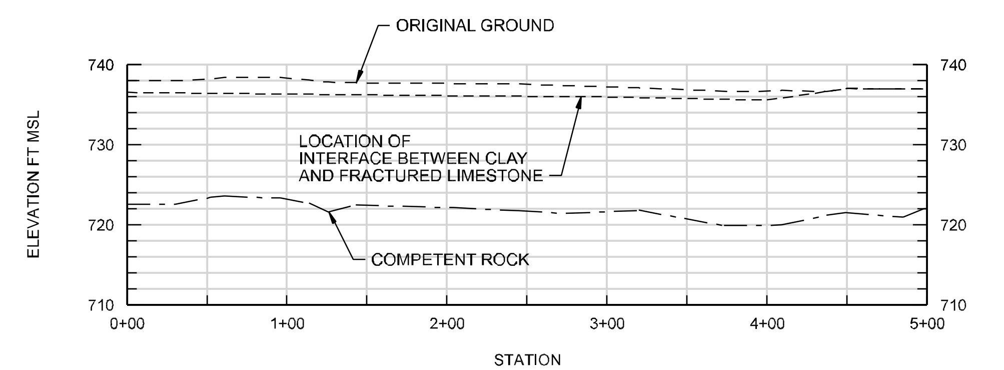
BIOWALL F-7 CONSTRUCTED PROFILE



BIOWALL F-6A ORIGINAL PROFILE



BIOWALL F-6B ORIGINAL PROFILE



BIOWALL F-7 ORIGINAL PROFILE

NOTES:
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER						VERIFY SCALE
DR J BOOTH						BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"
CHK W THOMAS						IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

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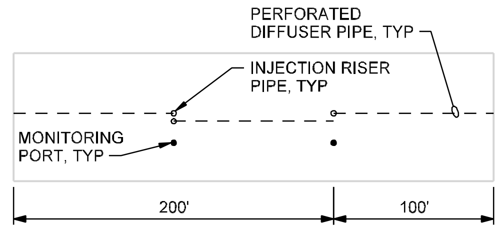
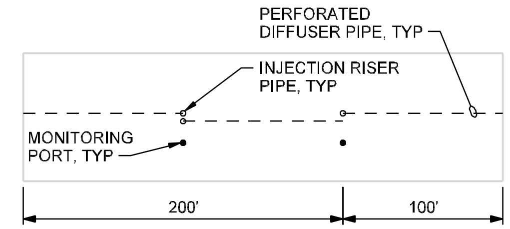
AS-BUILT
AREA F
BIOWALLS F-6A, F-6B, AND F-7
PLAN AND PROFILE

SHEET 10
DWG GWAB-10
DATE SEPTEMBER 2005
PROJ 327014

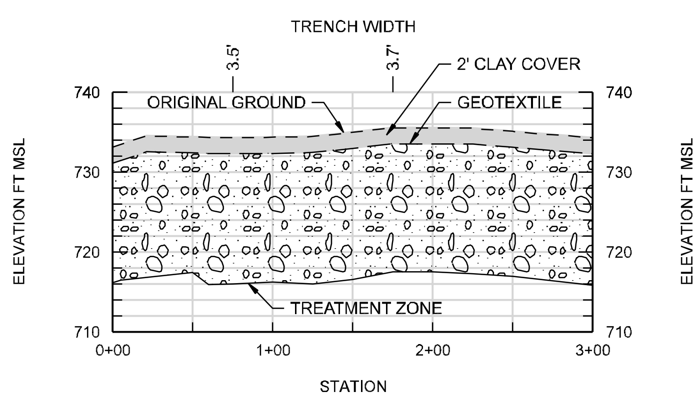
FILENAME: mc_gwab_f06.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:16:11



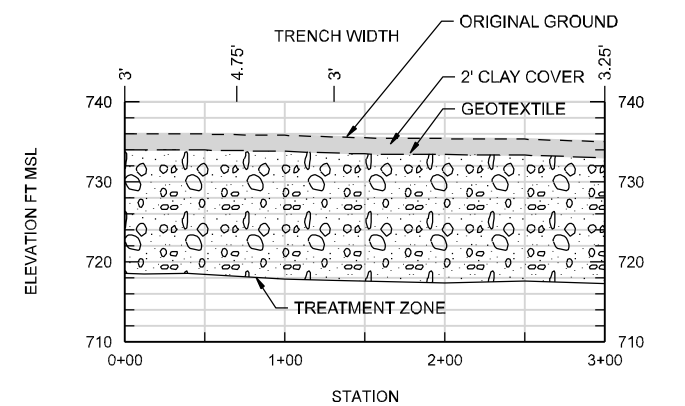
BIOWALL F-8A PIPING LAYOUT



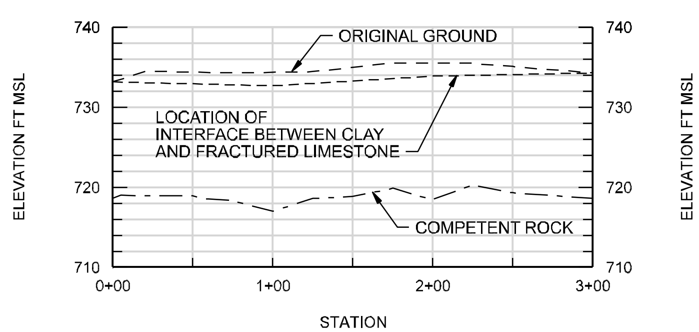
BIOWALL F-8B PIPING LAYOUT



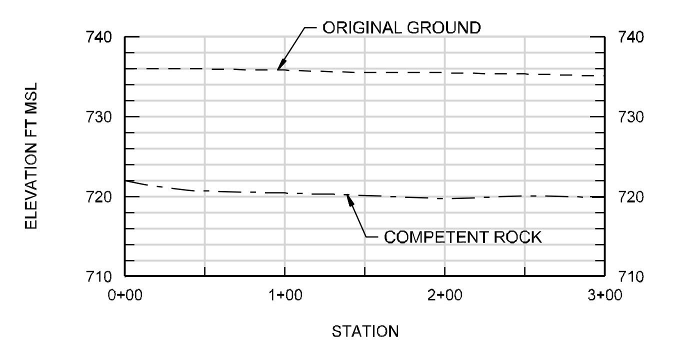
BIOWALL F-8A CONSTRUCTED PROFILE



BIOWALL F-8B CONSTRUCTED PROFILE



BIOWALL F-8A ORIGINAL PROFILE



BIOWALL F-8B ORIGINAL PROFILE

NOTES:

1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN	M PERLMUTTER
DR	J BOOTH
CHK	W THOMAS
APVD	T BEISEL

NO.	DATE	REVISION	BY	APVD

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RALEIGH,NC; COLOGNE, GERMANY

AS-BUILT
AREA F
BIOWALLS F-8A AND F-8B
PLAN AND PROFILE

SHEET	11
DWG	GWAB-11
DATE	SEPTEMBER 2005
PROJ	327014

FILENAME: mc_gwab_f07.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:16:23

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN	M PERLMUTTER
DR	J BOOTH
CHK	W THOMAS
APVD	T BEISEL

NO.	DATE	REVISION	BY	APVD

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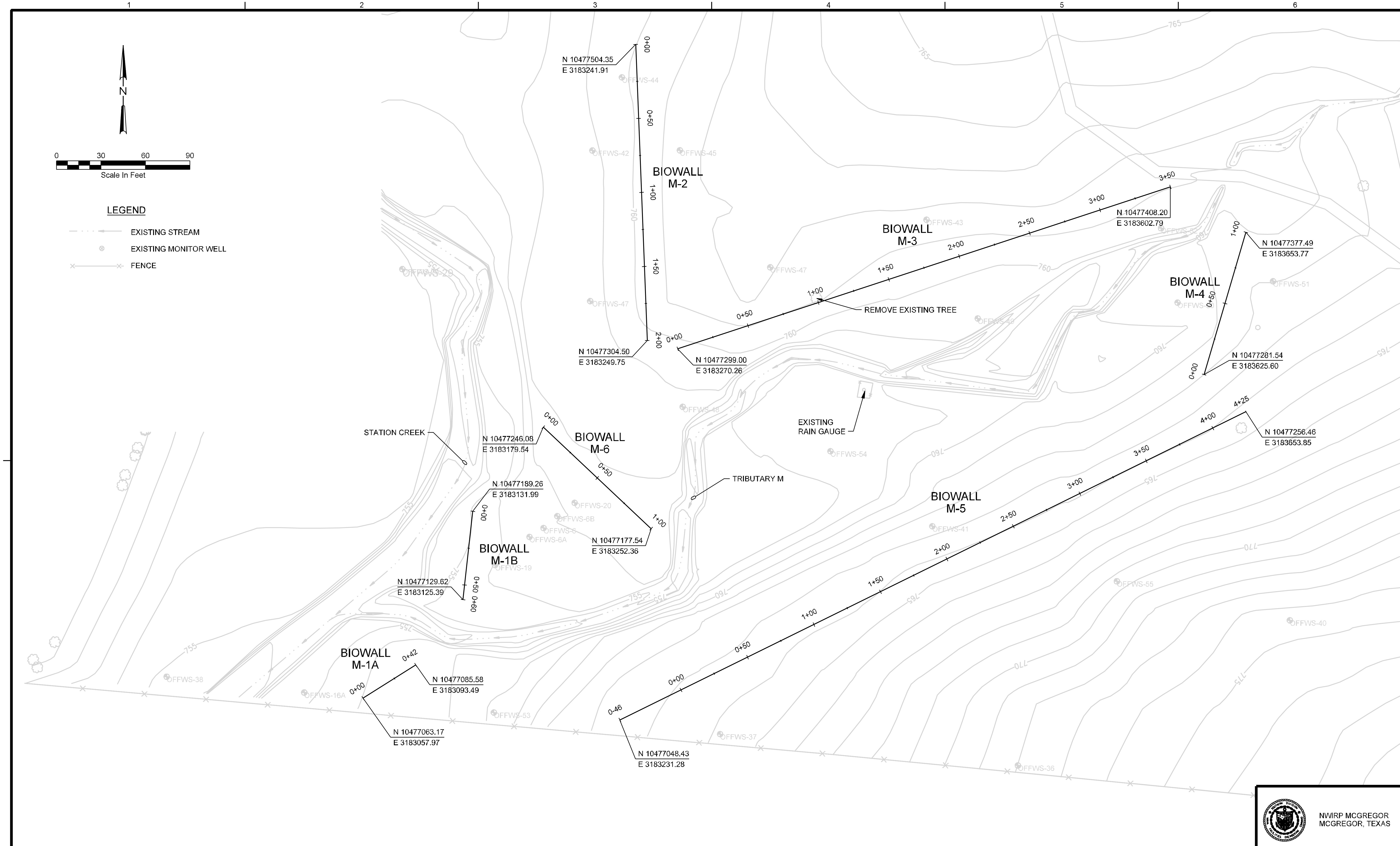
AS-BUILT
AREA M
BIOWALLS LOCATION

SHEET	12
DWG	GWAB-12
DATE	SEPTEMBER 2005
PROJ	327014

FILENAME: mc_gwab_m01.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:16:59



DSGN M PERLMUTTER						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
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CH2MHILL Constructors, Inc.

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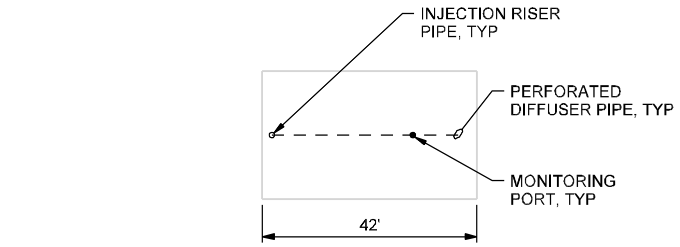
MEMPHIS, TENNESSEE

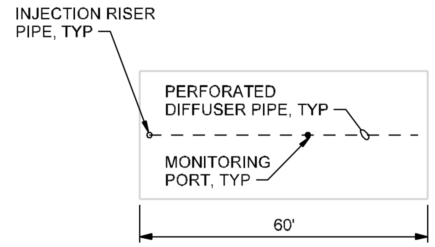
AS-BUILT
AREA M
BIOWALLS LAYOUT

SHEET 13
DWG GWAB-13
DATE SEPTEMBER 2005
PROJ 327014

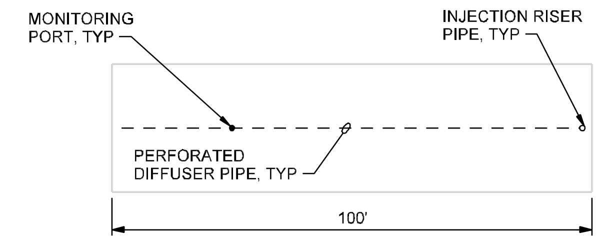
FILENAME: mc_gwab_m02.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:16:51



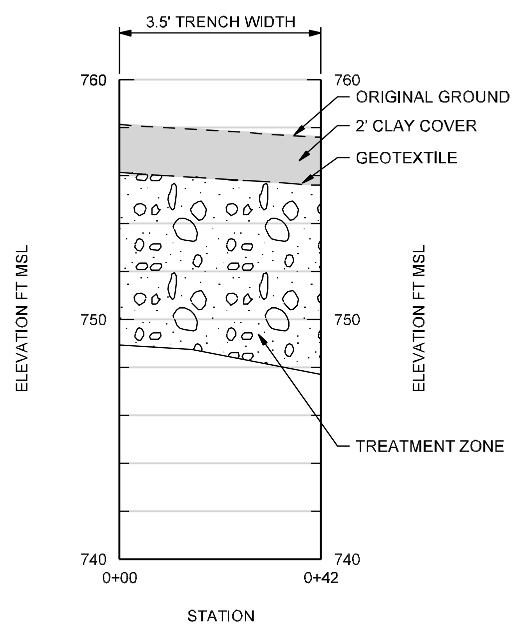
BIOWALL M-1A PIPING LAYOUT



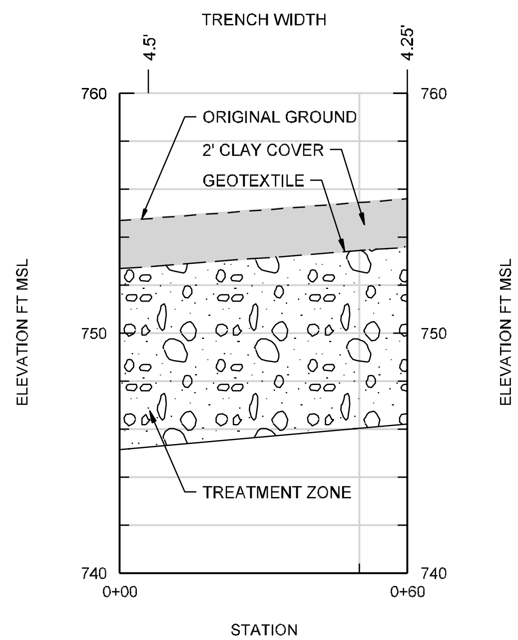
BIOWALL M-1B PIPING LAYOUT



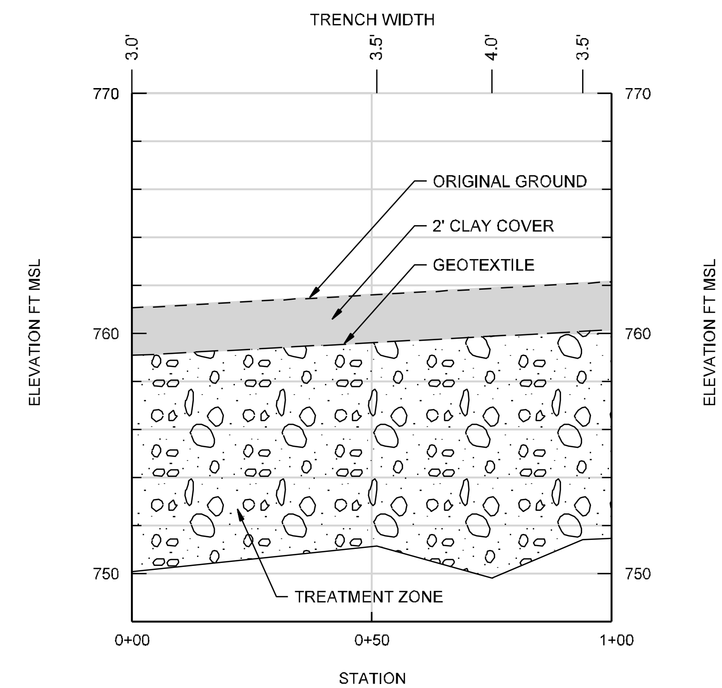
BIOWALL M-4 PIPING LAYOUT



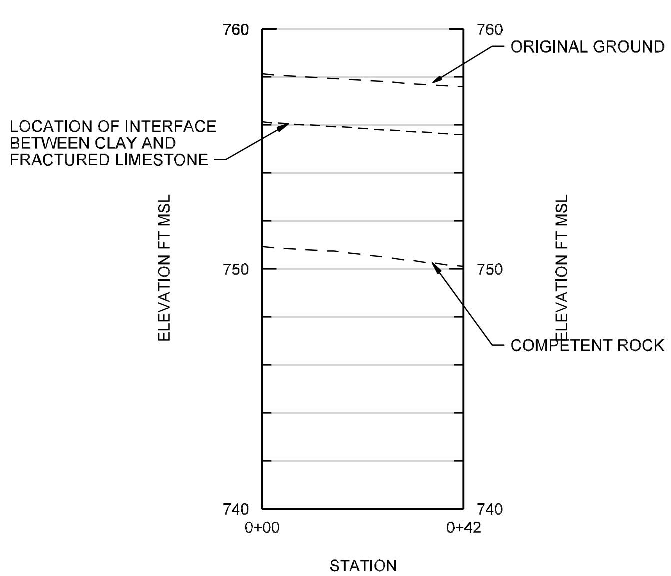
BIOWALL M-1A CONSTRUCTED PROFILE



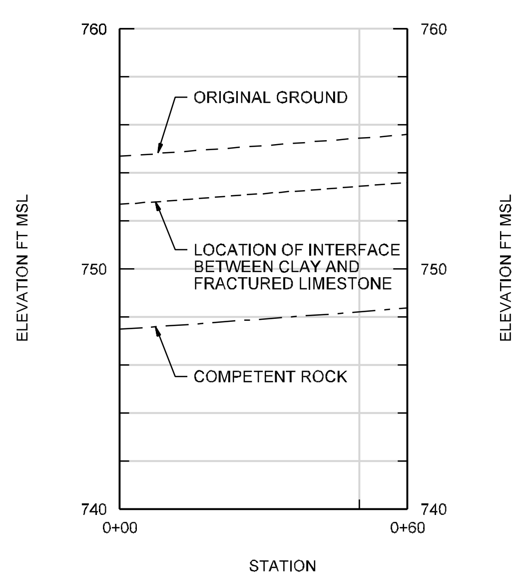
BIOWALL M-1B CONSTRUCTED PROFILE



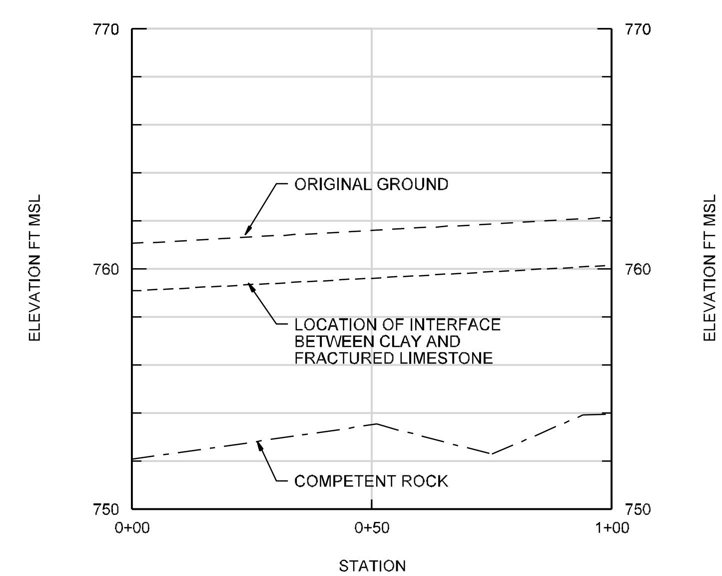
BIOWALL M-4 CONSTRUCTED PROFILE



BIOWALL M-1A ORIGINAL PROFILE



BIOWALL M-1B ORIGINAL PROFILE



BIOWALL M-4 ORIGINAL PROFILE

NOTES:

1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALE
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0 1"
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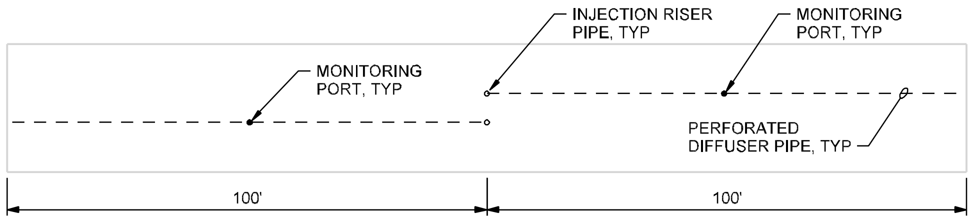
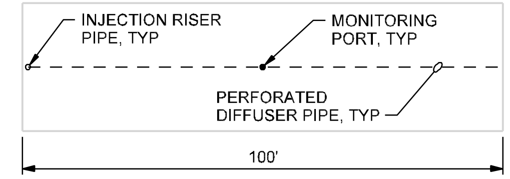
AS-BUILT
AREA M
BIOWALLS M-1 AND M-4 PLAN AND PROFILE

SHEET 14
DWG GWAB-14
DATE SEPTEMBER 2005
PROJ 327014

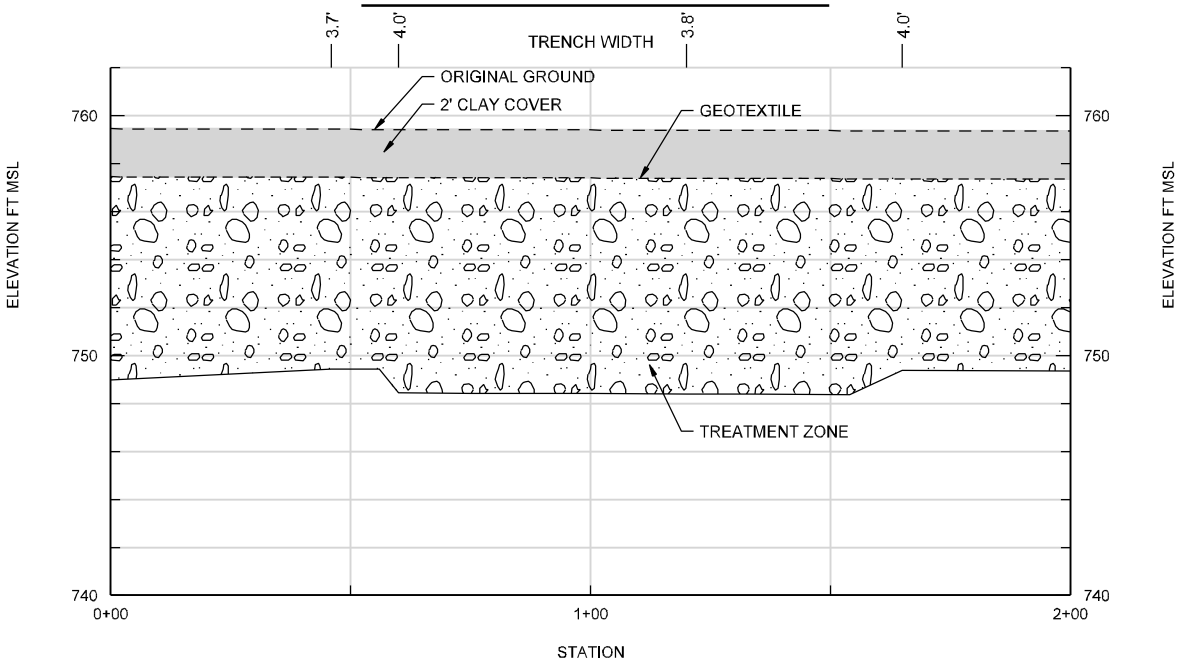
FILENAME: mc_gwab_m03.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:43:59



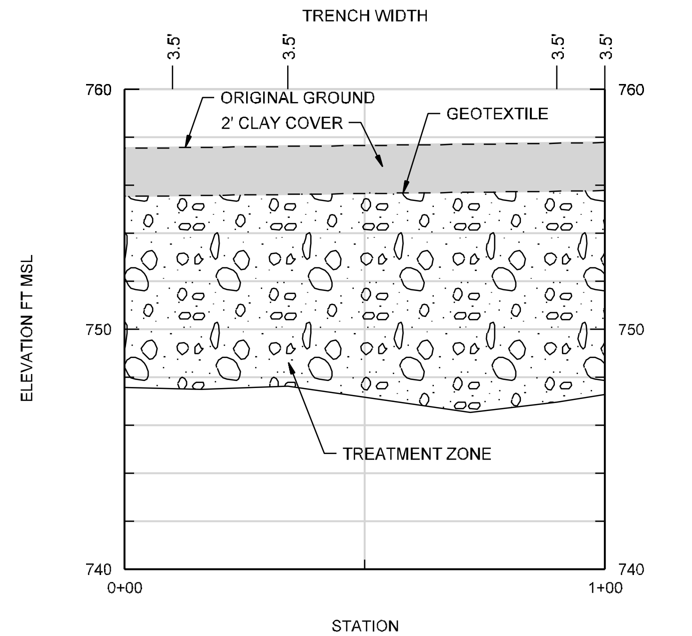
BIOWALL M-2 PIPING LAYOUT



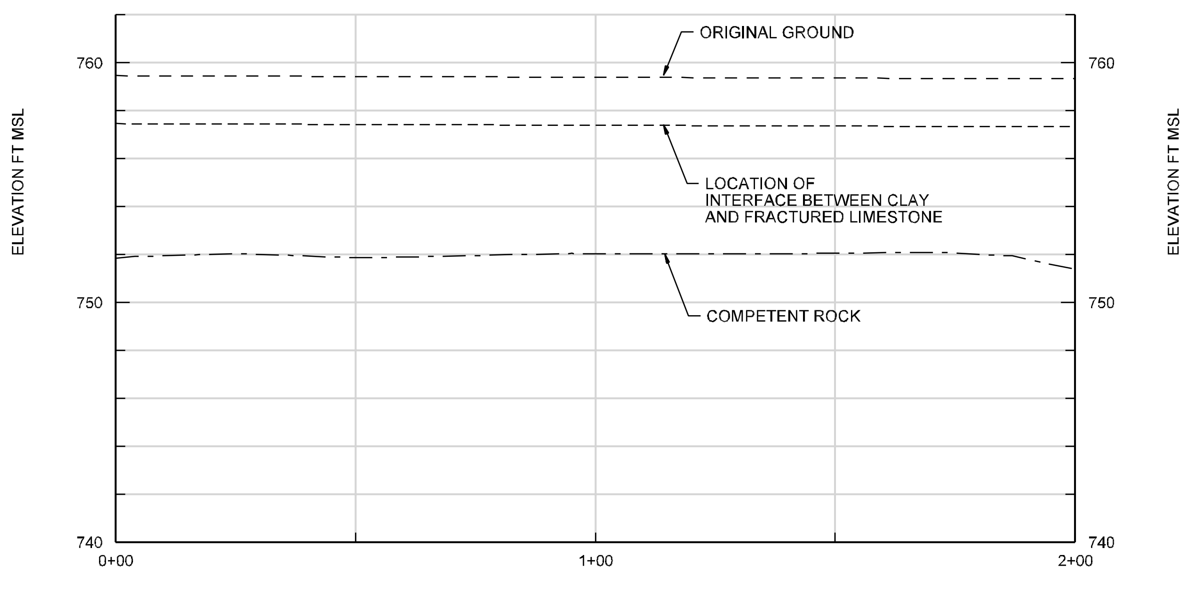
BIOWALL M-6 PIPING LAYOUT



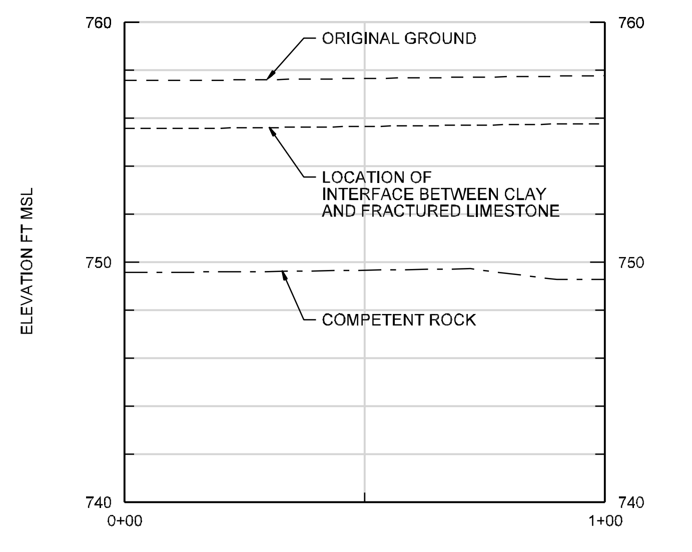
BIOWALL M-2 CONSTRUCTED PROFILE



BIOWALL M-6 CONSTRUCTED PROFILE



BIOWALL M-2 ORIGINAL PROFILE



BIOWALL M-6 ORIGINAL PROFILE

NOTES:

1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER	NO.	DATE	REVISION	BY	APVD
DR J BOOTH					
CHK W THOMAS					
APVD T BEISEL					

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL Constructors, Inc.

