TSM-26

Radiological Characterization Report for SPRU Outside Areas

Separations Process Research Unit Project

Prepared for

U.S. Department of Energy

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Revision 2

Prepared by

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Executive Summary

In accordance with Attachment 1 (Statement of Work) of Contract No. DE-AC03-00SF22043/ M042 for the U.S. Department of Energy (DOE) Separations Process Research Unit (SPRU) Project, this *Radiological Characterization Report for the SPRU Outside Areas* (Report) has been prepared to document the 2004 radiological characterization of the SPRU environmental media (soils, groundwater, sediment, and vegetation). The radiological characterization was conducted in accordance with the DOE-approved *Outside Characterization Plan, Separations Process Research Unit,* as supplemented by the sampling and analysis plans for the outside characterization areas.

The SPRU is an inactive complex, located at the Knolls Atomic Power Laboratory (KAPL), a continuing mission site with no anticipated closure date, in Niskayuna, New York, requiring decontamination and decommissioning (D&D) and environmental remediation. SPRU was operated by the Materials Production Division of the U.S. Atomic Energy Commission (AEC) from 1950 to 1953 as a pilot plant for research on chemical processes to extract uranium and plutonium from irradiated natural uranium. These operations resulted in radioactive and chemical contamination of the SPRU facilities and surrounding environmental media.

The SPRU areas at the Knolls Site are owned by DOE and are currently maintained by the DOE Schenectady Naval Reactors (SNR) Office and KAPL, Inc., a Lockheed Martin Company. However, responsibility for the characterization and any resulting environmental remediation activities associated with SPRU resides with the DOE Office of Assistant Secretary for Environmental Management (EM). Figure ES-1 identifies the extent of the following SPRU Outside Area investigation areas within the Knolls Site: (1) the Land Area affected by spills and releases from historic radioactive waste storage within the Former Slurry Drum Storage Area; (2) the Lower Level impacted by spills and releases from waste staging and loading operations in the Railbed Area and use of radioactively contaminated fill during construction of a parking lot; and (3) the Upper Level area affected by historic releases from the SPRU process buildings, Pipe Tunnel (containing waste transfer piping), and underground tank vault.

Concurrent with the radiological characterization of the Outside Areas, a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) was conducted in accordance with the New York State Department of Environmental Conservation (NYSDEC) Hazardous Waste Management Permit for the Knolls Site, Niskayuna, New York (Permit Number 4-4224-00024/00001, effective July 20, 1998). The purpose of the RFI was to characterize the environmental setting and chemical releases in groundwater at Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) associated with SPRU operations in the Knolls Site Upper and Lower Level areas. Results of the investigation are documented separately from the results of this radiological characterization in the *Task IV Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for Groundwater, Separations Process Research Unit Project*, herein after referred to as the SPRU Groundwater RFI Report.

The following sections summarize the objectives, results, conclusions, and recommendations of the radiological characterization of the SPRU Outside Areas.

Radiological Characterization Objectives

The objectives of the radiological characterization established in the Outside Characterization Plan were to:

- Identify the specific nature and extent of radioactive contamination of environmental media (soils, groundwater, sediment, and vegetation) in the Outside Areas resulting from releases from historical SPRU operations.
- Support cost estimating, procurement, and planning for subsequent remediation of contaminated SPRU environmental media by (1) estimating waste types and volumes associated with the presumed remedy of soil removal; (2) evaluating relationships between radiochemical analysis and field measurements that could reduce the cost of confirmation sampling by use of less costly surrogate measurements of radioactivity; and (3) identifying occupational hazards to be planned for during soil removal and remediation.

The radiological characterization evaluated radioactivity in soil and sediment relative to dose-based criteria calculated for three potential land uses covering the range of potential end states for the SPRU Outside Areas: (1) the Industrial scenario in which workers are onsite but not ingesting foodstuffs or water from the site; (2) the Residential Suburban scenario in which an onsite resident consumes vegetables from an onsite garden and has drinking and irrigation water supplied from offsite; and (3) a Subsistence Farmer scenario in which a farmer resides onsite and consumes foodstuffs from onsite sources and obtains drinking and irrigation water from an onsite well.

Radioactivity in groundwater was evaluated relative to current effluent discharge limits permitted through New York State for the Knolls Site, drinking water standards promulgated by the Environmental Protection Agency, and groundwater quality criteria promulgated by NYSDEC. The comparisons were made to evaluate groundwater radioactivity compliance with current permitted Industrial land use conditions that do not permit groundwater consumption and potential future Subsistence Farmer land use where Knolls Site groundwater is consumed.

Overall Results and Conclusions

General results and conclusions common to all of the investigation areas are summarized in this subsection. Additional conclusions specific to individual investigation areas are discussed in the following subsections.

Nature and Extent of Soil, Sediment, and Vegetation Contamination

The following radionuclides of concern were detected in the SPRU Outside Area soils: americium-241, cesium-137, strontium-90, plutonium-238, plutonium-239/240, thorium-232, uranium-234, uranium-235, uranium-238, and technetium-99. Cesium-137 is the most widespread radionuclide detected in soil and sediment and most frequently exceeds the evaluation criteria. Radioactivity levels in soils in all three areas that exceed criteria are generally within the upper 2 feet of soil, with the highest activities in the upper 6 inches of soil. Radioactivity is elevated above criteria in samples taken at depth around the SPRU Building H2 and Tank Farm facilities due to building releases that are captured by the facility footing drains.

Sediment contains radioactivity above criteria in an isolated sample taken from a drainage culvert below the H2 Hillside Sump (on the Upper Level hillside) caused by overtopping during periods of heavy precipitation or leakage around the sump, and in two catch basins in an abandoned storm sewer system in the Lower Level.

Analysis of vegetation matter in all three areas identified very low and sporadic activities of cesium-137, strontium-90, americium-241, and uranium isotopes, consistent with particles of soil attached to the vegetation in areas of elevated surface contamination.

Potential exposure to radioactivity through pathways and media that involve surface soil is viable. These include direct contact with soil and sediment and indirect contact via suspended sediment in surface water and air through dispersion of exposed surface soil.

Nature and Extent of Groundwater Contamination

Strontium-90 is the predominant radionuclide of SPRU origin that is impacting groundwater. Radioactive contamination of groundwater in the Land Area is limited. A strontium-90 plume exists in the Lower Level with the highest activities associated with the K5 Retention Basin and the Former K6 Storage Pad. Strontium-90 levels in the Lower Level exceed drinking water standards but are not above currently permitted effluent discharge levels. Strontium-90 is also being released to the Mohawk River via bedrock seeps and stormwater drainage from the Lower Level, but at activities well below currently permitted levels. Within the Upper Level, strontium-90 and cesium-137 activities in groundwater in the Building H2 footing drains exceed currently permitted levels; however, groundwater in the drain system is mostly contained and treated before discharge. Strontium-90 is detected in trace activities below both current permitted levels and drinking water standards in groundwater downgradient of the footing drain and sump system, indicating that the system is effective in containing the footing drain contamination.

Waste Volume Estimates

Estimates of soil removal volumes for each land use criteria were calculated based on the extent and depth of the soil exceeding land use-specific criteria, coupled with practical considerations regarding soil removal technology, such as combining multiple isolated areas exceeding criteria into one combined area to be removed. The following estimated volumes are preliminary but may be used to evaluate the relative impact of land use on soil removal.

Investigation Area	Industrial Volume (yd^3)	Industrial Approximate Truckload Equivalents[2]	Residential Suburban Volume (yd^3)	Residential Suburban Approximate Truckload Equivalents[2]	Subsistence Farmer Volume (yd^3)	Subsistence Farmer Approximate Truckload Equivalents[2]
	Preliminary Estimates of Soil Removal by Land Use[1]					
Land Area	720	47	4,780	308	5,180	334
Lower Level	1,920	124	7,390	477	7,500	484
Upper Level	640	41	1,260	81	1,260	81
Total	**3,280**	**212**	**13,430**	**866**	**13,940**	**899**

[1] Volumes are for in-situ soil prior to expected expansion during removal and transport.
[2] Assuming shipment as LSA-1 using intermodals (filled to approximately 15.5 yd^3 in-situ volume).

Estimated soil removal volumes to support remediation to Residential Suburban and Subsistence Farmer land use scenarios are nearly identical and significantly exceed the estimated removal volumes for the Industrial land use, particularly in the Land Area and Lower Level. These preliminary estimates show that removal, disposal, and transportation costs to remediate the area to Residential Suburban or Subsistence Farmer land use are roughly four times that for Industrial land use.

Use of Radionuclide Surrogates

Laboratory measurements of SPRU radionuclides of concern, such as cesium-137 and strontium-90, were not well correlated with each other in soil, precluding establishment of quantitative predictive correlations between the radioactivity of one radionuclide with another. However, gamma radiation measurements at the soil surface are highly correlated with and, therefore, are a reasonably good predictor of the likelihood that radioactivity exceeds criteria in the surface soil and the uppermost subsurface soil interval. Furthermore, in all cases where radioactivity in soil and sediment was elevated above criteria, cesium-137 was one of or the only radionuclide that exceeded criteria. Therefore, cesium-137 radioactivity can be used as a reasonable predictor of whether other radionuclides in soil are above or below criteria.

Hazardous Waste Characterization

Representative soil samples from each investigation area were analyzed for chemicals to determine the potential for hazardous waste classification by characteristic. None of the chemical analytical results exceeded the regulatory criteria, indicating a low potential for hazardous or mixed waste generation during future remedial activities.

Occupational Risk

The outside characterization work did not identify any field condition that presents a radiological risk to site personnel, maintenance workers, or workers engaged in soil removal or other remedial efforts that cannot be managed by common industrial practices to control soil exposure, coupled with radiological controls in accordance with 10 CFR 835 requirements. The Knolls Site comprehensive monitoring program demonstrates that nearby residents and the public have negligible exposure due to the SPRU-related contamination.

Completeness of Investigation

Soil, sediment, and vegetation sampling and analysis coupled with radiological walkover survey have characterized the extent of radioactive contamination sufficient to bound the extent of soil radiological contamination and provide a thorough basis for waste volume estimation. Groundwater contamination in all three investigation areas was identified and bounded in areas exceeding applicable groundwater criteria.

Area-Specific Results and Conclusions

This section presents results and conclusions specific to each investigation area.

Land Area Characterization Conclusions

Cesium-137 was the only radionuclide of concern detected above applicable criteria in the Land Area soils. Contamination is predominantly in the surface soil (upper 6 inches) in four areas of general widespread contamination. Soil contamination is also present sporadically in other smaller, isolated areas. Low levels of several SPRU radionuclides of concern, below the applicable criteria, were detected in each of the sediment samples collected from the Midline Stream drainage.

Radioactive contamination of groundwater is limited. Low-levels of strontium-90 are present in wells completed in permeable glacial deposits along the western edge of the Land Area, in the Midline Stream drainage. Somewhat elevated uranium is also present. Overall there is little impact to groundwater from radionuclides in the soil. Neither current permitted effluent discharge limits or other DOE criteria for groundwater were exceeded.

Lower Level Characterization Conclusions

Soil contamination is primarily along the former railbed in the Railbed Area and in a small area of soil beneath the northwestern portion of the Parking Lot Area. The most elevated concentrations of most radionuclides of concern were identified near the K5 Retention Basin and Former K6 Storage Pad in the Railbed Area. Cesium-137 was the most widely detected radionuclide of concern above applicable criteria. There were also several detections of strontium-90 and thorium-232 above applicable criteria, co-located with cesium-137 exceedances of the applicable criteria. Elevated concentrations of radionuclides in soil in the Lower Level were found predominantly in the upper 2 feet; however, contamination was present at depth near the K5 Retention Basin and the Former K6 Storage Pad and in one location in the northwestern portion of the paved area of the Parking Lot.

Several SPRU radionuclides of concern were detected in sediment samples from the base of the Parking Lot Area, but none exceeded criteria.

Strontium-90 is the most widespread and mobile radionuclide in the Lower Level groundwater. The primary area of groundwater contamination is defined by the strontium-90 plume immediately downgradient of the K5 Retention Basin and, to a lesser extent, the Former K6 Storage Pad. The downgradient perimeter of this plume is established. The maximum strontium-90 radioactivity in the till groundwater of about 300 picocuries per liter (pCi/L) exceeds drinking water criteria (8 pCi/L) but is below the current permitted effluent discharge level (1,000 pCi/L).

Strontium-90 in groundwater is being discharged to the KAPL storm sewer system via the largely abandoned storm sewer system in the Lower Level. Activities exiting the Railbed Area are just above the drinking water standard at one catch basin and are also detected but below the drinking water standard at two other basins. SPRU radionuclides of concern were also detected in sediment samples from catch basins within this same stormwater system at activities exceeding criteria. Water and sediment from the catch basins have the potential to be transported via turbidity in subsurface stormwater flow and ultimately discharge to the Mohawk River.

Consistent with previous monitoring performed by KAPL, strontium-90 was detected in one bedrock well but not in other bedrock wells sampled. Strontium-90 is also detected in groundwater seeps from outcropping bedrock northeast of the Parking Lot along the Mohawk River bluff. Strontium-90 in the bedrock well and one of the seep samples is above drinking water standards but is well below current permitted effluent discharge levels.

Upper Level Characterization Conclusions

Soil contamination was predominantly in surface samples; however, cesium-137 contamination was identified at multiple depth intervals at several locations and, in several instances, was associated with building footings. Soil contamination is within several small, isolated and one larger area along the Upper Level hillside. Contamination was also identified at the drain invert depth along Building H2. Again, cesium-137 was the predominant radionuclide of concern exceeding applicable criteria. However, there were several exceedances of applicable criteria for strontium-90, plutonium-239/240, and thorium-232, mostly co-located with elevated cesium-137 concentrations.

Sediment samples collected along the Lower Level Access Road indicate radioactivity elevated above criteria in sediments immediately below the H2 Hillside Sump that likely resulted from either overtopping of the sump during heavy precipitation or leaks from the sump or its supply drainpipe.

Strontium-90 is the most widespread radionuclide in the Upper Level groundwater and is elevated above applicable criteria at several locations. Groundwater flow between Buildings G2 and H2 is towards a groundwater trough between the buildings, where it is discharged to the Building H2 footing drain or potentially to the Upper Level hillside. Strontium-90 is slightly elevated above drinking water standards in groundwater immediately outside the Hillside Sump that is also discharged to the Upper Level hillside. Groundwater wells installed downgradient of the hillside do not indicate the presence of significantly elevated radionuclides; therefore, transport of radioactivity in groundwater, principally strontium-90, to the Lower Level is not occurring.

Recommendations

SPRU Radionuclides of Concern

Detected levels of some SPRU radionuclides of potential concern were consistently less than 10 percent of their most restrictive DCGL. Based on the results of this radiological characterization, it is recommended that the list of SPRU radionuclides of concern for future remediation efforts be reduced to four radionuclides (cesium-137, strontium-90, thorium-232, and plutonium-239/240) applicable for all land use scenarios. It is recommended that technetium-99 also be included for the Subsistence Farmer land use scenario and europium-152 also be included for the Subsistence Farmer and Residential Suburban land use scenarios.

Land Area

Radiological characterization in the Land Area is complete, and no further radiological characterization is needed. Elevated areas of radioactivity in soil and sediment are bounded by radiochemical analyses and walkover surveys. Because of the lack of radiological impact to groundwater above criteria, no further groundwater investigation or remedial action is necessary. Anticipated soil removal in the Land Area will result in further reductions in groundwater radioactivity. Representative groundwater monitoring wells within the Midline Stream drainage that contain low levels of strontium-90 should continue to be monitored to maintain a baseline of strontium-90 activity in this drainage area.

Lower Level

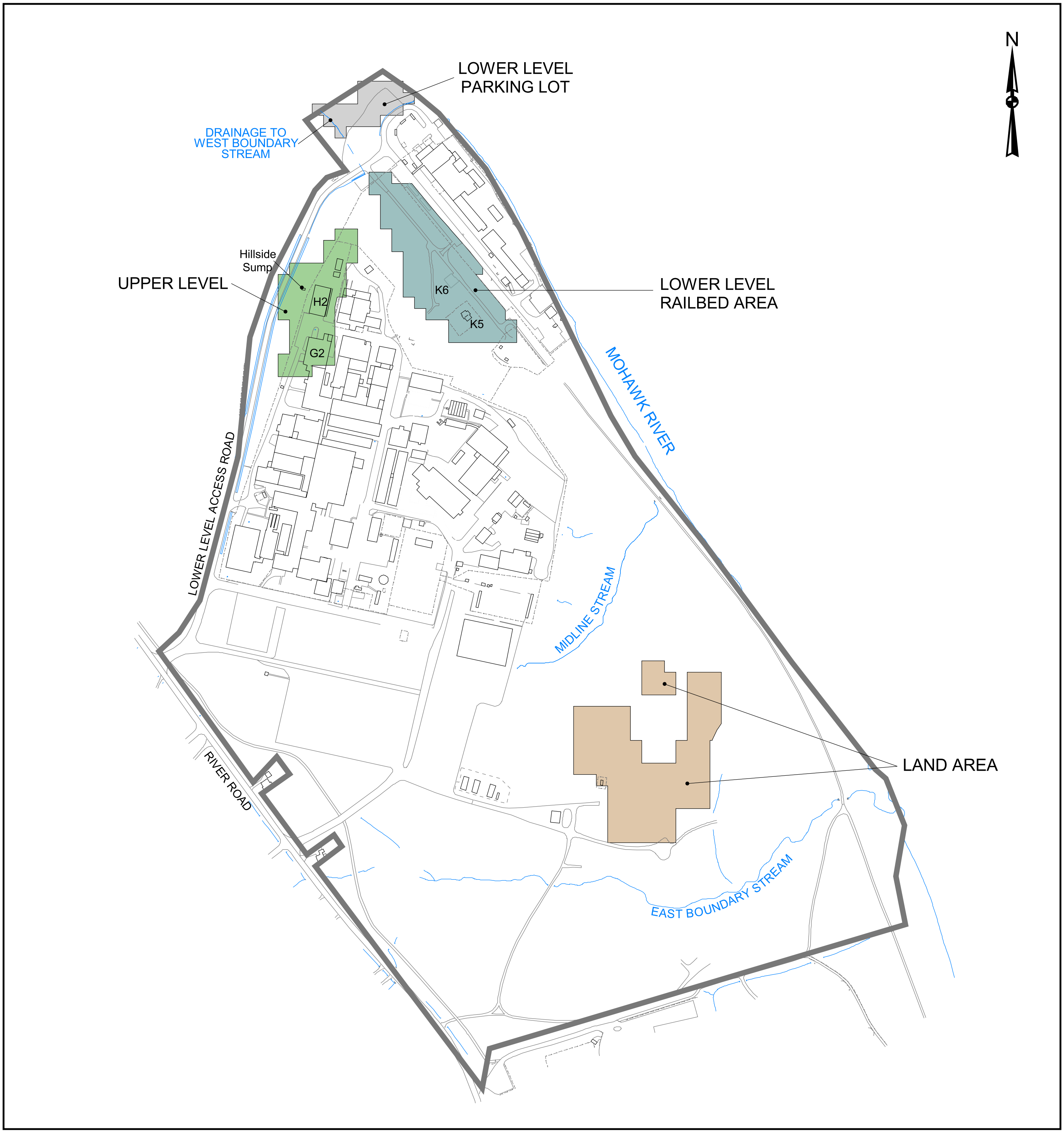
Radiological characterization of soil, sediment, and vegetation in the Lower Level is complete, and no further radiological characterization of these media is necessary. The close correlation between surface radioactivity and analytical results indicates that the investigation has adequately bounded radiologically impacted areas.

Strontium-90 activity in bedrock groundwater and in investigated seeps along the Mohawk River is below currently permitted effluent discharge limits. However, all potentially affected seeps along the Mohawk River have not been identified and sampled. A thorough reconnaissance survey to identify and sample seeps for radiological analysis should be performed to confirm that areas of more significant radioactive release to the river are not present.

Upper Level

Radiological characterization is complete in the Upper Level, and no further radiological characterization is necessary. Elevated areas of radioactivity in soil and sediment are bounded by radiochemical analysis and walkover surveys. Groundwater impacted by radioactivity is mostly contained in the building footing drains and effectively captured by the Hillside Sump, from which it is returned to Building H2 for treatment before discharge. Although groundwater does bypass the system, radioactivity in downgradient groundwater is not significantly increased. Removal of the buildings will remove radionuclide sources associated with the building foundation. Continued monitoring of the groundwater at the H2 Hillside Sump, the wellpoint adjacent to the sump, and a groundwater monitoring well downgradient of the sump is recommended to establish baseline data along this potential groundwater transport pathway from the Upper to Lower Level.

Figures



Building	
Fence	
Streams or Drainage	
Pavement	
Property Boundary	

0 500 1000 Feet

Note: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

U.S. DEPARTMENT OF ENERGY

NNSA SPRU FIELD OFFICE
SEPARATIONS PROCESS RESEARCH UNIT

SPRU RADIOLOGICAL
CHARACTERIZATION REPORT

LOCATION OF SPRU OUTSIDE AREAS

Figure ES-1

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Date: March 30, 2006

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Acronyms and Abbreviations

AEC	Atomic Energy Commission
amsl	above mean sea level
ANL	Argonne National Laboratory
AOC	Area of Concern
bgs	below ground surface
bss	below soil surface
CB	catch basin
cm^3	cubic centimeter
COC	contaminant of concern
cpm	counts per minute
CSM	conceptual site model
D&D	decontamination and decommissioning
DCG	Derived Concentration Guideline
DCGL	Derived Concentration Guideline Level
DOE	Department of Energy
DQE	data quality evaluation
DQO	data quality objective
EM-61	electromagnetic
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
°F	degrees Fahrenheit
ft	foot or feet
g	gram
GE	General Electric
GPC	gas proportional counter
GPR	ground-penetrating radar
hr	hour
ICPES	inductively coupled plasma emission spectroscopy
ID	identification
KAPL	Knolls Atomic Power Laboratory
K_d	distribution coefficient
kg	kilogram
L	liter
MARSSIM	Multi-Agency Radiation Site Survey and Investigation Manual
MCB	manhole catch basin
MDA	minimum detectable activity
mg	milligram
mL	milliliter
mR	milliroentgen
mrem	millirem
µCi	microcuries
µg	microgram

μR	microroentgen
NIST	National Institute of Standards and Technology
NNSA	National Nuclear Security Administration
NTU	nephelometric turbidity unit
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
OCP	Outside Characterization Plan
PAH	polycyclic aromatic hydrocarbon
pCi	picocuries
psig	pounds per square inch gauge
PUREX	Plutonium Uranium Extraction
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
REDOX	reduction/oxidation
RESRAD	RESidual RADioactivity
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SAP	sampling and analysis plan
SNR	Schenectady Naval Reactors
SPDES	State Pollutant Discharge Elimination System
SPRU	Separations Process Research Unit
SPUD	surface-penetrating underground detector
STL	Severn Trent Laboratory
SV	Sampling Visit
SVOC	semi-volatile organic compound
SWMU	Solid Waste Management Unit
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
VOC	volatile organic compound
yr	year

1. Introduction

The Separations Process Research Unit (SPRU) is an inactive complex, located at the Knolls Atomic Power Laboratory (KAPL) in Niskayuna, N.Y. (located near Schenectady, N.Y. [see Figure 1-1 for site location]), requiring decontamination and decommissioning (D&D) and environmental remediation. Although SPRU is inactive, the Knolls Site is a continuing mission site with no anticipated closure. SPRU was operated by the Materials Production Division of the U.S. Atomic Energy Commission (AEC) from 1950 to 1953 as a pilot plant for research on chemical processes to extract uranium and plutonium from irradiated natural uranium. These operations potentially contaminated the SPRU facilities and surrounding environmental media, both radioactively and chemically.

The first phase in support of the D&D and environmental remediation of SPRU is the radiological characterization of the environmental media, including soils, groundwater, sediment, and vegetation, in the SPRU Outside Areas, including inactive drains and storm drains. Chemical characterization of soil and groundwater is addressed separately in the *SPRU Project RCRA Facility Assessment Sampling Visit Report* (CH2M HILL, 2002) and the *Task IV RCRA Facility Investigation Report for Groundwater, Upper and Lower Levels* (CH2M HILL, 2006), respectively. This characterization has been performed under subcontract to the U.S. Department of Energy (DOE) Office of Assistant Secretary for Environmental Management (EM) and is documented in this *Radiological Characterization Report for the SPRU Outside Areas*. The requirements for the characterization were provided in Subcontract DE-AC03-00SF22043, Attachment I, *Separations Process Research Unit (SPRU) Clean-Up Project, Phase I (Characterization) Statement of Work (SOW)*, Section 2.2, "Soil and Groundwater Investigations." This characterization consisted of a historical site assessment, walkover radiological surveys, and field investigations in three outside, geographical areas of the Knolls Site potentially contaminated by spills and/or releases of SPRU wastes during historical SPRU operations:

- Areas at and adjacent to the Former Slurry Drum Storage Area in the North Field, herein termed the Land Area

- Areas in the Lower Level, including the Railroad Staging Area (hereinafter referred to as the Railbed Area) and the Lower Level Parking Lot
- Areas adjacent to Buildings H2 and G2 and the Pipe Tunnels, herein termed the Upper Level

These areas are shown in Figure 1-2. These areas and their relationship to identified SPRU Resource Conversation and Recovery Act (RCRA) Solid Waste Management Units (SWMU) and the Area of Concern (AOC) are described in Section 2.

The SPRU background, characterization objectives and requirements, characterization program overview, and report summary and organization are addressed in the following sections.

1.1 Separations Research Process Unit (SPRU) Background

The SPRU background information summarized in this section is from the SPRU Clean-Up Project, Phase 1 (Characterization) Request for Proposals (DOE, 1999a). SPRU, consisting mainly of operations in Buildings G2 and H2 (see Figure 1-3), was operated from February 1950 until October 1953 to develop a process for extracting plutonium and uranium from irradiated fuel. To understand the history of the SPRU facility at the Knolls Site, it is helpful to briefly review the former AEC needs for nuclear reactor fuel recovery and General Electric's (GE) involvement with the AEC during that era. The AEC was the predecessor to DOE.

In May 1946, GE entered into a prime contract with the newly formed AEC Materials Production Division to operate the AEC's Hanford Engineering Works in Richland, Washington, and to build and operate an AEC laboratory (KAPL) in Schenectady, N.Y. The laboratory was operated under the direction of the GE Corporate Research Laboratory staff in Schenectady. The objectives for the KAPL were twofold: to provide technical and scientific support to Hanford, and to develop and design nuclear power reactors. KAPL was assigned to the Hanford AEC field office in January 1947.

The principal program at that time at Hanford involved operation of natural-uranium-fueled reactors to produce plutonium. In early 1947, the AEC launched an urgent program to provide production facilities to recover plutonium and uranium from the irradiated fuel. GE-Hanford was requested to provide a full-scale recovery plant at Hanford by late 1949.

The Hanford fuel recovery plant was based on a solvent extraction process known as "REDOX," which stood for reduction/oxidation. On a laboratory-scale, this process removed acceptable levels of fission products and offered simultaneous removal of both uranium and plutonium. The principal uncertainty in production-scale REDOX development was the performance of packed solvent extraction columns, which was the standard method used to provide adequate contact time for efficient extraction between aqueous and organic solvents. In July 1947, the Standard Oil Development Company recommended that mixer-settler contactors be used for the REDOX process in lieu of packed columns, which resulted in a parallel effort to develop a mixer-settler design for the recovery plant at Hanford.

In December 1947, GE-Hanford asked KAPL to construct a REDOX pilot plant using mixer-settler contactors to demonstrate the complete processing cycle using irradiated fuel. In February 1948, KAPL hired Blaw-Knox to design the pilot plant. The pilot plant was named SPRU in June 1948, and construction started in August 1948. SPRU started pre-operational testing in July 1949, non-radioactive REDOX process runs in February 1950, non-radioactive REDOX process runs with slug dissolution in April 1950, and radioactive REDOX processing in June 1950. Due to some breakthroughs in packed column contactor design, the Hanford fuel recovery plant was constructed using column contactors, but SPRU testing using mixer-settler contactors contributed major refinements to the overall REDOX process. Most of these refinements were adopted for Hanford production use.

In October 1950, the AEC requested that SPRU support DuPont in the development of a fuel recovery plant at the AEC Savannah River Plant in South Carolina. The Savannah River Plant would use mixer-settler contactors and a new solvent extraction process called Plutonium Uranium Extraction (PUREX). In December 1950, SPRU terminated REDOX testing and started pilot plant modifications to support PUREX processing. In February 1951, the first PUREX run was made. PUREX work at SPRU was terminated in June 1953, and in October 1953 the SPRU plant was decommissioned. Through its operation and decommissioning, the SPRU facility remained under the direction of the AEC Materials Production Division, including onsite Government resident engineers. No further testing work has been conducted in this facility.

The process section of the plant located in Building G2 was decommissioned in 1953 after appropriate decontamination was performed. The decontamination consisted of flushing out all tanks with nitric acid and water. All nonessential steam, gas, and electrical services supporting the process plant were shut down. All other systems were shut down and drained, and fuses were removed from electrical disconnect switches. Inlet air dampers to the cell areas were closed. The air exhaust through high-efficiency particulate air (HEPA) filters in Buildings G2 and H2 remained in operation to control the flow of air from these facilities and to monitor the discharges.

In the late 1950s, more extensive changes were made to the building supply and exhaust ventilation systems to isolate the cell areas from the rest of Building G2 in preparation for converting parts of the building for general use. Some SPRU operating areas external to the cells were decontaminated, surveyed, and released for use as office, laboratory, and library space. The non-process areas of the building were used in this capacity until the late 1990s.

From the mid-1950s until the mid-1970s, the D3/G1 industrial drain line, a stretch of underground pipe that extended from Building D3 to G1, was used to convey metallurgical waste from Building D3 to Building H2 for processing. This line was excavated and removed in 1978. A radiological survey of the excavated drain line was performed, and no releases were detected (NYSDEC, 1998).

During the mid-1960s, further cleanup was performed in Buildings H2 and G2. Specifically, the work consisted of:

- Removal of loose contamination from accessible floor and equipment surfaces
- Isolation of process lines
- Removal of movable equipment and loose debris
- Removal of liquid and sludge from process tanks
- Packaging and shipment of contaminated waste for offsite disposal

This left only residual radioactive contamination on the floors, walls, pipes, equipment surfaces, and inside the process pipes, tanks, and equipment. The areas of SPRU that were not converted to general use still contain varying levels of loose and fixed radioactivity and quantities of radioactively contaminated equipment and materials. The levels of residual radioactivity were estimated by KAPL to be in the range of 10 curies of plutonium and 50 to

100 curies of long-lived mixed fission products, principally strontium-90 and cesium-137; these estimates could vary by a factor of 2 (DOE, 1999a). About 85 percent of the total radioactivity is contained in the tank farm tank residue (see Figure 1-3); about 12 percent of the total is contained in the tank farm vaults outside the tanks (DOE, 1999a). Only a few percent of the total residual radioactivity is located in remaining SPRU facilities outside the tank farm. The vast majority of this radioactivity is contained as residue in tanks, pipes, and other equipment or fixed in the building structure.

Some SPRU liquid wastes remained in underground tank farm storage by Building H2 until the early 1960s, at which time the waste was processed and disposed of. The tanks continued to be used for retention of radioactive liquid waste from the radioactive material and chemistry laboratories until 1978. At that time the tanks were drained, the liquid waste processed, and the tanks removed from service. All seven SPRU waste tanks remain in place in a drained condition, although they contain an average 8 inches of solid/semi-solid radioactive residue. Some evidence indicates that substantial areas of soil were also contaminated with these same radionuclides as a result of waste management activities and spills.

Modification of the H2 building systems in the mid-1970s allowed the KAPL "Reuse Water" system to begin operations. Liquid radioactive wastes from laboratory drains in the Radioactive Materials Laboratory, Chemistry, and D-4 Complex drain (non-pressurized), south and east of Building G2, are transported through two stainless steel pipes in the H2/G2 and G1 Tunnels to the South Tank Bay in H2 and are subsequently processed through a demineralizer/filter train. The "reuse water" collects in the east and west evaporator receiver tanks before it is piped back to the laboratories in E1, G1, and D4, south and east of Building G2, at 60 pounds per square inch gauge (psig) via two heavy-duty plastic lines installed in the H2/G2 and G1 Tunnels (DOE, 1999a; 1999b).

Radionuclides released by KAPL activities in Building H2 are identified in a series of spill reports (DOE, 2003b). However, with the exception of the presence of tritium in the tank vaults, cobalt-60 was the only other KAPL radionuclide of concern identified in the spill reports.

Operations within the SPRU Process facilities produced waste materials that were managed in the outside environs. The management of these wastes is described in Section 2 of this document. The scope of this radiological characterization involves the environmental media potentially impacted by spills and releases of SPRU wastes and materials outside of the SPRU Process facilities.

1.2 Characterization Objectives

As stated in the Outside Characterization Plan (OCP), TSM-08 (CH2M HILL, 2004a), the objectives of the radiological characterization were to:

- Identify the specific nature and extent of radioactive contamination of environmental media (soils, groundwater, sediment, vegetation) in the Outside Areas resulting from releases from historical SPRU operations
- Support cost estimating, procurement, and planning for subsequent remediation of contaminated SPRU environmental media

The OCP was developed with the objective of obtaining data to satisfy the aforementioned intended uses. The plan and subsequent characterization were based on the Multi-Agency Radiation Site Survey and Investigation Manual (MARSSIM) (EPA, 2000) Data Quality Objectives process to ensure that data are of the appropriate quality and quantity for the intended decisions and uses.

1.3 Characterization Requirements

The subcontract statement of work required all radiological soil characterization activities to be conducted in accordance with the MARSSIM guidance. The soil characterization was also required to be sufficient to:

- Identify and quantify the nuclides present in the soil to establish key health and safety information to protect workers, the environment, and the public

- Identify and develop the relationship, if any, between alpha- and beta-emitting radionuclides to the gamma-emitting radionuclide (cesium-137) that can be readily measured (also known as sampling by surrogates in the MARSSIM)
- Evaluate the distribution coefficient (K_d) for the major radionuclides identified in the soil
- Estimate the waste types and volumes that will be generated during potential cleanup activities. The minimum detectable concentrations of radionuclides will be such that either industrial or unrestricted land use criteria can be evaluated.
- Evaluate the occupational and public health and safety impacts expected during a possible cleanup activity
- Reassess the preliminary Derived Concentration Guideline Levels (DCGLs) and recommend final DCGLs based on the assumption of an industrial land use end state (and suburban residential and subsistence farmer land use alternatives) and incorporating site-specific modeling parameters

The groundwater characterization was required to be sufficient to:

- Identify and quantify radioactive groundwater contamination
- Assess health risks posed by radiological groundwater contamination to site workers, the public, and the environment
- Propose remediation alternatives to achieve groundwater quality criteria (but the characterization did not include preparation of corrective measure studies or assessments)

All characterization activities were required to be conducted in a manner that was protective of the workers, the public, and the environment.

1.4 Outside Characterization Program Overview

In accordance with Attachment 1 (Statement of Work) of Contract No. DE-AC03-00SF22043/M042 for the DOE SPRU Project, a radiological characterization of the SPRU environmental media (soils, groundwater, sediment, and vegetation) was performed and is documented in this report. The radiological characterization was conducted in accordance with the DOE-approved TSM-08, *Outside Characterization Plan, Separations Process Research Unit* (CH2M HILL, 2004a), as supplemented by the sampling and analysis plans for the three outside characterization areas (CH2M HILL, 2004b; 2004c; 2004d). Concurrent with the radiological characterization, the RCRA Facility Investigation (RFI) was conducted in accordance with Module II Condition E.5(a) of the 6 New York Code of Rules and Regulations (NYCRR) Part 373 Hazardous Waste Management Permit (Part 373 Permit) for the Knolls Site, Niskayuna, New York (New York State Department of Environmental Conservation [NYSDEC] Permit Number 4-4224-00024/00001 (NYSDEC, 1998) issued to the U.S. DOE, Schenectady Naval Reactors (SNR) and KAPL, Inc., effective July 20, 1998. The purpose of the RFI was to characterize the environmental setting and the contaminant releases at SWMUs and the AOC associated with SPRU operations in the Knolls Site Upper and Lower Level Areas. The RFI focused on chemical contamination, and the results of the investigation are documented separately from the results of this radiological characterization. RFI results are reported in the *Task IV RCRA Facility Investigation Report for Groundwater* (CH2M HILL, 2006).

The RFI was preceded by a RCRA Facility Assessment (RFA) Sampling Visit (SV). The RFA SV was conducted in accordance with Module III, Condition E.2 of 6 NYCRR Part 373, Hazardous Waste Management Permit for the KAPL (NYSDEC, 1998). The RFA SV was conducted between October 2000 and July 2001 for eight SWMUs and one AOC that are associated with the historical SPRU operations. The SV was implemented in accordance with an SV Work Plan (KAPL, 2000) approved by NYSDEC (NYSDEC, 2000). The purpose of the SV was to assess whether a release of hazardous waste or hazardous constituents had occurred or was occurring in the investigation areas. While the focus of the SV was on chemical constituents, limited data on radiological constituents were also obtained for sample shipping purposes. These data are discussed in the *SPRU Project RCRA Facility Assessment Sampling Visit Report* (CH2M HILL, 2002), approved by NYSDEC in February 2006 (NYSDEC, 2006a) and are summarized in Section 2.

Within each SWMU or AOC, additional objectives of the SV were to make preliminary determinations about the nature of any identified releases and to establish the need for further investigation and/or interim corrective measures. The RFA SV Report established that additional characterization of soil and groundwater was required to evaluate the nature and extent of chemicals in the Upper and Lower Level Areas. The RFA SV Report established that no further action was necessary for the single SPRU SWMU in the Land Area and two SWMUs in the Lower Level.

Although the SPRU SWMUs and AOC were initially included in the KAPL Part 373 Permit, the investigation and corrective action at these units are the responsibility of the DOE EM. The SWMUs and AOC that are the responsibility of DOE EM are shown in blue in Figures 1-3 through 1-5 for the Upper Level, Lower Level, and Land Area, respectively. SNR and KAPL are responsible for the remaining portions of each of the areas, including the adjacent SWMUs shown in gold in Figures 1-3 through 1-5. (Note: Only the SNR/KAPL SWMUs that are adjacent to and/or overlap the SPRU SWMUs and AOC are shown in the figures.)

To separate DOE EM's corrective action responsibilities for the SPRU SWMUs and AOC from SNR's ongoing hazardous waste management and corrective action responsibilities at the Knolls Site, DOE EM submitted an application (review pending) for a RCRA Corrective Actions Permit (Generator ID NYR 000 096 859) for the SPRU SWMUs and AOC to NYSDEC in September 2004 (DOE, 2004). Pursuant to the pending RCRA Corrective Actions Permit, DOE EM submitted a work plan (CH2M HILL, 2004e) to NYSDEC for an RFI for SWMUs and an AOC in the SPRU Upper and Lower Levels; NYSDEC approved the work plan in February 2006 (NYSDEC, 2006b). Because the NYSDEC-approved RFA SV Report established no further action was necessary for the single SPRU SWMU in the Land Area, an RFI is not required for the former SPRU-related operations in the Land Area.

As stated in the RFI Work Plan, the objective of the RFI was to characterize the environmental setting and the nature and extent of chemical releases at the affected Upper and Lower Level Areas, confirm the site conceptual models, and select remedial action alternative(s). Although the RFI Work Plan addressed only groundwater contamination, previously collected soil data were presented to evaluate potential sources of groundwater contamination. The RFI Work Plan did not include characterization of groundwater beneath the K5 Retention Basin, which will be conducted following D&D of the basin.

Concurrent with the RFA SV and the RFI work planning process, the Outside Characterization Program was developed to characterize the radiological constituents in the

SPRU Outside Areas as a result of historical SPRU operations. The purpose of the Outside Characterization was to identify the specific nature and extent of radioactive contamination of the land areas associated with the SPRU historical operations and to also support cost estimating, procurement, and planning for subsequent D&D and remediation of SPRU environmental media.

The initial focus of the Outside Characterization Program was on development of the Outside Characterization Plan (OCP) in 2001 (CH2M HILL, 2004a [revised]). A historical site assessment was also completed as part of the Outside Characterization Program. The results of the historical records and data review are documented in the *Outside Areas Historical Site Assessment*, TSM-11 (CH2M HILL, 2003).

Subsequent to the historical site assessment, gamma detector walkover radiological surveys were conducted of the ground surface in the SPRU Outside Areas. These surveys were conducted from May 2001 through October 2001, October 2002 through July 2003, and August 2004 through October 2004. Survey units of 100 by 100 feet or 150 by 150 feet were identified for the walkover surveys in the three Outside Areas based on historical documentation, historical surface-penetrating underground detector (SPUD) and surface survey data, and field reconnaissance activities.

Initial survey unit classifications, based on MARSSIM guidance for final status surveys, were documented in Appendix A of the OCP. Areas initially classified as Class 1 have, or had prior to remediation, a potential for radioactive contamination (based on site operating history) or known contamination (based on previous radiological surveys). MARSSIM Class 2 areas have, or had prior to remediation, a potential for radioactive contamination but are not expected to exceed DCGLs. Class 3 impacted areas are not expected to contain any residual radioactivity or are expected to contain levels of residual radioactivity at a small fraction of the DCGL, based on site operating history and previous radiological surveys. For initial survey unit classifications for the SPRU Outside Areas, Class 2 was combined with Class 1, and survey units in the three Outside Areas were, therefore, initially classified as either Class 1 or Class 3. An updated MARSSIM classification for each of the Outside Area survey units is provided in Section 8. These survey units were further subdivided into sections of 50 by 50 feet to facilitate the survey and ensure more accurate coverage when completing the survey scans. The results of the surveys are documented in the *Outside*

Characterization Report: Walkover Surveys for the SPRU Land Areas (CH2M HILL, 2005a) and are described further in Section 2**.**

More than 28 acres of SPRU Outside Areas—approximately 13.5 acres in the Land Area, 13.4 acres in the Lower Level (11.6 in the Railbed Area and 1.8 in the Parking Lot Area), and 1.9 acres in the Upper Level—were surveyed. In general, the results of the walkover surveys from 2001 through 2004 were consistent with SV, SPUD, and surface survey data collected in the areas (see Section 2 for further information on the survey data). However, the 2001 to 2004 walkover surveys covered additional portions of the three areas that were not included in the historical SPUD and surface surveys in order to encompass all areas potentially impacted by historical SPRU activities.

After the walkover surveys were completed and the current and historical data were evaluated, survey units (or subgrids within the survey units) were identified that were determined to be impacted (i.e., those with SPUD or surface survey data greater than twice background) or required further investigation. Survey units (or subgrids within the survey units) not impacted by SPRU operations were eliminated from the investigation area. The criteria for elimination of survey units/subgrids from further characterization (i.e., elimination from the investigation area) were as follows:

- No documentation available indicating that the survey unit had been impacted by historical SPRU operations (see the *Outside Areas Historical Site Assessment* [CH2M HILL, 2003] for the documentation evaluated for this criterion).
- No historical SPUD or surface survey data indicating elevated activity in the survey unit. In some instances, historical surface activity was not confirmed by the recent walkover surface surveys and, therefore, was not considered to be an indication of SPRU impact (i.e., such areas were not included in the investigation area unless there were also elevated historical SPUD data). Possible reasons for recent walkover surveys not detecting elevated historical surface activity include dispersion and/or radioactive decay of the historical surface activity.
- No recent elevated (i.e., greater than twice the background direct gross gamma activity) walkover surface survey data within the survey unit.

Sampling and analysis plans (SAP) provide details of the specific sampling locations for each of the SPRU environmental media (soils, sediment, vegetation, and groundwater) and analyses to be performed for the radiological characterization. The SAPs were developed based on the requirements established in the OCP, the results of radiological walkover surveys (CH2M HILL, 2005a), and historical information obtained on SPRU operations and waste management activities (CH2M HILL, 2003). The SAPs (one for each of the three areas) were not intended as stand alone documents but as supplements to the OCP. Although the focus of the SAPs was primarily radioactive characterization, RCRA hazardous waste characterization of the soils was also integrated into the SAPs to minimize the amount of additional chemical characterization required to determine whether environmental media would potentially require remediation as hazardous or mixed waste.

1.5 Report Summary and Organization

This report, including supporting appendixes, provides the basis for the conclusions and recommendations summarized in the Executive Summary and described in Section 8. This report is organized to address the characterization objectives and requirements in a two-tiered approach, allowing development of a fundamental understanding of the radiological characterization of the SPRU Outside Areas, while providing appropriate detail in appendixes. The main body of the report summarizes the radiological characterization (first tier) and relies on appendixes and, in some cases, other SPRU reports for detail and substantiating documentation (second tier). This approach facilitates review of the overall document through the succinct delivery of the data, conclusions, and recommendations, while allowing for detailed technical material to be provided in appendixes for technical review. The general contents and organization of the report are as follows:

The **Executive Summary** presents a brief description of the background and objectives of the radiological characterization and summarizes the results, conclusions, and recommendations of the characterization.

Section 1, Introduction, introduces the report and radiological characterization of the SPRU Outside Areas and summarizes the SPRU background. The objectives and requirements for the radiological characterization are discussed, and a brief overview of the Outside Characterization Program is presented.

Section 2, Site Background and Previous Investigations, summarizes previous investigation and characterization activities involving the SPRU Outside Areas that have resulted in approximately 1,800 samples of environmental media being collected and analyzed from approximately 240 soil borings, 75 monitoring wells and groundwater sampling points, 13 sediment sampling locations, and 11 vegetation sampling locations. These activities are discussed by SWMU/AOC in each area. Subsequent discussions in the report group the environmental data by each entire area, with the exception of the Lower Level, which includes separate discussions on the Railbed Area and Parking Lot.

Section 3, Environmental Setting, provides an understanding of the regional and Knolls Site-specific environmental setting and is used to evaluate the relationship between the physical setting and the distribution of SPRU-related contaminants.

Section 4, Summary of Characterization Activities, summarizes the activities performed in each of the three Outside Areas as part of this radiological characterization effort.

Section 5, Site Characterization, summarizes the contaminants of concern (COCs) for the SPRU Outside Areas and rationale for their selection, and the development of final DCGLs for these COCs to support development of remediation goals that are protective of human health and the environment for cleanup of the Outside Areas and to support estimation of soil remediation volumes. This section discusses the area-specific geologic and hydrogeologic setting and fate and transport conceptual model used for evaluating the relationship between the physical setting and the distribution, fate, and transport potential of SPRU COCs. The section also discusses the data sources, data evaluation procedures, exceptions to the Quality Assurance Project Plan, and the quality and usability of the data.

Section 6, Investigation Results, discusses the development and application of surrogate indicator radionuclides that would allow use of a more readily measurable radionuclide, such as cesium-137 (Cs-137), or activity level as a surrogate of other radionuclides that may be present. This section addresses the nature and extent of radioactive contamination present in each area by media type (soil, groundwater, sediment, and vegetation). Chemical data (e.g., Toxicity Characteristic Leaching Procedure [TCLP]) used for estimation of waste volume projections are also discussed.

Section 7, Fate and Transport and Conceptual Site Models, presents updated information on radionuclide fate and transport in soil, groundwater, surface water, sediment, and vegetation based on the radiological characterization results. This section also updates the initial conceptual site models.

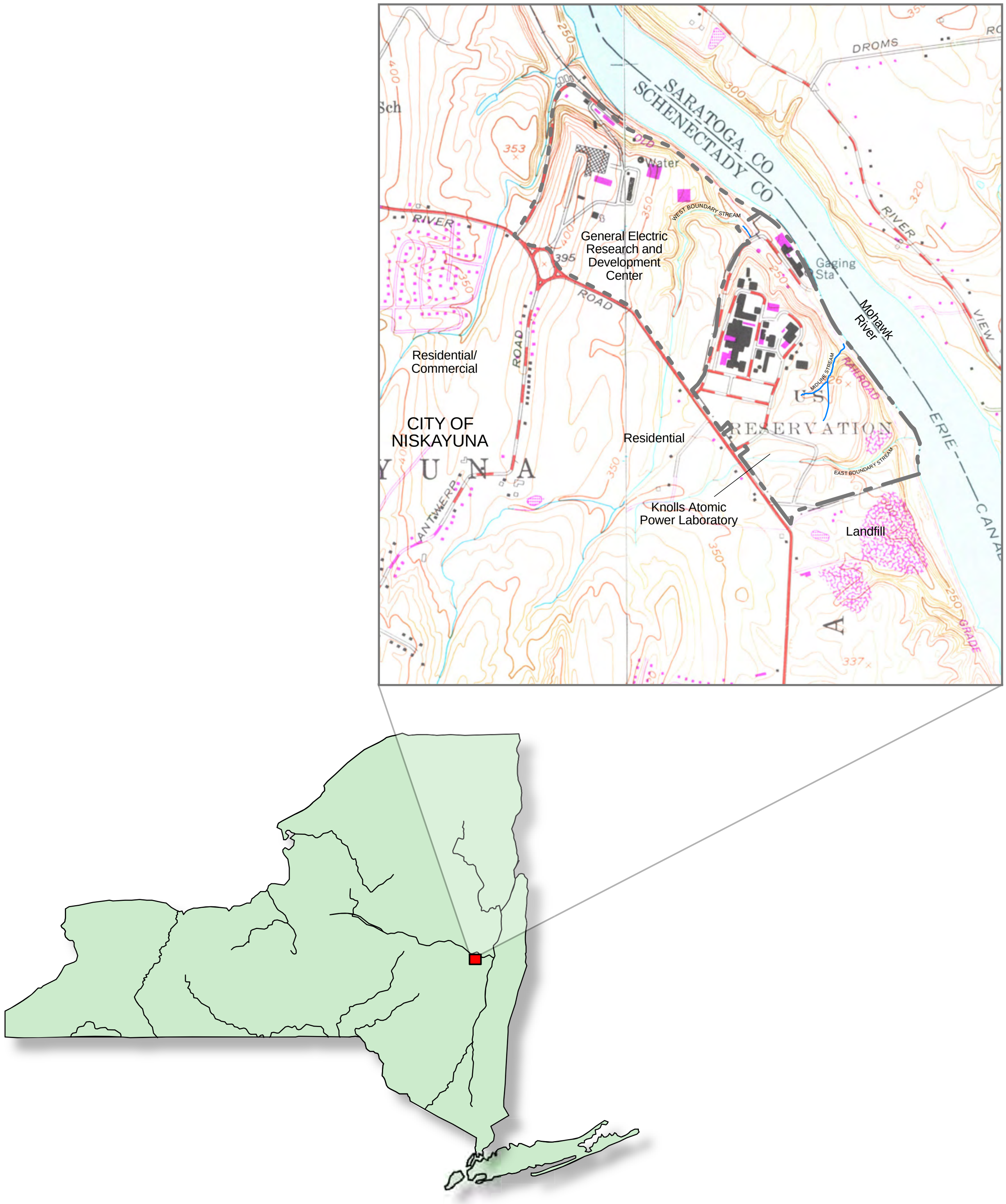
Section 8, Conclusions and Recommendations, presents the overall conclusions of the radiological characterization of the SPRU Outside Areas, as well as the conclusions of the characterization within each of the three areas. This section summarizes projected remediation waste types and volume estimates and identifies any existing or potential environmental, health, and safety risks during remediation. This section also identifies the recommended action(s) for soils exceeding DCGLs in each of the three areas and for groundwater sitewide and presents alternatives to achieve soil DCGLs and groundwater quality levels.

Section 9, References, provides detailed reference information for documents cited in this report.

This report provides detailed supporting information in Appendixes A through K as follows:

Appendix A Overview of Field Activities
Appendix B Soil Boring Geologic Logs
Appendix C Soil Boring Radiological Logs
Appendix D Sample Location Photographs
Appendix E Monitoring Well Installation Logs
Appendix F Hydraulic Conductivity Tests
Appendix G Investigation of the Lower Level Railbed Storm Drain System
Appendix H Radiological Waste Management and Disposition
Appendix I SPRU Radiological Characterization Data Quality Evaluation
Appendix J Analytical Data Summary Tables
Appendix K Statistical Analysis and Radionuclide Ratio Evaluation

Figures



Source: Niskayuna and Schenectady, NY, USGS 7.5 minute quadrangle maps (1954, photorevised 1980).

N

0 2200

Approximate Scale 1 Inch = 2200 Feet

Knolls Atomic Power Laboratory Property Boundary

General Electric Research and Development Center Property Boundary

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SEPARATIONS PROCESS RESEARCH UNIT

SPRU RADIOLOGICAL CHARACTERIZATION REPORT

KNOLLS ATOMIC POWER LABORATORY SITE LOCATION MAP

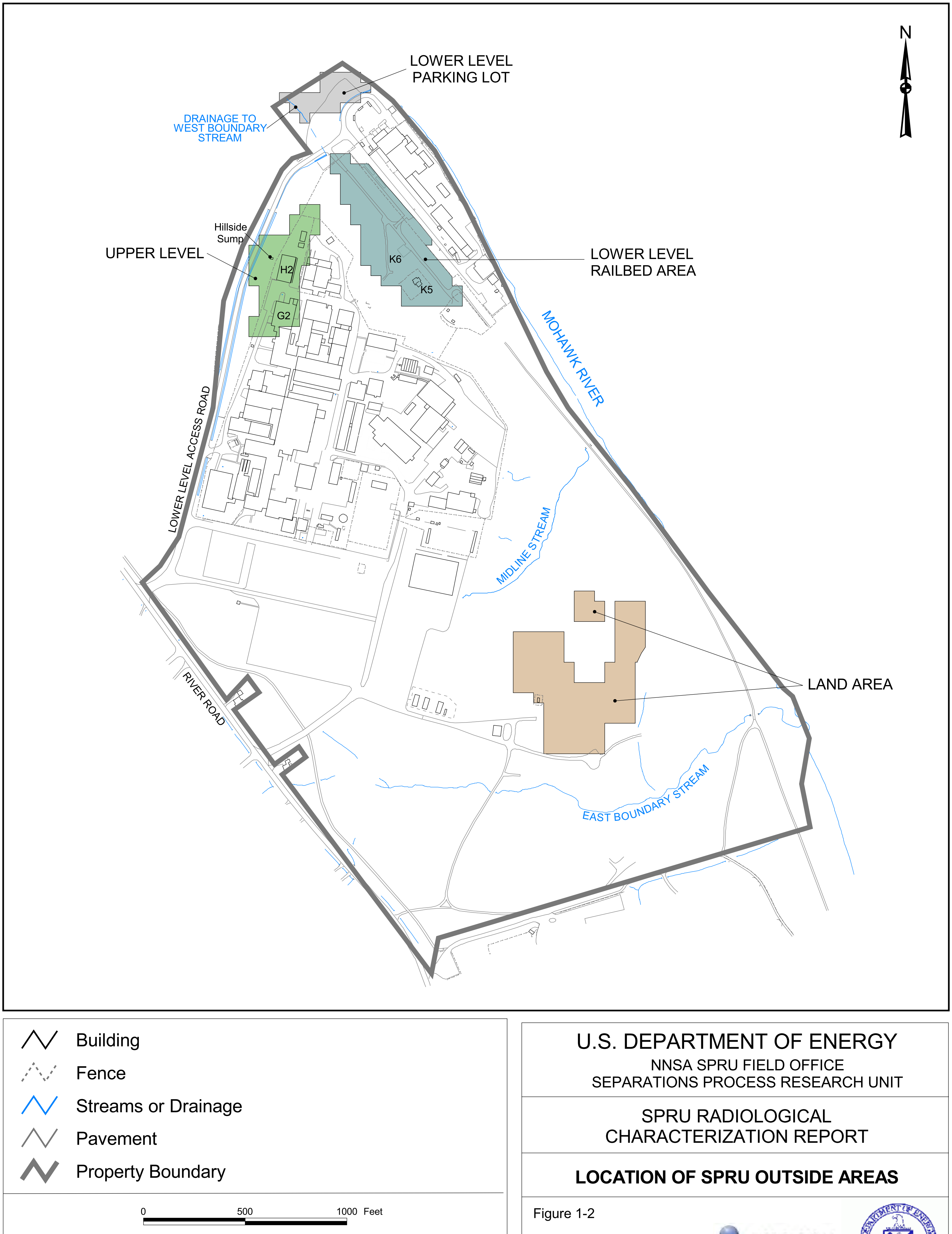
Figure 1-1

Prepared By: RMCCLINTOCK

Date: June 6, 2005

CH2MHILL

E062005005ATL \ USDOE 102.ai



Note: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

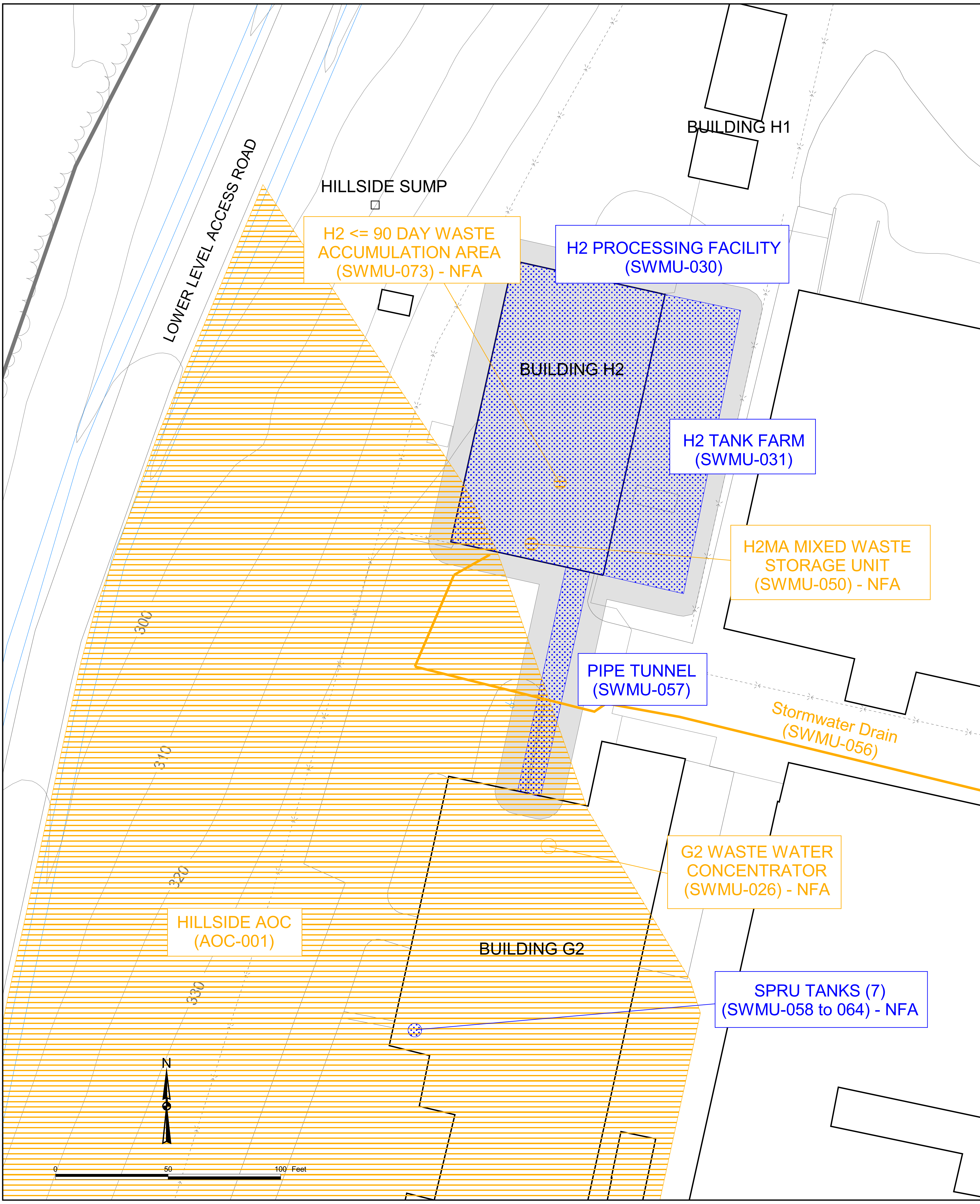
LOCATION OF SPRU OUTSIDE AREAS

Figure 1-2

Prepared By: ASPOSATO

Date: March 30, 2006

CH2MHILL



Legend	
Building	KAPL SWMUs/AOCs (Only the KAPL SWMUs/ AOCs adjacent to the SPRU SWMUs/AOCs are shown)
Fence	SPRU SWMUs (DOE EM Responsibility)
Streams or Drainage	SPRU RFI Responsibility
Pavement	
Property Boundary	
Topographic Contours (10 foot interval)	

SWMU/AOC Extents are Approximate

NFA - No Further Action

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

SPRU SWMU LOCATIONS IN THE UPPER LEVEL

Figure 1-3
Prepared By: ASPOSATO
Date: April 21, 2006

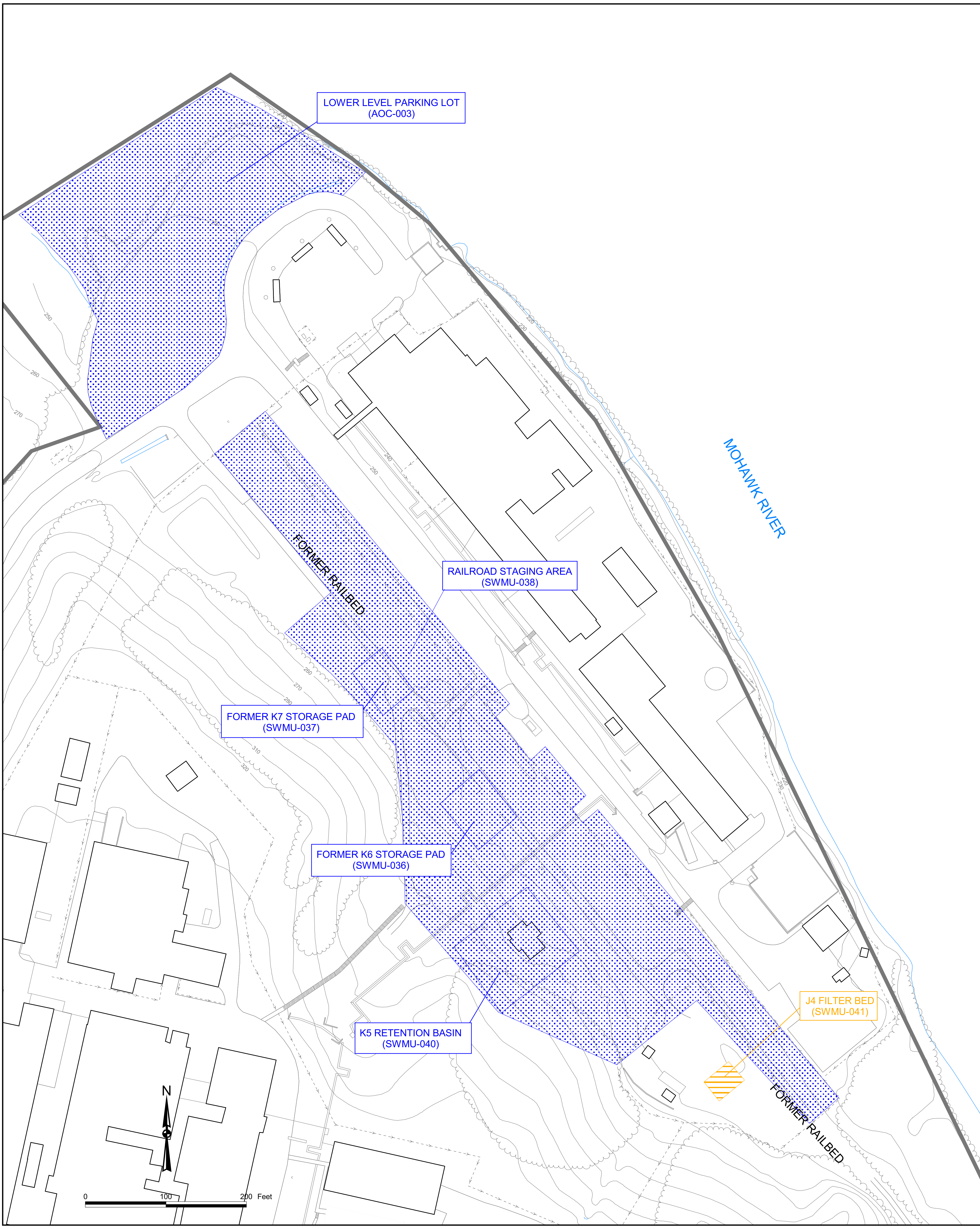
CH2MHILL

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

Hillside AOC Boundary Reference: KAPL. *RCRA Facility Investigation for the Hillside Area (AOC-001), Knolls Atomic Power Laboratory, Niskayuna, New York, Task IV Facility Investigation Workplan (including Task III Management Plans)*. April 2000 (revised September 2000).

