1045 0

File: 541.460.000n
M.D.

THE MEMPHIS DEPOT
TENNESSEE

ADMINISTRATIVE RECORD
COVER SHEET

AR File Number 1045

Memorandum

To: John Hill, CIV AFCEE/EXA
Mike Dobbs, DES-DDC-EE

From: John Sperry
Tom Holmes

Date: 30 June 2010

Re: **Intermediate Aquifer Well Installation**
Main Installation - Defense Depot Memphis, Tennessee
FA8903-08-D-8771, Task Order 0019

HDR|e²M has prepared this report to present the results of the Intermediate Aquifer Well Installation on the Main Installation (MI) at Defense Depot Memphis, Tennessee (DDMT). This work was performed for the Defense Logistics Agency under Contract FA8903-08-D-8771, Task Order 0019 to the Air Force Center for Engineering and the Environment.

Additional deep monitoring wells were recommended in the *Main Installation Interim Remedial Action Completion Report* (IRACR) (HDR|e²M, 2010) to support groundwater modeling results, which indicated the identified groundwater plumes in the Fluvial aquifer on the MI would not significantly impact groundwater quality in the deeper Memphis aquifer. Proposed locations of two Intermediate aquifer (IAQ) wells and two Memphis aquifer wells were provided in the IRACR. Following installation, the wells are to be incorporated into the long term monitoring (LTM) program.

The planned well installation and groundwater sampling were described in *Work Plan for Deep Wells and 2010 Long Term Monitoring* (HDR|e²M, 2010) submitted to the Tennessee Department of Environment and Conservation and the United States Environmental Protection Agency on 29 March 2010. The work plan called for installation of two IAQ wells, with final locations for the Memphis aquifer well and a possible third Intermediate aquifer well to be determined following review of the hydrogeologic information and analytical results for the initial IAQ wells.

FIELD ACTIVITIES

The field activities consisted of installation of two IAQ wells, abandonment of 5 LTM wells and a piezometer on the MI, and groundwater sampling at the new IAQ wells. Activities were performed in accordance with the work plan and the *Remedial Action Sampling and Analysis Plan* (RA SAP) (MACTEC, 2005).

Well Installation and Development

Wells MW-252 and MW-253 were installed with well screens in the first significant sand layer beneath the upper clay in the Jackson Formation/Upper Claiborne Group. The LTM well locations including the two new wells are shown on Figure 1.

The planned well locations were marked by Allen and Hoshall of Memphis, Tennessee, a Tennessee Registered Land Surveyor on 20 May and the locations were cleared for utilities by ALS, a private utility locating service, on 27 May. The wells were installed by Boart Longyear from 2 to 9 June 2010. HDR|e^{2}M field geologists were present during drilling to record field observations and log the soil core.

Borings were advanced 10 feet into the uppermost clay of the Jackson Formation/Upper Claiborne Group using rotasonic drilling methods with a 6-inch outer core barrel and a 4-inch inner core barrel. A 10-inch borehole was then advanced and a 6-inch diameter Schedule 80 polyvinyl chloride (PVC) surface casing was installed with the bottom section containing a seal and check valve. The driller pumped grout through an injection pipe connected to the check valve until it returned to the ground surface. Following grouting, potable water was pumped into the inner annulus of the casing. After the grout was allowed to cure for over 24 hours, the water in the inner annulus of the casing was pumped to a holding tank and the borehole was advanced using a 5-inch outer core barrel and a 3-inch inner core barrel.

Continuous soil cores were collected from ground surface to the termination depth of each boring. Soil core from the screened interval was placed in labeled core boxes and stored at the HDR|e^{2}M field office. Soil boring logs are provided in Appendix A.

At MW-252, the upper clay extended from 87.5 feet to 116.5 feet below ground surface (bgs) and the underlying fine sand extended to boring termination at 151 feet bgs. At MW-253, the upper clay extended from 107 feet to 125 feet bgs, sand with clay was observed from 125 feet to 137 feet bgs followed by grey clay to boring termination at 157 feet bgs. Although the sand layer in MW-253 was not as extensive as at MW-252, it was near the target depth for the IAQ wells and the next sand layer was at least 20 feet deeper. A temporary well was installed to confirm sufficient groundwater for sampling; the borehole was backfilled with sand to the bottom of the intermediate sand (with clay) layer and a well screen and filter pack were installed. Approximately 75 gallons of water was extracted using a Waterra pump and a bailer, and well installation was completed.

Well casings were new, unused, decontaminated, 2-inch I.D. schedule 80 PVC pipe with internal threaded flush joints. The well screens were 20 feet of schedule 80 PVC, 0.010 inch continuous slotted screen with a PVC cap at the bottom. Centralizers were used every 30 feet along the riser in MW-252, except in the well screen or bentonite seal section. Centralizers were not used in MW-253

The filter pack consists of 8-16 grade filter pack of inert, hard, well rounded sand (less than 2 percent flat particles) installed from the bottom of the boring to 5 feet above the top of the well screen. A 5-foot-thick bentonite seal was placed above the filter pack. The bentonite seal was allowed to hydrate for a minimum of 1 hour prior to installation of the grout seal. The annular space was filled with a cement-bentonite grout mixture to approximately 6 inches below the ground surface. All wells had flush-mount completions with a 12-inch ID manhole set within a 3-foot by 3-foot by 0.5-foot thick concrete pad. Steel bollards filled with concrete were placed around the wells for additional protection.

Well construction was performed by Boart Longyear under the supervision of an HDR|e^{2}M field geologist. Well installation diagrams are provided in Appendix B and a summary is provided on Table 1.

The wells were developed at least 24 hours after installation. The wells were initially developed using Typhoon and Grundfos submersible pumps; however, the Typhoon did not have sufficient power and the Grundfos motor burned out. Well development was completed with a Waterra inertial pump. The wells were surged with the pump during development. Water quality measurements were made to evaluate well development in accordance with the RA SAP criteria: stabilized turbidity less than 10 nephelometric turbidity units (NTUs), pH within 0.1 standard units, and temperature and specific conductance within 10 percent for three consecutive readings. A well development summary, including volume purged and final stabilization parameters, is shown on Table 2. MW-252 met the development criteria. MW-253 was developed for 12 hours but did not meet the development criteria for turbidity.

The completed wells were surveyed for location and elevation (ground surface and top of casing) by Allen and Hoshall on 17 June 2010. Horizontal and vertical coordinates are based on the North American Datum, 1927 used for all survey data at DDMT. Horizontal coordinates were provided in the Tennessee State Plane coordinate system.

Well Abandonment

Five monitoring wells and one piezometer were abandoned 6 and 8 June based on recommendations in the *Main Installation Annual Long-Term Monitoring Report - 2009* (HDR|e^{2}M, 2010). Total well depth, location, and date of abandonment are listed on Table 3. The abandoned well locations are shown on Figure 1.

Abandonment permits were not obtained from Memphis Shelby County Health Department since the wells were located on the MI. Well abandonment was performed by Boart Longyear and observed by an HDR|e^{2}M field geologist. Each well was checked to confirm that obstructions did not interfere with placement of the tremie pipe and grout. Sample tubing lodged in PZ-07 could not be removed due to the piezometer's small diameter. One half gallon of chlorine bleach was poured into each well. Bentonite was added to each well to absorb water in the screened interval and to fully seal the screen. The wells were then grouted with Portland type II cement with 5 percent bentonite. The grout was placed from the bottom to the top of the well casing using a tremie pipe. The grout was allowed to settle for 48 hours, and the well bore was capped with concrete. The tubing in PZ-07 and its small diameter prevented use of bentonite to seal the screen or use of a tremie pipe; a thinner grout mixture was slowly poured in the well during abandonment. Since all the wells were located in gravel or asphalt parking lots, the surface completions were left in place; the manhole covers were removed and the manholes were filled with concrete.

Water Level Measurements

Groundwater levels were measured in the MI intermediate aquifer wells on 18 June 2009. Measurements were made using Solinist Model 101 water level meters with electronic sensors and tapes graduated in 0.01-foot increments. The water level measurements are shown on Table 4.

Groundwater Sampling

Groundwater samples were collected from the new IAQ wells on 18 June 2010 using low-flow purging methods with stainless steel bladder pumps, Teflon® bladders and Teflon®-lined polyethylene tubing. The pumping rate at each well was set to limit the

water level drop to less than 1.2 inches (0.1 foot); MW-252 and MW-253 were pumped at 330 to 380 milliliters per minute and water levels declined approximately 0.3 ft.

