3.05 12/1/94 447

WORK PLAN for the REMEDIAL INVESTIGATION/ FEASIBILITY STUDY at the ALLEGANY BALLISTICS LABORATORY SUPERFUND SITE

Prepared for

Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia

Prepared by

CH2M HILL

Reston, Virginia

Contract No.
N62470-93-D-4098

December 1994

WDCR829/001.WP5

Table of Contents

Table of Contents
(continued)

Table of Contents
(continued)

Table of Contents
(continued)

Section 1

Introduction

This work plan describes the work necessary to perform a remedial investigation/feasibility study (RI/FS) at the Allegany Ballistics Laboratory Superfund Site (ABL), located in Rocket Center, West Virginia. ABL was recently added to the National Priorities List (NPL) on May 31, 1994 and includes multiple sites. Specifically these include sites 1, 2, 3, 4, 5, and PWA. A focused RI/FS will be performed at Site 1. The work included in the focused RI/FS for Site 1 is described in a separate work plan completed in October 1994. This work plan describes the work necessary to conduct an RI/FS at sites 2, 3, 4, 5, and PWA.

Included in this work plan is a description of the site background and physical setting in Section 2. Section 3 presents the initial evaluation of ABL based on the results of previous investigations. Section 4 discusses the work plan rationale and justification. Section 5 describes the individual RI/FS tasks and Section 6 presents the schedule for completion of these tasks.

WDCR829/002.WP5

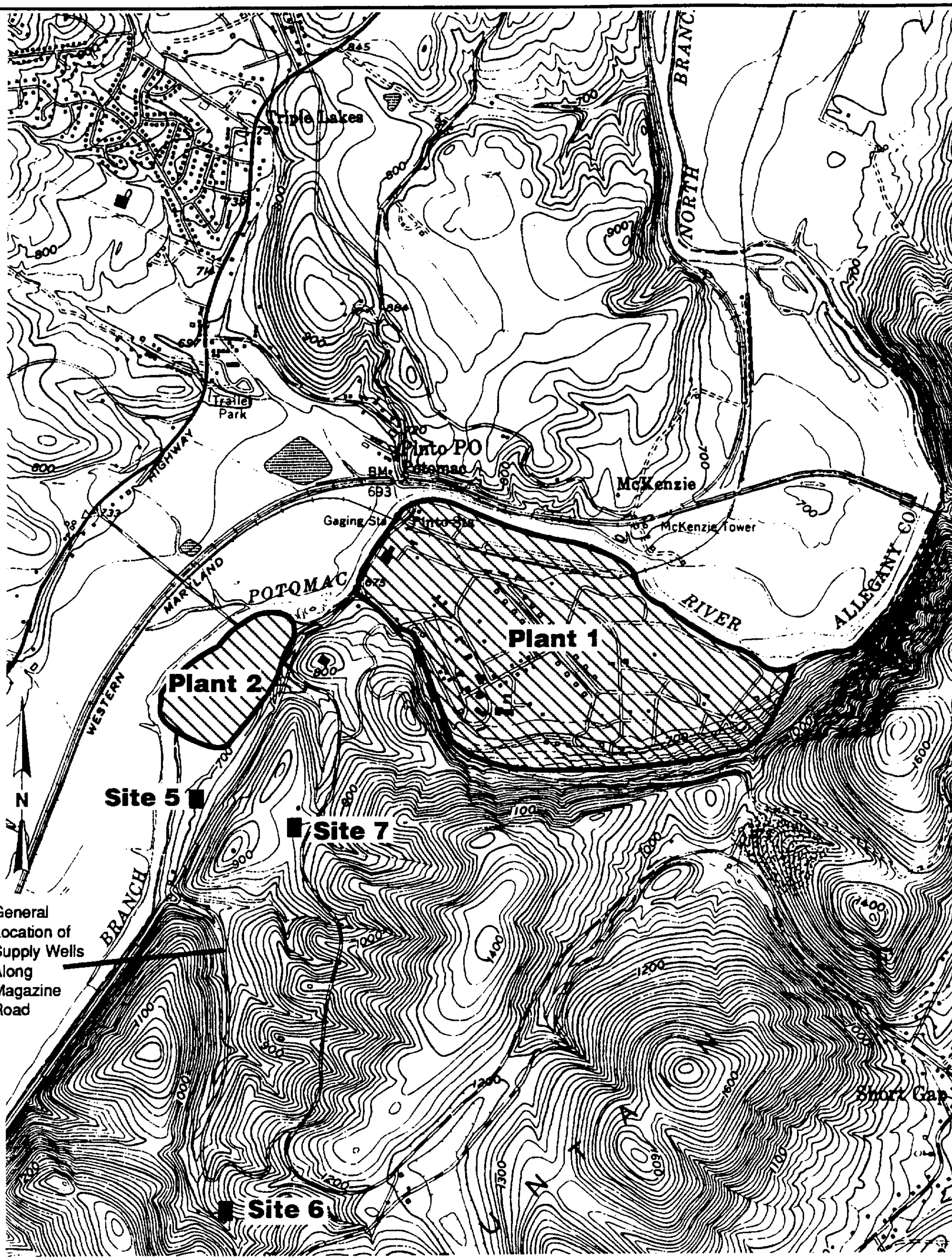
Section 2
Site Background and Physical Setting

ABL is a government-owned, contractor-operated research, development, and production facility located in Mineral County, West Virginia. Since 1943, the facility has been used primarily for research, development, and testing of solid propellants and motors for ammunition, rockets, and armaments. The facility consists of two plants (Figures 2-1 and 2-2). Plant 1, occupying approximately 1,572 acres, is owned by the Navy and operated by the Aerospace Division of Hercules (Hercules). Approximately 400 acres at Plant 1 is in the floodplain of the North Branch Potomac River, with the remaining acreage on forested mountainous land. Plant 2, a 56-acre area adjacent to Plant 1, is owned by Hercules.

Previous Investigations

A total of three previous investigations have been conducted at ABL including the Initial Assessment Study (IAS), the Confirmation Study, and the Remedial Investigation. The IAS was completed in 1983 under the Navy Assessment and Control of Installation Pollutants Program (NACIP). As promulgated by OPNAVNOTE 6240 and Marine Corps Order 6280.1, the purpose of the NACIP is to systematically identify, assess, and control contamination from past operations involving hazardous materials. The focus of the IAS was to identify sites where hazardous materials were handled and to assess the need for further evaluation of these site areas.

The IAS conducted at ABL was designed to (1) identify areas of contamination from past handling, storage, and disposal of hazardous substances; (2) assess the potential impact of the contamination on human health and the environment; and (3) recommend remedial

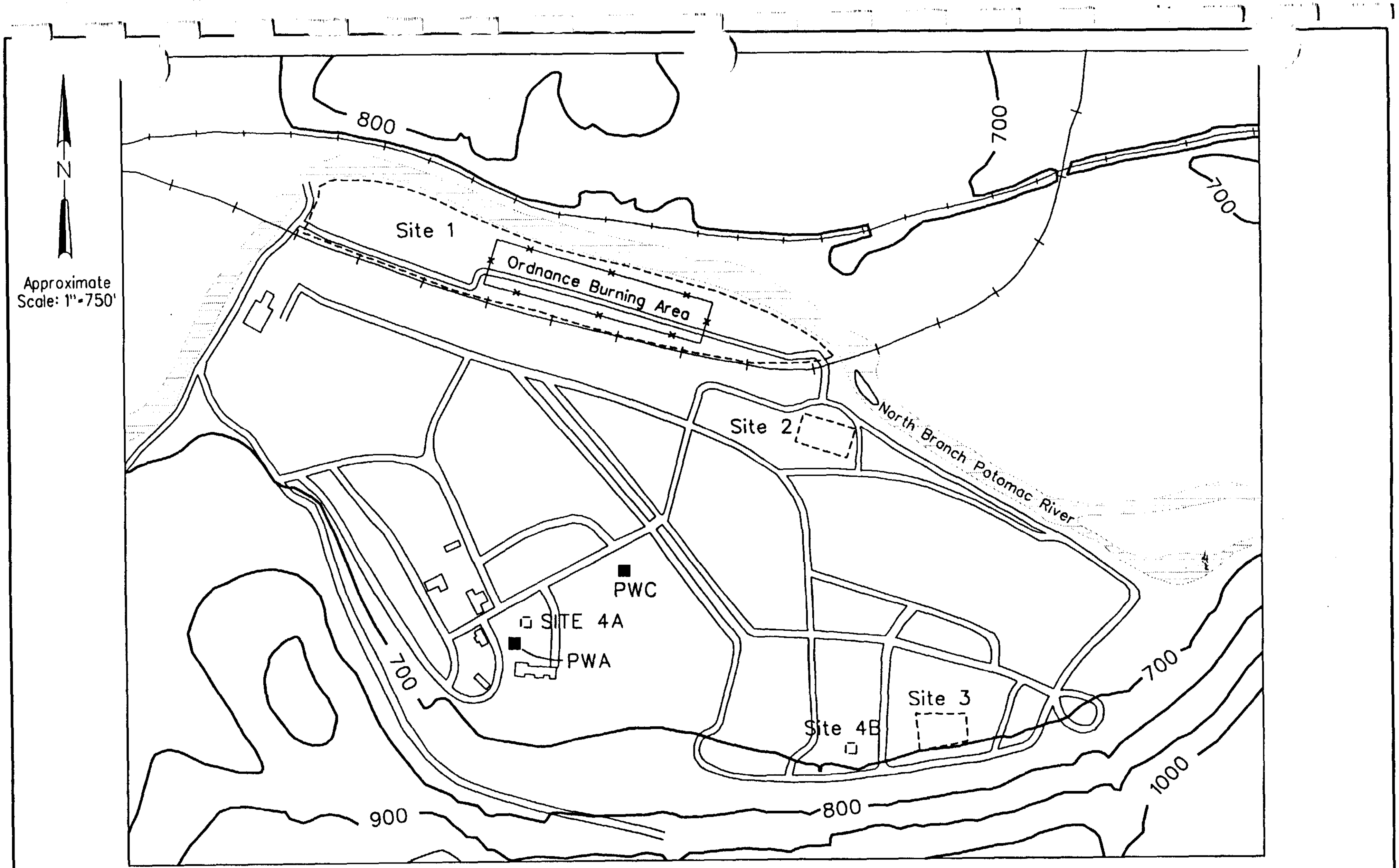


Source: USGS 7.5 minute Cresaptown, WV-MD quadrangle map.

0 1000 2000
Scale in Feet

Figure 2-1
LOCATION MAP
Remedial Investigation
Allegany Ballistics Laboratory

CH2M HILL



LEGEND

■ Production Well

Approximate Site Boundaries

— 900 — Topographic Contour (Elevation in ft above msl)

Railroad

Fence

Figure 2-2

PLANT 1 FEATURES AND SITE LOCATIONS

Allegany Ballistics Laboratory

measures that are appropriate to the area(s) of contamination. On the basis of information from historical records, aerial photographs, field inspections, and personnel interviews, nine sites were identified for further evaluation. The IAS concluded that these sites did not pose an immediate threat; however, results of the IAS showed the need for a confirmation study at seven of the nine sites to assess the potential impacts on human health and the environment of suspected contaminants. The seven sites selected for further evaluation included:

- Site 1: Northern Riverside Waste Disposal Area
- Site 2: Previous Burning Ground (1942-1949)
- Site 3: Previous Burning Ground (1950-1958)
- Site 4: Spent X-Ray Developing Solution Disposal Site
- Site 5: Inert (nonordnance) Landfill
- Site 6: Sensitivity Test Area Surface Water Impoundment
- Site 7: Beryllium Landfill

Following the IAS results and in accordance with the NACIP, a Confirmation Study was initiated in June 1984 and completed in August 1987. The confirmation study focused on identifying the existence, concentration, and extent of contamination at the seven sites recommended for further investigation in the IAS, along with production well PWA located on Plant 1. Field activities conducted under the Confirmation Study included installing monitoring wells; collecting and analyzing samples of groundwater, surface water, sediment, and soil gas; performing a geophysical survey inside the burn area at Site 1; and conducting a pump test at well PWA.

As a result of the Superfund Amendments and Reauthorization Act of October 1986 (SARA), the Navy changed its NACIP terminology and scope under the Installation and Restoration Program (IRP) to follow the rules, regulations, and guidelines, and criteria established by EPA for the Superfund program. For this reason, the results of the Confirmation Study are documented in the Interim Remedial Investigation (Interim RI) Report, October 1989. The Interim RI Report recommended further remedial investigation activities for six of the seven sites, with minimal activity suggested for sites 4A and 4B, the Spent X-Ray Developing Solutions Disposal Site. The report also recommended that activities be discontinued at Site 6, the Sensitivity Test Area Surface Water Impoundment.

Following the recommendations of the Interim RI Report and in accordance with the Navy's changed IRP policy, Hercules contracted CH2M HILL to conduct a Remedial Investigation (RI) following EPA's RI/FS format under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) described in the EPA document *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (October 1988 Interim Final). Although Hercules contracted CH2M HILL to conduct the RI, the Navy funded the effort and provided input throughout.

The RI included a number of investigation activities. Historical aerial photographs were reviewed in order to determine the type and location of waste disposal units at sites 1, 2, and 3. A focused facility audit was conducted to determine possible sources of VOC contamination at sites 1, 2, 3, and PWA. Field activities included installation of 17 monitoring wells, soil sampling, groundwater sampling, surface water and sediment sampling, well testing, a fracture orientation investigation, a down-hole camera survey, and water level measurements.

A variety of analytical methods and techniques were employed during the RI. An onsite mobile laboratory was used to analyze soil samples for select VOCs and X-ray fluorescence (XRF) was used to screen soil samples for inorganics. An offsite laboratory was used to perform all other analyses. Soil samples were analyzed for VOCs, semivolatile compounds (SVOCs), inorganics, and explosives. Ash samples collected at Site 1 were analyzed for inorganics, and dioxin, and the toxicity characteristic leaching procedure (TCLP) for inorganics was performed. Groundwater samples were analyzed for VOCs, explosives, and inorganics. Surface water and sediment samples were analyzed for VOCs and inorganics. The Draft RI Report was completed in October 1992.

The following discussions of topography and surface hydrology, regional geology, site geology, and hydrogeology are based on information provided in the IAS, Interim RI Report, Draft RI Report, and performance of the RI. Because Sites 2, 3, 4, and PWA are located on Plant 1 and to gain a more comprehensive understanding of the conceptual model at ABL, these discussions will focus on Plant 1, making specific references to individual sites where appropriate. Site 5 is located southwest of Plant 1 and will therefore, be discussed separately.

Topography and Surface Hydrology

Sites 1, 2, 3, 4, and PWA (Plant 1) are located in the floodplain of the North Branch Potomac River. The topography of the Plant 1 area is essentially flat, with the elevation ranging from about 655 feet above mean sea level (msl) along the top of the bank of the North Branch Potomac River to about 700 feet msl along the southern border.

Site 5, located southwest of Plant 1, is on a terrace above the North Branch Potomac River. The ground surface slopes gently west toward the river, from an elevation of about 725 feet msl along the east side to about 700 feet msl along the west side.

The predominant hydrologic feature of the ABL facility is the North Branch Potomac River which borders the western and northern sides of the facility. The elevation of the river ranges from about 655 feet msl in the vicinity of Site 5 to about 645 feet msl at the eastern end of the Plant 1 area. The discharge of the river at the Pinto gaging station (for which there are records from 1938 through 1981) averaged about 850 cubic feet per second.

Storm-water runoff from Plant 1 collects in ditches and flows to the river. The ditches are dry between storms. Storm-water runoff from Site 5 flows downslope away from the sites—westward from Site 5 into the course of an intermittent stream, which ultimately discharges into the river.

Regional Geology

ABL is located in the Valley and Ridge Physiographic Province near its' western boundary with the Allegheny Plateau Province. The transition between these provinces is referred to as the Allegheny Structural Front (Schultz, 1989). The Valley and Ridge Physiographic Province is underlain by sedimentary rocks folded and faulted during the late Paleozoic Era. The linear belts of ridges and valleys that characterize the province result from differential erosion of the various rock types. In general, more-resistant sandstones underlie ridges, whereas less-resistant shales and soluble limestones underlie lowlands.

The most significant physiographic feature in the vicinity of ABL is Knobly Mountain, which flanks Plant 1 to the south and east. Plant 1 is located on the floodplain of the North Branch Potomac River at a point where the river has cut into the base of Knobly Mountain. Knobly Mountain is the surface expression of a portion of the Wills Mountain anticlinorium the anticlinal axis of which trends approximately N30°E and plunges to the southwest (Eddy, 1964).

Shales, limestones, and sandstones of Silurian and Devonian age underlie the portion of the Wills Mountain anticlinorium passing through ABL. Table 2-1 presents a general description of the stratigraphic units of the Silurian and Devonian bedrock underlying ABL. Geological maps estimating the distribution of the various rock types in the region surrounding ABL have been prepared by Dyott (1956) and Eddy (1964).

The Wills Mountain anticlinorium is asymmetrical. To the southeast of the anticlinal axis, the strata dip relatively gently to the southeast at approximately 30 degrees (Dyott, 1956). The strata on the northwest limb of the anticline are generally vertical to slightly overturned (Schultz, 1989). Across the river to the north of Plant 1 at Pinto, Maryland, outcrops reveal vertical to overturned strata containing numerous small-scale folding and faulting features (Schultz, 1989).

Table 2-1
BEDROCK STRATIGRAPHIC UNITS OF THE WILLS MOUNTAIN ANTICLINORIUM UNDERLYING THE ABL FACILITY

System	Formation	Description	Approximate Thickness (ft)
Devonian	**Marcellus Shale**	Shale, thinly laminated to fissile, black or grayish black, pyritic.	250[1]
	Needmore Shale	Shale, usually calcareous, non fissile, medium dark gray.	100[1]
	Oriskany Formation	Sandstone, calcareous and cherty at bottom, siliceous at top, coarse-grained, bluish.	180 to 200[2]
	Helderberg Group	Limestone, medium to dark gray, with interbeds of crystalline limestone and dark gray chert nodules. Prominent basal unit called the Keyser Formation.	467[1]
Silurian	**Tonoloway Formation**	Argillaceous dolomitic limestone with interbedded calcareous shale, dark gray.	625[3]
	Wills Creek Formation	Calcareous shale and interbedded argillaceous limestone, medium to dark gray. Williamsport Sandstone Formation at base (21 feet thick[3]), consisting of an upper and lower sandstone unit separated by shale or limestone.	467[3]
	Mifflintown Formation: McKenzie Member	Shale, calcareous, medium gray, and interbedded argillaceous limestone.	241.5[3]
	Rochester Member	Shale, fissile, medium to dark gray, interbedded with fossiliferous limestone.	28[3]
	Keefer Member	Sandstone, fine-grained, dark gray, overlain by a thin seam of oolitic hematite.	7.5[3]
	Rose Hill Formation	Shale interbedded with lesser amounts of sandstone; a few beds of highly fossiliferous dolomitic limestone at the top of the formation. Greenish-gray to moderate brown.	420[2]

Sources for Lithologic Descriptions: Clark (1967), Dyott (1956), Eddy (1964), and Helfrich (1975).
Sources for Thicknesses: [1]Eddy (1964), [2]Dyott (1956), [3]Helfrich (1975).

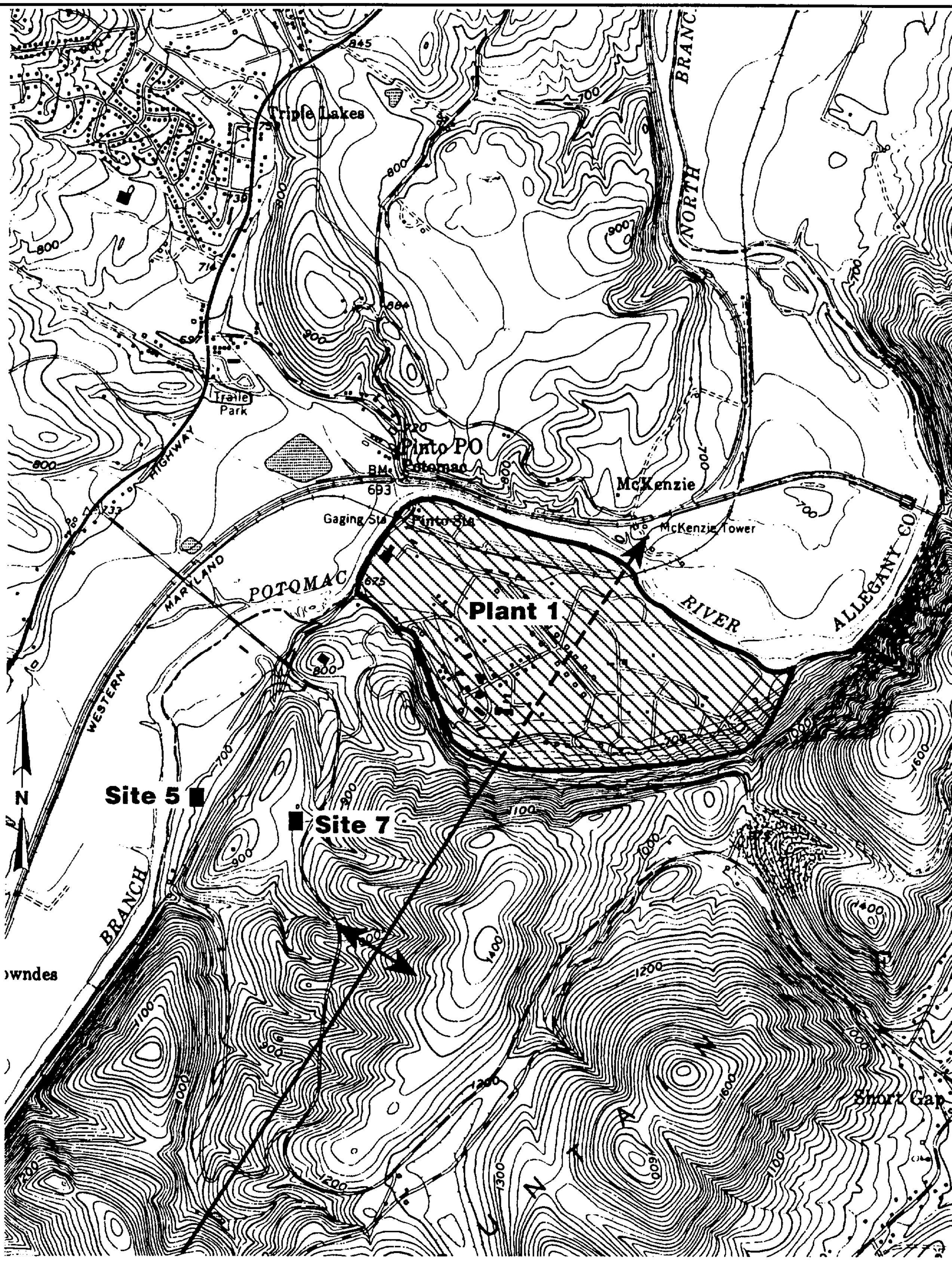
Figure 2-3 shows the approximate location of the Wills Mountain anticlinorium axis. The western half of Plant 1, including Site PWA and Site 5, is located on the vertical or overturned northwest limb of the anticlinorium; the dips of bedding planes in the bedrock underlying these portions of ABL are expected to be near vertical. Strata underlying the eastern half of Plant 1 including Sites 2, 3, and 4, are part of the southeast limb of the anticlinorium, and therefore, bedding planes dip gently to the southeast.

The measurement of the orientation of 96 fracture planes in the vicinity of ABL during the RI revealed two principal fracture sets:

	Average Strike	Frequency
Fracture Set 1	N26°E	44%
Fracture Set 2	N39°W	29%

Fracture Set 1 was the most common fracture pattern, constituting 44 percent of the fractures measured. This fracture set is parallel to the Wills Mountain anticlinorium and the structural trend of the Appalachian folds in the region. The fracture set was prevalent in most lithologies. Fracture set 2 is oblique to the Appalachian structural trend.

A regional study (Kribbs, 1982) of fractures in the Valley and Ridge Physiographic Province in portions of Mineral and Hampshire counties, West Virginia, identified 5 principal average fracture trends: N37°W, N53°E, N60°W, N30°E, and a set trending east-west. Kribbs identified the fracture sets trending N37°W and N30°E, as the most prevalent fracture trends, particularly in Silurian strata (Kribbs, 1982). Kribbs' fracture sets correspond well to fracture sets 1 and 2 identified during the RI.



Basemap: USGS 7.5 minute Cresaptown, WV-MD quadrangle map.

0 1000 2000
Scale in Feet

LEGEND
Approximate location of Anticlinal Axis (from Eddy, 1964)

Figure 2-3
APPROXIMATE LOCATION OF AXIS OF THE WILLS MOUNTAIN ANTICLINORIUM
Allegany Ballistics Laboratory

CH2M HILL

Site Geology

Information on the geology of Plant 1 and Site 5 was obtained during the installation of monitoring wells during the RI and Interim RI. Borehole logs recorded during alluvial drilling at ten well locations provided the lithologic characterization of the alluvium. Geologic information on the bedrock underlying ABL was obtained from samples of air-rotary drill cuttings collected during bedrock drilling at 12 locations. Additional geologic information was obtained from the logs of 25 monitoring well borings completed during the Confirmation Study.

Table 2-2 summarizes the stratigraphic data and the construction details of the monitoring wells obtained from drilling during the RI and reported in the Interim RI. Boring logs, well completion diagrams, and bedrock descriptions prepared during the RI and confirmation study are included in appendices in both the RI and Interim RI reports. In the following discussion, Plant 1 and Site 5 are discussed separately.

Plant 1

Three interpretative cross-sections of the materials underlying Plant 1 have been prepared to assist in formulating a conceptual model of the site geology.[1] Figure 2-4 shows monitoring well locations at Plant 1. Figure 2-5 shows the locations of the cross section alignments. Figures 2-6, 2-7, and 2-8 present the cross sections.

---

[1]In several instances where monitoring wells drilled during the RI are adjacent to wells installed during previous investigations, borehole logs from the new wells showed significant differences in such features as depth to bedrock and depth to top of the alluvial layer. For example, it was reported (Roy F. Weston, Inc., 1989) that bedrock was not encountered above a depth of 40 feet at Well 1GW5. However, during the RI, bedrock was encountered at a depth of approximately 25 feet Well 1GW14, which is located only about 20 feet from Well 1GW5, and at nearly the same surface elevation. In these instances, the data collected during the RI was considered more reliable, and was afforded more weight in the preparation of the cross sections. CH2M HILL feels this is justified because the RI included the collection of soil samples for lithologic characterization, whereas previous investigations relied almost exclusively on the description of drill cuttings.

Table

MONITORING WELL CONSTRUCTION DETAILS AND BOREHOLE LITHOLOGIC DATA[1]

Well	Ground Elevation[2] (ft. MSL)	Casing Elevation[2] (ft. MSL)	Depth of Boring (ft)	Screen Top		Screen Bottom		Screened Unit[3]	Surface Casing		Top of Clayey Gravel Alluvium		Top of Bedrock	
				Depth (ft)	Elevation (ft. MSL)	Depth (ft)	Elevation (ft. MSL)		Depth (ft)	Elevation (ft. MSL)	Depth (ft)	Elevation (ft. MSL)	Depth (ft)	Elevation (ft. MSL)
GGW1	668.79	671.65	23	18	650.79	23	645.79	A	NA	NA	NA	NA	NA	NA
GGW2	669.01	672.07	84.5	70	599.01	80	589.01	B	31	638.01	8	661.01	23.5	645.51
GGW3	667.53	670.57	22	12	655.53	22	645.53	A	NA	NA	NA	NA	NA	NA
GGW4	667.51	670.66	82	70	597.51	80	587.51	B	24	643.51	8	659.51	22	645.51
GGW5	663.92	666.59	26	15.5	648.42	25.5	638.42	A	NA	NA	NA	NA	NA	NA
GGW6	663.93	666.75	81	70	593.93	80	583.93	B	33	630.93	13	650.93	28.5	635.43
GGW7	660.36	663.21	23	13	647.36	23	637.36	A	NA	NA	NA	NA	NA	NA
GGW8	660.27	663.21	80	70	590.27	80	580.27	B	30	630.27	10	650.27	24	636.27
1GW1	667.62	670.09	40	10	657.62	40	627.62	A,B	NA	NA	9.5	658.12	24	643.62
1GW2	664.18	666.79	40	10	654.18	40	624.18	B	29	635.18	13	651.18	26	638.18
1GW3	665.95	668.25	40	10	655.95	40	625.95	A,B	24	641.95	13	652.95	29	636.95
1GW4	667.85	670.51	40	10	657.85	40	627.85	B	29	638.85	10	657.85	27	640.85
1GW5	666.58	668.47	40	10	656.58	40	626.58	A	30	636.58	18	648.58	NA	NA
1GW6	666.83	669.77	35	5	661.83	35	631.83	B	24	642.83	10	656.83	20.5	646.33
1GW7	704.46	707.34	60	27	677.46	57	647.46	A,B	NA	NA	44	660.46	50	654.46
1GW8	665.24	667.36	35	20	645.24	35	630.24	A	NA	NA	17	648.24	NA	NA
1GW9	665.76	668.12	80	65	600.76	80	585.76	B	30	635.76	17.5	648.26	28	637.76
1GW10	664.44	667.38	82	70	594.44	80	584.44	B	33	631.44	12	652.44	26	638.44
1GW11	664.64	667.53	18	11	653.64	18	646.64	A	NA	NA	NA	NA	NA	NA
1GW12	663.68	666.76	80	70	593.68	80	583.68	B	32.5	631.18	10	653.68	25	638.68
1GW13	665.59	668.43	121	111	554.59	121	544.59	B	33	632.59	13	652.59	26.5	639.09
1GW14	665.41	668.21	80.5	70.5	594.91	80.5	584.91	B	30	635.41	13	652.41	25	640.41
2GW1	665.86	667.04	40	10	655.86	40	625.86	A,B	24	641.86	13	652.86	30	635.86
2GW2	664.44	667.34	29.5	13	651.44	28	636.44	A	NA	NA	13.5	650.94	NA	NA

Table
MONITORING WELL CONSTRUCTION DETAILS AND BOREHOLE LITHOLOGIC DATA[1]

Well	Ground Elevation[2] (ft. MSL)	Casing Elevation[2] (ft. MSL)	Depth of Boring (ft)	Screen Top		Screen Bottom		Screened Unit[3]	Surface Casing		Top of Clayey Gravel Alluvium		Top of Bedrock	
				Depth (ft)	Elevation (ft. MSL)	Depth (ft)	Elevation (ft. MSL)		Depth (ft)	Elevation (ft. MSL)	Depth (ft)	Elevation (ft. MSL)	Depth (ft)	Elevation (ft. MSL)
2GW3	663.86	666.62	27	11	652.86	26	637.86	A	NA	NA	19	644.86	27	636.86
2GW4	665.48	667.59	39	24	641.48	39	626.48	A	NA	NA	13	652.48	NA	NA
2GW5	663.80	665.68	35	20	643.8	35	628.8	A	NA	NA	11.5	652.30	NA	NA
2GW6	664.08	666.11	80	65	599.08	80	584.08	B	49	615.08	13	651.08	37	627.08
2GW7	665.33	668.13	81	71	594.33	81	584.33	B	32	633.33	14	651.33	27	638.33
3GW1	663.25	666.00	35	5	658.25	35	628.25	A,B	24	639.25	12.5	650.75	28	635.25
3GW2	662.28	665.15	27	10	652.28	25	637.28	A	NA	NA	13	649.28	NA	NA
3GW3	678.73	681.91	42.5	24	654.73	39	639.73	A	NA	NA	25	653.73	42.5	636.23
3GW4	667.12	669.47	90.5	75.5	591.62	90.5	576.62	B	47	620.12	13	654.12	32	635.12
4GW1	664.83	667.61	28	12	652.83	27	637.83	A	NA	NA	18.5	646.33	NA	NA
5GW1	753.70	756.31	60	20	733.70	60	693.70	A	50	703.70	NA	NA	NA	NA
5GW2	685.84	688.60	50	20	665.84	50	635.84	B	37	648.84	NA	NA	33	652.84
5GW3	686.29	689.16	50	20	666.29	50	636.29	B	35	651.29	NA	NA	34.5	651.79
5GW4	685.48	688.74	83	73	612.48	83	602.48	B	39.5	645.98	NA	NA	33	652.48
5GW5	685.63	688.89	76	65	620.63	75	610.63	B	40	645.63	28	657.63	34	651.63
7GW1	NS	NS	64	10	NA	60	NA	B	NA	NA	NA	NA	1.5	NA
PWA1	669.63	671.23	78	63	606.63	78	591.63	B	NA	NA	22	647.63	47	622.63
PWA2	669.39	671.68	35	20	649.39	35	634.39	A	NA	NA	20	649.39	NA	NA

NOTES:
[1]All non-survey data for monitoring wells installed during previous investigations were taken from *Draft Interim Remedial Investigation for Allegany Ballistics Laboratory*, Roy F. Weston, Inc. (October 1989).
[2]Surveyed in August 1992. All elevations are in feet above mean sea level (ft. MSL).
[3]Screened Unit: A = Alluvium; B = Bedrock; A, B = well screened across the alluvium/bedrock contact.