KAPL SWMU/AOC Boundary Reference: "Knolls Site Solid Waste Management Units and Areas of Concern," Y-Y-13444, Revision 0. KAPL, Inc. March 10, 2004.

SPRU SWMU/AOC Boundary Reference: "RCRA Corrective Actions Part 373 Permit Application on the Solid Waste Management Units (SWMU) for the Separations Process Research Unit (SPRU)." DOE National Nuclear Security Administration, Albuquerque, N.M., to NYSDEC. September 30, 2004.



Building
Fence
Streams or Drainage
Pavement
Property Boundary
Topographic Contours (10 foot interval)

KAPL SWMUs/AOCs (Only the KAPL SWMUs/AOCs adjacent to the SPRU SWMUs/AOCs are shown)

SPRU SWMUs (DOE EM Responsibility)

SWMU/AOC Extents are Approximate

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

SPRU SWMU and AOC LOCATIONS IN THE LOWER LEVEL

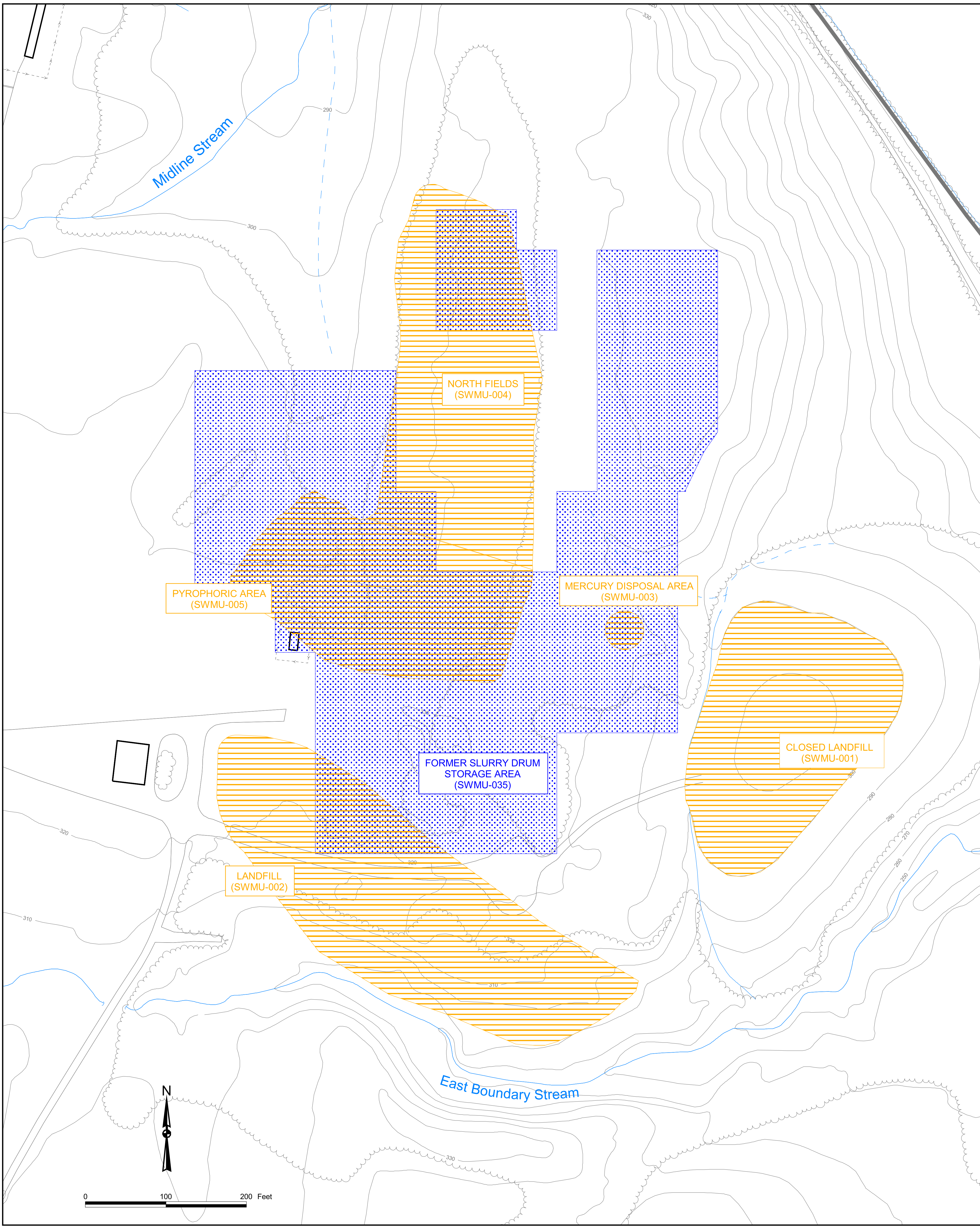
Figure 1-4
Prepared By: ASPOSATO
Date: April 21, 2006

CH2MHILL

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

KAPL SWMU/AOC Boundary Reference: "Knolls Site Solid Waste Management Units and Areas of Concern," Y-Y-13444, Revision 0. KAPL, Inc. March 10, 2004.

SPRU SWMU/AOC Boundary Reference: "RCRA Corrective Actions Part 373 Permit Application on the Solid Waste Management Units (SWMU) for the Separations Process Research Unit (SPRU)." DOE National Nuclear Security Administration, Albuquerque, N.M., to NYSDEC. September 30, 2004.



Building
Fence
Streams or Drainage
Ephemeral Drainage
Pavement
Property Boundary

KAPL SWMUs/AOCs
(Only the KAPL SWMUs/ AOCs adjacent to the SPRU SWMUs/AOCs are shown)
SPRU SWMUs
(DOE EM Responsibility)
Topographic Contours
(10 foot interval)

SWMU/AOC Extents are Approximate

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

SPRU SWMU LOCATIONS IN THE LAND AREA

Figure 1-5
Prepared By: ASPOSATO
Date: April 21, 2006

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.
KAPL SWMU/AOC Boundary Reference: "Knolls Site Solid Waste Management Units and Areas of Concern," Y-Y-13444, Revision 0. KAPL, Inc. March 10, 2004.
SPRU SWMU/AOC Boundary Reference: "RCRA Corrective Actions Part 373 Permit Application on the Solid Waste Management Units (SWMU) for the Separations Process Research Unit (SPRU)." DOE National Nuclear Security Administration, Albuquerque, N.M., to NYSDEC. September 30, 2004.

2. Site Background and Previous Investigations

Various environmental studies and investigations have been conducted on the three SPRU Outside Areas: the Land Area, the Lower Level, and the Upper Level. These studies include the KAPL Soils Program, the RFA SV, and the RFI for groundwater. In addition, radiological gamma walkover surveys have been performed in these areas. The following sections present overviews of these previous environmental studies and investigations (Sections 2.1 through 2.4). The overviews are followed by area-specific summaries (Sections 2.5 through 2.7) that include background information on historical SPRU operations pertaining to the Outside Areas (including the SWMUs and the AOC), and results of the studies and investigations described in the overviews.

2.1 KAPL Soil Program Overview

As part of the KAPL plan for decommissioning and stabilization of inactive radiological facilities, a soil program was established in 1979 to characterize and estimate the total volume of radioactively contaminated soil. KAPL performed walkover gamma scintillation surveys and SPUD surveys in the 1980s and early 1990s to determine the extent of radioactive contamination from historical SPRU operations. The SPUD surveys consisted of inserting a gamma scintillation detector probe into a 1-inch-diameter, stainless-steel tube inserted into a previously drilled hole at select soil locations. This method, commonly referred to as downhole gamma logging, involves collecting surface and subsurface gamma survey data at designated depths (typically 0.5-meter increments to 2 meters in total depth). Detailed soil program reports were generated to present the survey findings. The reports include areal distribution of contamination from walkover surveys and SPUD locations, and the respective downhole gamma logging results. Cesium-137 was identified at levels greater than or equal to twice background, nominally 20 picocuries per gram (pCi/g); the KAPL unconditional soil release limit is 20 pCi/g of cesium-137 (KAPL, 1984c; 1989; 1992). The KAPL soil program reports are referenced in *Outside Areas Historical Site Assessment* (CH2M HILL, 2003) and are available in the SPRU project files.

The historical elevated SPUD and gamma walkover survey data associated with SPRU Outside Areas are shown in Figures 2-1 through 2-4 for the Land Area, Lower Level Railbed Area, Lower Level Parking Lot Area, and Upper Level, respectively. The figures also display recent radiological gamma walkover surveys performed in accordance with the *Outside Characterization Plan* (CH2M HILL, 2004a). The recent walkover surveys are summarized in Section 2.4. Results of the KAPL soil program specific to each Outside Area are described in Sections 2.5 through 2.7.

2.2 SPRU RFA SV Overview

An RFA SV was implemented in the fall of 2000 and spring of 2001 for eight SWMUs and one AOC that are associated with the SPRU operations; seven additional tank SWMUs inside Building H2 were associated with SPRU operations but were designated as needing No Further Action in the KAPL Part 373 Permit (NYSDEC, 1998). Within each SWMU or AOC, the objective of the SV was to provide sufficient characterization data to evaluate whether a release of hazardous constituents from waste operations has occurred, to make preliminary determinations about the nature of any releases, and to establish the need for further investigation and/or interim corrective measures.

Results of this SV are detailed in *SPRU Project RCRA Facility Assessment Sampling Visit Report* (CH2M HILL, 2002), which was approved by NYSDEC in February 2006 (NYSDEC, 2006a). Chemical data were the focus of the sampling and analysis during the SV. Although radiological characterization was not an objective of this investigation, radiological data were also collected as necessary to support shipment of potentially radioactive materials. Radiological screening was limited to bulk sample gamma spectroscopy.

The eight SWMUs and one AOC are related to SPRU because they received waste materials or were potentially contaminated by spills and/or releases of waste materials associated with or generated at SPRU. The SWMUs and AOC are identified below, grouped in accordance with Knolls Site geographical areas.

Geographical Area *(SPRU Outside Area)*	**SWMU/AOC**[a]	**Relationship to SPRU Process**
Upper Level	H2 Processing Facility (SWMU-030)	SPRU waste and wastewater processing facility
	H2 Tank Farm (SWMU-031)	Process separations material and waste storage in tanks contained in underground vault
	Pipe Tunnel (SWMU-057)	SPRU waste drain lines between Buildings G2/G1/E1 and H2
Lower Level	Former K6 Storage Pad (SWMU-036)	Above-ground storage of containerized SPRU wastes
	Former K7 Storage Pad (SWMU-037)	Above-ground staging of solid containerized SPRU wastes
	Railroad Staging Area (SWMU-038) (also known as Railbed Area)	Waste staging and railroad car loading operations area potentially contaminated by spills of SPRU wastes
	K5 Retention Basin (SWMU-040)	Containment of nonhazardous process wastewater and laundry wastewater
	Lower Level Parking Lot (AOC-003)	Receipt of potentially contaminated fill material from the Railbed Area and Former K6 and K7 Storage Pads
Land Area	Former Slurry Drum Storage Area (SWMU-035)	Above-ground staging of SPRU slurry wastes in earthen berm

[a] Additional SWMUs are present in each area and are being addressed by KAPL under the Knolls Site Hazardous Waste Management Permit (NYSDEC, 1998).

The results of the RFA SV in the Upper Level led to the conclusion that the extent of the volatile organic compound (VOC) impact to groundwater at the Pipe Tunnel and H2 Processing Facility required further evaluation to determine the source and extent of VOCs in the Pipe Tunnel and to confirm whether there was an additional release from the foundation of Building H2. Potential transfer of metals (antimony) from soil to groundwater along the western side of Building H2 also required further evaluation.

Based on the results of the RFA SV in the Lower Level, low levels of VOCs and elevated metals in the southeast portion of the Railbed Area and Parking Lot required further evaluation to determine the nature and extent of the releases.

The RFA SV Report established no further action was necessary for three SWMUs: Former K6 Storage Pad (SWMU-036), Former K7 Storage Pad (SWMU-037), and Former Slurry Drum Storage Area (SWMU-035). The NYSDEC-approved RFA SV Report also established the following.

1. Due to current access limitations, the nature and extent of a trace level of trichloroethylene (TCE) detected in soil at the northeast corner of the K5 Retention Basin will be evaluated following D&D of the structure. At MW-SV7, trace levels of TCE (0.045

J[1] micrograms per liter [µg/L]) and cis-1,2-DCE (0.71 J µg/L) were detected in a groundwater sample collected on March 24, 2005, as reported in the RFI Report for Groundwater (CH2M HILL, 2006).

2. Polycyclic aromatic hydrocarbon (PAH) compounds and various metals (antimony, arsenic, copper, and lead) were detected in soil along the entire extent of the former railbed within the Railroad Staging Area. These PAHs and metals are attributed to railroad construction materials and operations, not to SPRU or KAPL waste management. Also, traces of gasoline components evident throughout the Railbed Area are attributed to motor vehicle use. No further action is necessary for these constituents in soil and groundwater.

3. Concentrations of chemical constituents in groundwater near the K5 Retention Basin are consistent with natural conditions.

As stated previously, no further action was established for the Former Slurry Drum Storage Area in the Land Area in the RFA SV Report. However, additional SV sampling in the Red Pines Area, in the northeast corner of the Land Area, has been completed and the documentation submitted to NYSDEC as an addendum to the SV investigation in response to indications of historical waste management activity in that area (CH2M HILL, 2004h; 2005c). The additional SV sampling in the Red Pines Area was conducted in 2004, in conjunction with the Outside Characterization, and in July and September 2005.

RFA SV results specific to each Outside Area are described in Sections 2.5 through 2.7.

2.3 Task IV Groundwater RFI Overview

The *Task IV RCRA Facility Investigation Work Plan for Groundwater, Upper and Lower Level Areas* (CH2M HILL, 2004e) was implemented to characterize the environmental setting and contaminant releases at SWMUs and AOC associated with SPRU operations within the Knolls Site Upper and Lower Level Areas. No further action was required in the Land Area. Chemical contamination in soil identified during the RFI will be evaluated during remedial design.

[1] J means the analyte was detected but the value was estimated.

Based on the SV Report, the RFI in the Upper Level encompassed further characterization to establish the nature and extent of SPRU-related releases to the environment at the SWMUs in the Upper Level.

The RFI in the Lower Level encompassed further characterization to establish the nature and extent of SPRU-related releases to the groundwater at the Railbed Area and the Parking Lot. Characterization of groundwater beneath the K5 Retention Basin will be performed in conjunction with D&D of the K5 Retention Basin.

The RFI of the Upper and Lower Levels was implemented in accordance with the approved Work Plan during March 2004 through December 2004. The RFI was conducted in conjunction with the Outside Characterization. The RFI focused on chemical data, and the Outside Characterization, the subject of this report, focused on radiological data. The results of the RFI are documented in the *Task IV RCRA Facility Investigation Report for Groundwater, Upper and Lower Levels* (CH2M HILL, 2006). Sections 2.5 through 2.7 do not include area-specific summaries of the RFI chemical results because this report is focused on radiological data.

2.4 Outside Characterization Gamma Walkover Survey Overview

Gamma walkover survey data were collected during May 30, 2001, to November 16, 2004, in accordance with Part IV, Section 4.2, Field Measurements, of the *Separations Process Research Unit (SPRU) Outside Characterization Plan* (CH2M HILL, 2004a). The scope consisted of gamma detector walkover surveys of the ground surface of the Outside Areas and representative general area gamma dose rate (exposure rate) measurements in each area. The results are documented in *Outside Characterization Report: Walkover Surveys for SPRU Land Areas* (CH2M HILL, 2005a). The walkover surveys provided qualitative data necessary to establish additional sampling and survey strategies to support the outside characterization and future remediation efforts.

After the walkover surveys of each area were completed and the current and historical data were evaluated, survey units (or subgrids within the survey units) were identified that were determined to be impacted (i.e., those with SPUD or surface survey data greater than twice background) or required further investigation. The area for further investigation during the outside characterization is delineated by the outer perimeter of the grids shown in Figures 2-1 through 2-4. Survey units (or subgrids within the survey units) not impacted by SPRU operations were eliminated from the characterization area based on the following criteria.

- No documentation was available indicating that the survey unit had been impacted by historical SPRU operations (see the *Outside Areas Historical Site Assessment* [CH2M HILL, 2003] for the documentation evaluated for this criterion).
- No historical SPUD or surface survey data indicated elevated activity in the survey unit. In some instances, historical surface activity was not confirmed by the recent walkover surface surveys and, therefore, was not considered to be an indication of SPRU impacts. Such areas were not included in the characterization unless there were elevated historical SPUD data. Possible reasons for recent walkover surveys not detecting elevated historical surface activity include dispersion and/or radioactive decay of the historical surface activity.
- No recent elevated (i.e., greater than twice background activity) walkover surface survey data were identified within the survey unit.

The gamma walkover survey data were used to establish a systematic and biased sampling methodology for further characterization of the Outside Areas. Detailed information on the development of sampling methodology are provided in the SAPs for the Land Area (CH2M HILL, 2004b), Lower Level (CH2M HILL, 2004c), and Upper Level (CH2M HILL, 2004d). The sampling methodology is also summarized in Section 4.

2.5 Land Area Summary

The Land Area is in the southeastern portion of the Knolls Site (outside the developed portion of the site) and is bounded by the East Boundary (Red Pines Area) and Midline streams (see Figure 1-5). The outer perimeter of the Land Area is partially wooded along the eastern, northern, and western perimeters and contains grass and brush in the nonwooded areas. The former KAPL Landfill (SWMU 002) borders the southern perimeter of the Land Area but is not part of the investigation area. Historically, the Land Area was known as the

North Field. The Land Area encompasses the Former Slurry Drum Storage Area (SWMU-035) and the Red Pines Area. The Red Pines Area consists of rows of white pine trees, characterized by their red color, along the northeastern boundary of the Land Area. The Red Pines Area was included in the Land Area after reconnaissance walkover surveys detected elevated radioactivity in this area. The following sections describe historical SPRU operations associated with the SWMU located in the Land Area and previous investigation results applicable to the Land Area.

2.5.1 Description of the Former Slurry Drum Storage Area

Soil in the Land Area was known to have low-level contamination due to the leakage of radioactive slurry waste from drum containers temporarily stored in the Former Slurry Drum Storage Area before offsite disposal during the 1950s (KAPL, 1966; KAPL–Pyle, 1978; KAPL, 1988; CH2M HILL, 2003). The Former Slurry Drum Storage Area, located in the southwest portion of the Land Area (see Figure 1-5), consisted of an approximately 900-square-foot, earthen bermed area. The earthen berm was physically confined within walls that were 5 to 6 feet thick and 8 to 10 feet high. During use of the area, containerized slurry waste leaked before a heavy rain. The heavy rain caused a pond to form and run out via a breach in the berm and into a north/south runoff bed. Before 1955 the waste containers were removed, and the area was decommissioned. In 1955 surveys indicated that radioactive contamination had spread beyond the bermed area, approximately 100 feet north in a path 12 feet wide. Historical records reveal several attempts to identify and remediate the soil contamination. During cleanup efforts, exposed ground areas of contamination were covered with asphalt-impregnated paper, and a layer of clean soil was placed on top of the asphalt paper. Approximately 1,000 cubic yards of soil were removed. No visible evidence of the earthen berm exists today.

Zirconium used in Knolls Facility operations is believed to have been historically stored near the KAPL Pyrophoric Building (Building Q-6, adjacent to the west side of the Land Area). Zirconium is a gray-white metal that is used in various applications for its corrosion-resistant properties and is used in various naval reactor components. When finely divided, the metal can spontaneously ignite in air.

2.5.2 Previous Investigations in the Land Area

Previous investigations included the KAPL Soil Program, SPRU RFA SV, and outside characterization gamma walkover survey; these are described in the following sections.

2.5.2.1 KAPL Soil Program

KAPL performed radiological surface walkover and SPUD surveys of the Land Area to determine the extent of radioactive contamination from historical operations, including SPRU operations (KAPL, 1989). The *Outside Areas Historical Site Assessment* (CH2M HILL, 2003) presents detailed gamma walkover survey and SPUD data for the Land Area. These data are summarized in Figure 2-1.

2.5.2.2 SPRU RFA SV

As part of the RFA SV, 125 soil samples were collected from 55 soil borings throughout the Land Area, as shown in Figure 2-5 (CH2M HILL, 2002). Boring depths were from 0 to 6 feet or 0 to 10 feet below ground surface (bgs), with the exception of three that were 10 to 14 feet bgs. Chemical data were collected at three intervals for each boring. Although radiological characterization was not an objective of this study, radiological data were also collected as necessary to support shipment of potentially radioactive materials. The 2- to 4-foot-bgs interval was screened onsite for gamma-emitting radionuclides.

A total of 47 samples from the Land Area were screened by gamma spectroscopy. Of these, only 7 samples (15 percent) had quantifiable cesium-137 levels. The maximum cesium-137 activity (3.7 pCi/g) was observed at soil boring B3519 (see Figure 2-5), which corresponds to an area of radioactive contamination identified during recent and historical walkover surveys of the area (see Figure 2-1). Other detected cesium-137 data ranged from 0.05 to 0.5 pCi/g; because of the extremely low levels, cesium-137 is believed to have resulted from background fallout. These data are discussed in the RFA SV Report (CH2M HILL, 2002).

Based on chemical data collected during the SV, lead could be present in the subsurface at soil boring B3555 (Figure 2-5) at levels exceeding the TCLP criteria. The maximum concentration (189 milligrams per kilogram [mg/kg]) from the bottom-most sampling interval of B3555 (4 to 5 feet bgs) exceeds all background ranges. Although the SV Report concluded that chemicals in the Land Area do not result from SPRU operations, soil samples near B3555 will be analyzed for TCLP to determine the potential for generation of hazardous or mixed waste during remediation.

2.5.2.3 Outside Characterization Gamma Walkover Survey

As described in Section 2.4, radiological gamma walkover surface surveys were performed in the Land Area in accordance with the OCP during 2001 through 2004. Twenty-seven 150- by 150-foot survey units (numbered LA-1001 through LA-1027) were identified for the walkover survey based on historical documentation, historical SPUD and surface survey data, and field reconnaissance activities. These survey units were further subdivided into sections of 50 by 50 feet to facilitate the survey and ensure more accurate coverage.

The results of the walkover surveys are shown in Figure 2-1 and documented in the *Outside Characterization Report: Walkover Surveys for SPRU Land Areas* (CH2M HILL, 2005a). Approximately 13.5 acres in the Land Area was surveyed, including areas along preferential paths down the hillside to the abandoned railbed, to evaluate whether any contamination might have migrated along the paths.

In general, the recent walkover surveys are consistent with historical SV, SPUD, and surface survey data collected in the Land Area. However, the recent walkover surveys covered portions of the Land Area (e.g., Red Pines Area in the northeastern portion of the Land Area and western portion of the Land Area northwest of Building Q-6) that were not included in the historical SPUD and surface surveys. Several areas of elevated activity (greater than or equal twice background) were detected in these areas. In addition, several discrete, sporadic historical surface survey points of elevated activity in the south, southeast, and northern Land Area were not detected in the recent walkover surveys. The only areas with elevated SPUD (and some historical surface survey) activity that were not detected by the recent walkover surveys were approximately 150 to 250 feet east and 75 to 150 ft east/southeast of the Building Q-6 in areas where disturbance of subsurface soil is known to have occurred. Elevated historical survey data not detected during the recent walkover surveys may be due to natural decay of the radioactivity previously detected, differences in instruments and identified background activity, and/or differences in techniques (e.g., subsurface versus surface-only survey). Locations and results of the historical SPUD surveys are shown in Figure 2-1, overlaid on the recent walkover survey data.

2.6 Lower Level Summary

The Lower Level consists of land adjacent to and south of the former SPRU railbed and encompasses the Railroad Staging Area (SWMU-038), Former K7 Storage Pad (SWMU-037), Former K6 Storage Pad soil (SWMU-036), and K5 Retention Basin (SWMU-040) (Figure 1-4). The Lower Level Parking Lot (AOC-003) is included in the Lower Level. The Lower Level characterization did not include any structures, such as the K5 Retention Basin and Former K6 Storage Pad concrete structures; however, soils surrounding, within, and beneath these structures are included. The following subsections describe historical operations associated with the Lower Level SWMUs and AOC and previous investigation results.

2.6.1 Descriptions of Lower Level SWMUs and AOC

The Lower Level contains four SWMUs and one AOC, as described in the following subsections.

2.6.1.1 Parking Lot

This AOC consists of the fill material located north of and adjacent to a 250-square-foot parking lot (see Figure 1-4). Fill material obtained from former SPRU waste management areas was used to expand the Lower Level Parking Lot in August 1962 (DOE, 1999d; KAPL, 1962; KAPL, 1983; KAPL 1988; CH2M HILL, 2003). Soil from west of the Former K6 Storage Pad and east of the Former K7 Storage Pad was removed and used as fill in the Parking Lot. During this process, radioactive contamination was uncovered between the storage pads in an area that is approximately 8 by 12 feet. A survey of the fill soil at the edge of the Parking Lot revealed a maximum dose of 6 milliroentgen per hour (mR/hr). Approximately 4 cubic yards of soil at the Parking Lot were identified as contaminated and remediated to less than 1 mR/hr at 2 inches from the surface.

The area of radiological impact within the Parking Lot was identified during a SPUD radiological survey. Radioactive contamination was also identified near soil boring B0304 (see Figure 2-6) during RFA SV sampling (CH2M HILL, 2002).

Results from ground-penetrating radar (GPR) and electromagnetic (EM-61) conductivity surveys (see Appendix F, Figure 9, of the *RCRA Facility Assessment Sampling Visit Report* [CH2M HILL, 2002]) indicate the possible presence of a disturbed zone and concrete materials (e.g., construction rubble) in the Parking Lot that may be fill materials from the Railbed Area.

2.6.1.2 Railroad Staging Area

The Railroad Staging Area (herein referred to as the Railbed Area) is adjacent to and south of the former railbed in the Lower Level (see Figure 1-4). The Former K6 Storage Pad, Former K7 Storage Pad, and K5 Retention Basin are located within the Railbed Area. The Railbed Area was used to fill and stage wooden boxes, concrete transport boxes, and 55-gallon drums of radioactive solid waste, soil, and slurry waste from Building H2 operations before the waste was shipped by rail for disposal (DOE, 1999d; CH2M HILL, 2003). Waste staging operations commenced in the early 1950s and ceased in the late 1960s. Undated historical photographs in the DOE EM files, believed to have been taken during this period, show shipment containers being filled primarily along the west side of the northern portion of the railbed. Drums were believed to have been handled throughout the Railbed Area and particularly near drum storage at the Former K6 and K7 Storage Pads. As evident in the photographs, a fence—present during at least part of the Lower Level waste management operations—confined waste staging operations along the current asphalt roadway. Waste containers were staged along the eastern perimeter of the railroad track and railroad track spur. Railroad loading operations occurred on the eastern side of the tracks. Although the waste transfer route is undocumented, the lack of a gate in the fencing along the eastern perimeter of the Lower Level indicates that waste containers were probably transferred from the western side of the railroad tracks to the eastern side using the roadway along the northern perimeter of the Lower Level.

2.6.1.3 Former K6 Storage Pad

The Former K6 Storage Pad, centrally located at the Lower Level (see Figure 1-4), was a concrete structure used to store and shield containerized, high-level radioactive SPRU slurry waste before shipment by rail to an offsite disposal location. The Former K6 Storage Pad was a 23-foot-wide by 48-foot-long, concrete-shielded, concrete storage pad with 8-foot-high walls (DOE, 1999d; CH2M HILL, 2003; DOE, 1999a). The inside of the concrete structure was partially divided into two storage cells (East Cell and West Cell) of equal dimension. With the exception of the pad’s southern wall, which was 8 inches thick, the shielding walls were more than 2.5 feet thick. An earthen embankment abutted the southern wall. The original K6 facility storage cells were unprotected and exposed to the environment; the unit was fitted with a roof in 1987.

This unit was used from the late 1950s until the fall of 1968 to store containerized solid waste potentially containing hazardous constituents. Floor drains in both storage cells were used to drain the area. A 4-inch-diameter drainpipe extended approximately 115 feet east toward a 36-inch storm sewer by way of a 4-inch clay tile drainpipe. The line was plugged and blanked off in 1973. No evidence of a release was found when the drain line was blanked off.

In 1987 D&D of the Former K6 Storage Pad (above ground) and environs was initiated. The concrete access pads, drains, 115-foot drainpipe, and cell floors were removed and disposed of as radioactive waste. Contaminated soil, resulting from spills and leaks from the stored waste, was excavated from within the Former K6 Storage Pad and surrounding environs. Soil with radioactivity measuring greater than or equal to 0.1 mR/hr was excavated to a maximum depth of 3 feet and either stockpiled or packaged and disposed of as radioactive waste. A localized excavation in the northeast quarter of the West Cell was made to evaluate the depth and extent of subsurface soil contamination. The highest radiation reading measured on the soil was 6 mR/hr at a depth of 5 feet bgs. Subsurface soil evaluation efforts ceased at the depth of 5.5 feet below the original grade. Remaining subsurface contaminated soils below 3 feet were not excavated, leaving behind contaminated soil. Excavated areas within and outside the Former K6 Storage Pad were backfilled with a mixture of stockpiled contaminated soil at lower depths, and clean fill towards the surface. No barriers were placed between the contaminated soil and clean fill materials. Six inches of new, back-run gravel was placed as the top layer inside the Former K6 Storage Pad footprint to the original grade.

In 2004 the entire Former K6 Storage Pad was demolished, packaged, and shipped to an offsite disposal facility. The remediation and demolition of the Former K6 Storage Pad did not include associated contaminated soils.

2.6.1.4 Former K7 Storage Pad

This former storage unit, which consisted of a fenced concrete pad, was centrally located in the Lower Level Railbed Area, northwest of the Former K6 Storage Pad (see Figure 1-4).

This unit was used during the 1960s to stage solid waste before offsite disposal. Wastes were generally containerized in 4-foot-square wooden boxes (DOE, 1999d; CH2M HILL, 2003).

The fencing and concrete pad were removed, and this area currently comprises the soils adjacent to and underneath the former pad location. A portion of the original K7 Storage Pad footprint is covered with asphalt to facilitate Lower Level traffic and personnel access.

Soil east of the Former K7 Storage Pad was excavated in August 1962 and used as fill to extend the Lower Level Parking Lot (DOE, 1999d; KAPL, 1962; KAPL, 1983a; KAPL 1988; CH2M HILL, 2003). The following day, an 8- by 12-foot area of ground contamination between the Former K6 and K7 Storage Pads was identified during continuation of the excavation. This area was remediated to 6 mR/hr and was later covered with stone and gravel to an approximate depth of 18 inches to obtain a dose rate of less than 1 mR/hr at 2 inches from the surface.

2.6.1.5 K5 Retention Basin

This unit is an in-ground, open-topped, concrete basin on the hillside between the Upper and Lower Levels, south of the Railbed Area (see Figure 1-4). The unit measures approximately 22 feet wide by 43 feet long by 11 feet deep and is constructed of 1-foot-thick concrete walls (DOE, 1999a; DOE, 1999d; CH2M HILL, 2003; Rockwell International, 1994). The unit is equally divided into two 30,000-gallon holding basins. Cracks have been observed in both basin floors. An influent drainage valve pit and an effluent drainage valve pit are located on the south and north sides of the building, respectively. Each valve pit is plumbed to both basins. The influent valve pit has a floor drain that drains to the hillside to the south-southeast. The effluent valve pit drains to the north into a catch basin.

This unit was operational from 1950 until the late 1960s. Wastewater, potentially containing hazardous constituents processed in Building H2, and radioactively contaminated laundry wastewater were accumulated in this retention basin before being discharged to a stormwater drain. Personnel interviews indicate that historical K5 basin overflows resulted in soil contamination adjacent to and north of the building; the contaminated soil was excavated and replaced with clean fill (CH2M HILL–Marr, 2002). In 1970 a roof was installed over the basin to minimize weather-related water infiltration and to keep in the residual radioactivity. A hatch in the roof provides access for periodic inspections. In the fall of 1970, sludge was removed from the K5 retention basins, the interior walls were cleaned of radioactivity, and a sealer was applied to the surfaces.

In December 1992 and continuing into 1993, KAPL performed an inspection and survey of the K5 facility to assess the radiological and physical conditions. KAPL observed that roof leakage directly into the retention basins was the cause for small amounts of accumulated water, not groundwater as originally determined. A tarpaulin was installed over the roof to minimize the water infiltration.

2.6.2 Previous Investigations in the Lower Level

Previous investigations included the KAPL Soil Program, SPRU RFA SV, and outside characterization gamma walkover survey; these are described in the following sections.

2.6.2.1 KAPL Soil Program

KAPL performed radiological surface walkover and SPUD surveys of the Lower Level to determine the extent of radioactive contamination from historical operations, including SPRU operations (KAPL, 1992). The *Outside Areas Historical Site Assessment* (CH2M HILL, 2003) presents detailed gamma walkover survey and SPUD data for the Lower Level. These data are summarized in Figures 2-2a and 2-2b for the Railbed Area and Figure 2-3 for the Parking Lot.

In 1984 KAPL conducted a series of surface and subsurface soil core borings at various locations at the Lower Level (KAPL, 1985). The core borings were located throughout the Railbed Area and adjacent to and south of the Parking Lot, as shown in Figures 2-2a and 2-3. A total of 78 samples from the Railbed Area were analyzed for cesium-137 and ranged from 0.1 to 274.9 pCi/g, with an average of 12.7 pCi/g. Of the 78 samples analyzed, 43 samples contained cesium-137 at less than 3 pCi/g. The 27 core boring samples adjacent to and south of the Parking Lot were all less than 3 pCi/g. Core boring sample results are summarized in the *Outside Areas Historical Site Assessment* (CH2M HILL, 2003).

2.6.2.2 SPRU RFA SV

As part of the RCRA SV, 250 soil samples were collected from 103 soil borings and trenches throughout the Lower Level (CH2M HILL, 2002), as shown in Figure 2-6. Boring depths were generally from 0 to 6 feet bgs. Chemical data were generally collected at three intervals for each boring. Although radiological characterization was not an objective of this study, radiological data were also collected to support shipment of potentially radioactive materials. The 0- to 2-foot-bgs interval was screened onsite for gamma-emitting radionuclides. Groundwater samples were also screened onsite for gross beta-gamma radioactivity.

Elevated levels of radioactivity were identified at various locations within the Railbed and Parking Lot Areas, which is consistent with radioactive contamination identified during recent and historical walkover surveys of the area (see Figures 2-2a and 2-3). Cesium-137 was elevated in soil borings near the Former K6 Storage Pad, northward toward the location of the Former K7 Storage Pad, and around the perimeter of the K5 Retention Basin. Gross beta-gamma radioactivity was elevated in groundwater downgradient of the K5 Retention Basin and Former K6 Storage Pad. The maximum cesium-137 activity (462 pCi/g) was observed beneath the Parking Lot Area at soil boring B0304 (see Figure 2-6).

Before soil borings were drilled for the RFA SV, EM-61 and GPR were used to identify potential subsurface features that could present a health and safety concern if encountered during the field investigation. Geophysical anomalies corresponding to subsurface features were identified and are documented in Appendix F of the SV Report (CH2M HILL, 2002). Section 6.2.7 of the SV Report discusses specific geophysical anomalies and their interpretation based on SV boreholes.

Except for the Parking Lot, SV boreholes completed in these anomalies did not contain elevated chemical concentrations and generally correspond with areas of radioactivity. The geophysical survey identified the presence of a disturbed zone containing scattered objects in the northern and northeastern portion of the Parking Lot that corresponded with elevated concentrations of chemicals and the presence of radioactive soils.

An evaluation of sediment collected in stormwater Catch Basin (CB)-26 in the Lower Level was also included in the SPRU RFA SV. The approximate location of CB-26 was determined based on as-built drawings. The catch basin was partially covered with soil that had to be removed to gain access to the basin.

The base of the CB-26 concrete structure was approximately 18 feet below the top of the structure. One effluent and two influent pipes were observed within the concrete structure. An influent pipe, approximately 3 inches in diameter with an invert (bottom-most portion), approximately 6.5 feet below the top of the structure, was on the eastern wall of the structure. Water was not observed discharging from the pipe at the time of the evaluation. An influent pipe, approximately 24 inches in diameter with an invert approximately 7 feet below the top of the structure, was on the southern wall. A moderate flow of water was observed discharging into the catch basin structure from this pipe. A slightly larger effluent pipe was located near the base of the structure on its northern side. Water discharging from the southern influent pipe was falling to the bottom of the structure, where it then entered the effluent pipe. Scour marks were observed on the northern wall of the structure.

The bottom of the structure was "sounded" using Geoprobe tooling rods to assess the presence of sediment. No sediment was found and, accordingly, a sample was not collected from CB-26 and the upgradient CB-5.

2.6.2.3 Outside Characterization Gamma Walkover Surveys

As described in Section 2.4, radiological gamma walkover surface surveys were performed in the Lower Level in accordance with the OCP during 2001 through 2004. Forty-four survey units (LA-1101 through LA-1144) were identified for the walkover survey in the Railbed Area based on historical documentation, historical SPUD and surface survey data, and field reconnaissance activities. These survey units were subdivided into sections of 50 by 50 feet to facilitate the survey and ensure more accurate coverage. The results of the walkover surveys are depicted in Figures 2-2a and 2-2b. (Note: Only those survey units that are part of the characterization investigation area, as described later in this section, are shown.) Approximately 11.6 acres in the Railbed Area was surveyed. Areas adjacent to the K5 Retention Basin were not included in this survey because of interference caused by elevated background radiation from the K5 Retention Basin structure. The highest concentrations detected were located north of the K5, K6, and K7 areas on and adjacent to the Railbed Area roadway. However, widespread surface radioactive contamination is present along and adjacent to the former railbed throughout most of the Railbed Area.

In general, the walkover surveys conducted in 2001 through 2004 are consistent with the historical SV, SPUD, and surface survey data collected in the Railbed Area. However, the recent walkover surveys covered portions of the Railbed Area (e.g., Riverview Road area in and near survey grids LA1142 and LA1143 and the former railbed and hillside south and southeast of the Railbed Area) that were not included in the historical SPUD and surface surveys. A discrete area of elevated activity was detected along Riverview Road. The areal extent of the historical elevated surface survey data is slightly larger than the areal extent of elevated activity identified by recent walkover surveys and may be due to natural decay of the radioactivity previously detected and/or differences in instruments and identified background activity. The locations and results of the historical SPUD and surface surveys, overlaid on the 2001 through 2004 walkover surveys, are shown in Figures 2-2a and 2-2b.

Four 150- by 150-foot survey units (numbered LA-1701 through LA-1704) were identified for the walkover survey in the Lower Level Parking Lot Area based on historical documentation, historical SPUD and surface survey data, and field reconnaissance activities. These survey units were further subdivided into sections of 50 by 50 feet to facilitate the survey and ensure more accurate coverage. The results of the walkover surveys are depicted in Figure 2-3. (Note: Only those portions of the four survey units that are part of the characterization investigation area, as described above, are shown.) Approximately 1.8 acres was surveyed in the Parking Lot. Several discrete, isolated areas of elevated activity (greater than twice background) were identified in two of the four survey units. No elevated activity greater than twice background was identified in the third survey unit or the surveyed area south of the survey units.

The recent walkover surveys did not identify an area of elevated surface activity within the paved Parking Lot area as large as that identified during the historical SPUD and surface surveys. However, this could be a result of resurfacing of the Parking Lot and burial of contaminated soil at depth. In addition, the recent walkover surveys identified several discrete areas of elevated surface activity in low-lying areas near the base of the perimeter slope of the Parking Lot. The locations and results of the historical SPUD and surface surveys are shown in Figure 2-3, overlaid on the recent walkover surveys.

2.7 Upper Level Summary

The Upper Level (see Figure 1-3) consists of two sub-areas that are associated with historical SPRU activities—the Upper Level Hillside Area (i.e., the hillside area west of Buildings H2 and G2 outside the KAPL security fence) and the SPRU process buildings H2 and G2, H2/G2 Pipe Tunnel, the Tank Farm, underground tank vaults, and associated land areas (inside the KAPL security fence). These areas lie to the west/northwest of the main KAPL process areas, near the western boundary of the site. The Upper Level also encompasses ancillary facilities, such as the Building H1 Pump House and Cooling Tower and the Hillside Sump. The buildings and structures and the soils beneath each of the structures are excluded from the outside characterization area; however, soils surrounding these structures are included.

The following subsections describe historical operations associated with the Upper Level SWMUs and previous investigation results.

2.7.1 Description of Upper Level SWMUs and Associated Facilities

The Upper Level encompasses three SWMUs: H2 Processing Facility (SWMU-030), H2 Tank Farm (SWMU-031), and the Pipe Tunnels (SWMU-057), as described in the following subsections and shown in Figure 1-3. Building G2 and the Hillside Area are also described.

2.7.1.1 H2 Processing Facility

Building H2 (see Figure 1-3), located at the northwest end of the Upper Level, was constructed in the late 1940s to house SPRU liquid waste processing equipment and storage tanks (NYSDEC, 1998; DOE, 1999a; DOE, 1999b; CH2M HILL, 2003). The building resides on a 2- to 3-foot-thick concrete foundation slab and is constructed of concrete walls more than 2 feet thick. Copper water stops were installed at all construction joints. The building consists of approximately 27,900 square feet of floor space on three main floors (332-, 319-, and 308-foot levels; elevation above mean sea level [amsl]). Nearly 70 percent of this space is located below grade. The majority of liquid waste processing equipment in the building was fabricated of stainless steel and resides on two floors at the 319- and 308-foot levels. Liquid waste processing area walls and ceilings were coated with a sealant or cocooning material. The floor areas are generally lined with stainless steel floor pans. Foundation footing drains are plumbed to a sump system in a concrete catch basin, downslope of the buildings, that pumps collected water back into Building H2 for processing to remove radionuclides before release. In an effort to reduce the amount of rainwater collected by the hillside sump system, the area around Building H2 was covered with an impermeable membrane. However, rainwater continues to accumulate in the hillside sump.

Chemical wastes from SPRU operations in Building G2 were processed in Building H2 during the early 1950s. Since then, the unit has been used to process KAPL laboratory wastewater (unrelated to SPRU). The chemical wastes were transferred to one of five stainless steel neutralizers, using stainless steel drain lines, where the wastes were neutralized, distilled, and/or concentrated. The neutralizer bottoms were transferred to the H2 Tank Farm (SWMU-031) for storage, the organic distillate was collected and containerized, and excess water generated during concentration was processed with other wastewaters before discharge.

SPRU wastewaters were accumulated in one of three stainless steel 10,000-gallon storage tanks. Accumulated wastewater was transferred to one of two evaporators, where it was concentrated 400-fold. Distillate from the evaporators was collected in a receiver tank, where it was monitored and, if within acceptable Mohawk River Advisory Committee limits, discharged to the Mohawk River via the K5 Retention Basin and/or the stormwater drainage system. Evaporator bottoms, referred to as slurry waste, were dried in one of two drum dryers and containerized in 55-gallon drums. Containerized slurry waste was staged at an undetermined location adjacent to Building H2 before being placed in storage at the Former Slurry Drum Storage Area in the Land Area, or the Former K6 Storage Pad, or the Railroad Staging Area in the Lower Level.

The evaporative wastewater processing technique was used from 1950 to 1964. After 1964 wastewater was processed using filtration and ion exchange before discharge. Discharge of treated wastewater ceased in 1977 when a water reuse system was installed. This system is still operational.

In addition to liquid waste processing, solid wastes were compacted in Building H2. The solid waste compaction process began in 1972, subsequent to the transfer of equipment from Building L7 to Building H2. The solid waste compaction operation in Building H2 was shut down in 2000.

2.7.1.2 H2 Tank Farm

The subsurface H2 Tank Farm abuts the eastern side of Building H2. One 5,000-gallon and six 10,000-gallon stainless steel storage tanks are located in seven underground concrete vaults (NYSDEC, 1998; DOE, 1999a; DOE, 1999b; CH2M HILL, 2003). The vaults are in a row in a north-south direction on the east side of the H2 Processing Facility (see Figure 1-3 for location). The floors and walls of these vaults are constructed of concrete ranging from 2 to 8 feet thick. A waterproof sealant was applied to the vault floors and walls, and copper water-stops were installed during construction. An emulsified asphalt, waterproof coating was applied to the exterior of the vault foundations. The vault ceilings are constructed of upright and inverted concrete “T” blocks that are covered with tarpaper, asphalt, and approximately 9 feet of fill. Sealed vault access-ways and tank vent lines penetrate the ground surface. An impermeable membrane, held in place with crushed rock, was placed above the tank vaults at ground surface to reduce groundwater infiltration by diverting rain and snow melt away from directly over the tank vaults. Visual inspections, conducted in 1989 and 1998, of the tanks and vaults showed that they were intact and in good condition. Groundwater seeps were observed in several vault ceilings.

Processed separations material and waste were accumulated within the various tanks until SPRU research was concluded in 1953. Some materials and waste remained in storage until the mid-1960s, when it was removed, processed via evaporation, and transported offsite for disposal. Subsequent to SPRU operations, several tanks were used to accumulate and store liquid waste from Knolls Site materials and chemistry laboratories. Before 1964 upset conditions were documented that resulted in the release of the tanks’ contents through vents in the tank vaults to the ground surface above. The activity in the soil surrounding the hatch cover to the 509C tank was estimated at 0.1 curies of fission products and 8 milligrams of plutonium-239. Radiation surveys measured up to 60 mR/hr on the ground surface within 3 feet from the 509C hatch cover. Approximately 10 inches of soil was removed within the general spill area. During 1978 all tanks were drained and removed from service. Tank heels remain today. Tank heels are residual waste that remains in storage tanks after as much of the liquid has been removed as can be using available equipment and technology. This includes liquids, suspended solids, and sludges that have settled out of the liquid. Tank heels are typically highly radioactive because the solids and sludges tend to concentrate the radioactive material.

2.7.1.3 Pipe Tunnel

This unit consists of a pipe tunnel that is located in and connects the basements of Buildings G2 and H2 (see Figure 1-3). The tunnel is more than 5 feet wide and 8 feet high (NYSDEC, 1998; DOE, 1999a; DOE, 1999b; CH2M HILL, 2003). Tunnel walls, floors, and ceilings are constructed of concrete more than 6 inches thick. A waterproof sealant was applied to the unit's floor and walls during construction. Copper water stops and asphalt filler were also installed at all construction joints. With the exception of an expansion joint at the north end of Building G2, the tunnel appeared intact and in good condition during a 1989 visual inspection. Groundwater intrusion was observed at the expansion joint.

The tunnel was constructed to house industrial and wastewater drain lines from operations in Buildings G2, G1, and E1. Wastewater accumulation was occasionally reported on the floor of this tunnel.

2.7.1.4 Building G2

Building G2 (see Figure 1-3) was built to house the SPRU pilot plant and was used for research and development between 1950 and 1953 (DOE, 1999a; DOE, 1999b; CH2M HILL, 2003). The separation processes involved chemically separating uranium and plutonium from irradiated fuel and used large quantities of chemicals, including solvents. The byproduct (waste) from the separations process was highly radioactive mixed fission products. Waste was pumped from Building G2 to Building H2 through the underground pipe tunnel. The SPRU facilities inside Building G2 were decommissioned in 1953. Decontamination activities were conducted inside Building G2 throughout the 1950s and 1960s. Adjacent to Building G2 are the foundations of an auxiliary building (Building G3) and a ventilation discharge. Building G3 was 14 by 22 feet in area, and the foundation extends 10 feet below grade. The stack foundation was 16 by 20 feet solid concrete, extending 18 feet below grade.

2.7.1.5 Hillside Area

The Upper Level Hillside Area lies outside the security fence to the west of Buildings G2 and H2 and east of the Lower Level Access Road (see Figure 1-3). A drain system around the footings of H2 directs groundwater from the building foundation to a concrete catch basin on the Upper Level hillside west of Building H2 (CH2M HILL, 2003). The water is pumped back to Building H2, processed to remove low levels of residual radioactivity, and discharged. The catch basin overflows into a concrete-lined drainage ditch that runs along the east side of the Lower Level Access Road during periods of heavy precipitation.

2.7.2 Previous Investigations in the Upper Level

Previous investigations included the KAPL Soil Program, SPRU RFA SV, outside characterization gamma walkover survey, and the KAPL 1973 soil investigation; these are described in the following sections.

2.7.2.1 KAPL Soils Program

KAPL performed radiological surface walkover and SPUD surveys of the Upper Lever to determine the extent of radioactive contamination from historical operations, including SPRU operations (KAPL, 1993). The *Outside Areas Historical Site Assessment* (CH2M HILL, 2003) presents detailed gamma walkover survey and SPUD data for the Upper Level. These data are summarized in Figure 2-4, overlaid on the 2001 through 2004 walkover survey data.

2.7.2.2 SPRU RFA SV

As part of the RFA SV, 43 soil samples were collected from 13 soil borings throughout the Upper Level (CH2M HILL, 2002), as shown in Figure 2-7. Boring depths varied up to approximately 30 feet bgs. Chemical data were collected at various intervals for each boring. Elevated levels of radioactivity were generally limited to the base of the building foundation excavations and drains. The 0- to 2-foot-bgs interval was screened onsite for gamma-emitting radionuclides. Only one sample (at soil boring B5701 shown in Figure 2-7) had concentrations of cesium-137 greater than 1.0 pCi/g. The maximum cesium-137 concentration in soil boring B5701 was 36 pCi/g at 22 to 24 feet bgs. This borehole was completed as well MW-SV3, which later yielded cesium-137 concentrations greater than 500 pCi/g from particulates in a groundwater filtrate sample (CH2M HILL, 2002). Groundwater samples were also screened onsite for gross beta-gamma radioactivity.

2.7.2.3 Outside Characterization Gamma Walkover Survey

As described in Section 2.4, radiological gamma walkover surface surveys were performed in the Upper Level in accordance with the OCP during 2001 through 2004. Five survey units (numbered LA-1301 through LA-1305) were identified for the walkover survey outside of the Upper Level security fence in the Upper Level hillside area based on historical documentation, historical SPUD and surface survey data, and field reconnaissance activities. Similarly, eight survey units (numbered LA-1401 through LA-1408) were identified for the walkover survey adjacent to Buildings H2 and G2 and associated structures inside the Upper Level security fence. Three of these grids overlap with three of the survey units for the hillside area because the Upper Level security fence divides these units. An additional survey unit (LA-1501) was identified for the walkover survey associated with the H2 underground tank vaults. These survey units were subdivided into sections of 50 by 50 feet to facilitate the survey and ensure more accurate coverage. The results of the walkover survey in the Upper Level hillside area are depicted in Figure 2-4. Walkover surveys were not performed throughout the Upper Level inside the security fence (e.g., surrounding Buildings H2 and G2) because of elevated background radioactivity from the buildings; these areas were surveyed to the extent possible in conjunction with the outside characterization activities in 2004. Approximately 1.9 acres in the Upper Level was surveyed. Several small areas of elevated activity (i.e., greater than twice background) were detected at various locations in the Upper Level, and one larger area of elevated activity was detected on the hillside west of H2.

In general, the walkover surveys conducted in 2001 through 2004 were consistent with the historical SV, SPUD, and surface survey data collected in the Upper Level. The exceptions are (1) some isolated points of elevated activity between Buildings G2 and H2 that were not surveyed during the recent walkover surveys because of elevated background activity in the area and (2) an area of elevated surface activity extending down the hillside from the Upper Level (northern part) to the Lower Level that was not detected during the recent walkover surveys. The latter may be due to natural decay of the radioactivity previously detected and/or differences in instruments and identified background activity. The locations and results of the historical SPUD and surface surveys, overlaid on the recent walkover surveys, are shown in Figure 2-4. Elevated gamma walkover survey data may be attributed to former waste management practices, including spills and releases from waste containers. Slurry waste containers were staged in the Upper Level prior to transport to the Former Slurry

Drum Storage. Elevated walkover survey data immediately adjacent to the east side of Building G2 may be attributed to one of the following scenarios (CH2M HILL, 2004g).