Purging continued at each well for up to two hours in order to meet the stabilization criteria: three successive readings within 0.1 for pH, 10 milliVolts for oxygen reduction potential, 10 percent for specific conductance, 10 percent for dissolved oxygen and <20 NTU for turbidity. Temperature was also measured and recorded but was not used as a stabilization parameter. Samples were collected when stabilization criteria were met or the field team leader approved the variance from the criteria. The final stabilization measurements are shown on Table 5. One sample was collected without meeting the stabilization criteria:

- Samples were collected from MW-253 after purging for 1.7 hours with turbidity at 1428 NTU, due to thunderstorms in the area and an increase in turbidity during purging.

Following stabilization, samples were collected in 40-milliliter vials preserved with hydrochloric acid. Samples were sent to Microbac Laboratories in Marietta, Ohio, for expedited laboratory analysis of volatile organic compounds (VOCs) by method 8260B.

IDW Management

The waste generated during well installation and groundwater sampling in June 2010 was classified as either non-investigative waste or investigation-derived waste (IDW). Non-investigative waste, such as packaging materials, personal protective equipment, disposable sampling supplies, and other inert refuse, was collected, containerized, and transported to a designated collection bin for disposal at a municipal landfill. The IDW consisted of soil cuttings from the monitoring well borings, waste water from equipment decontamination, and groundwater from well development and purging prior to sampling.

The soil cuttings were spread on Dunn Field.

Wastewater generated from decontamination of the drill rig and down hole equipment prior to drilling and of well construction materials prior to well installation was collected in a 20,000-gallon fractionation tank supplied by HDR|e^{2}M. Groundwater collected during well development was also transported to the fractionation tank. A water sample will be collected upon completion of the planned well installations and the wastewater will be discharged in accordance with the DDMT industrial discharge permit.

The purge water collected during sampling was placed in a separate fractionation tank used for collection of condensate from the fluvial soil vapor extraction system. A wastewater grab sample was collected on 1 June 2010 when the tank neared capacity and was analyzed for VOCs, semi-volatile organic compounds and metals in accordance with the permit. The analytical results were compared to the permit limits and a request for one-time discharge was submitted. The discharge was approved on 22 June 2010 and approximately 17,000 gallons was pumped from the tank to the sanitary sewer on 23 and 24 June 2010.

SUMMARY OF FINDINGS

Hydrogeology

Water level measurements in intermediate aquifer wells are shown on Figure 2. Groundwater elevation contours for the intermediate aquifer indicates flow to the moving generally to the northwest.

Soil borings for the new IAQ wells were drilled through the upper clay in the Jackson Formation/Upper Claiborne Group that forms the base of the fluvial aquifer and into the underlying fine sands. An updated top of clay contour map is shown on Figure 3 and a cross-section through the area is shown on Figure 4.

Analytical Results

Groundwater samples were collected from MW-252 and MW-253 on 18 June 2010. The complete analytical results are presented in Appendix C. Table 6 lists the analytical results for the primary chlorinated volatile organic compounds (CVOCs) and other VOCs that were detected above reporting limits (RLs). No VOCs were detected above RLs.

CONCLUSIONS AND RECOMENDATIONS

The water level measurements from the new IAQ wells show that groundwater flow in the intermediate aquifer west of the window (Figure 2) is more northerly than was understood during preparation of the work plan. The well locations were selected to place MW-252 downgradient and MW-253 side-gradient of the sentinel wells with higher CVOC concentrations, MW-90 and MW-202A, in order to determine the extent of elevated CVOCs within the IAQ. The analytical results support a limited extent of CVOCs in the IAQ but do not provide a clearly downgradient monitoring point. Based on these results, a third IAQ well, MW-256, will be installed approximately 500 feet north of MW-252. In addition, the two Memphis Aquifer well locations, MW-254 and MW-255, will be shifted. The proposed locations are shown on Figure 5.

TABLES

TABLE 1
WELL INSTALLATION SUMMARY
INTERMEDIATE AQUIFER WELL INSTALLATION
Main Installation - Defense Depot Memphis, Tennessee

Well	Date Completed	Northing	Easting	Location	Aquifer Screened	Top of Casing Elevation (ft, msl)	Ground Elevation (ft, msl)	Surface Casing Depth (ft, bgs)	Total Boring Depth (ft, bgs)	Groundwater Elevation (ft, msl)	Top of Clay Elevation (ft, msl)	Fluvial Aquifer Thickness (ft)	Screen Length (ft)	Total Well depth (ft. btoc)
MW-252	6/7/2010	278789.21	801364.70	MI	Intermediate	294.16	294.4	97.0	151.0	131.12	87.0	NM	20	146.08
MW-253	6/9/2010	278287.43	801191.42	MI	Intermediate	290.47	290.8	117.0	157.0	117.87	107.0	NM	20	138.25

Notes
MI: Main Installation
NM: Not measured

TABLE 2
WELL DEVELOPMENT SUMMARY
INTERMEDIATE AQUIFER WELL INSTALLATION
Main Installation - Defense Depot Memphis, Tennessee

Well ID	Date Developed	Volume Purged (gallons)	Final Stabilization Parameters pH	Specific Conductivity (mS/cm)	Turbidity (NTU)	Temperature (°C)
MW-252	6/15/2010	500.0	6.17	0.240	9.99	20.93
MW-253	6/17/2010	355.0	6.14	0.265	447	20.42

TABLE 3
WELL ABANDONMENT SUMMARY
INTERMEDIATE AQUIFER WELL INSTALLATION
Main Installation - Defense Depot Memphis, Tennessee

Well	Date Abandoned	Northing	Easting	Ground Elevation (ft, msl)	Well Depth (ft, btoc)
MW-86	6/6/2010	276696.65	806301.24	304.89	117.5
MW-115	6/8/2010	276588.14	800805.19	291.92	99.5
MW-125	6/8/2010	276594.62	800818.74	291.47	109.0
IW-1	6/6/2010	276705.58	806329.97	304.29	99.0
IW-6	6/8/2010	276580.44	800795.75	292.27	109.0
PZ-07	6/6/2010	277053.25	806006.75	305.22	100.0

TABLE 4
WATER LEVEL MEASUREMENTS
INTERMEDIATE AQUIFER WELL INSTALLATION
Main Installation - Defense Depot Memphis, Tennessee

Well ID	Aquifer	Top of Casing Elevation (ft, msl)	Top of Screen Elevation (ft, msl)	Depth to Water 18-Jun-2010 (ft, btoc)	Groundwater Elevation 18-Jun-2010 (ft, msl)
MW-34	Intermediate	299.97	163.37	129.70	170.27
MW-38	Intermediate	307.45	167.55	125.56	181.89
MW-63A	Fluvial/Intermediate	305.96	165.96	100.78	205.18
MW-90	Intermediate	304.19	189.19	111.58	192.61
MW-107	Fluvial/Intermediate	304.92	176.92	105.00	199.92
MW-108	Fluvial/Intermediate	303.07	143.07	105.29	197.78
MW-140	Intermediate	298.12	73.52	135.98	162.14
MW-141	Intermediate	303.71	155.01	109.28	194.43
MW-197A	Fluvial	291.26	129.30	92.11	199.15
MW-202A	Intermediate	299.23	122.73	119.07	180.16
MW-205A	Fluvial	291.93	150.96	93.48	198.45
MW-206A	Fluvial	299.92	172.58	102.06	197.86
MW-207A	Fluvial	303.78	154.13	106.01	197.77
MW-208A	Fluvial	301.50	118.05	103.90	197.60
MW-209A	Intermediate	298.05	109.07	102.33	195.72
MW-210A	Intermediate	289.66	112.60	97.15	192.51
MW-211	Intermediate	303.74	137.48	106.53	197.21
MW-229	Intermediate	311.77	123.34	148.72	163.05
MW-252	Intermediate	294.16	168.36	130.00	164.16
MW-253	Intermediate	290.47	172.47	117.89	172.58

