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NSWC CRANE
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Date: 28 June, 1990

To: Jeffrey Ciocco
JAC/1422
Northern Division
Naval Facilities Engineering Command
Philadelphia, PA 19112-5094

Jeff:

Enclosed is a copy of the final Work Plan for the Phase III ground water RFI for Rockeye (SWMU #10/15), NWSC Crane. Two copies have been forwarded to Crane (Hunsicker) with instructions to send one to EPA Region V, Carol Witt.

Bill Murphy

W.L. Murphy
USAEWES GG-YH

Corrective Action Work Plan
RCRA Facility Investigation Phase III
Release Characterization, Ground Water
Rockeye, SWMU #10/15, NWSC Crane

1. Task A: RFI Phase III Work Plan.

a. RFI Phase III Project Management Plan

The Waterways Experiment Station (USAEWES) will perform a RCRA Facility Investigation (RFI) Phase III Release Characterization for Ground Water at SWMU # 10/15 for the Naval Weapons Support Center (NWSC) Crane, Indiana at the Rockeye Solid Waste Management Unit (SWMU), also known as Corrective Action Plan (CAP) Site Number 10/15 (Figure 1). This document outlines the objectives of the RFI, discusses the technical approach, quality assurance/quality control measures, and personnel to be used in the RFI, and provides a schedule of work to be performed.

Objective. The objective of the Phase III work is to determine the rate and extent of migration of hazardous waste or hazardous constituents in the ground water. Phase III work will also further define groundwater flow patterns, identify affected aquifers at the site, and describe the hydrogeology at the site.

Technical Approach. Ground water monitoring wells will be installed, exploratory borings emplaced, and other subsurface investigations conducted to characterize ground water flow and the extent of contamination. Only two to four additional wells may be needed because of the large number of wells which have already been installed in support of the Phase III effort. Site specific conditions of contaminant distribution, to be evaluated from laboratory analysis of ground water quality, will determine what techniques will be used to determine aquifer parameters and the rate of contaminant migration. If pumping tests are needed to determine aquifer parameters, pumping wells and observation wells will be installed. Other options to be considered for determining aquifer parameters include falling head (slug) tests or dye tracer tests. At such time pumping or other tests are deemed necessary, the work plan will be revised and submitted to the EPA for approval.

Quantitative chemical analysis of ground water from existing and proposed monitoring wells will be conducted for specific compounds. Geologic and ground water profiles will be prepared from monitoring well and other data showing the orientation of the subsurface geologic units. Piezometric surface contour maps will be prepared showing direction of flow and lateral extent of contamination. The details of drilling and sampling activities to be conducted during the Phase III work are presented below.

Personnel. Phase III ground-water work will be conducted by WES personnel, other CE personnel, or other contractors working under WES supervision. All personnel working at the site will be trained in personal protection and safety and will have had a comprehensive physical examination within the 12 months preceding their involvement in the field work (see Health and Safety Plan, Part f.) An organizational chart of key personnel is presented in Table 1.

Schedule. The Regional Administrator will approve, modify and approve,

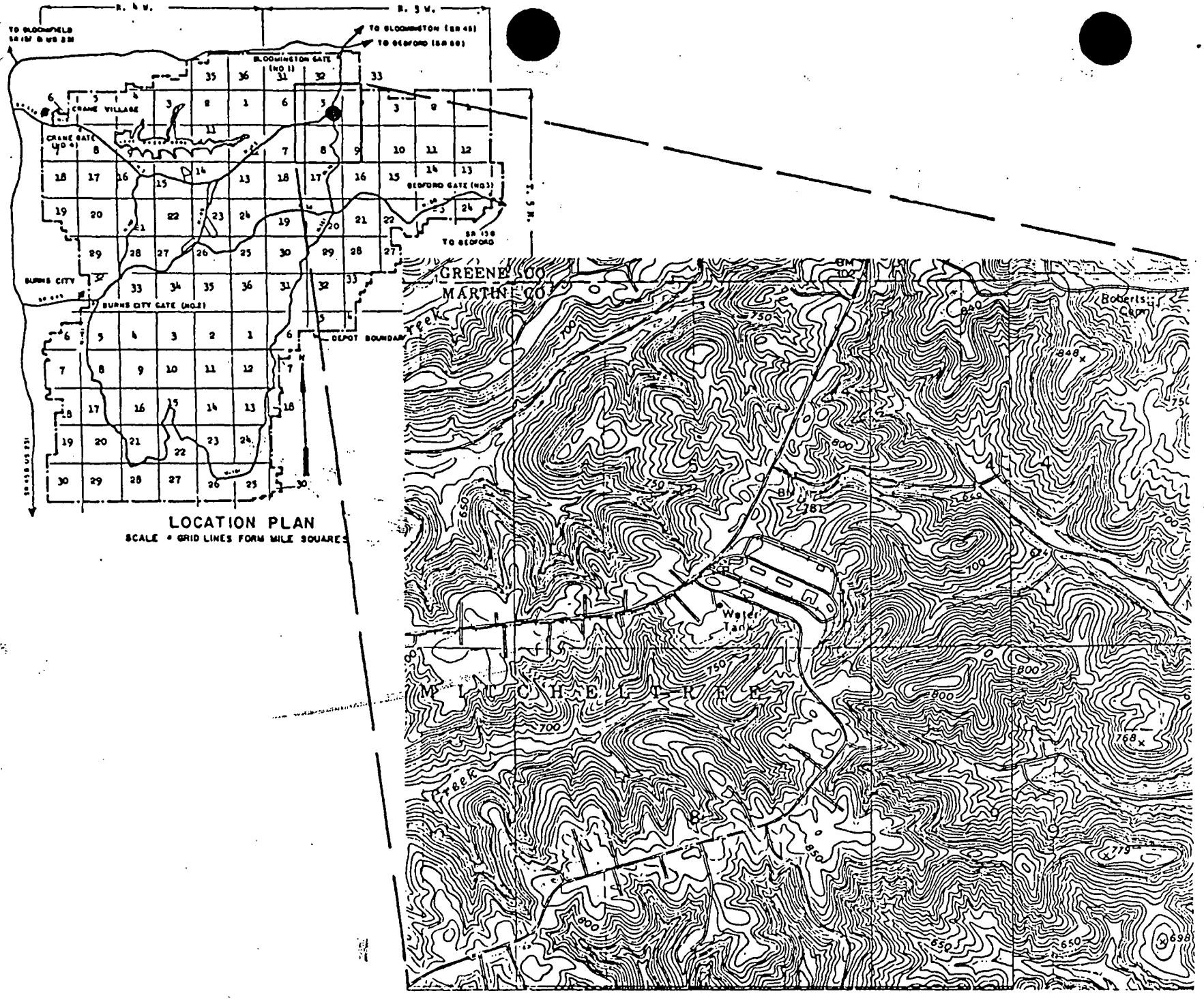
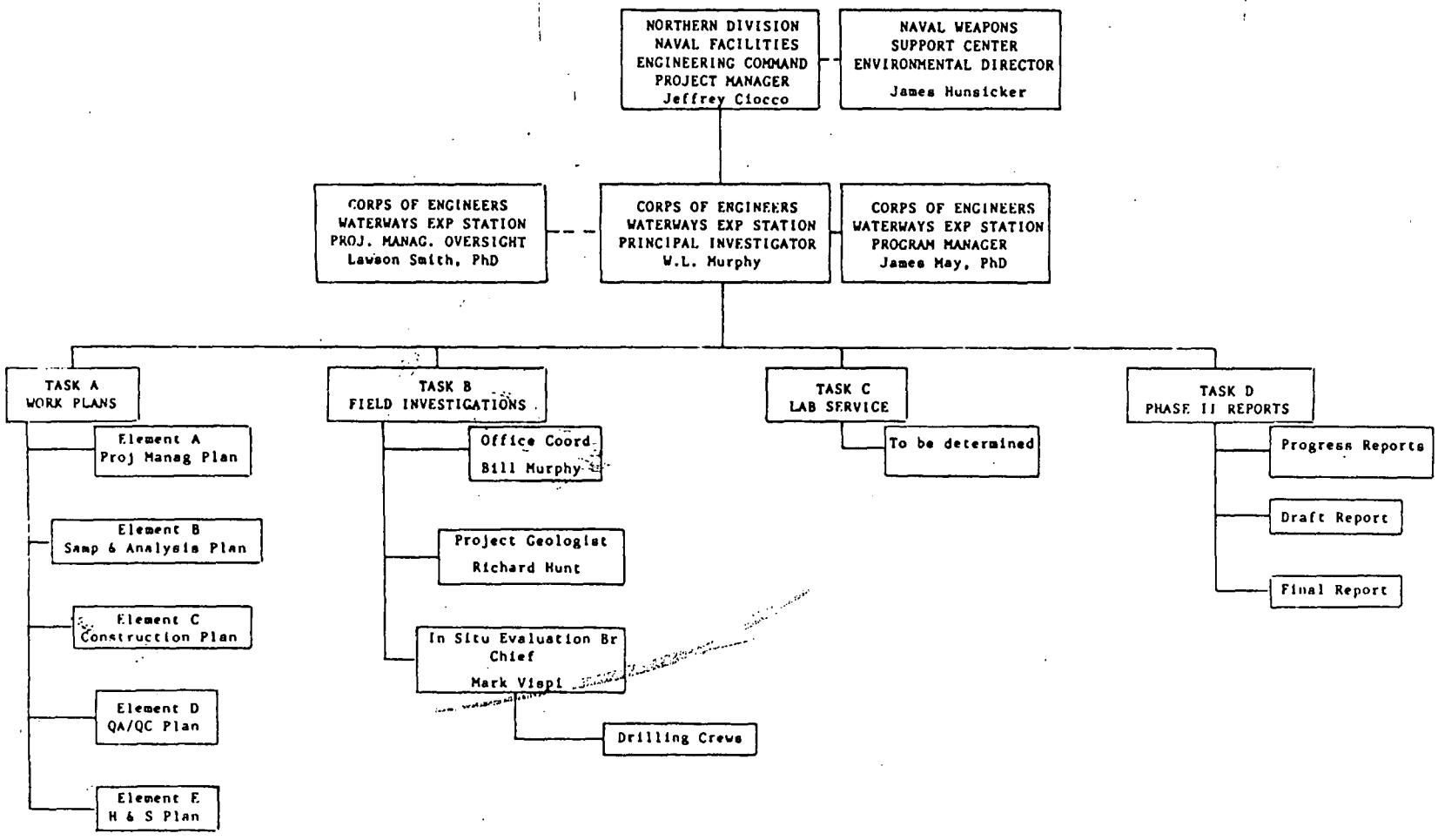


Figure 1. Location of Rockeye Munitions Facility

TABLE 1. RCRA FACILITY INVESTIGATION, PHASE III GROUND WATER
ROCKEYE MUNITIONS FACILITY
PROJECT ORGANIZATION CHART



or disapprove and provide comments to the Permittee as to the corrections or modifications needed for the RFI Phase III Work Plan. Within 30 days after receiving comments from the Regional Office the Permittee will modify or submit a new plan for approval. The Work Plan will be initiated within 45 days after it it has been approved. The results of Phase III ground water work will determine whether Corrective Measures are necessary. Figure 2 is a time-line for the Phase III ground water release characterization at the Rockeye site.

b. RFI Phase III Sampling and Analysis Plan

(1) Sampling Objectives. Sampling of the water in monitoring wells will be designed to determine the presence or absence of specified compounds in the ground water of aquifers underlying and adjacent to the Rockeye area. Monitoring wells will be placed and screened to sample water in discrete ground water zones that are isolated from other ground water zones. Screens will be placed in the uppermost zone encountered and in subsequent zones (using cluster wells) down to the lowermost aquifer determined to be susceptible to water migrating downward from the surface.