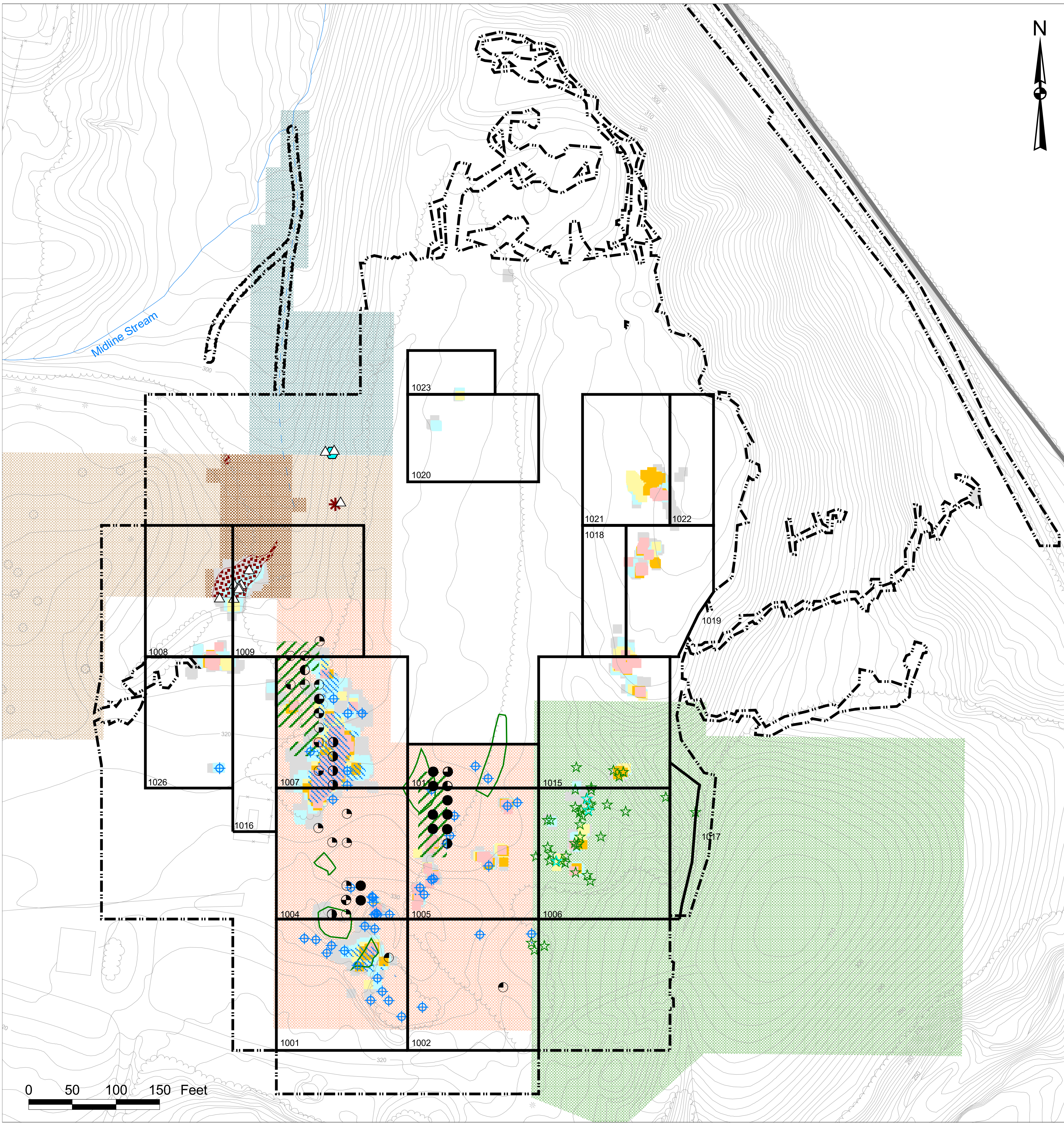
- Scenario One: Historical spills from the Batch Count Extraction Cell, at the 337-foot elevation level, could have migrated down the wall and onto the building footer. There is floor area in the cell shielded with lead bricks from previous area spills.
- Scenario Two: The floor drain located under the floor near the Batch Count Extraction Cell may have lost its integrity, allowing radioactive contamination to leach out.
- Scenario Three: Waste management activities, such as drum staging, were performed in the alley between Building G2 and Buildings E5 and E6. A drum temporarily staged in the area may have ruptured or leaked.

2.7.2.4 KAPL 1973 Soil Investigation

In 1973 KAPL conducted an investigation to determine the presence of radioactive contamination in the soil around the SPRU facilities in the Upper Level (KAPL, 1974). Soil borings were systematically advanced adjacent to Buildings G2 and H2. The investigation included soils adjacent to the footing drain systems. A review of the sampling data shows: (1) the absence of radioactive contamination in the soil outside the building footings and (2) the absence of a significant source of activity (exceeding 10 pCi/g of cesium-137) in the soil outside the footing drains to contribute to the activity in the Building H2 hillside sump water. There is a possibility that the footing drains around Building H2 may contain the contamination. Low-level contamination detected near the surface near Building H2 can probably be attributed to surficial spills that took place in KAPL’s early history.

Deep soil borings were also systematically advanced adjacent to the H2 Tank Farm vaults along the east side. A review of the sampling data shows the absence of radioactive contamination in soil outside the H2 Tank Farm footings.

Figures



1981 Northfield Radiological Survey (Excerpts from Y-RAD-10257)

- Surface SPUD survey data >= 2x background (Background is ~250 cpm)
- Subsurface SPUD survey data at xx meters > 60 cpm (Background = 20 +/- 10 cpm)
  - 0.5 M
  - 1.0 M
  - 1.5 M
  - 2.0 M
- Surface walkover survey data >= 2x background (Background is ~250 cpm)
- Indications of possible activity

1985 Northfield Radiological Survey (Background = 30 +/- 10 cpm)

- Surface SPUD survey data >= 2x background
- Subsurface SPUD survey data at 0.5 meters >= 2x background

1987 Northfield Perimeter Surface Survey (Background = 350 cpm)

- Surface SPUD survey data >= 2x background
- Surface walkover survey data >= 2x background

1988 Midline Stream Survey

- Surface SPUD data >= 20 pCi per gram
- Surface walkover survey data >= 2x background (Background = 300 cpm)

2002-2003 Walkover Survey Data

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,250 - 31000 cpm (3-4x Background)
- 31,000 - 38,750 cpm (4-5x Background)
- 38,750 - 46,000 cpm (5-6x Background)
- > 46,000 cpm (> 6x Background)

- Streams or Drainage
- Ephemeral Drainage
- Topographic Contour (2 foot interval)
- 1001 Survey Grid Identifier
- Potential Wetland Boundary
- Extent of 2002 through 2003 Surface Walkover Survey

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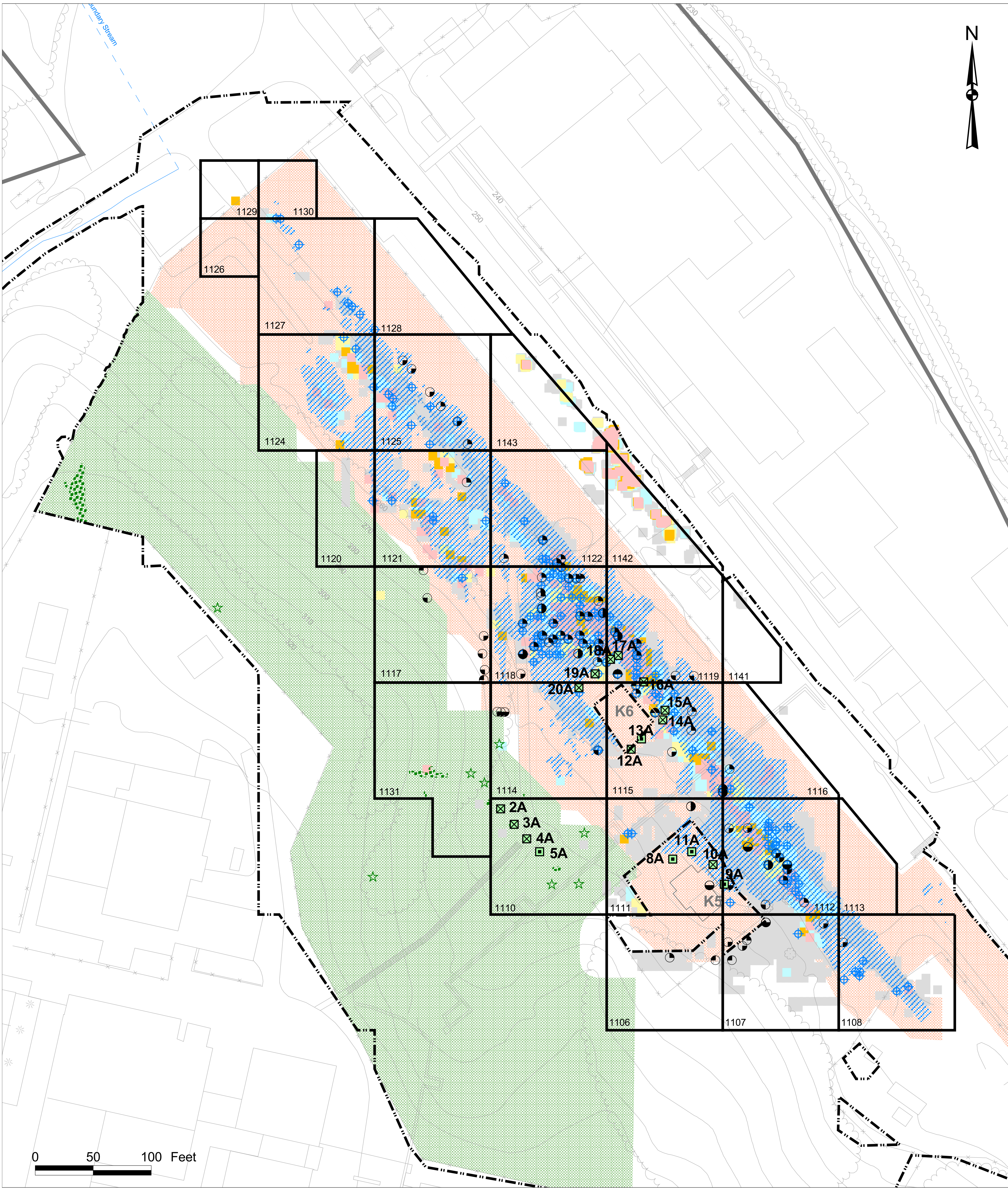
SPRU RADIOLOGICAL CHARACTERIZATION REPORT

HISTORICAL SPUD DATA AND RADIOLOGICAL WALKOVER SURVEY DATA FOR THE LAND AREA

Figure 2-1
Prepared By: ASPOSATO
Date: March 30, 2006

CH2MHILL

Notes:
1) Some discrete elevated measurements may not appear color coded appropriately due to scale of map. Where this occurs, Drawing SP-03012, "NaI Elevated measurements" identifies the location of the discrete elevated measurement.
2) Color-coded squares represent discrete range of gamma radiation within a 5x5 foot area.
3) Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.
4) SPUD = Surface Penetrating Underground Detector



1984 Radiological Survey

- Surface SPUD survey data >= 2x background (Background = 30 +/- 10 cpm)
- Subsurface SPUD survey data at xx meters >= 2x background (Background = 20 +/- 10 cpm)
  - 0.5 M
  - 1.0 M
  - 1.5 M
  - 2.0 M
- Surface walkover survey data >= 2x background (Background is ~100-200 cpm)
- Core Boring (Cs-137 < 3 pCi/g)
- Core Boring (Cs-137 >= 3 pCi/g)

1985 Lower Level Hillside Survey (Background = 200 cpm)

- Surface SPUD survey data >= 2x background
- Surface walkover survey data >= 2x background

2001-2004 Walkover Survey Data

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,250 - 31000 cpm (3-4x Background)
- 31,000 - 38,750 cpm (4-5x Background)
- 38,750 - 46,000 cpm (5-6x Background)
- > 46,000 cpm (> 6x Background)

- Topographic Contour (10 foot interval)
- 1101 Survey Grid Identifier
- Potential Wetland Boundary
- Extent of 2001 through 2004 Surface Walkover Survey

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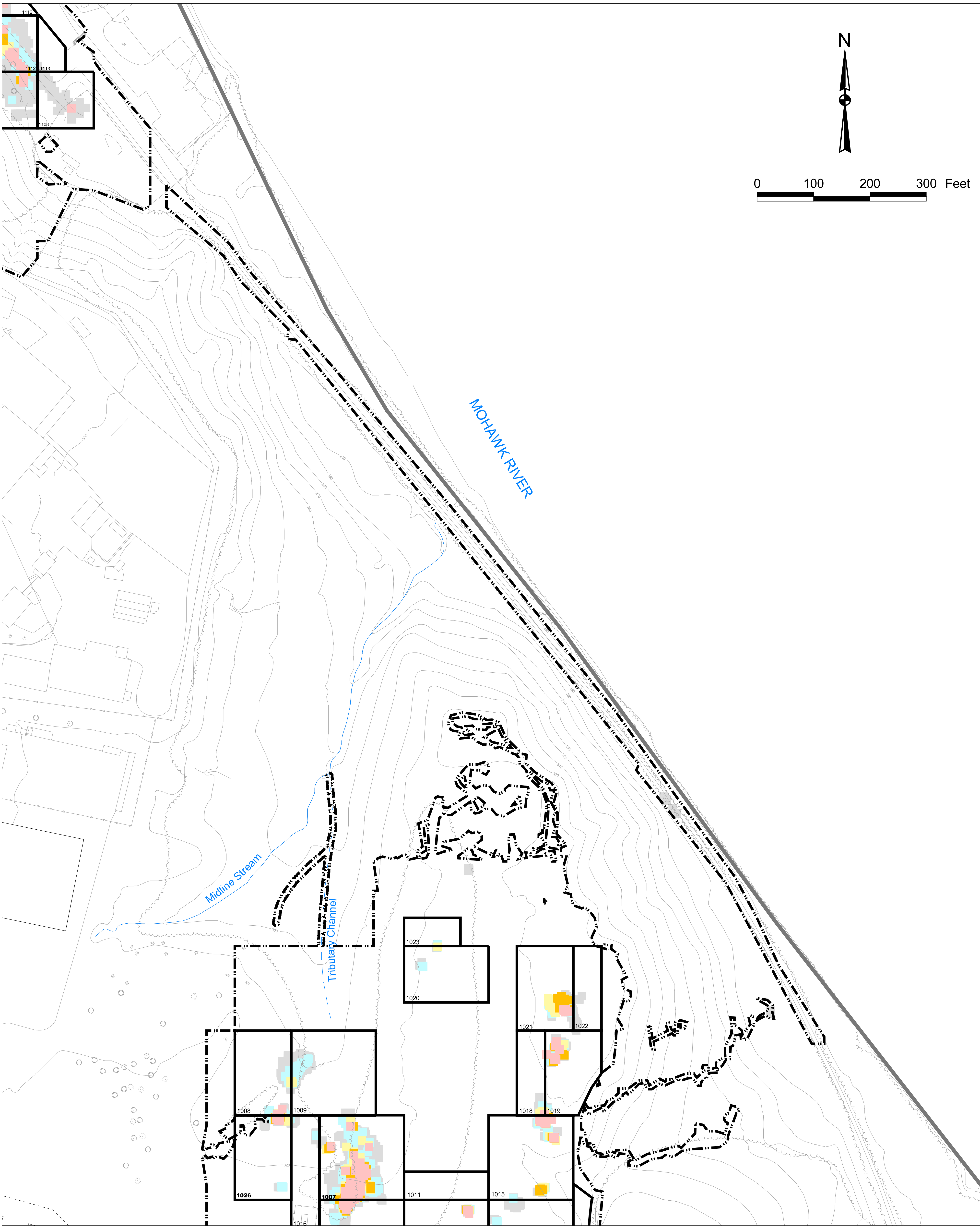
SPRU RADIOLOGICAL CHARACTERIZATION REPORT

HISTORICAL SPUD DATA AND RADIOLOGICAL WALKOVER SURVEY DATA FOR THE LOWER LEVEL RAILBED AREA

Figure 2-2a
Prepared By: ASPOSATO
Date: March 23, 2006

CH2MHILL

Notes:
1) Some discrete elevated measurements may not appear color coded appropriately due to scale of map. Where this occurs, Drawing SP-03012, "NaI Elevated measurements" identifies the location of the discrete elevated measurement.
2) Color-coded squares represent discrete range of gamma radiation within a 5x5 foot area.
3) Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.
4) SPUD = Surface Penetrating Underground Detector



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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

RADIOLOGICAL WALKOVER SURVEY DATA FOR THE LOWER LEVEL RAILBED AREA

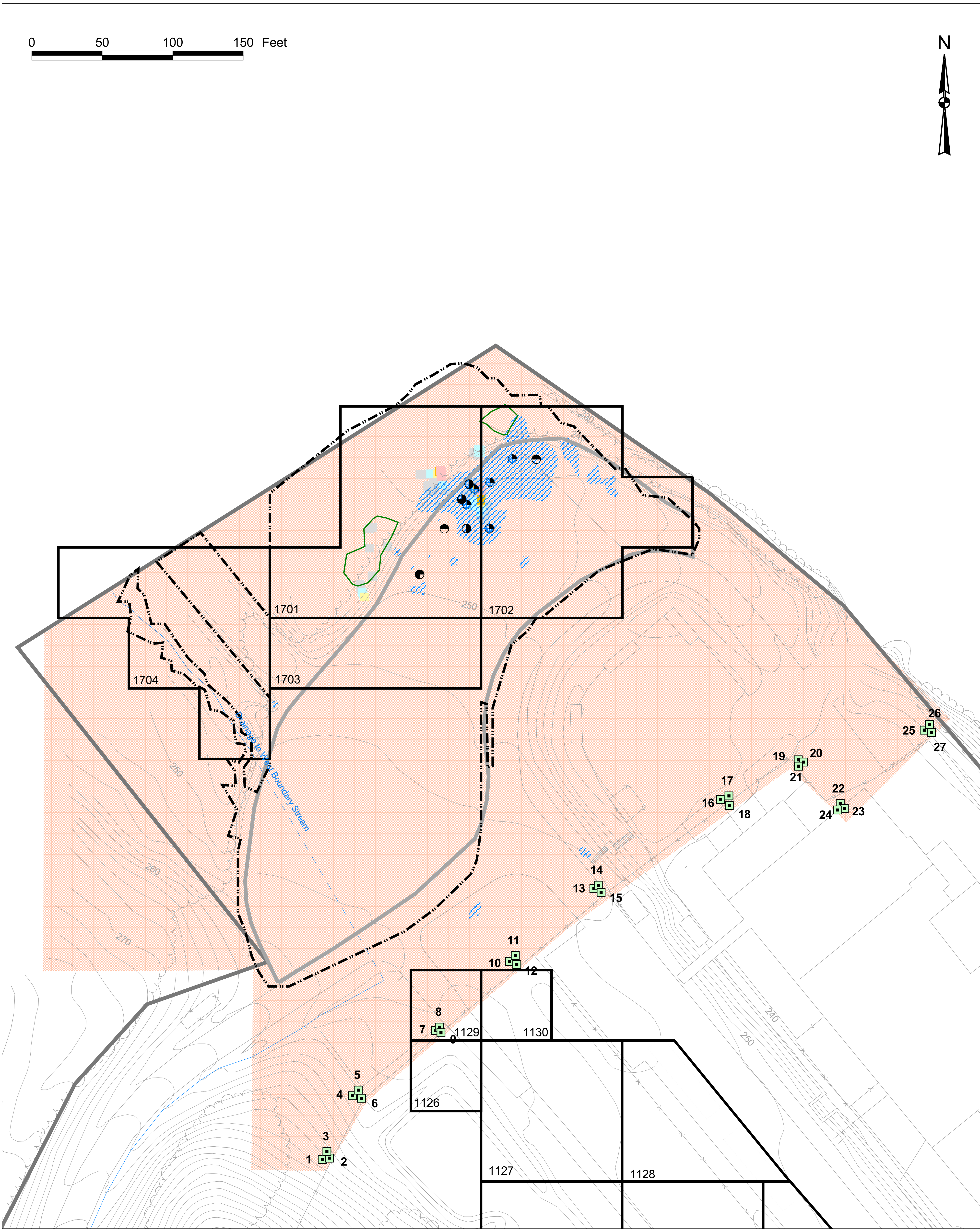
Figure 2-2b
Prepared By: ASPOSATO
Date: March 23, 2006

CH2MHILL

2001-2004 Walkover Survey Data
Gamma Radiation
- 15,501-23,250 cpm (2-3x Background)
- 23,250 - 31000 cpm (3-4x Background)
- 31,000 - 38,750 cpm (4-5x Background)
- 38,750 - 46,000 cpm (5-6x Background)
- > 46,000 cpm (> 6x Background)

- Topographic Contour (10 foot interval)
- 1101 Survey Grid Identifier
- Potential Wetland Boundary
- Extent of 2001 through 2004 Surface Walkover Survey

Notes:
1) Some discrete elevated measurements may not appear color coded appropriately due to scale of map. Where this occurs, Drawing SP-03012, "NaI Elevated measurements" identifies the location of the discrete elevated measurement.
2) Color-coded squares represent discrete range of gamma radiation within a 5x5 foot area.
3) Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.
4) SPUD = Surface Penetrating Underground Detector



1984 Radiological Survey

- Surface SPUD survey data >= 2x background (Background is ~200 cpm)
- Subsurface SPUD survey data at xx meters >= 2x background (Background = 30 +/- 10 cpm)
  - 0.5 M
  - 1.0 M
  - 1.5 M
  - 2.0 M
- Surface walkover survey data >= 2x background (Background is ~200 cpm)
- Core Boring (Cs-137 < 3 pCi/g)

2001-2004 Walkover Survey Data

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,250 - 31000 cpm (3-4x Background)
- 31,000 - 38,750 cpm (4-5x Background)
- 38,750 - 46,000 cpm (5-6x Background)
- > 46,000 cpm (> 6x Background)

- Topographic Contour (2 foot interval)
- Parking Lot Boundary
- 1701 Survey Grid Identifier
- Potential Wetland Boundary
- KAPL Property Boundary
- Extent of 2001 through 2004 Surface Walkover Survey

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

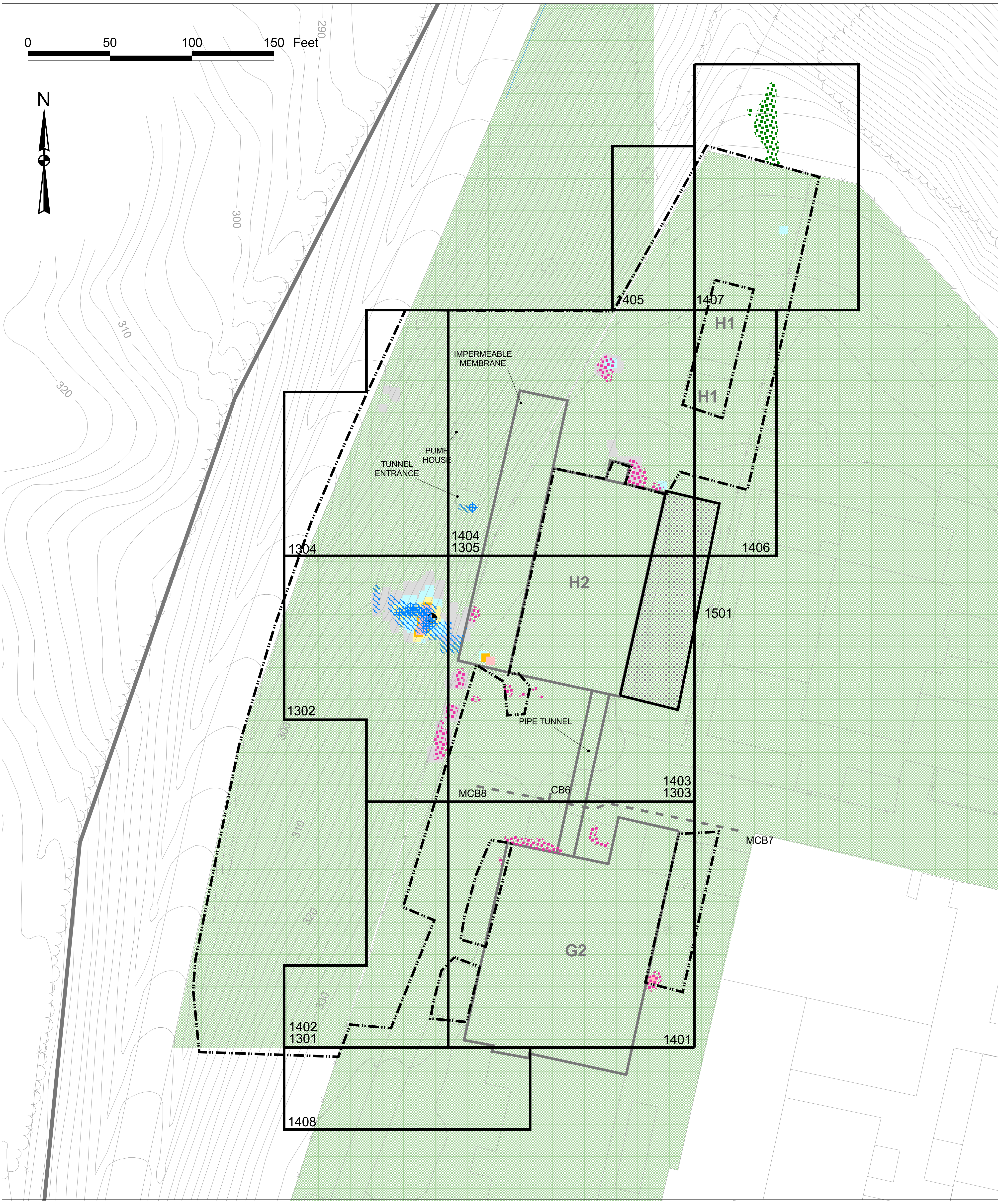
HISTORICAL SPUD DATA AND RADIOLOGICAL WALKOVER SURVEY DATA FOR THE LOWER LEVEL PARKING LOT AREA

Figure 2-3

Prepared By: ASPOSATO

Date: March 22 2006

Notes:
1) Some discrete elevated measurements may not appear color coded appropriately due to scale of map. Where this occurs, Drawing SP-03012, "NaI Elevated measurements" identifies the location of the discrete elevated measurement.
2) Color-coded squares represent discrete range of gamma radiation within a 5x5 foot area.
3) Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.
4) SPUD = Surface Penetrating Underground Detector



1985 Radiological Survey
- Surface SPUD survey data >= 2x background (Background <= 500 cpm)
- Surface walkover survey data >= 2x background (Background <= 500 cpm)
- Subsurface SPUD survey data at 0.5 meters >= 2x background (Background = 30 +/- 10 cpm)

1993 Upper Level Surface Scan
- Surface walkover survey data >= 2x background (Background = 800 cpm)

1985 Lower Level Hillside Survey
- Surface walkover survey data >= 2x background (Background = 200 cpm)

2001-2004 Walkover Survey Data
Gamma Radiation
- 15,501-23,250 cpm (2-3x Background)
- 23,250 - 31000 cpm (3-4x Background)
- 31,000 - 38,750 cpm (4-5x Background)
- 38,750 - 46,000 cpm (5-6x Background)
- > 46,000 cpm (> 6x Background)

- Topographic Contour (2 foot interval)
- 1301 Survey Grid Identifier
- Underground Tank Vaults
- Extent of 2001 through 2004 Surface Walkover Survey

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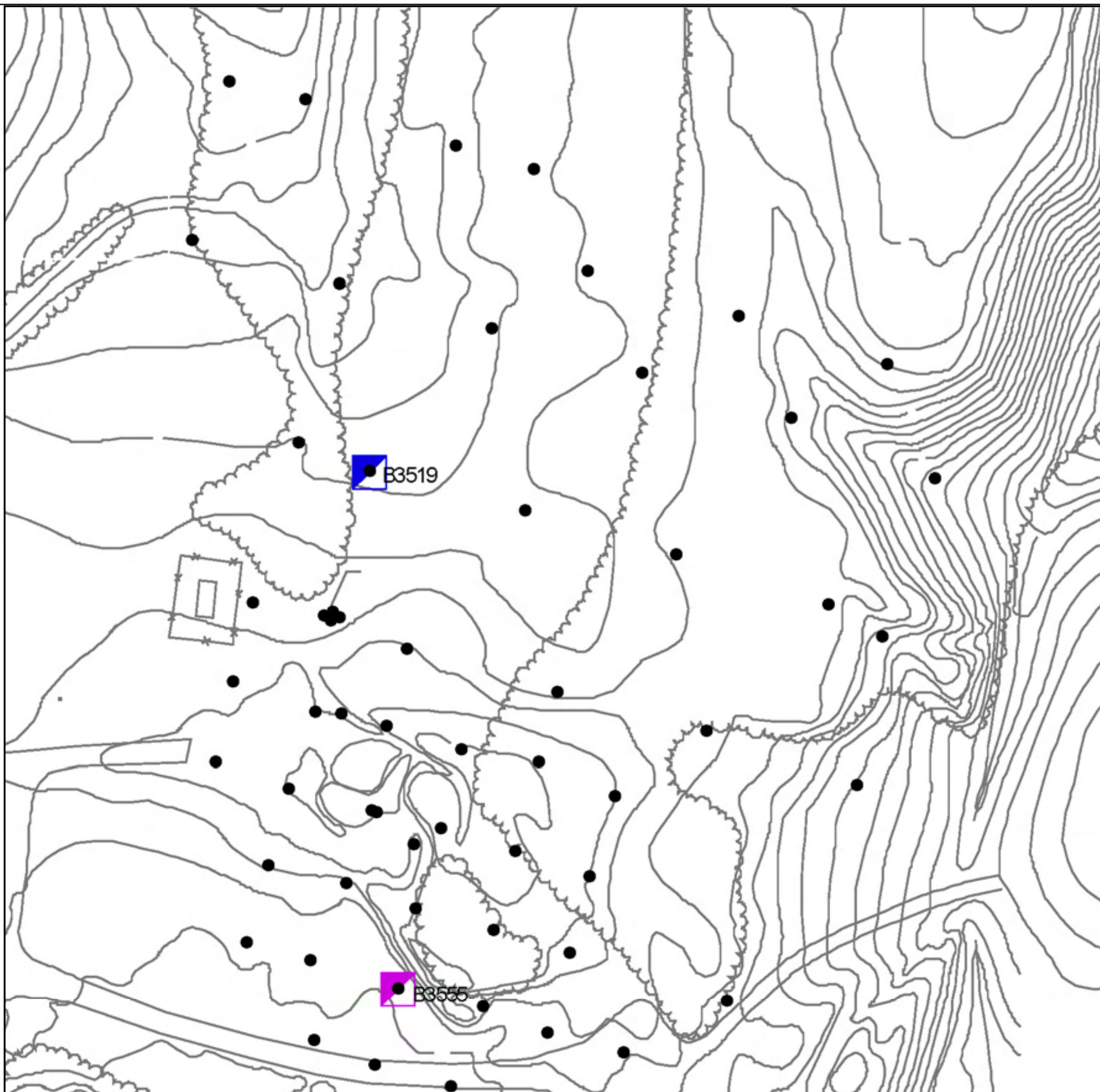
SPRU RADIOLOGICAL CHARACTERIZATION REPORT

HISTORICAL SPUD DATA AND RADIOLOGICAL WALKOVER SURVEY DATA FOR THE UPPER LEVEL

Figure 2-4
Prepared By: ASPOSATO
Date: March 22, 2006

CH2MHILL

Notes:
1) Some discrete elevated measurements may not appear color coded appropriately due to scale of map. Where this occurs, Drawing SP-03012, "NaI Elevated measurements" identifies the location of the discrete elevated measurement.
2) Color-coded squares represent discrete range of gamma radiation within a 5x5 foot area.
3) Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.
4) SPUD = Surface Penetrating Underground Detector



LEGEND

- ● SPRU Sampling Visit Soil Boring
- Cs-137 Exceeds 1 pCi/g
- Soil Potentially Exceeds TCLP

N

SCALE
20 0 20 40 60 Feet

SPRU Sampling Visit Screening Radioactivity above 1 pCi/g

Bore-hole	Upper Depth	Lower Depth	Radio-nuclide	Activity	Uncer-tainty
	Feet bgs			pCi/g	
B3519	2	4	Cs-137	3.7	0.6

Soil Potentially Exceeding TCLP Criteria

Bore-hole	Upper Depth	Lower Depth	Chem-ical	Solid Concen-tration	Max. TCLP Concen-tration	TCLP Criteria
	Feet bgs			mg/kg	mg/L	
B3555	2	4	Lead	189	9.45	5

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

LAND AREA SAMPLING VISIT RADIOLOGICAL DATA SUMMARY

Figure 2-5
Prepared By: RMCCLINTOCK
Date: June 6, 2005

CH2MHILL

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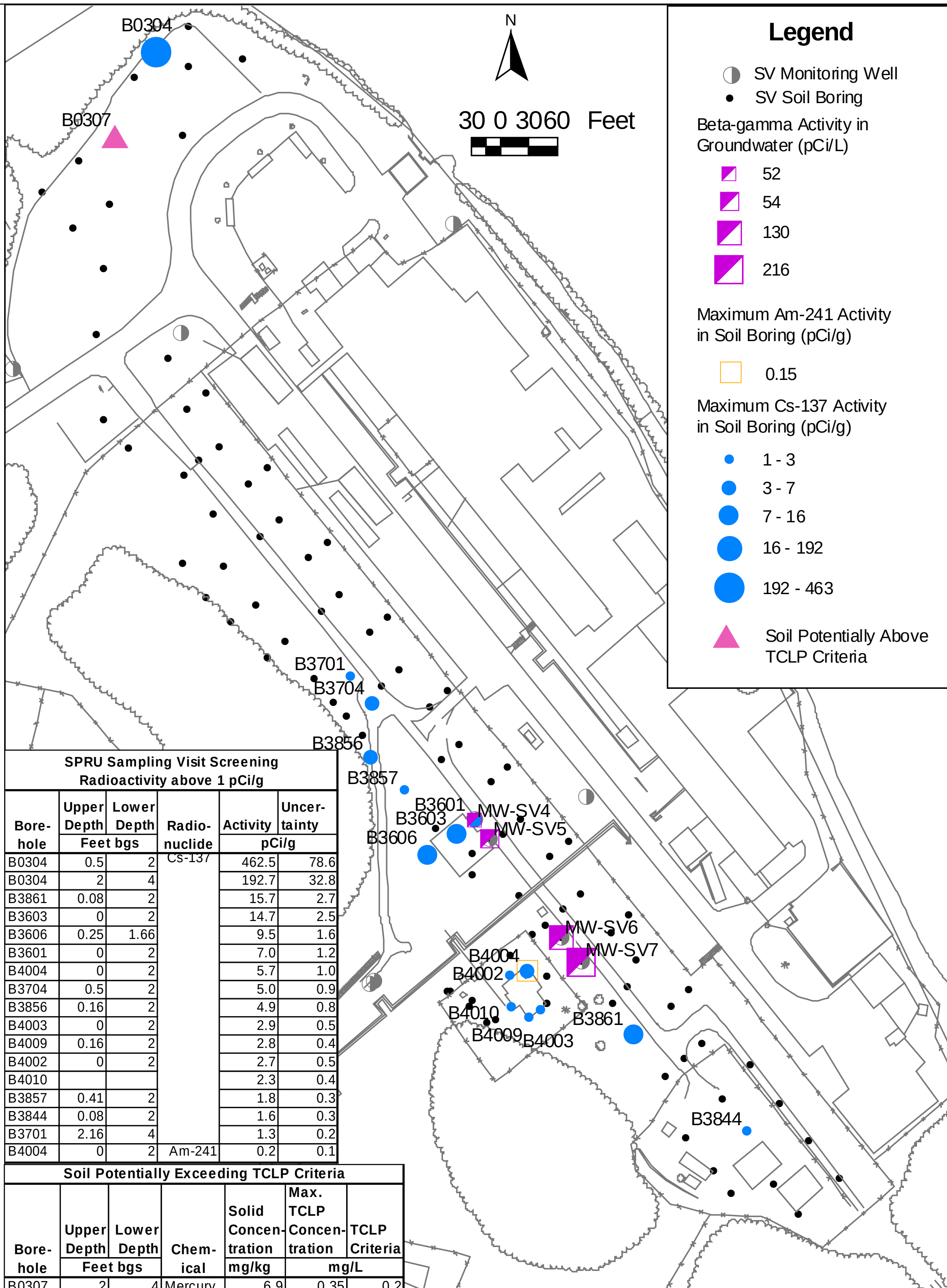

SPRU Sampling Visit Screening Radioactivity above 1 pCi/g

Bore-hole	Upper Depth Feet bgs	Lower Depth Feet bgs	Radio-nuclide	Activity pCi/g	Uncer-tainty pCi/g
B0304	0.5	2	Cs-137	462.5	78.6
B0304	2	4		192.7	32.8
B3861	0.08	2		15.7	2.7
B3603	0	2		14.7	2.5
B3606	0.25	1.66		9.5	1.6
B3601	0	2		7.0	1.2
B4004	0	2		5.7	1.0
B3704	0.5	2		5.0	0.9
B3856	0.16	2		4.9	0.8
B4003	0	2		2.9	0.5
B4009	0.16	2		2.8	0.4
B4002	0	2		2.7	0.5
B4010				2.3	0.4
B3857	0.41	2		1.8	0.3
B3844	0.08	2		1.6	0.3
B3701	2.16	4		1.3	0.2
B4004	0	2	Am-241	0.2	0.1

Soil Potentially Exceeding TCLP Criteria

Bore-hole	Upper Depth Feet bgs	Lower Depth Feet bgs	Chem-ical	Solid Concen-tration mg/kg	Max. TCLP Concen-tration mg/L	TCLP Criteria mg/L
B0307	2	4	Mercury	6.9	0.35	0.2

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

LOWER LEVEL SAMPLING VISIT RADIOLOGICAL DATA SUMMARY

Figure 2-6
Prepared By: RMCCLINTOCK
Date: June 6, 2005

CH2MHILL

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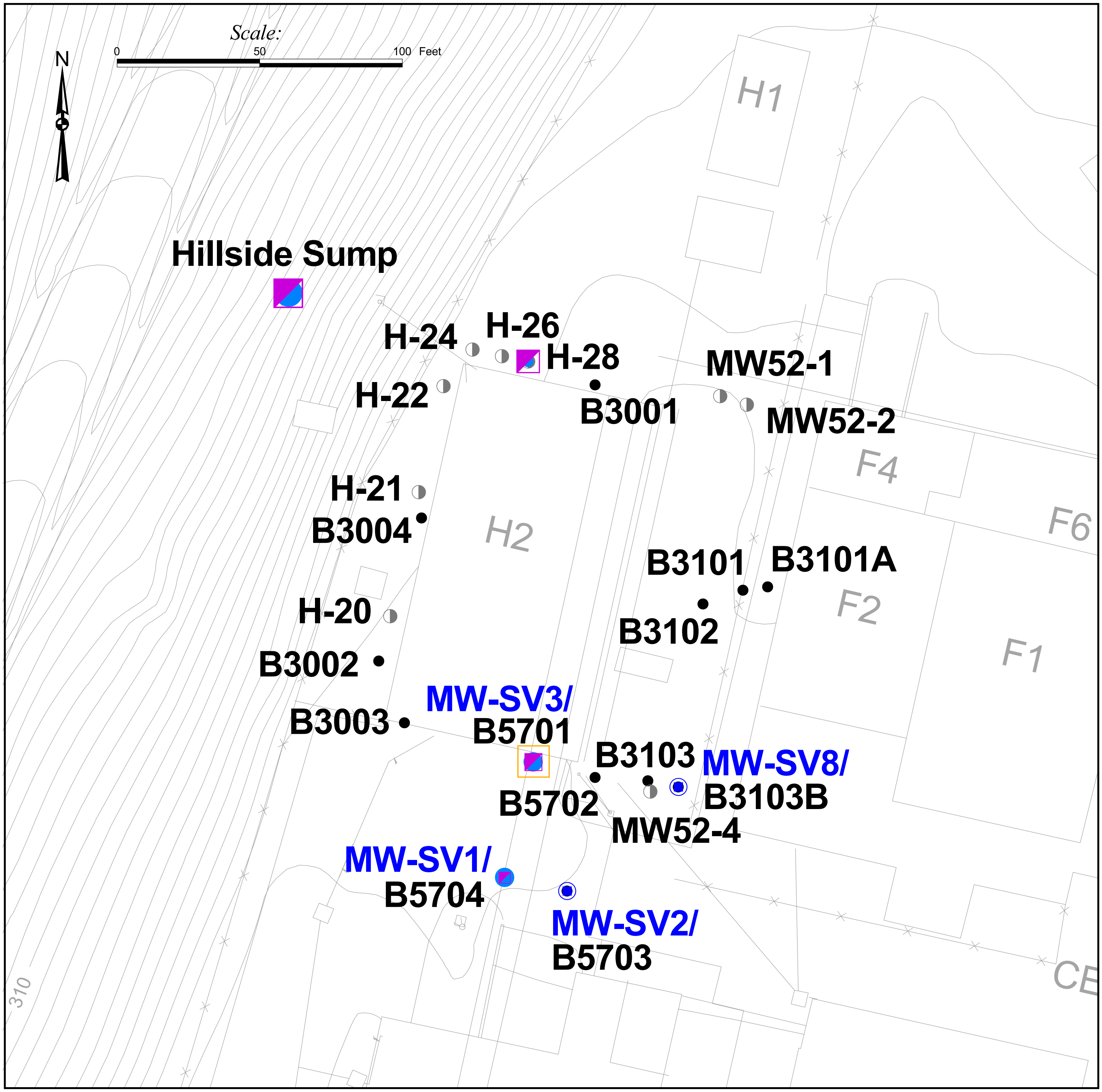

SV Monitoring Well
SV Soil Boring
Existing RCRA SV Well/Boring

Gross Beta-Gamma Activity (pCi/L) in Groundwater
19.4 47.7 263 5250

Cs-137 Activity (pCi/L) in Groundwater
17.5 102 4480

Cs-137 Activity (pCi/g) in Soil Boring
36.4

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

UPPER LEVEL SAMPLING VISIT RADIOLOGICAL DATA SUMMARY

Figure 2-7
Prepared By: ASPOSATO
Date: June 6, 2005

CH2MHILL

Notes: 1) Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.
2) Samples were taken December 2000 - January 2001 as part of the SPRU RCRA Sampling Visit

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3. Environmental Setting

This section describes the environmental setting of the Knolls Site, including the general layout of the facilities and the Outside Areas, the regional geology and hydrogeology, the climate, and the surface water at the site. Section 5.3 contains detailed descriptions of the geology and hydrogeology of the SPRU Outside Areas.

3.1 Facilities and Layout

The Knolls Site is in the Town of Niskayuna, Schenectady County, New York, on the southern bank of the Mohawk River. The Knolls Site consists of 170 acres, mostly on a bluff approximately 115 to 120 feet above the Mohawk River surface. Along the northern margin of the Knolls Site, the land surface slopes steeply to a natural bench about 15 to 20 feet above the river's surface. The Knolls Site, which fronts approximately 4,200 feet of the river, is bounded to the north by the Mohawk River; to the east by a mixture of open land, parks, and the Town of Niskayuna's closed municipal landfill; to the south by a low-density suburban residential area; and to the west by the General Electric Company Global Research Center.

Construction of the Knolls Site began in 1948, and laboratory operations began in 1949. The principal function of the Knolls Site was research and development in the design and operation of Naval nuclear propulsion plants. Facilities include administrative offices, machine shops, a sewage pumping station, wastewater treatment facilities, a boiler house, oil storage facilities, cooling towers, waste storage facilities, and chemistry, physics, and metallurgical laboratories. The buildings and support facilities occupy approximately 60 acres of the property. The remainder of the Knolls Site (about 110 acres) consists of undeveloped woods and fields.

As shown in Figure 3-1, the three SPRU investigation areas are in separate and distinct geographic areas within the Knolls Site.

- The **Upper Level** area comprises an investigation area around Buildings H2 and G2 in the northern portion of the bluff along the northwestern perimeter of the Knolls Site.

The area is developed and mostly covered by concrete and asphalt. The area surrounding Building H2 is covered by gravel overlying an impermeable geomembrane to the east, west, and north.

- The **Lower Level** extends along the parking lot and old railroad spur within the bench between KAPL's Lower Level Facility Area and the hill slope rising up to the Knolls Site Upper Level. The eastern portion of the Lower Level is a former railbed and is currently primarily a grassy surface with asphalt roadways bisecting the area along the east-west and north-south axes. The western portion of the Lower Level Area consists of an asphalt parking lot.
- The **Land Area** is located in the southeastern portion of the Knolls Site and bounded by the East Boundary and Midline stream drainages. The outer perimeter of the Land Area is partially wooded along the eastern, northern, and western perimeter, with grass and brush in the nonwooded areas.

3.2 Geology

The following subsections summarize the regional geology, hydrogeology, surface water, and climate of the Knolls Site.

3.2.1 Regional Geology

Most of the Knolls Site is located on the Upper Level bluff approximately 115 to 120 feet above the Mohawk River surface. Along the northern margin of the Knolls Site, the land surface slopes steeply to a natural bench comprising the Lower Level approximately 15 to 20 feet above the river's surface.

The geology underlying the Knolls Site consists of unconsolidated overburden materials, overlying bedrock. Bedrock at the Lower Level is at depths of approximately 5 to 20 feet below existing grade elevations and in the Upper Level at depths ranging from approximately 40 to 80 feet below existing grade elevations. Bedrock underlying the Knolls Site is mapped as the Upper-Middle Ordovician aged Schenectady Formation, which comprises a series of alternating beds of graywacke, sandstone, siltstone, and shale about 2,000 feet thick, dipping gently to the west and southwest. The Schenectady Formation is underlain by the Canajoharie shale, which is a dark gray to black, thinly bedded, fissile shale.

The unconsolidated materials at the Knolls Site consist mainly of glacial deposits. The till, which directly overlies the bedrock at most locations, consists of a grayish-blue, dense, compact till. This is known as the Mohawk Till, which is commonly referred to as gray till. The gray till extends from the bedrock typically to within 10 to 15 feet of the ground surface, where the gray till transitions into a yellowish-brown till, commonly referred to as brown till. The brown till originally was thought to be a separate depositional sequence from the gray till. However, evidence suggests that the brown till is the weathered surface of the gray till. Occasional lenses of graded material, usually fine sand, exist within the till. In areas of the Knolls Site where construction and site development has occurred, the uppermost portion of the brown till has been removed and re-emplaced as fill as needed. In some areas, excavations penetrated into the gray till, which was removed and included with the fill. In some instances, anthropogenic materials (e.g., asphalt and concrete) are commingled with the fill. Throughout this report, this interval is referred to as till-derived fill.

3.2.2 General Hydrogeology

The groundwater resources at the Knolls Site are limited because of the low permeability of the bedrock and unconsolidated deposits. The predominant unconsolidated deposits are composed of brown and gray till with occasional lenses of graded material, usually fine sand, within the till. Overlying the till in some areas are thin glacial lake sequences (silts and clays) and discontinuous ice-contact deposits (sand and gravel). Consequently, there are no principal or primary bedrock or overburden aquifers underlying the Knolls Site for development as commercial or public water supplies.

The gray till is almost entirely impermeable except for the occasional lenses of fine sand, which are capable of transmitting small quantities of water. Based on drilling records, these lenses are small in both vertical and horizontal extent and are isolated from one another. Over most of the Knolls Site, the gray till aquaclude serves as the base of the unconfined hydrogeologic unit. Exceptions are portions of the Lower Level where the gray till is absent or thinned due to scour from the Mohawk River. The brown till is also relatively impermeable; however, water can percolate through the brown till, as indicated by perched water at the brown till/gray till contact. In the horizontal shales and sandstones of the Schenectady Formation, groundwater is found in the bedrock fractures, joints, and bedding planes and in the upper portions of the bedrock where it interfaces with the unconsolidated deposits. These shales and sandstones are characteristically nonporous and impermeable, and they form poor aquifers.

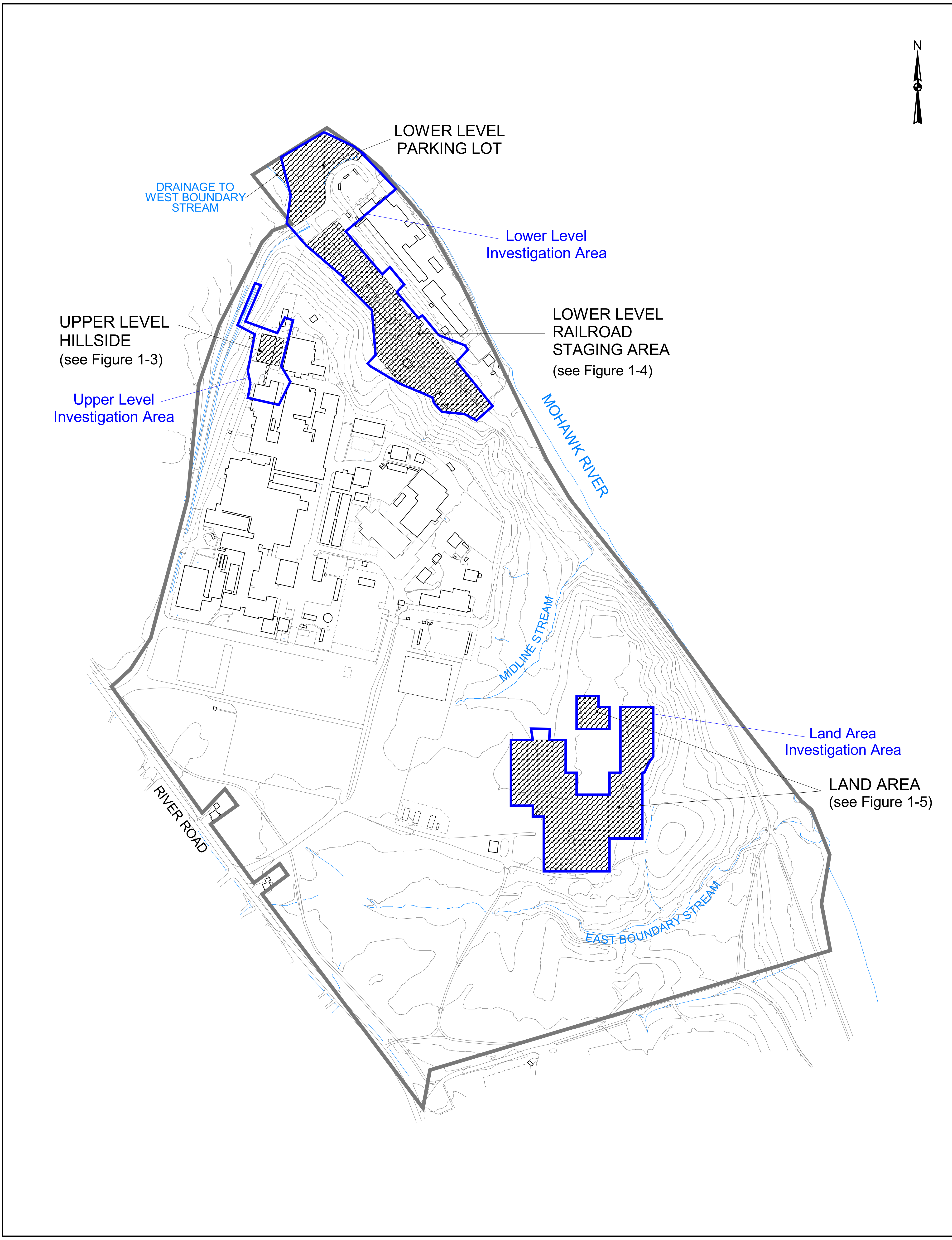
The overall sitewide direction of groundwater flow at the Knolls Site is generally northeast to the Mohawk River. Based on the relatively low permeability of the bedrock and till, groundwater movement is relatively slow. The movement of perched groundwater on the gray till mirrors the topography of the top of the till surface. The topography of the gray till is similar to the natural topography of the landscape where it has not been disturbed. In areas where gray till has been excavated for construction of site buildings, utilities, and other facilities, groundwater flow direction and velocities vary, with groundwater preferentially flowing into and along the less compact and more permeable backfill material.

3.2.3 Climate and Surface Water

The climate in the Knolls Site region is primarily continental in character but is subjected to some modification from the maritime climate that prevails in the extreme southeastern portion of New York State. Winters are usually cold and occasionally fairly severe. Maximum temperatures during colder winter months often are below freezing, and nighttime low temperatures frequently drop to 10 degrees Fahrenheit (°F) or lower. Subzero temperatures occur rather infrequently, about a dozen times a year. Snowfall in the area is quite variable, averaging approximately 65 inches a year. The mean annual precipitation for the region is approximately 36 inches per year, and winds are predominantly westerly to northwesterly.

The Knolls Site is adjacent to the Mohawk River, which serves as the main watercourse for the Mohawk River Drainage Basin. The river flows eastward to where it joins the Hudson River in Cohoes, New York. Three streams drain directly into the Mohawk River from the Knolls Site. The East Boundary Stream is located on the Knolls Site between the closed Knolls and Niskayuna Landfills and receives drainage from the southeastern portion of the Land Area. The Midline Stream drains the central area of the Knolls Site and receives only runoff from the Knolls Site property, including most of the Land Area. The West Boundary Stream, which is adjacent to the Knolls Site on General Electric Company Global Research Center property, receives some surface water runoff from the Knolls Site. Runoff from the southern and eastern area of the Upper Level mostly enters onsite storm sewers for subsequent discharge to the Mohawk River. Runoff from the western and northern perimeter of the Upper Level flows over the bluff slope into drainage channels for discharge to the West Boundary Stream. Runoff from the Lower Level also flows to the Mohawk via storm sewers or, in the case of the northwestern parking lot, directly into the West Boundary Stream and the Mohawk River. Seeps are present along the lower portion of the Mohawk River because of saturated conditions in the Schenectady Formation.

Figures



Building
Fence
Streams or Drainage
Pavement
Property Boundary
Topographic Contours (10 foot interval)
SWMU/AOC
Investigation Area

0 500 1000 Feet

U.S. DEPARTMENT OF ENERGY
NNSA SPRU FIELD OFFICE
SEPARATIONS PROCESS RESEARCH UNIT

SPRU RADIOLOGICAL CHARACTERIZATION REPORT

OUTSIDE CHARACTERIZATION INVESTIGATION AREAS

Figure 3-1

Prepared By: ASPOSATO

Date: March 30, 2006

CH2MHILL

Note: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

4. Summary of Characterization Activities

This section summarizes the radiological characterization activities performed in each of the three SPRU Outside Areas in March through December 2004 as part of the Outside Characterization Program. The characterization needs for each area were identified through a pathways analysis based on the initial conceptual model and documented in the SAP for the area. The summary of characterization activities is organized by area and, within each area, by media type. This summary is supplemented by Appendix A, an overview of field activities associated with the outside characterization, including sampling, decontamination, and survey procedures.

The following characterization activities apply to all investigation areas:

- At some soil boring locations, more than one drill or push was necessary to achieve or attempt to achieve the desired depth, due to refusal or other reasons. These "step-outs" were advanced as close as possible to the initial location—typically within 2 feet—and are treated as the same location as the original for purposes of evaluating and mapping the data.
- The procedures used to collect soil samples are described in Appendix A, Section A.1. Soil boring logs, both geologic and radiological, are provided in Appendixes B and C, respectively. Photographs of the boring locations are provided in Appendix D.
- Implementation of a background sampling program for soil and sediment was not necessary because the radionuclide activities in the samples did not consistently exceed or were not close to their respective final DCGL values. Background values for groundwater at the site are available in the Knolls Site Environmental Monitoring Report (KAPL, 2004). Instrument background associated with the walkover gamma radiation surveys is described in the *Outside Characterization Report: Walkover Surveys for the SPRU Land Areas* (CH2M HILL, 2005a).
- The bulk vegetation samples comprised a minimum of 1 kilogram ([kg] wet weight) of vegetative materials consisting of cut grass and/or mixed leaf and woody tissue

composite from a 1- by 1-meter (m) surface area where vegetation had been cleared and left in place. The vegetation samples were collected as described in Section A.5 of Appendix A and were analyzed for the full suite of radiochemical parameters identified in Section 4.1.1.

4.1 Land Area

The Land Area, one of the three SPRU Outside Areas, lies to the southeast of and outside the KAPL process areas (outside the security fence), as shown in Figure 1-2. The Land Area characterization area is approximately 6.7 acres. Based on the conceptual model and pathway analyses, the characterization needs for the Land Area were identified as follows:

- Vertical and lateral extent of radioactive contamination in surface and subsurface soil
- Presence of radioactive contaminants in sediments in the Midline Stream and/or its ephemeral drainage way
- Uptake of radioactive contamination by vegetation present in the affected areas
- Potential impacts to groundwater (CH2M HILL, 2004a; 2004b)

To fulfill the identified characterization needs, soil, sediment, vegetation, and groundwater samples were collected from the Land Area. All samples were screened onsite using gamma spectroscopy. Select samples were also analyzed for various radiological parameters at an offsite laboratory, Severn Trent Laboratories (STL) in St. Louis, Missouri. In addition, three soil samples were analyzed offsite by TCLP to support waste characterization for future remediation of the contaminated soil areas. The following sections summarize the characterization activities in the Land Area and exceptions to the Land Area SAP (CH2M HILL, 2004b).

4.1.1 Soil Boring Program

Surface and subsurface soil sampling and analysis were conducted to confirm the nature and extent of soil radioactive contamination, evaluate the extent of radioactive contamination in relation to the walkover and SPUD survey data, and evaluate the depth of radioactivity exceeding DCGLs. Soil sampling was limited to radiological characterization, except for two samples that were collected in the Land Area near B3555 (see Figure 2-6) for

TCLP analysis. Based on data collected during the RFA SV, levels of lead could be present in the subsurface at soil boring B3555 that could exceed the TCLP criteria. Although the SV Report concluded that chemicals in the Land Area do not result from SPRU operations, soil samples near B3555, and at another location where elevated radioactivity was identified in the Land Area (total of three samples), were analyzed by TCLP to support waste classification.

The soil radiological sampling consisted of a combination of systematic and biased samples. Biased samples were collected in areas of elevated surface and/or subsurface activity. Samples were collected at each location at up to six depths. The depths varied at each location to (1) span the depth of the contamination, (2) confirm the contamination identified in the walkover/SPUD surveys, and (3) evaluate the vertical extent of contamination. Systematic samples were collected at nominal 50-foot intervals in or adjacent to contiguous areas of elevated activity to confirm the extent of contamination.

Soil characterization borings were advanced at 85 locations in grids LA1001 through LA1026 in the Land Area, as shown in Figure 4-1. Each soil characterization boring was given an alphanumeric identification (ID) beginning with the grid number (LAxxxx), followed by the subgrid number (1 through 9), systematic or bias (S or B), sample depth interval (beginning with 1 at the surface), and ID of whether the sample is a normal or field duplicate sample (1 is normal, 2 is field duplicate) as follows: LANNNN-N-A-N-N (e.g., LA1001-3-S-1-2). Soil borings were also advanced at 17 locations for installation of groundwater monitoring wells. These soil borings were given an alphanumeric ID beginning with LA-SO, followed by the monitoring well ID (PW-xx or RW-xx), sample depth interval (beginning with 1 at the surface), and ID of whether the sample is a normal (1) or field duplicate (2) sample as follows: LA-SO-AW-N-N (e.g., LA-SO-PW-1-1-2).

The depths of the soil characterization borings ranged from 0.5 to 10 feet below soil surface (bss), based on historical surface and SPUD data, walkover survey data, and onsite screening gamma spectroscopy of the samples collected, as described in the Land Area SAP. The monitoring well soil borings ranged from 2 to 22 feet bss.

All soil samples were screened onsite using gamma spectroscopy. In accordance with the SAP, 120 samples were shipped offsite to STL for gamma spectroscopy, gross alpha and gross beta, strontium-90, americium-241, isotopic uranium, and isotopic plutonium (hereinafter referred to as the full radiological suite). Another 40 samples were shipped offsite to STL for confirmatory gamma spectroscopy, and 3 samples were submitted for TCLP. Samples of soil for evaluation of distribution coefficient (K_d) and other DCGL parameters were also collected from three locations in the Land Area. The soil sample analytical results are described in Section 6.2.1.