NA = Not applicable; NS = Not Surveyed

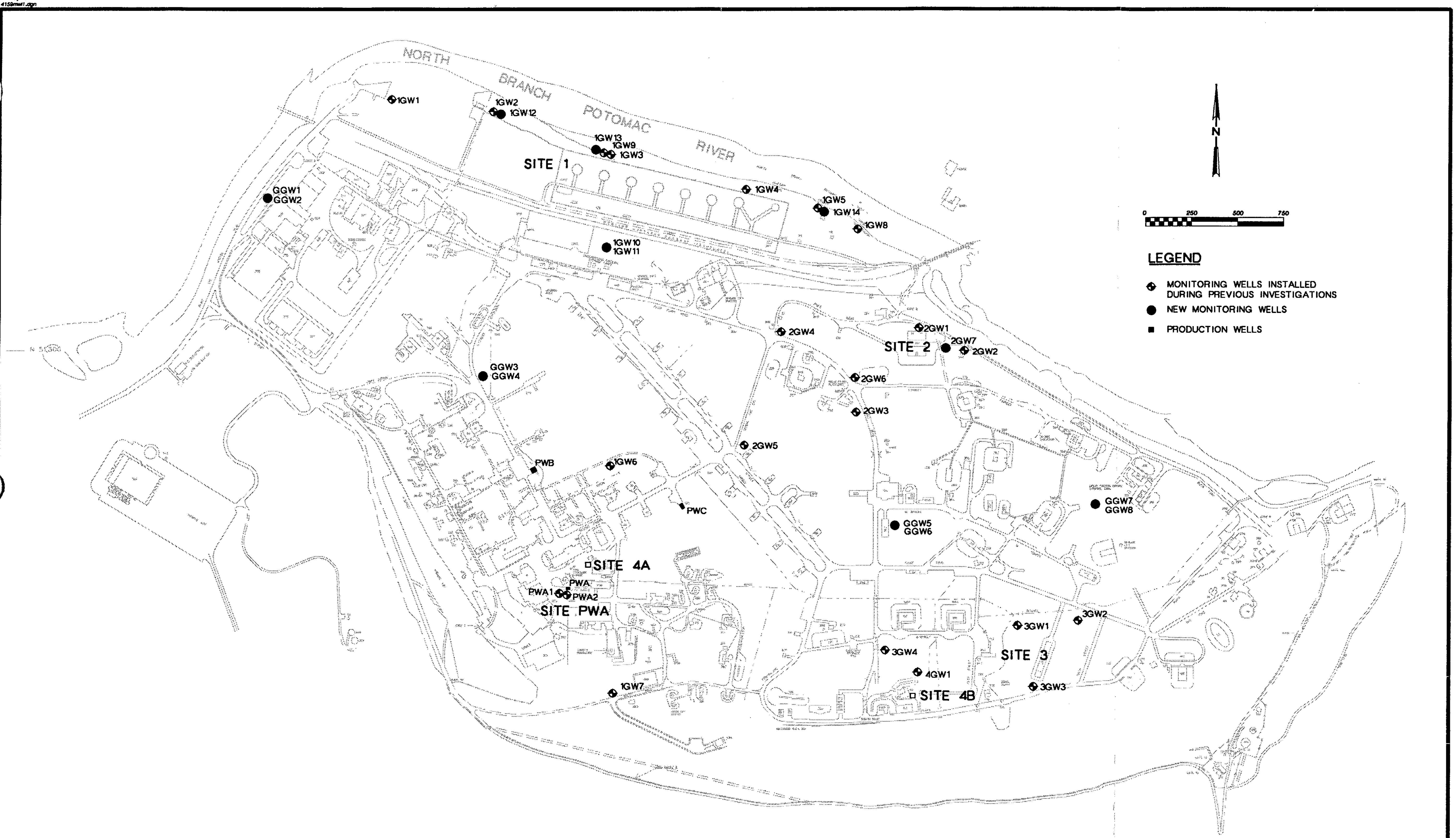


Figure 2-4

PLANT 1-MONITORING WELL AND PRODUCTION WELL LOCATION MAP
ALLEGANY BALLISTICS LABORATORY

CH2M HILL

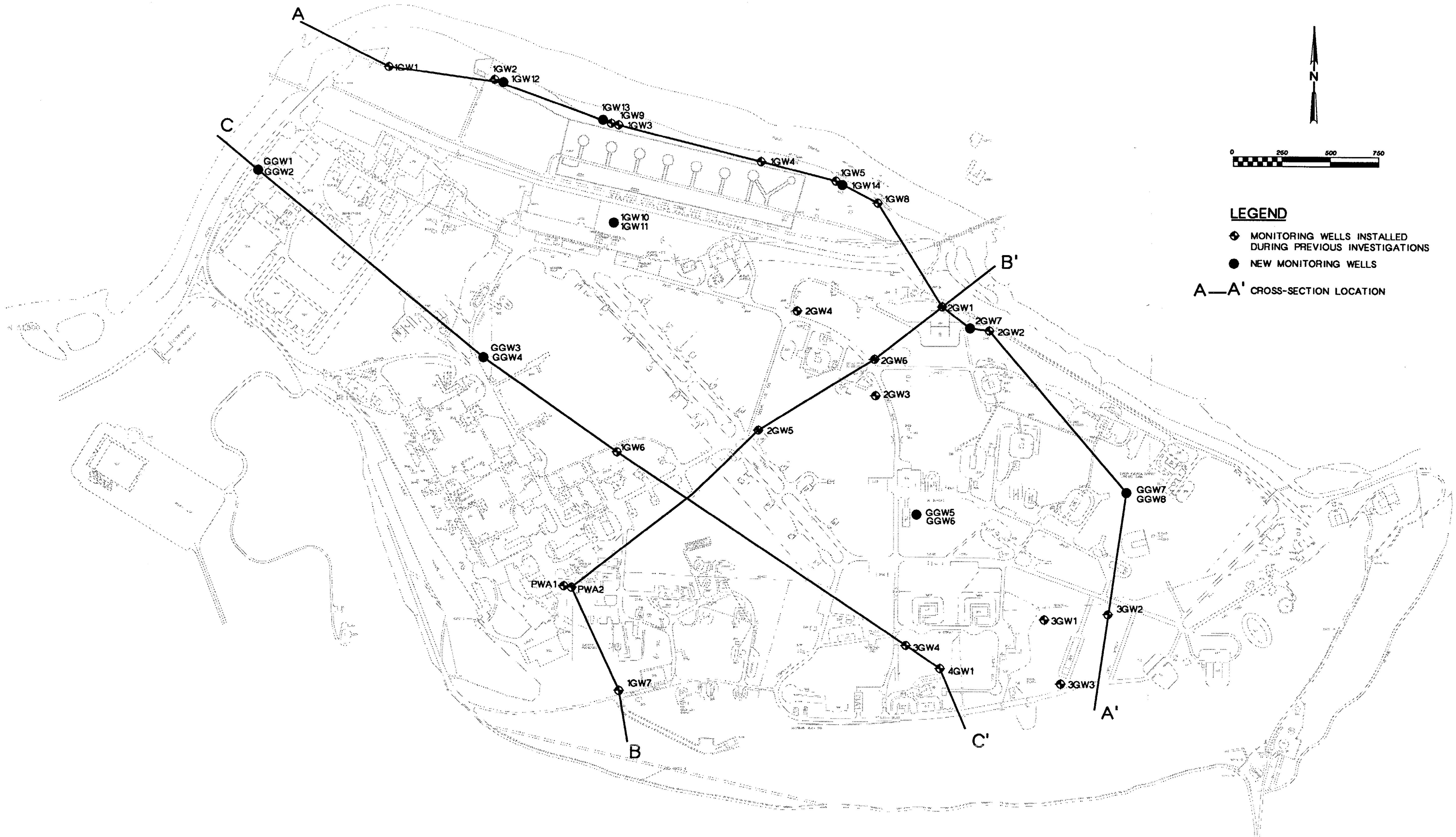
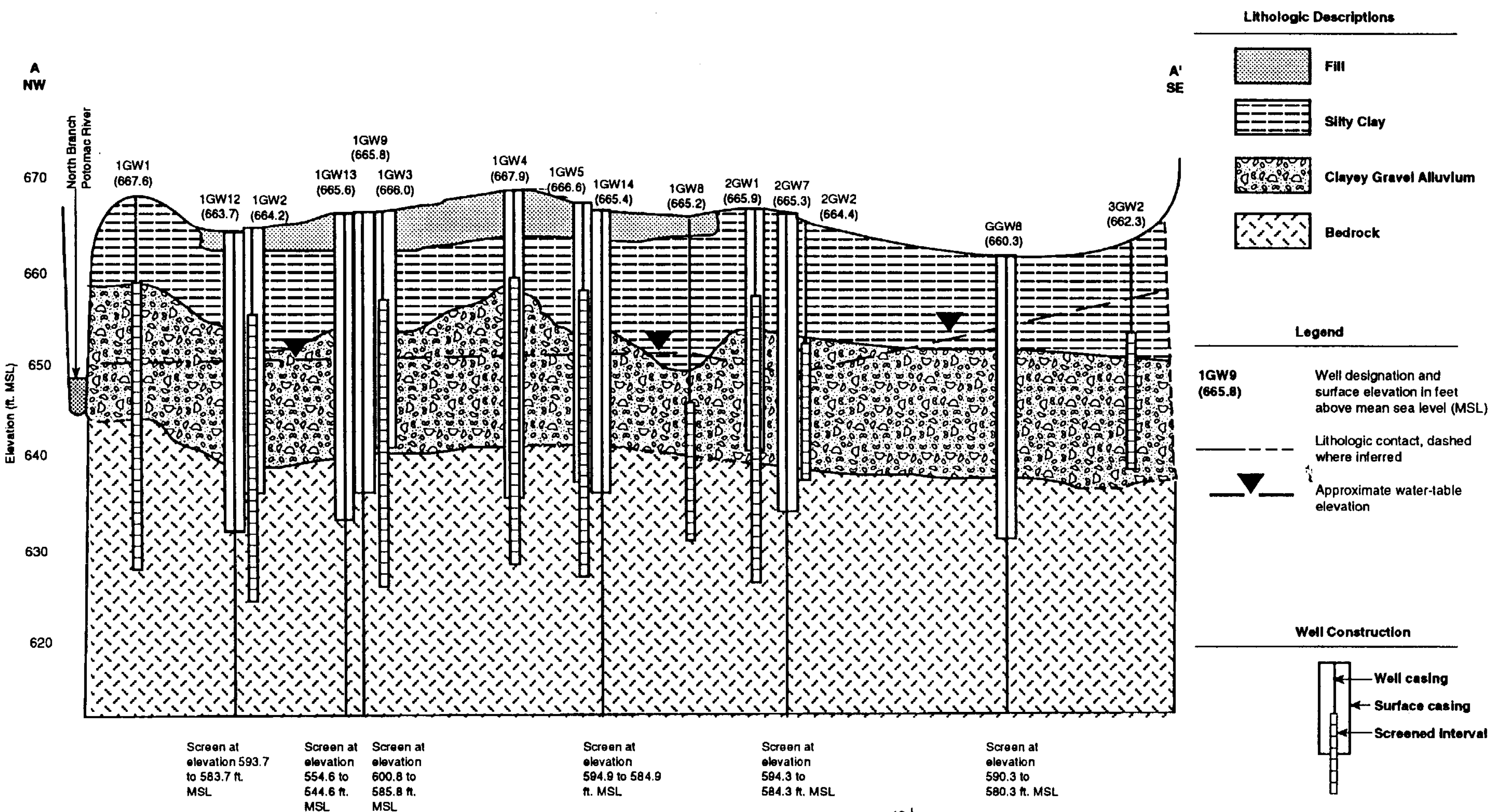


Figure 2-5

PLANT 1 - CROSS-SECTION ALIGNMENTS
ALLEGANY BALLISTICS LABORATORY

CH2M HILL

MAE70342 A2 PP/D3/09



Notes:

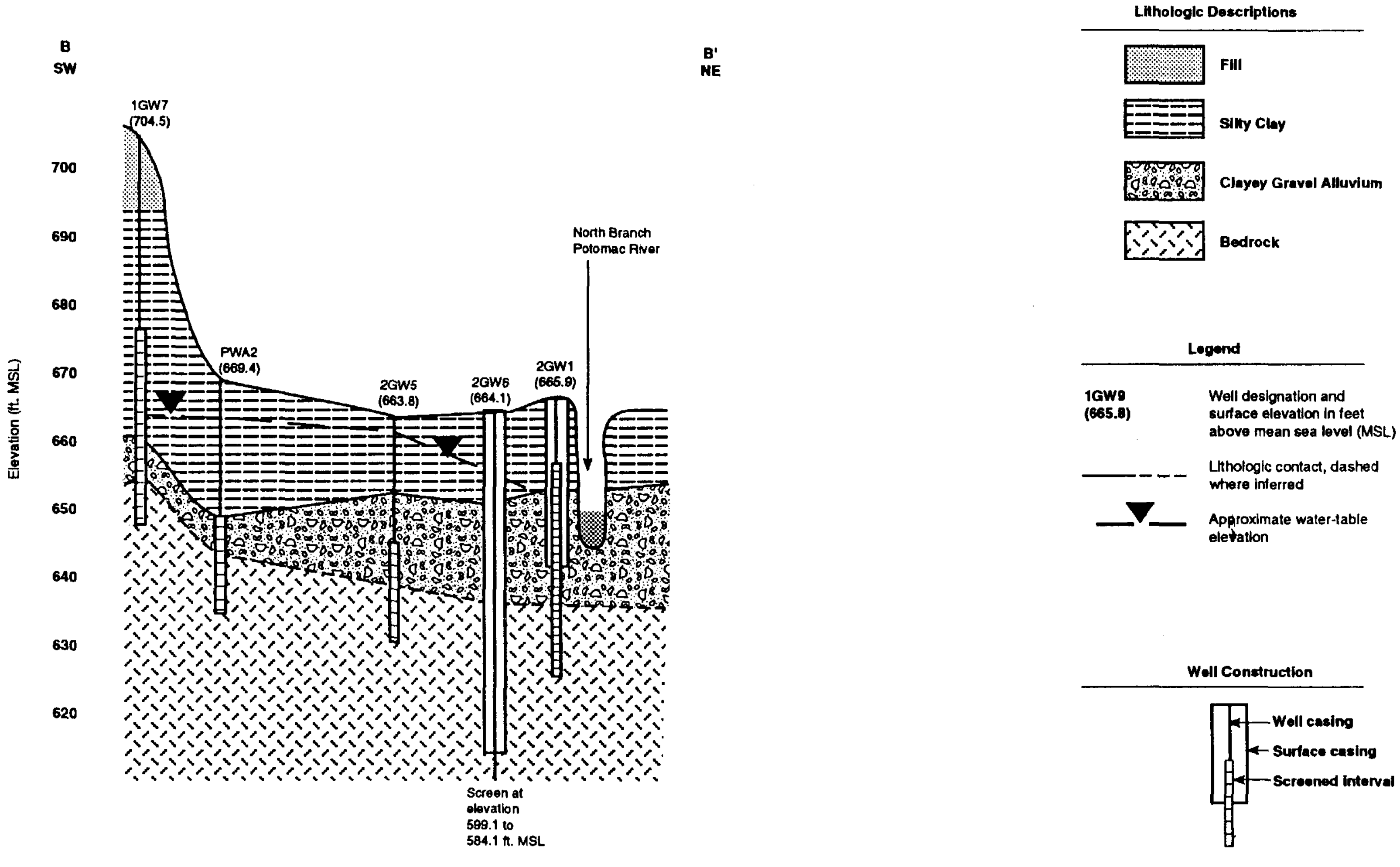
This cross-section was interpolated between boring locations. Actual conditions may differ from those shown here.

Cross-section location is shown in Figure 5-2.

Figure 2-6
CROSS-SECTION A-A'
Allegany Ballistics Laboratory

CH2M HILL

MAE70342.A2.PP/D3/09



Notes:

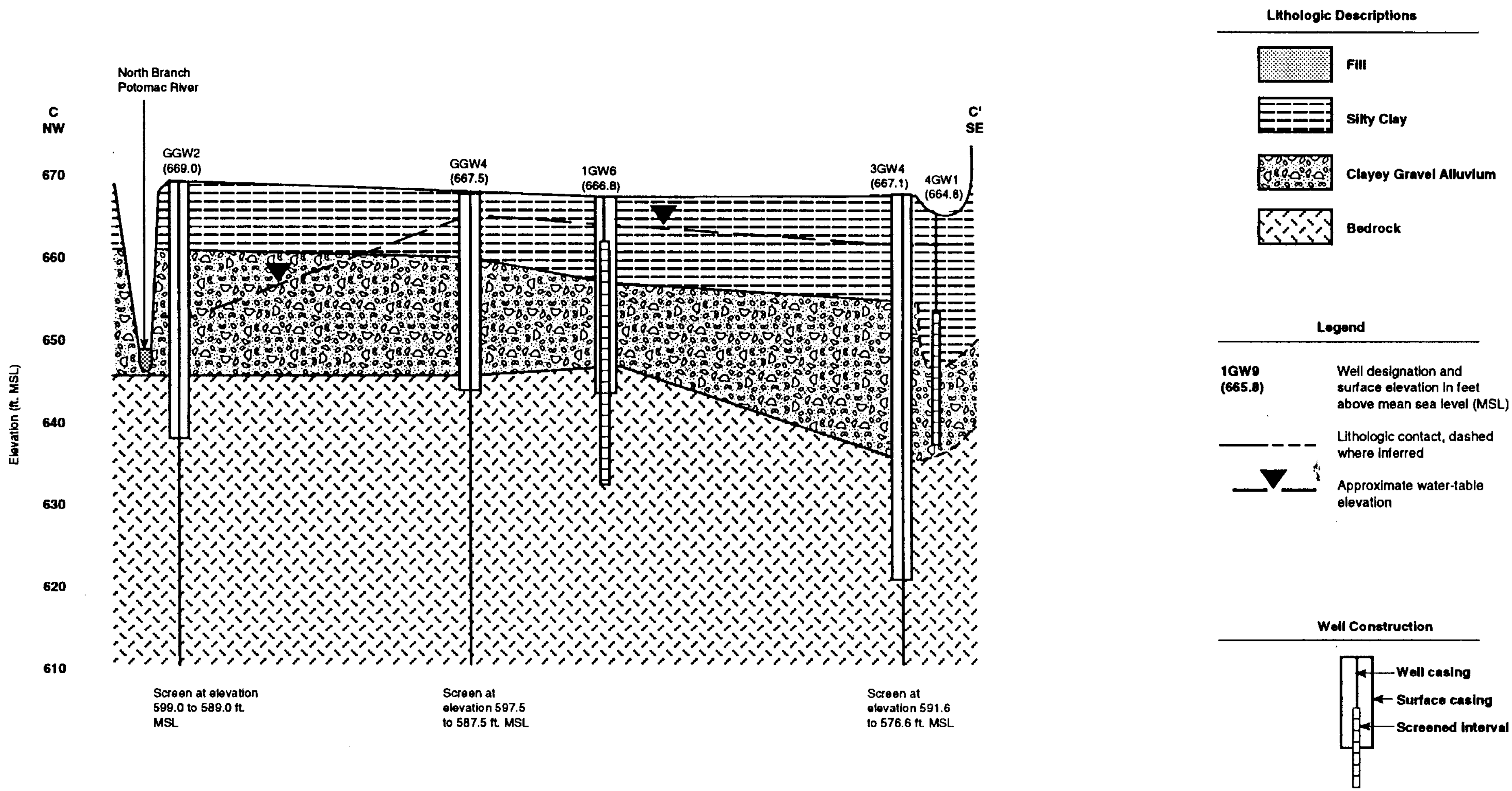
This cross-section was interpolated between boring locations. Actual conditions may differ from those shown here.

Cross-section location is shown in Figure 5-2.

Figure 2-7
CROSS-SECTION B-B'
Allegany Ballistics Laboratory

CH2MHILL

MAE70342.A2 PP/D3/10



Notes:

This cross-section was interpolated between boring locations. Actual conditions may differ from those shown here.

Cross-section location is shown in Figure 5-2.

Figure 2-8
CROSS-SECTION C-C'
Allegany Ballistics Laboratory

CH2M HILL

Alluvium and Floodplain Deposits

The cross sections illustrate that the unconsolidated deposits overlying bedrock at Plant 1 consist of two basic layers of earth. In descending order, they are:

- A silty clay layer, considered floodplain deposits of the North Branch Potomac River.

- A sand and gravel layer containing pebbles and cobbles, with variable but typically significant amounts of clay and silt. This layer is presumably alluvium deposited by the North Branch Potomac River.

The natural surficial material at Plant 1 is a silty clay layer. However, at some locations, particularly along the northern perimeter of Plant 1 adjacent to the river, up to several feet of fill material is located at the surface. The silty clay is typically light to dark brown. Towards the lower portions of the layer it contains traces of fine-grained sand. The thickness of the silty clay layer ranges from about 8 to 25 feet in the majority of Plant 1, averaging approximately 14 feet. The silty clay layer appears to thicken where the surface topography rises toward the base of Knobly Mountain, in the southern portion of Plant 1. This is evidenced by a silty clay layer thickness of 33 feet at Well 1GW7 (Figure 2-7).

Samples from the bottom of the silty clay layer were typically moist to wet. The elevation of the bottom of the silty clay layer ranges from about 645 to 661 feet msl, averaging approximately 652 feet msl. By comparison, the river surface elevation is estimated on the basis of measurements recorded during the RI, to average 648 feet msl.

An alluvium layer of generally poorly sorted gravel, sand, pebbles, and cobbles with variable, but typically significant amounts of clay and silt underlies the silty clay layer. Pebbles and cobbles generally were well-rounded and composed of sandstone or quartzite, but occasionally were composed of limestone and shale. This layer is greatly heterogeneous. The gravels and pebbles in the alluvium at the locations of monitoring wells GGW1/GGW2, GGW5/GGW6, GGW7/GGW8, 1GW10, and 1GW14, contained significant amounts of clay and silt. At the locations of wells GGW4, 2GW7, and 1GW12, the alluvium contained little or no fines. At Well 1GW13, the alluvium contained interbedded clayey gravels and clean sands.

The alluvium varies in thickness from about 6 to 24 feet at Plant 1. Typical thicknesses are approximately 15 feet. The alluvium generally is saturated through its entire thickness, except near the river. The average elevation of the bottom of the alluvium is about 640 feet msl.

Bedrock

Bedrock consisting of shale and limestone underlies the alluvium at Plant 1. Bedrock drilling during the RI at nine locations at Plant 1 revealed that shale is the most prevalent bedrock type beneath the site, particularly beneath the eastern half of Plant 1 where Sites 2, 3, and 4 exist. The shale, however, is slightly calcareous[2] at most locations, and contains visible calcite veins in a few places. No sandstone was encountered at ABL. However, the shale was noticeably siliceous in some beds. Limestone was not encountered east of Well 1GW10, except for some traces of argillaceous[3] limestone seen at Well 1GW14. The bedrock at wells 1GW10, 1GW12, and GGW4 consists of calcareous shale and argillaceous limestone; the limestone and shale are interbedded at wells GGW4 and 1GW10. At the location of the westernmost bedrock well, Well GGW2, bedrock consists of a calcite-veined limestone interbedded with a highly weathered shale. Drilling the borehole for Well GGW2 revealed a large void extending from approximately 80 to 82.5 feet below the ground surface. No other noticeable voids were encountered during bedrock drilling at ABL.

---

[2]Contains calcite as a noteworthy minor constituent.

[3]Clayey.

The bedrock characterization performed during the RI was based strictly on the examination of air-rotary drill cuttings; no rock-core samples were obtained. Drill cuttings do not preserve bedding relationships and structural features. Consequently, no attempt has been made to categorize the bedrock encountered at a particular well location according to the stratigraphic units defined in Table 2-1 for the regional geology. However, some general statements can be made.

The bedrock encountered at the westernmost monitoring well at Plant 1, Well GGW2, is most likely the limestone and shale of the Tonoloway Formation of Upper Silurian age (see Table 2-1). This is evinced by the composition of the rock; the location of the well in relation to regional geologic reports, which include mapped outcroppings north of Plant 1 at Pinto, Maryland; and the presence of voids in the limestone; geological literature documents the presence of solution channels and the development of karst topography above the Tonoloway Formation (Dyott, 1956; Clark, 1976).

The shales and occasional limestones of the Wills Creek, Mifflintown, and Rose Hill Formations probably constitute the bedrock beneath the remaining majority of Plant 1. No attempt was made to categorize the wells according to specific formation. However, the boreholes for monitoring wells GGW6 and 2GW7 definitely intersect the top of the Keefer Member of the Mifflintown Formation, as evinced by distinctive red-colored oolitic hematite encountered during drilling.

The elevation of the top of the bedrock surface at Plant 1 generally ranges from about 654 feet msl to a low of about 635 feet msl, averaging about 640 feet msl. Figure 2-9 presents a map of bedrock surface elevations across Plant 1, and provides interpretive contours at 5-foot intervals.

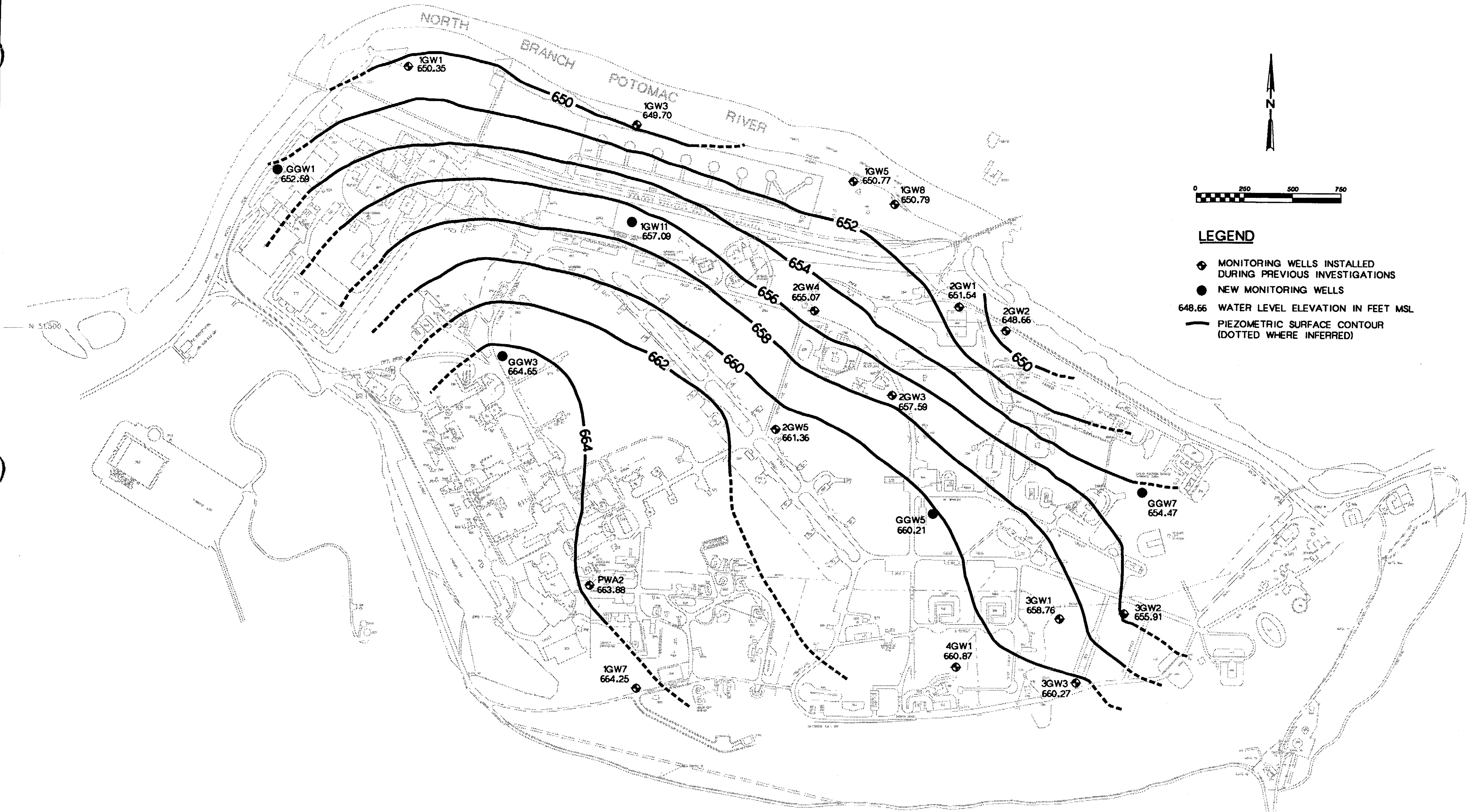


Figure 2-10

PLANT 1 - PIEZOMETRIC SURFACE OF THE ALLUVIAL AQUIFER
ALLEGANY BALLISTICS LABORATORY

CH2M HILL

00447G01Z

Both the bedrock surface contour map in Figure 2-9, and cross section in Figure 2-7, are based on questionable data from previous investigations. The reported depths to bedrock for wells PWA2, 2GW5, and 2GW6 may be invalid. Previous investigations relied exclusively on the interpretation of air-rotary drill cuttings to determine lithologic contacts, a method that can be very unreliable. The boring logs for wells PWA2 and 2GW5, indicate that the wells were drilled to elevations of approximately 634 and 629 feet msl, respectively, without encountering bedrock. This suggests the presence of a bedrock valley or depression. However, at production Well PWA, approximately 30 feet away from Well PWA2, a downhole television survey made during the RI indicated that in the vicinity of Well PWA bedrock occurs at an elevation of approximately 645 feet msl. In addition, the borehole log for Well 2GW5 indicates the presence of ''rock fragments'' in cuttings from near the bottom of the hole. These rock fragments might indicate that the borehole had entered bedrock after all, and at an elevation consistent with data collected during the recent RI. The recent data offers no evidence of a bedrock valley or depression beneath Plant 1.

Hydrogeology

In order to develop a conceptual hydrogeologic model of Plant 1, data and information were reviewed and interpreted. Boring logs and well completion diagrams of monitoring wells installed during the RI and Interim RI were interpreted. Also interpreted were the slug tests conducted during the RI to assess the hydraulic properties of the alluvial aquifer underlying Plant 1 and the straddle-packer tests conducted at production well PWA to evaluate the yields of isolated fracture intervals within the borehole, and to assess the degree of vertical interconnection between these intervals. The water-level measurements recorded at all monitoring wells on Plant 1 to evaluate the directions and rates of flow in the alluvial and bedrock aquifers beneath Plant 1 and the long-term water-level monitoring of the North Branch Potomac River and adjacent alluvial and bedrock wells to assess the degree of hydraulic interconnection between the aquifers and the river were interpreted.

Hydrogeologic information contained in the reports from previous investigations was reviewed and interpreted.

During the RI, some apparent errors were discovered in the data presented in the Interim RI concerning the screened units of monitoring wells. The errors that affect the development of a conceptual hydrogeologic model of the site are discussed briefly below.

Table 2-2 includes construction specifications for monitoring wells installed during the RI and previous investigations. On the basis of a review of the information from the Interim RI Report, monitoring wells 1GW2, 1GW4, 1GW6, 2GW1, and 3GW1 were determined to have been assigned to the wrong hydrogeological units. Wells that reportedly were screened across the alluvium/bedrock contact because of very long screen zones (wells 1GW2, 1GW4, and 1GW6), have been reinterpreted as being screened only in bedrock because their steel casings are reported to extend from the surface into the bedrock, presumably eliminating contact of the screens with the alluvium. Also, wells 2GW1 and 3GW1, which were reported in the Interim RI as being screened only in the bedrock, have been reinterpreted as being screened across the alluvium/bedrock contact because the reported depths of the steel surface casings do not reach the reported depths of the bedrock surface. The designations of the screened units for these wells have been revised in Table 2-2 to reflect the reinterpretations.

The geological information obtained during the RI indicates that the alluvium, which generally consists of clayey gravel, pebbles, and sand, constitutes the shallow aquifer beneath Plant 1. The alluvium is saturated throughout most of Plant 1, except close to the river at Site 1. The fractured bedrock underlying the alluvium constitutes a second, deeper aquifer that is to some degree hydraulically connected with the alluvium. Because of the lithologic differences between the alluvium and bedrock, the two units will be considered for discussion purposes as separate aquifers with some hydraulic interconnection.