Investigations at selected sites provided additional information on conditions at the Rockeye (Hydrogeologic Investigation of Waste Disposal Sites at the Naval Weapons Support Center, Crane Indiana", by Joseph B. Dunbar, USAEWES , April 1982 and " Hydrogeologic Investigation and Definition of Contaminated Ground-Water Plumes at Rockeye Munitions Facility, Naval Weapons Support Center, Crane, Indiana, by the same author. Twenty-two monitoring wells were installed around and near the Rockeye, two in 1981 and twenty in 1983, Figure 3 shows the locations of wells 10-01-81 and 10-02-81, which are located near building 1569 and a tributary to Big Sulphur Creek. Figure 4 shows the location of all of the wells emplaced to date at the Rockeye.

The aquifers beneath the Rockeye site are primarily sandstones of Pennsylvanian age. Well screens from the 1981-1983 wells were set at various depths. Preliminary contouring of water levels as a single aquifer indicated that flow of ground water away from the Rockeye was to the south, east and north, Interpretation of ground water and geological data is underway to further define the position and extent of aquifers and to delineate ground water flow directions and gradient. Water samples from the monitoring wells analyzed for the presence of explosives compounds TNT, RDX and HMX from March 1983 through January 1984 indicated that seven wells were contaminated: 10-02-81, -07-83,- 08-83,- 09-83,- 17-83,- 18-83, and- 20-83 (See Figures 3 and 4). Plume limits at the Rockeye were not defined in the investigations. The investigations concluded that the contamination detected ~~in the wells~~ was the result of an accidental discharge at the Rockeye on 6 July 1983 into a small stream between wells 10-7-83 and 10-8-83. Chemical analyses of well samples for January 85 and February 86 indicated that six of the original seven contaminated wells were still contaminated (well 10-20-83 was not contaminated) and well 10-01-83 was contaminated).

contam. resulted from wastewater from tray + bomblet washing

Eighty one new wells were installed for the Rockeye study by WES in 1988-89. Three aquifers were screened in Pennsylvanian sandstones and one screen was placed in the Beech Creek Limestone at a depth of approximately 280 ft. One round of samples was taken by WES on 26 April 89. Explosives analyzed by the High Performance Liquid Chromatography (HPLC) method were detected in some of the wells but all of the wells were not sampled. Table 2 lists the analytical results of the April 1989 sampling. All of the wells in Table 2 are on the northeast side of the facility. Five rounds of sampling are planned beginning the summer of 1990. The first round will be for Appendix IX contaminants, explosives, and pH and conductivity. Sampling rounds two to five will analyze only for compounds

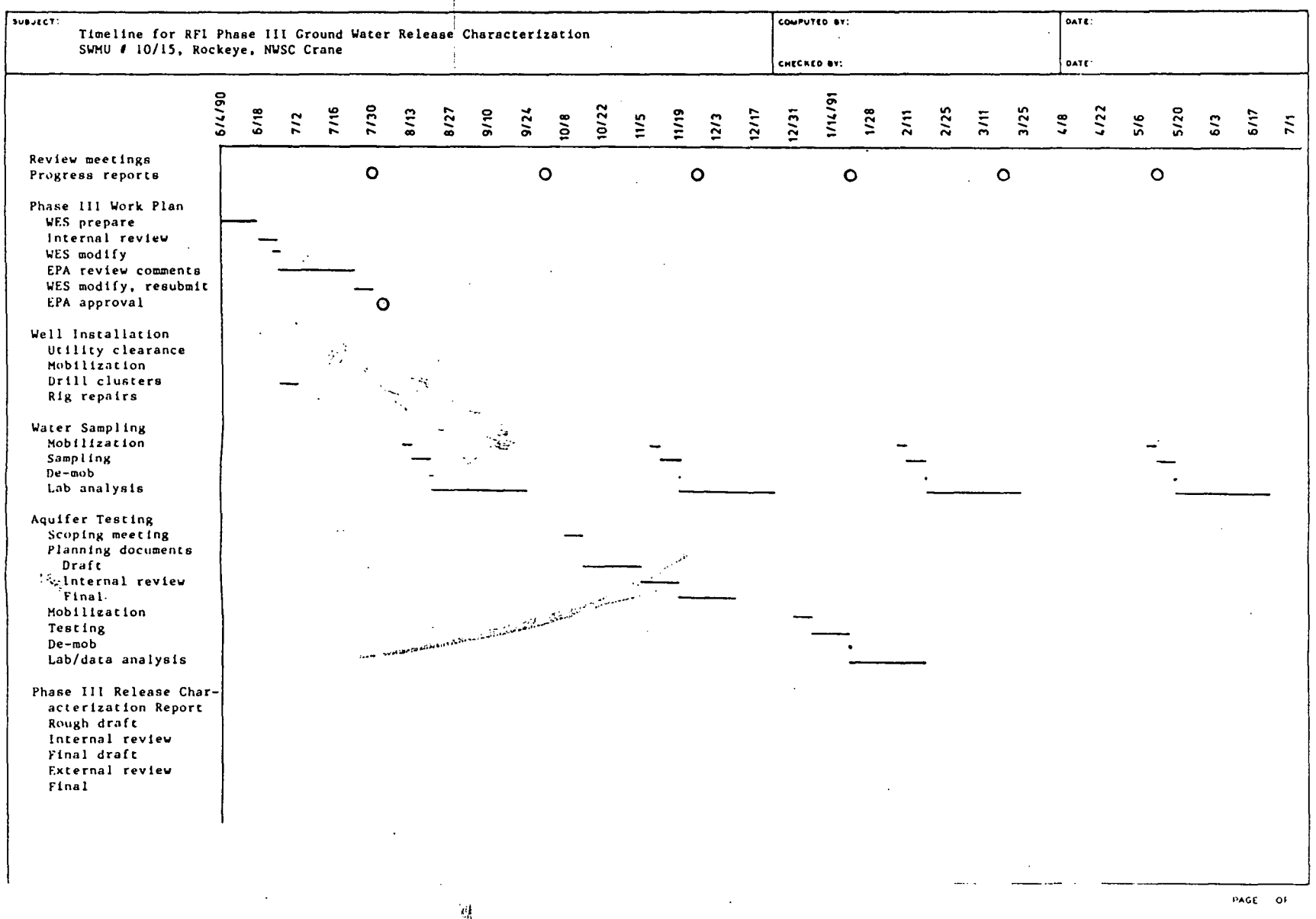


Figure 2. Time-line for Rockeye Ground Water Release Characterization.

SUBJECT: Timeline for RFI Phase III Ground Water Release Characterization
SWMU # 10/15, Rockeye, NWSC Crane (con'd)

COMPUTED BY: DATE:

CHECKED BY: DATE:

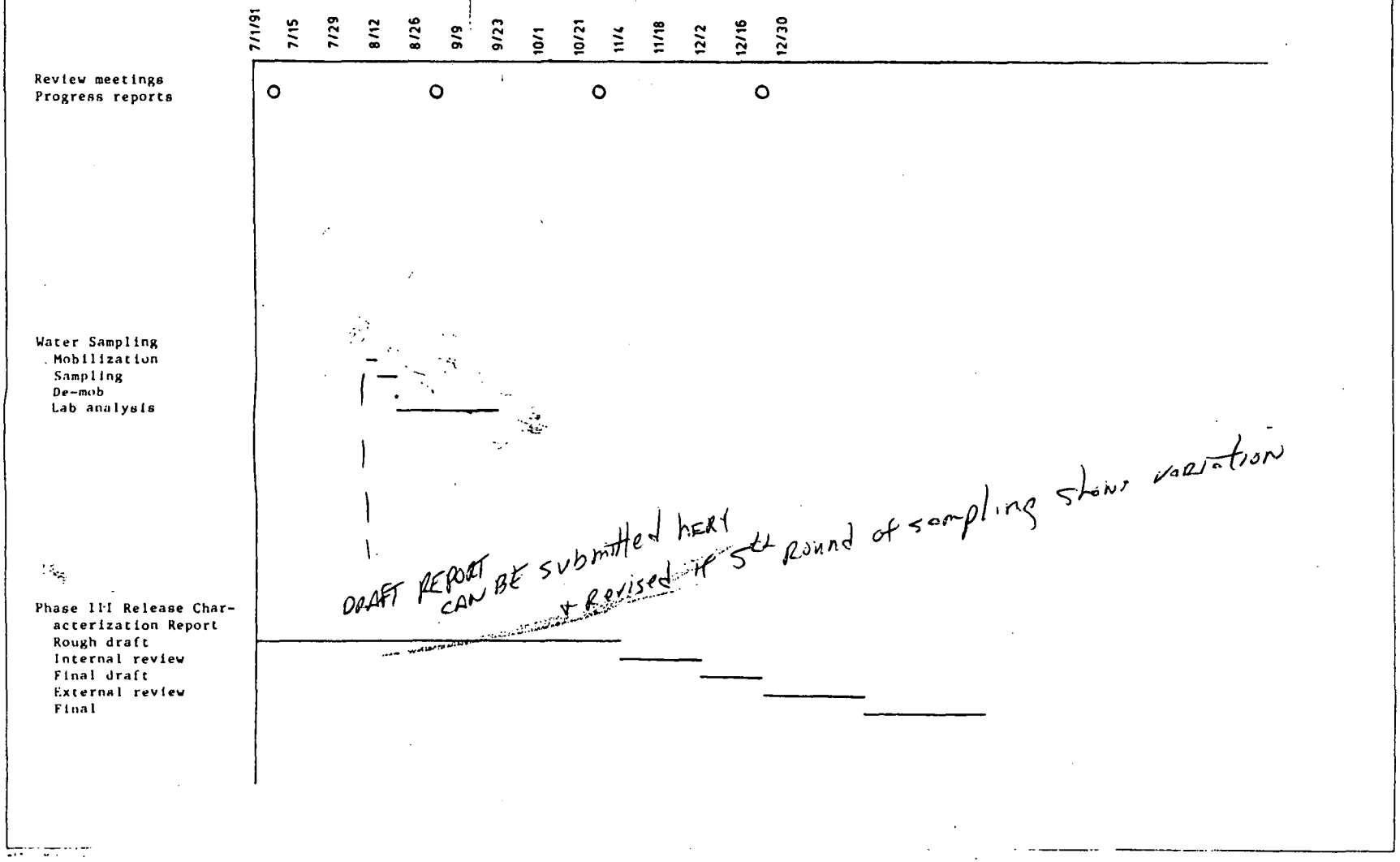


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Figure 2. continued

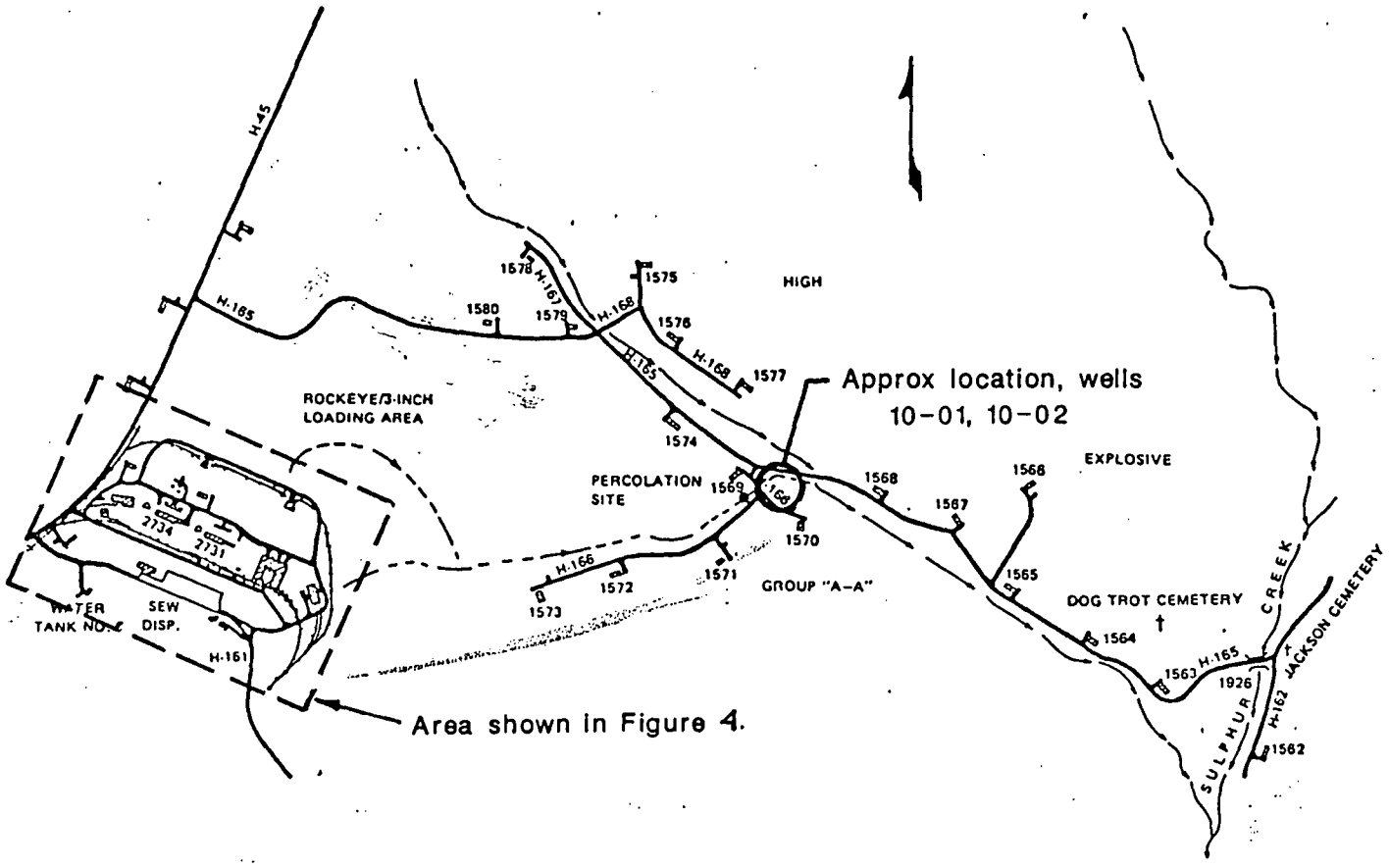

Figure 3. Rockeye facility and surface drainage features.

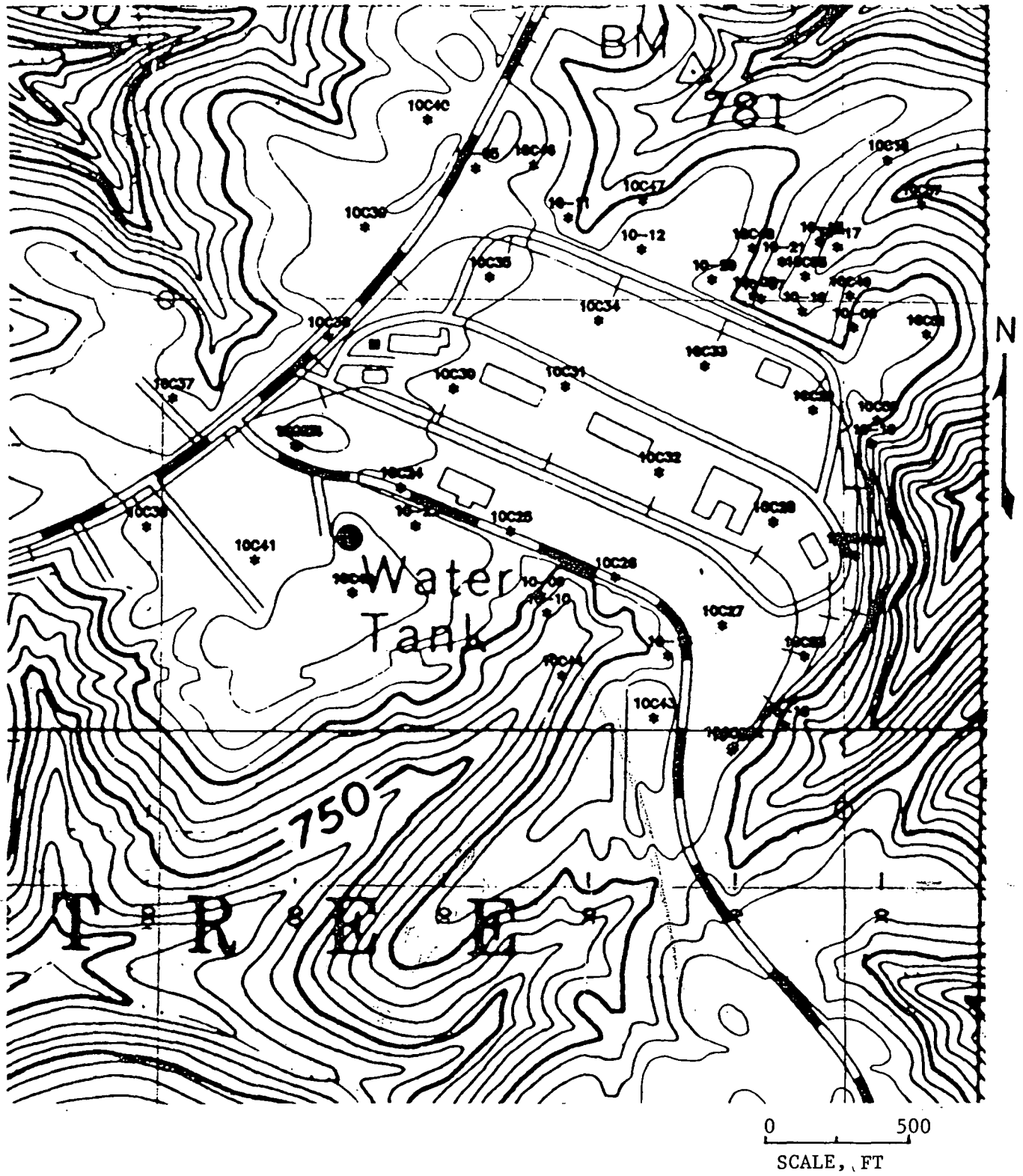

Figure 4. Locations of monitoring wells at Rockeye Munitions Facility. Base map is USGS topographic 7-1/2 min quadrangle, Kolleen, IN.

Table 2. NWSC-CRANE

Well Number	Parameter	First Round Concentration,ppm	Second Round Concentration,ppm
10-01	RDX	0.0234	
	HMX	0.0248	
10-02	RDX	0.0133	
	HMX	0.0244	
	4-AM-DNT	0.0046	
10-07	RDX	0.0830	
	HMX	0.1010	
	4-AM-DNT	0.0150	
	TNT	0.0098	
	2-AM-DNT	0.0150	
10-08	RDX	0.0338	
	HMX	0.0315	
	4-AM-DNT	0.0221	
	TNT	0.0035	
	2-AM-DNT	0.0181	
	TNB	0.0012	
10-17	RDX	1.3900	
	HMX	0.6730	
	4-AM-DNT	0.2060	
	TNT	0.9770	
	2-AM-DNT	0.2180	
	TNB	0.0445	
	24DNTOL	0.0038	
	26DNTOL	0.0285	
10-18	RDX	0.0849	
	HMX	0.1350	
	TNT	0.0038	
	2-AM-DNT	0.0036	

4-AM-DNT 4-AMINO-2,6-DINITROTOLUENE

2-AM-DNT 2-AMINO-4,6-DINITROTOLUENE

24DNTOL 2,4-Dinitrotoluene

26DNTOL 2,6-Dinitrotoluene

detected in the first round. Wells to be sampled in rounds two to five will be selected on the basis of round one results. Two to four more shallow wells will be installed for the Rockeye RFI. Tentative locations for these wells are downgradient to the north of Rockeye and towards Big Sulphur Creek . Many of the requirements for the Phase III Release Characterization have already been accomplished prior to the finalization of this work plan. Remaining tasks include the emplacement of additional wells (if needed), defining aquifers, defining plume limits and aquifer characteristics. Well screens emplaced at the Rockeye are either 5 or 10 ft in length, depending on the thickness of the aquifer being monitored.

There are currently two well clusters at the Rockeye site that are being considered for background wells. They are well clusters 10-C37 and 10-C40. Cluster 10-C37 consists of three wells placed in the Pennsylvanian sandstones and coal at depths of 94, 62 and 35 ft (wells 10-C37, 10-C37P2, and 10-C37P3, resp.). Well cluster 10-C37 is located west of the Rockeye facility. Well cluster 10-C40 consists of four wells, three in the Pennsylvanian and one deep well in the Mississippian Beech Creek limestone. Well cluster 10-C40 is northwest of the facility. Well 10-C40 is in the Beech Creek at 288 ft depth, well 10-C40P2 is in sandstone at 86 ft depth, well 10-C40P3 is in sandstone and coal at 54 ft depth, and well 10-C40P4 is in sandstone at 36 ft depth (all depths are bottom of screened interval). Previous sampling, limited to analysis for explosives, indicated no contamination in these well clusters. As stated above, ground water flow is generally to the north, east and south. For these reasons, cluster 10-C37 or -C40 is likely to suffice as a background cluster. Final determination of background suitability will depend on results of the first round of Appendix IX sampling.

