APPENDIX D

ENGINEERED BARRIERS AND POST-REMEDIATION ACTIVITIES

PURPOSE OF THIS APPENDIX

The purpose of this appendix is to provide additional detail on engineered barriers installed during Phase 1 decommissioning and describe the post-remediation monitoring, maintenance, and institutional control program to be implemented for the WVDP premises following Phase 1 Decommissioning.

INFORMATION IN THIS APPENDIX

This appendix includes information on engineered barrier conceptual designs and the conceptual post-remediation monitoring, maintenance, and institutional control program, organized as follows:

- Section 1 describes the conceptual designs of the engineered barriers to be installed during Phase 1 decommissioning;
- Section 2 describes the conceptual post-remediation site monitoring and maintenance program that will be implemented for the project premises at the conclusion of Phase 1 decommissioning;
- Section 3 describes the conceptual post-remediation site institutional control program that will be implemented for the project premises at the conclusion of Phase 1 decommissioning.

RELATIONSHIP TO OTHER PLAN SECTIONS

Information provided in Section 1 on the project background and Section 7 on decommissioning activities, will help place the information in this appendix into context. The content of Appendix D, like that of other parts of the plan, is consistent with the annotated NRC decommissioning plan checklist in Appendix A, which expresses NRC's expectations for section content.

1.0 Description of Engineered Barriers

This section presents a detailed description of the conceptual designs for the engineered barriers to be installed during Phase 1 decommissioning, supplementing the physical descriptions previously presented in Section 7. Engineered barriers will be installed at the WMA 1 and WMA 2 excavations to facilitate the removal of sub-grade structures, excavate contaminated soil to meet unrestricted release criteria, and to prevent the recontamination of the WMA 1 and WMA 2 excavated areas by the non-source area of the North Plateau Plume.

The final design of the barrier walls and French drain will be prepared by the site decommissioning contractor after Phase 1 decommissioning activities start in 2011. The final design details of the hydraulic barriers and French drain will be provided to the NRC for technical review before their installation, as indicated in Section 1.6 of this plan.

The development of the WMA 1 and WMA 2 hydraulic barrier walls and French drain designs will be supported by the collection of subsurface soil geotechnical data, the installation of groundwater monitoring wells to provide groundwater elevation monitoring data, and groundwater modeling to evaluate the potential impacts these structures have on groundwater flow patterns in WMA 1 and WMA 2 and in surrounding areas such as WMA 3.

> According to the NRC's Final Policy Statement (67 FR 22), engineered barriers are generally passive manmade structures or devices intended to improve a facility's ability to meet a site's performance objectives. While institutional controls are designed to restrict access, engineered barriers are usually designed to inhibit water from contacting waste, limit releases, or mitigate doses to intruders.

1.1 Waste Management Area 1

Phase 1 of the WVDP decommissioning will include the removal of all above grade and sub-grade structures of WMA 1 and the removal of the underlying soils associated with the source area of the north plateau groundwater plume to a maximum depth of approximately 50 feet. The removal of the sub-grade structures and the soils of the source area of the plume will require the installation of temporary and permanent subsurface hydraulic barrier walls prior to excavation as described in Section 7. A French drain system will be installed in the backfilled excavation to prevent mounding of groundwater against the permanent barrier wall as described in Section 7. The WMA 1 barrier walls and French drain will be designed to result in minimal changes to groundwater flow patterns and water levels in WMA 3. These barrier walls and the French drain system are described in greater detail below.

1.1.1 Need for Subsurface Engineered Barriers and French Drain

During Phase 1 decommissioning sub-grade structures (building cells, underground piping and tanks) and underlying vadose and saturated soils associated with the source area of the North Plateau Plume in WMA 1 will be removed down into the underlying Lavery till to meet the unrestricted release criteria in 10 CFR 20.1402. Much of the WMA 1 excavation will be within the saturated sand and gravel unit within the north plateau groundwater plume.

Subsurface hydraulic barrier walls will be installed on each side of the WMA 1 excavation to:

- Isolate the excavation from the non-source area of the north plateau groundwater plume,
- Prevent groundwater intrusion into the excavation from the surrounding sand and gravel unit,
- Allow dewatering of saturated soils within the excavation,
- Facilitate removal of sub-grade structures,
- Allow excavation of subsurface soil down into the Lavery till and up to the hydraulic barrier walls,
- Allow final status surveys and NRC confirmatory surveys to be performed in the bottom and sides of the excavation, and
- Prevent recontamination of the remediated and backfilled WMA 1 excavation from the

non-source area of the north plateau groundwater plume until a Phase 2 decommissioning decision is made.[1]

Subsurface soil characterization will be performed in WMA 1 before excavation begins to identify the lateral extent of subsurface soil contamination associated with the source area of the North Plateau Plume. This subsurface soil data will be used to locate the temporary interlocking sheet piling which will be driven through the uncontaminated sand and gravel unit into the underlying Lavery till on the upgradient and cross-gradient sides of the WMA 1 excavation to prevent groundwater intrusion into the excavation from upgradient sources. A permanent hydraulic barrier of slurry wall type construction will be installed on the downgradient side of the excavation in soil contaminated by the north plateau groundwater plume to act as an intrusion barrier to prevent the migration of Sr-90 contaminated groundwater from the non-source area of the north plateau groundwater plume into the WMA 1 excavation.

The permanent downgradient hydraulic barrier will:

- Prevent recontamination of the remediated and backfilled WMA 1 excavation from the non-source area of the plume until a Phase 2 decommissioning decision is made, and
- Minimize groundwater recharge to the non-source area of the plume, thereby minimizing hydraulic heads and groundwater velocity.

A French drain system will be installed adjacent and hydraulically upgradient of the permanent hydraulic barrier wall once the WMA 1 excavation has been backfilled to maintain groundwater elevations near their current levels. The French drain system will:

- Prevent groundwater mounding against, and potential overtopping of, the permanent downgradient hydraulic barrier wall;
- Maintain hydraulic heads on the upgradient side of the barrier wall that coincide with the elevation of the French drain system, that are higher than groundwater levels downgradient of the barrier wall. This will create a hydraulic gradient towards the non-source area of the north plateau groundwater plume, preventing seepage from the plume through the wall into the backfilled excavation; and
- In conjunction with the permanent downgradient hydraulic barrier, minimize groundwater recharge to the non-source area of the North Plateau Plume thereby minimizing hydraulic heads and groundwater velocity across the North Plateau.

1.1.2 Hydraulic Barrier Walls and French Drain System

The WMA 1 excavation will require the installation of approximately 2,250 linear feet of subsurface hydraulic barrier wall comprised of temporary interlocking steel sheet piling on the upgradient and cross-gradient sides of the excavation and a permanent hydraulic barrier wall on the downgradient side of the excavation before excavation begins as shown on Figure D-1.

Temporary Sheet Pile Barrier Walls

Approximately 1,500 feet of conventional interlocking sheet piles will be installed in uncontaminated soils along the upgradient and cross-gradient sides of the excavation boundary before excavation begins (Figure D-1). The piles will be driven a minimum of two feet into the underlying Lavery till to prevent groundwater from migrating beneath the piles into the WMA 1 excavation.

[1] The recontamination potential is low since groundwater flows northeast away from WMA 1.

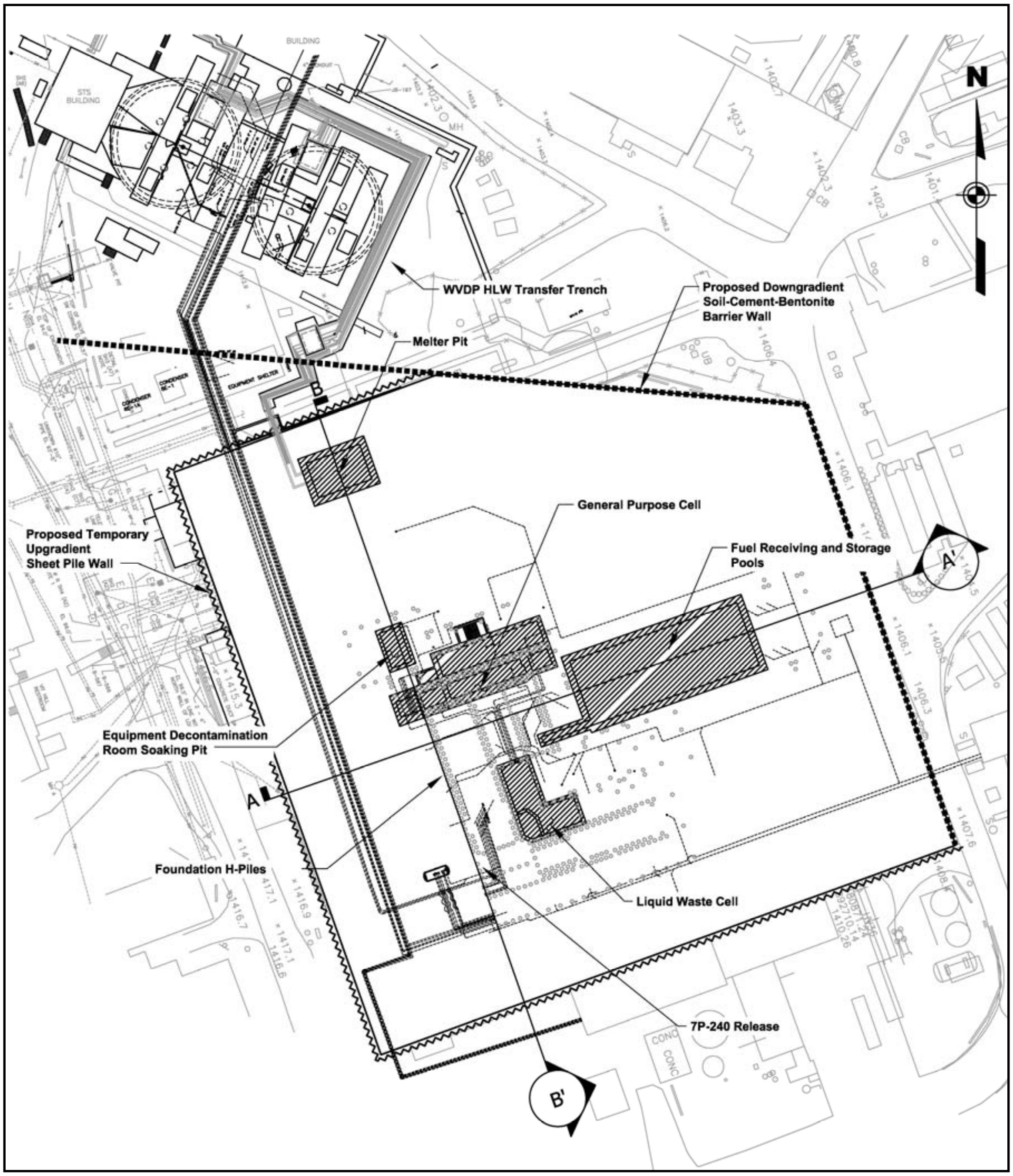


Figure D-1. Plan View of the WMA 1 Excavation

Contaminated soil exceeding the subsurface soil cleanup criteria specified in Section 5 will be excavated leaving a soil cut-back slope against the sheet pile walls containing soil with radionuclide concentrations below the subsurface soil clean-up criteria.[2] The soil cut-backs along the sheet pile walls will be surveyed during the Phase 1 final status surveys as specified in Sections 7 and 9 of this plan. The sheet pile barrier wall will be removed as specified in Section 7 once the final status survey, the independent verification survey, and backfilling of the

[2] Figure 7-8 in Section 7 of this plan shows typical excavation slopes.

WMA 1 excavation is completed to allow a return to typical groundwater flow patterns within the sand and gravel unit.

Permanent Downgradient Hydraulic Barrier Wall

The permanent hydraulic barrier wall constructed on the downgradient side of the WMA 1 excavation (Figure D-1) will be a vertical soil-cement-bentonite slurry wall installed using slurry wall trenching technology. This hydraulic barrier technology was selected because of its long history of successful usage. This wall will prevent migration of Sr-90 contaminated groundwater from the non-source area of the North Plateau Plume into the WMA 1 excavation both during excavation and after backfilling the excavation with clean fill.