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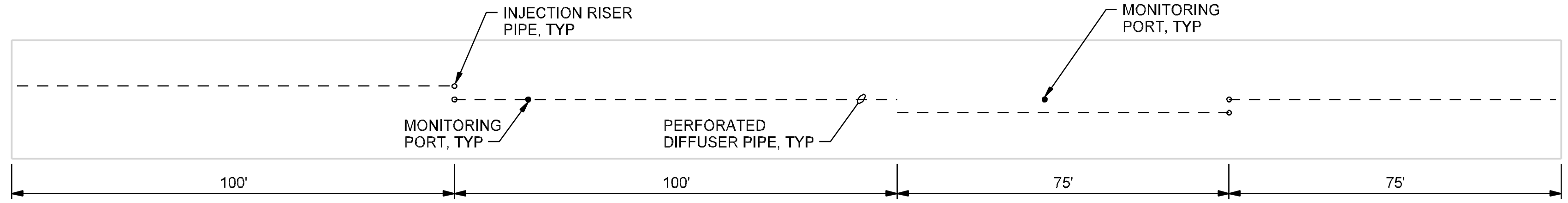
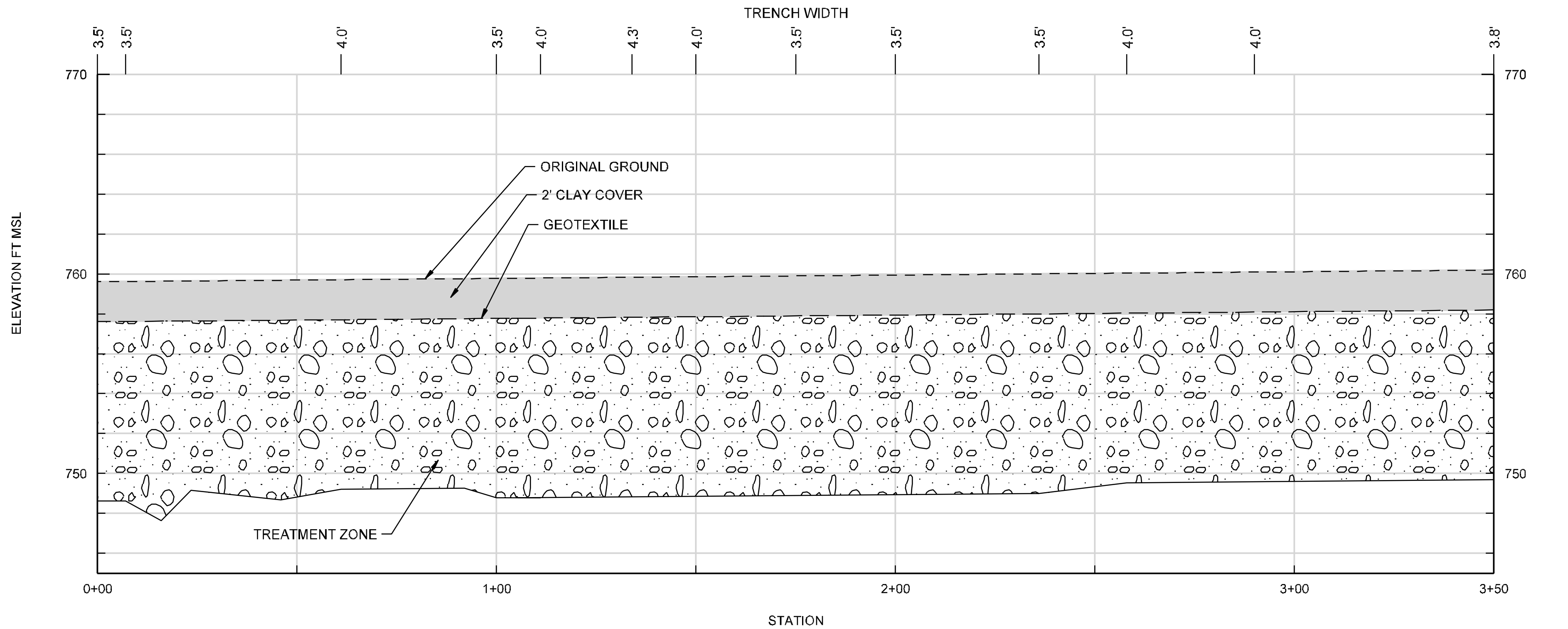
AS-BUILT
AREA M
BIOWALLS M-2 AND M-6 PLAN AND PROFILE

SHEET	15
DWG	GWAB-15
DATE	SEPTEMBER 2005
PROJ	327014

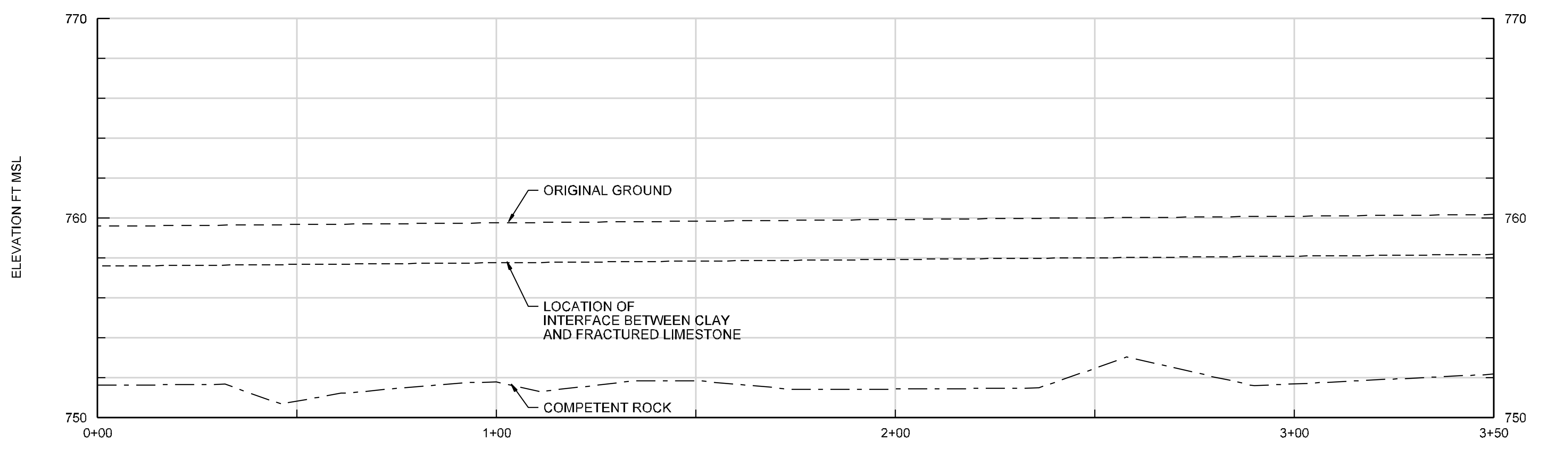
FILENAME: mc_gwab_m04.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:43:14



BIOWALL M-3 PIPING LAYOUT



BIOWALL M-3 CONSTRUCTED PROFILE



BIOWALL M-3 ORIGINAL PROFILE

NOTES:

1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALE
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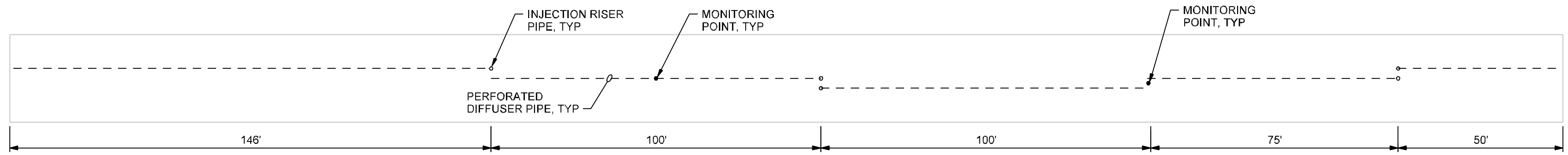
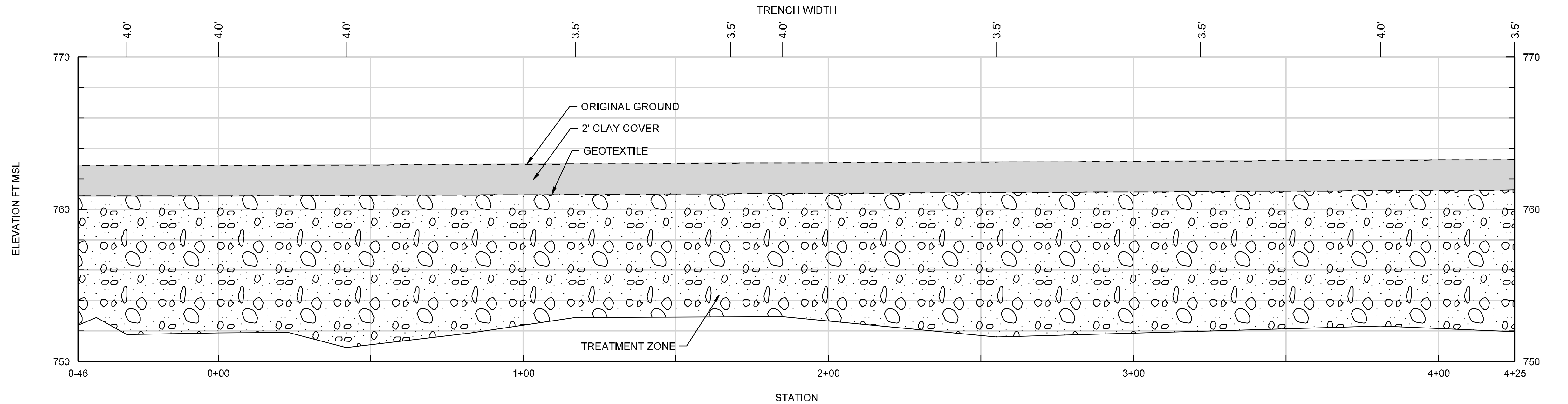
AREA M
BIOWALL M-3 PLAN AND PROFILE

SHEET	16
DWG	GWAB-16
DATE	SEPTEMBER 2005
PROJ	327014

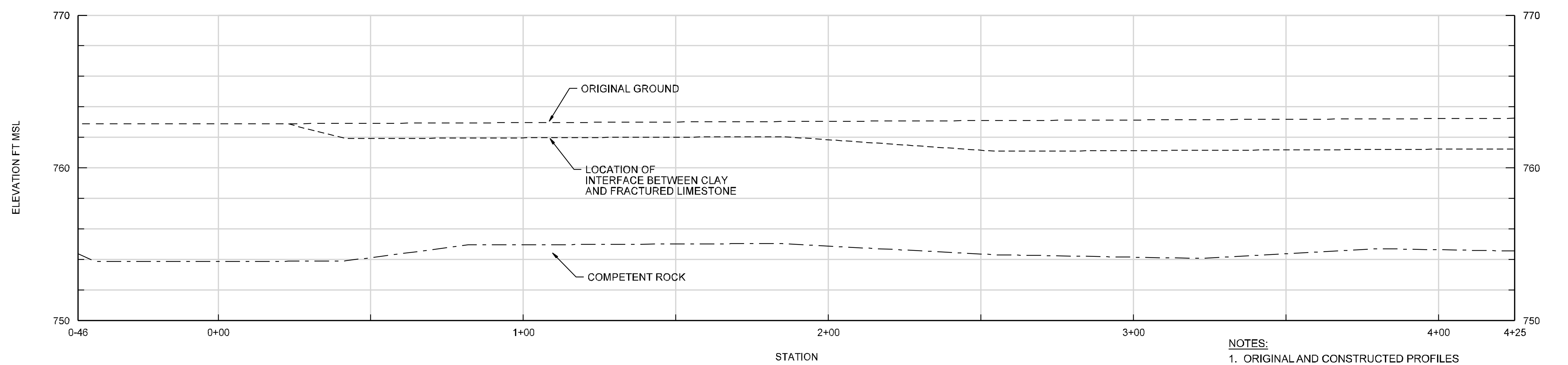
FILENAME: mc_gwab_m05.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:17:38



BIOWALL M-5 PIPING LAYOUT



BIOWALL M-5 CONSTRUCTED PROFILE



BIOWALL M-5 ORIGINAL PROFILE

NOTES:

1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER
DR J BOOTH
CHK W THOMAS
APVD T BEISEL

NO.	DATE	REVISION	BY	APVD

VERIFY SCALE
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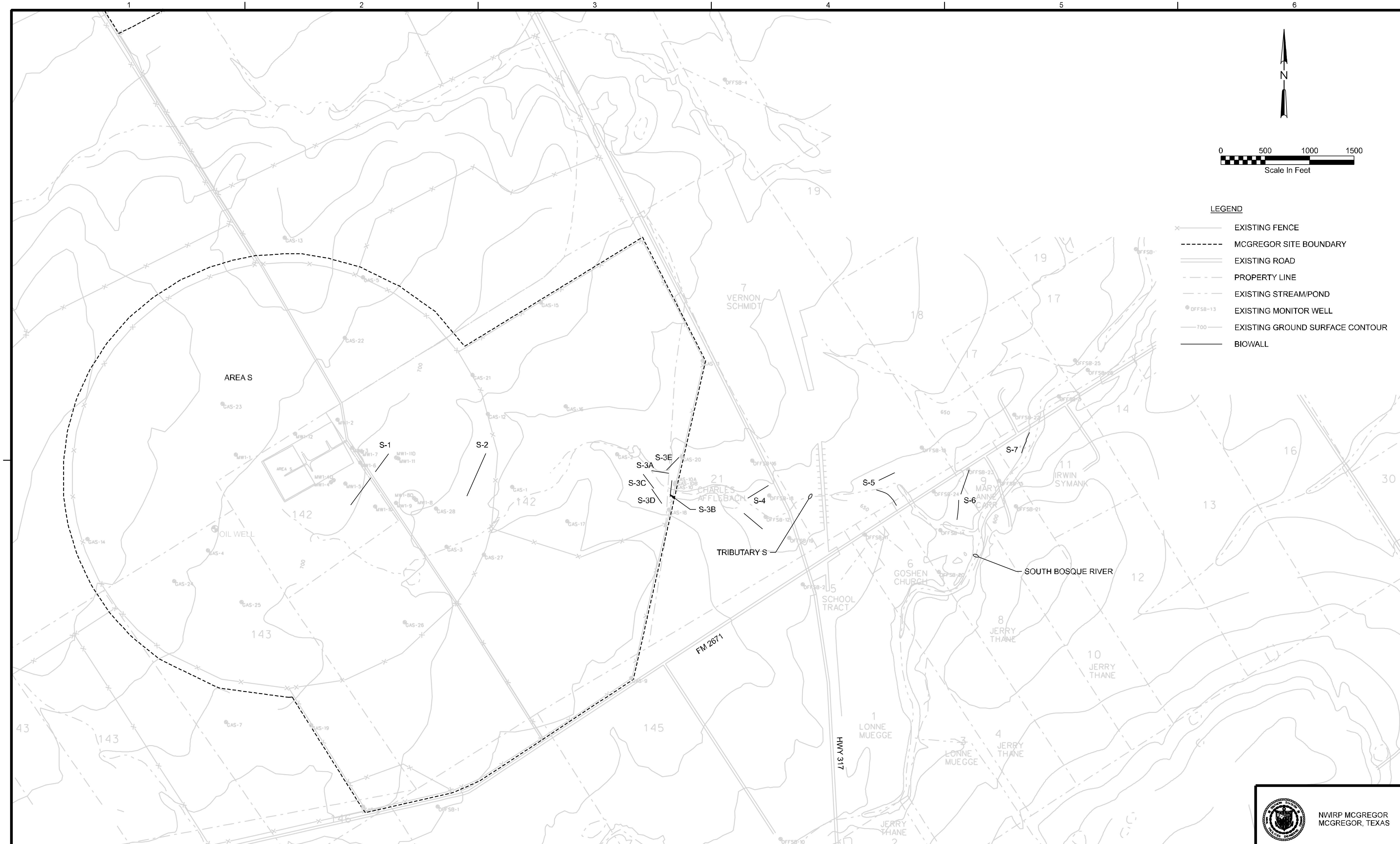
AS-BUILT
AREA M
BIOWALL M-5 PLAN AND PROFILE

SHEET 17
DWG GWAB-17
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_m06.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:48:51



NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN H SARTAIN						VERIFY SCALE
DR J BOOTH						BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

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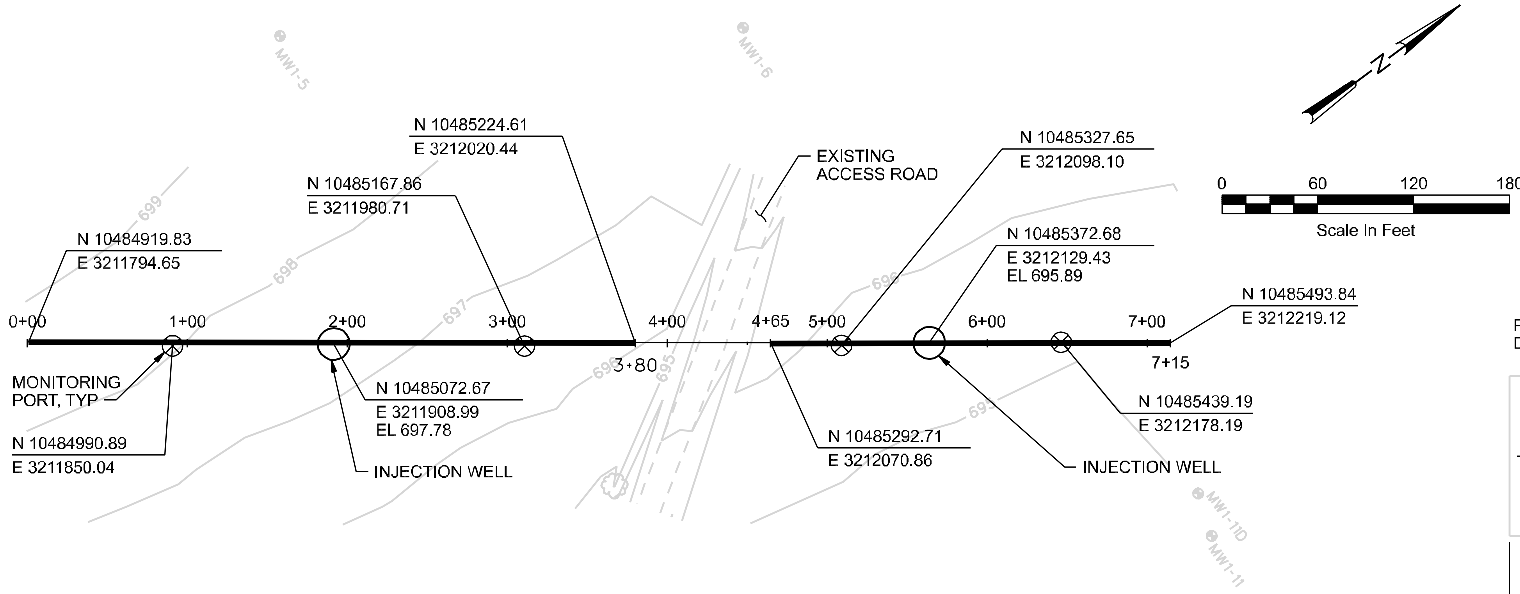
AS-BUILT
AREA S
BIOWALL LOCATIONS

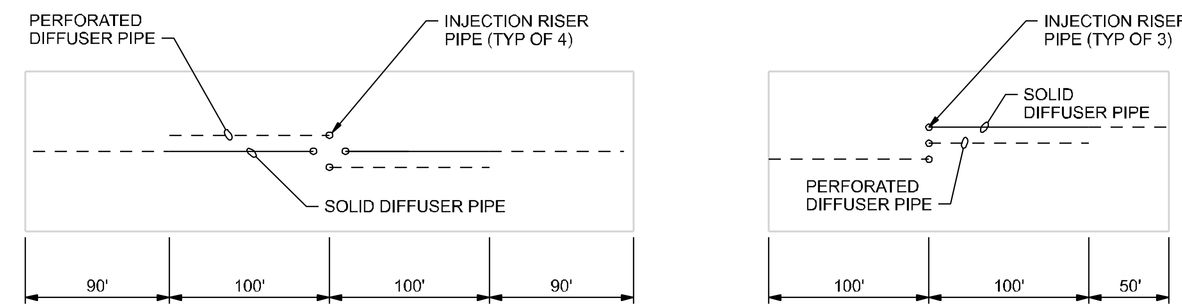
SHEET	18
DWG	GWAB-18
DATE	SEPTEMBER 2005
PROJ	327014

FILENAME: mc_gwab_s01.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:18:28

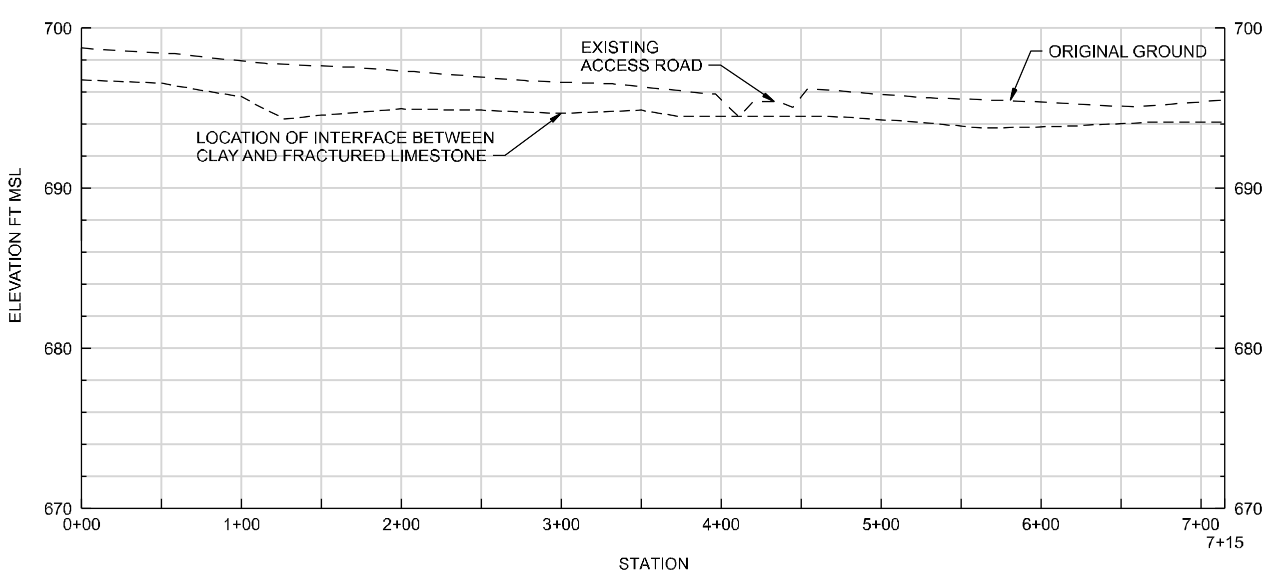
NOTES:
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.



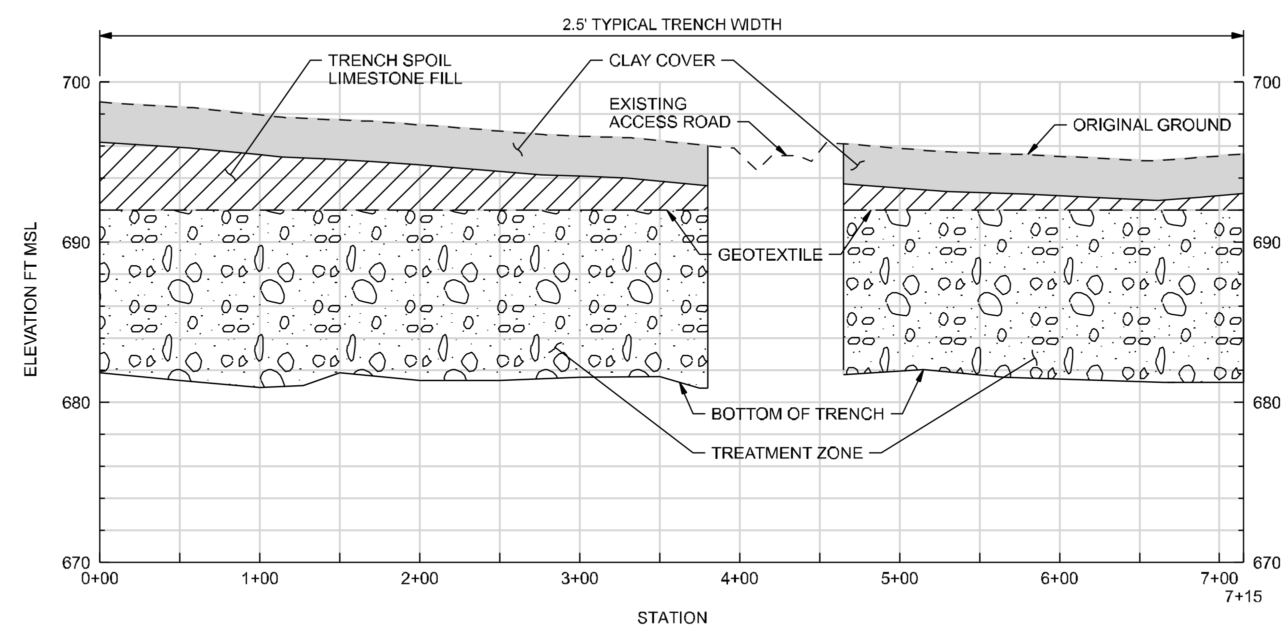
BIOWALL S-1 PLAN



BIOWALL S-1 PIPING LAYOUT



BIOWALL S-1 ORIGINAL PROFILE



BIOWALL S-1 CONSTRUCTED PROFILE

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN H SARTAIN						VERIFY SCALE
DR J BOOTH						BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

CH2MHILL Constructors, Inc.