Alluvial Aquifer

Slug tests were conducted at eight monitoring wells during the RI to provide estimates of the hydraulic conductivity of the alluvial aquifer. The test results are presented in Table 2-3. The observed hydraulic conductivities range from 1×10^{-5} centimeters per second (cm/sec), to 5×10^{-3} cm/sec with a median of approximately 6×10^{-4} cm/sec. The large range in hydraulic conductivities reflects the heterogeneity of the alluvium. At locations where the alluvium had a high clay content (wells GGW5, GGW7, 1GW11, and 3GW3), hydraulic conductivities were in the range of 10^{-5} to 10^{-4} cm/sec. Where the alluvium was relatively free of clay (wells GGW3, 1GW8, and PWA2), hydraulic conductivities were on the order of 10^{-3} cm/sec.

Water-level measurements recorded from all monitoring wells at ABL within a 4.5-hour period during the RI are presented in Table 2-4. The measurements from wells screened in the alluvial aquifer[4] were used to produce an interpretive contour map of the water levels (piezometric surface) in the alluvial aquifer (see Figure 2-10). The piezometric-surface contour map indicates that, on the scale of Plant 1 as a whole, the alluvial aquifer flow is generally toward the river. Beneath the eastern two-thirds (including Sites 2, 3, and 4) of Plant 1, groundwater flows predominantly toward the river in a northeasterly direction. Beneath the western one-third of the plant, groundwater flows generally toward the river in a northerly or northwesterly direction. The piezometric surface appears to slope relatively uniformly toward the river along the northern Plant 1 perimeter, but is noticeably flat in the south-central portion of Plant 1.

---

[4]Water-level measurements from five wells screened across the alluvium/bedrock contact also were used. Although the majority of the screened zone in these wells is in the alluvium, the water-level measurements from these wells are questionable because of compositing.

Table 2-3
SUMMARY OF SLUG TEST RESULTS AT WELLS SCREENED IN THE ALLUVIUM

Well	Date of Test	Nature of Alluvium in the Screened Zone	Test Number	Computed Hydraulic Conductivity	
				(cm/s)	(ft/day)
GGW3	7-30-92	Sand and gravel	1 2	4×10^{-3} 4×10^{-3}	12 12
GGW5	7-29-92	Clayey gravel	1 2	7×10^{-5} 9×10^{-5}	0.2 0.3
GGW7	7-30-92	Clayey gravel	1 2	1×10^{-4} 1×10^{-5}	0.3 0.04
1GW8	8-12-92	Sand and gravel	1 2	2×10^{-3} 2×10^{-3}	5 5
1GW11	8-13-92	Clayey sand and gravel	1 2	2×10^{-4} 3×10^{-4}	0.7 0.7
2GW4	7-30-92	Sand and gravel, trace clay	1 2	9×10^{-4} 1×10^{-3}	2 3
3GW3	8-12-92	Clayey gravel	1 2	2×10^{-5} 2×10^{-5}	0.05 0.05
PWA2	7-28-92	Sand and gravel	1 2	5×10^{-3} 5×10^{-3}	15 13

WDCR805/011.WP5

Table 2-4
SUMMARY OF WATER LEVEL MEASUREMENTS[1]

Well	Ground Elevation[2] (ft. MSL)	Casing Elevation[2] (ft. MSL)	Screen Depth Interval (ft)	Screened Unit[3]	Casing to Water Level (ft)	Water Level Elevation[2] (ft. MSL)
GGW1	668.79	671.65	18-23	A	19.06	652.59
GGW2	669.01	672.07	70-80	B	19.60	652.47
GGW3	667.53	670.57	12-22	A	5.92	664.65
GGW4	667.51	670.66	70-80	B	7.08	663.58
GGW5	663.92	666.59	15.5-25.5	A	6.38	660.21
GGW6	663.93	666.75	70-80	B	6.96	659.79
GGW7	660.36	663.21	13-23	A	8.74	654.47
GGW8	660.27	663.21	70-80	B	10.96	652.25
1GW1	667.62	670.09	10-40	A,B	19.74	650.35
1GW2	664.18	666.79	10-40	B	18.14	648.65
1GW3	665.95	668.25	10-40	A,B	18.55	649.70
1GW4	667.85	670.51	10-40	B	20.33	650.18
1GW5	666.58	668.47	10-40	A	17.70	650.77
1GW6	666.83	669.77	5-35	B	5.96	663.81
1GW7	704.46	707.34	27-57	A,B	43.09	664.25
1GW8	665.24	667.36	20-35	A	16.57	650.79
1GW9	665.76	668.12	65-80	B	19.73	648.39
1GW10	664.44	667.38	70-80	B	11.00	656.38

Table 2-4
SUMMARY OF WATER LEVEL MEASUREMENTS[1]

Well	Ground Elevation[2] (ft. MSL)	Casing Elevation[2] (ft. MSL)	Screen Depth Interval (ft)	Screened Unit[3]	Casing to Water Level (ft)	Water Level Elevation[2] (ft. MSL)
1GW11	664.64	667.53	11-18	A	10.44	657.09
1GW12	663.68	666.76	70-80	B	17.83	648.93
1GW13	665.59	668.43	111-121	B	17.98	650.45
1GW14	665.41	668.21	70.5-80.5	B	17.96	650.25
2GW1	665.86	667.04	10-40	A,B	15.50	651.54
2GW2	664.44	667.34	13-28	A	18.68	648.66
2GW3	663.86	666.62	11-26	A	9.03	657.59
2GW4	665.48	667.59	24-39	A	12.52	655.07
2GW5	663.80	665.68	20-35	A	4.32	661.36
2GW6	664.08	666.11	65-80	B	10.96	655.15
2GW7	665.33	668.13	71-81	B	14.46	653.67
3GW1	663.25	666.00	5-35	A,B	7.24	658.76
3GW2	662.28	665.15	10-25	A	9.24	655.91
3GW3	678.73	681.91	24-39	A	21.64	660.27
3GW4	667.12	669.47	75.5-90.5	B	8.44	661.03
4GW1	664.83	667.61	12-27	A	6.74	660.87
5GW1	753.70	756.31	20-60	A	29.68	726.63
5GW2	685.84	688.60	20-50	B	22.62	665.98

Table 2-4
SUMMARY OF WATER LEVEL MEASUREMENTS[1]

Well	Ground Elevation[2] (ft. MSL)	Casing Elevation[2] (ft. MSL)	Screen Depth Interval (ft)	Screened Unit[3]	Casing to Water Level (ft)	Water Level Elevation[2] (ft. MSL)
5GW3	686.29	689.16	20-50	B	22.72	666.44
5GW4	685.48	688.74	73-83	B	27.92	660.82
5GW5	685.63	688.89	65-75	B	22.46	666.43
PWA1	669.63	671.23	63-78	B	7.40	663.83
PWA2	669.39	671.68	20-35	A	7.80	663.88

NOTES:

[1]Water level measurements taken during 4.5-hour period on 8-12-92.
[2]All elevations are in feet above mean sea level (ft. MSL).
[3]Screened Unit: A = Alluvium; B = Bedrock; A,B = Well screened across the alluvium/bedrock contact.

11-May-1994
4159c03.dgn

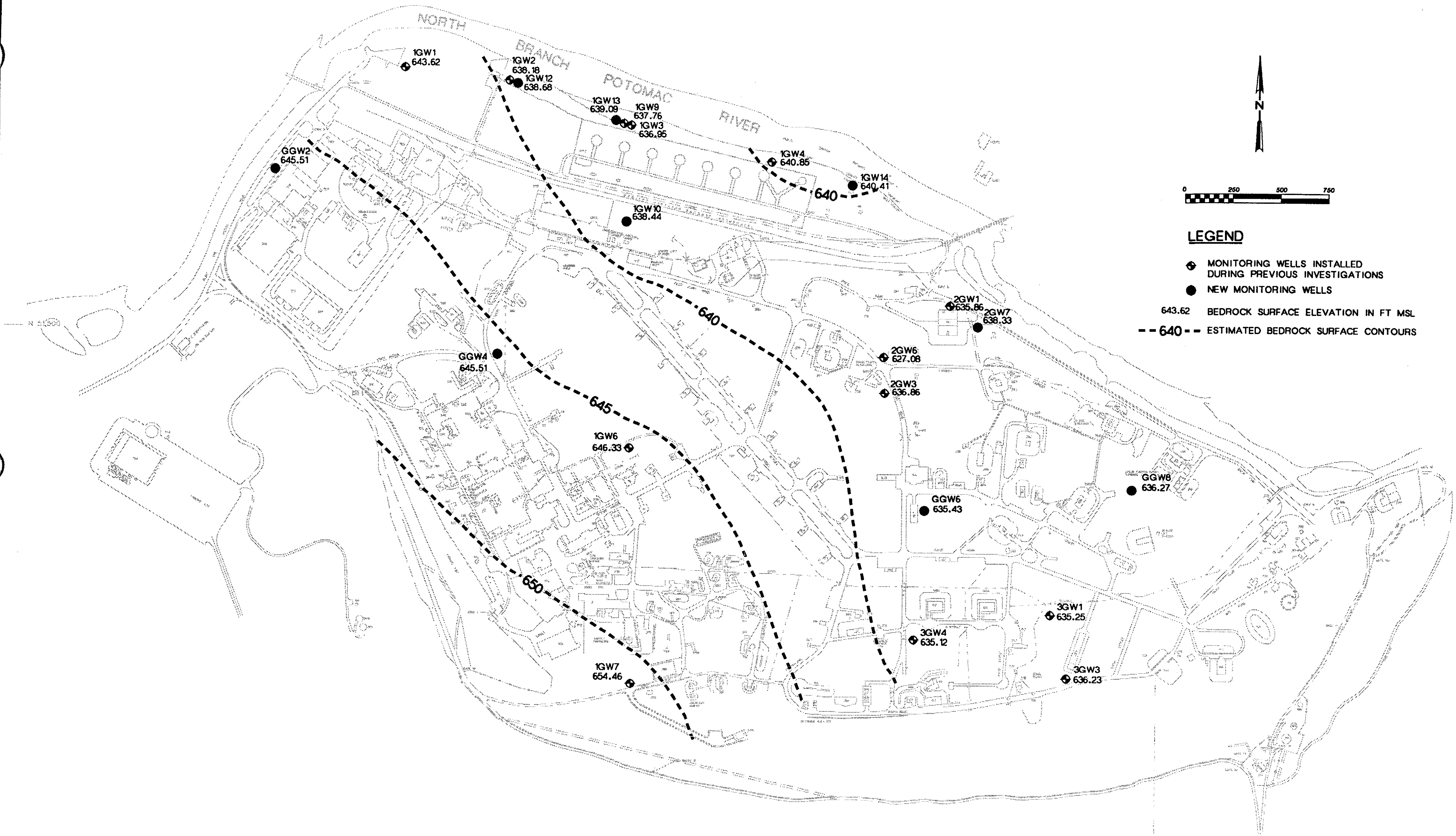


Figure 2-9

PLANT 1 - BEDROCK SURFACE ELEVATIONS
ALLEGANY BALLISTICS LABORATORY

CH2MHILL

00447G022

The top and bottom elevations of the alluvium are approximately 652 and 640 feet msl, respectively. During average flow conditions along Site 1 in the vicinity of Well 1GW13, the river level was twice measured at approximately 648 feet msl. The river level is therefore located within the elevation range of the alluvial aquifer across Plant 1. The elevation of the river and nearby shallow aquifer suggest that the river is the ultimate discharge zone for groundwater flowing laterally through the alluvium.

The term hydraulic gradient is defined as the change in hydraulic head between two measuring points. The horizontal hydraulic gradients at Plant 1 within the alluvial aquifer range from a low of approximately 0.002 feet per horizontal foot between the 662 feet msl contour and Well GGW5 in the south central portion of Plant 1, to a high of approximately 0.015 between wells 1GW11 and 1GW3 near the northern perimeter of the facility.

Using estimates of hydraulic conductivity and horizontal hydraulic gradient, the average linear velocity of horizontal groundwater flow can be calculated. The average linear velocity of horizontal groundwater flow is equal to the product of the hydraulic gradient and the hydraulic conductivity, divided by the effective porosity of the aquifer material. Adjacent to the river, where the steepest hydraulic gradients at Plant 1 are located, the estimated average linear velocity ranges from approximately 1 to 400 feet per year (ft/yr), with a median linear velocity of approximately 47 ft/yr. In the south-central portion of Plant 1 including sites 3, 4, and PWA, where the hydraulic gradients are flattest, the estimated average linear velocity ranges from 0.1 to 52 ft/yr, with a median linear velocity of approximately 6 ft/yr. These calculations assume an effective alluvium porosity of 20 percent. The large range of average linear velocities reflects the wide range of alluvial hydraulic conductivities.

Bedrock Aquifer

Unlike the alluvial aquifer, lateral groundwater flow in the bedrock aquifer is confined to fractures and solution channels. The directions and rates of groundwater movement in fractured bedrock are controlled by the size, frequency, and orientation of fractures and by the hydraulic gradient. Because of the significant number of compositionally and structurally varied bedrock stratigraphic units underlying ABL, the hydraulic characteristics of the bedrock aquifer are likely to vary greatly across the site.

One estimate of the hydraulic properties of a portion of the bedrock aquifer was calculated during a previous investigation. An 8-hour pumping test conducted in production well PWA produced an estimate of the transmissivity of the bedrock on the order of 2,000 to 6,300 gallons per day per foot in the vicinity of the well. The results of the pumping test also indicated a hydraulic connection between the alluvial and bedrock aquifers.

At eight locations on Plant 1, a monitoring well screened in the alluvium is located within about 20 feet of a well screened in bedrock. Water-level measurements from these paired wells were compared in order to determine the direction and magnitude of the vertical component of the hydraulic gradient between the alluvial and bedrock aquifers. The results, presented in Table 2-5, indicate that the calculated vertical components of flow between the alluvium and bedrock were downward at all locations, with gradients of varied magnitude. The alluvial and bedrock aquifers are most likely well connected at locations where the vertical hydraulic gradient is small.

Figure 2-11 presents an interpretive contour map of the piezometric surface in the bedrock aquifer, derived from the water-level elevations in monitoring wells screened entirely in bedrock. The contour map indicates that the horizontal flow patterns in the bedrock are similar to those in the overlying alluvium. The horizontal hydraulic gradients are similar also, ranging from approximately 0.003 in the south-central portion of the site between the 662 feet msl contour and Well GGW6, to 0.016 between wells 1GW11 and 1GW3 near the northern perimeter of the facility.

Table 2-5
CALCULATED VERTICAL COMPONENT OF THE HYDRAULIC GRADIENT AT PAIRED WELLS IN THE ALLUVIUM AND BEDROCK

Well Pair[a]	Measured Difference in Water Level Elevations (ft)	Distance Between Well Screens[b] (ft—max/min)	Vertical Component of Hydraulic Gradient (max/min)	Direction of Vertical Component of Flow
GGW1/GGW2	-0.12	62/47	0.0026/0.0019	Down
GGW3/GGW4	-1.07	68/48	0.022/0.016	Down
GGW5/GGW6	-0.42	64/44	0.0095/0.0066	Down
GGW7/GGW8	-2.22	67/47	0.047/0.033	Down
1GW11/1GW10	-0.71	69/52	0.014/0.010	Down
1GW3/1GW9[1]	-1.31	70/25	0.052/0.019	Down
1GW5/1GW14	-0.52	72/32	0.016/0.0072	Down
PWA2/PWA1	-0.05	58/28	0.0018/0.00086	Down

NOTES:

[a]Alluvial well/bedrock well.

[b]Max = Top of screen for alluvial well minus bottom of screen for bedrock well.
Min = Bottom of Screen for alluvial well minus top of screen for bedrock well.

[1]1GW3 is screened across the alluvium/bedrock contact, while 1GW9 is screened entirely in bedrock.

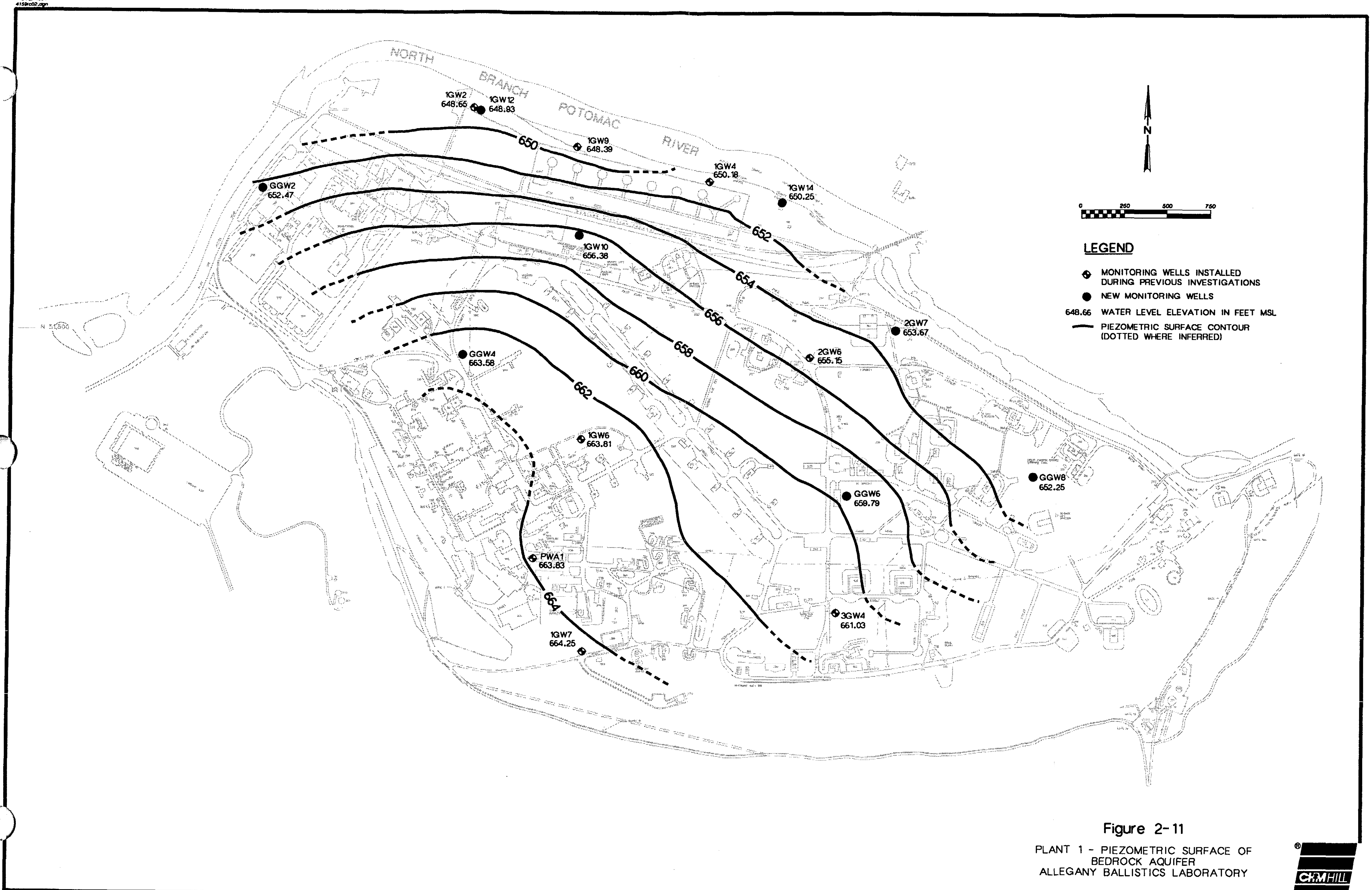


Figure 2-11

PLANT 1 - PIEZOMETRIC SURFACE OF BEDROCK AQUIFER
ALLEGANY BALLISTICS LABORATORY

CH2M HILL

00447603Z

As discussed with the Site Geology, the two principal fracture orientations measured near ABL had average strikes of N26°E and N39°W; Fracture Set 1 is roughly parallel to the strike of bedding planes in the Wills Mountain anticlinorium and Fracture Set 2 is oblique to the general structural trend. Fracture orientations similar to either of these sets in the bedrock beneath Plant 1 would facilitate the movement of groundwater toward the North Branch Potomac River. The water-level contour map of bedrock indicates that the general direction of the groundwater flow beneath the eastern two-thirds of Plant 1 is roughly parallel to the strike of Fracture Set 1. The general direction of groundwater flow beneath the western one-third of Plant 1 is roughly parallel to the strike of Fracture Set 2.

Solution-widened fractures in limestone and dolomite bedrock can facilitate rapid migration of groundwater. RI drilling did not reveal large solution channels except at Well GGW2, the westernmost bedrock well at Plant 1. As stated in Section 5, this well is thought to be screened in limestone and shale of the Tonoloway Formation, with characteristic solution cavities and karst topography. Bedrock drilling east of Well GGW2 during the RI revealed predominantly shale bedrock without voids or large solution cavities. However, because of the relatively few bedrock drilling locations at Plant 1, solution channels could have developed at other locations and not been discovered.

Water-level measurements were recorded on two occasions in a well cluster adjacent to the North Branch Potomac River; measurements of the water level in the river adjacent to the wells were recorded simultaneously. The measured wells included Well 1GW3 (screened across the alluvium/bedrock contact, from 24 to 40 feet below ground), Well 1GW9 (screened in moderately deep bedrock from 65 to 80 feet below ground), and Well 1GW13 (screened in deeper bedrock from 111 to 121 feet below ground). These measurements permit a comparison of well water level with river water level. They also permit evaluation of the vertical component of the hydraulic gradient between the alluvium and shallow bedrock, and between the shallow and deep bedrock. The water-level measurements are reported in Table 2-6. The results of the comparisons indicate a downward vertical component of groundwater flow at this location between the

Table 2-6
WATER LEVELS AT SELECTED ALLUVIUM AND BEDROCK MONITORING WELLS ADJACENT TO THE NORTH BRANCH POTOMAC RIVER

Location	Screened Unit[1]	Screen Depth Interval (ft)	Water Level (ft. MSL) 8-31-92	Water Level (ft. MSL) 9-16-92
1GW3	A,B	24-40[2]	649.20	648.75
1GW9	B	65-80	648.30	648.06
1GW13	B	111-121	650.35	650.17
River			648.07	647.98

NOTES:

[1]Screened Unit: A = Alluvium; B = Bedrock; A,B = Well screened across the alluvium/bedrock contact.
[2]Effective screen zone. Although the well screen extends from 10-40 ft., a steel surface casing extends from the surface to a depth of 24 ft.

WDCR805/010.WP5/2

alluvium/shallow bedrock and moderately deep bedrock. However, vertical groundwater flow between moderately deep bedrock and deeper bedrock was upward. The magnitude and direction of the gradients were consistent between measurement periods. Moreover, the water level in the moderately deep bedrock well (Well 1GW9) was slightly higher than the river level. Relative to the other wells, Well 1GW9 was closest to the river level. On the basis of these results, the bedrock aquifer appears to be hydraulically connected to the river at this location. Because the top-of-bedrock surface adjacent to the river at this location was measured at approximately 640 feet msl, compared to the river level at about 648 feet msl, the hydraulic connection is probably transmitted through some thickness of alluvial sediments beneath the river channel. A hydraulic connection between the bedrock and the river does not eliminate the possibility that some portion of horizontal groundwater flow crosses beneath the river. Without measurements of groundwater levels north of the river, the potential for this flow cannot be evaluated.

Simultaneous water-level measurements also were recorded continuously (i.e., at 15-minute intervals using pressure transducers and a datalogger) at wells 1GW3 and 1GW9 and the river for a period of approximately 5 weeks. Long-term water-level monitoring helped to determine the degree of hydraulic interconnection between the river and the alluvial and bedrock aquifers. The water-level changes in the bedrock well (Well 1GW9) correspond very closely in time and magnitude to changes in river level. This indicates a strong hydraulic connection between the bedrock aquifer and the river. However, the water-level changes in the well screened across the alluvium/bedrock contact (Well 1GW3) show only occasional very subdued responses to river-level changes, which would indicate an unexpectedly poor hydraulic connection with the river.

Well construction may explain the poor response of Well 1GW3 to the changes in the river level. Installed during the Interim RI, this well has a screen zone extending from 10 to 40 feet below ground. However, a steel surface casing extends from the ground surface to 24 feet below ground, reducing the effective screen zone to the interval from 24 to 40 feet below ground. During the installation of Well 1GW13, adjacent to Well 1GW3, bedrock was encountered at 26.5 feet below ground surface, and water-bearing fractures in bedrock were not encountered until a depth of approximately 62 feet. This means that Well 1GW3 is screened approximately 2.5 feet in alluvium and 13.5 feet in bedrock that is potentially devoid of fractures. Moreover, the alluvium at the 24 to 26.5 foot depth at this location was characterized during the RI as a clayey gravel, which generally has relatively low permeabilities. The limited exposure of Well 1GW3 to the alluvium, combined with the relatively low permeability of the alluvium at the location, may explain the poor response of Well 1GW3 to the changes in river level. These results likely are not indicative of the general degree of hydraulic connection between the alluvium and the river. Therefore, it is still conceivable that a hydraulic connection exists.

Site PWA

A number of downhole procedures were performed in production well PWA, a well approximately 200-feet deep and finished as an open borehole in bedrock. The downhole procedures included geophysical logging, downhole video logging, and straddle-packer testing of five borehole intervals. Complete testing procedures, copies of borehole logs, and packer test data are presented in Appendix E of the Draft RI Report.

Straddle-packer testing was performed in five depth intervals within the borehole of PWA. The tested intervals were:

- Interval 1 (0-40 ft.)
- Interval 2 (40-70 ft.)
- Interval 3 (72-102 ft.)
- Interval 4 (108-138 ft.)
- Interval 5 (138-200 ft.)

The hydrogeologic objectives of the packer testing helped to determine the yield of the fracture zones within each interval of the borehole, and to assess the natural interconnection between the tested interval and the intervals above and below.

The results of the packer tests indicated that the yield of Well PWA was highly variable over the length of the borehole. The yields of the intervals were, in gallons per minute (gpm): Interval 1, 2.3 gpm; Interval 2, 24 gpm; Interval 3, 13 gpm; Interval 4, greater than 26 gpm (the maximum flow rate of the pump at this depth); and Interval 5, 7 gpm. On the basis of these results, Intervals 2 and 4 appear to provide the majority of the total yield of Well PWA.

During the packer testing of Interval 4, pumping produced piezometric responses in Intervals 3 and 5, indicating some degree of hydraulic interconnection between the intervals. The pumping of the other intervals did not produce responses outside of the tested interval.

The variability of yields and interconnections between the tested intervals at Well PWA demonstrates that the bedrock aquifer is hydrogeologically complex. Because of the complexity, extrapolating the properties or distribution of specific fracture zones any great distance from site PWA is not feasible.

Site 5

Site 5 is located at the western end of ABL, on a terrace above the North Branch Potomac River (see Figure 2-1). A previous investigation found no significant thicknesses of unconsolidated deposits underneath Site 5. Instead weathered limestone and shale over limestone and shale bedrock were reported to underlay the site. However, RI drilling at Monitoring Well 5GW5, between the river and Site 5 (See Figure 2-12) and in line with

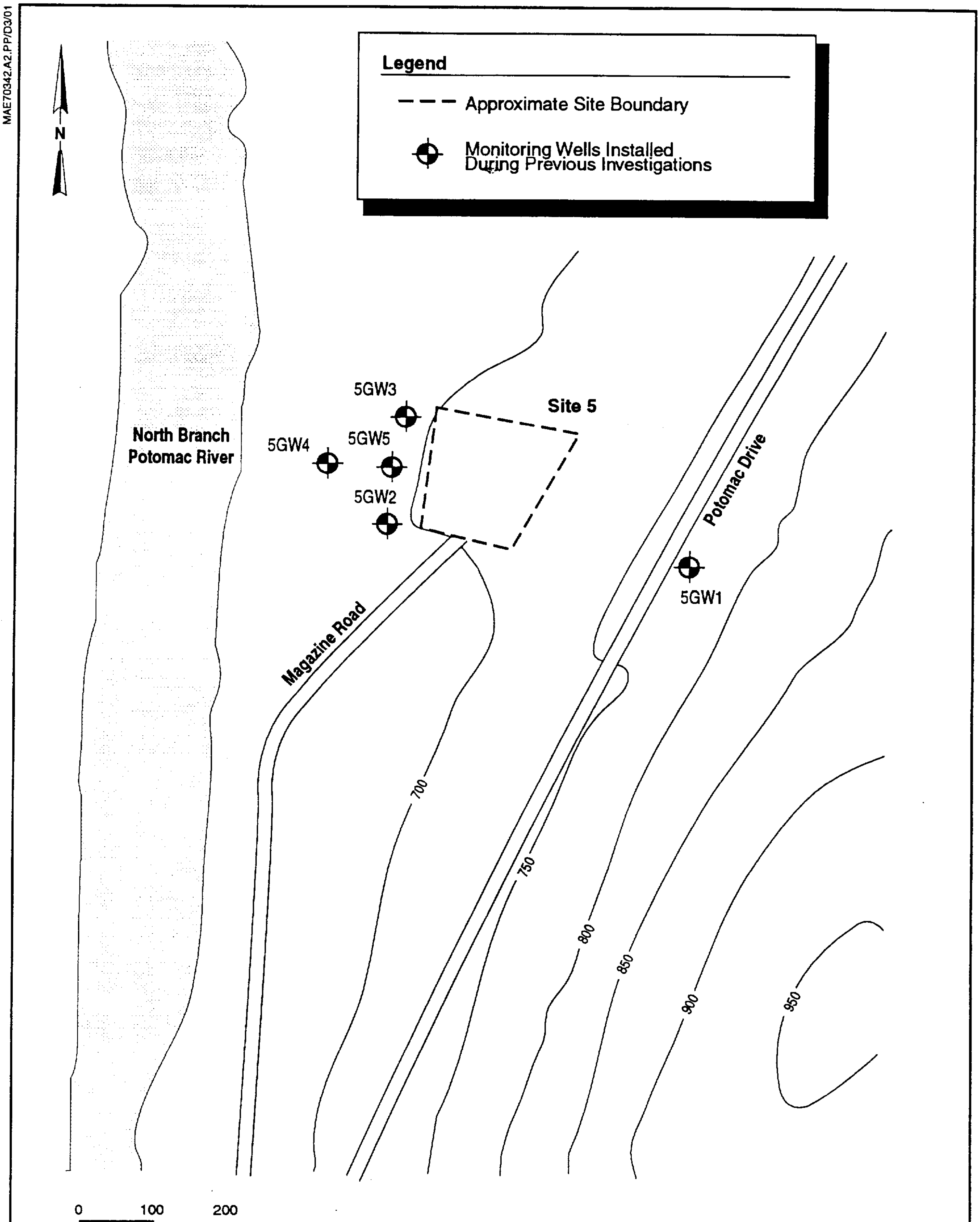


Figure 2-12
SITE 5—MONITORING WELL LOCATIONS
Allegany Ballistics Laboratory

two wells from a previous investigation, indicated that unconsolidated deposits overlie bedrock. The boring log for Well 5GW5 shows a clay containing gravel and limestone pebbles existing from the surface (685.63 feet msl) down to a depth of 14 feet (671.63 feet msl). This is probably fill material; a visual examination of the site supports this conclusion. A silty clay is present from a depth of 14 feet to a depth of 28 feet (657.63 feet msl). This resembles the silty clay floodplain deposits observed at Plant 1. From a depth of 28 feet to the top of bedrock at 34 feet (651.63 feet msl), there is a saturated clayey gravel alluvium with rounded pebbles. The composition, elevation, and thickness of this alluvium is similar to that observed beneath Plant 1.

The bedrock underlying the alluvium between Site 5 and the river consisted of dark gray to black calcareous shale with traces of calcite veins. Drilling revealed no detectable voids or solution cavities. The bedrock is probably part of the Needmore or Marcellus Shale Formations of middle Devonian age (see Table 2-1). The bedrock surface probably slopes towards the river west of Monitoring Well 5GW4 and it is essentially flat between wells 5GW5 and 5GW4.

The most significant hydrogeological discovery of the RI for Site 5 was the identification of saturated alluvial deposits downgradient of Site 5 analogous to those observed at Plant 1. A previous investigation had concluded that no significant thicknesses of unconsolidated deposits were beneath Site 5, and that the site was underlain by weathered limestone and shale over limestone and shale bedrock. However, drilling and soil sampling during the RI revealed that, beneath 14 feet of probable fill material, were 14 feet of silty clay floodplain deposits overlying 6 feet of saturated clayey gravel alluvium containing rounded pebbles. This clayey gravel layer constitutes an alluvial aquifer beneath Site 5. Because the alluvium was not known to exist before the RI drilling commenced, no monitoring wells screened in the alluvium have been installed. Therefore, no hydrogeologic information is available concerning this aquifer.