The hydraulic barrier wall downgradient of the WMA 1 excavation will be installed under a carefully planned and rigorous quality control-quality assurance program as described in Section 8.

The soil-cement-bentonite barrier wall will be a mixture of 85 percent soil, five percent Portland cement, and 10 percent bentonite. The Portland cement will provide internal stability to the barrier wall and it will have an initial maximum design hydraulic conductivity of 6.0E-06 cm/s.

The soil-cement-bentonite barrier wall will be approximately 750 feet long, two to 13 feet wide, and will be up to 50 feet deep with an average depth of 27 feet. The wall will extend through the sand and gravel unit and a minimum of two feet into the Lavery till to minimize groundwater flow beneath the bottom of the wall.

Approximately 225 feet of barrier wall outside of the excavation boundary will be two to three feet thick. The remaining 525 feet of barrier wall within the boundary of the excavation will be at least 13 feet thick to allow the excavation of subsurface soils up to and into the barrier wall. The thickness will allow an excavation cut back slope of 1:2 (horizontal to vertical), which is typical of what can be achieved in most stiff clayey soils. The barrier wall material within the excavation cut-back slope will be surveyed during the Phase 1 final status survey.[3]

The upper three feet of the barrier wall will be constructed of clean backfill similar to the surrounding sand and gravel unit. This material will allow vehicular traffic over the barrier wall without damaging the underlying barrier wall.

French Drain System

A French drain system will be installed upgradient of the permanent hydraulic barrier wall during the backfilling of the WMA 1 excavation (Figure D-1). The French drain will be installed to keep groundwater levels at their current level on the upgradient side of the barrier wall to prevent groundwater mounding against the wall, prevent potential overtopping of the wall, and promote groundwater flow towards the non-source area of the north plateau groundwater plume.

The French drain will be constructed by excavating a trench, approximately four feet wide and 10 feet deep, placing perforated pipe into the bottom of the trench, and backfilling the trench with permeable granular materials. The northwest and southeast portions of the French drain will meet at a concrete manhole located near the mid-point of the barrier wall. The French

[3] As explained in Section 7 of this plan, any soil found to exceed cleanup goals will be removed only within the confines of the planned excavation, that is, within the confines of the downgradient hydraulic barrier wall and the sheet piles.

drain will be sloped to the southeast to discharge by gravity flow to a surface water drainage discharging to Erdman Brook.

1.2 Waste Management Area 2

The Phase 1 decommissioning activities in WMA 2 will include the removal of Lagoons 1 through 3, the Neutralization Pit, Interceptors, Solvent Dike, and surrounding contaminated soils within a single excavation down into the underlying Lavery till. Most of this excavation is cross gradient to the non-source area of the North Plateau Plume (Figure D-2). The removal of the lagoons, sub-grade structures, and surrounding soils will require the installation of a permanent subsurface hydraulic barrier wall prior to excavation to facilitate removal activities and to prevent potential recontamination of the area from the non-source area of the north plateau groundwater plume as described in Section 7. The barrier wall for WMA 2 is described in greater detail below.

1.2.1 Need for Subsurface Engineered Barriers

Lagoons 1 through 3, sub-grade structures, and surrounding contaminated vadose and saturated soils will be removed to a depth of approximately 14 feet to meet the unrestricted release criteria in 10 CFR 20.1402. Most of the WMA 2 excavation may be impacted by migration of Sr-90 contaminated groundwater from the adjacent non-source area of the north plateau groundwater plume. The need for a subsurface hydraulic barrier wall for the 4.2-acre excavation area across WMA 2 is the same as the rationale described earlier in Section 1.1.1 of this Appendix for the excavation of WMA 1.

A permanent hydraulic barrier of slurry wall type construction will be installed on the northwest and northeast side of the WMA 2 excavation to act as an intrusion barrier to prevent the migration of Sr-90 contaminated groundwater from the non-source area of the north plateau groundwater plume into the WMA 2 excavation. This permanent downgradient hydraulic barrier will prevent recontamination of the remediated and backfilled WMA 2 excavation from the non-source area of the north plateau plume until a Phase 2 decommissioning decision is made.

1.2.2 Hydraulic Barrier Wall

Before excavation activities begin in WMA 2 a permanent subsurface hydraulic barrier wall will be installed on the northwest side of the WMA 2 excavation as shown on Figure D-3.

Permanent Hydraulic Barrier Wall

The permanent hydraulic barrier wall constructed on the northwest and northeast side of the WMA 2 excavation will be a vertical soil-cement-bentonite slurry wall installed using slurry wall trenching technology. This hydraulic barrier technology was selected because of its long history of successful usage. This wall will prevent migration of Sr-90 contaminated groundwater from the non-source area of the north plateau plume into the WMA 2 excavation both during excavation and after the excavation has been backfilled with clean fill.

The hydraulic barrier wall installed northwest of the WMA 2 excavation will be installed under a carefully planned and rigorous quality control-quality assurance program as described in Section 8. The barrier wall will be approximately 1,100 feet long, sufficiently wide to provide the stability necessary to permit excavation close to the edge of the excavation, and up to 20 feet deep, with an average depth of 16 feet. The wall will extend through the sand and gravel unit and a minimum of two feet into the Lavery till to minimize groundwater flow beneath the bottom of the wall.

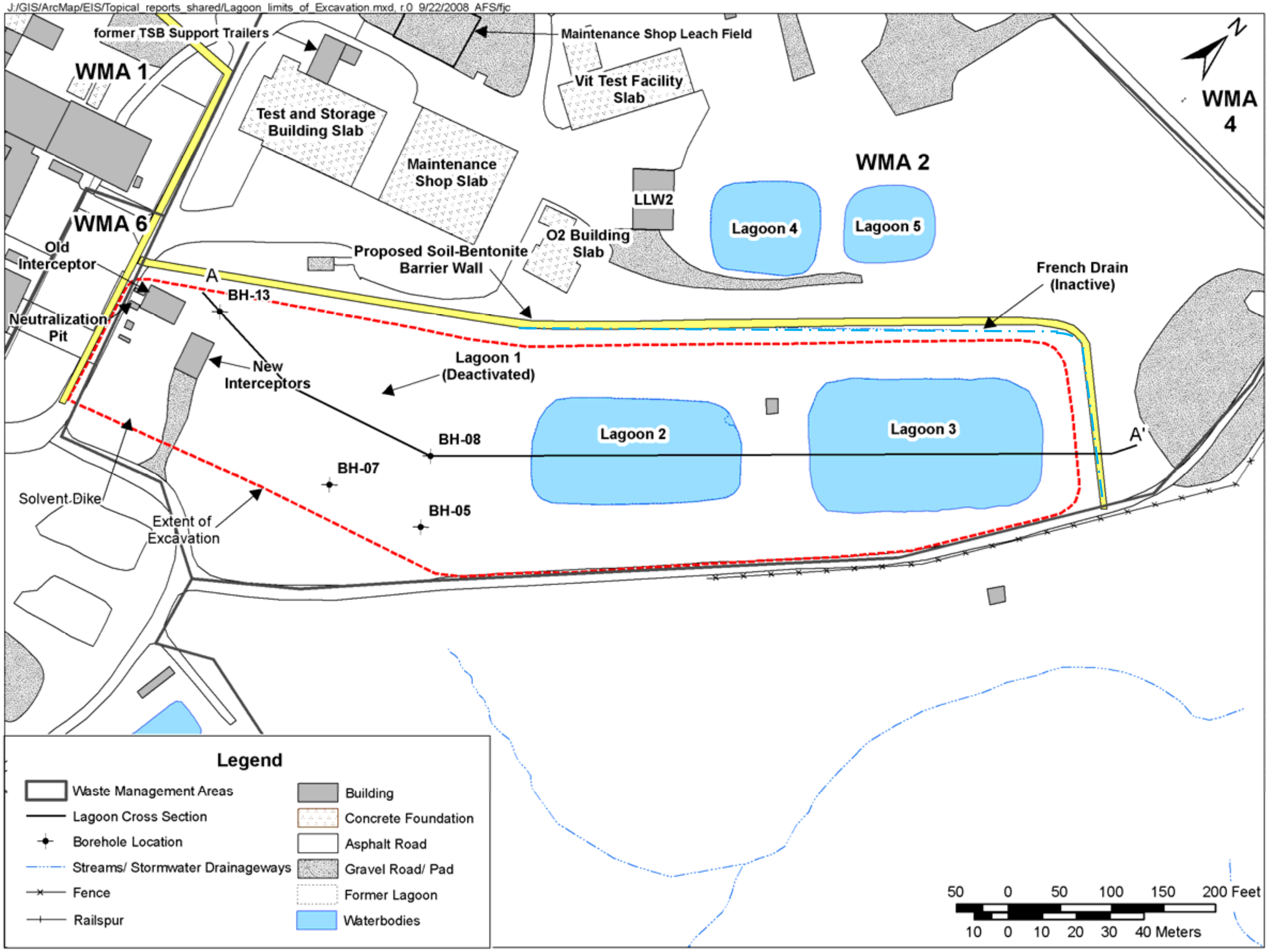


Figure D-2. Plan View of the WMA 2 Excavation

The upper three feet of the barrier wall will be constructed of clean backfill similar to the surrounding sand and gravel unit. This material will allow vehicular traffic over the barrier wall without damaging the underlying barrier wall.

1.3 Durability of Engineered Barriers

The materials used in the construction of the soil-cement-bentonite slurry walls are common natural geologic construction materials that exhibit long-term durability within the natural environment. The engineered barriers are expected to retain their design effectiveness until the start of Phase 2 of the decommissioning at a minimum. Their continued use will be among the factors evaluated in determining the approach to Phase 2 of the decommissioning.

The low-permeability bentonite used in the slurry wall construction is a natural geologic material exhibiting demonstrated long-term mineralogical and geologic stability (Mitchell 1986 and Mitchell 1993). Chemical contaminants that might degrade the physical characteristics and/or compromise the hydraulic conductivity of soil-bentonite slurry walls include:

- Concentrated solutions of organic fluids (Mille, et al. 1992 and Khera and Tirumala 1992),
- Organic groundwater contaminants (Evans, et al. 1985b and Grube 1992), and
- Acidic or highly alkaline solutions (Evans, et al. 1985a and Fang et al. 1992).

However, these conditions are not present within the project premises.

The backfill to be used for slurry wall construction will be a mixture of soil, Portland cement, and commercial sodium bentonite. The soil can be any material that could be classified as CL, CL/ML or ML/CL by the Unified Soil Classification System. The soil backfill will be natural geologic materials similar to the sand and gravel unit in the North Plateau. Uncontaminated sand and gravel from the trench excavation may also be used as soil backfill for the slurry wall. The sodium bentonite will be added at a rate recommended by the vendor to achieve a hydraulic conductivity on the order of 1 E-08 to 1 E-06 cm/s.

The geotechnical stability of the soil-cement-bentonite slurry wall has been evaluated under combined static and seismic loading conditions. The evaluation results indicate that the soil-cement-bentonite slurry wall will provide the necessary strength to withstand damage from static and seismic loads predicted to occur during a hypothetical earthquake generating a horizontal acceleration of 0.20 g in the soil, with an approximate factor of safety of greater than 1.3 to greater than 3.0 (URS 2000).

The French drain will be constructed of natural (stone backfill) and man-made (perforated drain pipe, geotextile) materials. The French drain trench backfill will be designed to minimize silting of the drainpipe. The French drain will be periodically monitored and maintained until the start of Phase 2 decommissioning to ensure it is functioning properly.

1.4 Engineered Barriers and Groundwater Flow

Groundwater flow in the sand and gravel unit is currently to the northeast across the north plateau through WMA 1 and parallel to WMA 2 (Figure D-2). The permanent hydraulic barrier wall and French drain to be installed on the downgradient side of the WMA 1 excavation will be nearly perpendicular to the current groundwater flow path in the sand and gravel unit in the north plateau.

1.4.1 Conceptual Model

A three-dimensional near-field groundwater model was developed to simulate groundwater flow conditions near the engineered barriers installed at WMA 1 and WMA 2 using the STOMP computer code (Nichols, et al. 1997)[4]. This model is a revised version of the near-field model described in Appendix E to the Decommissioning EIS. Figure D-3 shows the boundaries of the north plateau near-field model.