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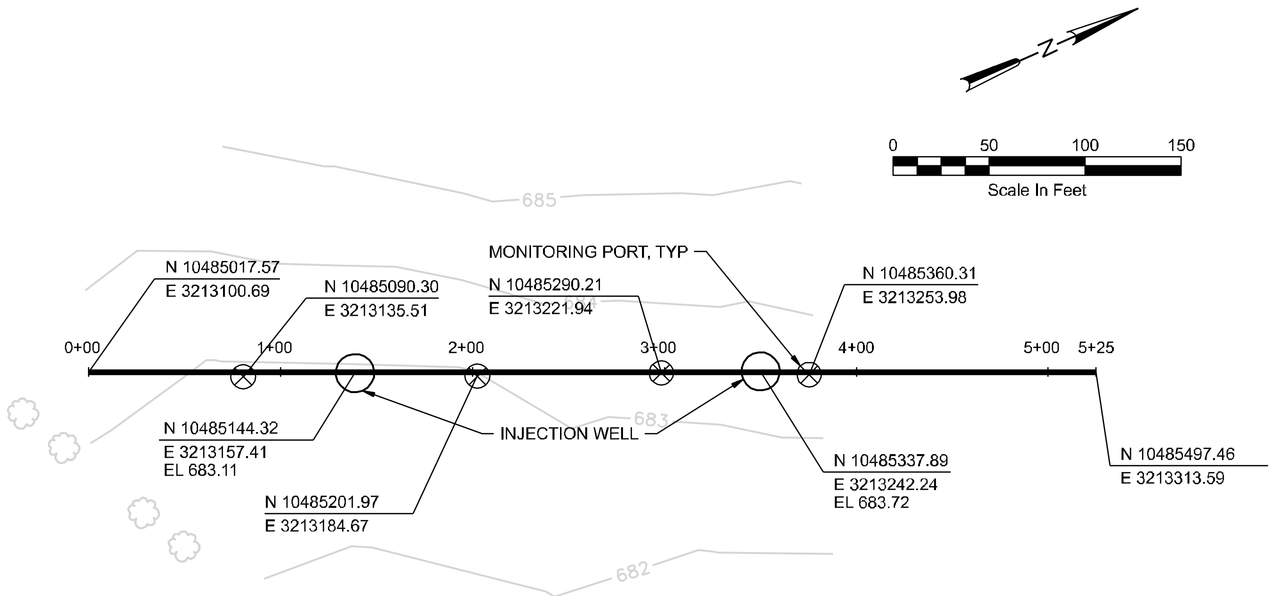
LANCASTER, PA • NASHVILLE, TN • NORFOLK, VA • PADUCAH, KY • PENSACOLA, FL
RALEIGH, NC • COLOGNE, GERMANY

AS-BUILT
AREA S
BIOWALL S-1 PLAN AND PROFILE

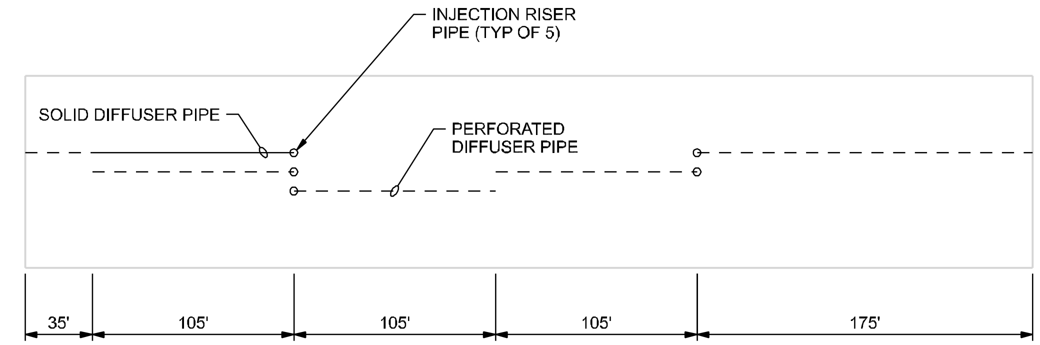
SHEET 19
DWG GWAB-19
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_s02.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:17:52

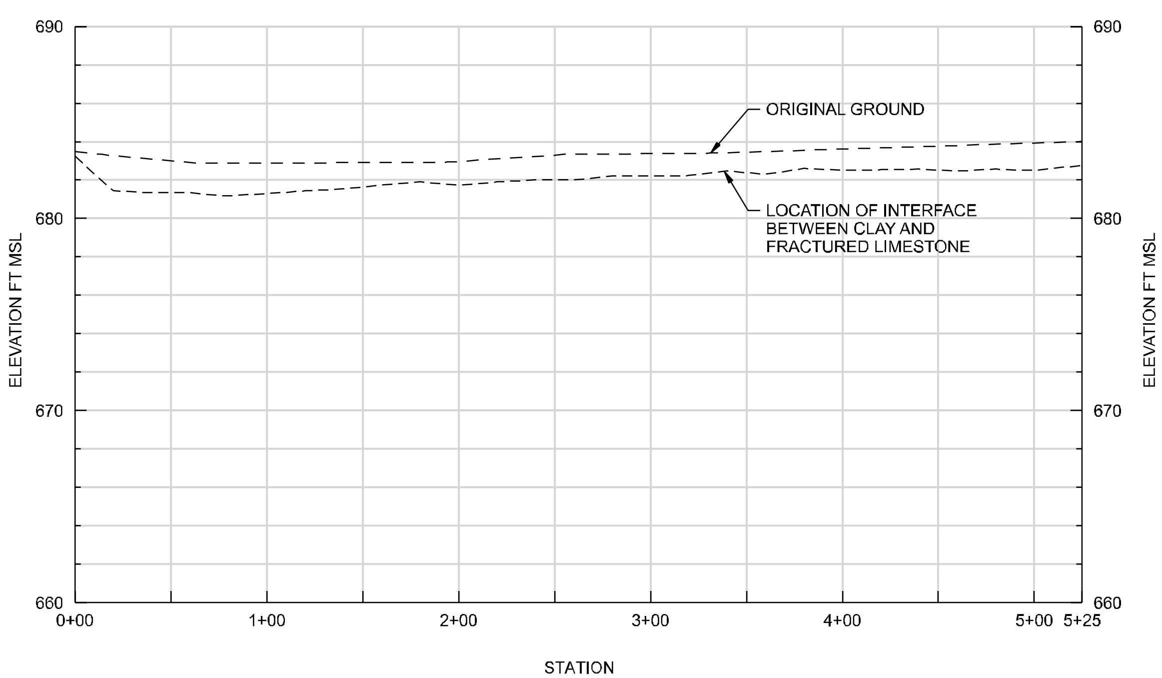
NOTES:
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.



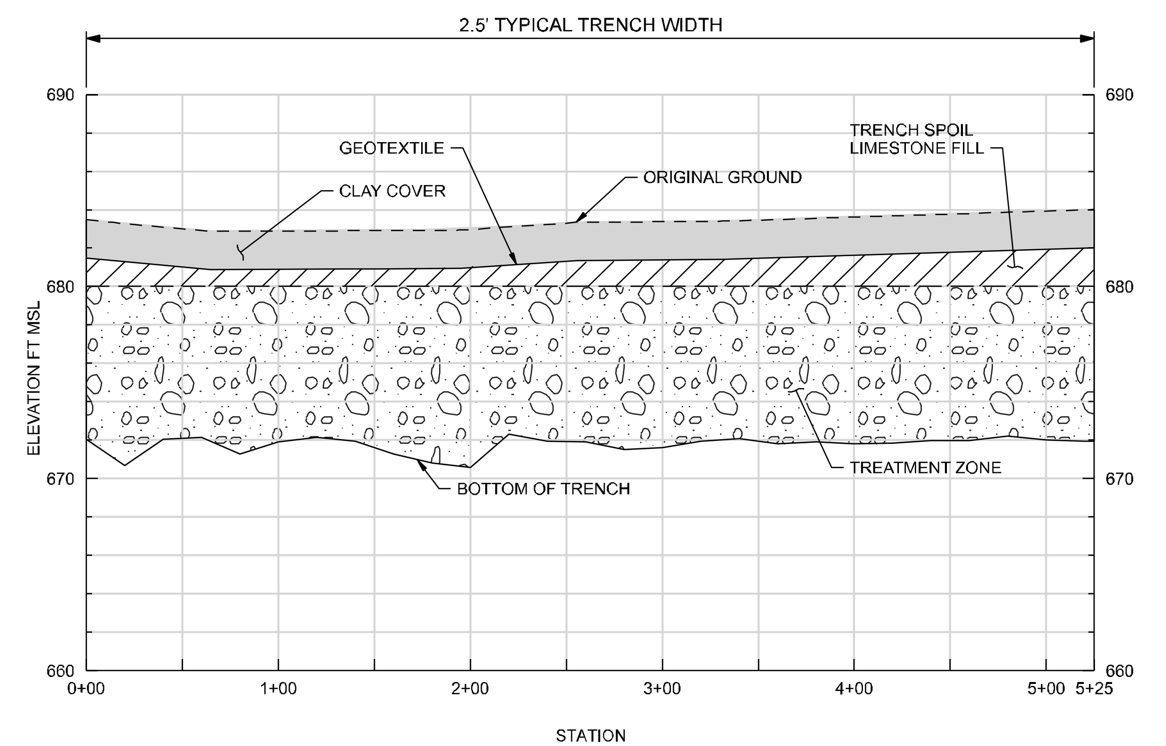
BIOWALL S-2 PLAN



BIOWALL S-2 PIPING LAYOUT



BIOWALL S-2 EXISTING PROFILE



BIOWALL S-2 CONSTRUCTED PROFILE

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN H SARTAIN						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALE
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0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL
Constructors, Inc.

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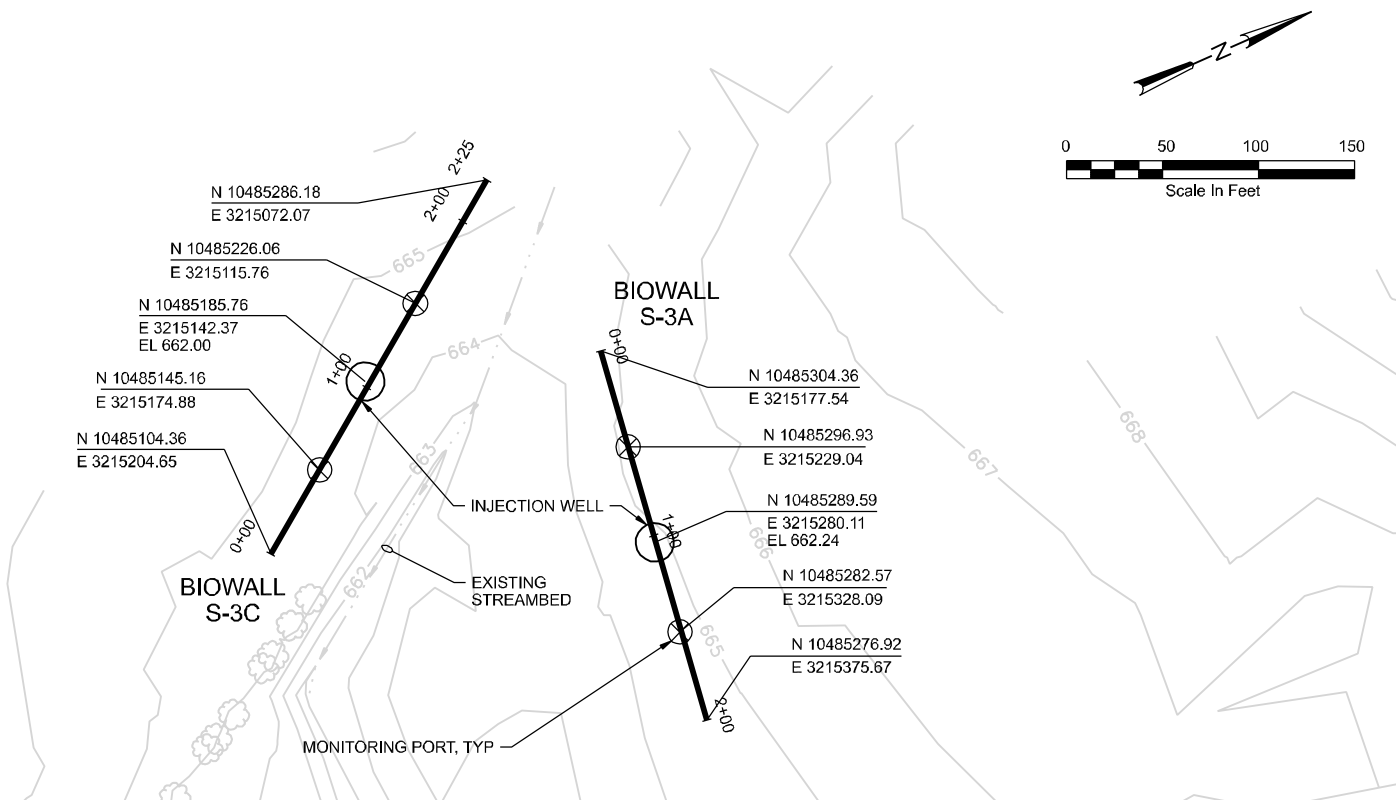
AS-BUILT
AREA S
BIOWALL S-2 PLAN AND PROFILE

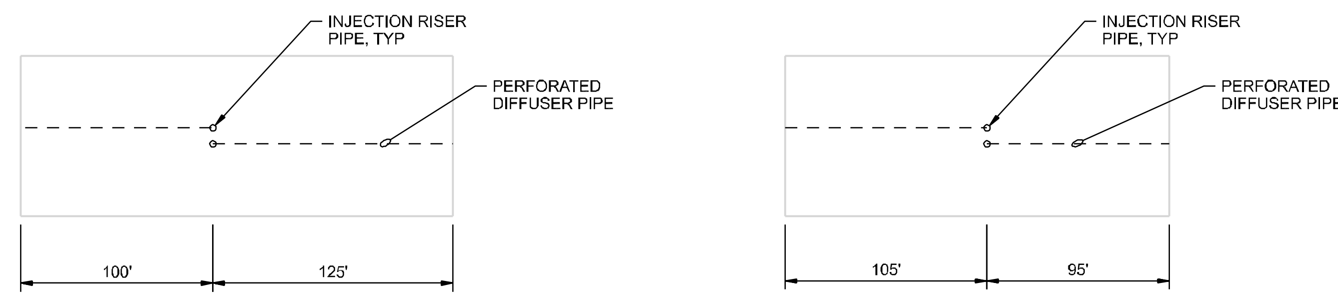
SHEET 20
DWG GWAB-20
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_s03.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:18:09

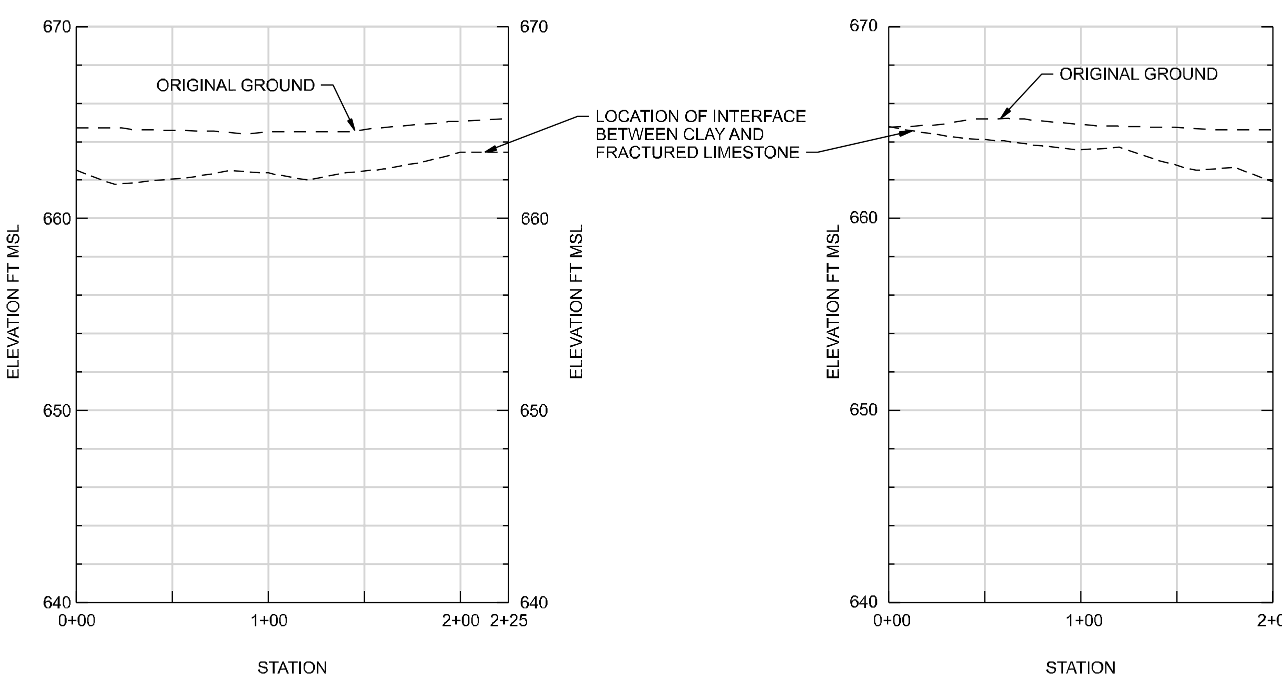
NOTES:
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.



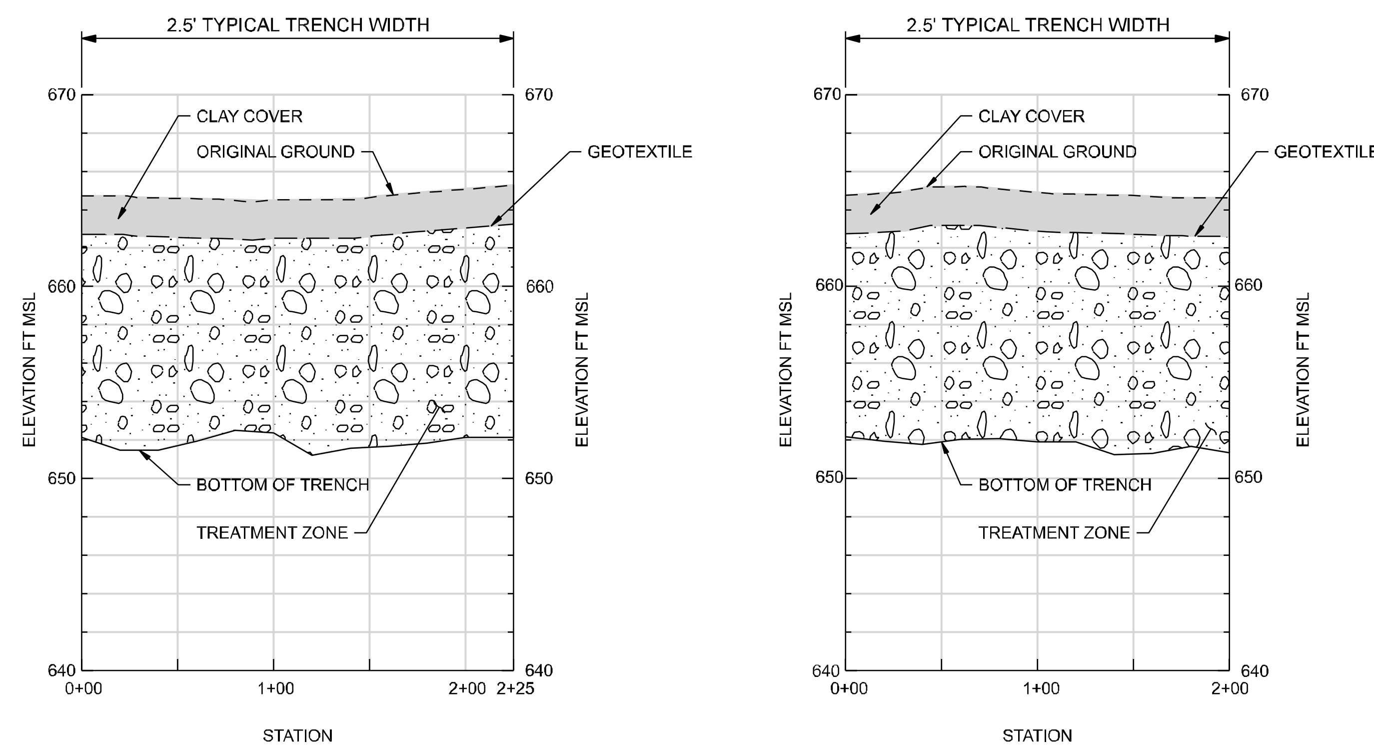
BIOWALL S-3A AND S-3C PLAN



BIOWALL S-3A AND S-3C PIPING LAYOUT



BIOWALL S-3A AND S-3C ORIGINAL PROFILE



BIOWALL S-3A AND S-3C CONSTRUCTED PROFILE

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN H SARTAIN						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL Constructors, Inc.

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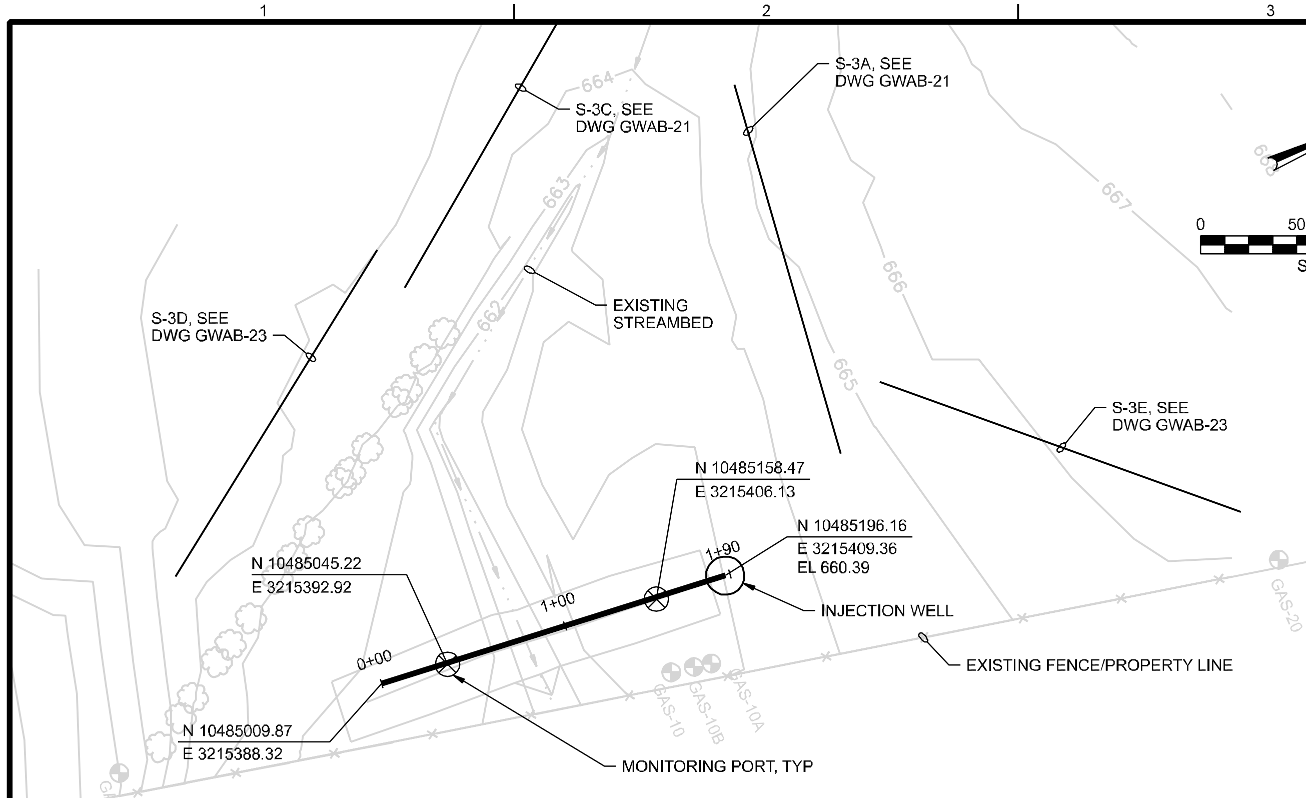
AS-BUILT
AREA S
BIOWALLS S-3A AND S-3C PLAN AND PROFILE

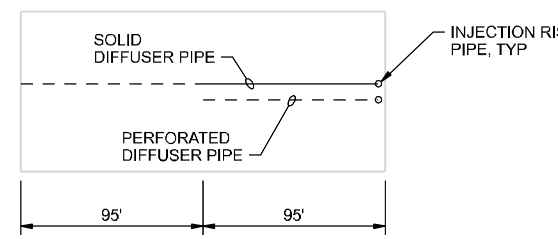
SHEET 21
DWG GWAB-21
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_s04.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:18:21

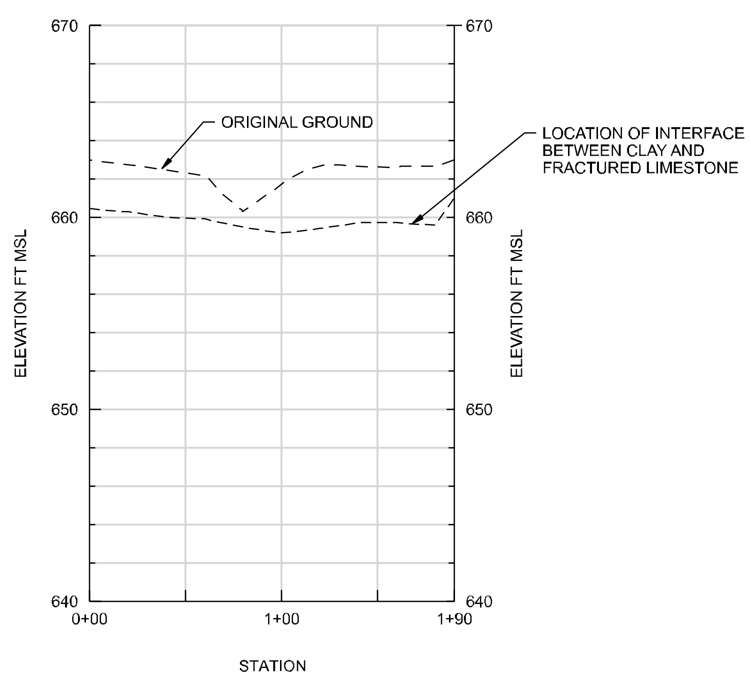
NOTES:
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.