The monitoring-well network at Site 5 consists of one upgradient alluvial well (Well 5GW1) and four downgradient bedrock wells (wells 5GW2, 5GW3, 5GW4, and 5GW5). The locations of the monitoring wells are shown in Figure 2-12. Water levels in the monitoring wells indicate that the piezometric surface in the bedrock aquifer slopes towards the west, in the general direction of the river (see Figure 2-13). The estimated horizontal hydraulic gradient between wells 5GW5 and 5GW4 is approximately 0.09 feet per horizontal foot.

WDCR829/003.WP5

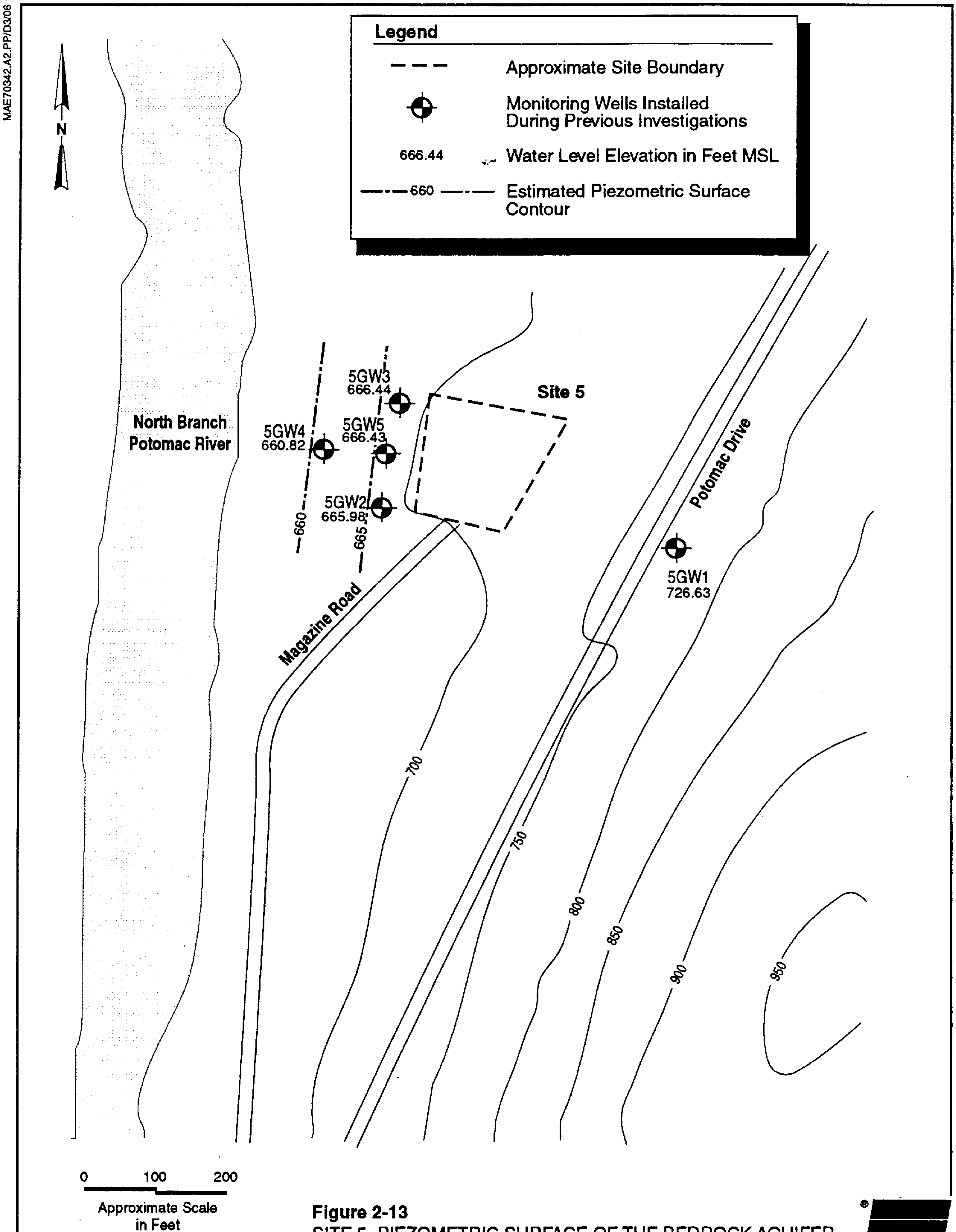


Figure 2-13
SITE 5–PIEZOMETRIC SURFACE OF THE BEDROCK AQUIFER
Allegany Ballistics Laboratory

Section 3

Initial Evaluation

This section presents and discusses analytical data for each medium sampled during previous investigations. Results of the soil and groundwater analyses are presented and discussed for each site. However, because sites 2, 3, 4, and PWA are all located within Plant 1 and their proximity to one another, results of groundwater analyses for Plant 1 are discussed first with references to sites 2, 3, 4, and PWA followed by a discussion for each site.

Soil Contamination

Except for a composite soil sample collected at Site 4B during the confirmation study and soil samples collected at Site 5 during the IAS, the RI was the only previous investigation that included the collection and analysis of soil samples at sites 2, 3, and PWA. However, no soil samples were collected at sites 4 or 5 during the RI and soil gas surveys were conducted at sites 2 and 3 during the confirmation study. The soil gas results are presented in the Interim RI Report and were used to direct the soil investigation conducted as part of the RI.

Analytical data of all soil samples collected at sites 2, 3, 4, 5, and PWA are presented and discussed below.

Soil Contamination at Site 2

The soil investigation conducted during the RI at Site 2 included investigations for VOCs, SVOCs, inorganics, and explosives. Section 4 of the Draft RI Report details the scope and rationale for the soil investigation conducted at Site 2. Figure 3-1 shows soil sample locations.

VOCs Detected in Soils

Overall, low levels of VOCs were detected at Site 2. Soil samples were analyzed for VOCs using an onsite mobile laboratory and an offsite laboratory. The onsite mobile laboratory analyzed for seven VOCs. The compounds were:

- 1,1,1-trichloroethane (1,1,1-TCA)
- 1,1-dichloroethane (1,1-DCA)
- 1,1-dichloroethane (1,1-DCE)
- cis-1,2-dichloroethene (cis-1,2-DCE)
- methylene chloride (MC)
- trans-1,2-dichloroethene (trans-1,2-DCE)
- trichloroethene (TCE)

The compounds 1,1,1-TCA, TCE, and methylene chloride represent three of the four primary solvents used at ABL as indicated by the focused facility audit. The offsite laboratory analyzed for TCL volatiles. Table 3-1 lists all VOCs detected in soil samples analyzed by the onsite mobile laboratory and the offsite laboratory. Sample numbers include the suffix ''ON'' indicating the sample was analyzed onsite. Duplicate samples are also included in the table indicated by the suffix ''DUPON.'' Nine soil samples were collected and analyzed for VOCs by the onsite mobile laboratory and the offsite laboratory analyzed splits from 4 of the 9 samples.

4159fc22.dgn

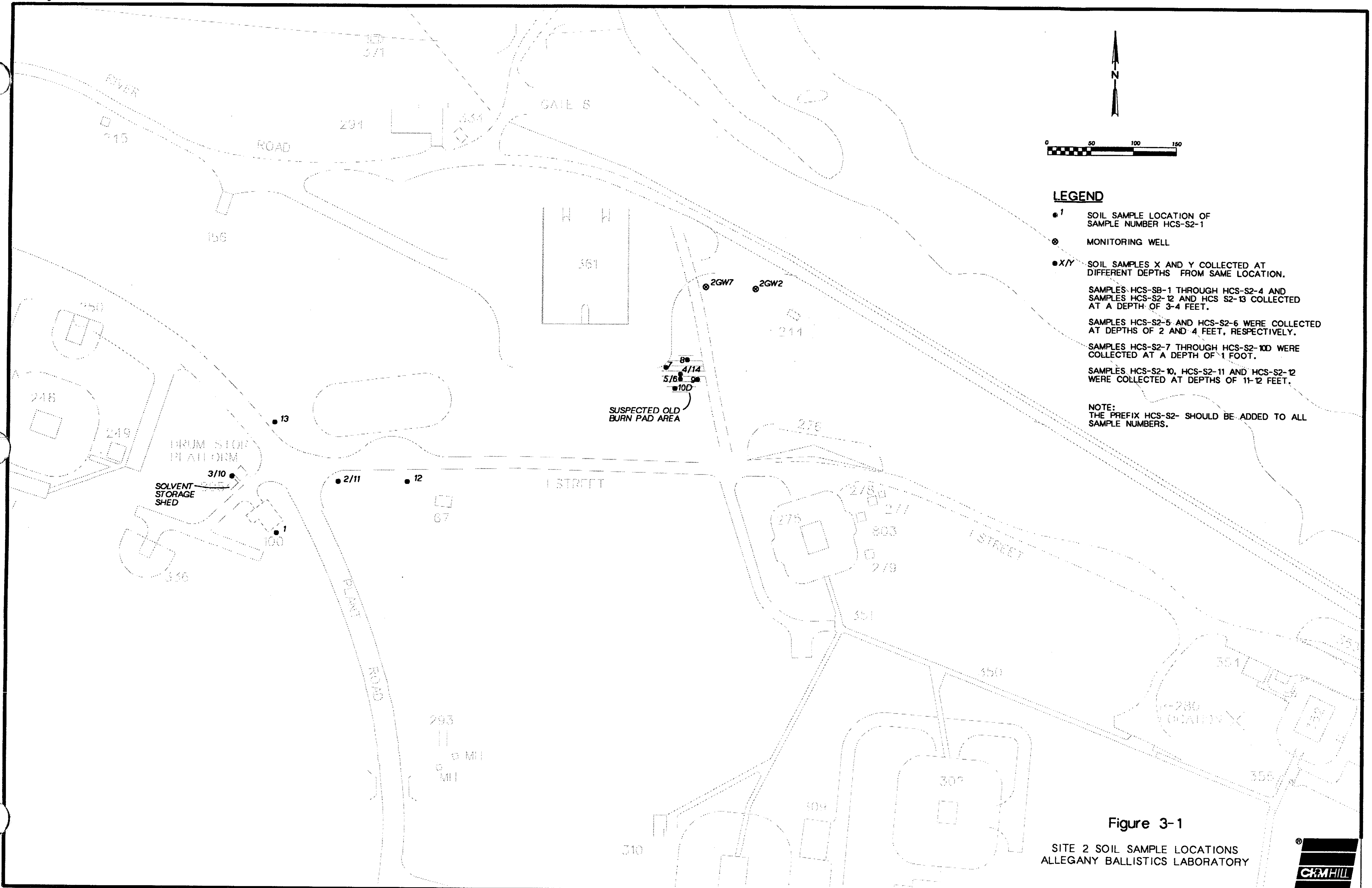


Figure 3-1

SITE 2 SOIL SAMPLE LOCATIONS
ALLEGANY BALLISTICS LABORATORY

00447604z

TABLE 3-1
SITE 2 - VOCs DETECTED FOR ALL SOIL SAMPLES
(UNITS IN UG/KG)

	HCS-S2-1DUPON		HCS-S2-1ON		HCS-S2-2		HCS-S2-2ON		HCS-S2-3ON		HCS-S2-4	
1,1-DICHLOROETHENE	19	U	19	U	6	UJS	19	U	19	U	6	UJS
ACETONE					12	JC					12	JC
CARBON DISULFIDE					3	JS					3	JS
METHYLENE CHLORIDE	19	U	19	U	36	JB	19	U	19	U	37	JB
TRICHLOROETHENE	9.6	U	9.6	U	14	JES	9.6	U	9.6	U	13	JES
XYLENES (TOTAL)					3	JS					5	JS

	HCS-S2-4ON		HCS-S2-10ON		HCS-S2-11		HCS-S2-11ON		HCS-S2-12ON		HCS-S2-13DUPON	
1,1-DICHLOROETHENE	19	U	20	U	6	U	920		290		20	U
ACETONE					12	UJB						
CARBON DISULFIDE					6	U						
METHYLENE CHLORIDE	19	U	20	U	12	UJ	20	U	18	U	20	U
TRICHLOROETHENE	9.6	U	9.8	U	6	U	10	U	9	U	10	U
XYLENES (TOTAL)					6	U						

	HCS-S2-13ON		HCS-S2-14		HCS-S2-14ON	
1,1-DICHLOROETHENE	19	U	6	U	18	U
ACETONE			13	UJC		
CARBON DISULFIDE			6	U		
METHYLENE CHLORIDE	19	U	12	UJB	18	U
TRICHLOROETHENE	9.7	U	6	U	8.8	
XYLENES (TOTAL)			6	U		

Table 3-1 shows few inconsistencies in the analytical data from the onsite and offsite laboratories, with the exception of TCE results for sample HCS-S2-14 and HCS-S2-2 (see Figure 3-1 for sampling locations). However, the inconsistencies can be attributed to the high number of non-detects. In addition, split samples of the few onsite samples in which significant levels of VOCs were detected (HCS-S2-11ON and HCS-S2-12ON) were not collected or analyzed by the offsite laboratory. Consequently, data for these samples could not be compared.

Table 3-2 summarizes a statistical analysis performed with VOC analytical data for all VOCs detected by either laboratory at Site 2. Analytical data generated from the onsite mobile laboratory and the offsite laboratory is included. Therefore, the total count shown in Table 3-2 represents the sum of all samples analyzed by both laboratories. Hence, VOC compounds only analyzed by the offsite laboratory show a total count of 4, those compounds only analyzed by the onsite mobile laboratory show a total count of 9, and those compounds analyzed by both laboratories show a total count of 13.

TCE, ranging from 5 to 14 μg/kg, was detected in 3 of the 9 samples. Acetone, carbon disulfide, methylene chloride, and total xylenes were detected at low levels in 2 of the 9 samples. The two samples were HCS-S2-2 and HCS-S2-4, which also contained TCE. The highest concentrations of VOCs detected were of 1,1-DCE in samples HCS-S2-11ON and HCS-S2-12ON.

SVOCs Detected in Soils

As discussed in Section 4 of the Draft RI Report, two soil samples were collected at different depths in the center of the suspected old burn pad area shown in Figure 3-1. Both samples were analyzed for the SVOCs included on the EPA TCL. No SVOCs were detected in soil samples collected at Site 2.

TABLE 3-2
SITE 2 - STATISTICAL ANALYSIS OF VOCs DETECTED IN SOIL

	Maximum Concentration	Minimum Concentration	Standard Deviation	Arithmetic Mean	Frequency	Detected Count	Total Count
VOLATILE ORGANICS (UG/KG)							
1,1-DICHLOROETHENE	920	5	259.4	97.3	0.15	2	13
ACETONE	12	5	4.0	8.5	0.50	2	4
CARBON DISULFIDE	5	3	1.2	4.0	0.50	2	4
METHYLENE CHLORIDE	37	5	11.8	9.8	0.15	2	13
TRICHLOROETHENE	14	5	3.2	6.6	0.23	3	13
XYLENES (TOTAL)	5	3	1.0	4.5	0.50	2	4

Note: A value equal to one-half the detection limit was entered for all non-detects.

Explosives Detected in Soils

As discussed in Section 4 of the Draft RI Report, two soil samples were collected at different depths in the center of the suspected old burn pad area at Site 2. No explosives were detected in soil samples collected at Site 2.

Inorganics Detected in Soils

The collection of two soil samples from the center of the suspected burn pad area for inorganics analysis is discussed in Section 4 of the Draft RI Report. Figure 3-1 shows the location of the sampling. Soil samples were screened using XRF and selected samples were sent to the offsite laboratory and analyzed for inorganics included on the TAL. Table 3-3 lists the inorganics included on the TAL and presents the results of the sample analysis. The XRF screening showed little indication of elevated levels of inorganics at Site 2. Therefore, the selection of the two soil samples for offsite analysis was based only on their location. Table 3-3 shows low levels of inorganics existing in the soil samples collected at Site 2. Arsenic, beryllium, cadmium, chromium, lead, and mercury all occur at low levels.

Soil Contamination at Site 3

The soil investigation at Site 3 included investigations for VOCs, SVOCs, inorganics, and explosives. Section 4 of the Draft RI Report details the scope and rationale for the soil investigation conducted at Site 3. Figure 3-2 gives the soil sample locations.

VOCs Detected in Soils

As with Site 2, an onsite mobile laboratory was used in conjunction with an offsite laboratory to analyze soil samples for VOCs at Site 3. Consequently, analyses performed by both laboratories are identical to those for Site 2.

4159fc32.dgn

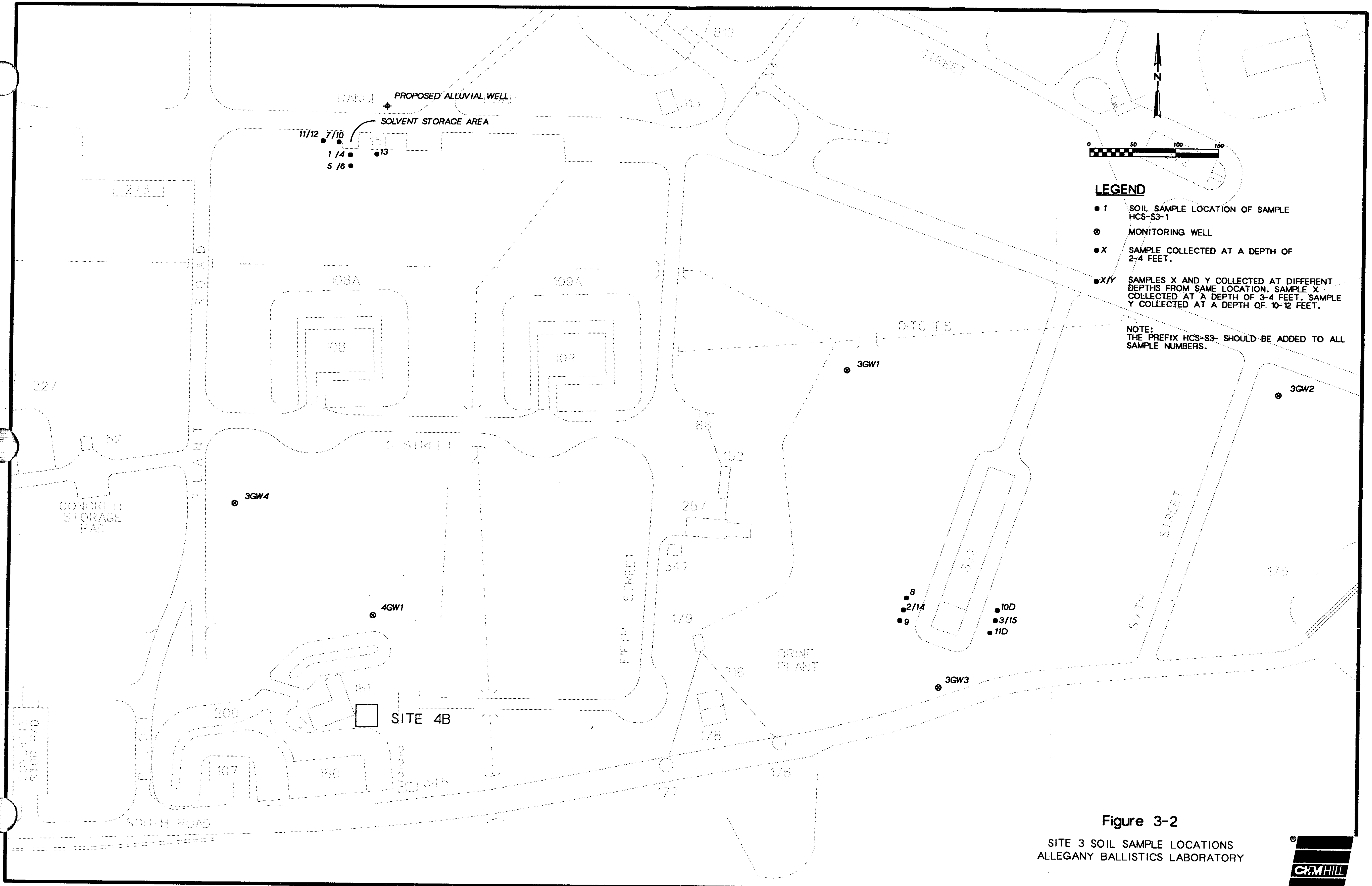


Figure 3-2

SITE 3 SOIL SAMPLE LOCATIONS
ALLEGANY BALLISTICS LABORATORY

004476057

Analytical data for VOC contamination in onsite and offsite samples are presented in Appendix A of the Draft RI Report. Table 3-4 shows VOCs detected in the soil samples analyzed by either laboratory. The sample numbering scheme indicating which laboratory analyzed each sample is identical to that for Site 2. Comparing data generated by the onsite mobile laboratory with those generated by the offsite laboratory reveals few inconsistencies. However, as shown with sample HCS-S3-1, for samples with very high concentrations of TCE and 1,2-DCE, the offsite laboratory indicates concentrations 4 to 10 times higher than the onsite mobile laboratory.

Table 3-5 presents a statistical analysis of analytical data generated by both laboratories for all VOC-contaminated soil. Duplicates were not included in the analysis. A total of 12 soil samples were collected and analyzed by the onsite mobile laboratory. In addition, 5 of these 12 samples were split and sent for analysis by the offsite laboratory. Therefore, the total count shown in Table 3-5 represents the sum of all samples analyzed by both laboratories. Hence, VOC compounds analyzed only by the offsite laboratory show a total count of 5, those compounds only analyzed by the onsite mobile laboratory show a total count of 12, and those analyzed by both laboratories show a total count of 17.

Table 3-5 shows that TCE, ranging from 2 to 49,000 μg/kg, was detected in 11 of the 17 total counts. However, Table 3-4 reveals that TCE was actually detected in 7 of the 12 samples. The maximum concentrations of VOCs were found in sample HCS-S3-1, from a location south of Building 151 (Figure 3-2). In addition, the maximum concentrations for methylene chloride, cis-1,2-DCE, 1,2-DCE (total), and acetone shown in Table 7-16 were all detected in sample HCS-S3-1. For this reason, an additional 8 samples were collected at various depths below and around sampling location HCS-S3-1 (see Figure 3-2). TCE was detected in only 3 of these 8 samples, with concentrations ranging from 94 to 390 μg/kg.

Four soil samples were collected at various depths from around the southern end of Building 362 (Figure 3-2). TCE was detected at concentrations ranging from 10 to 200 μg/kg in 3 of the samples.

TABLE 3-3
SITE 2 - ANALYTICAL DATA FOR
METALS IN SOIL

	HCS-S2-5		HCS-S2-6	
METALS (MG/KG)				
ALUMINUM	8220	JD	9800	JD
ANTIMONY	2.9	JS	3	JS
ARSENIC	5	N	6.7	N
BARIUM	220		205	
BERYLLIUM	1.2		1.2	
CADMIUM	1	JS	0.95	JS
CALCIUM	2540		2580	
CHROMIUM	13.8	JS	15.7	JS
COBALT	17.1		19	
COPPER	26.2	JS	31.6	JS
IRON	27500		31800	
LEAD	17.1		23.2	
MAGNESIUM	1190		1420	
MANGANESE	1170		1140	
MERCURY	0.08	U	0.09	U
NICKEL	23.2		27	
POTASSIUM	1120		1170	
SELENIUM	0.48	JS	0.45	RS
SILVER	0.35	U	0.48	
SODIUM	195	UJB	209	UJB
THALLIUM	0.48	U	0.5	U
VANADIUM	19.2		21.8	
ZINC	80.3	JS	84.3	JS

TABLE 3-4
SITE 3 - VOCs DETECTED IN SOIL
(UNITS IN UG/KG)

	HCS-S3-1		HCS-S3-1DL		HCS-S3-1ON		HCS-S3-2		HCS-S3-2ON		HCS-S3-3ON	
1,1,1-TRICHLOROETHANE	740	U	1500	U	14		7	U	9.1	U	9.1	U
1,2-DICHLOROETHENE (TOTAL)	12000		6500	D			7	U				
ACETONE	1500	UJB	1300	DJ			36					
BROMOMETHANE	1500	U	3000	U			13	JC				
CHLOROETHANE	1500	U	3000	U			13	JC				
CIS-1,2-DICHLOROETHENE					640				18	U	18	U
METHYLENE CHLORIDE	1500	UJB	540	BDJ	21	U	7	JC	18	U	19	
TRANS-1,2-DICHLOROETHENE					27				18	U	18	U
TRICHLOROETHENE	49000	JE	49000	D	11000		2	J	23		10	

	HCS-S3-4		HCS-S3-4ON		HCS-S3-5ON		HCS-S3-6ON		HCS-S3-7		HCS-S3-7D	
1,1,1-TRICHLOROETHANE	6	UJC	9.2	U	11	U	10	U	3	J	6	J
1,2-DICHLOROETHENE (TOTAL)	57	JS							7		19	J
ACETONE	15	UJB							5	J	13	U
BROMOMETHANE	12	UJC							13	U	13	U
CHLOROETHANE	12	UJS							13	U	13	U
CIS-1,2-DICHLOROETHENE			18	U	21	U	20	U				
METHYLENE CHLORIDE	17	UJB	18	U	21	U	20	U	7	J	13	U
TRANS-1,2-DICHLOROETHENE			18	U	21	U	20	U				
TRICHLOROETHENE	76	JES	94		11	U	10	U	220	J	390	J

	HCS-S3-7DDL		HCS-S3-7ON		HCS-S3-10ON		HCS-S3-11ON		HCS-S3-12ON			
1,1,1-TRICHLOROETHANE	4	DJ	15		9	U	9.7	U	10	U		
1,2-DICHLOROETHENE (TOTAL)	11	DJ										
ACETONE	25	U										
BROMOMETHANE	25	U										
CHLOROETHANE	25	U										
CIS-1,2-DICHLOROETHENE			20	U	18	U	19	U	21	U		
METHYLENE CHLORIDE	13	D	20	U	18	U	19	U	21	U		
TRANS-1,2-DICHLOROETHENE			20	U	18	U	19	U	21	U		
TRICHLOROETHENE	390	D	300		9	U	9.7	U	10	U		

TABLE 3-4
SITE 3 - VOCs DETECTED IN SOIL
(UNITS IN UG/KG)

	HCS-S3-13ON		HCS-S3-14DUPON		HCS-S3-14ON		HCS-S3-15ON					
1,1,1-TRICHLOROETHANE	10	U	9.8	U	9.8	U	8.8	U				
1,2-DICHLOROETHENE (TOTAL)												
ACETONE												
BROMOMETHANE												
CHLOROETHANE												
CIS-1,2-DICHLOROETHENE	20	U	20	U	20	U	18	U				
METHYLENE CHLORIDE	20	U	20	U	20	U	18	U				
TRANS-1,2-DICHLOROETHENE	20	U	20	U	20	U	18	U				
TRICHLOROETHENE	170		200		200		8.8	U				

TABLE 3-5
SITE 3 - STATISTICAL
ANALYSIS OF VOCs DETECTED IN SOIL

VOLATILE ORGANICS (UG/KG)	Maximum Concentration	Minimum Concentration	Standard Deviation	Arithmetic Mean	Frequency	Detected Count	Total Count
1,1,1-TRICHLOROETHANE	14	3	2.3	5.4	0.12	2	17
1,2-DICHLOROETHENE (TOTAL)	12000	5	5415.1	3713.8	0.80	4	5
ACETONE	1300	5	575.8	270.2	0.60	3	5
BROMOMETHANE	13	5	3.6	6.6	0.20	1	5
CHLOROETHANE	13	5	3.6	6.6	0.20	1	5
CIS-1,2-DICHLOROETHENE	640	10.5	181.7	63.0	0.08	1	12
METHYLENE CHLORIDE	540	5	129.5	37.5	0.24	4	17
TRANS-1,2 DICHLOROETHENE	27	10.5	4.8	11.9	0.08	1	12
TRICHLOROETHENE	49000	2	16228.1	6460.3	0.65	11	17

Note: A value equal to one-half the detection limit was entered for all non-detects.

SVOCs Detected in Soils

Samples HCS-S3-2 and HCS-S3-4 were collected and analyzed for SVOCs (see Figure 3-2). The samples were analyzed for all SVOCs included on the TCL. Bis(2-ethylhexyl)phthalate was the only SVOC detected in the soil samples. Samples HCS-S3-2 and HCS-S3-4 contained 570 and 44 μg/kg of bis(2-ethylhexyl)phthalate, respectively.

Explosives Detected in Soils

Samples HCS-S2-2 and HCS-S3-4 were analyzed for explosives. No explosives were detected in either of the soil samples collected at Site 3.

Inorganics Detected in Soils

As with samples from Site 2, XRF was used to screen soil samples for inorganics to select samples for offsite analysis. The XRF did not detect elevated levels of inorganics in any of the soil samples. Hence, the selection of the two soil samples for offsite analysis was based on sampling location. Samples HCS-S3-2 and HCS-S3-3 were collected from either side of the southern end of Building 362 where aerial photographs show disturbed areas (Figure 3-2).

Table 3-6 presents the inorganic analytical data for these samples. The offsite laboratory analyzed for metals included on the EPA TAL. The table shows that arsenic, beryllium, cadmium, chromium, lead, and mercury all occur at relatively low levels.

Soil Contamination at Site 4

Soil sampling at Site 4 was performed during the confirmation study only. Site 4 is comprised of two disposal sites (4A and 4B) for spent x-ray developing solutions.

TABLE 3-6
SITE 3 - ANALYTICAL DATA FOR METALS IN SOIL

	HCS-S3-2		HCS-S3-3	
METALS (MG/KG)				
ALUMINUM	11100	JD	12400	JD
ANTIMONY	3.2	JS	3	JS
ARSENIC	6.4	N	6.4	N
BARIUM	106		70.2	
BERYLLIUM	0.99		0.88	
CADMIUM	0.71	UN	0.66	UN
CALCIUM	22400		14000	
CHROMIUM	13.3	JS	13.5	JS
COBALT	16.5		14.7	
COPPER	40.8	JS	28.9	JS
IRON	30000		30700	
LEAD	55		27	
MAGNESIUM	3780		3800	
MANGANESE	945		471	
MERCURY	0.09	U	0.11	
NICKEL	32		22.9	
POTASSIUM	1700		1930	
SELENIUM	0.48	RS	0.45	RS
SILVER	0.39	U	0.36	U
SODIUM	262	UJB	228	UJB
THALLIUM	0.53	U	0.5	U
VANADIUM	18		18.6	
ZINC	98.5	JS	55.2	JS

Figure 2-2 shows their location. Soil samples were collected from disposal sites 4A and 4B, and analyzed for total silver. The scope and analytical results are described in Section 5 of the Interim RI Report.

Analytical results indicate no silver was detected in the composite soil sample collected from 4A but silver was detected in soil samples collected from 4B. In October 1984, two soil samples were collected from the surface water drainage ditch southeast of building 181 (4B) and concentrations of silver detected were 8,512 and 12,8000 mg/kg. Consequently, in March of 1986 eight soil samples were collected from 0'-1' and 1'-2' intervals at four soil boring locations and analyzed for total silver. Concentrations of silver detected in these samples ranged from 10.1 to 122 mg/kg. EP toxicity extract of two of these samples were analyzed for total silver and no silver was detected.

Soil Contamination at Site 5

Soil sampling at Site 5 was performed and/or reported in the IAS only. The IAS reports that soil samples were collected at the "toe" of the landfill in 1981 and analyzed for EPA priority pollutants. No contamination was detected. However, the number of samples and analytical results were not presented in the IAS.

Soil Contamination at Site PWA

The objective of the soil investigation at Site PWA was to determine if soil contaminated with VOCs has contributed or continues to contribute to VOC contamination detected in groundwater samples collected from production wells PWA and PWC. Therefore, VOCs were the only compounds analyzed for in soil samples collected at Site PWA.

VOCs Detected in Soils

As with sites 2 and 3, the VOC soil investigation used an onsite mobile laboratory in conjunction with an offsite laboratory. A total of 28 soil samples were collected from various depths and the VOC analyses performed were identical to those performed at sites 2, and 3. Seven of the 28 samples analyzed by the onsite mobile laboratory were split and analyzed by the offsite laboratory. Figure 3-3 gives soil sample locations.

Analytical data for all VOC analyses performed by both laboratories is presented in Appendix A of the Draft RI Report. Table 3-7 shows all VOCs detected in soil samples analyzed by the onsite mobile laboratory and the offsite laboratory. Comparing the seven samples analyzed by both laboratories reveals that in every case the VOC concentrations determined by the onsite mobile laboratory are higher than the concentrations determined by the offsite laboratory. This is consistent with observations made for sites 1 and 3 for low levels of TCE (10 to 400 μg/kg).