Figure D-3. North Plateau Groundwater Flow Model Boundary

The north plateau model mimics the shape of the lateral extent of the sand and gravel unit. It is oriented from the southwest to the northeast and extends downward from the ground surface to the top of the Kent Recessional Sequence.

Hydrogeologic units represented in the model are the thick-bedded unit, the slack-water sequence and the unweathered Lavery till. Together, the thick-bedded unit and the slack-water sequence comprise the surficial sand and gravel unit. The thick-bedded unit comprises glaciofluvial gravel and alluvial deposits that range from one to six meters in thickness overlying the unweathered Lavery till. The slack-water sequence is a depositional sequence with layers of gravel, sand and silt filling a southwest-to-northeast trending channel in the upper portion of the unweathered Lavery till. The slack-water sequence varies in thickness from zero to five meters with the thickest portions beneath the Process Building. The unweathered Lavery till is a glacial till with a thickness range of 10 to 17 meters in the model volume.

[4] STOMP (Subsurface Transport Over Multiple Phases) solves the relevant conservation equations for the flow of both liquid and gas (air with water vapor) phases in a porous matrix confined in a cylindrical shape. This computer code was developed by DOE's Pacific Northwest National Laboratory.

The hydrogeologic units incorporated into the north plateau near-field flow model are represented in Figures D-4 through D–8. The slack-water sequence appears in the northeastern portion of the model as shown in Figures D-6 through D–8. The hydraulic conductivities of these units are assumed constant over the model domain with values of 2.5 E-03, 5.3 E-03, and 6.0 E-08 centimeters per second for the thick-bedded unit, slack-water sequence, and unweathered Lavery till, respectively. Two variants of the north plateau near-field model were developed to simulate current north plateau groundwater flow conditions and to evaluate north plateau groundwater flow conditions associated with the hydraulic barriers to be installed during Phase 1.

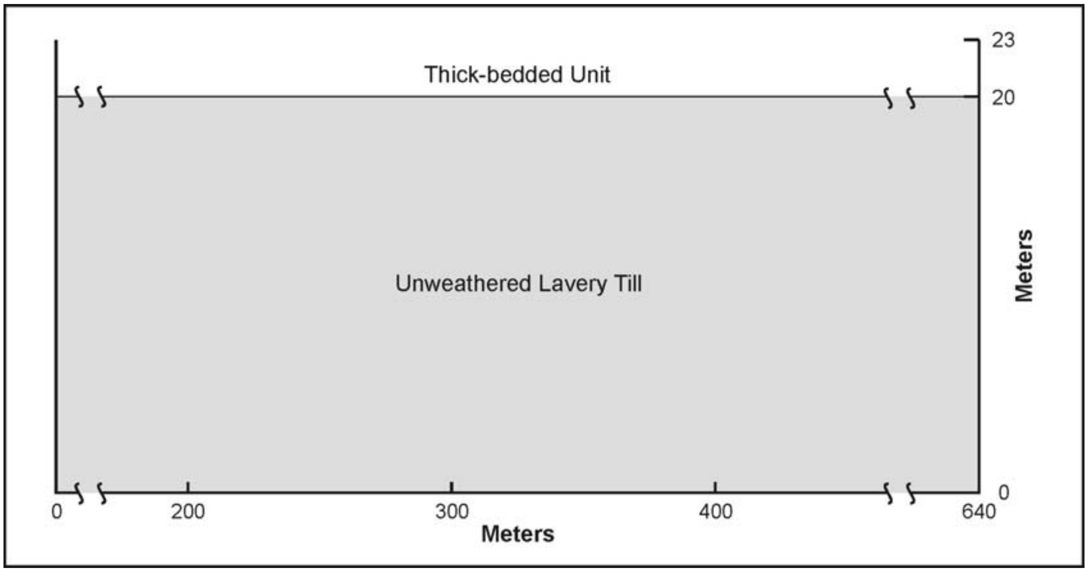


Figure D-4. Cross Section of North Plateau Near-Field Model – Southwest to Northeast Distance of 0 to 80 Meters

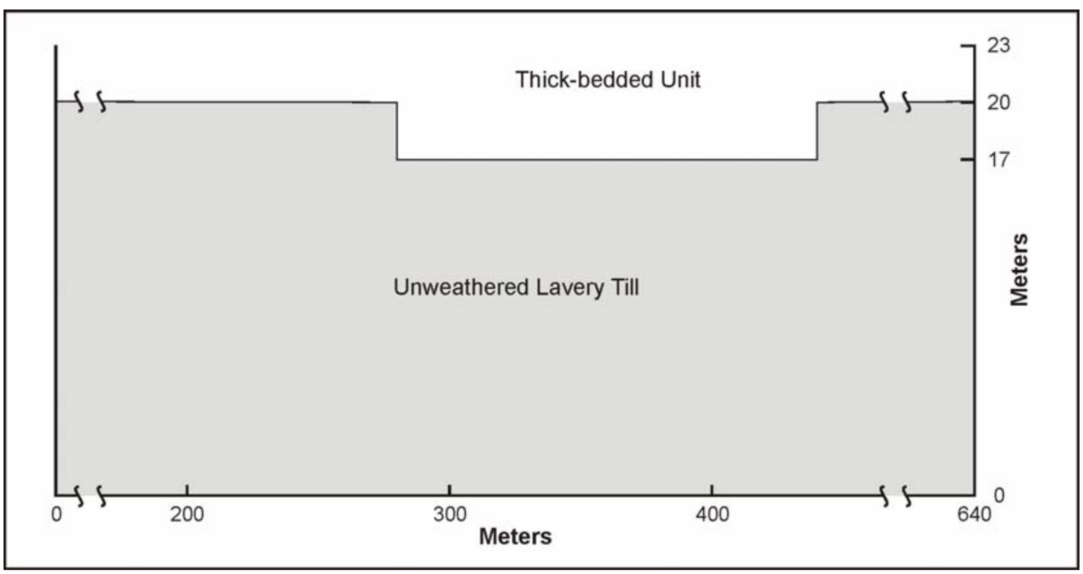


Figure D-5. Cross Section of North Plateau Near-Field Model – Southwest to Northeast Distance of 80 to 120 Meters

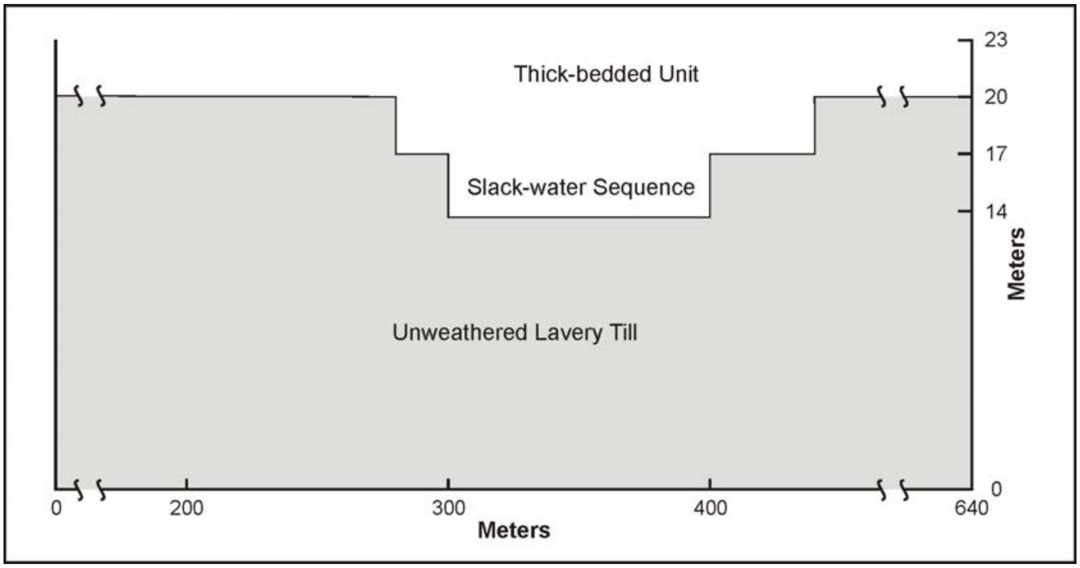


Figure D-6. Cross Section of North Plateau Near-Field Model – Southwest to Northeast Distance of 120 to 250 Meters

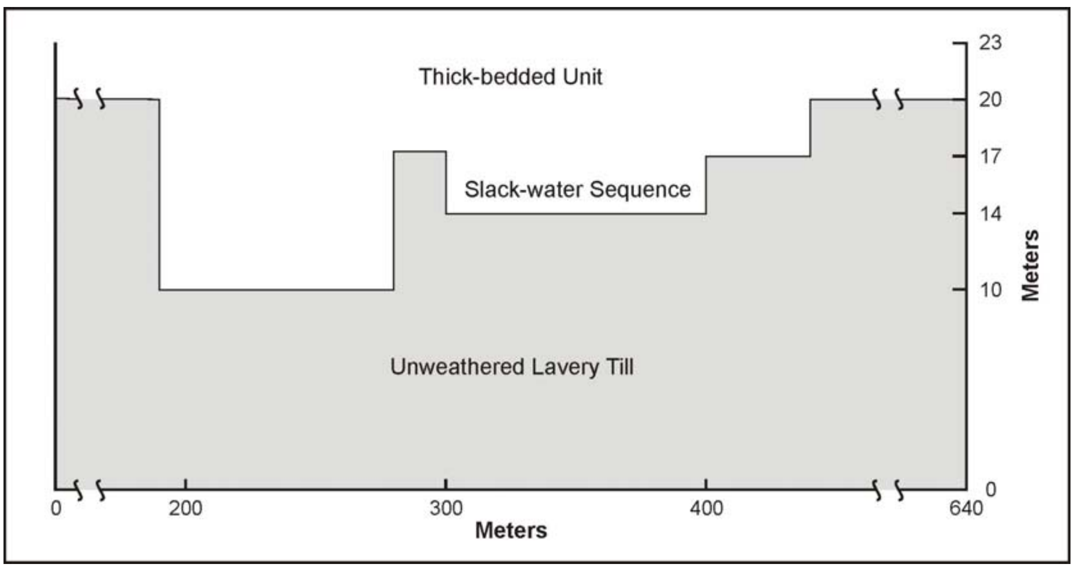


Figure D-7. Cross Section of North Plateau Near-Field Model – Southwest to Northeast Distance of 250 to 310 Meters

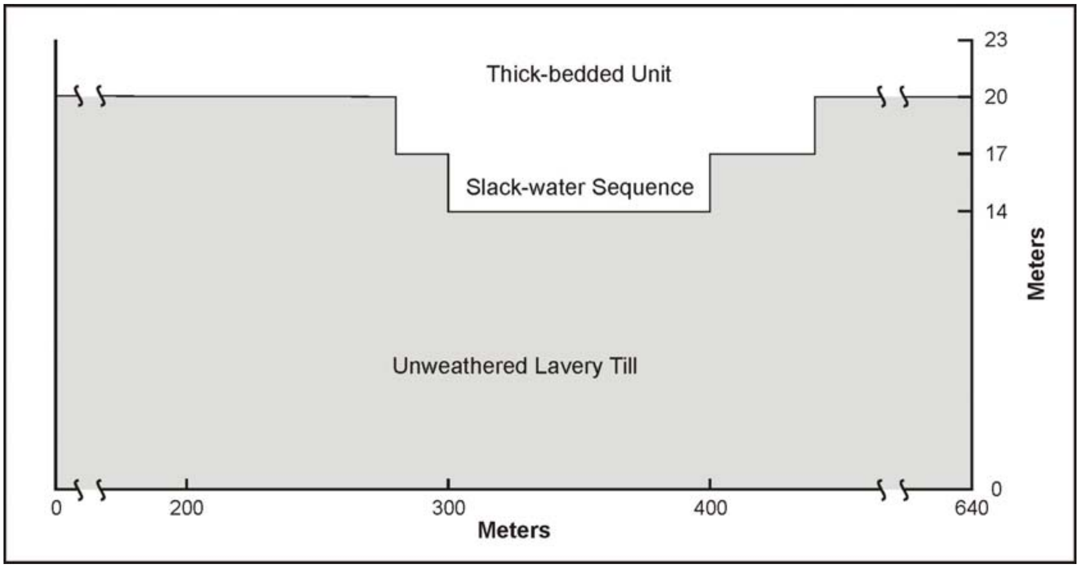


Figure D-8. Cross Section of North Plateau Near-Field Model – Southwest to Northeast Distance of 310 to 820 Meters

1.4.2 Modeling Current Conditions

To simulate current conditions, the horizontal portion of the near-field groundwater model grid comprised rectangular blocks with 81 blocks in the southwest-to-northwest direction and 64 blocks in the southwest-to-southeast direction. Grid blocks with horizontal dimension as large as 50 meters were used along the west and north boundaries while grid block horizontal dimensions range from 1 to 10 meters over most of the model domain. For the vertical direction, the upper three meters were represented using 15 0.2-meter-thick layers, the next three meters were represented using six 0.5-meter-thick layers, and the bottom 17 meters were represented using 17 1.0-meter-thick layers. With these dimensions, the model utilized approximately 174,000 grid blocks.