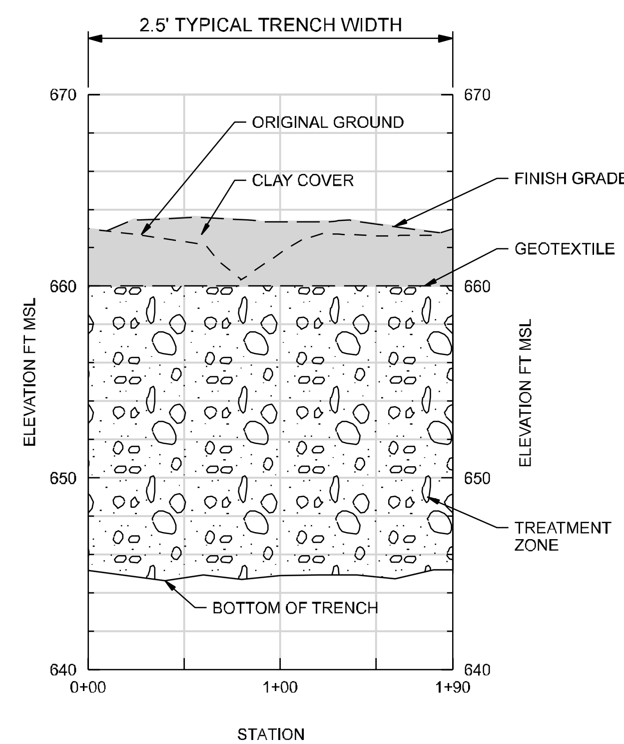
BIOWALL S-3B PLAN



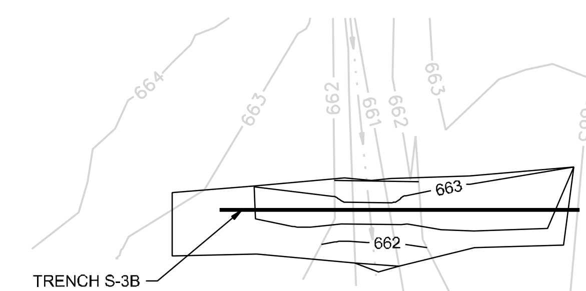
BIOWALL S-3B PIPING LAYOUT



BIOWALL S-3B ORIGINAL PROFILE



BIOWALL S-3B CONSTRUCTED PROFILE



BIOWALL S-3B BERM DETAIL

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN H SARTAIN						VERIFY SCALE
DR J BOOTH						BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"
CHK W THOMAS						IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

CH2MHILL Constructors, Inc.

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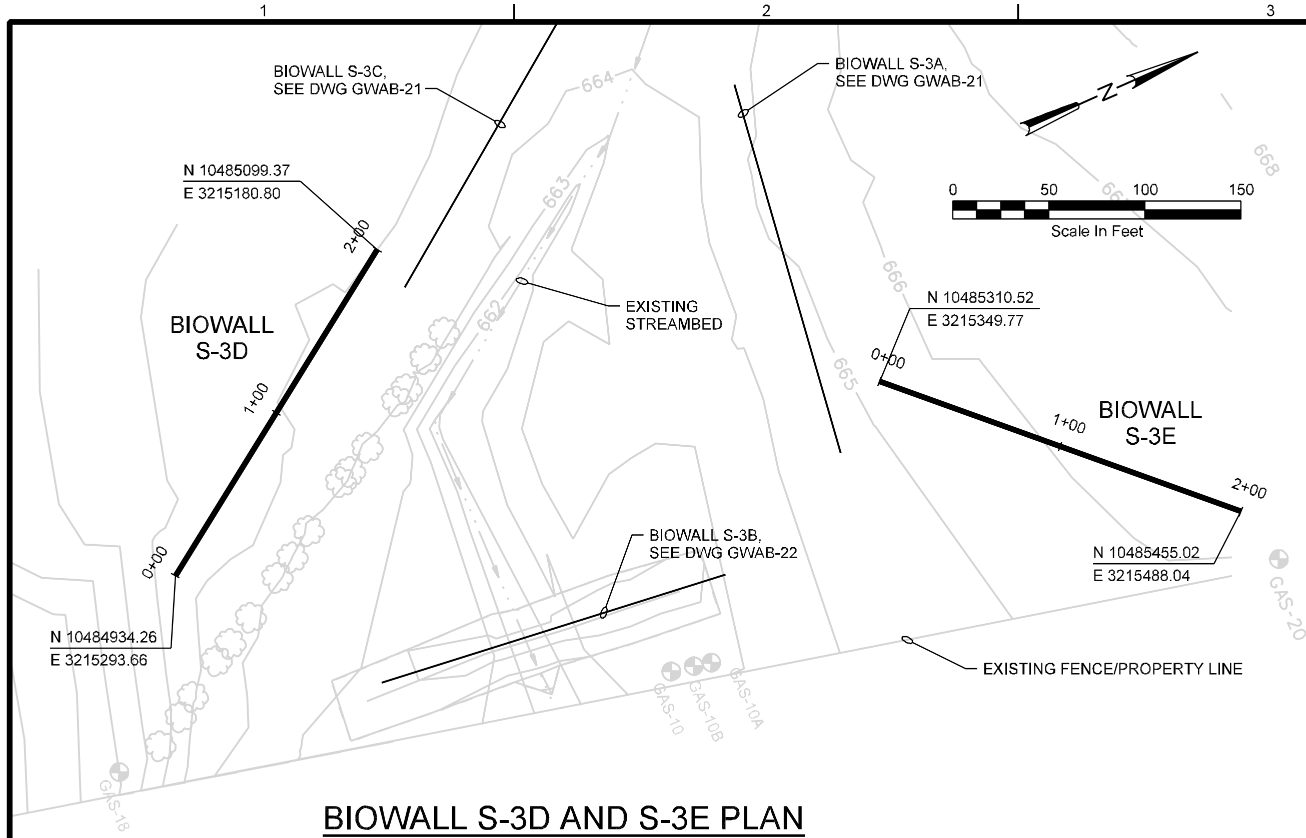
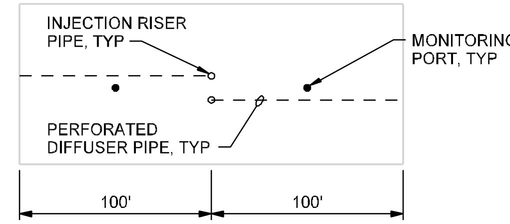
AS-BUILT
AREA S
BIOWALL S-3B PLAN AND PROFILE

SHEET 22
DWG GWAB-22
DATE SEPTEMBER 2005
PROJ 327014

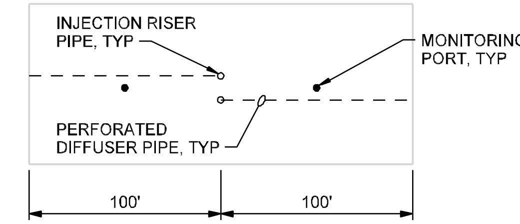
FILENAME: mc_gwab_s05.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:18:34



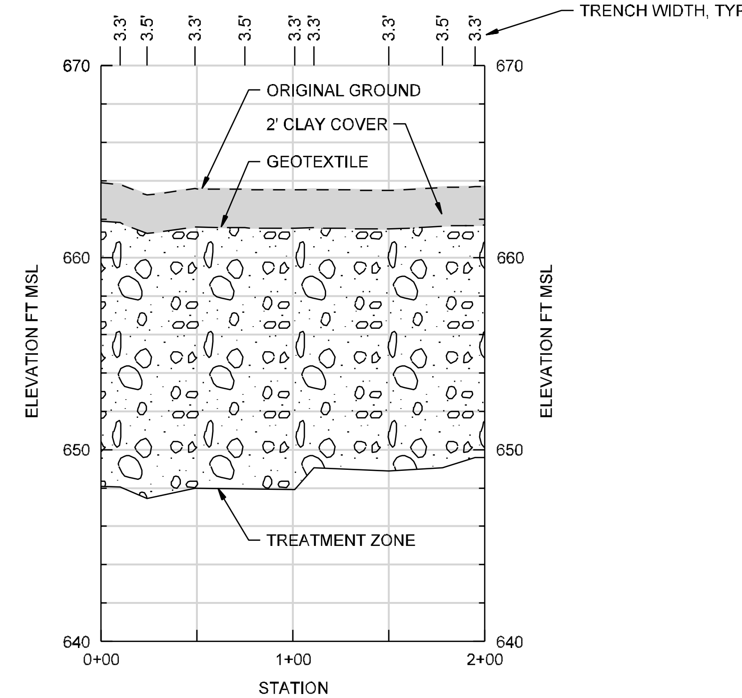
BIOWALL S-3D AND S-3E PLAN



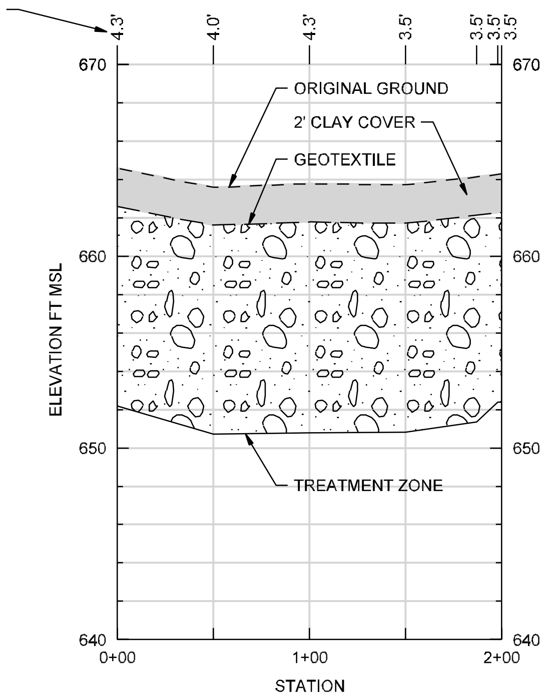
BIOWALL S-3D PIPING LAYOUT



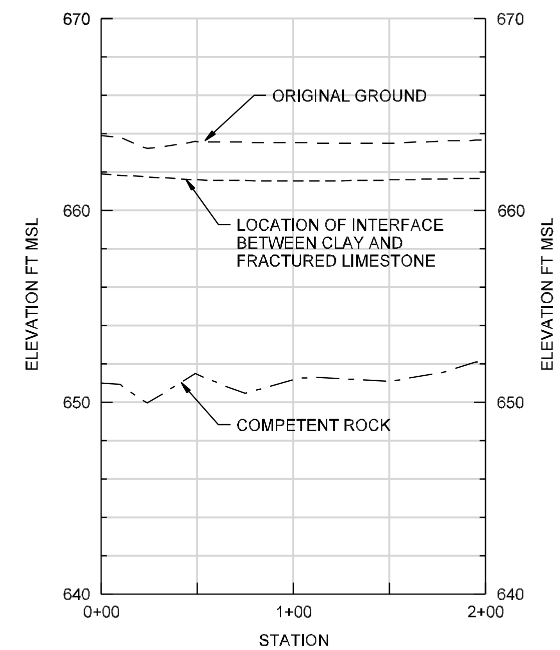
BIOWALL S-3E PIPING LAYOUT



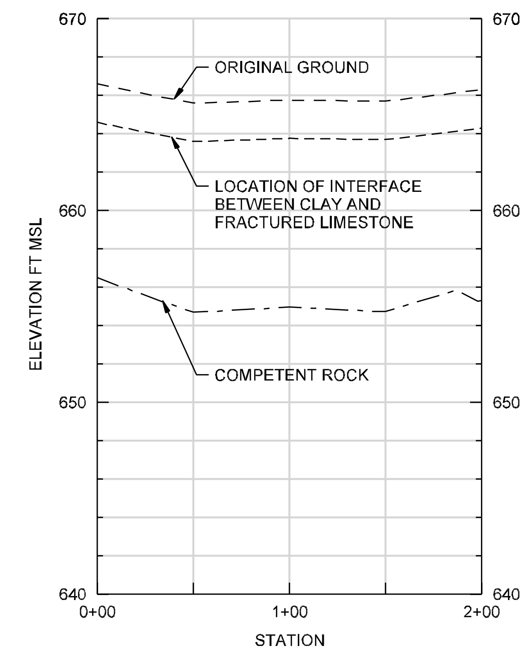
BIOWALL S-3D CONSTRUCTED PROFILE



BIOWALL S-3E CONSTRUCTED PROFILE



BIOWALL S-3D ORIGINAL PROFILE



BIOWALL S-3E ORIGINAL PROFILE

NOTES:

1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER						VERIFY SCALE	
DR J BOOTH						BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	
CHK W THOMAS							
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD		

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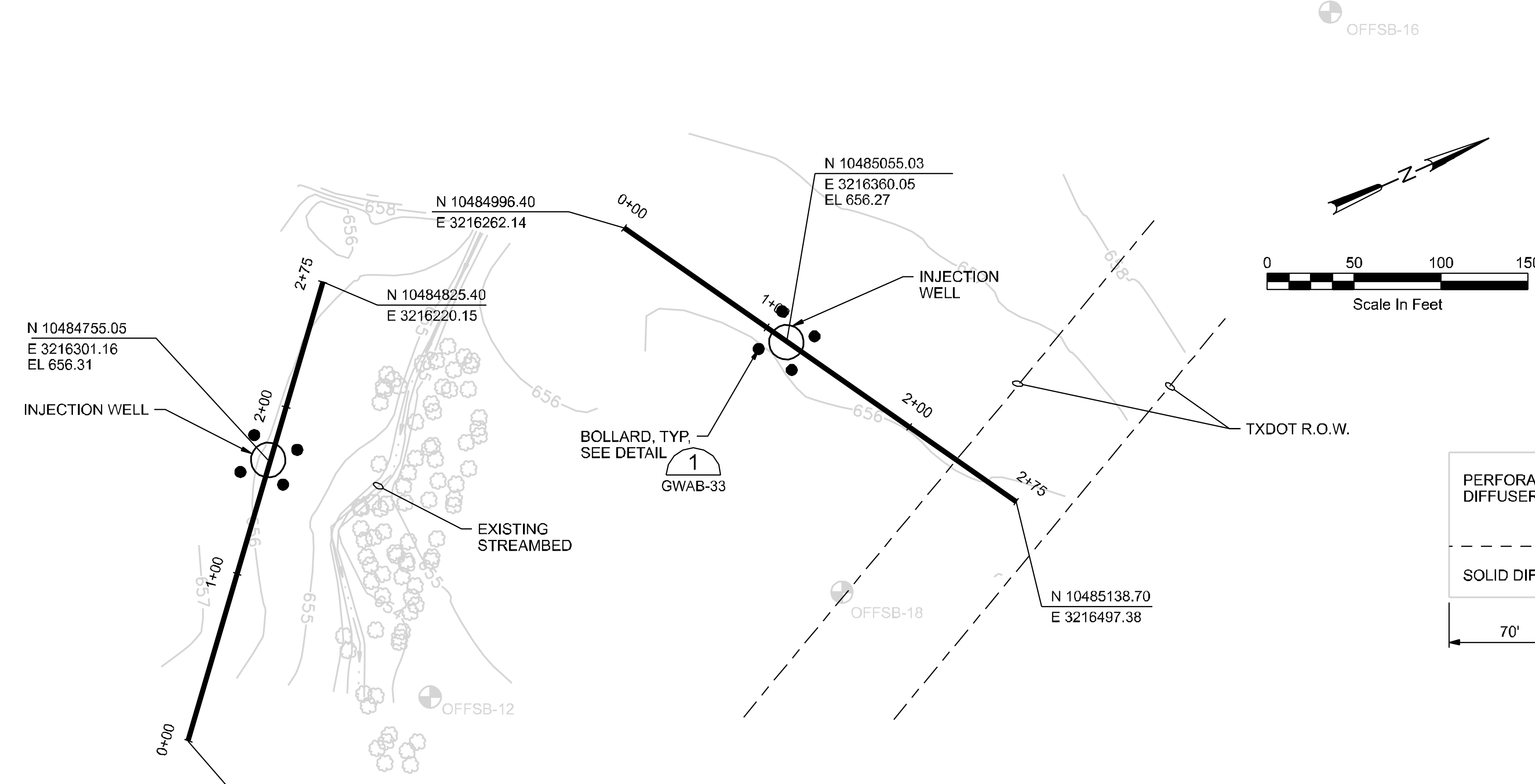
AREA S
BIOWALLS S-3D AND S-3E PLAN AND PROFILE

SHEET 23
DWG GWAB-23
DATE SEPTEMBER 2005
PROJ 327014

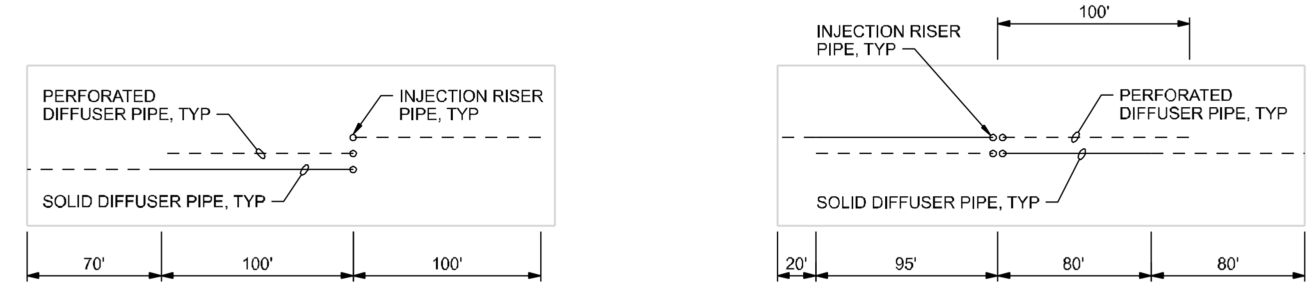
FILENAME: mc_gwab_s07.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:18:45



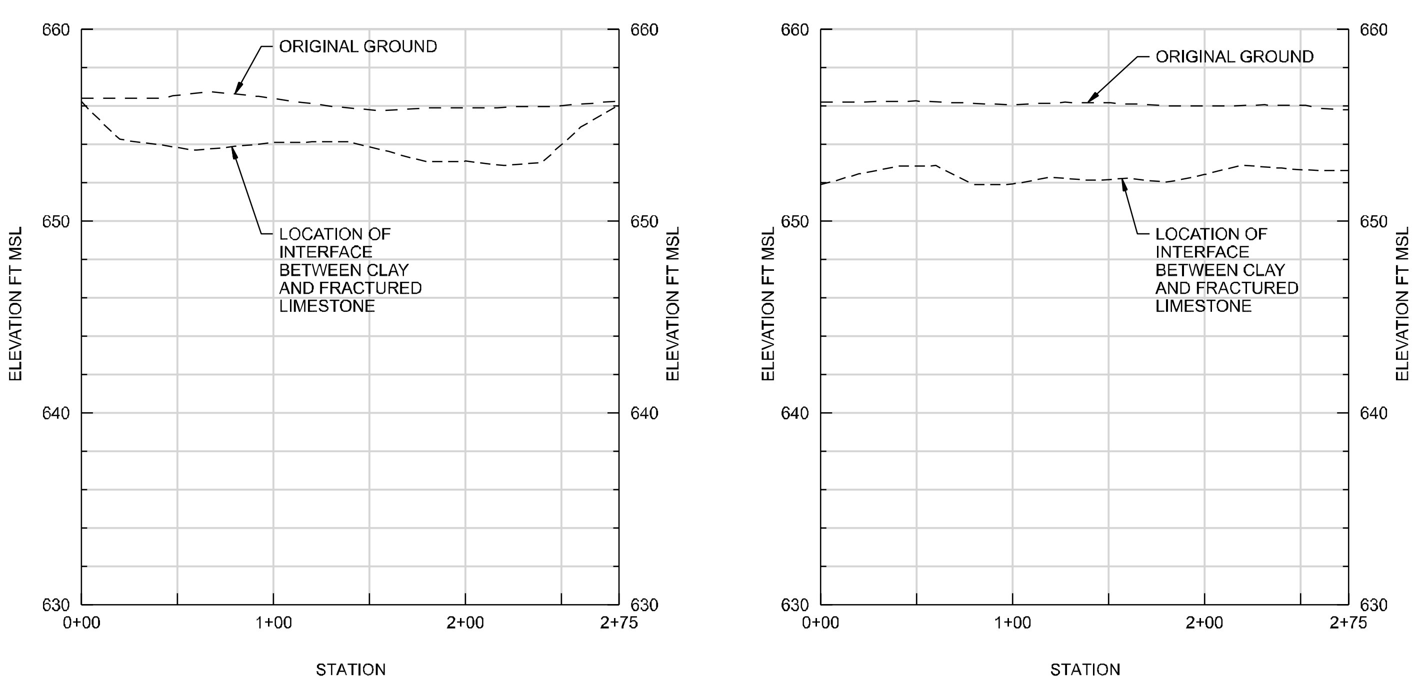
BIOWALL S-4 PLAN

NOTES:

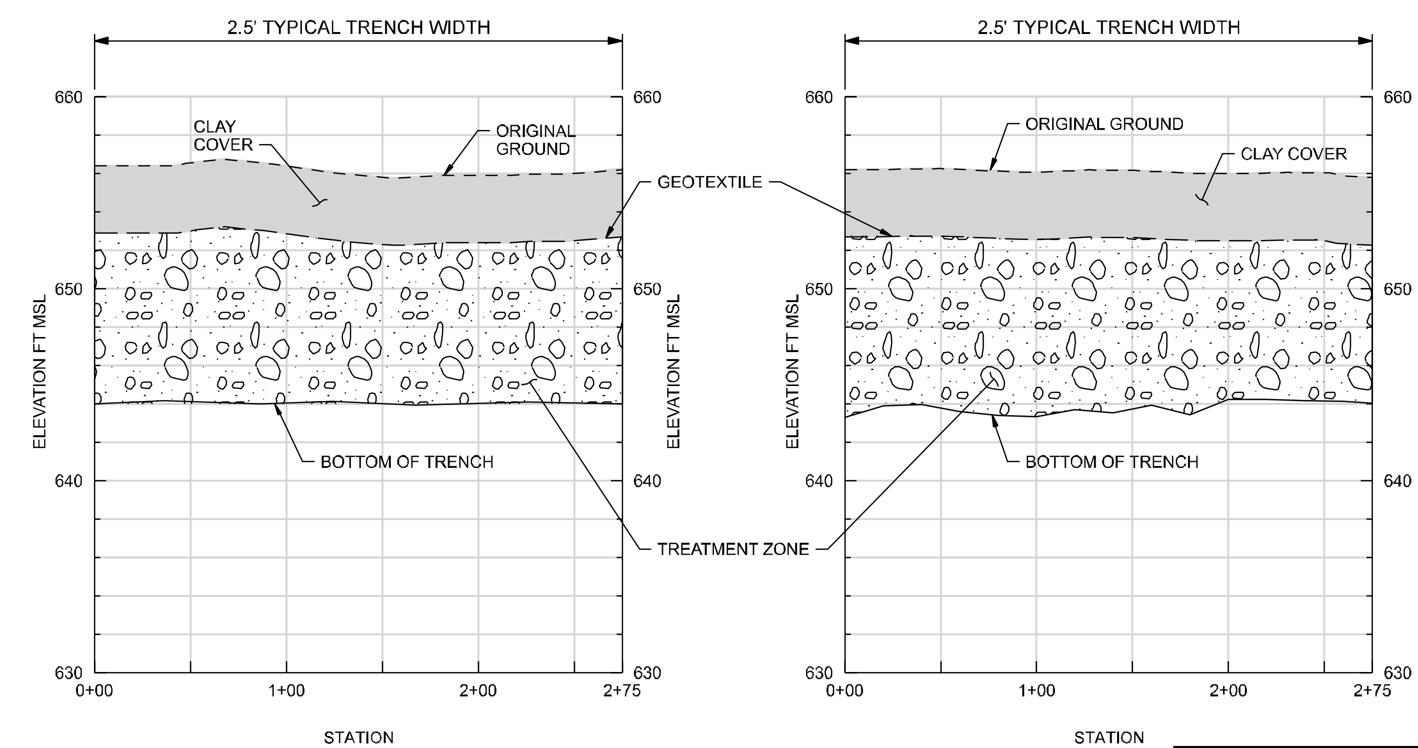
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.
5. ALL TREES WITHIN WORK LIMITS REMOVED, SEE LIST ON DRAWING GWAB-33.



BIOWALL S-4 SCHEMATIC PIPING LAYOUT



BIOWALL S-4 EXISTING PROFILE



BIOWALL S-4 CONSTRUCTED PROFILE

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MCGREGOR, TEXAS

DSGN H SARTAIN						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

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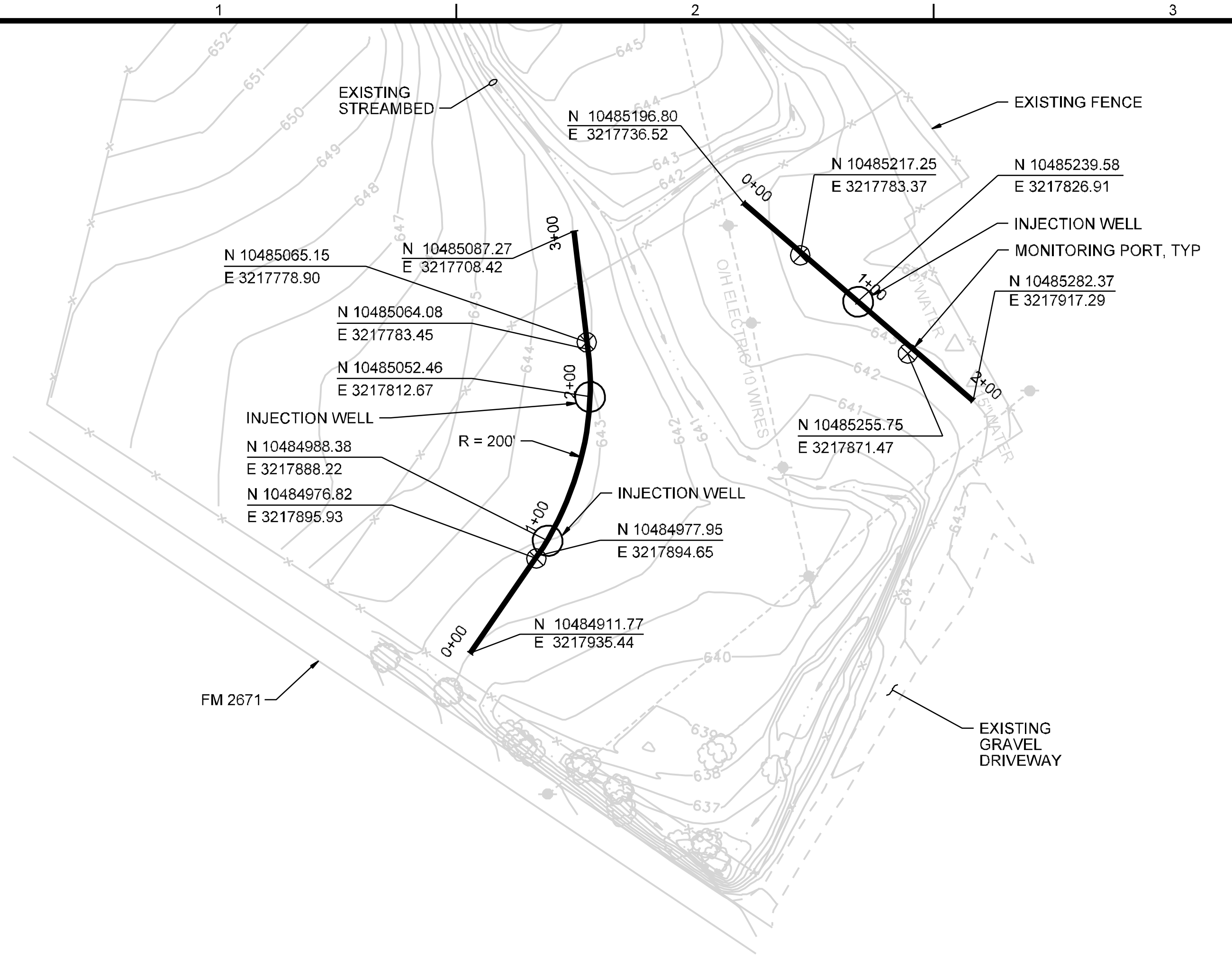
BIOWALL S-4 PLAN AND PROFILE

SHEET 24
DWG GWAB-24
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_s08.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:18:56

