# GROUNDWATER PROTECTION PROGRAM

## Groundwater Monitoring Program

Groundwater monitoring at the West Valley Demonstration Project (WVDP or Project) complied with all applicable state and federal regulations and meets the requirements of United States (U.S.) Department of Energy (DOE) Order 450.1A, "Environmental Protection Program," and the Resource Conservation and Recovery Act (RCRA) §3008(h) Administrative Order on Consent (Consent Order).

**Environmental Surveillance.** The WVDP Environmental Management System (EMS) required environmental monitoring to detect and evaluate changes in the environment resulting from Project (or pre-Project) activities and to assess the effect of such changes on the public and the environment, including changes due to groundwater contamination. The WVDP EMS included implementation of a site-wide approach for groundwater protection. The "WVDP Groundwater Protection Management Program Plan" documented the Project's approach to the groundwater protection from on-site activities.

The primary focus of the groundwater monitoring program (GMP), summarized in the WVDP "Groundwater Monitoring Plan," identified, delineated, and monitored groundwater migration pathways that could transport contaminants off site and to support mitigative actions. The groundwater monitoring well network at the WVDP was designed to monitor groundwater conditions in six subsurface geologic units. For a description of these geologic units refer to "Geology and Hydrogeology" later in this chapter.

**Regulatory Compliance: RCRA §3008(h) Consent Order.** The RCRA Facility Investigation (RFI) reports and Consent Order require routine monitoring of certain analytes at specified groundwater monitoring locations.

**Groundwater Use and History.** Site groundwater is not used for drinking or operational purposes, nor is effluent discharged directly to groundwater. The majority of the site groundwater eventually flows to Cattaraugus Creek and then to Lake Erie. Surveys have determined that no public water supplies are drawn from groundwater downgradient of the site or from Cattaraugus Creek downstream of the WVDP. However, upgradient of the site, groundwater is used as a public and private drinking water supply by local residents.

Highlights of the groundwater monitoring history on the site and the evolution of the GMP are summarized in Table 4-1. The most significant groundwater protection program activity that occurred in 2010 was installing a full-scale permeable treatment wall (PTW) on the north plateau. This is discussed in further detail later in this chapter.

## Geology and Hydrogeology

The Western New York Nuclear Service Center (WNYNSC) is situated upon a layered sequence of glacial-age sediments that fill a steep-sided bedrock valley composed of interbedded shales and siltstones (Rickard, 1975). Erdman Brook bisects the WVDP into the north and south plateaus. The main plant process building (MPPB), waste tanks, and lagoons are located on the north plateau. The drum cell, the U.S. Nuclear Regulatory Commission (NRC)-Licensed Disposal Area (NDA), and the New York State-Licensed Disposal Area (SDA) are located on the south plateau.

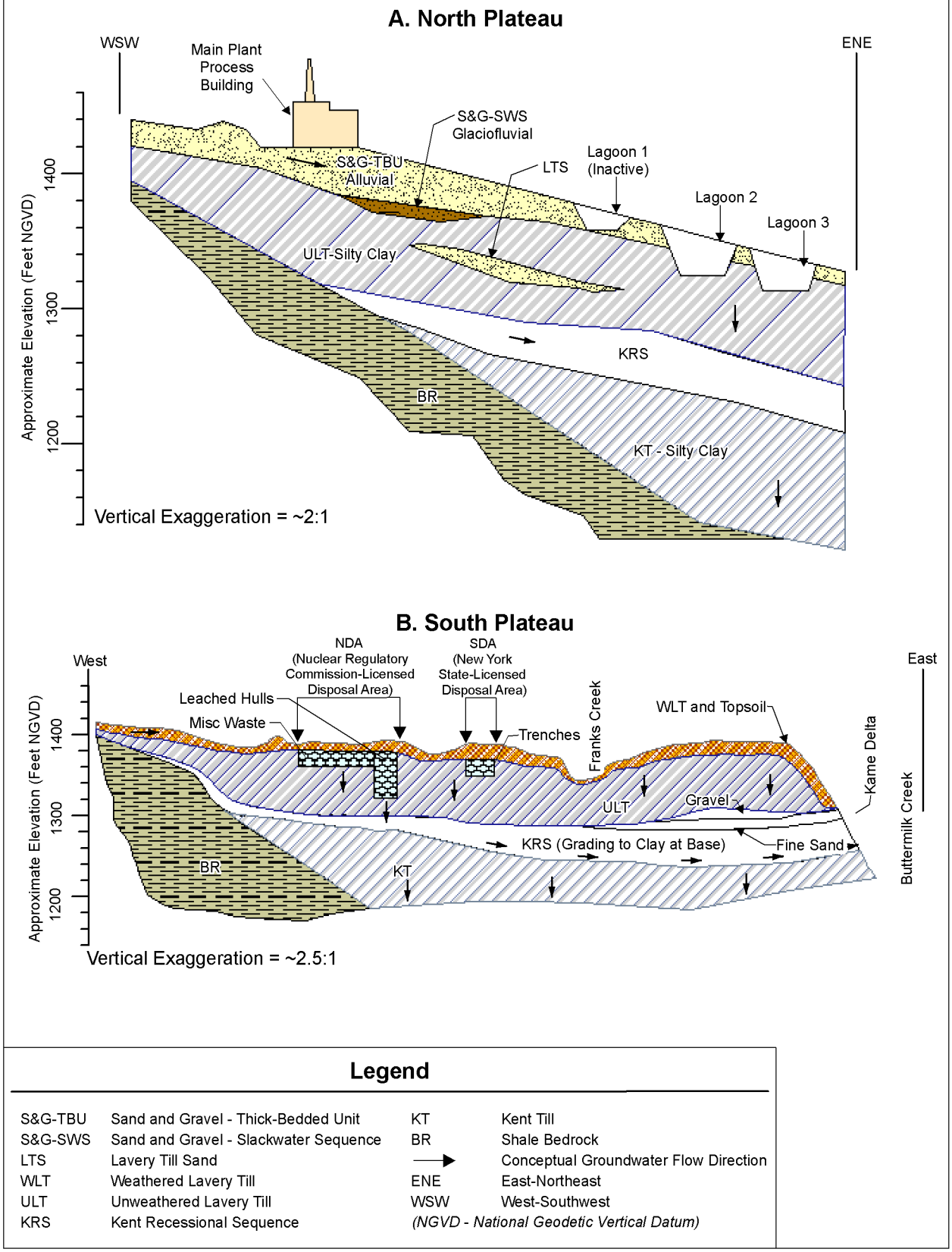
The glacial sediments overlying the bedrock consist of a sequence of three silt- and clay-rich glacial tills of Lavery, Kent, and possibly Olean age. The tills are separated by stratified fluvio-lacustrine deposits (silty or silty/sandy lakebed sediments). The units above the Kent till, which include the Kent recessional sequence, the weathered Lavery till (WLT) and unweathered Lavery till (ULT), the intra-Lavery till-sand, and the alluvial sand and gravel (S&G), are generally regarded as containing all of the potential routes for contaminant migration from the Project via groundwater. The S&G unit only exists on the Project's north plateau. The Kent till has a relatively low permeability and does not provide a pathway for contaminant movement from the WVDP; therefore, it is not discussed here. See Figure 4-1 for a cross-sectional view of the subsurface and Table 4-2 for the descriptions and the geographic distribution of these units. The S&G unit consists of two subunits: the thick-bedded unit (TBU) and the slackwater sequence (SWS).

**TABLE 4-1**
**Highlights of Groundwater Monitoring History at the WVDP and the WNYNSC**

| *Year* | *Highlight* |
|---|---|
| 1961–1980 | From the time the Western New York Nuclear Service Center was established in 1961, to passage of the West Valley Demonstration Project (WVDP) Act in 1980, groundwater at the WVDP was periodically sampled by Nuclear Fuel Services (NFS), the New York Geological Society, and the United States Geological Survey during construction of the main plant process building (MPPB), for spill investigations, and for post-NFS research studies. |
| 1982 | Groundwater monitoring at the WVDP began in 1982 under the United States (U.S.) Department of Energy (DOE) and site subcontractor (West Valley Nuclear Services), and continued to expand through 1992. |
| 1984 | By 1984, 40 wells provided groundwater monitoring coverage near the MPPB and the U.S. Nuclear Regulatory Commission-Licensed Disposal Area (NDA). |
| 1986 | Additional wells were installed to supplement the existing groundwater monitoring network. |
| 1990–1991 | Ninety-six wells were installed upgradient and downgradient of the WVDP solid waste management units (SWMUs) for the DOE and Resource Conservation and Recovery Act (RCRA) monitoring programs. (The total included wells at the New York State-licensed disposal area.) |
| 1992 | The RCRA 3008(h) Order on Consent was signed. |
| 1993 | Elevated gross beta activity was discovered in groundwater from the sand and gravel (S&G) unit on the north plateau. Subsequent investigation delineated a plume of strontium-90-contaminated groundwater originating beneath the MPPB, extending northeast. |
| 1993–1994 | A RCRA Facility Investigation (RFI) expanded characterization program was conducted to assess potential releases of hazardous constituents from on-site SWMUs. Results from the RFI influenced decisionmaking for the groundwater monitoring program (GMP). |
| 1994 | A Geoprobe® investigation of groundwater and soil beneath and downgradient of the MPPB was performed to characterize the elevated gross beta activity in the S&G unit. The presumed source was found to be near the southwest corner of the MPPB. The primary isotopes responsible for the beta activity were strontium-90 and its daughter product yttrium-90. |
| 1995 | The GMP was evaluated and analytical constituents were tailored to each sampling point for a more focused and cost-effective program. The north plateau groundwater recovery system (NPGRS) was installed near the leading edge of the main lobe of the strontium-90 plume to minimize migration. The NPGRS consisted of three extraction wells that recovered groundwater for treatment by ion exchange. |
| 1996 | Several groundwater seeps on the northeast edge of the north plateau were added to the monitoring program. |
| 1997 | A Geoprobe® soil and groundwater sampling program was conducted to delineate the leading edge of the strontium-90 plume. |
| 1998 | In response to recommendations from a 1997 external review of WVDP actions regarding the north plateau, another Geoprobe® soil and groundwater sampling program was carried out to further characterize the core area of the plume. The new radiological data were compared to the 1994 data. |
| 1999 | A pilot-scale permeable treatment wall (PTW) was installed in the eastern lobe of the plume to test this passive in-situ remediation technology. Well points were installed near the PTW. |
| 2000–2001 | Additional wells and well points were installed across the leading edge of the strontium-90 plume to monitor the plume's movement and assess the effectiveness of the pilot PTW. |
| 2003 | Four new wells were installed to monitor groundwater upgradient and downgradient of the newly constructed remote-handled waste facility. |
| 2005 | Number of analytes or sampling frequencies were reduced at 14 groundwater monitoring locations. |
| 2007 | The GMP was evaluated, considering current site conditions, activities, and environmental exposure pathways. The analytes and sampling frequencies at 20 monitoring points were reduced and sampling at four wells was discontinued. Off-site drinking water sampling was also discontinued after an evaluation of historical data had confirmed that site operations had no impact on off-site upgradient groundwater. |
| 2008 | Two replacement wells, and 21 piezometers, were installed near the NDA during installation of a slurry wall and geomembrane cover at the NDA. On the north plateau, three subsurface investigations were performed upgradient, within, and downgradient of the strontium-90 plume. |
| 2010 | An approximately 860-foot-long full-scale PTW was installed along the leading edges of the strontium-90 plume. Sixty-six groundwater monitoring wells were installed upgradient, downgradient, and within the PTW to monitor wall performance. Four new wells were installed downgradient of the MPPB to supplement the strontium-90 source area monitoring. |

**FIGURE 4-1**
**Geologic Cross Sections of the North and South Plateaus at the WVDP**

J:/GIS/ArcMap/ASER/ASER_2010/ASER_2010_Fig4-1_20110602.mxd FJC/skw



## Routine Groundwater Monitoring Program

**Monitoring Well Network.** The WVDP groundwater monitoring network is an essential component of the Environmental Protection Program implemented under DOE Order 450.1A. Groundwater is routinely monitored across the WVDP north and south plateaus and in the six hydrogeologic units described in Table 4-2. In calendar year (CY) 2010, groundwater samples were collected from a total of 69 on-site routine groundwater monitoring locations (see Figures A-7 and A-8). The on-site locations included 63 monitoring wells and well points, five groundwater seepage points, and one trench sump. Many of the wells were installed to monitor one or more solid waste management units (SWMUs) on the WVDP in accordance with the Consent Order. Table 4-3 lists the wells in the routine groundwater monitoring network, the super SWMUs and the geologic units they monitor, and the analytes measured in CY 2010. Table 4-4 defines the analyte groups. (See "RCRA §3008(h) Administrative Order on Consent" in the "Environmental Compliance Summary.")

Table 4-3 includes four new groundwater monitoring wells, MP-01 through MP-04, that were installed immediately downgradient of the MPPB in March 2010. Two of these wells are replacements for two smaller-diameter direct pushed, pre-constructed wells (WP20S and WP20D) that were removed and two are new wells installed 50 feet east of the fuel receiving and storage (FRS) building. These new wells have been incorporated into the routine site-wide groundwater monitoring program.

The monitoring frequency and the constituents analyzed under the GMP are a function of regulatory requirements, historical site activities, current operating practices, and ongoing evaluations of groundwater data. Tables 4-5 and 4-6 provide an overview of groundwater monitoring performed during CY 2010 organized by geographic area and monitoring purpose.

**Groundwater Elevation Monitoring.** Water level measurements were taken at the monitoring network wells in conjunction with the quarterly analytical sampling. (See Figures A-7 and A-8 in Appendix A.) Groundwater elevation data were used to produce maps that depict groundwater flow directions and gradients. Long-term trend graphs were used to illustrate variations in groundwater elevations over time, such as seasonal fluctuations or changes resulting from installing water diversions, such as caps, trenches, or slurry walls, and groundwater treatment systems, such as the north plateau pumping wells and pilot- and full-scale PTWs.

Groundwater elevation mapping is particularly important in areas where knowledge of groundwater flow direction is critical for monitoring groundwater that is or may become impacted by contaminant migration, such as for analysis of the strontium-90 plume migration. (See "Strontium-90 Plume on the North Plateau.") Surface water elevations are also measured on the north plateau where the water table in the S&G intersects the ground surface, providing flow direction.

At the NDA on the south plateau, groundwater elevation mapping of the WLT helps evaluate the effectiveness of the interceptor trench, as well as the slurry wall and geomembrane cover that were installed in 2008 to minimize groundwater and surface water migration through the burial area. (See "Groundwater Sampling Observations on the South Plateau: Weathered Lavery Till and the NDA.")

**Groundwater Trigger Level Evaluation.** A computerized data-screening program uses "trigger levels" – preset conservative values for chemical and radiological concentrations and groundwater elevation measurements – to promptly identify anomalies in monitoring results that may require further investigation. The trigger levels are statistically derived from historical results or are based on regulatory criteria or detection limits.

Analytical results exceeding the trigger levels may be the result of normal seasonal fluctuations, laboratory analytical problems, or changes in groundwater quality. Response actions are identified for each analytical result exceeding a trigger level. Each quarter, trigger level exceptions, defined as a current measurement above or below an upper or lower trigger level, are compiled, evaluated, and summarized with recommended response actions.

**Groundwater Screening Levels (GSLs).** In 2009, GSLs were developed as a tool to identify the presence of chemical and radiological constituents in groundwater above levels of concern (e.g., regulatory limits, guidance limits, background). Methods used to develop the GSLs are discussed in detail in Appendix D. Analytical results for 2010 are compared with applicable GSLs, and summarized in Table 4-10 at the end of this chapter.

**TABLE 4-2**
**Summary of Hydrogeology at the WVDP**

| *Geologic Unit* | *Description* | *Groundwater Flow Characteristics* | *Hydraulic Conductivity* [a] | *Location* |
|---|---|---|---|---|
| **Sand and Gravel; Thick-Bedded Unit (S&G-TBU)** | Silty sand and gravel layer composed of younger Holocene alluvial deposits | Flow is generally northeast across the plateau toward Franks Creek, with groundwater near the northwestern and southeastern margins flowing radially outward toward Quarry Creek and Erdman Brook. | 9.0 feet (ft)/day (3.2E-03 centimeters [cm]/second [sec]) | Surficial unit on the north plateau |
| **Sand and Gravel; Slackwater Sequence** | Interbedded silty sand and gravel layers composed of Pleistocene-age glaciofluvial deposits partially separated from the S&G-TBU by a discontinuous silty clay interval | Flow is to the northeast along gravel layers toward Franks Creek. | 17 ft/day (6.0E-03 cm/sec) | Underlies a portion of the north plateau |
| **Weathered Lavery Till** | Upper zone of the Lavery till which has been exposed at the ground surface; weathered and fractured to a depth of 3–16 ft (0.9–4.9 meters [m]); brown in color due to oxidation; contains numerous desiccation cracks and root tubes | Flow has both horizontal and vertical components allowing groundwater to move laterally across the south plateau before moving downward into the unweathered lavery till or discharging to nearby incised stream channels. | 0.07 ft/day (2.4E-05 cm/sec); the highest conductivities are associated with dense fracture zones found within the upper 7 ft (2 m) of the unit | Surficial unit on the south plateau |
| **Unweathered Lavery Till** | Olive gray silty clay with intermittent lenses of silt and sand; ranges up to 130 ft (40 m) in thickness | Flow is vertically downward at a relatively slow rate; unit is considered an aquitard. | 0.002 ft/day (8.1E-07 cm/sec) | Underlies both the north and south plateaus |
| **Lavery Till Sand** | Thin, sandy unit of limited areal extent and variable thickness within the Lavery till. | Flow is to the east-southeast toward Erdman Brook. | 0.2 ft/day (8.6E-05 cm/sec) | Primarily beneath the southeastern portion of the north plateau |
| **Kent Recessional Sequence** | Interbedded clay and silty clay layers locally overlain by coarser-grained sands and gravels; pinches out near the east side of Rock Springs Road | Flow is to the northeast; recharge from the overlying till and from bedrock to the southwest; discharges into Buttermilk Creek. | 0.01 ft/day (4.3E-06 cm/sec) | Underlies most of the Project, except areas adjacent to Rock Springs Road |

Note: Hydrologic conditions of the site are more fully described in "Environmental Information Document, Volume III: Hydrology, Part 4" (West Valley Nuclear Services Co. [WVNSCO], March 1996) and in the "RCRA Facility Investigation Report (RFI) Vol. 1: Introduction and General Site Overview" (WVNSCO and Dames & Moore, July 1997).

[a] Hydraulic conductivities represent an average of testing results from 1991 through 2010.

## TABLE 4-3
## WVDP Groundwater Monitoring Network Sorted by Geologic Unit

| Well ID | SSWMU | Gradient Position | Analytical Parameters (See Table 4-4) | Well ID | SSWMU | Gradient Position | Analytical Parameters (See Table 4-4) |
|---|---|---|---|---|---|---|---|
| **Sand and Gravel Wells** | | | | | | | |
| 103[a] | 1, 3 | D | I, RI, V | 803[a] | 8 | D | I, RI, SV, V |
| 104 | 1 | C | I, RI | 804[a] | 8 | D | I, RI, V |
| 105 | 1 | C | I, RI | 1302[b] | NA | D | I, RI, M, |
| 106 | 1 | D | I, RI | 1304[b] | NA | U | I, RI, M, R |
| 111[a] | 1 | D | I, RI, M, SV, V | 8603 | 8 | U | I, RI |
| 116[a] | 1, 8 | C, U | I, RI, V | 8604 | 1 | C | I, RI |
| 205 | 2 | D | I, RI | 8605[a] | 1, 2 | D | I, RI, M, SV, V |
| 301[a] | 3 | U | I, RI | 8607[a] | 4, 6 | D, U | I, RI, V |
| 302 | 3 | U | I, RI | 8609[a] | 3, 4, 6 | D, D, U | I, RI, S, V |
| 401[a] | 3, 4 | U | I, RI, R | 8612[a] | 8 | D | I, RI, SV, V |
| 402 | 4 | U | I, RI | MP-01[a] | 3 | D | I, RI, M, R-MP, SV, V, T |
| 403 | 4 | U | I, RI | MP-02[a] | 3 | D | I, RI, M, R-MP, SV, V, T |
| 406[a] | 4, 6 | D, U | I, RI, R, V | MP-03[a] | 3 | D | I, RI, M, R-MP, SV, V, T |
| 408[a] | 3, 4 | D | I, RI, R, V | MP-04[a] | 3 | D | I, RI, M, R-MP, SV, V, T |
| 501[a] | 5 | U | I, RI, S, V | WP-A[c] | NA | NA | I, RI |
| 502[a] | 5 | D | I, RI, S, SM, V | WP-C[c] | NA | NA | I, RI |
| 602A | 6 | D | I, RI | WP-H[c] | NA | NA | I, RI |
| 604 | 6 | D | I, RI | SP04[d] | NA | NA | RI |
| 605 | 6 | D | I, RI | SP06[d] | NA | NA | RI |
| 706[a] | 7 | D | I, RI, M | SP11[d] | NA | NA | RI |
| 801[a] | 6, 8 | U, D | I, RI, S, V | SP12[a,d] | 8 | D | I, RI, V |
| 802 | 8 | D | I, RI, V | GSEEP[a,d] | 8 | C, D | I, RI, V |
| **Lavery Till Sand Wells** | | | | | | | |
| 204[a] | 2, 3 | D | I, RI | 206 | 2 | C | I, RI |
| **Weathered Lavery Till Wells** | | | | | | | |
| 906[a] | 9 | D | I, RI | 1005[a] | 9, 10 | C, U | I, RI |
| 908R[a] | 9 | B | I, RI | 1006[a] | 9, 10 | C, D | I, RI |
| 909[a] | 9 | D | I, RI, M, R, SV, V | 1008C[a] | 9, 10 | U | I, RI |
| NDATR[a] | 9 | D | I, RI, M, R, SV, V | | | | |
| **Unweathered Lavery Till Wells** | | | | | | | |
| 107 | 1 | D | I, RI | 704 | 7 | D | I, RI |
| 108 | 1 | D | I, RI | 707 | 7 | C | I, RI |
| 110[a] | 1 | D | I, RI, V | 910R[a] | 9 | D | I, RI |
| 405 | 4 | D | I, RI, M | 1301[b] | NA | D | I, RI |
| 409 | 4 | D | I, RI | 1303[b] | NA | U | I, RI, M |
| **Kent Recessional Sequence Wells** | | | | | | | |
| 901[a] | 9 | U | I, RI | 1008B | 10 | U | I, RI |
| 902[a] | 9 | U | I, RI | 8610[a] | 9 | D | I, RI |
| 903[a] | 9 | D | I, RI | 8611[a] | 9 | D | I, RI |

Gradient Positions: B (background); C (crossgradient); D (downgradient); U (upgradient)

[a] Monitoring for some parameters at this well is required by the RCRA §3008(h) Consent Order.
[b] Monitors upgradient or downgradient of the remote-handled waste facility.
[c] Monitors north and east of the main plant process building.
[d] Monitors groundwater emanating from seeps along the edge of the north plateau.

**TABLE 4-4**
**WVDP Groundwater Sampling and Analysis Agenda**

| *Analyte Group* | *Description of Parameters* |
|---|---|
| Indicator Parameters (I) | pH, specific conductance (field measurements) |
| Radiological Indicator Parameters (RI) | Gross alpha, gross beta, tritium |
| Volatile Organic Compounds (V) | Title 6 of the New York State Official Compilation of Codes, Rules, and Regulations (6 NYCRR) Part 373-2 Appendix 33 Volatile Organic Compounds |
| Semivolatile Organic Compounds (SV) | 6 NYCRR Part 373-2 Appendix 33 Semivolatile Organic Compounds and tributyl phosphate |
| Groundwater metals (M) | 6 NYCRR Part 373-2 Appendix 33 Metals (antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, thallium, vanadium, zinc) |
| Special Monitoring Parameters for early warning wells (SM) | Aluminum, arsenic, barium, cadmium, chromium, cobalt, copper, Iron, lead, manganese, mercury, nickel, selenium, silver, vanadium, zinc |
| Radioisotopic Analyses: alpha-, beta-, and gamma-emitters (R) | Carbon-14, strontium-90, technetium-99, iodine-129, cesium-137, radium-226, radium-228, uranium-232, uranium-233/234, uranium-235/236, uranium-238, total uranium |
| Radioisotopic Analyses MPPB Area (R-MP) | Carbon-14, potassium-40, cobalt-60, strontium-90, technetium-99, iodine-129, cesium-137, europium-154, neptunium-237, plutonium-238, plutonium-239/240, plutonium-241, uranium-232, uranium-233/234, uranium-235/236, uranium-238, americium-240, curium-244 |
| Strontium-90 (S) | Strontium-90 |
| Turbidity (T) | Turbidity |

**TABLE 4-5**
**WVDP 2010 Groundwater Monitoring Overview by Geographic Area**

| *Number of…* | *Total WVDP* | *North Plateau* | *South Plateau* |
|---|---|---|---|
| Monitoring Points Sampled - Analytical | 69 | 55 | 14 |
| Monitoring Points - Water Elevations Only | 73 | 34 | 39 |
| Monitoring Events | 4 | 4 | 4 |
| Analyses (analyses groups) | 1,084 | 926 | 158 |
| Results (individual) | 8,019 | 6,830 | 1,189 |
| Percent of Nondetectable Results | 84% | 84% | 85% |
| Water Elevation Measurements | 554 | 321 | 233 |

**TABLE 4-6**
**WVDP 2010 Groundwater Monitoring Overview by Purpose**

| *Number of…* | *Total* | *Regulatory/ Waste Management* | *Environmental Surveillance* |
|---|---|---|---|
| Monitoring Points Sampled - Analytical | 69 | 38 | 31 |
| Monitoring Points - Water Elevations Only | 73 | 1 | 72 |
| Monitoring Events | 4 | 4 | 4 |
| Analyses (analyses groups) | 1,084 | 746 | 338 |
| Results (individual) | 8,019 | 7,115 | 904 |
| Percent of Nondetectable Results | 84% | 88% | 52% |
| Water Elevation Measurements | 554 | 144 | 410 |

## Strontium-90 Plume on the North Plateau

Elevated gross beta activity has been observed on the north plateau since 1993. This contamination is predominantly confined to the S&G unit, the shallowest hydrogeologic unit on the north plateau. (See the highlights for 1993 and 1994 in Table 4-1.) The routine GMP network in the S&G unit on the north plateau includes 44 monitoring locations (including wells MP-01 through MP-04, installed in March 2010); three well points; and five groundwater seepage locations.

At the WVDP, DOE derived concentration guides (DCGs) are sometimes used as a reference for evaluating liquid radionuclide effluents. Because there is no DCG for gross beta in liquid effluents, the strontium-90 DCG (1E-06 microcuries per milliliter [µCi/mL]) is used as a conservative basis for comparison where beta-emitting radionuclides are detected in groundwater. The strontium-90 DCG is the most restrictive of the beta emitters at the WVDP. For the purpose of the following discussions, the strontium-90 DCG is used for comparison with both gross beta and strontium-90. (See the "Useful Information" section at the end of this report for a discussion of the DOE DCGs, and Table UI-4 for a list of the DCGs for radionuclides of interest at the WVDP.)

Figure 4-2 shows the plume outline, as defined by the 1E-06-µCi/mL gross beta isopleth (the strontium-90 DCG), at three time intervals spanning 17 years (in 1994, 2002, and 2010). As shown, although the plume's western boundary has remained relatively constant since 1994, over time the plume has migrated to the northeast and east, consistent with the groundwater flow direction in the S&G unit. The leading edge has divided into three small lobes due to the variable rate of migration resulting from the heterogeneous nature of soil within the S&G, TBU, and SWS subunits (i.e., the uneven distribution of coarse and fine soils) which creates preferential pathways for groundwater migration. The GMP wells that monitor the plume, and the gross beta concentrations measured in December 2010, are shown on Figure 4-2. In December 2010, a relatively large increase in gross beta concentration was observed in groundwater from well 803, located in the northeast corner of the north plateau downgradient of the plume's central lobe. The gross beta concentration increased by roughly two orders of magnitude during CY 2010, from approximately 1.0E-08 µCi/mL to 9.0E-07 µCi/mL. In March 2011, the gross beta concentration at well 803 exceeded the DOE DCG for strontium-90 (1.0E-06 µCi/mL). This increasing trend is attributable to continued migration of the strontium-90 plume's central lobe. It is anticipated that these concentrations may continue to increase for a period of time, and then eventually decrease when groundwater influenced by the PTW's strontium-90 removal begins to reach the location of well 803.

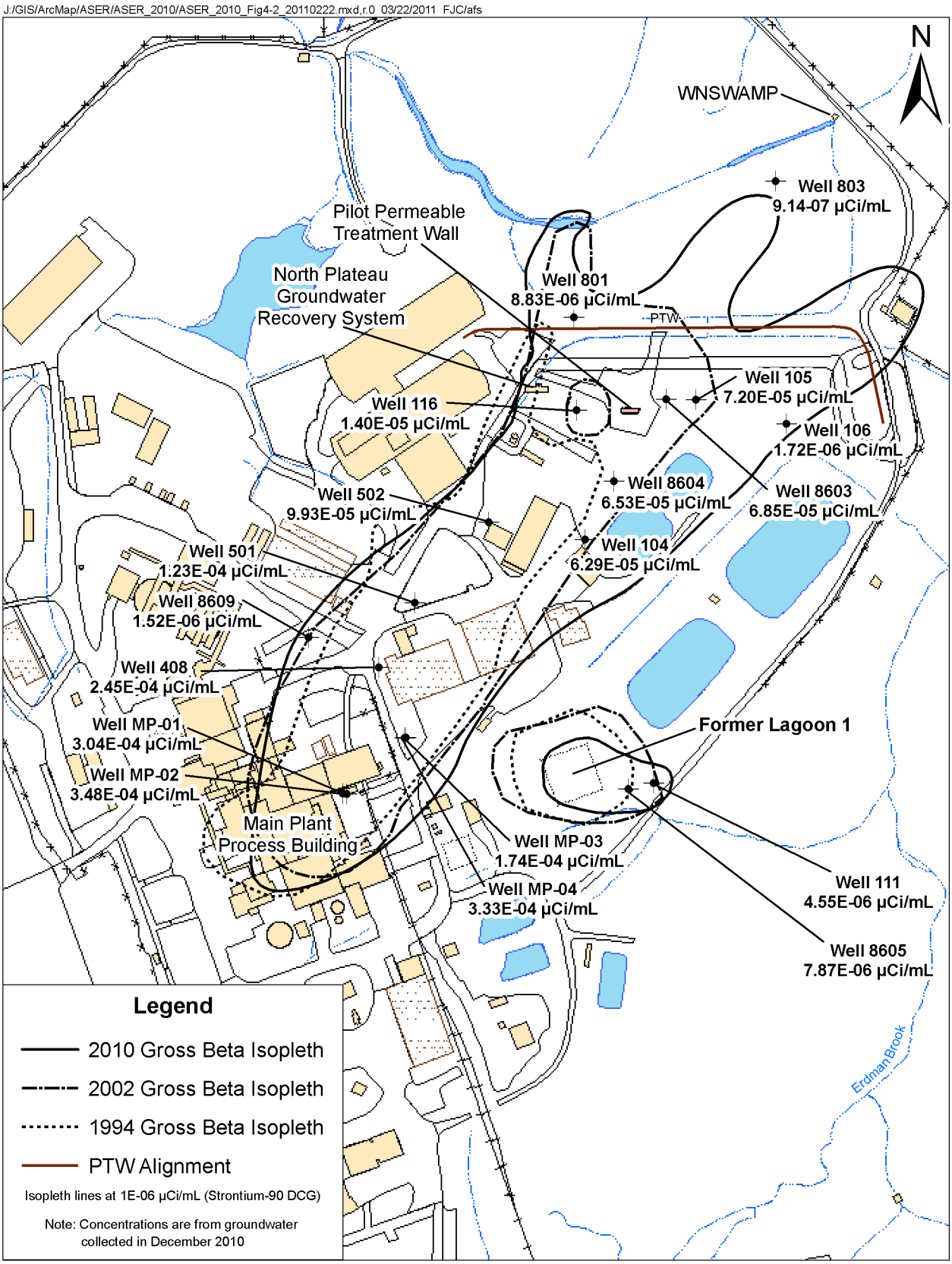
Historical monitoring has established that strontium-90 is the predominant radioisotope contributing to the gross beta activity measured in the north plateau groundwater plume. Therefore, monitoring wells are routinely sampled for gross beta concentrations, supported by periodic sample collection at select wells for strontium-90 analysis. Gross beta concentration trends over the last 10 years at monitoring wells located within the plume are shown on Figures 4-4 and 4-5. These data are plotted on a log scale; therefore, an increase from one gridline to the next represents a 10-fold increase in concentration. The log scale was used so that data from background locations (with concentrations in the 1.0E-09 µCi/mL range) and data from the central plume (with concentrations in the 1.0E-04 µCi/mL range, 100,000 times higher than background) could be plotted on the same graphs.

Figure 4-6 illustrates the gross beta concentrations in groundwater from wells located downgradient of the MPPB and the strontium-90 source area. The four new wells (MP-01, -02, -03, and -04) installed in CY 2010, within the central portion of the plume and closer to the MPPB, exhibit the highest gross beta concentrations of any routinely monitored wells in the program since they are located closest to the source area. The gross beta concentrations range from a high of 6.7E-04 µCi/mL at location MP-02 to a low of 1.8E-04 µCi/mL at location MP-03. All of the gross beta concentrations at the MPPB wells are significantly above the DOE DCG for strontium-90 (1.0E-06 µCi/mL) and consistent with their location within the core of the plume.

Gross beta concentrations in the center of the plume did not change significantly in 2010. Gross beta concentrations, downgradient of the high-level radioactive waste (HLW) tanks near the western edge of the plume, remained about two orders of magnitude lower than the concentrations directly downgradient of the MPPB. Well 8609 is located cross-gradient to the predominant flowpath of the plume.

The leading edge of the plume (defined by the 1.0E-06-µCi/mL isopleth) migrated beyond all of the

**FIGURE 4-2**
**North Plateau Strontium-90 Plume Plotted by Gross Beta Data: 1994, 2002, and 2010**



downgradient GMP wells (801, 8603, 105, 106, and 116) in 2008. Consequently, the new leading edge of the plume was delineated during a March 2009 plume characterization program, for which more than 70 geoprobe locations were drilled and sampled. Figure 4-5 illustrates trends in the gross beta concentrations in the GMP wells located downgradient, near the leading edge, where the plume splits into three lobes. Gross beta concentrations at wells 105, 801, 8603, and 8604 upgradient of the leading edge of the plume have not changed significantly since 2009. However, concentrations at wells 106, 116, and 803, closest to the leading edge showed a distinct increase in 2010 as the plume continued to migrate to these downgradient areas.

**Monitoring at the Northeast Swamp Drainage.** The western and central lobes of the plume are partially intercepted by a drainage ditch flowing west-to-east across the plume's leading edge (see Figure 4-2 and Figure A-2 in Appendix A). The surface water flow rate in this ditch is measured biweekly. Surface water flowing through this ditch is sampled monthly and analyzed for radiological constituents at the WNSWAMP sampling location at the edge of the WVDP property boundary.

Groundwater from the north plateau plume seeping into this ditch is believed to be the main source of the strontium-90 activity at WNSWAMP. An estimated 37.7 million gallons (gal) (143 million liters [L]) of water flowed through this monitoring point in 2010. (See "Effluent Monitoring" in Chapter 2.)

As shown in the 10-year trend plot on Figure 4-7, annual average strontium-90 concentrations in the drainage ditch have been above the strontium-90 DCG for nine of the last 10 years. Gross beta and strontium-90 concentrations at WNSWAMP exhibit seasonal variability. The average annual strontium-90 concentration measured in samples from the WNSWAMP ditch increased in 2010 to a level approximately equal to the 2008 annual average concentration. The flow through WNSWAMP accounted for an annual estimated dose of 5.47E-02 millirem in 2010. See "Maximum Dose (Waterborne) to an Off-Site Individual" in Chapter 3.

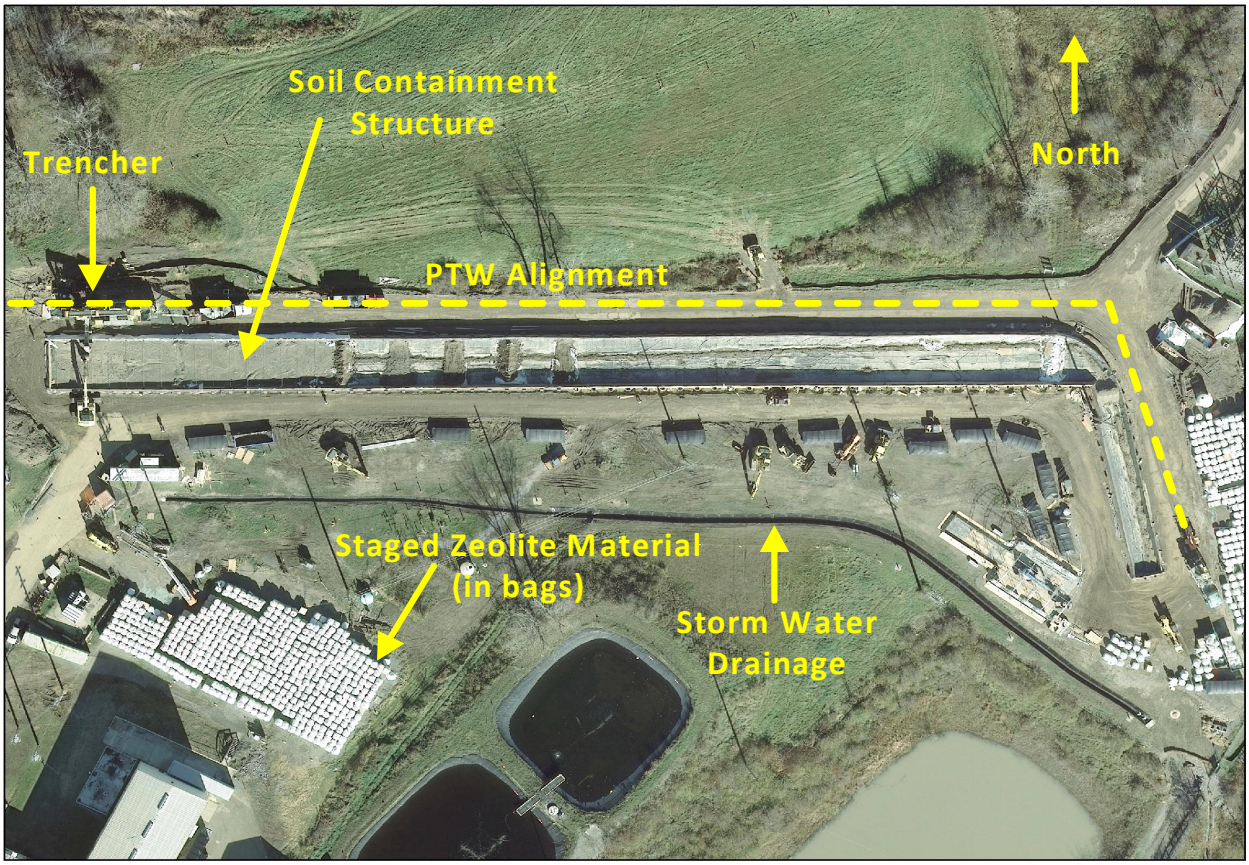
Monitoring of surface water downstream of the WVDP at the first point of public access, Felton Bridge on Cattaraugus Creek (location WFFELBR), continued to show that strontium-90 concentrations in 2010 were indistinguishable from historical concentrations from the Cattaraugus Creek background surface water location at Bigelow Bridge (WFBIGBR).

**Monitoring at North Plateau Seeps.** Groundwater is also monitored along the northeast edge of the north plateau, where it seeps from the steep banks of the stream channels incised by Erdman Brook and Franks Creek. The seepage locations (GSEEP, SP04, SP06, SP11, and SP12), located east of the construction demolition and debris landfill (CDDL) outside of the WVDP fenceline, monitor conditions on the downgradient edge of the north plateau where the groundwater discharges to the surface. (See Figure A-7 in Appendix A.) Ten-year trends of gross beta concentrations at five seep monitoring points are shown on Figure 4-8. Annual averages were plotted against surface water background values because water from seepage points occasionally may include surface water (i.e., at seepage location SP11).

The highest gross beta concentration among the seepage locations has been observed at SP04, which is believed to be groundwater discharging from the S&G unit to the ground surface. This location first exhibited a significant increase in mid-2007, and has continued to increase through 2010. The December 2010 concentration represents approximately 57% of the DOE DCG for strontium-90. The second highest gross beta concentration at the seeps sampling locations occurred at SP11, located within the discharge area of the swamp drainage ditch. The gross beta at this seep location has slowly, but steadily, increased since monitoring began in 1996. The December 2010 concentration is the highest of record and represents approximately 22% of the DOE DCG for strontium-90. The elevated concentrations at SP11 are thought to be contaminated groundwater from the S&G unit that has come to the surface and percolated back into the ground. Gross beta concentrations at seep locations SP06, SP12, and GSEEP have also increased over the past two years, with the most recent concentration being the highest of record. Average annual concentrations at these three seeps represent approximately 2% to 6% of the DOE DCG for strontium-90.

Recent increasing trends at the seeps are attributable to continued migration of the eastern lobe of the strontium-90 plume. It is anticipated that these concentrations may continue to increase for a period of time, and then eventually decrease when groundwater influenced by the strontium-90 removal by the PTW begins to reach the seep locations.

**FIGURE 4-3**
**Installation of the North Plateau Permeable Treatment Wall (November 2010)**




## Strontium-90 Plume Remediation-Related Activities

**North Plateau Groundwater Recovery System (NPGRS).** In 1995, the NPGRS was installed to minimize the advance of the strontium-90 plume. (See Figure 4-2.) The NPGRS consists of three wells that extract contaminated groundwater, which is then treated by ion exchange to remove strontium-90. Treated water is transferred to the lagoon system and is ultimately discharged to Erdman Brook via the New York State Pollutant Discharge Elimination System (SPDES)-permitted outfall 001.

The NPGRS operated throughout 2010, processing about 3.0 million gal (11.4 million L) of water. The system has extracted and processed approximately 59.5 million gal (225 million L) since November 1995.

The NPGRS will remain in operation while the performance of the PTW is evaluated. When the full-scale PTW is determined to be performing as intended, the NPGRS may no longer be needed and the decommissioning of this system could be considered.

**North Plateau Groundwater Quality Early Warning Monitoring for NPGRS.** Early-warning monitoring of groundwater directly upgradient of the NPGRS is performed to provide the monitoring results that can be used to identify metals concentrations in groundwater that may affect compliance with the SPDES-permitted effluent limits. Metals results from well 502 in CY 2010 were below concentrations likely to affect SPDES permit compliance. (See Appendix D-2[CD].)

**Pilot-Scale PTW.** A pilot-scale PTW was constructed in 1999 within the eastern lobe of the strontium-90 plume to test this passive, in-situ remediation technology. The pilot PTW is a 7-foot by 30-foot by 25-foot-deep trench that was backfilled with clinoptilolite, a medium selected for its ability to adsorb strontium-90 ions from groundwater. Strontium-90 concentrations have consistently remained several orders of magnitude lower in groundwater from wells within the pilot PTW, compared to wells outside the pilot wall, indicating that strontium-90 is being removed from the water that passes through the wall. Gross beta concentrations inside a portion

of the PTW were as high as 9.0E-07 µCi/mL, suggesting some reduction in treatment capacity.

The limited size of the pilot PTW and complex local geology affected its performance, and the wall itself may be affecting the natural groundwater flow path in a localized portion of the eastern lobe of the plume. In the 12 years since the pilot PTW was installed, the plume migrated past the pilot PTW, as it was not designed to treat the entire plume. Nevertheless, the data collected during the wall's operation helped determine that the PTW technology is an effective remediation method for strontium-90-contaminated groundwater.

**Full-Scale PTW.** In 2008, a Geoprobe® investigation was completed to characterize soils and groundwater downgradient of the plume to obtain data for use in the full-scale PTW design. The field work included soil and groundwater sampling and installing small-diameter microwells along the leading edge of the strontium-90 plume. In February 2010, 39 soil borings were advanced along the proposed PTW alignment to define the thickness of the S&G subunits and the depth to the ULT.

In June 2010, to prepare for installing the full-scale PTW, 29 monitoring wells and one inclinometer were decommissioned and removed due to their location in the PTW construction zone. The decommissioned wells included select microwells, north plateau monitoring wells installed in 2001, and well points initially installed to support design of the NPGRS. A lined storm water drainage ditch (Smart-Ditch™) was also installed in September 2010 south of the PTW alignment to intercept storm water from upland portions of the site and route it around the PTW to Franks Creek.

In November 2010, installation work was completed for a full-scale 860-foot-long PTW north plateau strontium-90 plume downgradient, along the existing roadway south of the construction and demolition debris landfill, as shown on Figure 4-3. The PTW was installed through the entire thickness of the S&G unit (including the TBU and the SWS, where present), and was keyed into the underlying, low-permeability ULT. The treatment material used in the PTW is a granular clinoptilolite (i.e., zeolite). The zeolite used in the PTW is a natural mineral with a porous structure that can trap positively charged ions, such as strontium, by ion exchange while allowing the groundwater to pass through the wall. The PTW was designed to address three remedial action objectives (RAOs):

- RAO 1: Reduce or eliminate strontium-90 presence in groundwater seepage leaving or potentially exiting the north plateau to as low as practically achievable, with a goal to be less than the DOE DCG of 1.0E-06 µCi/L;
- RAO 2: Minimize the future expansion of the strontium-90 plume beyond its current mapped limits; and
- RAO 3: Ensure that a technology selected for current containment of the strontium-90 plume does not preclude any strategies for addressing the plume during site decommissioning.

The DOE is also evaluating long-term strategies for management of the plume, including excavating subsurface soils from the source area beneath the MPPB. Removal of the MPPB and the plume source area are components of DOE's Record of Decision for decommissioning or long-term stewardship of the WVDP and the WNYNSC.

**PTW Performance Monitoring Plan (PMP).** A new PTW PMP was developed and implemented immediately following installation of the PTW. This plan required installing 66 new groundwater monitoring wells within and adjacent to the full-scale PTW in December 2010 for performance monitoring. The objectives of the PTW PMP (WVDP-512) include the following activities, with the overall objective of evaluating whether the functional requirements for the PTW are being met:

- Monitoring the physical integrity of the PTW and its components;
- Assessing the movement of strontium-90-affected groundwater in the vicinity of the PTW; and
- Assessing the removal of strontium-90 from groundwater moving through the PTW.

The PTW performance monitoring system consists of 21 existing groundwater monitoring wells, along with the 66 new wells installed within and immediately adjacent to the PTW. The PTW PMP testing activities include: (1) tracer dilution tests in select wells within the PTW to assess flow velocities (e.g., using non-reactive sodium bromide solution as a tracer), (2) hydraulic conductivity testing in select wells within and adjacent to the PTW, and (3) continuous hydraulic head monitoring. The injection of tracer solutions into groundwater wells was authorized by the Environmental Protection Agency in accordance with the Underground Injection Control Program Regulation. The PTW PMP sampling includes sampling and

analysis for strontium-90, as well as for geochemical parameters to evaluate ion-exchange processes occurring within the wall. Table 4-7 summarizes the various elements of the PTW PMP.

**North Plateau Groundwater Monitoring Program (NPGMP).** With the completion of the full-scale PTW, the objective of the NPGMP has shifted from monitoring overall groundwater conditions within the north plateau and evaluating the NPGRS and the pilot PTW, to monitoring the strontium-90 plume and evaluating the effectiveness of the full-scale PTW. A supplementary NPGMP (WVDP-518) was also developed in 2010, in conjunction with the completion of the full-scale PTW. The primary objective of the NPGMP is to monitor the strontium-90 plume migration in groundwater farther upgradient and downgradient of the PTW than the areas monitored under the PTW PMP.

The NPGMP includes quarterly monitoring for gross beta and water levels at 26 well locations. Fourteen additional wells are monitored for water level only. Groundwater seep and surface water samples continue to be collected on the north plateau as part of other site sampling programs (WVDP-098, Environmental Monitoring Program Plan, and WVDP-239, Groundwater Monitoring Plan).

**PTW Protection and Best Management Plan.** A protection and best management plan for the PTW (WVDP-516) was also prepared in 2010. The plan includes measures that will be implemented to protect the physical integrity of the PTW during its operational lifetime, and describes best management practices that will be implemented to increase the effectiveness and longevity of the PTW.

## Other Groundwater Sampling Observations on the North Plateau

**Monitoring Near Former Lagoon 1.** Southeast of the strontium-90 plume, elevated gross beta concentrations have also been observed in groundwater downgradient of former lagoon 1, which was backfilled in 1984. (See Figure 4-2.) Gross beta concentrations in wells 8605 and 111 are consistently above the strontium-90 DCG and are remaining stable from year to year, as shown in the 10-year trend graph on Figure 4-9. The source of the gross beta activity is assumed to be radiologically contaminated material in the backfill and remaining sediment in the location of former lagoon 1.

**Metals Sampling on the North Plateau.** In 2005, 2007, and 2008, select groundwater wells were sampled to evaluate metals concentrations in groundwater within the strontium-90 plume area associated with MPPB sources. In 2008, a Geoprobe® investigation was performed to collect soil and groundwater data to further evaluate metals contamination. Using newly established groundwater background metals concentrations and the Technical and Operational Guidance Series (TOGS) 1.1.1 Class GA Groundwater Quality Standards, a set of site-specific GSLs were established. (Refer to Appendix D for a description of the methodology by which GSLs were established.)

During 2010, no special metals sampling was performed. Wells were routinely sampled for metals according to the GMP. Data are presented in Appendix D. These results were compared with the established WVDP GSLs and background levels (see Table 4-10). Nickel and chromium were detected, as in previous years, at concentrations above the GSLs in wells 706, 502, and 405, which are constructed of stainless steel. Elevated concentrations were attributed to corrosion of the well screens. (For additional detail, refer to "Investigation of Chromium and Nickel in the S&G Unit and Evaluation of Corrosion in Groundwater Monitoring Wells" in previous Annual Site Environmental Reports.)

Groundwater from well 1303, a polyvinyl chloride well downgradient of the remote-handled waste facility, contained arsenic at a maximum of 51 micrograms per liter (µg/L) (compared with the GSL of 25 µg/L), beryllium at a maximum concentration of 3.2 µg/L (compared with the GSL of 3.0 µg/L), chromium at a maximum of 86 µg/L (compared with the GSL of 52.3 µg/L), nickel at a maximum concentration of 122 µg/L (compared with the GSL of 100 µg/L), and vanadium at a maximum of 113 µg/L (compared with the GSL of 69.6 µg/L). These values are consistent with historical concentrations from this location.

As discussed previously in this chapter, four new standard-construction monitoring wells (MP-01 through MP-04) were installed downgradient of the MPPB, south and west of the FRS. The wells replaced two well points (WP20D and WP20S) and supplement downgradient surveillance by providing more representative groundwater monitoring data in that area. Groundwater samples from these locations were analyzed for metals listed in Title 6 of the Official Compilation of Codes, Rules, and Regulations of the State of New York Part 373-2 Appendix 33 during three sampling events in 2010. Arsenic, barium, beryllium,

**TABLE 4-7**
**Permeable Treatment Wall (PTW) Performance Monitoring Program (PMP)**

| *Activity or Parameter Type* | *Description of Measurement* | *Purpose* |
|---|---|---|
| **Hydraulic Monitoring** | | |
| Water level measurements | Field measurement of depth to groundwater | Water level measurements will allow for evaluation of the three-dimensional flow path in the vicinity of and through the PTW. |
| Continuous water level monitoring | Water level/pressure-head measurements (measurements continuously recorded at regular intervals) | Continuous water level measurements inside the PTW provide supplemental data to evaluate flow within and through the PTW as well as rate of response to weather events. |
| Tracer dilution tests | Field measurement of the rate of decreasing concentration of sodium bromide tracer solution injected into wells within the PTW | Dilution tests are used to determine groundwater flow velocity within the PTW. |
| Hydraulic characterization of hydrogeologic units | Single well tests (slug tests) | Slug tests provide estimates of hydraulic conductivity within and adjacent to the PTW used to evaluate variable rates of groundwater flow at different depths within the zeolite and within the native soils in proximity to the PTW. |
| **Groundwater Quality Monitoring** | | |
| Field parameters | Temperature, pH, oxidation-reduction potential, specific conductance, dissolved oxygen, and turbidity | Results from these field tests will be utilized to identify the overall conditions in the groundwater and any potential changes in conditions that may occur due to site decommissioning activities. |
| Geochemical parameters | Sodium, potassium, calcium, magnesium, carbonate, bicarbonate, sulfate and chloride | Monitoring of geochemical parameters allows for evaluation of cation exchange occurring within and downgradient of the PTW as groundwater flows through the treatment media. |
| Radioisotopic analyses | Strontium-90 (Sr-90) | Collection and analysis of groundwater samples for Sr-90 provides for evaluation of the performance of the treatment media in reducing Sr-90 concentrations and provides upgradient conditions of groundwater entering the PTW. |
| **Reconnaissance Inspections** | | |
| Visual inspections | Inspection Checklist Items | Visual inspections document the condition of the PTW, the PTW wells, and the nearby storm water drainage system. |

chromium, lead, nickel, and zinc were sporadically detected in these wells near or slightly above the detection limits. Higher concentrations of metals were detected in the first samples collected at these locations. Metals concentrations and sample turbidity decreased significantly in the subsequent sampling events. Only one sample from the four new MPPB wells exceeded the GSLs for metals. Lead was measured at MP-02 at a maximum of 47 µg/L compared with the GSL of 42.7 µg/L. (See Appendix D.)

**Tritium in Groundwater on the North Plateau.** On the north plateau, elevated tritium concentrations have historically been observed near the lag storage area, the lag storage hardstand, and adjacent to and downgradient of the lagoon system. Tritium concentrations sitewide have been consistently decreasing. Residual tritium activity is attributed to former operations as part of nuclear fuel reprocessing. No new source of tritium is suspected. As shown in Table 4-8, the maximum tritium concentration measured in groundwater from the north plateau in 2010, 3.5E-05 µCi/mL, was at well point WP-C, downgradient of the MPPB (see Figure A-7). This concentration was two orders of magnitude below the DOE DCG for tritium of 2.0E-03 µCi/mL.

Tritium concentrations in groundwater at the WVDP have been steadily decreasing, because tritium has a relatively short half-life, about 12.3 years. Dilution from surface water infiltration and groundwater recharge is also contributing to the decrease, as is evaporation. Current tritium concentrations in groundwater from most monitoring locations on the north plateau are close to or within the range of background values. Monitoring locations where tritium exceeded GSLs and background concentrations are listed in Table 4-10.

**Radioisotopic Sampling Results on the North Plateau.** In addition to being analyzed for gross alpha, gross beta, tritium, and strontium-90, samples from eight groundwater wells in the S&G unit in the north plateau (401, 406, 408, 1304, and the new MPPB wells MP-01 through MP-04) were analyzed for specific radionuclides (see Tables 4-3 and 4-4). Well 401 serves as a background well. Two sampling locations in the south plateau (well 909 and the NDA sump [NDATR]) are also analyzed for specific radionuclides. (Note that radium-226, radium-228, uranium-234, and uranium-238 occur naturally in the environment.) (See Appendix D-2.)

**TABLE 4-8**
**2010 Maximum Concentrations of Radionuclides[a] in Groundwater at the WVDP Compared With WVDP Groundwater Screening Levels (GSLs)[b]**

| *Radionuclide* | *Regulatory Requirement* | | | *Environmental Surveillance* | | | *GSL (µCi/mL)* |
|---|---|---|---|---|---|---|---|
| | *Well ID With Maximum Concentration* | *Flag [c]* | *Maximum Concentration (µCi/mL)* | *Well ID With Maximum Concentration* | *Flag [c]* | *Maximum Concentration (µCi/mL)* | |
| Tritium | NDATR | | **1.06E-06** | WP-C | | **3.50E-05** | 1.78E-07 |
| Strontium-90 | MP-02 | | **3.70E-04** | – | | – | 5.90E-09 |
| Technetium-99 | MP-04 | | **3.42E-08** | – | | – | 5.02E-09 |
| Iodine-129 | NDATR | | **1.99E-08** | – | | – | 9.61E-10 |
| Cesium-137 | NDATR | J | 3.70E-09 | – | | – | 1.03E-08 |
| Radium-226 | 408 | | 5.15E-10 | – | | – | 1.33E-09 |
| Radium-228 | 408 | | 1.40E-09 | – | | – | 2.16E-09 |
| Uranium-232 | MP-01 | J | 1.18E-10 | – | | – | 1.38E-10 |
| Uranium-233/234 | MP-04 | | **1.75E-09** | – | | – | 6.24E-10 |
| Uranium-235/236 | MP-04 | J | **2.34E-10** | – | | – | 8.07E-11 |
| Uranium-238 | MP-04 | | **1.40E-09** | – | | – | 4.97E-10 |
| Total Uranium | NDATR | | **3.03E-03** | – | | – | 1.34E-03 |

Note: Bolding indicates that the radionuclide exceeds the GSL.
-- Indicates that none of the environmental surveillance wells exhibited positive results for these radionuclides.
[a] The table presents the maximum concentrations of radionuclides that were positively identified in groundwater wells at the WVDP; all other radionuclides were not positively identified.
[b] GSLs for radiological constituents are set equal to the larger of the background concentrations or NYSDEC Technical and Operational Guidance Series 1.1.1 Class GA Groundwater Quality Standards (see Table D-1A).
[c] The "J" flag indicates the result is an estimated value.

The maximum concentration of radionuclides measured in groundwater at the WVDP during 2010 is presented in Table 4-8. No carbon-14 was detected in 2010, so this radionuclide is not included. The maximum concentrations of radionuclides for the RCRA regulatory wells were observed at the recently installed wells, MP-01, -02, -03, and -04, immediately downgradient of the MPPB, and in well 408 in the same vicinity on the north plateau. Strontium-90, technetium-99, radium-226, radium-228, uranium-232, uranium-233/234, uranium-235/236, and uranium-238 were observed at the wells within the core area of the plume immediately downgradient of the MPPB.

The MP wells (MP-01, -02, -03, and -04) were also analyzed for supplemental radioisotopes, not routinely included in the WVDP analytical suites. These isotopes include neptunium-237, plutonium-238, plutonium-239/240, plutonium-241, americium-241, and curium-243/244. Testing for these radionuclides was included in the program to investigate the potential for contamination from historic operations within the MPPB. During the first three rounds of sampling during 2010, none of these supplemental radionuclides were detected. (See Appendix D[CD], Table D-2H.)

**Results for Volatile and Semivolatile Organic Compounds (VOCs and SVOCs).** In accordance with the Consent Order, select wells within the S&G unit are monitored for VOCs and SVOCs because concentrations exceeding TOGS 1.1.1 Class GA Groundwater Quality Standards were found during the RFI.

Currently, the only S&G monitoring location with consistent positive detections of VOCs is well 8612, located northeast and downgradient of the CDDL at the northeast edge of the north plateau. (See Tables 4-9 and 4-10, and Figure A-7 in Appendix A.) Figure 4-10 illustrates the concentration ranges of four detected VOCs at well 8612. Only one VOC continues to be detected slightly above the TOGS 1.1.1 Class GA Groundwater Quality Standards. The concentrations are steadily decreasing and are currently not significantly above detection limits. The VOCs in well 8612 are presumed to be from wastes buried in the CDDL.

Two SVOCs (benzo[b]fluoranthene and benzo[k]fluoranthene), although estimated below their practical quantitation limit, were above their TOGS 1.1.1 Class GA standard in September 2010. However, these analytes were not detected in the subsequent sampling in December 2010 or March 2011.

In 2010, downgradient of former lagoon 1, the SVOC tributyl phosphate (TBP), which has been detected in this area since routine monitoring began, was again detected in groundwater from well 8605. However, the maximum concentration was significantly lower than the historic high of 700 µg/L in December 1996. TBP has also been detected in well 111, near well 8605, but at concentrations close to the quantitation limit of 10 µg/L. (See Figure 4-11.) TBP in this area is believed to be from residual contamination from liquid waste management activities in the former lagoon 1 area during nuclear fuel reprocessing. No TOGS 1.1.1 screening criterion has been established for TBP.

A summary of maximum concentrations of organic compounds detected in WVDP groundwater wells for TBP and the VOCs that exceeded TOGS 1.1.1 criteria in 2010 is provided in Table 4-9.

## Groundwater Sampling Observations on the South Plateau: Weathered Lavery Till and the NDA

**Interim Measures (IM).** In 1990, a trench system was constructed through the WLT along the northeast and northwest sides of the NDA to intercept and collect groundwater that was potentially contaminated with

**TABLE 4-9**
**2010 Summary of Maximum Concentrations of Organic Constituents in Select WVDP Groundwater Wells**

| *Constituent* | *Regulatory/Waste Management Monitoring Program* | | *New York State Class GA Groundwater Quality Standards[a] (µg/L)* |
|---|---|---|---|
| | *Well with the Highest Concentration* | *Maximum Concentration (µg/L)* | |
| 1,2-Dichloroethylene (total) | 8612 | 16 | 5.0 |
| Tributyl phosphate | 8605 | 181 | NA |

NA - Not applicable.
[a] Source: 6 NYCRR Part 703, Division of Water TOGS 1.1.1, Class GA Groundwater Quality Standards.

a mixture of radioactive n-dodecane and TBP. Sampling location NDATR is a sump at the lowest point of the interceptor trench. Groundwater is collected at NDATR and is transferred to the low-level waste treatment facility for processing. (See also "Interim Measures [IM]" under "NDA Cap" in the Environmental Compliance Summary and "U.S. Nuclear Regulatory Commission-Licensed Disposal Area Interceptor Trench and Pretreatment System" in Chapter 1.) Monitoring results in 2010 detected no TBP in groundwater from the NDA interceptor trench. Groundwater elevations are monitored quarterly in and around the interceptor trench to ensure that an inward gradient is maintained, thereby minimizing outward migration of contaminated groundwater.

A second IM, to stabilize the NDA cover and to minimize infiltration of groundwater, surface water, and precipitation into the NDA, was completed in December 2008. This included installing a geosynthetic cap over the NDA, a low-permeability subsurface groundwater slurry wall upgradient of the NDA, and surface water drainage diversions. Twenty-one piezometers were installed to monitor groundwater elevation differences both upgradient and downgradient of the slurry wall. Water level data from 2009 and 2010 suggest that water levels in areas covered by the geomembrane are continuing to decline. Water levels in piezometers outside the cap and along the upgradient side of the slurry wall have increased slightly in some areas due to groundwater mounding but generally continue to follow seasonal trends. The reduction in the volume of water extracted from the NDA interceptor trench since the cap and barrier wall were installed is the strongest indication that the IM is effectively reducing flow through the NDA. The volume pumped from the NDA trench in 2010 (63,000 gallons) was less than one-fifth of the volume pumped in CY 2007, before the interim measure. Note that the volume of water pumped from the NDA during 2008 includes volume collected during new cover construction activities, when the old NDA cover was being removed. (See Figure 4-13.)

Refer to Environmental Compliance Summary "Interim Measures" under "RCRA §3008(h) Administrative Order on Consent" for further discussion of the NDA IM.

**Radioisotopic Sampling Results on the South Plateau.** Gross beta, tritium, and several radioisotope concentrations in groundwater from NDATR (see Table 4-10 in this chapter and Figure A-8 in Appendix A) continued to be elevated with respect to GSLs and to concentrations in background monitoring locations on the south plateau. Gross beta concentrations at NDATR have increased with time, with even steeper increases observed since installing the IM. The most recent increases are believed to be attributable to less dilution of water that collects within the trench because groundwater and surface water infiltration into the NDA has been significantly reduced. Similar to the north plateau, strontium-90 is the predominant contributing radioisotope to the measured gross beta concentrations.

Samples from the NDATR sump also exhibited the highest concentrations for tritium, iodine-129, cesium-137, and total uranium. Tritium concentrations at NDATR have continued to decrease, but remain the highest of any WVDP regulatory/waste management groundwater monitoring location on the site (1.06E-06 µCi/mL, 2010 maximum) (see Table 4-8). However, this tritium concentration is well below the DOE DCG of 2.0E-03 µCi/mL. The recent increases in iodine-129 and cesium-137 are believed to be attributable to less dilution of the water that collects within the trench, as described above.

WLT well 909 also exhibited elevated tritium, and other radioisotopic concentrations above the GSL during 2010, consistent with historical values. The gross alpha concentration exhibited an increase at well 909 during the December 2010 sampling event. This result was the highest of record at 1.53E-08 µCi/mL (marginally above the GSL of 1.50E-08 µCi/mL). Recent gross beta concentrations at well 909 are not increasing.

Radionuclide concentrations in groundwater downgradient of the NDA are presumed to be associated with former waste burial operations.

## Additional Monitoring and Investigations

**Groundwater Monitoring Downgradient of the Waste Tank Farm (WTF).** The HLW in the underground tanks has been removed and solidified through the vitrification process. The tanks containing the residual waste remain in place. In 2005, DOE evaluated the current and historical groundwater conditions in the vicinity of the WTF. Throughout waste processing activities, groundwater controls were in place to (1) reduce the upward hydrostatic pressure on the tanks, and (2) to maintain an inward hydraulic gradient toward the tanks, thereby inhibiting any potential leaks from the tanks. The natural inward hydraulic gradient is influenced by periodically pumping a dewatering well (DWW), located outside the vault, that also controls the hydrostatic pressure near the tanks.

Radioactivity in groundwater near the WTF is routinely monitored and evaluated. Elevated gross beta concentrations from well 8607 have been observed since 1994, with the maximum concentration measured in 2005. Gross beta activity has also been observed in the DWW and the tank 8D-2 pan. Radionuclide samples from these locations were collected in 2007 to determine the source(s) of the gross beta activity. After evaluating the radiological results, it was concluded that the gross beta activity in well 8607 was most likely attributed to residual contamination from historical events in and around the WTF (i.e., minor leaks from condensate lines or the WTF underdrain) and was not believed to have originated from the tanks themselves. Monitoring of specific radionuclides at these sampling points was discontinued in favor of continued gross beta monitoring, because gross beta results provide an adequate indicator of radioactivity concentrations. During 2010, gross beta concentrations at well 8607 continued to exhibit a decreasing trend from the 2005 maximum. The underground waste tanks are being stabilized by a tank and vault drying system that began operations in December 2010. (See "WTF Tank and Vault Drying System" in the Environmental Compliance Summary.)

**Groundwater Infiltration to FRS Pool.** During mid-2005, water was found trickling into the empty FRS pool during a quarterly inspection. Approximately four to six inches of water had accumulated via a slope in the floor to a deeper stainless-steel-lined cask unloading pool (CUP). Analytical data for the FRS CUP water indicated that groundwater seepage was the source of the water. During periods of high precipitation or snow melt, slight seepage entered along the south wall. Elevated cesium-137 concentrations were observed in water samples collected from within the FRS pool. The cesium-137 is believed to be from residuals that adhered to the FRS pool walls when the pool was full. Groundwater seepage into the pool is thought to have dissolved some of the cesium. Because the water does not pose operational or safety concerns, it has been left in the CUP under routine monitoring. Currently, the water level in the CUP is measured daily by facility operators. There has been no change in these levels that would indicate additional groundwater has seeped into the FRS pool or that would indicate leakage out of the pool.

## Summary

Evaluation of groundwater results from 2010, as discussed in the previous sections and summarized in Table 4-10, continued to show that the most widespread area of groundwater contamination at the WVDP is the strontium-90 plume in the S&G unit on the north plateau. Other localized areas of contamination have been observed downgradient of the former lagoon 1, also on the north plateau, and downgradient of the NDA on the south plateau. Near-term measures to reduce water moving through the NDA included installing a slurry wall and geomembrane cover in 2008. The near-term activity to reduce contaminant levels in the strontium-90 plume on the north plateau was the installation of the full-scale PTW across the leading edge of the plume. Longer-term measures described in Phase 1 of the Final Environmental Impact Statement preferred alternative selected by the DOE in the Record of Decision (April 2010), as discussed in the "Environmental Compliance Summary," include removing the MPPB, removing the lagoons, and remediating the source of the north plateau plume.

## TABLE 4-10
## 2010 Groundwater Monitoring Results Exceeding Groundwater Screening Levels (GSLs) and Background Levels

| *Geologic Unit* | *Total # of Sampling Locations* | *# Locations with Results Greater Than GSLs* | *Locations with Results Greater than GSLs [a] (Constituent)* | *# Locations with Results Greater Than Background* | *Locations with Results Statistically Greater than Background (Constituent)* |
|---|---|---|---|---|---|
| **North Plateau** | | | | | |
| Sand and Gravel Unit | 44 | 26 | ***Radiological Parameters***<br>**GSEEP** (tritium [H-3])<br>**SP04** (H-3)<br>**104** (Gross beta)<br>**105** (Gross beta, H-3)<br>**106** (Gross beta, H-3)<br>**111** (Gross beta)<br>**116** (Gross beta)<br>**408** (Gross beta, strontium-90 [Sr-90], technetium-99 [Tc-99])<br>**501** (Gross beta, Sr-90)<br>**502** (Gross beta, Sr-90)<br>**602A** (H-3)<br>**801** (Gross beta, Sr-90)<br>**803** (H-3)<br>**8603** (Gross beta, H-3)<br>**8604** (Gross beta)<br>**8605** (Gross beta)<br>**8609** (Gross beta, Sr-90)<br>**8612** (H-3)<br>**WP-A** (H-3)<br>**WP-C** (H-3)<br>**WP-H** (Gross beta, H-3)<br>**MP-01** (Gross beta, Sr-90, Tc-99, uranium-233/234 [U-233/234], U-235/236)<br>**MP-02** (Gross beta, H-3, Sr-90, Tc-99, U-233/234, U-238, lead)<br>**MP-03** (Gross beta, Sr-90, Tc-99, U-233/234, U-238)<br>**MP-04** (Gross beta, Sr-90, Tc-99, U-233/234, U-235/236, U238<br><br>***Metals***<br>**502** (Chromium, nickel)<br>**706** (Chromium, nickel)<br>**MP-02** (Lead)<br><br>***Organics***<br>**8605** (tributyl phosphate [TBP])<br>**8612** (1,2-Dichloroethylene, total)<br>**MP-03** (Benzo[b]fluoranthene, Benzo[k]fluoranthene) | 34 | ***All Parameters***<br>**GSEEP** (Gross beta, H-3)<br>**SP04** (Gross beta, H-3)<br>**SP06** (Gross beta)<br>**SP11** (Gross beta)<br>**SP12** (Gross beta)<br>**103** (Gross beta)<br>**104** (Gross beta)<br>**105** (Gross alpha, gross beta, H-3)<br>**106** (Gross beta, H-3)<br>**111** (Gross beta)<br>**116** (Gross beta)<br>**302** (Gross beta)<br>**402** (Gross alpha)<br>**408** (Gross beta, Sr-90, Tc-99)<br>**501** (Gross beta, Sr-90)<br>**502** (Gross beta, Sr-90, barium, chromium, copper, nickel)<br>**602A** (H-3)<br>**605** (Gross beta)<br>**706** (Chromium, nickel)<br>**801** (Gross beta, Sr-90)<br>**802** (Gross beta)<br>**803** (Gross beta, H-3)<br>**804** (Gross beta)<br>**8603** (Gross beta, H-3)<br>**8604** (Gross beta)<br>**8605** (Gross alpha, gross beta)<br>**8607** (Gross beta)<br>**8609** (Gross beta, Sr-90)<br>**8612** (H-3, 1,2-Dichloroethylene, total)<br>**WP-A** (Gross beta, H-3)<br>**WP-C** (Gross beta, H-3)<br>**WP-H** (Gross beta, H-3)<br>**MP-01** (Gross beta, Sr-90, Tc-99 U-233/234, U-235/236, barium)<br>**MP-02** (Gross beta, Sr-90, H-3, Tc-99, U-233/234, U-238, arsenic, barium, copper, lead, zinc)<br>**MP-03** (Gross alpha, gross beta, Sr-90, Tc-99, U-233/234, U-238)<br>**MP-04** (Gross beta, Sr-90, Tc-99, U-233/234, U-235/236, U-238) |

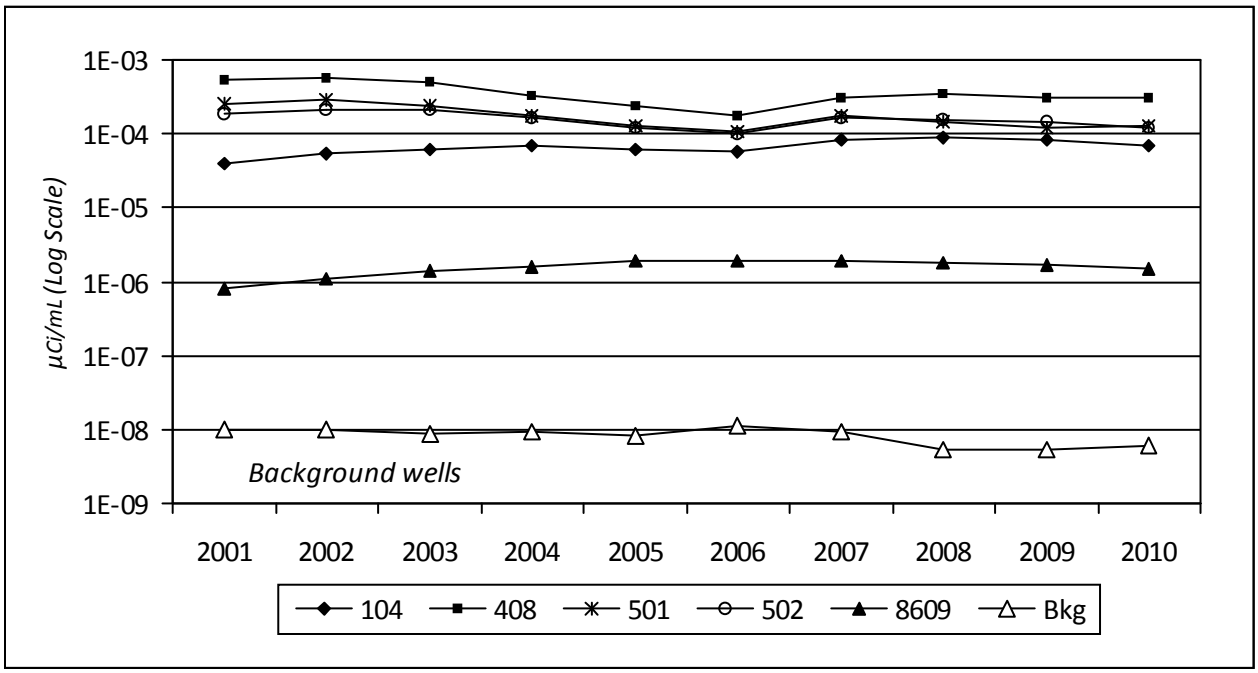
[a] The site-specific GSLs for radiological constituents were set to equal the larger of the WVDP background concentrations or NYSDEC TOGS 1.1.1 Class GA Groundwater Quality Standards as discussed on page D-1 and presented in Table D-1A. The GSLs for metals were set to equal the larger of the background concentration or NYSDEC TOGS 1.1.1 Class GA Groundwater Quality Standards as presented in Table D-1B. Organic constituents were compared directly with NYSDEC TOGS 1.1.1 Class GA Groundwater Quality Standards. Tributyl phosphate, detected in wells 111 and 8605, is not shown on these tables because no TOGS 1.1.1 standards have been established.

**TABLE 4-10 *(concluded)***
**2010 Groundwater Monitoring Results Exceeding Groundwater Screening Levels and Background Levels**

| *Geologic Unit* | *Total # of Sampling Locations* | *# Locations with Results Greater Than GSLs* | *Locations with Results Greater than GSLs [a] (Constituent)* | *# Locations with Results Greater Than Background* | *Locations with Results Statistically Greater than Background (Constituent)* |
|---|---|---|---|---|---|
| Lavery Till | 2 | 0 | None | 0 | None |
| Unweathered Lavery Till | 9 | 4 | ***Radiological Parameters***<br>**108** (H-3)<br>**110** (H-3)<br><br>***Metals***<br>**405** (Chromium, nickel)<br>**1303** (Arsenic, beryllium, chromium, nickel, vanadium) | 4 | ***Radiological Parameters***<br>**108** (H-3)<br>**110** (Gross beta, H-3)<br><br>***Metals***<br>**405** (Chromium, nickel)<br>**1303** (Arsenic, barium, beryllium, chromium, copper, nickel, vanadium, zinc) |
| Kent Recessional Sequence | 2 | 0 | None | 0 | None |
| **South Plateau** | | | | | |
| Weathered Lavery Till | 7 | 2 | ***Radiological Parameters***<br>**NDATR** (Gross beta, H-3, Sr-90, Tc-99, I-129, U-233/234, U-238, Total U)<br>**909** (Gross alpha, H-3, Sr-90, iodine-129 [I-129], U233/234, U-238, total uranium) | 3 | ***Radiological Parameters***<br>**NDATR** (Gross beta, H-3, Sr-90, Tc-99, I-129, U-233/234, U-238, total U, zinc)<br>**908R** (Gross alpha)<br>**909** (Gross alpha, gross beta, H-3, Sr-90, I-129, U-233/234, U-238, total U)<br><br>***Metals***<br>**NDATR** (Zinc) |
| Unweathered Lavery Till | 1 | 1 | ***Radiological Parameters***<br>**910R** (Gross alpha, duplicate<GSL) | 1 | ***Radiological Parameters***<br>**910R** (Gross alpha) |
| Kent Recessional Sequence | 4 | 0 | None | 0 | None |

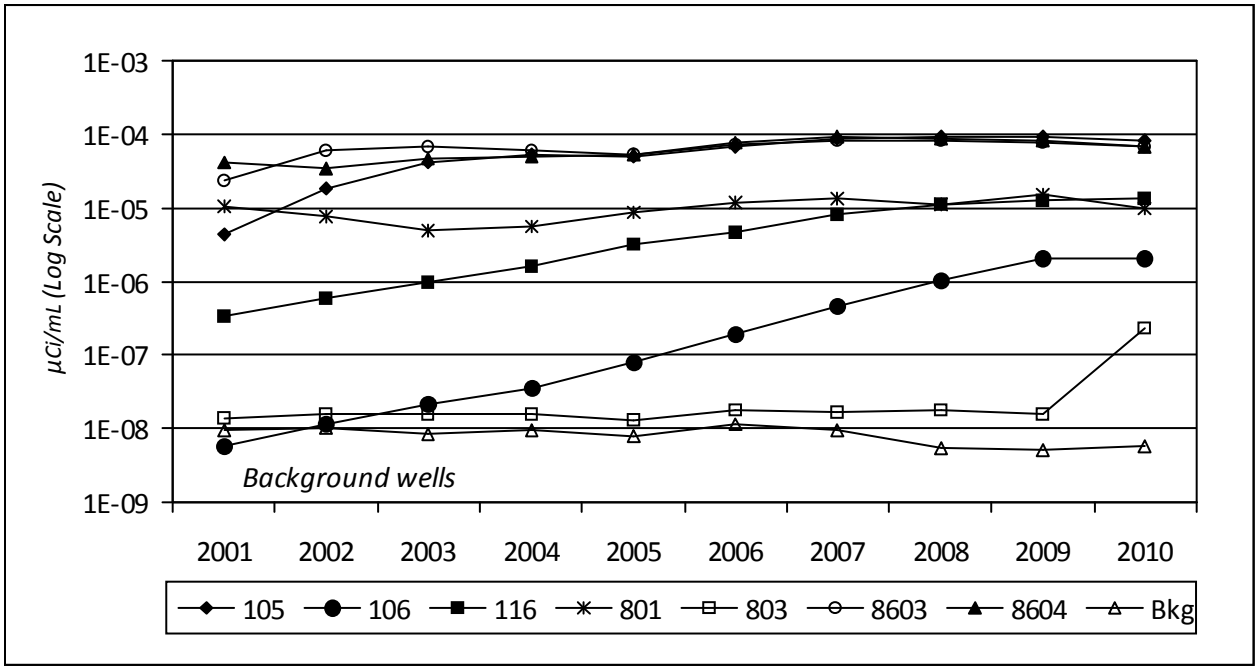
[a] The site-specific GSLs for radiological constituents were set to equal the larger of the WVDP background concentrations or NYSDEC TOGS 1.1.1 Class GA Groundwater Quality Standards as discussed on page D-1 and presented in Table D-1A. The GSLs for metals were set to equal the larger of the background concentration or NYSDEC TOGS 1.1.1 Class GA Groundwater Quality Standards as presented in Table D-1B. Organic constituents were compared directly with NYSDEC TOGS 1.1.1 Class GA Groundwater Quality Standards. Tributyl phosphate, detected in wells 111 and 8605, is not shown on these tables because no TOGS 1.1.1 standards have been established.

**FIGURE 4-4**
**Average Annual Gross Beta Concentrations**
**at Monitoring Wells Centrally Located Within the North Plateau Strontium-90 Plume**



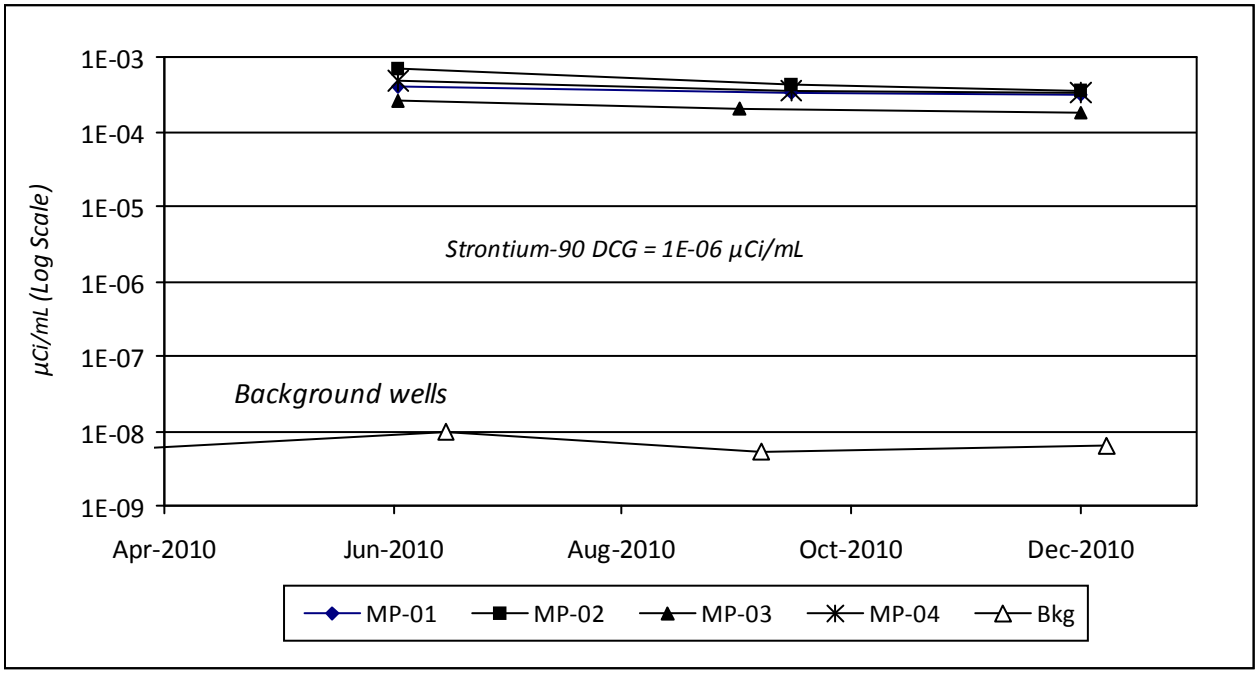

Note: Background (Bkg) wells 301, 401, 706, and 1302 (future proposed background well) are averaged for this comparison.

**FIGURE 4-5**
**Average Annual Gross Beta Concentrations**
**at Monitoring Wells Near the Leading Edge of the North Plateau Strontium-90 Plume**



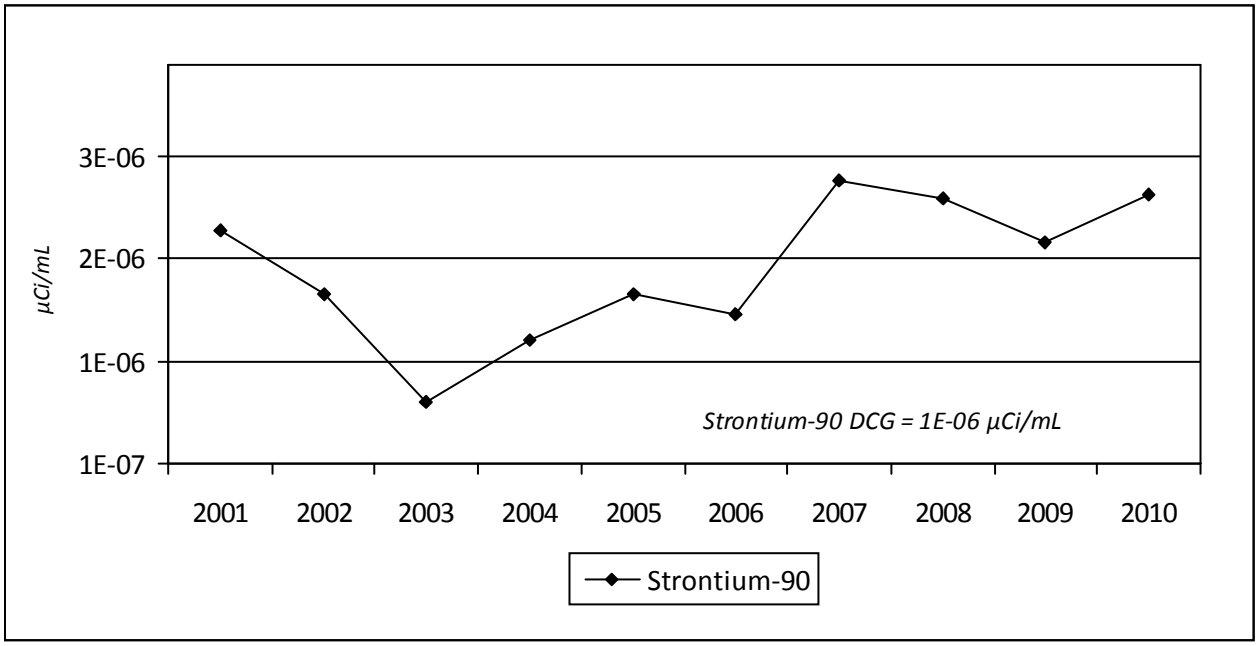

Note: Background (Bkg) wells 301, 401, 706, and 1302 (future proposed background well) are averaged for this comparison.

**FIGURE 4-6**
**First Three Quarters of Gross Beta Concentrations at the New Main Plant Process Building Wells**



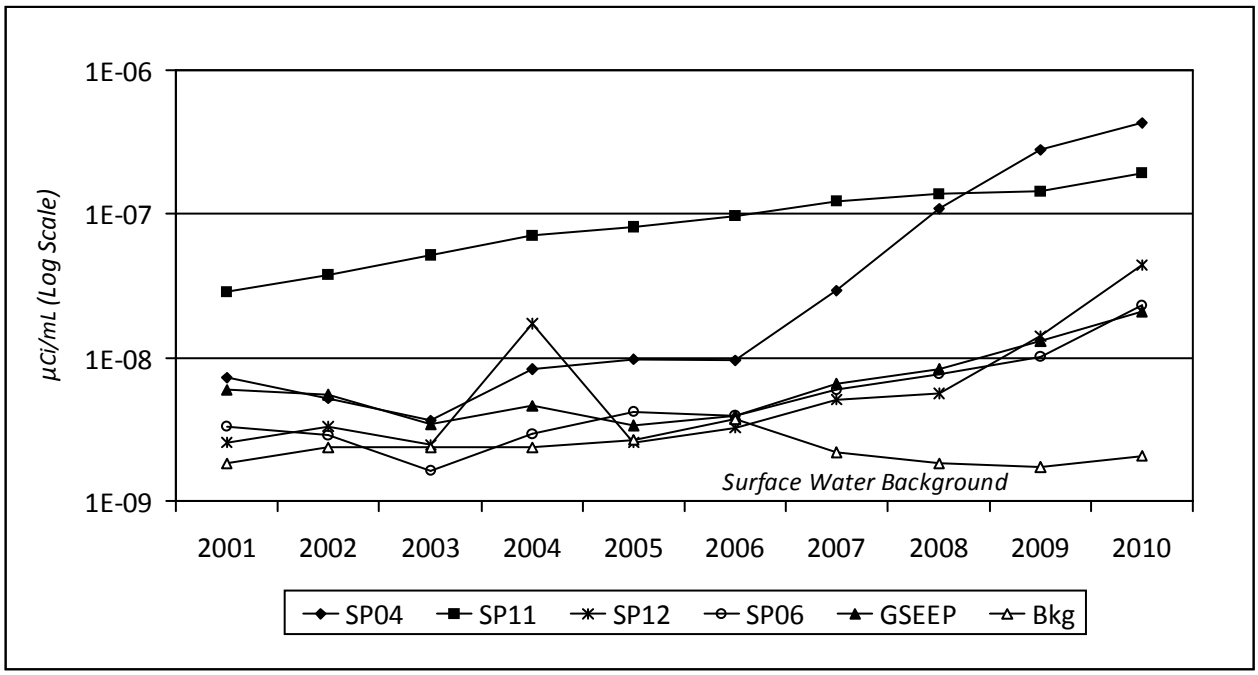

Note: Background (Bkg) wells 301, 401, 706, and 1302 (future proposed background well) are averaged for this comparison.

**FIGURE 4-7**
**Average Annual Strontium-90 Concentrations at WNSWAMP**



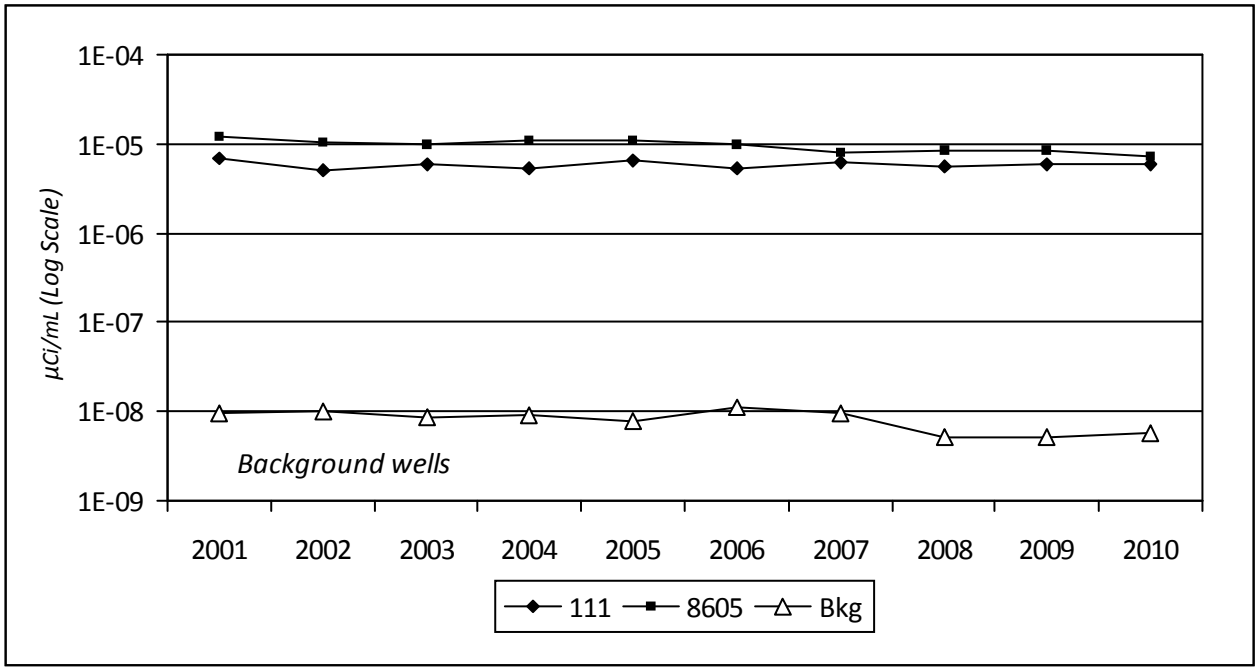

Note: Derived concentration guides (DCGs) are used as an evaluation tool for results from on-site locations as part of the routine environmental monitoring program. However, DOE DCGs are applicable only at locations accessible to members of the public. The WNSWAMP location is not accessible to the public.

**FIGURE 4-8**
**Average Annual Gross Beta Concentrations at Seeps From the Northeast Edge of the North Plateau**



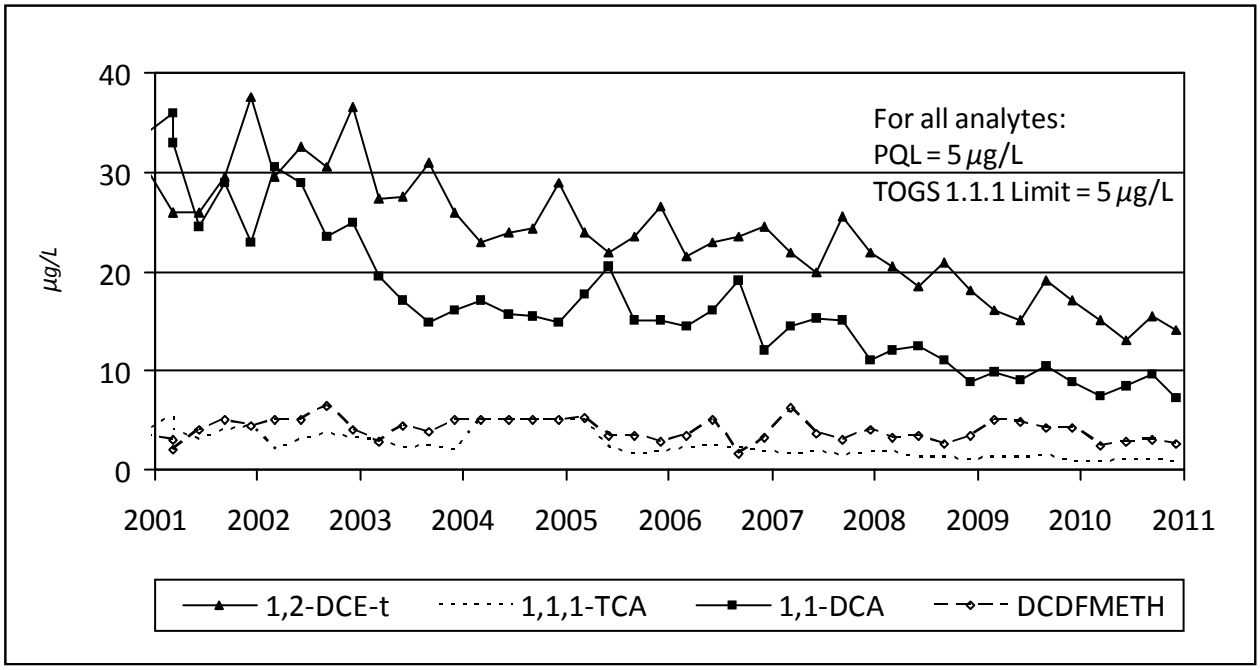

Note: Background (Bkg) from surface water sampling location WFBCBKG at Felton Bridge upgradient of the WVDP.

**FIGURE 4-9**
**Average Annual Gross Beta Concentrations at Monitoring Wells Near Former Lagoon 1**




Note: Background (Bkg) wells 301, 401, 706, and 1302 (future proposed background well) are averaged for this comparison.

**FIGURE 4-10**
**Concentrations of 1,2-DCE-t, 1,1,1-TCA, 1,1-DCA, and DCDFMeth at Well 8612 in the Sand and Gravel Unit**




Note: PQL = Practical Quantitation Limit
1,2-DCE-t = 1,2-Dichloroethylene (total)
1,1,1-TCA = 1,1,1-Trichloroethane
1,1-DCA = 1,1-Dichloroethane
DCDFMeth = Dichlorodifluoromethane

**FIGURE 4-11**
**Concentrations of Tributyl Phosphate at Monitoring Wells Near Former Lagoon 1 in the Sand and Gravel Unit**

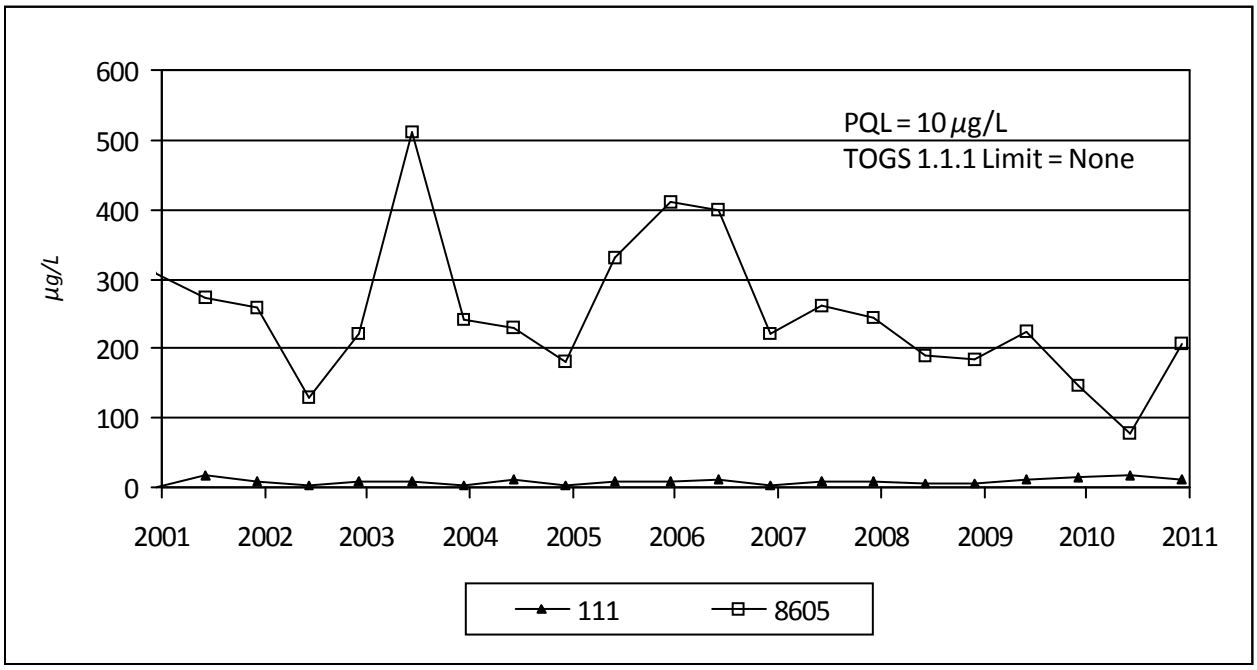
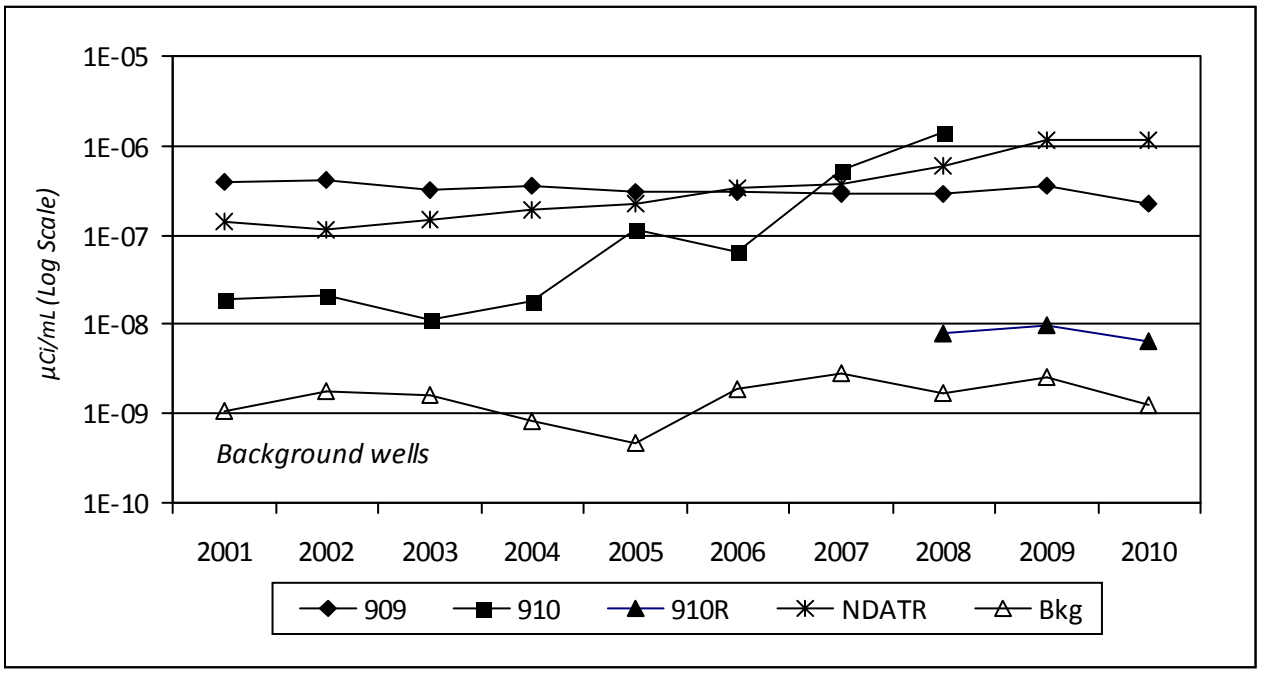
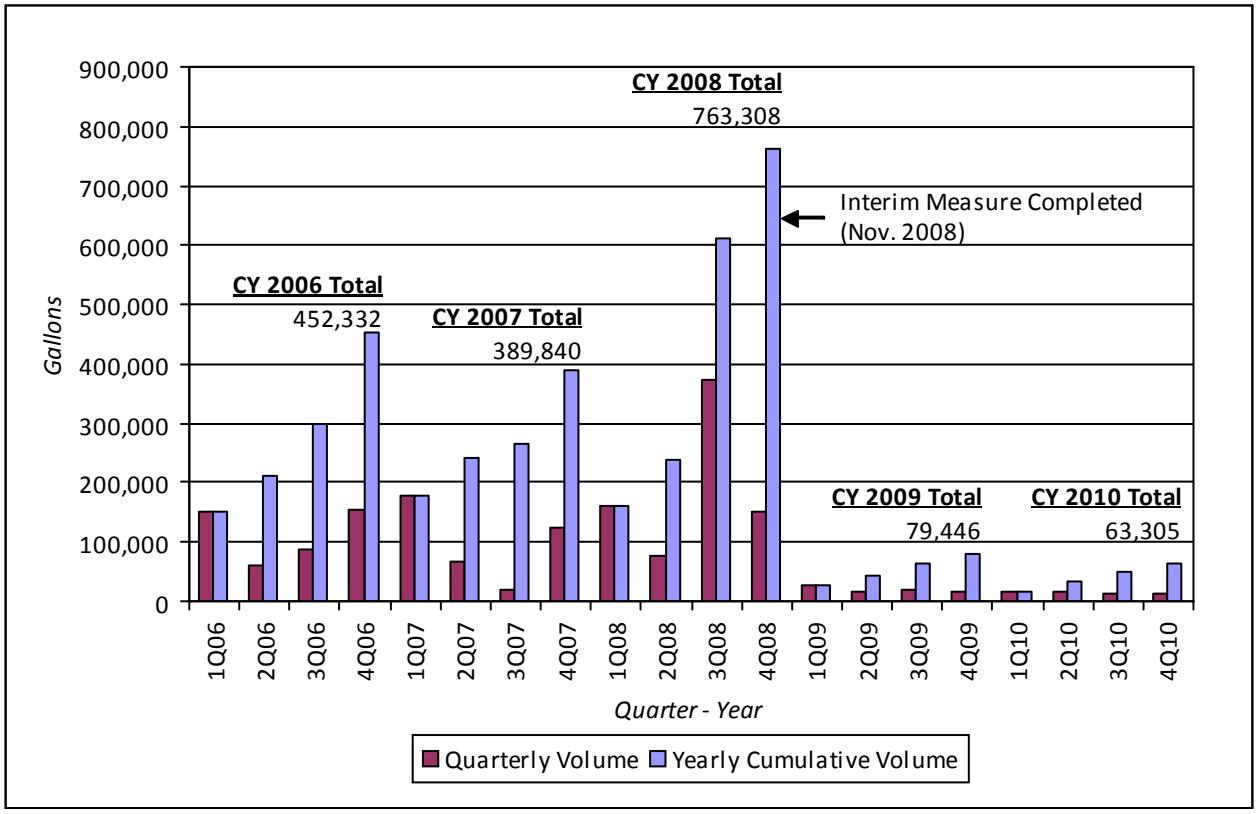


**FIGURE 4-12**
**Average Annual Gross Beta Concentrations**
**at Monitoring Wells Downgradient of the NDA and at the NDA Trench**




Notes: Background well for the south plateau is 1008C.
Well 910 became damaged in 2007 and was decommissioned in 2008 when well 910R was installed.

**FIGURE 4-13**
**Volume of Water Pumped From the NDA Interceptor Trench During Calendar Year (CY) 2010**




Note: 1Q = Jan–Mar
2Q = Apr–Jun
3Q = Jul–Sep
4Q = Oct–Dec