4.1.2 Sediment Sampling

Surface sediment samples were collected from the Midline Stream and its ephemeral drainage way and analyzed to fulfill an identified characterization need in the Land Area. The sediment samples also served as indicators for potential contamination of surface water and seeps in the Land Area because the radionuclides in the water tend to adhere to particulates that concentrate in areas where sediment associated with surface water and seeps deposit. Field reconnaissance radiological survey data were used to identify two locations of slightly elevated radiological readings (but still below twice background levels (the *Outside Characterization Report: Walkover Surveys for SPRU Land Areas* [CH2M HILL, 2005a] contains further information on the background levels)) in areas where surface soil had eroded and deposited in the Midline Stream and ephemeral drainages; no areas of greater than twice background levels were identified in the Midline Stream and ephemeral drainages based on recent walkover and historical SPUD surveys. Two biased sediment samples (0 to 0.5 foot and 0.5 to 2.0 feet in depth) were collected at each of the two sediment sampling locations shown in Figure 4-2. The sediment samples were given an alphanumeric ID beginning with LA followed by either MLS (for Midline Stream) or MST (Midline Stream Ephemeral Drainage), SD (for sediment), the sample depth interval (1 for surface or 2 for subsurface), and ID as either a normal (1) or field duplicate (2) sample as follows: LA-AAA-SD-N-N (e.g., LA-MLS-SD-2-1). The sediment samples were collected in accordance with the sampling procedures described in Appendix A, Section A.6.

The sediment samples were analyzed for the full suite of radiochemical parameters identified in Section 4.1.1. The Land Area sediment sample analytical results are described in Section 6.2.2.

4.1.3 Vegetation Sampling

Three bulk vegetation samples were collected in the Land Area to fulfill an identified characterization need. The vegetation samples were collected from locations of elevated surface activity identified during the 2002–03 radiological walkover survey. A field duplicate was also collected from one of the locations for quality control purposes. The vegetation samples were given an alphanumeric ID beginning with the grid number (LAXXXX) followed by the subgrid number (1 through 9), V for vegetation sample, and ID of whether the sample was a normal (1) or field duplicate (2) sample as follows: LANNNN-N-V-N (e.g., LA1001-5-V-1). These three locations are shown in Figure 4-3. The Land Area vegetation sample analytical results are described in Section 6.2.3.

4.1.4 Groundwater Monitoring

Section 8.4 of the Land Area SAP (CH2M HILL, 2004b) required installation, completion, and sampling of 15 newly installed wells and sampling of 6 existing groundwater monitoring wells in the Land Area to satisfy the following characterization objectives:

- Evaluate radioactivity in groundwater within the uppermost hydrogeologic unit resulting from leaching of soil
- Evaluate potential downward migration of radioactivity into bedrock
- Identify and delineate the source(s) of elevated radioactivity in groundwater

A total of 16 permanent groundwater monitoring wells were installed within the Land Area as summarized in Tables A-1 and A-10 of Appendix A. The monitoring well locations are depicted in Figure 4-4. One of the originally planned 15 wells (PW-13) was not completed, and two were added to survey grid LA-1015 to evaluate potential radiological and chemical impacts to groundwater as part of the RFA SV of the Red Pines Area. PW-13 was planned to be installed within the footprint of the Former Slurry Drum Storage Area, but it encountered shallow, nonradioactive buried refuse and was abandoned. Monitoring wells PW-1, PW-2, and PW-3 were installed near Building Q-6, in the southwest portion of the North Field (see also Figure 1-5). Monitoring wells PW-4, PW-5, PW-12, PW-14, and PW-15 were installed in the Former Slurry Drum Storage Area. PW-10 and PW-11 were installed in the Mercury Disposal Area northeast of the Former Slurry Drum Storage Area. Monitoring wells PW-6, PW-7, PW-8, and PW-9 were installed in the Red Pines Area, east of the North Field in the northeastern portion of the Land Area. Well PW-22 and PW-23 were installed along the southern flank of the Red Pines Area.

Groundwater samples were collected from the new wells and several historical monitoring wells located within or downstream of areas of elevated radioactivity in the Midline Stream drainage, in two field sampling rounds, depending on the availability of water. Groundwater samples were given an alphanumeric ID beginning with LA-GW followed by the well ID (e.g., PW-2), sample round number (1 or 2), and ID of whether the sample was a normal (1) or field duplicate (2) sample as follows: LA-GW-AW-N-N-N (e.g., LA-GW-PW-2-1-1). Samples were analyzed for the full suite of radiochemical analyses identified in Section 4.1.1, including gamma spectroscopy, isotopic uranium, isotopic plutonium, alpha spectroscopy, and strontium-90.

Groundwater level measurements were obtained for all Land Area wells on July 30 and October 5, 2004 (see Appendix A, Section A.3.1) and used to generate groundwater contour maps provided in Section 5. Hydraulic conductivity testing (Appendix A, Section A.9) was performed on Land Area wells PW-2, PW-4, PW-11, PW-15, and PW-23, which were the only wells in the Land Area with sufficient groundwater yield to support hydraulic conductivity testing. However, due to an equipment malfunction, data from the testing of well PW-2 could not be retrieved.

4.1.5 Exceptions to Land Are SAP

Exceptions to the SAP for the Land Area involved soil samples, vegetation samples, and installation and sampling of monitoring wells. The exceptions are described in Sections A.1.7, A.5, and A.3.4, respectively.

4.2 Lower Level

The Lower Level lies to the north and northwest of the main KAPL process areas, as shown in Figure 1-2. The Lower Level consists of two subareas associated with historical SPRU activities—the Railroad Staging Area (also referred to as the Railbed Area) and the Parking Lot. The Railbed Area is located inside the KAPL security fence. The Parking Lot is outside the security fence, in the northwest corner of the Knolls Site, with property boundaries along both the west and north sides of the area. The Lower Level characterization area is approximately 6.3 acres. Based on the conceptual model and pathway analyses, the characterization needs for the Railbed Area were identified as follows:

- Vertical and lateral extent of radioactive contamination in the surface and subsurface soil in the Railbed Area (includes soils surrounding the K5 and K6 structures)
- Uptake of radioactive contamination by vegetation in affected areas of the Railbed Area
- Presence of radioactive contaminants in sediments from surface water runoff that may collect in stormwater basins and low-lying areas in the Railbed Area
- Potential impacts to groundwater beneath the Railbed Area
- Isotopic distribution of radionuclides in the K5 and K6 concrete structures (CH2M HILL, 2004a; 2004c)

Based on the conceptual model and pathway analyses, the characterization needs for the Parking Lot Area were identified as follows:

- Vertical and lateral extent of radioactive contamination in the surface and subsurface soil in the Parking Lot
- Uptake of radioactive contamination by vegetation in affected areas of the Parking Lot
- Presence of radioactive contaminants in sediments in low-lying areas adjoining the Parking Lot and in the Drainage to West Boundary Stream
- Potential impacts to groundwater beneath the Parking Lot (CH2M HILL, 2004a; 2004c)

To fulfill the identified characterization needs, soil, sediment, vegetation, and groundwater samples were collected from both subareas within the Lower Level. All samples were screened onsite using gamma spectroscopy. Select samples were also analyzed for various radiological parameters at the offsite laboratory, STL. In addition, six locations were sampled for TCLP analysis to support waste characterization. The following sections summarize the characterization activities in the Lower Level and exceptions to the Lower Level SAP (CH2M HILL, 2004c).

4.2.1 Soil Boring Program

Surface and subsurface soil sampling and analysis were conducted to confirm the nature and extent of soil radioactive contamination, evaluate the extent of radioactive contamination in relation to the walkover and SPUD survey data, and evaluate the depth of radioactivity exceeding DCGLs. Soil sampling was limited to radiological characterization, except for four samples that were collected from the Parking Lot and two samples that were collected from the Railbed Area for TCLP analysis. Based on data collected during the RFA SV, levels of mercury could be present in the subsurface of the Parking Lot that could exceed the TCLP criteria (see Figure 2-8). The TCLP samples from the Parking Lot and two locations within the areas of highest radioactivity throughout the Railbed Area were analyzed to support waste classification.

The soil radiological sampling consisted of a combination of systematic and biased samples. Biased samples were collected in areas of elevated surface and/or subsurface activity. Samples were collected at each location at up to eight depths. The depths varied at each location to (1) span the depth of the contamination, (2) confirm the contamination identified in the walkover/SPUD surveys, and (3) evaluate the vertical extent of contamination. Systematic samples were collected at nominal 50-foot intervals in or adjacent to contiguous areas of elevated activity to confirm the extent of contamination.

Soil characterization borings were advanced at 65 locations in grids LA1106 through LA1143 (Railbed Area) and grids LA1701 through LA1704 (in the Parking Lot Area), as shown in Figure 4-5. At one location (LA1106-4-B1), a boring was unable to be installed because refusal was encountered in the shale. Soil borings were also advanced at 20 locations for installation of groundwater monitoring wells. At some locations, more than one drill or push was necessary to achieve or attempt to achieve the desired depth, due to refusal or other reasons. These “step-outs” were advanced as close as possible to the initial location—typically within 2 feet—and are treated as the same location as the original for purposes of evaluating and mapping the data.

The depths of the soil characterization borings ranged from 0.5 to 10 feet bss, based on historical surface and SPUD data, walkover survey data, and onsite screening gamma spectroscopy of the samples collected, as described in the Lower Level SAP. The depths of soil borings for installation of monitoring wells ranged from 6 to 24 feet bss. Each soil boring was given an alphanumeric ID as described in Section 4.1.1.

All soil samples were screened onsite using gamma spectroscopy. In accordance with the SAP, 114 samples were shipped offsite to STL for the full radiological suite. Another 44 samples were shipped offsite to STL for confirmatory gamma spectroscopy. In addition, 16 samples were submitted for other radionuclide analysis, and 6 samples were submitted for TCLP. Samples of soil for evaluation of K_d and other DCGL parameters were also collected from five locations in the Lower Level. The soil sample analytical results are described in Section 6.3.1.

4.2.2 Sediment Sampling

Sediment samples were collected from both subareas in the Lower Level and analyzed to fulfill identified characterization needs. These sediment samples also served as surrogates for surface water in the Lower Level as explained in Section 4.1.2. The sediment samples were collected in accordance with the sampling procedures described in Appendix A, Section A.6.

The sediment samples were analyzed for the full suite of radiochemical parameters identified in Section 4.1.1. The Lower Level sediment sample analytical results are described in Section 6.3.2.

The following sections describe the sediment samples collected in each subarea within the Lower Level. Sediment sampling locations in both subareas are shown in Figure 4-6.

4.2.2.1 Lower Level Railbed Area

Two stormwater catch basin systems are in the Railbed Area (see Figure G-1 in Appendix G). One system actively conveys stormwater from the general KAPL Upper Level through the railbed, where it picks up additional stormwater flow that is discharged to the Mohawk River. One catch basin in this system (CB-26), northwest of Building K5, was opened during the SV and lacked sediment (CH2M HILL, 2002). This system was not sampled because it was not possible to separate KAPL input sediment from that in the Lower Level and because any input from the Lower Level would be diluted and flushed away by stormwater from the Upper Level.

The other catch basin system originates in the Lower Level at an open catch basin between Buildings K5 and K6. It traverses northward in approximately the center of the Railbed Area and northeastward through the Parking Lot; it then discharges to the Mohawk River. This system receives runoff only from the Lower Level. Two catch basins in this system are open to receive runoff. Four additional catch basins, previously buried under as much as 3 feet of soil, were excavated and sampled during the investigation, for a total of 6 catch basins sampled (6 samples total—one sample from each catch basin), as shown in Figure 4-6. The sediment samples from the catch basins were given an alphanumeric ID beginning with LA-SD-CB followed by the catch basin number as follows: LA-SD-CBN or NN (e.g., LA-SD-CB9). Sediment samples were collected as described in Section A.6 of Appendix A. The catch basins were not entered because of safety considerations. The catch basins were also characterized for surface contamination in accordance with procedures described in Appendix A.1.5.

4.2.2.2 Lower Level Parking Lot

Sediment samples from two depths (0 to 0.5 foot and 0.5 to 2.0 feet) were collected from each of three biased sampling locations in the Parking Lot. Sediment reconnaissance samples were collected from two locations in the Drainage to West Boundary Stream, one at the southwestern edge of the Parking Lot at the culvert discharge from the Upper Level and one near the KAPL–GE property boundary. Walkover surveys of these areas identified no elevated radioactivity. However, this drainage area could be contaminated at depth from historical discharges. Sediment samples were also collected at two depths from a location where elevated surface activity was identified (based on the 2002-03 radiological walkover survey) in a low-lying area containing eroded soil from the perimeter of the Parking Lot. The sediment samples from the Parking Lot were given an alphanumeric ID beginning with the grid number (LAXXXX), followed by the subgrid number (1 through 9), SD (for sediment), sample depth interval (1 for surface or 2 for subsurface), and ID of whether the sample is a normal (1) or field duplicate (2) sample as follows: LANNNN-N-SD-N-N (e.g., LA1701-5-SD-2-1).The three sediment sampling locations in the Parking Lot are shown in Figure 4-6.

4.2.3 Vegetation Sampling

Three bulk vegetation samples were collected in the Railbed Area, and two bulk vegetation samples were collected in the Parking Lot to fulfill identified characterization needs. The vegetation samples were collected from locations of high surface activity identified during the 2001-04 radiological walkover survey. A field duplicate was also collected from one of the locations for quality control purposes. The vegetation samples were given alphanumeric IDs as described in Section 4.1.3. The Lower Level vegetation sampling locations are shown in Figure 4-7. The Lower Level vegetation sample analytical results are described in Section 6.3.3.

4.2.4 Groundwater Monitoring

Section 8.5 of the Lower Level SAP (CH2M HILL, 2004c) required installation, completion, and sampling of 14 groundwater monitoring wells and sampling of 8 existing groundwater wells in the Lower Level to satisfy the following characterization objectives:

- Evaluate radioactivity in groundwater within the uppermost hydrogeologic unit resulting from leaching of soil
- Evaluate potential downward migration of radioactivity into bedrock
- Identify and delineate the source(s) of elevated radioactivity in groundwater

A total of 17 groundwater monitoring wells were installed in the Lower Level, as shown in Figure 4-8 and summarized in Table A-2, Appendix A. These include eight wells installed to evaluate field conditions that were not identified in the Lower Level SAP. Some of the wells planned in the SAP (RW-2, PW-21, PW-24, PW-25, and PW-26) were not installed because of unsaturated conditions.

Monitoring wells RW-4 and RW-5 were installed in the Parking Lot; however, RW-5 has been dry since its installation. Wells RW-6, RW-7, RW-8, PW-18, PW-19, PW-20, and PW-21 were installed north and hydraulically downgradient of the Railbed Area. Monitoring wells PW-16 and PW-17 were installed just north of Riverview Road, generally downgradient and between RW-7 and RW-8. RW-9 was installed north of the K5 Retention Basin and immediately east of the 42-inch-diameter stormwater line. Wells PW-27 and PW-28 were installed south of the Railbed, within a pre-existing drainage swale feature. Wells PW-29 and PW-30 were installed north of the K5 Retention Basin along the southern side of Riverview Road adjacent to the concentration of buried utility conduits. PW-32 was installed northeast of the K5 Retention Basin. Temporary monitoring wells LWT-1 and LWT-2 were installed northeast and south, respectively, of the K5 Retention Basin.

Groundwater samples were collected from the new wells and the existing KAPL and SV monitoring wells within or downstream of areas of elevated radioactivity in the Lower Level, in two field sampling rounds, depending on the availability of water. Samples were analyzed for the suite of radiochemical analyses identified in Section 4.1.1, including gamma spectroscopy, isotopic uranium, isotopic plutonium, alpha spectroscopy, and strontium-90. Groundwater samples were also collected from six catch basins in the Lower Level and analyzed for the suite of radiochemical analyses identified in Section 4.1.1. Groundwater samples from the wells were given alphanumeric IDs as described in Section 4.1.4. The groundwater samples from the catch basins were given alphanumeric IDs beginning with LA-GW-CB (or SCB or MCB) followed by the catch basin number and ID of whether the sample was a normal (1) or field duplicate (2) sample as follows: LA-GW-CB-N or NN-N (e.g., LA-GW-CB-9-1).

Groundwater level measurements were obtained for all Lower Level wells on August 3, 2004, October 6, 2004, and February 10, 2005 (see Appendix A, Section A.3.1) and used to generate groundwater contour maps provided in Section 5. Hydraulic conductivity testing (Appendix A, Section A.9) was performed on Lower Level wells RW-6, RW-8, MW-SV4, MW-SV7, and PW-16, which were the only wells in the Lower Level with sufficient groundwater yield to support hydraulic conductivity testing.

During the field investigation, several locations were identified on the cliff along the Mohawk River where groundwater dripped from bedrock; this provided an opportunity to obtain groundwater samples from the bedrock. Three seeps near the Lower Level Parking Lot (see Figure 4-8) were sampled in April 2005 by KAPL environmental staff in accordance with KAPL's permit with the Canal Authority, the New York State agency that owns the land immediately adjacent to the Mohawk River. The samples were analyzed by KAPL's onsite radiological laboratory.

4.2.5 Exceptions to Lower Level SAP

Exceptions to the Lower Level SAP involved soil samples, vegetation samples, and installation and sampling of monitoring wells. The exceptions are described in Sections A.1.7, A.5, and A.3.4, respectively.

4.3 Upper Level

The Upper Level lies to the northwest of the main KAPL process areas, near the western boundary of the site, as shown in Figure 1-2. The Upper Level consists of two subareas associated with historical SPRU activities—the hillside area and the process building foundation, pipe tunnel, and underground tank vaults area (hereinafter referred to as the H2-G2 Area). The hillside area is located outside the KAPL security fence, east of the Lower Level Access Road. The H2-G2 Area is inside the security fence in the Upper Level. The Upper Level characterization area is approximately 3.2 acres. Based on the conceptual model and pathway analyses, the characterization needs for the Upper Level were identified as follows:

- Vertical and lateral extent of radioactive contamination in the surface and subsurface soil in the Upper Level
- Potential uptake of radioactive contamination by vegetation in affected areas of the hillside area
- Potential presence of radioactive contaminants in sediments from surface water runoff that may collect in stormwater drainages and low-lying areas in the hillside area
- Potential impacts to groundwater beneath the Upper Level (CH2M HILL, 2004a; 2004d)

To fulfill the identified characterization needs, soil, sediment, vegetation, and groundwater samples were collected from the Upper Level. All samples were screened onsite using gamma spectroscopy. Select samples were also analyzed for various radiological parameters at the offsite laboratory, STL. In addition, 26 samples were analyzed offsite by TCLP to support waste characterization. The following sections summarize the characterization activities in the Upper Level and exceptions to the Upper Level SAP.

4.3.1 Soil Boring Program

Surface and subsurface soil sampling and analysis were conducted to confirm the nature and extent of soil radioactive contamination, evaluate the extent of radioactive contamination in relation to the walkover and SPUD survey data, and evaluate the depth of radioactivity exceeding DCGLs. The soil sampling was limited to radiological characterization, except for one sample for confirmatory TCLP analysis of organic and metal constituents and 25 samples for TCLP analysis of chromium and other metal constituents from the soil borings around the cooling towers (H1) (see Figure 1-3). These samples will support future waste classification.

The soil radiological sampling consisted of a combination of systematic and biased samples. Biased samples were collected in areas of elevated surface and/or subsurface activity. Samples were collected at each location at up to 17 depths. The depths varied at each location to (1) span the depth of the contamination, (2) confirm the contamination identified in the walkover/SPUD surveys, and (3) evaluate the vertical extent of contamination. Systematic samples were collected at nominal 50-foot intervals in or adjacent to contiguous areas of elevated activity to confirm the extent of contamination.

Soil characterization borings were advanced at 46 locations in grids LA1301 through LA1305, LA1401 through LA1408, and LA1501 in the Upper Level, as shown in Figure 4-9. Several of the soil characterization borings were also designated as chemical (RCRA) monitoring well locations in the SAP (joint radiological characterization/RCRA monitoring well borings). Soil borings were advanced at eight additional locations for the installation of monitoring wells. At some locations, more than one drill or push was necessary to achieve or attempt to achieve the desired depth, due to refusal or other reasons. These "step-outs" were advanced as close as possible to the initial location—typically within 2 feet—and are treated as the same location as the original for purposes of evaluating and mapping the data.

The depths of the soil borings ranged from 0.5 to 30 feet bss, based on historical surface and SPUD data, walkover survey data, and onsite screening gamma spectroscopy of the samples collected, as described in the Upper Level SAP. Each soil boring was given an alphanumeric ID as described in Section 4.1.1, except that the joint radiological characterization/RCRA monitoring well borings were designated with a "W" (for well) in lieu of an S (for systematic) or B (for bias). Also, the soil borings for installation of monitoring wells contain well IDs beginning with "U" instead of "R."

All soil samples were screened onsite using gamma spectroscopy. In accordance with the SAP, 65 samples were shipped offsite to STL for the full radiological suite. Another 30 samples were shipped offsite to STL for confirmatory gamma spectroscopy. In addition, 4 samples were submitted for other radionuclide analysis, and 26 samples were submitted for TCLP analysis. The soil sample analytical results are described in Section 6.4.1.

4.3.2 Sediment Sampling

Surface sediment samples were collected from two locations on the hillside area along the drainage culvert adjacent to the Lower Level Access Road, downstream of the majority of the Upper Level area, and analyzed to fulfill identified characterization needs. The specific locations were determined through field reconnaissance radiological surveys at the time of sampling. One location of elevated radioactivity (greater than twice background levels (the *Outside Characterization Report: Walkover Surveys for SPRU Land Areas* [CH2M HILL, 2005a] contains further information on the background levels) and another location of slightly elevated radioactivity (not greater than twice background levels) were identified in the culvert where sediments had deposited; these two sediment sampling locations are shown in Figure 4-10. Each sediment sample was given an alphanumeric ID beginning with the grid number (LAXXXX), followed by the subgrid number (1 through 9), SD (for sediment), and ID of whether the sample is a normal (1) or field duplicate (2) sample as follows: LANNNN-N-SD-N (e.g., LA1304-5-SD-1).These sediment samples also served as surrogates for surface water in the Lower Level, as explained in Section 4.1.2. The sediment samples were collected in accordance with the sampling procedures described in Appendix A, Section A.6.

The sediment samples were analyzed for the full suite of radiochemical parameters identified in Section 4.1.1. The Upper Level sediment sample analytical results are described in Section 6.4.2.

4.3.3 Vegetation Sampling

Three bulk vegetation samples were collected in the Upper Level to fulfill an identified characterization need. The vegetation samples were collected from locations of elevated surface activity or areas potentially contaminated by overtopping and runoff identified during the radiological walkover surveys during 2002 and 2004. A field duplicate was also collected from one of the locations for quality control purposes. The vegetation samples were given alphanumeric IDs as described in Section 4.1.3. The Upper Level vegetation sampling locations are shown in Figure 4-11. The Upper Level vegetation sample analytical results are described in Section 6.4.3.

4.3.4 Groundwater Monitoring

Section 8.5 of the Upper Level SAP (CH2M HILL, 2004d) required installation, completion, and sampling of seven groundwater monitoring wells plus four optional groundwater monitoring wells and sampling of five existing groundwater monitoring wells and one drainage sump to satisfy the following characterization objectives:

- Evaluate radioactivity in groundwater in the uppermost hydrogeologic unit resulting from leaching of soil
- Evaluate potential downward migration of radioactivity into bedrock
- Identify and delineate the source(s) of elevated radioactivity in groundwater

A total of 20 groundwater monitoring wells and one well point were installed in the Upper Level to support the SPRU radiological characterization. These include nine wells installed to evaluate field conditions that were not identified in the Upper Level SAP. Two of the wells planned in the SAP were not installed because of unsaturated conditions (UW-5 and UW-7). The installed groundwater monitoring wells and well point are identified as: UW-1 through UW-4, UW-6, UW-8, UW-8A, UW-9, UW-9A, UW-10, UW-12, UW-14, UW-14A, UW-17, UW-18, UWT-1, UWT-2, UWT-2A, PW-31, and WP-01 as presented in Table A-3, Appendix A. The monitoring well locations are depicted in Figure 4-12.

Wells UW-1 and UW-2 were installed at the northwestern corner of Building H2, and a temporary well point WP01 was installed adjacent to the Hillside Sump. Well UW-3 was completed at the northwestern corner of Building G2, and well UW-4 was completed along the northern wall of Building G2, near the Pipe Tunnel. Groundwater monitoring well UW-6 was completed between Buildings G2 and H2 west of the Pipe Tunnel. UW-8, UW-8A, UW-17, and UW-18 were completed at the northeastern corner of the H2 Tank Farm, and UW-9 and UW-9A were installed at the southeastern corner of the H2 Tank Farm. UW-14 and UW-14A were completed at the northwestern corner of H2. UW-10 was installed on the eastern side of the Pipe Tunnel, adjacent to stormwater manhole catch basin MCB-7, and UW-12 was completed along the eastern wall of Building G2. Temporary monitoring well UWT-1 was completed southeast of the H1 Cooling Tower, and UWT-2 and UWT-2A were completed along the western side of the Building G2. PW-31 was completed immediately adjacent to the drainage culvert along the Lower Level Access Road downstream of the Upper Level.

Permanent and temporary monitoring wells UW-14, UW-14A, UW-10, UW-12, UWT-1, UWT-2, UWT-2A, PW-31, and WP-01 were installed to evaluate changed field conditions and are not specifically identified in the Upper Level SAP.

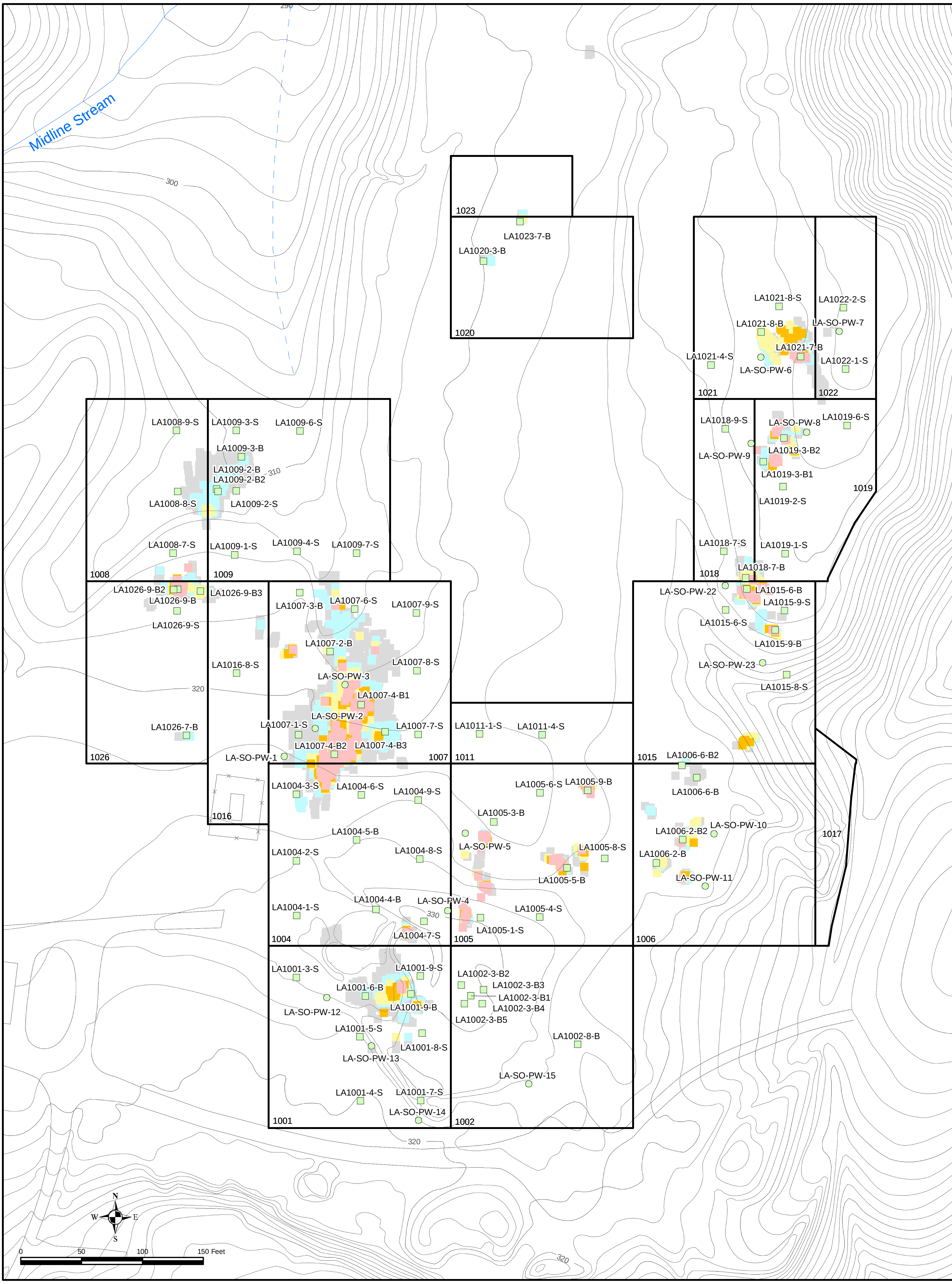
Groundwater samples from the new wells, and 10 existing wells and a sump in the investigation area that have a history of elevated radioactivity or chemical constituents (CH2M HILL, 2002; 2004d), were collected in two field sampling rounds, depending on the availability of water. The groundwater samples were given alphanumeric IDs as described in Section 4.1.4. Samples were analyzed for the full suite of radiochemical analyses identified in Section 4.1.1 and tritium. A groundwater sample was also collected from the discharge of a clay pipe in the Upper Level hillside area west of the northwestern corner of Building H2 near the Lower Level Access Road.

Groundwater level measurements were obtained for Upper Level wells on August 31, 2004, October 6, 2004, November 10-11, 2004, and February 9, 2005 (see Appendix A, Section A.3.1), and used to generate groundwater contour maps provided in Section 5. Hydraulic conductivity testing (Appendix A, Section A.9) was performed only on Upper Level well UW-2 because of a lack of sufficient groundwater yield in other Upper Level wells.

4.3.5 Exceptions to Upper Level SAP

Exceptions to the Upper Level SAP involved soil samples, vegetation samples, and installation and sampling of monitoring wells as described in Sections A.1.7, A.5, and A.3.4, respectively; and a sediment sample. In addition to sediment sampling in the drainage culvert, a composite sediment sample was to be collected from the collection basin beneath the cooling tower (Building H1). However, the collection basin was empty, except for a small amount of debris in the lowest corner, and no sediment was present to sample.

Figures



2002-2003 Walkover Survey Grid

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,251-31,000 cpm (3-4x Background)
- 31,001-38,750 cpm (4-5x Background)
- 38,751-46,000 cpm (5-6x Background)
- >46,000 cpm (>6x Background)

Characterization Soil Boring

Monitoring Well Soil Boring

Topographic Contour (2 foot interval)

Streams or Drainage

Ephemeral Drainage

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

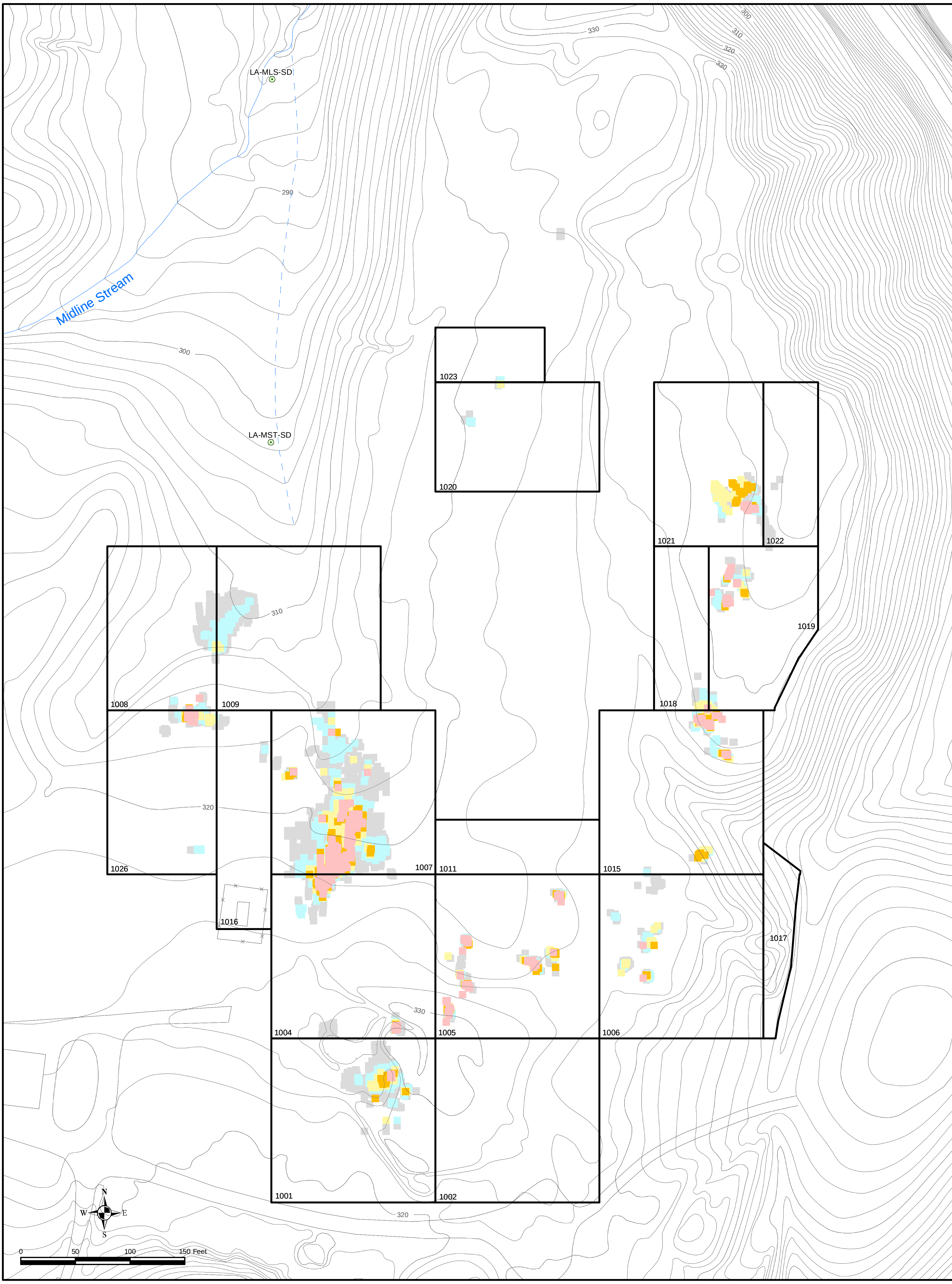
LAND AREA SOIL BORING LOCATIONS

Figure 4-1

Prepared By: ASPOSATO

Date: March 30, 2006

CH2MHILL



2002-2003 Walkover Survey Grid

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,251-31,000 cpm (3-4x Background)
- 31,001-38,750 cpm (4-5x Background)
- 38,751-46,000 cpm (5-6x Background)
- >46,000 cpm (>6x Background)

Sediment Sample

Topographic Contour (2 foot interval)

Streams or Drainage

Ephemeral Drainage

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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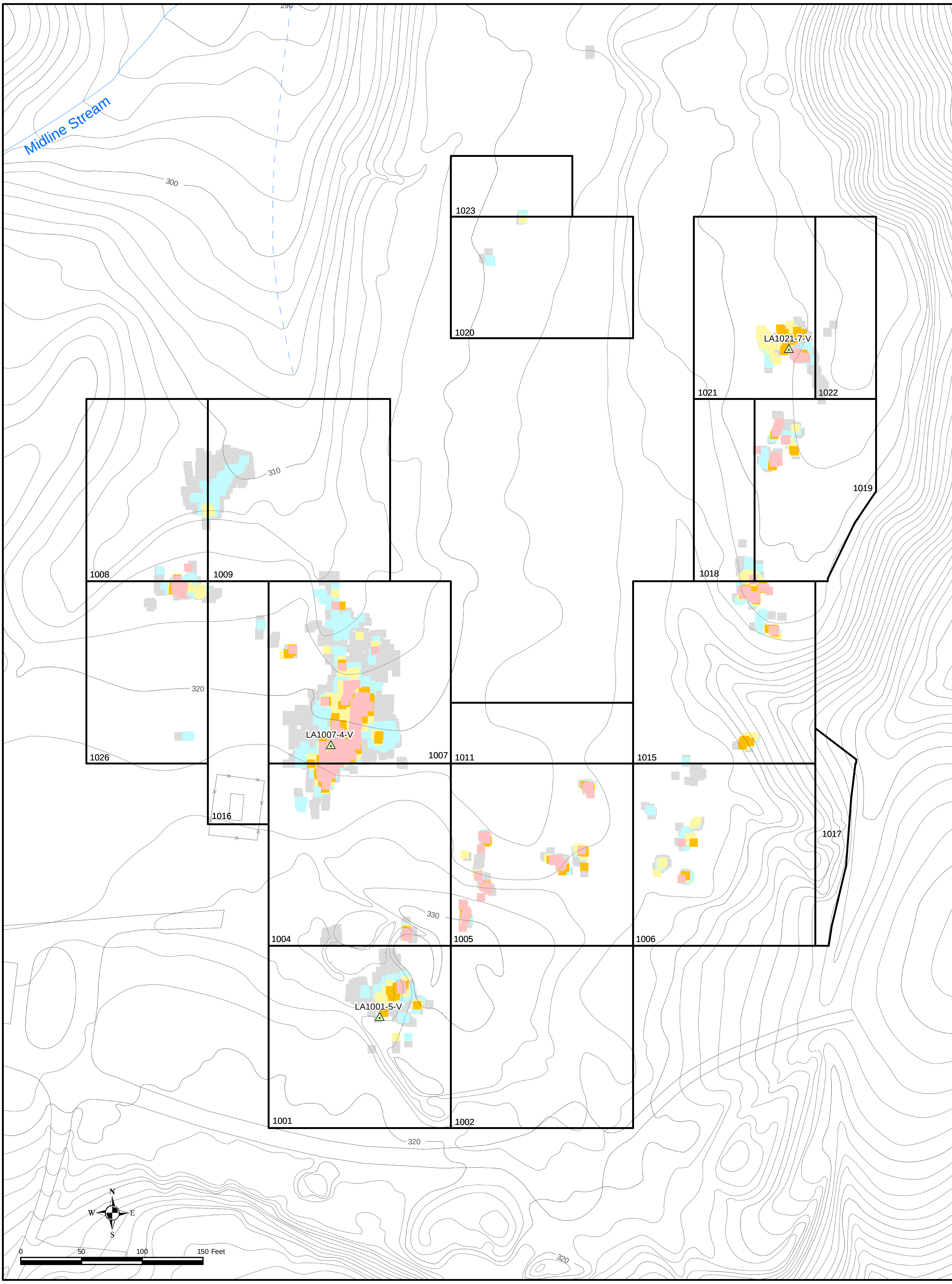
SPRU RADIOLOGICAL CHARACTERIZATION REPORT

LAND AREA SEDIMENT SAMPLE LOCATIONS

Figure 4-2

Prepared By: ASPOSATO

Date: March 30, 2006



2002-2003 Walkover Survey Grid

Gamma Radiation

15,501-23,250 cpm (2-3x Background)

23,251-31,000 cpm (3-4x Background)

31,001-38,750 cpm (4-5x Background)

38,751-46,000 cpm (5-6x Background)

>46,000 cpm (>6x Background)

Vegetation Sample

Topographic Contour (2 foot interval)

Streams or Drainage

Ephemeral Drainage

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

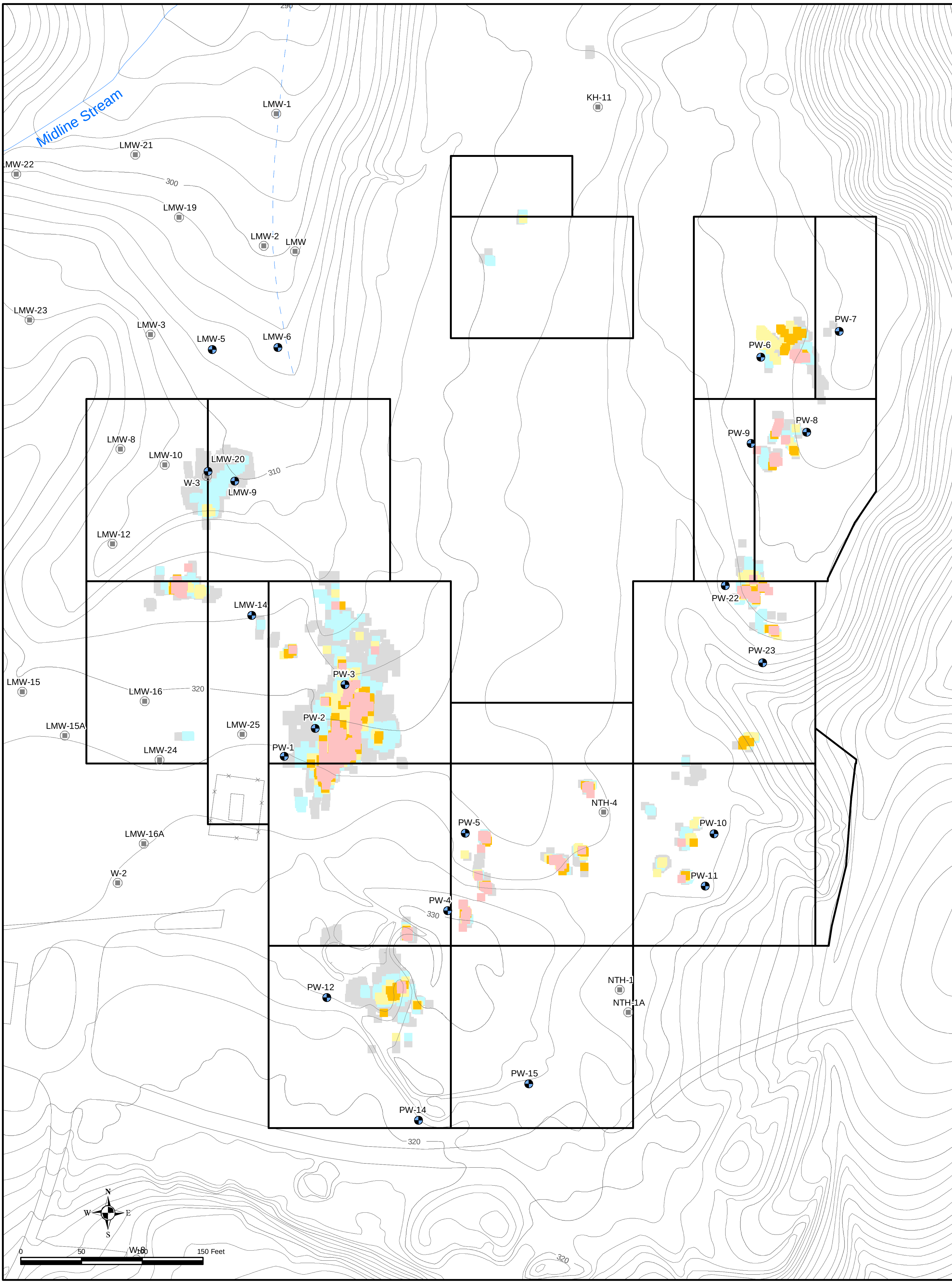
LAND AREA VEGETATION SAMPLE LOCATIONS

Figure 4-3

Prepared By: ASPOSATO

Date: March 30, 2006

CH2MHILL



2002-2003 Walkover Survey Grid

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,251-31,000 cpm (3-4x Background)
- 31,001-38,750 cpm (4-5x Background)
- 38,751-46,000 cpm (5-6x Background)
- >46,000 cpm (>6x Background)
- Groundwater Sample
- Well Not Sampled

Topographic Contour (2 foot interval)

Streams or Drainage

Ephemeral Drainage

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

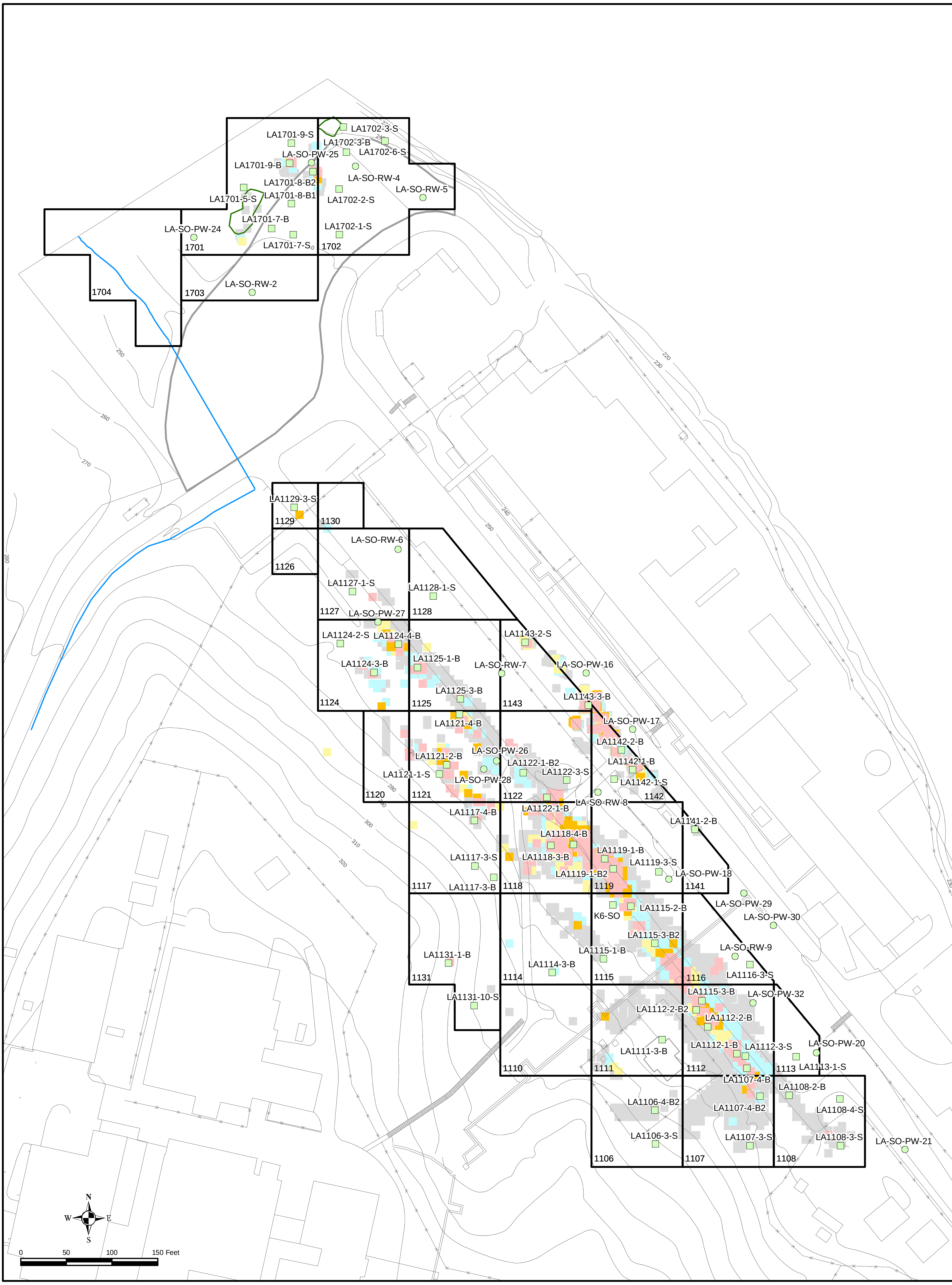
LAND AREA GROUNDWATER SAMPLE LOCATIONS

Figure 4-4

Prepared By: ASPOSATO

Date: March 30, 2006

CH2MHILL



- 2001-2004 Walkover Survey Grid

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,251-31,000 cpm (3-4x Background)
- 31,001-38,750 cpm (4-5x Background)
- 38,751-46,000 cpm (5-6x Background)
- >46,000 cpm (>6x Background)
- Characterization Soil Boring
- Monitoring Well Soil Boring
- Topographic Contour (10 foot interval)

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

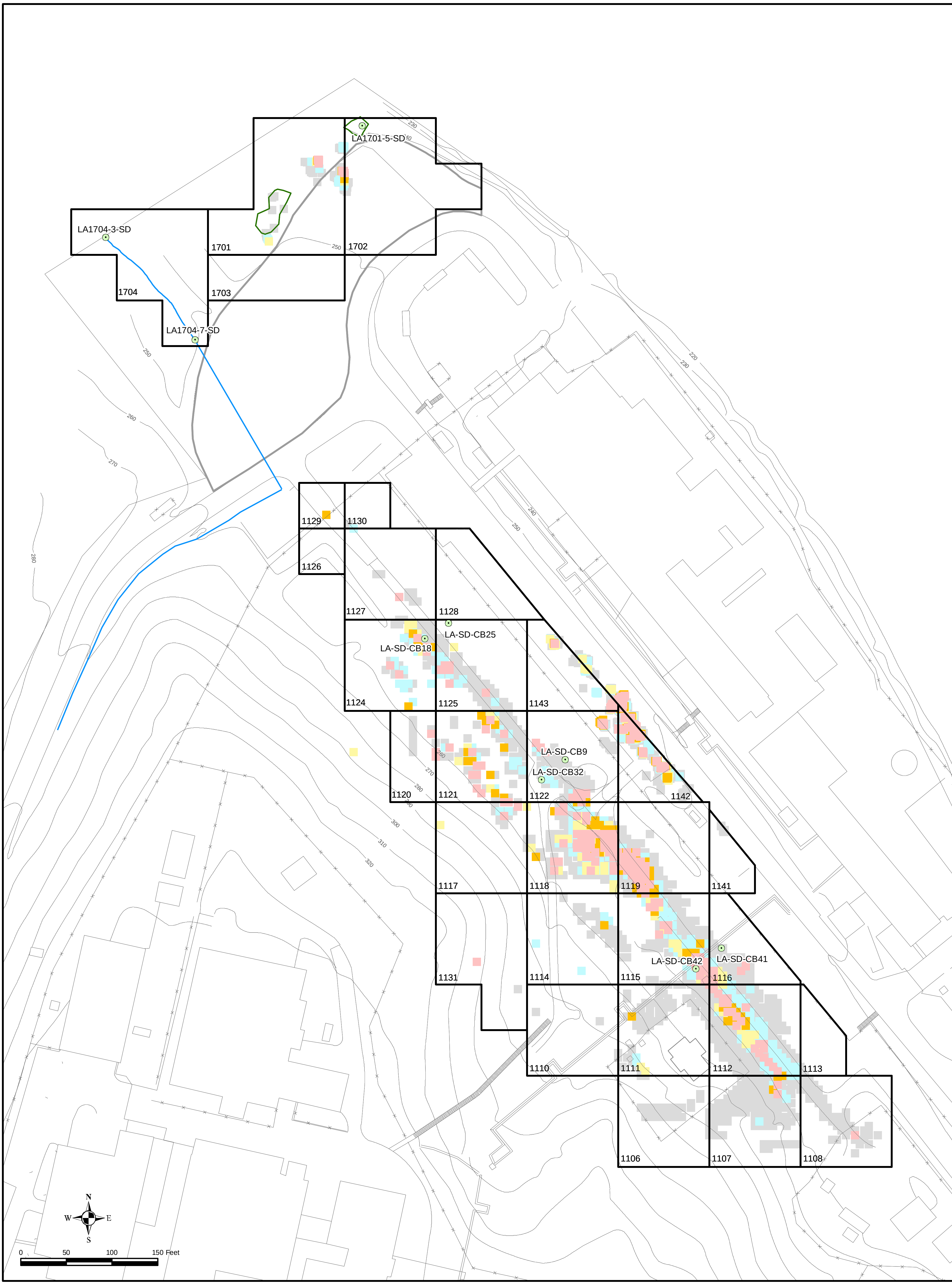
LOWER LEVEL SOIL BORING LOCATIONS

Figure 4-5

Prepared By: ASPOSATO

Date: March 27, 2006

CH2MHILL



2001-2004 Walkover Survey Grid

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,251-31,000 cpm (3-4x Background)
- 31,001-38,750 cpm (4-5x Background)
- 38,751-46,000 cpm (5-6x Background)
- >46,000 cpm (>6x Background)

Sediment Sample

Topographic Contour (10 foot interval)

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

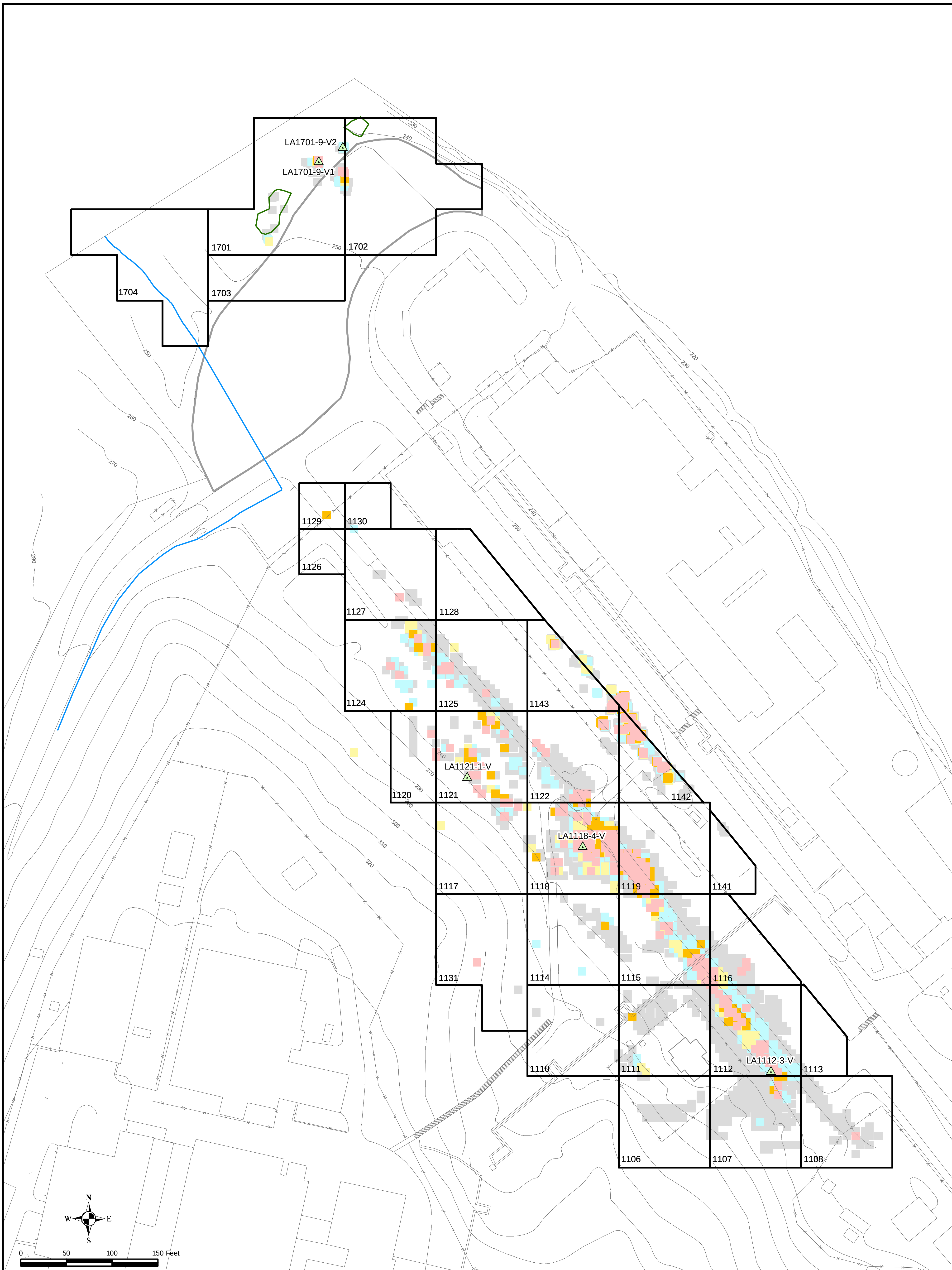
LOWER LEVEL SEDIMENT SAMPLE LOCATIONS

Figure 4-6

Prepared By: ASPOSATO

Date: March 27, 2006

CH2MHILL



2001-2004 Walkover Survey Grid

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,251-31,000 cpm (3-4x Background)
- 31,001-38,750 cpm (4-5x Background)
- 38,751-46,000 cpm (5-6x Background)
- >46,000 cpm (>6x Background)

Vegetation Sample

Topographic Contour (10 foot interval)

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

LOWER LEVEL VEGETATION SAMPLE LOCATIONS

Figure 4-7

Prepared By: ASPOSATO

Date: March 27, 2006

CH2MHILL

2001-2004 Walkover Survey Grid

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,251-31,000 cpm (3-4x Background)
- 31,001-38,750 cpm (4-5x Background)
- 38,751-46,000 cpm (5-6x Background)
- >46,000 cpm (>6x Background)

Groundwater Sample

Topographic Contour (10 foot interval)

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

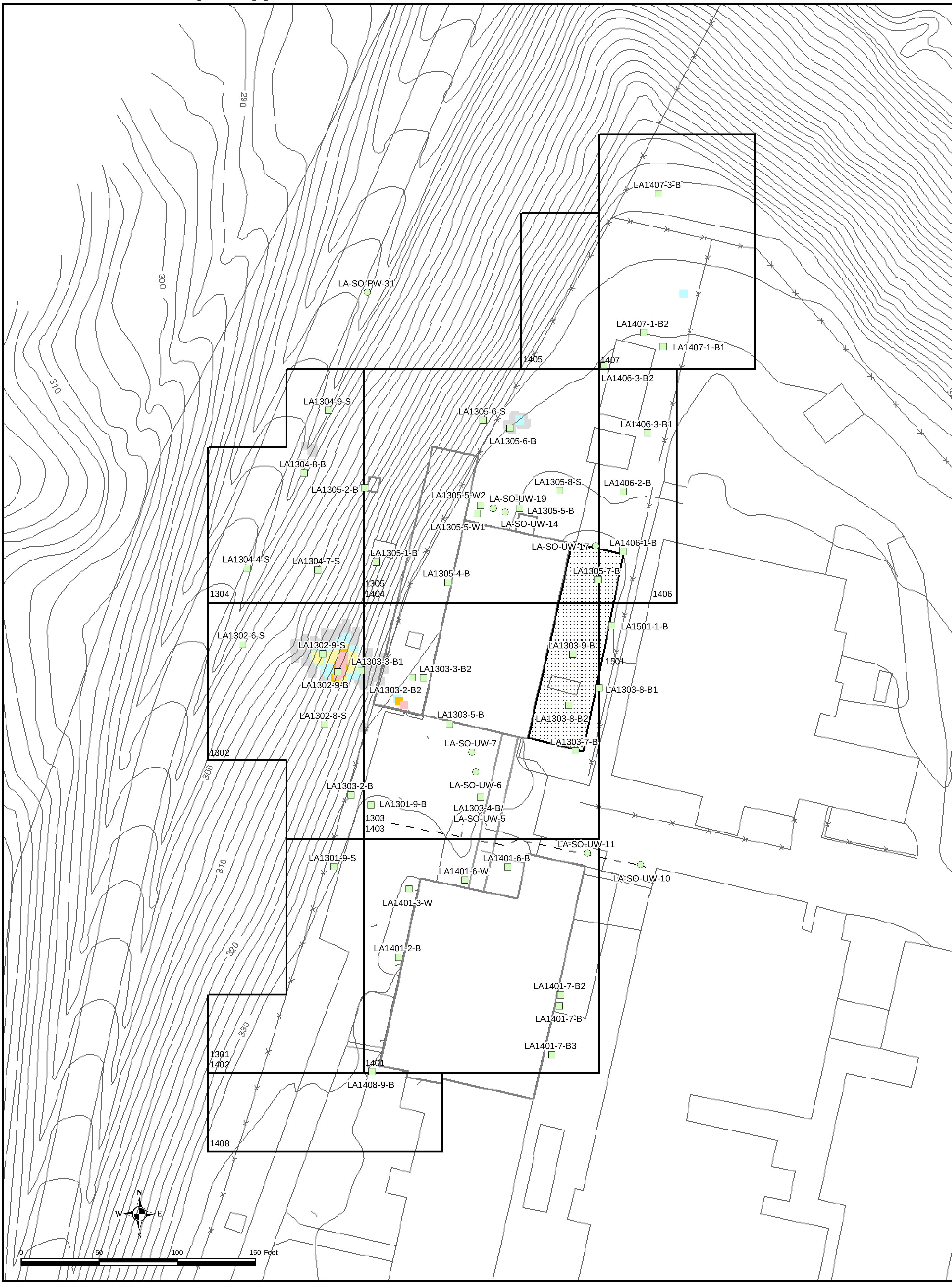
LOWER LEVEL GROUNDWATER SAMPLE LOCATIONS

Figure 4-8

Prepared By: ASPOSATO

Date: March 27, 2006

ATL \\ATL31004305\PROJECTS\KAPL\SPRU GIS PROJECTS\RAD_CHAR\STATIONS_UL_SB.MXD FIGURE 4-9 UPPER LEVEL SOIL BORING LOCATIONS.PDF 06/18/2005 15:38:57



2001-2004 Walkover Survey Grid

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,251-31,000 cpm (3-4x Background)
- 31,001-38,750 cpm (4-5x Background)
- 38,751-46,000 cpm (5-6x Background)
- >46,000 cpm (>6x Background)

Characterization Soil Boring

Monitoring Well Soil Boring

Topographic Contour (2 foot interval)

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

UPPER LEVEL SOIL BORING LOCATIONS

Figure 4-9

Prepared By: ASPOSATO

Date: June 18, 2005

ATL \\ATL31004305\PROJECTS\KAPL\SPRU GIS PROJECTS\RAD_CHAR\STATIONS_UL_SD.MXD FIGURE 4-10 UPPER LEVEL SEDIMENT SAMPLE LOCATIONS.PDF 06/14/2005 01:34:55

2001-2004 Walkover Survey Grid

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,251-31,000 cpm (3-4x Background)
- 31,001-38,750 cpm (4-5x Background)
- 38,751-46,000 cpm (5-6x Background)
- >46,000 cpm (>6x Background)

Sediment Sample

Topographic Contour (2 foot interval)

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

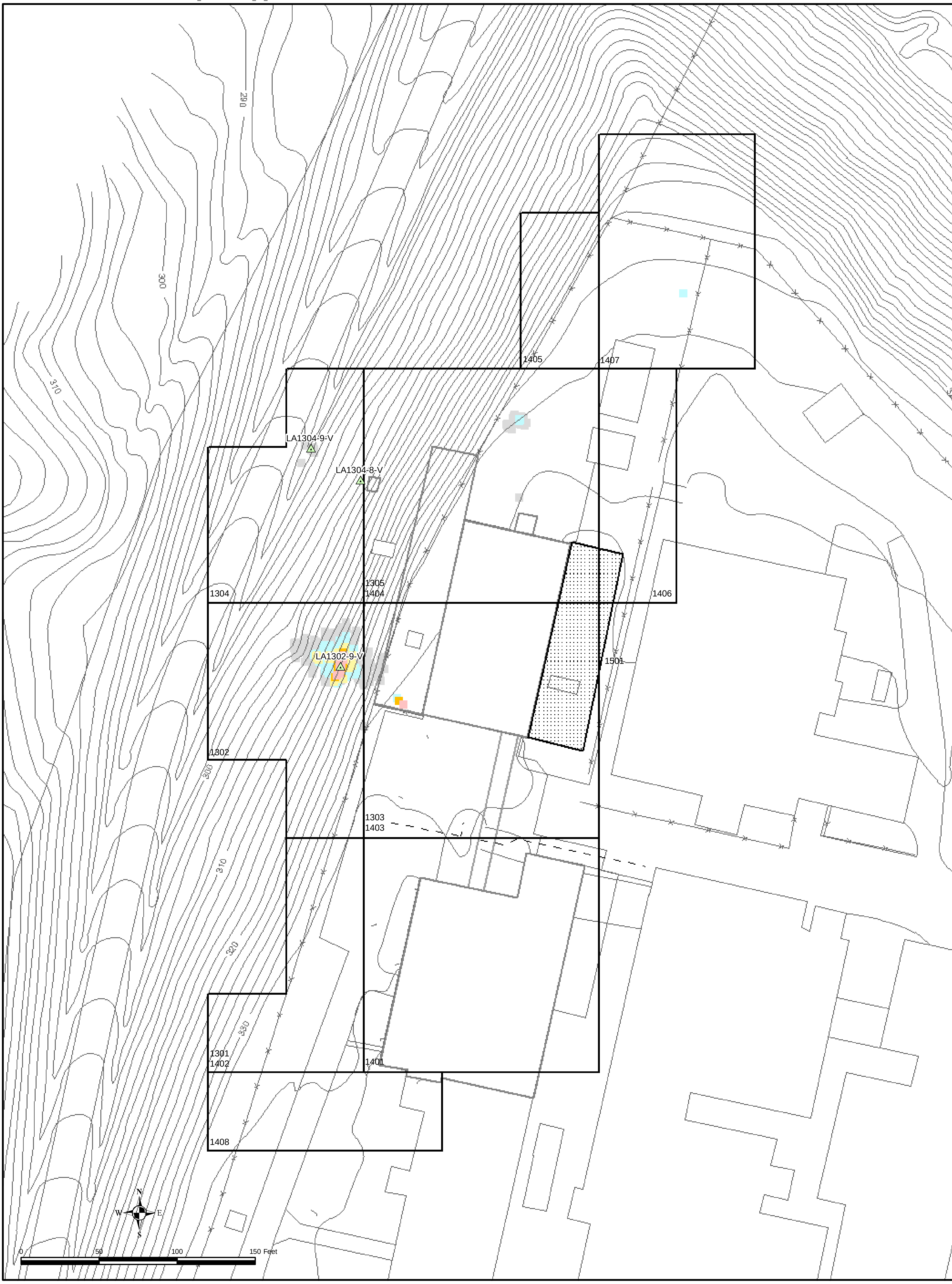
UPPER LEVEL SEDIMENT SAMPLE LOCATIONS

Figure 4-10

Prepared By: ASPOSATO

Date: June 13, 2005

CH2MHILL



2001-2004 Walkover Survey Grid

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,251-31,000 cpm (3-4x Background)
- 31,001-38,750 cpm (4-5x Background)
- 38,751-46,000 cpm (5-6x Background)
- >46,000 cpm (>6x Background)

Vegetation Sample

Topographic Contour (2 foot interval)

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

UPPER LEVEL VEGETATION SAMPLE LOCATIONS

Figure 4-11

Prepared By: ASPOSATO

Date: June 18, 2005

CH2MHILL

ATL \\ATL31004305\PROJECTS\KAPL\SPRU GIS PROJECTS\RAD_CHAR\STATIONS_UL_GW.MXD FIGURE 4-12 UPPER LEVEL GROUNDWATER SAMPLE LOCATIONS.PDF 10/17/2005 12:40:10

2001-2004 Walkover Survey Grid

Gamma Radiation

- 15,501-23,250 cpm (2-3x Background)
- 23,251-31,000 cpm (3-4x Background)
- 31,001-38,750 cpm (4-5x Background)
- 38,751-46,000 cpm (5-6x Background)
- >46,000 cpm (>6x Background)

Groundwater Sample

Well Not Sampled

Topographic Contour (2 foot interval)

NOTE: Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999.