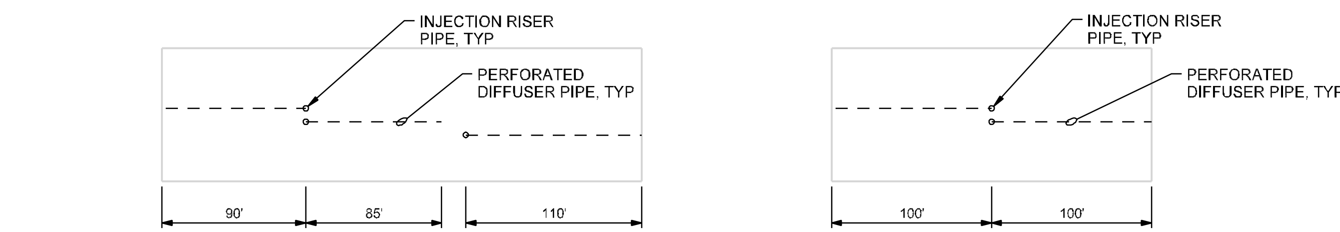


BIOWALL S-5 PLAN

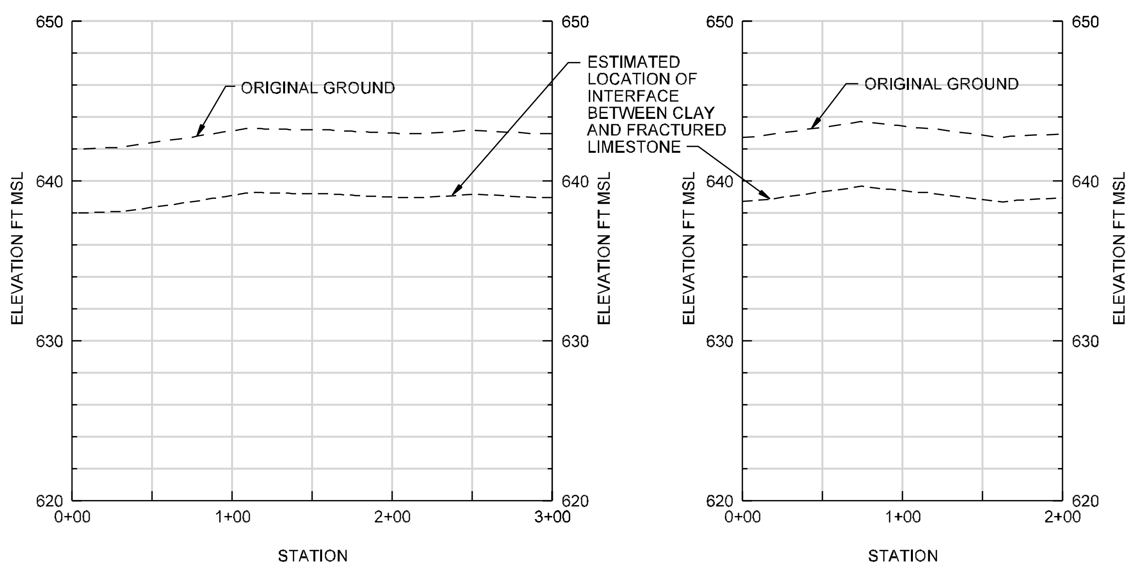
0 60 120 180
Scale In Feet

NOTES:

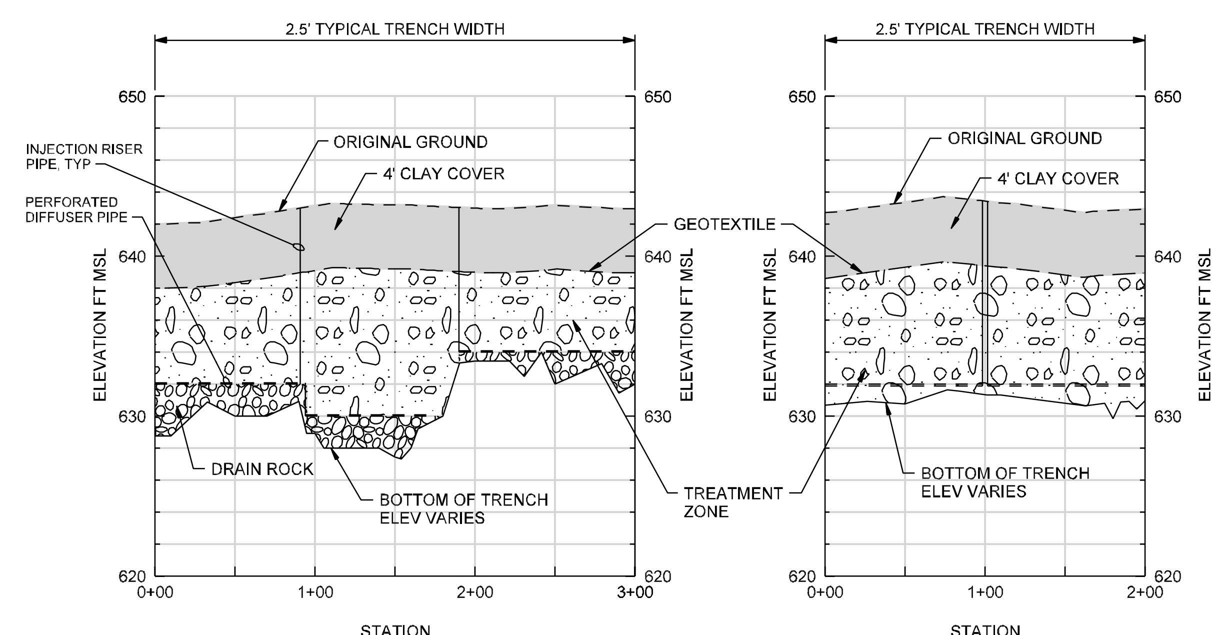
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.



BIOWALL S-5 PIPING LAYOUT



BIOWALL S-5 ORIGINAL PROFILE



BIOWALL S-5 CONSTRUCTED PROFILE

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN H SARTAIN						VERIFY SCALE
DR J BOOTH						BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

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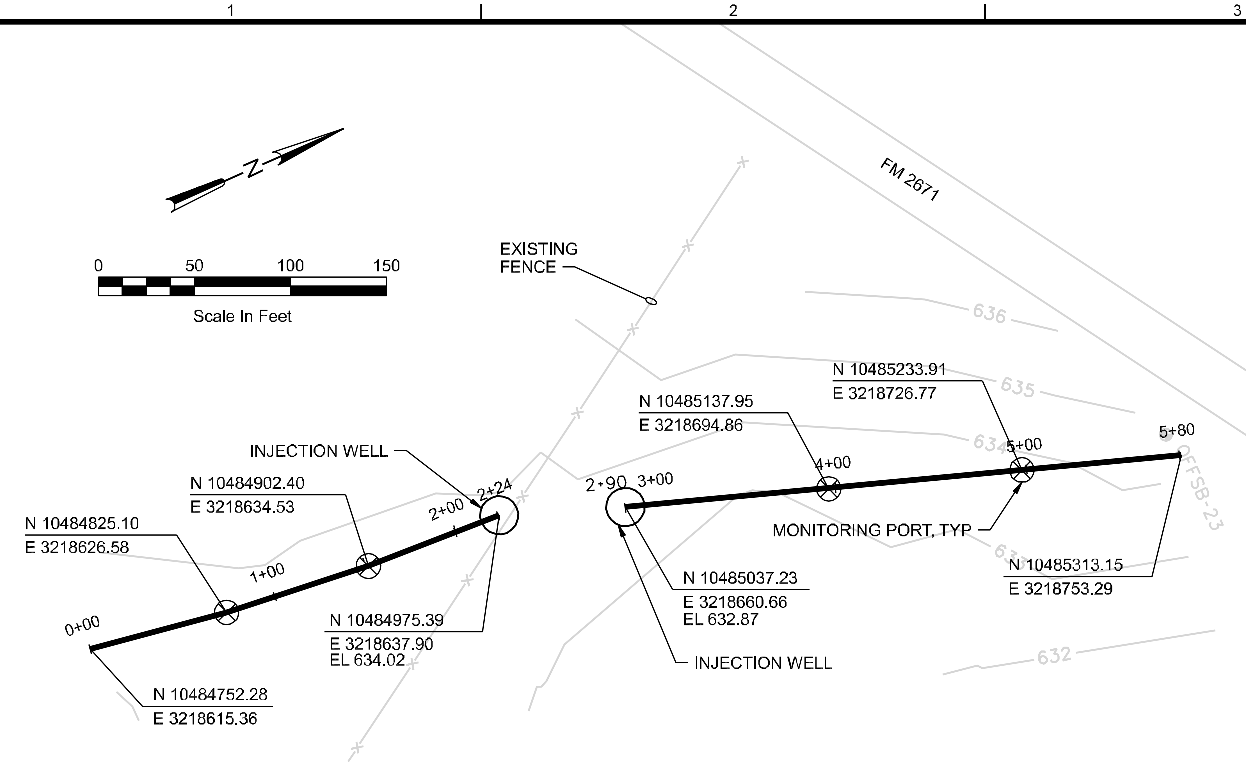
AREA S
BIOWALL S-5 PLAN AND PROFILE

SHEET 25
DWG GWAB-25
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_s09.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:19:07

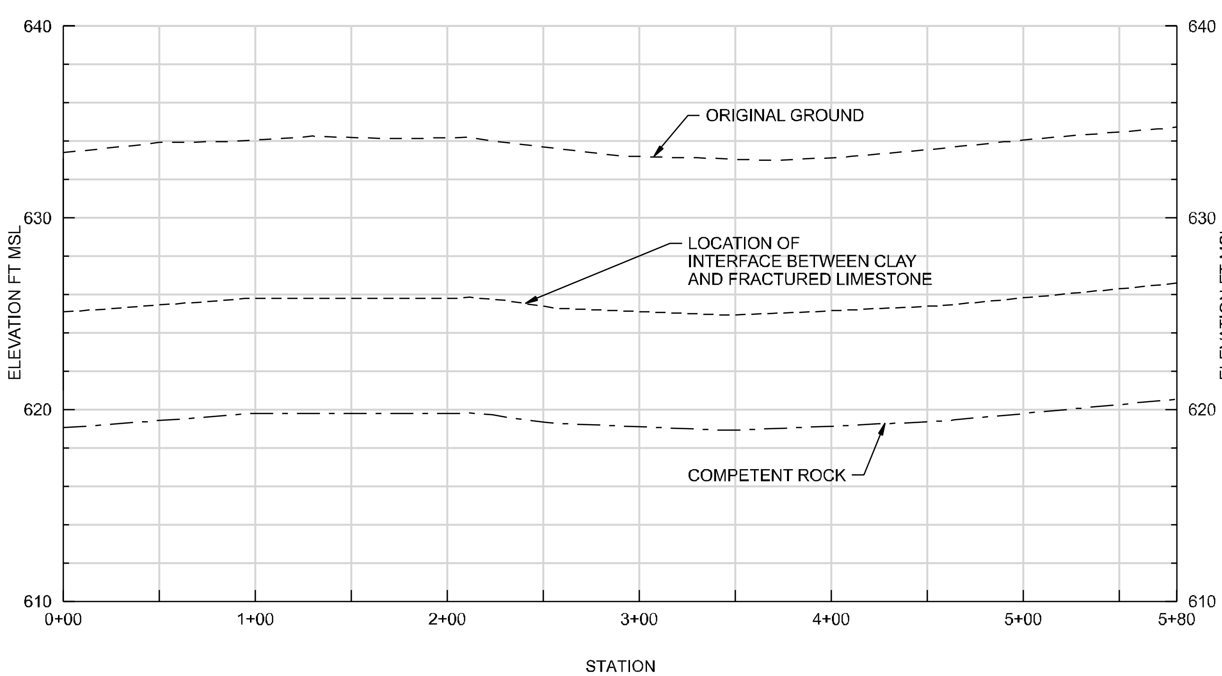
NOTES:
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.



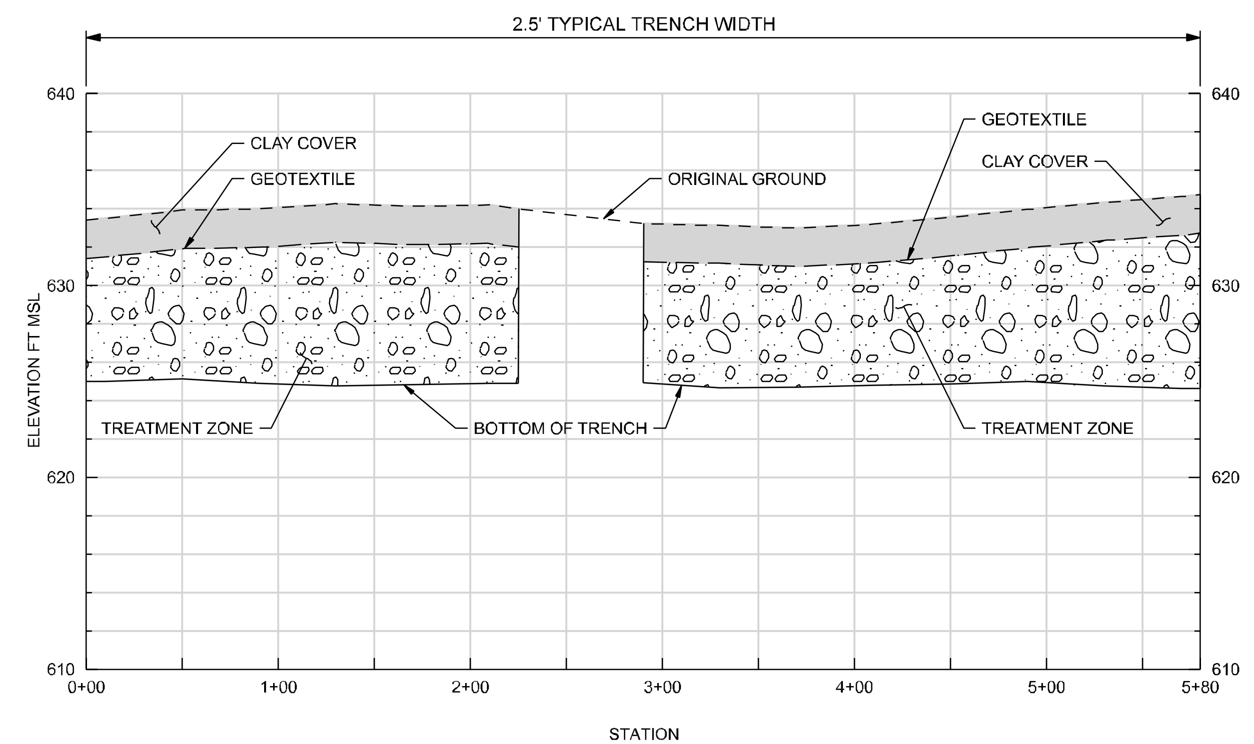
BIOWALL S-6 PLAN

FOR PIPING LAYOUT, SEE GWAB-28

BIOWALL S-6 PIPING LAYOUT



BIOWALL S-6 ORIGINAL PROFILE



BIOWALL S-6 CONSTRUCTED PROFILE

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN	H SARTAIN
DR	J BOOTH
CHK	W THOMAS
APVD	T BEISEL

NO.	DATE	REVISION	BY	APVD

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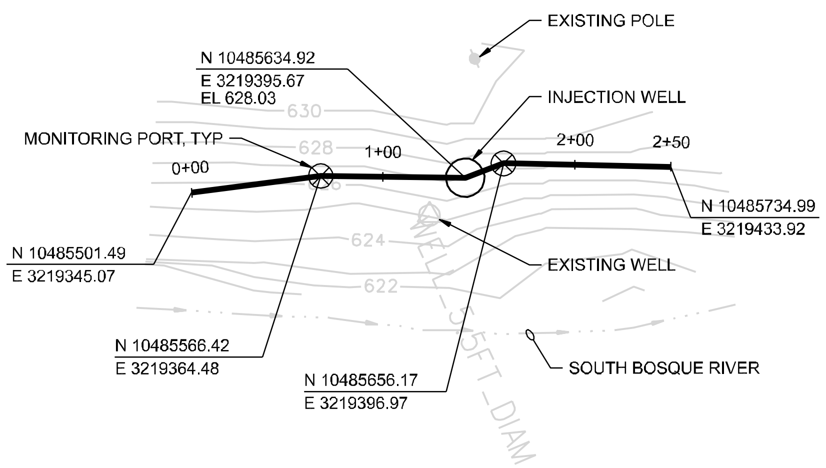
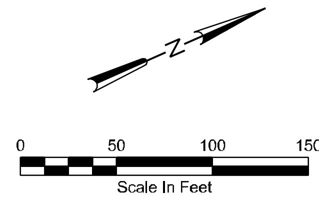
AREA S
BIOWALL S-6 PLAN AND PROFILE

SHEET 26
DWG GWAB-26
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_s10.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:19:18

NOTES:
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

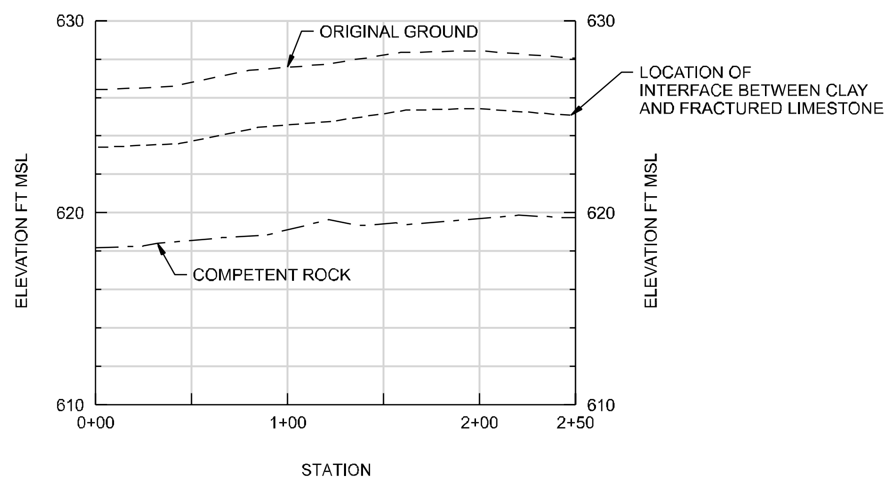




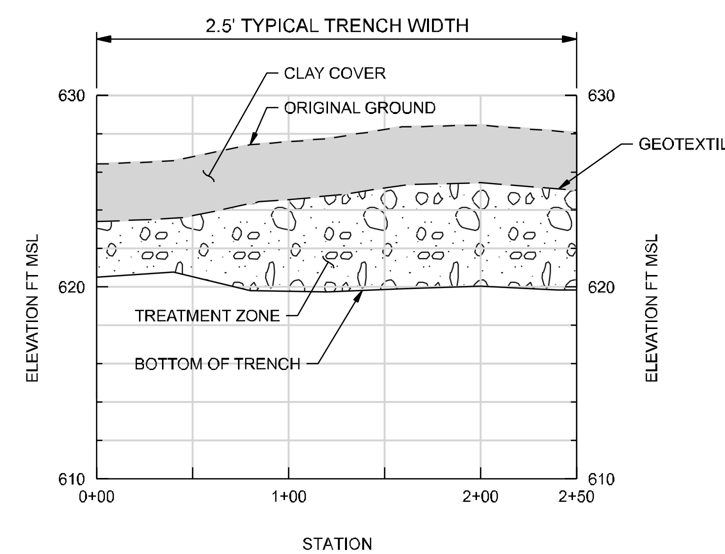
BIOWALL S-7 PLAN

FOR PIPING LAYOUT, SEE DWG GWAB-28

BIOWALL S-7 PIPING LAYOUT



BIOWALL S-7 ORIGINAL PROFILE



BIOWALL S-7 CONSTRUCTED PROFILE

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN H SARTAIN					
DR J BOOTH					
CHK W THOMAS					
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD

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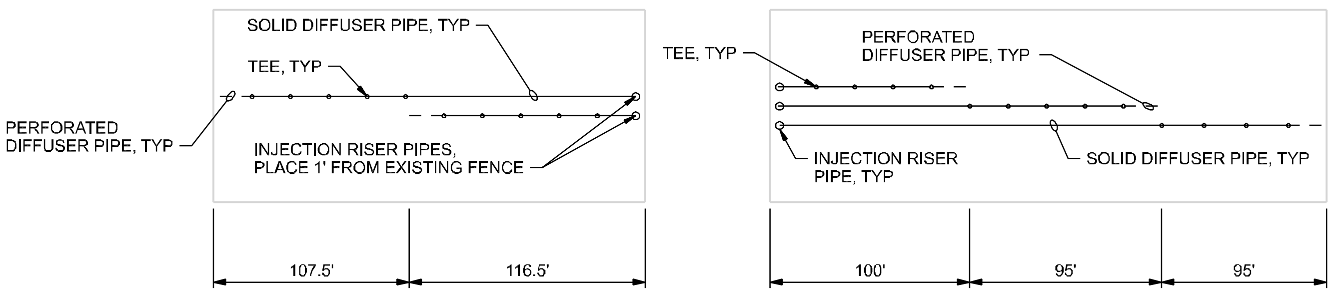
AREA S
BIOWALL S-7 PLAN AND PROFILE

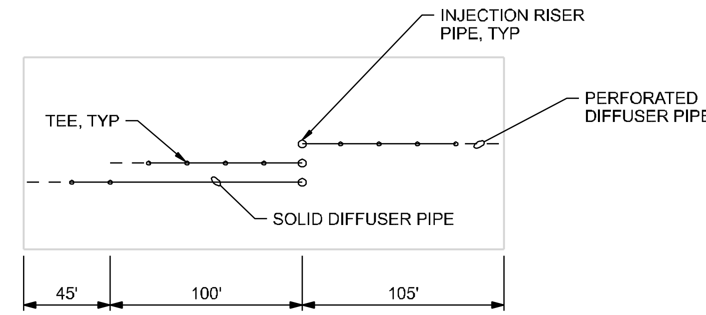
SHEET 27
DWG GWAB-27
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_s11.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:19:29

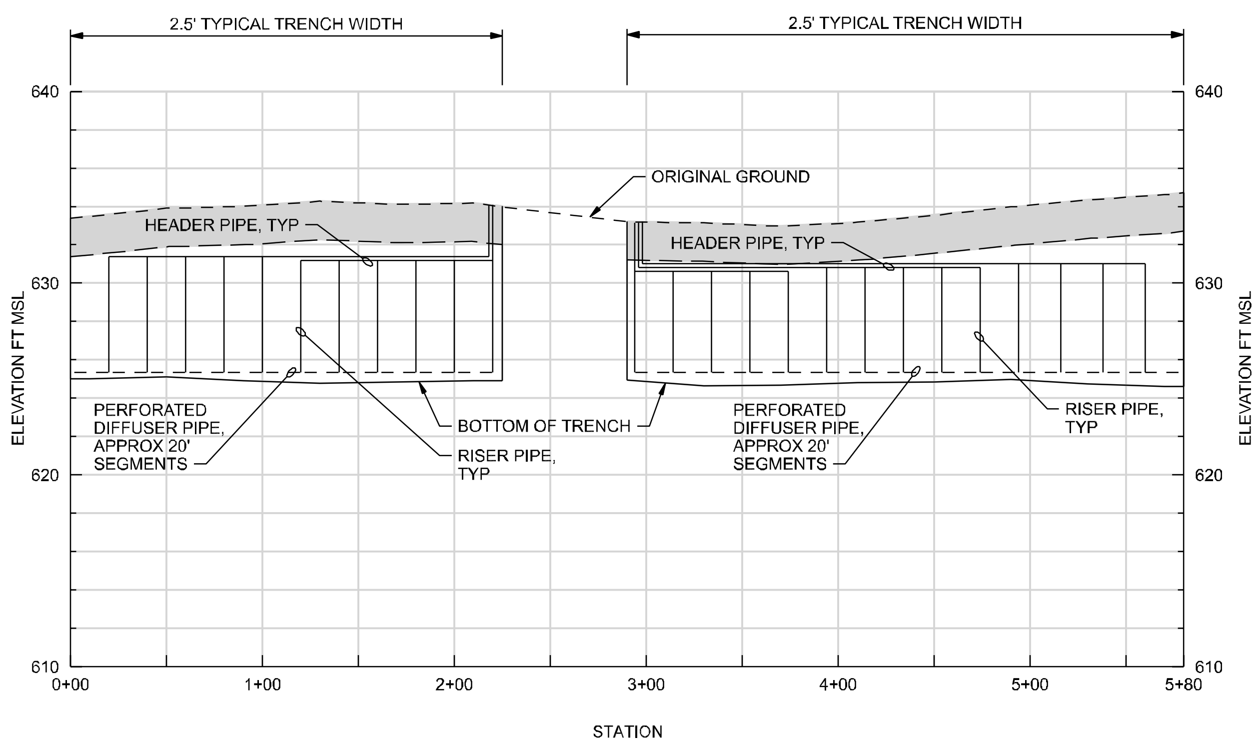
NOTES:
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.