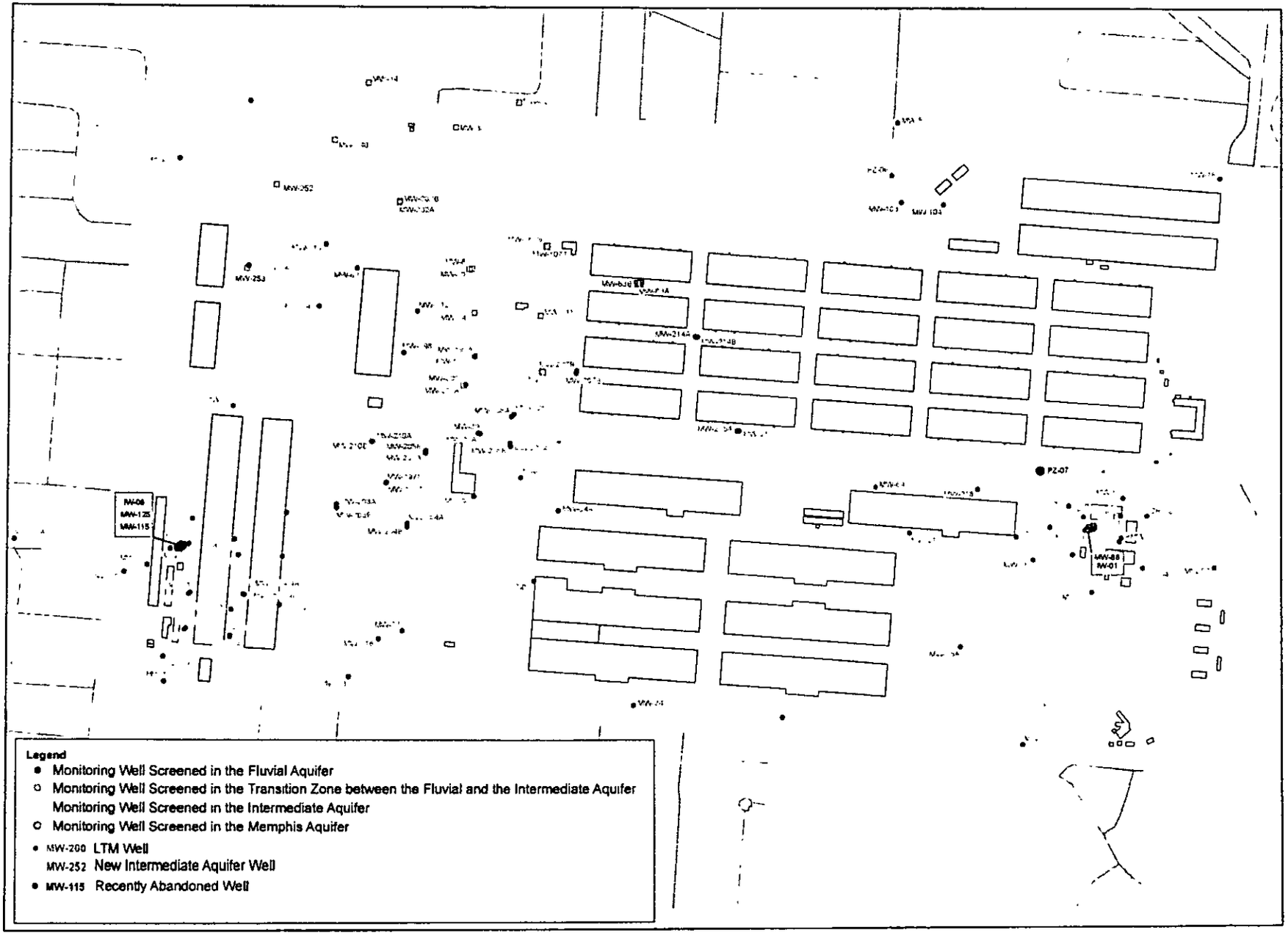
Notes:
ft, msl feet mean sea level
ft, btoc feet below top of casing

TABLE 5
FINAL WELL STABILIZATION MEASUREMENTS
INTERMEDIATE AQUIFER WELL INSTALLATION
Main Installation - Defense Depot Memphis, Tennessee

Well ID	Sample Date	Method	Time Sampled	Sample Pump Depth (ft, btoc)	Water Depth (ft, btoc)	Purge Rate (mL/min)	Volume Purged (L)	pH	Temp (°C)	Specific Conductivity (mS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)
MW-252	6/18/2010	low flow	9:00	138.2	130.00	380	9.3	6.0	21.1	0.209	0.0	117.1	7.67
MW-253	6/18/2010	low flow	16:50	124.2	117.89	330	33.5	5.9	21.1	0.252	1.6	128.0	1428.0

Notes
na : not available
ft, btoc: feet below top of casing
mL/min: milliliters per minute
L : liters
°C : degrees Celsius
mS/cm : milliSiemens per centimeter
mg/L : milligrams per liter
mV :millivolts
NTU: nephelometric turbidity units
DO : Dissolved Oxygen
ORP : Oxidation Reduction Potential