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SPRU RADIOLOGICAL CHARACTERIZATION REPORT

UPPER LEVEL GROUNDWATER SAMPLE LOCATIONS

Figure 4-12

Prepared By: ASPOSATO

Date: October 17, 2005

CH2MHILL

5. Site Characterization

As stated earlier, the outside characterization was conducted during March through December 2004. The following sections summarize the contaminants of concern; the development of DCGLs used for the characterization; the geologic and hydrogeologic setting for each area; and the data sources, quality, and usability for the outside characterization.

5.1 Contaminants of Concern

The outside characterization focused on radiological characterization in each of the three Outside Areas. Some limited chemical characterization was performed to support waste classification. The following subsections summarize the radioactive and chemical contaminants of concern associated with SPRU operations.

5.1.1 Radioactive

As described in Section 2, KAPL has conducted limited remediation in each of the three Outside Areas, primarily within the SPRU SWMUs and AOC. The radionuclides remaining in the SPRU buildings have not been fully characterized. However, historical data regarding SPRU operations, knowledge of the composition of the spent radioactive fuels used in the SPRU process (see Section 6.2.1.2), and studies conducted by KAPL before 1998 provide adequate data to place bounding limits on the quantity and general characteristics of the remaining radionuclides. Historical data and studies pertaining to SPRU are documented in the *Outside Areas Historical Site Assessment* (CH2M HILL, 2003) and are summarized in Section 2 of this characterization report. In general, these data indicate that approximately 50 to 100 curies of mixed fission products and less than 600 grams of total plutonium remain in the SPRU buildings (KAPL–Stone, 1972; KAPL, 1974; KAPL–Leboeuf, 1976; KAPL, 1984a; KAPL–Ruben, 1990; KAPL–Darling, 2000; KAPL–Gervasio, 2000). The majority of these nuclides are contained in the waste tanks, piping, and abandoned process equipment.

Radiological measurements (dose rates, fixed and loose contamination levels, assays of materials from inside systems) are consistent with this source term.[1]

The radionuclides typical of natural uranium-fueled, light-water-cooled, graphite-moderated reactors (LM/GE, 1996) were used as a starting point to identify the SPRU radionuclides of potential concern. Many of these typical radionuclides were eliminated from further consideration as a SPRU radionuclide of potential concern after meeting two or more of three different criteria: short half-life, low abundance, or not detected/reported as present by KAPL. Application of these criteria to eliminate radionuclides from further consideration is described in detail in Appendix B of the *Final Derived Concentration Guideline Levels Technical Basis* (CH2M HILL, 2005b).

After application of the criteria, the list of radionuclides of potential concern was further reduced by eliminating short-lived daughter products that can be assumed to be present in equilibrium with their parent radionuclides. Radionuclides with a half-life of ½ year or less were treated as associated radionuclides. The radionuclides "associated" with a principal radionuclide consist of all decay products down to, but not including, the next principal radionuclide in the chain. All associated radionuclides were assumed to be in secular equilibrium (a state in which the activities of all radionuclides in a decay series are nearly equal) with their principal radionuclide in the contaminated zone and also at the location of human exposure. Only the principal radionuclides in the contaminated zone were considered. As a consequence, barium-137m, protactinium-234, thorium-228, thorium-234, and yttrium-90 were deleted from the list. In addition, uranium-233 and uranium-236 were deleted from the list due to measurement resolution problems with other uranium radionuclides. The resulting list of SPRU radionuclides of concern and analysis strategy for each radionuclide is provided in Table 5-1.

As described in Section 6.2.1.2, cesium-137 and strontium-90 are the primary fission and non-actinide activation products remaining by two orders of magnitude after more than 50 years of decay since SPRU operations ceased. As a result, cesium-137 is the primary radionuclide present in soils and sediment in the SPRU Outside Areas, and strontium-90 is

---

[1] General area exposure rates in Buildings G2 and H2 are between <0.02 and 300 mrem/hr. The interconnecting Pipe Tunnel and H2 Tank Farm vaults general area exposure rates are between 50 and 600 mrem/hr. Beneath the tanks, the exposure rate maximum noted in 1989 was 1.7 rem/hr.

the primary radionuclide present in groundwater (see Section 6 for detailed information on the investigation results).

5.1.2 Chemical

As stated previously, the focus of the outside characterization was radiological characterization of environmental media in the Outside Areas. Chemical characterization was limited to TCLP analysis of select samples collected in each area to determine if hazardous or potentially mixed wastes could be generated during remediation, and analysis of select samples for zirconium metal to determine if pyrophoric conditions might remain in an area historically used for burning of zirconium chips. The TCLP sampling locations were limited to the areas of highest radioactivity within each Outside Area identified during the outside characterization and to RFA SV sampling locations that could potentially exceed TCLP limits based on application of the 20 times rule-of-thumb to the RFA SV total metals analyses[2]. These chemical contaminants of concern are listed in Table 5-2. However, extensive chemical characterization was conducted in parallel with the outside characterization as part of the RFI for groundwater, as documented in the *Task IV RCRA Facility Investigation Report for Groundwater* (CH2M HILL, 2006).

5.2 Derived Concentration Guideline Levels (DCGLs)

The MARSSIM (EPA, 2000) process was used to develop a basis for future land use of the SPRU property. The MARSSIM recognizes residual contamination limits in terms of dose, as specified by regulation or regulatory guidance. Dose limits are typically stated as total effective dose equivalent or committed effective dose equivalent. Such release limits generally cannot be measured directly. As a consequence, pathways analyses are performed to translate dose and/or risk into equivalent environmental concentrations as measured by radiochemical analyses. These concentrations are termed DCGL values by the MARSSIM.

---

[2] The total concentration results can be divided by 20 and compared to the regulatory concentrations on the TCLP list. If the result is less than the TCLP regulatory limit (for each respective TCLP constituent of concern) then the waste is not a “toxicity characteristic” hazardous waste. If the total concentration of a chemical is less than 20 times the TCLP regulatory limit, then the sample cannot leach enough of that constituent to fail the TCLP limit, even if all the chemical dissolved into the extraction fluid.

Development of area-specific DCGLs was necessary to support development of remediation goals that are protective of human health and the environment for cleanup of the Outside Areas and to support estimation of soil remediation volumes. DCGLs were developed for the SPRU Outside Areas based on a dose limit of 25 mrem/yr using the RESidual RADioactivity (RESRAD) Version 6.22 computer code developed by Argonne National Laboratory (ANL, 2004), which calculates area-specific residual radioactive material guidelines, radiation dose, and excess lifetime cancer risk to a chronically exposed onsite resident.

RESRAD uses a pathway analysis method in which the relationship between radionuclide concentrations in soil and the dose to a member of a selected critical population group is expressed as a pathway sum, which is the sum of products of "pathway factors." Pathway factors correspond to pathway segments connecting compartments in models of the environment between which radionuclides can be transported. Radiation doses, health risks, soil guidelines, and media concentrations are calculated over user-specified time intervals. The modeled source is adjusted over time to account for radioactive decay and in-growth, leaching, erosion, and mixing. RESRAD uses a one-dimensional groundwater model that accounts for differential transport of parent and daughter radionuclides with different distribution coefficients.

Three land use scenarios were evaluated to support development of DCGLs that are protective of human health and the environment. The land use scenarios were:
(1) Subsistence Farmer, (2) Residential Suburban, and (3) Industrial. The important features of these scenarios are described below.

- The **Subsistence Farmer** land use scenario assumes that a farmer resides on the individual waste sites (contaminated areas), grows crops and livestock, and drinks and irrigates from an onsite well. Protection of groundwater from radioactive contaminants in soil is evaluated by RESRAD modeling of water that originates from the saturated zone and is used for drinking. Use of well water is unlikely when city water and river water are readily available and is, therefore, a conservative assumption.

- The **Residential Suburban** land use scenario describes an onsite resident who uses supplied water for drinking and irrigation and has a garden but does not produce meat or milk onsite.
- The **Industrial** land use scenario describes a worker who is onsite for 2,000 hours per year and does not ingest foodstuffs or water from the site.

The pathways used to model each land use are summarized in Table 5-3. The *Final Derived Concentration Guideline Levels Technical Basis* (CH2M HILL, 2005b) describes the development of area-specific RESRAD input parameters and assumptions, analytical results, application and use of DCGL values, and development of final DCGLs for post-remediation verification surveys. The final DCGLs developed for each land use scenario in each area are summarized in Section 6.

5.3 Geologic and Hydrogeologic Setting

The following subsections describe the geologic and hydrogeologic conditions in the SPRU investigation areas; regional geology and hydrogeology are described in Section 3. Geologic information from select radiological characterization borings and groundwater well borings installed during the outside characterization is provided, along with historical soil boring information from the SPRU RFA SV and previous and ongoing KAPL investigations.

5.3.1 Land Area Geologic Conditions

Portions of the Land Area have been disturbed, starting when the Knolls Site was constructed and later when the Land Area was used for temporary storage and permanent placement of various waste materials. These disturbances have modified the near-surface geologic character through the removal of native materials, reworking of native materials, and emplacement of reworked soils from other areas within the Knolls Site.

The main soil types encountered in the Land Area are as follows:

- **Granular fill**: These soils are composed predominately of sands and gravels with varying percentages of silt and clay.

- **Till-derived fill**: This fill is composed of either brown or gray glacial till, the main constituent being silt with lesser percentages of sands and gravels and varying percentages of clay.
- **Lacustrine**: These soils are composed predominately of silts and clays, with varying percentages of sands. Lenses of more granular sands and gravels are found within the silt and clay deposits. Lacustrine deposits are formed in large, quiet water bodies.
- **Kame**: These deposits are formed at the margins of glacial ice and are typically composed of sands and gravels with varying percentages of silt and clay.
- **Glacial till**: These deposits are composed of sands and gravels within a clayey silt matrix. The glacial tills are either brown or gray in color, and the brown till is typically present above the gray till. The brown and gray tills are lodgement tills and are typically dense with low permeability due to compression from overlying ice sheets; however, the brown till is relatively less dense than the gray till.

Generally, granular fill and till-derived fill mantle much of the southern and western portions of the Land Area. Brown and gray till are present at or near grade in the central and northern portions of the Land Area (North Field), as a result of the brown till and (to a lesser extent) gray till having been removed for use as construction fill in other portions of the Knolls Site. Figure 5-1 (photo) depicts the North Field in 1948 possibly soon after the till was mined from the area. Northeastern portions of the Land Area (near survey grids LA-1018, -1019, -1021, and -1022, known as the Red Pines Area) may be thinly mantled by brown till-derived fill over native brown till, below which is native gray till. Lacustrine and kame deposits, found primarily in the western portions of the Land Area near the tributary to the Midline Stream, were deposited over either native brown or gray till.

Soil borings and wells installed during the outside characterization are shown in Figure 5-2. A comprehensive map of soil borings and groundwater monitoring wells in the Land Area, including the RFI and RFA SV locations, is provided in Plate A-1 in Appendix A. Soil boring/monitoring well logs and survey coordinates are provided in Appendixes B and E, respectively. The Land Area soil borings used to prepare geologic cross-sections A-A′, B-B′, and C-C′ are shown on Plate 5-1. The geologic cross-sections are presented in Figures 5-3 through 5-5. Geologic cross-section A-A′ starts in the southern portion of the Land Area at PW-14, running north over the footprint of the Former Slurry Drum Storage Area, past the eastern side of Building Q6, and then further northward into the topographic swale leading to the Midline Stream, and ending at KAPL monitoring well LMW-1 (see Figure 5-3).

The majority of the southwestern portion of the Land Area is covered with granular fill that is underlain by till-derived fill in its southern portions, and brown till in its central and northern portions. In the west-central portion of the Land Area near PW-1, lacustrine deposits are present from grade to depths of approximately 10 feet, extending the length of the cross section line to well LMW-1. A discontinuous, thin layer (1 to 2 feet thick) of brown till is present beneath the lacustrine deposits. Gray till is present across the entire cross section line, which slopes downward from the south to the north.

Cross-section line B-B′ generally runs from west to east between monitoring wells LMW-23 and PW-7 (see Figure 5-4). The western portion of the section line, generally from LMW-23 east to the north-central portion of the Land Area, depicts a buried channel type feature. The upper portions of the buried channel are covered by lacustrine deposits beneath which are kame deposits lying over brown or gray till. The lacustrine and kame deposits pinch out at the ground surface in an eastern direction in the north-central portion of the Land Area. Where the lacustrine deposits pinch out, brown till is present at grade. The brown till extends easterly at grade into the northeastern portion of the Land Area, beyond which it pinches out within the steep hill slope east of the Land Area. Gray till is present along the entire section line, sloping downward from the east to west.

Cross-section line C-C′ generally runs from south to north from KAPL monitoring well NTH-1A to PW-7 (see Figure 5-5). The majority of the section line is mantled lacustrine deposits, except in the northeastern portion of the Land Area, where brown till is present at grade. Brown till is present beneath the lacustrine deposits and is underlain by gray till. The gray till slopes downward to the south from PW-7 to PW-23 and to the north between PW-11 and PW-23. The gray till slopes to the south, south of PW-11.

5.3.1.1 Top of Gray Till Topography

The top of gray till elevation contours for the Land Area are shown in Plate 5-2. A north-south trending ridge of gray till (elevation 320 feet amsl) is present in the central portion of the Land Area, with the axis of the ridge trending through the locations of soil borings LA1023-7-B, B3509, LA1004-8-S, and LA1001-8-S. On the western, southern, and eastern sides of this ridge, the gray till slopes downward and away from the ridge. The gray till forms a saddle east of the till ridge, in the northeastern portion of the Land Area (i.e., Red Pines Area) that trends to the northwest from well PW-7.

The gray till slopes steeply downward in the western portion of the Land Area into a depression in the area of the buried channel, which runs into the Midline Stream drainage course, as depicted in cross-section A–A′ (Figure 5-3). The deepest point of the depression is at 287 feet amsl in the area of wells W-3 and LMW-20. On the western side of the depression, the gray till surface rises in elevation to approximately 301 feet amsl at well MW-2 and 299 feet amsl at MW-4.

5.3.2 Land Area Hydrogeology

Groundwater movement in the Land Area is strongly influenced by the topography of the top of gray till surface. There are no building structures with deep foundation systems or buried utilities, so groundwater movement is not altered by such features as it is in the Upper and Lower Levels.

Groundwater contour maps were prepared based on water level data collected from the site monitoring wells. These monitoring wells are associated with KAPL's previous and ongoing groundwater monitoring program (i.e., KH, MW, W, NTH, and LMW series of wells), and the SPRU outside characterization (PW series). The groundwater level data from July 30, 2004, and October 5, 2004 (Table A-12, Appendix A) were used to prepare the water level contour maps, Figures 5-6 and 5-7, respectively.

As shown on these figures, a groundwater ridge exists in the eastern portion of the Land Area that connects groundwater mounds centered over well PW-4 (groundwater elevation 326. 32 feet amsl, Figure 5-7) and well PW-6 (groundwater elevation 320.63 feet amsl, Figure 5-7). Groundwater movement east of the groundwater ridge is to the east following the slope of the ground surface topography and the gray till topography as depicted in Figure 5-6. Radial groundwater movement is apparent off the mounds in the southwestern and northeastern portions of the Land Area. Groundwater movement west of the groundwater ridge is to the west into a groundwater trough feature that is fairly well aligned with the topographic ground surface swale that leads into the drainage course of the Midline Stream and its tributary channel. Groundwater movement west of the trough is generally from the west to east toward the trough, with a northern component of flow towards the Midline Stream. A groundwater divide or saddle is present south of the head of the groundwater depression, generally near the Salt Shed. Groundwater north of the Salt Shed flows to the north, and groundwater flow south of the shed is to the south. These flow patterns are similar to the October 5, 2004, groundwater contour map (Figure 5-7). Based on the above-normal amount of precipitation in the summer of 2004, the July data represent a period of increased precipitation, as compared to the water level data collected in October.

5.3.3 Lower Level Geologic Conditions

Soil boring and groundwater monitoring well locations completed during the outside characterization are provided in Figure 5-8. A comprehensive map of soil borings and groundwater monitoring wells in the Lower Level, including the RFI and RFA SV locations, is provided in Plate A-2 in Appendix A. Soil boring/monitoring well logs and survey coordinates are provided in Appendixes B and E, respectively. The Lower Level soil borings used to prepare geologic cross-sections A-A′, B-B′, C-C′, D-D′, E-E′, F-F′, and G-G′ (and their transects) are shown in Plate 5-3. The geologic cross-sections are presented in Figures 5-9 through 5-15.

Three different types of fill materials were encountered at soil boring locations in the Lower Level.

- Railbed ballast—composed of darkly colored crushed stone, ash, cinders, and coal
- Structural/granular fill—composed primarily of sand and gravel with lower percentages of finer silt and clay components or crushed stone
- Till-derived fill—composed primarily of silt and clay with lesser percentages of sand and gravel, or silt and clay with approximately equal percentages of sand and gravel

Soil borings KH-21, LA-SO-PW-16 (well PW-16), LA-SO-PW-17 (well PW-17), LA1141-2-B, KH-20, LA-SO-PW-29 (well PW-29), and LA-SO-PW-30 (well PW-30) were used to develop cross-section A-A′ (Figure 5-9), which begins just outside the Lower Level security gate and runs southeast parallel to the road, ending near the steam lines at LA-SO-PW-30. Beneath the ground surface and/or asphalt pavement and sub-base sand/gravel, granular fill extends down to either till-derived fill or native brown till lying directly above bedrock at the northwest end of the cross-section, pinching out to the southeast. Both the ground surface and bedrock surface gently slope to the southeast, with a slight depression in the bedrock surface near the center of the cross-section. At the northwest end of the cross-section, soil boring KH-21 reaches a total depth of 34.5 feet bgs, with granular fill from the surface to 11 feet bgs, where the native brown till is encountered and extends to bedrock at 20.5 feet bgs. At LA-SO-PW-17 granular fill extends from 0.4 feet bgs, below asphalt and sub-base, to 1 foot bgs, with till-derived fill from 1 to 21 feet bgs, followed by 0.5 feet of native brown till to the boring total depth of 21.5 feet bgs. At KH-20 till-derived fill extends down to a weathered shale/bedrock layer at 14 feet bgs and then competent shale bedrock at 15 feet bgs. No native till was found overlying shale bedrock.

Soil borings B0309, LA-SO-RW-2, KH-21, LA-SO-RW-6 (well RW-6), LA-SO-RW-7 (well RW-7), LA-SO-RW-8 (well RW-8), LA-SO-PW-18 (well PW-18), LA-SO-RW-9 (well RW-9), and LA-SO-PW-20 (well PW-20) were used to develop cross-section B-B′ (Figure 5-10), which begins at the northwest edge of the Lower Level Parking Lot and runs southeast parallel to the security fence through the Railbed Area, terminating near the northwest corner of the wastewater process facility (fenced area). Granular fill is present at or near the surface at most of the borings along this line, underlain by till-derived fill over nearly the entire line, except for a pocket of granular fill below KH-21. Shale bedrock generally follows the topography, with the exception of a ridge/high point at LA-SO-RW-8. A lense of fractured shale (shown as a lense of shale bedrock) is present at LA-SO-RW-8, while two lenses, one of railbed ballast and one of granular fill, were encountered at LA-SO-RW-9. At KH-21, granular fill extends from the ground surface to 11 feet bgs and is underlain by native brown till, which extends down to bedrock at 20.5 feet bgs. The till-derived fill layer that follows this cross-section encompasses a smaller lense of railbed ballast at LA-SO-RW-9 from 2.5 to 4 feet bgs, with the granular fill lense from 4.2 to 12.4 feet bgs.

Soil borings KH-23, LA-SO-PW-27 (well PW-27), LA-SO-PW-28 (well PW-28), B3602 (well MW-SV5), B4013 (well MW-SV6), B4014 (well MW-SV7), LA1112-1-B/-Ba (LWT-1), B3845, and B3846 were used to develop cross-section C-C′ (Figure 5-11). Cross-section C-C′ begins at the southwest end of the Lower Level Parking Lot and runs southeast parallel to the existing road through the Lower Level Railbed, in front of the Former K7 and K6 Storage Pads and the K5 Retention Basin, terminating at the wastewater process facility (in the fenced area). Along this line, granular fill extends from the ground surface, to shale bedrock at the western end, and to till-derived fill over glacial till elsewhere. Fractured/weathered shale was identified at the base of wells MW-SV5 and MW-SV6.

The soil boring at monitoring well KH-23 reached a total depth of 28 feet bgs; the upper 9.5 feet is granular fill with 1.5 feet of weathered bedrock, followed by competent shale bedrock at 11 feet bgs. At boring LA-SO-PW-27 (well PW-27), a total depth of 16.8 feet bgs was achieved, and the soil boring was composed almost entirely of till-derived fill. Well MW-SV6 reached a total depth of 12.8 feet bgs; the upper 5.6 feet is granular fill with till-derived fill extending from 5.6 to 10 feet bgs, where native gray till was encountered above 1.8 feet of weathered shale. The extent of native gray till along cross-section C-C′ is discontinuous overlying shale bedrock.

Soil borings and groundwater monitoring wells B4009, B4011, B4014 (well MW-SV7), LA-SO-PW-32 (well PW-32), and LA-SO-PW-30 (well PW-30) were used to develop cross-section D-D′ (Figure 5-12), which begins uphill of the K5 Retention Basin, running northeast through K5 and across the road to LA-SO-PW-30. Granular fill thinly mantles till-derived fill, which is underlain by a layer of fractured/weathered shale that presumably tops shale bedrock, following the slope of the ground surface along this line. There is a lense of granular fill at the center of the section. Soil boring B4009 is a shallow boring, reaching a total depth of only 3 feet bgs, with the upper 2 feet composed of granular fill and the remainder of till-derived fill. At B4011 till-derived fill is present from the ground surface to 9 feet bgs, with weathered shale encountered from 9 feet bgs to the bottom of the boring at 10 feet bgs. A lense of granular fill begins at well MW-SV7, from 2.6 to 6 feet bgs, and extends to LA-SO-PW-32, from 12 to 14 feet bgs.

Soil borings B3604, B3602 (well MW-SV5), LA-SO-PW-18 (well PW-18), and KH-20 were used to develop cross-section E-E′ (Figure 5-13), which begins at the Former K6 Storage Pad and runs northeast, across the road to KH-20. Native brown till is present directly above fractured/weathered shale bedrock along the majority of the section line but is absent at LA-SO-PW-18 and KH-20, where a thin surficial granular fill layer above till-derived fill is present above bedrock. Soil boring B3604 reached a total depth of 12 feet bgs, with 1 foot of granular fill at the surface, till-derived fill from 1 to 6 feet bgs, and native brown till from 6 to 11 feet bgs where shale was encountered.

Soil borings B3866, LA1124-2-S/-Sa, LA-SO-PW-27 (well PW-27), B3827, and LA-SO-RW-6 (well RW-6) were used to develop cross-section F-F′ (Figure 5-14), which begins at the southeast corner of the former location of the L5 aboveground storage tank in the northwestern portion of the Railbed Area, running north-northeast to LA-SO-RW-6 near the security fence. Granular fill is present north of LA1124-2-S/-Sa, above till-derived fill, with native brown till present above fractured weathered shale at the north end of the cross section. At soil boring B3827, 2.1 feet of granular fill overlays till-derived fill to the total depth of 6 feet bgs.

Soil borings KH-23, LA-SO-RW-2, LA1702-2-S, LA-SO-RW-4 (well RW-4), and LA-SO-RW-5 (well RW-5) were used to develop cross-section G-G′ (Figure 5-15), which runs generally southwest to northeast across the Lower Level Parking Lot. Asphalt and sub-base material are present at the surface over much of this cross-section, with granular fill material extending down to shale bedrock at the southern end. Till-derived fill occupies much of the rest of the cross-section, with a thin layer of brown till extending southward from LA-SO-RW-5 to the vicinity of LA-SO-RW-2. At LA-SO-RW-4, granular fill is present below asphalt from 1 to 15 feet bgs, with wood present from 7 to 13.6 feet bgs. Additionally, a depression in the bedrock surface may exist under LA-SO-RW-4, although this surface is largely inferred between KH-23 and LA-SO-RW-5.

5.3.3.1 Top of Till Topography

Plate 5-4 provides the topography of the top of till surface within the Lower Level, particularly in the Lower Level Railbed near the K5 Retention Basin and the Former K6 Storage Pad. The top of till represents the elevation at which either undisturbed brown or gray till was encountered within the subsurface borings completed in the area. As shown, the surface generally dips to the north/northeast toward the Mohawk River, with a high point at well KH-18 (273 feet amsl), and is generally present around 245 feet amsl in the Railbed Area. Two till ridges/mounds extend downgradient, one northeast of the Former K6 Storage Area and the other near LA1116-3-S (across the road from the K5 Retention

Basin). Although it is difficult to fully define the extent of these ridges with the available data, their presence is consistent with the direction of groundwater movement, as measured on August 3, 2004, and February 10, 2005, and shown in Figures 5-16 and 5-17, respectively. The till ridges correspond to mounds and steeper slopes in the groundwater surface. The top of till surface and till ridges/mounds are significant in terms of groundwater movement through the Lower Level, as discussed in the following section.

There are also four areas where glacial till is not present in the Lower Level. Two areas are found beneath the K5 Retention Basin and northeast of K5, one along the former railbed between wells RW-7 and PW-18, and one large area extending northward from well PW-27 into the southern portions of the Lower Level Parking Lot.

5.3.4 Lower Level Hydrogeology

Groundwater contour maps were prepared based on water level data collected from the site monitoring wells. These monitoring wells are associated with KAPL (KH series), the RFA SV characterization (SV series), wells installed to meet the joint requirements of the SPRU Groundwater RFI and radiological characterization (RW series), and the SPRU radiological characterization (PW and LWT series) investigations. The groundwater level data from August 3, 2004, and February 10, 2005 (Appendix A, Table A-13) were used to prepare the water level contour maps—Figures 5-16 and 5-17, respectively.

Overall groundwater movement is generally from the southwest to northeast with some deviation in the western portions of the study area. Within the northern portion of Figures 5-16 and 5-17 in the area bounded by KH-21, KH-23, and the West Boundary Stream tributary, groundwater movement is to the north, generally mirroring the topography of the landscape and surface water drainage patterns. Within the central and northern portions of the Lower Level Parking Lot, a groundwater flow divide is present, somewhat centered over monitoring well RW-4. Groundwater northwest of RW-4 flows to the northwest toward the low-lying wet area bordering the northwestern edge of the paved parking lot. Groundwater flow east of RW-4 is to the east toward the Mohawk River.

Within the central and southeastern portions of the Lower Level Railbed Area, two apparent groundwater mounds are positioned over monitoring wells PW-17 and PW-18 (Figure 5-16). These mounds are formed in part by lower groundwater elevations at RW-8, KH-20, and

RW-9. Groundwater movement between PW-17 and PW-18 converges into a trough-like feature. Groundwater movement on the outside margins of the mounds flows off to the north (from PW-17) and east (from PW-18).

The February 10, 2005 contoured set of groundwater data (Figure 5-17) reveals a similar groundwater flow pattern to the August 3, 2004, data. Several additional monitoring wells (LWT-1, LWT-2, PW-27, PW-28, PW-29, PW-30, and PW-32) were installed after August 3, 2004. A flow divide is apparent in the central and northern sections of the Parking Lot, and groundwater mounds are positioned over monitoring wells PW-17, KH-20, and PW-29.

Site utility mapping for the Lower Level shows that buried utilities are clustered near the overhead steam lines running in a southwest to northeast direction from the Upper Level and through the Lower Level, generally along the northern side of the K5 Retention Basin to monitoring well PW-29. These buried utility conduits are near monitoring wells KH-20, PW-29, and PW-30. A stormwater drain line between catch basin (CB) CB-4 and manhole catch basin (MCB) MCB-4 exists near the trough between the groundwater mounds associated with monitoring wells PW-17, KH-20, and PW-29. The stormwater utility runs and drains from southwest to northeast. The upgradient portion of the stormwater line is near monitoring well PW-18, which forms the bottom of the groundwater trough. The significance of these utility features is that the buried utility conduit excavations may serve as a zone of preferential groundwater flow because higher groundwater conductivity can serve as a transport pathway for radioactivity in groundwater.

5.3.5 Upper Level Geologic Conditions

The following subsections describe the geologic and hydrogeologic conditions in the Knolls Site Upper Level surrounding the SPRU Process Buildings H2 and G2, the Tank Farm, and the Pipe Tunnel connecting Buildings G2 and H2. The SPRU outside characterization of the Upper Level used previous characterization activities by DOE and KAPL. These previous activities included historical investigations of radiological conditions around the SPRU process buildings, well installation and soil sampling performed by DOE during the 2000 RFA SV, and ongoing KAPL RFIs in the area between Buildings G2 and H2.

This section describes geologic information from select radiological characterization borings and groundwater well borings installed during the outside characterization, along with historical soil boring information from the RFA SV and previous and ongoing KAPL investigations. Soil boring and groundwater monitoring well locations are identified in Figure 5-18 and Plate A-3 in Appendix A.

The soils within the Upper Level are generally composed of fills consisting of granular sands and/or gravels, reworked native soils composed of brown or gray glacial till, and native undisturbed brown and gray till. Reworked soils from other areas of the Knolls Site emplaced in the Upper Level are found to be associated predominantly with the buried subsurface improvements (i.e., utilities) and adjacent to the subsurface building structures (i.e., footing drains). Sand and gravel are associated primarily with the various building foundation wall footings and footing drains. Till-derived fill is found throughout the Upper Level to varying depths, particularly in abundance adjacent to the building foundation walls and above areas of buried utilities. Native brown and gray till are found at varying depths and represent the vertical limits of soil disturbance during construction in the Upper Level.

5.3.5.1 Historical Construction Photographs

Historical site photographs are important in interpreting groundwater flow conditions around structures in the Upper Level. As depicted in Figure 5-19, the foundation of Building H2 and the Tank Farm were constructed within a deep excavation into the native brown and gray tills. The lowest portion of the building floor slab shown is believed to be the lowest level floor slab of Building H2. The vaults shown on the right in the photo are the SPRU underground tank vaults. Concrete slabs were eventually installed immediately above the vaults and covered with approximately 8 feet of fill to bring them up to finished ground surface elevation. The tops of the eastern and southern excavations are believed to represent the approximate existing ground surface. The presence of the compact and dense glacial till allowed the establishment of the near-vertical excavation walls on all sides of the building. Near-vertical excavation walls are absent from the northwestern portion of the building, where it appears that an access/haul road was developed in support of the construction activity. The stockpile of soils shown in the background is believed to be the soils excavated for building location, which are referred to herein as till-derived fill, and used in part as foundation backfill. The Lower Level Access Road is shown on the left in the photo (two trucks are traveling south on the road). The construction of the Pipe Tunnel, just below the midsection of the crane boom depicted in the foreground, does not appear to have been started yet.

The second photograph (Figure 5-20) depicts an advanced stage of construction at Building H2. The photo shows that the southern, eastern, and northern foundation walls have been backfilled up to the level of construction completed. The photograph does not depict the condition of the backfilling at the northwestern or western sides of the building but shows that the hillside slope was not established, so little backfilling of the western wall was completed at that time. Of notable mention is the coal-fired boiler building on the north side of the building and adjacent to Building H1, the cooling tower, and the pile of coal just in front of the crane. This is a potential source of “slag” observed in some of the soil samples collected in the Upper Level. The slag is also a potential source of naturally occurring uranium and thorium. Additionally, the Building H2 tank vaults have been covered, and the construction of the Pipe Tunnel in the foreground appears to be well underway. The pile of stockpiled soil in the background appears to be smaller and reveals evidence that the pile is being actively worked, based on the absence of snow on the face of the pile.

The last photograph (Figure 5-21) shows that portion of Building H2 that was completed above grade. The southwestern corner and western wall of the building have been only partially backfilled, as the Lower Level Access Road can be seen through the open steel structural members. The photograph shows that the hillside has not yet been fully established as it exists today. The top of the Pipe Tunnel is shown just below the main door at the southeastern side of the building. The pile of soil in the background, just to the right of the cooling tower, is depleted. Based on this observation, another source of fill was required to build the hillside.

5.3.5.2 Previous Upper Level Geologic Investigations

KAPL wells H-20, H-21, H-22, H-24, H-26, and H-28 were completed in 1973 along the western and northwestern sides of the exterior wall of Building H2 (see Figure 5-22). The wells are in effect standpipes installed in borings and were used for downhole radiological monitoring of the Building H2 foundation area (see KAPL, 1974). They are referred to herein as cased borings. Well construction details are lacking, and it is not apparent that any well screens were installed. Groundwater enters the casings presumably through leaks in the casing or casing seams. The borings were drilled to depths of up to 40 feet bgs, below the depth of the Building H2 basement floor, typically at 22 to 23 feet bgs. The boring logs identify soils composed of silt, sand, gravel, and clay from grade to depths of 20 to 26 feet bgs. This soil was classified as fill and, based on more recent soil characterization, is likely till-derived fill. Gray till was present directly beneath the fill material, with the exception of soil boring H-26, where a 3-foot layer of brown gravel was present beneath the fill, on top of the gray till, between the depths of 20 and 23 feet bgs.

KAPL monitoring wells MW52-1, MW52-2, MW52-3[3], and MW52-4 were advanced along the southern, eastern, and northern ends of the H2 Tank Farm (Knapp, 1954) (see Figure 5-22). The boring logs for these wells provide little detail regarding the subsurface conditions encountered. The wells were constructed of 3-inch inside diameter polyvinyl chloride (PVC) casing. "Windows" were cut into the casing to allow monitoring of the subsurface with downhole radiological monitoring equipment. Wells MW52-1, MW52-3, and MW52-4 were drilled to depths of about 40 feet bgs, with three windows cut into each well casing from depths between 23 and 35 feet bgs. Well MW52-2 was drilled to a depth of about 196.5 feet bgs and encountered bedrock at 64.5 feet bgs (elevation of 266.6 feet amsl). MW52-2 is cased to a depth of 71.5 feet bgs, and the rest of the well consists of uncased and unscreened open hole in bedrock.

During the RFA SV, soil borings B5701 (well MW-SV3), B3103B (well MW-SV8), B5702, B3101, B3101A, B3103, B3001, B3002, B3003, B3004, B5703 (well MW-SV2), and B5704 (well MW-SV1) were completed along the southern, western, and northern sides of Building H2, along the southern and eastern sides of the H2 Tank Farm, and along the eastern and western sides of the Pipe Tunnel. Samples from these borings indicate the presence of granular fill and till-derived fill around the perimeter of Building H2, and support the steepness and proximity of the excavation walls formed at the time Building H2 and the Pipe Tunnel were constructed. Three of the borings (B3001, B3004, and B3103B) confirmed the presence of granular fill at the base elevation of Building H2 and the H2 Tank Farm, lying on top of gray till. Otherwise, till-derived fill extended to the contact with undisturbed

[3] Well MW52-3 is no longer accessible. It was located along the eastern side of the Tank Farm 65.6 feet south of the northeast corner of the Tank Farm (Knapp, 1954; Figure 5).

gray till, generally at the footing depth of the structures if the borings were completed close enough to the foundation walls. Additional details on these borings and the SV groundwater monitoring wells are provided in the SV Report (CH2M HILL, 2002).

5.3.5.3 Outside Characterization Program Geologic Investigation

The monitoring wells (UW-xx) and soil borings (beginning with LA) completed around the immediate perimeter of Building H2 are UW-1 (LA1305-5-W1), UW-2 (LA1305-5-W2), UW-8 (LA1406-1-B), UW-8A (LA-SO-UW-8A), UW-9 (LA1303-7-B), UW-9A (LA-SO-UW-9A), UW-14 (LA-SO-UW-14), UW-14A (LA-SO-UW-14A), UW-17 (LA-SO-UW-17), UW-18 (LA-SO-UW-18), LA-SO-UW-19, LA1303-2-B2, and LA1303-3-B2 (Figure 5-22). Other than UW-1 (LA1305-5-W1) and UW-2 (LA1305-5-W2), these borings/monitoring wells were installed to support the outside characterization efforts; UW-1 (LA1305-5-W1) and UW-2 (LA1305-5-W2) were installed to jointly support the RFI and outside characterization efforts.

Soil borings LA1305-5-W1 (well UW-1), LA1305-5-W2 (well UW-2), LA-SO-UW-14 (well UW-14), LA-SO-UW-14A (well UW-14A), and LA-SO-UW-19 were completed at the northwest corner of Building H2. At LA1305-5-W1 (well UW-1), till-derived fill was encountered below the surface materials to the top of gray till (307.8 feet amsl). Asphalt, wood, and plastic were noted at various depths within the till-derived fill. Crushed stone or sand and gravel were not found at the till-derived fill/gray till interface. At LA1305-5-W2 (well UW-2), similar subsurface conditions to LA1305-5-W1 (well UW-1) were encountered; however, a layer of sand and gravel was encountered from approximately 21 to 26.5 feet bgs. This sand and gravel layer was on top of the gray till at elevation 303.2 feet amsl. These findings are notable because: (1) LA1305-5-W1 (well UW-1) was completed closer to the wall of Building H2 than LA1305-5-W2 (well UW-2), and sand and gravel were not encountered at LA1305-5-W1 (well UW-1) as would be expected, but were encountered at LA1305-5-W2 (well UW-2); and (2) groundwater was not encountered at LA1305-5-W1 (well UW-1) but was found at LA1305-5-W2 (well UW-2).

As described in Section 5.3.5.1, an access road leading to the northwest corner of Building H2 was apparent in the historical construction photographs. Based on review of these photographs, the lowest portion of the northern wall of Building H2 may have been backfilled with till-derived fill to seal around the foundation footing drain, and the sand and gravel may represent the old construction roadbed running up to Building H2. To evaluate radioactive contamination in cased boring H-28 (see Section 6.4.4.1), LA-SO-UW-14 (well UW-14) and LA-SO-UW-14A (well UW-14A) were completed east of LA1305-5-W1 (well UW-1) and LA1305-5-W2 (well UW-2). LA-SO-UW-14 was completed closer to the northern wall of Building H2 than LA-SO-UW-14A. LA-SO-UW-14 was a blind Geoprobe push to elevation 302.2 feet amsl to establish a monitoring well adjacent to the footing drain and, therefore, soils were not recovered for classification. At LA-SO-UW-14A till-derived fill was encountered to a depth of 16.2 feet bgs (314.3 feet amsl), which contained a piece of rebar, slag, and wood fragments. Gray till was present directly beneath the till-derived fill (314.3 feet amsl). The shallow depth at which gray till was encountered suggests that this location was completed on the steep excavation wall formed during building construction. To further evaluate subsurface conditions in this area (see Section 6.4.4.2), soil boring LA-SO-UW-19 was advanced east of LA1305-5-W2 (well UW-2). Sand and gravel were not encountered at this boring, and gray till was present at 22 feet bgs (308.1 feet amsl). These boring results suggest that the foundation backfilling activity was not completed with a specific type of backfill materials, but rather a variety of materials, mostly site-derived soils.

Soil borings LA1406-1-B (well UW-8), LA-SO-UW-8A (well UW-8A), LA-SO-UW-17 (well UW-17), and LA-SO-UW-18 (well UW-18) were advanced at the northeast corner of the H2 Tank Vault. At boring LA1406-1-B (well UW-8), till-derived fill was encountered to a depth of 22 feet bgs, where an approximate 2-foot layer of saturated sand and gravel was encountered on top of gray till (307.1 feet amsl). Portions of the upper till-derived fill were saturated such that a shallow (13-foot) monitoring well was installed at blind push boring LA-SO-UW-8A. Borings LA-SO-UW-17 and LA-SO-UW-18 were completed west of LA1406-1-B (well UW-8) and LA-SO-UW-8A. These borings were terminated above the building footing elevations and did not encounter gray till. The soils within these borings were predominantly gray and brown till-derived fill.

Soil borings LA1303-7-B and LA-SO-UW-9A were completed at the southeast corner of the H2 Tank Vault. These borings were blind push Geoprobe installations, and soils were not recovered for classification. LA1303-7-B was advanced to 25 feet bgs (307.8 feet amsl) with monitoring well UW-9 set at this elevation. LA-SO-UW-9A was advanced to 13 feet bgs (319.8 feet amsl) with monitoring well UW-9A installed at this elevation. These borings/wells were installed to further evaluate groundwater conditions at elevations corresponding to the upper and lower depths of the tank vaults near SV monitoring well MW-SV8.

Soil borings LA1303-2-B2 and LA1303-3-B2 were completed along the southern portions of Building H2. LA1303-3-B2 was completed at the southwestern corner of Building H2 and advanced to a total depth of 21.5 feet bgs. Gray and brown till-derived fill was present to a depth of 20 feet bgs. A sand and gravel layer with fragments of red drain pipe was present beneath the till-derived fill to a depth of 21.5 feet bgs, at which point spoon refusal was encountered. A monitoring well was not installed at this location. LA1303-2-B2 was a relatively shallow boring advanced to a depth of 4 feet bgs along the southern wall of Building H2 to evaluate a localized area of elevated radioactivity identified during the walkover surface radiological survey of the area.

Soil borings (and associated monitoring wells shown in parentheses, where applicable) installed along the western and northern perimeters of Building G2 and in the open area between Buildings G2 and H2 are LA1401-3-W (UW-3), LA1401-6-Wc (UW-4), LA-SO-UW-5, LA-SO-UW-6 (UW-6), LA-SO-UW-7, LA-SO-UW-10 (UW-10), LA-SO-UW-11, LA1401-2-B (UWT-2), and LA1401-2-Ba (UWT-2A). Boring LA1401-3-W (well UW-3) was advanced at the northwest corner of G2, adjacent to SB/MW-22. Till-derived fill was encountered to 7 feet bgs, below which was brown till to the termination depth of the boring at 14 feet bgs. At soil boring LA-1401-6-W (well UW-4) several attempts were made to achieve the target invert depth of the Building G2 footing (approximately 14 feet bgs); however, each attempt encountered obstructions, which resulted in drilling refusal at depths generally less than 8.3 feet bgs. An exception was at LA1401-6-We, where the boring was advanced to 11.3 feet bgs before encountering refusal. Monitoring well UW-4 was installed at boring LA1401-6-Wc. Borings LA1401-2-B (well UWT-2) and LA1401-2-Ba (well UWT-2A) were advanced along the western wall of Building G2, south of the northwest corner of the building. LA1401-2-B (well UWT-2) was advanced to a total depth of 12 feet bgs (321.8 feet amsl), at which point spoon refusal was encountered. Till-derived fill was present in the upper portions of the boring, with granular fill below, and a thin layer of till-derived fill at the base. Concrete fragments were noted in the upper fills, and a nail and clay pipe fragments were noted in the sample interval at 11 to 12 feet bgs.

Three soil borings (LA-SO-UW-5, LA-SO-UW-6, and LA-SO-UW-7) were completed in the area between Buildings G2 and H2. Each boring was terminated at depths between 7 and 8 feet bgs because of split spoon refusal, probably the result of encountering native till. A monitoring well (UW-6) was installed at LA-SO-UW-6 but not at borings LA-SO-UW-5 or LA-SO-UW-7 because of the presence of unsaturated conditions. Groundwater monitoring well UW-10 was installed east of the Pipe Tunnel, adjacent to the buried stormwater line. Boring LA-SO-UW-10 was advanced to a depth of 16.8 feet bgs (316.6 feet amsl), which is below the invert elevation of the stormwater line. Soils encountered from grade to the termination depth were composed primarily of granular fills, with evidence of concrete fragments to approximately 13 feet bgs, and till-derived fill with evidence of nails, wood, and paper to 16.8 feet bgs.

The Upper Level soil borings used to prepare geologic cross-sections A-A′, B-B′, C-C′, and D-D′ are shown in Figure 5-22. Figures 5-23 through 5-26 provide the geologic cross-sections for A-A′ running east to west, B-B′ running southwest to northeast, C-C′ running southwest to northeast, and D-D′ running east to west, respectively.

Soil borings LA-SO-UW-10 (well UW-10), B5703 (well MW-SV2), B5704 (well MW-SV1), SB-24 (well MW-24), SB-2 (well MW-2), SB-23, SB-6 (well MW-6), and SB-27 (well MW-27) were used to construct cross-section A-A′, which crosses the Pipe Tunnel from east to west between Buildings H2 and G2. Beneath the asphalt pavement and sub-base sand and gravel is a granular fill composed of poorly sorted sands with varying percentages of silt, clay, and gravel. This fill material is generally underlain by till-derived fill that may be contiguous with the till-derived fill used as backfill around the Building H2 foundation wall. This reworked till lies directly above native gray till along this line, except at the western end of the cross-section, where the till-derived fill pinches out in the area of SB/MW-24, and native brown till lies in contact with gray till. Along this cross-section, the gray till surface crests on the west side of the Pipe Tunnel; gently sloping downward to either side. The overall slope of the top of the gray till is from east to west, west of the Pipe Tunnel; and west to east, east of the Pipe Tunnel. At the center of the cross-section, soil boring B5703 (MW-SV2), on the east side of the Pipe Tunnel, reached a total depth of 18.2 feet bgs, with the till-derived fill extending from 0.6 to 15 feet bgs, where the native gray till was encountered. Soil boring B5704 (MW-SV1), on the west side of the Pipe Tunnel, reached a total depth of 16.2 feet bgs, with the till-derived fill extending from 0.6 to 13.1 feet bgs, where the native gray till was encountered.

Soil borings SB-42, SB-21, LA-SO-UW-6 (well UW-6), B5701 (well MW-SV3), LA-SO-UW-17 (well UW-17), LA1406-2-B/-Ba, and LA-1406-3-B1 (well UWT-1) were used to construct cross-section B-B′, which extends from the northwest corner of Building G2 to the southeast corner of Building H1, crossing Building H2 and the Tank Farm. Asphalt pavement and sub-base sand and gravel are present at the southern and northern ends of this cross-section, while granular fill is present at grade along the central portion of this section. The granular fill material is dominantly underlain by till-derived fill, which was used as backfill around the Building H2 foundation wall, except at the southern end where a thin layer of native brown till is present. Native gray till is present below the brown till and slopes downward, toward Building H2, where (based on historical site photographs and building construction drawings) the gray till surface likely descends steeply downward to the base of the foundation excavation along the southern wall of Building H2. Native brown till was encountered in soil boring LA-SO-UW-6 at a depth of approximately 8 feet, identifying a ridge of native brown till lying between Buildings G2 and H2. At the southern end of the cross-section, soil boring SB-42 reached a total depth of 19.5 feet bgs, with granular fill extending from 1 to 12 feet bgs, where 2 feet of native brown is present above native gray till at 14 feet bgs. Groundwater monitoring well MW-SV3 (boring B5701), at the southern wall of Building H2, reached a total depth of 25 feet bgs, with till-derived fill extending to a depth of 22.5 feet bgs, where native gray till was encountered.

Soil borings SB-26 (well MW-26), SB-23, SB-3 (well MW-3), B3003, and LA-SO-UW-14A (well UW-14A) were used to develop cross-section C-C′, which extends from the fence west of Building G2 to the north side of Building H2, crossing Building H2. Asphalt pavement and sub-base sand and gravel are present in the area between Buildings G2 and H2, while granular fill is present at grade at the other locations. Subsurface conditions along C-C′ are similar to those along B-B′, with granular fill extending downward to till-derived fill. Native brown till is present at the southern end of the cross-section, above native gray till, which again slopes downward toward Building H2 and descends steeply downward to the base of the foundation excavation along the southern wall of Building H2. Near the southern end of the cross-section, soil boring SB-23 reached a total depth of 19.3 feet bgs, with granular fill extending from 1 to 8 feet bgs, encountering about 7.5 feet of till-derived fill, and then 1 foot of native brown till above native gray till at 17 feet bgs. Boring SB-3 (well MW-3) reached a total depth of 14.5 feet bgs, with granular fill extending to 11 feet bgs, where native brown till was encountered to a depth of 14 feet bgs, with 0.5 feet of native gray till at the bottom. Boring B3003, at the southern wall of Building H2, reached a total depth of 27.8 feet bgs, with 8 feet of granular fill at the top, and till-derived fill extending from 8 to 24 feet bgs, where native gray till was encountered. The gray till contact slopes from a high at well MW-3 to the south towards well MW-26 and to the north towards the Building H2 excavation.

Soil borings LA1406-1-B (well UW-8), LA-SO-UW-17 (well UW-17), and LA1305-2-B/-Ba; cased borings H-28, H-26, and H-24; and monitoring well KH-15 were used to develop cross-section D-D′. This cross-section extends from the northeast corner of the Tank Farm, along the north side of Building H2, and down the hillside to the Lower Level Access Road. It is similar to the south side of Building H2, where a thin layer of granular fill (deeper at cased boring H-26) extends down from the surface to intercept till-derived fill. This till-derived fill was used as backfill material in the excavations for Building H2 and the Tank Farm, with native gray till below. Gravels were encountered at the base of soil boring LA1406-1-B at the northeast corner of the Tank Farm. The till-derived fill material comes up to grade at the top of the hillside. In general, along this cross-section line, the gray till follows the topography. Boring LA1406-1-B, at the east end of the cross-section, reached a total depth of 24.6 feet bgs (well UW-8 installed in boring LA1406-1-B was pushed to a depth of 27 feet), with till-derived fill mixed with granular fill throughout the boring. An approximately 2-foot-thick layer of poorly sorted gravel was encountered at the bottom in the reworked till. At soil boring LA-SO-UW-17, the till-derived fill begins near the surface, at a depth of 0.7 foot bgs, and is interbedded with granular fill to its total depth of 22.2 feet bgs. At cased boring H-26, the surficial granular fill is approximately 5 to 6 feet deeper than any other location along the line. Reaching a total depth of 40 feet bgs, granular fill is present in H-26 from the surface to 7 feet bgs, where till-derived fill extends to 20 feet bgs. Granular fill is present from 20 to 23 feet bgs, and native gray till is present from 23 feet bgs to the bottom of the boring.

5.3.5.4 Top of Till Topography

Plate 5-5 shows the topography of the top of till surface in the Upper Level, particularly in the immediate area between Buildings G2 and H2. The top of till represents the elevation at which either undisturbed brown or gray till was encountered within the subsurface borings completed in the area. An east/west-trending ridge of undisturbed till is present. The highest point of the ridge is found at well UW-6 (323 feet amsl), but the ridge is generally at an elevation of 318 to 319 feet amsl. The existence of the till ridge and its steep fall to the north are consistent with the construction of Building H2 in that a near-vertical wall into the till was created to enable the construction of the southern foundation wall. The southern portion of the ridge, although not documented in photos, was likely created as a result of the installation of the fire water lines and stormwater lines. As the Pipe Tunnel extends from the base elevation of Building G2 to the near-base elevation of Building H2, a trench excavated into glacial till would have been required for construction of the utility lines.