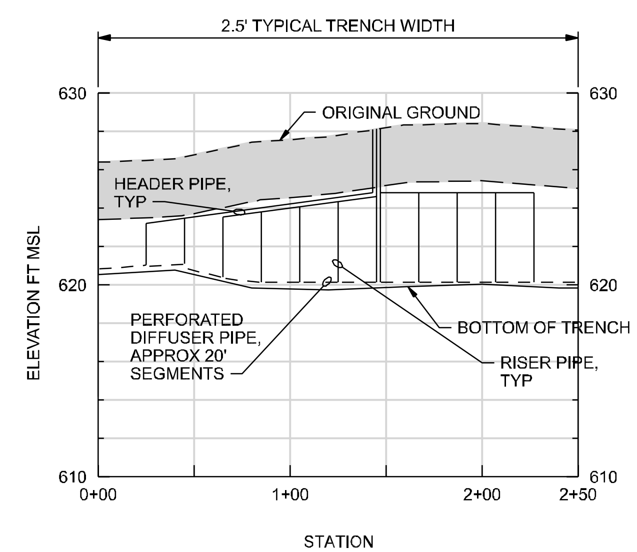
BIOWALL S-6 PIPING LAYOUT



BIOWALL S-7 PIPING LAYOUT



BIOWALL S-6 PIPING PROFILE



BIOWALL S-7 PIPING PROFILE

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN H SARTAIN						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

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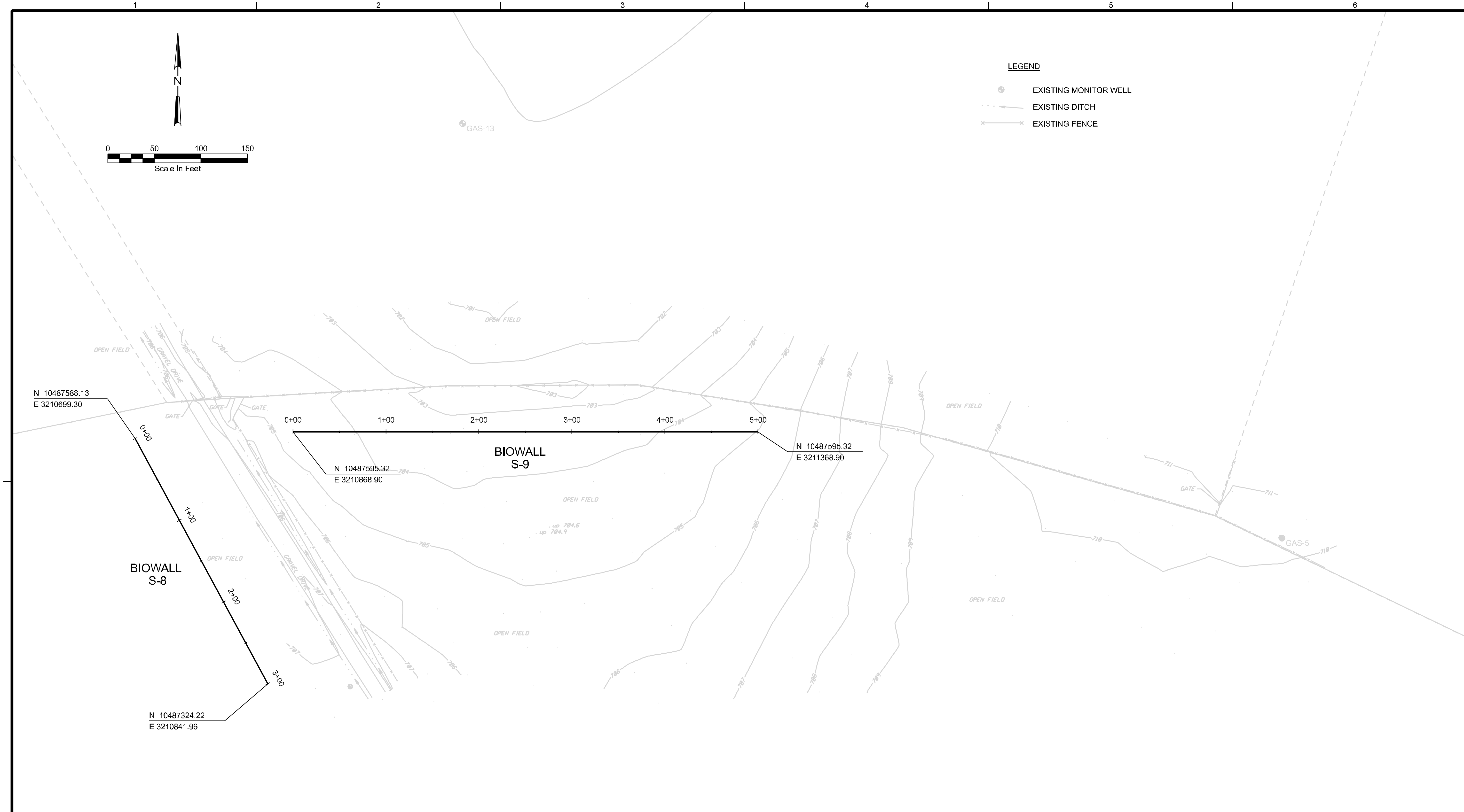
AS-BUILT
AREA S
BIOWALLS S-6 AND S-7 PIPING

SHEET 28
DWG GWAB-28
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_s12.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:19:39



NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER						VERIFY SCALE	
DR J BOOTH						BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	
CHK W THOMAS							
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD		

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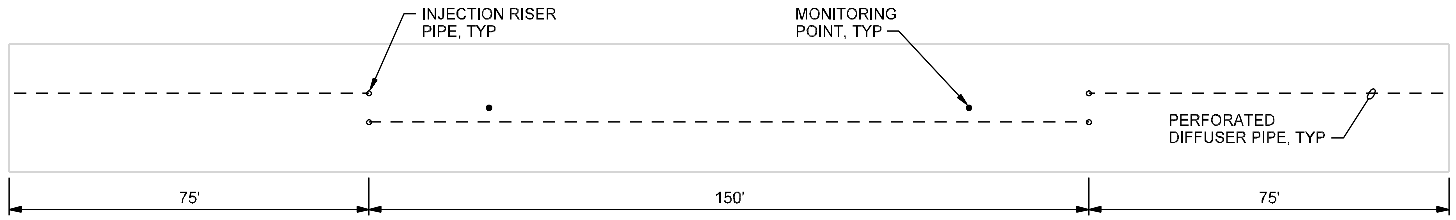
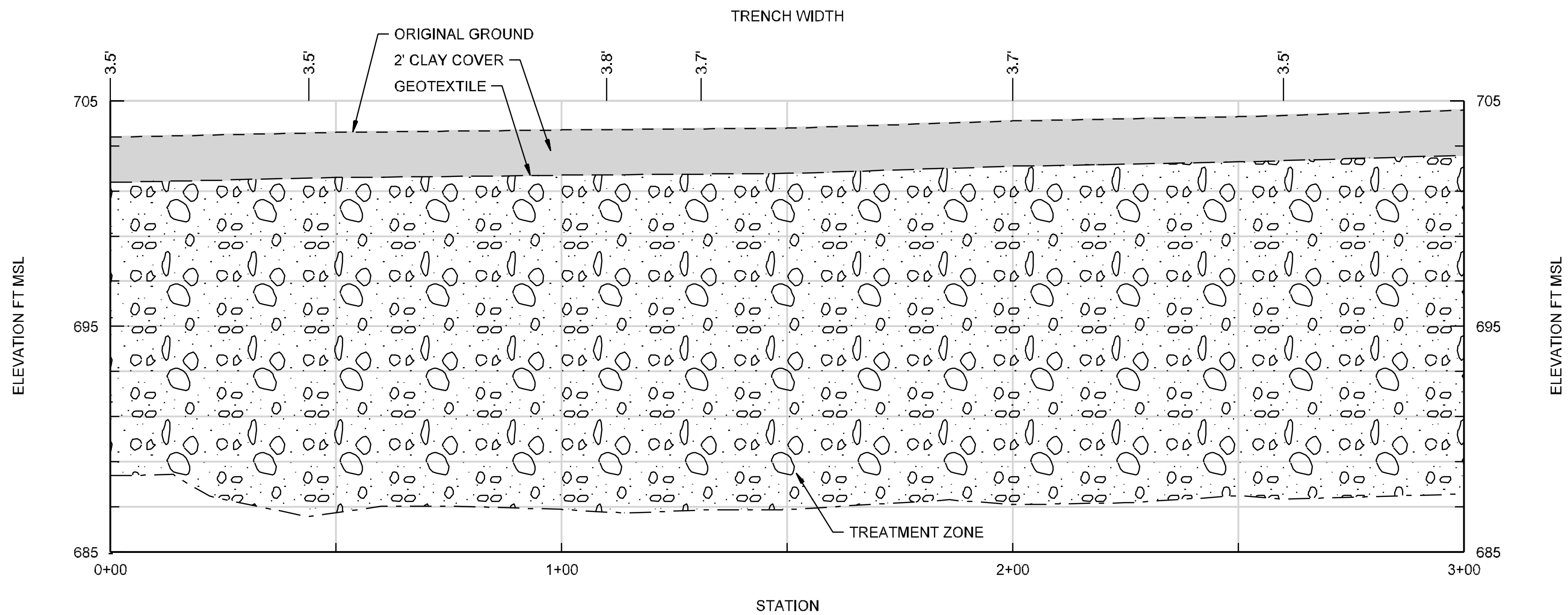
AS-BUILT
AREA S
BIOWALLS S-8 AND S-9 LAYOUT

SHEET	29
DWG	GWAB-29
DATE	SEPTEMBER 2005
PROJ	327014

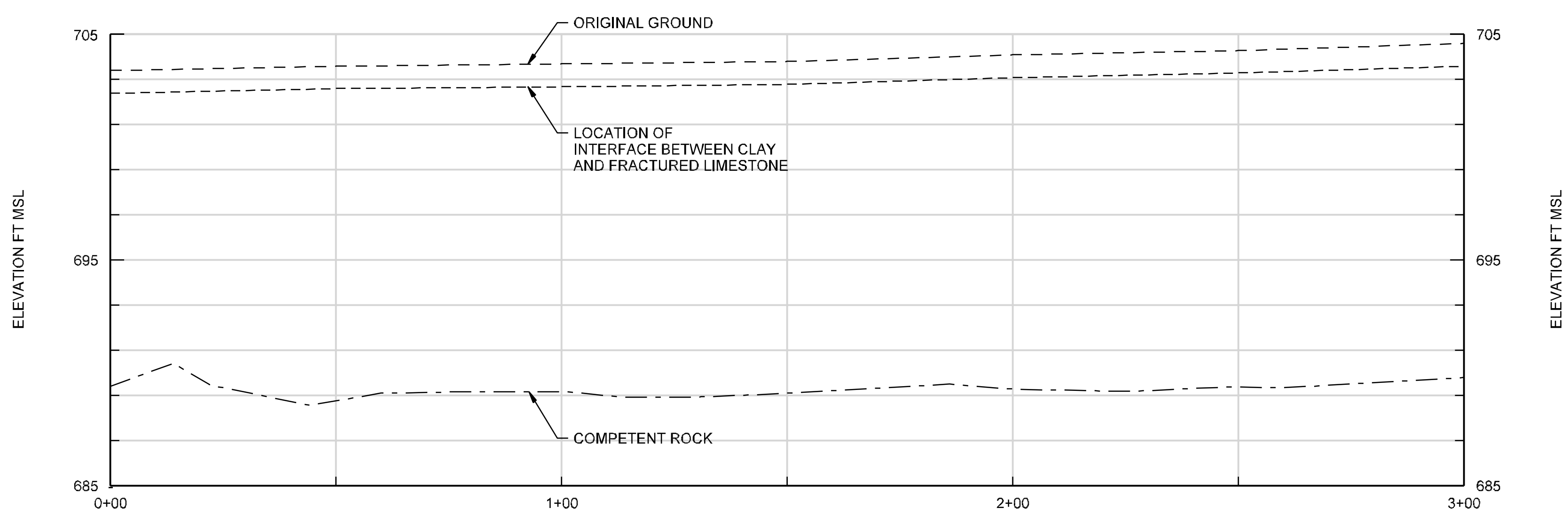
FILENAME: mc_gwab_s13.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:24:24



BIOWALL S-8 PIPING LAYOUT



BIOWALL S-8 CONSTRUCTED PROFILE



BIOWALL S-8 ORIGINAL PROFILE

NOTES:

1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER							
DR J BOOTH							
CHK W THOMAS							
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD		

VERIFY SCALE
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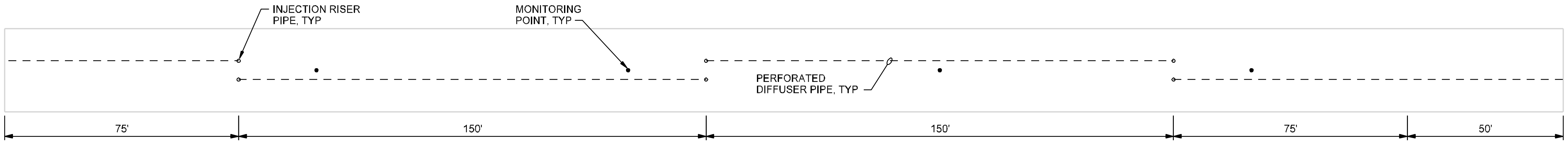
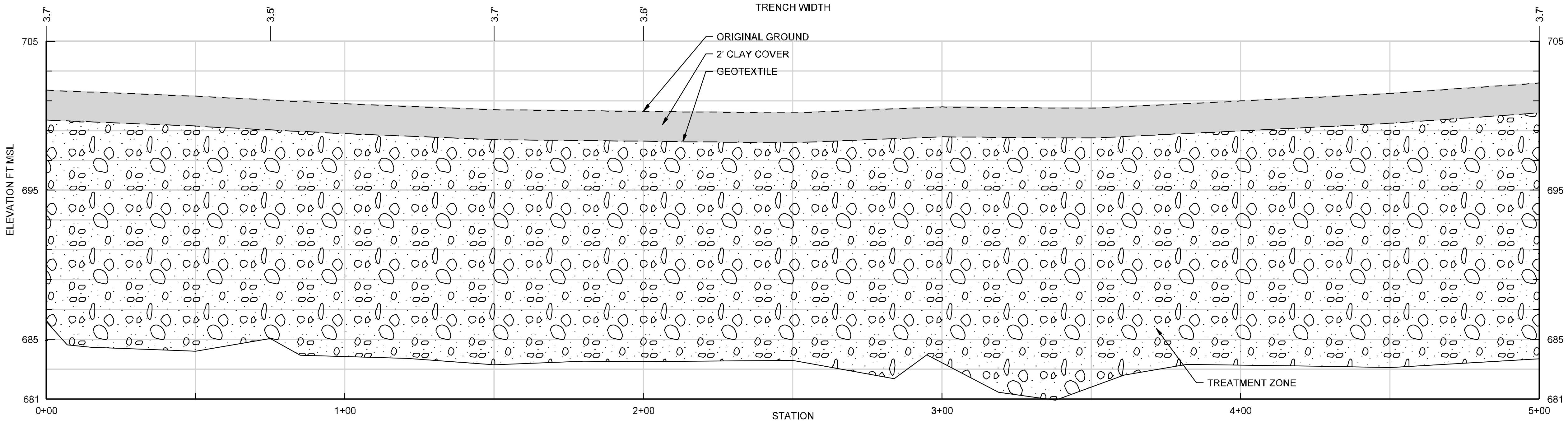
AS-BUILT
AREA S
BIOWALL S-8 PLAN AND PROFILE

SHEET 30
DWG GWAB-30
DATE SEPTEMBER 2005
PROJ 327014

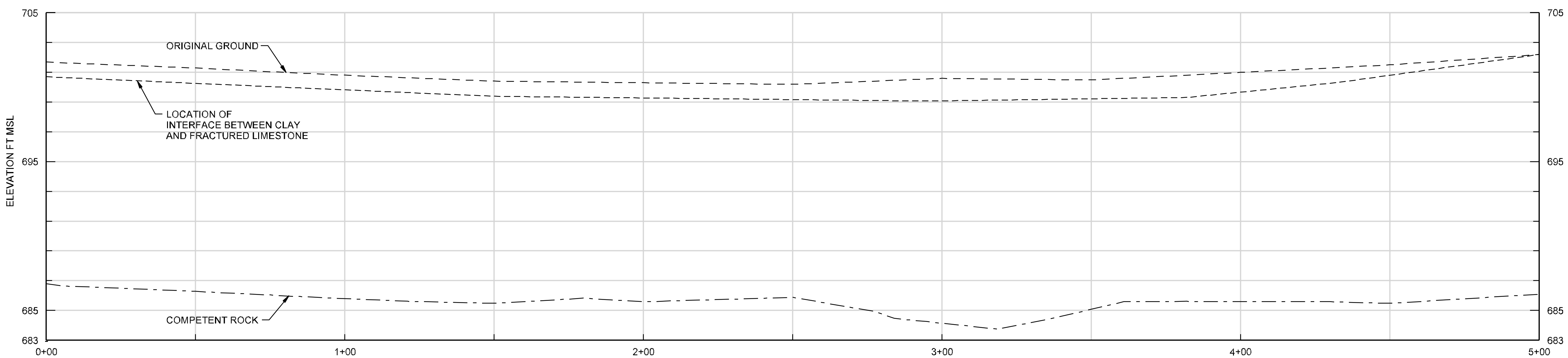
FILENAME: mc_gwab_s14.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:24:41



BIOWALL S-9 PIPING LAYOUT



BIOWALL S-9 CONSTRUCTED PROFILE



BIOWALL S-9 ORIGINAL PROFILE

NOTES:
1. ORIGINAL AND CONSTRUCTED PROFILES BASED ON FIELD OBSERVATION.
2. SEE SHEET 33 FOR BIOWALL DETAILS.
3. SEE SHEET 34 FOR INJECTION SYSTEM DETAILS.
4. SEE SHEET 35 FOR MONITORING PORT DETAILS.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALE
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0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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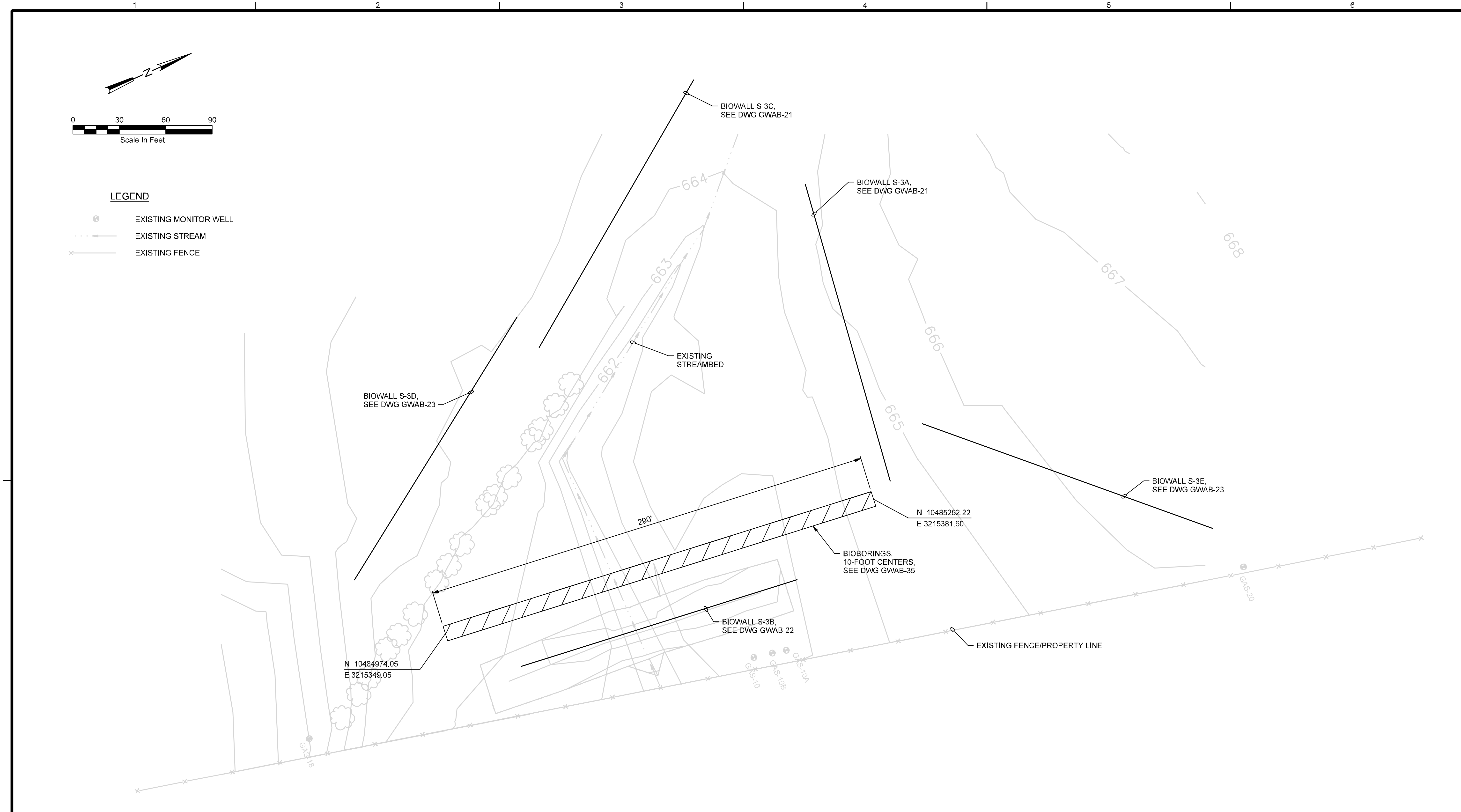
AS-BUILT
AREA S
BIOWALL S-9 PLAN AND PROFILE

SHEET 31
DWG GWAB-31
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_s15.dgn PLOT DATE: 05-OCT-2005 PLOT TIME: 13:19:52

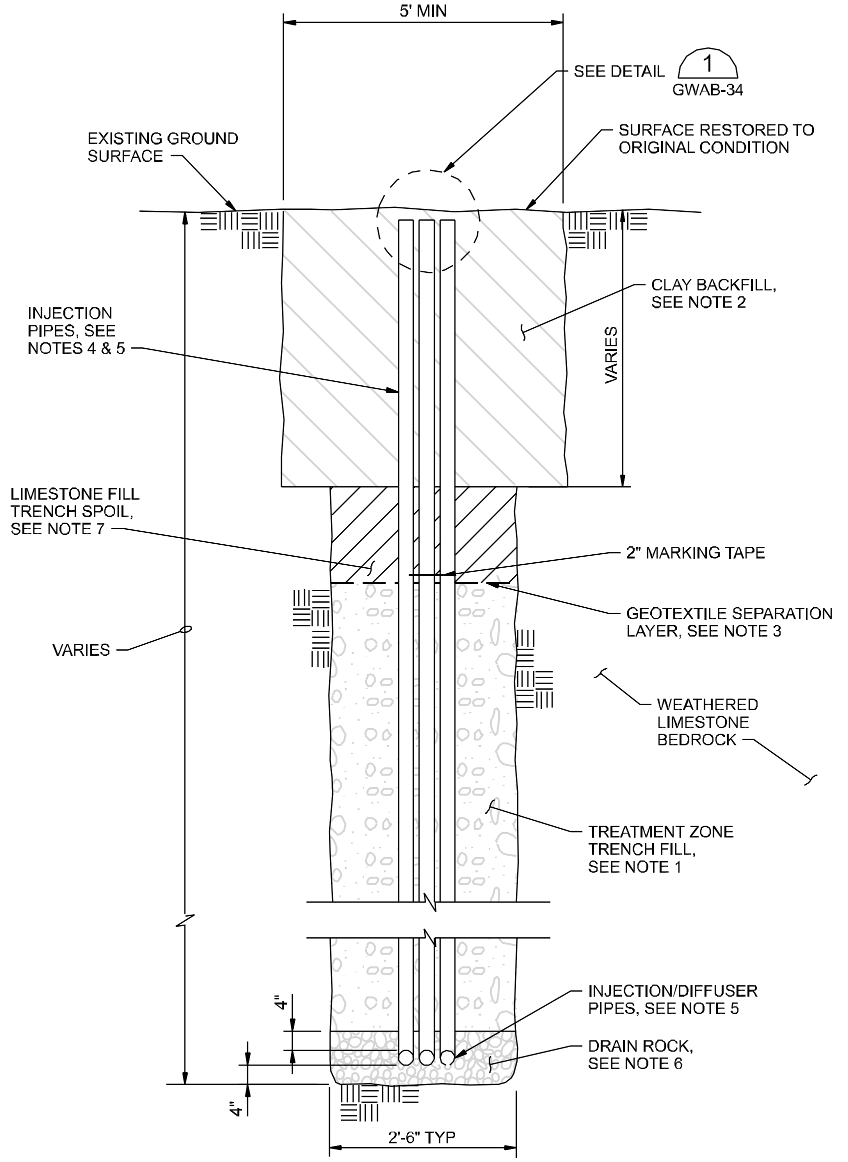


NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN	M PERLMUTTER	VERIFY SCALE	CH2MHILL Constructors, Inc.	ENSAFE	AS-BUILT	SHEET 32
DR	J BOOTH	BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"		800-588-7962 MEMPHIS, TENNESSEE	AREA S	DWG GWAB-32
CHK	W THOMAS	IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.		CHARLESTON, SC • CINCINNATI, OH • DALLAS, TX • JACKSON, TN • KNOXVILLE, TN • LANCASTER, PA • NASHVILLE, TN • NORFOLK, VA • PADUCAH, KY • PENSACOLA, FL • RALEIGH, NC • COLOGNE, GERMANY	BIOBORINGS LAYOUT	DATE SEPTEMBER 2005
APVD	T BEISEL					PROJ 327014

NO.	DATE	REVISION	BY	APVD

FILENAME: mc_gwab_s16.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:25:12



BIOWALL TYPICAL SECTION

NTS

NOTES:

1. TREATMENT ZONE TRENCH FILL IS A MIXTURE OF 60% GRAVEL, 20% COMPOST, AND 20% WOOD CHIPS BY VOLUME. GRAVEL IS SIZE 57 DRAIN ROCK CONFORMING TO AASHTO M43-88 (SEE NOTE 6). COMPOST IS MUSHROOM COMPOST PROVIDED BY MONTEREY MUSHROOMS (936-730-3600) OR EQUAL AS APPROVED BY CCI. WOOD CHIPS ARE NEW 3/4-INCH PINE CHIPS, FREE FROM CONTAMINATION AS PROVIDED BY CLW INC. (281-593-3092) OR EQUAL AS APPROVED BY CCI. OIL IS 100% INDUSTRIAL GRADE SOYBEAN OIL AS PROVIDED BY AGP (800-247-1345) OR EQUAL AS APPROVED BY CCI.

   WOOD CHIPS AND COMPOST WERE SATURATED WITH SOYBEAN OIL. WOOD CHIPS WERE SPREAD OUT INTO A THIN LAYER ON A CLEAN SURFACE, AND ALLOWED TO AIR-DRY FOR AT LEAST ONE WEEK BEFORE USE. THE AIR-DRIED WOOD CHIPS WERE MIXED WITH THE COMPOST AND THE MIXTURE WAS SATURATED WITH SOYBEAN OIL PRIOR TO MIXING WITH GRAVEL. THE SUBCONTRACTOR DEVELOPED A PLAN FOR SATURATING THE WOOD CHIPS/ COMPOST MIXTURE AND SUBSEQUENT MIXING WITH GRAVEL TO OBTAIN THE REQUIRED PERCENTAGES OF TREATMENT ZONE TRENCH FILL. PRIOR TO, AND AFTER SATURATION WITH SOYBEAN OIL, MIXTURE WAS COMPLETELY COVERED WITH WATERPROOF TARPS EACH NIGHT AND ANY TIME WHEN RAIN WAS ANTICIPATED.

   TREATMENT ZONE TRENCH FILL MIXTURE WAS CAREFULLY HANDLED TO AVOID SEGREGATION OF COMPONENTS AND PLACED IN THE TRENCH IN MAXIMUM 18-INCH THICK LIFTS. EACH LIFT WAS COMPACTED WITH A VIBRATORY HOE-PAC OR OTHER COMPACTION EQUIPMENT AS APPROVED BY CCI TO MINIMIZE SUBSEQUENT CONSOLIDATION OF THE TRENCH FILL MATERIAL.

2. CLAY BACKFILL IS CLAY FROM THE EXCAVATIONS WITH A MAXIMUM PARTICLE SIZE OF 1-INCH. MATERIAL IS FREE FROM CLODS LARGER THAN 4-INCH DIAMETER AND IS FREE OF HAZARDOUS OR TOXIC CONTAMINANTS AND DOES NOT CONTAIN ROOTS OR OTHER ORGANIC MATTER, TRASH, DEBRIS, OR OTHER DELETERIOUS MATERIAL. MATERIAL CONTAINING MORE THAN 10 PERCENT LIMESTONE PARTICLES WAS UNACCEPTABLE. MATERIAL PLACED IN MAXIMUM 8-INCH THICK LIFTS AND EACH LIFT WAS COMPACTED WITH AT LEAST SIX PASSES OF A FOOTED COMPACTOR TO ACHIEVE A FIRM, NON-YIELDING SURFACE. DURING PLACEMENT, MOISTURE CONTENT WAS MAINTAINED SUFFICIENT TO ACHIEVE PROPER COMPACTION.

3. GEOTEXTILE IS A NON-WOVEN, POLYPROPYLENE, BLACK, UV-STABILIZED GEOTEXTILE MATERIAL WITH THE FOLLOWING PHYSICAL PROPERTIES:
   - WEIGHT: MINIMUM 6 OUNCES PER SQUARE YARD
   - PUNCTURE STRENGTH: MINIMUM 65 POUNDS (ASTM D4833)
   - FLOW RATE: MINIMUM 175 GALLONS PER MINUTE PER SQUARE FOOT (ASTM D4491)
   - TRAPEZOIDAL TEAR: MINIMUM 45 POUNDS (ASTM D4533)

   GEOTEXTILE WAS PLACED IN THE TRENCH SO THAT IT PROVIDES A COMPLETE SEPARATION BETWEEEN THE TREATMENT ZONE TRENCH FILL AND THE ADJACENT LAYER ABOVE (EITHER LIMESTONE FILL TRENCH SPOIL OR CLAY BACKFILL).