Boundary conditions applied for the near-field model are consistent with site observations and with those applied for the site-wide model. At the bottom of the unweathered Lavery till, atmospheric pressure was applied representing the presence of a water table in the Kent Recessional Sequence. On the sides of the model, no flow conditions were applied for the unweathered Lavery till. On the southwest side of the model, lateral recharge into the thick-bedded unit of 20 cubic meters per day was applied. On the northwest, southeast, and northeast sides of the model, atmospheric pressure conditions were applied for the thick-bedded unit and slack-water sequence to represent seepage to Quarry Creek, Erdman Brook, and Franks Creek, respectively.

Evaluation of simulated pressures and measured conditions in target groundwater wells showed that a uniform recharge of 26 centimeters per year produced the closest match to existing conditions. Table D-1 compares measured hydraulic heads in wells screened in the sand and gravel unit from the north plateau with predicted hydraulic heads generated by the near-field model for three different recharge rates. Figure D-9 shows the resulting plot of water table elevation in the thick bedded unit for a recharge of 26 centimeters per year. These water table elevations are consistent with the measured heads and the predictions of the site-wide groundwater model described in Appendix E to the Decommissioning EIS. Table D-2 shows the modeled flow balance.

Table D-1. North Plateau Near-field Flow Model Calibration for Head(1)

Groundwater Well	Measured Head (ft)	Predicted Head (ft) at Specified Recharge		
		18 cm/y	26 cm/y	34 cm/y
103	1391.4	1386.8	1391.6	1394.5
104	1385.5	1379.6	1383.1	1385.7
116	1380.5	1372.4	1376.8	1379.4
203	1394.4	1400.2	1401.6	1404.2
205	1393.1	1397.9	1399.2	1401.2
301	1410.7	1401.9	1406.8	1410.6
401	1410.3	1401.5	1406.4	1409.5
406/86-08	1393.5	1394.1	1397.4	1400.0
601	1377.3	1376.9	1378.9	1380.9
603	1391.9	1395.0	1397.0	1399.6
604	1391.6	1389.7	1391.9	1394.6
86-09	1391.8	1391.6	1396.5	1399.8
86-12	1364.8	1343.6	1345.2	1346.8
408	1391.8	1391.0	1394.8	1398.4
501	1391.3	1386.8	1391.5	1394.5
403	1408.0	1401.1	1405.8	1409.1
801	1376.6	1369.3	1373.1	1375.7
804	1369.9	1356.0	1359.2	1360.4
Sum of Squared Residuals (ft^2)(2)		1111.4	730.1	831.4

NOTES: (1) This specified recharge is the net inflow at the ground surface that results from the balance of precipitation, evapotranspiration, and run-off.
(2) Sum of squared residuals = $(\text{Measured Head} - \text{Predicted Head})^2$ for each location, then summed.

Table D-2. Summary of Sand and Gravel Unit Flow Balance(1)

Inflow		Outflow	
Location	Rate (m^3/y)	Location	Rate (m^3/y)
Recharge at the Ground Surface	107,624	Down Flow to the KRS	9,060
Recharge from Bedrock from the	7,304	Seepage to Quarry Creek	8,456
		Seepage to Erdman Brook	15,238

Table D-2. Summary of Sand and Gravel Unit Flow Balance[1]

Inflow		Outflow	
Location	**Rate (m^3/y)**	**Location**	**Rate (m^3/y)**
Southwest		Seepage to Frank's Creek	66,713
		Seepage to North Plateau Ditch	15,445
Totals	114,928		114,912

NOTE: (1) For a recharge rate of 26 centimeters per year
LEGEND: KRS = Kent Recessional Sequence

The relationship between rate of flow in the slack-water sequence and the thick-bedded unit above the slack-water sequence was investigated through tabulation of groundwater velocities along a flow path extending from the location of the Process Building to the north plateau ditch. Average linear velocities predicted by the near-field model for this path are presented in Table D-3. An effective porosity value of 0.225 was used for the thick-bedded unit and an effective porosity value of 0.35 for the slack-water sequence. For the slack-water sequence and thick-bedded unit above the slack-water sequence, the travel time and average velocity along the flow path are 1.90 years and 161 meters per year and 2.0 years and 157 meters per year, respectively.

Table D-3. Average Linear Velocity for Flow Path Originating at the Process Building

Distance Along Flow Path (m)	Average Linear Velocity (m/y)	
	Slack-water Sequence	**Thick-bedded Unit**
0 to 10	114	105
10 to 63	130	132
63 to 110	143	147
110 to 160	156	161
160 to 210	171	174
210 to 260	192	180
260 to 310	220	176

NOTE: To convert meters per year to feet per year, multiply by 3.2803.

1.4.3 Modeling Conditions Following Phase 1 of the Decommissioning

The near-field groundwater flow model developed to assess current groundwater flow conditions was used to evaluate groundwater flow following the installation of the Phase 1 hydraulic barriers and WMA 1 French drain. The WMA 1 and WMA 2 slurry walls are modeled as one-meter thick extending downward to the unweathered Lavery till with a hydraulic conductivity of 1.0 E-06 cm/s. The WMA 1 hydraulic barrier wall downgradient of the Process Building is oriented parallel to the groundwater elevation contours and perpendicular to groundwater flow as shown in Figure D-9. The segment of barrier wall between the Process Building and the Waste Tank Farm has been modeled parallel to groundwater flow due to the model constraints. The French drain for WMA 1 was modeled as one-meter thick with a depth of three meters and a hydraulic conductivity of 10 cm/s.

The cross-sectional structure of the aquifer is that represented in Figures D-4, D-5, D-6, D-7, and D-8 with the same vertical discretization as the current conditions case.

Figure D-9 shows the distribution of hydraulic heads predicted following completion of Phase 1 of the decommissioning. The results indicate an overall increase in water table elevation of several feet across the large backfilled WMA 1 and WMA 2 excavations formerly occupied by the Process Building and the lagoons, respectively.

The higher groundwater elevations in the backfilled WMA 1 excavation suggest that groundwater would flow through the WMA 1 slurry wall to the northeast, towards the non-source area of the north plateau groundwater plume. However, a significant volume of this flow would be diverted by the French drain and discharged to Erdman Brook (Table D-4). Groundwater elevations coincide on either side of the slurry wall separating the backfilled WMA 1 excavation from the Waste Tank Farm, suggesting little potential for groundwater flow from the backfilled WMA 1 excavation toward the Waste Tank Farm.

Groundwater elevations coincide with the bottom of the French drain near the WMA 1 barrier wall. Groundwater elevations on the downgradient side of the WMA 1 barrier wall are approximately 10 feet lower than on the upgradient side, resulting in a steep hydraulic gradient across the barrier wall and a shallower gradient along the non-source area of the north plateau groundwater plume.

Groundwater levels in the backfilled WMA 2 excavation are several feet higher than modeled in the current conditions scenario and would be below grade across the backfilled WMA 2 excavation. Groundwater elevations are up to 10 feet lower on the north plateau plume side of the WMA 2 barrier wall, suggesting groundwater flow to the northwest and northeast through the WMA 2 slurry wall towards the non-source area of the north plateau groundwater plume and to the southeast towards Erdman Brook.

Table D-4 summarizes the modeled flow balance. Table D-5 shows the average linear velocities predicted by the near-field model for conditions after Phase 1.

Table D-4. Summary of Sand and Gravel Unit Flow Balance After Phase 1(1)

Inflow		Outflow	
Location	**Rate (m^3/y)**	**Location**	**Rate (m^3/y)**
Recharge at the Ground Surface	107,624	Down Flow to the KRS	8,909
Recharge from Bedrock from the Southwest	7,304	Seepage to Quarry Creek	8,780
		Seepage to Erdman Brook (TBU)	14,915
		French Drain to Erdman Brook	21,698
		Seepage to Frank's Creek	46,791
		Seepage to North Plateau Ditch	13,783
Total	114,928		114,876

NOTE: (1) For a recharge rate of 26 centimeters per year.

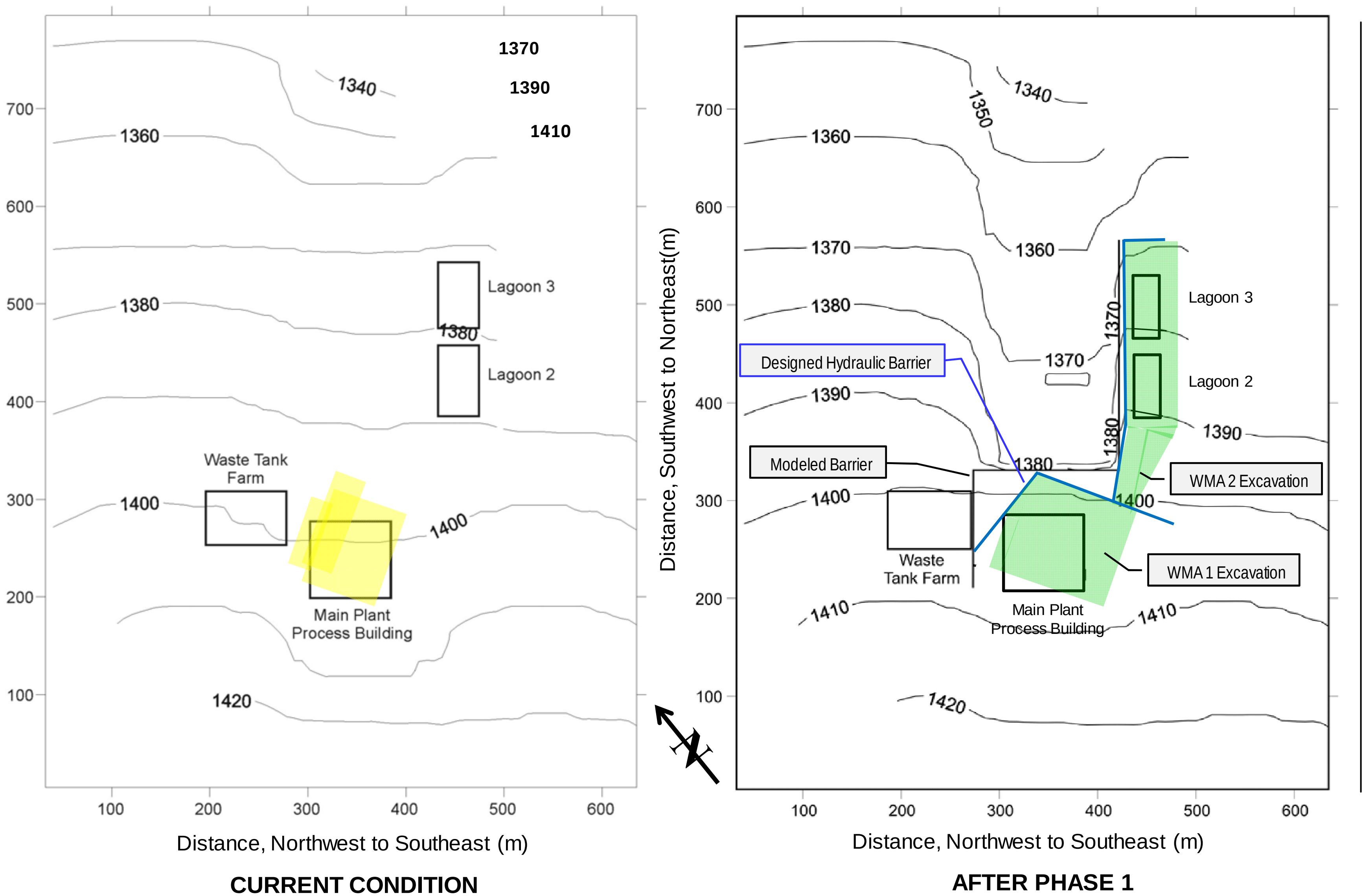


Figure D-9. Groundwater Flow Associated with the WMA 1 and WMA 2 Engineered Barriers

Table D-5. Average Linear Velocity for Flow Path Originating at the Process Building Area After Phase 1

Distance Along Flow Path (m)	Average Linear Velocity (m/y)	
	Slack-water Sequence	Thick-bedded Unit
0 to 40	81.0	81.2
40 to 80	79.2	82.2
80 to 120	22.5	1.9
120 to 160	61.2	1.8
160 to 200	104.3	1.9
200 to 240	95.6	6.0
240 to 280	112.6	84.7
280 to 320	131.3	111.5

NOTE: To convert meters per year to feet per year, multiply by 3.2803.