Table 3-8 summarizes a statistical analysis of VOCs detected in soil samples analyzed by either laboratory. The table shows that TCE was detected in 14 of the 35 samples. The total counts are the sum of the 28 samples analyzed by the onsite mobile laboratory and the 7 split samples analyzed by the offsite laboratory. In addition, VOCs analyzed only by the offsite laboratory have a total count of seven and VOCs analyzed only by the onsite mobile laboratory have a total count of 28. Therefore, TCE was actually detected in 13 of the 28 samples analyzed and 4 of the 13 samples contained estimated levels of TCE that were below the detection limit. The maximum concentration of TCE detected was 280 μg/kg. None of the other 8 VOCs detected were found in more than 3 samples. 1,1-DCE was detected in sample HCS-PWA-21ON collected at a depth of 10 to 11 feet near the solvent storage shed for Building 16 (see Figure 3-3). 1,1-DCE was detected at a concentration of 8,700 μg/kg in sample HCS-PWA-21ON and at 630 μg/kg in sample HCS-PWA-24ON. However, 1,1-DCE was not detected in other samples collected in the vicinity.

11-May-1994
4159fc42.dgn

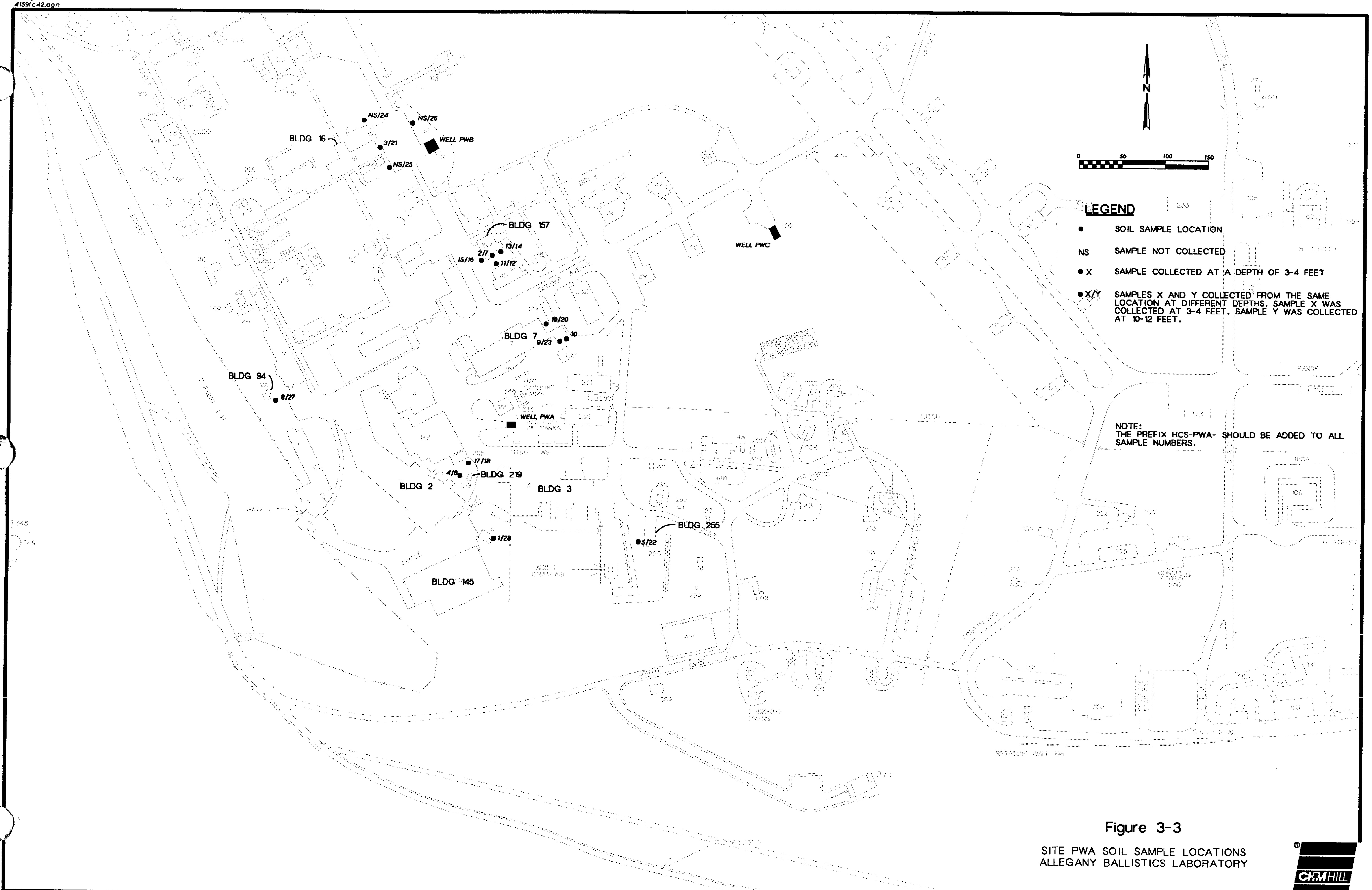


Figure 3-3
SITE PWA SOIL SAMPLE LOCATIONS
ALLEGANY BALLISTICS LABORATORY

CH2M HILL

00447G062

TABLE 3-7
SITE PWA - VOCs DETECTED IN SOIL
(UNITS IN UG/KG)

	HCS-PWA-10N		HCS-PWA-20N		HCS-PWA-3		HCS-PWA-30N		HCS-PWA-40N	
1,1,1-TRICHLOROETHANE	10	U	9.5	U	6	UJC	9.5	U	100	
1,1-DICHLOROETHANE	20	U	19	U	6	UJS	19	U	21	U
1,1-DICHLOROETHENE	20	U	19	U	6	UJS	19	U	21	U
ACETONE					12	UJB				
CIS-1,2-DICHLOROETHENE	20	U	20				89		21	U
METHYLENE CHLORIDE	20	U	19	U	22	UJB	19	U	21	U
TETRACHLOROETHENE					6	UJS				
TRICHLOROETHENE	10	U	140		7	JES	9.5	U	11	U
XYLENES (TOTAL)					3	JS				
	HCS-PWA-5DUPON		HCS-PWA-50N		HCS-PWA-6		HCS-PWA-60N		HCS-PWA-70N	
1,1,1-TRICHLOROETHANE	9.2	U	9.3	U	27	JC	31		9.1	U
1,1-DICHLOROETHANE	18	U	19	U	6	UJS	21	U	18	U
1,1-DICHLOROETHENE	18	U	19	U	2	JS	21	U	18	U
ACETONE					12	UJB				
CIS-1,2-DICHLOROETHENE	18	U	19	U			21	U	18	U
METHYLENE CHLORIDE	18	U	19	U	16	UJB	21	U	18	U
TETRACHLOROETHENE					6	UJS				
TRICHLOROETHENE	9.2	U	9.3	U	2	JES	11	U	72	
XYLENES (TOTAL)					6	UJS				
	HCS-PWA-80N		HCS-PWA-9		HCS-PWA-90N		HCSD-PWA-9		HCS-PWA-100N	
1,1,1-TRICHLOROETHANE	10	U	7	U	10	U	6	U	10	U
1,1-DICHLOROETHANE	35		7	U	20	U	6	U	20	U
1,1-DICHLOROETHENE	21	U	7	U	20	U	6	U	20	U
ACETONE			41	UJB			28	UJB		
CIS-1,2-DICHLOROETHENE	21	U			20	U			20	U
METHYLENE CHLORIDE	21	U	13	UJB	20	U	13	UJ	20	U
TETRACHLOROETHENE			7	U			6	U		
TRICHLOROETHENE	10	U	1	J	10	U	3	J	10	U
XYLENES (TOTAL)			7	U			6	U		

TABLE 3-7
SITE PWA - VOCs DETECTED IN SOIL
(UNITS IN UG/KG)

	HCS-PWA-11ON		HCS-PWA-12ON		HCS-PWA-13		HCS-PWA-13ON		HCS-PWA-14DUPON	
1,1,1-TRICHLOROETHANE	10	U	8.5	U	6	U	11	U	10	U
1,1-DICHLOROETHANE	20	U	17	U	6	U	21	U	20	U
1,1-DICHLOROETHENE	20	U	17	U	6	U	21	U	20	U
ACETONE					13	UJC				
CIS-1,2-DICHLOROETHENE	20	U	17	U			21	U	20	U
METHYLENE CHLORIDE	20	U	17	U	13	UJ	21	U	20	U
TETRACHLOROETHENE					4	J				
TRICHLOROETHENE	78		170		34		90		45	
XYLENES (TOTAL)					6	U				

	HCS-PWA-14ON		HCS-PWA-15ON		HCS-PWA-16ON		HCS-PWA-17ON		HCS-PWA-18ON	
1,1,1-TRICHLOROETHANE	9.6	U	8.9	U	9.6	U	10	U	8.5	U
1,1-DICHLOROETHANE	19	U	18	U	19	U	20	U	17	U
1,1-DICHLOROETHENE	19	U	18	U	19	U	20	U	17	U
ACETONE										
CIS-1,2-DICHLOROETHENE	19	U	18	U	40		20	U	17	U
METHYLENE CHLORIDE	19	U	18	U	19	U	20	U	17	U
TETRACHLOROETHENE										
TRICHLOROETHENE	52		110		280		10	U	8.5	U
XYLENES (TOTAL)										

	HCS-PWA-19		HCS-PWA-19ON		HCS-PWA-20ON		HCS-PWA-21ON		HCS-PWA-22ON	
1,1,1-TRICHLOROETHANE	6	U	9.6	U	9.6	U	9.3	U	10	U
1,1-DICHLOROETHANE	6	U	19	U	19	U	19	U	20	U
1,1-DICHLOROETHENE	6	U	19	U	19	U	8700		20	U
ACETONE	5	J								
CIS-1,2-DICHLOROETHENE			19	U	19	U	19	U	20	U
METHYLENE CHLORIDE	7	JC	19	U	19	U	19	U	20	U
TETRACHLOROETHENE	6	U								
TRICHLOROETHENE	6	U	9.6	U	9.6	U	9.3	U	10	U
XYLENES (TOTAL)	6	U								

TABLE 3-7
SITE PWA - VOCs DETECTED IN SOIL
(UNITS IN UG/KG)

	HCS-PWA-230N		HCS-PWA-24		HCS-PWA-240N		HCS-PWA-250N		HCS-PWA-260N	
1,1,1-TRICHLOROETHANE	9.2	U	6	U	9.6	U	9.2	U	9.6	U
1,1-DICHLOROETHANE	18	U	6	U	19	U	18	U	19	U
1,1-DICHLOROETHENE	18	U	6	U	630		18	U	19	U
ACETONE			12	UJC						
CIS-1,2-DICHLOROETHENE	18	U			19	U	18	U	19	U
METHYLENE CHLORIDE	18	U	12	UJ	19	U	18	U	19	U
TETRACHLOROETHENE			6	U						
TRICHLOROETHENE	9.2	U	9	JE	9.6	U	9.2	U	9.6	U
XYLENES (TOTAL)			6	U						

	HCS-PWA-270N		HCS-PWA-280N	
1,1,1-TRICHLOROETHANE	9.6	U	10	U
1,1-DICHLOROETHANE	20	U	20	U
1,1-DICHLOROETHENE	20	U	20	U
ACETONE				
CIS-1,2-DICHLOROETHENE	20	U	20	U
METHYLENE CHLORIDE	20	U	20	U
TETRACHLOROETHENE				
TRICHLOROETHENE	9.6	U	10	U
XYLENES (TOTAL)				

TABLE 3-8
SITE PWA - STATISTICAL ANALYSIS
OF VOCs DETECTED IN SOIL

	Maximum Concentration	Minimum Concentration	Standard Deviation	Arithmetic Mean	Frequency	Detected Count	Total Count
VOLATILE ORGANICS (UG/KG)							
1,1,1-TRICHLOROETHANE	100	5	16.8	9.1	0.09	3	35
1,1-DICHLOROETHANE	35	5	5.1	5.9	0.03	1	35
1,1-DICHLOROETHENE	8700	2	1470.4	271.2	0.09	3	35
ACETONE	5	5	0.0	5.0	0.14	1	7
CIS-1,2-DICHLOROETHENE	89	10.5	15.7	14.7	0.11	3	28
METHYLENE CHLORIDE	7	5	0.3	5.1	0.03	1	35
TETRACHLOROETHENE	5	4	0.4	4.9	0.14	1	7
TRICHLOROETHENE	280	1	60.6	32.9	0.40	14	35
XYLENES (TOTAL)	5	3	0.8	4.7	0.14	1	7

Note: A value equal to one-half the detection limit was entered for all non detects

Figure 3-4 shows the levels of TCE detected in all soil samples collected at Site PWA. For the seven samples analyzed by both laboratories, the higher concentration reported is included on the figure. TCE was only detected near two of the buildings targeted as a result of the focused facility audit. TCE was detected in all eight samples collected from the south side of Building 157 where a TCE still operated during the early 1960s. Of these eight samples, only sample HCS-PWA-13 was analyzed by the offsite laboratory, which reported a concentration of 34 μg/kg of TCE whereas the onsite mobile laboratory reported 90 μg/kg. This is consistent with the trends seen for TCE analytical data reported by both laboratories for soil samples collected at sites 1 and 3. Because all onsite mobile laboratory data has been higher than offsite laboratory data for low levels of TCE at these sites, these eight samples probably contain lower levels of TCE than indicated on the figure.

Groundwater Contamination

Groundwater monitoring wells were installed and sampled at Plant 1 and Site 5 during the Confirmation Study and the RI. Wells in the vicinity of sites 2, 3, 4, 5, and PWA were analyzed for TCL SVOCs and VOCs, TAL inorganics, xylenes, MEK, MIBK, TCDD, explosives, TNT breakdown products, and nitrates during the Confirmation Study. After review of the groundwater analytical results presented in the Interim RI Report, the RI installed additional wells at Plant 1 and Site 5 and analyzed groundwater samples collected from all wells installed during the Confirmation Study and RI for TCL VOCS, TAL inorganics and explosives. Results of both investigations have indicted VOCs to be the primary contaminants in groundwater at Plant 1 and Site 5 with inorganics and explosives detected at low levels. For this reason, only results of these analyses are discussed. In addition, groundwater contamination is discussed generally for Plant 1 with specific reference to individual sites as appropriate. Site 5 is discussed separately.

25-May-1994
4159fc43.dgn

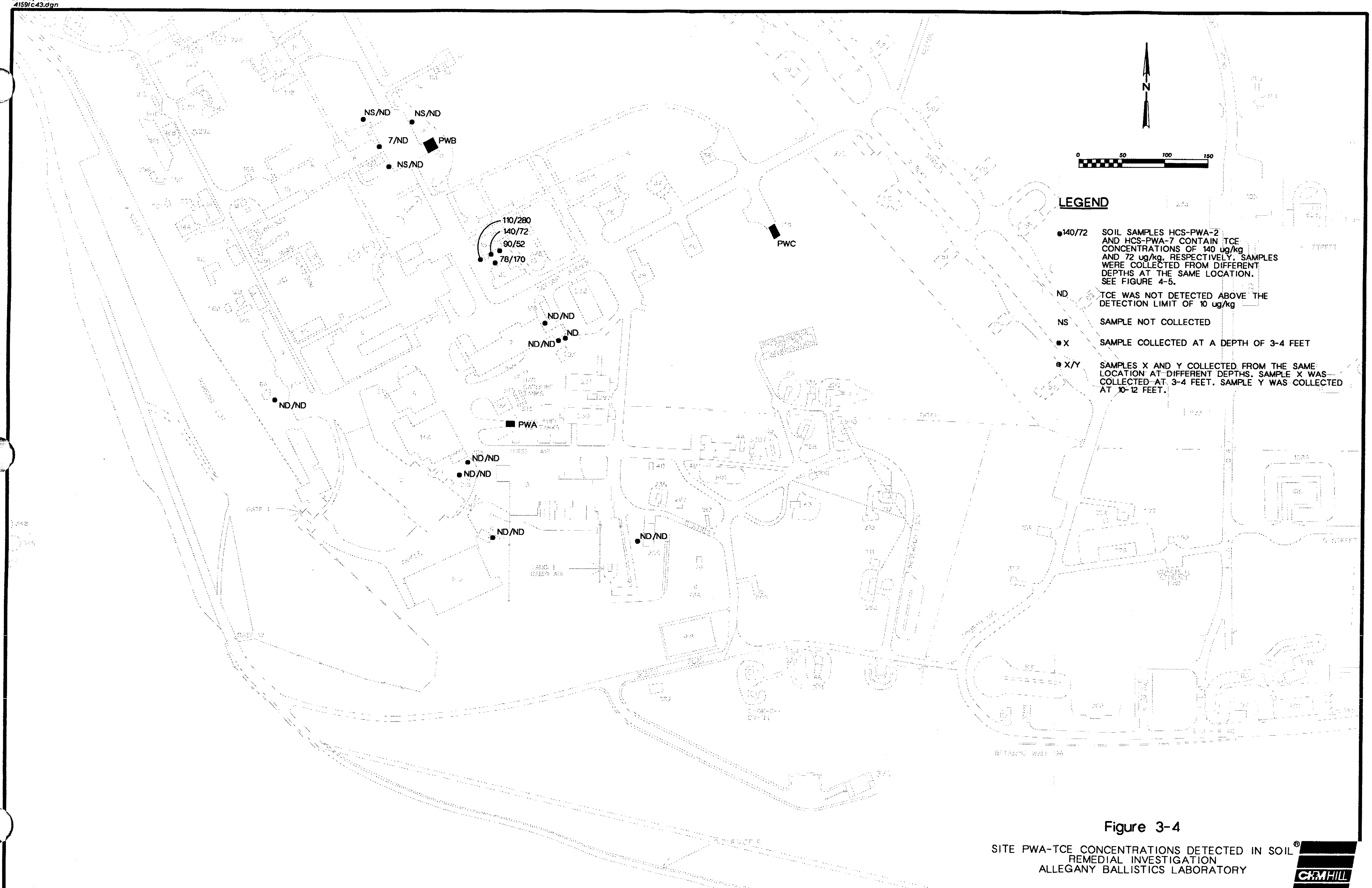


Figure 3-4

SITE PWA-TCE CONCENTRATIONS DETECTED IN SOIL
REMEDIAL INVESTIGATION
ALLEGANY BALLISTICS LABORATORY

CH2M HILL

00447G072

Groundwater Contamination at Plant 1

VOCs, inorganics, and explosives were detected in groundwater samples collected from monitoring wells at Plant 1. Analytical results for each of these contaminant types are discussed below.

VOCs Detected in Groundwater

The VOC analytical data generated during the RI for Plant 1 wells are presented in Tables 7-20 and 7-21 and Appendix A of the Draft RI Report. The data indicate that fourteen VOCs[1] were detected in the groundwater beneath Plant 1:

- 1,1,1-TCA
- 1,1-DCA
- 1,1-DCE
- 1,2-Dichloroethane (1,2-DCA)
- 1,2-DCE (Total)
- 2-Butanone, or MEK
- Acetone
- Carbon Disulfide
- Carbon Tetrachloride
- Chloroform
- Methylene Chloride
- PCE
- Toluene
- TCE

---

[1]Two VOCs, carbon tetrachloride and 2-butanone were only detected in groundwater samples from straddle-packer testing, and therefore, are not included in the statistical analysis presented in Table 7-21 of the Draft RI Report.

The six most prevalent VOCs (detected in six or more samples), in order of frequency of detection were: TCE, methylene chloride, 1,2-DCE, acetone, PCE, and 1,1,1-TCA. The locations and concentrations of these six VOCs in the alluvial and bedrock aquifers beneath Plant 1 are shown in Figures 3-5 and 3-6, respectively. Each of the remaining eight detected VOCs were found in three or fewer samples.

TCE was the most frequently detected VOC at Plant 1. It was detected in 25 of the 37 wells sampled, at concentrations ranging from 1 to 98,000 μg/l. TCE also was the most widely distributed VOC across Plant 1. All of the alluvium and bedrock monitoring wells adjacent to the North Branch Potomac River at Site 1 contained detectable levels of TCE. Of the VOC concentrations found in the wells along the river at Site 1, the highest concentrations were found downgradient of the solvent disposal pits, in well cluster 1GW3, 1GW9, 1GW13. Here, TCE was found in the alluvium and shallow bedrock at a concentration of 98,000 μg/l (Well 1GW3), in moderately deep bedrock at a concentration of 71,000 μg/l (Well 1GW9), and in deeper bedrock at a concentration of 1,300 μg/l (Well 1GW13). The magnitude of the concentrations in the three wells suggests that TCE may occur as a DNAPL in this area.

Other relatively high concentrations of TCE found adjacent to the river include 690 μg/l at alluvium well 1GW5, and 220 μg/l at bedrock well 1GW4. TCE also was detected in production well PWA at a concentration of 29 μg/l, and in Site PWA bedrock and alluvium monitoring wells PWA1 (33 μg/l) and PWA2 (9 μg/l).

Other detections of TCE occurred upgradient of Site 2, in alluvium Well 2GW3 at a concentration of 10 μg/l, and in bedrock Well 2GW6 at a concentration of 18 μg/l. Downgradient of Site 2, TCE was detected in alluvium wells 2GW1 and 2GW2 at concentrations of 3 and 5 μg/l, respectively, and in bedrock Well 2GW7 at a concentration of 1 μg/l. TCE also was found in the alluvium/bedrock well pair GGW5 and GGW6 at concentrations of 13 and 20 μg/l, respectively. Low concentrations of TCE were detected in alluvium wells GGW7 (1 μg/l) and 1GW7 (1 μg/l), and bedrock well 1GW6 (6 μg/l).

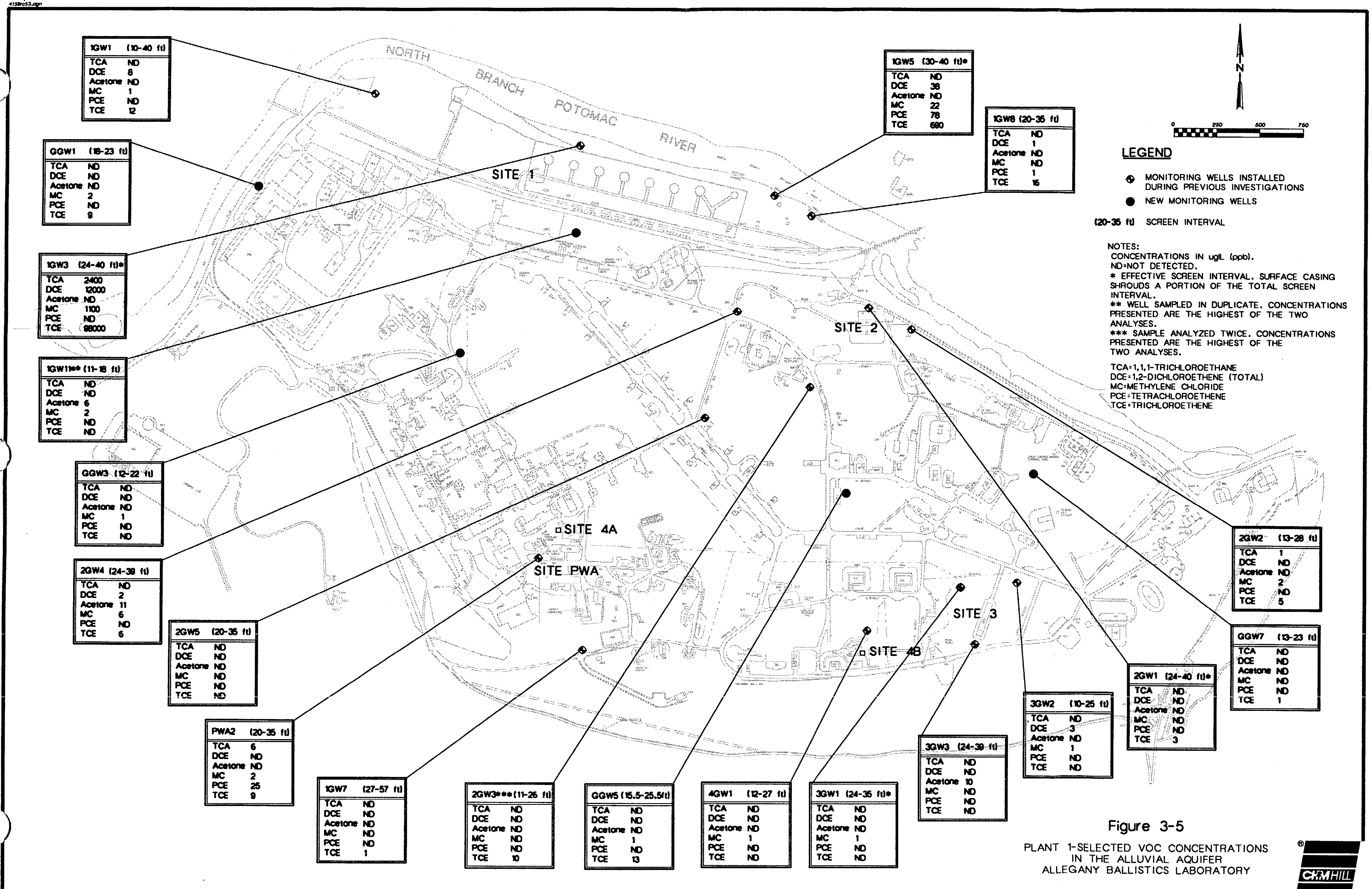


Figure 3-5

PLANT 1-SELECTED VOC CONCENTRATIONS IN THE ALLUVIAL AQUIFER
ALLEGANY BALLISTICS LABORATORY

00447G B22

11-May-1994
4159FC52.dgn

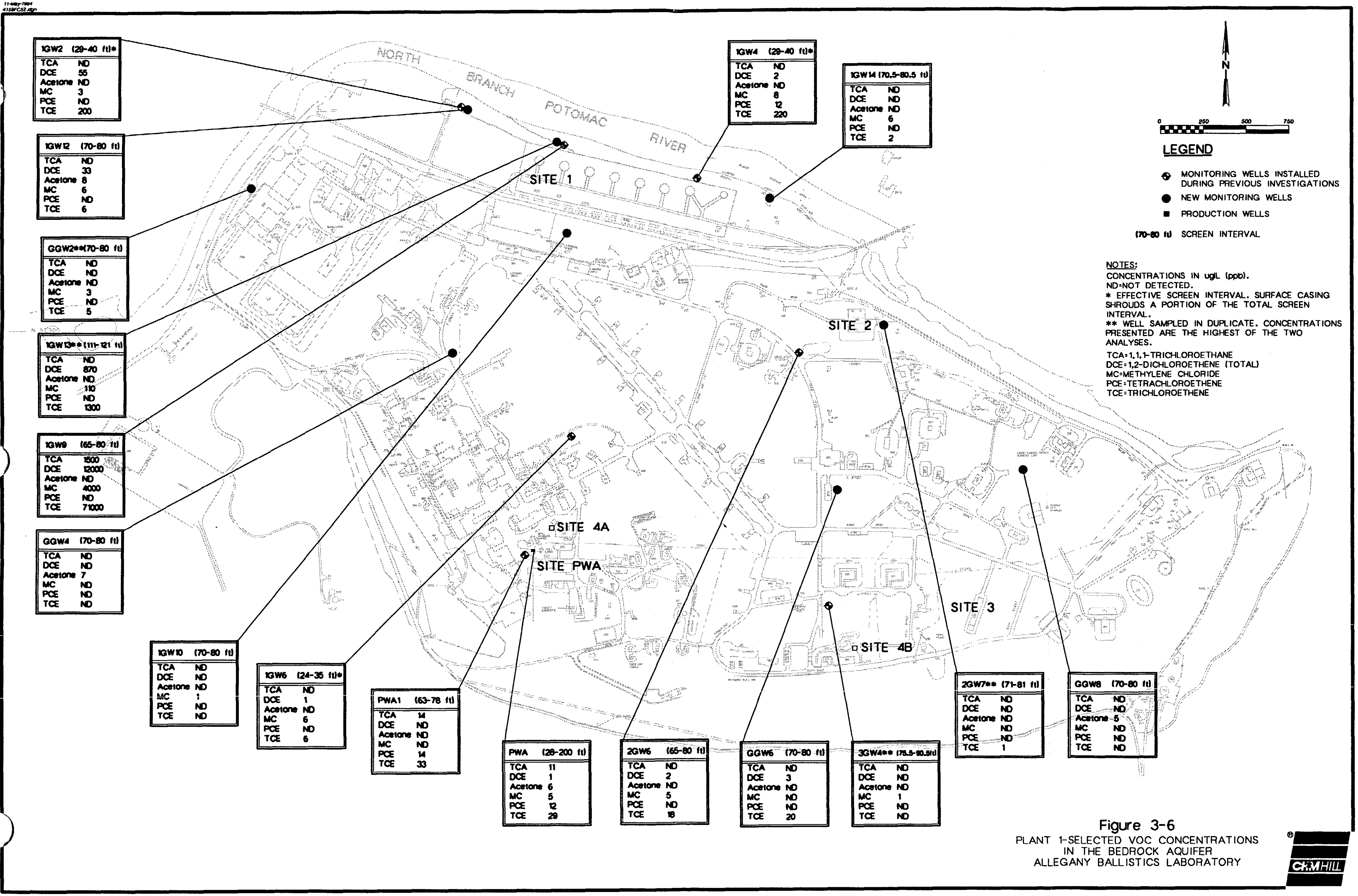


Figure 3-6
PLANT 1-SELECTED VOC CONCENTRATIONS IN THE BEDROCK AQUIFER
ALLEGANY BALLISTICS LABORATORY

Methylene chloride was detected at Plant 1, in 24 of the 37 wells sampled, at concentrations ranging from 1 to 4000 μg/l. However, only nine of the samples had concentrations above 5 μg/l, the stated quantitation limit. Most of the samples with concentrations above 5 μg/l were obtained from monitoring wells at Site 1 along the river. These wells include the 1GW3, 1GW9, 1GW13 well cluster, downgradient of the solvent disposal pits, where the highest concentrations were found. At this location, methylene chloride concentrations were 1,100 μg/l in the alluvium and shallow bedrock (Well 1GW3), 4,000 μg/l in moderately deep bedrock (Well 1GW9), and 110 μg/l in deeper bedrock (Well 1GW13). Other detections of methylene chloride at concentrations above 5 μg/l along the river included alluvium Well 1GW5 (22 μg/l) and bedrock wells 1GW12 (6 μg/l) 1GW4 (8 μg/l), and 1GW14 (6 μg/l).

Other detections of methylene chloride at concentrations above 5 μg/l across Plant 1 included alluvium Well 2GW4 (6 μg/l) and bedrock wells PWA (5 μg/l), 1GW6 (6 μg/l), and 2GW6 (5 μg/l).

1,2-DCE was detected at Plant 1 in 15 of the 37 wells sampled with concentrations ranging from 1 μg/l to 12,000 μg/l. The only monitoring wells that had 1,2-DCE concentrations above 3 μg/l are located along the river at Site 1. As with TCE and methylene chloride, the highest concentrations of 1,2-DCE were collected from the well cluster 1GW3, 1GW9, 1GW13. 1,2-DCE concentrations were 12,000 μg/l in the alluvium and shallow bedrock (Well 1GW3), 12,000 μg/l in moderately deep bedrock (Well 1GW9), and 870 μg/l in deeper bedrock (Well 1GW13). Other 1,2-DCE concentrations from wells along the river were 8, 38, and 1 μg/l at alluvium wells 1GW1, 1GW5, and 1GW8, respectively, and 55, 33, and 2 μg/l at bedrock wells 1GW2, 1GW12, and 1GW4, respectively.

Acetone was detected at Plant 1 in 7 of 37 wells sampled, at relatively low concentrations ranging from 5 to 11 μg/l. Acetone was detected at scattered locations throughout Plant 1 (Figures 3-5 and 3-6).

PCE was detected in 6 of 37 wells sampled at Plant 1 with concentrations ranging from 1 to 78 μg/l. All of the PCE detected was found in two general areas: along the river at Site 1, and at Site PWA. At Site 1, PCE was found in alluvium wells 1GW5 and 1GW8 at concentrations of 78 and 1 μg/l, respectively, and in bedrock Well 1GW4 at a concentration of 12 μg/l. At Site PWA, production well PWA contained a PCE concentration of 12 μg/l and monitoring wells PWA1 (bedrock) and PWA2 (alluvium) contained concentrations of 14 and 25 μg/l, respectively.

1,1,1-TCA was detected in 6 of 37 wells sampled at Plant 1, at concentrations ranging from 1 to 2400 μg/l. The only high concentrations of 1,1,1-TCA were found in the two shallowest wells of the well cluster 1GW3, 1GW9, 1GW13, at a concentration of 2,400 μg/l in Well 1GW3 (alluvium and shallow bedrock) and a concentration of 1,500 μg/l in Well 1GW9 (moderately deep bedrock). 1,1,1-TCA was not detected in the deeper bedrock Well 1GW13. Other locations where 1,1,1-TCA was detected included alluvium Well 2GW2 (1 μg/l), adjacent to the river near Site 2; production well PWA (11 μg/l); and the Site PWA monitoring wells PWA1 (bedrock) and PWA2 (alluvium) at concentrations of 14 and 6 μg/l, respectively.