4. THE NUMBER AND LOCATION OF INJECTION PIPES VARIES FROM TRENCH TO TRENCH. REFER TO SPECIFIC TRENCH PLAN AND PROFILE SHEETS.

5. FOR INTRODUCTION OF SOYBEAN OIL, SOLID INJECTION/DIFFUSER PIPE IS 2" SCHEDULE 40 PVC. PERFORATED DIFFUSER PIPE IS 2" SCHEDULE 40 PVC WITH 0.1" DIAMETER PORTS AT 2'-0" SPACINGS ON THE BOTTOM OF THE PIPE. ENDS OF DIFFUSER PIPES CAPPED. PIPE SEGMENTS SOLVENT WELDED PER MANUFACTURER'S RECOMMENDATIONS.

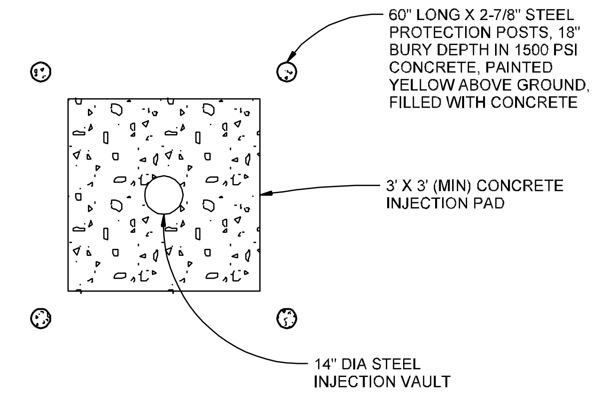
6. DRAIN ROCK IS SIZE 57 ROCK CONFORMING TO AASHTO M43-88.

PARTICLE SIZE	% PASSING
1 1/2"	100
1"	95-100
1/2"	25-60
NO. 4	0-10
NO. 8	0-5

7. LIMESTONE FILL TRENCH SPOIL IS EXCAVATED WEATHERED AND NON-WEATHERED LIMESTONE FRAGMENTS AND TAN CLAY MATRIX MATERIAL FROM THE TRENCHING OPERATIONS, FREE OF ORGANICS, DEBRIS, AND DARK BROWN/BLACK SURFICIAL CLAY. MAXIMUM PARTICLE SIZE WAS 6". MATERIAL PLACED IN MAXIMUM 12" THICK LIFTS AND EACH LIFT COMPACTED WITH AT LEAST 4 PASSES OF A VIBRATORY HOE-PAC OR OTHER COMPACTION EQUIPMENT APPROVED BY CCI.

8. EXISTING 95' X 190' 20 MIL SYNTHETIC LINER PANELS WERE PROVIDED BY CCI. PANELS SEAMED IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS AS REQUIRED TO COVER THE AREA AND PREVENT RAINWATER OR SURFACE WATER INFILTRATION. MATERIALS BACK DUMPED OVER BOTTOM LINER TO PREVENT DAMAGE TO LINER.

9. DIMENSIONS OF STOCKPILES ADJUSTED AS NECESSARY BASED ON ACTUAL EXCAVATION VOLUMES AS DIRECTED BY CCI, MAINTAINING 3:1 SLOPES AND 4' MAX HEIGHT. STOCKPILES COMPLETELY COVERED WITH WATERPROOF TARPS OR 20 MIL LINER MATERIAL EACH NIGHT AND ANY TIME WHEN RAIN WAS ANTICIPATED. IF LINER MATERIAL WAS USED AS TEMPORARY COVER, IT WAS PROTECTED TO ENSURE INTEGRITY OF LINER FOR FINAL COVER SYSTEM.



BOLLARD INSTALLATION DETAIL 1 GWAB-24

NTS

TRENCH S-4

NUMBER	SIZE	SPECIES
2	2"	HACKBERRY
2	3"	HACKBERRY
1	4"	HACKBERRY
5	6"	HACKBERRY
6	8"	HACKBERRY
6	10"	HACKBERRY
2	12"	HACKBERRY
4	14"	HACKBERRY
2	15"	HACKBERRY
1	18"	HACKBERRY
4	20"	HACKBERRY
1	24"	HACKBERRY
1	30"	HACKBERRY

37 TOTAL HACKBERRY TREES REMOVED

NUMBER	SIZE	SPECIES
2	6"	PECAN
4	8"	PECAN
1	10"	PECAN
1	12"	PECAN
1	14"	PECAN

9 TOTAL PECAN TREES REMOVED

46 TOTAL TREES REMOVED

TREE REMOVAL LIST

TRENCH S-4 GWAB-24

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN	H SARTAIN
DR	J BOOTH
CHK	W THOMAS
APVD	T BEISEL

NO.	DATE	REVISION	BY	APVD

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL
Constructors, Inc.

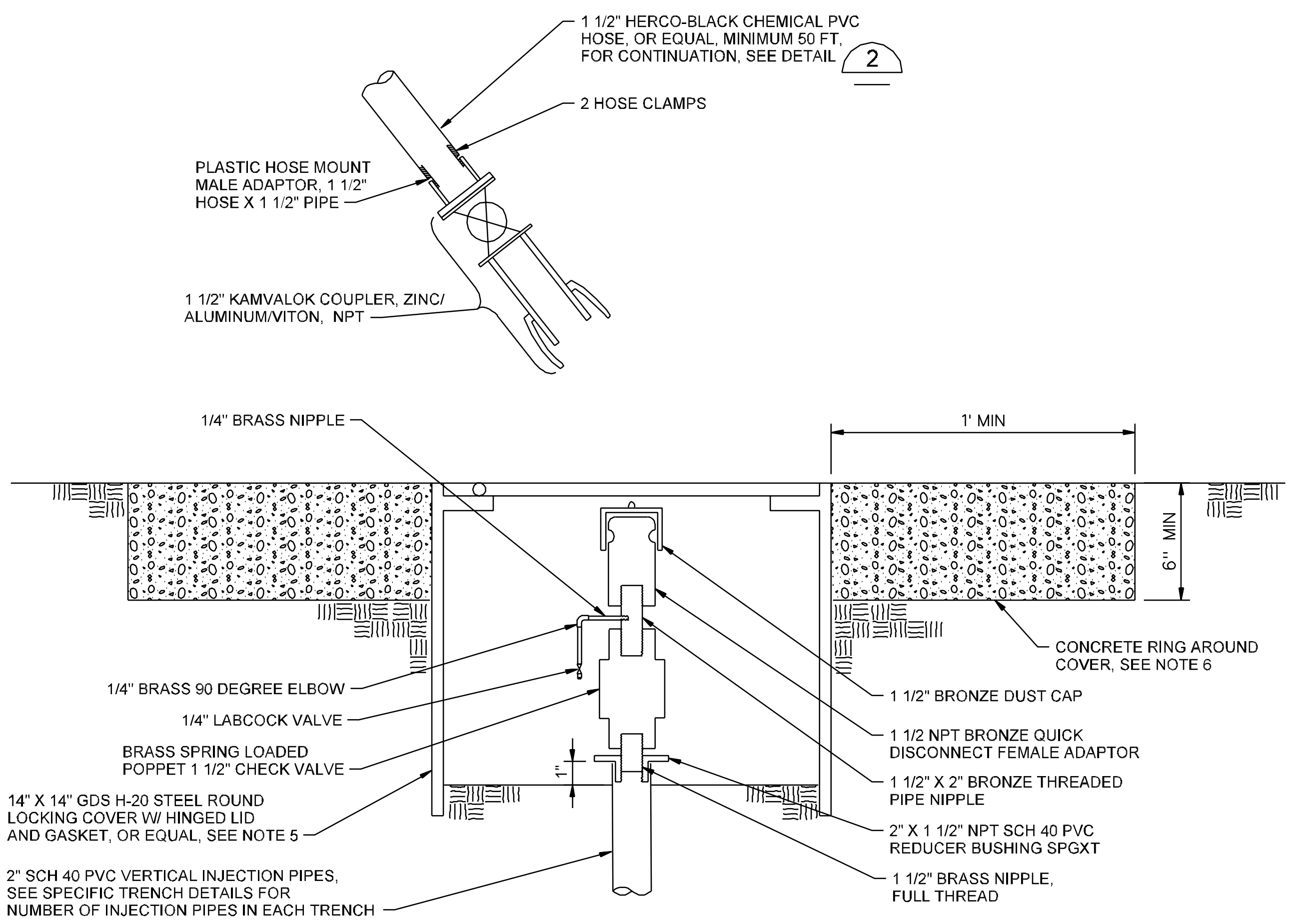
ENSAFE
800-588-7962
MEMPHIS, TENNESSEE
CHARLESTON,SC CINCINNATI,OH DALLAS,TX JACKSON,TN KNOXVILLE,TN LANCASTER,PA NASHVILLE,TN NORFOLK,VA PADUCAH,KY PENSACOLA,FL RALEIGH,NC COLOGNE, GERMANY

AS-BUILT

BIOWALL DETAILS

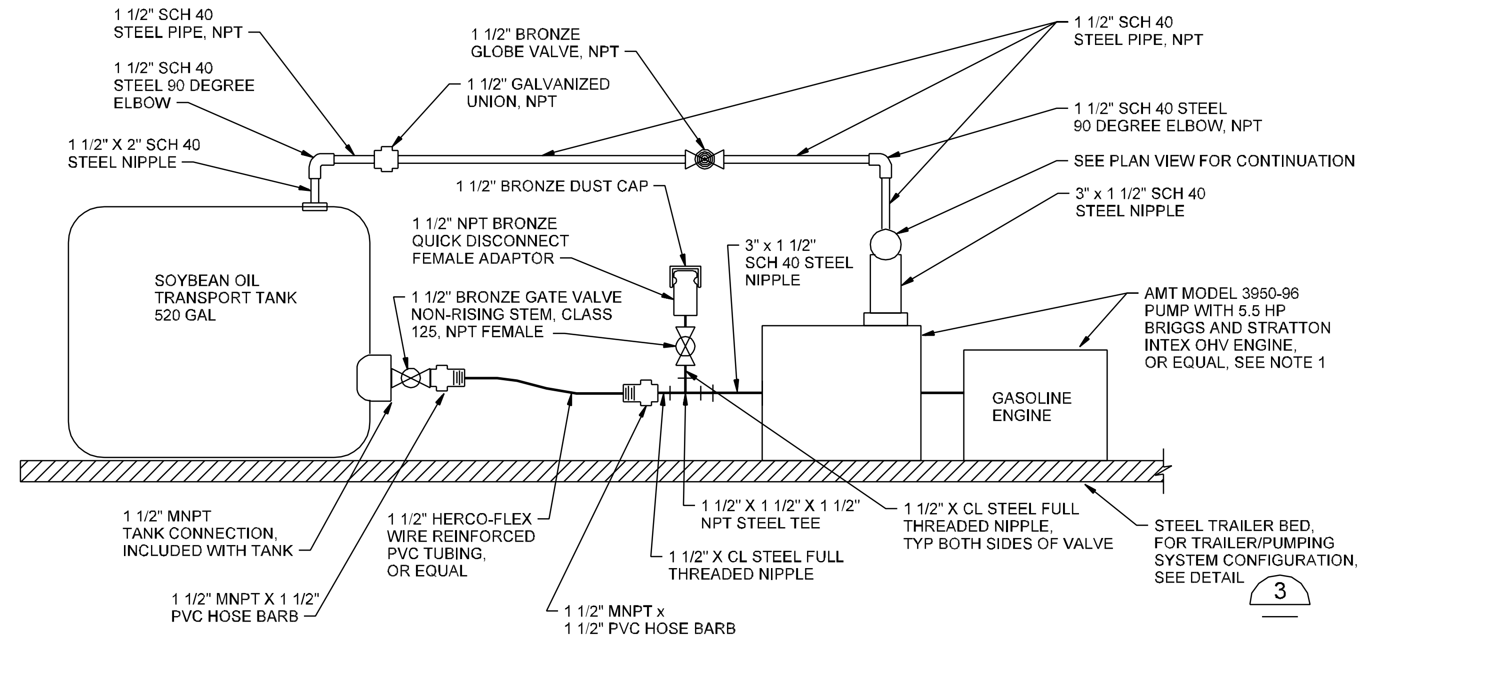
SHEET 33
DWG GWAB-33
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_02.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:13:09

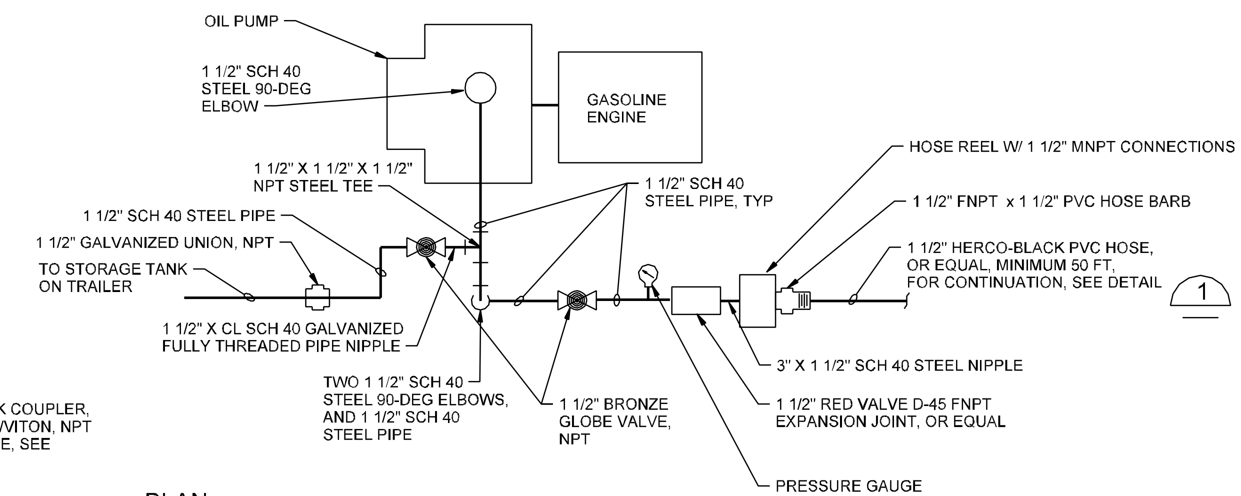


INJECTION CONNECTION DETAIL 1

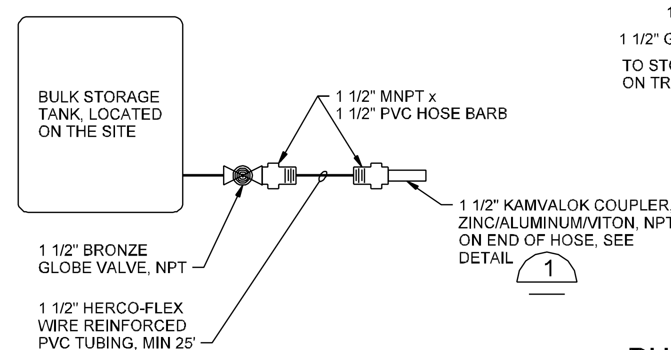
NTS GWAB-33



PROFILE

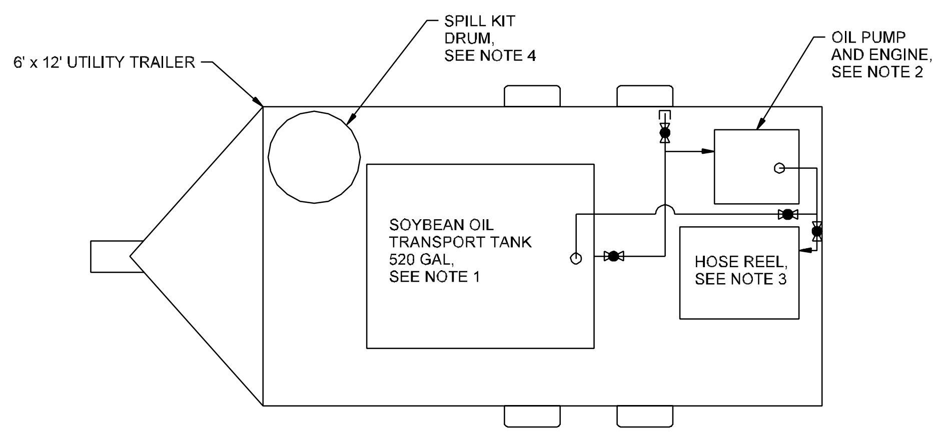


PLAN



PUMPING SYSTEM DETAIL 2

NTS



MOBILE PUMPING SYSTEM 3

NTS

NOTES:

1. TANK ANCHORED TO THE TRAILER BED USING BOLTED ANCHOR BANDS PROVIDED BY THE VENDOR. BOLTS WELDED TO STEEL TRAILER BED.
2. PUMP SYSTEM ANCHORED TO THE TRAILER BED USING BOLTS WELDED TO STEEL TRAILER BED.
3. HOSE REEL ANCHORED TO THE TRAILER BED WITH BOLTS.
4. SPILL KIT DRUM ANCHORED TO THE TRAILER BED USING BOLTS WELDED TO BED AND RACHET STRAPS.
5. COVER INSTALLED AROUND THE SET OF INJECTION PIPES FOR EACH TRENCH. COVER FLUSH MOUNTED TO THE EXISTING GRADE. SEE SPECIFIC TRENCH DETAILS FOR NUMBER OF INJECTION PIPES AT EACH LOCATION.
6. CONCRETE IS 2500 PSI MIX FROM READY-MIX SUPPLIER OR MIXED ONSITE FROM PREMEASURED BAGS.
7. ALL MISCELLANEOUS EQUIPMENT (BOLTS, STRAPS, FITTINGS, ETC.) MET BUY AMERICA REQUIREMENTS AS OUTLINED IN 23CFR635.410.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN A CHANG						VERIFY SCALE	
DR P VALENTINE						BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	
CHK W THOMAS							
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD		

CH2MHILL Constructors, Inc.

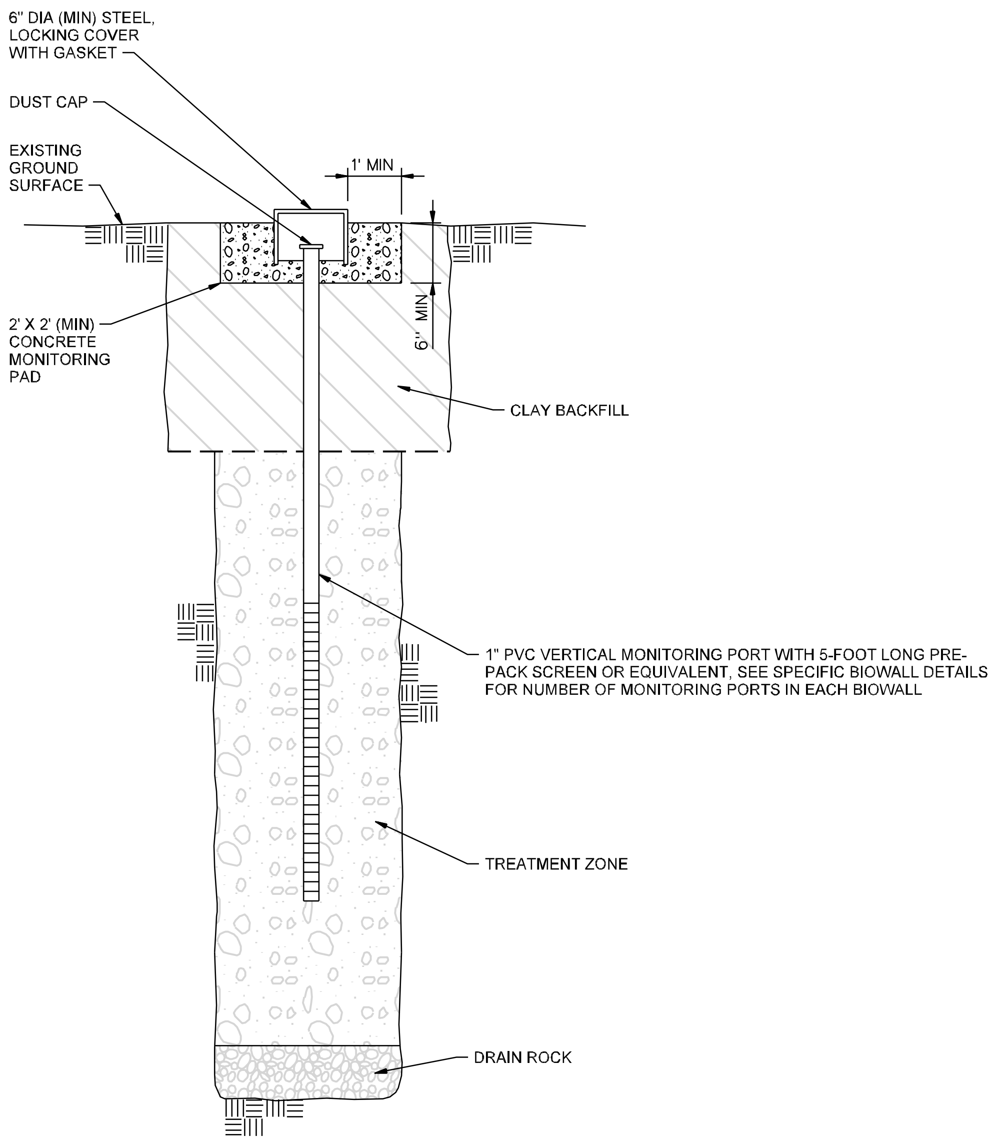
ENSAFE
800-588-7962
MEMPHIS, TENNESSEE
CHARLESTON,SC• CINCINNATI,OH• DALLAS,TX• JACKSON,TN• KNOXVILLE,TN• LANCASTER,PA• NASHVILLE,TN• NORFOLK,VA• PADUCAH,KY• PENSACOLA,FL• RALEIGH,NC• COLOGNE, GERMANY

AS-BUILT

INJECTION PUMPING SYSTEM DETAILS

SHEET 34
DWG GWAB-34
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_03.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:13:21

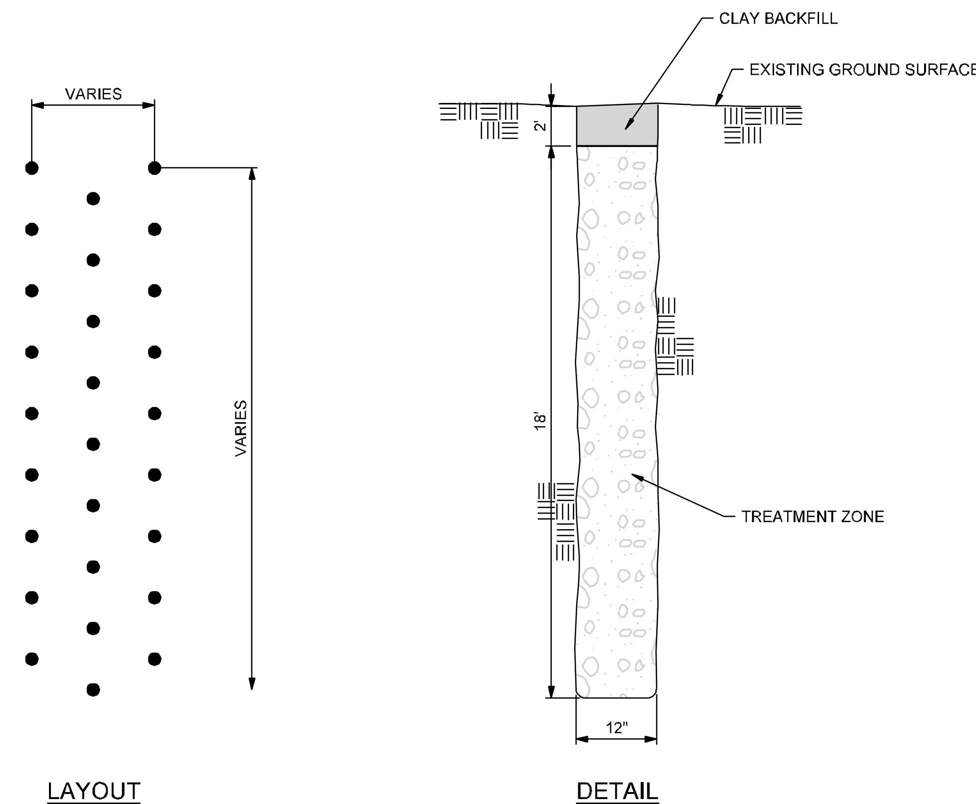


MONITORING PORT DETAIL

NTS

NOTES:

1. MONITORING PORTS ARE 1" DIAMETER PVC WITH A 5-FOOT LONG PRE-PACK SCREENED INTERVAL INSTALLED TO INTERSECT THE VERTICAL MIDPOINT OF THE TREATMENT ZONE.



BIOBORINGS

NTS

NOTES:

1. BIOBORINGS (12" DIAMETER HOLES) INSTALLED WITH AIR ROTARY DRILLING AND BACKFILLED WITH SAME MATERIAL AS USED IN BIOWALLS. TREATMENT MATERIAL PLACED IN 18' LIFTS AND COMPACTED BY HAND.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN M PERLMUTTER						
DR J BOOTH						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL
Constructors, Inc.

ENSAFE
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AS-BUILT

MONITORING PORT AND BIOBORING DETAILS

SHEET 35
DWG GWAB-35
DATE SEPTEMBER 2005
PROJ 327014

FILENAME: mc_gwab_04.dgn PLOT DATE: 03-OCT-2005 PLOT TIME: 18:13:35

Appendix B
Effectiveness Monitoring Result and Screening Tables

Biowall ID __________________

Sample Date __________________

Effectiveness Monitoring Results				
	Monitoring Port ID			
Parameter				
TOC				
Nitrate				
Methane				
ORP				
Perchlorate				

Screening Results				
	Monitoring Port ID			
Parameter				
TOC				
Nitrate				
Methane				
ORP				
Perchlorate				
Total				

Appendix C
Offsite Property Owners

Offsite Property Owners

South of Area M

A & M UNIVERSITY
773 AG FARM ROAD
MCGREGOR TX 76657

North – Northeast of Area F

JERRY THANE
1235 WEST WINDSOR ROAD
MCGREGOR TX 76657

GLADYS GELTEMEYER
3588 OLD OGLESBY ROAD
MCGREGOR, TX 76657

FLOYD BALLARD
3470 OLD OGLESBY ROAD
MCGREGOR, TC 76657

PASCHALL, SKIPPER, AND ASSOCIATES
PO BOX 316
MCGREGOR, TX 76657

GLADYS BOHNE HOLLAN (PINTER)
224 OLD OGLESBY ROAD
MCGREGOR, TX 76657

East of Area S

CHARLES AFFLERBACH
221 CINDY ANN STREET
LORENA TX 76655

MR. VERNON SCHMIDT
P.O. BOX 153
MCGREGOR, TX 76657

JERRY THANE
1235 WEST WINDSOR RD.
MCGREGOR TX 76657

MARY ANNE CARR
534 MCGREGOR SOUTH LOOP
MCGREGOR TX 76657

CLARENCE LESLIE
746 MCGREGOR SOUTH LOOP
MCGREGOR TX 76657

Appendix D

Underground Injection Permit Approval Letter

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

September 23, 2002

Mr. Hunter Sartain
CH2M Hill
115 Perimeter Center Place NE, Suite 700
Atlanta, GA 30346

Re: Authorization and Registration of Class V Aquifer Remediation Injection Wells
TCEQ Authorization Number 5X2600249, ISW 30056 HW 50081

Naval Weapons Industrial Reserve Plant
1751 Plant Road
McGregor, Texas 76657

Dear Mr. Sartain:

The Underground Injection Control (UIC) staff has completed their review of the Aquifer Remediation inventory/authorization form dated August 21, 2002 addressing the use of gravel, mushroom compost, and wood chips in seven trenches, with the additional injection of soybean oil, potassium acetate, and diammonium phosphate at periodic levels to promote anaerobic degradation of the contaminants at the above site. Additionally, UIC staff has coordinated with the Remediation Division on this project and authorization by rule is hereby given for the construction and operation of the Class V injection wells for this site contingent upon you meeting the requirements set by the Remediation Division and the provisions of 30 TAC Chapter 331. All injection wells are to be constructed according to 30 TAC Chapter 331.132 relating to construction standards.