The analysis of hydrogeological data from field mapping and exploration boring and well emplacement at the Rockeye is underway. The hydrogeology will be reported as a section in the report of release characterization, which will include analysis of the laboratory water quality data.

(2) Sampling equipment and containers. Sampling equipment and containers are discussed in Part I of "QA/QC Document for Sampling and Analysis of Ground Water at Crane NWSC, Crane, IN", in preparation pending selection of analytical laboratory.

(3) Analytical parameters and test methods. Analytical methods in general are described in Part II of the accompanying QA/QC document (in preparation). Data validation and reporting will conform to Naval Energy and Environmental Support Activity (NEESA) guidance (reference NEESA 20.2-047B). Table 3 summarizes the sampling requirements of Phase III work. Appendix IX compounds will be analyzed in the first round. Appendix IX compounds and suggested analytical methods are presented in Appendix 1. Specific analytical methods to be used are to be supplied by the laboratory. Explosives compounds to be analyzed by the HPLC method include the compounds TNT (trinitrotoluene), RDX (Hexahydro-trinitro) and HMX (octahydro-tetranitro-tetrazocine). TNT, RDX and HMX have been detected previously in some wells within Crane. Other compounds typically included in the HPLC suite of analyses are TNB (trinitrobenzene), DNB (dinitrobenzene), Tetryl (methyl trinitro phenyl nitramine), and DNT (dinitrotoluene).

(4) Sample Types. Well placement and water sampling at the ORR will be biased because of the previous work at the site. The deep boring at each cluster site will be continuously cored to obtain samples necessary to interpret

Table 3. Phase III Ground-Water Sampling Summary, Rockeye Munitions Facility

PARAMETER	SAMPLES	FIELD DUPS	QC BLANKS		
EQUIP.RINSATE	(103 wells)	(10% of Samples)	Trip Blnks 1/day	Field Blnks 1/day	1/day
Appendix IX	103	10	3 (volatiles)	1	3
Explosives by HPLC	103	10			
Group III					
pH (quad)	412				
Conductivity (quad)	412				

the subsurface geology (stratigraphy, hydrology, structure and lithology).

(5) Sample locations, depths and frequency. No more than four new well clusters are planned for the Phase III Investigation. There will be at least two wells per cluster. In general a 10-foot screen will be installed at the base of the aquifer being tested. If necessary a third screen may be installed at a particular cluster site if additional permeable zones are encountered.

As discussed earlier, the majority of the drilling and soil sampling for the Phase III effort has been completed. Water quality samples will be collected in five consecutive rounds on a quarterly frequency as required by the CAP. The first round of samples will be tested for Appendix IX contaminants and explosives.

(6) Sampling schedule. The ground water sampling schedule will depend on the date of implementation of the Phase III work plan. The time line for Rockeye Phase III ground water release characterization is presented in Figure 2.

(7) Sampling procedures. Monitoring well sampling procedures will be described in detail in B.1.d of the QA/QC document. Soil and rock sampling will be conducted from a truck-mounted rotary drilling rig. Rock cores will be collected continuously using a diamond-bit HQ wireline core barrel (HQ wireline retrieves a 2-1/2 in. diameter core from a 3-3/4 in. diameter borehole) The wireline coring technique has been shown to be effective in obtaining high quality core during previous drilling / sampling work at Crane.

Drilling water is currently taken from the water treatment plant at the Crane installation, which draws its potable water from Lake Greenwood, located within the NWSC boundaries. Prior to the start of drilling, the drill rig and appurtenances will be steam-cleaned. Drill cuttings will be removed from the boring by circulating clean water from a steel mud pan sealed around the boring top to prevent contamination of the subsurface from surface runoff. The mud pan will be cleaned and refilled periodically as conditions warrant. In borings penetrating more than one aquifer the upper zones will be sealed before the boring is advanced. PVC casing will be grouted 3 to 5 ft. into the confining stratum at the base of the aquifer and allowed to set overnight before advancing the boring. The boring will then be advanced through the upper casing and grouted. Smaller casing will be set for drilling the next aquifer.

(8) Rationale for sampling location and choice of analytes. The locations of the new well clusters will be based on the previous work at the Rockeye as described above. The first round samples will be tested for Appendix IX contaminants and explosives.

(9) Environmental conditions at the time of sampling. Environmental conditions at the Rockeye are affected by potential release to the air of contaminants released by boring operations. The presence of volatile organic compounds in the air at the drill locations will be continuously monitored using a photoionization organic vapor detector and a combustible gas detector. Dust will not be released by drilling operations because drilling is done with water. The majority of the drilling has already been completed.

(10) Chain-of-custody forms and procedures. Chain-of-custody will be described in the QA/QC document, Section d.

(11) Decontamination Procedures. Decon procedures for water sampling are

described in detail in Part I of the accompanying QA/QC document. Decontamination of the drilling and coring equipment will consist of steam cleaning the drilling rig and appurtenances before start of a new boring. In addition, the down-hole equipment such as drill rods, rock bits, and core barrels will be steam cleaned after sealing of a ground-water zone and before advancing through the aquiclude to the next aquifer.

(12) Documentation. Ground-water sampling logs will be kept as described in the QA/QC document. Soil and rock sampling logs will be kept for each borehole and well as the borehole is advanced. Figures 5,6 and 7 are examples of soil sampling, rock sampling, and well installation logs typically prepared during field operations. All sampling activities, methods, and analytical results will be presented in written reports at the end of the RFI for the Rockeye.

(13) Calibration of field devices. Calibration of the air-monitoring devices is described in the Health and Safety Plan (part f. of this document).

(14) Sample preservation. Ground-water sample preservation methods are described in the QA/QC document. Soil and rock core samples collected for geologic analysis are stored in lidded jars and wooden core boxes respectively.

c. RFI Phase III Construction Plan.

(1) Objective of Construction of Monitoring/ Sampling Wells. Additional monitoring wells may be installed in and around the Rockeye to provide monitoring of ground-water and samples for chemical analysis. Wells also provide access to aquifers for determining the aquifer parameter needed to calculate the rate and extent of contaminant movement. Wells will be positioned to define and intercept contaminant transport paths and to describe and monitor flow away from the Rockeye. Wells will be constructed with materials and methods designed to prevent addition of contaminants to the well environment and cross-contamination of individual aquifers.

(2) List of equipment. Drilling of all well borings will be with a truck-mounted Failing 1500 hydraulic drill rig or equivalent. Flight augers or hollow stem augers will advance the hole through soil overburden until rock is encountered. Diamond-impregnated HQ-sized wireline core bit and barrel will drill and retrieve the core samples. Standard rotary rock bits will be used to advance the boring in a non-sampled borehole (only the first and deepest well boring of a cluster of wells is cored and logged). A stainless steel bailer will be used to develop the well after the screen and casing are emplaced and grouted

(3) Construction Materials. The well riser pipe will consist of standard 2-in I.D. Schedule 40 PVC flush-fit threaded casing. Well screen will consist of 5-or 10-ft.lengths of 2-in, 0.020-in slotted PVC. Aquifer zones will be sealed off and casing emplaced using Portland cement with a bentonite seal. Siliceous coarse sand, certified clean and shipped to the site in sealed bags, will be used to fill the annulus around the screen in the aquifer zones and serve as a filter pack for the well.

(4) Construction locations. Locations and depths of wells were presented in section b. (5) of this document.

(5) Construction schedule. Well installation is effectively complete. As

Hole No. WES-3-VFC-87

DRILLING LOG	DIVISION US Navy	INSTALLATION NWSC	SHEET 1 OF 1 SHEETS
1. PROJECT Hydrogeologic Studies, ABG		10. SIZE AND TYPE OF BIT 7" Splitspoon + Auger	
2. LOCATION (Coordinates or Station) ABG Valley Fill		11. DATUM FOR ELEVATION (SHOWN ITEM 6 HOLE)	
3. DRILLING AGENCY WES		12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500	
4. HOLE NO. (As shown on drawing title and file number) 3-VFC		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER Dan Taylor		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 6/23/87 / COMPLETED 6/23/87
7. THICKNESS OF OVERBURDEN 7.5		17. ELEVATION TOP OF HOLE 581.5	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 7.5		19. SIGNATURE OF INSPECTOR Geologist R.W. Hunt	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Clayey silt, w/ss pebbles + frags, mid Br, firm, sli moist dry		1	Samples were put in qt Jars
	1				1.5	
	2				2	
	3				3.0	
			Increase in ss frags below 3.0', + moist		3	
	4		Blk coal? flakes between 4.0 + 4.5		4.5	
	5		Weathered Big cliffy ss w/ silty clay + clayey silt in eroded open jts, moist		4	
	6				6.0	
	7				7.5	
	8		Est. Depth 7.5' (Refusal on Top of Big cliffy ss)			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Figure 5

Hole No. WES-3-C1-86

DRILLING LOG	DIVISION US Navy	INSTALLATION Crane In	SHEET 1 OF 10 SHEETS
1. PROJECT NWSC Groundwater Study		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station) ABG Geologic Studies		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY WES		12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500	
4. HOLE NO. (As shown on drawing title and file number) WES-3-C1-86		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED	
5. NAME OF DRILLER Don Taylor		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE: STARTED Aug 2 1986 / COMPLETED Sept 29 1986	
7. THICKNESS OF OVERBURDEN 4.2'		17. ELEVATION TOP OF HOLE ~~[illegible]~~ 624.8	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 197.2		19. SIGNATURE OF ~~[illegible]~~ Geologist Richard W. Hunt	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Ls rk surface (work area)			Started Sampling w/an 8" dia Jetting Auger
	1		clayey Silt, (ml-cl) yBr - rBr, w/rk frags, firm - v firm,			
	2					
	3					
	4					Set 6" dia casing to 4.3' (steel)
	5		Sandstone, yBr & lGr, Fine grained cross bedded, wea to oxidized, occ soft clay lens, numerous random fractures that are tight to partially open and coated w/ manganese, few frac have a clay filling. Frac are rough & irregular. (Fractures are shown in legend w/ amount of dip)	Run 1		Started coring w/ 4 x 5½" dia. Core bbl at 4.2' SS is either Hardinburg or (Penn)
	6			4.6/5.0		Core Recovery / Run length
	7		sdy silty, gnGr	(3.4)		Core loss (or go...)
			clay, gnGr, calcareous veins			
	8		clay lens			
						Contact - 8.7' Golconda Fm
	9		Shale, olive Gr & yBr, ml bd, flsky, wea (mostly ground away)	9.2 Run 2		
	10		Limestone, brGr, v hard crystalline, Fossils	2.4/2.2 (0.8)		Core bbl started [illegible]

PROJECT | HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

Figure 6

DRILLING LOG	Division	INSTALLATION	SHEET OF SHEETS
1. PROJECT: WELL INSTALLATION		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number): WES 23-C1-86		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED	
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE: STARTED / COMPLETED	
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-C1-E6 (Beaver Creek LS)			Date well screen was set: 12/12/86
627.5			+2.7			
624.8			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting Screen – 109.2' Note: small amount of water was leaking around casing the. ial over seated in the Elwren Shale at the time of drilling the well. Higher than normal water level was due to this leakage from the Beach Creek LS.
			160.0'			
			Bentonite Pellets			
			162.0			
			Filter Pack			
450.8			174.0'			
			Well Screen			
440.8			184.0			
			Trap			
			185.0'			
			187.2' Boring Depth			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) PROJECT HOLE NO.