In calculation of linear velocities shown in Table D-5, the value of effective porosity of 0.35 was used for the slack-water sequence while the moisture content of the thick-bedded unit was used to reflect unsaturated conditions that develop along the flow path north of the location of the slurry wall. For the slack-water sequence and thick-bedded unit above the slack-water sequence, the travel time and average velocity along the flow path are 6.37 years and 50 meters per year and 70 years and 4.6 meters per year, respectively.

1.4.4 Groundwater Modeling Predictions for Conditions Following Phase 1

The revised near-field groundwater model for the north plateau suggests that the engineered barriers to be installed during Phase 1 decommissioning would have the following effect on groundwater flow in the north plateau:

- Groundwater flow patterns upgradient of the WMA 1 barrier wall and French drain would be similar to current flow patterns in the sand and gravel unit shown in Figure D-9.
- Water table elevations in WMA 1 would be approximately 10 feet higher on the upgradient side of the northeastern segment of the WMA 1 barrier wall compared to water levels immediately downgradient of this wall segment.
- This steep hydraulic gradient suggests that groundwater would preferentially flow from the backfilled WMA 1 excavation to the northeast across the barrier wall into the non-source area of the north plateau plume, rather than from the non-source area of the plume into the backfilled WMA 1 excavation.
- Groundwater elevations coincide on either side of the northwestern segment of the WMA 1 barrier wall separating the backfilled WMA 1 excavation from the Waste Tank Farm, suggesting low potential for groundwater flow across the barrier wall from either the backfilled excavation or Waste Tank Farm.

- Flow contours southeast of the WMA 1 barrier wall suggest that groundwater would flow to the east into the area of the backfilled WMA 2 excavation, as discussed in Section 1.4.3 of this appendix.
- Downgradient of the WMA 1 barrier wall groundwater flow in the sand and gravel unit would continue to the northeast across the north plateau. However, the upgradient diversion of groundwater flow by the barrier wall system would result in an overall reduction in the hydraulic gradient of the non-source area of the north plateau groundwater plume.
- Groundwater elevations in the backfilled WMA 2 excavation are expected to be up to 10 feet higher than present in the non-source area of the north plateau groundwater plume.
- Higher groundwater elevations within the backfilled WMA 2 excavation suggests groundwater would flow across the WMA 2 barrier wall to the northwest and northeast toward the non-source area of the north plateau groundwater plume and also to the southeast toward Erdman Brook.

2.0 Conceptual Post-Remediation Site Monitoring and Maintenance

DOE will be responsible for maintaining institutional controls and for monitoring and maintenance of the project premises until the completion of Phase 2 of the WVDP decommissioning.

This section describes the post-remediation site monitoring and maintenance program to be implemented by the DOE at the project premises following the completion of Phase 1 decommissioning. The Phase 1 program will include monitoring and maintenance associated with engineered barriers installed within the project premises and monitoring of environmental media within and outside the project premises. This monitoring and maintenance program will continue until the start of Phase 2 of the decommissioning, when the program requirements will be re-evaluated. DOE concludes that this program will be adequate to control and maintain the project premises because it is similar to the successful program currently in use and because it appropriately addresses all facilities of importance.

2.1 Monitoring and Maintenance of Engineered Barriers and Systems

The performance of the engineered barriers installed at WMA 1 and WMA 2 during Phase 1 decommissioning will be routinely monitored up to the start of Phase 2 of the decommissioning to ensure they function as designed. Systems and engineered barriers installed during work leading to the interim end state, such the Tank and Vault Drying System at WMA 3 and the geomembrane cover and slurry wall at WMA 7, will also be routinely monitored and maintained as part of the DOE monitoring and maintenance program. Corrective actions will be implemented to correct any observed defects or irregularities with these engineered barrier and systems.

2.1.1 North Plateau Subsurface Barrier Walls and French Drain

The monitoring and maintenance program will monitor the performance and condition of the subsurface hydraulic barriers installed at WMA 1 and WMA 2, and the French drain at WMA 1. This program will include routine inspections of these systems for signs of degradation or loss of performance.

Hydraulic Barrier Walls

A series of nested piezometers screened at different depth intervals will be installed at regular intervals upgradient and downgradient of the permanent hydraulic barrier walls installed downgradient of the WMA 1 and northwest of the WMA 2 excavations (Figure D-10) to monitor their performance. These piezometers will be spaced at intervals at least equal to the maximum lateral spacing recommended by the U.S. Environmental Protection Agency (EPA 1998). Water levels in these piezometers will be routinely monitored to identify any changes in water levels that may indicate the development of defects within the barrier walls that require corrective action. Groundwater will be routinely sampled and analyzed for radiological indicator parameters (gross alpha, gross beta, tritium) and for Sr-90 to evaluate the effectiveness of the barrier walls in preventing recontamination of WMA 1 and WMA 2. Changes in groundwater concentrations of these radiological indicator parameters may identify defects associated with the barrier walls that require corrective action to limit the potential recontamination of the backfilled WMA 1 and WMA 2 excavations.

If groundwater monitoring suggests repairs to the walls are required, these repairs will be accomplished through grouting, consistent with past industry experience and practice (e.g., EPA 1998).

French Drain

Monitoring and maintenance activities associated with the French drain installed upgradient of the WMA 1 hydraulic barrier wall will include monitoring of groundwater levels in piezometers installed on the upgradient and downgradient sides of the French drain following installation.

The need for and extent of repairs to the French drain, if any, will be determined based on analysis of the groundwater level data, which will be evaluated to identify evidence for any localized defect(s) in the French drain.

2.1.2 Waste Tank Farm Tank and Vault Drying System

The Tank and Vault Drying System installed in WMA 3 during the work to establish the interim end state will be routinely monitored and maintained during the Phase 1 period to ensure its continued operation as designed. The major components of the system – such as the blowers, heaters, and dehumidifier units – will be inspected and repaired or replaced as necessary to ensure continued operation of the system.

2.1.3 Waste Tank Farm Dewatering Well

As specified in Section 7 of this plan, the existing dewatering well will continue to be used to artificially lower the water table to minimize in-leakage of groundwater into the tank vaults. The water from this well will be collected, sampled, treated if necessary using a portable wastewater treatment system, and released to Erdman Brook through a State Pollutant Discharge Elimination System-permitted outfall.

2.1.4 NRC-licensed Disposal Area Engineered Barriers

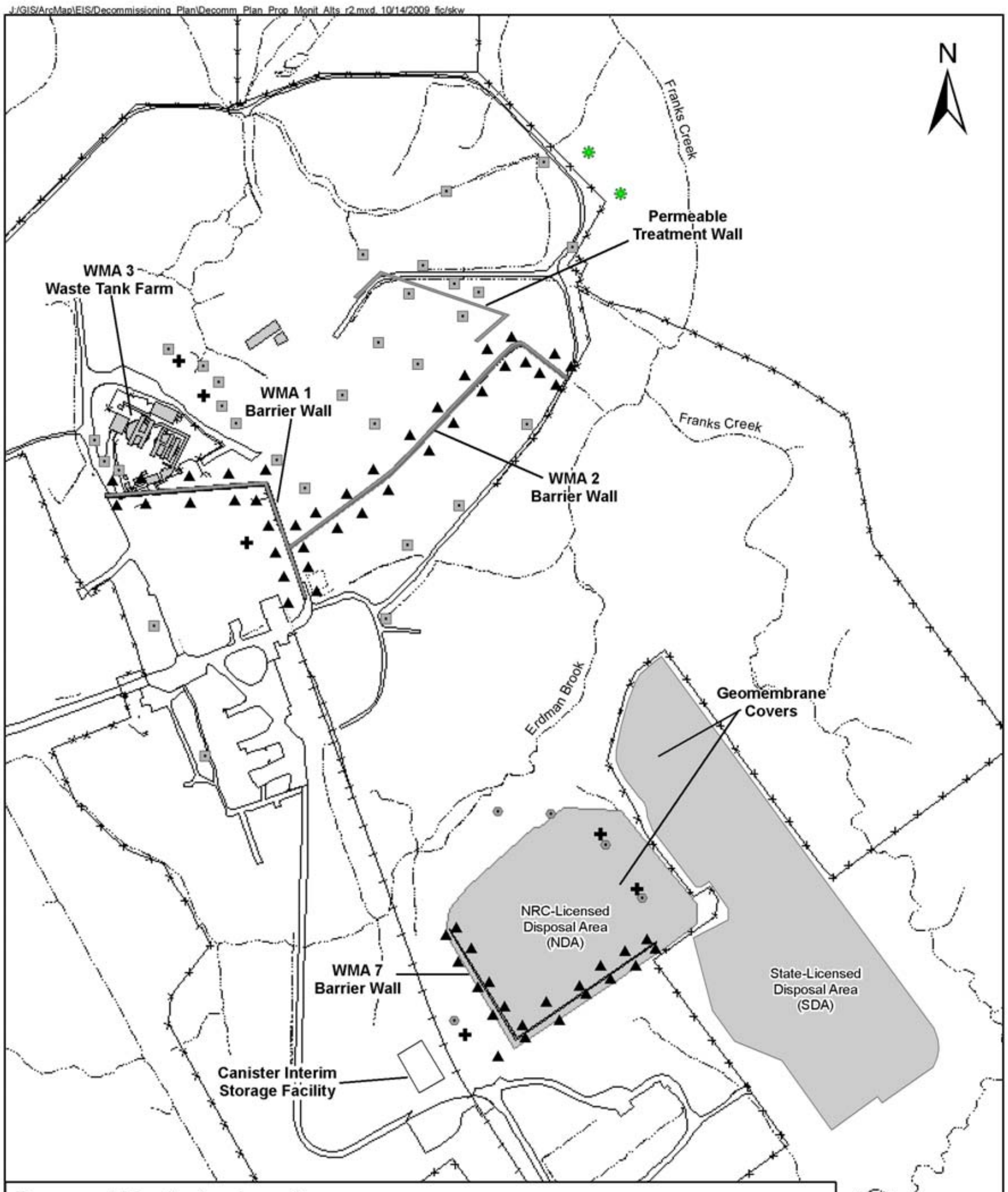
The geomembrane cover and the hydraulic barrier wall installed at the NDA during work to establish the interim end state will be routinely monitored and maintained throughout Phase 1.

Geomembrane Cover

The geomembrane cover will be routinely inspected for signs of deterioration or damage to the membrane. The seams connecting the geomembrane panels will be inspected to evaluate their condition. The geomembrane cover will be repaired to remedy any defects or irregularities identified during these inspections.

Hydraulic Barrier Wall

A monitoring and maintenance program similar to that described for the barrier walls installed at WMA 1 and WMA 2 will be implemented for the hydraulic barrier wall installed upgradient of the NDA. Twenty-one piezometers were installed upgradient and downgradient of the barrier wall during its construction. Water levels in these piezometers will be routinely monitored during Phase 1 to evaluate the performance of the barrier wall in limiting groundwater flow into the NDA.