In order to maintain authorization by rule, monitoring data and remediation results, as well as the injection volumes, pressures, and concentrations shall be submitted to the Industrial and Hazardous Waste Permits Section within 90 days of project completion. Also, closure of injection wells is to be done according to 30 TAC 331.133 relating to closure standards for injection wells. Operational and/or status changes shall be reported to and approved by the UIC Permits Team.

Should you have any questions regarding this matter, please contact me at (512) 239-6075. If you will be corresponding by mail, please use mail code (MC 130).

Sincerely,

Bryan S. Smith

Bryan Smith, Project Manager
UIC Permits Team
Industrial and Hazardous Waste Permits Section
Waste Permits Division

BS/cm

TEXAS NATURAL RESOURCE CONSERVATION COMMISION

RETURN TO:
TNRCC
Waste Permits Division MC 130
PO Box 13087
Austin, Texas 78711-3087
512/239-2334

CLASS V INJECTION WELL
INVENTORY/AUTHORIZATION FORM

AQUIFER REMEDIATION

EPA CODE 5X26

SC No.
Reg. No.

Received
Authorized

1. TNRCC Program Area (PST, VCP, IHW, etc.), Solid Waste Code # ISW reg No. 30056HW-50081 EPA ID No. TX9170024708	2. TNRCC Contact Mark Arthur	3. Phone No. 512-239-6633
4. Agent/Consultant Name and Address (Street, City, State and Zip Code) CH2M HILL/CCI, 115 Perimeter Center Place N.E., Suite 700, Atlanta, GA 30346-1278	5. Contact Person Hunter Sartain	6. Phone No. 770-604-9182
7. Operator/Owner Name Address (Street, City, State and Zip Code) - Owner Type: U S Naval Air Systems Command, Building 404, Suite 200, 22145 Arnold Circle, Patuxent River, MD 20670-1547	8. Contact Person Ms. Judithanne Hare	9. Phone No. (301) 757-2152
10. Facility Name and Address (Street, City, State and Zip Code) Naval Weapons Industrial Reserve Plant, 1751 Plant Road, McGregor, Texas 76657	11. Contact/Phone Fred Lamb (254) 840-9546	12. TNRCC/Region Contact Don Naylor Region 9 – Waco (254) 751-0335
13. Type of Well Construction Trenches as Permeable Reactive Barriers	14. Well No(s). N/A	15. County McLennan
16. Water Well Driller and Address (Street, City, State and Zip Code) Not yet determined.	17. License No. N/A	18. Phone No. N/A

19. Purpose and Description of Injection System, (Attach approved remediation plan if necessary)

The proposed in-situ corrective action is intended as an Interim Stabilization Measure (ISM) consisting of a series of cutoff trenches in area S of the Naval Weapons Industrial Reserve Plant (NWIRP) McGregor and down gradient of Area S, offsite on Tributary S and the South Bosque River. The purpose of the ISM is to establish a zone of amended groundwater downgradient of the respective ISM in which enhanced bio-remediation can take place whereby perchlorate contamination in groundwater can be degraded to its mineral components. Trench lengths range from approximately 200 to 600 feet long. Each trench typically will be 2.5 feet wide. Trench depths will vary (see trench drawings). The trenches are proposed to be filled with a mixture of gravel, mushroom compost and wood chips. The wood chips will be saturated with food grade soybean oil. Additionally soybean oil, potassium acetate, and diammonium phosphate may be injected into the trenches at periodic intervals to promote anaerobic degradation of the contaminants.

Well Site Location (Attach Quad Map)

20. Legal Location (Subd. & Lot and/or Sec., Blk., of Survey; give perpendicular calls from two designated survey lines) See attached Quad map	21. Distance and Direction FROM nearest Town or Post Office NWIRP McGregor is located at McGregor, Texas, approximately 20 miles southwest of Waco, Texas.	22. Longitude/Latitude and USGS Topo Quad (Attach) Latitude: 31^{o} 24' 33" Longitude: 97^{o} 26' 01"

Construction							
Name of String	Well No.	Size	Setting Depth	Sacks Cement/Grout - Slurry Volume - Top of Cement	Top Determined By	Hole Size	Weight PVC/Steel
23. Casing	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24. Tubing	N/A	N/A	N/A	N/A	N/A	N/A	N/A
25. Screen	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Infiltration Gallery (Attach Design)			
26. Trench(s) (Plat Location) see attached figure	27. Trench Dimension see attached figure	28. Trench Construction See attached figure	29. Fluid Level(s) N/A

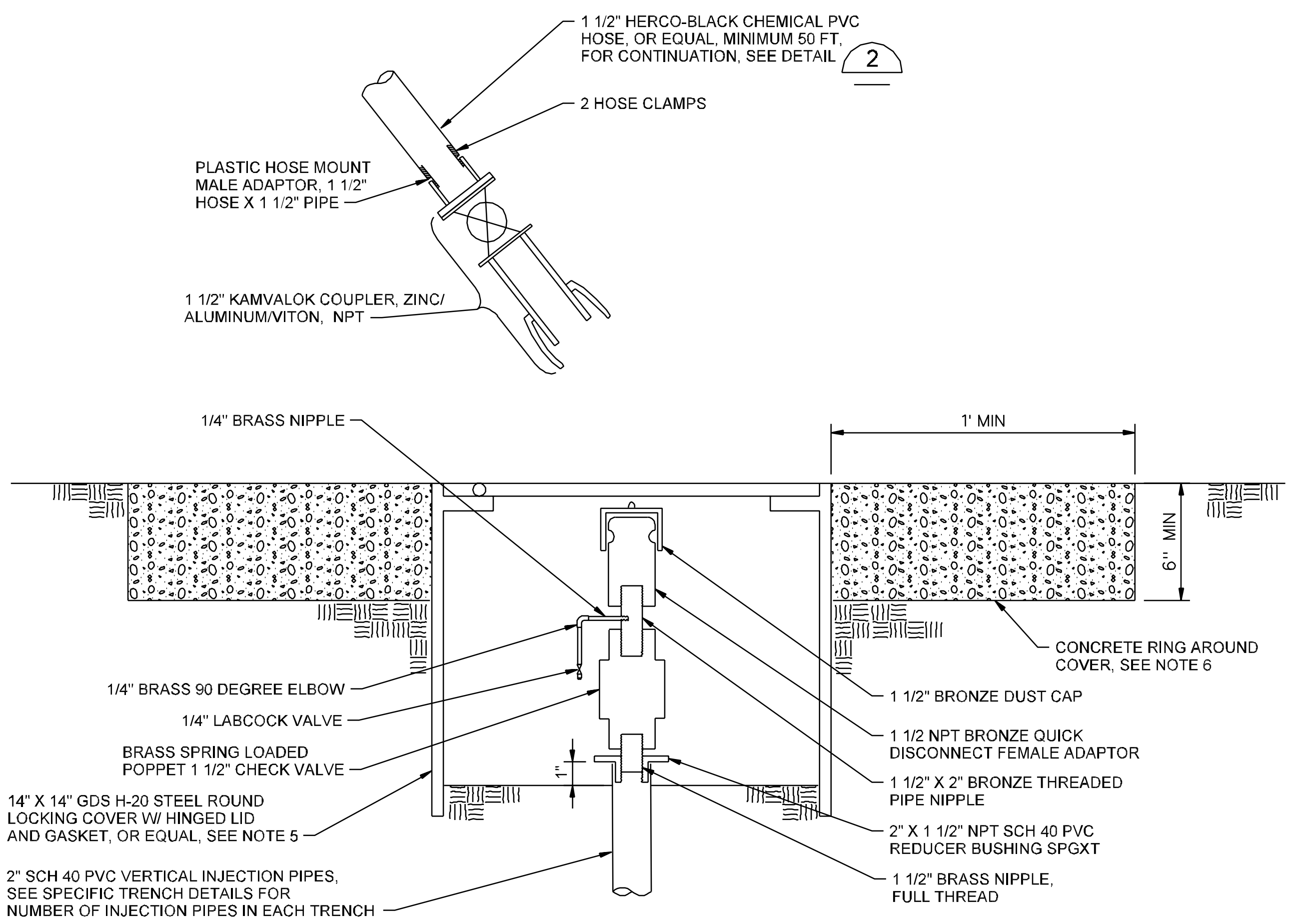
Site Hydrogeological and Injection Zone (IZ) Data					
30. Contaminated Aquifer Name perched	31. Formation Name (IZ) Main Street Limestone	32. Well/Trench Total Depth Trench depths will vary (see trench drawings).	33. Surface Elevation At proposed trench locations elevations vary from approximately 700 feet to 630 feet	34. Depth to Ground Water Piezometric surface can vary seasonally as much as 4 to 15 feet and can be at ground surface as a result of rain events.	35. IZ Depth IZ depth will vary depending on trench location (see trench drawings).
36. IZ Vertically isolated (geologically)? Impervious Strata (in feet) between IZ and nearest Aquifer The IZ (water bearing section of the Main Street Limestone) is isolated from the nearest aquifer system (the Hensel and Hosston sands) by the non water bearing section of the Mainstream Limestone and the Pawpaw Shale/Weno Limestone. The non water bearing section of Main Street Limestone 20 to 35 feet deep is followed by the Pawpaw Shale/Weno Limestone (undifferentiated) typically 35 to 40 feet deep. **The next major water bearing system (the Hensel and Hosston sands) is 900 feet beneath the Main Street and Pawpaw-Weno.** Source: Final Compliance Plan Application, Interim Status Unit 4, Burn Pit, Area S, EnSafe, Inc. August 2001.	37. Contaminant levels (ppm) in contaminated aquifer 1st quarter 2002 data perchlorate onsite: 13.0-0.0001 offsite: 0.23-0.001 U 1,1-DCE onsite: 0.120-0.001 U TCE Onsite: 1.70-0.001 U Offsite: 0.0078-0.001 U	38. Horizontal & Vertical extent of contamination Horizontally the plume of impacted groundwater extends west to east for approximately 10,000 feet. At its widest (onsite Area S) the plume of impacted groundwater is approximately 2,000 feet wide. Vertically the plume extends too a depth of approximately 12 feet.	39. Formation (IZ) Water Chemistry (Background levels) TDS, etc. pH: 6-8 DO: 2-4 mg/L ORP: 200-300 mV TDS: 300-1400 mg/L	40. Injection Fluid Chemistry in PPM at the Well Head. The trenches will be initially filled with a mixture of gravel, mushroom compost and wood chips saturated with food grade soybean oil. Additionally soybean oil, potassium acetate, and diammonium phosphate may be injected into the trenches at periodic intervals to promote anaerobic degradation of the contaminants.	41. Lowest Known Depth of GW with <10,000 PPM TDS unknown

Site Hydrogeological and Injection Zone (IZ) Data					
42. Injection Vol/Pres Av/Max Injection volume will vary from approximately 1 to 10 gal./ linear foot, depending on trench depth. The estimated pressure will vary from 19 to 30 ft. of water pressure.	43. Water Wells within ¼ mile radius(attach map) EnSafe, Inc. reported that there are no known water supply wells located within 1/4 mile of Area S.	44. Injection Wells within ¼ mile radius (attach map) none	45. Monitor Wells (attach WWD-12s and map) See attached map	46. Sampling Frequency Currently, existing Area S monitoring wells are sampled annually.	47. Known **Hazardous Components** in Injection Fluid none

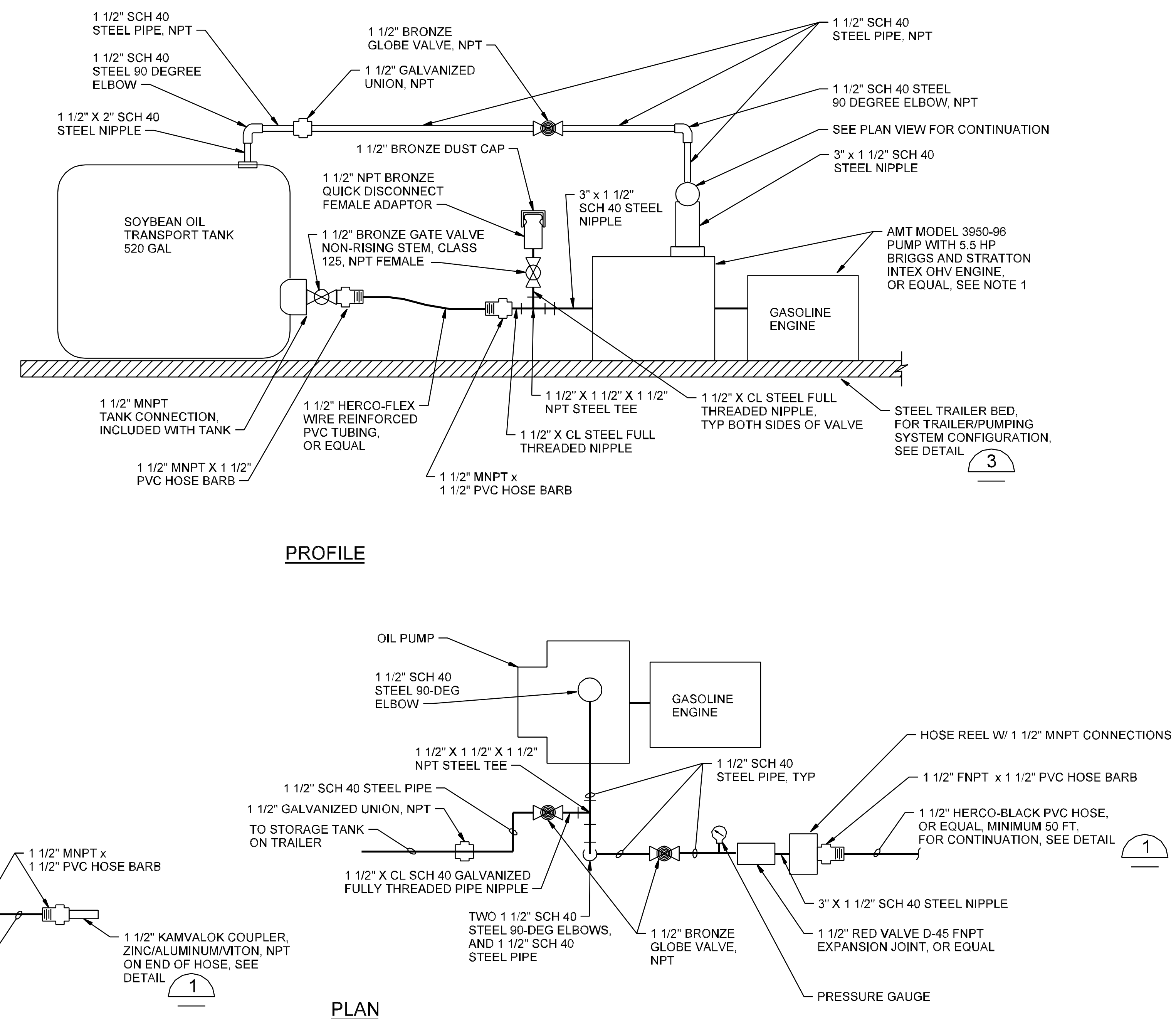
Site History			
48. Type of Facility and Contamination Event(s) NWIRP McGregor was originally established in 1942 as the Bluebonnet Ordnance Plant by the U.S. Army Ordnance Corps. Activities included solid-fuel rocket propulsion systems manufacturing. These manufacturing operations ceased in 1995. Area S is located on the southeast side of NWIRP McGregor which includes the Burn Pit which is part of a perchlorate and chlorinated VOC source. The contaminant plume emanated from the former Burn Pit area.	49.Contamination Date(s) 1942 to 1995	50. Original Contamination (VOCs, TPH, BTEX, etc) & Concentrations perchlorate: 8.6 - 0.0045 mg/L total VOC: 1.92 - 0.0003 mg/L	51. Previous Remediation none

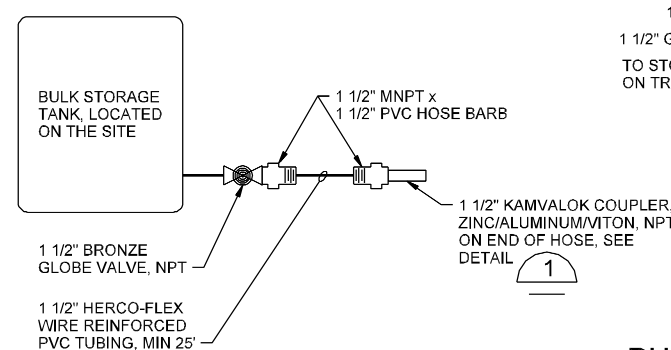
Appendix E

Chemical Injection Trailer As-Built Drawing

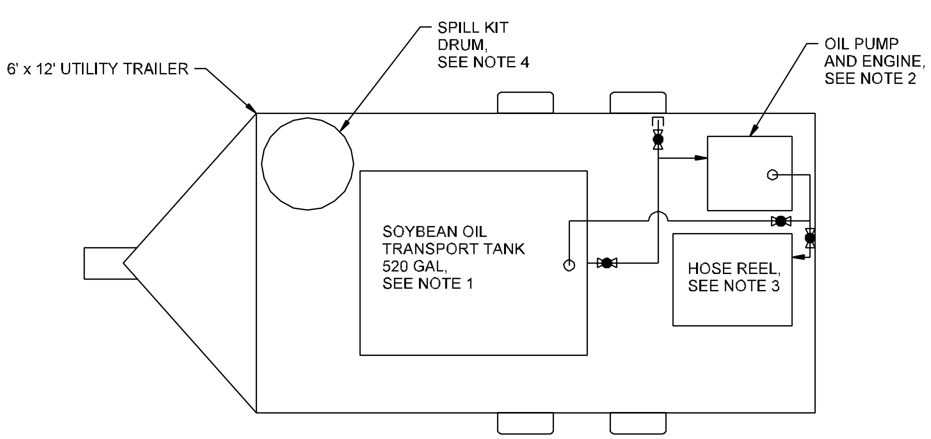


INJECTION CONNECTION DETAIL 1
NTS GWAB-33





PUMPING SYSTEM DETAIL 2
NTS



MOBILE PUMPING SYSTEM 3
NTS

NOTES:
1. TANK ANCHORED TO THE TRAILER BED USING BOLTED ANCHOR BANDS PROVIDED BY THE VENDOR. BOLTS WELDED TO STEEL TRAILER BED.
2. PUMP SYSTEM ANCHORED TO THE TRAILER BED USING BOLTS WELDED TO STEEL TRAILER BED.
3. HOSE REEL ANCHORED TO THE TRAILER BED WITH BOLTS.
4. SPILL KIT DRUM ANCHORED TO THE TRAILER BED USING BOLTS WELDED TO BED AND RACHET STRAPS.
5. COVER INSTALLED AROUND THE SET OF INJECTION PIPES FOR EACH TRENCH. COVER FLUSH MOUNTED TO THE EXISTING GRADE. SEE SPECIFIC TRENCH DETAILS FOR NUMBER OF INJECTION PIPES AT EACH LOCATION.
6. CONCRETE IS 2500 PSI MIX FROM READY-MIX SUPPLIER OR MIXED ONSITE FROM PREMEASURED BAGS.
7. ALL MISCELLANEOUS EQUIPMENT (BOLTS, STRAPS, FITTINGS, ETC.) MET BUY AMERICA REQUIREMENTS AS OUTLINED IN 23CFR635.410.

NWIRP MCGREGOR
MCGREGOR, TEXAS

DSGN A CHANG						
DR P VALENTINE						
CHK W THOMAS						
APVD T BEISEL	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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AS-BUILT

INJECTION PUMPING SYSTEM DETAILS

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Appendix F
Substrate Injection Procedures

SUBSTRATE INJECTION PROCEDURES

This section details the proper operation and maintenance of the carbon substrate injection system. This section outlines operational procedures and safe work practices for the following activities:

1. Hitching the injection trailer to the tow vehicle
2. Towing the injection trailer
3. Filling the injection trailer
4. Substrate injection

In addition to a *Biowall Sampling Log Sheet*, a dedicated *Injection Log Book* will be used to document biowall O&M. At a minimum, the following information will be recorded in the logbook, which will be retained at the site:

- Time and date of substrate injection(s)
- Personnel peforming injection(s)
- Biowall and injection point location(s)
- Injected substrate quantity
- System pressures and flows
- Water levels in the biowall and nearby monitoring wells, before, during and after substrate injection
- General System Conditions (injection ports, locks, valves and controls) and general conditions of towing vehicle and trailer

Hitching the Injection Trailer to the Tow Vehicle

1. Ensure that wheels of trailer are chocked or otherwise secured prior to backing the tow vehicle into position. The hitching area should be level and free of any obstructions.

Maintenance Tip
Inspect the trailer for any problems (check tire pressure, inspect for evidence of damage, leaking fittings, etc.) prior to use.

2. A tow vehicle that is equipped with a 2” receiver should be utilized. A Class V hitch with a 2” X 1 ¼” ball should be stored with the trailer. After placing tow vehicle in “Park” and setting the emergency/parking brake, install the hitch and ensure that the retainer pin is fully inserted through both the receiver and the hitch. Insert cotter pin to ensure that retainer pin cannot work itself loose while in transit.

3. Release the parking brake and slowly back the tow vehicle towards the trailer, taking care to line up the vehicle with the trailer. Personnel attempting to guide the driver from outside the vehicle should stay clear of the ball/hitch contact area and maintain visual contact with the driver at all times until the vehicle comes to a full stop and is placed in “Park” with the parking brake applied.

4. Once vehicle and trailer are properly aligned, slowly raise (if necessary to allow clearance of ball) and/or lower the trailer hitch onto the ball using the trailer jack provided. Once the tongue of the trailer is securely seated on the ball, ensure that trailer hitch lock is fully engaged. Be sure to fully retract trailer jack.

5. The trailer is equipped with trailer lamps (running lights, turn indicators, and brake lights) and trailer brakes. Install trailer safety chains and make electrical connections for trailer lamps and brakes. Once trailer is secured, remove chocks from wheels of trailer.

Maintenance Tip
Confirm proper operation of turn signals, brake lights, and trailer brakes. Consult the manufacturer’s literature or owner’s manual for information regarding proper installation and operation of trailer brakes.

Towing the Injection Trailer

1. Initially drive at lower speeds to confirm proper operation of trailer brakes and to develop a “feel” for the trailer.

2. Trailer clearance side-to-side is less than that of tow vehicle. Use care when passing through gated or narrow entrances and make wider turns than usual to allow trailer to follow properly.

3. Use care when backing up to avoid binding or fishtailing of trailer.

4. Allow for increased stopping distance, particularly when fully loaded and/or when driving in inclement weather.

5. Avoid parking on grades; however, if this is unavoidable, place wheel chocks beneath trailer's wheels.

6. Always set parking brake when filling trailer tank or injecting oil at trenches.

Filling the Injection Trailer

1. Back trailer into position as close to the substrate storage area as possible to minimize impacts of a spill/release. Use a spotter to guide driver into position. Make sure that spill kit is both accessible and properly stocked in the event of a spill/release.

Once in position, set parking brake and chock/block wheels (if necessary). Begin trailer tank filling. Follow appropriate procedures based on the specific configuration of the substrate trailer being used.

2. After the desired volume of substrate has been transferred, use absorbent pads from spill kit to clean up any incidental spills.

If filling from vendor substrate drums (or other containers)

Per operator discretion, substrate (and water) can be transferred directly from the vendor substrate drums (or other containers) to the trailer tank rather than using the bulk storage tank and trailer pump. Using proper spill/release precautions, the alternative transfer operation can be conducted at the bulk storage area or in the field to hasten the injection process.

Injecting Substrate

1. Use care when driving on unimproved site roads to access biowalls. Be especially careful when trailer is fully loaded and/or potentially hazardous site conditions exist (inclement weather, heavily rutted roads, reduced or restricted visibility, etc.).

2. Once at biowall injection point (pipe vault), position trailer as close to the injection ports as possible. The trailer should be as level as possible. Place vehicle in "Park", set emergency brake, and chock/block wheels if necessary.

3. Open injection vault cover and select port to be injected. Note the biowall, vault location, and port designation, e.g. "Biowall S-2, North Vault, Pipe #3" and record in the *Injection Log Book*. Inspect the condition of the injection ports and note any damage, leaks, or evidence of groundwater/substrate infiltration. Record any observations in the *Injection Log Book*.

4. Unreel appropriate length of 1.5 “ hose from reel on trailer. Remove cam-lock dust cap on injection port and connect 2” to 1 ½” adapter to port using integral cam-lock fitting. Ensure that all connections are tight (cams flush with hose connection). Connect substrate delivery nozzle (“dry” connection) to adapter secured to injection port.

CAUTION!!
Check to see that pressure relief valve (petcock) on port to be injected is in the closed position. Failure to do so will result in transfer of substrate to injection vault.

5. Once connections are made and a “closed-loop” system exists, open the trailer tank suction valve (blue handle at base of on-board tank), the “dry” connection substrate injection valve (at the hose nozzle) and crack the hose reel discharge valve (red handle). Before proceeding further, confirm that both the discharge/fill valve (red handle) at the trailer tank and the tank fill valve (blue handle on suction side of pump) are closed. Note current totalizer reading (if not reset to zero) and record in *Injection Log Book*. Reset totalizer to zero.

6. Start the fluid transfer pump. Follow manufacturer’s recommendations for proper start-up, operation, and maintenance procedures.

CAUTION!!
When engine starts, pump is instantly engaged and fluid begins to move immediately!

7. Close hose reel discharge valve and allow pump to “deadhead” briefly. Reduce throttle setting until a deadhead pressure of 30 pounds per square inch (psi) is achieved. Note deadhead pressure and record in *Injection Log Book*. Check for any signs of leakage at connections or anywhere along the transfer lines. If a leak is present, immediately shut off the pump, close all open valves, and repair the leak.

8. If no leaks are noted and system operation appears normal following deadheading, start substrate injection by opening the hose reel discharge valve until valve is fully open. Note time substrate injection started and record in log book, along with starting injection pressure.

9. Do not leave trailer unattended while performing substrate injections (that is, any time that transfer pump is in operation and/or valves are open). Periodically inspect connections, system piping, and on-board tank during filling process for any leaks.

10. Carefully monitor the totalizer meter and the injection pressure gauge during the injection process. The pump is rated for pressures in the normal operating range of 30-60 psi, although actual operating pressures will vary based on individual injection port characteristics (length of sub-surface riser, solid vs. perforated casing, etc.) An initial rise in pressure will be noted as the subsurface pipe volume is filled. This will be followed by a second, more gradual rise in pressure as substrate begins to flow from the system piping into the biowall.

11. Once the desired quantity of substrate has been delivered to the biowall, note the final injection pressure and totalizer reading and record in log book. Shut off the pump and close the hose nozzle delivery valve, the trailer tank suction valve, and the hose reel discharge valve.

12. Once system is shut down and all open valves are closed, disconnect the hose nozzle from the fill port adapter. Use caution when disconnecting hose as slight residual pressure/fluid may be present.

13. Reel up hose onto hose reel and inspect injection trailer for any leaks at pipe connections, fittings, etc. Use absorbent pads from spill kit to clean up any incidental spills.

14. Replace cam-lock dust cap on oil injection port and secure. Close pipe vault cover and lock using vault key.