FIGURES



G:\121803\008\GIS\Fig 1 LTM Well Location Map.mxd

N
W E
S

Figure 1

LTM WELL LOCATIONS

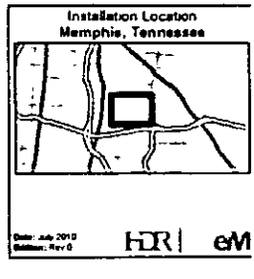
INTERMEDIATE AQUIFER
WELL INSTALLATION

MAIN INSTALLATION
DEFENSE DEPOT
MEMPHIS, TENNESSEE

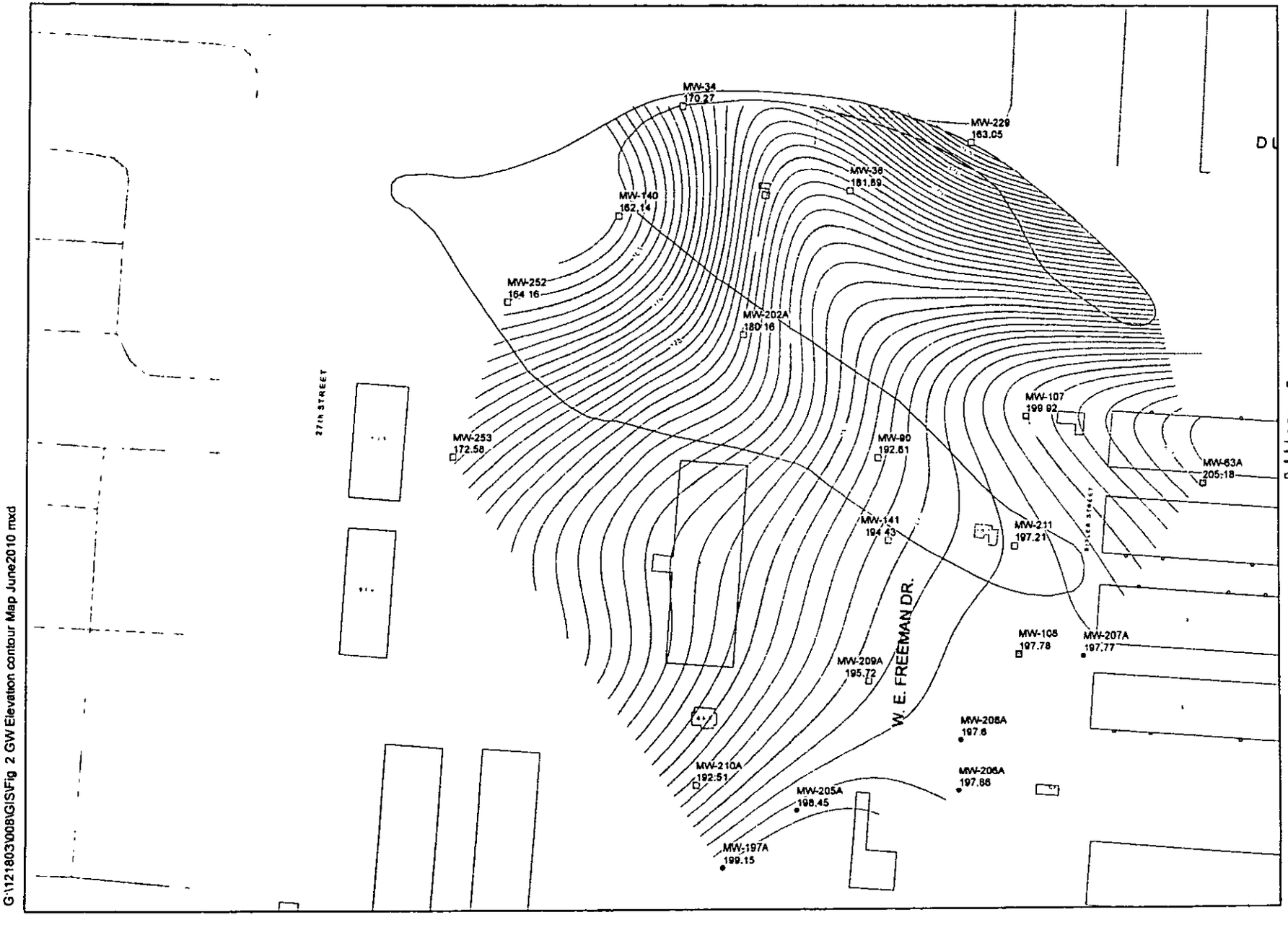
1045 13

Projection: NAD 1927 StatePlane Tennessee
Units: Feet

0 250 500 1,000
Feet



HDR | eM



G:\121803\008\GIS\Fig 2 GW Elevation contour Map June2010.mxd

Figure 2

INTERMEDIATE AQUIFER GROUNDWATER ELEVATIONS JUNE 2010

INTERMEDIATE AQUIFER WELL INSTALLATION

MAIN INSTALLATION
DEFENSE DEPOT
MEMPHIS, TENNESSEE

Legend

- Monitoring Well Screened in the Fluvial Aquifer
- Monitoring Well Screened in the Intermediate Aquifer
- Monitoring Well Screened in the Transition Zone
- Potentiometric surface of the Fluvial Aquifer 1-ft. contour
- Potentiometric surface of the Fluvial Aquifer 5-ft. contour
- Potentiometric surface of the Intermediate Aquifer 5-ft. contour
- Clay Elevation Exceeds Groundwater Elevation

1045 144

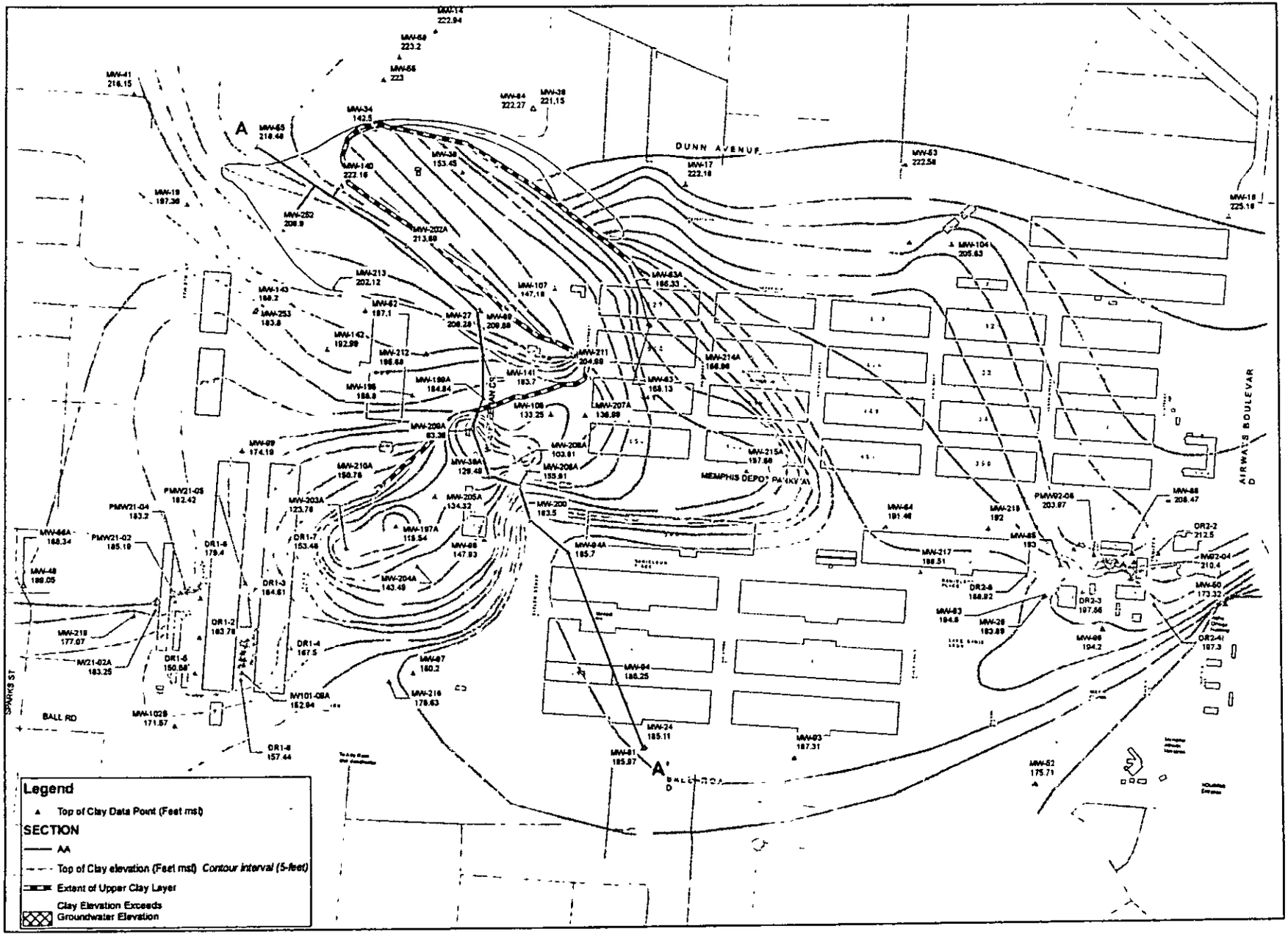
Projection: NAD 1927 StatePlane Tennessee
Units: Feet