Proposed Monitoring Locations

	North Plateau Total	South Plateau Total
Seepage Monitoring Location	2	0
Hydraulic Monitoring Piezometer	38	21
Kent Recessional Unit Groundwater Monitoring Well	3	3
Sand & Gravel Unit Groundwater Monitoring Well	29	0
Weathered Till Unit Groundwater Monitoring Well	0	5

Figure D-10. Groundwater Monitoring Locations within the Project Premises during the Phase 1 Institutional Control Period

2.1.5 Security Features

The features important to security on the project premises and to security of the new Canister Interim Storage Facility during the period before Phase 2 of the decommissioning will be periodically inspected and maintained in good repair. These features include the security fences, signs, and security lighting described in Section 3.2 of this appendix.

2.2 Environmental Monitoring

The Phase 1 decommissioning activities will include the removal of the following facilities:

- Above-ground and below-grade facilities in WMA 1 and the underlying source area of the north plateau groundwater plume within a single excavation down into the underlying Lavery till;
- Lagoons 1, 2, and 3, the Neutralization Pit, Interceptors, Solvent Dike, and surrounding contaminated soils in WMA 2 within a single excavation down into the underlying Lavery till; and
- Most remaining facilities and concrete slabs down to a maximum depth of two feet.

The following facilities and contamination areas within the project premises will not be considered during Phase 1 decommissioning but will be addressed during Phase 2:

- The Waste Tank Farm in WMA 3, including the Permanent Ventilation System Building and the Supernatant Treatment System Support Building;
- The Construction Demolition Debris Landfill in WMA 4;
- The NDA in WMA 7; and
- The non-source area of the north plateau groundwater plume.

The DOE will implement an environmental monitoring program to monitor closed and remaining facilities and the non-source area of the north plateau groundwater plume as part of its management of the project premises during the Phase 1 institutional control period. Environmental monitoring will include onsite groundwater, storm water, and air monitoring, and onsite and offsite surface water, sediment, and radiation monitoring as described below. Annual reports will be issued summarizing the monitoring results. These reports will include analyses of the data collected, along with conclusions about trends and compliance with regulatory limits.

2.2.1 Groundwater Monitoring Within the Project Premises

Groundwater within the project premises will be monitored during the Phase 1 institutional control period in accordance with the DOE WVDP Groundwater Monitoring Plan in effect at the time. Offsite groundwater monitoring will not be performed as this monitoring program was discontinued in 2007. The onsite grounding monitoring program for the project premises is described below and shown on Figure D-10. A total of 40 groundwater wells will be routinely monitored along with 59 piezometers.

WMA 1 - Process Building and Vitrification Facility Area

Groundwater in the sand and gravel unit in the backfilled WMA 1 excavation will be monitored using the network of piezometers installed to monitor the effectiveness of the hydraulic barrier wall and French drain described in Section 2.1.1 of this Appendix. A monitoring well screened in the sand and gravel unit will also be installed in the upgradient portion of the WMA 1 excavation to provide information on groundwater quality flowing into the backfilled excavation.

An additional monitoring well screened in the Kent Recessional Sequence will be installed immediately upgradient of the WMA 1 hydraulic barrier wall to monitor groundwater in this unit and to evaluate potential migration of groundwater from the source area of the north plateau groundwater plume that was removed during Phase 1 decommissioning.

Groundwater from these piezometers and monitoring wells will be sampled semiannually for radiological indicator parameters (gross alpha, gross beta, and tritium) and for Sr-90 during the Phase 1 institutional control period.

WMA 2 - Low-Level Waste Treatment Facility Area

Groundwater in the sand and gravel unit in the backfilled WMA 2 excavation will be monitored using the network of piezometers installed to monitor the effectiveness of the hydraulic barrier wall and French drain described in Section 2.1.1 of this Appendix. Three monitoring wells screened in the sand and gravel unit will also be installed on the southeastern boundary of the WMA 2 excavation to provide information on groundwater flow and quality in this area.

Groundwater from these piezometers and monitoring wells will be sampled semiannually for radiological indicator parameters (gross alpha, gross beta, and tritium) and for Sr-90 during the Phase 1 institutional control period.

WMA 3 - Waste Tank Farm Area

Groundwater in the sand and gravel unit and the Kent Recessional Sequence will be routinely monitored at WMA 3 during the Phase 1 institutional control period. Eight wells will be screened in the sand and gravel unit with three wells upgradient and five wells downgradient of the Waste Tank Farm. Two wells screened in the Kent Recessional Sequence will be installed downgradient of the Waste Tank Farm.

Groundwater from these wells will be sampled semiannually for radiological indicator parameters (gross alpha, gross beta, and tritium) and for Sr-90 during the Phase 1 institutional control period.

WMA 4 - Construction Demolition Debris Landfill Area

Groundwater in the sand and gravel unit at WMA 4 will be routinely monitored at six locations, including four monitoring wells around the Construction and Demolition Debris Landfill, and at two groundwater seep locations along the edge of the north plateau outside of the WVDP fence line.

Groundwater at WMA 4 will be sampled semiannually for radiological indicator parameters (gross alpha, gross beta, and tritium) and for Sr-90.

WMA 6 - Central Project Premises

Groundwater in the sand and gravel unit at WMA 6 will be routinely monitored at two well locations, including one well upgradient of the rail spur and the other well downgradient of the rail spur and the removed Demineralizer Sludge Ponds and Equalization Basin.

Groundwater at these locations will be sampled semiannually for radiological indicator parameters (gross alpha, gross beta, and tritium).

WMA 7 – NDA

Groundwater in the weathered Lavery till and Kent recessional unit at WMA 7 will be routinely monitored by five wells screened in the weathered Lavery till and three wells screened in the Kent Recessional Sequence. One well cluster will be located upgradient of the NDA and will include a well screened in the weathered Lavery till and one screened in the Kent Recessional Sequence. Two well clusters, each with a well screened in the weathered Lavery till and Kent Recessional Sequence, will be located downgradient of the burial area. The two remaining wells screened in the weathered Lavery till will be located downgradient of the burial area.

Groundwater at WMA 7 will be sampled semiannually for radiological indicator parameters (gross alpha, gross beta, and tritium) and annually for specific radionuclides (Cs-137, Sr-90, Am-241, and Pu isotopes).

Non-Source Area of the North Plateau Plume

Groundwater in the sand and gravel unit will be routinely monitored at 11 well locations within the non-source area of the north plateau groundwater plume. These wells are located along the length of the plume from the WMA 1 barrier wall to the Construction and Demolition Debris Landfill in WMA 4. Three wells are located downgradient of the Permeable Treatment Wall to evaluate its effectiveness in reducing Sr-90 concentrations in groundwater from the sand and gravel unit.

Groundwater in the non-source area of the north plateau groundwater plume will be sampled semiannually for radiological indicator parameters (gross alpha, gross beta, and tritium) and for Sr-90.

2.2.2 Surface Water, Sediment, and Storm Water Monitoring

Surface water and associated stream sediments will be routinely monitored both within and outside the project premises during the Phase 1 institutional control period. The monitoring locations are currently part of the DOE WVDP annual environmental monitoring program. These locations have been uniquely sited to monitor surface water releases from the WVDP and the Center. Several of the locations have been actively monitored since the implementation of the program in 1982 providing a significant historical record of surface waters leaving the WVDP and the Center.

Eight surface water-sampling locations within the project premises will be routinely monitored during the Phase 1 institutional control period (Figure D-11). These locations monitor streams both within (WNDNKEL, WNSP005, WNNDADR, WNFRC67, WNERB53) and leaving the project premises (WNSW74A, WNSWAMP, and WNSP006). Sediment samples will be collected from three locations where surface waters leave the project premises (SNSW74A, SNSWAMP, and SNSP006).

Surface water will be routinely collected and analyzed from three sampling locations outside of the project premises (Figure D-12). These locations will monitor surface water quality in Buttermilk Creek and Cattaraugus Creek where these streams leave the Center (WFFELBR, WFBCTCB) and where Buttermilk Creek enters the Center (WFBCBKG). Sediment samples will be collected from all three off-site locations (SFBCSED, SFTCSED, SFCCSED).

Surface water and sediment samples will be collected from these locations semi-annually and will be analyzed for radiological indicator parameters (gross alpha, gross beta, and tritium).

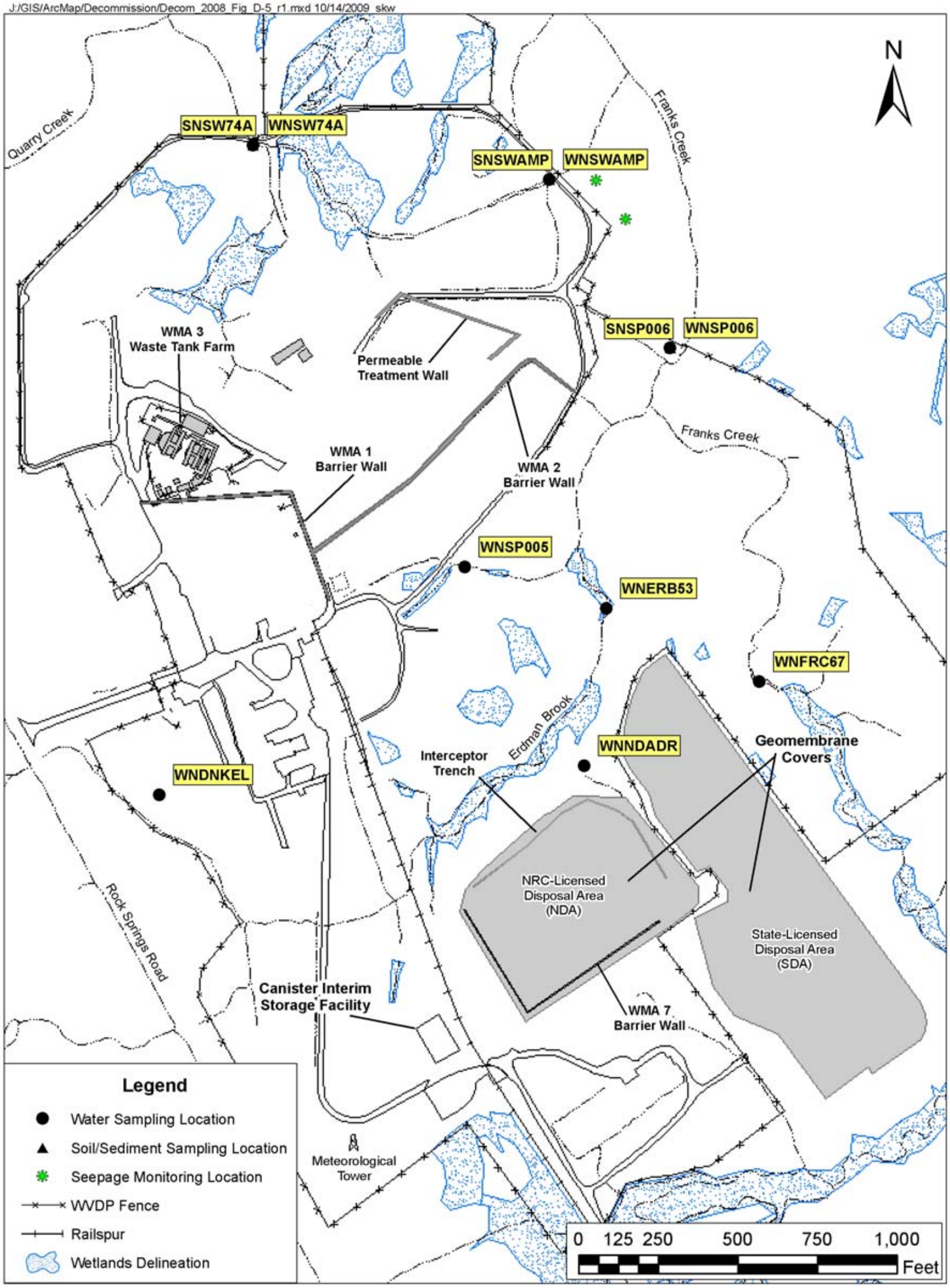


Figure D-11. Surface Water and Sediment Sampling Locations on the Project Premises during the Phase 1 Institutional Control Period

