5.0 BUILDING D&D MONITORING

The DOE decontamination and decommissioning (D&D) process is the sequence of events that occurs in the disposition of surplus DOE facilities. D&D is primarily concerned with decontamination, dismantling, removal, or entombment of the surplus facilities. The primary tasks associated with D&D are:

- Surveillance and Maintenance
- Assessment and Characterization
- Environmental Review
- Close Out

Activities associated with these tasks involve the removal of fixed materials (including residual constituents of concern), equipment, piping, tanks, ducts, ceilings and other internal building structures, and the buildings themselves. In general, implementation of D&D will be performed in phases, allowing alternative interim use of most buildings before the final decommissioning of the buildings (DOE 1994b).

- Building specific D&D activities involve three major steps:
- Deactivation of Building Processes
- Demolition of Building Structures
- Remediation of Building Foundations and Surroundings

Based on the IMP, four groundwater sampling events are required to collect a data set to be used for determination of a unique baseline for each building which will undergo D&D groundwater monitoring. Monitoring will be accomplished by the installation of D&D monitoring wells immediately adjacent to the specific building. These wells, in conjunction with appropriately located existing wells, will provide the baseline data, and also be utilized for future D&D monitoring of the building specific impacts, if any, on downgradient groundwater quality. As long as time permits, baseline determination will be based on current and future data. If the D&D schedule for a given building becomes accelerated, existing monitoring wells in the vicinity of the building may be utilized, as the IM/IRA suggests, to sample for collection of baseline data utilizing the previous three years sampling data. Depending on the groundwater flow conditions existing at a specific building, it may be possible to create a baseline even though the building has previously been demolished. If linear flow velocities in the immediate vicinity of the building are relatively low, then contaminants potentially mobilized by D&D may take a year or two to reach the D&D monitoring wells.

The IM/IRA for the IA outlines groundwater monitoring activities established to ensure that building D&D activities do not inadvertently impact surface water by degrading groundwater beneath or in contact with the base of the demolished buildings. The required groundwater monitoring will provide the data necessary to determine if the

precautions and actions taken during D&D have prevented or allowed migration of contaminants to groundwater. If existing information regarding a proposed D&D activity indicates the potential to contaminate groundwater, generally through a knowledge of historical building activity and use, then a pre-D&D groundwater baseline will be established for that building. Exceedances to the baseline are defined as detected concentrations greater than the mean + 2 standard deviations above the baseline (K-H 1998b).

This section is relatively new to the Annual RFCA Groundwater Monitoring Report. It will be expanded during each successive year to incorporate the D&D groundwater activities for that calendar year. The subsections are organized by the particular buildings addressed in a given D&D SAP. The subsections below discuss historical D&D activities through 1999 for Buildings 123, 444, 771, 886, and 779; and Buildings 707, 776/777, 371/374, 865, and 883. Buildings 707, 776/777, 371/374, 865 and 883 are discussed in the same subsection, because no D&D groundwater monitoring data has been collected for them through CY99.

5.1 Building 123

Building 123, used as a laboratory for bioassay, dosimetry, and water quality parameter analyses, was located on Central Avenue between Third and Fourth Streets at RFETS. The building underwent D&D activities, and was ultimately demolished in 1998. Subsequent to demolition, six monitoring wells (10098-10598) were installed with a Geoprobe rig immediately adjacent to the building foundation. Wells 10098 and 10198 are upgradient. The rest of the wells are downgradient, with well 10598 potentially being cross gradient. The purpose of these wells was twofold. First, to assess the potential impact of D&D activities on local groundwater quality and, second, to prepare an IHSS ranking for prioritizing the Building 123 site on the ER ranking list. This report is only concerned with the potential impact of Building 123 D&D activities on downgradient groundwater quality. Figure 5-1 presents the location of Building 123 and associated D&D monitoring wells.

As described above, four sampling events are required to collect a data set to be used for determination of a unique baseline for each building which will undergo D&D groundwater monitoring. Unfortunately, the schedule for Building 123 D&D became accelerated and it was not possible to collect the required amount of pre-demolition data to derive baseline values for the site. In addition, there were not an appropriate number or distribution of existing monitoring wells in the vicinity of Building 123 to sample for collection of baseline data utilizing the previous three years sampling data. Through 1999, three sampling rounds have been completed at the Building 123 D&D monitoring wells. One sampling round, post demolition, was accomplished at the Building 123 D&D monitoring wells during 1998. Two sampling rounds, one in the 1st Quarter and one in the 3rd Quarter, were accomplished during 1999.

Because a baseline cannot be established, water quality with respect to Building 123 must be evaluated in terms of an upgradient/downgradient comparison of water quality. Analytes are screened in terms of exceedances to Tier I and Tier II groundwater action levels, which is an effective method for determining contaminants of concern. The results of the three sampling rounds completed at Building 123 during 1998 and 1999 indicate that metals analyses

exhibited no results above Tier II action levels. There were no Tier I exceedances for VOCs, nitrates, or radionuclide species. A few slight Tier II exceedances occurred for VOCs, nitrates, and radionuclides during 1998 and 1999. Downgradient monitoring well 10498 appears to be the most impacted to date. The Tier II exceedances are listed below.

VOCs:

- Monitoring well 10498; PCE results of 15 µg/L and 58.9 µg/L on 8/12/98 and 2/17/99, respectively

Nitrates:

- Monitoring well 10498; nitrates results of 27 mg/L and 17 mg/L on 8/12/98 and 2/17/99, respectively

Radionuclides:

- Monitoring well 10098; uranium 233/234 result of 1.13 pCi/L and uranium 238 result of 1.08 pCi/L on 8/10/98
- Monitoring well 10298; uranium 233/234 result of 1.08 pCi/L and uranium 238 result of 1.10 pCi/L on 8/11/98
- Monitoring well 10398; uranium 233/234 result of 1.264 pCi/L and uranium 238 result 1.007 pCi/L on 8/27/99
- Monitoring well 10498; uranium 233/234 results of 1.41 pCi/L and 2.02 pCi/L on 8/12/98 and 2/17/99 respectively, and uranium 238 results of 1.22 pCi/L and 1.51 pCi/L on 8/12/98 and 2/17/99, respectively

In conclusion, there are no Building 123 upgradient D&D well VOC or nitrate Tier II exceedances compared to slight PCE and nitrates exceedances in downgradient D&D well 10498. For uranium isotopes there were slight exceedances for U-233/234 and U-238 in upgradient well 10098 compared to slight U-233/23 and U-238 exceedances in three downgradient wells (10298, 10398, and 10498).

5.2 Building 444

The Sampling and Analysis Plan for the D&D monitoring of Building 444 was initiated during late 1998. The SAP was submitted Final to the Agencies in July 1999. The D&D monitoring wells associated with the building were installed before the end of 1999. Building 444 complex is currently scheduled for demolition in 2002. This will allow adequate time to construct a groundwater chemistry baseline for these facilities.

Building 444 is located on the south side of Cottonwood Avenue between fourth and Sixth Streets at RFETS. The Building 444 cluster was used for the manufacturing of depleted uranium and beryllium components, and did not handle plutonium or enriched uranium. Major processes conducted in the building included machining, welding, and cleaning. Building 444 also contained a foundry and a laboratory where parts could be etched, electroplated, and coated. Uranium and beryllium are the major constituents that were used in the building. In addition, solvents

from machining and cleaning, and other wastes associated with electroplating were generated. Figure 5-2 presents the location of Building 444 and the D&D groundwater monitoring wells associated with it.

Six new D&D monitoring wells were installed at Building 444 during the fall of 1999 (40099 – 40499, and 41299). Wells 40099 and 40199 are upgradient wells, and the rest, in addition to existing well P419689, are downgradient wells. Except for existing well P419689, Building 444 D&D monitoring wells had generally only been sampled once through CY 1999, although wells 40199 and 40299 were sampled in both 3rd Quarter and 4th Quarter, 1999. Existing well P419689 had no groundwater samples collected from it between 12/20/96 and 11/9/99 (a D&D groundwater sampling round); therefore, the previous three years of data are not available for baseline consideration.

Until a geochemical baseline is established for groundwater in the vicinity of Building 444, analytes are discussed in terms of exceedances to Tier I and Tier II groundwater action levels. The results of the D&D sampling completed through 1999 indicate that there are no Tier I exceedances for nitrates, metals, or VOCs from any Building 444 D&D well with the exception of a November 1999 sample from upgradient well 40099. This sample yielded a TCE concentration of 830 µg/L. A few Tier II exceedances occurred during 1999 for wells 40099, 40299, 40499, 41299 and existing well P419689 for VOCs. All five wells exhibited Tier II exceedances for PCE in addition to a 1,2-DCE exceedance in well 40099 and a TCE exceedance in well 41299. Well 41299 also exhibited Tier II exceedances for U-233,234 and U-238 that were below the Site M2DS's for those analytes (see Section 5.4). Monitoring wells 40199 and 40399 had no results over Tier II groundwater action levels.

5.3 Building 771

The Sampling and Analysis Plan for the D&D monitoring of Building 771 was initiated during late 1998. The SAP was submitted Final to the Agencies in July 1999. The D&D monitoring wells associated with the building were installed before the end of 1999. Building 771, including Buildings 771C and 774, is currently scheduled for demolition in 2003. This will allow adequate time to construct a groundwater chemistry baseline for Building 771.

Building 771 is located in the PA, at the northeast end of the diagonal road, immediately south of the PACS-3 entrance to the PA. Building 771 was the plutonium component production facility at Rocky Flats from 1953 through 1957. After 1957 the building was used for the chemical recovery of plutonium and americium from manufacturing residues and scrap metal. The building also contained a laundry. Building 774 is part of the Building 771 complex and is located approximately 200 east of Building 771. Building 771C connects the two buildings. Building 774 was used for the treatment of radioactive aqueous waste, waste oils, and non-radioactive photograph solutions. Buildings 771C and 774 are to be decommissioned along with Building 771. Plutonium, americium, and solvents are the major contaminants of concern. Figure 5-3 presents the location of Building 771, including Buildings 771C and 774, and the D&D groundwater monitoring wells associated with them.

Six new D&D monitoring wells (40599 through 40899, 41499, and 41599) were installed at the Building 771 area during the fall of 1999. Monitoring well 40899 and existing well 18199 are upgradient D&D wells. Wells 40599,

40699, 40799, 41499, and 41599 are downgradient D&D wells. Existing well 20998 is cross gradient to Building 771. Only existing wells 20998 and 18199 (associated with IHSS 118.1, the carbon tetrachloride site) had any sample results through CY 1999. The six new D&D monitoring wells for Building 771 failed to produce enough water for any samples to be collected from them during the fourth quarter of 1999.

Until a geochemical baseline is established for groundwater in the vicinity of Building 771, analytes will discussed in terms of exceedances to Tier I and Tier II groundwater action levels. Only one D&D sampling round (4th quarter 1999) was attempted at Building 771 through 1999. As stated above, neither existing well 20998 nor any of the new D&D wells produced enough water to collect any samples. A sample was collected from existing monitoring well 18199 during the first D&D sampling round for Building 771. This well yielded results that indicated a Tier I exceedance for carbon tetrachloride (associated with IHSS 118.1) and a Tier II exceedance for PCE. There were no metals or nitrates exceedances in samples collected from well 18199.

Previous results from well 20998 indicate Tier II carbon tetrachloride exceedances in September 1998 and April 1999 as well as a Tier II chloroform exceedance in September 1998. Only VOCs were analyzed for in these samples. Previous results from well 18199 (March and September 1999) indicate Tier I carbon tetrachloride exceedances and Tier II PCE exceedances from both samples. In addition, hexachloroethane was found above the Tier II action level in the March 1999 sample and vinyl chloride was found above the Tier II action level in the September 1999 sample. Metals and nitrates were not analyzed for in these samples. A complete data set for these wells can be found in the 1999 RFCA Quarterly Groundwater Reports.

5.4 Building 886

The Sampling and Analysis Plan for the D&D monitoring of Building 886 was initiated during late 1998. The SAP was submitted Final to the Agencies in July 1999. The D&D monitoring wells associated with the building were installed before the end of 1999. Building 886 is currently scheduled for demolition in 2003. This may allow adequate time to construct a groundwater chemistry baseline for this building.

Building 886 is located on the south side of Central Avenue at RFETS, approximately 300 feet southeast of the PACS-1 entrance to the PA. The building was first occupied in 1965 and housed the Critical Mass Laboratory that was used to conduct criticality experiments for nuclear safety research and development. Plutonium, uranium, and nitrates are the contaminants of concern at Building 886. Figure 5-4 presents the location of Building 886 and the D&D groundwater monitoring wells associated with it.

Three new D&D monitoring wells (40999, 41099, and 41199) were installed at Building 886 during the fall of 1999. Wells 40999 and existing well P317989 are upgradient D&D wells. Wells 41099, 41199, and existing well 22996 are downgradient D&D wells. New Building 886 D&D monitoring wells were sampled once during 1999 (4th Quarter). There was generally sufficient water at all wells to complete this D&D sampling round, with the exception of existing well P317989, from which only a partial suite could be collected. Existing well P317989 had

no groundwater samples collected from it between 3/21/95 and 11/10/99 (a D&D groundwater sampling round); therefore, the previous three years of data are not available for D&D groundwater chemistry baseline consideration. Groundwater data have been collected from well 22996 for the 3rd and 4th quarters of 1996, the 1st quarter of 1998, and the 1st and 4th (D&D round) quarters of 1999.

Until a geochemical baseline is established for Building 886, analytes will be discussed in terms of exceedances to Tier I and Tier II groundwater action levels. The results of the D&D sampling round completed at Building 886 in the fall of 1999 indicate that there were no Tier I exceedances for any analytes. Tier II exceedances for the first D&D sampling round consisted of U-233,-234 and U-238 at all wells except P317989. The most impacted well, 41099, had U-233,-234 and U-238 results of 51.65 pCi/L and 33.72 pCi/L, respectively. These results are below the U-233,-234 and U-238 site background values (mean plus two standard deviations) of 60.7 pCi/L and 41.8 pCi/L, respectively. Well 41099 also had a Tier II exceedance for nitrates (47mg/L) and U-235 (2.32pCi/L). Existing well P317989 had a first D&D round Tier II exceedance for selenium (121mg/L). Historical results from existing well 22996 show consistent Tier II exceedances for U-233,-234 from 1996 through the first D&D (fall 1999) sampling round. None of these U-233,-234 results exceed Site background M2SD values.

5.5 Building 779

Building 779, placed into service in 1979, housed minor production and plutonium recovery operations, but was primarily a research and development facility. Some metal parts were assembled in this building and bulk plutonium residues were recovered in the hydride operations (DOE 1992a). The building was located in the PA approximately 200 feet south of the westernmost Solar Pond was demolished in 1999. Three D&D monitoring wells, 02297, 02397, and 02497 were installed with a Geoprobe rig in 1997. Well 02397 is for upgradient D&D monitoring; wells 02297 and 02497 are for downgradient D&D monitoring. Figure 5-5 presents the building location and the associated D&D monitoring wells. There would have been adequate time for collecting the appropriate amount of data and determining the D&D groundwater chemical baseline but the demolition schedule originally proposed for 2000 accelerated and occurred during 1999.

No sampling rounds were completed during 1997 at the Building 779 D&D monitoring wells because of lack of water. Sampling rounds were accomplished with varying success at the Building 779 D&D monitoring wells during 1998. Not all monitoring wells produced the same number of sampling rounds or amount of samples per round because the wells were either dry or did not produce enough groundwater for full sample suites. Monitoring well 02297 produced enough groundwater in 2nd Quarter 1998 for VOC analyses only. Monitoring well 02397 produced enough water in 1st Quarter 1998 for VOCs only, and in 4th Quarter 1998 for VOCs, metals and nitrates. Monitoring well 02497 produced enough water in 1st and 2nd Quarters 1998 for VOCs and nitrates only; in 4th Quarter 1998 for VOCs only. During 1999, no samples were collected from D&D well 02397 because of insufficient water. Monitoring well 02297 produced enough water in 2nd Quarter 1999 for the collection of VOCs, uranium isotopes, and nitrates. Monitoring well 02497 produced enough water during the 2nd Quarter sampling round for the

collection of VOCs and uranium isotopes. Wells 02297 and 02497 did not produce enough water to collect any 4th quarter 1999 D&D samples.

The results of the 1998 samples indicated that there were no concentrations from any Building 779 D&D monitoring well above Tier I action levels. Wells 02297 and 02497 had no results above Tier II action levels. The only result during 1998 above Tier II action levels was at monitoring well 02397, in November, where nitrates analysis resulted in a concentration of 12 mg/L. Results of the May 1999 samples (wells 02297 and 02497 only) indicated that there were no exceedances of Tier I action levels. Each well exhibited a Tier II exceedance for U-233,-234 and U-238. All the uranium isotope results were below Site background M2SD values.

While the demolition of Building 779 was occurring, it was learned from building personnel that there was a small sub-basement area beneath the Building 779 basement. The sub-basement area contained four vaults, the bases of which are approximately 24 feet below the Building 779 ground floor. Upon inspection, it was noted that three of the vaults contained water; potentially groundwater which may have seeped into them and mobilized existing point source contamination. The CDPHE was notified and expressed their concern because the previously submitted Final Building 779 D&D Groundwater Monitoring SAP did not address the presence of these below basement structures. CDPHE requested that the vaults with water be sampled. The results of the December 1999 sampling effort indicate that water from all three vaults (Pit 1A, Pit 2A, Pit 2B) contain numerous metals (including beryllium) above Tier II but below Tier I groundwater action levels. The water in Pit 1A contained U-233,-234 and U-238 in concentrations which exceed the site background values for groundwater (60.7 pCi/L for U-233,-234 and 41.8 pCi/L for U-238). Plutonium and Americium are found above their Tier II groundwater action levels in Pits 2A and 2B. The levels found in Pit 1A (plutonium 74.9pCi/L and americium 31.3pCi/L) exceed their respective Tier I groundwater action levels. In addition, 1,1,2,2,-tetrachloroethane (PCA) was found in the Pit 1A sample at a concentration exceeding its Tier I groundwater action level. Pit 1A appeared to be the most impacted. The Building 779 sumps/vaults were pumped out after the first sampling round. A second sampling round to confirm the first was undertaken in May 2000. The results of the May 2000, confirmatory sampling round indicate that Pit 1A was the only Building 779 vault which had any results above Tier II action levels. The Tier II exceedances were for metals (cadmium, chromium, lead, and nickel) and radionuclides (americium, plutonium, uranium-238, and uranium-233/234. There were no uranium isotope results above the site background values listed above.

In addition to the Building 779 vaults, Building 783, containing three below grade vaults, and Building 782, which contains a sump, were sampled in May 2000. These below grade structures were not included in the initial, December 1999, sampling round. The results of the May 2000 sampling indicate that there is some contamination in these structures. The Building 783 vaults show some slight Tier II exceedances for americium, uranium isotopes U-233/234 and U-238, arsenic and manganese. The Building 782 sump showed Tier II exceedances for U-233/234, nitrate, and TCE.

The results of the two rounds of Building 779 vault sampling imply that the source of the contamination is material contained in the below grade vaults and not the groundwater which apparently seeps into the vaults. If the source of

the contamination was the infiltrating groundwater, then the results of the two rounds of sampling for the vaults would be similar, and wells adjacent to B770 would probably show similar contamination. PCA was detected in Pit 1A during the first round of sampling above its Tier I action level, but was not even detected above its Tier II action level in the second round. Vaults 2A and 2B showed no Tier II exceedances for any analytes for the second round after having many Tier II exceedances for metals and radionuclides during the first sampling round. The fact that the water in the vaults was pumped out between the first and second sampling events probably contributed to the vast difference in concentrations of radionuclides, PCA, and some metals.

One year of quarterly water level measurements will be collected from the vaults, including the vaults and sumps associated with Buildings 782 and 783. The vaults will be accessed through sampling hatches that were installed when the Building 779 foundation was sealed off to isolate the basement areas. At the request of CDPHE, a new D&D monitoring well (00100) will be constructed in CY 2000 northeast of Building 779 and completed to the appropriate depth to monitor groundwater downgradient of the sub-basement vaults.

5.6 Buildings 707, 776/777, 371/374, 865, and 883

A Sampling and Analysis Plan for the D&D monitoring of these buildings was prepared early in CY 2000 and submitted to the CDPHE and U.S. EPA in April 2000. Comments were received from the Agencies in early July 2000, and a meeting was held at RFETS on July 19, 2000, to resolve issues pertaining to the investigations at the individual building areas. The Final SAP for these buildings was submitted to the Agencies in August 2000. It is anticipated that well installation and groundwater sampling activities will take place during the summer and fall of 2000.

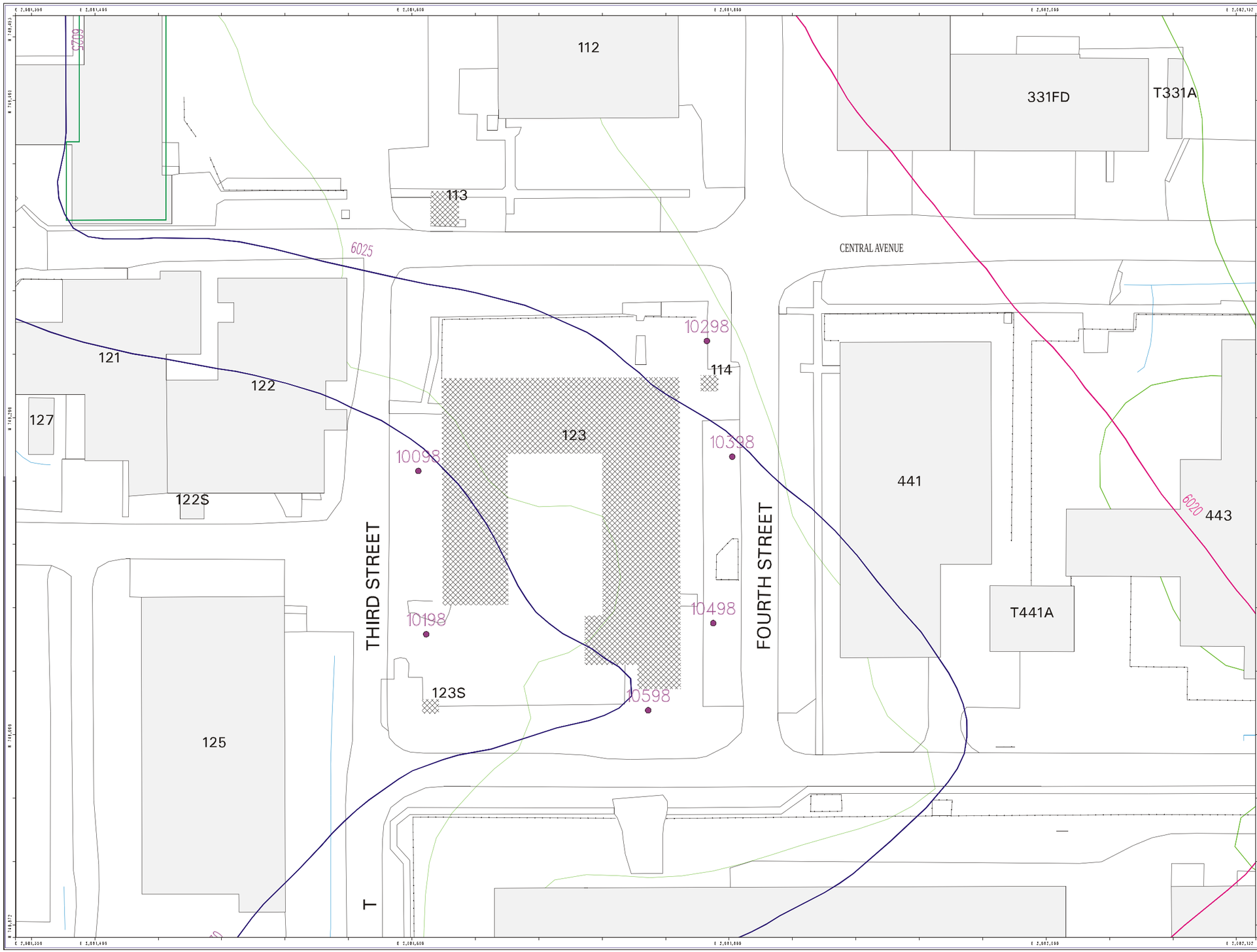

Figure 5-1
Building 123 Location Map with D&D Monitoring Wells
1999 Annual RFCA Groundwater Monitoring Report

EXPLANATION

IMP Well Type

- Water Quality Flow Monitoring
- Industrial Area Flow Monitoring
- Background Flow Monitoring
- D&D Monitoring
- Non-IMP

5-Foot Water Level Contours Second Quarter 1999

- 20-Foot Water Level Contour
- Dashed where inferred
- 5-Foot Intermediate Contour
- Dashed where inferred

Standard Map Features

- Buildings and other structures
- Demolished Buildings
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

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N

Scale = 1 : 750
1 Inch represents approximately 63 feet

15 0 30 60ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

Prepared for: KAISER-HILL

MAP ID: rfca-rpt/figures/dd_figs

November 20, 2000

Original map contents are preserved. Logo and date have changed.

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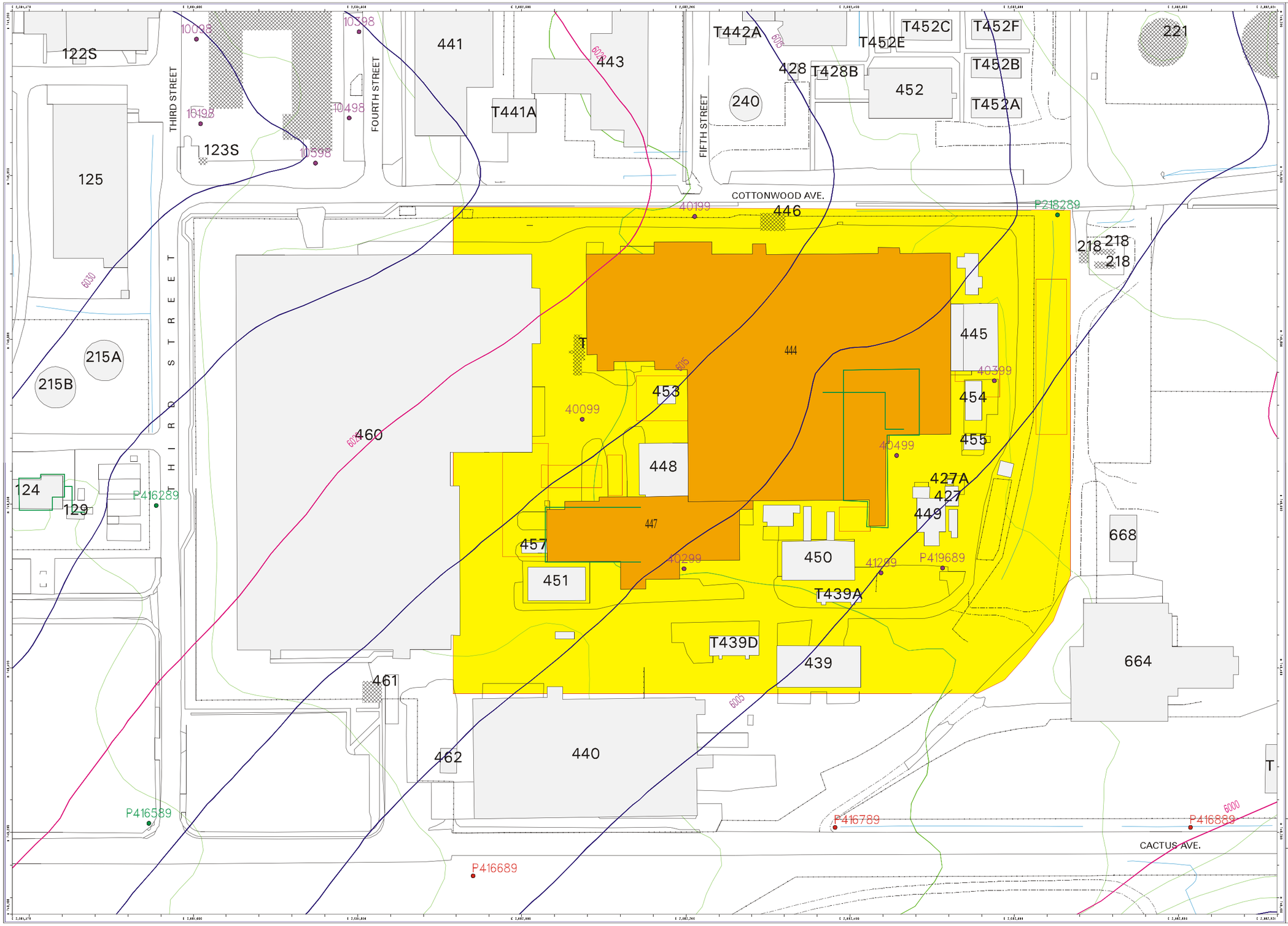

Figure 5-2

Building 444 Site Location with D&D Monitoring Wells

1999 Annual RFCA Groundwater Monitoring Report

EXPLANATION

IMP Well Type

- Water Quality Flow Monitoring
- Industrial Area Flow Monitoring
- Background Flow Monitoring
- D&D Monitoring
- Non-IMP

5-Foot Water Level Contours Second Quarter 1999

- 20-Foot Water Level Contour
- Dashed where inferred
- 5-Foot Intermediate Contour
- Dashed where inferred

Industrial Area Operable Units

- Pertinant B444 IHSSs
- D&D Building Cluster

Standard Map Features

- Buildings and other structures
- Demolished Buildings
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. DEM post-processing performed by MK, Winter 1997.

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N

Scale = 1 : 1,360
1 inch represents approximately 113 feet

0 25 50 75 100 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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Prepared by: DynCorp THE ART OF TECHNOLOGY

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MAP ID: rfca-rpt/figures/dd_figs November 20, 2000

Original map contents are preserved. Logo and date have changed.

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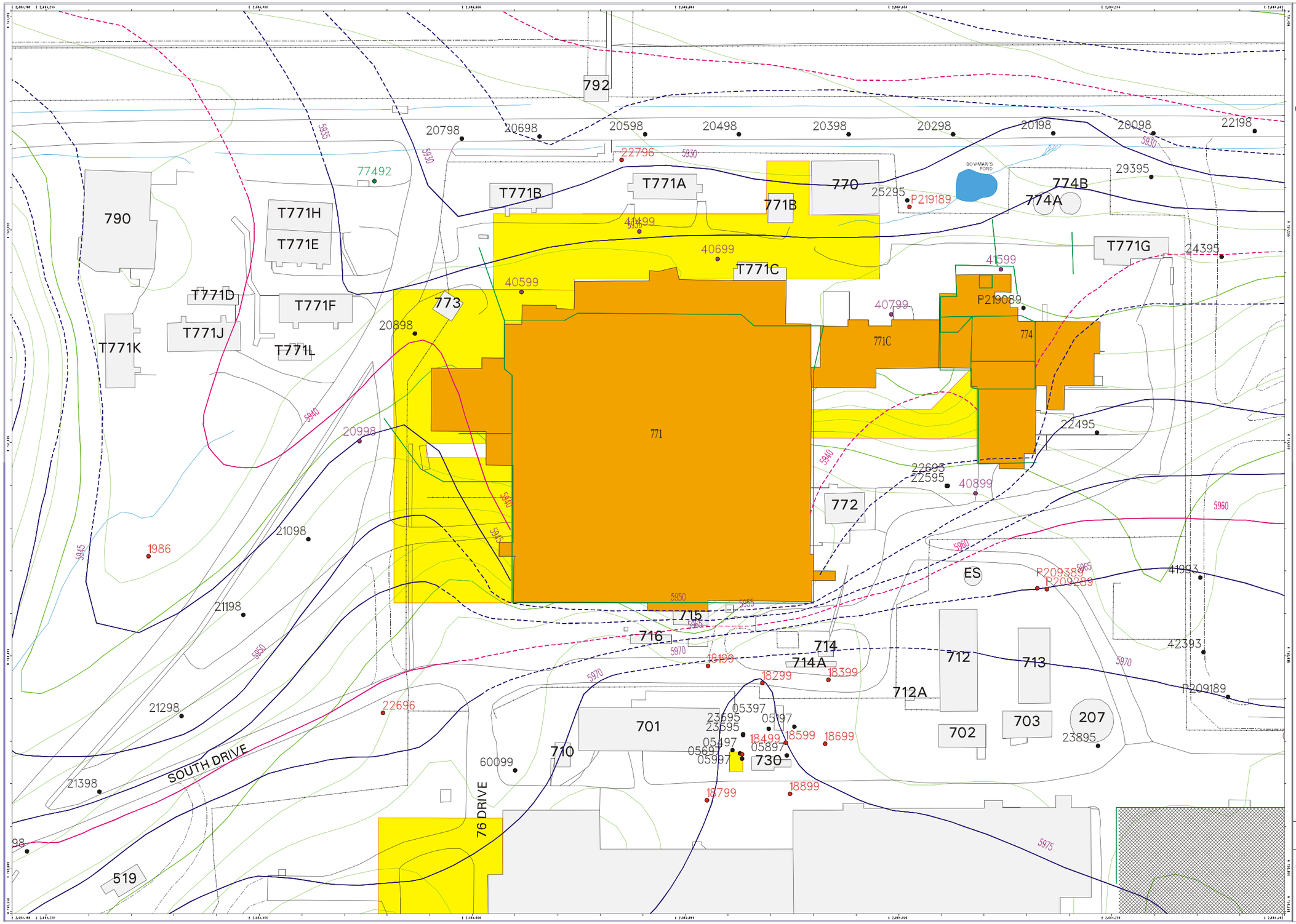

Figure 5-3

Building 771 Site Location with D&D Monitoring Wells

1999 Annual RFCA Groundwater Monitoring Report

EXPLANATION

IMP Well Type

- Water Quality Flow Monitoring
- Industrial Area Flow Monitoring
- Background Flow Monitoring
- D&D Monitoring
- Non-IMP

5-Foot Water Level Contours Second Quarter 1999

- 20-Foot Water Level Contour
- Dashed where inferred
- 5-Foot Intermediate Contour
- Dashed where inferred

Industrial Area Operable Units

- Pertinant B771 IHSSs
- D&D Building Cluster

Standard Map Features

- Buildings and other structures
- Demolished Buildings
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by: EG&G RSL, Las Vegas.
Digitized from the orthophotographs. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5 foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
DEM post-processing performed by: MK, Winter 1997.

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Scale = 1 : 1050
1 inch represents approximately 88 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Prepared by: DynCorp THE ART OF TECHNOLOGY

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MAP ID: rfca-rpt/figures/dd_ffgs November 20, 2000

Original map contents are preserved. Logo and date have changed.

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Figure 5-4

Building 886 Site Location With D&D Monitoring Wells

1999 Annual RFCA Groundwater Monitoring Report

EXPLANATION

IMP Well Type

- Water Quality Flow Monitoring
- Industrial Area Flow Monitoring
- Background Flow Monitoring
- D&D Monitoring
- Non-IMP

5-Foot Water Level Contours Second Quarter 1999

- 20-Foot Water Level Contour
- Dashed where inferred
- 5-Foot Intermediate Contour
- Dashed where inferred

Industrial Area Operable Units

- Pertinant 886 IHSSs
- D&D Building Cluster

Standard Map Features

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc Tiff and LATTICE to process the DEM data to create 5-foot contours. The DSM data was captured by the Remote Sensing Lab, Las Vegas, 11/1, 1994 Aerial Flyover at ~ 10 meter resolution. DSM post-processing performed by MK, Winter 1997.

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Scale = 1:540
1 inch represents 45 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum NAD27

U.S. Department of Energy

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MAP ID: rfca-rpt/figure/dd_figs

November 20, 2000

Original map contents are preserved. Logo and date have changed.

NT_Svr w:/projects/fy2k/rfca-rpt/figures/dd_figs/bldg_886-nt.aml

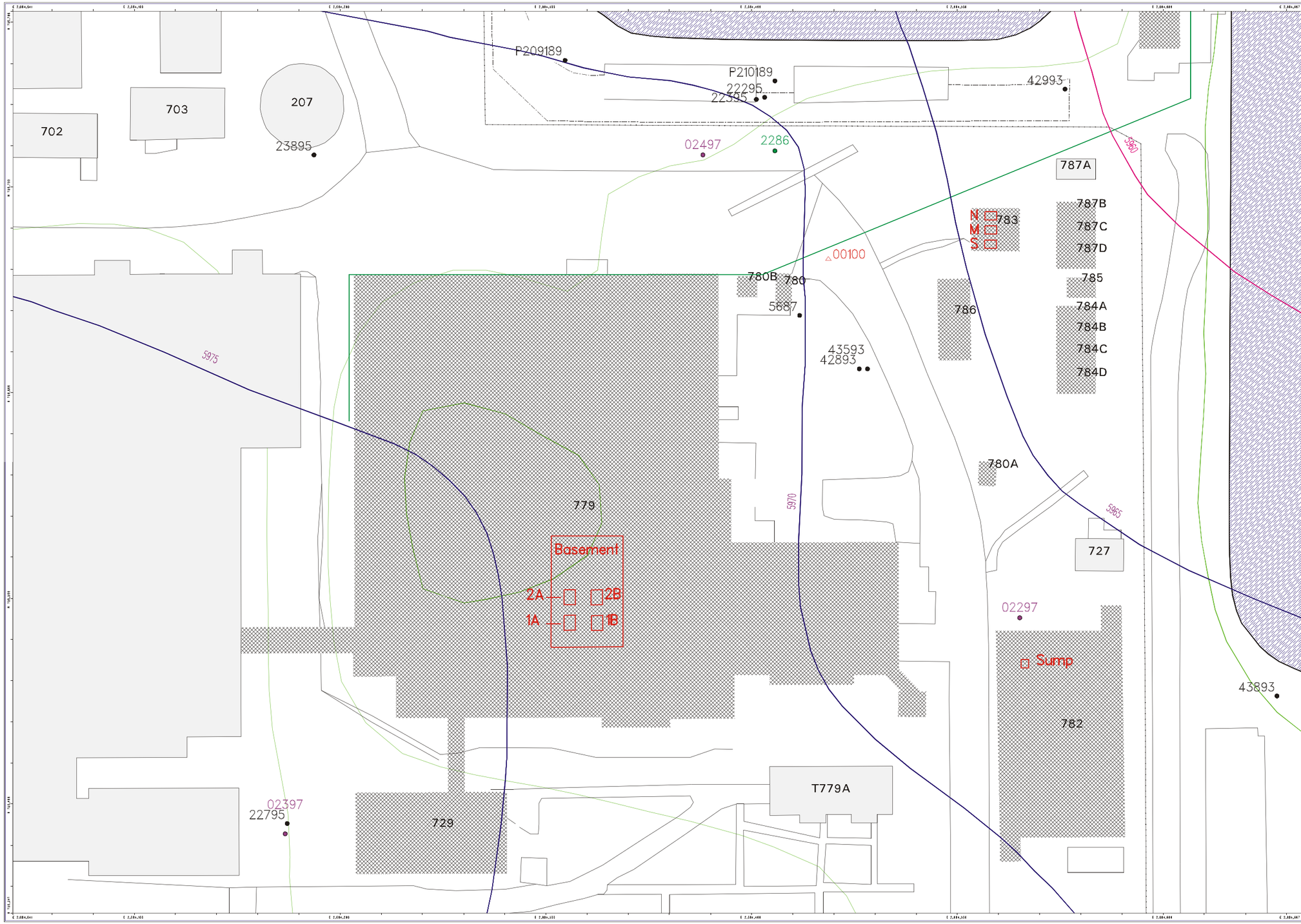

Figure 5-5
Building 779 Location Map with D&D Monitoring Wells

1999 Annual RFCA Groundwater Monitoring Report

EXPLANATION

IMP Well Type

- Water Quality Flow Monitoring
- Industrial Area Flow Monitoring
- Background Flow Monitoring
- D&D Monitoring
- Non-IMP
- New D&D Well Proposed for 2000

5-Foot Water Level Contours Second Quarter 1999

- 20-Foot Water Level Contour
- Dashed where inferred
- 5-Foot Intermediate Contour
- Dashed where inferred

Standard Map Features

- Basements
- Buildings and other structures
- Demolished Buildings
- Solar Evaporation Ponds (SEP)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

NOTE:
Building 779 sub-basement vaults located directly below basement.

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Scale = 1:570
1 inch represents approximately 48 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

Prepared for: KAISER-HILL

MAP ID: rfca-rpt/figures/dd_figs

November 20, 2000

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NT_Svr w:/projects/fy2k/rfca-rpt/figures/dd_figs/bldg_779-nt.aml

6.0 PRESENT SANITARY LANDFILL

This section presents 1999 groundwater quality data for the Present Sanitary Landfill (previously known as Operable Unit 7). The Present Sanitary Landfill, located in the Buffer Zone north of the PA, occupies approximately 44 acres (encompassing both the landfill and East Landfill Pond) at the western end of the No Name Gulch drainage (Figure 6-1). It utilizes a surface and subsurface water intercept and diversion system to route surface run-on and upgradient groundwater around the facility, and a leachate collection and treatment system to improve the water quality of leachate exiting the toe of the landfill near the west end of the East Landfill Pond. The landfill served as a former solid waste disposal facility for RFETS and is one of three interim status units at RFETS that are regulated under RCRA. The landfill is currently scheduled for cover and final closure during year 2004.

Throughout 1999, groundwater monitoring was conducted in accordance with the requirements of the RFCA, as set forth in the IMP (K-H, 1999a). This plan, under an agreement with the U. S. EPA and the CDPHE, supersedes Title 6 of the Colorado Code of Regulations, *6 CCR 1007-2* and *6 CCR 1007-3,* as the governing authority for groundwater monitoring at RFETS.

Information presented in this section includes a review of historical activities at the Present Sanitary Landfill (Section 6.1); a summary of previous investigations (Section 6.2); the status of the current groundwater monitoring program (Section 6.3); the current understanding of the physical characteristics of groundwater flow at the site (Section 6.4); an assessment of groundwater quality (Section 6.5); an update on groundwater intercept system operation (Section 6.6); and general conclusions regarding groundwater quality and the groundwater monitoring program at the landfill (Section 6.7).

6.1 Operating History of the Present Sanitary Landfill

The Present Sanitary Landfill began operating on August 14, 1968, for the disposal of Rocky Flats sanitary waste. However, records indicated that, prior to 1986, some hazardous waste was disposed of at the landfill; therefore, in 1986, the landfill was classified as a RCRA-regulated unit. Disposal of hazardous constituents in the landfill was halted in November 1986. The landfill remained in operation, accepting only sanitary waste until March 1998. At that time, the landfill was placed in contingent operational status because it was nearing capacity, and was seeded to stabilize soils and control erosion. All RFETS sanitary waste is currently delivered to an offsite commercial Subtitle D sanitary waste landfill for disposal. The following paragraphs provide a brief historical summary of landfill operations.

In September 1973, tritium was detected in leachate draining from the landfill. In response to this detection, a sampling program was initiated to determine the location of the tritium source. In addition, radiation monitoring of waste prior to burial was initiated to prevent further disposal of radioactive material, and interim-response measures

were undertaken to control the generation and migration of landfill leachate. Interim-response measures included the construction of two ponds (Ponds No. 1 and No. 2, also known as the West Landfill Pond and East Landfill Pond, respectively) immediately east of the landfill, and the installation of a subsurface leachate-collection system and subsurface intercept system for diverting groundwater around the landfill. Ditches were also constructed to control surface water.

The West Landfill Pond embankment was built approximately 500 ft east of the 1974 position of the advancing face of the landfill. The East Landfill Pond embankment was constructed approximately 1,000 ft east of the West Landfill Pond embankment. A cutoff wall, set in bedrock, was constructed in the East Landfill Pond embankment to reduce seepage through the embankment foundation. The embankments and ponds were built to collect and evaporate groundwater, surface water, and leachate collected by the subsurface drainage-control system. The West Landfill Pond was removed in 1981 (see discussion below). The existing (East Landfill) pond contains no outlet other than a spillway that is designed for use during extreme storm events. Groundwater exiting the landfill discharges to the East Landfill Pond where it either evaporates or is pumped to Pond A-3 via the Pond A-1 bypass for eventual discharge from the Site. Subsurface leakage of the East Landfill Pond may also occur; this would recharge the unconsolidated deposits below the pond dam and the underlying bedrock claystones. The amount of leakage is expected to be small considering the low hydraulic conductivity of the underlying bedrock materials.

An inner leachate-collection system and outer groundwater-intercept/diversion system were constructed around the north, west, and south perimeters of the landfill (Figure 6-1). The leachate collection system was designed to provide a perimeter drain for the prevention of leachate migration outside the landfill boundary and to reduce water levels within landfill refuse. The groundwater-intercept/diversion system was constructed along the outside edge of the leachate collection system to prevent groundwater from entering the landfill area. Groundwater diverted from the landfill by the intercept system is, as currently understood, directed eastward around waste materials and discharges either to the East Landfill Pond or No Name Gulch below (east of) the East Landfill Pond dam (at surface water monitoring locations SW099 and SW100).

Between 1977 and 1981, the leachate-collection trench was buried beneath waste during landfill expansion (DOE, 1996c). The west embankment and West Landfill Pond were removed in 1981, and two slurry walls were constructed, extending from the ends of the north and south groundwater-interceptor ditches. These slurry walls, ranging in depth from 10 ft to 25 ft, were reportedly seated in bedrock.

Sometime after the Present Sanitary Landfill went into operation in 1968, excess water from the landfill pond was sprayed onto a ridge south of the East Landfill Pond. The sprayed water collected on the roadway and flowed into North Walnut Creek. When this misdirected flow was discovered, the spraying activities were moved to an area north of the landfill pond adjacent to an irrigation ditch. Because the subsequent spray water then collected in local drainage channels and flowed around the landfill pond to the main drainage, the spraying activities were again moved. The final spray location was an area south of the western end of the landfill pond; excess spray water then flowed back into the East Landfill Pond.

In 1995, a gravity flow treatment system was constructed to collect contaminated groundwater and leachate flowing from the eastern end of the Present Sanitary Landfill. The Passive Seep Interception and Treatment System (PSITS) became operational in early 1996 and was designed to treat landfill leachate to eliminate F039-listed wastes prior to discharge into the East Landfill Pond. The treatment system was originally composed of a settling basin, bag filters to remove suspended solids, and granular activated carbon to remove organic chemical constituents, but was modified in the fourth quarter of 1998 to allow passive aeration of leachate water. The treated effluent is sampled monthly for VOCs; semivolatile organics; metals; isotopic plutonium, uranium, and americium; gross alpha and beta; and tritium, with results published in the Quarterly Report for the Consolidated Water Treatment Facility and Operable Unit 7 (OU7) Passive Seep Interception System.

Groundwater monitoring was originally instituted in 1989 in accordance with *6 CCR 1007-2* and *6 CCR 1007-3, Subsection 265.90(d)*. This 1999 Annual RFCA Groundwater Monitoring report addresses monitoring requirements pertaining to RCRA units as specified in the IMP. Monitoring pertaining to RFETS RCRA units prior to 1996 are addressed in the Annual RCRA Groundwater Monitoring Reports (DOE, 1990, 1991a, 1992d, 1993c, 1994c, 1995, and 1996a). Subsequent groundwater monitoring activities conducted under the authority of RFCA during calendar years 1996 and 1997 are presented in annual Present Sanitary Landfill Groundwater Monitoring Reports (DOE, 1997b and 1998). The regulations require that the groundwater-monitoring program be capable of determining the impact of a facility on the water quality in the uppermost aquifer.

The Annual RCRA Reports for RFETS (referenced above) describe chemical and physical aspects of groundwater (for 1989 through 1995) at the Present Sanitary Landfill. The *Phase I RCRA Facility Investigation/Remedial Investigation (RFI/RI) Work Plan for Operable Unit 7: Present Sanitary Landfill* (DOE, 1991b) presents additional information regarding construction, operation, regulatory history, and site characterization. Work conducted for Phase I included cone-penetrometer testing, soil sampling, and the installation and sampling of additional groundwater monitoring wells outside of and within the landfill.

A closure plan for the Present Sanitary Landfill was developed in the IM/IRA decision document (DOE, 1996c), in accordance with the RFCA (RFCA, 1996) and applicable Colorado hazardous-waste regulations. Because of the Present Sanitary Landfill's position on the Environmental Restoration Ranking (26th of 357), action has been deferred until higher ranked areas are remediated. Post-closure groundwater monitoring of the Present Sanitary Landfill will be performed in accordance with the requirements of the IMP.

6.2 Summary of Previous Investigations

Annual RCRA Groundwater Monitoring Reports from 1989 through 1995 and Present Sanitary Landfill Groundwater Monitoring Reports from 1996 through 1998 describe groundwater elevations and flow rates as well as the results of the groundwater analyses. The sampling and analysis records were maintained in compliance with *6 CCR 1007-3* and *40 CFR 265.94(b)*. The *Phase I RFI/RI Work Plan for OU7 - Present Sanitary Landfill* (DOE,

1991b) and the Operable Unit 7 Revised Draft IM/IRA Decision Document and Closure Plan (DOE, 1996c) present additional information.

The impact of the Present Sanitary Landfill on groundwater quality has been evaluated in previous Annual RCRA and Landfill Groundwater Monitoring Reports (DOE, 1990, 1991a, 1992d, 1993c, 1994c, 1995, 1996a, 1997e, 1998a). In 1992, groundwater from surficial deposits within and around the Present Sanitary Landfill had concentrations of major anions (bicarbonate, chloride, nitrate/nitrite, and sulfate), total dissolved solids (TDS), dissolved metals (calcium, chromium, lithium, magnesium, potassium, sodium, and strontium), and radionuclides that were elevated relative to mean background concentrations/activities. Some VOCs were also detected. The dissolved radionuclides present included americium-241, plutonium-239/240, uranium-233/234, uranium-238, and radium-226. Throughout 1992, concentrations of dissolved metals and radionuclides were only rarely greater than mean background concentrations.

During 1992, VOCs were detected sporadically and infrequently in wells screened in surficial materials of the UHSU. In UHSU bedrock, VOCs were detected in groundwater sampled from two wells. Methylene chloride, acetone, and toluene were detected once. The infrequent occurrence of VOCs in the UHSU bedrock indicated that the Present Sanitary Landfill had not adversely impacted groundwater in UHSU bedrock, even though some contamination of groundwater had occurred in UHSU surficial materials overlying the bedrock.

In 1993, the groundwater chemistry at the Present Sanitary Landfill was generally consistent with water-quality conditions of 1992 (DOE, 1994c). The 1993 statistical comparisons of upgradient versus downgradient UHSU groundwater at the Present Sanitary Landfill indicated statistically significant increases in downgradient concentrations of dissolved metals (calcium, lithium, magnesium, potassium, sodium, and strontium), and major anions (chloride and sulfate). None of the radionuclides or VOCs showed a statistically significant difference in upgradient versus downgradient activities or concentrations, respectively. Radionuclide activities and concentrations of VOCs, metals, and anions were notably highest within the landfill and in the area adjacent to IHSSs located southeast of the landfill, relative to other areas in the vicinity of the Present Sanitary Landfill. In groundwater from UHSU bedrock beneath and downgradient of the landfill, VOCs were detected infrequently, but radionuclides were present at activities higher than mean background.

Analysis of 1994 data by analysis of variance (ANOVA) indicated statistically significant differences in upgradient versus downgradient groundwater quality in the UHSU for radionuclides (uranium-233/234 and uranium-238), dissolved metals (calcium, lithium, magnesium, sodium, and strontium), anions (carbonate, chloride, fluoride, and sulfate), and TDS (DOE, 1995). In the UHSU bedrock, there were statistically significant differences in upgradient versus downgradient groundwater quality for dissolved metals (calcium, lithium, magnesium, sodium, and strontium), anions (bicarbonate, chloride, and sulfate), and TDS. All VOCs had less than 50-percent quantifiable results.

For 1995 data, statistical comparisons of upgradient versus downgradient UHSU groundwater at the Present Sanitary Landfill indicated statistically significant increases in levels of dissolved barium, calcium, lithium, magnesium, silicon, sodium, strontium, uranium-233/234, and gross beta, as well as bicarbonate, chloride, sulfate, and TDS. Activities of total americium-241, plutonium-239/240, and tritium did not show statistically significant differences between upgradient and downgradient UHSU groundwater. VOCs were detected in fewer than 50 percent of the samples, so these analytes were not statistically evaluated.

Analyses of the 1996 data tend to confirm the results of previous sampling (DOE, 1997f). Approved well abandonments and deactivations combined with an inadequate volume of water for sampling of downgradient wells prevented statistical analysis for many analytes during these years. Detected analytes and concentration ranges during 1996 were generally consistent with corresponding data from prior years. Barium, calcium, chromium, lithium, magnesium, potassium, selenium, and sodium were detected in downgradient wells at levels below mean background concentrations. Nitrate and tritium were evaluated using ANOVA techniques and were determined to be statistically similar in upgradient versus downgradient samples. As in prior investigations, there was no indication of VOC contamination in downgradient wells.

For 1997, statistical analyses of groundwater data were again prevented by an insufficient number of analyses, as explained above for the 1996 data. Fluoride, sulfate, TDS, barium, copper, iron, lithium, manganese, selenium, strontium, nitrate, and zinc appeared to be elevated in one or more downgradient versus upgradient wells. Tritium and certain VOCs were detected in upgradient wells at concentrations that exceeded the downgradient well concentrations. The trends of potential contaminants detected in the downgradient wells did not, however, appear to be increasing with time, resulting in no reportable exceedances for 1997 (DOE, 1998b).

Results of hydrogeologic investigations of the Present Sanitary Landfill suggest that the groundwater-intercept system may not completely isolate the landfill from the surrounding groundwater. Hydraulic assessments for specific areas on the north, west, and south sides of the groundwater-intercept system indicate that groundwater may flow into the landfill on the north side where the leachate collection system may not have been completely keyed into bedrock (DOE, 1996c). In addition, previous reports indicate that the leachate collection trench was buried beneath waste during landfill expansion (DOE, 1996c). Therefore, the clay cutoff wall no longer extends to the surface of the landfill; this would allow groundwater to flow across the clay cutoff wall if the water table were to rise sufficiently. Landfill wastes do not extend to the surface-water interceptor ditch.

An evaluation of groundwater-elevation data for 1991 through 1995 and the hydrologic evaluation data for the OU7 IM/IRA indicate that previous conclusions made regarding the impact of the leachate/groundwater-intercept system are still valid. These conclusions are:

- The groundwater-intercept system diverts groundwater away from the landfill and is most effective in diverting flow on the west and south sides.

- The clay barrier is an effective barrier to groundwater flow in the landfill along the west but it may not be completely keyed into bedrock on the northwest side. This may allow groundwater to enter the north side of the landfill.

6.3 Current Groundwater Monitoring Program

The Present Sanitary Landfill at RFETS currently operates under CDPHE and EPA guidelines for solid waste disposal sites and facilities. The current groundwater monitoring program was instituted in accordance with the RFCA, as further defined for RCRA units in the IMP. RCRA groundwater monitoring is conducted to detect potential releases of contamination beyond an established point of compliance based on comparisons of upgradient to downgradient groundwater quality. Under the IMP, if significant impacts to groundwater quality are detected in downgradient RCRA wells and contaminant concentrations are observed to increase with time, then the results are reported to EPA and CDPHE and an investigation into possible causes is initiated. Special attention is given to groundwater contaminants listed in the Action Levels and Standards Framework (ALF) for Surface Water, Ground Water, and Soils document, Attachment 5 (RFCA, 1996), which if exceeded, trigger an evaluation, remedial action, and/or management action. Non-ALF constituents, such as the major cation metals sodium, potassium, calcium, and magnesium, are not reportable under RFCA, and are, therefore, not emphasized in this report. Figure 6-1 illustrates the location of existing and abandoned monitoring wells in relationship to relevant surface and subsurface features at the Present Sanitary Landfill.

Recent changes to the site groundwater monitoring program are outlined in the IMP (K-H, 1999a). This plan specifies the monitoring and reporting requirements for the Present Sanitary Landfill, including well identification, sampling frequency, analytical requirements, and reporting.

For the CY99 reporting period, upgradient wells 5887, 70193, 70393, and 70493, and downgradient wells 4087, 52894, 52994, and B206989, were sampled on a quarterly basis (January-March, April-June, July-September, and October-December) to determine compliance with RFCA, as set forth in the IMP. Table 6-1 summarizes sampling activities and shows the hydrostratigraphic unit monitored and material screened for all wells sampled in and near the Present Sanitary Landfill in 1999. The limited number and position of these wells makes it infeasible to construct potentiometric surface maps and concentration isopleth maps, thus current and future reports will only assess impacts to or from the landfill at the upgradient and downgradient landfill boundaries.

Table 6-1 Well Completion Information and Sampling Summary for Present Sanitary Landfill Wells

Well	Hydro-Stratigraphic Unit	Screened Material	Quarterly Sampling Summary			
			Q1	Q2	Q3	Q4
Upgradient Wells						
5887	UPPER	ALLUVIUM	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U
70193	UPPER	BEDROCK	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U
70393	UPPER	ALLUVIUM	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U
70493	UPPER	BEDROCK	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U
Downgradient Wells						
4087	UPPER	ALLUVIUM	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U	Dry
52894	UPPER	ALLUVIUM	Dry	V,W,N,M,T,U	V,W,N,M,T,U	Dry
52994	UPPER	BEDROCK	Dry	Dry	Dry	Dry
B206989	UPPER	BEDROCK	V,N	Dry	V,N,M,T,U	V,N,M.T,U

V = Volatile organic compounds
W = Water quality parameters
N = Nitrate/Nitrite
M = Metals
T = Tritium
U = Uranium isotopes

Groundwater elevations for active wells were measured quarterly as directed in the IMP. Quarterly groundwater samples were analyzed for radionuclides (tritium [liquid scintillation counting] and uranium isotopes [alpha spectroscopy]), VOCs (EPA 524.2), metals (CLP-SOW), and major anions (TDS [EPA 160.1], sulfate [SW846], fluoride [EPA 300.0], and nitrate/nitrite [EPA 353.1]), in accordance with Appendix E-2 of the IMP. The absence of complete analyte suites in most quarters for the downgradient wells listed in Table 6-1 is caused by sample volume limitations (also see dry and lacked water [LW] codes in Figure 6-2 through 6-5) imposed by slow recharge and/or thin saturation conditions. The alluvium and weathered bedrock at these localities are frequently dry or thinly saturated because the dam for the East Landfill Pond acts as a barrier to alluvial groundwater flow from the west. In addition, evapotranspiration through valley-bottom vegetation consumes much of the available shallow groundwater in the gulch during the summer months. For these reasons, it is normally not possible to collect complete sample sets for each quarterly sampling period during the year.

Some historical potential contaminants-of-concern (PCOC), such as semi-VOCs, were not included in the sampling program as a result of PCOC screening conducted during the IMP data quality objective process and acceptance of the plan by EPA and CDPHE. Table 6-2 lists the constituents monitored for in wells within and near the Present Sanitary Landfill. The records of analyses and evaluations are currently maintained in compliance with (*6 CCR 1007-2*).

6.4 Physical Characteristics of the Groundwater System

6.4.1 Description of the "Uppermost Aquifer"

The "uppermost aquifer" is equivalent to the UHSU as described in recent RFETS reports (EG&G, 1995a, 1995b, and 1995c). In most of RFETS, including the area of the Present Sanitary Landfill, the UHSU is composed of unconsolidated surficial deposits and weathered bedrock. The unconsolidated deposits consist of Rocky Flats Alluvium, colluvium, and valley-fill alluvium. The Rocky Flats Alluvium and artificial fill (landfilled wastes and soil-cover materials) are present upgradient of and within the landfill; colluvium and valley-fill alluvium are present downgradient of the landfill. Weathered claystones and weathered sandstones (where present) that are in direct hydraulic communication with the overlying surficial deposits are also considered part of the "uppermost aquifer". The weathered claystones are generally more permeable than unweathered bedrock. Unweathered claystones are not considered as part of the uppermost aquifer, rather they are included as part of the LHSU. Bedrock wells were assigned to a hydrostratigraphic unit based on geochemical data from the well, hydraulic conductivity measurements (where available), and geological information from borehole logs.

Table 6-2 Chemical Constituents Monitored at the Present Sanitary Landfill

Volatile Organic Compounds	Volatile Organic Compounds	Metals
1,1,1,2-Tetrachloroethane	cis-1,2-Dichloroethene	Cadmium
1,1,1-Trichloroethane	Cis-1,3-Dichloropropene	Calcium
1,1,2,2-Tetrachloroethane	Dibromochloromethane	Chromium
1,1,2-Trichloroethane	Dibromomethane	Cobalt
1,1-Dichloroethane	Dichlorodifluoromethane	Copper
1,1-Dichloroethene	Ethylbenzene	Iron
1,1-Dichloropropene	Hexachlorobutadiene	Lead
1,2,3-Trichlorobenzene	Isopropylbenzene	Lithium
1,2,3-Trichloropropane	Methylene Chloride	Magnesium
1,2,4-Trichlorobenzene	Naphthalene	Manganese
1,2,4-Trimethylbenzene	n-Butylbenzene	Mercury
1,2-Dibromo-3-chloropropane	n-Propylbenzene	Molybdenum
1,2-Dibromoethane	o-Chlorotoluene	Nickel
1,2-Dichlorobenzene	p-Chlorotoluene	Potassium
1,2-Dichloroethane	4-Isopropyltoluene	Selenium
1,2-Dichloropropane	sec-Butylbenzene	Silver
1,3,5-Trimethylbenzene	Styrene	Sodium
1,3-Dichlorobenzene	tert-Butylbenzene	Strontium
1,3-Dichloropropane	Tetrachloroethene	Thallium
1,4-Dichlorobenzene	Toluene	Tin
2,2-Dichloropropane	Total Xylenes	Vanadium
Benzene	Trans-1,2-Dichloroethene	Zinc
Bromobenzene	Trans-1,3-Dichloropropene	**Water Quality Parameters**
Bromochloromethane	Trichloroethene	Fluoride
Bromodichloromethane	Trichlorofluoromethane	Nitrate/Nitrite
Bromoform	Vinyl Chloride	Sulfate
Bromomethane	**Metals**	Total Dissolved Solids
Carbon Tetrachloride	Aluminum	**Radionuclides**
Chlorobenzene	Antimony	Tritium
Chloroethane	Arsenic	Uranium-233/234
Chloroform	Barium	Uranium-235
Chloromethane	Beryllium	Uranium-238

The Rocky Flats Alluvium is 25 to 30 feet thick on the northwest, west, and southwest sides of the landfill, and 10 to 15 feet thick on the divides north and south of the landfill pond. Colluvium is 1 to 5 feet thick on the slopes around the East Landfill Pond and below the dam. The valley-fill alluvium ranges in thickness from 3 to 8 feet in the landfill area and becomes thicker downstream to the east. The thickness of artificial fill increases from about 5 feet at the perimeter of the landfill to about 45 feet near the centerline of the valley (DOE, 1996c). Weathered bedrock thicknesses vary considerably in the vicinity of the landfill, ranging from approximately 4 to 35 feet, as indicated by weathered bedrock isopach mapping of the area (EG&G, 1995a).

Average depth to groundwater ranges from 5 to 15 feet in surficial deposits (excluding artificial fill) (EG&G, 1995b). Within the landfill, groundwater is found at approximately 20 feet at the western end, 16 feet in the middle, and 33 feet at the eastern end (DOE, 1996c). The depth to groundwater in weathered bedrock is generally greater than in the overlying surficial deposits because of steep downward vertical gradients in bedrock materials. The saturated thickness of UHSU deposits varies widely across the landfill, with the thickest sections found in the Rocky Flats Alluvium at the western end, and thinnest sections found in colluvial and valley fill deposits east of the East Landfill Pond and in the Rocky Flats Alluvium along the south divide. EG&G (1995b) reported saturated thicknesses ranging from 0 to 20 feet for surficial deposits at the landfill.

Geometric mean hydraulic conductivities, calculated from field tests of the different geologic units, are given in Section 6.4.4.

6.4.2 Potentiometric Surface

Groundwater is present in surficial deposits and artificial fill, and in bedrock sandstones and claystones in the area of the Present Sanitary Landfill. Groundwater flow patterns in the UHSU tend to mimic the surface topography. Within landfill wastes, groundwater flows toward the center of the landfill, then flows eastward toward the East Landfill Pond. Outside the landfill, groundwater generally flows eastward within saturated UHSU surficial deposits, except near stream valleys, which disrupt UHSU flow patterns and function as drains for UHSU groundwater. For example, near the East Landfill Pond, groundwater flows from the north, west, and south toward the pond because of its topographically low position in the No Name Gulch drainage. Groundwater entering the pond mixes with surface water and is discharged by evaporation or is pumped to Pond A-3, to a limited extent, pond waters percolate downward into underlying bedrock materials or laterally through the dam. Any groundwater seepage past the dam into the lower drainage would flow eastward along the stream course until discharged via evapotranspiration, surface water, or as lateral subsurface flow at the Indiana Street east RFETS boundary.

Groundwater elevations in monitoring wells are measured at least quarterly. Water levels in the surficial deposits of the UHSU are characterized by seasonal variations of as much as 10 feet. The water-table elevation is generally lowest in late winter and early spring, prior to recharge by snowmelt, and highest during June and July. Groundwater elevations in the weathered bedrock of the UHSU typically show seasonal variations of as much as 15 feet.

6.4.3 Vertical Hydraulic Gradients

The vertical hydraulic gradient is the quotient of the differences in water levels measured concurrently in two adjacent wells with different screened intervals, and the vertical distance between the two measuring points, which are specified here as the midpoint of each screened interval. Vertical hydraulic gradient calculations provide a means to evaluate whether groundwater flow has a potential for movement either downward or upward through geologic media.

Most of the Present Sanitary Landfill well pairs have been abandoned or deactivated in recent years in preparation for landfill closure. Consequently, current water level data is unavailable for calculation of vertical gradients. The results of historical vertical hydraulic gradient calculations at 8 landfill monitoring well pairs (70093/70193, 70193/70293, 70493/70593, 70693/70893, 72393/72093, 1086/0986, 0786/0886, and B206989/B207089) monitored through 1995 (DOE, 1996a) provide information relevant to understanding groundwater conditions at the landfill. The calculated vertical hydraulic gradients for all well pairs, except 72393/72093, indicate a downward (recharging) component of flow, with values ranging from 0.022 to 1.099 ft/ft. The significance of downward gradients at well pairs 0786/0886 and B206989/B207089, located near the bottom of No Name Gulch, are, however, potentially invalid considering that the water levels in the bedrock wells at these locations recharge slowly and never fully recover between sampling episodes. At well pair 72393/72093, situated within the center of the landfill, groundwater had an upward (discharging) vertical gradient ranging from 0.020 to 0.026 ft/ft. Data from all well pairs indicate that vertical hydraulic gradients have generally remained constant over time. This condition may exist because disturbances to the landfill hydrologic system have been minimal in recent years. In addition, groundwater flow within the deeper portions of the UHSU and in LHSU bedrock is relatively insensitive to fluctuations in seasonal water levels and other short-term transient effects because of the prevalent low permeability character of bedrock materials.

6.4.4 Average Linear Groundwater-Flow Velocities

The average linear groundwater-flow velocity has historically been calculated for three flow-paths in UHSU surficial deposits and three flow-paths in UHSU bedrock in the vicinity of the Present Sanitary Landfill (DOE, 1996b). Most of the well pairs were deactivated in 1995 in preparation for landfill closure. However, the variables used in calculating flow velocities (hydraulic conductivity, porosity, and hydraulic gradient) have remained effectively constant over time. Hence, the following discussion summarized from the 1995 RCRA Groundwater Monitoring report is considered indicative of current conditions in the Present Sanitary Landfill.

Migration rates for conservative, dissolved constituents approximate the average linear groundwater-flow velocity; however, attenuated, volatile, biodegradable, or redox-sensitive species can exhibit migration rates much less than the average linear groundwater-flow velocity. The values of hydraulic conductivity used for surficial deposits and bedrock of the UHSU are the geometric means of hydraulic-conductivity values for each unit at the Present Sanitary Landfill, and include results of historic slug tests (DOE, 1994c). Values of hydraulic conductivity used for flow velocity calculations are 1.1×10^{-4} centimeters/second (cm/sec) for surficial deposits (including landfill wastes) and 5.3×10^{-7} cm/sec for UHSU bedrock materials. The assumed effective porosity for all units is 0.1 (DOE, 1991b).

Using these data, the calculated average linear groundwater-flow velocities in fill materials range from approximately 1 foot per year at the west end of the landfill to approximately 160 feet per year at the advancing eastern face of the landfill. Calculated average linear groundwater-flow velocities in UHSU bedrock at the Present Sanitary Landfill ranged from approximately 0.20 feet to 0.22 feet per year beneath the landfill, to approximately 0.07 feet to 0.41 feet per year downgradient of the landfill (DOE, 1996a). The calculated average linear

groundwater-flow velocities for UHSU bedrock in 1995 were similar to those reported in the *1994 Annual RCRA Groundwater Monitoring Report* (DOE, 1995).

6.5 Groundwater Quality at the Present Sanitary Landfill

The assessment of groundwater chemistry at the Present Sanitary Landfill includes an evaluation of the spatial distribution of groundwater constituents in and around the landfill, and a statistical evaluation of the chemistry of downgradient groundwater with respect to upgradient groundwater, as specified in *6 CCR 1007-2* and the IMP. Statistical comparisons between downgradient and upgradient groundwater data were made using the methodology described in the *1995 Annual RCRA Groundwater Monitoring Report* (DOE, 1996a) and *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities* (EPA, 1992b).

Figures 6-2 through 6-5 depict the analytical results for each well in individual box-plots. To show as much data as possible without overcrowding, box-plots for metals include only those analytes for which the uncensored arithmetic mean of pooled downgradient well values were greater than the pooled upgradient well values. Box-plots for VOCs include all detected compounds for upgradient and downgradient wells. All data for radionuclides and water quality parameters are presented.

6.5.1 Spatial Distribution of Groundwater Constituents

6.5.1.1 Upgradient Wells

Currently, four wells (5887, 70193, 70393, and 70493) monitor groundwater chemistry in the UHSU immediately upgradient of the Present Sanitary Landfill. Wells 5887 and 70393 are completed in UHSU alluvial materials and wells 70193 and 70493 are completed in UHSU bedrock. All four wells yielded complete quarterly sample sets for a total of 16 upgradient samples per analyte.

As shown in Figure 6-2, concentrations of water quality parameters (fluoride, nitrate/nitrite, sulfate, and TDS) fall within the range of background concentrations reported for these analytes in the *1993 Background Geochemical Characterization Report* (EG&G, 1993a). A similar situation exists for all of the metal and radionuclide analytes detected in these wells (see Figures 6-3 and 6-4, respectively). Except for the major cations (calcium, magnesium, sodium, potassium, and strontium), the concentrations of most metal analytes were undetected or were reported below the CRDL ("B" qualified data). Aluminum was detected in wells 5887, 70393, and 70493 (71.2 µg/L maximum). Chromium (7.9 µg/L maximum), copper (4.6 µg/L maximum), and lead (2.4 µg/L) were detected in well 5887 (a stainless steel well). Selenium (5.5 µg/L maximum) was detected in well 70193. Well 70493 contained single detections of barium (101 µg/L), chromium (2.3 µg/L), selenium (5.8 µg/L), and silver (1.4 µg/L). Strontium in well 70493 ranged from 202 to 233 µg/L. Tritium was not detected in any of the upgradient samples. Uranium-233/234 was detected in two wells (5887 and 70493) and U-238 was detected in well 70493.

Alluvial well 70393 yielded consistent detections of ten chlorinated VOCs, including TCE (22 µg/L maximum), PCE (8 µg/L maximum), carbon tetrachloride (1 µg/L maximum), 1,1,1-TCA (25 µg/L maximum), 1,1-DCE (16.3 µg/L maximum), cis-1,2-DCE (0.4 µg/L maximum), chloroform (0.4 µg/L), and single detections of 1,1-DCA (0.1 µg/L), dichlorodifluoromethane (0.8 µg/L), and trichlorofluoromethane (0.2 µg/L). Weathered bedrock well 70493, paired with well 70393, contained generally lower concentrations and less consistent detections of the type of VOCs found in the overlying alluvium. VOCs found in this well included TCE (1 µg/L maximum), PCE (0.2 µg/L maximum), 1,1,1-TCA (0.9 µg/L maximum), 1,1-DCE (0.2 µg/L maximum), and single detections of toluene (0.1 µg/L) and trichlorofluoromethane (0.2 µg/L). Alluvial well 5887 contained 1,1,1-TCA (0.3 µg/L maximum), methylene chloride (3 µg/L maximum), and single detections of dichlorodifluoromethane (0.8 µg/L) and trichlorofluoromethane (0.3 µg/L). Weathered bedrock well 70193 contained 1,1,1-TCA (0.2 µg/L maximum), methylene chloride (0.71 µg/L maximum), and a single detection of PCE (0.2 µg/L). These results are generally consistent with the results of previous monitoring (DOE, 1998), which determined that the PU&D Yard was the source of this contamination. Results for all other VOC constituents monitored in upgradient wells were below detection.

6.5.1.2 Downgradient Wells

Four wells located east of the East Landfill Pond embankment are used to monitor the chemistry of downgradient groundwater in the UHSU (wells 4087, 52894, 52994, and B206989). Wells 52994 and B206989 monitor groundwater in the UHSU bedrock and wells 4087 and 52894 monitor the quality of alluvial groundwater. All of the well locations are consistent with *6 CCR 1007-2*, which allows alternate placement of monitoring wells downgradient of an interim-status facility where existing physical obstacles prevent installation of wells at the boundary.

In general, the sampling conditions experienced at downgradient well locations during 1999 were characteristic of previous years, with groundwater availability limited by seasonal availability. Complete sample suites could only be collected from alluvial wells 4087 (3 quarters collected) and 52894 (2 quarters collected). Only partial sample suites could be collected from well B206989 (3 quarters collected) because of low well yields, despite repeated visits to the well to obtain additional sample aliquots. Dry well conditions were prevalent at all wells during the remaining quarters, including all four quarters at bedrock well 52994. The statistical significance of these data relative to upgradient groundwater quality will be evaluated later in Section 6.5.2.

Downgradient groundwater quality monitored at wells 4087, 52894, and B206989 indicate that concentrations of all water quality parameters and selected hazardous trace metals exceed concentrations reported for upgradient wells 5887, 70193, 70393, and 70493 (Figure 6-2 and 6-3). All other ALF groundwater constituents in downgradient groundwater, including VOCs, were detected at or below upgradient concentration levels. The majority of antimony, arsenic, cadmium, cobalt, and molybdenum results were reported with a “B” qualifier, signifying that the concentration of these metals were low enough to occur below the CRDL but above the instrument detection limit

(IDL). Apart from arsenic concentrations, these metals were also commonly reported at low concentrations in many upgradient well samples. Slightly elevated concentrations of chromium and nickel were reported in most downgradient samples, but seem to be mainly associated with wells 4087 and B206989. Well 4087 (and upgradient well 5887) is constructed with stainless steel well casing and screen, thus raising the possibility that trace quantities of some metals may have originated from well materials. Lead was reported below detection in all downgradient samples except one at well 52894 (1.8 µg/L, "B" qualified). Elevated concentrations of lithium (66.1 to 1,640 µg/L), manganese (0.87 to 75.5 µg/L), selenium (2.5 to 266 µg/L), and strontium (440 to 5,960 µg/L) were reported in downgradient samples, especially lithium and selenium at well B206989. Thallium was not detected in any downgradient sample, but is mentioned because the downgradient sample mean exceeds the upgradient sample mean (Table 6-3). Elevated concentrations of the non-hazardous metals sodium, potassium, calcium, and magnesium were also detected in downgradient wells, but have no ALF groundwater action levels and, consequently, are not shown in Figure 6-3.

The uranium isotopes U-233/234, U-235, and U-238 (Figure 6-4) also appear to have elevated activity-concentrations in downgradient wells compared to upgradient wells. Tritium was reported as being undetected in all upgradient and downgradient wells.

6.5.2 Statistical Evaluation of Groundwater Constituents

According to the IMP, the decision logic for RCRA designated wells requires the performance of a comparison of pooled upgradient groundwater sample means to individual downgradient well sample means in order to evaluate potential contaminant releases from the regulated unit into the "uppermost aquifer". This type of comparison is usually accomplished using statistical analysis procedures such as described in *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities* (EPA, 1992b). A pre-analysis assessment of the 1999 individual downgradient well data sets indicated that the number of sample analyses in all sets (maximum three samples) were insufficient for performing nonparametric analysis (minimum four samples) on an individual well basis. This situation is a result of the existence of dry conditions in all of the downgradient wells for at least one sampling quarter. To provide adequate data for nonparametric statistical analysis, which applies to the majority of analytes based on normality testing results of the data sets, it was necessary to pool the downgradient well data for comparison to the upgradient data. The rationale for this approach is further justified later in this section.

Table 6-3 presents a sampling and detection summary for each groundwater analyte monitored during 1999. Statistical comparisons were not performed for analytes with upgradient sample means that were equal to or greater than downgradient sample means; analytes with less than 10 percent quantifiable results; or for analytes with less than four quantifiable results, as recommended by EPA guidance (EPA, 1992b) for nonparametric analysis. A sufficient number of samples were collected from upgradient and downgradient well groups to perform pooled statistical comparisons for all analytes with more than 10 percent quantifiable results. Volatile organic compounds were excluded from statistical analysis because it has been shown that upgradient landfill groundwater is

contaminated relative to downgradient landfill groundwater (Figure 6-5) because of the PU&D Yard VOC plume. Data for mercury and tritium met the sample volume criteria, but non-detections exceeded 90 percent of the data sets, so it was necessary to exclude these compounds from statistical evaluation. Conclusions concerning these analytes are described following the discussion of statistical comparisons.

For analytes with greater than 10 percent quantifiable results, parametric ANOVA or nonparametric Wilcoxon Rank-Sum testing was performed, depending on the percentage of non-detections present in the sample groups and sample distribution characteristics. All UHSU results (alluvial and bedrock) were grouped by analyte into upgradient and downgradient data sets to simplify analyses and provide adequate data to perform statistical testing. This approach is justifiable because all downgradient wells are closely located in a well-defined, narrow drainage way that defines the sole groundwater flow path leading from the landfill. The Wilcoxon Rank-Sum test (also known as the Mann-Whitney U test) was selected to perform nonparametric comparisons in place of the Kruskall-Wallis test based on EPA guidance for statistical evaluations involving two data groups (EPA, 1992a). The reader is referred to the EPA guidance document for further description of the statistical methods and parameters used in this section.

Table 6-4 summarizes the results of statistical comparisons for the upgradient and downgradient data groups. Statistically significant differences (at the 1- percent significance level) in upgradient versus downgradient groundwater quality were found for fluoride, sulfate, TDS, cadmium, calcium, copper, lithium, magnesium, molybdenum, potassium, selenium, sodium, strontium, U-233/234, U-235, and U-238. These results are similar those reported in previous RCRA and Present Sanitary Landfill groundwater monitoring reports (see Section 6.2).

Table 6-3 Groundwater Sample and Detection Summary for Present Sanitary Landfill Wells

Parameter	Number of Samples			Number of Detections			Percent Detections			Percent Non-Detects	Sample Mean	
	Upgradient	Down-Gradient	Total	Upgradient	Down-Gradient	Total	Upgradient	Down-Gradient	Total	Non-Detects	Upgradient	Down-Gradient
Water Quality (mg/L)												
Fluoride	16	5	21	14	5	19	87.5	100.0	90.5	9.5	0.31	1.88
Nitrate/Nitrite	16	8	24	16	8	24	100.0	100.0	100.0	0.0	3.3	18.3
Sulfate	16	5	21	16	5	21	100.0	100.0	100.0	0.0	23	338
Total Dissolved Solids	16	5	21	16	5	21	100.0	100.0	100.0	0.0	159	954
Metals (ug/L)												
Aluminum	16	7	23	15	7	22	93.8	100.0	95.7	4.3	20.9	23.4
Antimony	16	7	23	5	5	10	31.3	71.4	43.5	56.5	0.50	0.75
Arsenic	16	7	23	0	3	3	0.0	42.9	13.0	87.0	0.68	1.01
Barium	16	7	23	16	7	23	100.0	100.0	100.0	0.0	73.9	36.5
Beryllium	16	7	23	8	3	11	50.0	42.9	47.8	52.2	0.03	0.03
Cadmium	16	7	23	10	7	17	62.5	100.0	73.9	26.1	0.11	0.37
Calcium	16	7	23	16	7	23	100.0	100.0	100.0	0.0	22425	175886
Chromium	16	7	23	16	6	22	100.0	85.7	95.7	4.3	1.66	14.71
Cobalt	16	7	23	6	6	12	37.5	85.7	52.2	47.8	0.17	0.44
Copper	16	7	23	16	7	23	100.0	100.0	100.0	0.0	1.45	3.76
Iron	16	7	23	16	7	23	100.0	100.0	100.0	0.0	38.6	34.5
Lead	16	7	23	7	1	8	43.8	14.3	34.8	65.2	0.65	0.75
Lithium	16	7	23	16	7	23	100.0	100.0	100.0	0.0	7.9	503.3
Magnesium	16	7	23	16	7	23	100.0	100.0	100.0	0.0	5015	71214

Table 6-3, Continued

Parameter	Number of Samples			Number of Detections			Percent Detections			Percent Non-Detects	Sample Mean	
	Upgradient	Down-Gradient	Total	Upgradient	Down-Gradient	Total	Upgradient	Down-Gradient	Total	Non-Detects	Upgradient	Down-Gradient
Manganese	16	7	23	16	7	23	100.0	100.0	100.0	0.0	1.5	22.5
Mercury	16	7	23	0	0	0	0.0	0.0	0.0	100.0	0.1	0.1
Molybdenum	16	7	23	12	7	19	75.0	100.0	82.6	17.4	0.87	6.20
Nickel	16	7	23	16	7	23	100.0	100.0	100.0	0.0	1.6	6.2
Potassium	16	7	23	16	7	23	100.0	100.0	100.0	0.0	966	6574
Selenium	16	7	23	9	7	16	56.3	100.0	69.6	30.4	2.3	81.5
Silver	16	7	23	3	0	3	18.8	0.0	13.0	87.0	0.30	0.27
Sodium	16	7	23	16	7	23	100.0	100.0	100.0	0.0	11754	321843
Strontium	16	7	23	16	7	23	100.0	100.0	100.0	0.0	147	2086
Thallium	16	7	23	4	0	4	25.0	0.0	17.4	82.6	0.87	1.10
Tin	16	7	23	6	0	6	37.5	0.0	26.1	73.9	1.14	0.61
Vanadium	16	7	23	12	5	17	75.0	71.4	73.9	26.1	5.03	0.43
Zinc	16	7	23	16	6	22	100.0	85.7	95.7	4.3	8.4	6.4
Radionuclides (pCi/L)												
Tritium	16	7	23	0	0	0	0.0	0.0	0.0	100.0	-104.896	-129.691
U-233/234	16	7	23	5	7	12	31.3	100.0	52.2	47.8	0.277	25.803
U-235	16	7	23	1	7	8	6.3	100.0	34.8	65.2	0.0124	1.0480
U-238	16	7	23	5	7	12	31.3	100.0	52.2	47.8	0.1532	18.7426
Volatile Organic Compounds (ug/L)												
1,1,1,2-Tetrachloroethane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,1,1-Trichloroethane	16	8	24	12	0	12	75.0	0.0	50.0	50.0	N/D	N/D
1,1,2,2-Tetrachloroethane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,1,2-Trichloroethane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D

Table 6-3, Continued

Parameter	Number of Samples			Number of Detections			Percent Detections			Percent Non-Detects	Sample Mean	
	Upgradient	Down-Gradient	Total	Upgradient	Down-Gradient	Total	Upgradient	Down-Gradient	Total	Non-Detects	Upgradient	Down-Gradient
1,1-Dichloroethane	16	8	24	1	0	1	6.3	0.0	4.2	95.8	N/D	N/D
1,1-Dichloroethene	16	8	24	6	0	6	37.5	0.0	25.0	75.0	N/D	N/D
1,1-Dichloropropene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,2,3-Trichlorobenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,2,3-Trichloropropane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,2,4-Trichlorobenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,2,4-Trimethylbenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,2-Dibromo-3-chloropropane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,2-Dibromoethane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,2-Dichlorobenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,2-Dichloroethane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,2-Dichloropropane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,3,5-Trimethylbenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,3-Dichlorobenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,3-Dichloropropane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
1,4-Dichlorobenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
2,2-Dichloropropane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
4-Isopropyltoluene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Benzene	16	8	24	0	1	1	0.0	12.5	4.2	95.8	N/D	N/D
Bromobenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Bromochloromethane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Bromodichloromethane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Bromoform	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Bromomethane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Carbon Tetrachloride	16	8	24	3	1	4	18.8	12.5	16.7	83.3	N/D	N/D
Chlorobenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Chloroethane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Chloroform	16	8	24	3	0	3	18.8	0.0	12.5	87.5	N/D	N/D
Chloromethane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D

Table 6-3, Continued

Parameter	Number of Samples			Number of Detections			Percent Detections			Percent Non-Detects	Sample Mean	
	Upgradient	Down-Gradient	Total	Upgradient	Down-Gradient	Total	Upgradient	Down-Gradient	Total	Non-Detects	Upgradient	Down-Gradient
Cis-1,2-Dichloroethene	16	8	24	3	0	3	18.8	0.0	12.5	87.5	N/D	N/D
Cis-1,3-Dichloropropene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Dibromochloromethane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Dibromomethane	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Dichlorodifluoromethane	16	8	24	2	0	2	12.5	0.0	8.3	91.7	N/D	N/D
Ethylbenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Hexachlorobutadiene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Isopropylbenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Methylene Chloride	16	8	24	7	1	8	43.8	12.5	33.3	66.7	N/D	N/D
Naphthalene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
n-Butylbenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
n-Propylbenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
o-Chlorotoluene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
p-Chlorotoluene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Sec-Butylbenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Styrene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Tert-Butylbenzene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Tetrachloroethene	16	8	24	8	0	8	50.0	0.0	33.3	66.7	N/D	N/D
Toluene	16	8	24	1	0	1	6.3	0.0	4.2	95.8	N/D	N/D
Total Xylenes	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Trans-1,2-Dichloroethene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Trans-1,3-Dichloropropene	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D
Trichloroethene	16	8	24	8	0	8	50.0	0.0	33.3	66.7	N/D	N/D
Trichlorofluoromethane	16	8	24	3	0	3	18.8	0.0	12.5	87.5	N/D	N/D
Vinyl Chloride	16	8	24	0	0	0	0.0	0.0	0.0	100.0	N/D	N/D

[1]No correction made for non-detections
[2]N/D = Not determined for VOCs because most detections were estimated quantitations ("J" qualifier) below the detection limit

Table 6-4 Comparative Statistics for Groundwater Analytes with <90 Percent Sample Non-Detections and Downgradient Sample Means Greater than Upgradient Sample Means

Parameter	% Non-Detects	Shapiro-Wilk Normality Test				Levene Test				Parametric ANOVA (Single Factor)				Wilcoxon Rank-Sum Test			
		W_x	$W_{Ln\ x}$	$W_{n,0.05}$	Distribution Type	F_z	$F_{Ln\ z}$	$F_{.05}$	Variances Equal?	F_x	$F_{Ln\ x}$	$F_{.05}$	Significant	W	Z	$Z_{.01}$	Significant Difference?[1]
Water Quality																	
Fluoride	**9.5**	**0.684**	**0.838**	**0.908**	**Unknown**				**Unknown**					**80.0**	**3.269**	**2.326**	**Yes**
Nitrate/Nitrite	0	0.510	0.912	0.916	Unknown				Unknown					25.0	-2.424	2.326	No
Sulfate	**0**	**0.590**	**0.766**	**0.908**	**Unknown**				**Unknown**					**80.0**	**3.270**	**2.326**	**Yes**
TDS	**0**	**0.640**	**0.755**	**0.908**	**Unknown**				**Unknown**					**80.0**	**3.273**	**2.326**	**Yes**
Metals																	
Aluminum	4.3	0.783	0.922	0.914	LogNormal		0.727	4.325	Yes		0.973	4.325	No	N/A	N/A	N/A	N/A
Antimony	**56.5**	**N/A**	**N/A**	**N/A**	**Unknown**				**Unknown**					**103.0**	**3.142**	**2.326**	**Yes**
Arsenic	87.0	N/A	N/A	N/A	Unknown				Unknown					90.0	2.293	2.326	No
Cadmium	**26.1**	**N/A**	**N/A**	**N/A**	**Unknown**				**Unknown**					**108.0**	**3.453**	**2.326**	**Yes**
Calcium	**0**	**0.478**	**0.755**	**0.914**	**Unknown**				**Unknown**					**112.0**	**3.709**	**2.326**	**Yes**
Chromium	4.3	0.496	0.915	0.914	LogNormal		17.95	4.325	No		N/A	4.325	N/A	72.0	1.036	2.326	No
Cobalt	47.8	N/A	N/A	N/A	Unknown				Unknown					86.0	1.994	2.326	No
Copper	**0**	**0.869**	**0.888**	**0.914**	**Unknown**				**Unknown**					**100.5**	**2.942**	**2.326**	**Yes**
Lead	65.2	N/A	N/A	N/A	Unknown				Unknown					63.5	0.489	2.326	No
Lithium	**0**	**0.444**	**0.879**	**0.914**	**Unknown**				**Unknown**					**112.0**	**3.708**	**2.326**	**Yes**
Magnesium	**0**	**0.451**	**0.757**	**0.914**	**Unknown**				**Unknown**					**112.0**	**3.708**	**2.326**	**Yes**
Manganese	13.6	0.372	0.788	0.914	Unknown				Unknown					84.5	1.874	2.326	No
Molybdenum	**17.4**	**N/A**	**N/A**	**N/A**	**Unknown**				**Unknown**					**112.0**	**3.718**	**2.326**	**Yes**
Nickel	**0**	**0.7321**	**0.9716**	**0.914**	**LogNormal**		**0.185**	**4.325**	**Yes**		**17.092**	**4.325**	**Yes**	**N/A**	**N/A**	**N/A**	**N/A**
Potassium	**0**	**0.429**	**0.809**	**0.914**	**Unknown**				**Unknown**					**112.0**	**3.709**	**2.326**	**Yes**
Selenium	**30.4**	**N/A**	**N/A**	**N/A**	**Unknown**				**Unknown**					**104.0**	**3.180**	**2.326**	**Yes**
Sodium	**0**	**0.534**	**0.779**	**0.914**	**Unknown**				**Unknown**					**109.0**	**3.511**	**2.326**	**Yes**
Strontium	**0**	**0.453**	**0.781**	**0.914**	**Unknown**				**Unknown**					**112.0**	**3.710**	**2.326**	**Yes**
Thallium	82.6	N/A	N/A	N/A	Unknown				Unknown					71.0	0.993	2.326	No
Radionuclides																	
U-233/234	**47.8**	**N/A**	**N/A**	**N/A**	**Unknown**				**Unknown**					**112.0**	**3.708**	**2.326**	**Yes**
U-235	**65.2**	**N/A**	**N/A**	**N/A**	**Unknown**				**Unknown**					**112.0**	**3.710**	**2.326**	**Yes**
U-238	**47.8**	**N/A**	**N/A**	**N/A**	**Unknown**				**Unknown**					**112.0**	**3.710**	**2.326**	**Yes**

N/A = not applicable

[1] Significant difference in downgradient to upgradient sample groups shown in bold typeface

Mercury, the only trace metal reported with non-detections exceeding 90 percent of the sample set, was not detected in any sample. Similarly, tritium was absent in all samples at or above the CRDL. The elevated concentration of this analyte in well B206989, as also observed for nitrate/nitrite, lithium, and selenium in this well, may signify an association with a contaminant source other than the landfill. The elevated activity-concentrations of uranium isotopes in this well and possibly wells 4087 and 52894, compared to upgradient well activity-concentrations, could also result from some other source.

6.5.3 Trend Plots and Data Interpretation

Trend plots of analytes in downgradient wells that exceed upgradient concentrations are presented in Appendix C per the requirements of the IMP. Concentration trends for most analytes with three or more data points tend to be fluctuate somewhat, but are generally flat or declining, and therefore indicate that potentially contaminated landfill groundwater is not currently migrating eastward past the East Landfill Pond dam. Specifically, the fluoride, sulfate, TDS, cadmium, calcium, molybdenum, potassium, sodium, strontium, and U-235 concentrations in all downgradient wells (except fluoride, sulfate, and TDS in well B206989) do not appear to be increasing above historical levels. The data sets for fluoride, sulfate, and TDS in well B206989 consist of only two data points, which is insufficient for discerning trends and can not be interpreted without additional data. Copper, lithium, selenium, U-233/234, and U-238 concentrations in well B206989 show evidence of an increasing trend, making these analytes reportable occurrences under RFCA. The magnesium concentration in well B206989 also appears to be rising; however, this constituent is non-hazardous and lacks a RFCA action level criterion.

Assuming that seepage of contaminated groundwater past the dam is not appreciable enough to influence downgradient groundwater quality, the elevated concentrations of inorganic and radiological analytes in downgradient groundwater can be caused by several factors. Some potential causes include:

- lateral underflow of landfill leachate beneath the pond and dam through UHSU bedrock materials;
- evaporative concentration of solutes in pond water in combination with other factors, such as mineral build-up in soils resulting from seasonal desaturation of valley-fill alluvial materials;
- contribution of more highly mineralized groundwater from the underlying LHSU to UHSU bedrock;
- natural mineralization of groundwater resulting from prolonged contact with aquifer materials as it travels along a flow path, and
- a secondary contaminant source that is upgradient of the well, but is not associated with the landfill or pond.

Analysis of analyte trends showing concentration increases must account for these conditions in order to differentiate between natural and anthropogenic influences.

In general, natural processes involving evapotranspiration, upwelling of LHSU groundwater, and mineralization along the flow path do not appear to provide satisfactory explanations for the geochemistry at well B206989, mainly because the elevated nitrate/nitrite, lithium, and selenium concentrations lie well above their normal background ranges. They also do not appear to be landfill related, as the concentrations of these analytes in landfill leachate and pond water have historically been relatively low. For example, the mean concentrations of nitrate/nitrite (0.3 mg/L), lithium (40 µg/L), and selenium (2 µg/L) at surface water monitoring station SW097 (landfill leachate), and nitrate/nitrite (0.093 mg/L) and lithium (77 µg/L) at SW098 (landfill pond) (DOE, 1996a, Tables 2-2 and 2-3), are significantly lower than concentrations found in well B206989 groundwater. In addition, elevated concentrations of nitrate/nitrite (mean=143.5 mg/L), lithium (199 µg/L) and selenium (504 µg/L) have been detected in samples from UHSU bedrock well B206889, located to the south and upgradient of well B206989. Elevated concentrations of some or all of these constituents have been found in other contaminant plumes, including the Solar Evaporation Ponds and IHSS 119.1.

As suggested above and reported in the *1998 Groundwater Monitoring at the Present Sanitary Landfill* report (DOE, 1999), the most likely cause for anomalous groundwater quality at well B206989 is an unknown secondary contaminant source located upgradient of well B206889. Regardless of their source, the absence of contaminants at high concentrations in landfill groundwater and surface water indicate the presence of potential non-landfill interference in interpreting downgradient weathered bedrock groundwater quality.

6.6 Groundwater Intercept System Sampling

Observation of drain outfalls SW099 and SW100 located below the landfill pond dam was conducted periodically during 1999. Discharge at drain outfalls SW099 and SW100 is usually minimal or absent. In April 1999, flows from both outfalls were observed and a complete sample set was collected for VOCs, unfiltered metals, radionuclides (tritium and uranium isotopes), and water quality parameters. Discharges of 0.5 gallons per minute (gpm) at SW099 and 1.3 gpm at SW100 were measured prior to sampling. The analytical results for these samples reveal that no contamination above RFCA Tier II groundwater action levels was detected at these stations.

6.7 Conclusions

Groundwater conditions at the Present Sanitary Landfill in 1999 appear to be generally consistent with the results of previous monitoring. Statistical comparisons of upgradient versus downgradient UHSU groundwater at the Present Sanitary Landfill were performed for analytes meeting the minimum evaluation criteria of <90 percent non-detections and at least four samples per upgradient and downgradient data set. Significant differences (at the 1% level) in upgradient compared to downgradient groundwater quality were found for fluoride, sulfate, TDS, cadmium, calcium, copper, lithium, magnesium, molybdenum, potassium, selenium, sodium, strontium, U-233/234, U-235, and U-238. Volatile organic compounds were not evaluated statistically because the percentage of non-detections exceeded 90 percent or because contaminants were found only in upgradient samples.

Apart from copper, lithium, selenium, U-233/234, and U-238 in well B206989, the trends of potential inorganic and radionuclide contaminants do not appear to be increasing with time in the downgradient wells. The increasing trends of copper, lithium, selenium, U-233/234, and U-238 in well B206989 represent groundwater quality exceedances that are reportable under the IMP. A more complete review of available groundwater and soils data associated with potential upgradient, non-landfill contaminant sources appears to be warranted to investigate the elevated occurrences of copper, lithium, selenium, and uranium isotopes in downgradient well B206989.

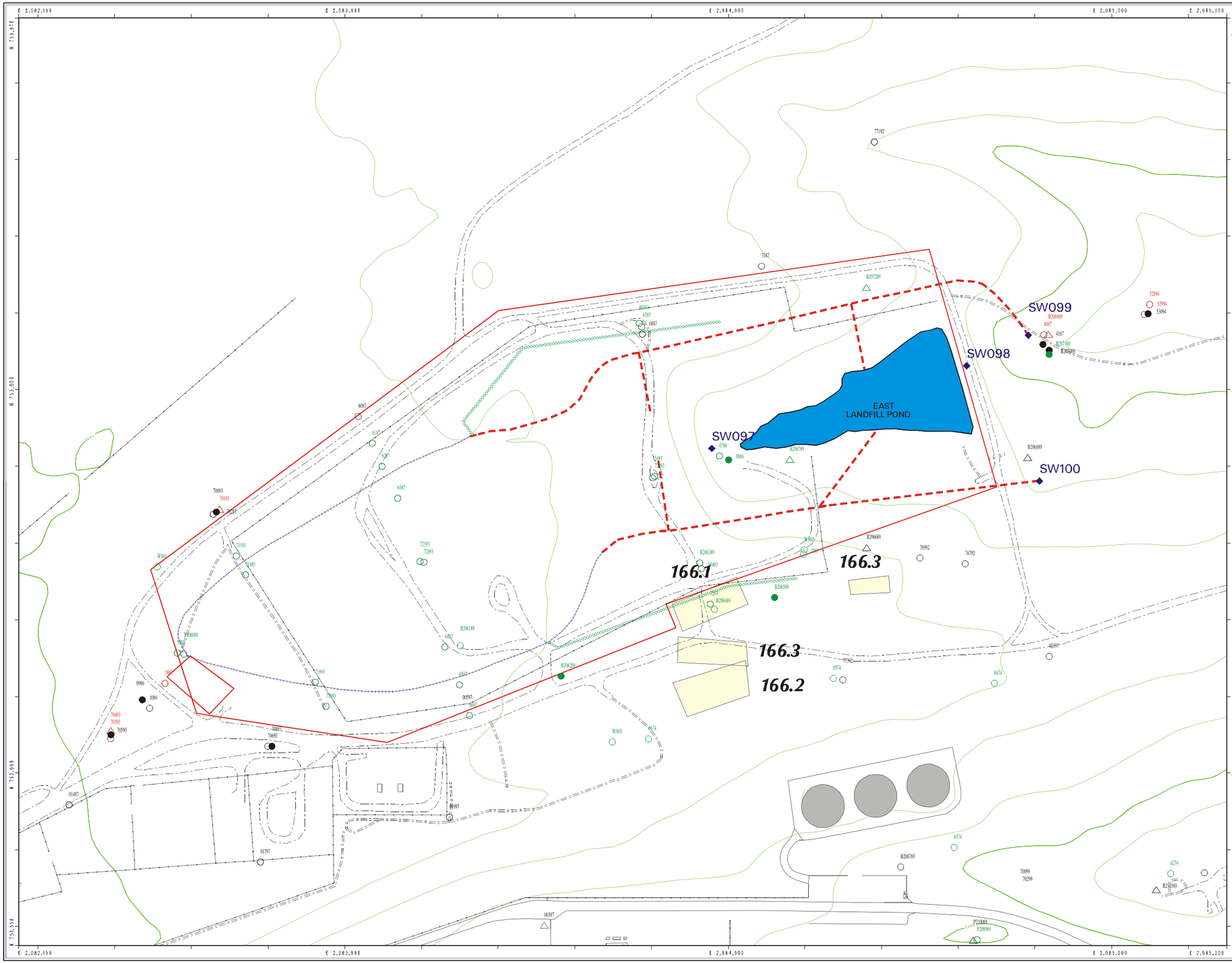


Figure 6-1

Groundwater Intercept and Diversion System Layout at the Present Sanitary Landfill

1999 Annual RFCA Groundwater Monitoring Report

EXPLANATION

- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Surface Water Monitoring Locations
- Landfill Groundwater Monitoring Wells
- All Other Existing Wells
- Abandoned Wells
- IHSS 166.1, 166.2 and 166.3
- Slurry Wall
- GW Intercept System - Perforated
- GW Intercept System - Non-Perforated
- Individual Hazardous Substance Site
- East Landfill Pond
- Tanks
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

Scale = 1 : 2930
1 inch represents approximately 244 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

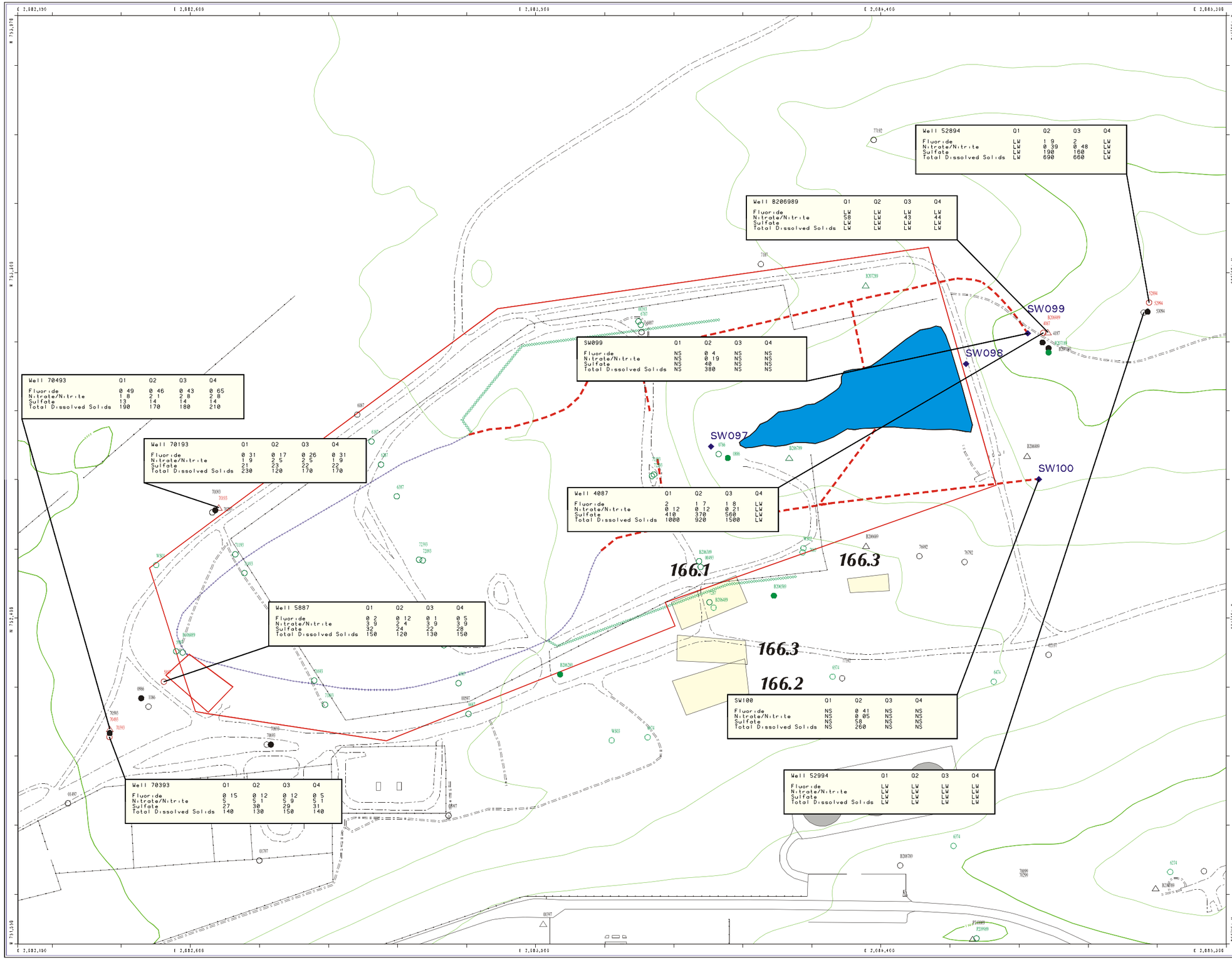
Prepared for: KAISER-HILL

MAP ID: fy2k/rfca-rpt/box_landfill

December 06, 2000

Original map contents are preserved. Logo and date have changed.

NT_Svr w:/projects/fy2k/rfca-rpt/figures/box_landfill/map-wqp/uhsu_well-loc.aml



Well 52894	Q1	Q2	Q3	Q4
Fluoride	LW	1 9	2	LW
Nitrate/Nitrite	LW	0 39	0 48	LW
Sulfate	LW	190	160	LW
Total Dissolved Solids	LW	690	660	LW

Well 8206989	Q1	Q2	Q3	Q4
Fluoride	LW	LW	LW	LW
Nitrate/Nitrite	58	LW	43	44
Sulfate	LW	LW	LW	LW
Total Dissolved Solids	LW	LW	LW	LW

SW099	Q1	Q2	Q3	Q4
Fluoride	NS	0 4	NS	NS
Nitrate/Nitrite	NS	0 19	NS	NS
Sulfate	NS	40	NS	NS
Total Dissolved Solids	NS	380	NS	NS

Well 70493	Q1	Q2	Q3	Q4
Fluoride	0 49	0 46	0 43	0 65
Nitrate/Nitrite	1 8	2 1	2 8	2 8
Sulfate	13	14	14	14
Total Dissolved Solids	190	170	180	210

Well 70193	Q1	Q2	Q3	Q4
Fluoride	0 31	0 17	0 26	0 31
Nitrate/Nitrite	1 9	2 5	2 5	1 9
Sulfate	21	23	22	22
Total Dissolved Solids	230	120	170	170

Well 4087	Q1	Q2	Q3	Q4
Fluoride	2	1 7	1 8	LW
Nitrate/Nitrite	0 12	0 12	0 21	LW
Sulfate	410	370	560	LW
Total Dissolved Solids	1000	920	1500	LW

Well 5887	Q1	Q2	Q3	Q4
Fluoride	0 2	0 12	0 1	0 5
Nitrate/Nitrite	3 9	2 4	3 9	3 9
Sulfate	32	24	22	28
Total Dissolved Solids	150	120	130	150

SW100	Q1	Q2	Q3	Q4
Fluoride	NS	0 41	NS	NS
Nitrate/Nitrite	NS	0 05	NS	NS
Sulfate	NS	58	NS	NS
Total Dissolved Solids	NS	260	NS	NS

Well 70393	Q1	Q2	Q3	Q4
Fluoride	0 15	0 12	0 12	0 5
Nitrate/Nitrite	5	5 1	5 9	5 1
Sulfate	27	30	29	31
Total Dissolved Solids	140	130	150	140

Well 52994	Q1	Q2	Q3	Q4
Fluoride	LW	LW	LW	LW
Nitrate/Nitrite	LW	LW	LW	LW
Sulfate	LW	LW	LW	LW
Total Dissolved Solids	LW	LW	LW	LW

Figure 6-2

Water Quality Parameters (mg/L) at the Present Sanitary Landfill

1999 Annual RFCA Groundwater Monitoring Report

EXPLANATION

- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Surface Water Monitoring Locations
- Landfill Groundwater Monitoring Wells
- All Other Existing Wells
- Abandoned Wells
- IHSS 166.1, 166.2 and 166.3
- Slurry Wall
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- Individual Hazardous Substance Site
- East Landfill Pond
- Tanks
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

NOTE:
LW - Lacked Water
NS - Not Sampled/Dry Conditions

Source of GIS data available upon request.

Scale = 1 : 2970
1 inch represents approximately 248 feet

50 0 100 200ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

Prepared for: KAISER•HILL

MAP ID: fy2k/rfca-rpt/box_landfill

December 06, 2000

Original map contents are preserved. Logo and date have changed.

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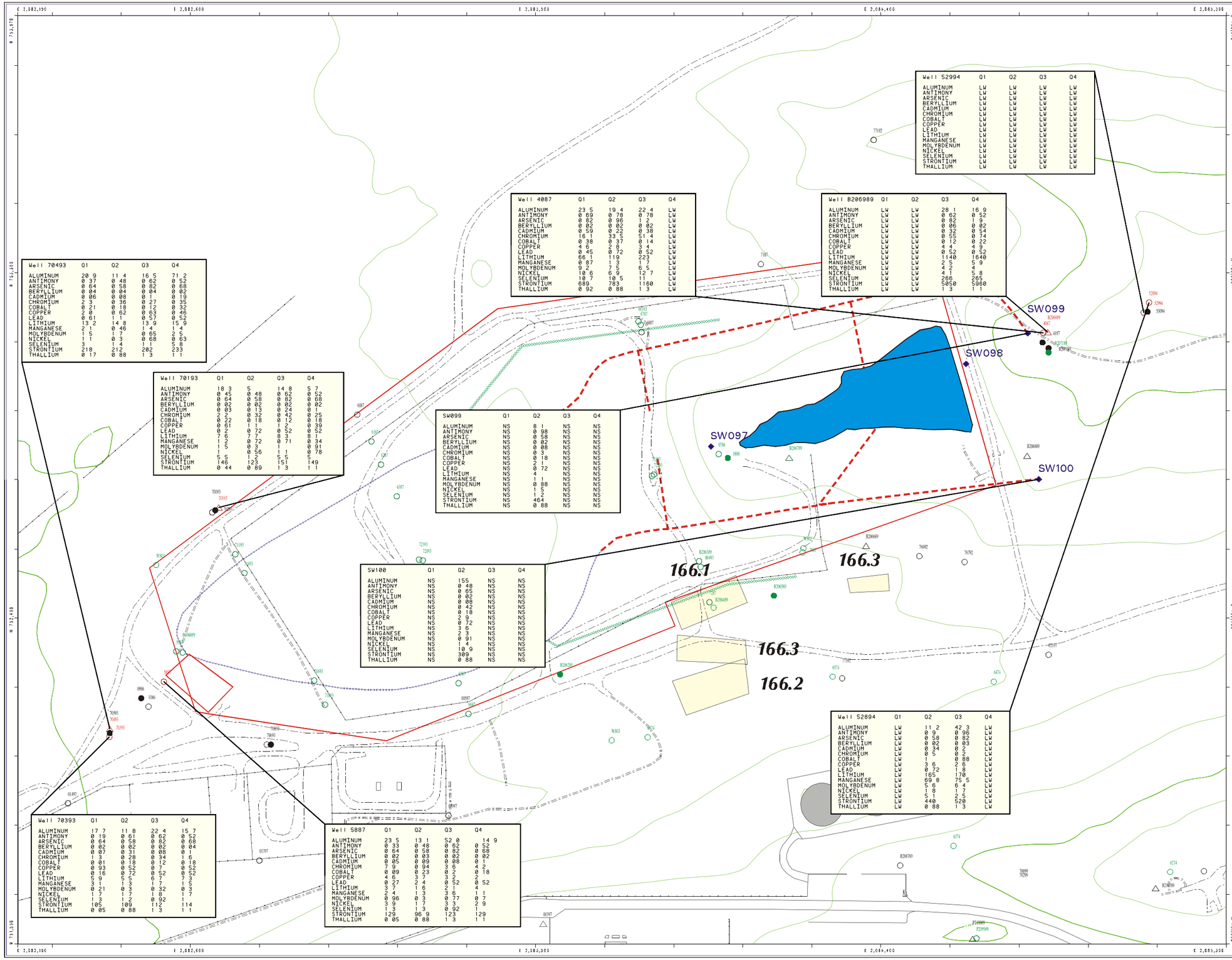

Well 70493	Q1	Q2	Q3	Q4
ALUMINUM	20.9	11.4	16.5	71.2
ANTIMONY	0.37	0.46	0.62	0.52
ARSENIC	0.64	0.58	0.82	0.68
BERYLLIUM	0.04	0.04	0.04	0.02
CADMIUM	0.06	0.08	0.1	0.19
CHROMIUM	2.3	0.36	0.27	0.35
COBALT	0.21	0.18	0.12	0.32
COPPER	2.0	0.62	0.63	0.46
LEAD	0.61	1	0.57	0.52
LITHIUM	13.2	14.8	13.9	15.9
MANGANESE	2.1	0.46	1.4	1.4
MOLYBDENUM	1.5	1.7	0.65	2.5
NICKEL	1.1	0.3	0.68	0.63
SELENIUM	3	1.4	1.1	5.8
STRONTIUM	218	212	202	233
THALLIUM	0.17	0.88	1.3	1.1

Well 70193	Q1	Q2	Q3	Q4
ALUMINUM	18.3	5	14.8	5.7
ANTIMONY	0.45	0.48	0.62	0.52
ARSENIC	0.64	0.58	0.82	0.68
BERYLLIUM	0.02	0.02	0.02	0.02
CADMIUM	0.03	0.13	0.24	0.1
CHROMIUM	2.2	0.32	0.42	0.25
COBALT	0.22	0.18	0.12	0.18
COPPER	0.61	1.1	1.2	0.39
LEAD	0.2	0.72	0.52	0.52
LITHIUM	7.6	7.7	8.3	8.1
MANGANESE	1.2	0.72	0.71	0.34
MOLYBDENUM	1.5	0.3	1	0.91
NICKEL	1	0.56	1.1	0.78
SELENIUM	5.5	1.2	5.5	5
STRONTIUM	146	123	151	149
THALLIUM	0.44	0.89	1.3	1.1

Well 70393	Q1	Q2	Q3	Q4
ALUMINUM	17.7	11.8	22.4	15.7
ANTIMONY	0.19	0.61	0.62	0.52
ARSENIC	0.64	0.58	0.82	0.68
BERYLLIUM	0.02	0.02	0.02	0.04
CADMIUM	0.07	0.31	0.08	0.1
CHROMIUM	1.3	0.28	0.34	1.6
COBALT	0.01	0.18	0.12	0.18
COPPER	0.93	0.52	0.7	0.52
LEAD	0.16	0.72	0.52	0.52
LITHIUM	5.9	5.5	6.7	7.3
MANGANESE	3.1	1.3	1.7	1.5
MOLYBDENUM	0.21	0.3	0.32	0.3
NICKEL	1.7	1.7	1.8	1.7
SELENIUM	1.3	1.2	0.92	1
STRONTIUM	105	109	112	114
THALLIUM	0.05	0.88	1.3	1.1

Well 4087	Q1	Q2	Q3	Q4
ALUMINUM	23.5	19.4	22.4	LW
ANTIMONY	0.69	0.78	0.78	LW
ARSENIC	0.82	0.96	1.2	LW
BERYLLIUM	0.02	0.02	0.02	LW
CADMIUM	0.59	0.22	0.38	LW
CHROMIUM	16.1	33.5	51.4	LW
COBALT	0.38	0.37	0.14	LW
COPPER	4.6	2.8	3.4	LW
LEAD	0.45	0.72	0.52	LW
LITHIUM	66.1	119	223	LW
MANGANESE	0.87	1.3	1.7	LW
MOLYBDENUM	9.2	7.5	6.5	LW
NICKEL	10.6	6.9	12.7	LW
SELENIUM	10.7	10.5	11	LW
STRONTIUM	689	783	1160	LW
THALLIUM	0.92	0.88	1.3	LW

Well B206989	Q1	Q2	Q3	Q4
ALUMINUM	LW	LW	28.1	16.9
ANTIMONY	LW	LW	0.62	0.52
ARSENIC	LW	LW	0.82	1.9
BERYLLIUM	LW	LW	0.06	0.02
CADMIUM	LW	LW	0.32	0.54
CHROMIUM	LW	LW	0.55	0.74
COBALT	LW	LW	0.12	0.22
COPPER	LW	LW	4.4	4.9
LEAD	LW	LW	0.52	0.52
LITHIUM	LW	LW	1140	1640
MANGANESE	LW	LW	2.5	5.9
MOLYBDENUM	LW	LW	4.2	4
NICKEL	LW	LW	4.1	5.8
SELENIUM	LW	LW	266	265
STRONTIUM	LW	LW	5050	5960
THALLIUM	LW	LW	1.3	1.1

Well 52994	Q1	Q2	Q3	Q4
ALUMINUM	LW	LW	LW	LW
ANTIMONY	LW	LW	LW	LW
ARSENIC	LW	LW	LW	LW
BERYLLIUM	LW	LW	LW	LW
CADMIUM	LW	LW	LW	LW
CHROMIUM	LW	LW	LW	LW
COBALT	LW	LW	LW	LW
COPPER	LW	LW	LW	LW
LEAD	LW	LW	LW	LW
LITHIUM	LW	LW	LW	LW
MANGANESE	LW	LW	LW	LW
MOLYBDENUM	LW	LW	LW	LW
NICKEL	LW	LW	LW	LW
SELENIUM	LW	LW	LW	LW
STRONTIUM	LW	LW	LW	LW
THALLIUM	LW	LW	LW	LW

SW099	Q1	Q2	Q3	Q4
ALUMINUM	NS	8.1	NS	NS
ANTIMONY	NS	0.98	NS	NS
ARSENIC	NS	0.58	NS	NS
BERYLLIUM	NS	0.02	NS	NS
CADMIUM	NS	0.08	NS	NS
CHROMIUM	NS	0.3	NS	NS
COBALT	NS	0.18	NS	NS
COPPER	NS	2.1	NS	NS
LEAD	NS	0.72	NS	NS
LITHIUM	NS	4	NS	NS
MANGANESE	NS	1.1	NS	NS
MOLYBDENUM	NS	0.88	NS	NS
NICKEL	NS	1.5	NS	NS
SELENIUM	NS	1.2	NS	NS
STRONTIUM	NS	464	NS	NS
THALLIUM	NS	0.88	NS	NS

SW100	Q1	Q2	Q3	Q4
ALUMINUM	NS	155	NS	NS
ANTIMONY	NS	0.48	NS	NS
ARSENIC	NS	0.65	NS	NS
BERYLLIUM	NS	0.02	NS	NS
CADMIUM	NS	0.08	NS	NS
CHROMIUM	NS	0.42	NS	NS
COBALT	NS	0.18	NS	NS
COPPER	NS	2.9	NS	NS
LEAD	NS	0.72	NS	NS
LITHIUM	NS	3.6	NS	NS
MANGANESE	NS	2.3	NS	NS
MOLYBDENUM	NS	0.91	NS	NS
NICKEL	NS	1.4	NS	NS
SELENIUM	NS	10.9	NS	NS
STRONTIUM	NS	309	NS	NS
THALLIUM	NS	0.88	NS	NS

Well 5887	Q1	Q2	Q3	Q4
ALUMINUM	23.5	13.1	52.0	14.9
ANTIMONY	0.33	0.48	0.62	0.52
ARSENIC	0.64	0.58	0.82	0.68
BERYLLIUM	0.02	0.03	0.02	0.02
CADMIUM	0.05	0.09	0.08	0.1
CHROMIUM	7.9	0.94	3.6	4.2
COBALT	0.09	0.23	0.2	0.18
COPPER	4.6	3.7	3.2	2
LEAD	0.27	2.4	0.52	0.52
LITHIUM	3.7	1.6	2.1	4
MANGANESE	2.4	1.3	3.6	1.1
MOLYBDENUM	0.96	0.3	0.77	0.7
NICKEL	3.9	1.7	3.3	2.9
SELENIUM	1.3	1.3	0.92	1
STRONTIUM	129	96.9	123	129
THALLIUM	0.05	0.88	1.3	1.1

Well 52894	Q1	Q2	Q3	Q4
ALUMINUM	LW	11.2	42.3	LW
ANTIMONY	LW	0.9	0.96	LW
ARSENIC	LW	0.58	0.82	LW
BERYLLIUM	LW	0.02	0.03	LW
CADMIUM	LW	0.34	0.2	LW
CHROMIUM	LW	0.5	0.2	LW
COBALT	LW	1	0.88	LW
COPPER	LW	3.6	2.6	LW
LEAD	LW	0.72	1.8	LW
LITHIUM	LW	165	170	LW
MANGANESE	LW	69.8	75.5	LW
MOLYBDENUM	LW	5.6	6.4	LW
NICKEL	LW	1.8	1.7	LW
SELENIUM	LW	5.1	2.5	LW
STRONTIUM	LW	440	520	LW
THALLIUM	LW	0.88	1.3	LW

Figure 6-3

Selected Metals (ug/L) at the Present Sanitary Landfill 1999

1999 Annual RFCA Groundwater Monitoring Report

EXPLANATION

- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Surface Water Monitoring Locations
- Landfill Groundwater Monitoring Wells
- All Other Existing Wells
- Abandoned Wells
- IHSS 166.1, 166.2 and 166.3
- Slurry Wall
- GW Intercept System - Perforated
- GW Intercept System - Non-Perforated
- Individual Hazardous Substance Site
- East Landfill Pond
- Tanks
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

NOTE:

BDL - Below Detection Limit
LW - Lacked Water
NS - Not Sampled/Dry Conditions

Source of GIS data available upon request.

Scale = 1 : 2970
1 inch represents approximately 248 feet

50 0 100 200ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

Prepared for: KAISER-HILL

MAP ID: fy2k/rfca-rpt/box_landfill

December 06, 2000

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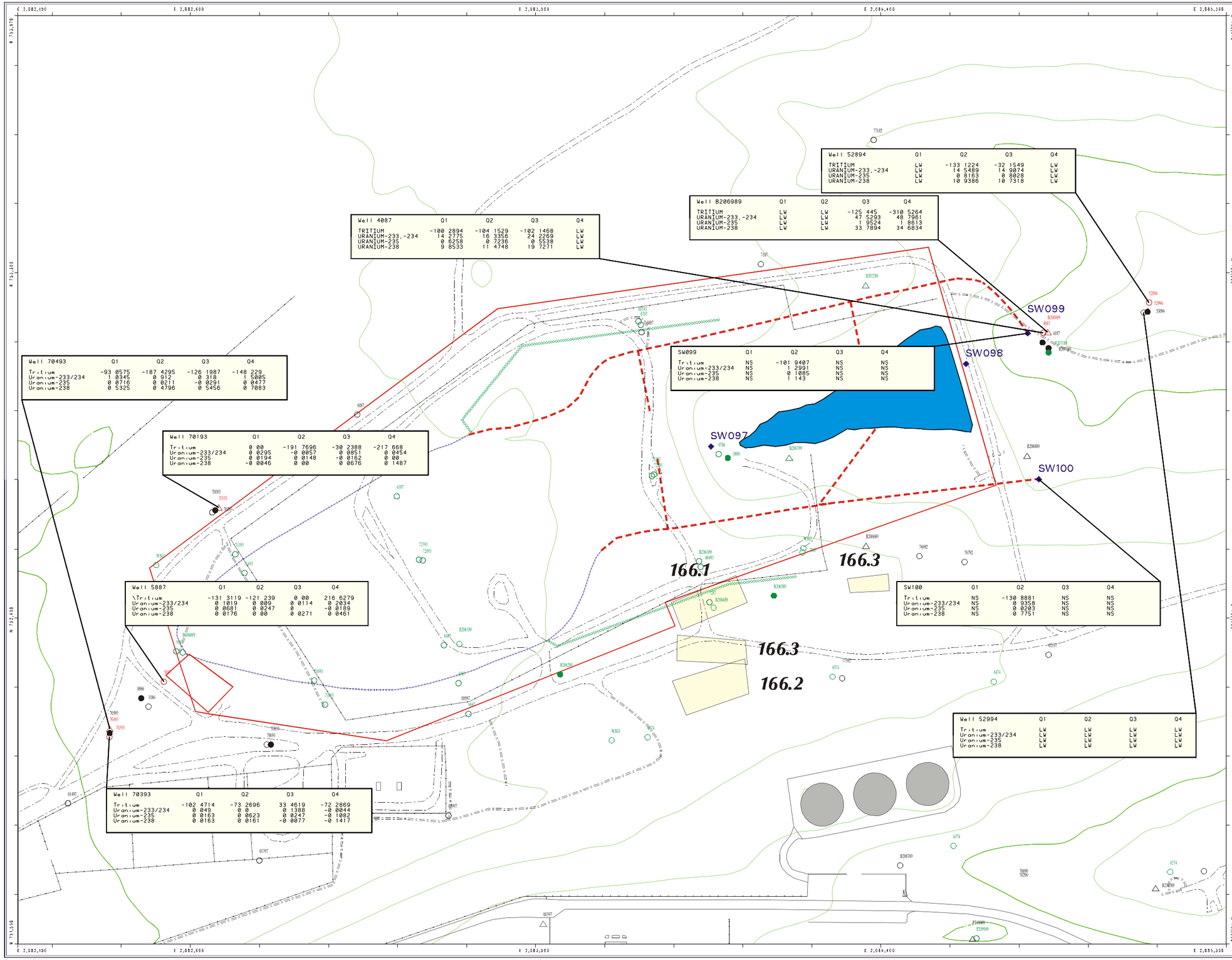
Figure 6-4

Tritium & Dissolved Uranium (pCi/L) at the Present Sanitary Landfill

1999 Annual RFCA Groundwater Monitoring Report



Well 4087	Q1	Q2	Q3	Q4
TRITIUM	-100 2894	-104 1529	-102 1468	LW
URANIUM-233,-234	14 2775	16 3356	24 2269	LW
URANIUM-235	0 6258	0 7236	0 5538	LW
URANIUM-238	9 8533	11 4748	19 7271	LW

Well 52894	Q1	Q2	Q3	Q4
TRITIUM	LW	-133 1224	-32 1549	LW
URANIUM-233,-234	LW	14 5489	14 9074	LW
URANIUM-235	LW	0 8163	0 8028	LW
URANIUM-238	LW	10 9386	10 7318	LW

Well B206989	Q1	Q2	Q3	Q4
TRITIUM	LW	LW	-125 445	-310 5264
URANIUM-233,-234	LW	LW	47 5293	48 7961
URANIUM-235	LW	LW	1 9524	1 8613
URANIUM-238	LW	LW	33 7894	34 6834

Well 70493	Q1	Q2	Q3	Q4
Tritium	-93 0575	-187 4295	-126 1987	-148 229
Uranium-233/234	1 0345	0 912	0 318	1 5005
Uranium-235	0 0716	0 0211	-0 0291	0 0477
Uranium-238	0 5325	0 4796	0 5456	0 7083

SW099	Q1	Q2	Q3	Q4
Tritium	NS	-101 9407	NS	NS
Uranium-233/234	NS	1 2991	NS	NS
Uranium-235	NS	0 1085	NS	NS
Uranium-238	NS	1 143	NS	NS

Well 70193	Q1	Q2	Q3	Q4
Tritium	0 00	-191 7696	-30 2388	-217 668
Uranium-233/234	0 0295	-0 0057	0 0851	0 0454
Uranium-235	0 0194	0 0148	-0 0162	0 00
Uranium-238	-0 0046	0 00	0 0676	0 1487

Well 5887	Q1	Q2	Q3	Q4
\Tritium	-131 3119	-121 239	0 00	216 6279
Uranium-233/234	0 1019	0 009	0 0114	0 2034
Uranium-235	0 0681	0 0247	0	-0 0189
Uranium-238	0 0176	0 00	0 0271	0 0461

SW100	Q1	Q2	Q3	Q4
Tritium	NS	-130 8881	NS	NS
Uranium-233/234	NS	0 9358	NS	NS
Uranium-235	NS	0 0203	NS	NS
Uranium-238	NS	0 7751	NS	NS

Well 52994	Q1	Q2	Q3	Q4
Tritium	LW	LW	LW	LW
Uranium-233/234	LW	LW	LW	LW
Uranium-235	LW	LW	LW	LW
Uranium-238	LW	LW	LW	LW

Well 70393	Q1	Q2	Q3	Q4
Tritium	-102 4714	-73 2696	33 4619	-72 2869
Uranium-233/234	0 049	0 0	0 1388	-0 0044
Uranium-235	0 0163	0 0623	0 0247	-0 1082
Uranium-238	0 0163	0 0161	-0 0077	-0 1417

EXPLANATION

- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Surface Water Monitoring Locations
- Landfill Groundwater Monitoring Wells
- All Other Existing Wells
- Abandoned Wells
- IHSS 166.1, 166.2 and 166.3
- Slurry Wall
- GW Intercept System - Perforated
- GW Intercept System - Non-Perforated
- Individual Hazardous Substance Site
- East Landfill Pond
- Tanks
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

NOTE:
LW - Lacked Water
NS - Not Sampled/Dry Conditions

Source of GIS data available upon request.

Scale = 1 : 2970
1 inch represents approximately 248 feet

50 0 100 200ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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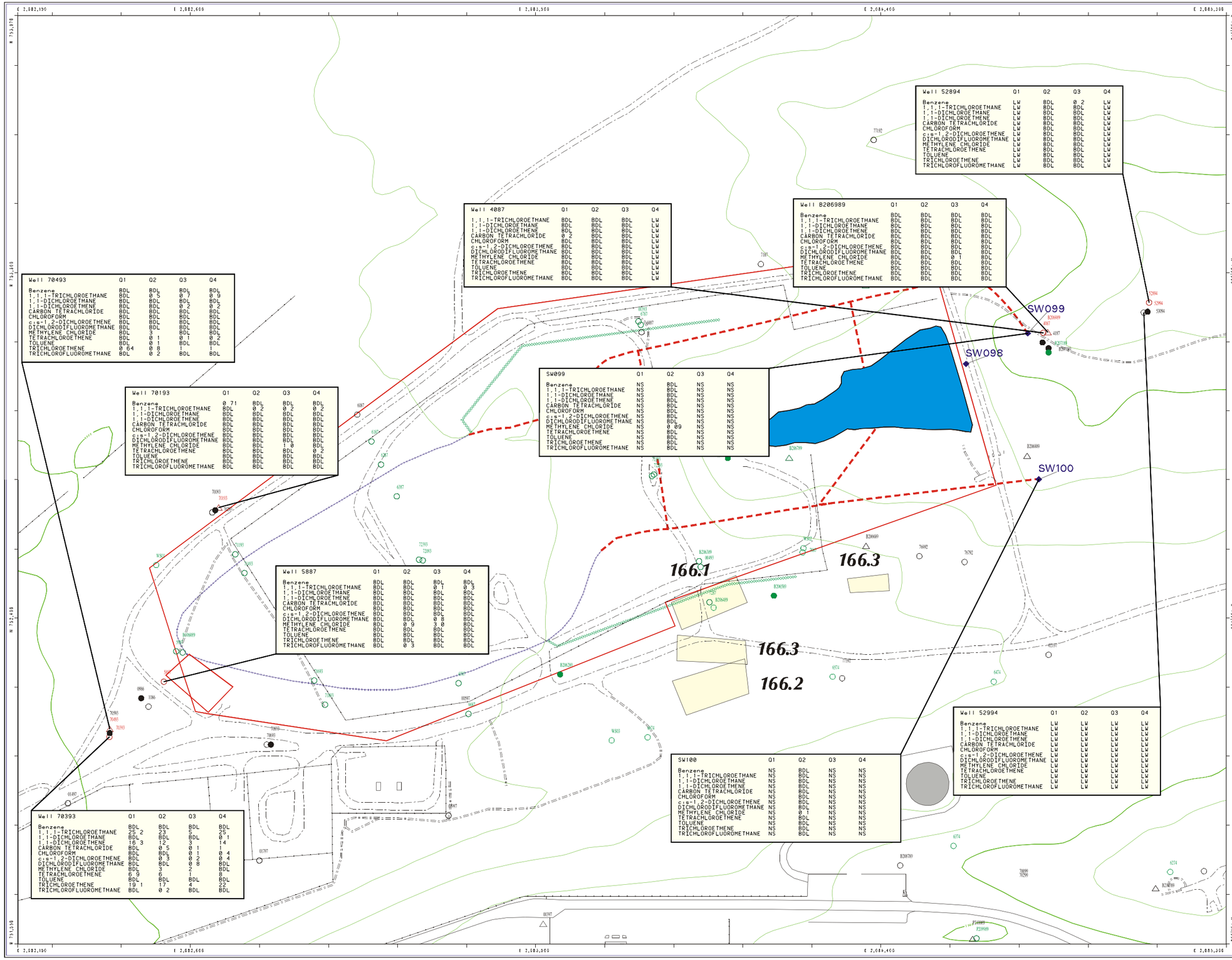

Well 70493	Q1	Q2	Q3	Q4
Benzene	BDL	BDL	BDL	BDL
1,1,1-TRICHLOROETHANE	BDL	0 5	0 7	0 9
1,1-DICHLOROETHANE	BDL	BDL	BDL	BDL
1,1-DICHLOROETHENE	BDL	BDL	0 2	0 2
CARBON TETRACHLORIDE	BDL	BDL	BDL	BDL
CHLOROFORM	BDL	BDL	BDL	BDL
cis-1,2-DICHLOROETHENE	BDL	BDL	BDL	BDL
DICHLORODIFLUOROMETHANE	BDL	BDL	BDL	BDL
METHYLENE CHLORIDE	BDL	3	BDL	BDL
TETRACHLOROETHENE	BDL	0 1	0 1	0 2
TOLUENE	BDL	0 1	BDL	BDL
TRICHLOROETHENE	0 64	0 8	1	1
TRICHLOROFLUOROMETHANE	BDL	0 2	BDL	BDL

Well 70193	Q1	Q2	Q3	Q4
Benzene	0 71	BDL	BDL	BDL
1,1,1-TRICHLOROETHANE	BDL	0 2	0 2	0 2
1,1-DICHLOROETHANE	BDL	BDL	BDL	BDL
1,1-DICHLOROETHENE	BDL	BDL	BDL	BDL
CARBON TETRACHLORIDE	BDL	BDL	BDL	BDL
CHLOROFORM	BDL	BDL	BDL	BDL
cis-1,2-DICHLOROETHENE	BDL	BDL	BDL	BDL
DICHLORODIFLUOROMETHANE	BDL	BDL	BDL	BDL
METHYLENE CHLORIDE	BDL	BDL	1 0	BDL
TETRACHLOROETHENE	BDL	BDL	BDL	0 2
TOLUENE	BDL	BDL	BDL	BDL
TRICHLOROETHENE	BDL	BDL	BDL	BDL
TRICHLOROFLUOROMETHANE	BDL	BDL	BDL	BDL

Well 70393	Q1	Q2	Q3	Q4
Benzene	BDL	BDL	BDL	BDL
1,1,1-TRICHLOROETHANE	25 2	23	5	25
1,1-DICHLOROETHANE	BDL	BDL	BDL	0 1
1,1-DICHLOROETHENE	16 3	12	3	14
CARBON TETRACHLORIDE	BDL	0 5	0 1	1
CHLOROFORM	BDL	BDL	0 1	0 4
cis-1,2-DICHLOROETHENE	BDL	0 3	0 2	0 4
DICHLORODIFLUOROMETHANE	BDL	BDL	0 8	BDL
METHYLENE CHLORIDE	BDL	3	2	BDL
TETRACHLOROETHENE	6 9	6	1	8
TOLUENE	BDL	BDL	BDL	BDL
TRICHLOROETHENE	19 1	17	4	22
TRICHLOROFLUOROMETHANE	BDL	0 2	BDL	BDL

Well 4087	Q1	Q2	Q3	Q4
1,1,1-TRICHLOROETHANE	BDL	BDL	BDL	LW
1,1-DICHLOROETHANE	BDL	BDL	BDL	LW
1,1-DICHLOROETHENE	BDL	BDL	BDL	LW
CARBON TETRACHLORIDE	0 2	BDL	BDL	LW
CHLOROFORM	BDL	BDL	BDL	LW
cis-1,2-DICHLOROETHENE	BDL	BDL	BDL	LW
DICHLORODIFLUOROMETHANE	BDL	BDL	BDL	LW
METHYLENE CHLORIDE	BDL	BDL	BDL	LW
TETRACHLOROETHENE	BDL	BDL	BDL	LW
TOLUENE	BDL	BDL	BDL	LW
TRICHLOROETHENE	BDL	BDL	BDL	LW
TRICHLOROFLUOROMETHANE	BDL	BDL	BDL	LW

Well 5887	Q1	Q2	Q3	Q4
Benzene	BDL	BDL	BDL	BDL
1,1,1-TRICHLOROETHANE	BDL	BDL	0 1	0 3
1,1-DICHLOROETHANE	BDL	BDL	BDL	BDL
1,1-DICHLOROETHENE	BDL	BDL	BDL	BDL
CARBON TETRACHLORIDE	BDL	BDL	BDL	BDL
CHLOROFORM	BDL	BDL	BDL	BDL
cis-1,2-DICHLOROETHENE	BDL	BDL	BDL	BDL
DICHLORODIFLUOROMETHANE	BDL	BDL	0 8	BDL
METHYLENE CHLORIDE	BDL	0 9	3 0	BDL
TETRACHLOROETHENE	BDL	BDL	BDL	BDL
TOLUENE	BDL	BDL	BDL	BDL
TRICHLOROETHENE	BDL	BDL	BDL	BDL
TRICHLOROFLUOROMETHANE	BDL	0 3	BDL	BDL

SW099	Q1	Q2	Q3	Q4
Benzene	NS	BDL	NS	NS
1,1,1-TRICHLOROETHANE	NS	BDL	NS	NS
1,1-DICHLOROETHANE	NS	BDL	NS	NS
1,1-DICHLOROETHENE	NS	BDL	NS	NS
CARBON TETRACHLORIDE	NS	BDL	NS	NS
CHLOROFORM	NS	BDL	NS	NS
cis-1,2-DICHLOROETHENE	NS	BDL	NS	NS
DICHLORODIFLUOROMETHANE	NS	BDL	NS	NS
METHYLENE CHLORIDE	NS	0 09	NS	NS
TETRACHLOROETHENE	NS	BDL	NS	NS
TOLUENE	NS	BDL	NS	NS
TRICHLOROETHENE	NS	BDL	NS	NS
TRICHLOROFLUOROMETHANE	NS	BDL	NS	NS

Well B206989	Q1	Q2	Q3	Q4
Benzene	BDL	BDL	BDL	BDL
1,1,1-TRICHLOROETHANE	BDL	BDL	BDL	BDL
1,1-DICHLOROETHANE	BDL	BDL	BDL	BDL
1,1-DICHLOROETHENE	BDL	BDL	BDL	BDL
CARBON TETRACHLORIDE	BDL	BDL	BDL	BDL
CHLOROFORM	BDL	BDL	BDL	BDL
cis-1,2-DICHLOROETHENE	BDL	BDL	BDL	BDL
DICHLORODIFLUOROMETHANE	BDL	BDL	BDL	BDL
METHYLENE CHLORIDE	BDL	BDL	0 1	BDL
TETRACHLOROETHENE	BDL	BDL	BDL	BDL
TOLUENE	BDL	BDL	BDL	BDL
TRICHLOROETHENE	BDL	BDL	BDL	BDL
TRICHLOROFLUOROMETHANE	BDL	BDL	BDL	BDL

Well 52894	Q1	Q2	Q3	Q4
Benzene	LW	BDL	0 2	LW
1,1,1-TRICHLOROETHANE	LW	BDL	BDL	LW
1,1-DICHLOROETHANE	LW	BDL	BDL	LW
1,1-DICHLOROETHENE	LW	BDL	BDL	LW
CARBON TETRACHLORIDE	LW	BDL	BDL	LW
CHLOROFORM	LW	BDL	BDL	LW
cis-1,2-DICHLOROETHENE	LW	BDL	BDL	LW
DICHLORODIFLUOROMETHANE	LW	BDL	BDL	LW
METHYLENE CHLORIDE	LW	BDL	BDL	LW
TETRACHLOROETHENE	LW	BDL	BDL	LW
TOLUENE	LW	BDL	BDL	LW
TRICHLOROETHENE	LW	BDL	BDL	LW
TRICHLOROFLUOROMETHANE	LW	BDL	BDL	LW

SW100	Q1	Q2	Q3	Q4
Benzene	NS	BDL	NS	NS
1,1,1-TRICHLOROETHANE	NS	BDL	NS	NS
1,1-DICHLOROETHANE	NS	BDL	NS	NS
1,1-DICHLOROETHENE	NS	BDL	NS	NS
CARBON TETRACHLORIDE	NS	BDL	NS	NS
CHLOROFORM	NS	BDL	NS	NS
cis-1,2-DICHLOROETHENE	NS	BDL	NS	NS
DICHLORODIFLUOROMETHANE	NS	BDL	NS	NS
METHYLENE CHLORIDE	NS	0 1	NS	NS
TETRACHLOROETHENE	NS	BDL	NS	NS
TOLUENE	NS	BDL	NS	NS
TRICHLOROETHENE	NS	BDL	NS	NS
TRICHLOROFLUOROMETHANE	NS	BDL	NS	NS

Well 52994	Q1	Q2	Q3	Q4
Benzene	LW	LW	LW	LW
1,1,1-TRICHLOROETHANE	LW	LW	LW	LW
1,1-DICHLOROETHANE	LW	LW	LW	LW
1,1-DICHLOROETHENE	LW	LW	LW	LW
CARBON TETRACHLORIDE	LW	LW	LW	LW
CHLOROFORM	LW	LW	LW	LW
cis-1,2-DICHLOROETHENE	LW	LW	LW	LW
DICHLORODIFLUOROMETHANE	LW	LW	LW	LW
METHYLENE CHLORIDE	LW	LW	LW	LW
TETRACHLOROETHENE	LW	LW	LW	LW
TOLUENE	LW	LW	LW	LW
TRICHLOROETHENE	LW	LW	LW	LW
TRICHLOROFLUOROMETHANE	LW	LW	LW	LW

Figure 6-5

Detected Volatile Organic Compounds (ug/L) at the Present Sanitary Landfill

1999 Annual RFCA Groundwater Monitoring Report

EXPLANATION

- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Surface Water Monitoring Locations
- Landfill Groundwater Monitoring Wells
- All Other Existing Wells
- Abandoned Wells
- IHSS 166.1, 166.2 and 166.3
- Slurry Wall
- GW Intercept System - Perforated
- GW Intercept System - Non-Perforated
- Individual Hazardous Substance Site
- East Landfill Pond
- Tanks
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

NOTE:
BDL - Below Detection Limit
LW - Lacked Water
NS - Not Sampled/Dry Conditions

Source of GIS data available upon request.

Scale = 1 : 2970
1 inch represents approximately 248 feet

50 0 100 200ft

State Plane Coordinate Projection
Colorado Central Zone
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7.0 PLUME DEGRADATION MONITORING

7.1 Carbon Tetrachloride Plume

This section summarizes the results of the IHSS 118.1 carbon tetrachloride plume natural attenuation study, which was initiated in 1999. The object of this report is to provide sample results for the suite of analytes that were sampled in the CY99 sampling rounds and determine whether natural attenuation is occurring given the results obtained. The overall goal of the project is to characterize the potential for natural attenuation as a significant factor in the remediation strategy for the IHSS 118.1 Dense Non-Aqueous Phase Liquid (DNAPL) source. Carbon tetrachloride is the main contaminant of concern at IHSS 118.1 and is the result of spills related to a carbon tetrachloride storage tank, which has been subsequently removed. Characterization work was initiated in 1997 to identify the extent of the DNAPL source and determine the feasibility of extracting the DNAPL through pumping or excavation. Source removal was postponed because it is presently not feasible to excavate the source due to the number of active process pipes and utilities that run through the source area. The decision was then made to evaluate the potential for the carbon tetrachloride plume to be undergoing natural attenuation processes.

A drilling and sampling program was designed to collect the data necessary for decision making with respect to natural attenuation. Eight wells were installed in a pattern so as to have two wells upgradient of the DNAPL source (18799, 18899), three wells along an east-west line where two wells were in the source, and one well located cross gradient to the source (18499, 18599, and 18699). The remaining three wells were installed in a line approximately 60 –70 feet downgradient from the source (18199, 18299, 18399). The wells were installed in February 1999 and samples were collected in March and September of 1999. In addition, data from well 21098 was added to the evaluation because of the causal relationship between carbon tetrachloride in this well and the location of IHSS 118.1 that was identified in the 1998 RFCA Annual Groundwater Report. Figure 4-9 shows the location of the wells and sampling locations.

Dedicated bladder pumps were installed in the 1999 wells so that samples could be collected with minimal aeration of the sample. This is important when collecting VOC samples and when measuring dissolved oxygen (DO) and oxidation-reduction potential (redox) parameters. A flow-through cell containing the field parameter probes was used to measure temperature, DO, redox, alkalinity, specific conductance and pH. In December 1999, Troll 8000 down-hole probes were installed to continuously measure water level, temperature, DO, redox and pH. Unfortunately the probes malfunctioned and did not provide useful data. A Hach spectrophotometer was used to measure ferrous iron. Analytical samples were sent to off-site laboratories for analysis. Full suites were obtained from seven of the eight wells. Upgradient well 18899 was dry and could not be sampled. Table 7.1 lists the analyses performed for the IHSS 118.1 study as listed in the IHSS 118.1 Sampling and Analysis Plan (RMRS, 1998c). Water levels were obtained for all wells in the project.

Footing Drain Outfall Samples

A one time sample was collected from two outfalls which are associated with the Building 771 footing drain system. Building 771 is located approximately 120 feet due north of IHSS 118.1 and has a footing drain system that collects groundwater from the south (upgradient) side of the building. Because the footing drain system is downgradient of the carbon tetrachloride. groundwater plume, it was important to sample the outfalls from this system to determine if significant concentrations of VOCs were present. Figure 7-1 shows the sample locations. One outfall is located to the west of Building 771 and flows to a small stream which enters North Walnut Creek to the north. This outfall could be sampled directly at its terminus on the hillside, and has a location name of 771-FDOUT2. The other outfall is believed to be located under the North Perimeter Road and probably enters North Walnut Creek. The pipeline to this outfall is believed to extend out from the northwest corner of Building 771 and has two manholes that were available for sampling. Sample location 771-Manhole3 is a manhole accessing the outfall pipeline outside Building 771. The second location (NW771-Manhole) is located at the confluence of drainpipes near the North Perimeter Road.

Table 7-1 Sample Types/Analytical Methods

Line Item Code	Analytes	Analytical Method	Media Type	Container	Preservative
SS01B005	Volatile Organic Compounds	SW-846 Method 8260	Water	2 x 40 ml VOA vials - Teflon lined septa lids	Cool, 4° C, HCl
SS01B006	Volatile Organic Compounds	SW-846 Method 8260	Soil, Waste	60-ml wide mouth glass jar with Teflon lined lid	Cool, 4°C,
SS02B006	Semivolatiles	SW-846 Method 8270B	Water	3-liter glass jar	Cool, 4°C
SS02B006	Semivolatiles	SW-846 Method 8270B	Soil	250-ml wide mouth glass jar with Teflon lined lid	Cool, 4° C
RC01B0003	Americium, Plutonium & Uranium	ASD SOW for Isotopics RC01	Soil	125-g wide mouth glass jar	Cool, 4° C
OS01A002	Gross Alpha/Beta	ASD SOW for Isotopics RC01 Module OS01A	Water	1 liter plastic bottle	Cool, 4° C
OS01A003	Gross Alpha/Beta	ASD SOW for Isotopics RC01 Module OS01A	Soil	60-g wide mouth glass jar	Cool, 4° C
SS06B037	Sulfates	SW-846, 9035, 9036	Water	1 liter plastic bottle	Cool, 4° C
SS06B039	Sulfides	SW-846 9030A	Water	1 liter plastic bottle	Cool, 4° C
SS06B002	Alkalinity	SW-846 310.1, 320.2	Water	1 Liter plastic bottle	Cool, 4° C
SS06B020	Nitrates	SW-846 , 300.0	Water	1 liter plastic bottle	Cool, 4° C
SS06B025	Total Organic Carbon	SW-846 415.1	Water	1 liter plastic bottle	Cool, 4° C pH<2 w/HCl
SS06B024	Dissolved Organic Carbon	SW-846 415.1	Water	1 liter plastic bottle	Cool, 4° C
SS06B010	Chlorides	E300.0	Water	100 ml. plastic bottle	None
Field	pH	SW9040	Water	N/A	N/A
Field	Dissolved Oxygen	E360.1	Water	N/A	N/A
Field	Oxidation-Reduction Potential	ASTM D1498	Water	N/A	N/A
Field	Temperature	E170.1	Water	N/A	N/A
Field	Conductivity	SW9050	Water	N/A	N/A

For purposes of this preliminary evaluation, three of the seven wells were chosen for discussion. Well 18799 is the only upgradient well that had water, so it is used for background comparison. Well 18499 is north of 18799 and is screened in the DNAPL source. Samples were collected above the DNAPL in the well. Well 18199 is a downgradient well due north of well 18499. Well 21098 was added to the evaluation because it probably represents the distal western portion of the carbon tetrachloride plume emanating from IHSS 118.1. These wells comprise a representative cross section of groundwater quality across the IHSS 118.1 site. In most cases, data from the other wells conform to those found in this subset. Charts were derived to show the relative changes in water quality across the IHSS. Table 7-2 shows the pertinent data from which Figures 7-2 – 7-5 were derived. The complete analytical data set for these wells can be found in Appendix A from document RF/RMRS-98-420.UN, *Status Report for Monitoring of Natural Attenuation at IHSS 118.1(RMRS,1999d)* and *The 1999 Third Quarter RFCA Groundwater Monitoring Report(RMRS, 2000).* Evaluation of the various parameters used for the natural attenuation project leads to a number of conclusions regarding to whether the parameters are necessary for the continued tracking of VOC degradation.

Table 7-2 Sample Results for Natural Attenuation Wells

Well	18799	18799	18499	18499	18199	18199	21099	771 FD OUT #2
1999 Sampling Results	1st Qtr	3rd Qtr	1st Qtr	3rd Qtr	1st Qtr	3rd Qtr	1st Qtr	1st Qtr
CARBON TETRACHLORIDE	927	220	57800	16000	15400	14000	1200	12
CHLOROFORM	511	590	8750	4900	2200	2400	110	23
METHYLENE CHLORIDE	12.3	21	83.5	380	12.6	590	0.09	4
CHLOROMETHANE	50	18	8.9	U	U	U	1	U
METHANE	3.1	2.5	210	50	7.4	12		
NITRATE	2.2	0.05	0.05	0.14	3	3.3		
SULFATE	46	53	21	31	35	33		
SULFIDE	0.02	0.026	0.05	0.003	0.041	0.011		
DOC	3	6	4	5	4	6		
CHLORIDE	63	72	64	90	69	72		
FERROUS IRON	0.01	1.67	1.6	0.84	0.11	0.01		
TOC	3.051	3	4	5	3	3		
DISSOLVED OXYGEN	5.37	2.6	0.063	0.5	2.23	3		

Note: VOC's in ug/L, all others in mg/L

7.1.1 Natural Attenuation

Natural attenuation is defined as an observed reduction in contaminant concentrations as contaminants migrate from the source in environmental media. This reduction in concentration can be due to a number of fate and transport processes in groundwater, including dilution, dispersion, sorption, volatilization, and biotic and abiotic

transformations. Biodegradation and bioremediation are used to describe the portion of natural attenuation that is brought about by biological degradation mechanisms. Biological degradation typically involves bacteria that occur naturally in soil and groundwater. Under the right conditions these bacteria can break down certain fuel hydrocarbons and certain chlorinated organic compounds.

The main mechanism for the biological breakdown of chlorinated organics is through reductive dechlorination reactions. Under reductive dechlorination, a chlorinated organic compound such as carbon tetrachloride is an electron acceptor, causing the compound to gain a hydrogen atom at the expense of a chlorine atom. The successive dechlorination of carbon tetrachloride would form chloroform, methylene chloride and chloromethane chlorine atoms are progressively removed from the original carbon tetrachloride molecule.

For biodegradation to occur, there must be an electron acceptor, a source of carbon to serve as an electron donor, and a favorable environment for the metabolic reactions to take place. The IHSS 118.1 sampling program was designed to investigate whether these processes are taking place. Wiedemeier et al (1996) have developed a simple method of determining whether biodegradation is occurring to a significant degree at a site based on applying scores to the chemical parameters discussed in this report. The criteria used are summarized in Table 7-3. A score of 0 to 5 points is suggestive of inadequate evidence of biodegradation. A score of 6 to 14 suggests limited evidence of biodegradation, a score of 15 to 20 shows adequate evidence and scores above 20 show strong evidence of biodegradation.

Table 7-3 Checklist for Determination of Biodegradation

Analyte	Concentration in most contaminated zone	Significance	Points	IHSS in Source	IHSS 118.1 Outside source
Oxygen	< 0.5 mg/L	Tolerated at this concentration	3	3	0
Oxygen	> 1.0 mg/L	Prohibits reductive dechlorination	-3	0	-3
Nitrate	< 1.0 mg/L	Competes with reductive pathway at higher concentrations	2	2	0
Ferrous Iron	> 1.0 mg/L	Reductive pathway possible	3	3	0
Sulfate	< 20 mg/L	Competes with reductive pathway at higher concentrations	2	0	0
Sulfide	> 1.0 mg/L	Reductive pathway possible	3	0	0
Methane	> 0.1 mg/L	Ultimate reductive daughter product	2	2	0
Redox	< 50 mV	Reductive pathway possible	1	1	0
Redox	< -100 mV	Reductive pathway more possible	2	0	0
TOC	> 20 mg/L	Carbon and energy source - drives dechlorination	2	0	0
Temperature	> 20 degrees C	Biochemical process accelerated	1	0	0
Carbon Dioxide	> 2x background	Ultimate oxidative daughter product	1	na	na
Alkalinity	> 2x background	Results from interaction of CO2 with aquifer	1	1	0
Chloride	> 2x background	Daughter product of organic chlorine	2	0	0
Hydrogen	> 2 nM	Reductive pathway possible	3	na	na
Chloroform	Present	Daughter product of Carbon Tetrachloride	2	2	2
Methlyene Chloride	Present	Daughter product of Chloroform.	2	2	2
Chloromethane	Present	Daughter product of Methylene Chloride	2	2	2
			Score	18	3
na - not analyzed					

7.1.2 Electron Donors

The process of natural attenuation that would degrade chlorinated organic compounds such as carbon tetrachloride is reductive dechlorination. Reductive dechlorination is the substitution of hydrogen for chlorine atoms within the chlorinated organic compound, which causes it to progressively break down into daughter products. This process requires that there be a source of electron donors, which is typically organic carbon. Carbon can be utilized either as natural carbon in the aquifer, or can be acquired from the breakdown of petroleum hydrocarbons. The following analyses were performed on groundwater samples from IHSS118.1 wells to determine the availability of electron donor activity at IHSS 118.1.

Semivolatile Organic Suite

The semivolatile organic suite was collected because of a perception that there had been a diesel spill in the area of IHSS 118.1. Diesel by-products could supply the electron donors that are necessary for reductive dechlorination of the carbon tetrachloride and breakdown products. Diesel fuel is composed of such indicator compounds as napthalene, phenanthrene, anthracene, chrysene etc., as opposed to the BTEX compounds (benzene, toluene, ethylbenzene and xylenes) which are common in gasoline. Based on the data collected in 1999, there is no evidence of either diesel or gasoline indicator compounds in the vicinity of IHSS 118.1. Therefore, the semivolatile analyte suite was discontinued.

Total Organic Carbon and Dissolved Organic Carbon

Total organic carbon (TOC) and dissolved organic carbon (DOC) were collected to ascertain the availability of carbon in the environment to serve as an energy source for reductive dechlorination. DOC was not plotted because concentrations were similar to TOC and is not used for the evaluation of biodegredation. Figure 7-2 shows that TOC is within the 3-5 mg/L range. Wiedemeier et al (1996), suggest that TOC above 20 mg/L assures that enough carbon is present to drive dechlorination. Therefore the limited amount of carbon in groundwater may be retarding the rate of reductive dechlorination at IHSS 118.1. Because the Wiedemeier paper uses TOC as an indicator parameter, but does not discuss DOC, DOC will be discontinued in future IHSS118.1 sampling rounds.

7.1.3 Electron Acceptors

In order to effect reductive dechlorination of chlorinated organic solvents, the solvents must be potential electron acceptors. This reaction mechanism occurs when there are sufficient electron donor sources present, the proper chemical environment exists, and there is a lack of other electron acceptors. The following analyses wee performed on groundwater samples from 1999 IHSS118.1 wells to determine the availability of electron acceptors in this water.

Carbon Tetrachloride

Carbon tetrachloride is the dominant organic compound present in groundwater at IHSS 118.1. If biodegradation is occurring by reductive dechlorination, carbon tetrachloride would break down progressively to chloroform, dichloromethane, chloromethane, and ultimately to carbon dioxide and water. If reductive dechlorination was occurring, carbon tetrachloride would be seen to progressively decrease in concentration with time as the breakdown products increased in concentration. Downgradient wells would also reflect an increase in breakdown products relative to carbon tetrachloride. Figures 7-3 and 7-4 show the trends in carbon tetrachloride and daughter species. The sample from well 21098 is also included. In Figure 7-3 carbon tetrachloride can be seen to decrease in concentration from the source to downgradient well 21098. This would be expected if biodegradation was occurring. However, the trends in chloroform and chloromethane do not increase in downgradient wells 18199 and 21098. Methylene chloride exhibits a similar behavior, but must be viewed with caution because it is a common lab contaminant and was reported in the lab blank.

The data suggest that there are daughter products from reductive dechlorination of carbon tetrachloride in the source area, but increased breakdown downgradient of the source is not readily apparent. By looking at the ratio of daughter products to carbon tetrachloride with time, a better indication of in-source biodegradation would be obtained. Therefore, it is suggested that sampling for these compounds continue for a sufficient time period to establish a rate of breakdown at the source. The Building 771 outfall locations described above were also sampled for the VOC suite. Location 771-FDOUT2 shows a carbon tetrachloride concentration of 12 ug/L and a chloroform concentration of 23 ug/L. The outfall has a very low flow, which suggests that it may be shut off. Because carbon tetrachloride and chloroform are the dominant components of the carbon tetrachloride plume, it appears that some of the plume is being collected in the footing drain system. The other two sample locations showed no significant VOC detections.

Dissolved Oxygen

Dissolved oxygen is the favored electron acceptor used by bacteria for the biodegradation process. Anaerobic bacteria cannot function at DO concentrations above .5 mg/L and hence, reductive dechlorination cannot occur (Wiedemeier, et al, 1999). Figure 7-2 shows that upgradient DO concentration at well 18799 ranges from 2.5 to 5.4 mg/L and decreases to .06 - .5 mg/L in source well 18499. DO concentration rises again in downgradient well 18199. Taking the data at face value, it would appear that DO levels are detrimental for anaerobic degradation of organic compounds except at the source. DO was measured using a DO probe housed inside a flow-through cell. It may be that this method, though far superior to measurements obtained from bailed water, may allow for some oxygenation of the groundwater.

Nitrate and Sulfate

Nitrate and sulfate were analyzed because these species, along with dissolved oxygen, can compete with chlorinated solvents as electron acceptors. If high levels of nitrate and/or sulfate were to exist in the groundwater in the vicinity of IHSS 118.1, the reductive dechlorination of carbon tetrachloride and its by products could be retarded. The graph on Figure 7-2 shows the concentrations of nitrate along the three - well cross section at IHSS 118.1. The nitrate concentration in upgradient well 18799 is .26 to 2 mg/L which is near the RFETS background mean of 1.4 mg/L for Rocky Flats Alluvium (DOE, 1993b). In Figure7-2, nitrate concentration is seen to decrease at the source and then increase again in concentration away from the source. This trend would be expected if biodegradation was occurring in the source area. Wiedemeier et al, 1996 have a scoring system for determining the potential for biodegradation. They suggest that a concentration of nitrate above 1 mg/L may impact biodegradation of chlorinated organics. Given the low concentration of nitrate in the vicinity of the IHSS (.05 mg/L at source well 18499), it appears nitrate is being removed locally but may be hampering the biodegradation process away from the source. Because nitrate is a key indicator of the efficacy of biodegradation on chlorinated solvents, continued sampling is advised.

The sulfate concentrations in upgradient well 18799 was 46 to 53 mg/L, which is above the RFETS background mean of 22 mg/L (DOE, 1993b). Figure 7-5 shows the concentration of sulfate dropping near source well 18499, and then increasing in downgradient wells. Because sulfate and nitrate behave similarly with respect to their electron acceptance, this trend would be expected if biodegradation was occurring in the source area.

Wiedemeier et al (1996) suggest that sulfate above 20 mg/L could compete with the chlorinated solvents as an electron acceptor and thus retard the biodegradation process of the latter. Given that sulfate was found at 30 mg/L in the source area and at higher levels away from the source, it can be deduced that sulfate may be retarding the biodegradation of carbon tetrachloride occurring at IHSS 118.1. Because sulfate is a key indicator of the efficacy of biodegradation on chlorinated solvents, continued sampling is advised.

7.1.4 Metabolic By-Products

Measurement of the metabolic by-products of biodegradation is a valuable indication of the predominant microbial and chemical processes occurring at IHSS 118.1. The following analyses were performed to help determine whether actual biodegradation is occurring.

Ferrous Iron

Ferric iron (Fe III) is reduced to ferrous iron (FeII) during anaerobic biodegradation of organic hydrocarbons. Therefore an increase in ferrous iron concentration in the source area can suggest the amount of biodegradation that is occurring. Figure 7-2 shows that in the first quarters, sampling event ferrous iron increases from 0.01 mg/L in background well 18799 to 1.6 mg/L in source well 18499, then decreases to 0.10 mg/L in downgradient well 18199.

The second quarter sampling event shows a higher value of 1.61 at the upgradient well, decreasing downgradient through the source. Wiedemeier et al (1996) believe that ferrous iron above 1 mg/L would allow reductive dechlorination to take place. Given the difference in the results obtained in the two sampling rounds it is difficult to conclude whether reductive dechlorination is occurring at the source. Because ferrous iron is a key indicator of the efficacy of biodegradation on chlorinated solvents, continued sampling is advised.

Sulfide

The production of hydrogen sulfide occurs during sulfate reduction and verifies that sulfate is acting as an electron acceptor during biodegradation. Figure 7-2 shows that sulfide is 0.02 mg/L in background well 18799 and does not change in concentration in the source and downgradient wells. Wiedemeier et al (1996) believe that sulfide above 1 mg/L would allow reductive dechlorination to take place. These results suggest that though sulfate was decreasing in concentration in the source area, the amount of hydrogen sulfide generated was insufficient to support reductive dechlorination. Because of the conflicting evidence for biodegradation given by sulfate/sulfide analyses, and because sulfide is a key indicator of the efficacy of biodegradation on chlorinated solvents, continued sampling is advised.

Methane

The presence of methane in groundwater is indicative of strongly reducing conditions. Methane can be produced through the biodegradation of petroleum hydrocarbons. The presence of methane in groundwater containing chlorinated solvents suggests that the chemistry of the groundwater is favorable for reductive dechlorination. Figure 7-4 shows that methane increases from approximately 0.003 mg/L to .05 - 0.20 mg/L in the source area, then decreased to 0.007 in downgradient well 18199. Wiedemeier et al (1996) believe that methane above 0.1 mg/L would allow reductive dechlorination to take place. Methane values at IHSS118.1 were fairly low, suggesting that there is little if any petroleum hydrocarbons present there. However, the increase in methane production in the source relative to the upgradient well suggests that some reductive dechlorination is occurring. Because methane is a key indicator of the efficacy of biodegradation on chlorinated solvents, continued sampling is advised.

Chloride

The presence of elevated concentrations of chloride in groundwater relative to upgradient locations suggests that reductive dechlorination of organic solvents is taking place. This is because the replacement of hydrogen for chlorine in the chemical structure of the chlorinated organic compound during reductive dechlorination releases chlorine in the process. Figure 7-5 shows the concentrations of chloride seen in the vicinity of IHSS 118.1. Chloride concentration was reported in the 63 – 90 mg/L range and does show change across the source in the third quarter sample. The RFETS background mean concentrations for chloride in alluvial materials is 8 to 18 mg/L (DOE, 1993b). The Groundwater Geochemistry Report for RFETS (EG&G, 1995c) shows that chloride concentration increases from west to east at RFETS and that chloride concentrations in the Industrial Area range

from 25 to 100 mg/L. Given the lack of dramatic change in chloride concentration at IHSS 118.1 relative to both upgradient and downgradient wells and the surrounding Industrial Area, it may be that only limited reductive dechlorination is occurring at the IHSS. Because chloride values on Site can be affected by the use of salt on the roadways during the winter, the data may be suspect as a key indicator of the efficacy of biodegradation on chlorinated solvents.

7.1.5 Conclusions and Recommendations

Based on the 1999 results, a number of conclusions can be made. There is evidence of biodegradation at the IHSS 118.1 source. If the assumption is made that the breakdown products found at IHSS 118.1 are not part of the original free product composition, then based on the scoring system discussed in Wiedemeier et al (1996), the source area rates a score of 18 (see Table 7-3). The upgradient and downgradient wells rate a score of 3, which suggests that the environment of the aquifer away from the source may be hostile to biodegradation. These scores are derived using data from the three wells used for the cross section discussed above. Given the downgradient score with respect to biodegradation, the decrease in composition of organic solvents away from the source must be partly attributed to physical processes such as dilution and dispersion rather than strictly to biodegradation. These preliminary results suggest that some reduction in carbon tetrachloride is occurring at the source, but the discovery of carbon tetrachloride above Tier I action levels at downgradient well 21098 suggests that natural attenuation is not completely restricting the plume from migrating towards surface water in this area. Additional monitoring will help determine the rate at which biodegradation is occurring.

One of the footing drain outfalls shows low levels of carbon tetrachloride and chloroform that is probably attributable to inflow of carbon tetrachloride plume groundwater into the footing drain system. Given the low concentration of VOCs in outfall sample 771-FDOUT2, and the very low flow from the outfall, there does not appear to be a major contribution of VOCs to surface water from this source.

The results of continuing sampling at IHSS 118.1 will be used to validate these preliminary findings and can also be used to assess possible remedial strategies. The Groundwater program will be evaluating the downgradient extent of VOC plumes in the Industrial Area in the future to determine potential impacts to surface water. This information will be incorporated with data from IHSS 118.1 and other projects to provide an integrated approach to groundwater management at the Site.

7.1.6 Sampling Recommendations

Based on the results obtained to date the following recommendations can be made with respect to future sampling:

1. The present sampling suite should be reduced for future sampling. At this point it is prudent to eliminate the semivolatile organic suite and DOC sample. The semivolatile organic suite was collected to determine whether there is evidence of fuel hydrocarbons that would aid in the breakdown of carbon tetrachloride. Since these

compounds were not encountered in the two sampling rounds the analyses can be discontinued. DOC can be eliminated because only TOC is used in the scoring system for determining the degree of biodegradation.

2. The wells used as part of the natural attenuation study can also be reduced. The North IA Plume project identified the extent of the Carbon Tetrachloride Plume to the west of IHSS 118.1. It is suggested that wells 18799, 18499 and 18199 be retained so that this evaluation can continue in the future using the same methodology as presented here. Well 21098 should be added to the Plume evaluation because it may reflect conditions at the distal end of the plume. This well will also be designated as a Plume Extent well given the close proximity of the well to surface water. Upgradient well 18899 has been dry, and side gradient well 18699 does not appear to be in the pathway for the plume given the low VOC values encountered. Well 18399 should probably be maintained as a plume definition well given that it may be detecting a northern pathway for the carbon tetrachloride plume. Well 18299 is probably redundant to well 18199 and can be eliminated from the sampling program. Well 18599 is redundant to well 18499 and can be eliminated from the sampling program.

3. Given the probable involvement of the Building 771 French drain with carbon tetrachloride plume capture, efforts should be made to ascertain the exact nature of the outfalls from this system. Initial evaluation has shown little flow from the outfall near the creek, and the other outfall location shows no detections for VOCs at all. The former location shows detections for VOCs but little water and the latter location shows significant water but no detections for VOCs. Location 771 FD OUT #2 should be sampled to make sure significant flow with high VOC concentrations is not occurring. Efforts will be made to better understand the effluent from the French drain in the future.

7.2 903 Pad/Ryan's Pit Plume

The 903 Pad/Ryan’s Pit Plume is located directly south of the southeast corner of the PA and between the 903 Pad and Woman Creek at RFETS. Two sources, the 903 Pad and Ryan’s Pit, contribute to this plume of contaminated groundwater. The primary analytes comprising the 903 Pad/Ryan’s Pit Plume are carbon tetrachloride, TCE, and PCE. The nearest receiving streams for the plume are the South Interceptor Ditch (SID), located approximately 150 feet north of Woman Creek, and Woman Creek. There was an agreed upon 1999 compliance milestone for characterizing 903 Pad/Ryan’s Pit Plume groundwater to protect surface water quality in Woman Creek. The Ryan’s Pit source removal began in September 1995, with the removal of contaminated soil. The soil was treated in February 1996, and the project was completed in August 1996, with the replacement of treated soil. The 903 Pad source removal is scheduled for 2001. Figure 7-6 presents the location of the 903 Pad/Ryan’s Pit Plume area.

The 903 Pad was utilized as a drum storage area from the summer of 1958 to January 1967. The drums contained oils and VOCs contaminated with various radionuclides. Approximately 75 percent of the drums contained plutonium contaminated liquids and most of the remaining drums contained uranium contaminated liquids. Within

the drums containing plutonium, the liquid was primarily lathe coolant and carbon tetrachloride in varying amounts. Also stored in drums were hydraulic, vacuum pump, and silicon oils, TCE, PCE, and acetone still bottoms. Leaking drums were observed in 1964 during routine handling operations. The area was fenced to restrict access, and the contents of leaking drums were transferred to new drums.

When cleanup of the 903 Pad began in 1967, there were a total of 5,237 drums at the storage site, approximately 420 of which had leaked to some degree. An estimated 50 drums had leaked their entire contents. It was estimated that approximately 5,000 gallons of contaminated liquid, containing about 86 grams of plutonium, had escaped to the subsurface. During 1968 and 1969, some of the radiologically contaminated material was removed, the area regraded, and much of the area capped with asphalt. High concentrations of VOCs are present in groundwater beneath and downgradient of the site.

Ryan's Pit (previously known as Trench T-2) is located approximately 150 feet south of the 903 Pad and was approximately 20 feet long, 10 feet wide, and 5 feet deep. The source removal excavation was 32 feet long, 18 feet wide, and varied in depth from 5.5 to 8 feet. It was originally thought that Ryan's Pit was used for disposal of sludge from the sanitary wastewater treatment plant. An extensive evaluation of aerial and low angle oblique photography, spanning the years of 1953 through 1971, indicated that Ryan's Pit did not exist until 1969 (DOE 1996b). Ryan's Pit was used from approximately 1969 to 1971 for the disposal of nonradioactive liquid chemical wastes. The wastes were primarily solvents (PCE, TCE, and carbon tetrachloride), paint thinners, diesel fuel, and other construction related chemicals Radiation screening of the wastes was performed and if identified as nonradioactive, the liquids were dumped in the trench. However, wells downgradient of Ryan's Pit contain anomalous activities of uranium 233/234 and U238 (DOE 1997b, Plates 17 and 21). Only liquids were put into the pit; containers were either reused or disposed of in other areas (DOE 1992b).

In 1998, the RFETS program to characterize the 903 Pad/Ryan's Pit Plume was approved by the EPA and the CDPHE. A field investigation was performed during 1998 to delineate the extent of groundwater contamination in areas with potential impact to surface water at the distal end of the 903 Pad/Ryan's Pit plume. The investigation included the installation of 26 Geoprobe boreholes with six yielding enough water for VOC sample collection. The results were used to develop preliminary recommendations regarding the need for remedial action(s) to contain and/or treat contaminated groundwater from this plume**.** The results appeared to indicate that the extent of the 903 Pad/Ryan's Pit plume adjacent to Woman Creek was limited, that VOC concentrations within the plume are relatively low, and the ability of the saturated colluvium and weathered claystone within the area of the groundwater plume to transmit significant amounts of groundwater (and therefore a significant flux of contaminants) to the Woman Creek drainage was minimal. The results also appeared to indicate that the contaminated groundwater plume was not affecting surface water quality, and there was evidence of the occurrence of natural attenuation (RMRS, 1999h). Based on the results, it was proposed that the preliminary remedial design consist of natural attenuation, which involves intrinsic biodegradation coupled with physical loss mechanisms, as a groundwater evaluation strategy for the 903 Pad/Ryan's Pit plume.

Work completed during 1999 on this project included the preparation of a SAP *(Sampling and Analysis Plan for Groundwater Monitoring at the 903 Pad/Ryan's Pit VOC Plume*, RF/RMRS-99-312) describing monitoring and characterization activities to evaluate if monitored natural attenuation is an effective means of ensuring the protection of surface water quality at Woman Creek. Four permanent downgradient monitoring wells, 90099 through 90399, were installed to monitor VOCs. One of these new wells, 90099, twinned 1998 Geoprobe well 01298. The other three wells are downgradient of the 1998 Geoprobe wells and upgradient of the SID. These wells will provide the necessary information to establish a trend in downgradient VOC concentrations.

Monitoring well 90199 has been dry since its completion. Monitoring wells 90099, 90299, and 90399 were sampled in August (3rd quarter) 1999 and in January/February (1st quarter) 2000. The results of samples collected from these wells during the two sampling rounds described above are summarized in Table 7-4 and indicate that monitoring well 90299 is relatively unaffected by VOCs; none are found above Tier II groundwater action levels. However, the samples collected from monitoring wells 90099 and 90399 exhibit elevated VOC concentrations, especially for TCE and carbon tetrachloride.

Table 7-4 903 Pad / Ryan's Pit SAP Wells Results

Monitoring Well	Sample Date	TCE (µg/L)	Carbon Tetrachloride (µg/L)	PCE (µg/L)
90099	8/4/99	***820***	**460**	**30**
90099	1/12/00	***710***	**310**	**18**
90299	8/5/99	3	Undetected	0.2
90299	1/12/00	2	1	Undetected
90399	8/2/99	**220**	**380**	**10**
90399	2/14/00	**380**	**450**	**13**

Note: Bold italicized results are Tier I exceedances; bold results are Tier II exceedances

Well 90399 lies approximately 220 feet north of Woman Creek and well 90099 lies to the north/northeast, crossgradient and potentially upgradient, of well 90399. The concentrations of TCE in well 90099 are Tier I exceedances. The remaining TCE Tier II exceedances in well 90399 and all the carbon tetrachloride Tier II exceedances in wells 90099 and 90399 are approaching Tier I concentrations.

The SAP specified that surface water samples were to be collected from the South Interceptor Ditch (SID), Woman Creek, and seeps. A surface water sample from the seep identified in Figure 7-6 had a concentration of TCE at 4

µg/L, which is just slightly below its Tier II groundwater action level. This seep sample also contained a result of 3 µg/L of chloroform. The seep is located immediately north of Woman Creek. All other seeps in the area were dry. VOC results of the two Woman Creek samples were below detection. The Woman Creek sample locations are identified on Figure 7-6. The SID was dry at the time of sampling.

Based on groundwater and surface water data described above, there may be a pathway to surface water for VOCs. IT Corporation has previously derived calculations of contaminant flux to Woman Creek via groundwater. These calculations can be found in Appendix C of the *Final Technical Memorandum, Monitoring of the 903 Pad/Ryan's Pit Plume* (RMRS, 1999h). The conclusions of this analysis were that "Flow and contaminant flux in the weathered bedrock is negligible. The colluvium is inconsistently saturated, and the distal portion of the plume transmits little flow and contaminants to the Woman Creek drainage".

It is apparent that groundwater VOC contamination is more widespread than previously thought, although at this point there is no detectable impact to Woman Creek immediately upstream or downstream of the impacted seep. Because of the concentrations of VOCs at well 90399, natural attenuation may not be a viable mechanism to ensure that the water quality of Woman Creek is not impacted by the 903 Pad/Ryan’s Pit Plume.

In an effort to determine if biodegradation of VOC species is occurring along the pathway to Woman Creek, concentrations of the major VOCs (TCE and carbon tetrachloride) and daughter species were plotted in Figure 7-7 and 7-8. As can be seen in Figure 7-7, although the PCE and TCE levels decrease downgradient along the line of wells identified from Ryan's Pit towards Woman Creek, there is not a corresponding increase in PCE and TCE daughter products that might indicate that biodegradation was occurring. Carbon tetrachloride and its daughter products are presented in Figure 7-8. It is known that groundwater diverges from the 903 Pad to the northeast and the southeast. The northeast component follows a buried paleochannel. The southeast component contributes to the 903 Pad/Ryan's Pit Plume. Groundwater only flows to the southeast if the seasonal water table is at a high enough elevation to breach the paleochannel bank. Section 9.1, 903 Pad VOC Investigation, describes groundwater samples collected in 1998 to support the 903 Pad Borehole Investigation. Even in a very wet year (1998), concentrations of carbon tetrachloride in wells southeast of the 903 Pad were low. Although it has been thought that the 903 Pad is the primary source of carbon tetrachloride, Figure 7-8 implies that the Ryan's Pit contribution of carbon tetrachloride to the 903 Pad/Ryan's Pit Plume is greater than the 903 Pad contribution of this contaminant.

Well installations and sampling performed over the past several years have led to a greater understanding of the nature and extent of groundwater contamination at the 903 Pad/Ryan’s Pit Plume. These newer data and locations can be used to improve the groundwater sampling program in that area, while eliminating unnecessary and unproductive wells from the program. Figure 4-7 shows the wells in this area.

Several wells installed along the SID east of Pond C-1 are currently monitored in support of this plume, but show no contamination. These wells include well pair 2987 and 3087, and well 23196. Well 2987 is a stainless-steel alluvial well screened from 3.5 to 20.3 feet bgs; 3087 is a stainless-steel bedrock well screened from 85.8 to 94.4 feet bgs;

and 23196 is a PVC alluvial well screened from 15.0 to 25.0 feet bgs. All three are located several hundred feet east of the newly installed 903 Pad/Ryan's Pit Plume wells (90099 through 90399).

Geologic logs from these older boreholes indicate a bedrock low at 23196 (27 feet bgs) that shallows to the east and reaches 19.8 and 16.0 feet bgs at wells 2987 and 3087, respectively. These data indicate groundwater flow would be more likely in the bedrock low at 23196; however, this well is frequently dry. Water is present in the well pair, but is free of VOCs.

The primary 903 Pad/Ryan's Pit Plume pathway appears to be west of these three older wells, in the vicinity of the newer ones. Evidence supporting this conclusion includes the presence of ample water in several of the newer wells, VOCs exceeding action level thresholds in two of these wells, VOCs absent in the older eastern wells, and the subsurface configuration at the older eastern wells. These newer wells (90099 through 90399) are therefore more appropriate for monitoring the 903 Pad/Ryan's Pit Plume. In addition, well 2987 is no longer suitable for monitoring due to downhole damage.

Therefore, these eastern wells – 2987, 3087, and 23196 – should be omitted from the IMP in favor of newer wells 90099, 90199, 90299, and 90399. Wells 6286, 6386, 00491, 07391, and 23096 should continue to be sampled.

Table 7-5 Proposed 903 Pad/Ryan's Pit Plume Sampling

Well Number	In 1999 Program	Proposed for 2001 Program?	Water Levels or Sampling?
6286	Yes	Yes	Both
6386	Yes	Yes	Both
2987	Yes	No	Neither
3087	Yes	No	Neither
00491	Yes	Yes	Both
07391	Yes	Yes	Both
23096	Yes	Yes	Both
23196	Yes	No	Neither
90099	No*	Yes	Both
90199	No*	Yes	Both
90299	No*	Yes	Both
90399	No*	Yes	Both

*While these wells were sampled in 1999, sampling was driven by the 903 Pad/Ryan's Pit Plume SAP, not by the IMP.

7.3 PU&D Yard Plume Investigations

In 1997, RFETS conducted a field investigation into the nature and extent of VOC groundwater contamination found in upgradient monitoring wells at the Present Sanitary Landfill. This investigation resulted in the identification of the PU&D Yard as the probable source area and implicated the landfill groundwater intercept and diversion system as an important factor in contributing to longitudinal plume spreading (Figure 7-9). The results of

this evaluation were summarized in the *1997 Annual RFCA Groundwater Monitoring Report* (DOE, 1998a). Further investigation into the function of the groundwater intercept and diversion system and its possible role in collecting and discharging PU&D Yard plume contaminants downgradient of the landfill were undertaken in 1998. This section summarizes the results of the 1998 investigation, including field observations of drain valving, flow, and analytical results of samples collected at the drain outfalls in 1998 and 1999.

Figure 7-9 illustrates the layout of the groundwater intercept and diversion system. Information presented in the *Phase I RFI/RI Work Plan for Operable Unit No. 7 - Present Sanitary* Landfill (DOE, 1991b) and other Operable Unit 7 documentation contain engineering design specifications and a hydrologic analysis of system effectiveness, but contain little information on system operation, such as valving configurations and discharge data. Discharge at drain outfalls SW099 and SW100, located below the East Landfill Pond dam, is usually minimal or absent despite evidence, such as an abundance of valley head-cut seeps in pre-landfill aerial photographs, that suggest flow should be greater than currently observed assuming proper drain function. Explanations for the lack of appreciable discharge at these outfalls involve at least four scenarios: 1) discharge is currently routed toward the landfill pond by valving and piping shown in design drawings, 2) the lines have been broken or breached, resulting in subsurface discharge of drain water to refuse materials, 3) the drain system was never properly functional because of leakage caused by geological irregularities, design or installation flaws, or other potential shortcomings, and 4) groundwater levels at the perimeter of the landfill drop below the elevation of the groundwater diversion system drainpipe during extended periods of the year.

A preliminary investigation into drain operation was undertaken to gain additional information on the fate of groundwater collected by the system. This investigation consisted of a records search to locate additional documentation on the historical operation and valve configuration; a field search to locate valves, drain line locations, and drain outfall locations at the landfill pond; and a monitoring program for sampling flow issuing from SW099 and SW100.

A records search resulted in the disclosure of no new information relevant to drain operation beyond that contained within DOE (1991b). The field survey, however, was more successful, resulting in the location of valving for both the north and south intercept lines, the location of apparent pond line locations indicated by subtle changes in topography and vegetation leading from the valves, and location of the south pond drain outfall during a period of low pond stage (May 1999). Significantly, no discharge was observed at this outfall during a time when SW099 and SW100 were both flowing.

Observation of drain outfalls SW099 and SW100, located on Figure 7-9, was conducted at roughly monthly intervals during the fall and winter of 1998, and spring of 1999. The outfalls can only be sampled when flow permits. In December 1998, a sufficient amount of flow was observed at SW099 (0.007 gallons per minute [gpm] on 12/18/98) to justify sampling for VOCs. The SW100 outfall was dry during all site visits prior to April 1999, except for incident precipitation that had built up inside the weir box. On April 29, 1999, flows from both outfalls were observed and a complete sample set was collected for VOCs, metals, radionuclides (Pu-239/240, Am-241,

uranium isotopes, and tritium), and water quality parameters (total dissolved solids, sulfate, fluoride, and nitrate/nitrite). Discharges of 0.5 gpm at SW099 and 1.3 gpm at SW100 were measured prior to sampling. No other SW099 and SW100 outfall samples were collected during 1999.

VOCs characteristic of PU&D Yard groundwater contamination were not detected in samples collected at either outfall. Dissolved metals, water quality constituents, Pu-239/240, Am-241, and tritium were all found below Tier II action levels for 1998. During the April 1999 sampling event, U-233/234 was detected above the Tier II action level at 1.2991 pCi/L in SW099, but below the Tier II action level at SW100 (0.9358 pCi/L). U-235 was detected below the Tier II action level and U-238 was detected above the Tier II action level at both locations. In all cases, the reported uranium isotope activities were well below their respective background M2SD activities and, as such, are not reportable values. The information collected thus far indicates that the PU&D Yard VOC plume does not contribute significant concentrations of contaminants to the landfill groundwater intercept and diversion system.

Monitoring of the drain outfalls will be continued during CY 2000, and if flow permits, samples will be collected to further investigate the potential impact of PU&D Yard contamination on groundwater and surface water quality downgradient of the landfill. In addition, during CY 2000 a SAP will be prepared and submitted to the CDPHE and U.S. EPA for natural attenuation monitoring of the PU&D Yard VOC plume. The SAP will incorporate the sampling of existing and new monitoring wells (shown in figure 7-9) to evaluate whether or not monitored natural attenuation is an effective mechanism for ensuring the protection of surface water quality with regard to the location of the PU&D Yard VOC plume. New monitoring wells associated with this SAP are expected to be installed in late CY 2000.

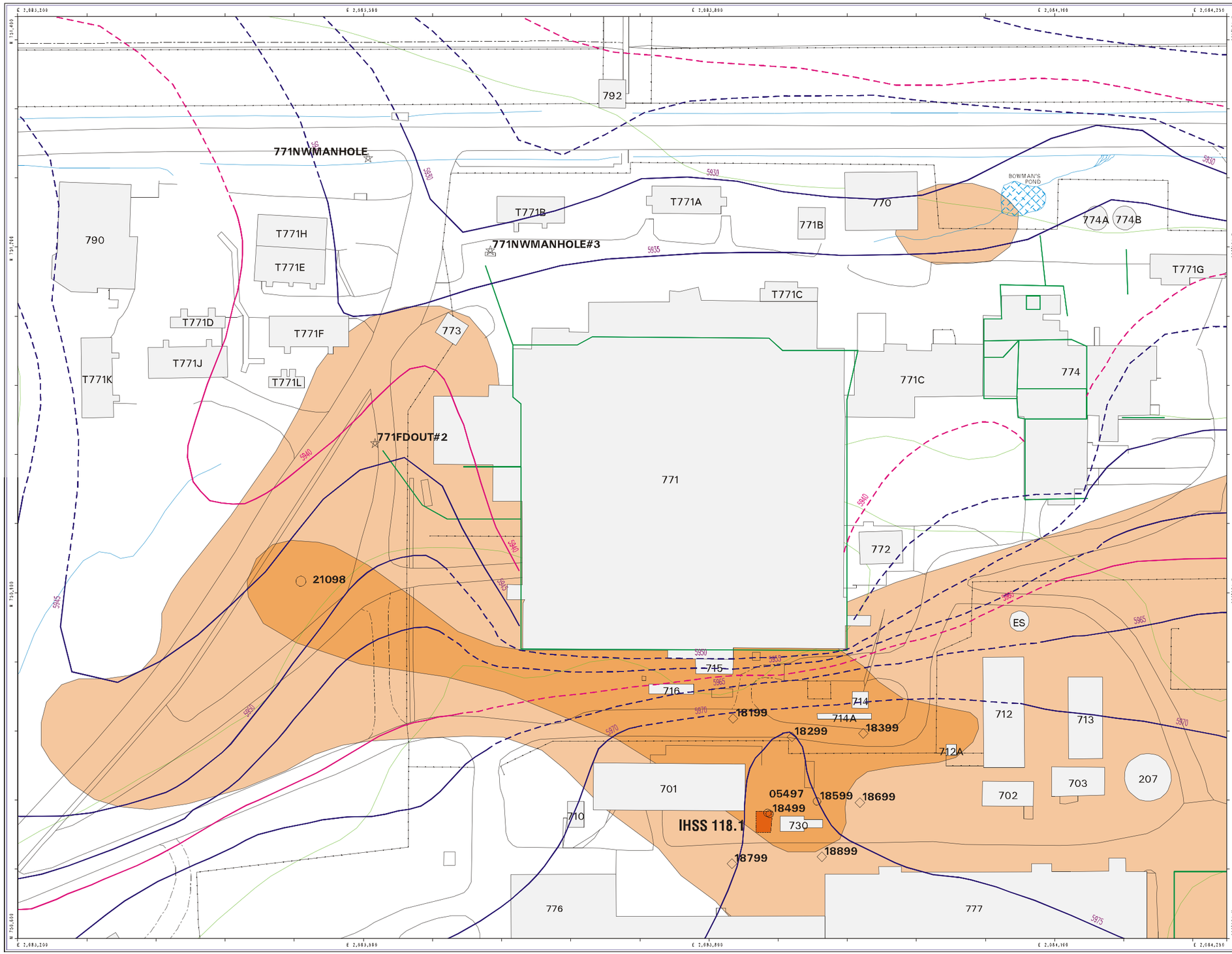

Figure 7-1
Location Map
IHSS 118.1 Wells

1999 Annual RFCA Groundwater Monitoring Report

IHSS 118.1 Wells

- Alluvial Wells
- Alluvial/Bedrock Wells
- Surface Water Monitoring Locations
- Location of IHSS 118.1

VOC Groundwater Plumes

- Carbon Tetrachloride concentration equal to or greater than 5 ug/L
- Carbon Tetrachloride concentration equal to or greater than 500 ug/L

Standard Map Features

- Buildings and other structures
- Solar Evaporation Ponds (SEP)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

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N

Scale = 1 : 1030
1 inch represents approximately 86 feet

25 0 50 100 ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

Prepared for: KAISER-HILL

MAP ID: rfca-rpt

November 14, 2000

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NT_Svr w:/projects/fy2k/rfca-rpt/figures/ihss118_yoos/ihss-118.aml

Figure 7- 2
Nitrate, DOC, TOC, Sulfide, Ferrous Iron and DO Concentrations at IHSS 118.1

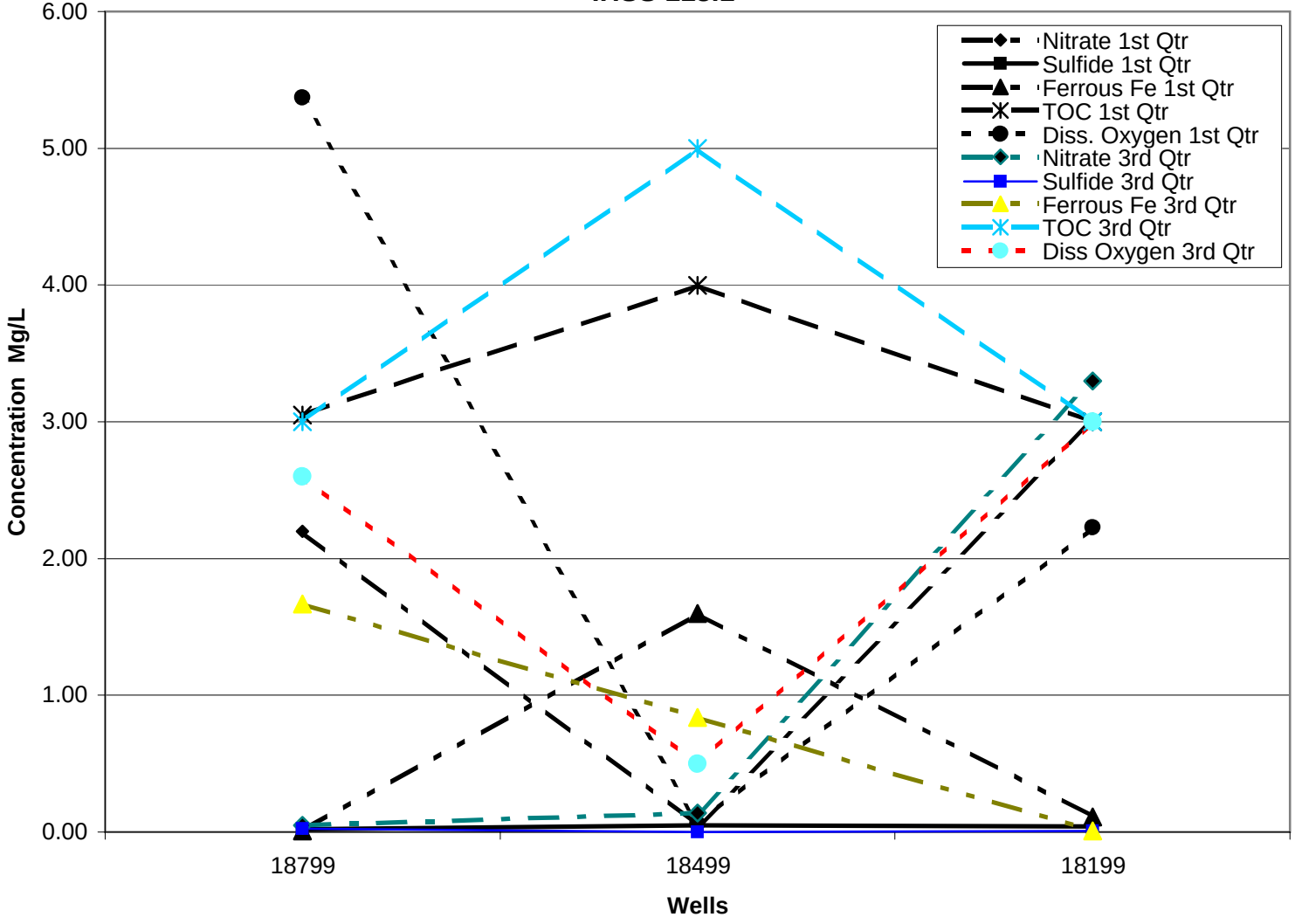


Figure 7- 3
Carbon Tetrachloride and Chloroform Concentrations at IHSS 118.1

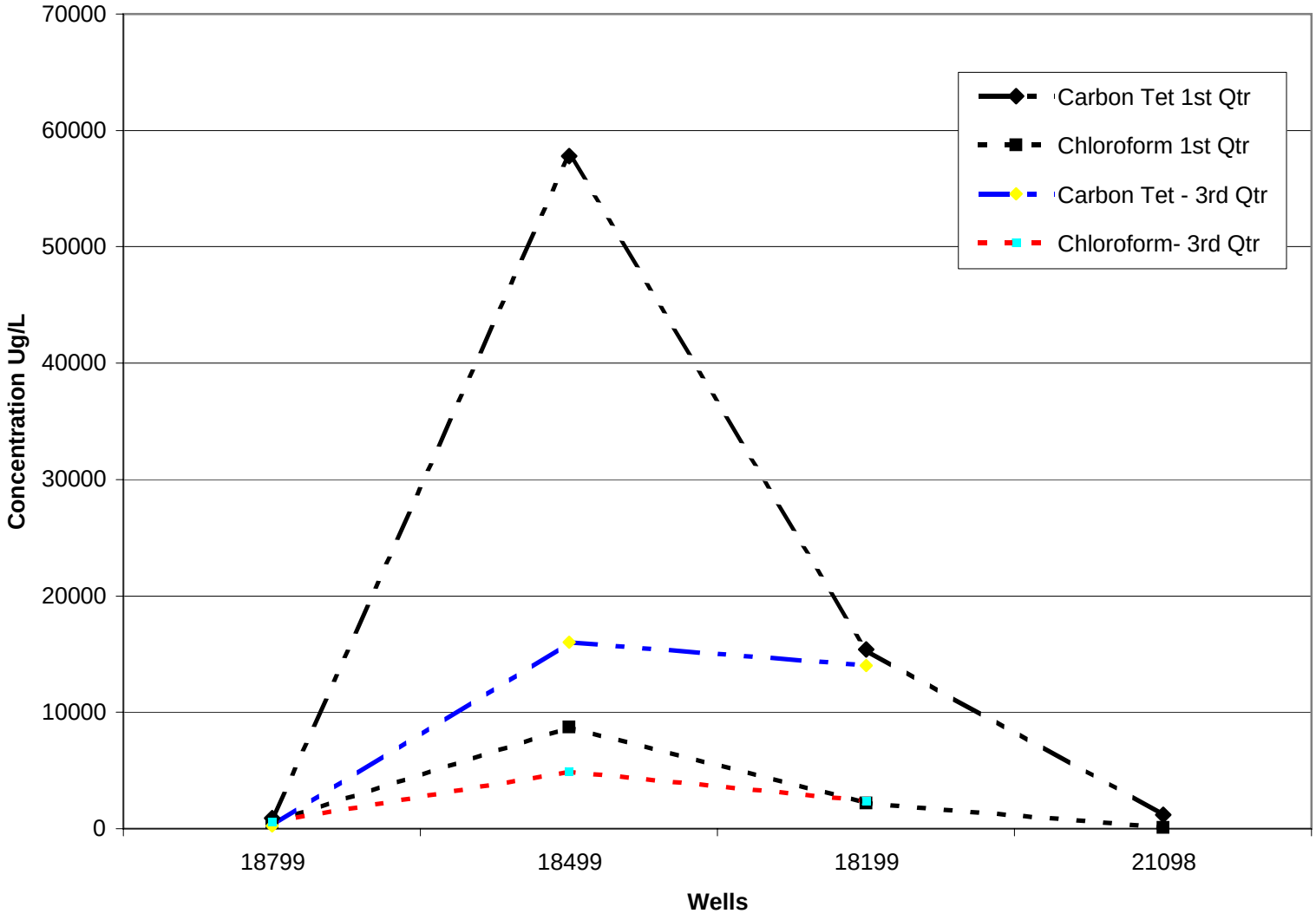


Figure 7- 4
Methylene Chloride, Chloromethane and Methane Concentrations at IHSS 118.1

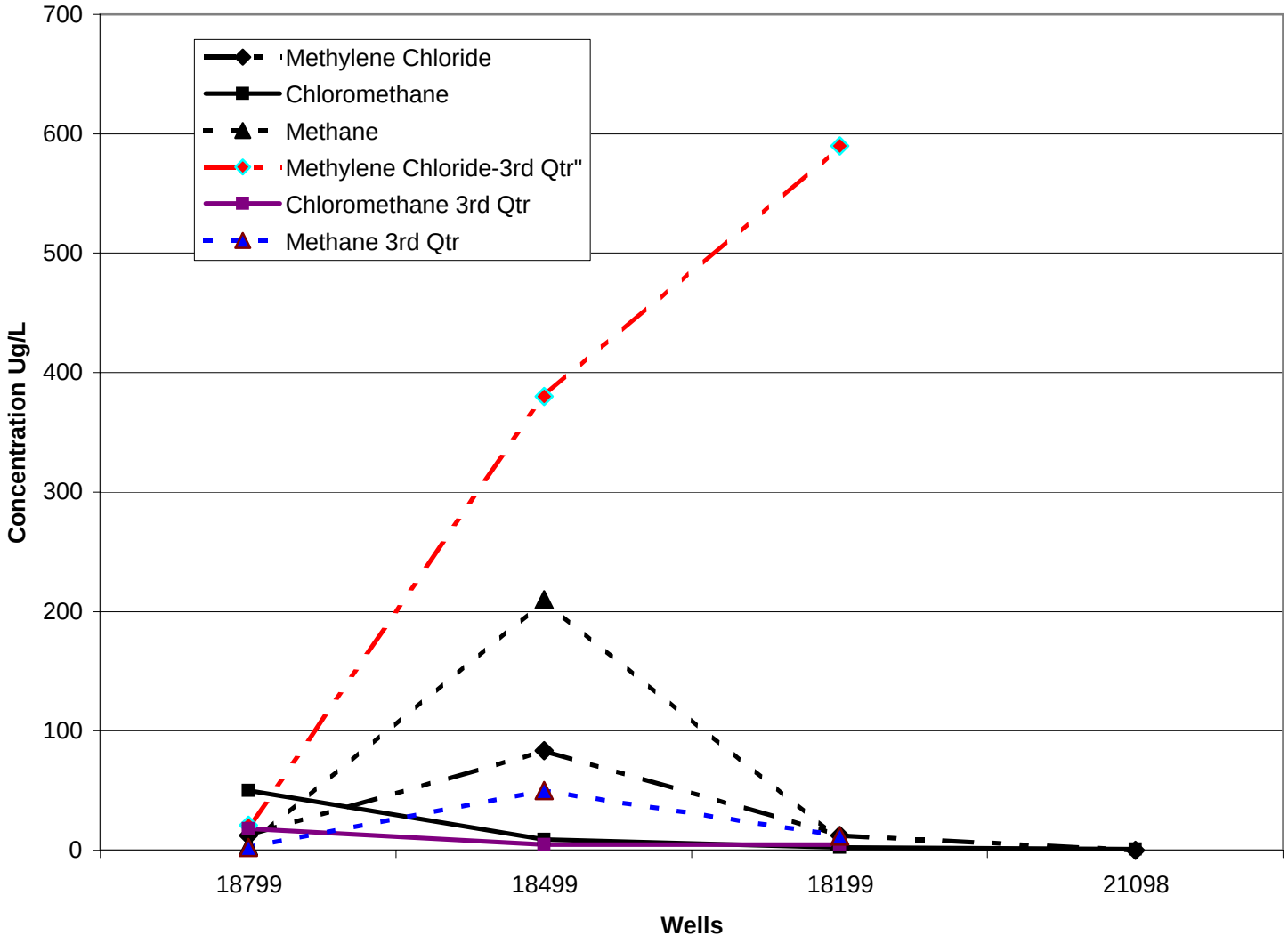
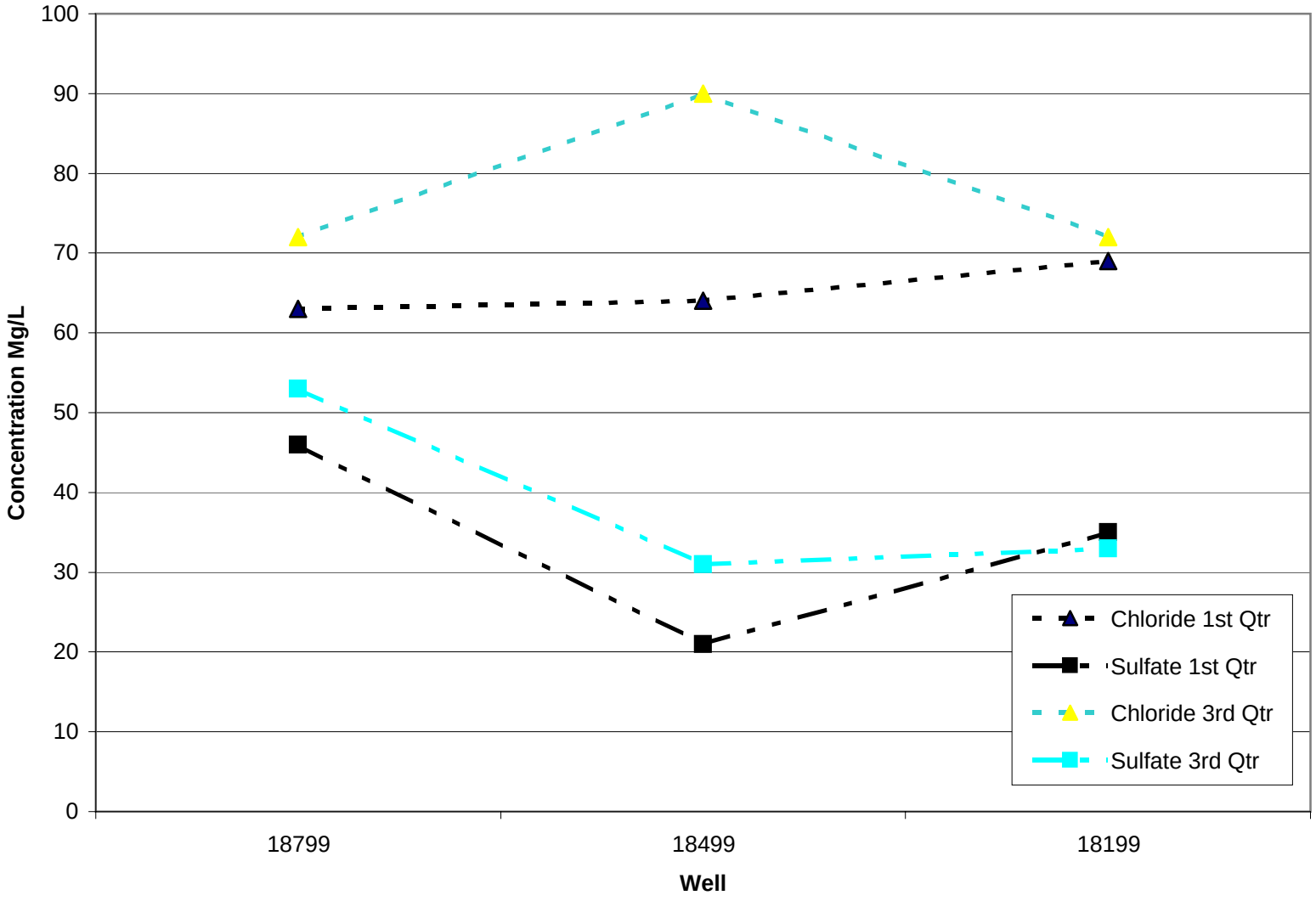


Figure 7- 5
Chloride and Sulfate Concentrations at IHSS 118.1



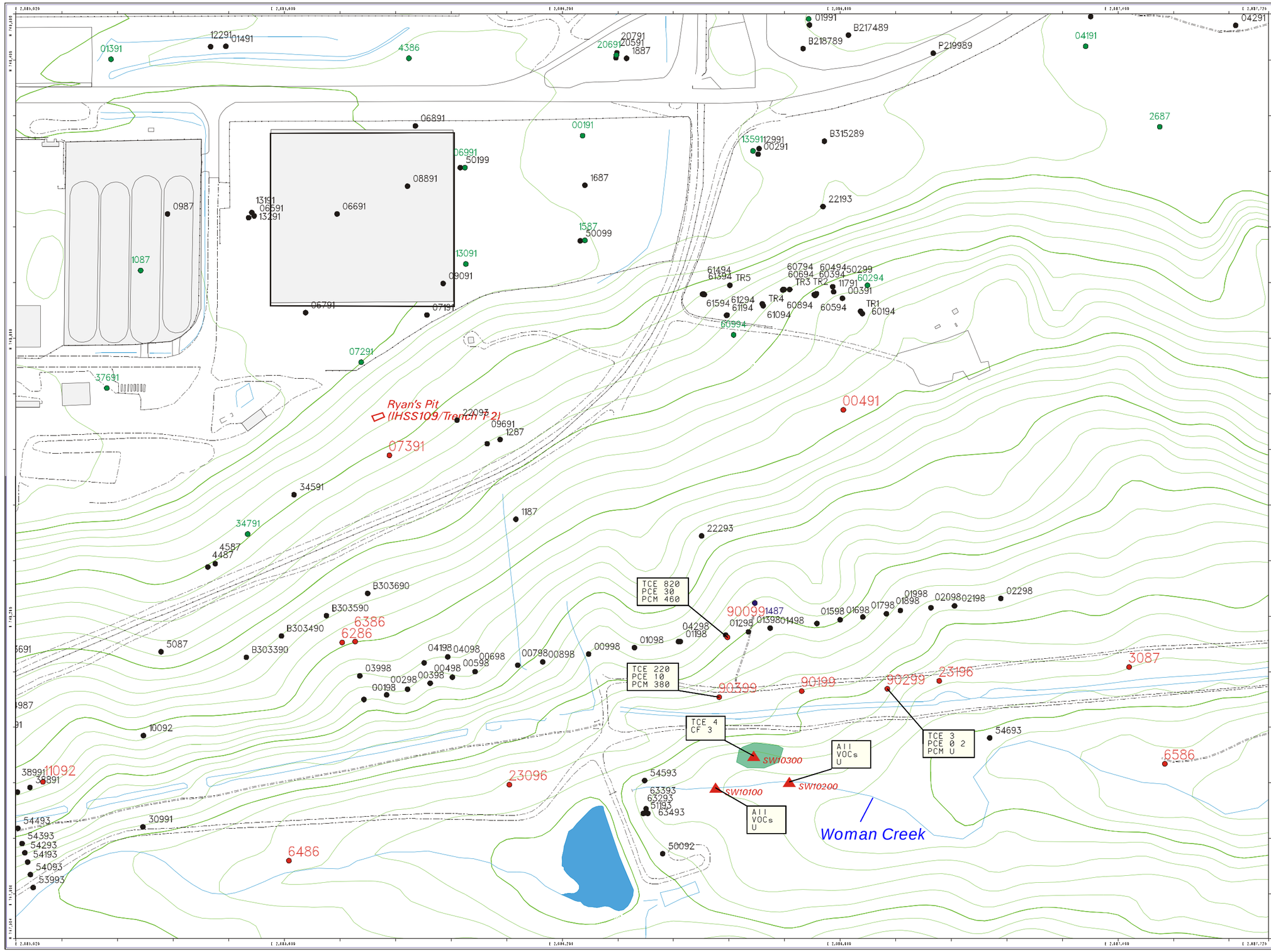


Figure 7-6
903 Pad/Ryan's Pit Area Location Map

1999 Annual RFCA Groundwater Monitoring Report

EXPLANATION

IMP Well Type

- Water Quality Flow Monitoring
- Industrial Area Flow Monitoring
- Background Flow Monitoring
- D&D Monitoring
- Non-IMP
- Surface Water Sampling Locations
- Seeps

Standard Map Features

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

NOTE:

Notes:

Temporary Wells 00198-00898, 01098,01598 01898,02098-02298 and 03998-04198 are DRY.

Permanent Well 90199 is DRY

Well 00998 not sampled because of insufficient water

PCM = Carbon Tetrachloride
CF = Chloroform

All concentrations in ug/l

Scale = 1 : 2470
1 inch represents approximately 206 feet

50 0 100 200ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

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MAP ID: rfca-rpt/figures/903pad_ryan_plt

December 06, 2000

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NT_Svr w:/projects/fy2k/rfca-rpt/figures/903pad_ryan_pit/bb_ryans-pit_loc-other-map.aml

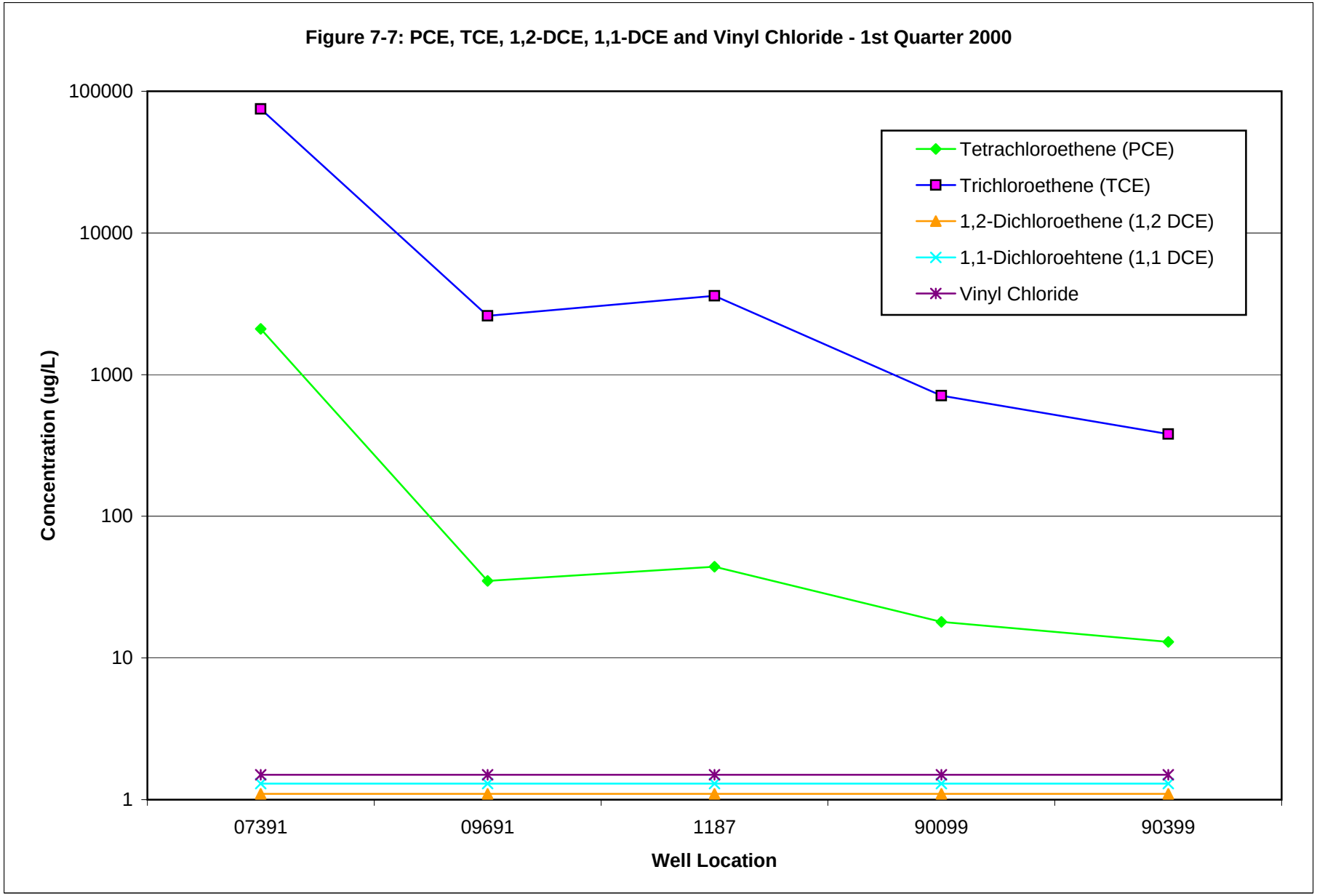
Figure 7-7: PCE, TCE, 1,2-DCE, 1,1-DCE and Vinyl Chloride - 1st Quarter 2000
100000
10000
1000
100
10
1
Concentration (ug/L)
07391
09691
1187
90099
90399
Well Location
Tetrachloroethene (PCE)
Trichloroethene (TCE)
1,2-Dichloroethene (1,2 DCE)
1,1-Dichloroehtene (1,1 DCE)
Vinyl Chloride

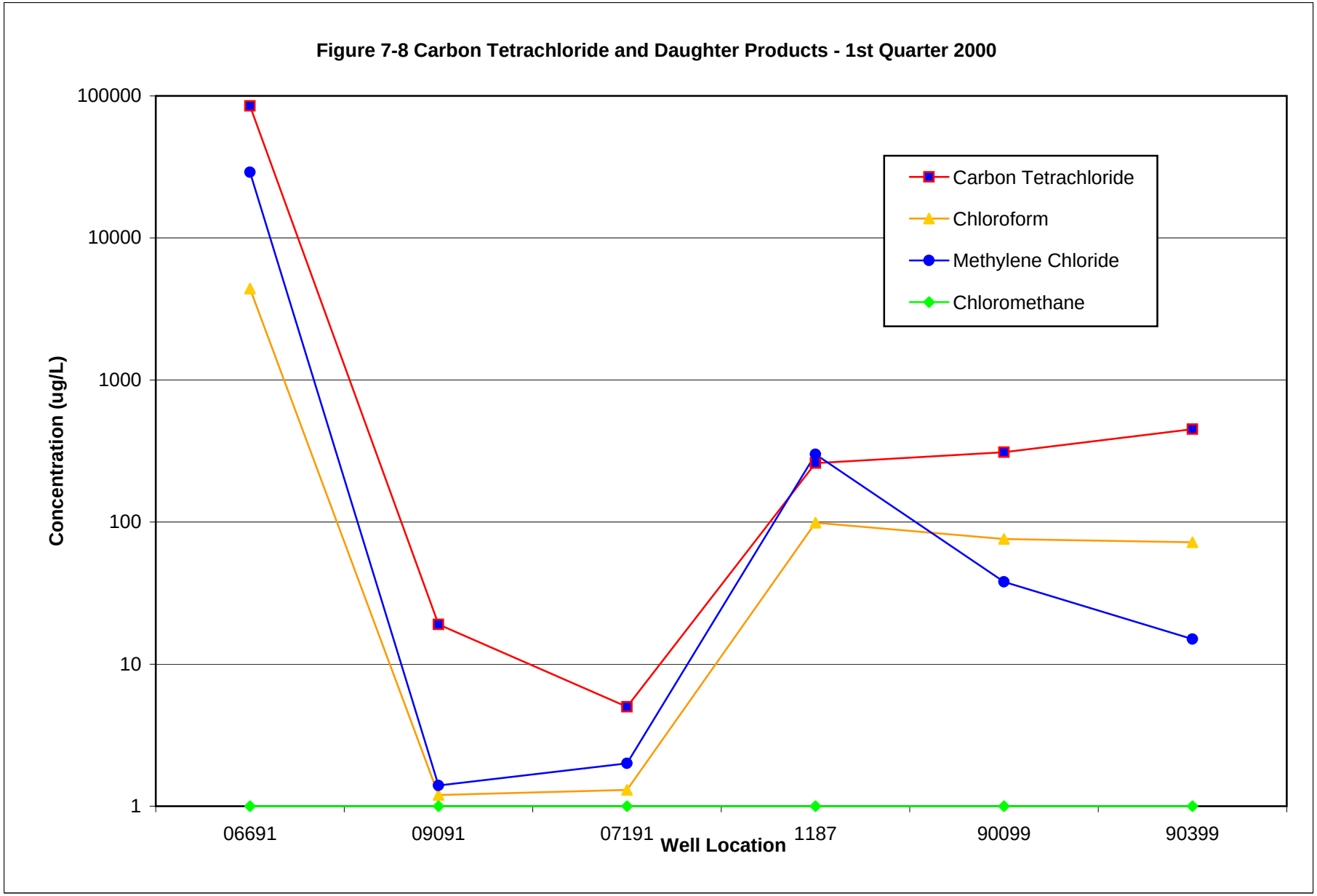
Figure 7-8 Carbon Tetrachloride and Daughter Products - 1st Quarter 2000
100000
10000
1000
100
10
1
Concentration (ug/L)
06691
09091
07191
1187
90099
90399
Well Location
Carbon Tetrachloride
Chloroform
Methylene Chloride
Chloromethane

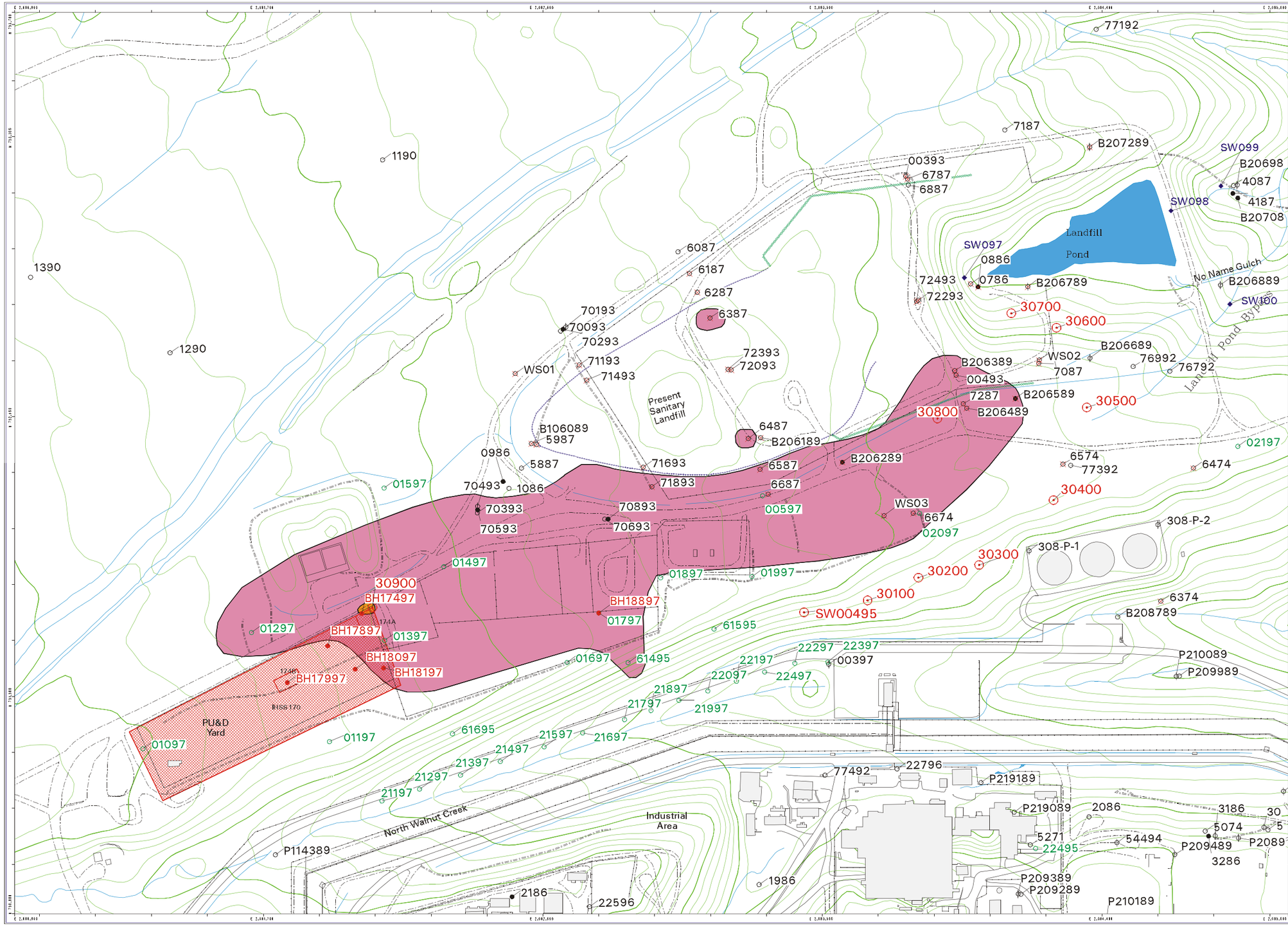

Figure 7-9
PU&D Yard
Groundwater VOC Plume
Location of Proposed Monitoring Wells

1999 Annual RFCA Groundwater Monitoring Report

EXPLANATION

- PU&D Yard Monitoring Well
- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Borehole Locations
- Surface Water Monitoring Locations
- Abandoned Monitor Well
- Proposed and Temporary PU&D Yard VOC Plume Monitoring Wells
- Groundwater Intercept System
- Landfill Slurry wall
- PU&D Yard IHSS

VOC Composite Plume

- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)

Standard Map Features

- Buildings and other structures
- Landfill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

NOTE:
Source of GIS data available upon request.

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Scale = 1:3780
1 inch represents approximately 313 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Prepared for: KAISER-HILL

MAP ID: 2K-0201

September 28, 2000

NT_Svr w:/projects/fy2k/rfca-rpt/figures/pu-d_yard/pud-yard-proposed-wells.aml