0 100 200 400
Feet

Installation Location
Memphis, Tennessee

Date: July 2010
Edition: Rev 0

HDR | eM



G:\1218103008\GIS\Fig 3 TOP OF CLAY ELEVATIONS.mxd

Figure 3

TOP OF CLAY ELEVATIONS

INTERMEDIATE AQUIFER WELL INSTALLATION

MAIN INSTALLATION DEFENSE DEPOT MEMPHIS, TENNESSEE

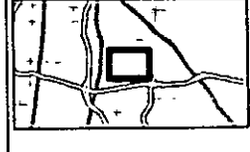
1045 15

Projection: NAD 1927 StatePlane Tennessee
Units: Feet

0 200 400 800

Feet

Installation Location
Memphis, Tennessee



Date: July 2010
Edition: Rev 0

HDR | eM

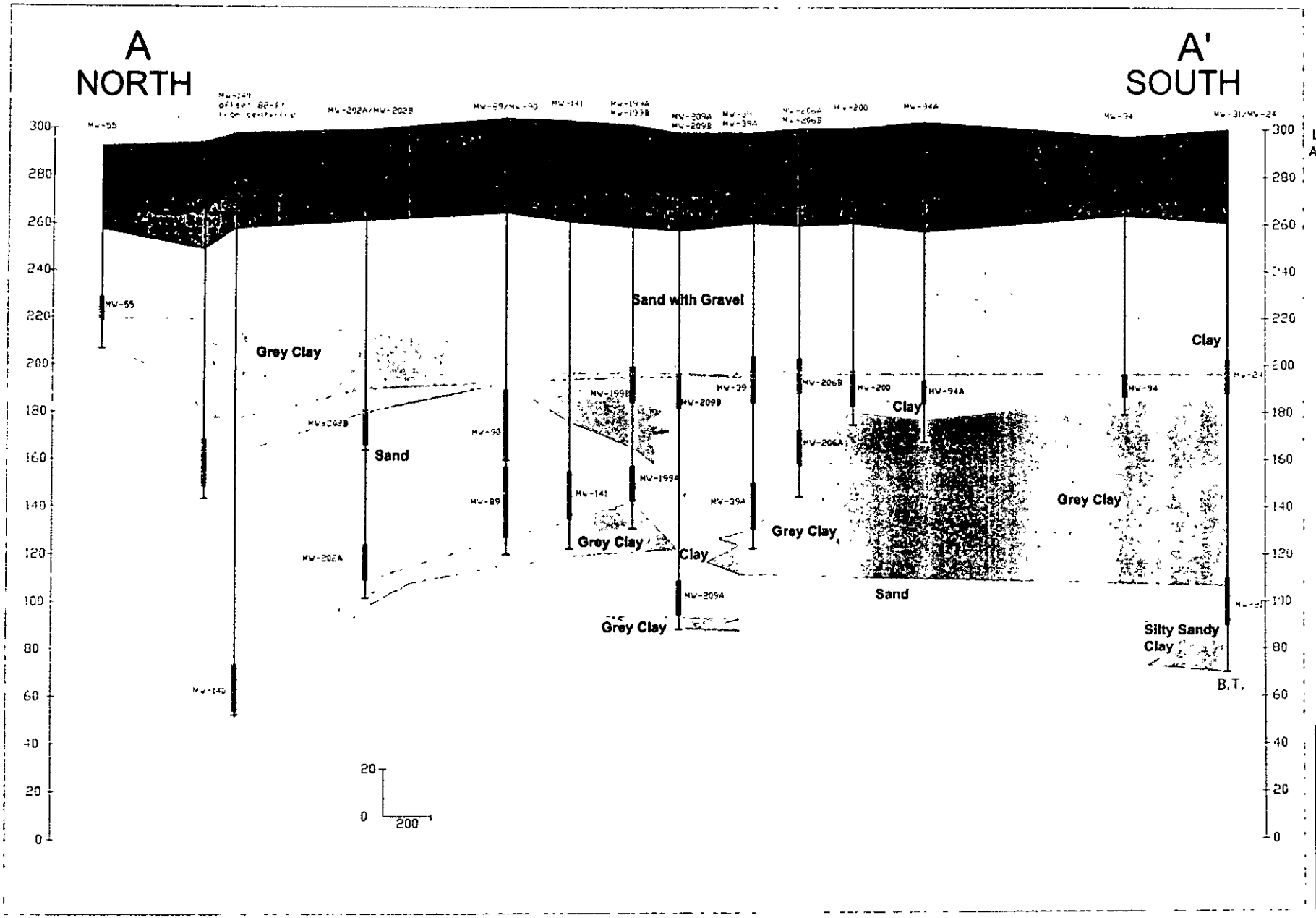


Figure 4

LITHOLOGIC CROSS-SECTION AND PROPOSED WELL DEPTHS

INTERMEDIATE AQUIFER WELL INSTALLATION

MAIN INSTALLATION
DEFENSE DEPOT
MEMPHIS, TENNESSEE

Silty Clay to Clayey Silt

Sandy Clay to Clayey Sand

Fluvial Sand or Sand with Gravel

Clayey Sand to Silty Clay

Intermediate Sand

Clay

Groundwater Elevation Fluvial Aquifer 5/4/2007

Groundwater Elevation Intermediate Aquifer 6/19/2018

Well Screen Interval

Installation Location
Memphis, Tennessee

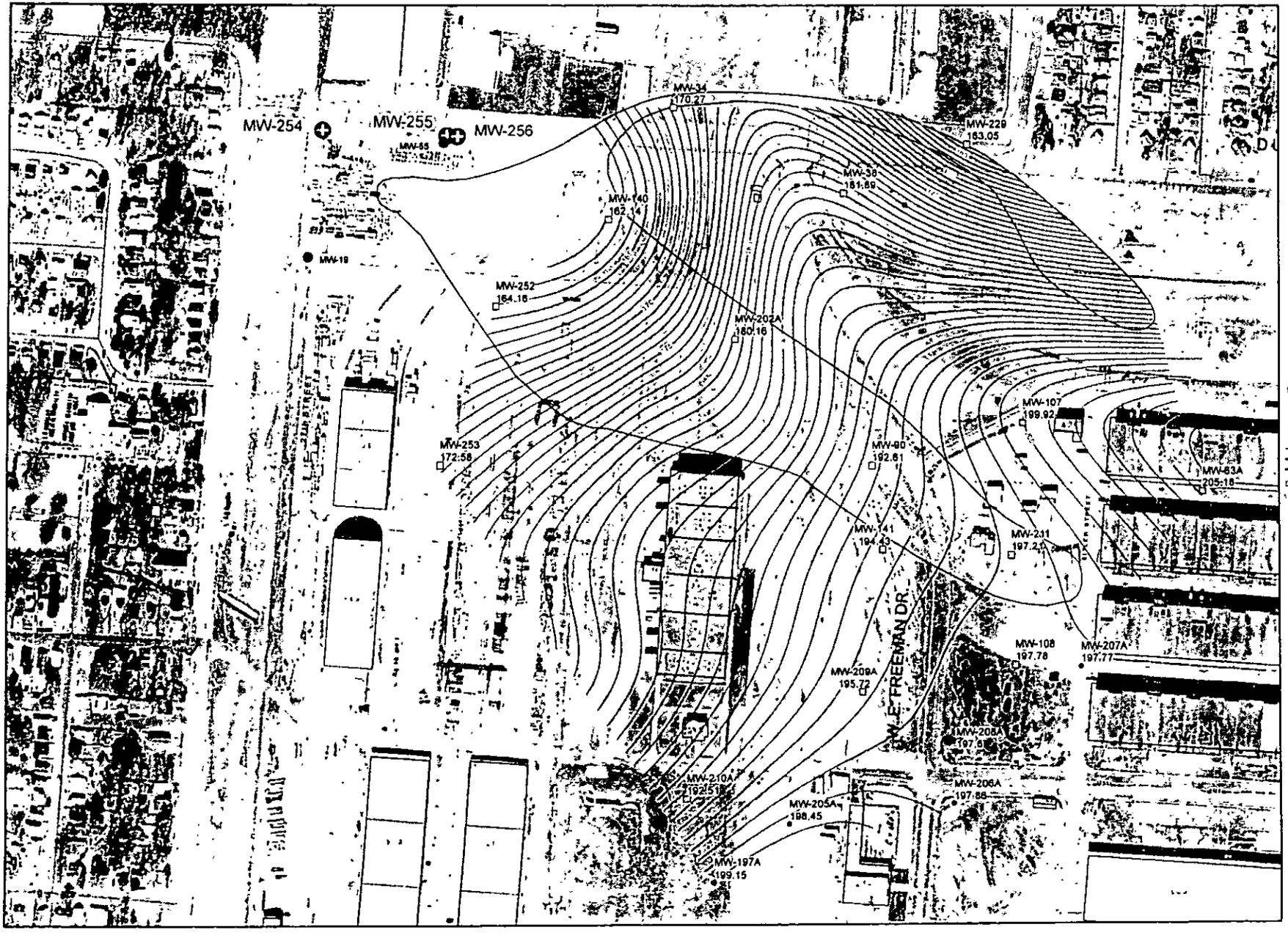


Figure 5

PROPOSED WELL LOCATIONS

INTERMEDIATE AQUIFER WELL INSTALLATION

MAIN INSTALLATION
DEFENSE DEPOT
MEMPHIS, TENNESSEE

Legend

- Monitoring Well Screened in the Fluvial Aquifer
- Monitoring Well Screened in the Intermediate Aquifer
- Monitoring Well Screened in the Transition Zone
- Potentiometric surface of the Fluvial Aquifer 1-ft. contour
- Potentiometric surface of the Fluvial Aquifer 5-ft. contour
- Potentiometric surface of the Intermediate Aquifer 5-ft. contour
- Clay Elevation Exceeds Groundwater Elevation