Figure 7

explained above, results of ground water sampling and analysis may lead to installation of 2 to 4 additional shallow wells to the northeast of the site.

(6) Construction Procedures. Wells will be bored and emplaced in the following manner. Prior to the start of drilling and between setups at each of the boring sites the drill rig and drilling tools will be steam cleaned. The soil zone in each of the core borings will be sampled with a folding auger or hollow-stem auger down to refusal (top of rock). If the depth to refusal is less than approximately 11 ft. (the depth needed to start coring with the HG wire line core barrel), a 2-ft-long NX core barrel will be used to sample the rock to 11 ft. Remaining cores will be obtained with the wireline rig. A surface casing will be installed from approximately 6 inches above the ground surface to just below top of rock to prevent caving of the soil portion of the boring and to serve as surface protection. The surface casing will consist of 8-or 10-in casing as needed and will extend well below the freeze depth.

Drill cuttings will be removed by circulating clean water in a steel mud pan sealed around the surface casing. The mud pan will be cleaned and refilled from the water truck as necessary. In borings penetrating more than one aquifer, the upper aquifer will be sealed off before advancing the boring. PVC casing will be grouted a few feet into the aquiclude stratum (usually shale) underlying the upper zone and allowed to set overnight. Down-hole drilling equipment will be steam-cleaned before advancing into the next aquifer zone. In well borings penetrating three aquifer zones, typically an 8-in surface casing will be followed by 6-in casing in the next deeper zone and finally an open hole in the lower zone in which the 2-in casing and screen are set. Well screens will be set at the base of the well in lengths dependent on aquifer thickness. PVC riser pipe attached to the well screen will extend through the protective casing to approximately 2.5 ft above the ground. The annulus of the screened section of the well and the entire thickness of the aquifer zone (the formation producing water) will be backfilled with siliceous sand. The sand will be poured in slowly from the top of the well and checked for depth periodically with a tape measure. The filter sand will be brought up to the next higher aquiclude and capped with a 3- to 5-ft thickness of bentonite pellets as a sealer. This method of well packing assures that no grout will be introduced into the aquifer and thus prevent potential clogging of the aquifer. The bentonite will be allowed to set 1/2 to 1 hour to allow time for the pellets to swell and form a seal. The well will then be grouted from the bentonite to the top of ground. The grout will be piped into the well from the bottom up through a 3/4-in diameter pipe. A PVC vented cap will be placed atop the 2-in riser. A cylindrical steel well cap with locking lid will be placed over the PVC riser and cemented into the surface casing to protect the well casing.

(7) Rationale for Construction Location. See section b.(8) above.

(8) Environmental Conditions. See section b.(9) above.

(9) Decontamination Procedures. See section b. (11) above.

(10) Documentation. See section b. (12) above.

(11) Well Development Procedures. The wells will be developed by alternating a surging and bailing technique. Surging will be done with a stainless steel rod with rubber washers attached at each end. The surging tool

will be lowered into the well on 1/8-in steel cable and pulled up and down to create a surging action in the well. The well will be bailed alternately with a 1-1/8 in diameter, 5-ft long stainless steel bailer lowered by a stainless steel cable. The bailer will be operated by a portable wire-line winch straddling the well. The well will be bailed until the water from the well becomes clear.

(12) Soil Classification and Description of Cores. Soils encountered during drilling well be examined by a certified professional geologist at the site and classified under the Unified Soil Classification System (USCS). Any other characteristics of the soil, such as color, odor, or inclusions will also be noted and logged. Cores will be examined and classified by the geologist and their descriptions logged in a permanent field log (see figure 5). The geologist will describe the lithology of the sample, grain size, color, texture, odor (if any) and will evaluate its in situ condition. He (or she) will note the presence of joints and other discontinuities, taking care to describe and measure open discontinuities capable of transmitting ground water. He will also note other descriptive features of the core that allow interpretation of the stratigraphy of the geologic units encountered at the ORR area for correlation from well to well. The geologist will also note the presence of hydrologic indicators such as loss or gain of water during drilling, zones of oxidation in the core, and the presence and condition of potential confining strata such as shales or clays.

(13) Survey Data. All well sites will be surveyed by certified professional surveyors. The top of casing of every well will be surveyed to determine its elevation (NGVD) and east-west coordinates using the Indiana State Plane Coordinate System. The surveyors will supply WES with all survey data and a table of well elevations and locations.

d. RFI Phase III Quality Assurance/Quality Control (QA/QC) Plans.

The QA/QC documentation is in preparation. The U.S. Army Engineer Missouri River Division's (MRD) analytical laboratory and the WES Analytical Lab Group have been scheduled for the ground-water sampling and analysis and are supplying the WES with documentation of analytical methods and QA/QC. The QA/QC plan for the Rockeye work will be submitted following receipt of the information from the MRD Lab.

e. RFI Phase III Data Management Plan.

(1). RFI Phase III Data Record. Records of data collected in the field and in the laboratory will be maintained indefinitely for the Rockeye RFI in a dedicated file at WES. Some duplicate records will be maintained at the NWSC. Field data records will include logs of all borings and the core or other samples extracted from them, well installation logs, results of any aquifer tests performed, memoranda for record of field visits, raw and final positioning survey data, and monitoring well sampling activities.

Each sample taken during the investigation will be assigned a unique number corresponding to the well or boring from which it was obtained. Well numbers will identify the SWMU number (Site 10) and the particular well in a cluster. An example of a well number would be 10C24P2, which identifies well P2 of cluster C24 of site 10. Water samples will be identified by well number, depth and date sampled. Each water sample will be assigned a laboratory analysis ID number by the contract laboratory.

(2). RFI Phase III Tabular Displays. Tables of data will be prepared for

well information and water sampling and analysis events. Well information tables will list well numbers, dates installed, type of boring, total depth, elevation of well casing and ground, depth to screen and screen length, and identification of aquifer. Water level measurements for dates measured for each well will be tabulated. Tabulated water sampling data will include site, well number, date and depth sampled and laboratory analysis results for each parameter tested.

(3). RFI Phase III Graphical Displays. Graphical displays will include site maps showing well locations, topographic maps of the site, water table or piezometric surface contour maps of the aquifers encountered, contour maps of pertinent geologic structure, maps of ground-water contamination distribution in sampled aquifers, and other maps as needed. Line or bar graphs will be constructed to show variations in water or piezometric levels for different aquifers, for different wells, and for different dates. Graphs will also be constructed showing distribution in contaminant concentrations for different aquifers, wells and dates. Other graphs will be constructed as necessary.

f. RFI Phase III Health and Safety Plan.

Background. An initial assessment study of the NWSC conducted in 1981 to identify potential contamination sources determined that past activities at the NWSC have resulted in possible contamination of soil and ground water by potentially hazardous chemicals in several areas of the facility. The chemicals, by their presence in the soil and ground water, present a potential hazard to personnel conducting RFIs. RFI activities will require drilling of subsurface borings, installation of wells, and sampling of soils, rock and ground and surface waters. The health and safety plan is intended to (a) describe field activities to identify potential hazards associated with each activity, (b) insure safety consciousness by each individual involved with the field activities, (c) control exposure to potentially hazardous chemical compounds by specifying protective gear and monitoring procedures commensurate with the anticipated risk, and (d) provide emergency procedures in the event of unanticipated high contaminant concentrations, incident response, control and disposal of generated waste materials.

Drilling and Well Installations. Drilling and well installation operations will require a combination of up to four steps:

Step 1. Step 1 drilling will consist of dry auger boring using an Iwan or flight type auger. The drilling operation will extend to rock, to the water table, to unstable soil or to some other change of condition that requires a different drilling technique. Step 1 operations should produce no appreciable dust and no liquid splash hazard. The operators will contact the drilled soil with their hands in removing the soil from the auger. The operators will be near the freshly cut and disturbed soils and thus could be subjected to the release of residual chemical vapors.

Step 2. Step 2 drilling will be by the air rotary method by which the material drilled is cut by the rotation of a cutter or bit while compressed air is pumped down through the drill pipe to cool the bit and remove the cuttings. The air escapes through the annulus of the drilled hole and carries the cuttings to the surface. Since rotary drilling requires fluid circulation, compressed air will be used instead of a liquid in Step 2 to reduce the risk of injecting contamination into the soils if site conditions require. Step 2 drilling will produce significant dust, but the dust ingestion and inhalation problem will be mitigated by an air jet eductor at the top of the boring which will draw much of the dust away from the drill operators. The air jet eductor will be positioned

so as to blow the dust downwind from the operators. Step 2 drilling can submit the operators to chemical vapors released from the disturbed soils. However, the hazard is mitigated by dilution in the injected air and the effect of the air jet eductor.

Step 3. Step 3 drilling will be by the wet (water) rotary method, which is similar to Step 2 drilling except that the fluid is liquid and the working conditions are somewhat different. Dust problems are eliminated and some vapors are absorbed in the fluid. There is, however, a liquid splash and spill hazard. Chemical compounds in the fluid are somewhat diluted but can contact operators' skin.

Step 4. Step 4 operations will not involve drilling or other disturbing of the in situ materials. Step 4 will consist of the installation of monitoring wells and will entail setting well casing, placing filter materials, bentonite seals, and grouting of previously drilled borings. None of the potential hazards associated with Steps 1, 2, and 3 are anticipated. However, it is possible that vapor released from the subsurface soils will be present at the top of the boring and operators could contact and/or inhale the vapors.

Other activities. Other field activities that could expose personnel to contaminants include well sampling, well testing, and surface water sampling and flow measurement. Well sampling requires removal of several bore quantities of water from the well, the retention of a sample of the ground water entering the well, and preparation of the sample for shipment to the laboratory for analysis.

Well testing requires measuring the rate of flow of water being withdrawn from or injected into the aquifer through the well, for example by pumping tests or by slug tests, for the purpose of determining aquifer flow parameters. Well testing may also require measurement of water levels in monitoring wells near the pumping well. Because personnel may contact withdrawn ground water and be exposed to vapors emanating from the wells, potential splash and vapor ingestion hazards exist similar to those of Step 3 drilling operations.

Additional flow measurement may be required whereby surface waters in streams and water issuing from springs are sampled and the rate of flow determined. Concentrations of contaminants in surface waters will be decreased by dilution. Some dilution and aeration will also occur in spring fed waters. Field personnel should nonetheless be alert for any signs of contamination such as discoloring of the water or the presence of odors or vapors.

A particular hazard to personnel exists at the Demolition Area as a result of demolition activities there. Explosive destruction of ordnance at the Demolition area produces blast waves and flying debris. All personnel are required to leave the vicinity of the Demolition area during demolition activities. Control of personnel evacuation is the responsibility of the range safety officer at the Demolition area.

Previous laboratory analysis of monitoring wells at the Demolition area has indicated the presence of only minor amounts of some heavy metals in the ground water. Unexpected releases to the air near the boreholes will be monitored by air monitoring devices as described below. Drilling will not be done in areas with potential buried unexploded ordnance or other hazardous materials.

General Personnel Safety. The monitoring and precautionary measures specified in the following paragraphs are considered reasonable and prudent for general field investigations planned for the RFI. Each employee will have a comprehensive physical examination within the 12 months preceding his/her field

involvement to provide background information. Upon completion of the project, or annually, whichever occurs first, each employee will have a routine physical examination. Physical examinations will consist of the following:

a. Comprehensive Physical Examination. Basic health history, basic physical examination, routine EKG, chest X-ray, pulmonary function, audio testing, eye evaluation, hemoccult, Chem-screen 26, CBC w/differential, acetylcholinesterase activity, heavy metals in blood to include lead, cadmium, mercury, arsenic, chromium, and strontium; urinalysis.

b. Routine Physical Examination. Basic physical examination, resting EKG, chest X-ray, pulmonary function, SMA-26, urinalysis, audiometric.

Air Monitoring. The most common halogenated organic compounds in industrial use and OSHA allowable inhalation limits are listed in Table 4 (OSHA Safety and Health Standards 29CFR 1910).

Table 4. Limits of Exposure and Detection for Common Organic Solvents.

Solvent	Maximum Allowable* Exposure, 8 hrs.	Sensitivity** Photoionization	Detection*** Limit
Benzene	10 ppm	High	5 ppm
1,1 Dichloroethane	100 ppm	High	-
1,2 Dichloroethane	200 ppm	High	-
Methylene Chloride	500 ppm	High	100 ppm
Trichloroethylene	100 ppm	High	2 ppm

* OSHA Safety and Health Standards (29 CFR 1910) OSHA 2206

** HNu Model PI-101 with 11.7 ev lamp, HNu Systems, Newton, Mass.

*** Draeger Detector Tubes, National Draeger Inc., Pittsburg, PA

Air monitoring efforts will concentrate on monitoring for organic solvents and combustible gas. The presence of dust will be determined visually.

The presence of volatile organic compounds in the air at the drill location will be continuously monitored using a photoionization organic vapor detector (HNu Systems Model 101, Hazardous Waste Detector) and a combustible gas detector (Neotronics Meter, EXOTOX Model 40-OFH).

The photoionization unit is a non-specific detector that can semiquantitatively determine the concentration of a broad range of potentially hazardous organic compounds in the air. The unit will be calibrated relative to benzene concentration or to standards traceable to benzene. The unit will be set to provide an audible alarm at 75 percent of the threshold limit value (TLV) for benzene. The photoionization unit will be calibrated in accordance with manufacturer's recommendation and checked periodically for proper operation.

The combustible gas/respirable air unit is a catalytic and thermal conductivity unit that measures the concentration of flammable gas, hydrogen sulfide and oxygen levels in the air. The combustible gas sensor is calibrated on methane and will provide an alarm at 25 percent of the lower explosive limit (LEL) of methane in air. The combustible gas/respirable air unit will be calibrated before field work is started and semiannually throughout the period of use as recommended by the manufacturer.

a. Specific monitoring. The concentration of three common solvents (benzene, methylene chloride, and trichloroethylene) in the air will be determined at the drilling location at the beginning of the morning and afternoon work periods using colorimetric monitoring devices (detector tubes). The limits of detection of the colorimetric tubes are at or below 50 percent of the TLV in all cases. Records of readings will be maintained and correlated with readings from continuous monitoring devices.

b. Control of particulates. Dust generated from off-site locations could move over the drilling locations and other field activity areas intermittently. Dust will be generated by Step 2 drilling operations also on an intermittent basis. Monitoring for intermittently occurring particulates is of limited value. The effects of Step 2 drilling-generated dust will be mitigated by the use of an air jet eductor. Efforts to avoid ingestion of significant amounts of dust will include:

a. Physically avoiding the main stream concentration of dust.
b. Wetting down the work area as feasible.
c. Injecting water into drilling air stream if necessary.
d. Discontinuing work when dust cannot be adequately controlled.
e. Respirators with organic vapor cartridges and dust filters will be accessible at the drill location for each worker.

c. Action levels. In the event air monitoring indicates levels of combustible gas or organic vapors that exceed the action levels (Table 5), work will be suspended and the work site evacuated. A Crane NWSC industrial hygiene specialist will be brought onsite to define the specific hazard and specify necessary protective measures which will be implemented before work is resumed.

Table 5. Action Levels for Air Monitoring Instruments.

Instrument	Level	Rationale
Photoionization	40 ppm Benzene equivalent	80 percent of OSHA threshold level for benzene, 8-hr exposure
Combustible gas	1.25 percent methane, equiv. methane	25 percent LEL[‡]

[‡] Lower Explosive Limit

To permit a safe and orderly shutdown of operations and evacuation of the crew from the site, respirators with particulate filters and organic vapor cartridges will be issued and fitted by NWSC to each worker. Each respirator will be individually fitted to the crew member to whom it is issued. Respirators will be checked for serviceability, readiness and accessibility. Respirators will be kept in sealed plastic (Ziplock) bags.

Limiting skin contact. All persons involved in handling soil samples or equipment contaminated with soil from the work site will wear rubber gloves, safety-toe rubber boots, disposable coveralls, hard hats and safety glasses or face shields. Higher levels of protective clothing, such as Levels A, B, or C, will be issued and worn if or when working conditions require them. Protective equipment will be inspected daily. Worn or damaged equipment will be cleaned and discarded or disposed of as contaminated waste.

Decontamination. All tools and equipment contaminated by material from drill locations will be cleaned with high-pressure hot water or steam and/or commercial washing compounds and water when removed from that location. The intention is to limit the spread of contamination and prevent cross-contamination from one site to another. Wash water and waste from contaminated sites will be retained for disposal. Wash water and wastes will be tested for contaminants and disposed of in compliance with local requirements.

Well casings and screens and sampling and pumping apparatus will be thoroughly cleaned using high pressure hot water or steam before they are installed or placed in a boring. Filter material used will be clean natural gravel and/or sand that has been tested or certified to assure that no contaminants are introduced into the borings.

Appendix 1

Appendix IX Ground-Water Monitoring List

APPENDIX IX—GROUND-WATER MONITORING LIST [1]

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	POL (µg/L) [6]
Acenaphthene	83-32-9	Acenaphthylene, 1,2-dihydro-	8100	200
			8270	10
Acenaphthylene	208-96-8	Acenaphthylene	8100	200
			8270	10
Acetone	67-64-1	2-Propanone	8240	100
Acetophenone	98-86-2	Ethanone, 1-phenyl-	8270	10
Acetonitrile; Methyl cyanide	75-05-8	Acetonitrile	8015	100
2-Acetylaminofluorene; 2-AAF	53-96-3	Acetamide, N-9H-fluoren-2-yl-	8270	10
Acrolein	107-02-8	2-Propenal	8030	5
			8240	5
Acrylonitrile	107-13-1	2-Propenenitrile	8030	5
			8240	5
Aldrin	309-00-2	1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro- (1α,4α,4aβ,5α,8α,8aβ)-	8080	0.05
			8270	10
Allyl chloride	107-05-1	1-Propene, 3-chloro-	8010	5
			8240	100
4-Aminobiphenyl	92-67-1	[1,1'-Biphenyl]-4-amine	8270	10
Aniline	62-53-3	Benzenamine	8270	10
Anthracene	120-12-7	Anthracene	8100	200
			8270	10
Antimony	(Total)	Antimony	6010	300
			7040	2,000
			7041	30
Aramite	140-57-8	Sulfurous acid, 2-chloroethyl 2-[4-(1,1-dimethylethyl)phenoxy]-1-methylethyl ester	8270	10
Arsenic	(Total)	Arsenic	6010	500
			7060	10
			7061	20
Barium	(Total)	Barium	6010	20
			7080	1,000
Benzene	71-43-2	Benzene	8020	2
			8240	5
Benzo[a]anthracene; Benzanthracene	56-55-3	Benz[a]anthracene	8100	200
			8270	10
Benzo[b]fluoranthene	205-99-2	Benz[e]acephenanthrylene	8100	200
			8270	10
Benzo[k]fluoranthene	207-08-9	Benzo[k]fluoranthene	8100	200
			8270	10
Benzo[ghi]perylene	191-24-2	Benzo[ghi]perylene	8100	200
			8270	10
Benzo[a]pyrene	50-32-8	Benzo[a]pyrene	8100	200
			8270	10
Benzyl alcohol	100-51-6	Benzenemethanol	8270	20
Beryllium	(Total)	Beryllium	6010	3
			7090	50
			7091	2
alpha-BHC	319-84-6	Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1α,2α,3β,4α,5β,6β)-	8080	0.05
			8250	10
beta-BHC	319-85-7	Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1α,2β,3α,4β,5α,6β)-	8080	0.05
			8250	40
delta-BHC	319-86-8	Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1α,2α 3α,4β,5α,6β)-	8080	0.1
			8250	30
gamma-BHC; Lindane	58-89-9	Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1α,2α,3β,4α,5α,6β)-	8080	0.05
			8250	10
Bis(2-chloroethoxy)methane	111-91-1	Ethane, 1,1'-[methylenebis (oxy)]bis[2-chloro-	8270	10
Bis(2-chloroethyl)ether	111-44-4	Ethane, 1,1'-oxybis[2-chloro-	8270	10
Bis(2-chloro-1-methylethyl) ether; 2,2'-Dichlorodiisopropyl ether	108-60-1	Propane, 2,2'-oxybis[1-chloro-	8010	100
			8270	10
Bis(2-ethylhexyl) phthalate	117-81-7	1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl)ester	8060	20
			8270	10
Bromodichloromethane	75-27-4	Methane, bromodichloro-	8010	1
			8240	5
Bromoform; Tribromomethane	75-25-2	Methane, tribromo-	8010	2
			8240	5

APPENDIX IX—GROUND-WATER MONITORING LIST [1]—Continued

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	PQL (µg/L) [6]
4-Bromophenyl phenyl ether	101-55-3	Benzene, 1-bromo-4-phenoxy-	8270	10
Butyl benzyl phthalate; Benzyl butyl phthalate	85-68-7	1,2-Benzenedicarboxylic acid, butyl phenylmethyl ester	8060	5
			8270	10
Cadmium	(Total)	Cadmium	6010	40
			7130	50
			7131	1
Carbon disulfide	75-15-0	Carbon disulfide	8240	5
Carbon tetrachloride	56-23-5	Methane, tetrachloro-	8010	1
			8240	5
Chlordane	57-74-9	4,7-Methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-	8080	0.1
			8250	10
p-Chloroaniline	106-47-8	Benzenamine, 4-chloro-	8270	20
Chlorobenzene	108-90-7	Benzene, chloro-	8010	2
			8020	2
			8240	5
Chlorobenzilate	510-15-6	Benzeneacetic acid, 4-chloro-α-(4-chlorophenyl)-α-hydroxy-, ethyl ester	8270	10
p-Chloro-m-cresol	59-50-7	Phenol, 4-chloro-3-methyl-	8040	5
			8270	20
Chloroethane; Ethyl chloride	75-00-3	Ethane, chloro-	8010	5
			8240	10
Chloroform	67-66-3	Methane, trichloro-	8010	0.5
			8240	5
2-Chloronaphthalene	91-58-7	Naphthalene, 2-chloro-	8120	10
			8270	10
2-Chlorophenol	95-57-8	Phenol, 2-chloro-	8040	5
			8270	10
4-Chlorophenyl phenyl ether	7005-72-3	Benzene, 1-chloro-4-phenoxy-	8270	10
Chloroprene	126-99-8	1,3-Butadiene, 2-chloro-	8010	50
			8240	5
Chromium	(Total)	Chromium	6010	70
			7190	500
			7191	10
Chrysene	218-01-9	Chrysene	8100	200
			8270	10
Cobalt	(Total)	Cobalt	6010	70
			7200	500
			7201	10
Copper	(Total)	Copper	6010	60
			7210	200
m-Cresol	108-39-4	Phenol, 3-methyl-	8270	10
o-Cresol	95-48-7	Phenol, 2-methyl-	8270	10
p-Cresol	106-44-5	Phenol, 4-methyl-	8270	10
Cyanide	57-12-5	Cyanide	9010	40
2,4-D; 2,4-Dichlorophenoxyacetic acid	94-75-7	Acetic acid, (2,4-dichlorophenoxy)-	8150	10
4,4'-DDD	72-54-8	Benzene 1,1'-(2,2-dichloroethylidene)bis[4-chloro-	8080	0.1
			8270	10
4,4'-DDE	72-55-9	Benzene 1,1'-(dichloroethylidene)bis[4-chloro-	8080	0.05
			8270	10
4,4'-DDT	50-29-3	Benzene 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro-	8080	0.1
			8270	10
Diallate	2303-16-4	Carbamothioic acid, bis(1-methylethyl)-, S-(2,3-dichloro-2-propenyl) ester	8270	10
Dibenz[a,h]anthracene	53-70-3	Dibenz[a,h]anthracene	8100	200
			8270	10
Dibenzofuran	132-64-9	Dibenzofuran	8270	10
Dibromochloromethane; Chlorodibromomethane	124-48-1	Methane, dibromochloro-	8010	1
			8240	5
1,2-Dibromo-3-chloropropane; DBCP	96-12-8	Propane, 1,2-dibromo-3-chloro-	8010	100
			8240	5
			8270	10
1,2-Dibromoethane; Ethylene dibromide	106-93-4	Ethane, 1,2-dibromo-	8010	10
			8240	5
Di-n-butyl phthalate	84-74-2	1,2-Benzenedicarboxylic acid, dibutyl ester	8060	5
			8270	10
o-Dichlorobenzene	95-50-1	Benzene, 1,2-dichloro-	8010	2
			8020	5
			8120	10
			8270	10

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APPENDIX IX—GROUND-WATER MONITORING LIST [1]—Continued

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	PQL (µg/L) [6]
m-Dichlorobenzene	541-73-1	Benzene, 1,3-dichloro-	8010	5
			8020	5
			8120	10
			8270	10
p-Dichlorobenzene	106-46-7	Benzene, 1,4-dichloro-	8010	2
			8020	5
			8120	15
			8270	10
3,3'-Dichlorobenzidine	91-94-1	[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dichloro-	8270	20
trans-1,4-Dichloro-2-butene	110-57-6	2-Butene, 1,4-dichloro-, (E)-	8240	5
Dichlorodifluoromethane	75-71-8	Methane, dichlorodifluoro-	8010	10
			8240	5
1,1-Dichloroethane	75-34-3	Ethane, 1,1-dichloro-	8010	1
			8240	5
1,2-Dichloroethane; Ethylene dichloride	107-06-2	Ethane, 1,2-dichloro-	8010	0.5
			8240	5
1,1-Dichloroethylene; Vinylidene chloride	75-35-4	Ethene, 1,1-dichloro-	8010	1
			8240	5
trans-1,2-Dichloroethylene	156-60-5	Ethene, 1,2-dichloro-, (E)-	8010	1
			8240	5
2,4-Dichlorophenol	120-83-2	Phenol, 2,4-dichloro-	8040	5
			8270	10
2,6-Dichlorophenol	87-65-0	Phenol, 2,6-dichloro-	8270	10
1,2-Dichloropropane	78-87-5	Propane, 1,2-dichloro-	8010	0.5
			8240	5
cis-1,3-Dichloropropene	10061-01-5	1-Propene, 1,3-dichloro-, (Z)-	8010	20
			8240	5
trans-1,3-Dichloropropene	10061-02-6	1-Propene, 1,3-dichloro-, (E)-	8010	5
			8240	5
Dieldrin	60-57-1	2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-, (1aα,2β,2aα,3β,6β,6aα,7β,7aα)-	8080	0.05
			8270	10
Diethyl phthalate	84-66-2	1,2-Benzenedicarboxylic acid, diethyl ester	8060	5
			8270	10
O,O-Diethyl O-2-pyrazinyl phosphorothioate; Thionazin	297-97-2	Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester	8270	10
Dimethoate	60-51-5	Phosphorodithioic acid, O,O-dimethyl S-[2-(methylamino)-2-oxoethyl] ester	8270	10
p-(Dimethylamino)azobenzene	60-11-7	Benzenamine, N,N-dimethyl-4-(phenylazo)-	8270	10
7,12-Dimethylbenz[a]anthracene	57-97-6	Benz[a]anthracene, 7,12-dimethyl-	8270	10
3,3'-Dimethylbenzidine	119-93-7	[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dimethyl-	8270	10
alpha, alpha-Dimethylphenethylamine	122-09-8	Benzeneethanamine, α,α-dimethyl-	8270	10
2,4-Dimethylphenol	105-67-9	Phenol, 2,4-dimethyl-	8040	5
			8270	10
Dimethyl phthalate	131-11-3	1,2-Benzenedicarboxylic acid, dimethyl ester	8060	5
			8270	10
m-Dinitrobenzene	99-65-0	Benzene, 1,3-dinitro-	8270	10
4,6-Dinitro-o-cresol	534-52-1	Phenol, 2-methyl-4,6-dinitro-	8040	150
			8270	50
2,4-Dinitrophenol	51-28-5	Phenol, 2,4-dinitro-	8040	150
			8270	50
2,4-Dinitrotoluene	121-14-2	Benzene, 1-methyl-2,4-dinitro-	8090	0.2
			8270	10
2,6-Dinitrotoluene	606-20-2	Benzene, 2-methyl-1,3-dinitro-	8090	0.1
			8270	10
Dinoseb; DNBP; 2-sec-Butyl-4,6-dinitrophenol	88-85-7	Phenol, 2-(1-methylpropyl)-4,6-dinitro-	8150	1
			8270	10
Di-n-octyl phthalate	117-84-0	1,2-Benzenedicarboxylic acid, dioctyl ester	8060	30
			8270	10
1,4-Dioxane	123-91-1	1,4-Dioxane	8015	150
Diphenylamine	122-39-4	Benzenamine, N-phenyl-	8270	10
Disulfoton	298-04-4	Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio)-ethyl]ester S-[2-	8140	2
			8270	10
Endosulfan I	959-98-8	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-, 3-oxide, (3α,5aβ,6α,9α,9aβ)-	8080	0.1
			8250	10

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APPENDIX IX—GROUND-WATER MONITORING LIST [1]—Continued

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	POL (µg/L) [6]
Endosulfan II	33213-65-9	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro- 1,5,5a,6,9,9a-hexahydro-, 3-oxide, (3α,5aα,6β,9β,9aα)-	8080	0.05
Endosulfan sulfate	1031-07-8	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro- 1,5,5a,6,9,9a-hexahydro-, 3,3-dioxide.	8080 8270	0.5 10
Endrin	72-20-8	2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-, (1aα, 2β,2aβ,3α,6α, 6aβ,7β,7aα)-	8080 8250	0.1 10
Endrin aldehyde	7421-93-4	1,2,4-Methenocyclopenta[cd]pentalene-5-carboxaldehyde, 2,2a,3,3,4,7-hexachlorodecahydro-, (1α,2β,2aβ,4β ,4aβ,5β,6aβ,6bβ,7R*)-	8080 8270	0.2 10
Ethylbenzene	100-41-4	Benzene, ethyl-	8020 8240	2 5
Ethyl methacrylate	97-63-2	2-Propenoic acid, 2-methyl-, ethyl ester	8015 8240 8270	10 5 10
Ethyl methanesulfonate	62-50-0	Methanesulfonic acid, ethyl ester	8270	10
Famphur	52-85-7	Phosphorothioic acid, O-[4-[(dimethylamino)sulfonyl]phenyl]-O,O-dimethyl ester	8270	10
Fluoranthene	206-44-0	Fluoranthene	8100 8270	200 10
Fluorene	86-73-7	9H-Fluorene	8100 8270	200 10
Heptachlor	76-44-8	4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-	8080 8270	0.05 10
Heptachlor epoxide	1024-57-3	2,5-Methano-2H-indeno[1,2-b]oxirene, 2,3,4,5,6,7,7-heptachloro-1a,1b,5,5a,6,6a,-hexahydro-, (1aα,1bβ,2α,5α ,5aβ,6β,6aα)	8080 8270	1 10
Hexachlorobenzene	118-74-1	Benzene, hexachloro-	8120 8270	0.5 10
Hexachlorobutadiene	87-68-3	1,3-Butadiene, 1,1,2,3,4,4-hexachloro-	8120 8270	5 10
Hexachlorocyclopentadiene	77-47-4	1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-	8120 8270	5 10
Hexachloroethane	67-72-1	Ethane, hexachloro-	8120 8270	0.5 10
Hexachlorophene	70-30-4	Phenol, 2,2'-methylenebis[3,4,6-trichloro-	8270	10
Hexachloropropene	1888-71-7	1-Propene, 1,1,2,3,3,3-hexachloro-	8270	10
2-Hexanone	591-78-6	2-Hexanone	8240	50
Indeno(1,2,3-cd)pyrene	193-39-5	Indeno[1,2,3-cd]pyrene	8100 8270	200 10
Isobutyl alcohol	78-83-1	1-Propanol, 2-methyl-	8015	50
Isodrin	465-73-6	1,4,5,8-Dimethanonaphthalene,1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a hexahydro-(1α,4α,4aβ,5β,8β,8aβ)-	8270	10
Isophorone	78-59-1	2-Cyclohexen-1-one, 3,5,5-trimethyl-	8090 8270	60 10
Isosafrole	120-58-1	1,3-Benzodioxole, 5-(1-propenyl)-	8270	10
Kepone	143-50-0	1,3,4-Metheno-2H-cyclobuta- [cd]pentalen-2-one, 1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro-	8270	10
Lead	(Total)	Lead	6010 7420 7421	40 1,000 10
Mercury	(Total)	Mercury	7470	2
Methacrylonitrile	126-98-7	2-Propenenitrile, 2-methyl-	8015 8240	5 5
Methapyrilene	91-80-5	1,2,Ethanediamine, N,N-dimethyl-N'-2-pyridinyl-N'-(2-thienylmethyl)-	8270	10
Methoxychlor	72-43-5	Benzene, 1,1'-(2,2,2,trichloroethylidene)bis[4-methoxy-	8080 8270	2 10
Methyl bromide; Bromomethane	74-83-9	Methane, bromo-	8010 8240	20 10
Methyl chloride; Chloromethane	74-87-3	Methane, chloro-	8010 8240	1 10
3-Methylcholanthrene	56-49-5	Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-	8270	10
Methylene bromide; Dibromomethane	74-95-3	Methane, dibromo-	8010 8240	15 5
Methylene chloride; Dichloromethane	75-09-2	Methane, dichloro-	8010 8240	5 5

APPENDIX IX—GROUND-WATER MONITORING LIST [1]—Continued

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	POL (µg/L) [6]
Methyl ethyl ketone; MEK	78-93-3	2-Butanone	8015	10
			8240	100
Methyl iodide; Iodomethane	74-88-4	Methane, iodo-	8010	40
			8240	5
Methyl methacrylate	80-62-6	2-Propenoic acid, 2-methyl-, methyl ester	8015	2
			8240	5
Methyl methanesulfonate	66-27-3	Methanesulfonic acid, methyl ester	8270	10
2-Methylnaphthalene	91-57-6	Naphthalene, 2-methyl-	8270	10
Methyl parathion; Parathion methyl	298-00-0	Phosphorothioic acid, O,O-dimethyl O-(4-nitrophenyl) ester	8140	0.5
			8270	10
4-Methyl-2-pentanone; Methyl isobutyl ketone	108-10-1	2-Pentanone, 4-methyl-	8015	5
			8240	50
Naphthalene	91-20-3	Naphthalene	8100	200
			8270	10
1,4-Naphthoquinone	130-15-4	1,4-Naphthalenedione	8270	10
1-Naphthylamine	134-32-7	1-Naphthalenamine	8270	10
2-Naphthylamine	91-59-8	2-Naphthalenamine	8270	10
Nickel	(Total)	Nickel	6010	50
			7520	400
o-Nitroaniline	88-74-4	Benzenamine, 2-nitro-	8270	50
m-Nitroaniline	99-09-2	Benzenamine, 3-nitro-	8270	50
p-Nitroaniline	100-01-6	Benzenamine, 4-nitro-	8270	50
Nitrobenzene	98-95-3	Benzene, nitro-	8090	40
			8270	10
o-Nitrophenol	88-75-5	Phenol, 2-nitro-	8040	5
			8270	10
p-Nitrophenol	100-02-7	Phenol, 4-nitro-	8040	10
			8270	50
4-Nitroquinoline 1-oxide	56-57-5	Quinoline, 4-nitro-, 1-oxide	8270	10
N-Nitrosodi-n-butylamine	924-16-3	1-Butanamine, N-butyl-N-nitroso-	8270	10
N-Nitrosodiethylamine	55-18-5	Ethanamine, N-ethyl-N-nitroso-	8270	10
N-Nitrosodimethylamine	62-75-9	Methanamine, N-methyl-N-nitroso-	8270	10
N-Nitrosodiphenylamine	86-30-6	Benzenamine, N-nitroso-N-phenyl-	8270	10
N-Nitrosodipropylamine; Di-n-propylnitrosamine	621-64-7	1-Propanamine, N-nitroso-N-propyl-	8270	10
N-Nitrosomethylethylamine	10595-95-6	Ethanamine, N-methyl-N-nitroso-	8270	10
N-Nitrosomorpholine	59-89-2	Morpholine, 4-nitroso-	8270	10
N-Nitrosopiperidine	100-75-4	Piperidine, 1-nitroso-	8270	10
N-Nitrosopyrrolidine	930-55-2	Pyrrolidine, 1-nitroso-	8270	10
5-Nitro-o-toluidine	99-55-8	Benzenamine, 2-methyl-5-nitro-	8270	10
Parathion	56-38-2	Phosphorothioic acid, O,O-diethyl-O-(4-nitrophenyl) ester	8270	10
Polychlorinated biphenyls; PCBs	See Note 7	1,1'-Biphenyl, chloro derivatives	8080	50
			8250	100
Polychlorinated dibenzo-p-dioxins; PCDDs	See Note 8	Dibenzo[b,e][1,4]dioxin, chloro derivatives	8280	0.01
Polychlorinated dibenzofurans; PCDFs	See Note 9	Dibenzofuran, chloro derivatives	8280	0.01
Pentachlorobenzene	608-93-5	Benzene, pentachloro-	8270	10
Pentachloroethane	76-01-7	Ethane, pentachloro-	8240	5
			8270	10
Pentachloronitrobenzene	82-68-8	Benzene, pentachloronitro-	8270	10
Pentachlorophenol	87-86-5	Phenol, pentachloro-	8040	5
			8270	50
Phenacetin	62-44-2	Acetamide, N-(4-ethoxyphenyl)	8270	10
Phenanthrene	85-01-8	Phenanthrene	8100	200
			8270	10
Phenol	108-95-2	Phenol	8040	1
			8270	10
p-Phenylenediamine	106-50-3	1,4-Benzenediamine	8270	10
Phorate	298-02-2	Phosphorodithioic acid, O,O-diethyl S-[(ethylthio)methyl] ester	8140	2
			8270	10
2-Picoline	109-06-8	Pyridine, 2-methyl-	8240	5
			8270	10
Pronamide	23950-58-5	Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)-	8270	10
Propionitrile; Ethyl cyanide	107-12-0	Propanenitrile	8015	60
			8240	5
Pyrene	129-00-0	Pyrene	8100	200
			8270	10
Pyridine	110-86-1	Pyridine	8240	5
			8270	10

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APPENDIX IX—GROUND-WATER MONITORING LIST [1]—Continued

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	POL (µg/L) [6]
Safrole	94-59-7	1,3-Benzodioxole, 5-(2-propenyl)-	8270	10
Selenium	(Total)	Selenium	6010	750
			7740	20
			7741	20
Silver	(Total)	Silver	6010	70
			7760	100
Silvex; 2,4,5-TP	93-72-1	Propanoic acid, 2-(2,4,5-trichlorophenoxy)-	8150	2
Styrene	100-42-5	Benzene, ethenyl-	8020	1
			8240	5
Sulfide	18496-25-8	Sulfide	9030	10,000
2,4,5-T; 2,4,5-Trichlorophenoxyacetic acid	93-76-5	Acetic acid, (2,4,5-trichlorophenoxy)-	8150	2
2,3,7,8-TCDD; 2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	Dibenzo[b,e][1,4]dioxin, 2,3,7,8-tetrachloro-	8280	0.005
1,2,4,5-Tetrachlorobenzene	95-94-3	Benzene, 1,2,4,5-tetrachloro-	8270	10
1,1,1,2-Tetrachloroethane	630-20-6	Ethane, 1,1,1,2-tetrachloro-	8010	5
			8240	5
1,1,2,2-Tetrachloroethane	79-34-5	Ethane, 1,1,2,2-tetrachloro-	8010	0.5
			8240	5
Tetrachloroethylene; Perchloroethylene; Tetrachloroethene	127-18-4	Ethene, tetrachloro-	8010	0.5
			8240	5
2,3,4,6-Tetrachlorophenol	58-90-2	Phenol, 2,3,4,6-tetrachloro-	8270	10
Tetraethyl dithiopyrophosphate; Sulfotepp	3689-24-5	Thiodiphosphoric acid (((HO)$_2$P(S))$_2$O), tetraethyl ester	8270	10
Thallium	(Total)	Thallium	6010	400
			7840	1,000
			7841	10
Tin	(Total)	Tin	7870	8,000
Toluene	108-88-3	Benzene, methyl-	8020	2
			8240	5
o-Toluidine	95-53-4	Benzenamine, 2-methyl-	8270	10
Toxaphene	8001-35-2	Toxaphene	8080	2
			8250	10
1,2,4-Trichlorobenzene	120-82-1	Benzene, 1,2,4-trichloro-	8270	10
1,1,1-Trichloroethane; Methylchloroform	71-55-6	Ethane, 1,1,1-trichloro-	8240	5
1,1,2-Trichloroethane	79-00-5	Ethane, 1,1,2-trichloro-	8010	0.2
			8240	5
Trichloroethylene; Trichloroethene	79-01-6	Ethene, trichloro-	8010	1
			8240	5
Trichlorofluoromethane	75-69-4	Methane, trichlorofluoro-	8010	10
			8240	5
2,4,5-Trichlorophenol	95-95-4	Phenol, 2,4,5-trichloro-	8270	10
2,4,6-Trichlorophenol	88-06-2	Phenol, 2,4,6-trichloro-	8040	5
			8270	10
1,2,3-Trichloropropane	96-18-4	Propane, 1,2,3-trichloro-	8010	10
			8240	5
O,O,O-Triethyl phosphorothioate	126-68-1	Phosphorothioic acid, O,O,O-triethyl ester	8270	10
sym-Trinitrobenzene	99-35-4	Benzene, 1,3,5-trinitro-	8270	10
Vanadium	(Total)	Vanadium	6010	80
			7910	2,000
			7911	40
Vinyl acetate	108-05-4	Acetic acid, ethenyl ester	8240	5
Vinyl chloride	75-01-4	Ethene, chloro-	8010	2
			8240	10
Xylene (total)	1330-20-7	Benzene, dimethyl-	8020	5
			8240	5
Zinc	(Total)	Zinc	6010	20
			7950	50

[1] The regulatory requirements pertain only to the list of substances; the right hand columns (Methods and POL) are given for informational purposes only. See also footnotes 5 and 6.

[2] Common names are those widely used in government regulations, scientific publications, and commerce; synonyms exist for many chemicals.

[3] Chemical Abstracts Service registry number. Where "Total" is entered, all species in the ground water that contain this element are included.

[4] CAS index names are those used in the 9th Cumulative Index.

[5] Suggested Methods refer to analytical procedure numbers used in EPA Report SW-846 "Test Methods for Evaluating Solid Waste", third edition, November 1986. Analytical details can be found in SW-846 and in documentation on file at the agency. CAUTION: The methods listed are representative SW-846 procedures and may not always be the most suitable method(s) for monitoring an analyte under the regulations.

[6] Practical Quantitation Limits (POLs) are the lowest concentrations of analytes in ground waters that can be reliably determined within specified limits of precision and accuracy by the indicated methods under routine laboratory operating conditions. The POLs listed are generally