The till ridge on the east side of the Pipe Tunnel is more difficult to interpret because there are fewer borings to define the till there. The invert elevation of the outlet at MCB-8, off the northwest corner of Building G2 where the stormwater line turns south, is at 318.7 feet amsl, and the invert elevation of the inlet of MCB-7, off the northeast corner of Building G2, is at 317.9 feet amsl; therefore, the stormwater line connecting the two catch basins required it to be excavated into the till, passing beneath the Pipe Tunnel foundation. Similarly, the fire water line passes beneath the Pipe Tunnel foundation. The stormwater line between MCB-8 and MCB-7 and the fire water line beneath the Pipe Tunnel are likely interconnected by the trenching/excavations required for installation.

Another ridge of till is also present west of Building G2, although not as pronounced as that adjacent to the southern wall of Building H2. This north-south trending ridge of till parallels the topography west of Building G2 and is the result of the natural hillside topography, with some modification likely along the western perimeter of Building G2 during its construction.

The existence of the till ridges, troughs, and the topography of the top of till are significant in terms of groundwater movement, as discussed in the following subsection.

5.3.6 Upper Level Hydrogeology

If the site were not in a developed state, natural groundwater movement would be expected to follow the topography of the native brown or gray tills. In the area of Buildings G2 and H2, natural groundwater movement would likely be from southeast to northwest.

Groundwater movement in the soils in the Upper Level, however, is influenced and controlled by manmade subsurface features related to building foundation systems, utility conduits, and the limits of earthwork during the construction of these features. Conditions influencing the movement of groundwater are:

1. Buildings that have been constructed into or above the underlying native gray till and that have been backfilled with more permeable fill soils
2. Buried piping that has either been installed within trenches excavated into the native gray till or above the gray till and backfilled with more permeable fill soils
3. Areas where native soils were not totally removed in support of site construction and development

A pertinent example of the interconnection between subsurface utilities and hydrogeologic conditions was a water pressure test of the storm sewer line between MCB-7 and MCB-8 conducted by KAPL in November 2003. The sewer line integrity was tested because of periodic surcharging of the Hillside Sump during heavy precipitation. The test involved blanking off ancillary sewer lines to isolate the sewer line between MCB-7 and MCB-8. Water was added under pressure to the sewer line, and the pressure was monitored. The groundwater level was measured in monitoring wells MW-SV1, MW-SV2, MW-SV3, MW-24, and MW-25 north of the stormwater line and south of Building H2 during the test; MW-SV3 is adjacent to the south side of Building H2 and immediately west of the main entrance to the building (see Figure 5-22). The storm sewer piping failed to hold water pressure, indicating that its integrity was compromised. During the test, the MW-SV3 water level increased by approximately 8 feet, and water was heard cascading into the well. The water level in the Hillside Sump also increased. However, the water level in the other four wells did not change. The increased water levels in MW-SV3 and the Hillside Sump suggested that a conduit for stormwater from the storm sewer piping between MCB-7 and MCB-8 existed that allowed stormwater to enter the Pipe Tunnel and Building H2 foundation drains. To eliminate stormwater leakage to groundwater between Buildings G2 and H2, KAPL relined the stormwater lines between manhole catch basins MCB-7, MCB-8, and MCB-9 in May 2005. The periodic leaking of the stormwater line between manhole catch basins MCB-7 and MCB-8, generally running west to east between Buildings G2 and H2, when the system was charged with stormwater, may have resulted in isolated and infrequent groundwater movement variations. Prolonged periods of leakage during storm events could have increased groundwater levels over the broader area between Buildings G2 and H2 and the Pipe Tunnel.

Groundwater contour maps were prepared based on water level data collected from the site monitoring wells. These monitoring wells are associated with KAPL investigations (KH, B, H, and MW52 series), the KAPL Hillside RFI (MW series), the RFA SV (SV series), and the outside characterization (UW and UWT series). The groundwater level data from October 6, 2004, and February 9, 2005 (Appendix A, Table A-14) were used to prepare the groundwater contour maps in Figures 5-27 and 5-28, respectively.

The overall pattern of groundwater flow in the area of Buildings G2 and H2 is from the southeast to northwest; however, groundwater flow is altered adjacent to each building and between the two buildings. The flow patterns on both measurement dates are similar, although October 6, 2004, data represent a period following relatively high precipitation, and February 9, 2005, data represent a period following the onset of a frost cap and little infiltration of precipitation.

As shown in both Figures 5-27 and 5-28, a groundwater depression is present between Buildings G2 and H2, which is elongated in a west to east lineation. The deepest portion of the depression is centered around monitoring wells MW-2 and B-15. The western end of the depression is contained within the 325-foot groundwater contour. Although not delineated, the eastern end of the depression is believed to be controlled at some point by the 325-foot contour in this portion of the site. This is because the groundwater at UW-10 (east of the Pipe Tunnel) is at a higher elevation (320.5 feet amsl [2/9/05] to 320.8 feet amsl [10/6/04]), compared with the groundwater elevation (319.4 feet amsl [2/9/05] and 319.3 feet amsl [10/6/05]) at MW-SV2, which is adjacent to the east wall of the Pipe Tunnel. Groundwater movement in the depression is from the Pipe Tunnel to the west.

The stormwater pipe was shown through KAPL testing to be leaking water while under hydraulic pressure before it was relined in May 2005. So it may also have been an infiltration point for groundwater into the storm sewer, and it may have had a role in the development and presence of the groundwater depression. Potential changes in groundwater flow directions resulting from the leak repair have not yet been determined.

The groundwater depression coincides well with the top of till contour map (Plate 5-5), as discussed in Section 5.3.5.4, and the gray till surface in cross-section A-A′ (Figure 5-23).

Groundwater movement immediately west of Building G2 is easterly toward the building from the approximate top of the north/south-trending hillside ridge and the top of the till ridge depicted in Plate 5-5. Groundwater movement west of these ridges is westerly and away from Building G2. Groundwater movement at the north end of Building G2 appears to be northerly toward the groundwater depression between Buildings G2 and H2.

Groundwater movement west of the western wall of Building H2 flows easterly toward the building from the 325-foot-amsl groundwater contour that forms a groundwater ridge (flow divide), generally mirroring the top of the hillside ridge. Groundwater movement on the north side of Building H2 is to the south toward the northern side of the building. This is apparent because the groundwater elevations at UW-14A and UW-2 are higher than at monitoring wells UW-14 and H-24, which are closer to the foundation wall of Building H2. A groundwater ridge is located farther north of Building H2 (at the 325-foot-amsl contour), where groundwater flows in a northerly direction. Groundwater along the southern wall of Building H2 flows to the north, north of an east/west-trending, 325-foot-amsl groundwater contour ridge and till ridge, and to the south, south of the 325-foot groundwater ridge, into the depressed groundwater area between Buildings G2 and H2.

Both water level contour maps show a high groundwater condition at SB/MW-24. This observation is evident in cross-section A-A′ (Figure 5-23), which shows that MW-24 was installed within a mound of brown till. The water elevation at MW-24 was approximately 320 feet amsl on both dates of recording, which establishes the groundwater within the brown till. The elevated groundwater levels in MW-24 probably result from groundwater being retained in the less permeable brown till, causing a retarded drop in the groundwater table. The brown till is charged with groundwater during precipitation periods when the overall area groundwater levels rise, with potential contributions during long-term precipitation events caused by leakage from stormwater lines near MW-24.

All of these variations of groundwater movement, except in SB/MW-24, reflect the more permeable soils (granular fill or till-derived fill) adjacent to the building foundation walls and within the buried utility lines. Foundation walls and utility lines intersect groundwater and are situated on gray till or in excavation troughs in the gray till. Flow directions are also controlled by the topography of the native gray or brown till, as discussed in Section 5.3.5.4.

One bedrock monitoring well (MW52-2) is present in the Upper Level. The well is about 7 feet north of the northern wall of the Tank Farm and was installed in 1952 (Knapp, 1954). According to the well construction log for MW52-2, bedrock was encountered at a depth of approximately 64.5 feet bgs (266.5 feet amsl). The bedrock was then drilled out another 70 feet to a total depth of 134.5 feet bgs (196.5 feet amsl). The interval through the overlying clay and 4 feet into bedrock was cased off, leaving the rest of the well as an open hole through the shale bedrock. The water level in the well was recorded at depths of approximately 95 feet bgs. Based on these data, the groundwater in the bedrock is separate from the groundwater found both perched and in the native tills in the Upper Level. Because there is only one bedrock well near Building H2, the direction of groundwater movement within the bedrock is not defined.

In December 2004 soil boring LA-SO-UW-19 was drilled 8 feet northwest of cased boring H-28 to evaluate the stratigraphy below the top of the gray till, which was not completely described in the basic soil logs (KAPL, 1974). The specific objectives were to determine whether the gray till was continuously impermeable in this area and to confirm that permeable strata were not present in the gray till. Such permeable zone could transport groundwater with elevated radioactivity from the interior of the Building H2 foundation to intercept the H-28 cased boring below the building footing invert at 308 feet amsl and the bottom of the boring at 293 feet amsl (KAPL, 1974). Other than an isolated inclusion of fractured shale bedrock between 300.1 and 298.1 feet amsl, the 40-foot-deep borehole contained low-permeability gray till from 306.1 to 290.1 ft amsl. The shale bedrock inclusion was not saturated, indicating that it was not a conduit for groundwater within the gray till sequence. No evidence of other water-bearing strata was identified in the gray till, indicating that at least the upper portion of the gray till serves as an effective aquaclude preventing downward flow from the native tills to bedrock.

5.4 Data Sources, Quality, and Usability

The analytical data collected as part of the outside characterization sampling event underwent a data quality evaluation (DQE) process that is documented in Appendix I. Appendix I contains separate DQEs pertaining to the radiological data set (I1), the TCLP data set (I2), the zirconium data set (I3), and the KAPL seep data (I4).

The DQE process assesses the effect of the overall analytical process on the usability of the data. This includes evaluation of the laboratory performance and compliance with the analytical method requirements, and review of the data for potential matrix interferences. The following sections summarize the results of the DQEs.

5.4.1 Radiological Data Quality Evaluation

The radiological DQE (Appendix I1) written for the outside characterization sampling was split into an evaluation of onsite screening level data (from the SPRU onsite laboratory) and an evaluation of the offsite definitive (from the Severn Trent Laboratory [STL] in St. Louis) radiological data.

Onsite screening data were collected and analyzed for gamma-emitting radionuclides. Appendix I1 provides the frequency of detection of these samples and their respective radionuclides. All of the quality assurance (QA) actions provide a means to assess control and measure the performance of equipment and processes to the established laboratory requirements. The overall QA process included, but was not limited to:

- Complete documentation of each step in the preparation, analysis, and reporting/evaluation of results
- Performance and documentation of the calibration of peripheral equipment, such as balances, pipettes, glassware, efficiency and energy calibration per geometry
- Use of second source, National Institute of Standards and Technology (NIST) traceable calibration checks at least once daily or upon “cold” startup

Additionally, field duplicate precision indicated good sample homogeneity, which would not alter the determined activities.

The offsite radiochemistry laboratory (STL) analyzed selected samples for gamma, beta, and alpha emitters. QC measurements included evaluation (as appropriate to the methods) of holding times, blank contamination, tracer and carrier recoveries, matrix spike/matrix spike duplicate accuracy and precision, field duplicate precision, analytical method accuracy, and total versus dissolved concentrations. These QC statistics are presented in Appendix I1. Some early reported strontium-89 activities are false positives, which is also discussed in Appendix I, Attachment A. The analytical methodologies used by STL for the radiological DQE were:

- Gross alpha and beta by U.S. Environmental Protection Agency (EPA) method 900, modified (M) and SW846 9310
- Gamma-emitting radionuclides in drinking water by EPA method 901.1M
- Radioactive strontium in drinking water by EPA method 905.0
- Tritium in water by EPA method 906.0
- Alpha spectroscopy isotopes by methods EML-Am-01M, EML-Pu-02M, EML-U-02M (Environmental Measurements Laboratory)
- Technetium by liquid scintillation counting method EML-Tc-02M
- Strontium by method EML Sr-03M (Beta GPC [gas proportional counter])
- Gamma spectroscopy by DOE method GA-01-R, M
- Isotopic plutonium by DOE method A-01-R and STL method RC-0245 (preparation)

Many naturally occurring radionuclides that are not SPRU radionuclides of concern were reported by the analytical laboratories in their gamma spectroscopy analysis reports. These radionuclides are as follows.

Non-SPRU Radionuclides of Concern Reported by Gamma Spectroscopy

Uranium Decay Chain	Thorium Decay Chain	Other
Thorium-234	Radium-228 (by actinium-228)	Beryllium-7
Radium-226 (by lead-214)	Actinium-228	Potassium-40
Lead-214	Radium-224	Thorium-231
Bismuth-214	Lead-212	
Lead-210	Bismuth-212	
	Thallium-208	

The gamma analyses were not optimized for uranium and thorium decay chain radionuclides whose quantitation requires equilibrium with radon-220 and -222. These radionuclides are bismuth-212 and -214; lead-212 and-214; radium-226; and thallium-208. The results for these radionuclides cannot be used to support any decisions.

The radionuclides listed above are not discussed further because of the minimal impact on the evaluations and conclusions of this report. However, for completeness these radionuclides are included in the analytical data summary provided in Appendix J.

Several radionuclides of concern were reported by both gamma spectroscopy and the more sensitive and less interference prone alpha spectrometry methods EML-Am-01M and EML-U-02M. These radionuclides are americium-241, uranium-235 and uranium-238 (by thorium-234 for gamma spectroscopy). When this occurs, the alpha spectrometry result is evaluated in this report. For completeness, all reported results are provided in the analytical summary tables in Appendix J.

Many SPRU radionuclides of concern were detected throughout the three Outside Areas at concentrations well below the associated action levels. These low-level detections often do not correlate with expected isotopic ratios based on naturally occurring phenomenon or historical data on SPRU process materials. Low-level detections in groundwater samples were sometimes not repeated in paired (i.e., unfiltered and filtered) samples or subsequent sampling rounds. The causes of these discrepancies could be laboratory contamination, variations in field sampling, or large uncertainties in the results near the method detection limits. These discrepancies are of little significance to the evaluations and conclusions of this report because the associated activities are well below action levels, and no further investigation regarding their cause is warranted. Low-level detections associated with SPRU radionuclides of concern are identified in the text, although no further evaluations or conclusions are provided.

An evaluation of uranium isotopic ratios to determine (or attempt to determine) whether any detected uranium in the environmental samples could have resulted from release of enriched uranium from non-SPRU sources is not included in this report. The alpha spectrometry methodology implemented to quantify isotopic uranium yields uranium-235 data that are positively biased due to spectral tailing of uranium-234. The resulting uranium-235 to uranium-238 ratios are therefore inaccurate and cannot be used to study potential uranium enrichment. No instances of substantial disequilibrium between uranium-238 and uranium-234 were observed in SPRU soil samples. Therefore, there is no evidence to support the hypothesis that enriched uranium was released in the Outside Areas. Further, because all isotopic uranium results are well below the associated action levels, the determination of uranium enrichment is of little consequence to the evaluations and conclusions of this report.

The DQE process concluded the following.

- The samples were analyzed in accordance with the methods stated in the work plan and appropriate laboratory QC was performed, as demonstrated by the deliverable summaries and analytical run sequences.
- Field duplicate results indicate good field sampling precision and homogeneity of the sample matrix.
- The completeness for this data set was 99.99 percent, indicating that the analytical method or matrix effects had little impact on the final numerical result. A single record was rejected out of 8,439 individual records for extremely low tracer recovery (sample LA1408-9-B-3-1 for americium-241).
- The data are usable for their intended purpose as qualified.

5.4.2 TCLP Data Quality Evaluation

A TCLP DQE (Appendix I2) addresses the TCLP samples collected from 34 locations throughout the three Outside Areas to support future waste characterization. The analytical methods used by the laboratory for the TCLP analyses were:

- Volatile organic compounds (VOCs) by SW-846 method 8260B
- Semivolatile organic compounds (SVOCs) by SW-846 method 8270C
- Total metals by SW-846 method 6010B (ICPES [inductively coupled plasma emission spectroscopy])
- Total mercury by SW-846 method 7470A and 7471A
- TCLP by SW-846 method 1311

QC included, but was not limited to, the analysis of surrogate spike recoveries, matrix spike recoveries, blank spikes, calibrations, lab blanks, and duplicate sample results. Field QC samples collected included field duplicates. The QC statistics are presented in Appendix I2.

The DQE process concluded the following.

- The laboratory analyzed the samples in accordance with the EPA methods stated in the work plan, as demonstrated by the deliverable summaries and analytical run sequences.
- The accuracy and precision results for blank spikes/blank spike duplicates indicate that the laboratory's analytical methods were in control.
- Field duplicate results indicate good field sampling precision and homogeneity of the sample matrix even through the TCLP process.
- All type spike recoveries, surrogates, and field duplicate samples indicate that the specific sample matrix did not interfere with the analytical process or the final numerical result.
- The completeness for this data set was 100 percent (none of the data were rejected).
- The data are usable for their intended purpose as qualified.

5.4.3 Zirconium Data Quality Evaluation

A DQE (Appendix I3) was prepared for the 54 zirconium samples collected in the Land Area near Building Q6 (adjacent to the west side of the Land Area) to support future waste characterization. The collected samples were analyzed using the following method:

- Total Zirconium by SW-846 method 6010B, ICPES

QC included, but was not limited to, the analysis of surrogate spike recoveries, matrix spike recoveries, blank spikes, calibrations, lab blanks, and duplicate sample results. Field QC samples collected included field duplicates. The QC statistics are presented in Appendix I3.

Conclusions of the DQE process include the following.

- The laboratory analyzed the samples in accordance with the EPA methods stated in the Outside Characterization Plan, as demonstrated by the deliverable summaries and analytical run sequences.
- The blank spike accuracy and precision results indicate that the analytical methods were in control within the laboratory.
- All type spike recoveries indicate that the specific sample matrix did not significantly interfere with the analytical process or the final numerical result.
- The completeness for this data set was 100 percent (none of the data were rejected).
- The data are usable for their intended purpose as qualified.

5.4.4 KAPL Seep Data Quality Evaluation

A DQE (Appendix I4) was prepared for the three groundwater seep samples collected by KAPL from the Mohawk River bluff east of the Lower Level Parking Lot. The collected samples were analyzed using the following methods:

- Gross alpha and beta by EPA method 900.1
- Gamma-emitting radionuclides in drinking water by EPA method 901.1
- Strontium-90 by KAPL method EIC-SRW01M

Evaluation of data quality is presented in Appendix I4. Because of limited sample volume, field QC samples were not collected; however, laboratory duplicates were analyzed from separate aliquots of the samples or recounting of the same sample.

Conclusions of the DQE process include the following.

- QC data indicate that the analytical process was in control.
- The completeness for this data set was 100 percent (none of the data were rejected).
- The data are usable for their intended purpose as qualified.

Tables

TABLE 5-1
SPRU Radionuclides of Concern
SPRU Radiological Characterization Report

Radionuclide	Analysis Strategy[a]
Americium-241	A
Cesium-137	A
Cobalt-60[c]	A
Europium-152	C
Europium-154	A
Europium-155	C
Hydrogen-3 (Tritium)	A[b]
Nickel-63	B (Analyze if Cesium-137 > 1,800 pCi/g)
Plutonium-238	A
Plutonium-239	A
Plutonium-240	A
Plutonium-241	B (Analyze if Americium > 0.4 pCi/g and Plutonium-239 > 5 pCi/g)
Promethium-147	B (Analyze if Cesium-137 > 280 pCi/g)
Samarium-151	B (Analyze if Cesium-137 > 280 pCi/g)
Strontium-90	A
Technicium-99	B (Analyze if Cesium-137 > 1,100 pCi/g)
Thorium-232	B (Analyze if Actinium-228 > 5 pCi/g)[d]
Uranium-234	A
Uranium-235	A
Uranium-238	A
Zirconium-93	B (Analyze if Cesium-137 > 77,000 pCi/g)

[a] Analysis Strategy:
A = Analyze all samples.
B = Analyze if trigger value (in parenthesis) is exceeded (see Appendix B of the *Final Derived Concentration Guideline Levels Technical Basis* [CH2M HILL, 2005b]). Based on the low comparative risk and the analytical difficulties presented by some of the low-abundance radionuclides (e.g., Ni-63, Tc-99, Zr-93), samples would be analyzed only if a certain trigger concentration was exceeded that approximates the detection capability of the laboratory. The trigger concentrations were based on the ORIGEN code predicted activity yield ratios (to the listed trigger radionuclides) and the expected analytical detection limits. At concentrations below the identified trigger levels, the analytical methodology cannot detect the low-yield radionuclides. See Appendix B of the *Final Derived Concentration Guideline Levels Technical Basis* for more details.
C = Analyze statistically representative number of samples for confirmation of absence, if not detected by gamma spectroscopy.

[b] Upper Level water samples only. Tritium is a KAPL radionuclide potentially present in the Upper Level due to historical spills and releases.

[C] Cobalt-60 may be encountered if contamination resulting from KAPL activities is encountered. As an indicator of contamination resulting from KAPL activities, this radionuclide is included in the list of SPRU radionuclides of concern.

[d] Although actinium-228 is not a radionuclide of concern, actinium-228 is reported, when detected, during gamma spectroscopy. Therefore, actinium-228 may be used as a surrogate trigger for the parent radionuclide.

TABLE 5-2
Chemical Contaminants of Concern
SPRU Radiological Characterization Report

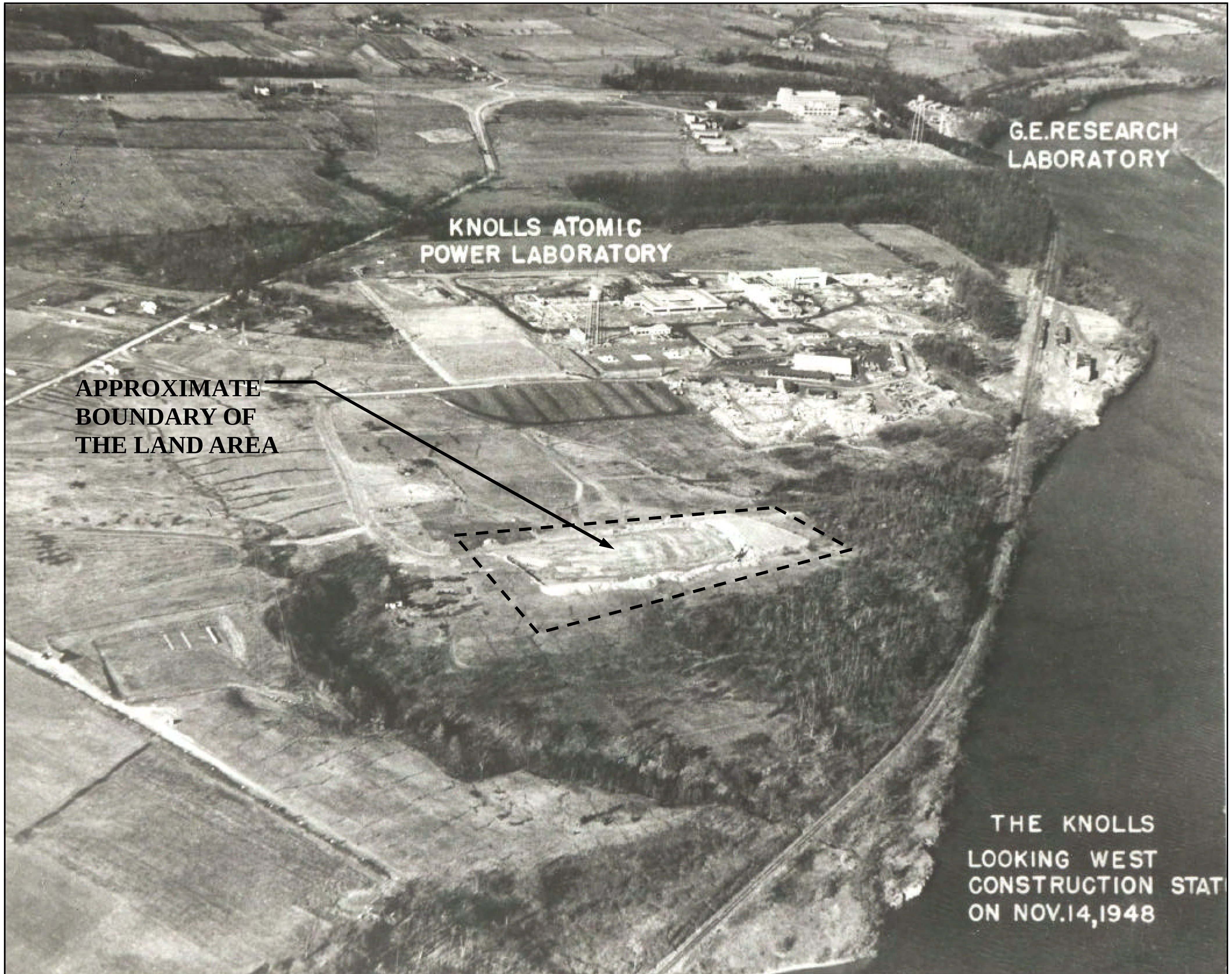
Hazardous Waste Number/ Chemical Name	**Chemical Abstracts Service Number**	**Regulatory Level (mg/L)**
D004 Arsenic	7440–38–2	5.0
D005 Barium	7440–39–3	100.0
D018 Benzene	71–43–2	0.5
D006 Cadmium	7440–43–9	1.0
D019 Carbon tetrachloride	56–23–5	0.5
D020 Chlordane	57–74–9	0.03
D021 Chlorobenzene	108–90–7	100.0
D022 Chloroform	67–66–3	6.0
D007 Chromium	7440–47–3	5.0
D023 o-Cresol	95–48–7	200.0[a]
D024 m-Cresol	108–39–4	200.0[a]
D025 p-Cresol	106–44–5	200.0[a]
D026 Cresol		200.0[a]
D016 2,4-D	94–75–7	10.0
D027 1,4-Dichlorobenzene	106–46–7	7.5
D028 1,2-Dichloroethane	107–06–2	0.5
D029 1,1-Dichloroethylene	75–35–4	0.7
D030 2,4-Dinitrotoluene	121–14–2 3	0.13[b]
D012 Endrin	72–20–8	0.02
D031 Heptachlor (and its epoxide)	76–44–8	0.008
D032 Hexachlorobenzene	118–74–1 3	0.13[b]
D033 Hexachlorobutadiene	87–68–3	0.5
D034 Hexachloroethane	67–72–1	3.0
D008 Lead	7439–92–1	5.0
D013 Lindane	58–89–9	0.4
D009 Mercury	7439–97–6	0.2
D014 Methoxychlor	72–43–5	10.0
D035 Methyl ethyl ketone	78–93–3	200.0
D036 Nitrobenzene	98–95–3	2.0
D037 Pentrachlorophenol	87–86–5	100.0
D038 Pyridine	110–86–1 3	5.0[b]
D010 Selenium	7782–49–2	1.0
D011 Silver	7440–22–4	5.0
D039 Tetrachloroethylene	127–18–4	0.7
D015 Toxaphene	8001–35–2	0.5
D040 Trichloroethylene	79–01–6	0.5
D041 2,4,5-Trichlorophenol	95–95–4	400.0
D042 2,4,6-Trichlorophenol	88–06–2	2.0
D017 2,4,5-TP (Silvex)	93–72–1	1.0
D043 Vinyl chloride	75–01–4	0.2
NA Zirconium metal	7440-67-7	NA

NA = not applicable
[a] If o-, m-, and p-Cresol concentrations cannot be differentiated, the total cresol (D026) concentration is used. The regulatory level of total cresol is 200 mg/L.
[b] Quantitation limit is greater than the calculated regulatory level. The quantitation limit therefore becomes the regulatory level.

TABLE 5-3
Exposure Pathways Used in RESRAD Modeling of SPRU Land Use Scenarios
SPRU Radiological Characterization Report

Exposure Pathways	Land Use		
	Subsistence Farmer	Residential Suburban	Industrial
External Gamma	Active	Active	Active
Inhalation	Active	Active	Active
Plant Ingestion	Active	Active	Suppressed
Meat Ingestion	Active	Suppressed	Suppressed
Milk Ingestion	Active	Suppressed	Suppressed
Aquatic Foods	Active	Suppressed	Suppressed
Drinking Water	Active	Suppressed	Suppressed
Soil Ingestion	Active	Active	Active
Radon	Active	Active	Active

Figures



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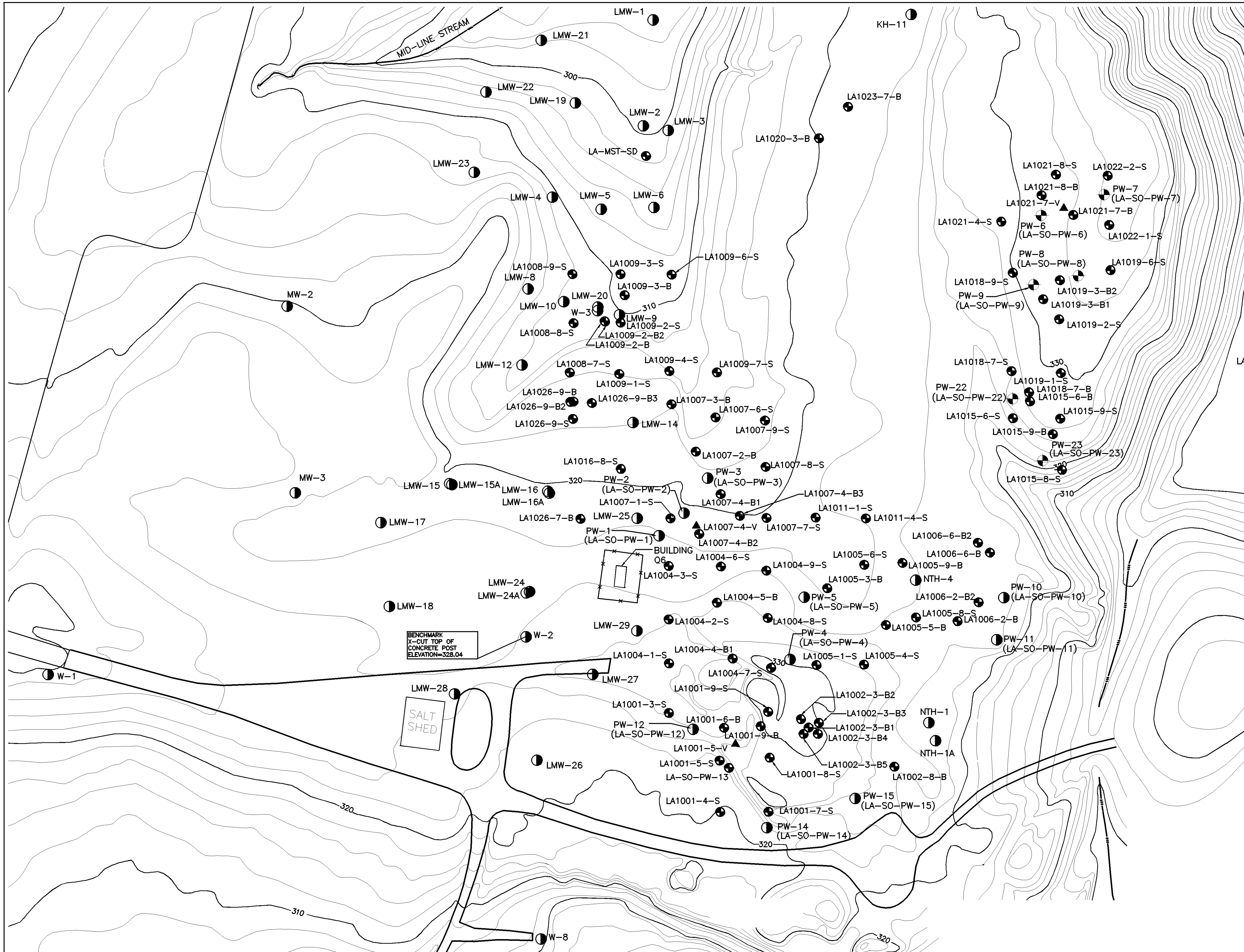
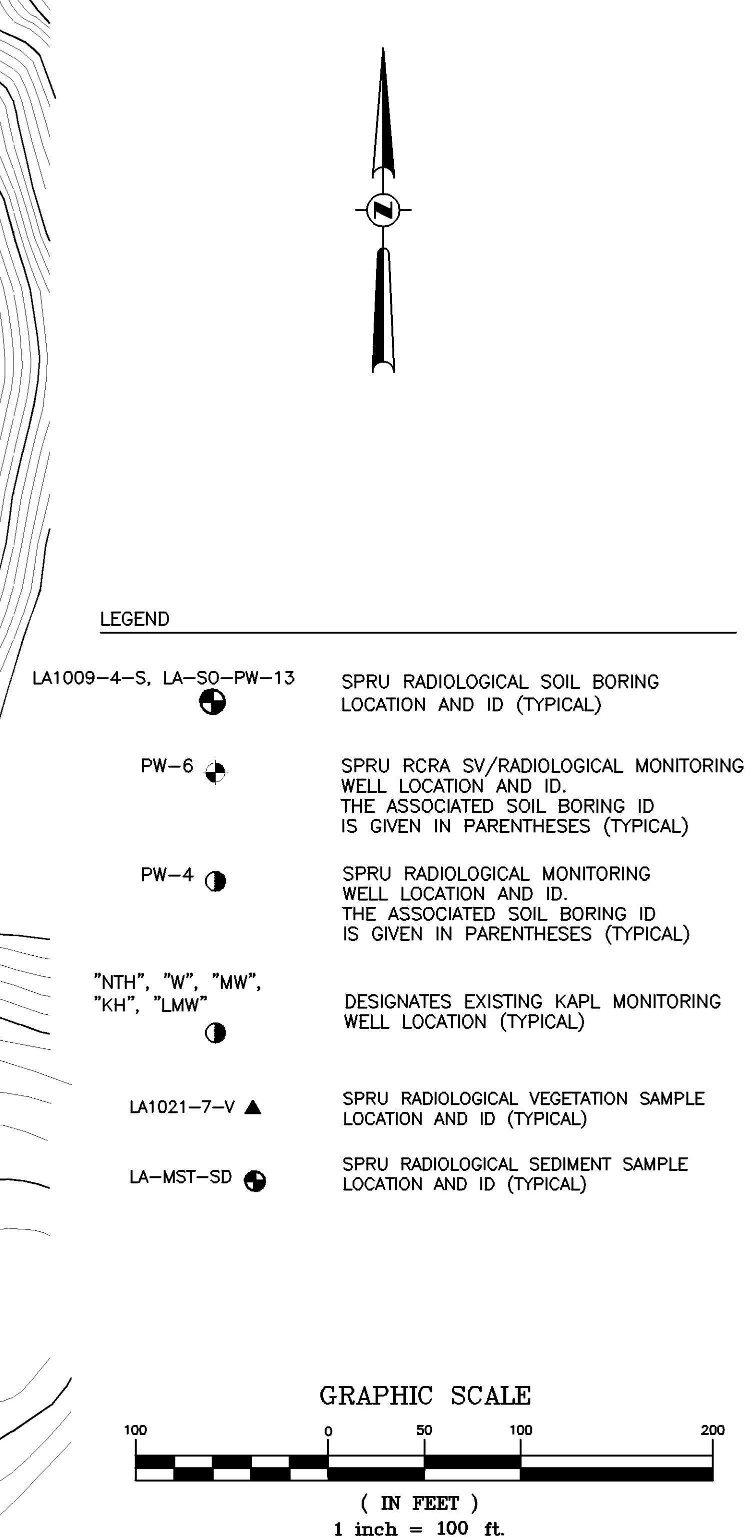
RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS		
FIGURE 5-1 PHOTOGRAPH OF LAND AREA AFTER REMOVAL OF TILL		
DATE APRIL 06, REV. 2	DRAWING NO.	CTM PROJ. NO: 04.9080





MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.

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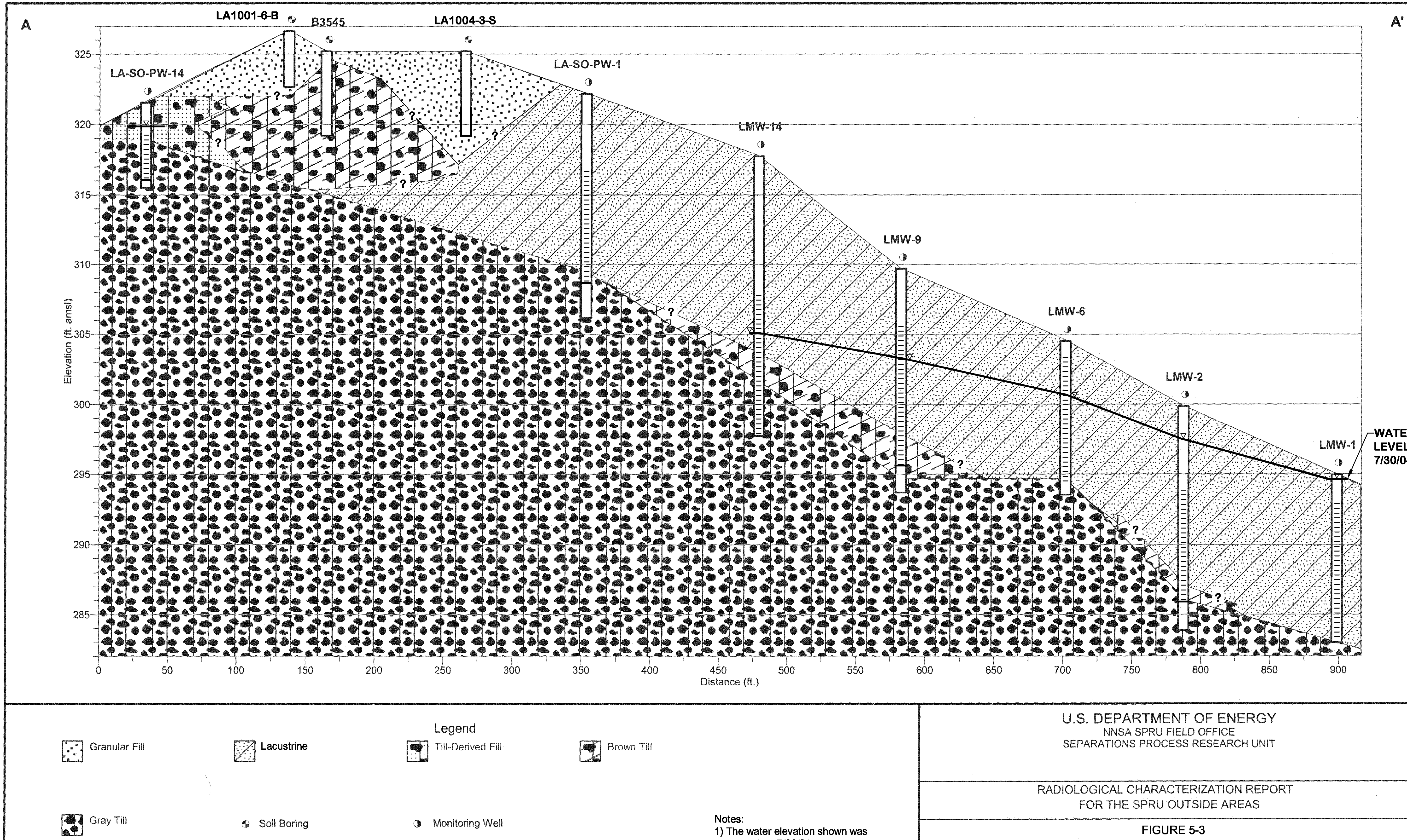
FIGURE 5-2
LAND AREA
SAMPLE LOCATION MAP

DATE: APRIL 2006, REV. 2	DRAWING NO. 05-366	CTM PROJ. NO.: 04.9080



Notes:
1) The water elevation shown was measured on 7/30/04.
2) The diameter of the soil borings and monitoring wells are not shown to scale.

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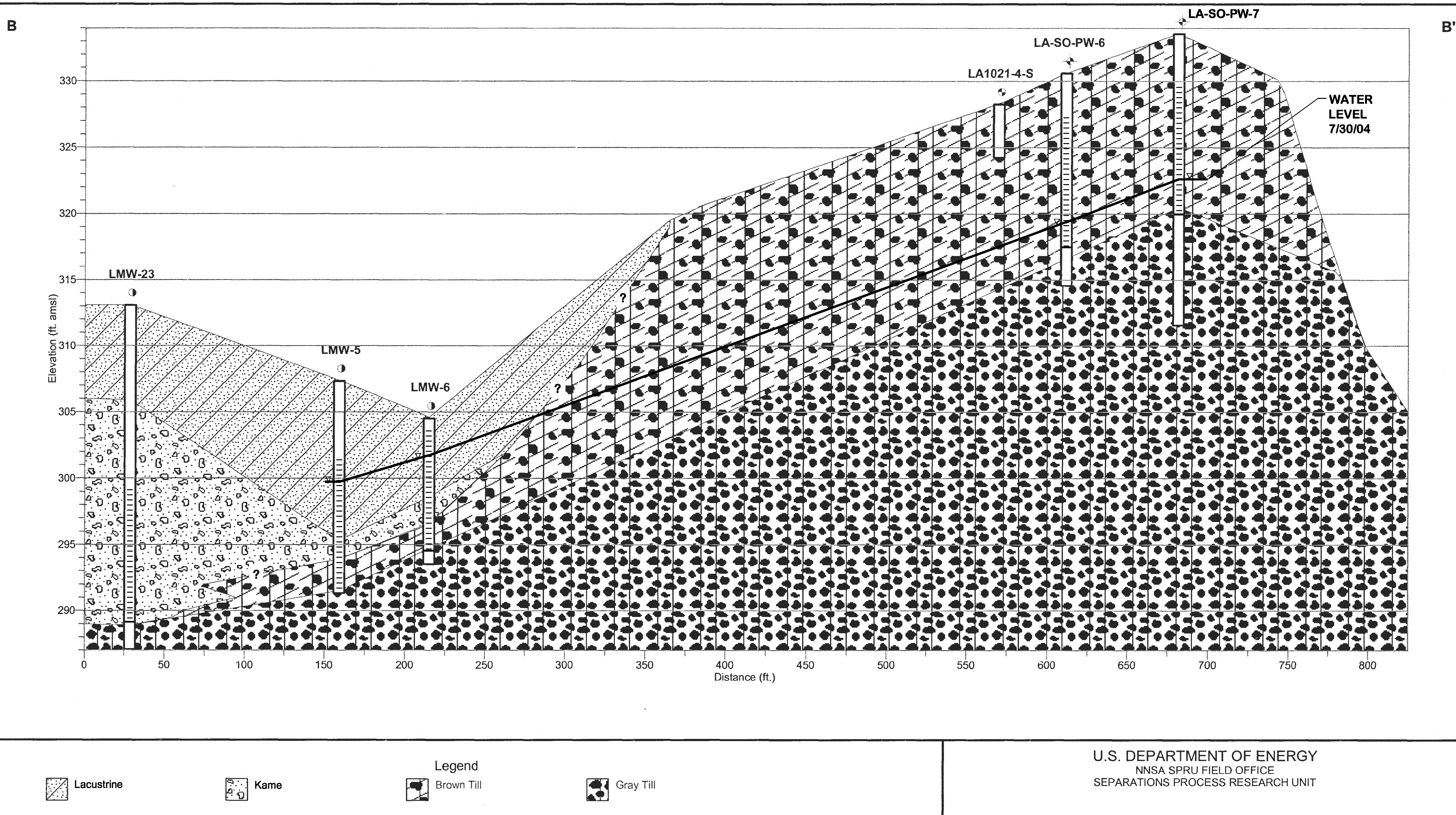
RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS

FIGURE 5-3

LAND AREA CROSS SECTION A-A'

Date: APRIL 2006, REVISION 2 | CTM Project No.: 04.9080



Notes:
1) The water elevation shown was measured on 7/30/04.
2) The diameter of the soil borings and monitoring wells are not shown to scale.

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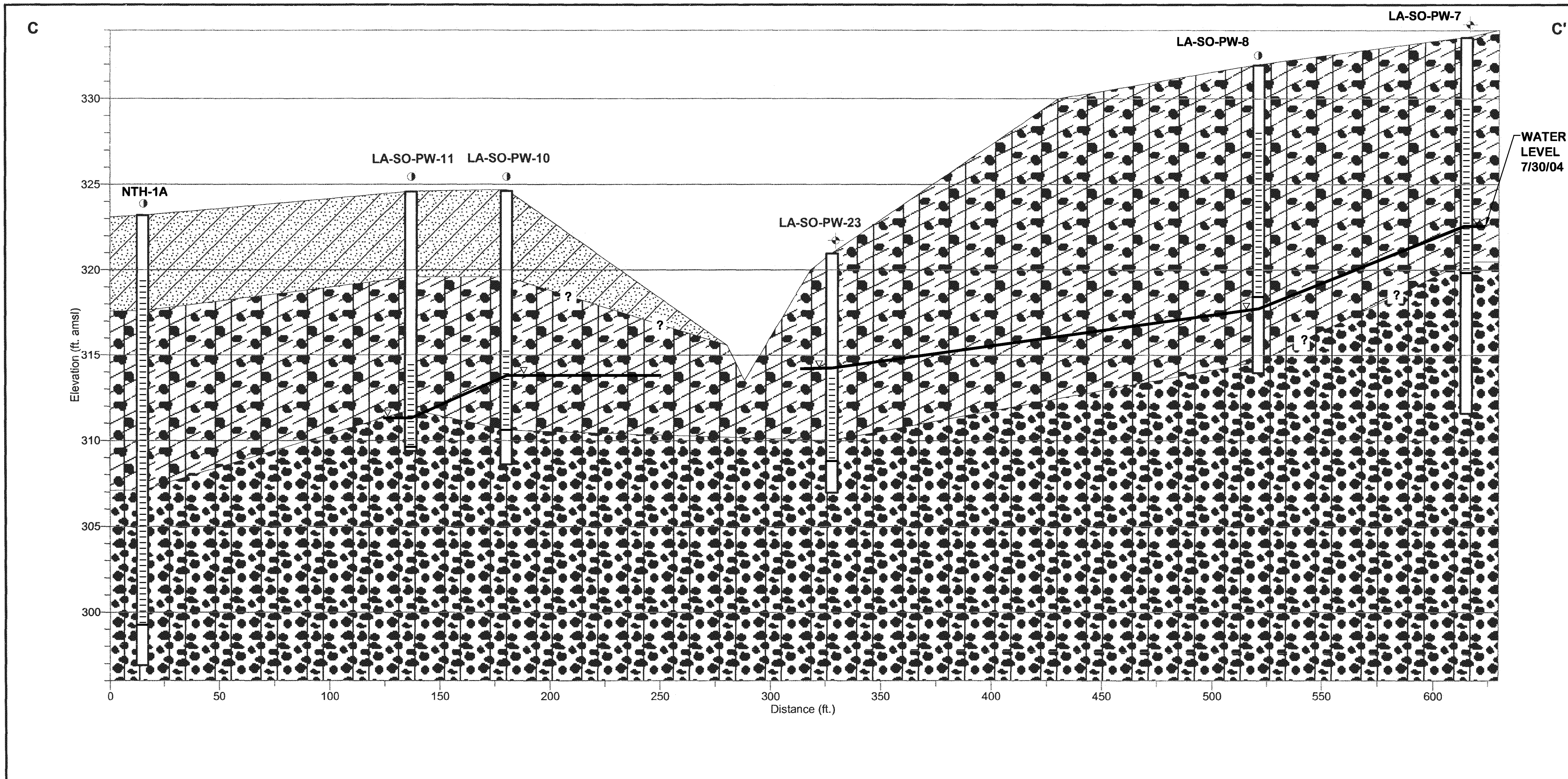
RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS	
FIGURE 5-4	
LAND AREA CROSS SECTION B-B'	
Date: APRIL 2006, REVISION 2	CTM Project No.: 04.9080



Legend

- Lacustrine
- Brown Till
- Gray Till
- ◑ Monitoring Well
- ⌖ Monitoring Well

Notes:
1) The water elevation shown was measured on 7/30/04.
2) The diameter of the soil borings and monitoring wells are not shown to scale.

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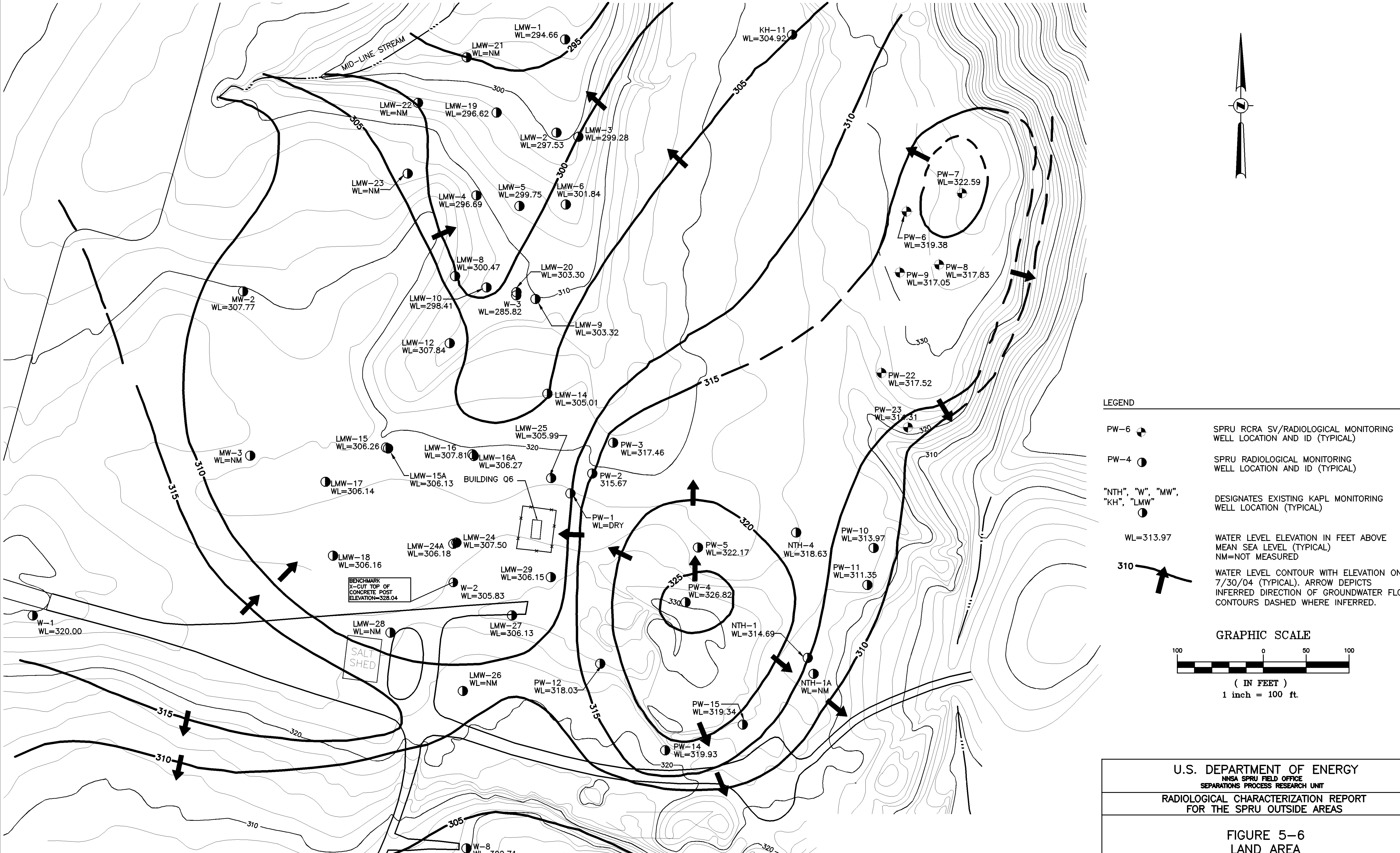
FIGURE 5-5

LAND AREA CROSS SECTION C-C'

Date: APRIL 2006, REVISION 2	CTM Project No.: 04.9080



MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.

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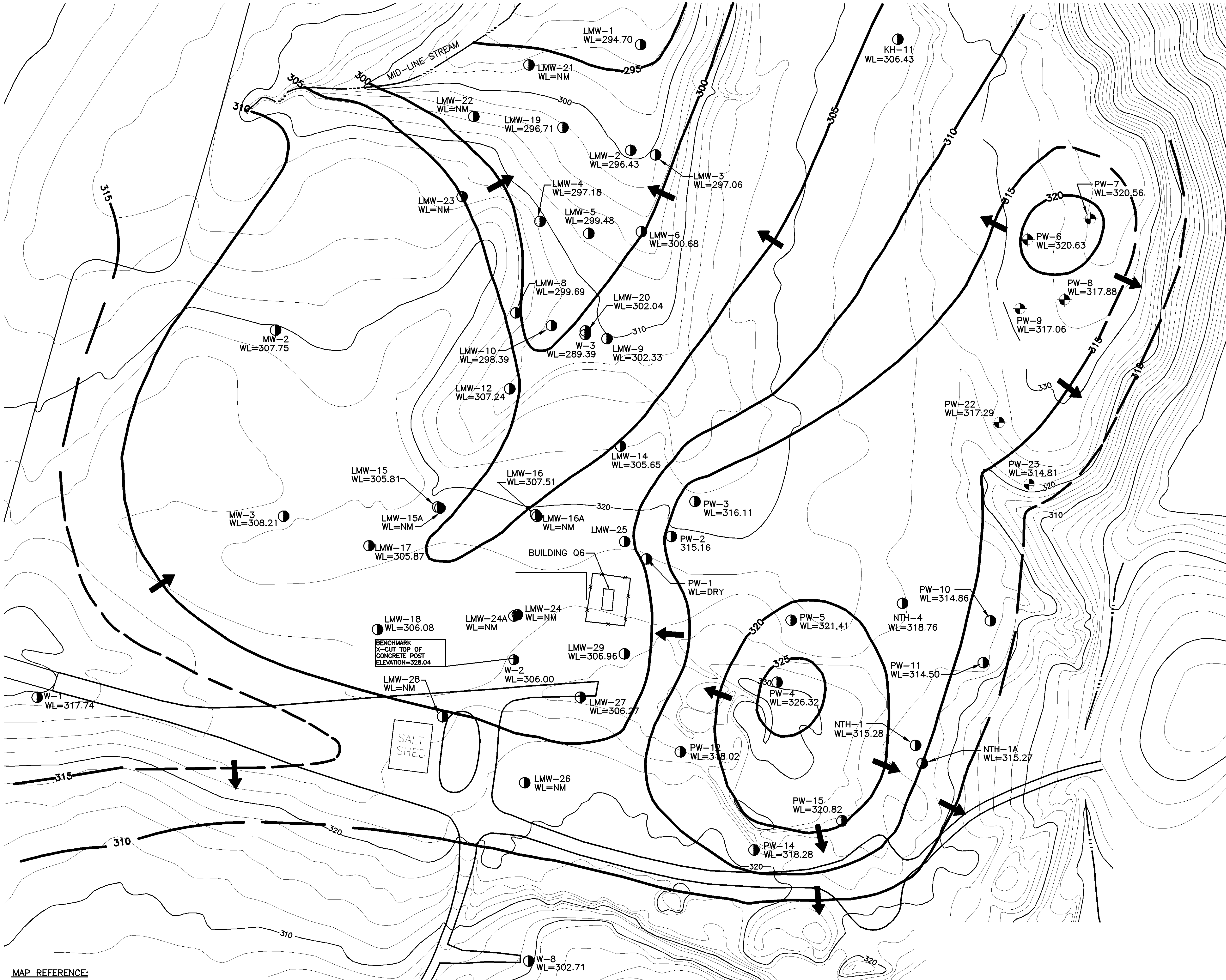
FIGURE 5-6
LAND AREA
WATER LEVEL CONTOUR MAP (7/30/04)

DATE:APRIL 2006, REV. 2	DRAWING NO. 05-366	CTM PROJ. NO.: 04.9080



LEGEND

PW-6	SPRU RCRA SV/RADIOLOGICAL MONITORING WELL LOCATION AND ID (TYPICAL)
PW-4	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID (TYPICAL)
"NTH", "W", "MW", "KH", "LMW"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL)
WL=314.86	WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (TYPICAL) NM=NOT MEASURED
310	WATER LEVEL CONTOUR WITH ELEVATION ON 10/5/04 (TYPICAL). ARROW DEPICTS INFERRED DIRECTION OF GROUNDWATER FLOW. CONTOURS DASHED WHERE INFERRED.

GRAPHIC SCALE

100 0 50 100

(IN FEET)
1 inch = 100 ft.

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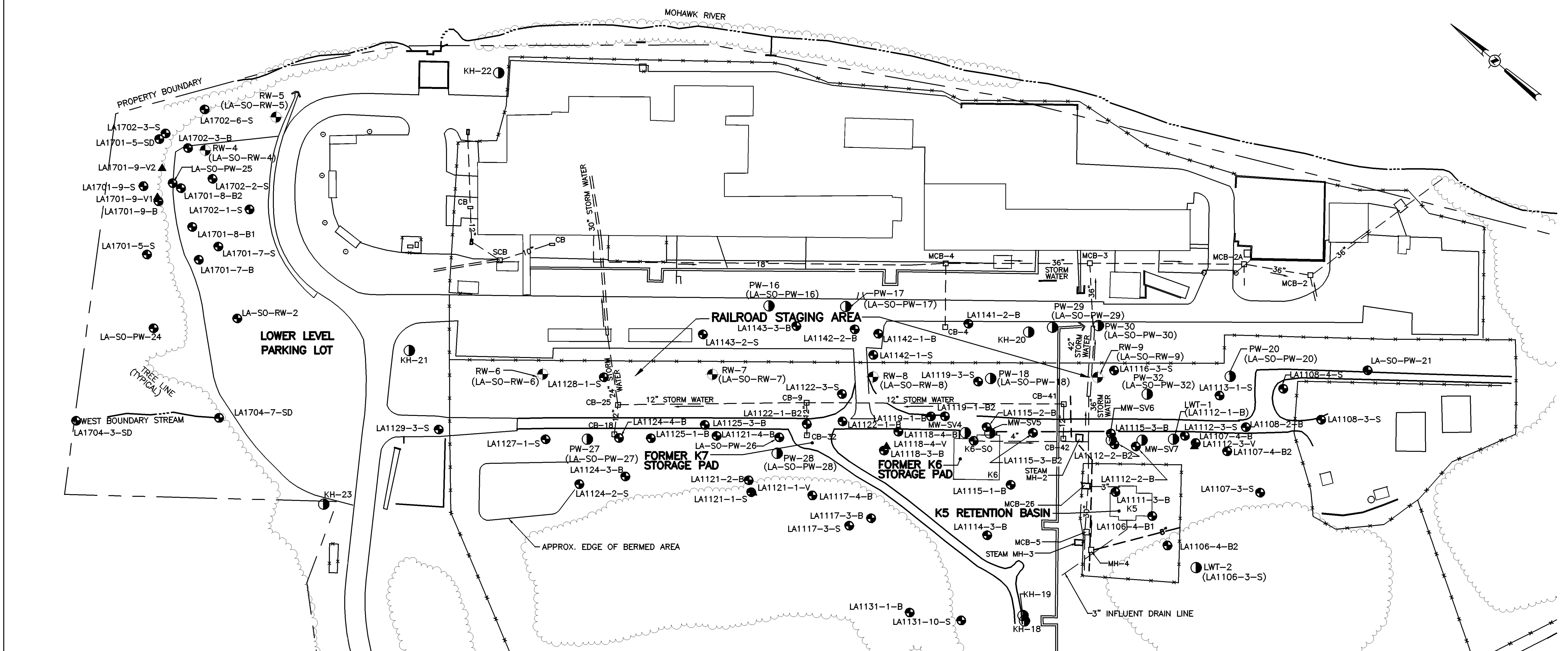
FIGURE 5-7
LAND AREA
WATER LEVEL CONTOUR MAP (10/05/04)

DATE:APRIL 2006, REV. 2	DRAWING NO. 05-366	CTM PROJ. NO.: 04.9080

MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.



LEGEND

LA1127-1-S, LA-SO-RW-2	SPRU RCRA AND/OR RADIOLOGICAL SOIL BORING LOCATION AND ID (TYPICAL)	"KH"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL)
RW-5	SPRU RCRA / RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)	LA1701-9-V2	SPRU RADIOLOGICAL VEGETATION SAMPLE LOCATION AND ID (TYPICAL)
		LA1704-3-SD	SPRU RADIOLOGICAL SEDIMENT SAMPLE LOCATION AND ID (TYPICAL)
PW-20, LWT-1	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)	CB-18	DESIGNATES EXISTING KAPL CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
		MCB-5	DESIGNATES EXISTING KAPL MANHOLE CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
MW-SV5	SV MONITORING WELL LOCATION AND ID (TYPICAL)		

MAP REFERENCE:
1. BASE OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.

GRAPHIC SCALE

100 0 50 100 200

(IN FEET)
1 inch = 100 ft.

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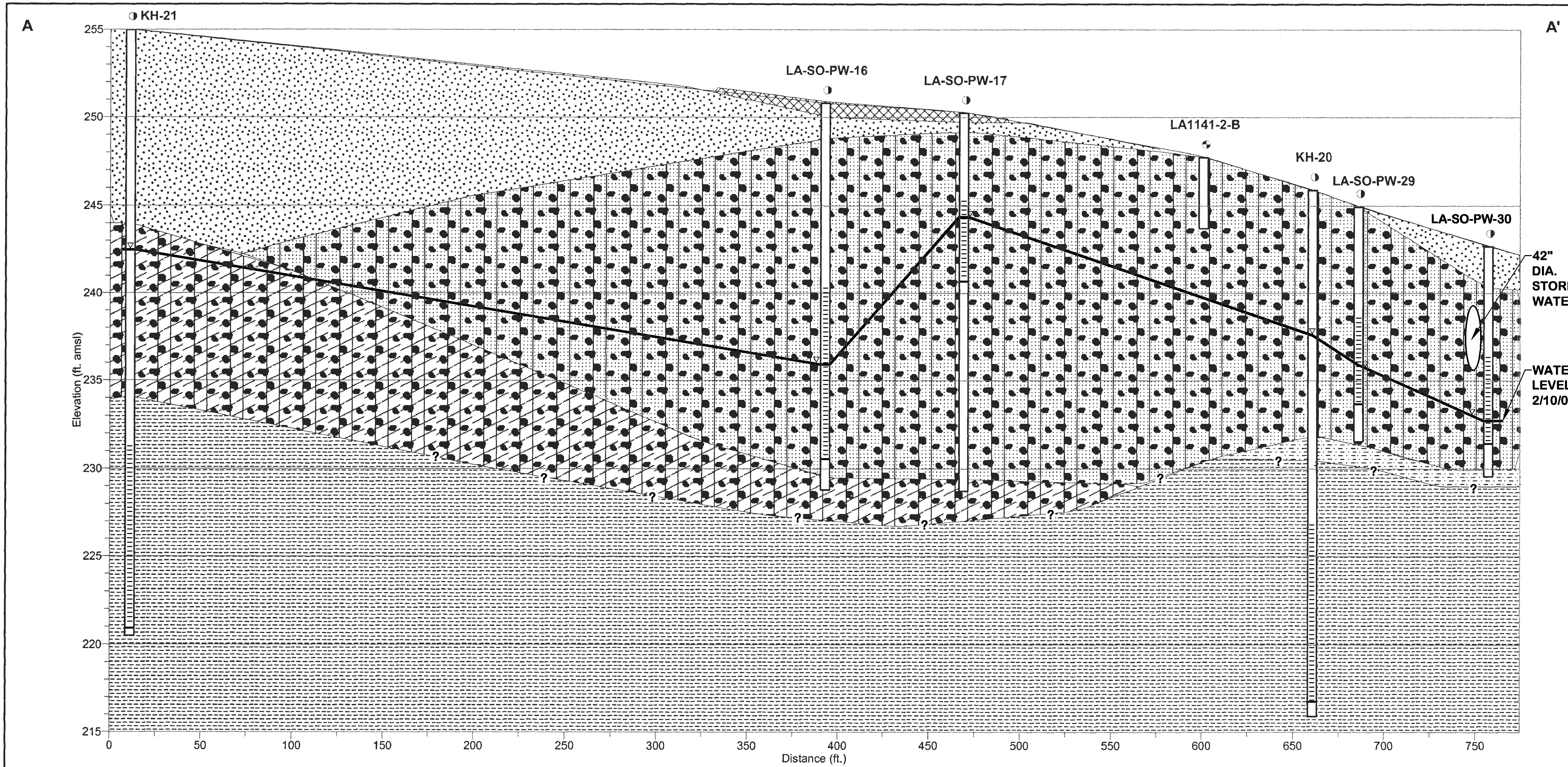
RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS

FIGURE 5-8
LOWER LEVEL
SAMPLE LOCATION MAP

DATE:APRIL 2006, REV. 2	DRAWING NO. 05-366	CTM PROJ. NO.: 04.9080



Legend

- Asphalt and Sub-Base
- Granular Fill
- Till-Derived Fill
- Brown Till
- Shale Bedrock
- Weathered Rock
- Soil Boring
- Monitoring Well

Notes:
1) The water elevation shown was measured on 2/10/05.
2) The diameter of the soil borings and monitoring wells are not shown to scale.

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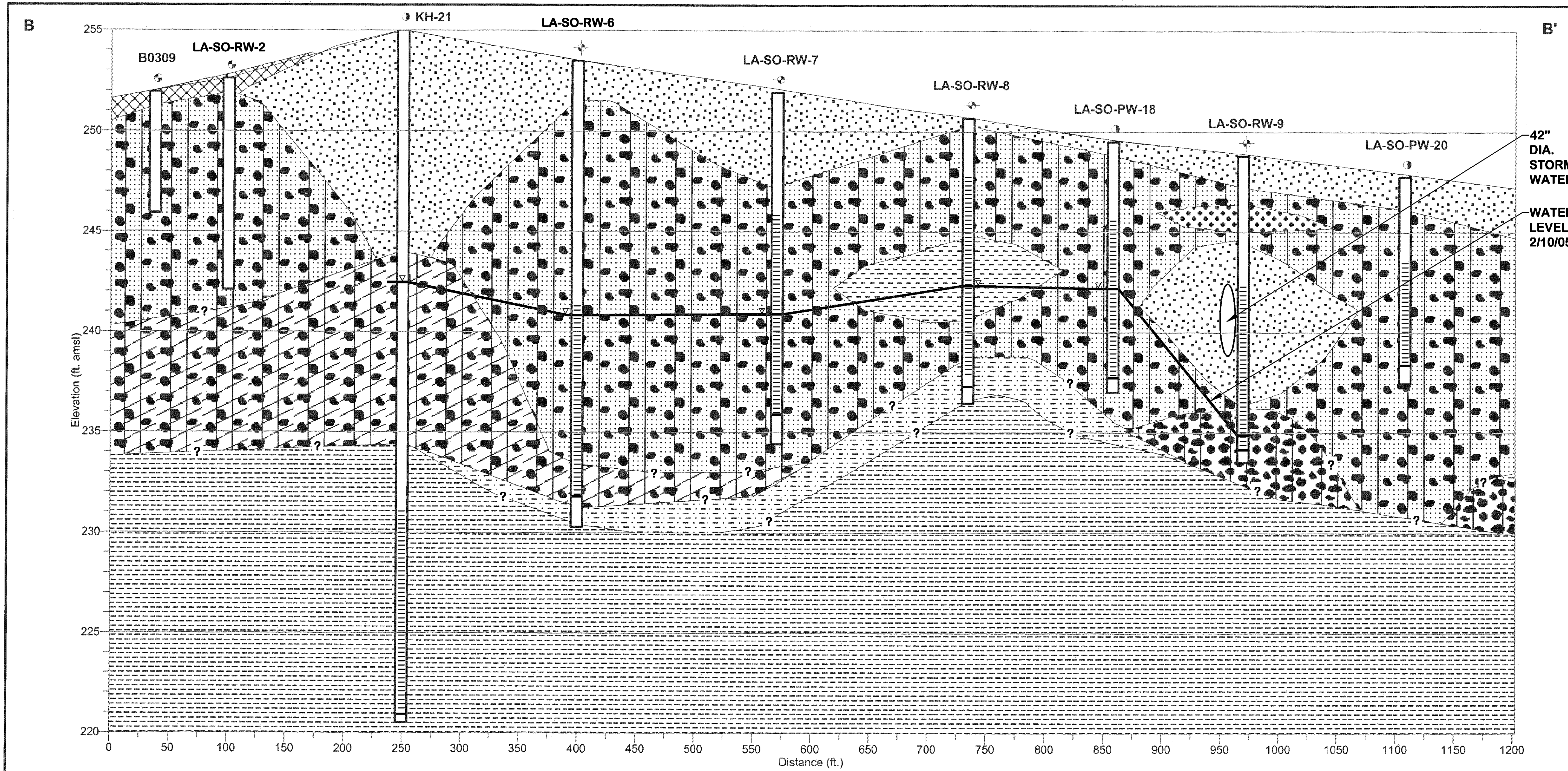
FIGURE 5-9

LOWER LEVEL CROSS SECTION A-A'

Date: APRIL 2006, REVISION 2 | CTM Project No.: 04.9080



Legend

- Asphalt and Sub-Base
- Granular Fill
- Railbed Ballast
- Till-Derived Fill
- Soil Boring
- Monitoring Well
- Monitoring Well
- Brown Till
- Gray Till
- Weathered Rock
- Shale Bedrock

Notes:
1) The water elevation shown was measured on 2/10/05.
2) The diameter of the soil borings and monitoring wells are not shown to scale.

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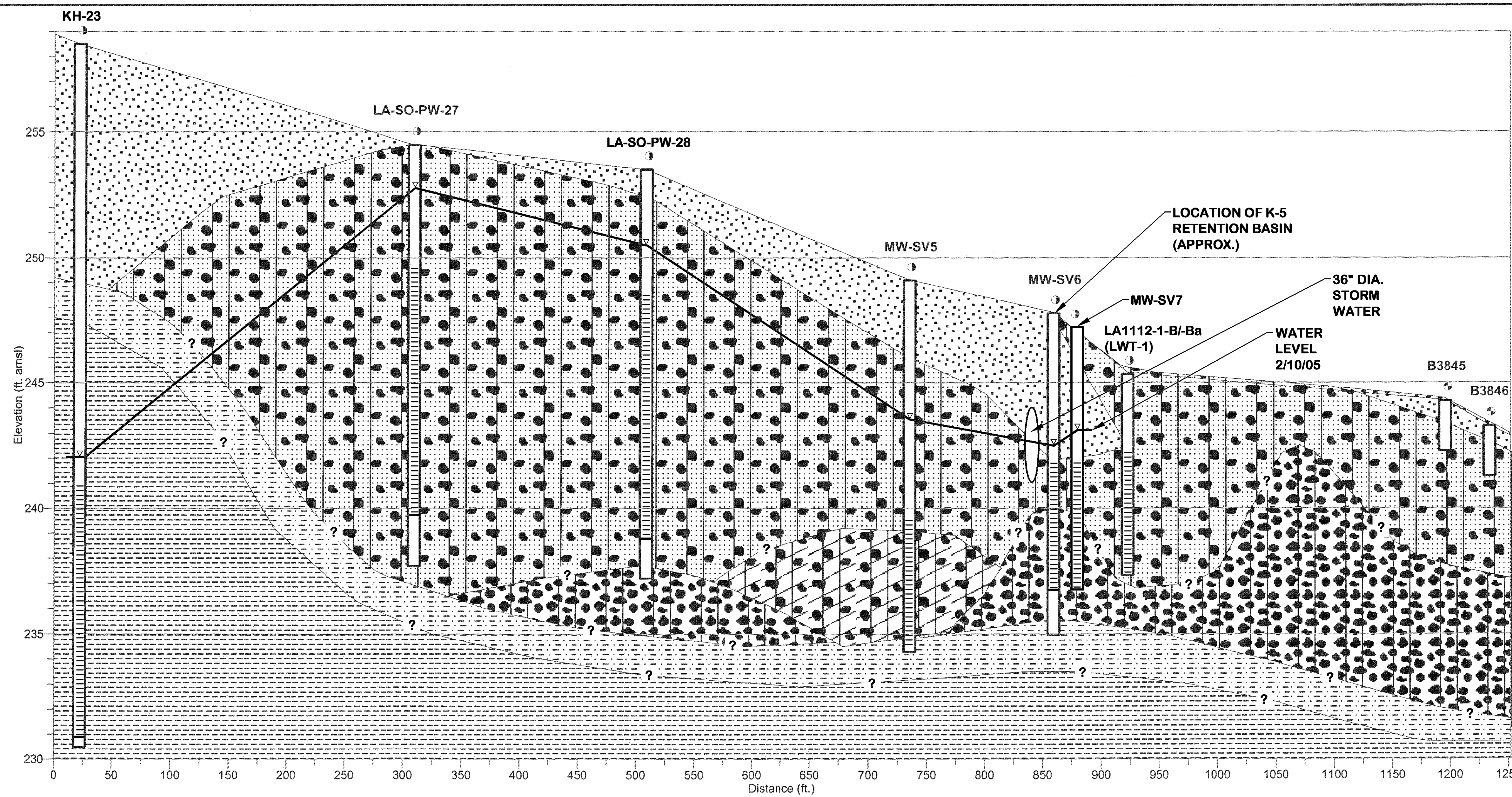
FIGURE 5-10

LOWER LEVEL CROSS SECTION B-B'

Date: APRIL 2006, REVISION 2	CTM Project No.: 04.9080



Legend

- Granular Fill
- Railbed Ballast
- Till-Derived Fill
- Brown Till
- Gray Till
- Weathered Rock
- Shale Bedrock
- Soil Boring
- Monitoring Well

Notes:
1) The water elevation shown was measured on 2/10/05.
2) The diameter of the soil borings and monitoring wells are not shown to scale.

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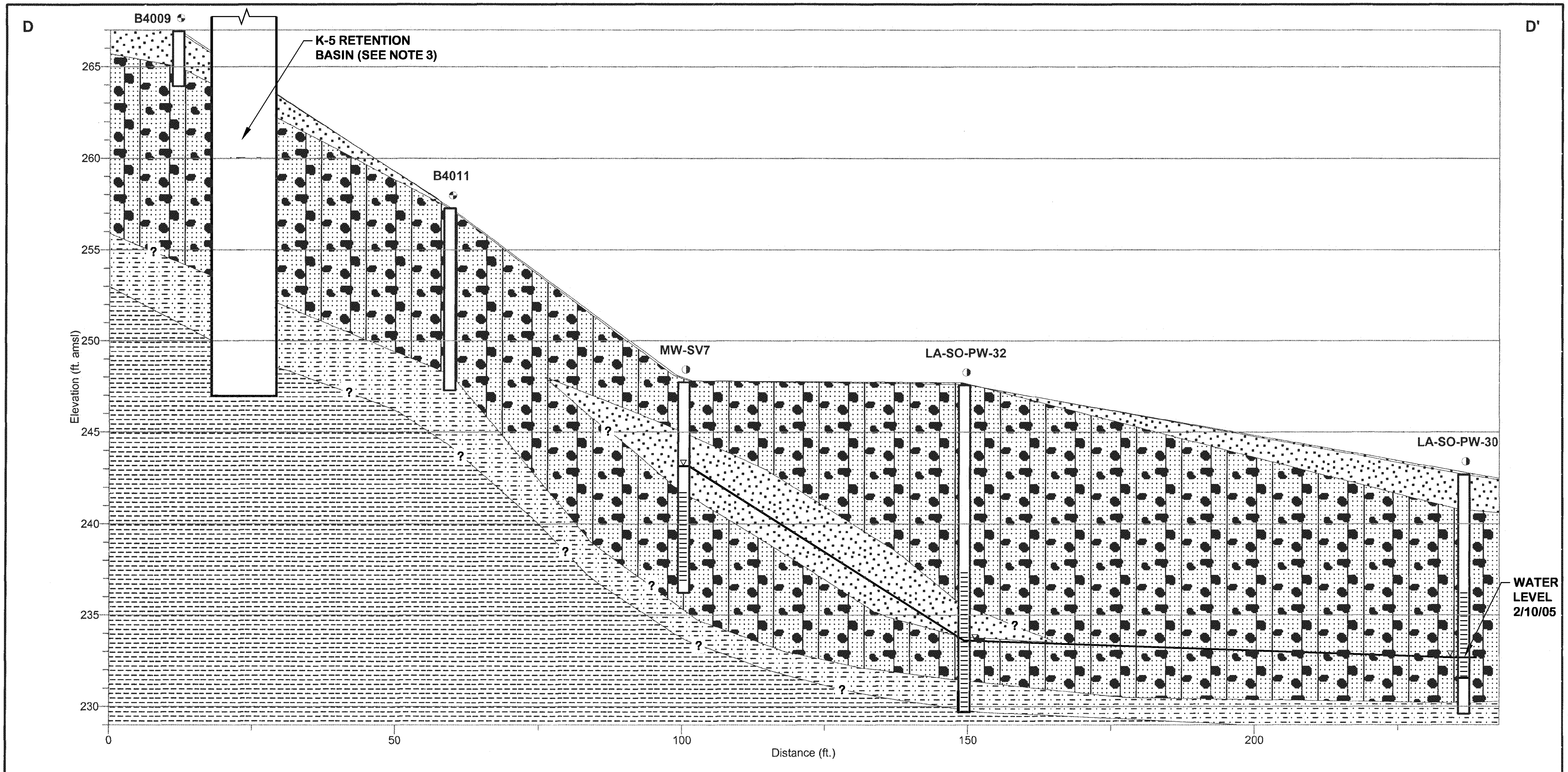
FIGURE 5-11

LOWER LEVEL CROSS SECTION C-C'

Date: APRIL 2006, REVISION 2 | CTM Project No.: 04.9080



Legend

- Granular Fill
- Till-Derived Fill
- Weathered Rock
- Shale Bedrock
- Soil Boring
- Monitoring Well

Notes:
1) The water elevation shown was measured on 2/10/05.
2) The diameter of the soil borings and monitoring wells are not shown to scale.
3) The width of the building is not shown to scale so that the lithology can be depicted. Refer to Plate 5-3 - Lower Level Cross Section Locations for actual building width.

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FIGURE 5-12

LOWER LEVEL CROSS SECTION D-D'

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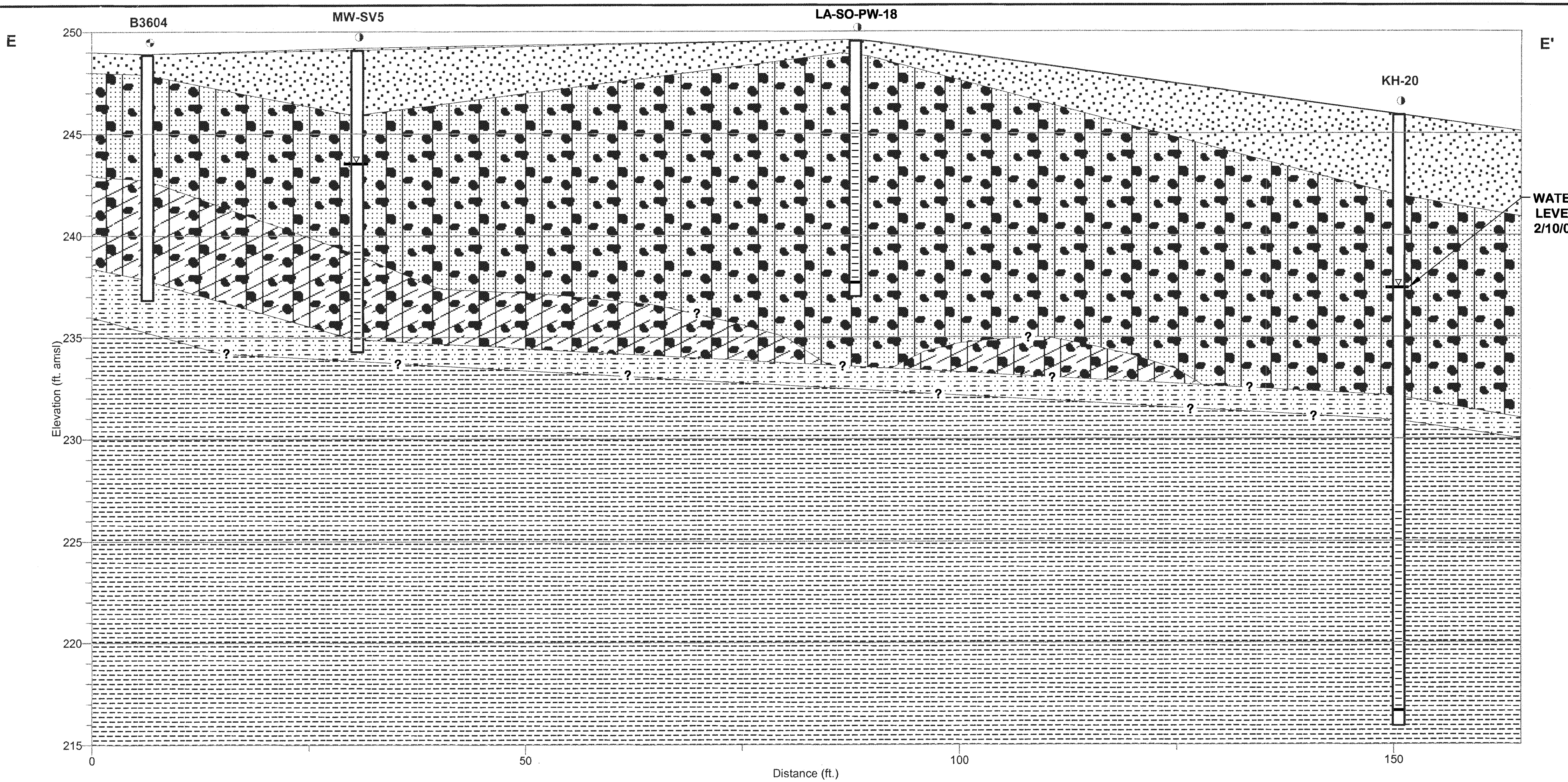

Legend

Granular Fill

Till-Derived Fill

Brown Till

Weathered Rock

Shale Bedrock

Soil Boring

Monitoring Well

Notes:
1) The water elevation shown was measured on 2/10/05.
2) The diameter of the soil borings and monitoring wells are not shown to scale.

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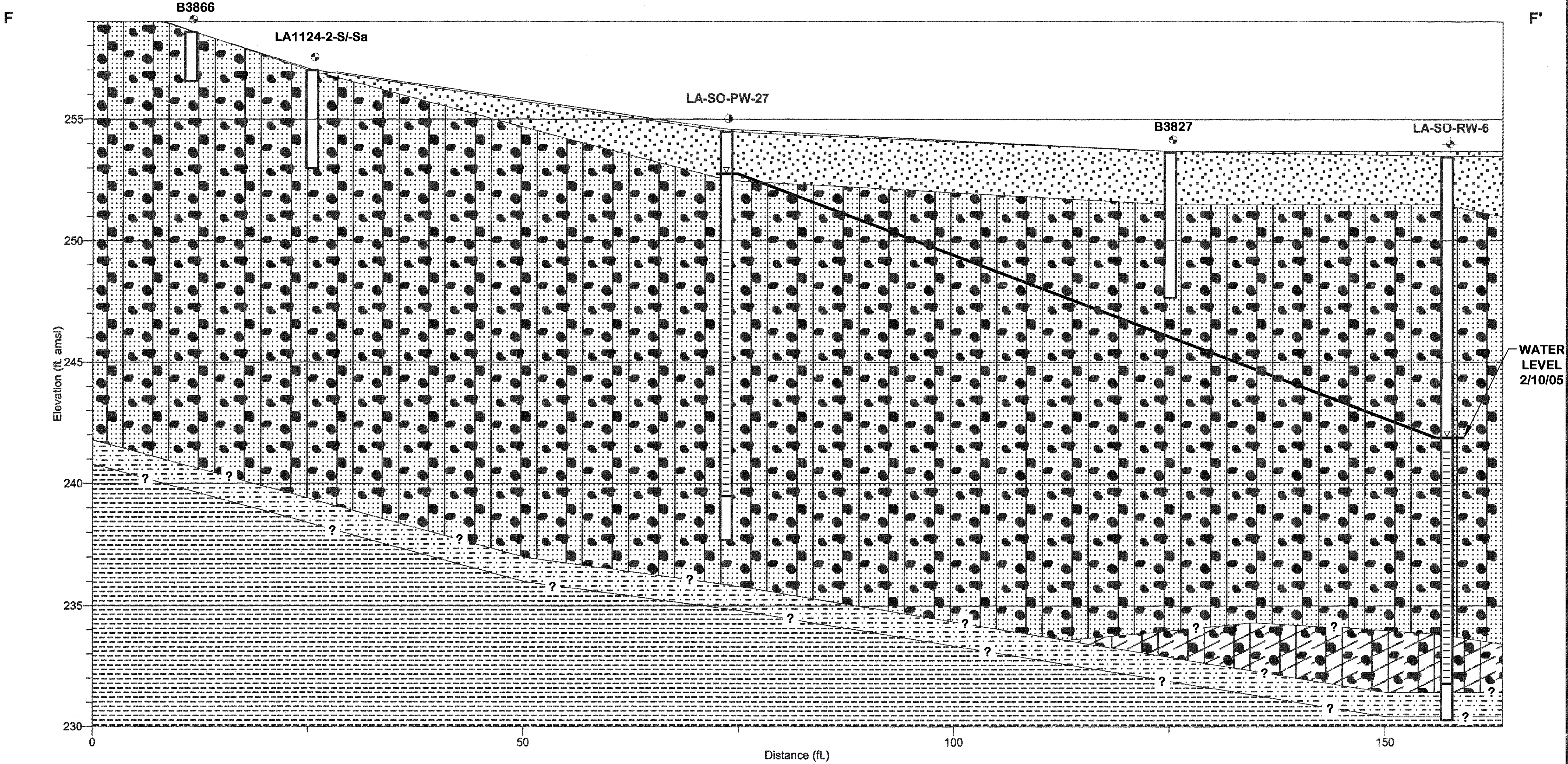
FIGURE 5-13

LOWER LEVEL CROSS SECTION E-E'

Date: APRIL 2006, REVISION 2

CTM Project No.: 04.9080



Legend

Granular Fill | Till-Derived Fill | Brown Till | Weathered Rock

Shale Bedrock | Soil Boring | Monitoring Well | Monitoring Well

Notes:
1) The water elevation shown was measured on 2/10/05.
2) The diameter of the soil borings and monitoring wells are not shown to scale.

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FIGURE 5-14

LOWER LEVEL CROSS SECTION F-F'

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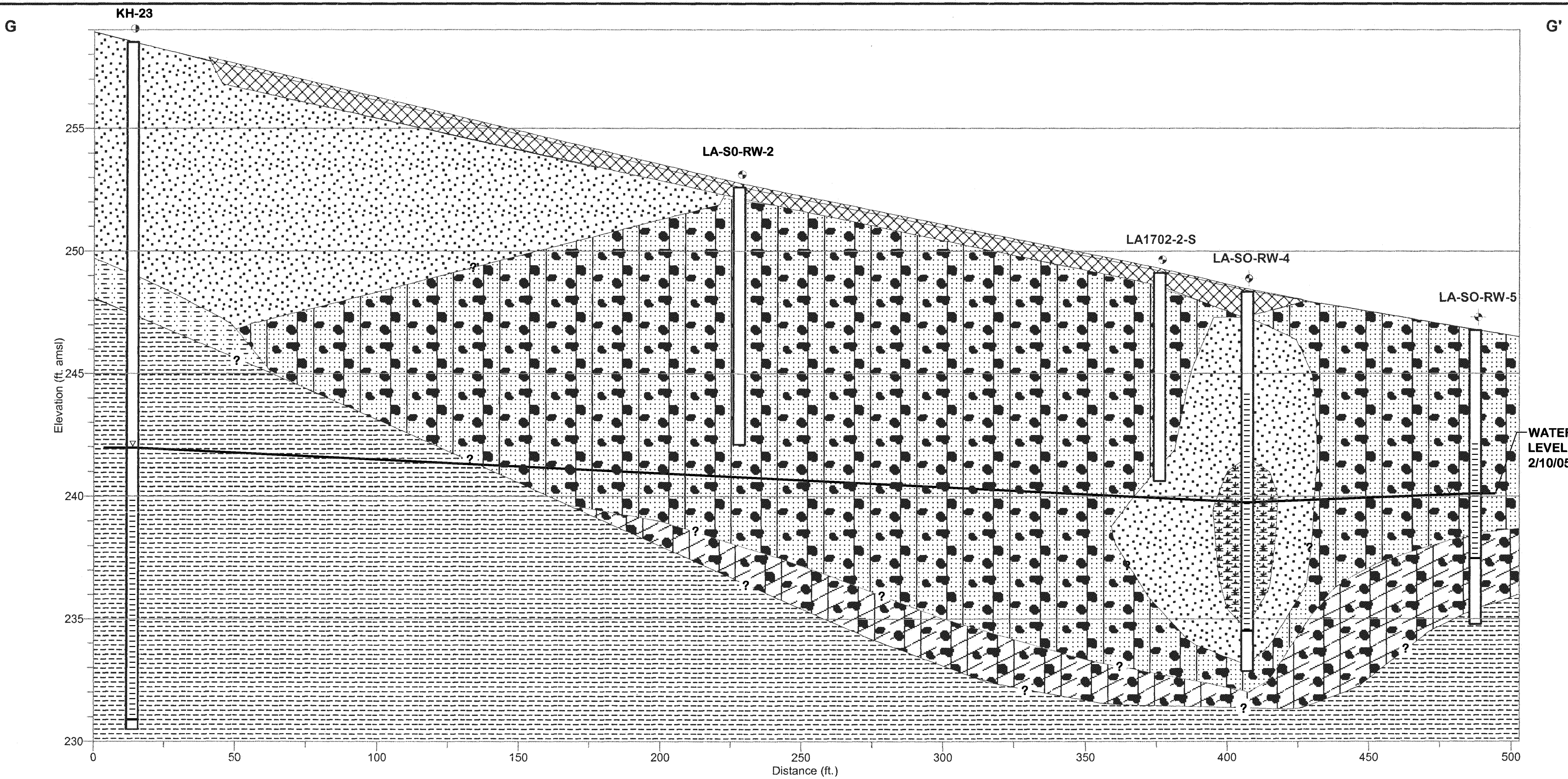

Legend

- Asphalt and Sub-Base
- Granular Fill
- Till-Derived Fill
- Wood
- Brown Till
- Weathered Rock
- Shale Bedrock
- Soil Boring
- Monitoring Well
- Monitoring Well

Notes:
1) The water elevation shown was measured on 2/10/05.
2) The diameter of the soil borings and monitoring wells are not shown to scale.

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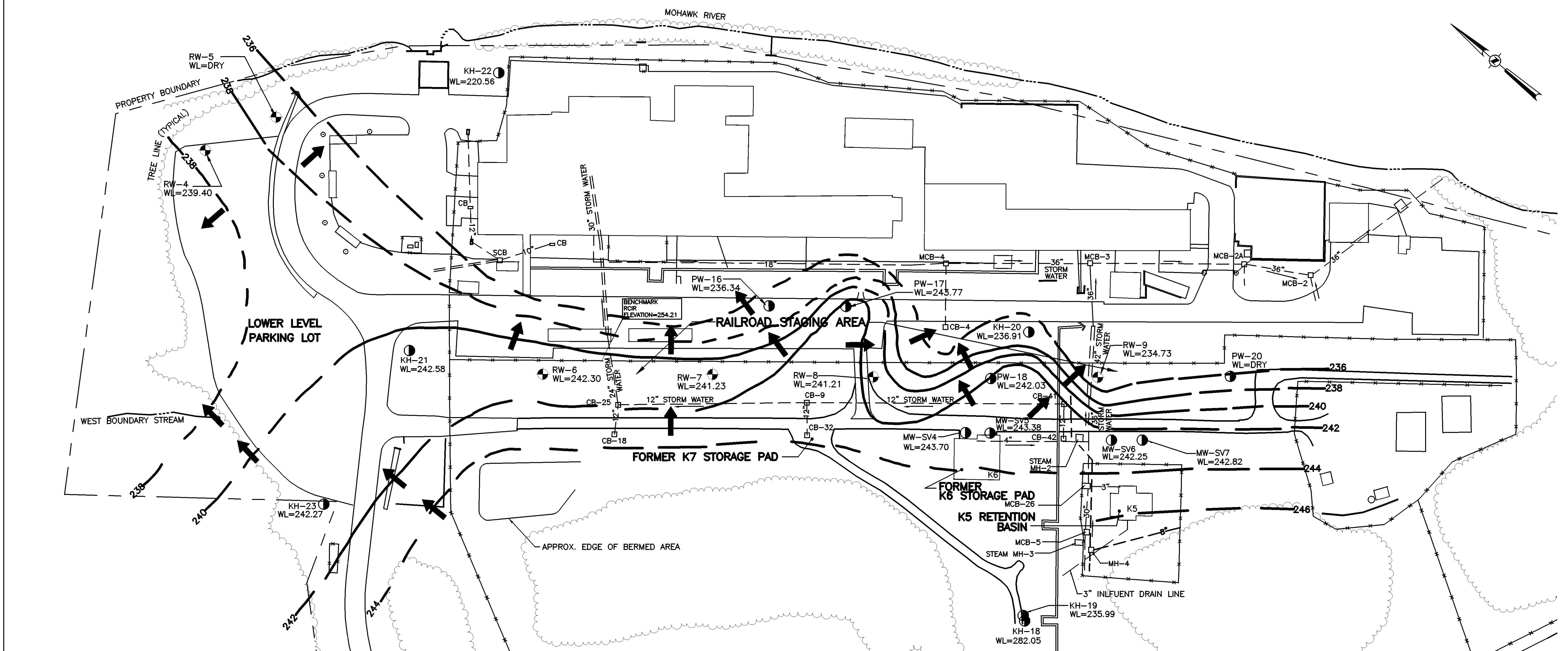
FIGURE 5-15

LOWER LEVEL CROSS SECTION G-G'

Date: APRIL 2006, REVISION 2 | CTM Project No.: 04.9080



LEGEND

RW-4	SPRU RCRA/RADIOLOGICAL MONITORING WELL LOCATION AND ID (TYPICAL)
PW-20, LWT-1	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID (TYPICAL)
MW-SV5	SV MONITORING WELL LOCATION AND ID (TYPICAL)
"KH"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL)
WL=242.82	WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (TYPICAL) NM=NOT MEASURED
240	WATER LEVEL CONTOUR WITH ELEVATION ON 8/3/04 (TYPICAL) ARROW DEPICTS INFERRED DIRECTION OF GROUND WATER FLOW. CONTOURS DASHED WHERE INFERRED
CB-18	DESIGNATES EXISTING KAPL CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
MCB-5	DESIGNATES EXISTING KAPL MANHOLE CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)

GRAPHIC SCALE

100 0 50 100 200

(IN FEET)
1 inch = 100 ft.

MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.

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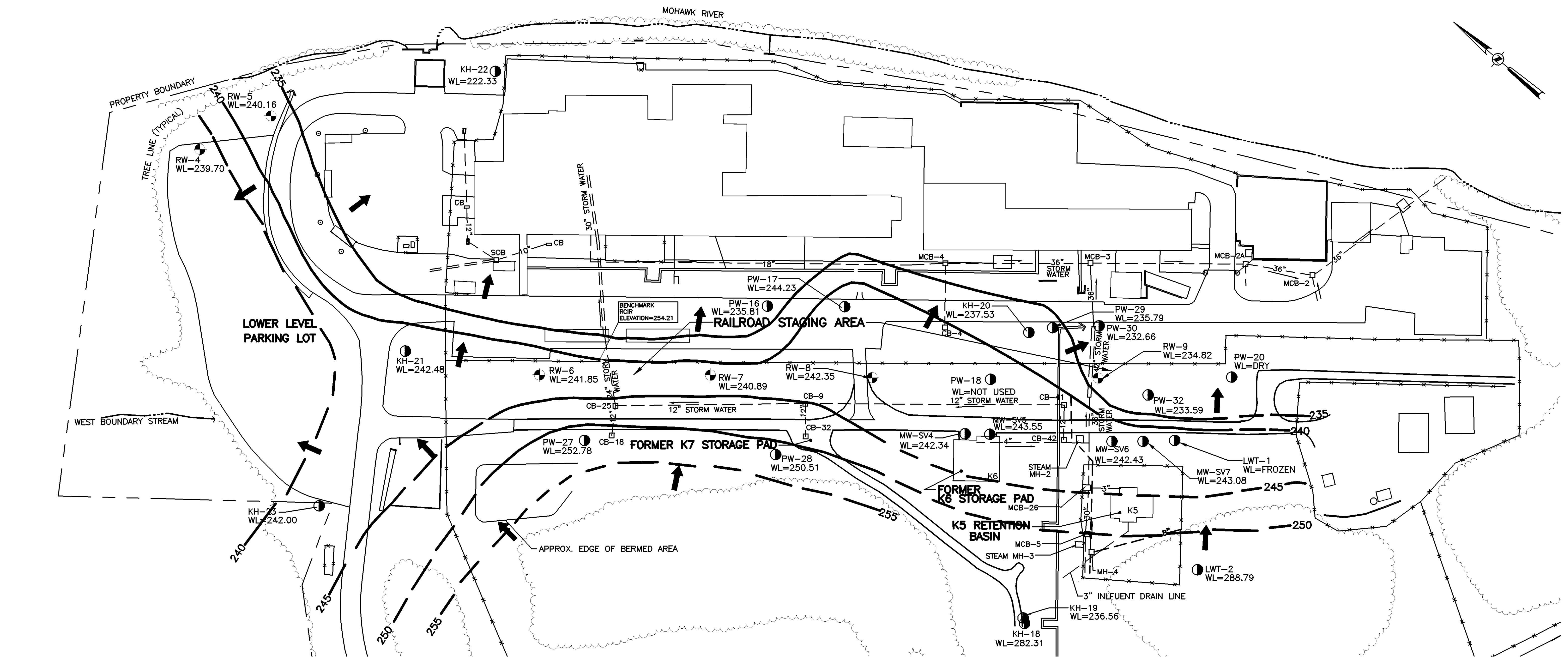
FIGURE 5-16
LOWER LEVEL
WATER LEVEL CONTOUR MAP (8/3/04)

DATE:APRIL 2006, REV. 2	DRAWING NO. 05-366	CTM PROJ. NO.: 04.9080



LEGEND

RW-4	SPRU RCRA/RADIOLOGICAL MONITORING WELL LOCATION AND ID (TYPICAL)
PW-20, LWT-1	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID (TYPICAL)
MW-SV5	SV MONITORING WELL LOCATION AND ID (TYPICAL)
"KH"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL)
WL=241.16	WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (TYPICAL)
240	WATER LEVEL CONTOUR WITH ELEVATION ON 2/10/05 (TYPICAL) ARROW DEPICTS INFERRED DIRECTION OF GROUND WATER FLOW. CONTOURS DASHED WHERE INFERRED
CB-18	DESIGNATES EXISTING KAPL CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
MCB-5	DESIGNATES EXISTING KAPL MANHOLE CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)

GRAPHIC SCALE

100 0 50 100 200

(IN FEET)
1 inch = 100 ft.

MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.

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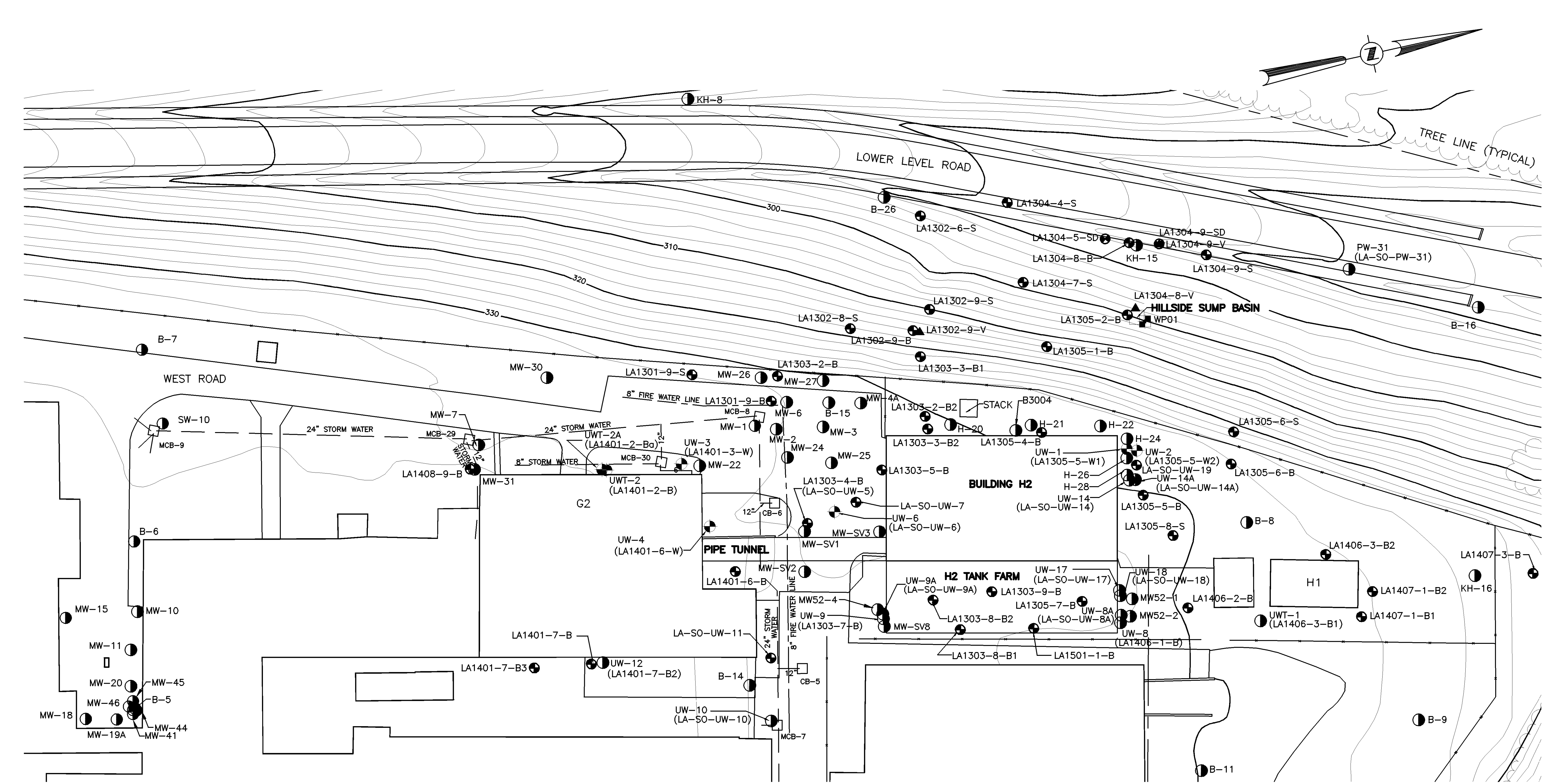
FIGURE 5-17
LOWER LEVEL
WATER LEVEL CONTOUR MAP (2/10/05)

DATE: APRIL 2006, REV. 2 | DRAWING NO. 05-366 | CTM PROJ. NO.: 04.9080



LEGEND

LA-SO-UW-19, LA1401-7-B	SPRU RCRA AND/OR RADIOLOGICAL SOIL BORING LOCATION AND ID (TYPICAL)
UW-1, UWT-2	SPRU RCRA/RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
PW-31, UW-10, UWT-1	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
MW-SV1, B3004	SV MONITORING WELL LOCATION AND ID (TYPICAL)
"MW", "KH", "H", "B", "MW52"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL)
WP01	SPRU RADIOLOGICAL WELL POINT LOCATION AND ID
LA1304-9-V	SPRU RADIOLOGICAL VEGETATION SAMPLE LOCATION AND ID (TYPICAL)
LA1304-9-SD	SPRU RADIOLOGICAL SEDIMENT SAMPLE LOCATION AND ID (TYPICAL)
MCB-8	DESIGNATES EXISTING KAPL MANHOLE CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
CB-6	DESIGNATES EXISTING KAPL CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)

MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.

GRAPHIC SCALE

50 0 25 50 100

(IN FEET)
1 inch = 50 ft.

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RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS

FIGURE 5-18
UPPER LEVEL
SAMPLE LOCATION MAP

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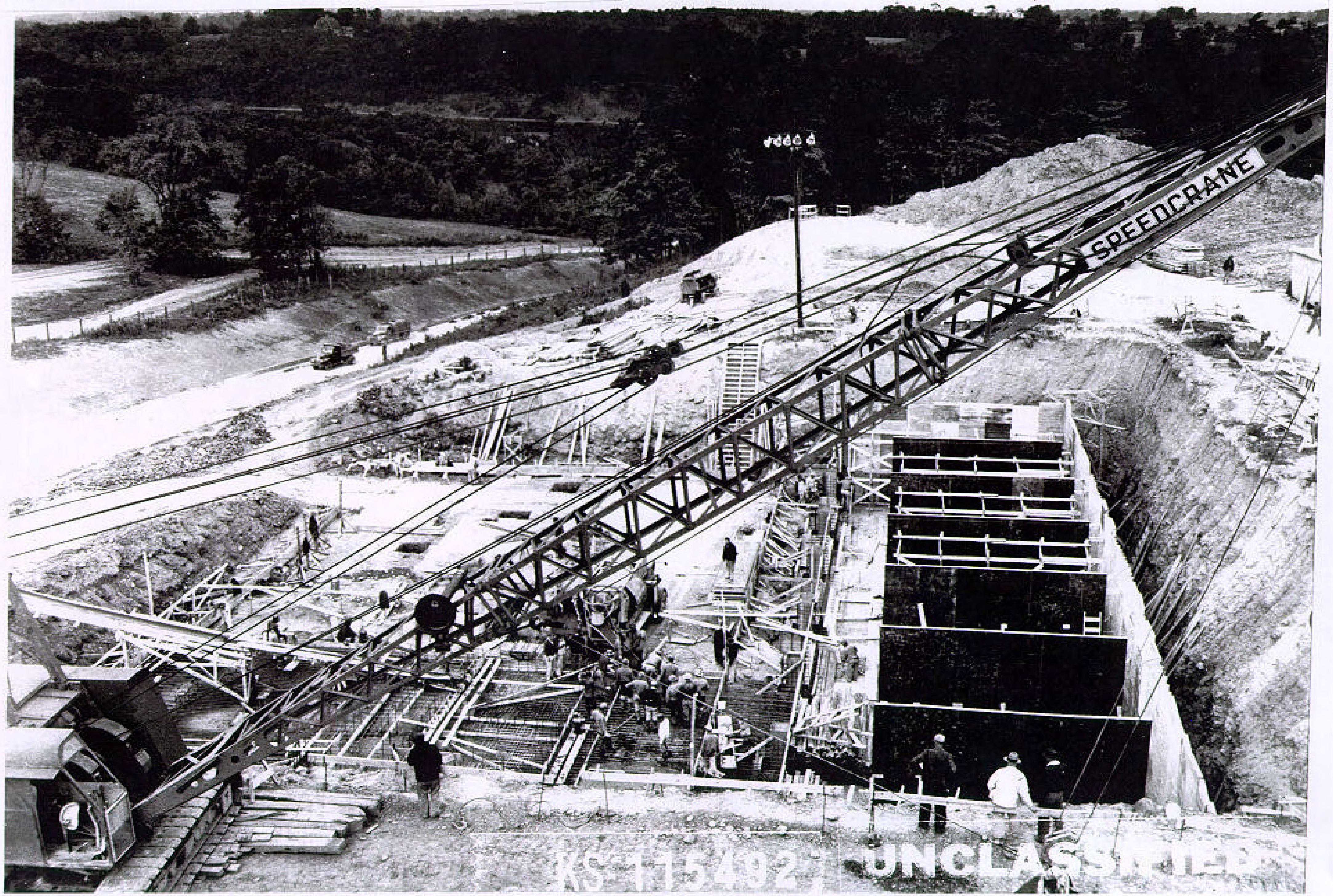
Looking North at H Building and Tank Farm
from G2 Roof (September 24, 1948)



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RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS

FIGURE 5-19
TANK FARM EXCAVATION AND CONSTRUCTION

DATE APRIL 06, REV. 2	DRAWING NO.	CTM PROJ. NO: 04.9080

Looking North at H Building, Tank Farm, and
H1 Cooling Tower from G2 Roof (December 22, 1948)

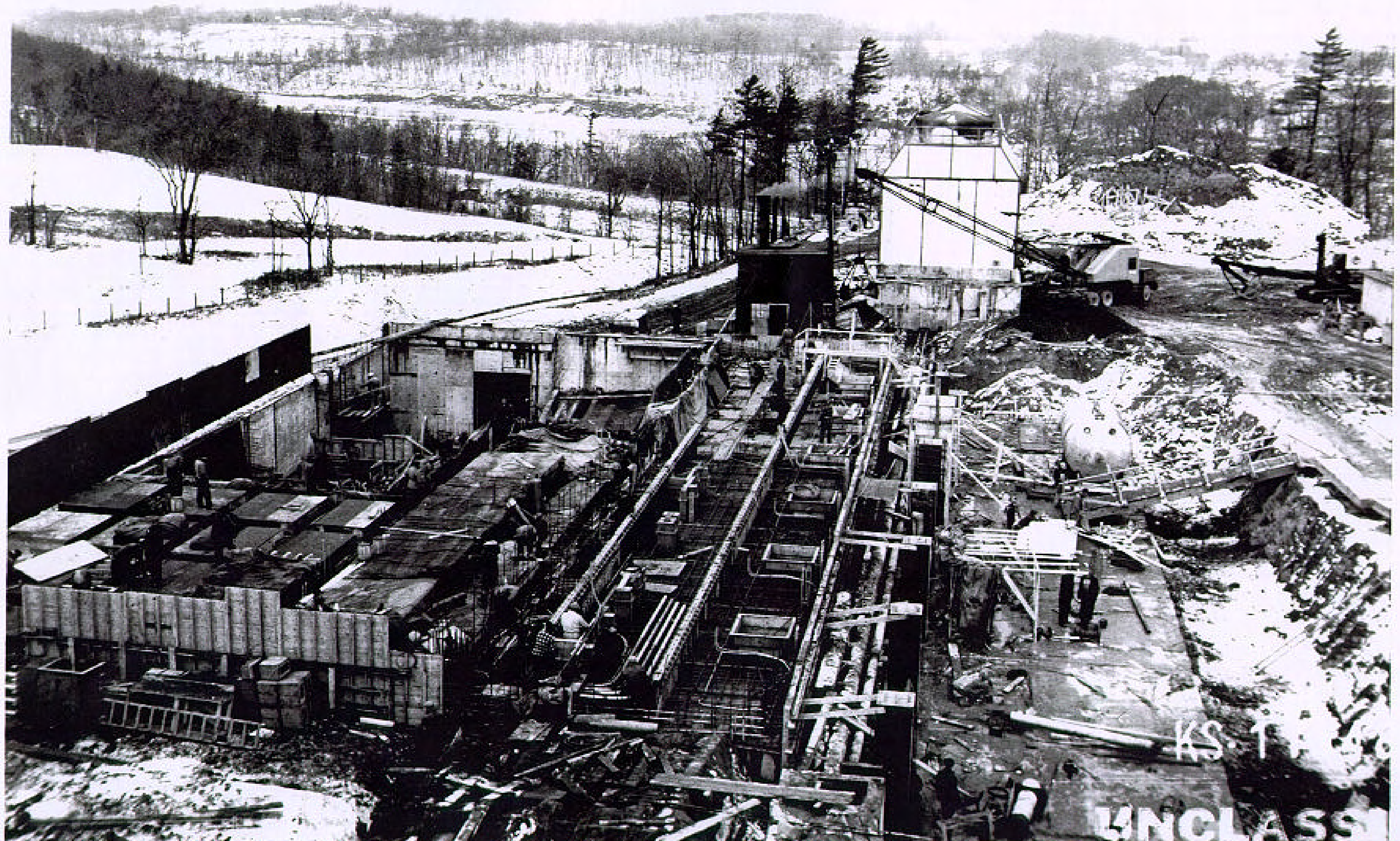

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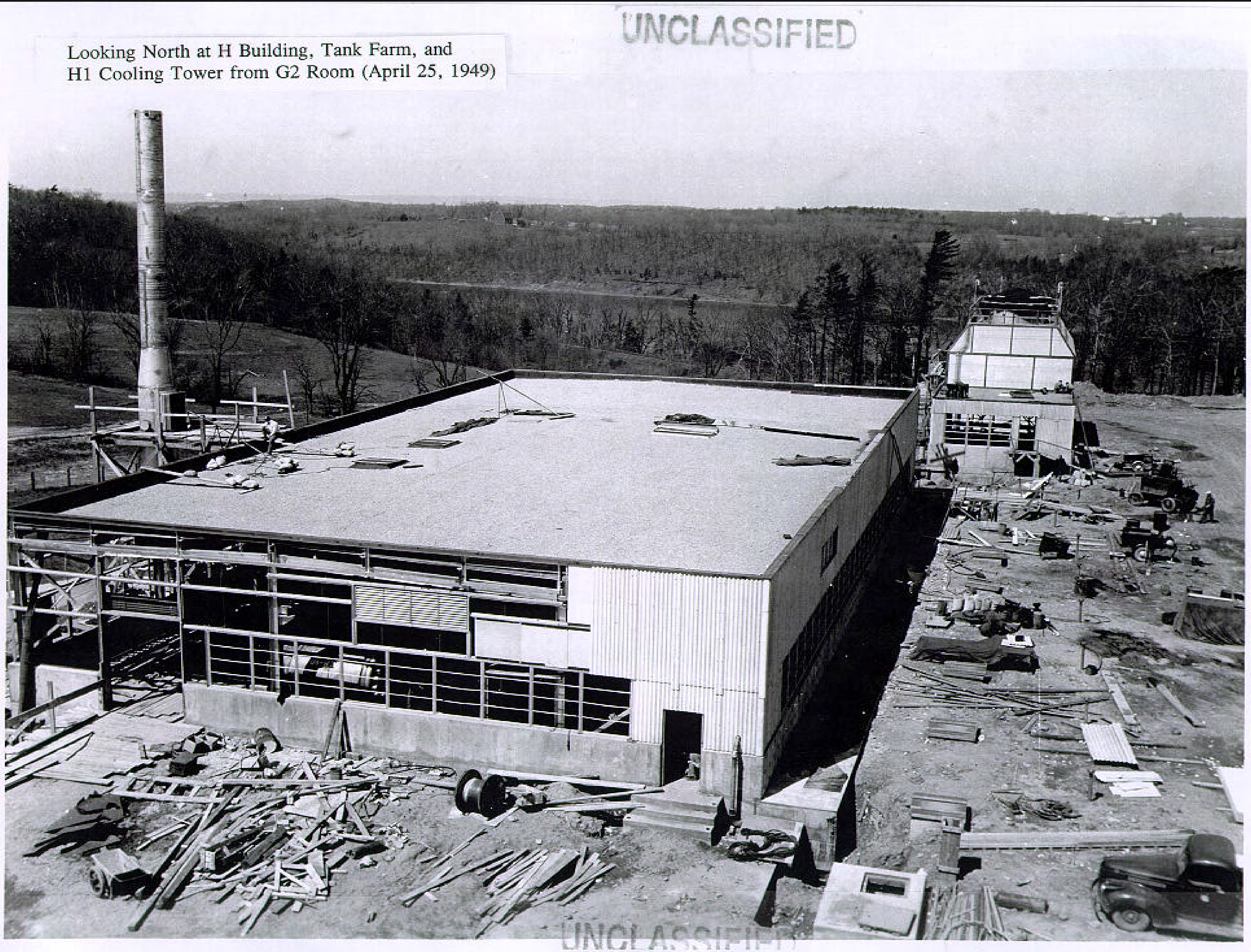
FIGURE 5-20
BUILDING H2 EXCAVATION AND CONSTRUCTION

DATE APRIL 06, REV. 2	DRAWING NO.	CTM PROJ. NO: 04.9080



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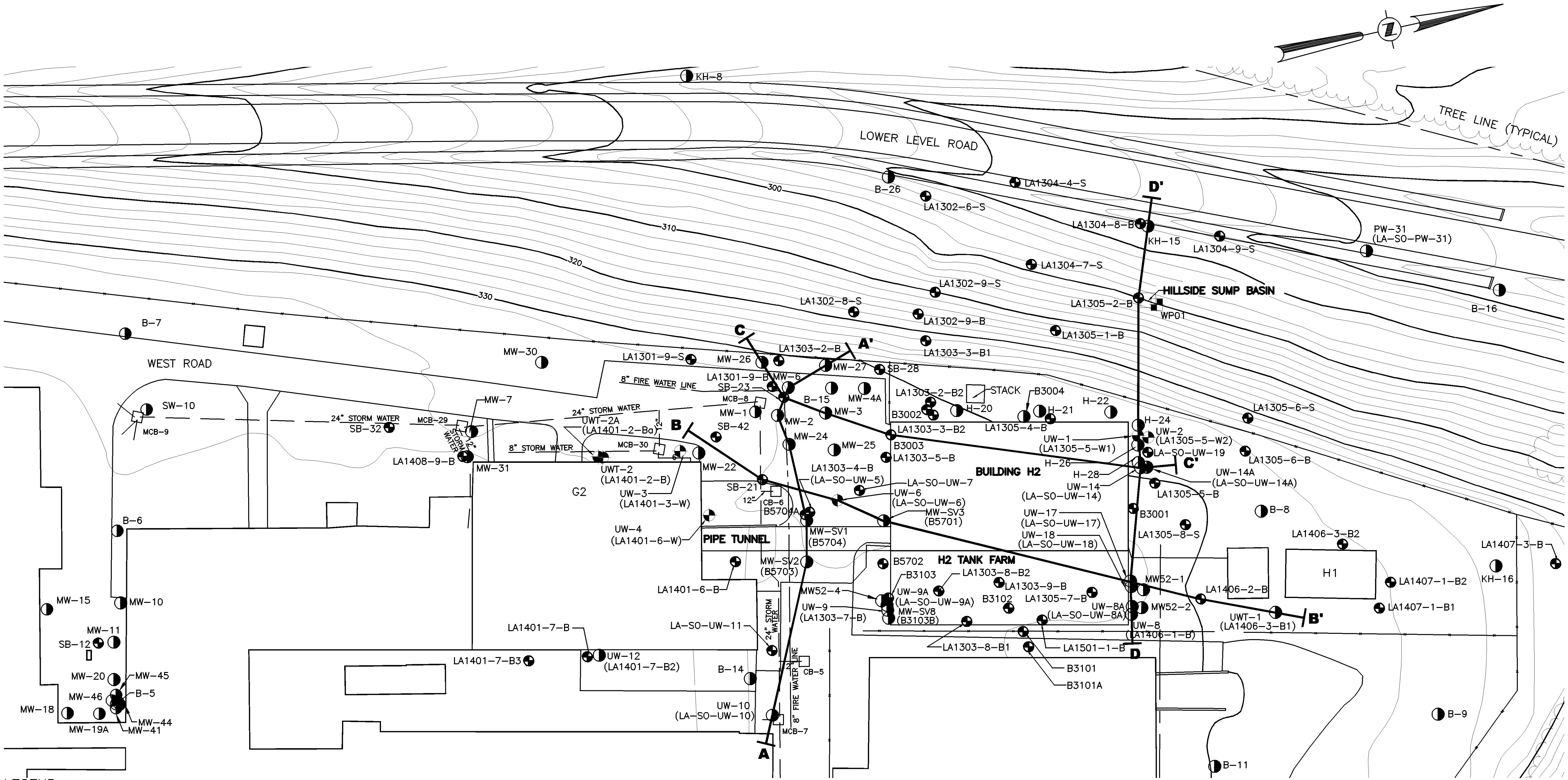
RADIOLOGICAL CHARACTERIZATION

FIGURE 5-21
BUILDING H2 EXCAVATION AND CONSTRUCTION - SOUTHERN PORTION

DATE APRIL 06, REV. 2	DRAWING NO.	CTM PROJ. NO: 04.9080



LEGEND

LA-SO-UW-19, LA1401-7-B	SPRU RCRA AND/OR RADIOLOGICAL SOIL BORING LOCATION AND ID (TYPICAL)
UW-1, UWT-2	SPRU RCRA/RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
PW-31, UW-10, UWT-1	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
WP01	SPRU RADIOLOGICAL WELL POINT LOCATION AND ID
B3002, B5702	SV SOIL BORING LOCATION AND ID (TYPICAL)
MW-SV1, B3004	SV MONITORING WELL LOCATION AND ID (TYPICAL)
"MW", "KH", "H", "B", "MW52"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL) NOTE: FOR THE MW-SERIES WELLS, THE WELL HAS AN ASSOCIATED SOIL BORING (SB-SERIES) THAT IS CO-LOCATED WITH THE WELL BUT NOT SHOWN ON THE MAP.
SB-21	KAPL HILLSIDE AREA SOIL BORING LOCATION AND ID (TYPICAL)
MCB-8	DESIGNATES EXISTING KAPL MANHOLE CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
CB-6	DESIGNATES EXISTING KAPL CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
A ——— A'	GEOLOGIC CROSS SECTION

GRAPHIC SCALE

50 0 25 50 100

(IN FEET)
1 inch = 50 ft.

MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.
2. "SPRU SAMPLING VISIT, U.S. DEPARTMENT OF ENERGY, OAKLAND SPRU FIELD OFFICE KNOLLS ATOMIC POWER LABORATORY, PLATE 1, UPPER LEVEL SWMUs BASE MAP CH2MHILL" PREPARED BY C.T. MALE ASSOCIATES, P.C. DATED 02/11/02, BEARING DRAWING NO. 01-144, PROJECT NO. 00.6556.

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RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS

FIGURE 5-22
UPPER LEVEL
CROSS SECTION LOCATIONS

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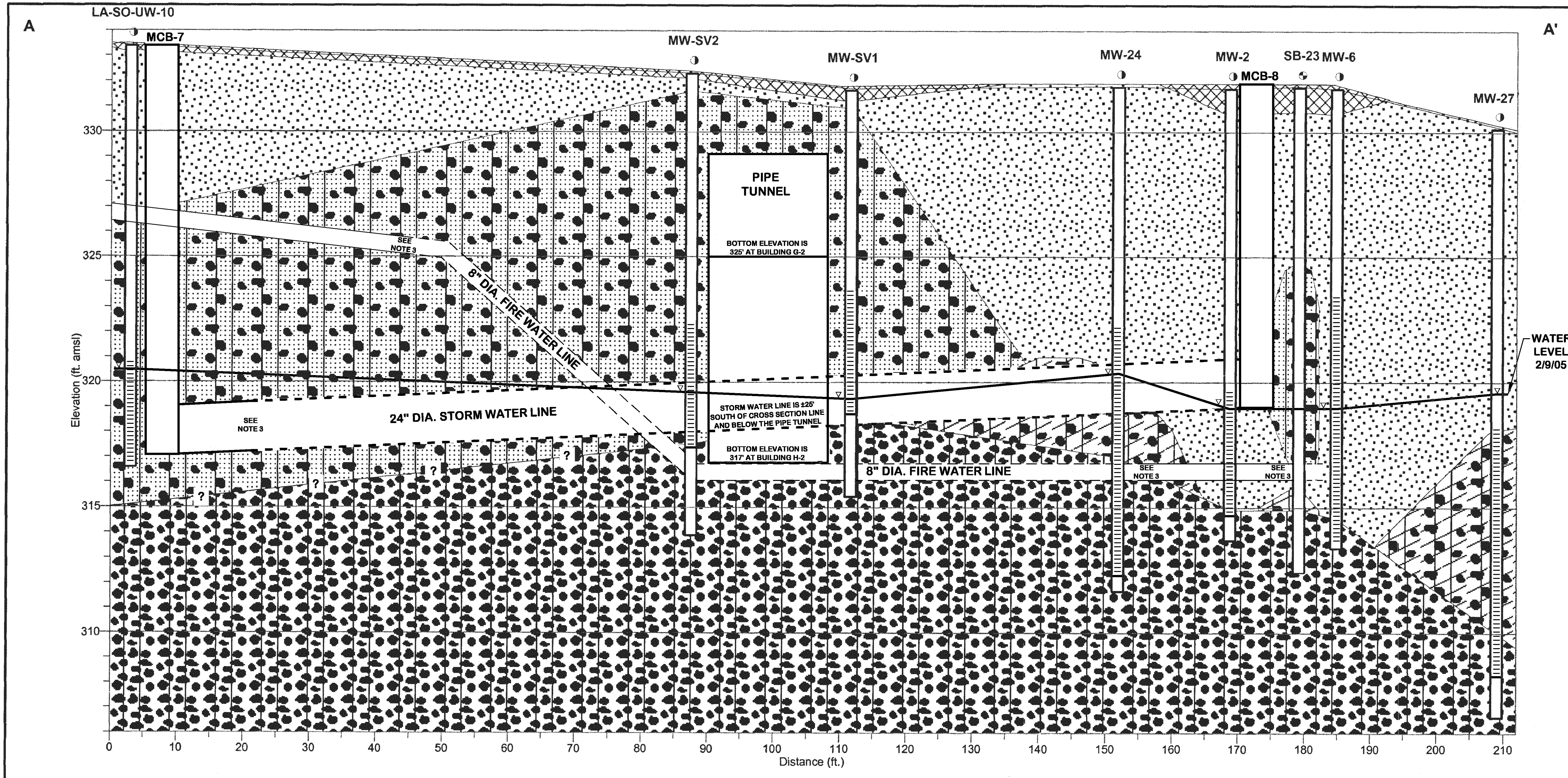

Legend

- Asphalt and Sub-Base
- Granular Fill
- Till-Derived Fill
- Brown Till
- Gray Till
- Soil Boring
- Monitoring Well
- **MCB-7** Manhole Catch Basin

Notes:
1) The water elevation shown was measured on 2/9/05.
2) The diameter of the soil borings and monitoring wells are not shown to scale.
3) The utilities cross the section line at the transition from solid line to dotted line. Solid line denotes in front of the section line and dotted line denotes behind the section line.

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FIGURE 5-23

UPPER LEVEL CROSS SECTION A-A'

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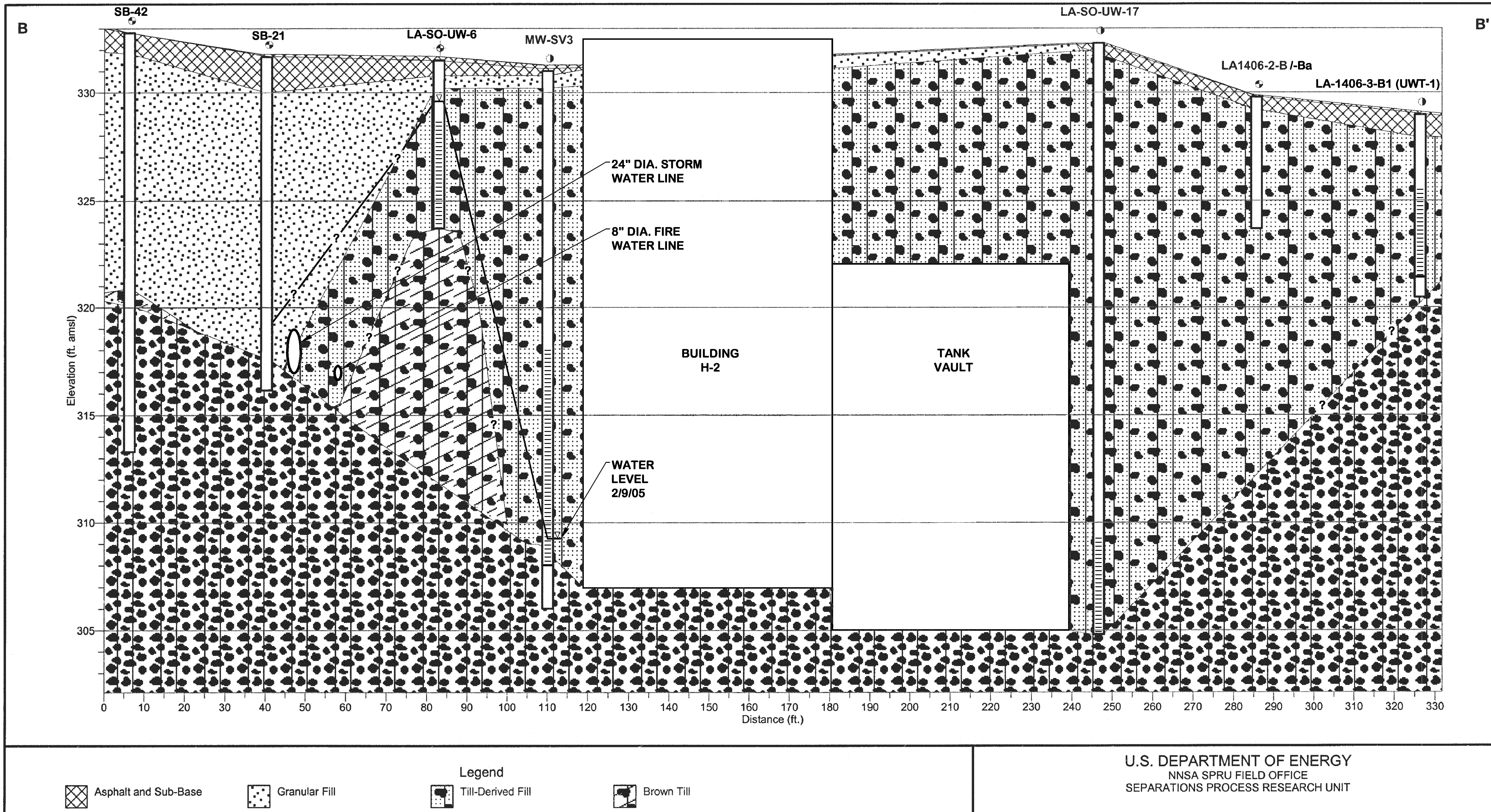

Notes:
1) The water elevation shown was measured on 2/9/05.
2) The diameter of the soil borings and monitoring wells are not shown to scale.

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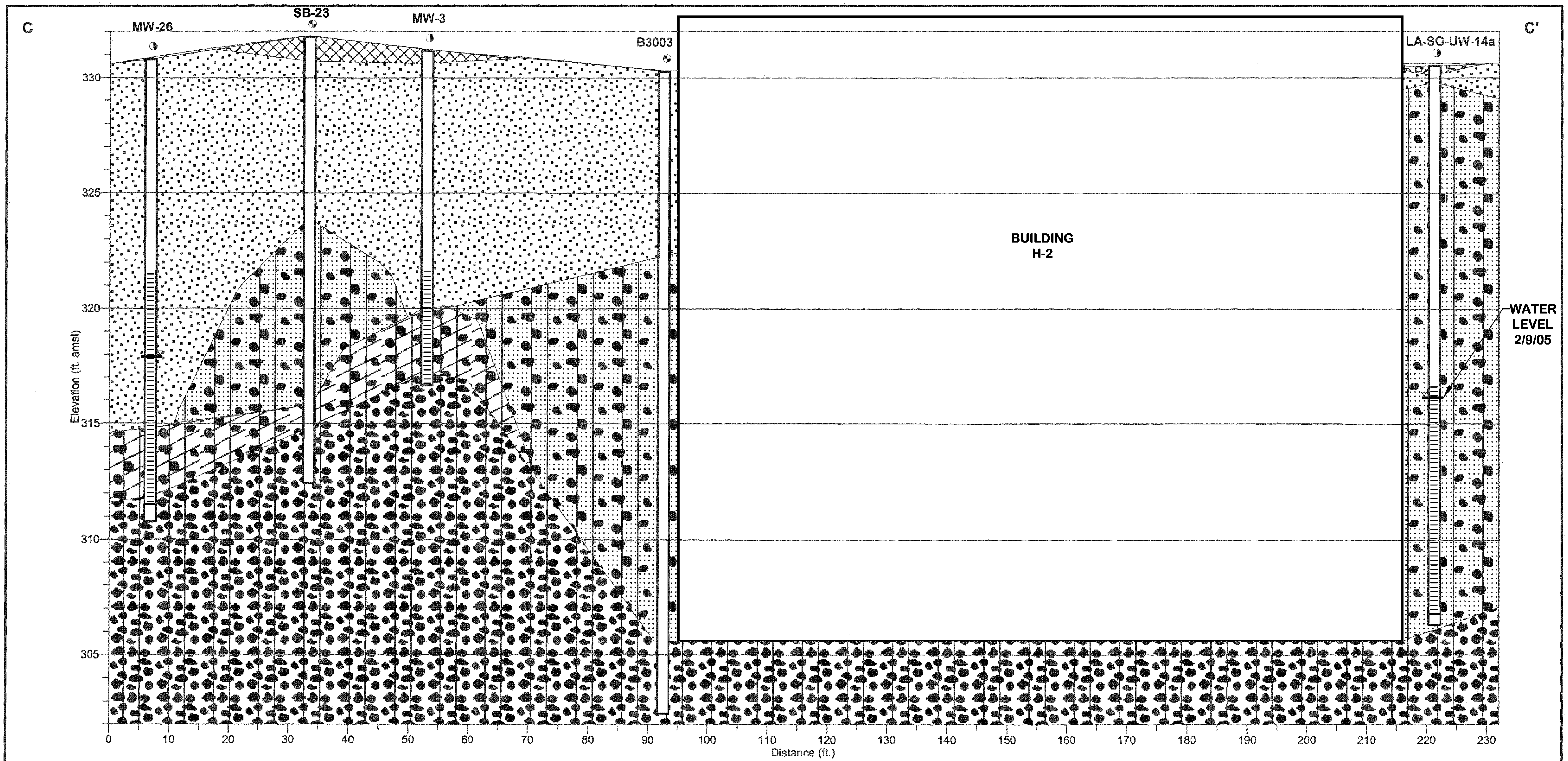
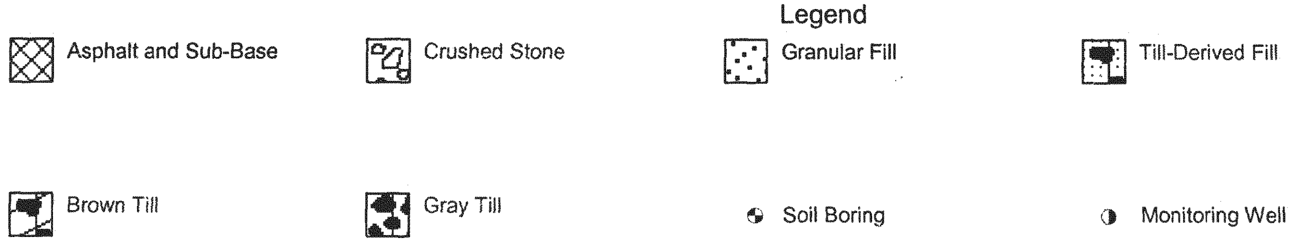
FIGURE 5-24	
UPPER LEVEL CROSS SECTION B-B'	
Date: APRIL 2006, REVISION 2	CTM Project No.: 04.9080



Legend



Notes:
1) The water elevation shown was measured on 2/9/05.
2) The diameter of the soil borings and monitoring wells are not shown to scale.

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FIGURE 5-25

UPPER LEVEL CROSS SECTION C-C'

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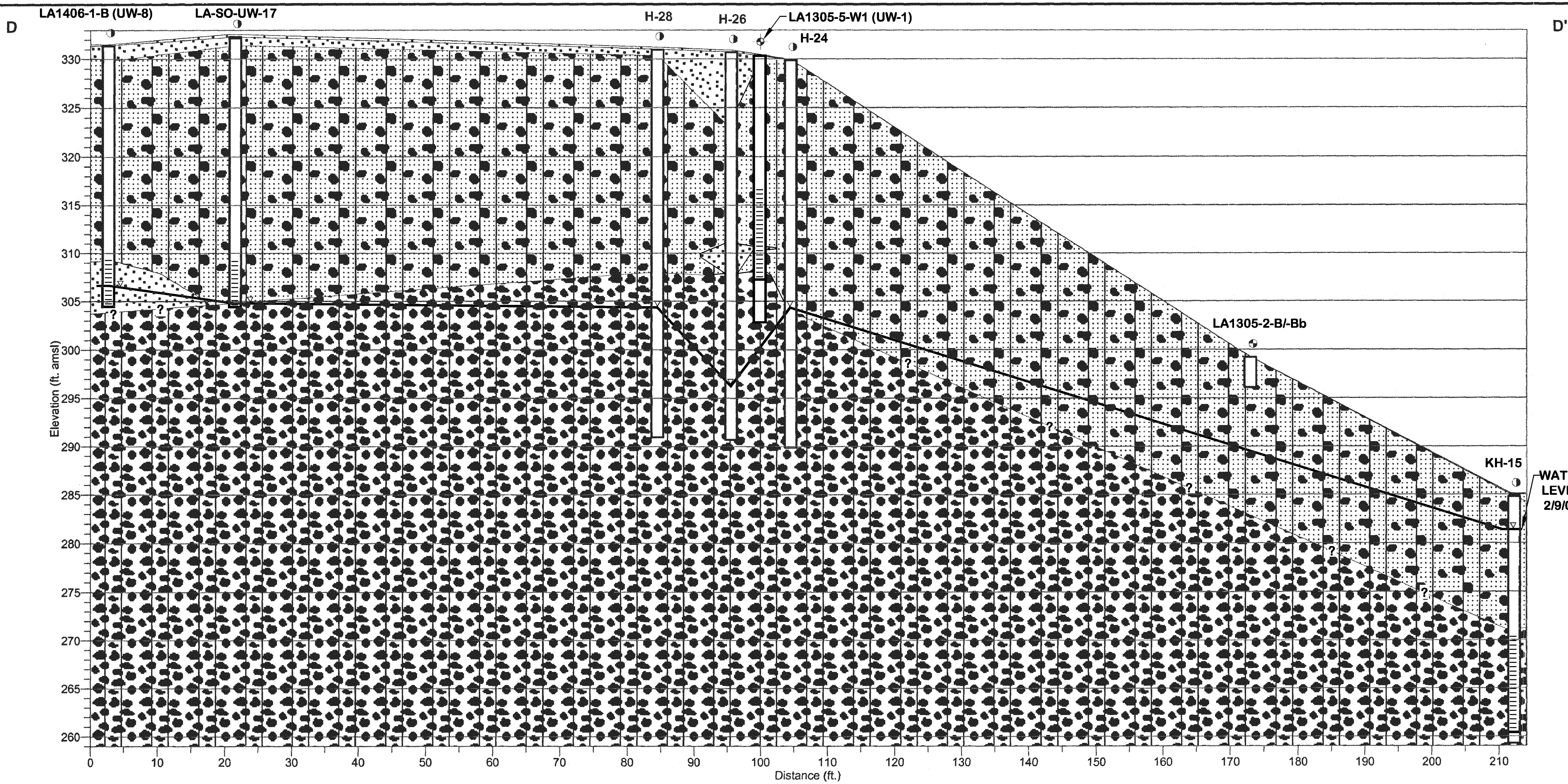
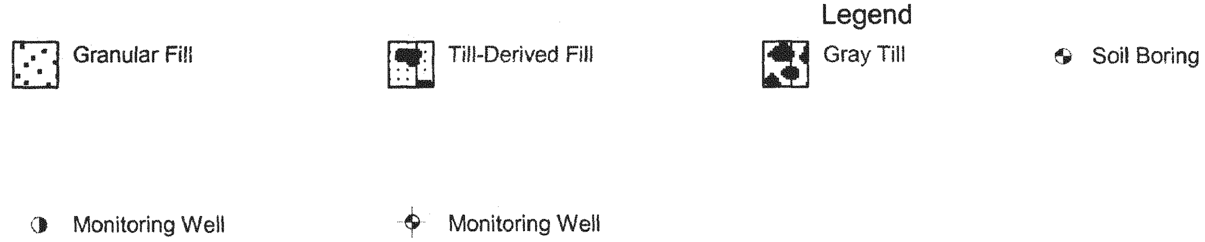


Legend



Notes:
1) The water elevation shown was measured on 2/9/05.
2) The diameter of the soil borings and monitoring wells are not shown to scale.

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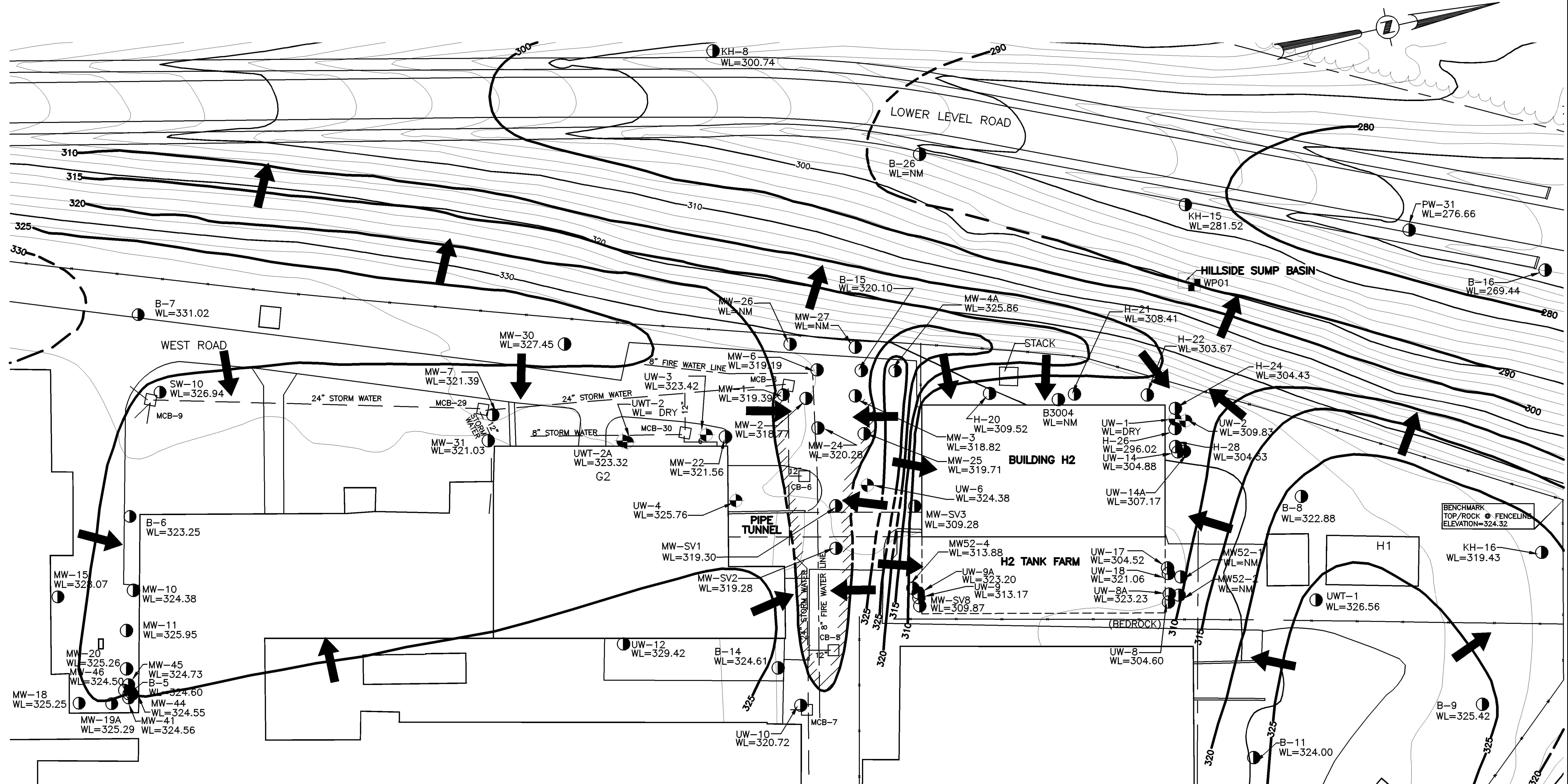
FIGURE 5-26	
UPPER LEVEL CROSS SECTION D-D'	
Date: APRIL 2006, REVISION 2	CTM Project No.: 04.9080



LEGEND

PW-31, UW-10, UWT-1	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID (TYPICAL)	WL=319.29	WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (TYPICAL) NM=NOT MEASURED
UW-1 UWT-2	SPRU RCRA/RADIOLOGICAL MONITORING WELL LOCATION AND ID (TYPICAL)	320	WATER LEVEL CONTOUR WITH ELEVATION ON 10/6/04 (TYPICAL) ARROW DEPICTS INFERRED DIRECTION OF GROUNDWATER FLOW. CONTOURS DASHED WHERE INFERRED. WATER TABLE UNCERTAIN DUE TO INFLUENCE OF PIPE TUNNEL ABOVE 317 FEET MEAN SEA LEVEL.
MW-SV1 B3004	SV MONITORING WELL LOCATION AND ID (TYPICAL)		
"MW", "KH", "H", "B", "MW52"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL)	WP01	SPRU RADIOLOGICAL WELL POINT LOCATION AND ID
		MCB-8	DESIGNATES EXISTING KAPL MANHOLE CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
		CB-6	DESIGNATES EXISTING KAPL CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)

MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.

GRAPHIC SCALE

50 0 25 50

(IN FEET)
1 inch = 50 ft.

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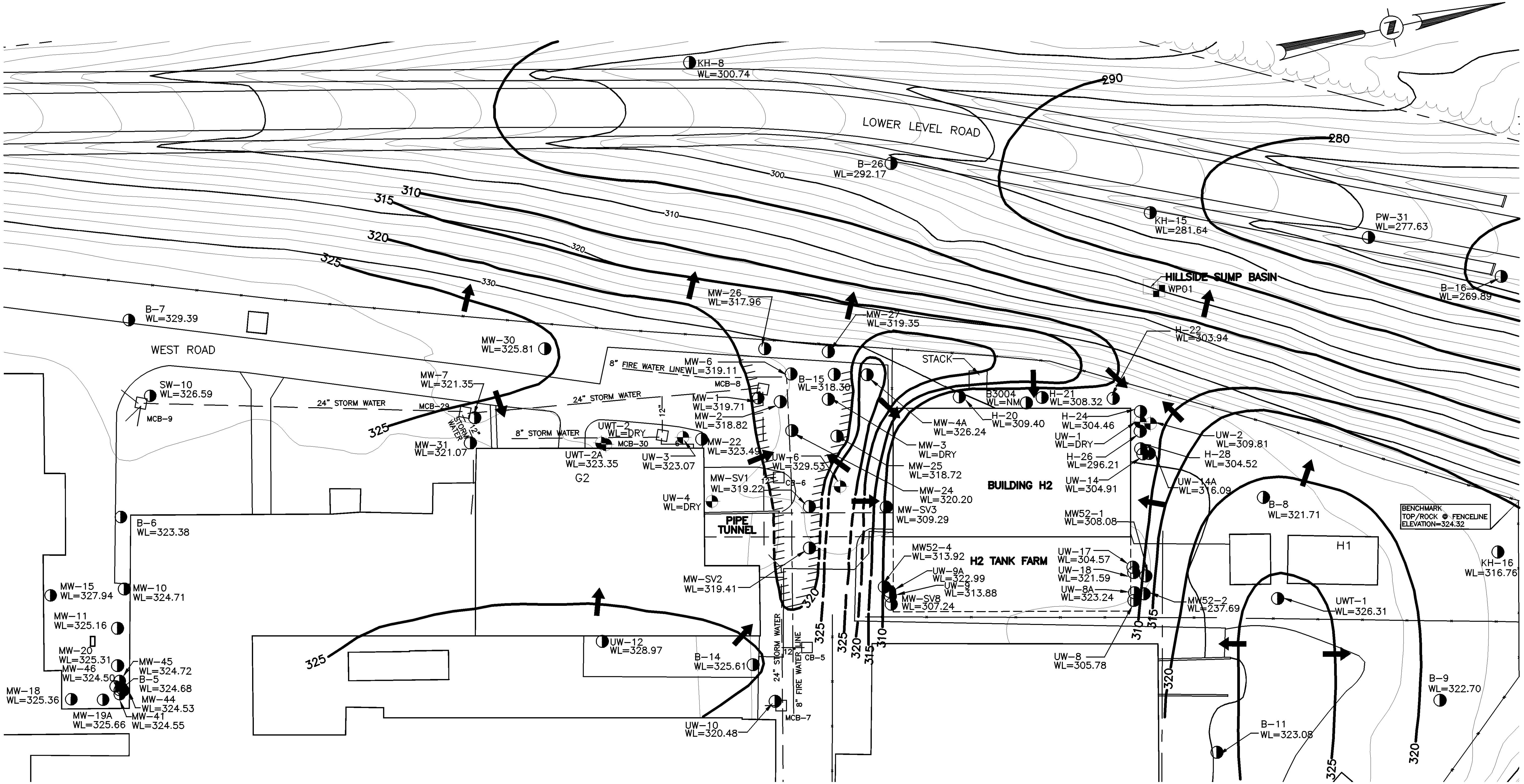
RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS

FIGURE 5-27
UPPER LEVEL
WATER LEVEL CONTOUR MAP (10/6/04)

DATE:APRIL 2006, REV. 2	DRAWING NO. 05-366	CTM PROJ. NO.: 04.9080



LEGEND

PW-31, UW-10, UWT-1	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID (TYPICAL)
UW-1 UWT-2	SPRU RCRA/RADIOLOGICAL MONITORING WELL LOCATION AND ID (TYPICAL)
MW-SV1 B3004	SV MONITORING WELL LOCATION AND ID (TYPICAL)
"MW", "KH", "H", "B", "MW52"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL)
WL=328.97	WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (TYPICAL) NM=NOT MEASURED
320	WATER LEVEL CONTOUR WITH ELEVATION ON 2/9/05 (TYPICAL) ARROW DEPICTS INFERRED DIRECTION OF GROUNDWATER FLOW, DASHED WHERE INFERRED. WATER TABLE UNCERTAIN DUE TO INFLUENCE OF PIPE TUNNEL ABOVE 317 FEET MEAN SEA LEVEL.
WP01	SPRU RADIOLOGICAL WELL POINT LOCATION AND ID
MCB-8	DESIGNATES EXISTING KAPL MANHOLE CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
CB-6	DESIGNATES EXISTING KAPL CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)

MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.

GRAPHIC SCALE

50 0 25 50

(IN FEET)
1 inch = 50 ft.

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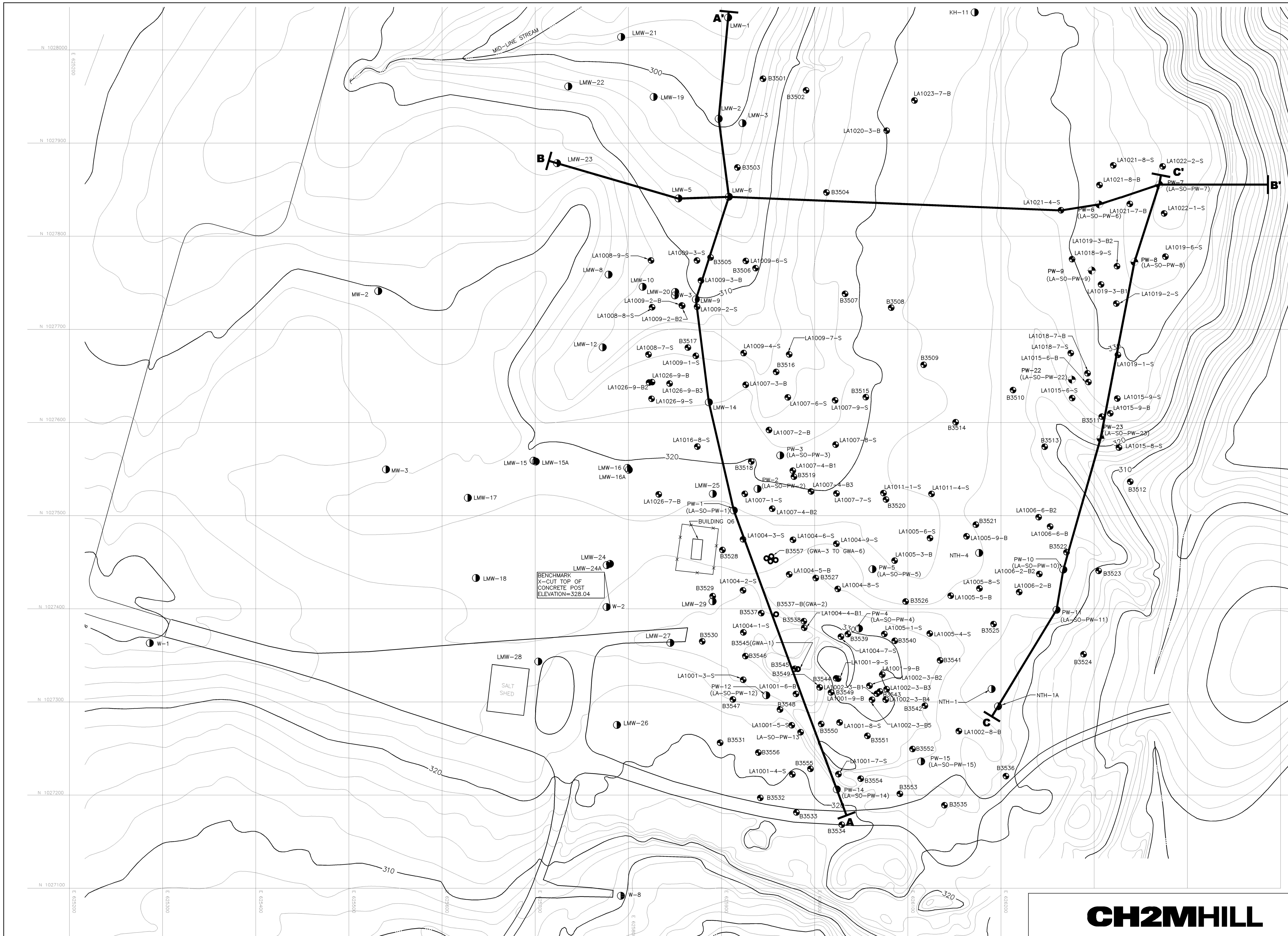
FIGURE 5-28
UPPER LEVEL
WATER LEVEL CONTOUR MAP (2/9/05)

DATE:APRIL 2006, REV. 2	DRAWING NO. 05-366	CTM PROJ. NO.: 04.9080

Plates



MAP NOTES:

1. VERTICAL DATUM ESTABLISHED FROM N.G.V.D. 1929. BASED ON CONTROL MONUMENT NO. 20 KAPL-ELEVATION 252.619.
2. NORTH ORIENTATION AND BEARINGS ARE BASED ON THE NEW YORK STATE PLANE COORDINATE SYSTEM, EAST ZONE, NAD 1927. DETERMINED THROUGH CONVENTIONAL SURVEY METHODS BASED ON KAPL MONUMENTS NUMBER 1, 2, 3, 4 & 20.
3. SPRU SAMPLING VISIT LOCATIONS OBTAINED BY FIELD SURVEY CONDUCTED BY C.T. MALE ASSOCIATES, P.C. DURING JUNE 2004 THROUGH JANUARY 2005.
4. COORDINATE UNITS ARE U.S. SURVEY FEET.

MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.

LEGEND

LA1009-4-S, LA-SO-PW-13	SPRU RADIOLOGICAL SOIL BORING LOCATION AND ID (TYPICAL)
B3537	SV SOIL BORING LOCATION AND ID (TYPICAL)
B3545-B (GWA-1)	SV ATTEMPTS TO LOCATE GROUNDWATER FOR MONITORING WELL INSTALLATION. (TYPICAL)
"NTH", "W", "MW", "KH","LMW"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL)
PW-6	SPRU RCRA SV/RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
PW-4	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
A —— A'	GEOLOGIC CROSS SECTION

GRAPHIC SCALE

50 0 25 50 100

(IN FEET)
1 inch = 50 ft.

CLASS	AUTHORIZED CLASSIFIER	DATE

CH2MHILL

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ENVIRONMENTAL SERVICES * SURVEY & LAND INFORMATION SERVICES

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CTMA PROJECT NO. 04.9080 | CTMA DWG. NO. 05-366
DATE: APRIL 2006, REVISION 2

FOR	BY	DATE	DWG. NO.	DRAWING TITLE
APPROVALS			REFERENCE DRAWINGS	

REV. NO.	DESCRIPTION	REVISED BY AND DATE	APPROVED BY AND DATE
	REVISIONS		

SCALE: 1"=50'

		APPROVALS		
DRAWN	DATE	BY	DIV.	DATE
CHECKED	DATE			
DESIGN ENGR	DATE			
ISSUED	DATE			

RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS

U.S. DEPARTMENT OF ENERGY

NNSA SPRU FIELD OFFICE
SEPARATIONS PROCESS RESEARCH UNIT

PLATE 5-1
LAND AREA
CROSS SECTION LOCATIONS

JOB NO.	DRAWING NO.	REV. NO.

MAP NOTES:

1. VERTICAL DATUM ESTABLISHED FROM N.G.V.D. 1929. BASED ON CONTROL MONUMENT NO. 20 KAPL-ELEVATION 252.619.
2. NORTH ORIENTATION AND BEARINGS ARE BASED ON THE NEW YORK STATE PLANE COORDINATE SYSTEM, EAST ZONE, NAD 1927. DETERMINED THROUGH CONVENTIONAL SURVEY METHODS BASED ON KAPL MONUMENTS NUMBER 1, 2, 3, 4 & 20.
3. SPRU SAMPLING VISIT LOCATIONS OBTAINED BY FIELD SURVEY CONDUCTED BY C.T. MALE ASSOCIATES, P.C. DURING JUNE 2004 THROUGH JANUARY 2005.
4. COORDINATE UNITS ARE U.S. SURVEY FEET.

MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.

LEGEND

LA1009-4-S, LA-SO-PW-13	SPRU RADIOLOGICAL SOIL BORING LOCATION AND ID (TYPICAL)
B3537	SV SOIL BORING LOCATION AND ID (TYPICAL)
B3545-B (GWA-1)	SV ATTEMPTS TO LOCATE GROUNDWATER FOR MONITORING WELL INSTALLATION. (TYPICAL)
"NTH", "W", "MW", "KH","LMW"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL)
PW-6	SPRU RCRA SV/RADIOLOGICAL MONITORING WELL LOCATION AND ID (TYPICAL)
PW-4	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID (TYPICAL)
TILL=290.87	TOP OF TILL ELEVATION IN FEET ABOVE MEAN SEA LEVEL AT SOIL BORING LOCATION (TYPICAL)
296	CONTOUR OF TOP OF TILL. DASHED WHERE INFERRED. NO DISTINCTION BETWEEN BROWN OR GRAY TILL. ELEVATION IN FEET ABOVE MEAN SEA LEVEL (TYPICAL)

GRAPHIC SCALE

50 0 25 50 100

(IN FEET)
1 inch = 50 ft.

CLASS	AUTHORIZED CLASSIFIER	DATE

CH2MHILL

C.T. MALE ASSOCIATES, P.C.
50 CENTURY HILL DRIVE, P.O. 727, LATHAM, NY 12110
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CTMA PROJECT NO. 04.9080 | CTMA DWG. NO. 05-366

DATE: APRIL 2006, REVISION 2

FOR	BY	DATE	DWG. NO.	DRAWING TITLE
APPROVALS			REFERENCE DRAWINGS	

REV. NO.	DESCRIPTION	REVISED BY AND DATE	APPROVED BY AND DATE
	REVISIONS		

SCALE: 1"=50'

		APPROVALS: BY	DIV.	DATE
DRAWN	DATE			
CHECKED	DATE			
DESIGN ENGR	DATE			
ISSUED	DATE			

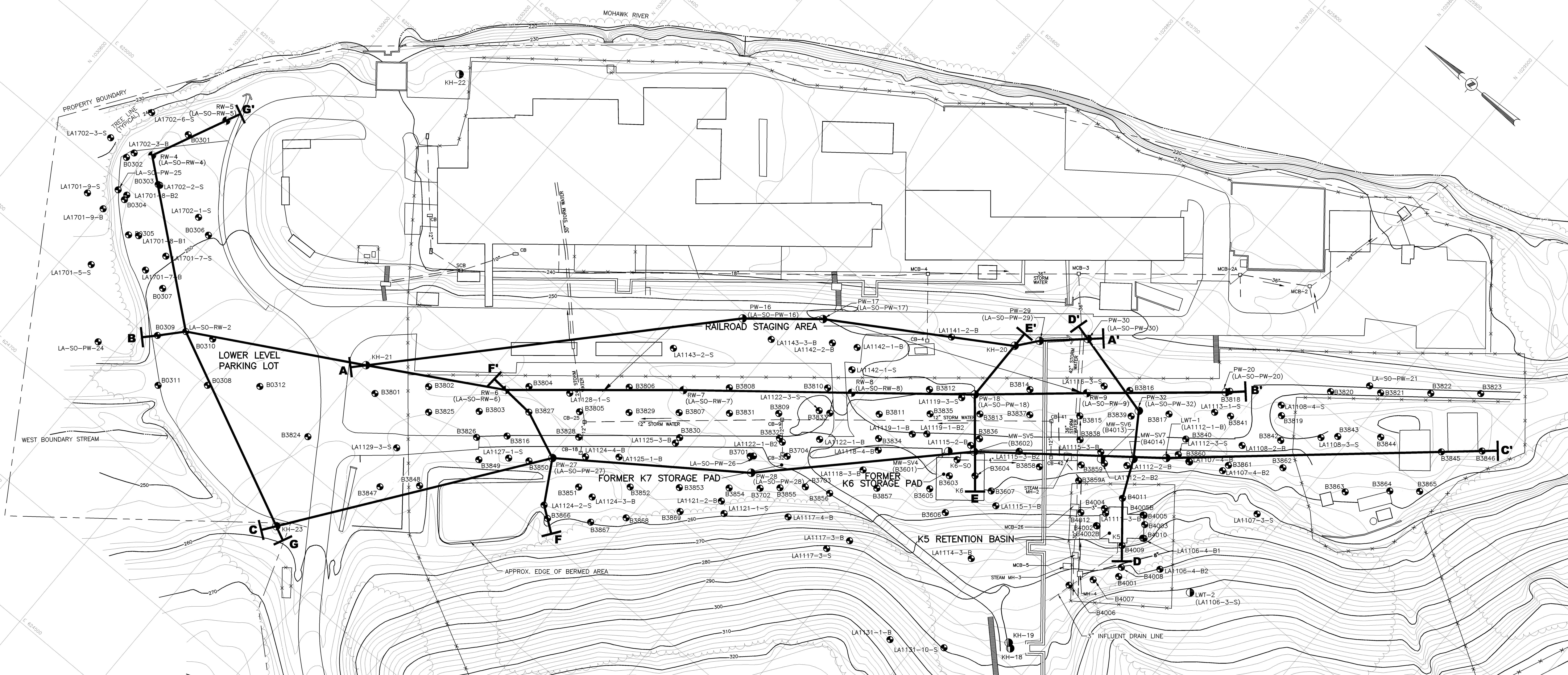
RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS

U.S. DEPARTMENT OF ENERGY

NNSA SPRU FIELD OFFICE
SEPARATIONS PROCESS RESEARCH UNIT

PLATE 5-2
LAND AREA
TOP OF TILL CONTOUR MAP

JOB NO.	DRAWING NO.	REV. NO.



MAP NOTES:

1. VERTICAL DATUM ESTABLISHED FROM N.G.V.D. 1929. BASED ON CONTROL MONUMENT NO. 20 KAPL—ELEVATION 252.619.
2. NORTH ORIENTATION AND BEARINGS ARE BASED ON THE NEW YORK STATE PLANE COORDINATE SYSTEM, EAST ZONE, NAD 1927. DETERMINED THROUGH CONVENTIONAL SURVEY METHODS BASED ON KAPL MONUMENTS NUMBER 1, 2, 3, 4 & 20.
3. SPRU LOCATIONS OBTAINED BY FIELD SURVEY CONDUCTED BY C.T. MALE ASSOCIATES, P.C. DURING JUNE 2004 THROUGH JANUARY 2005.
4. COORDINATE UNITS ARE U.S. SURVEY FEET.

MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931—001, SEPTEMBER 1999.
2. "SPRU SAMPLING VISIT, U.S. DEPARTMENT OF ENERGY, OAKLAND SPRU FIELD OFFICE KNOLLS ATOMIC POWER LABORATORY, PLATE 1, UPPER LEVEL SWMUs BASE MAP CH2MHILL" PREPARED BY C.T. MALE ASSOCIATES, P.C. DATED 02/11/02, BEARING DRAWING NO. 01—144, PROJECT NO. 00.6556.

LEGEND

Symbol	Description
LA1127—1—S, LA—SO—RW—2	SPRU RCRA AND/OR RADIOLOGICAL SOIL BORING LOCATION AND ID (TYPICAL)
B3825	SV SOIL BORING LOCATION AND ID (TYPICAL)
RW—5	SPRU RCRA / RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
PW—20, LWT—1	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
MW—SV5	SV MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
"KH"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL)
A A'	GEOLOGIC CROSS SECTION
CB—18	DESIGNATES EXISTING KAPL CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
MCB—5	DESIGNATES EXISTING KAPL MANHOLE CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)

GRAPHIC SCALE

50 0 25 50 100

(IN FEET)
1 inch = 50 ft.

CLASS	AUTHORIZED CLASSIFIER	DATE

CH2MHILL

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DATE: APRIL 2006, REVISION 2

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REV. NO.	DESCRIPTION	REVISED BY AND DATE	APPROVED BY AND DATE
	REVISIONS		

SCALE: 1"=50'		APPROVALS		
DRAWN	DATE	BY	DIV.	DATE
CHECKED	DATE			
DESIGN ENGR	DATE			
ISSUED	DATE			

RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS

U.S. DEPARTMENT OF ENERGY

NNSA SPRU FIELD OFFICE
SEPARATIONS PROCESS RESEARCH UNIT

PLATE 5-3
LOWER LEVEL
CROSS SECTION LOCATIONS

JOB NO.	DRAWING NO.	REV. NO.

MAP NOTES:

1. VERTICAL DATUM ESTABLISHED FROM N.G.V.D. 1929. BASED ON CONTROL MONUMENT NO. 20 KAPL-ELEVATION 252.619.
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3. SPRU LOCATIONS OBTAINED BY FIELD SURVEY CONDUCTED BY C.T. MALE ASSOCIATES, P.C. DURING JUNE 2004 THROUGH JANUARY 2005.
4. COORDINATE UNITS ARE U.S. SURVEY FEET.

MAP REFERENCE:

1. BASE MAP OBTAINED FROM CH2M HILL IN AUTOCAD RELEASE 14; O'BRIEN & GERE ENGINEERS, INC. FILE NO. 10350.23931-001, SEPTEMBER 1999.
2. "SPRU SAMPLING VISIT, U.S. DEPARTMENT OF ENERGY, OAKLAND SPRU FIELD OFFICE KNOLLS ATOMIC POWER LABORATORY, PLATE 1, UPPER LEVEL SWMUs BASE MAP CH2MHILL" PREPARED BY C.T. MALE ASSOCIATES, P.C. DATED 02/11/02, BEARING DRAWING NO. 01-144, PROJECT NO. 00.6556.

LEGEND

Symbol	Description
LA1127-1-S, LA-SO-RW-2	SPRU RCRA AND/OR RADIOLOGICAL SOIL BORING LOCATION AND ID (TYPICAL)
B3825	SV SOIL BORING LOCATION AND ID (TYPICAL)
RW-5	SPRU RCRA / RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES WHERE IT DIFFERS FROM THE WELL ID (TYPICAL)
PW-20, LWT-1	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES WHERE IT DIFFERS FROM THE WELL ID (TYPICAL)
MW-SV5	SV MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
"KH"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL)
240	CONTOUR OF TOP OF TILL. NO DISTINCTION BETWEEN BROWN OR GRAY TILL. ELEVATION IN FEET ABOVE MEAN SEA LEVEL (TYPICAL). DASHED CONTOUR LINES REPRESENT INFERRED TOP OF TILL ELEVATION.
TILL=245.66	TOP OF TILL ELEVATION IN FEET ABOVE MEAN SEA LEVEL AT SOIL BORING LOCATION (TYPICAL)
CB-18	DESIGNATES EXISTING KAPL CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
MCB-5	DESIGNATES EXISTING KAPL MANHOLE CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
(hatched area)	APPROXIMATE AREA WITHOUT GLACIAL TILL

GRAPHIC SCALE

50 0 25 50 100

(IN FEET)
1 inch = 50 ft.

CLASS	AUTHORIZED CLASSIFIER	DATE

CH2MHILL

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CTMA PROJECT NO. 04.9080 | CTMA DWG. NO. 05-366

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	REVISIONS		

SCALE: 1"=50'

		APPROVALS: BY	DIV.	DATE
DRAWN	DATE			
CHECKED	DATE			
DESIGN ENGR	DATE			
ISSUED	DATE			

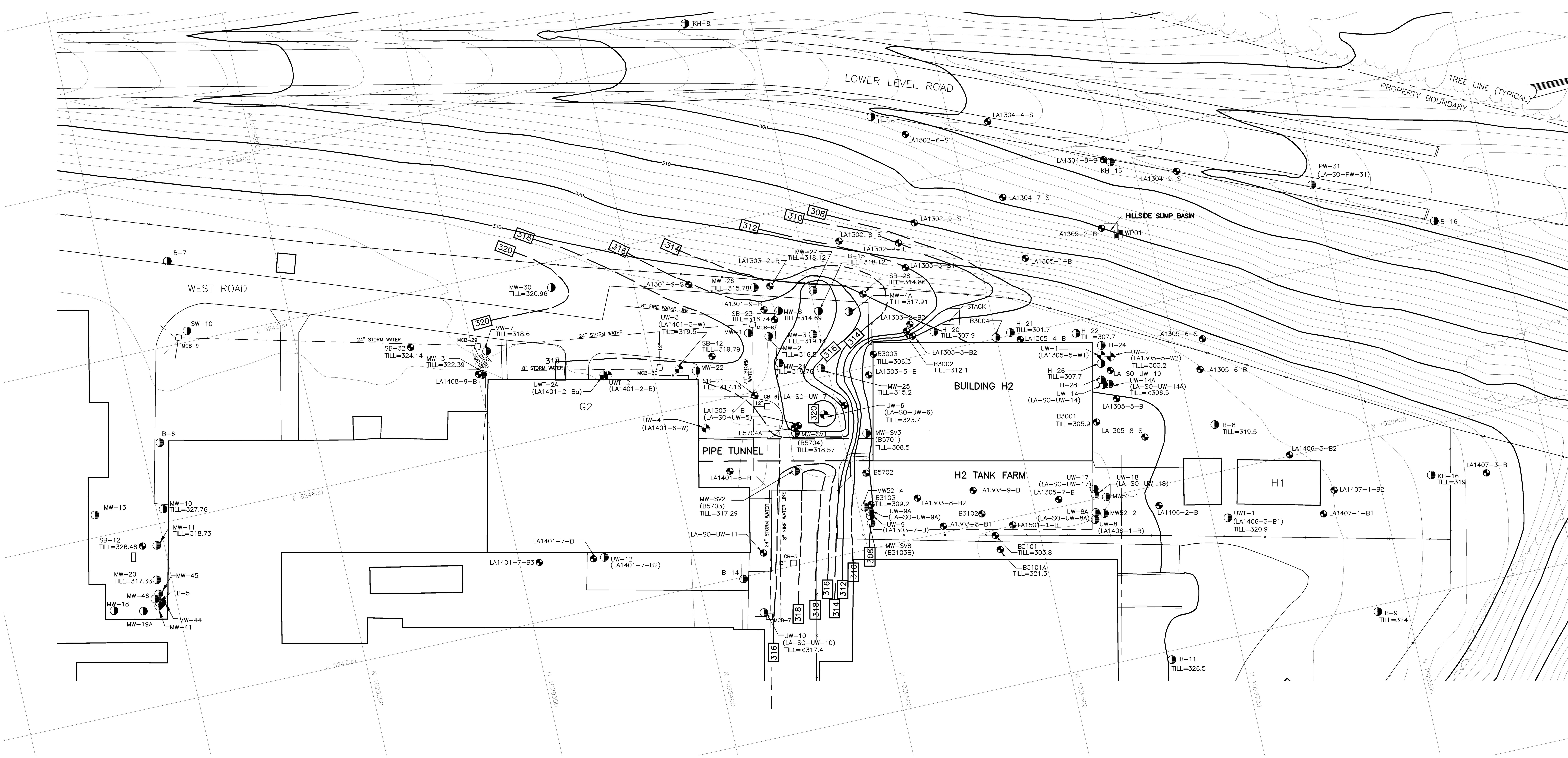
RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS

U.S. DEPARTMENT OF ENERGY

NNSA SPRU FIELD OFFICE
SEPARATIONS PROCESS RESEARCH UNIT

PLATE 5-4
LOWER LEVEL
TOP OF TILL CONTOUR MAP

JOB NO.	DRAWING NO.	REV. NO.



LEGEND

LA-SO-UW-19, LA1401-7-B	SPRU RCRA AND/OR RADIOLOGICAL SOIL BORING LOCATION AND ID (TYPICAL)
B3002, B5702	SV SOIL BORING LOCATION AND ID (TYPICAL)
SB-21	KAPL HILLSIDE AREA SOIL BORING LOCATION AND ID (TYPICAL)
UW-1, UWT-2	SPRU RCRA / RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
PW-31, UW-10, UWT-1	SPRU RADIOLOGICAL MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
MW-SV1, B3004	SV MONITORING WELL LOCATION AND ID. THE ASSOCIATED SOIL BORING ID IS GIVEN IN PARENTHESES (TYPICAL)
"MW", "KH", "H", "B", "MW52"	DESIGNATES EXISTING KAPL MONITORING WELL LOCATION (TYPICAL) NOTE: FOR THE MW-SERIES WELLS, THE WELL HAS AN ASSOCIATED SOIL BORING (SB-SERIES) THAT IS CO-LOCATED WITH THE WELL BUT NOT SHOWN ON THE MAP.
WP01	SPRU RADIOLOGICAL WELL POINT LOCATION AND ID
318	CONTOUR OF TOP OF TILL. DASHED WHERE INFERRED. NO DISTINCTION BETWEEN BROWN OR GRAY TILL. ELEVATION IN FEET ABOVE MEAN SEA LEVEL (TYPICAL)
TILL=320.96	TOP OF TILL ELEVATION IN FEET ABOVE MEAN SEA LEVEL AT SOIL BORING LOCATION (TYPICAL)
MCB-8	DESIGNATES EXISTING KAPL MANHOLE CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)
CB-6	DESIGNATES EXISTING KAPL CATCH BASIN, APPROXIMATE LOCATION (TYPICAL)

MAP NOTES:

1. VERTICAL DATUM ESTABLISHED FROM N.G.V.D. 1929. BASED ON CONTROL MONUMENT NO. 20 KAPL-ELEVATION 252.619.
2. NORTH ORIENTATION AND BEARINGS ARE BASED ON THE NEW YORK STATE PLANE COORDINATE SYSTEM, EAST ZONE, NAD 1927. DETERMINED THROUGH CONVENTIONAL SURVEY METHODS BASED ON KAPL MONUMENTS NUMBER 1, 2, 3, 4 & 20.
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4. COORDINATE UNITS ARE U.S. SURVEY FEET.

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2. "SPRU SAMPLING VISIT, U.S. DEPARTMENT OF ENERGY, OAKLAND SPRU FIELD OFFICE KNOLLS ATOMIC POWER LABORATORY, PLATE 1, UPPER LEVEL SWMUs BASE MAP CH2MHILL" PREPARED BY C.T. MALE ASSOCIATES, P.C. DATED 02/11/02, BEARING DRAWING NO. 01-144, PROJECT NO. 00.6556.

GRAPHIC SCALE

30 0 15 30 60

(IN FEET)
1 inch = 30 ft.

CLASS	AUTHORIZED CLASSIFIER	DATE

CH2MHILL

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50 CENTURY HILL DRIVE, P.O. 727, LATHAM, NY 12110
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SCALE: 1"=30'

	DATE	APPROVALS BY	DIV.	DATE
DRAWN	DATE			
CHECKED	DATE			
DESIGN ENGR	DATE			
ISSUED	DATE			

RADIOLOGICAL CHARACTERIZATION REPORT FOR THE SPRU OUTSIDE AREAS

U.S. DEPARTMENT OF ENERGY

NNSA SPRU FIELD OFFICE
SEPARATIONS PROCESS RESEARCH UNIT

PLATE 5-5
UPPER LEVEL
TOP OF TILL CONTOUR MAP

JOB NO.	DRAWING NO.	REV. NO.