Projection: NAD 1927 StatePlane Tennessee
Units: Feet

0 100 200 400

Feet

Installation Location
Memphis, Tennessee

Date: July 2010
Revision: Rev 0

HJR GW

G:\121803\008\GIS\Fig 2 GW Elevation contour Map June2010.mxd

1045 11

APPENDICES

Appendix A

Soil Boring Logs

HDR | eM

FIELD BOREHOLE LOG

BOREHOLE NO.: MW-252
TOTAL DEPTH: 151

PROJECT INFORMATION

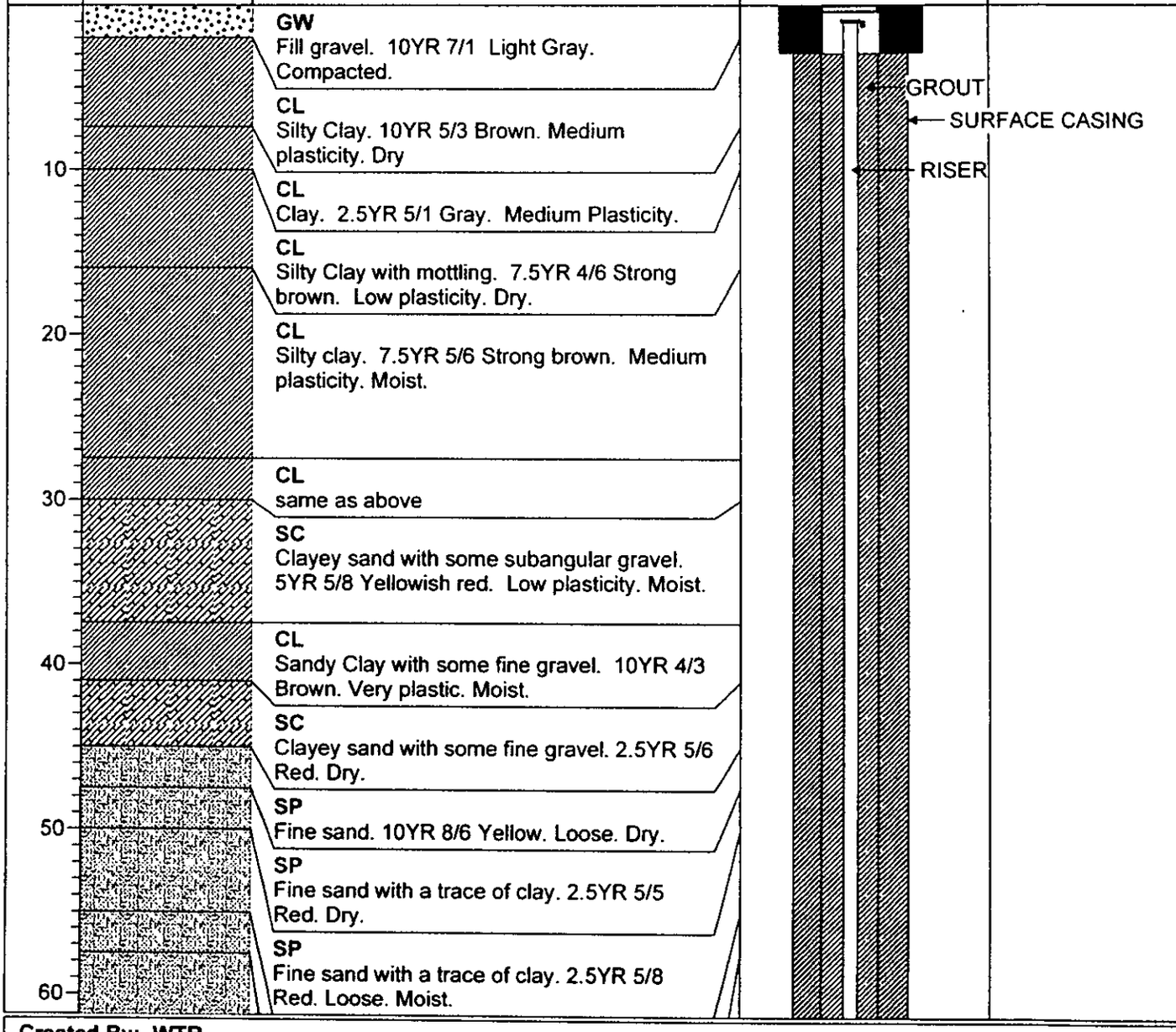
PROJECT: IAQ Drilling
PROJECT NO.: 121803-008
SITE LOCATION: DDMT-MI
PROJECT MANAGER: T. Holmes
FIELD STAFF: J. Sperry
BOREHOLE STARTED: 6/2/2010
BOREHOLE FINISHED: 6/7/2010

DRILLING INFORMATION

DRILLING CO.: Boart Longyear
DRILLER: Thomas Ardito
DRILLING METHOD/RIG: Sonic
BOREHOLE DIAMETER: 6x10 and 3x5
GROUND SURFACE ELEVATION: 294.4
WATER DEPTH/ DATE: 131.12 / 6/21/2010
BOREHOLE USE: Monitoring Well

NOTES:

Depth	Soil Symbol	Soil Description	Well Completion	Well Description
	GW	Fill gravel. 10YR 7/1 Light Gray. Compacted.	GROUT	
	CL	Silty Clay. 10YR 5/3 Brown. Medium plasticity. Dry	SURFACE CASING	
10	CL	Clay. 2.5YR 5/1 Gray. Medium Plasticity.	RISER	
	CL	Silty Clay with mottling. 7.5YR 4/6 Strong brown. Low plasticity. Dry.		
20	CL	Silty clay. 7.5YR 5/6 Strong brown. Medium plasticity. Moist.		
	CL	same as above		
30	SC	Clayey sand with some subangular gravel. 5YR 5/8 Yellowish red. Low plasticity. Moist.		
	CL	Sandy Clay with some fine gravel. 10YR 4/3 Brown. Very plastic. Moist.		
40	SC	Clayey sand with some fine gravel. 2.5YR 5/6 Red. Dry.		
	SP	Fine sand. 10YR 8/6 Yellow. Loose. Dry.		
50	SP	Fine sand with a trace of clay. 2.5YR 5/5 Red. Dry.		
	SP	Fine sand with a trace of clay. 2.5YR 5/8 Red. Loose. Moist.		
60				



Created By: WTR
Checked By: JBS

HDR | eM

FIELD BOREHOLE LOG

BOREHOLE NO.: MW-252

TOTAL DEPTH: 151

Depth	Soil Symbol	Soil Description	Well Completion	Well Description
		SP Medium sand with a trace of gravel. 7.5YR 6/6 Reddish yellow. Loose. Dry.		
		SP Clean fine sand with trace of fine gravel. 5YR 5/8 Yellowish Red. Loose. Moist.		
		SP same as above		
70		**SP** Fine sand. 10YR 8/6 Yellow. Loose. Moist.		
		SP Fine sand. 5YR 5/8 Yellowish Red. Loose. Moist.		
80		**SW** Sandy Gravel. 10YR 5/8 Yellowish brown. Wet.		
		CH Clay. 10YR 4/1 Dark Gley. High Plasticity. Moist.		
90				
		CH same as above		
100				
		CH same as above		
110			BENTONITE	
		SP Fine sand. 10YR 6/1 gray. Loose. Dry.		
120				

Created By: WTR

Checked By: JBS

FIELD BOREHOLE LOG

BOREHOLE NO.: MW-252
TOTAL DEPTH: 151

Depth	Soil Symbol	Soil Description	Well Completion	Well Description
		SP Fine sand. 10YR 6/1 gray. Moist.	SAND PACK	
130		**SP** Fine sand with some silt. 10YR 5/1 Gray. Wet.	131.12 -ft.	
140		**SP** same as above	SCREEN	
		SP Fine sand. 10YR 7/6 Yellow. Wet.	END CAP	
150		**SP** Fine sand with clay lenses. 10YR 6/2 light brownish gray. Loose. Wet.		
		End of Log		
160				
170				
180				

Created By: WTR
Checked By: JBS

HDR | eM

FIELD BOREHOLE LOG

BOREHOLE NO.: MW-253
TOTAL DEPTH: 157

PROJECT INFORMATION

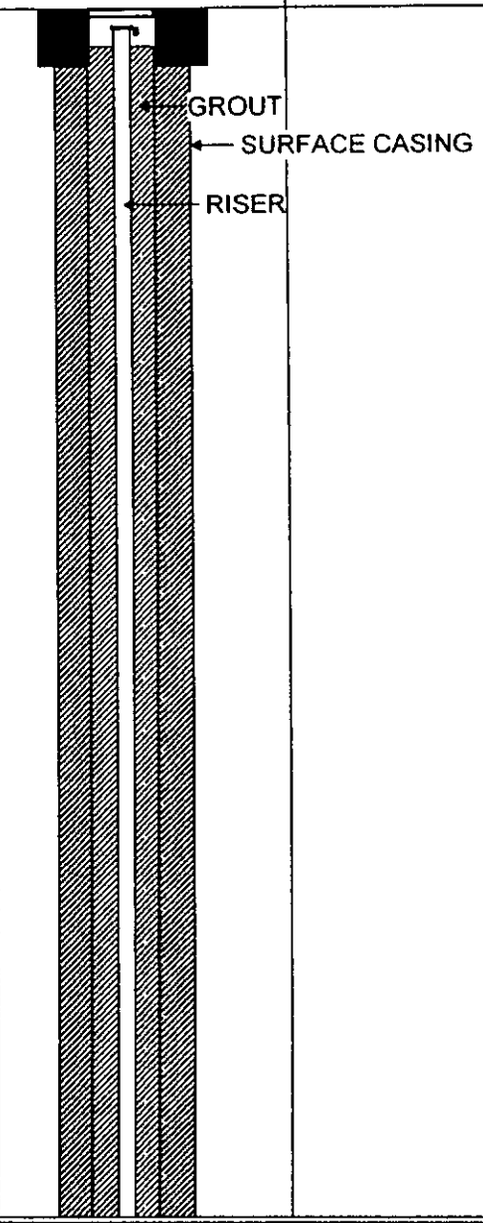
PROJECT: IAQ Drilling
PROJECT NO.: 121803-008
SITE LOCATION: DDMT-MI
PROJECT MANAGER: T. Holmes
FIELD STAFF: J. Sperry
BOREHOLE STARTED: 6/4/2010
BOREHOLE FINISHED: 6/9/2010