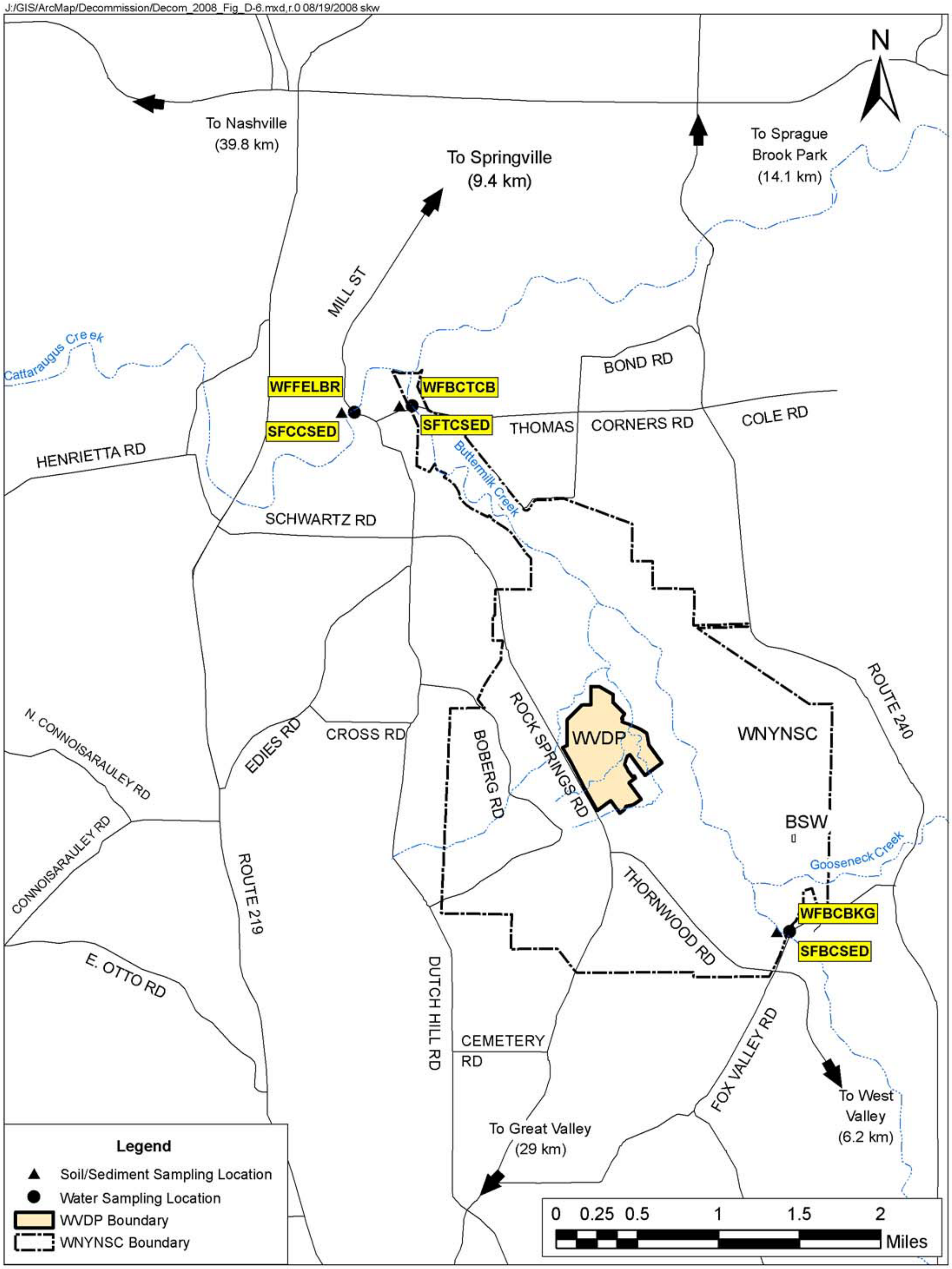


Figure D-12 – Offsite Surface Water and Sediment Sampling Locations during the Phase 1 Institutional Control Period

The New York State Pollutant Discharge Elimination System permit issued to the DOE WVDP requires periodic sampling from storm water outfalls located within the project premises. Sampling from these outfalls during storm events is designed to assess specific chemicals in storm water discharges that may originate from industrial or construction activity runoff from locations within the project premises. The planned storm water sampling locations are identified on Figure D-13. Sampling will be performed semi-annually for the non-radiological parameters specified in the New York State Pollutant Discharge Elimination System permit.

2.2.3 Air Monitoring

The stack discharge from the Permanent Ventilation System Building in the Waste Tank Farm in WMA 3 will be the only air monitoring location to be routinely monitored within and outside of the project premises during the Phase 1 institutional control period (Figure D-14).

The Permanent Ventilation System ventilates the Supernatant Treatment System Valve Aisle and Tanks 8D-1, 8D-2, 8D-3, and 8D-4 in WMA 3. The air discharged from these facilities passes though high-efficiency particulate air filters before discharge through the Permanent Ventilation System Building stack. Air discharged from the Tank and Vault Drying System will also be treated in the Permanent Ventilation System Building.

Air discharges from this location will be analyzed for radiological indicator parameters (gross alpha, gross beta, and tritium) and specific radionuclides (Cs-137, Sr-90, I-129, Am-241, and U and Pu isotopes).

2.2.4 Direct Radiation Monitoring

Direct radiation monitoring using thermoluminescent dosimeters will be performed at 19 locations within and outside of the project premises. These monitoring locations are currently part of the DOE WVDP annual environmental monitoring program and were sited to monitor both on-site and off-site radiation exposure from facilities within the project premises and the State-Licensed Disposal Area. Several of these locations have been actively monitored since 1982.

Eight monitoring locations will be within the project premises (Figure D-15) and eleven stations will be located on the perimeter of the Center (Figure D-16). All locations will be routinely monitored for gamma radiation exposure on a quarterly monitoring schedule.

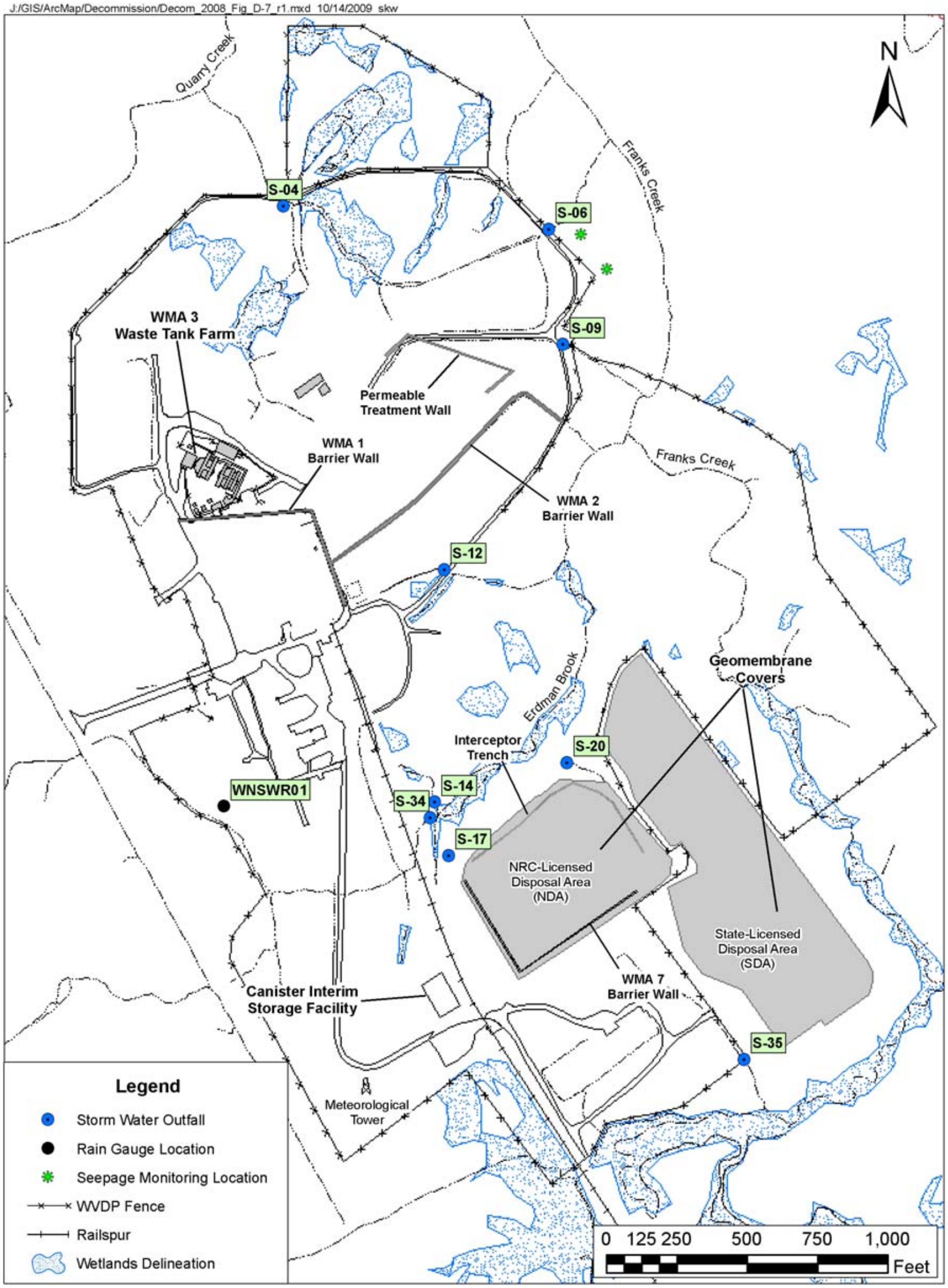


Figure D-13. Storm Water Sampling Locations on the Project Premises during the Phase 1 Institutional Control Period

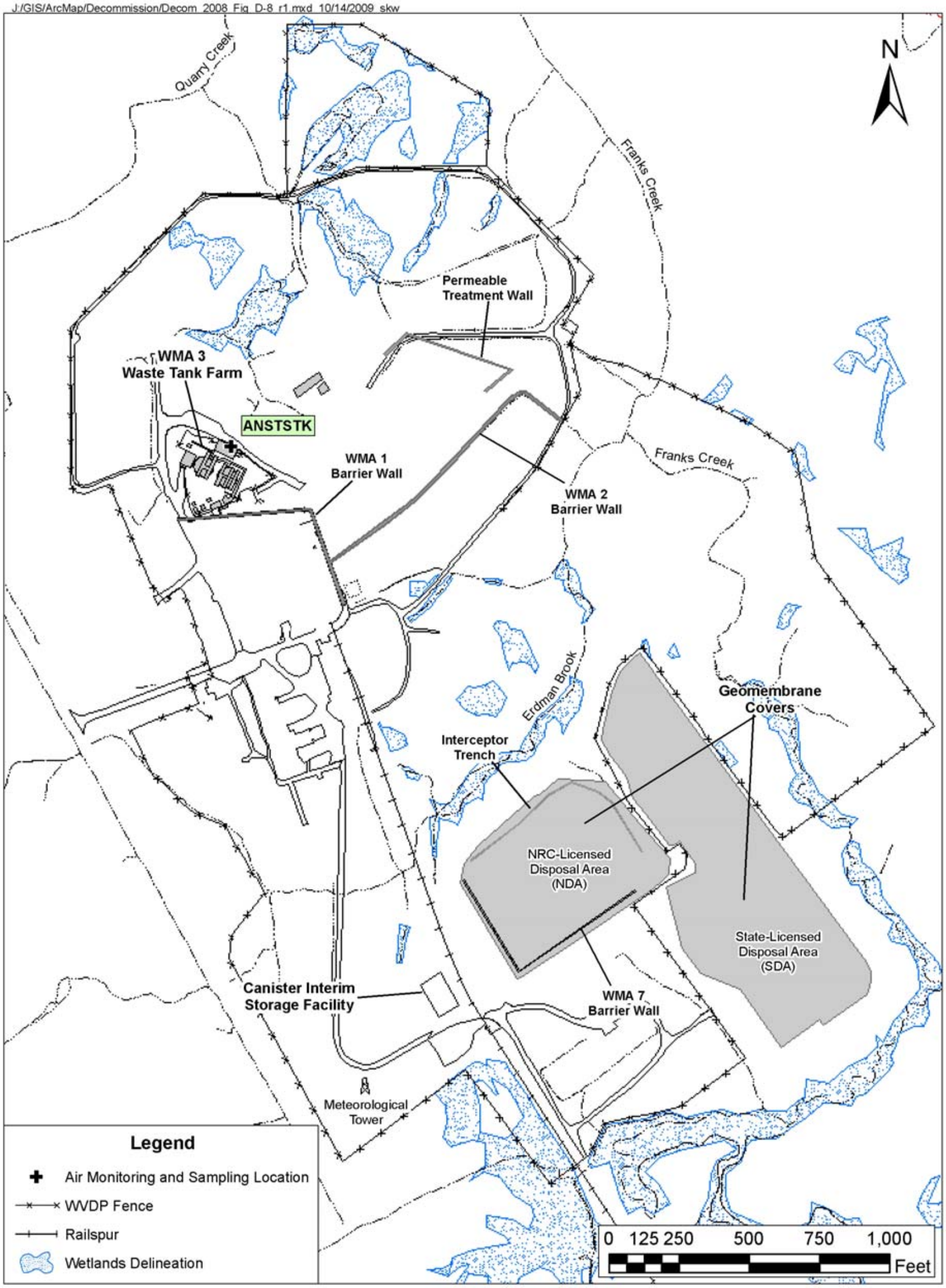


Figure D-14. Air Monitoring Locations on the Project Premises during the Phase 1 Institutional Control Period