The eight remaining VOCs that were detected in Plant 1 wells were each found in 3 or fewer samples. With the exceptions of 1,1-DCA found at a concentration of 920 μg/l in bedrock Well 1GW9, and chloroform found at a concentration of 12 μg/l in alluvium Well 1GW5, none of the compounds were detected at concentrations exceeding 5 μg/l.

Groundwater samples were collected in each of the five intervals isolated during straddle-packer testing in production well PWA. The samples were collected to determine the contaminant contribution of individual intervals to the water quality of the entire borehole. The results are shown in Table 7-20 included in the Draft RI Report. The packer test samples are named according to the depth interval number as follows: PWA-P1 (Interval 1, 0-40 ft.), PWA-P2 (Interval 2, 40-70 ft.), PWA-P3 (Interval 3, 72-102 ft.), PWA-P4 (Interval 4, 108-138 ft.), and PWA-P5 (Interval 5, 138-200 ft.). Ten VOCs were detected in one or more intervals, ranging in concentration from 1 to 71 μg/l. Not surprisingly, all of the compounds were found in one or more intervals at concentrations exceeding the concentrations found in the sample from the entire well (PWA). Two VOCs were detected in samples from individual intervals, and not detected in the entire well sample, presumably due to dilution. The two VOCs included carbon tetrachloride (Intervals 1 and 2 at concentrations of 1 and 2 μg/l, respectively) and 2-butanone (Interval 1 at a concentration of 15 μg/l). No single interval was found to contain the highest concentrations of all detected compounds. For example, TCE concentrations were highest in Intervals 3 (71 μg/l) and 5 (47 μg/l) and 1,1,1-TCA concentrations were highest in Intervals 1 and 2 (both 26 μg/l). This distribution is probably indicative of different source areas for the compounds.

Table 7-22 included in the Draft RI Report, presents a comparison between the analytical data for the groundwater VOCs generated during the RI and the Confirmation Study. Only wells where VOCs were detected in any sampling round are included. When comparing analytical data from different investigations, recognize that sampling techniques, which can have a substantial effect on sample results, may have varied significantly between the RI and the Interim RI report, especially for VOCs.

During the RI, TCE was detected for the first time at very low concentrations in wells 1GW6 (6 μg/l), 1GW7 (1 μg/l), and 2GW1 (3 μg/l). Conversely, TCE was not found in several wells where previous detections had been reported, including wells 3GW1, 3GW3, and 4GW1. The table also shows that a number of VOCs, other than TCE, detected during the Confirmation Study were not detected in the same wells during the RI.

Explosive Compounds Detected In Groundwater

Groundwater samples from 33 wells at Plant 1 were analyzed for explosive compounds. No explosive compounds were detected in any sample.

Inorganics Detected in Groundwater

Table 7-23 presented in the Draft RI Report gives the analytical data for inorganics for all Plant 1 wells.

Plant 1 alluvium monitoring Well 1GW7 was selected to be used as a point of comparison, or ''background'' well, so the inorganics data could be evaluated. This well is more suited for this purpose than other wells at Plant 1 because it is upgradient of nearly all Plant 1 structures and roadways. Inorganics found in one or more wells at concentrations significantly higher than at Well 1GW7 then were identified. Nine inorganics were identified:

- Arsenic
- Barium
- Beryllium
- Chromium
- Lead
- Mercury
- Nickel
- Vanadium
- Zinc

Four of the inorganics—arsenic, chromium, lead, and mercury—were considered to be contaminants of concern. Figures 3-7 and 3-8 show concentrations of these four inorganics in the alluvial and bedrock aquifers beneath Plant 1, respectively. In general, the highest concentrations of most inorganics were detected in bedrock monitoring wells.

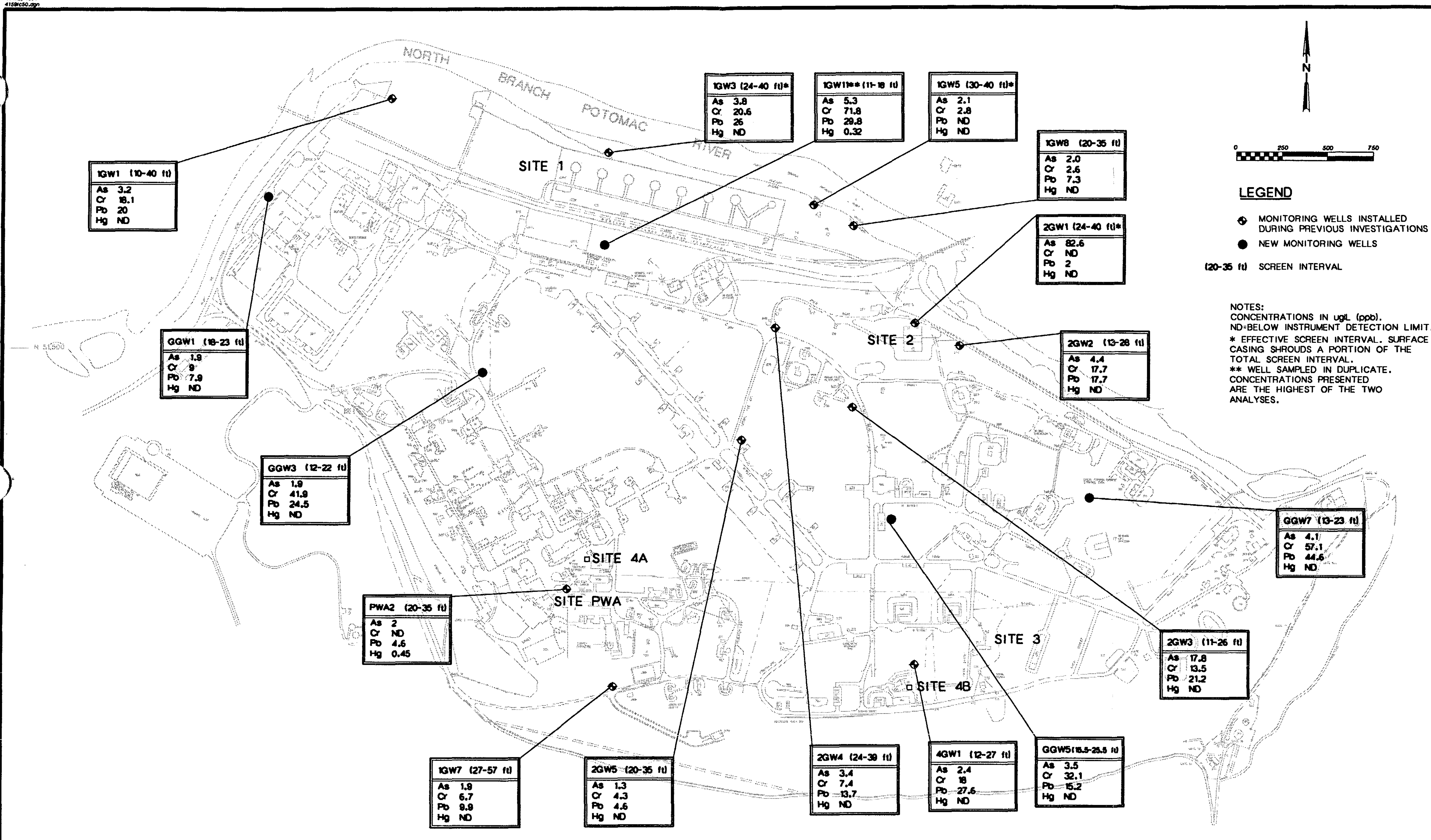


Figure 3-7

PLANT 1-SELECTED METALS CONCENTRATIONS IN THE ALLUVIAL AQUIFER ALLEGANY BALLISTICS LABORATORY

CH2M HILL

00447 G B32

11-May-1994
4159FC51.dgn

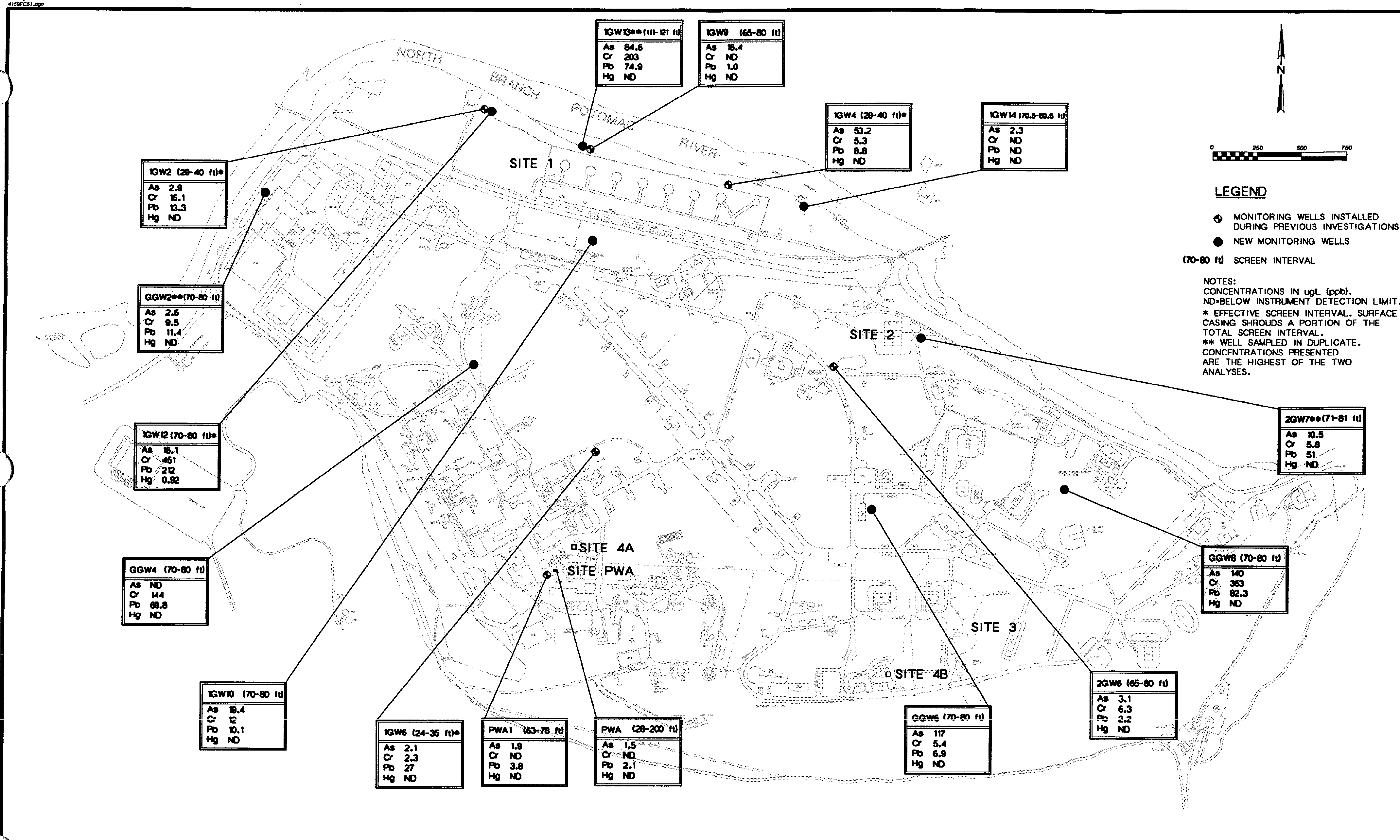


Figure 3-8

PLANT 1-SELECTED METALS CONCENTRATIONS
IN THE BEDROCK AQUIFER
ALLEGANY BALLISTICS LABORATORY

CH2MHILL

Four bedrock wells with consistently high levels of these inorganics were wells GGW4, GGW8, 1GW12, and 1GW13. Arsenic was found at relatively high concentrations in alluvium well 2GW1 (82.6 μg/l), and in bedrock wells GGW6 (117 μg/l), GGW8 (140 μg/l), and 1GW13 (84.6 μg/l). The highest levels of chromium were found at bedrock wells GGW4 (144 μg/l), GGW8 (363 μg/l), 1GW12 (451 μg/l), and 1GW13 (203 μg/l). The highest levels of lead were found at bedrock wells GGW4 (69.8 μg/l), GGW8 (82.3 μg/l), 1GW12 (212 μg/l), and 1GW13 (74.9 μg/l). Mercury was detected at low levels in alluvial wells 1GW11 (0.32 μg/l) and PWA2 (0.45 μg/l), and bedrock well 1GW12 (0.92 μg/l).

Groundwater Contamination at Site 2

An evaluation of upgradient and downgradient well analytical results suggest that the suspected burn pad is not a source of groundwater contamination at Site 2. Wells 2GW3 and 2GW4 serve as the upgradient alluvial wells and 2GW1 and 2GW2 serve as the downgradient alluvial wells at Site 2. Wells 2GW6 and 2GW7 are the upgradient and downgradient bedrock wells for Site 2, respectively. Analytical results for these wells indicate that concentrations of TCE detected in the downgradient wells are at or below the maximum contaminant level (MCL) of 5 μg/l for TCE while the upgradient wells contain higher levels (6-18 μg/l). It is also important to note that the highest concentration of TCE was detected in the upgradient bedrock well while only 1 μg/l was detected in the downgradient well.

Groundwater Contamination at Site 3

Only low levels of VOCs and no TCE was detected in wells at Site 3. 3GW1 and 3GW2 are downgradient alluvial wells and 3GW3 is an upgradient alluvial well. Wells 3GW4 and GGW8 are the upgradient and downgradient bedrock wells for Site 3, respectively. Except for DCE detected in 3GW2 at 3 μg/l, only acetone and methylene chloride (common laboratory contaminants) are detected at low levels in the alluvial and bedrock wells at low concentrations. In addition, the upgradient alluvial well contains the highest concentration of acetone. This suggests that the historical burn areas and trenches are not a source of VOC contamination at Site 3.

Groundwater Contamination at Site 4

Only one alluvial downgradient well exists for Site 4B (4GW1) and Site 4A (2GW5). No VOCs were detected in either well with the exception of 4GW1 where 1 $\mu g/l$ of methylene chloride was detected in the RI. Well 3GW4 is a downgradient bedrock well for Site 4B and no VOC contamination was detected in this well. In addition, no silver or phenols were detected in these wells during the confirmation study or the RI.

Groundwater Contamination at Site PWA

Wells PWA1 and PWA2 are alluvial and bedrock wells proximate to well PWA. VOC contamination has been detected in all wells. Analysis of packer test samples indicate that VOC contamination occurs in deep bedrock (138-200 ft below grade). The TCE still reported to have operated in 1959-1960 at Building 157 is the probable source of groundwater contamination at PWA.

Groundwater Contamination at Site 5

During the groundwater sampling program at Site 5, samples were collected and analyzed for VOCs and metals.

VOCs Detected in Groundwater

The VOC analytical data for Site 5 monitoring wells are presented in Appendix A and Tables 7-25 and 7-26 of the Draft RI Report. Five VOCs were detected in the groundwater beneath Site 5. They are TCE, methylene chloride, 1,2-DCE, 1,1,1-TCA, and acetone. Figure 3-9 shows the locations and concentrations of the VOCs detected in Site 5 monitoring wells.

TCE was the only VOC detected in all five of the Site 5 monitoring wells. The lowest concentration of TCE, 3 μg/l, was found in the upgradient alluvium well, 5GW1. The four downgradient wells, all in bedrock, contained TCE at concentrations ranging from 6 to 33 μg/l. The deepest of the monitoring wells immediately downgradient of Site 5 (Well 5GW5, screened 65 to 75 feet) contained the highest detected concentration of TCE (33 μg/l). TCE was detected at a concentration of 17 μg/l in Well 5GW2 and 29 μg/l in Well 5GW3; both of these wells are 50 feet deep. The lowest concentration, 6 μg/l, was detected in the monitoring well farthest downgradient of Site 5 (Well 5GW4).

Methylene chloride was detected in the three downgradient monitoring wells closest to Site 5 (wells 5GW2, 5GW3, and 5GW5) at concentrations of 2, 12, and 6 μg/l, respectively.

1,2-DCE and acetone were detected downgradient of Site 5 at low concentrations. 1,2-DCE was detected at a concentration of 2 μg/l in two of the downgradient bedrock wells closest to Site 5 (wells 5GW3 and 5GW5). Acetone was detected only in 5GW3, at a concentration of 7 μg/l.

Table 3-9 compares analytical data for VOC-contaminated groundwater collected during the RI and VOC groundwater data collected during the Interim RI from wells sampled during both investigations. Table 3-9 indicates that at upgradient well 5GW1, where TCE was detected at a concentration of 3 μg/l during the RI, a concentration of 10 μg/l of TCE was detected in 1986 during the Interim RI. At Well 5GW3, the detected concentrations of TCE increased from 3 μg/l in 1986 and 5 μg/l in 1987, to 29 μg/l in 1992.

MAE70342.A2.PP/D3/03

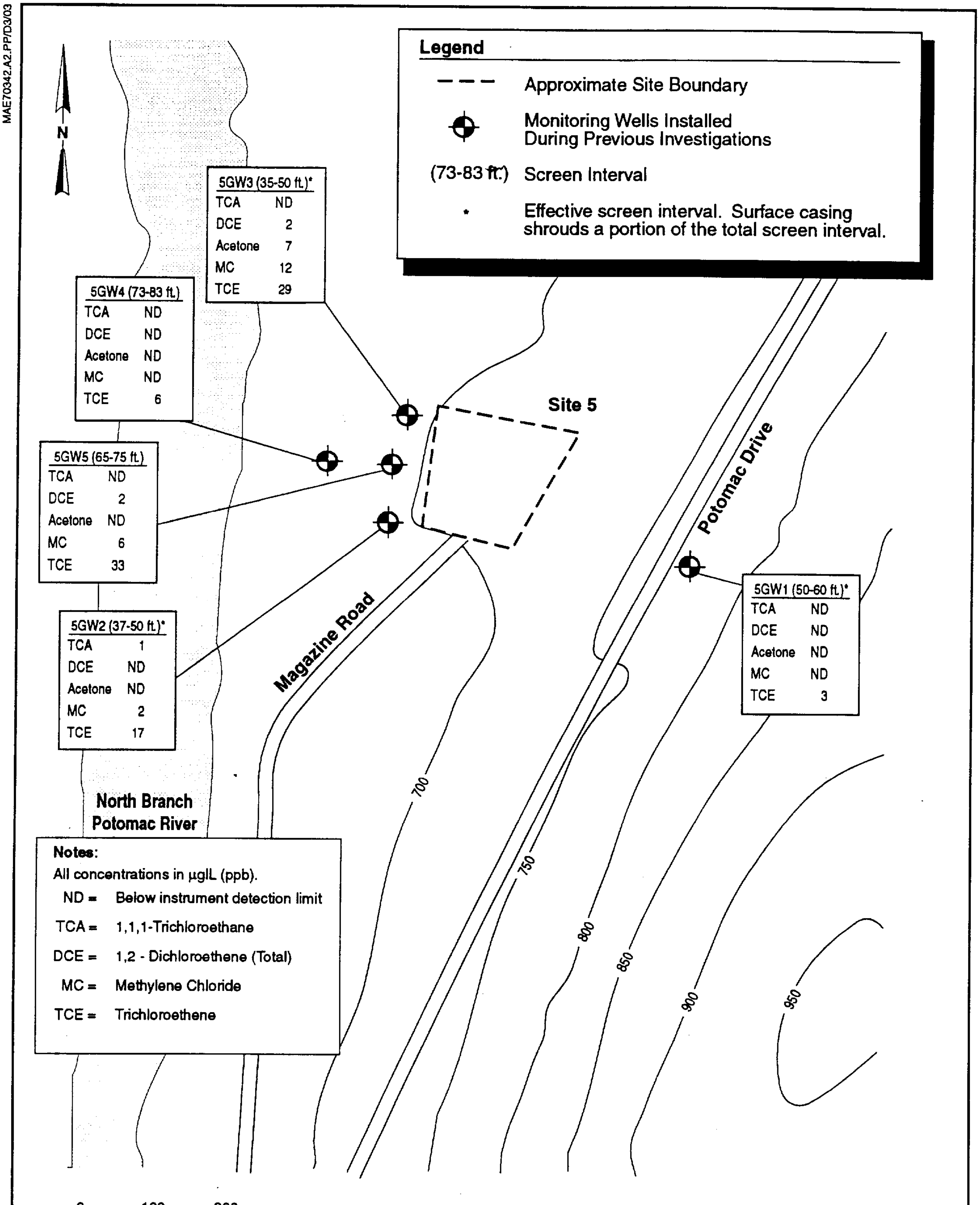


Figure 3-9
SITE 5–VOC CONCENTRATIONS IN MONITORING WELLS
Allegany Ballistics Laboratory

CH2M HILL

TABLE 3-9
SITE 5 - COMPARISON OF HISTORICAL ANALYTICAL RESULTS VOCs DETECTED IN GROUNDWATER
(UNITS IN UG/L)

	5GW1(84)		5GW1(86)		5GW1(87)		5GW1(92)		5GW2(84)		5GW2(86)		5GW2(87)	
1,1,1-TRICHLOROETHANE	10	U	10	U	5	U	5	UJC	10	U	10	U	1	J
1,2-DICHLOROETHENE (TOTAL)			10	U	5	U	5	U			10	U	5	U
ACETONE					10	U	10	U					1000	B
METHYLENE CHLORIDE	10	U	5	J	9	B	5	U	10	U	4	J	9	B
TRICHLOROETHENE	10	U	10		5	U	3	J	15		17		18	

	5GW2(87)DL		5GW2(92)		5GW3(84)		5GW3(86)		5GW3(87)		5GW3(92)	
1,1,1-TRICHLOROETHANE	50	U	1	JC	10	U	10	U	1	J	5	UJC
1,2-DICHLOROETHENE (TOTAL)	50	U	5	U			10	U	5	U	2	J
ACETONE	2000	B	10	U					2	JB	7	J
METHYLENE CHLORIDE	110	B	2	J	10	U	5	J	9	B	12	
TRICHLOROETHENE	16	J	17		10	U	3	J	5		29	

Inorganics Detected In Groundwater

Analytical data for inorganics at Site 5 monitoring wells are presented in Table 3-10.

Figure 3-10 shows the locations and concentrations of four inorganics detected in monitoring wells at Site 5. The highest concentrations of inorganics, except barium, were found in the upgradient alluvium well (Well 5GW1). Barium was found at a concentration of 2,840 μg/l in the farthest downgradient bedrock well (Well 5GW4).

WDCR829/006.WP5

TABLE 3-10
SITE 5 - METALS DETECTED IN GROUNDWATER
(UNITS IN UG/L)

	5GW1		5GW2		5GW3		5GW4		5GW5	
ALUMINUM	125000		2330		426		78.2	UJB	278	
ANTIMONY	12.4	U	12.4	U	12.4	UNJS	12.4	U	12.4	UNJS
ARSENIC	3.4		2.2	BNJS	1	UNJS	1.6	BNJS	1	UNJS
BARIUM	634		136		40.4		2840		120	
BERYLLIUM	8.5		0.24	U	0.24	U	0.24	U	0.24	U
CADMIUM	2.7	U	2.8		2.7	U	2.7	U	2.7	U
CALCIUM	47500		65000		49200		64200		70400	
CHROMIUM	174		4.5		1.9	U	1.9	U	1.9	U
COBALT	87.7		7		1.6	U	2.7	UJB	1.6	U
COPPER	192		22.8	JB	5.7	UJB	12.5	UJB	4.9	UJB
IRON	225000	JS	6070		1450		160		5270	
LEAD	128		10.2		0.94	U	1.8	U	0.94	U
MAGNESIUM	18900		23800		15100		11000		12800	
MANGANESE	1470		2520		372		59.7		422	
MERCURY	0.17		0.16	U	0.08	U	0.16	U	0.08	U
NICKEL	177		42.5		36.8		10.7	U	10.7	U
POTASSIUM	12400		3340		2400		602	U	602	U
SELENIUM	1.9	U	1.9	U	1.9	UNRS	1.9	U	1.9	UNRS
SILVER	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U
SODIUM	3160	JB	65100		45800		13500		8190	
THALLIUM	2.1	U	2.1	UNJS	2.1	UNJS	2.1	UNJS	2.1	UNJS
VANADIUM	233		3.9		1.3	U	1.3	U	1.3	U
ZINC	808		66.2	UJB	51		22.4	UJB	23.4	

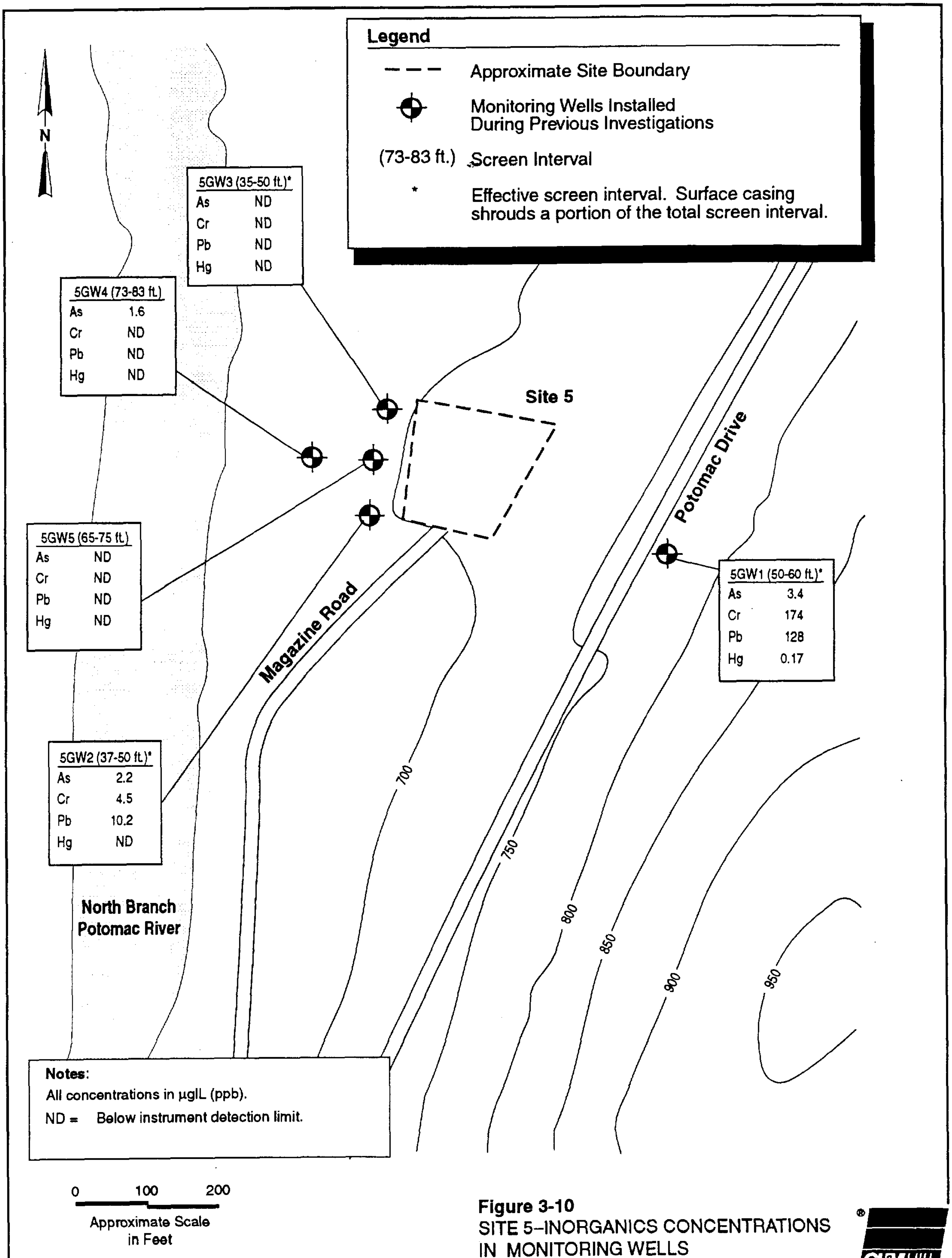


Figure 3-10
SITE 5–INORGANICS CONCENTRATIONS IN MONITORING WELLS
Allegany Ballistics Laboratory

CH2M HILL

Section 4
Work Plan Rationale and Justification

An RI must be sufficient to support a risk assessment and an FS and/or decision document that addresses applicable or relevant and appropriate requirements (ARARs) and risks for mitigating confirmed contamination at sites 2, 3, 4, 5, and PWA. Conceptual site models illustrating possible contaminant migration pathways and potential current exposure pathways are presented and discussed below for each site. Additional data needs recommended to adequately characterize each of these sites and preliminary remediation goals (PRGs) are also discussed. The specific scope of work necessary to address these data needs are detailed in Section 5- Technical Approach.

Site 2

Figure 4-1 illustrates the conceptual site model for possible contaminant migration pathways and potential current exposure pathways for Site 2. The historical burn pad area may be a primary source of contamination. The Aerial Photographic Site Analysis (APSA) performed in August 1994 by EPA Region III indicates a probable burn area at a different location than the suspected old burn pad area investigated in the RI (see Figure 5-4). Contaminants released in these areas may have contaminated soils and infiltrated into the groundwater. Contaminated soils present a risk of exposure through ingestion or dermal contact and may also serve as a secondary source of contamination for groundwater and surface water. Contaminated groundwater presents a risk of exposure through ingestion, inhalation, and dermal contact. There is no current exposure to groundwater at the site although, a remote possibility exists for contaminated groundwater to flow underneath the river to residential wells exposing area residents to contamination. Stormwater runoff may

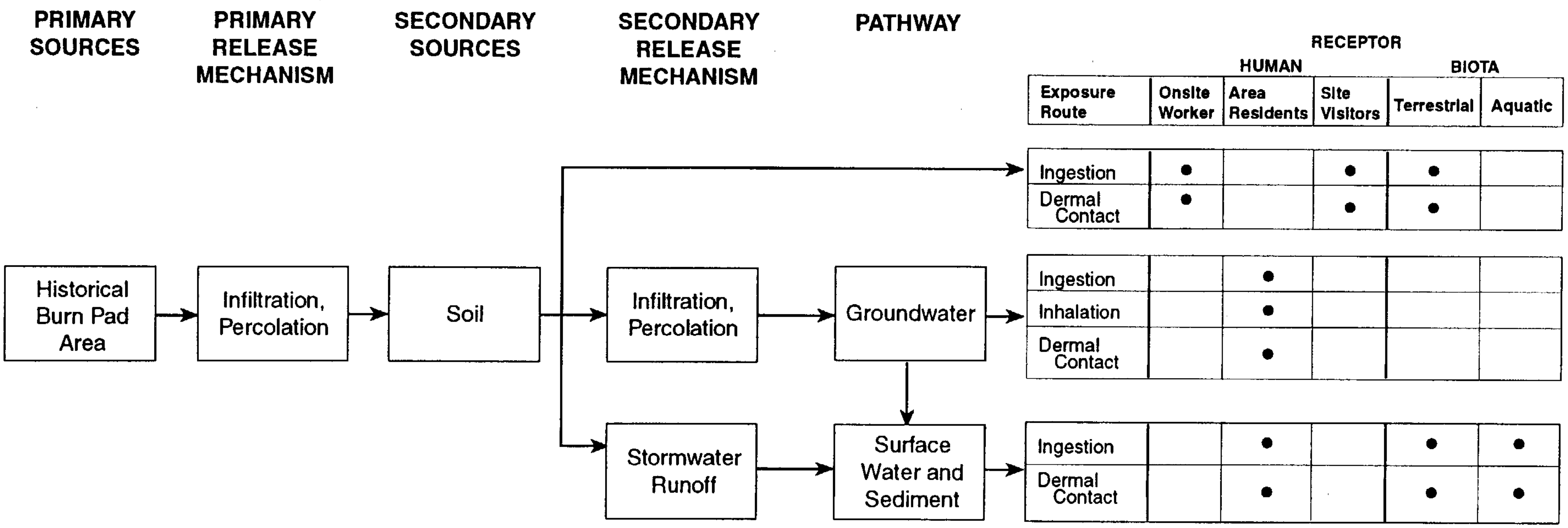


Figure 4-1
CONCEPTUAL SITE MODEL–SITE 2
Allegany Ballistics Laboratory

also transport contaminated soils to surface water and sediments in the river. However, this is an unlikely transport mechanism for VOCs and no SVOCs, explosives, and only low levels of inorganics were detected in surface soil samples collected at the burn pad in the RI.

Potential contaminants of concern (PCCs) at Site 2 change for different media. VOCs and inorganics are the PCCs for groundwater, since no explosives or SVOCs have been detected in groundwater samples analyzed in previous investigations. It is important to note that VOCs have only been detected at levels at or below the MCL in monitoring wells downgradient of the suspected burn pad or probable burn area. PCCs for soil include VOCs, inorganics, and SVOCs. Although SVOCs were not detected in soil samples collected from the suspected burn pad area in the RI, it is possible they exist in soil at the probable burn area identified in the APSA. Inorganics and SVOCs are PCCs for surface water and sediment. Preliminary remediation goals (PRGs) for groundwater are the MCLs, PRGs for soil and sediment are those indicated by the National Oceanographic Atmospheric Administration (NOAA), and PRGs for surface water are the ambient water quality criteria (AWQC).

The environmental impacts of historical operations at the suspected burn pad area have been characterized in previous investigations sufficiently to support a risk assessment and FS. However, the probable burn area identified in the APSA should be investigated to determine if it may be a primary source of contamination. In addition, groundwater quality at Site 2 should be investigated to determine if it has changed since the RI.

Site 3

Figure 4-2 illustrates the conceptual site model for possible contaminant migration pathways and potential current exposure pathways at Site 3. The historical burn area and

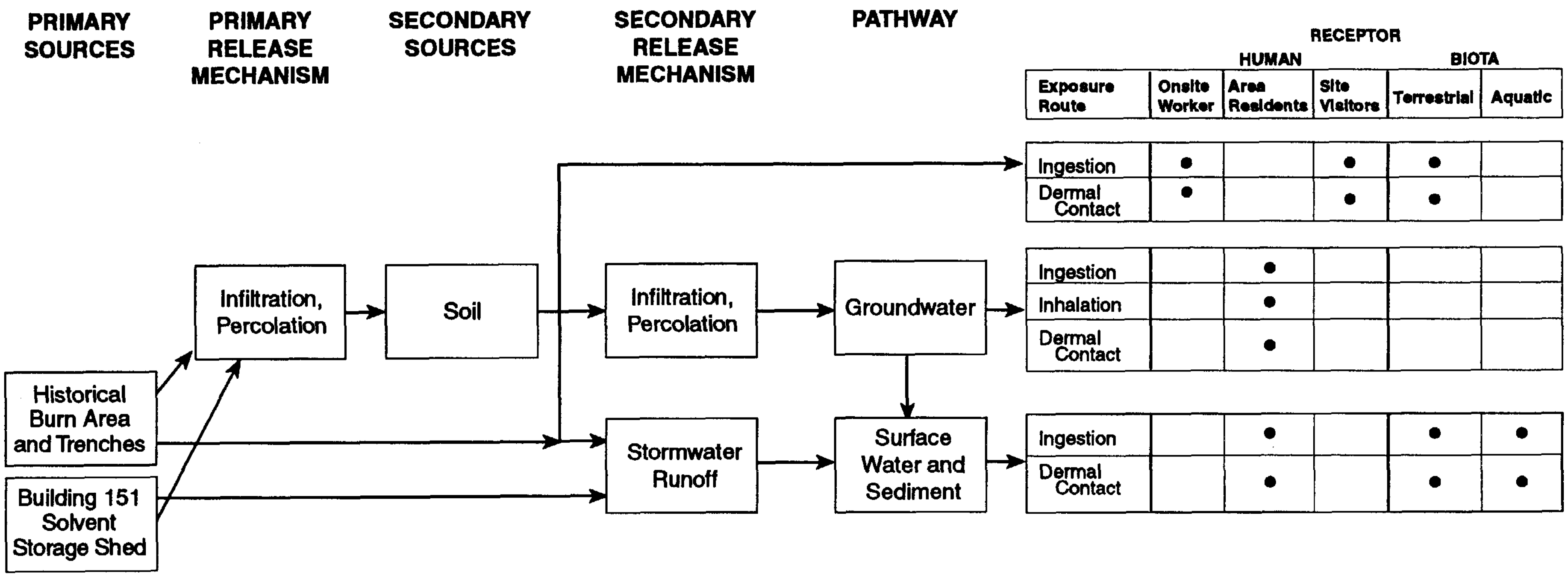


Figure 4-2
CONCEPTUAL SITE MODEL–SITE 3
Allegany Ballistics Laboratory

trenches once located about Building 362 and the solvent storage shed at Building 151 are the primary sources of contamination at Site 3. Contaminants that may have been released at these areas may have contaminated soils and infiltrated into the groundwater. Contaminated soils present a risk of exposure through ingestion or dermal contact and may also serve as secondary sources of contamination for groundwater and surface water and sediment. Contaminated groundwater presents a risk of exposure through ingestion, inhalation, and dermal contact. There is no current exposure to groundwater at the site although, a remote possibility exists for contaminated groundwater to flow underneath the river to residential wells exposing area residents to contamination. However as discussed in Section 3, low levels of groundwater contamination were detected at Site 3. Stormwater runoff may also transport contaminated soils to surface water and sediments in the river. However, this is an unlikely transport mechanism for VOCs and no explosives and only low levels of SVOCs and inorganics were detected in surface soil samples collected at the burn area and trenches in the RI.

PCCs at Site 3 change for different media. VOCs and inorganics are the PCCs for groundwater, since no explosives or SVOCs have been detected in groundwater samples analyzed in previous investigations. PCCs for soil include VOCs, inorganics, and SVOCs. Inorganics and SVOCs are PCCs for surface water and sediment. PRGs for groundwater are the MCLs, PRGs for soil and sediment are those indicated by NOAA, and PRGs for surface water are the AWQC.

The two primary sources of contamination at Site 3 require further investigation to more conclusively determine their impact on soil and groundwater and to better support a risk assessment. Deep soil and groundwater should be sampled at the western side of Building 362 since historical aerial photographs indicate trenches may have been buried in this area during construction of Building 362. In addition, groundwater and surface soil should be sampled and analyzed for VOCs at Building 151 to determine if VOC soil contamination detected in this area has affected groundwater quality and to evaluate risk of exposure to soils, respectively.

Site 4

Figure 4-3 illustrates the conceptual site model for possible contaminant migration pathways and potential current exposure pathways at Site 3. The discharge pipe from Building 181 is the primary source of possible contamination at Site 4. Since no contamination has been detected at Site 4A and reports that a release probably never occurred, only 4B is considered to be a possible source of contamination at Site 4. Contaminants that may have been released from the discharge pipe may have contaminated soils and infiltrated into the groundwater. Contaminated soils present a risk of exposure through ingestion or dermal contact and may also serve as secondary sources of contamination for groundwater and surface water and sediment. Contaminated groundwater presents a risk of exposure through ingestion, inhalation, and dermal contact. There is no current exposure to groundwater at the site although, a very remote possibility exists for contaminated groundwater to flow underneath the river to residential wells exposing area residents to contamination. However as discussed in Section 3, no groundwater contamination was detected at Site 4. Stormwater runoff may also transport contaminated soils to surface water and sediments in the drainage ditch (see Figure 5-2 in Section 5).

PCCs at Site 4 change for different media. Photographic solutions were reportedly released from the discharge pipe during the 1950s and early 1960s. Solutions generated during this period typically contained silver, cyanide, and phenols. Consequently, SVOCs and inorganics are the PCCs for groundwater, since no explosives or VOCs have been detected in groundwater samples analyzed in previous investigations. PCCs for soil, surface water and sediment include SVOCs and inorganics. PRGs for groundwater are the MCLs, PRGs for soil and sediment are those indicated by NOAA, and PRGs for surface water are the AWQC.

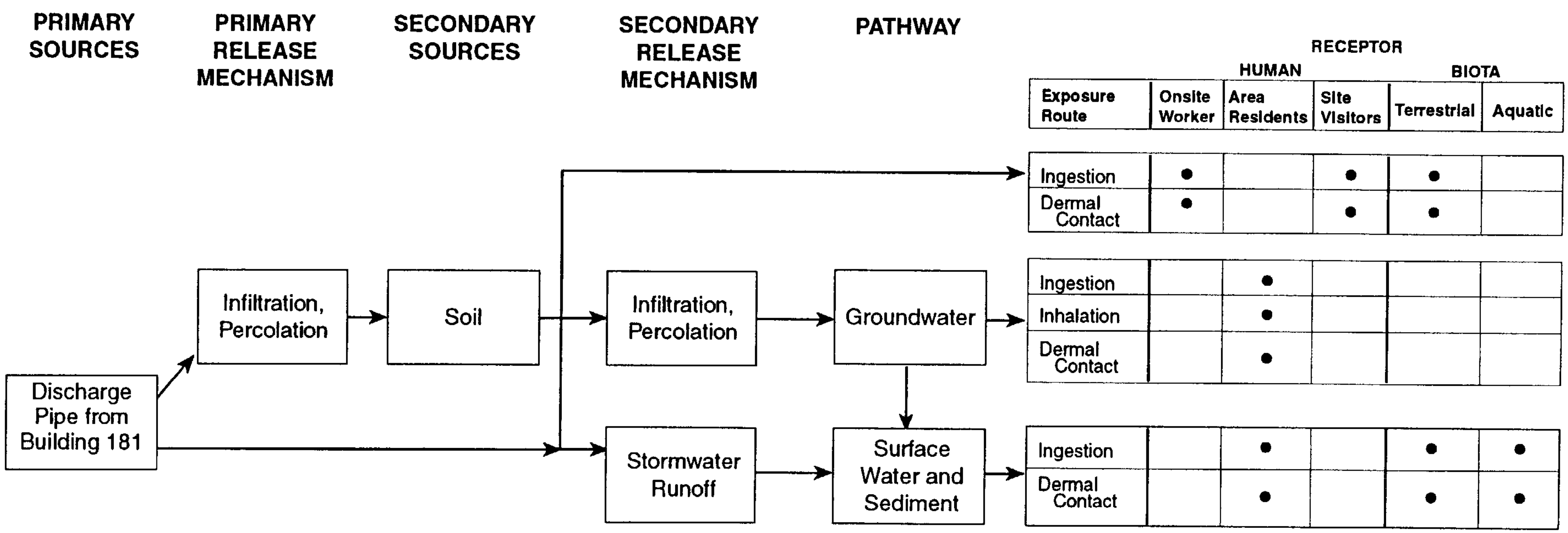


Figure 4-3
CONCEPTUAL SITE MODEL–SITE 4
Allegany Ballistics Laboratory

CH2M HILL

The primary source of contamination at Site 4 requires further investigation to more conclusively determine it's impact on soil and groundwater and to better support a risk assessment. Soil and groundwater should be sampled at the end of the discharge pipe and surface soil/sediment samples should be collected in the drainage ditch. In addition, well 4GW1 should be sampled and analyzed.

Site PWA

Figure 4-4 illustrates the conceptual site model for possible contaminant migration pathways and potential current exposure pathways at Site PWA. The TCE still reported to have operated at Building 157 in 1959-1960 is the primary source of contamination at Site PWA. Contaminants that may have been released from the still contaminated soils and infiltrated into the groundwater. Contaminated soils present a risk of exposure through ingestion or dermal contact and may also serve as secondary sources of contamination for groundwater and surface water and sediment. Contaminated groundwater presents a risk of exposure through ingestion, inhalation, and dermal contact. There is no current exposure to groundwater at PWA since it no longer supplies potable water to ABL although, a very remote possibility exists for contaminated groundwater to flow underneath the river to residential wells exposing area residents to contamination. Stormwater runoff may also transport contaminated soils to surface water and sediments in the river. However, this is an unlikely transport mechanism for VOCs.

PCCs at Site PWA include primarily VOCs and also SVOCs and inorganics. The TCE still recycled TCE that had been used as a solvent in plant operations. Therefore, the used TCE may have contained some SVOCs or inorganics. Consequently, PCCs for soil and groundwater at Site PWA are VOCs, SVOCs, and inorganics. PRGs for groundwater are the MCLs, PRGs for soil and sediment are those indicated by NOAA, and PRGs for surface water are the AWQC.

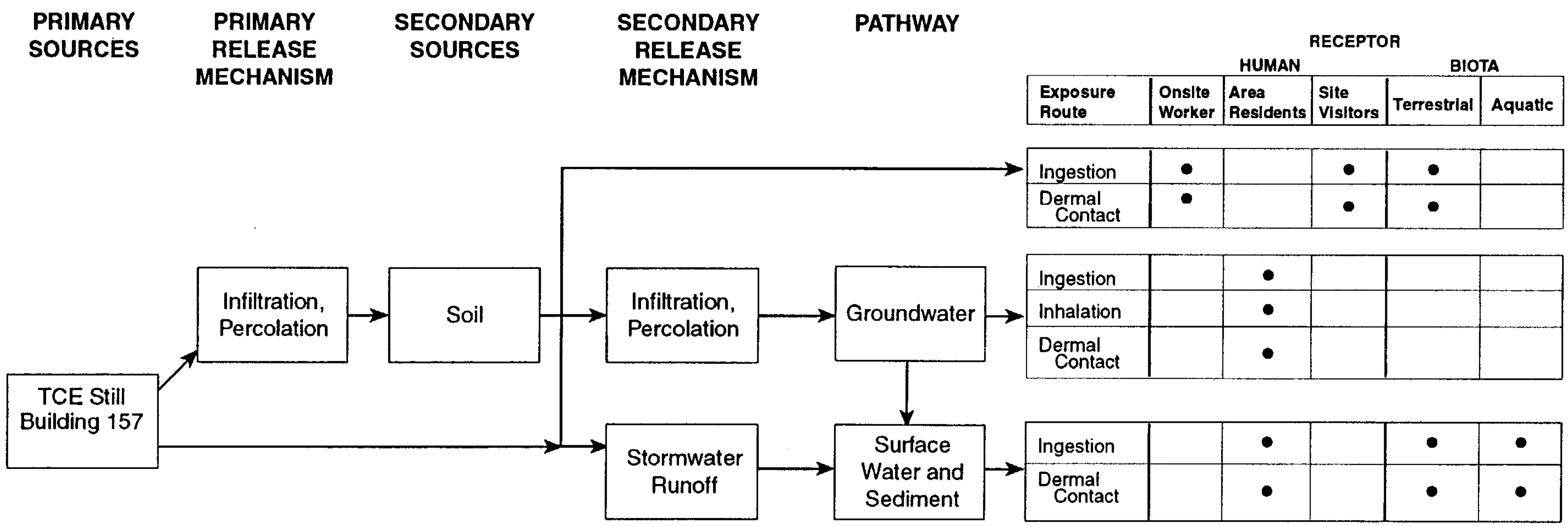


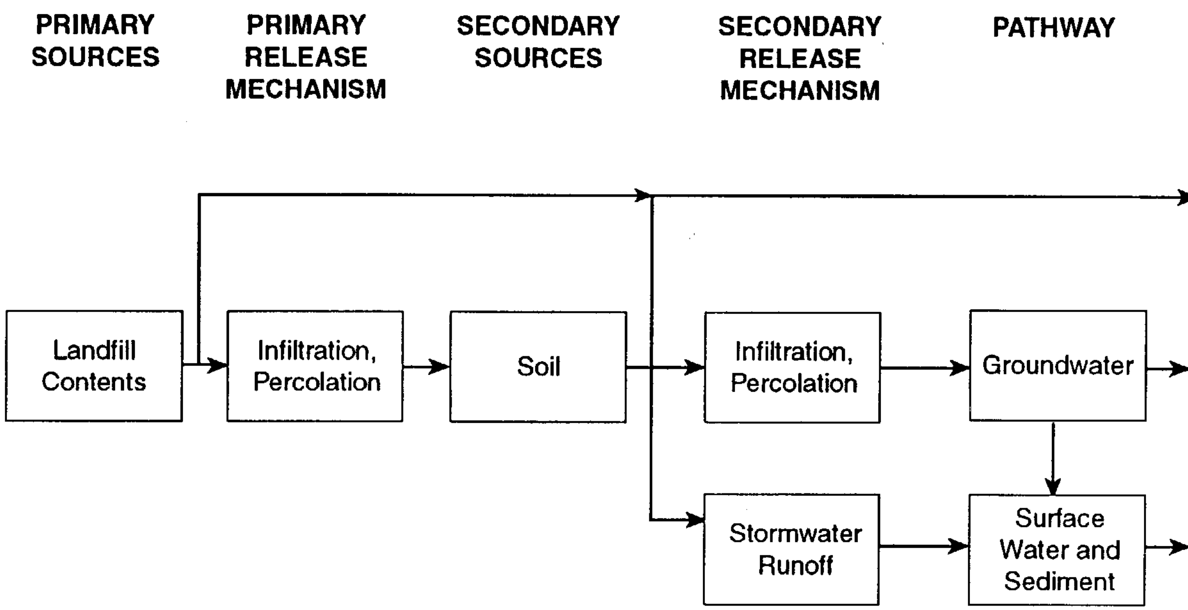
Figure 4-4
CONCEPTUAL SITE MODEL–SITE PWA
Allegany Ballistics Laboratory

The primary source of contamination identified at PWA requires further investigation to more conclusively determine it's impact on soil and groundwater and to better support a risk assessment. Soil and groundwater samples should be collected in the area of the former TCE still operations. In addition, PWA wells should be sampled to determine if groundwater quality in these wells has changed since the RI.

Site 5

Figure 4-5 illustrates the conceptual site model for possible contaminant migration pathways and potential current exposure pathways at Site 5. The landfill contents are the primary source of contamination at the site. Contaminants that may have been released from the landfill contents may have contaminated soils and infiltrated into the groundwater. Contaminated soils and uncovered landfill contents present a risk of exposure through ingestion or dermal contact and contaminated soils may also serve as secondary sources of contamination for groundwater and surface water and sediment. Contaminated groundwater presents a risk of exposure through ingestion, inhalation, and dermal contact. There is no current exposure to groundwater at the site, although a possibility exists for contaminated groundwater to flow underneath the river to residual wells exposing area residents to contamination. Stormwater runoff may also transport contaminated soils to surface water and sediments in the river. However, this is an unlikely transport mechanism for VOCs.

PCCs at Site 5 change for different media. PCCs for groundwater include VOCs and inorganics, since SVOCs and explosives were not detected in groundwater samples in the confirmation study or RI. PCCs for soil, surface water, and sediment include VOCs, SVOCs, and inorganics. PRGs for groundwater are the MCLs, PRGs for soil and sediment are those indicated by NOAA, and PRGs for surface water are the AWQC.



RECEPTOR

Exposure Route	Onsite Worker (HUMAN)	Area Residents (HUMAN)	Site Visitors (HUMAN)	Terrestrial (BIOTA)	Aquatic (BIOTA)
Ingestion	●		●	●	
Dermal Contact	●		●	●	
Ingestion		●			
Inhalation		●			
Dermal Contact		●			
Ingestion		●		●	●
Dermal Contact		●		●	●

Figure 4-5
CONCEPTUAL SITE MODEL–SITE 5
Allegany Ballistics Laboratory

CH2M HILL

Further investigation is required at Site 5. The approximate boundary of the landfill should be determined and the monitoring well network reevaluated. Although no historical records indicating the type and location of wastes disposed were kept, geophysical methods and soil gas sampling should be used in an effort to identify possible hot spots. Surface water and sediment in the North Branch Potomac River should be sampled and analyzed to determine if groundwater contamination detected in wells at Site 5 has migrated to the river.

The hydrogeology at Site 5 should be investigated and better defined. The Interim RI Report indicated groundwater did not exist in the alluvium. However, groundwater was observed in the alluvial aquifer during the installation of bedrock wells as part of the RI investigation. Therefore, groundwater quality of the alluvial aquifer should be characterized and hydraulic characteristics of both aquifers should be determined.

The production wells that supply all potable water to ABL are located approximately 2,000 feet south of Site 5 (see Figure 2-1). These wells pump large quantities of groundwater from the bedrock aquifer. Consequently, it should be determined if the operation of the supply wells affects groundwater flow at Site 5.

The IAS indicates that Site 5 is currently covered with soil and Hercules representatives indicate that the landfill is covered with 1 to 4 feet of crushed limestone and soil. In addition, the IAS indicates soil samples were collected at the "toe" of the landfill and analyzed for EPA priority pollutants in 1981 and no contamination was detected. However, surface soil samples should be collected at locations where drums or other possible sources of contamination can be observed at the face of the landfill.

WDCR905/031.WP5

Section 5

Technical Approach

This section details the technical approach developed to perform the RI/FS activities at sites 2, 3, 4, 5, and PWA. The tasks included in the technical approach are listed below; the remainder of this section provides detailed discussions of each task.

Task 1: Work Plan
Task 2: Health and Safety Plan
Task 3: Sampling Plan
Task 4: Well Installation
Task 5: Well Testing
Task 6: Geophysical Investigation
Task 7: Evaluate Production Wells
Task 8: Groundwater Sampling
Task 9: Soil Sampling
Task 10: Surface Water and Sediment Sampling
Task 11: Soil Gas Sampling
Task 12: Sample Analysis
Task 13: Data Validation
Task 14: RI Report
Task 15: Baseline Human Health Risk Assessment
Task 16: Baseline Ecological Risk Assessment
Task 17: Feasibility Study
Task 18: Community Relations
Task 19: Proposed Plan

Task 1: Work Plan

This task consists of the development of this work plan for performing all activities associated with the RI/FS at sites 2, 3, 4, 5, and PWA. The work plan was developed in accordance with EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*.

Task 2: Health and Safety Plan

To maintain the health and safety of CH2M HILL employees during all RI/FS field activities, a site-specific health and safety plan (HSP) will be developed. The HSP will be used by CH2M HILL personnel and subcontractors during field activities associated the project. The HSP will include health and safety assessments to identify problem areas where exposure to hazardous substances in water, soil, and air may occur.

The assessment will address safe working procedures, restrictions that will apply to the site work, and potential human exposure to hazardous substances and the toxicological effects of these substances.

Task 3: Sampling Plan

This task consists of the preparation of a Sampling Plan, which is comprised of a Field Sampling Plan (FSP), a Quality Assurance Project Plan (QAPP), and an Investigation Derived Waste (IDW) Management Plan. The Sampling Plan will be developed in compliance with all requirements of the U.S. Navy QA/QC Program Manual.

The FSP will be used during field activities, providing guidance for all fieldwork by describing in detail the procedures for sampling and data collection. The FSP will include the following sections: Site Background, Sampling Objectives, Sample Locations and Frequency, Sample Designations, Sampling Equipment and Procedures, and Sample Handling and Analysis.

The QAPP will include a description of field quality assurance and quality control (QA/QC) procedures mandated by the EPA and the U.S. Navy QA/QC Program Manual.

The IDW Management Plan will detail the handling and disposal of all IDWs generated during the RI/FS field activities. The plan includes a discussion presenting the rationale in arriving at the recommended disposal procedures.

Task 4: Well Installation

A total of five shallow alluvial wells and three bedrock wells will be installed using Odex and air rotary drilling techniques at Site 5. Figure 5-1 gives the approximate location of these wells. Three alluvial wells will be installed downgradient of the landfill and screened in the alluvial aquifer to monitor groundwater quality and perform well testing. The boring log of 5GW1 included in the Interim RI Report indicates that this well is likely screened in the alluvium but may bridge across the bedrock or weathered bedrock. For this reason, one bedrock well will be installed upgradient of the landfill proximate to well 5GW1. Two alluvium and bedrock well pairs will be installed at the northern and southern ends of the landfill. These wells will monitor groundwater quality at each end of the landfill to determine if contaminated groundwater is moving along the near-vertical bedding planes running north-south in the bedrock.

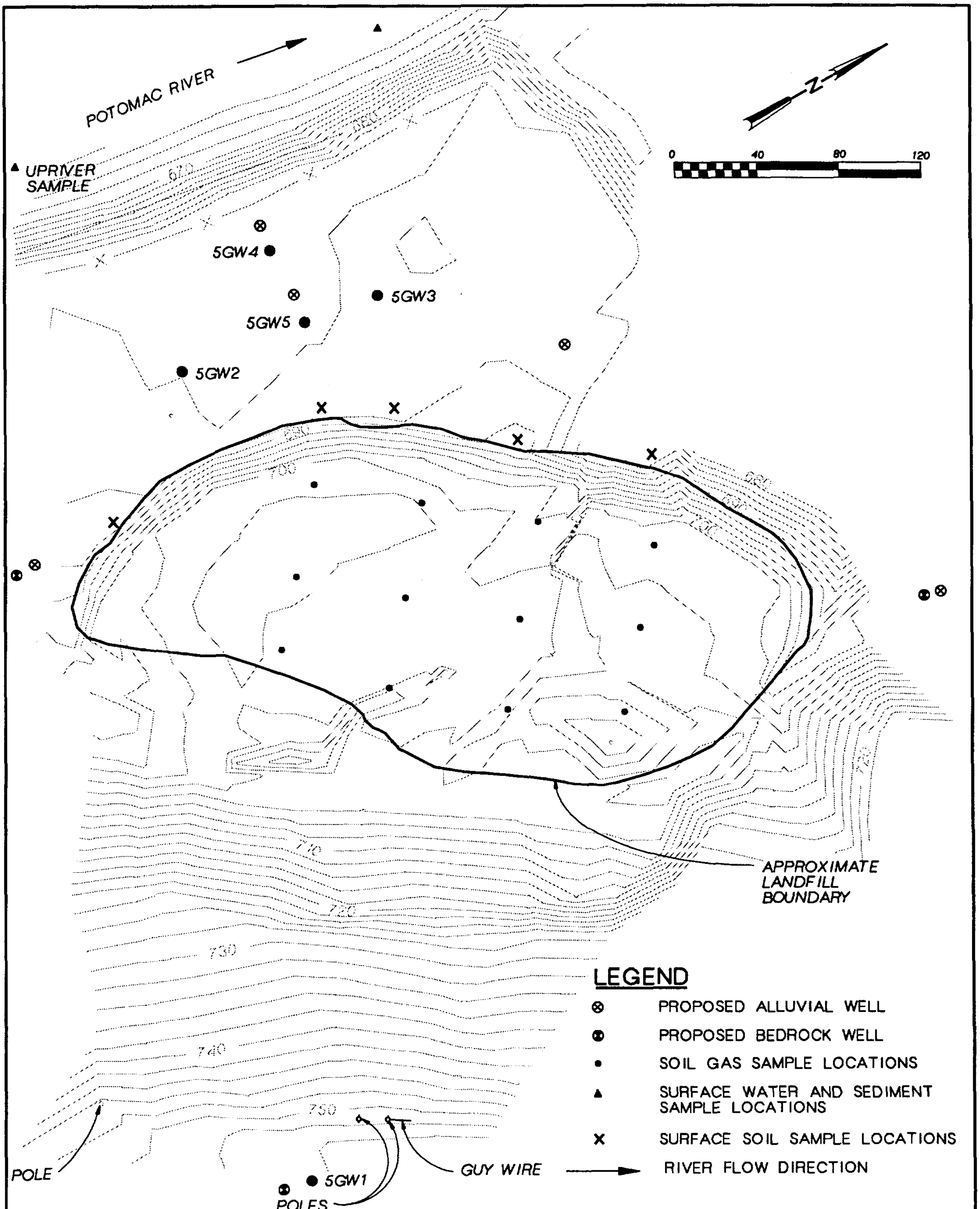


Figure 5-1
SITE 5 PROPOSED MONITORING WELL
AND SAMPLING LOCATIONS
ALLEGANY BALLISTICS LABORATORY

CH2M HILL

27-DEC-1994 0342FC01.DGN

One shallow well will be installed directly downgradient of building 151 (see Figure 3-2) and screened in the alluvial aquifer at Site 3. Odex drilling techniques will be used to install the well. This well will be used to evaluate groundwater quality downgradient of VOC soil contamination detected in the RI.

Task 5: Well Testing

Hydraulic conductivity tests (slug tests) will be performed at three alluvial wells and three bedrock wells at Site 5. Time of depression and recovery will be measured at each well. Test results will be used to approximate the hydraulic conductivity of each aquifer and evaluate contaminant transport and the feasibility of groundwater extraction systems.

Two separate rounds of water level measurements will be performed at Site 5. Each round will occur over an eight hour period and at least three months apart. Results will be used to approximate the piezometric surface of the bedrock and alluvial aquifers at Site 5.

Task 6: Geophysical Investigation

Geophysical investigations including magnetometer and ground penetrating radar (GPR) surveys, along with a topographic survey, will be performed at Site 5. The objective of the GPR investigation is to determine the approximate areal extent of the landfill. The magnetometer survey will be used to determine the distribution of metal in the landfill. This information will be interpreted to evaluate the existence of buried drums or hot spots in the landfill.

The GPR investigation will be performed using a digital radar system such as the Sensors and Software pulseEKKO IV or GSSI SIR-10 systems. The depth of investigation of GPR is often limited by the presence of clay, which is present at Site 5. The nature of the landfill contents is unknown, but is anticipated to be different than the undisturbed soil. Even with limited penetration, there should be a discernable difference between the landfill and soil. It is unlikely, however, that the depth of investigation through the landfill will be sufficient to map the thickness. Therefore, GPR traverses will be run at 25 foot intervals around the perimeter of the landfill to delineate it's boundary. Lines will be 100 feet long or as needed to achieve the objective. If it appears that the bottom of the landfill can be seen in the data, lines will be extended across the landfill in an effort to determine it's thickness.

A magnetometer will be used to map the distribution of buried metal in the landfill. The amplitude of magnetic anomalies is generally a function of the amount of metal present. Magnetometer data, consisting of the total magnetic and vertical magnetic gradient, will be collected along traverses 10 feet apart. The survey will be performed with a GEM GSM 19 ''walking'' magnetometer designed to take readings at intervals of one second. This will result in measurements at intervals of 2 to 4 feet depending on the walking speed.

Task 7: Evaluate Production Wells

Data loggers will be used to perform continuous water level measurements at Site 5 monitoring wells over a 1 week period. Results will be evaluated to determine if fluctuations in groundwater elevations at Site 5 correspond to supply well pumping. The objective is to determine if operation of the supply wells affects a response in the alluvial or bedrock aquifers at Site 5. In addition, continuous water level measurements will be taken in the river to determine if a hydraulic connection exists between the alluvial and bedrock aquifers and the river.

Task 8: Groundwater Sampling

Table 5-1 summarizes the groundwater sampling program giving the sampling location, and analyses performed for each sample. Figure 5-1, 3-2, and 2-4 give the locations of the wells listed in Table 5-1. The sampling program for each site is discussed below.

Site 2

All alluvial and bedrock wells will be sampled and analyzed for VOCs to determine if groundwater quality has changed since the RI. Samples collected from all wells except for 2GW4 and 2GW6, will be analyzed for dissolved inorganics because elevated levels of total inorganics were detected in these wells during the RI. Since low levels of total inorganics were detected in wells 2GW4 and 2GW6, dissolved concentrations should be even lower. No samples will be analyzed for SVOCs or explosives because they were not detected in samples analyzed during the confirmation study. Pesticide/PCB analysis will not be performed on the groundwater samples because no potential source of these compounds has been identified.

Site 3

All wells except for the new well at Building 151 will be sampled for total and dissolved inorganics because these wells were not sampled during the RI. Samples from these wells will not be analyzed for VOCs since they were infrequently detected at low levels and no TCE was detected in the RI. No samples will be analyzed for SVOCs or explosives because they were not detected in samples analyzed during the confirmation study. Pesticide/PCB analysis will not be performed on the groundwater samples because no potential source of these compounds has been identified.

The new well at Building 151 will be analyzed for VOCs, SVOCs, and total and dissolved inorganics since it is a new well.

Table 5-1
GROUNDWATER SAMPLING PROGRAM FOR SITES 2, 3, 4B, 5, AND PWA

Site	Well Location	VOC	SVOC	TAL (dissolved)	TAL (total)	CN (total)	Pest/PCB	Hardness	DO	BOD	COD
Site 2	2GW-1	X		X		X					
Site 2	2GW-2	X		X		X					
Site 2	2GW-3	X		X		X					
Site 2	2GW-4	X									
Site 2	2GW-6	X									
Site 2	2GW-7	X		X		X					
Site 3 (New)	Downgradient of 151	X	X	X	X	X					
Site 3	3GW-1			X	X	X					
Site 3	3GW-2			X	X	X					
Site 3	3GW-3			X	X	X					
Site 3	3GW-4			X	X	X					
Site 3	Geoprobe sample near Bldg 362	X	X		X						
Site 4	4GW-1					X					
Site 4	Geoprobe sample near Bldg 181	X	X		X	X					
Site 5 (New)	Adjacent to 5GW-1	X	X	X	X	X					
Site 5 (New)	Adjacent to 5GW-2	X	X	X	X	X		X	X	X	X
Site 5 (New)	Adjacent to 5GW-3	X	X	X	X	X					
Site 5 (New)	Adjacent to 5GW-4	X	X	X	X	X					
Site 5 (New)	Bedrock well north of Site 5	X	X	X	X	X	X	X	X	X	X
Site 5 (New)	Alluvial well north of Site 5	X	X	X	X	X	X				

Table 5-1
GROUNDWATER SAMPLING PROGRAM FOR SITES 2, 3, 4B, 5, AND PWA

Site	Well Location	VOC	SVOC	TAL (dissolved)	TAL (total)	CN (total)	Pest/PCB	Hardness	DO	BOD	COD
Site 5 (New)	Bedrock well south of Site 5	X	X	X	X	X	X	X	X	X	X
Site 5 (New)	Alluvial well south of Site 5	X	X	X	X	X	X				
Site 5	5GW-1	X	X	X		X					
Site 5	5GW-2	X	X			X					
Site 5	5GW-3	X	X			X					
Site 5	5GW-4	X	X			X					
Site 5	5GW-5	X	X			X					
Site PWA	PWA	X						X	X	X	X
Site PWA	PWA-1	X									
Site PWA	PWA-2	X									
Site PWA	Geoprobe sample at Bldg 157	X	X		X						
Site PWA	Geoprobe sample downgradient of Bldg 157	X									
Site PWA	Geoprobe sample upgradient of Bldg 157	X									
Background Well	1GW-7	X		X		X					
Plant 1	1GW-6	X		X							
Plant 1	GGW1	X									
Plant 1	GGW5	X		X		X					
Plant 1	GGW6	X		X		X					
Plant 1	GGW7			X		X					
Plant 1	GGW8			X		X					

One groundwater sample will be collected west of Building 362 shown in Figure 5-2. This sample will be collected using a geoprobe and analyzed for VOCs, SVOCs, and total inorganics. This sample location is estimated to be where the former burn area and trenches were located.

Site 4

Well 4GW1 will be sampled and analyzed for cyanide since it is a compound associated with photographic solutions used in the 1950s and 1960s. The sample will not be analyzed for VOCs because they were not detected in this well in the RI. The sample will not be analyzed for SVOCs or explosives because they were not detected in the sample analyzed during the confirmation study. Pesticide/PCB analysis will not be performed on the groundwater sample because no potential source of these compounds has been identified.

Figure 5-2 shows the location of a groundwater sample to be collected using a geoprobe at Building 181. This sample will be analyzed for VOCs, SVOCs, and total inorganics.

Site PWA

All wells will be sampled and analyzed for VOCs to determine if their concentration has changed since the RI. No samples will be analyzed for SVOCs or explosives because they were not detected in samples analyzed during the confirmation study. Pesticide/PCB analysis will not be performed on the groundwater samples because no potential source of these compounds has been identified.

The PWA groundwater sample will be analyzed for biological oxygen demand (BOD), chemical oxygen demand (COD), hardness, and dissolved oxygen (DO) to be used for evaluating treatment technologies in the feasibility study.

0342FC03.DGN

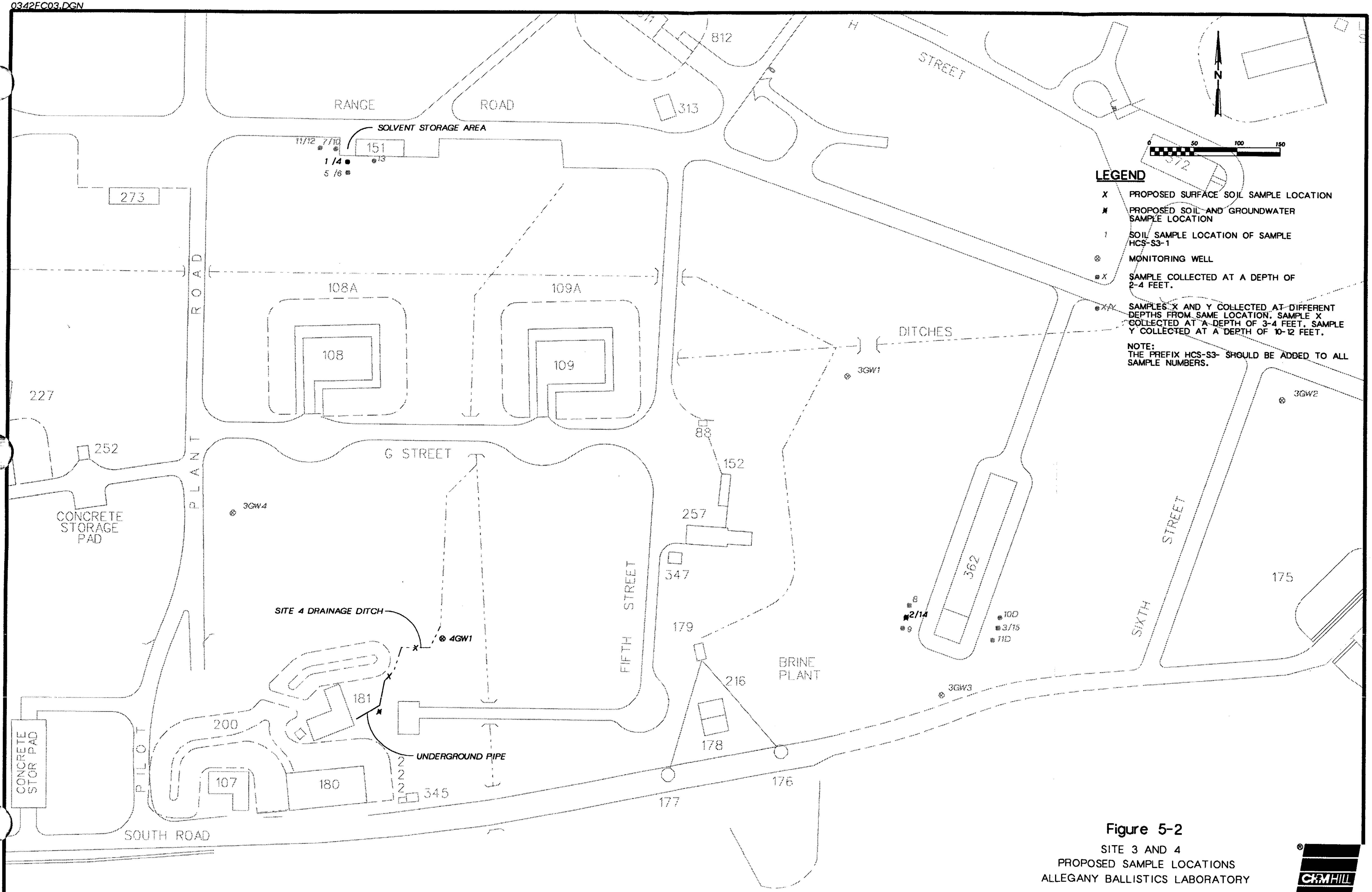


Figure 5-2
SITE 3 AND 4
PROPOSED SAMPLE LOCATIONS
ALLEGANY BALLISTICS LABORATORY

00447B082

Figure 5-3 shows the locations of groundwater samples to be collected using the geoprobe. All samples will be analyzed for VOCs to determine whether VOCs detected in soil samples at Building 157 have entered the shallow groundwater. The sample collected at Building 157 will also be analyzed for SVOCs and total inorganics to determine if these contaminants were released with the spent solvents recycled at the TCE still.

Site 5

All existing wells at Site 5 will be sampled and analyzed for VOCs, SVOCs, and cyanide. Well 5GW1 will also be analyzed for dissolved inorganics since high concentrations of total inorganics were detected in this well in the RI. Low levels of total inorganics were detected in the other existing wells during the RI. All wells will be analyzed for cyanide since none of the wells were analyzed for cyanide in the RI. No existing well samples will be analyzed for SVOCs because they were not detected in samples analyzed during the confirmation study.

All new wells will be analyzed for VOCs, SVOCs, and total and dissolved inorganics. Two bedrock and two alluvial wells will also be analyzed for pesticides/PCBs since it is possible these contaminants may be included in the landfill contents.

Groundwater samples from one alluvial well and two bedrock wells will be analyzed for BOD, COD, hardness, and DO to be used for evaluating treatment technologies in the feasibility study.

Task 9: Soil Sampling

The soil sampling program includes the collection of soil samples at each site. Samples collected and specific analyses performed are outlined below for each site.

0342FC04.DGN

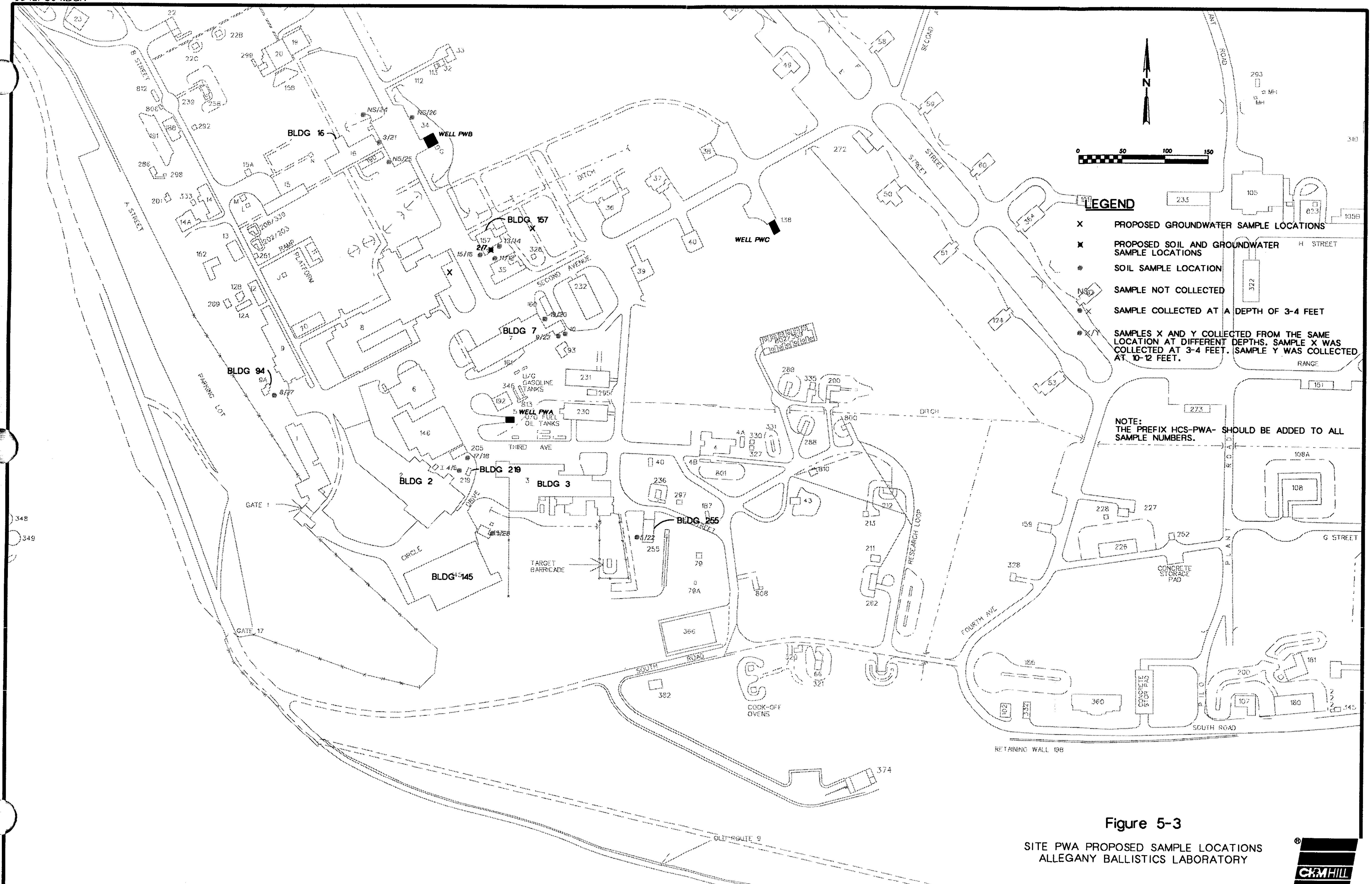


Figure 5-3

SITE PWA PROPOSED SAMPLE LOCATIONS
ALLEGANY BALLISTICS LABORATORY

CH2M HILL

00447609Z

Site 2

Figure 5-4 illustrates the locations where soil samples will be collected at Site 2. A total of eight soil samples will be collected from four locations at the probable burn area identified in the APSA. A surface soil sample (0-1 foot) and a deep soil sample (4-6 feet) will be collected at each location. All samples will be analyzed for VOCs, SVOCs, and inorganics. Pesticide/PCB analysis will not be performed on the soil samples because no potential source of these compounds has been identified.

Site 3

Figure 5-2 gives the location of the two soil samples to be collected at Site 3. One surface soil sample will be collected at soil sample location HCS-S3-1 near Building 151. The sample will be analyzed for VOCs. The sample will only be analyzed for VOCs since only pure solvents were stored at the solvent storage shed and used or spent solvents were sent to Site 1. The analytical results along with soil analytical results generated during the RI will be used to evaluate risks associated with soil exposure at the site.

One deep soil sample (4-6 feet) will be collected from sample location HCS-S3-2 west of Building 362. The sample will be analyzed for VOCs, SVOCs, and inorganics. Pesticide/PCB analysis will not be performed on the soil sample because no potential source of these compounds has been identified.

Site 4

Figure 5-2 gives the location of soil samples to be collected at Site 4. One surface soil sample and one deep soil sample (4-6 feet) will be collected from one location near the discharge pipe at Building 181. Both samples will be analyzed for VOCs, SVOCs, and inorganics. Pesticide/PCB analysis will not be performed on the soil samples because no potential source of these compounds has been identified.

0342fc02.dgn

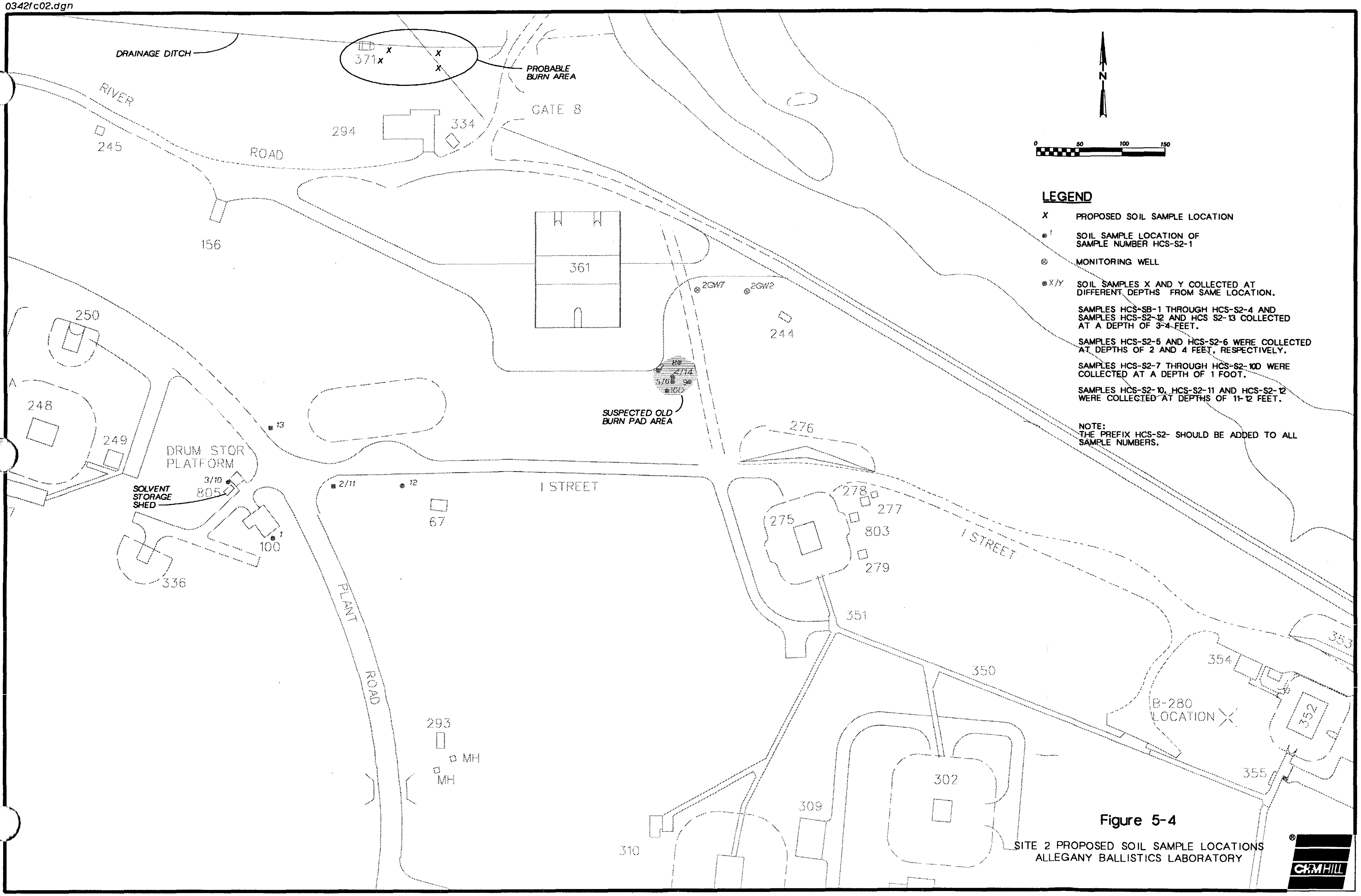


Figure 5-4

SITE 2 PROPOSED SOIL SAMPLE LOCATIONS
ALLEGANY BALLISTICS LABORATORY

00447B10Z

Two surface soil samples will be collected from the drainage ditch. Each sample will be analyzed for inorganics. The samples will not be analyzed for VOCs because the photographic solutions were not reported to have contained VOCs and if they had, VOCs would likely volatilize from soils as they were transported down the drainage ditch.

Site PWA

Figure 5-3 gives the location of the soil samples to be collected at Site PWA. Two soil samples will be collected from one location at Building 157 where the former TCE still operated. One surface soil sample and one deep soil sample (4-6 feet) will be collected and analyzed for SVOCs and inorganics. The samples will not be analyzed for VOCs since VOC analysis was performed on soil samples collected from this location in the RI. Pesticide/PCB analysis will not be performed on the soil samples because no potential source of these compounds has been identified.

Site 5

Figure 5-1 gives the location of soil samples to be collected at Site 5. A total of five surface soil samples will be collected from locations where drums or other possible sources of contamination can be observed at the face of the landfill. All samples will be analyzed for VOCs, SVOCs, inorganics, and PCB/Pesticides.

Task 10: Soil Gas Sampling

Figure 5-1 gives the soil gas sample locations to be collected at Site 5. A total of twelve soil gas samples will be collected across the landfill in an effort to determine if hot spots of

VOC contamination exist. The samples will be analyzed using a field gas chromatograph for selected VOCs including:

- TCE
- 1,1,1-TCA
- 1,1-DCE
- 1,1-DCA
- cis 1,2-DCE
- trans 1,2-DCE
- methylene chloride

Task 11: Surface Water and Sediment Sampling

A total of two surface water and two sediment samples will be collected from two different locations in the North Branch Potomac River along Site 5. One sampling location will be upriver from Site 5 and the other will be directly downgradient from monitoring wells at Site 5. All samples will be analyzed for VOCs, SVOCs and inorganics.

Task 12: Sample Analysis

All analyses of soil, groundwater, surface water, and sediment will be conducted at CEIMIC Laboratory in Narragansett, Rhode Island. CEIMIC fulfills all requirements of the U.S. Navy's QA/QC Program Manual and EPA's Contract Laboratory Program. A signed certificate of analysis will be provided with each laboratory analysis, along with a certificate of compliance certifying that all work was performed in accordance with the applicable federal, state, and local regulations. All analyses will be performed following NEESA guidance for Level D.

Task 13: Data Validation

All data will be validated before the project staff performs an interpretation. The data validation will be performed by Heartland Environmental Services, Inc., an independent subcontractor, and will conform to the NEESA guidance for Level D. Data that should be qualified will be flagged with the appropriate symbol. Results for quality assurance/quality control (QA/QC) samples will be reviewed and the data will be qualified further, if necessary. Finally the data set as a whole will be examined for consistency, anomalous results, and reasonableness.

Task 14: RI Report

A draft and final RI report detailing the investigation activities and findings will be prepared in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (U.S. EPA, 1988 Interim Final). The RI will summarize data from previous investigations as well as all new data generated during this investigation. Nine sections will be included in the RI Report: Executive Summary; Introduction; Background and Physical Setting; Remedial Investigation Activities; Geology; Hydrogeology; Nature and Extent of Contamination; Contaminant Fate and Transport; and Preliminary ARARs.

Task 15: Baseline Human Health Risk Assessment

A baseline Human Health Risk Assessment (RA) will be performed for sites 2, 3, 4B, 5, and PWA. The RA will address contaminants and exposure pathways associated with potential risks to human health. Risks will be evaluated separately for the sites. The RA will be quantitative to the extent possible and be conducted in accordance with EPA Region III's supplementary risk assessment guidance. On the basis of the current understanding of sites 2,3,and PWA, human health risks will be evaluated for exposure through the following pathways:

- Current worker and future residential exposure to ingestion, inhalation of, and dermal absorption of contaminated groundwater.

- Current and future worker exposure to ingestion and dermal absorption of contaminated soils.

- Future residential exposure to ingestion and dermal absorption to contaminated soils.

Based on the current understanding of Site 4B, the exposure pathways considered to evaluate health risks are identical to those for sites 2, 3, and PWA. Exposure pathways considered for Site 5 are described below:

- Current public exposure through ingestion of and dermal contact with contaminated surface water.

- Current worker and future residential exposure to ingestion, inhalation of, and dermal absorption of contaminated groundwater.

- Current and future worker exposure to ingestion and dermal absorption of contaminated soils.

- Future residential exposure to ingestion and dermal absorption to contaminated soils.

The following will be performed as part of the RA for all sites:

- Toxicity assessment—The toxicity assessment will include a brief discussion of the toxicological characteristics of the major contaminants at sites 2, 3, 4B, 5, and PWA. It will also discuss the quantitative approach used to assess the potential effects on human health, including aggregate effects, of the carcinogenic and systemic toxicants. Summaries of the toxicological effects of the major contaminants will be provided.

- Exposure assessment—The exposure assessment will discuss ways in which identified receptors could come into contact with contaminants at the sites. The pathways that will be evaluated are listed above, exposures through these pathways will be quantified using data collected at the sites during previous investigations and this investigation.

- Risk characterization—The risk characterization will include quantifying the potential incremental risks on the basis of information from the toxicity and exposure assessments.

Task 16: Baseline Ecological Risk Assessment

A baseline ecological RA will be performed for each site. The RA will evaluate the potential risks to the environment in the absence of any remedial action. Characterization of environmental risks involves identifying the potential exposures to the surrounding ecological receptors and evaluating the potential effects associated with such exposures. The RA will be conducted in accordance with the *Risk Assessment Guidance for Superfund Volumes II: Environmental Evaluation Manual* (U.S. EPA, 1989) and Region III's supplementary risk assessment guidance documents. The scope of the RA is detailed below.

Description of Areas for Ecological Consideration

An ecological investigation will be conducted to describe the habitats potentially impacted at the ABL site. A qualitative description will be prepared, based on existing data from other sources and from a site reconnaissance survey. The description will address a physical description of the site and it's surroundings and the identification of habitats in potentially exposed areas.

The site and surrounding area will be characterized through a review of reports provided by the Navy for this site, through contacts with resource agencies having knowledge of environmental resources in the vicinity of the site and the results of the site reconnaissance.

Terrestrial Onsite Reconnaissance Studies

An inventory of terrestrial species will be conducted in the Site 1 area. Visual observations of vegetation and wildlife will be made via walking transects through the wetland/upland habitats in the Site 1 area of concern. In addition, similar observations will be made in control areas. Species lists and associations of both plant and wildlife will be prepared. Signs of visual stress of plants, unvegetated areas, or unusual wildlife observations also will be noted.

Contaminants of Concern

Analytical results from the previous studies and the water, sediment, and soil sampling and analysis conducted as part of this work plan will be reviewed to select contaminants of concern. Contaminants will be evaluated for the following to help in selecting contaminants of concern:

- Toxicity characteristics and action concentration
- Bioaccumulation potential in plants and animals

- Translocation properties and tissue accumulation
- Environmental and within-organism persistence
- Potential update by aquatic and terrestrial organisms, and
- Mode of toxic action.

Exposure Assessment

The objectives of the exposure assessment will be to:

- Identify significant pathways/routes of exposure,
- Identify habitat types that may receive contaminants,
- Identify the plants, fish and/or wildlife that may be potentially exposed to the contaminants of concern,
- Select target species, and
- Predict exposure concentrations or body burdens of contaminants whenever tissue concentrations are unavailable.

The potential magnitude and frequency of contact with the contaminants through appropriate pathways for selected species will be evaluated. The first step will be to identify both the pathways of concern specific to the individual areas of concern and the habitats potentially affected by those areas of concern. Factors that will be further evaluated in the pathways selection process include the location of contaminant sources; local topography and geology; surrounding terrestrial and aquatic/wetlands habitats; prediction of contaminant migration; and persistence and mobility of migrating contaminants.

Target species would be selected using criteria such as species that are important to the well-being of protected species or species considered to be valuable for recreational purposes, species that are critical to the structure and function of the particular ecosystem, species that are sensitive indicators of ecological change, and species or functional groups that are sensitive to the contaminants at the site.

Exposure points will be defined after the potential contaminant migration pathways and affected habitats have been defined and potential target receptors have been identified. Exposure point concentrations will be estimated based on water, soil, and sediments data collected during other tasks.

Toxicity Assessment

The toxicities of the contaminants of concern will be assessed for aquatic life, terrestrial wildlife, and vegetation, where relevant. Scientific literature and regulatory guidelines will be reviewed for media-specific and/or species-specific toxicity data. These data will be used to determine critical toxicity values for the contaminants of concern, which will be compared to media contaminant concentrations or estimated daily intakes. In the absence of toxicological data for target species, critical toxicity values may be derived using data from related species or applying safety factors that reflect interspecies extrapolation.

Risk Characterization

Exposure and toxicity assessment results will be integrated to estimate the potential hazard or risk to ecological receptors. The media concentrations or estimated daily intakes will be compared, where relevant. Ecological effects levels will be compared with maximum concentrations of contaminants. The results will be summarized in an Ecological Risk Assessment Report.

Task 17: Feasibility Study Report

An FS report for sites 2, 3, 4B, 5, and PWA will be developed in accordance with the *"Guidance for Conducting remedial Investigations and Feasibility Studies Under CERCLA"* (U.S. EPA, 1988 Interim Final). The FS Report will contain an executive summary and five sections. The executive summary will be a brief overview of the FS and the analysis underlying the remedial actions that were evaluated.

The FS will contain the following six sections:

- Section 1—Introduction and Site Background
- Section 2—Remedial Action Objectives
- Section 3—Identification and Screening of Remedial Technologies
- Section 4—Development and Initial Screening of Remedial Alternatives
- Section 5—Description and Detailed Analysis of Alternatives
- Section 6—Comparative Analysis of Alternatives

The introduction will summarize the conclusions of the RI and RAs. Section 2 will present and discuss the remedial action objectives and the ARARs. In Section 3, feasible technologies and process options for site remediation will be identified for each remedial action objective and the results of the remedial technologies screening will be described. In Section 4, remedial alternatives will be developed by combining the technologies identified in the previous screening process. The results of the screening of remedial alternatives for effectiveness, implementability, and cost will be described. Each remedial alternative surviving the screening process will be evaluated in detail with respect to each of the evaluation criteria identified in Section 5. A detailed description of the cost and noncost features of each remedial action alternative passing the initial screening will be presented. Section 6 will discuss the advantages and disadvantages of each alternative relative to the others.

Task 18: Community Relations

The intent of the Community Relations (CR) task is to identify community concerns about RI/FS activities at ABL, and to provide opportunities for public involvement in the decision-making process. CR activities will be prepared in accordance with public involvement guidelines of the Office of Solid Waste and Emergency Response (OSWER) Directive 9230.0-3B, *Community Relations in Superfund: A Handbook*, issued by the EPA.

A Community Relations Plan (CRP), tailored to the surrounding communities' expressed concerns, was prepared for the ABL site as part of the RI. The CRP has recently been updated.

Task 19: Proposed Plan

One proposed plan will be developed for sites 2, 3, 4, and PWA and one will be prepared for Site 5. Each will be submitted as a separate document. The document will include a summary of the focused RI/FS report, as it pertains to sites 2, 3, 4, and PWA or Site 5, and will include the following sections: Introduction, Summary of Remedial Investigation, Summary of Baseline Risk Assessment, Summary of Feasibility Study, Preferred Alternative, and an Engineer's Cost Estimate. The proposed plan will include the evaluation of the adverse effects of the proposed remedial action (Preferred Alternative) and develop mitigative measures for remediation.

WDCR829/035.WP5

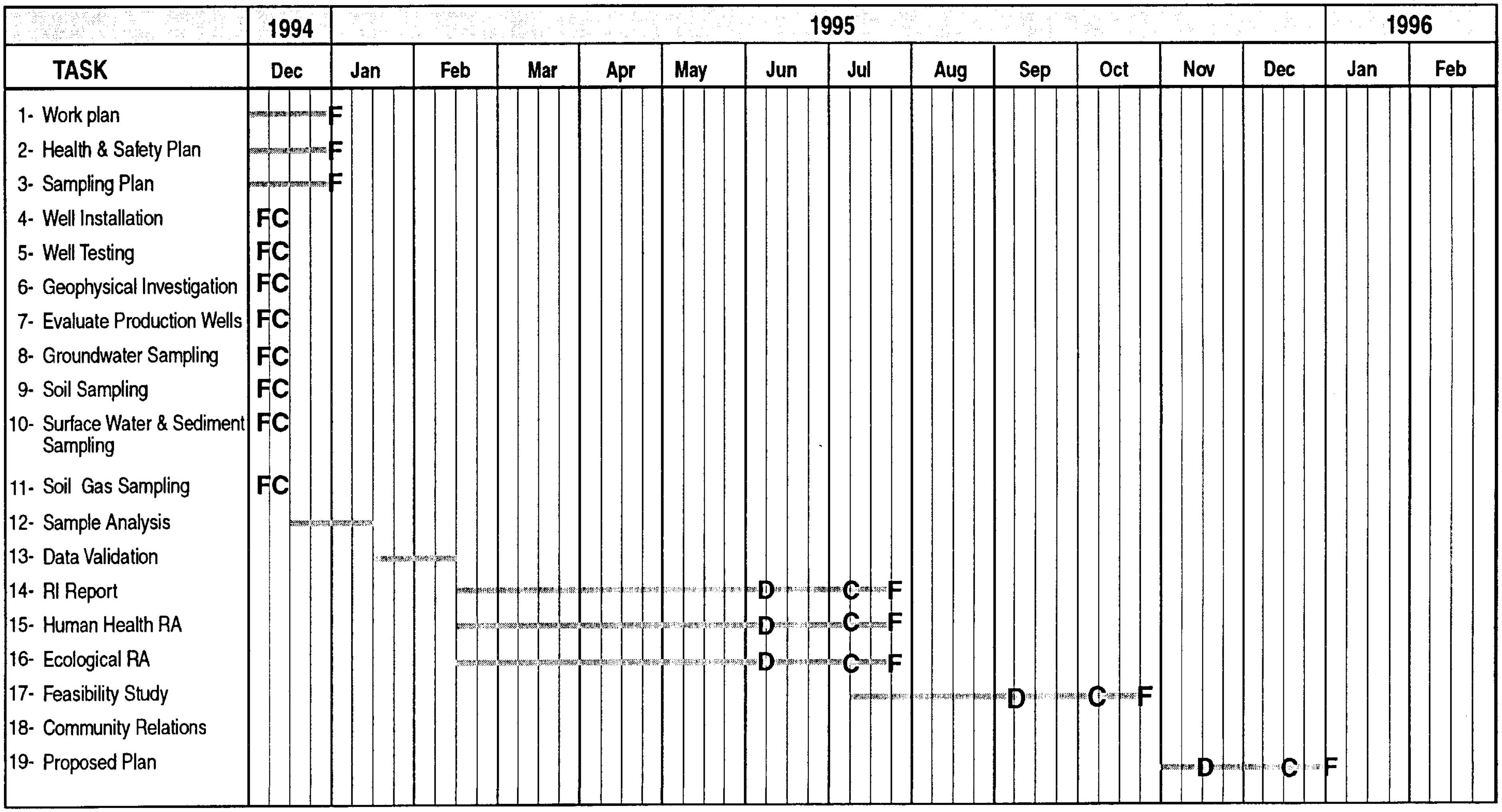
Section 6

Project Schedule

Figure 6-1 presents the schedule anticipated to complete tasks 1 through 19 described in Section 5. Included in the schedule are periods set aside for EPA and State review. For scheduling purposes, a 30-day review period for all submittals was assumed. Longer review periods will result in an extended schedule.

WDCR829/036.WP5

MAE70342.A0.W /94



LEGEND

- **D-** Submit Draft deliverable
- **C-** EPA & State submit review comments
- **F-** Submit final deliverable incorporating EPA & State Comments
- **FC-** Fieldwork Complete

Figure 6-1
SCHEDULE FOR RI/FS AT ABL
Allegany Ballistics Laboratory