DRILLING INFORMATION

DRILLING CO.: Boart Longyear
DRILLER: Thomas Ardito
DRILLING METHOD/RIG: Sonic
BOREHOLE DIAMETER: 6x10 and 3x5
GROUND SURFACE ELEVATION: 290.8
WATER DEPTH/ DATE: 117.87 6/21/2010
BOREHOLE USE: Monitoring Well

NOTES:

Depth	Soil Symbol	Soil Description	Well Completion	Well Description
		ML Clayey Silt.10YR 4/4 Dark Yellowish Brown. Low Plasticity. Dry		
10		**ML** same as above.		
20		**CL** Silty Clay. 10YR 4/4 Dark Yellowish Brown. Low Plasticity. Dry		
		CL Silty Clay. 10YR 4/4 Dark Yellowish Brown with Orange Mottles . Low Plasticity. Dry		
30		**SM** Silty Sand. 10YR 5/2 Grayish Brown. Loose. Moist		
		SW Silty Sand. 10YR 5/6 Yellowish Brown. Trace Gravel. Moderately Consolidated. Moist		
40		**SP** Fine Sand. 5YR 5/8 Yellowish Red. Loose. Moist		
		SM Silty Sand. 10YR 5/8 Yellowish Brown. Trace Gravel. Loose. Moist		
50		**SP** Fine Sand. 10YR 5/6 Yellowish Red. Loose. Moist		
		SW Medium Sand. 10YR 6/6 Brownish Yellow. Loose. Moist		
60				



Created By: WTR
Checked By: JBS

FIELD BOREHOLE LOG

BOREHOLE NO.: MW-253

TOTAL DEPTH: 157

Depth	Soil Symbol	Soil Description	Well Completion	Well Description
		SW Fine to Medium Sand. 7.5YR 6/8 Medium Yellow. Loose. Moist		
		SW Fine to Coarse Sand. 10YR 5/8 Yellowish Brown. Some Gravel. Loose. Moist		
70		**SP** Fine Sand. 10YR 8/4 Very Pale Brown. Loose. Dry.		
		SW Fine to Coarse Sand. 10YR 5/8 Yellowish Brown. Some Gravel. Loose. Moist		
80		**SW** Fine to Coarse Sand. 10YR 5/6 Yellowish Brown. Trace Gravel. Loose. Moist		
90		**SW** same as above.		
		SW Fine Sand. 10YR 8/4 Very Pale Brown. Stiff. Wet.		
100		**SM** Silty Sand. 10YR 4/4 Dark Yellowish Brown. Trace Gravel. Loose. Moist		
		SP Medium to Fine Sand. 10YR 8/3 Very Pale Brown. Loose. Wet	BENTONITE	
110		**CH** Clay. 10YR 5/1 Grey. Stiff. Moist	SAND PACK	
		CH same as above.	117.87-ft.	
120		**CH** Clay. 10YR 5/1 Grey. Highly Plastic. Moist		

Created By: WTR

Checked By: JBS

HDR | eM

FIELD BOREHOLE LOG

BOREHOLE NO.: MW-253

TOTAL DEPTH: 157

Depth	Soil Symbol	Soil Description	Well Completion	Well Description
130		**SP** Sand with some Clay. 10YR 6/3 Pale Brown. Moist. Loose	SCREEN	
		SP Sand with some Clay. 10YR 6/3 Pale Brown. Moist. Loose		
		SP Sand with some Clay. 10YR 6/3 Pale Brown. Wet. Loose		
140		**CH** Clay. 10YR 5/1 Grey. Highly Plastic. Moist	END CAP	
150		**CH** same as above.		
		End of Log		
160				
170				
180				

Created By: WTR

Checked By: JBS

Appendix B

Well Installation Diagrams

HDR | e2M

WELL INSTALLATION DIAGRAM

WELL NO.: MW-252

PROJECT: IAQ Drilling
PROJECT NUMBER: 121803-008
SITE LOCATION: DDMT-MI
e2M PROJECT MANAGER: Tom Holmes
e2M FIELD STAFF: B. Sperry
DATE COMPLETED: 6/7/2010
WELL LOCATION: DDMT-MI

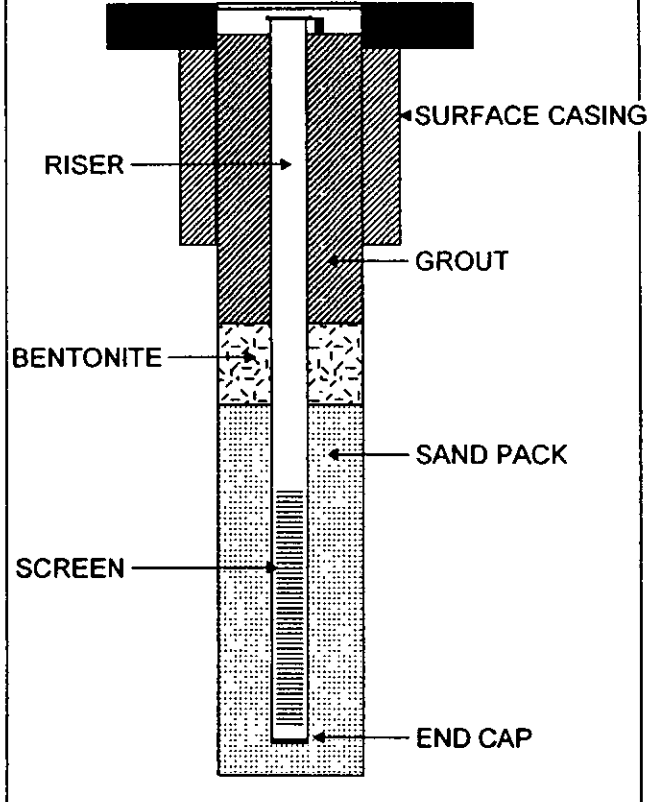
NORTHING: 278789.21
EASTING: 801364.7
GROUND SURFACE ELEVATION (ft, msl): 294.4
TOP OF CASING ELEVATION (ft, msl): 294.16
TOP OF SCREEN ELEVATION (ft, msl): 168.36

DRILLING CO.: Boart Longyear
DRILLING METHOD: Sonic
BOREHOLE DIAMETER (in): 6x10 and 3x5
SURFACE COMPLETION: Flush Mount
BOLLARDS: Yes
WELL DIAMETER (in): 2
TYPE OF SCREEN/RISER MATERIAL: PVC Schedule 80
SLOT SIZE OF SCREEN: 0.010 inch

TYPE OF FILTER PACK: Sand
GRADATION OF FILTER PACK: 8/16
QUANTITY OF FILTER PACK: 9-50 lb. Bags
TYPE OF BENTONITE IN SEAL: Medium
QUANTITY OF BENTONITE IN SEAL: 1.5-50 lb. Bags
TYPE OF GROUT: Portland Cement with bentonite powder
QUANTITY OF GROUT: 16-94 lb. Bags
DEVELOPMENT METHOD: Surge and pump (Waterra)
DATE DEVELOPED: 6/14 6/15/2010
DEPTH TO WATER (ft.btoc): 131.12 on 6/21/2010

NOTES: 6-inch Schedule 80 PVC surface casing installed to depth of 97.5 feet bgs, approximately 10 feet into the clay at the base of the fluvial aquifer.