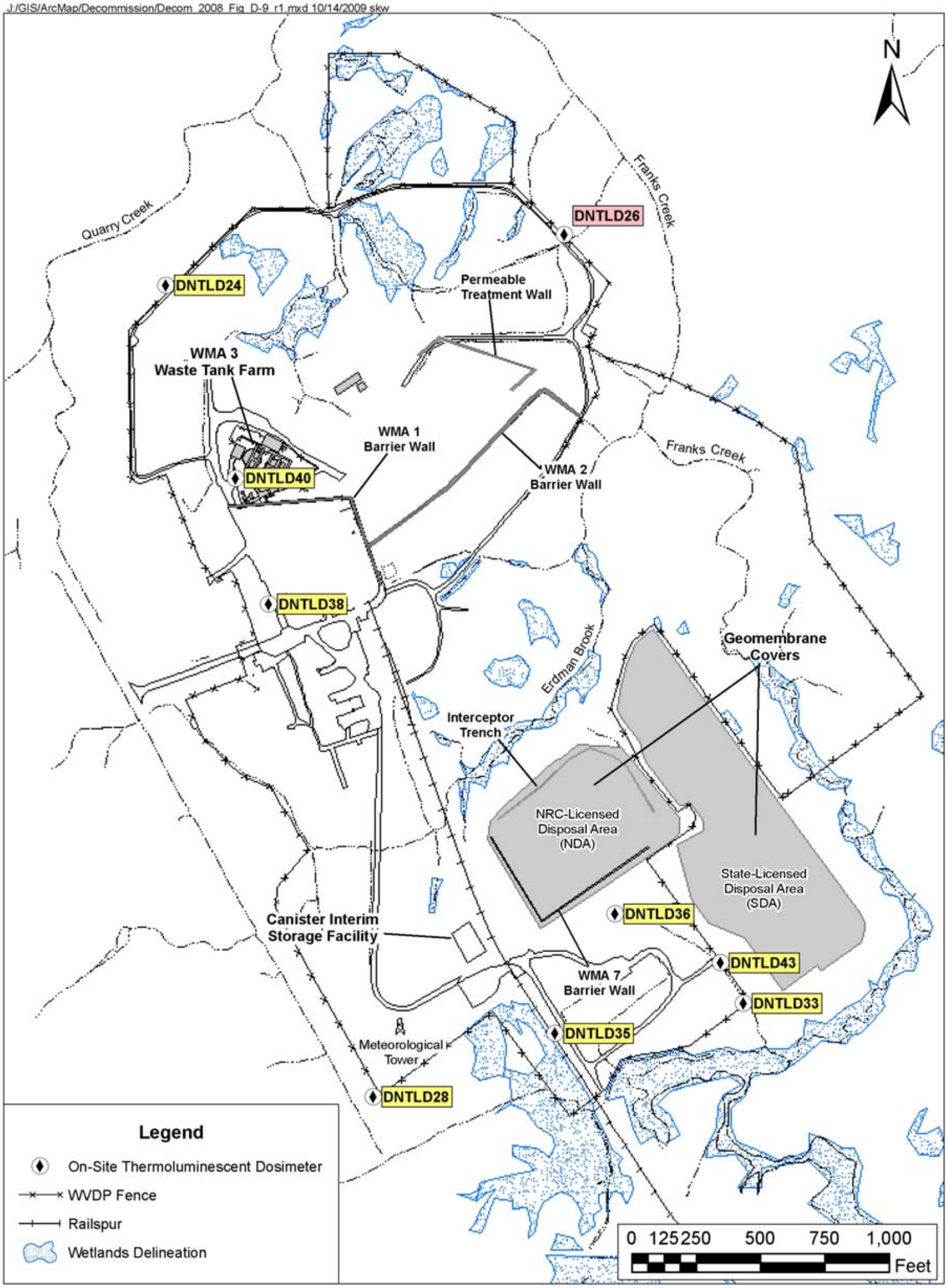


Figure D-15 – Direct Radiation Monitoring Locations on the Project Premises during the Phase 1 Institutional Control Period

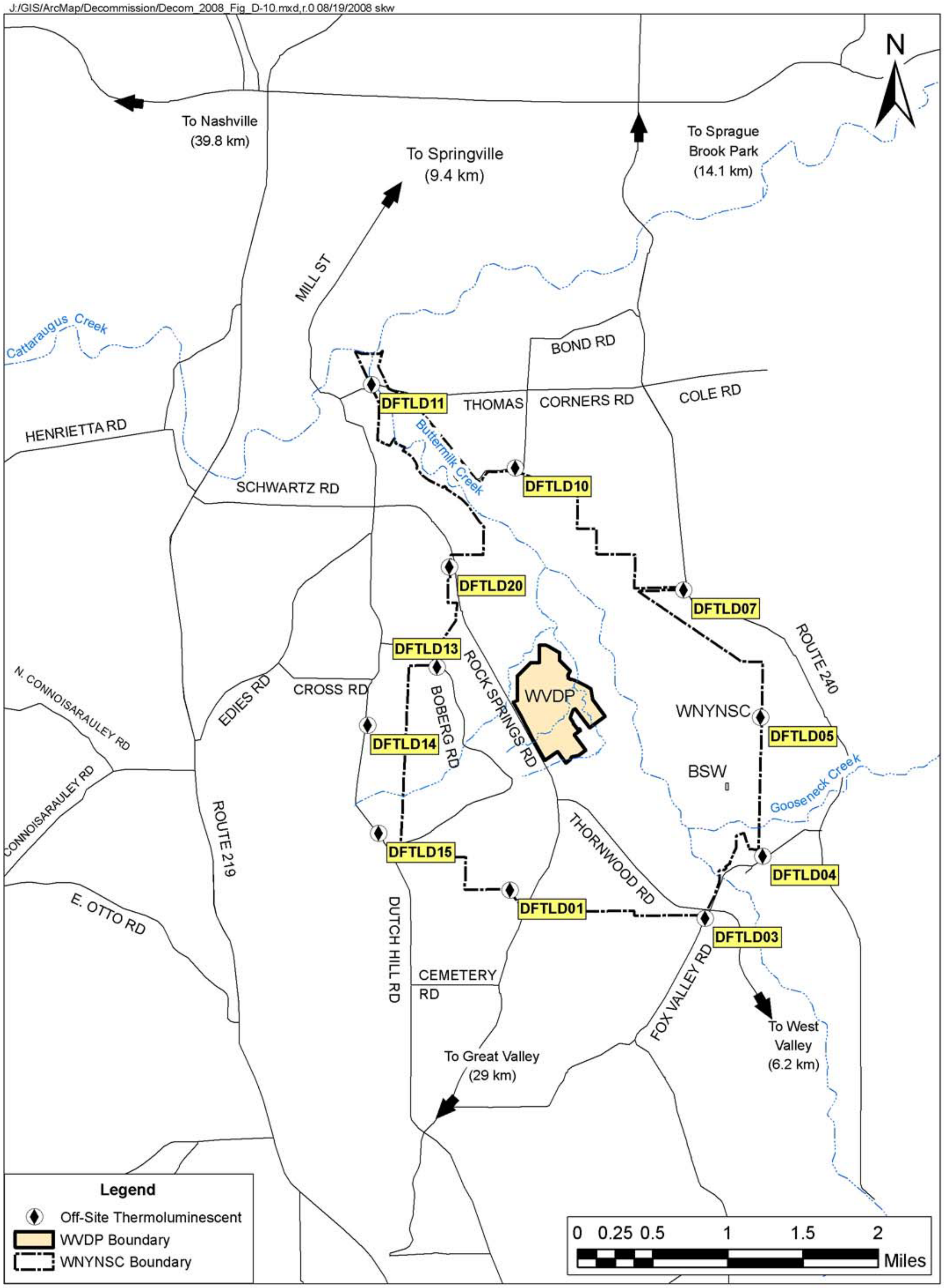


Figure D-16. Offsite Direct Radiation Monitoring Locations during the Phase 1 Institutional Control Period

3.0 Phase 1 Institutional Control Program

This section describes the institutional control program that will be implemented for the project premises during and following the completion of the Phase 1 remedial activities.

3.1 Government Control of the Project Premises

NYSERDA is the current owner of the project premises property and will remain owner following Phase 1 activities. As stipulated in the Cooperative Agreement with NYSERDA, DOE shall remain in exclusive use and possession of the project premises and project facilities throughout the remainder of the project term (DOE and NYSERDA 1981). DOE will therefore continue control of the project premises during the implementation of the Phase 1 decommissioning activities and during the Phase 1 institutional control period. In this capacity, DOE carries the full authority of the federal government in enforcing institutional controls over the project premises.

DOE will be responsible for operating and maintaining facilities within the project premises such as the Waste Tank Farm, the NDA, and the non-source area of the north plateau groundwater plume in a safe manner. DOE will continue to implement the environmental radiation protection program for the project premises as required by DOE Order 5400.5*, Radiation Protection of the Public and the Environment*. NRC will also be involved in a regulatory oversight capacity over the project premises, which will remain under NRC license.

3.2 Institutional Control Design Features

The institutional control program for the project premises will prevent its unacceptable use and protect against inadvertent intrusion into the site. DOE in its capacity as the steward of the site will ensure that institutional controls are maintained at the project premises during Phase 1 decommissioning and during the Phase 1 institutional control period. These institutional controls will include:

- Security fencing and signage along the perimeter of the project premises to prevent inadvertent intrusion into the site and to notify individuals that access is forbidden without permission from the DOE,
- A full time security force to prevent unauthorized access into the project premises,
- Authorized personnel and vehicle access into the project premises will be limited to designated gateways through the perimeter security fence
- The environmental monitoring program implemented at the project premises during the Phase 1 institutional control period will ensure that operations at the site protect members of the public and the environment from radiation risk.

Additional institutional controls will be provided for the new Canister Interim Storage Facility on the south plateau. These will include measures such as security fencing around the area and appropriate security lighting.

4.0 References

Code of Federal Regulations and Federal Register Notices

10 CFR 20 Subpart E, *Radiological Criteria for License Termination*.

67 FR 22, *Decommissioning Criteria for the West valley Demonstration Project (M-32) at the West Valley Site; Final Policy Statement*, U.S. Nuclear Regulatory Commission, Washington, D.C., February 1, 2002.

DOE Orders

DOE Order 5400.5, Change 2, *Radiation Protection of the Public and the Environment*. U.S. Department of Energy, Washington, D.C., January 7, 1993.

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URS 2000, *Evaluation of Stability of Proposed WMA1&3/WMA7 Slurry Walls Under Hypothetical Seismically-induced Horizontal Acceleration of 0.2g*, Calculation BUF-2000-069, Rev. 0. URS Corp., Orchard Park, New York, July 17, 2000.