Well Completion (Not to Scale)



Well Details

DIMENSIONS OF CONCRETE PAD: 3 x 3

SURFACE CASING: 97.5

LENGTH OF RISER (ft): 125.8

DEPTH TO TOP OF BENTONITE (ft, bgs): 112

DEPTH TO TOP OF SAND PACK (ft, bgs): 120

LENGTH OF SCREEN (ft): 20

LENGTH OF END CAP: 0.6

TOTAL DEPTH OF WELL (ft, btoc): 146

TOTAL DEPTH OF BORING (ft, bgs): 151

Prepared by: WTR **Date: 6/21/2010** **Checked by: JBS** **Date: 6/21/2010**

HDR | e2M

WELL INSTALLATION DIAGRAM

WELL NO.: MW-253

PROJECT: IAQ Drilling
PROJECT NUMBER: 121803-008
SITE LOCATION: DDMT-MI
e2M PROJECT MANAGER: Tom Holmes
e2M FIELD STAFF: B. Sperry
DATE COMPLETED: 6/9/2010
WELL LOCATION: DDMT-MI

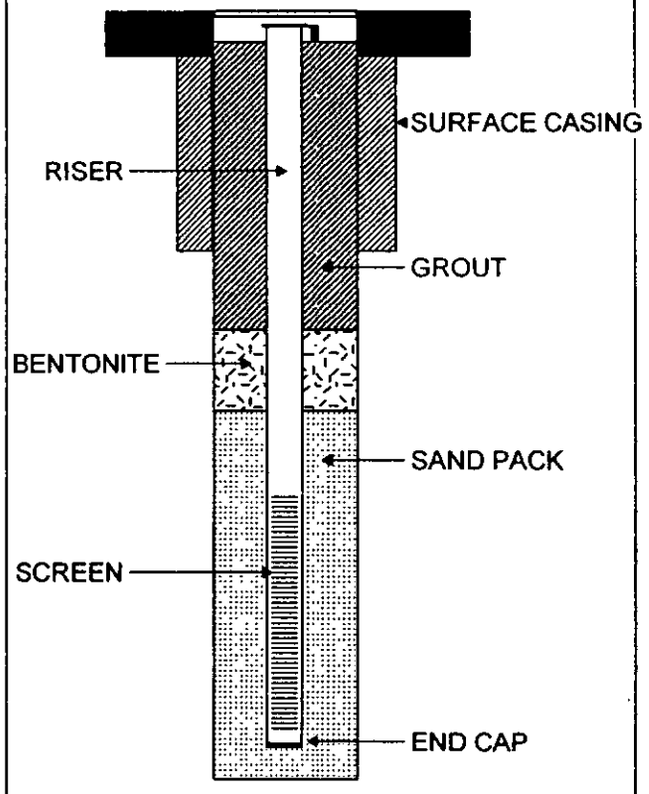
NORTHING: 278287.43
EASTING: 801191.424
GROUND SURFACE ELEVATION (ft. msl): 290.8
TOP OF CASING ELEVATION (ft. msl): 290.47
TOP OF SCREEN ELEVATION (ft. msl): 172.47

DRILLING CO.: Boart Longyear
DRILLING METHOD: Sonic
BOREHOLE DIAMETER (in): 6x10 and 3x5
SURFACE COMPLETION: Flush Mount
BOLLARDS: Yes
WELL DIAMETER (in): 2
TYPE OF SCREEN/RISER MATERIAL: PVC Schedule 80
SLOT SIZE OF SCREEN: 0.010 inch

TYPE OF FILTER PACK: Sand
GRADATION OF FILTER PACK: 8/16
QUANTITY OF FILTER PACK: 12-50 lb. Bags
TYPE OF BENTONITE IN SEAL: Medium
QUANTITY OF BENTONITE IN SEAL: 1.5-50 lb. Bags
TYPE OF GROUT: Portland Cement with bentonite powder
QUANTITY OF GROUT: 25-94 lb. Bags
DEVELOPMENT METHOD: Surge and pump (Waterra)
DATE DEVELOPED: 6/16/2010
DEPTH TO WATER (ft.btoc): 117.87 on 6/21/2010

NOTES: 6-inch schedule 80 PVC surface casing installed to depth of 117 feet bgs, approximately 10 feet into the clay

Well Completion (Not to Scale)



Well Details

DIMENSIONS OF CONCRETE PAD: 3 x 3
SURFACE CASING: 117
LENGTH OF RISER (ft): 118
DEPTH TO TOP OF BENTONITE (ft. bgs): 103
DEPTH TO TOP OF SAND PACK (ft. bgs): 111
LENGTH OF SCREEN (ft): 19.6
LENGTH OF END CAP: 0.6
TOTAL DEPTH OF WELL (ft. btoc): 138.2
TOTAL DEPTH OF BORING (ft. bgs): 157

Prepared by: WTR **Date: 6/21/2010** **Checked by: JBS** **Date: 6/21/2010**

Appendix C

Results of Laboratory Analyses

TABLE C-1
ANALYTICAL RESULTS
INTERMEDIATE AQUIFER WELL INSTALLATION
Main Installation - Defense Depot Memphis, Tennessee

	Well ID	MW-252	MW-253
	Lab ID	L10060573-01	L10060573-02
	Date	6/18/2010	6/18/2010
Analyte	Units		
1,1,1,2-Tetrachloroethane	ug/L	<0 5	<0 5
1,1,1-Trichloroethane	ug/L	<1	<1
1,1,2,2-Tetrachloroethane	ug/L	<0.5	<0.5
1,1,2-Trichloroethane	ug/L	<1	<1
1,1-Dichloroethane	ug/L	<1	<1
1,1-Dichloroethene	ug/L	<1	<1
1,1-Dichloropropene	ug/L	<1	<1
1,2,3-Trichlorobenzene	ug/L	<1	<1
1,2,3-Trichloropropane	ug/L	<1	<1
1,2,4-Trichlorobenzene	ug/L	<1	<1
1,2,4-Trimethylbenzene	ug/L	<1	<1
1,2-Dibromo-3-chloropropane	ug/L	<2	<2
1,2-Dibromoethane	ug/L	<1	<1
1,2-Dichlorobenzene	ug/L	<1	<1
1,2-Dichloroethane	ug/L	<0.5	<0.5
1,2-Dichloropropane	ug/L	<1	<1
1,3,5-Trimethylbenzene	ug/L	<1	<1
1,3-Dichlorobenzene	ug/L	<1	<1
1,3-Dichloropropane	ug/L	<0.4	<0 4
1,4-Dichlorobenzene	ug/L	<0.5	<0.5
1-Chlorohexane	ug/L	<1	<1
2,2-Dichloropropane	ug/L	<1	<1
2-Chlorotoluene	ug/L	<1	<1
2-Hexanone	ug/L	<10	<10
4-Chlorotoluene	ug/L	<1	<1
Acetone	ug/L	<10	<10
Benzene	ug/L	<0.4	<0 4
Bromobenzene	ug/L	<1	<1
Bromochloromethane	ug/L	<1	<1
Bromodichloromethane	ug/L	<0.5	<0.5
Bromoform	ug/L	<1	<1
Bromomethane	ug/L	<1	<1
Carbon disulfide	ug/L	<1	<1
Carbon tetrachloride	ug/L	<1	<1
Chlorobenzene	ug/L	<0.5	<0 5
Chloroethane	ug/L	<1	<1
Chloroform	ug/L	<0.3	0.156 F
Chloromethane	ug/L	<1	<1
cis-1,2-Dichloroethene	ug/L	<1	<1
cis-1,3-Dichloropropene	ug/L	<0.5	<0.5
Dibromochloromethane	ug/L	<0.5	<0.5
Dibromomethane	ug/L	<1	<1
Dichlorodifluoromethane	ug/L	<1	<1
Ethylbenzene	ug/L	<1	<1
Hexachlorobutadiene	ug/L	<0.6	<0 6
Isopropylbenzene	ug/L	<1	<1
m-,p-Xylene	ug/L	<2	<2
MEK (2-Butanone)	ug/L	<10	<10
Methyl t-butyl ether (MTBE)	ug/L	<5	3.71 F
Methylene chloride	ug/L	<1	<1
MIBK (methyl isobutyl ketone)	ug/L	<10	<10
Naphthalene	ug/L	<1	<1
n-Butylbenzene	ug/L	<1	<1
n-Propylbenzene	ug/L	<1	<1
o-Xylene	ug/L	<1	<1
p-Isopropyltoluene	ug/L	<1	<1
sec-Butylbenzene	ug/L	<1	<1
Styrene	ug/L	<1	<1
tert-Butylbenzene	ug/L	<1	<1
Tetrachloroethene	ug/L	<1	<1
Toluene	ug/L	<1	<1
trans-1,2-Dichloroethene	ug/L	<1	<1
trans-1,3-Dichloropropene	ug/L	<1	<1
Trichloroethene	ug/L	<1	0.344 F
Trichlorofluoromethane	ug/L	<1	<1
Vinyl chloride	ug/L	<1	<1

NOTES:
VOC samples analyzed using method 8260B
ug/L : micrograms per liter
<: Not detected at sample reporting limit
DQE FLAGS:
F: Concentration estimated below RL and above the MDL

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE