3.1 100 Areas

The Hanford Site 100 Areas are located in the northern part of the site along the Columbia River. Eight nuclear reactors were located in the 100 Areas. They operated from the mid 1940s until 1987 and were used for production of defense related nuclear material. Considerable vadose zone contamination is associated with those past-practice activities. Current decontamination and remediation activities focus on sites in the 100 Area because they are located near the Columbia River.

This section describes the significant vadose zone related activities that occurred in the 100 Areas in fiscal year 1999. These activities include soil sampling and analysis to support remediation of the 116-C-1 process effluent trench and the 1301-N and 1325-N cribs and trenches, sampling and analysis to select a waste site for initial deployment of technology for in situ reduction of hexavalent chromium, and laboratory studies to measure the distribution coefficient and leachability of chromium in sediment to support future remedial action goals and plans. This section does not discuss excavation done to remediate contaminated sites. Those efforts are described in the appropriate parts of Section 2.0.

3.1.1 Soil Remediation at 116-C-1 Trench

D. G. Horton

The 116-C-1 process effluent trench was remediated in 1997, and a test pit was dug to groundwater in early 1998 by Bechtel Hanford, Inc. Analysis of data from the pit became available in 1999 (CVP-98-00006, Rev. 0). This section summarizes the results of those analyses. For a full description of the work, see CVP-98-00006, Rev. 0.

The 116-C-1 trench is located within the 100-BC-1 Operable Unit in the 100 B/C Area of the Hanford Site (see Plate 1). The trench is 167 meters long, 32 meters wide, and 5 meters deep. The 116-C-1 site is an unlined trench that was used to dispose of 700 million liters of contaminated cooling water from the 100 B/C Area retention basins after ruptured fuel elements were detected in the reactors. The 116-C-1 trench continued to receive contaminated cooling water until reactor operations ceased in 1968. An additional 40 billion liters of high-temperature reactor cooling water was discharged to the trench during a 150-day infiltration test in 1967. That water contained 700 ppb chromium as the major contaminant. The infiltration likely influenced the distribution of contaminants beneath the site.

The most mobile contaminants at the 116-C-1 trench have been flushed through the vadose zone to groundwater as a result of infiltration testing in 1967.

The contaminants of concern at the 116-C-1 trench include americium-241; cobalt-60; cesium-137; europium-152, -154, and -155; nickel-63; plutonium-238, -239/240; strontium-90; uranium-238; total chromium; hexavalent chromium; mercury; and lead.

The remedial actions taken at the 116-C-1 trench included (1) excavating the site to the extent required to meet specified soil cleanup levels, (2) disposing of contaminated excavation materials at the Environmental Restoration Disposal Facility at the 200 Areas, and (3) backfilling the site with clean soil to adjacent grade elevations and support subsequent revegetation. As part of the remediation activities, a characterization test pit was excavated to groundwater.

The vadose zone beneath the 116-C-1 site consists of the Hanford formation and is predominantly sand and gravel with various amounts of silt and cobble-size material. The groundwater is ~12.8 meters below the surface.

The test pit was 38 by 38 meters square and was located in the southwestern third of the trench. The test pit was centered at an area of elevated activity near the trench inlet pipe. The material was removed in 1.5-meter lifts using a backhoe. Soil samples were taken from each quadrant of the test pit and composited for each of the eight lifts. Figure 3.1-1 shows a cross section of the 116-C-1 trench with the locations of the test pit and samples.

Figure 3.1-2 shows the distribution of the constituents of concern with respect to depth beneath the trench. The results were obtained using U.S. Environmental Protection Agency approved methods on the bulk sample. The figure shows that most remaining contamination in the vadose zone is within ~5 meters of the base of the remedial action excavation. More mobile contaminants, such as strontium-90, however, are slightly deeper in the soil column. The most mobile contaminants, such as hexavalent chromium, that was present at ~700 µg/L in the cooling water, have been flushed through the vadose zone to groundwater as a result of the infiltration test done on the trench after disposal of contaminated cooling water. See Section 2.2 for discussions of groundwater under the 100 C Area.

The maximum concentration of total chromium is ~10 times higher than background values. It is possible that some of the hexavalent chromium was reduced in the vadose zone to form the distribution of total chromium seen in Figure 3.1-2. Alternatively, some trivalent chromium may have been disposed to the trench.

As part of the remedial action, the RESRAD computer code (ANL 1997) was used to model the impact of residual contaminants of concern on the vadose zone, groundwater, and Columbia River. A rural residential exposure scenario was used, though future land use of the 100 Area is not yet defined (CVP-98-00006, Rev. 0). The model predicted a maximum dose rate of 8.2 mrem/yr at the present, decreasing to 0.066 mrem/yr in 1,000 years from direct exposure to the soil. The total excess cancer risk from direct exposure to radionuclides was calculated to be the largest, 7.7×10^{-5}, at the present and decreasing to 1.8×10^{-7} in 1,000 years.

All concentrations of the non-radionuclide contaminants of concern (total chromium, hexavalent chromium, lead, and mercury) were below remedial action goals, or cleanup levels, for direct exposure to the soil. The excess cancer risk from hexavalent chromium in the overburden and the excavated zone was well below the individual and cumulative risk limits.

The estimated radionuclide dose via the groundwater and/or the Columbia River was well below the 4-mrem/yr dose rate limit. Also, the remaining concentrations of total chromium, hexavalent chromium, lead, and mercury in the soil were either less than 100 times the maximum contamination level, less than background concentration, or modeled with RESRAD to be less than remedial action goals.

Remediation of the 116-C-1 trench meets cleanup standards and the site is reclassified as closed in accordance with the Tri-Party Agreement (Ecology et al. 1989). A more complete description of the project and the results can be found in CVP-98-00006, Rev. 0.

3.1.2 Soil Sampling and Analysis at 1301-N and 1325-N Trenches

D. G. Horton

Bechtel Hanford, Inc. collected and analyzed four subsurface soil samples from test pits excavated in each of the 1301-N and 1325-N trenches in 1998. They also collected and analyzed four samples of surface soil from each of the 1301-N trench and the 1325-N crib. Plate 1 shows the locations of the facilities. Figures 3.1-3 and 3.1-4 show the sample locations. The purpose of the activity was to facilitate the remedial action design and disposal process of contaminated soil that will be excavated from the site. This section summarizes the sampling activities and the analytical results. A much more complete description can be found in BHI-01271, Rev. 0.

The 1301-N and 1325-N cribs and trenches received radioactive liquid waste containing activation and fission products as well as small quantities of corrosive liquids and laboratory chemicals generated by various N Reactor operations. Overflow from the cribs was discharged to the trenches. As the liquid waste percolated through the vadose zone soil beneath the trenches, radioactive and hazardous materials were sorbed onto the soil. Different contaminants would have migrated to different depths based on adsorption characteristics of individual constituents.

Previous investigations had shown that soil contamination was highest near the surface of the facilities and decreased dramatically with depth. The contaminants of concern were cesium-137, chromium, cobalt-60, europium-154 and -155, mercury, nitrate, plutonium-239/240, strontium-90, and tritium at both 1301-N and 1325-N.

Samples from test pits in the 1301-N and 1325-N trenches show that radionuclide concentrations drop sharply in the upper 0.6 meter of the surface or the base of the backfill.

Four samples of soil were obtained from the surface of the 1301-N trench and four from the surface of the 1325-N crib. The samples were collected in sample bottles that were attached to a telescoping painter pole. The sample bottles were lowered through hatchways in the covers of the crib and trench. The upper 50 to 75 millimeters of soil were scraped into the sample bottle and removed from the facility through the access port.

The samples from 1301-N trench were sandy silt with between 5% and 50% organic debris. The samples from the 1325-N crib ranged from semi-dry to slightly moist silt to coarse sand and silt. One sample contained ~50% pebbles; a second sample contained some animal hair and pieces of wood; and a third sample contained a piece of clay.

Figure 3.1-5 shows the results of the analyses of radionuclide concentrations in the surface samples from the 1301-N trench. Radionuclide concentrations are plotted according to their distance down the trench from the crib. Also shown on the figure are the average values of process sample data collected between 1980 and 1985 for comparison. All older data were decay corrected to January 1999. One value for plutonium-239/240, collected in 1982 at 147 meters from the crib, is not included in the calculated average because it was considered unrepresentative.

The 1999 data show that, within a factor of 10, concentrations of radionuclides are fairly constant along the length of the trench. There is a slight increase in the concentrations of all constituents in the 1999 samples obtained ~150 meters from the crib and this is mirrored for some radionuclides at 112 meters distance in the older data set. The exact locations of the older data are not known with certainty because each set of data included only nine locations, yet there are 10 access ports in the trench. BHI-01271, Rev. 0 assumed that ports 1 through 9 (the closest to the crib) were historically sampled. However, if it were assumed that ports 2 through 10 were sampled, the older data would be shifted one location farther from the crib. This would improve the match between the 1999 and the historical 150-meter sample for several isotopes.

Figure 3.1-6 shows the results of the analyses of radionuclide concentrations in the surface samples from the 1325-N crib. Radionuclide concentrations are plotted according to their position within the crib. Also shown on the figure are the average values of process sample data collected between 1985 and 1987 for comparison. The older data were decay corrected to January 1999. The 1999 data show that, within a factor of 10, concentration levels are fairly constant across the crib. Also, the 1999 values are within a factor of 10 of the average 1985 to 1987 process data.

A hydraulic excavator was used to dig one test pit in each trench. The excavator bucket was used to collect three discrete grab samples of soil at selected

depths. Also, one composite soil sample was taken at each trench by combining and homogenizing a portion of each grab sample.

The samples from the 1301-N trench were collected from depths of 0 to 0.3 meters, 0.3 to 0.6 meters, and 0.6 to 1.5 meters. The samples were from the Hanford formation and were moist, sandy gravel to gravel. The gravel content increased with depth. Samples from the 1325-N trench were obtained from depths of 0.61 to 1 meters, 1 to 1.4 meters, and 1.4 to 1.8 meters. A 0.61-meter layer of backfill was removed before collecting the shallowest sample. The Hanford formation sediment was poorly sorted sandy gravel to gravel, and the gravel content increased with depth in the 1325-N trench pit.

Field instruments were used to map the soil in each excavation bucket to locate the highest alpha and beta-gamma concentration. Samples were collected from the areas of highest concentration, placed in a clean stainless steel bowl, homogenized, and then transferred to sample bottles for transport to the laboratory.

Figure 3.1-7 shows the results of analysis of the radionuclides in samples from the pits in both trenches. The average depth of each excavation bucket is used as the sample depth. The data from 0 meter for the 1301-N trench in Figure 3.1-7 are the average values of the surface samples taken from that trench. Also, the top of the first sample from the 1325-N trench is placed at a depth of 0.6 meter because 0 meter was the top of the gravel backfill, which was removed. The data on Figure 3.1-7 show that the concentration of most radionuclides drops off rapidly with depth by a factor of 10 to 100 within the first 0.6 meter of the surface at the 1301-N trench or the base of gravel backfill at the 1325-N trench. However, the concentration of most isotopes below 0.6 meter remains substantial. See Section 2.4 for discussion of groundwater beneath the 1301-N and 1325-N facilities.

3.1.3 In Situ Gaseous Reduction Approach

E. C. Thornton, K. J. Cantrell, J. M. Faurote, T. J Gilmore, K. B. Olsen, R. Schalla

This section summarizes the fiscal year 1999 activities to identify a waste site for initial deployment of the in situ gaseous reduction approach to remediation of hexavalent chromium. A full account of the activities can be found in PNNL-13107.

In situ gaseous reduction is a technology currently being developed by the U.S. Department of Energy (DOE) for the remediation of soil waste sites contaminated with hexavalent chromium. The chemical reaction of primary interest is the reduction of hexavalent chromium to trivalent chromium, with subsequent precipitation as a non-toxic solid product. The technique involves injection of a dilute hydrogen sulfide gas mixture into the vadose zone at a hexavalent chromium waste site through a central borehole (Figure 3.1-8). The gas mixture is then drawn through the waste site by vacuum applied at extraction boreholes located at the site boundary. Monitoring the breakthrough of hydrogen sulfide at the extraction wells provides a basis to assess treatment progress.

In fiscal year 1999, investigators searched for suitable locations to test an innovative method of removing chromium from the vadose zone. The best site for initial use of the method was found to be the 183-DR facility in the 100 D Area.

Field testing of the in situ gaseous reduction approach was demonstrated at White Sands Missile Range in 1998 by injecting 200 mg/L hydrogen sulfide into chromate-contaminated soil. Final findings indicate that 70% of the hexavalent chromium present at the site was reduced to trivalent chromium during the test.

The primary objective of the Hanford Site 1999 study was to select one or two waste sites for an initial deployment of the in situ gaseous reduction technology. Six sites were selected for screening. The selected sites were suspected to contain small but highly contaminated vadose zone plumes. As such, the chance of detecting a vadose plume was less than that for a larger plume such as those associated with retention basins or cribs.

The selected sites were the 100 C plutonium crib, the 183-DR head house and filter plant, an area near the 108-D Building, the 190-D complex, the 183-H solar evaporation basins, and the 183-KE and 183-KW chromate transfer stations. The soil samples collected at the 100 C plutonium crib were obtained from an excavation pit. Subsurface samples collected at the other sites were obtained by Geoprobe™ and cone penetrometer. In addition, surface samples were collected for analysis at several of the above sites.

One hundred eighty-three soil samples were collected and analyzed in the laboratory for hexavalent chromium by colorimetry. Also, 70 samples were collected from 7 new boreholes drilled in the 100 D Area to support in situ reduction/oxidation (redox). These samples were also analyzed for hexavalent chromium. This section summarizes the results of those analyses. A detailed description of the work will be finalized and published in fiscal year 2000 (PNNL-13107).

3.1.3.1 Summary of Characterization Activities

Characterization data collected during this study is summarized below.

100 D Well Cuttings

Bechtel Hanford, Inc. drilled 12 new groundwater monitoring wells at 100 D Area in fiscal year 1999. Pacific Northwest National Laboratory (PNNL) participated in this effort by analyzing vadose zone samples (cuttings) from seven of these wells for hexavalent chromium. The objective of this effort was to obtain information regarding sources of hexavalent chromium contamination associated with the plume west of the DR Reactor. The wells chosen for sediment analyses were 199-D4-20 and 199-D5-38 through 199-D5-43 (Figure 3.1-9). The samples ranged from depths of 1.5 to 24 meters (top of the unconfined aquifer).

All sample analytical results were non-detections (less than 0.4 mg/kg hexavalent chromium). These negative results may be related, in part, to the locations of the wells. The wells were not drilled near the vadose zone source, which appears to be in the vicinity of the 183-DR facility (see Figure 3.1-9). However, it also appears that hexavalent chromium may be reduced during the drilling process. Reduction may be brought about by iron released during abrasion of the drill bit or by exposure of fresh ferrous iron-bearing surfaces of basalt cobbles fractured during drilling. It is concluded that future efforts to characterize the distribution of hexavalent chromium in the vadose zone by drilling should be undertaken by collecting unaltered core (e.g., split spoon) samples.

100 C Plutonium Crib

The 100 C plutonium crib (116-C-2A on Plate 1) in the 100 C Area is being remediated, primarily by excavation. Following recent excavation of surface material at this site, sediment samples were collected from the pit for analysis of hexavalent chromium. All samples were below the limits of detection for hexavalent chromium for the analytical method used. Thus, this site is eliminated from the list of candidate test sites for deployment of the in situ gaseous reduction technology.

183-DR Head House and Filter Plant

The location of the 183-DR facility is shown in Figure 3.1-9. This facility appears to be the source of hexavalent chromium present in the plume west of the site. This facility was originally used to remove suspended solid material from the cooling water and to add hexavalent chromium as a corrosion inhibitor before passing the water into the DR Reactor.

A series of Geoprobe™ holes were driven in the vicinity of the former head house and filter plant by CH2M Hanford, Inc. and PNNL staff to obtain sediment samples for analysis of hexavalent chromium. The locations of these holes are shown in Figure 3.1-10. The Geoprobe™ had difficulty obtaining samples at depths greater than ~4.6 meters, which appears to be the top of an open-framework gravel. However, some samples were collected down to 7.2 meters. Essentially no hexavalent chromium was detected in any of these samples.

A cone penetrometer, operated by Applied Research Associates, Inc., was used to obtain sediment samples at a depth of 3.9 meters near the center of the site (see Figure 3.1-10). Possible hexavalent chromium contamination was found at less than or at 0.5 mg/kg in these samples.

Groundwater monitoring data strongly suggest that the 183-DR facility was responsible for the hexavalent chromium groundwater plume present in this area. However, it appears that hexavalent chromium has migrated too deeply in the vadose zone at this site to be reached by Geoprobe™ or cone penetrometer. Vadose zone boreholes should be drilled and sediment samples analyzed to determine the vertical distribution of hexavalent chromium contamination at the 183-DR site.

108-D Site

This facility is located north of D Reactor (see Figure 3.1-9). It appears that the 108-D facility may have been the source of the hexavalent chromium groundwater plume located north of the reactor and may originally have been a chromate transfer station. Access to this site is difficult because of the presence of underground radionuclide contamination. However, a Geoprobe™ sampling location was set up a short distance to the west of a fence surrounding the area of subsurface radioactivity. Hexavalent chromium was detected at low concentrations (less than or at 1 mg/kg) in samples collected by Geoprobe™ at the site.

It is concluded that the 108-D site is not suitable for a demonstration of the in situ gaseous reduction technology because of underground radionuclide contamination, which would increase the costs and complexity of conducting a demonstration, and because of the low levels of hexavalent chromium contamination observed.

190-D Complex

This facility is located west of D Reactor. Hexavalent chromium was added to cooling water at this facility before entering the reactor, and fairly widespread contamination is present in the area. Hexavalent chromium staining of soil and concrete debris is visible in surface materials, commonly reaching levels of several hundred to greater than 1,000 mg/kg.

The locations of ten Geoprobe™ and two cone penetrometer holes at this site are shown in Figure 3.1-11. The highest value of hexavalent chromium obtained was 6.3 mg/kg from a sample collected from depths of 3 to 3.6 meters at location GPD26. This is the same location where a value of 6.96 mg/kg was reported by Bechtel Hanford, Inc. (BHI-01185, Rev. 0) from a sample collected at a depth of 4 meters. Samples from two cone penetrometer holes, which were drilled to a depth of 9.7 meters, suggest that the depth of contamination does not exceed 6.1 meters.

It is concluded that significant levels of hexavalent chromium contamination exist in the soil at the 190-D site. However, the contamination appears to be localized and restricted to shallow depths. Thus, in situ remediation probably is not a viable option at this site.

183-H Solar Evaporation Basins

The 183-H solar evaporation basins were a former waste storage facility in the 100 H Area. The basins are associated with contaminated soil and groundwater in the area. A total of four Geoprobe™ and four cone penetrometer holes (Figure 3.1-12) were driven at this site and sediment samples were collected and analyzed

for hexavalent chromium. Levels of hexavalent chromium in all samples were at or below the limits of detection (less than or at 0.4 mg/kg).

183-KE and 183-KW Chromate Transfer Stations

The 183-KE and 183-KW chromate transfer stations are located in the 100 K Area. They are sites where hexavalent chromium stock solutions were unloaded from railcars near the head house of the water treatment basins. As at 183-DR and 190-D, hexavalent chromium was added to reactor cooling water as a corrosion inhibitor. Surface soil stained by hexavalent chromium is particularly noticeable at 183-KW, where an area containing ~400 mg/kg hexavalent chromium has been identified. Chromium contamination of groundwater at 183-KE also has been monitored in the past several years.

Geoprobe™ sampling was undertaken at both 183-KE and 183-KW. Samples collected to a depth of ~2.3 meters at 183-KE did not contain detectable hexavalent chromium. Deeper sampling could not be achieved because of gravel or cobble beds. It is probable that hexavalent chromium contamination exists at depth in light of existing groundwater contamination but is apparently deeper than 3 meters. A field demonstration would be difficult to undertake at this site because the facility is still being used and access is limited because of utilities.

Hexavalent chromium was detected in sediment samples obtained from several Geoprobe™ holes at 183-KW. Geoprobe™ hole GPKW2 (Figure 3.1-13) had especially high concentrations, up to 420 mg/kg at depth of 2.6 meters. Significant hexavalent chromium concentrations were also detected in samples collected from hole GPKW3, which was driven in the area of surface soil contaminated with hexavalent chromium. A concentration of 11 mg/kg was measured in a sample collected at depths of 0.6 to 1.3 meters. Hexavalent chromium concentrations decreased to 3 mg/kg between 1.3 to 1.8 meters. Two cone penetrometer holes were also driven at 183-KW, but analysis of samples indicated that hexavalent chromium concentrations are relatively low (less than or at 2 mg/kg).

The 183-KW site was originally considered to be a potential test site for in situ gaseous remediation because of the presence of elevated levels of hexavalent chromium in the soil and because the site has been identified for remediation. However, Geoprobe™ and cone penetrometer refusal was commonly encountered at ~3 meters, due to a gravel or cobble layer, so that no samples could be collected below that depth. In addition, contamination appears to be sporadic and may be largely found on the surface. Finally, site utilities limit access to the site.

3.1.3.2 Conclusions and Recommendations

The 190-D site has significant concentrations of hexavalent chromium in the soil (as high as 7 mg/kg). However, contamination is limited to depths shallower than 6 meters and is in localized areas. Significant concentrations of hexavalent chromium also occur in sediment at the 183-KW site, but the distribution appears to be sporadic. At the 183-KW site, the use of the Geoprobe™ and cone penetrometer was limited to shallow sampling activities because of refusal at depths of 3 meters.

The 183-DR site is judged to be the best site available for undertaking an initial deployment of the in situ gaseous reduction technology at the Hanford Site. Geoprobe™ and cone penetrometer sampling at this site were severely hampered by the presence of concrete and construction debris and fill. Nevertheless, recent groundwater monitoring data strongly indicate that a deep vadose zone source of hexavalent chromium exists at 183-DR, and several sediment samples were obtained that appear to have low concentrations of hexavalent chromium. It is recommended that several vadose zone boreholes be drilled to groundwater at 183-DR. Sediment and groundwater samples should be collected and analyzed to verify that this site is the source for the groundwater plume.

3.1.4 Bench Scale Distribution Coefficient and Leach Studies on Hexavalent Chromium in Contaminated Vadose Zone Sediment from 100 D Area

R. J. Serne and D. G. Horton

Important decisions affecting the cost and extent of remedial actions in the 100 Areas are currently based on the predictions of the very conservative computer model RESRAD. To date, the RESRAD code has used only the distribution coefficient (K_d), and not leachability, to evaluate impact to groundwater. K_d is a measure of the relative concentration of contaminant sorbed on the sediment to that dissolved in solution; the smaller the K_d, the more contaminant is in solution (groundwater). The modeling results indicate a potential impact to groundwater from contaminated vadose sediment at the 100 D Area, assuming a hexavalent chromium K_d value of zero.

Scientists performed laboratory tests in 1999 to study factors that affect the way chromium moves through the vadose zone. Preliminary results suggest that relatively insoluble forms of chromium may be present.

Use of the distribution coefficient assumes that hexavalent chromium is adsorbed on exchange sites of minerals in the sediment. Alternatively, hexavalent chromium, in 100 D Area contaminated sediment, may be present as an insoluble precipitate. Batch and flow-through leach tests are appropriate to evaluate this alternative. The results of leach tests combine the effects of desorption and dissolution. Currently, results of leach tests for hexavalent chromium in sediment are not as readily available in the literature as are K_d results, and chromium leach tests have not been performed on Hanford Site sediment.

The rate of hexavalent chromium movement through the vadose zone to groundwater will depend on which mechanism, desorption or dissolution, releases hexavalent chromium to pore water. Therefore, experiments were done in 1999 to measure both the leach rate and K_d of hexavalent chromium using sediment samples from the 100 D Area. The RESRAD computer model can evaluate hexavalent chromium impact on groundwater using leachability parameters, which represent combined dissolution and desorption effects. Implementing the results of the 1999 experiments will provide a more accurate picture of actual potential impact to groundwater and support future remedial action cleanup goals and planning.

3.1.4.1 Samples and Methods

The 116-D-7 retention basin site, located north of the 100-DR-1 Operable Unit, was selected as the field area to obtain samples for K_d and leachability tests. Both contaminated and uncontaminated samples were obtained for use in the bench-scale testing. The primary objectives of the bench-scale tests were to estimate K_d and leach rates for hexavalent chromium specific to the Hanford formation sediment in the 100 Areas.

Batch adsorption tests were run using 50 grams of oven dry Hanford formation sediment and 200 milliliters of Hanford Site groundwater spiked with hexavalent chromium. Three different spike levels, 0.1, 1.0, and 10 mg/L of hexavalent chromium (as sodium dichromate) were used. Triplicate container blanks, consisting of spiked groundwater without sediment, were analyzed to account for hexavalent chromium stability in groundwater and container adsorption of hexavalent chromium. Triplicate sediment blanks, consisting of uncontaminated Hanford formation sediment and deionized water, were analyzed to determine whether native chromium was leached from the sediment. Tests were run in triplicate for contact times of 4 and 14 days.

In addition, one leach test was performed using contaminated Hanford formation sediment from the 100 D Area. The test was done by packing a vertical column with a measured amount (weight and volume) of sediment and allowing a source of water to flow through the column at a constant rate for 43 days.

Hexavalent chromium was measured by colorimetry in solutions from the batch tests and by both colorimetry and inductive coupled plasma/mass spectrometry in column leach tests.

3.1.4.2 Results

The results of the K_d batch experiments are shown in Tables 3.1-1 and 3.1-2. The conclusion from the tests is that there is no significant hexavalent chromium adsorption onto the Hanford formation sediment. The average K_d for hexavalent chromium from the most dilute concentration tests after both 4 and 14 days of contact is 0.2 ± 0.1 mL/g. The K_d was found to be 0 at higher hexavalent chromium concentrations. The very low K_d measured from the smallest hexavalent chromium concentrations may well be an artifact of (1) the use of batch tests for very low sorbing constituents combined with (2) testing very near the detection limit for the analytical method used.

The results of the column leach test are shown in Figure 3.1-14. The results show that typical Hanford Site groundwater does not readily leach chromium bound to the Hanford formation sediment. After 43 days, less than 1% of the chromium present in the sediment was removed by ~12 pore volumes of solution. The 12 pore volumes represent the total amount of water that would flush through the vadose zone for a scenario with 15 centimeters of rainfall and 0.76 meter of irrigation per year.

A direct mass balance measurement of the hexavalent chromium in the sediment before leaching and after 43 days of leaching showed no measurable loss of hexavalent chromium from the sediment; within the analytical error both the pre- and post-leached sediment samples gave the same result. This corroborates the leachate solution analyses that found less than 1% of the hexavalent chromium was removed from the sediment.

Additional batch water leach tests, using contaminated sediment, showed that less than 1% of the hexavalent chromium was leached after 16 hours of vigorous shaking. The exact amount removed varied from 0.04% to 0.71% depending on which analytical technique was used to measure chromium.

3.1.4.3 Conclusion

The findings of this study suggest that there is very little soluble chromium in the vadose zone sediments of the 100 D Area. This is contrary to the existence of high chromium concentrations in groundwater from some 100 D locations. The apparent incongruity may be an artifact of sampling (i.e., samples were collected outside areas of chromium contamination) or may represent some, as yet, unidentified geochemical process.

All solutions generated by mixing the contaminated sediment with uncontaminated Hanford Site groundwater resulted in hexavalent chromium concentrations between 0.002 to 0.05 mg/L. Also, the column effluents reached a steady state chromium concentration of either 0.003 or <0.01 mg/L depending on the analytical technique. These data suggest that a hexavalent chromium-bearing precipitate that is very insoluble in Hanford Site groundwater may be present in the sediment. Alternatively, the chromium in the sediment may be trivalent chromium that slowly oxidizes when leached with water. Therefore, the resulting leachate would contain very small concentrations of oxidized chromium as hexavalent chromium.

If hexavalent chromium in solution is controlled by slow oxidation of sediment containing trivalent chromium, then more kinetic testing is needed. More kinetic testing would allow extrapolation of the short-term laboratory leach data to the longer time spans to reflect natural dissolution of chromium from Hanford formation sediment in the 100 Areas. More column leach tests need to be performed using contaminated sediment with higher hexavalent chromium levels and at several flow rates slower than those used for the irrigation scenario in this work.

Table 3.1-1. Average 4-Day Contact Time K_d and Standard Deviation for Hexavalent Chromium (Cr[VI]) and Total Chromium Adsorption

Cr(VI) Concentration (mg/L)	K_d for Cr(VI) (mL/g)	Standard Deviation (mL/g)	K_d for Total Cr (mL/g)	Standard Deviation (mL/g)
0.1	0.3	0.1	0.0	0.3
1.0	0.0	0.0	0.2	0.3
10.0	0.0	0.05	0.3	0.3

Table 3.1-2. Average 14-Day Contact Time K_d and Standard Deviation for Hexavalent Chromium (Cr[VI]) and Total Chromium Adsorption

Cr(VI) Concentration (mg/L)	K_d for Cr(VI) (mL/g)	Standard Deviation (mL/g)	K_d for Total Cr (mL/g)	Standard Deviation (mL/g)
0.1	0.2	0.1	0.0	0.1
1.0	0.0	0.0	0.1	0.1
10.0	0.0	0.0	-0.2	0.1

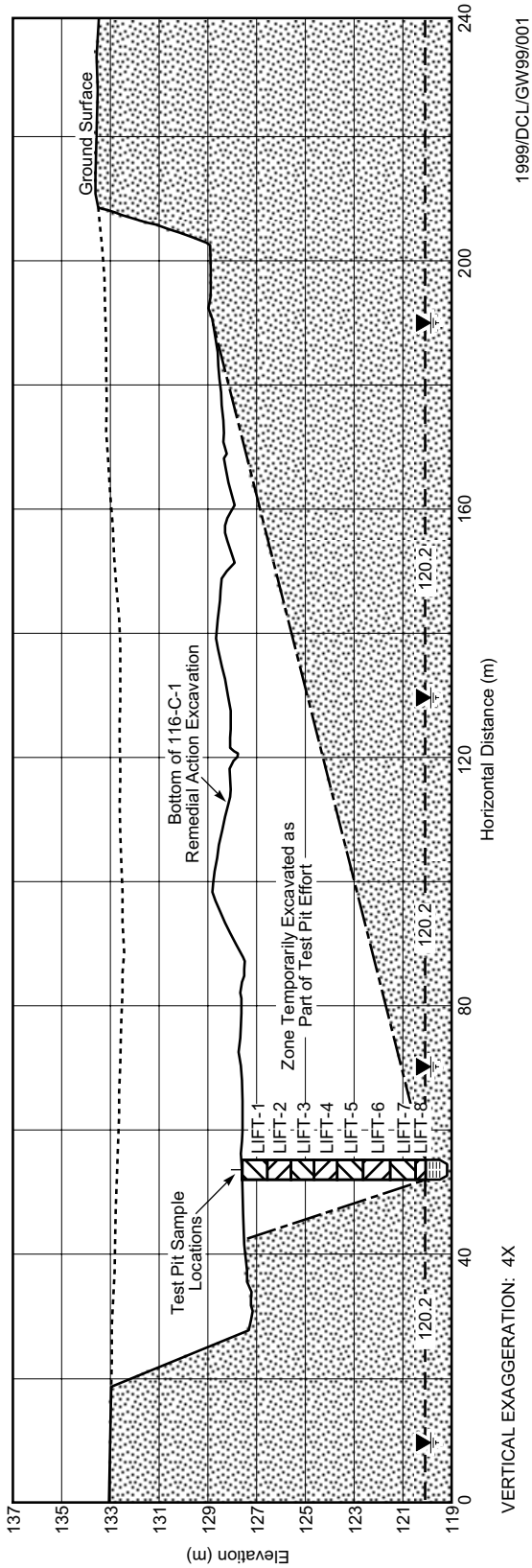


Figure 3.1-1. Cross Section of the 116-C-1 Trench Showing Location of the Test Pit and Distribution of Samples (adapted from CVP-98-00006, Rev. 0)

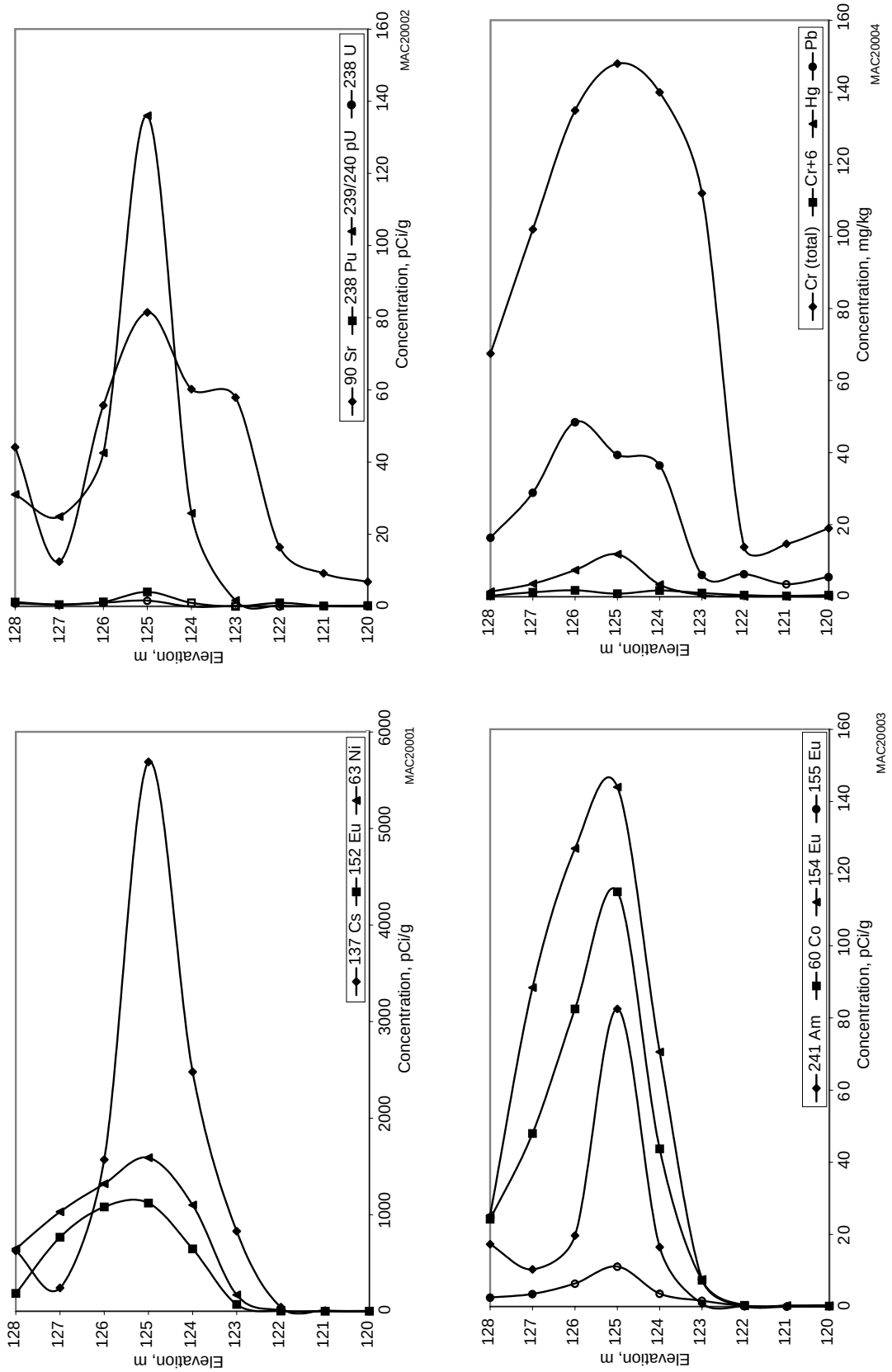
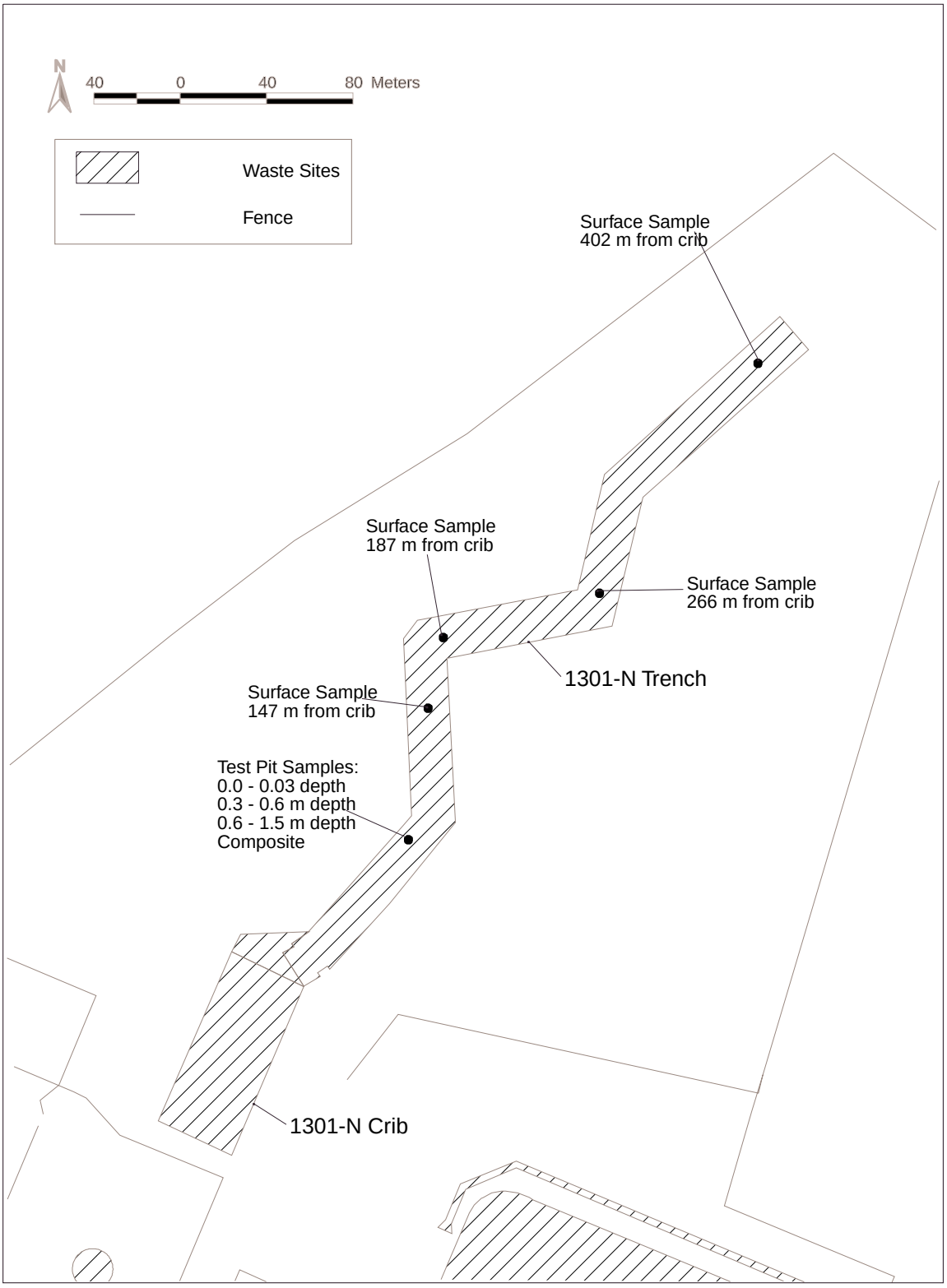


Figure 3.1-2. Analytical Results versus Depth for Selected Constituents in the 116-C-1 Trench Test Pit (adapted from CVP-98-00006, Rev. 0). Open circles indicate values less than laboratory detection limit.



nac002 12/10/99

Figure 3.1-3. Map of the 1301-N Crib and Trench Showing the Locations of Samples Collected (adapted from BHI-01271, Rev. 0)

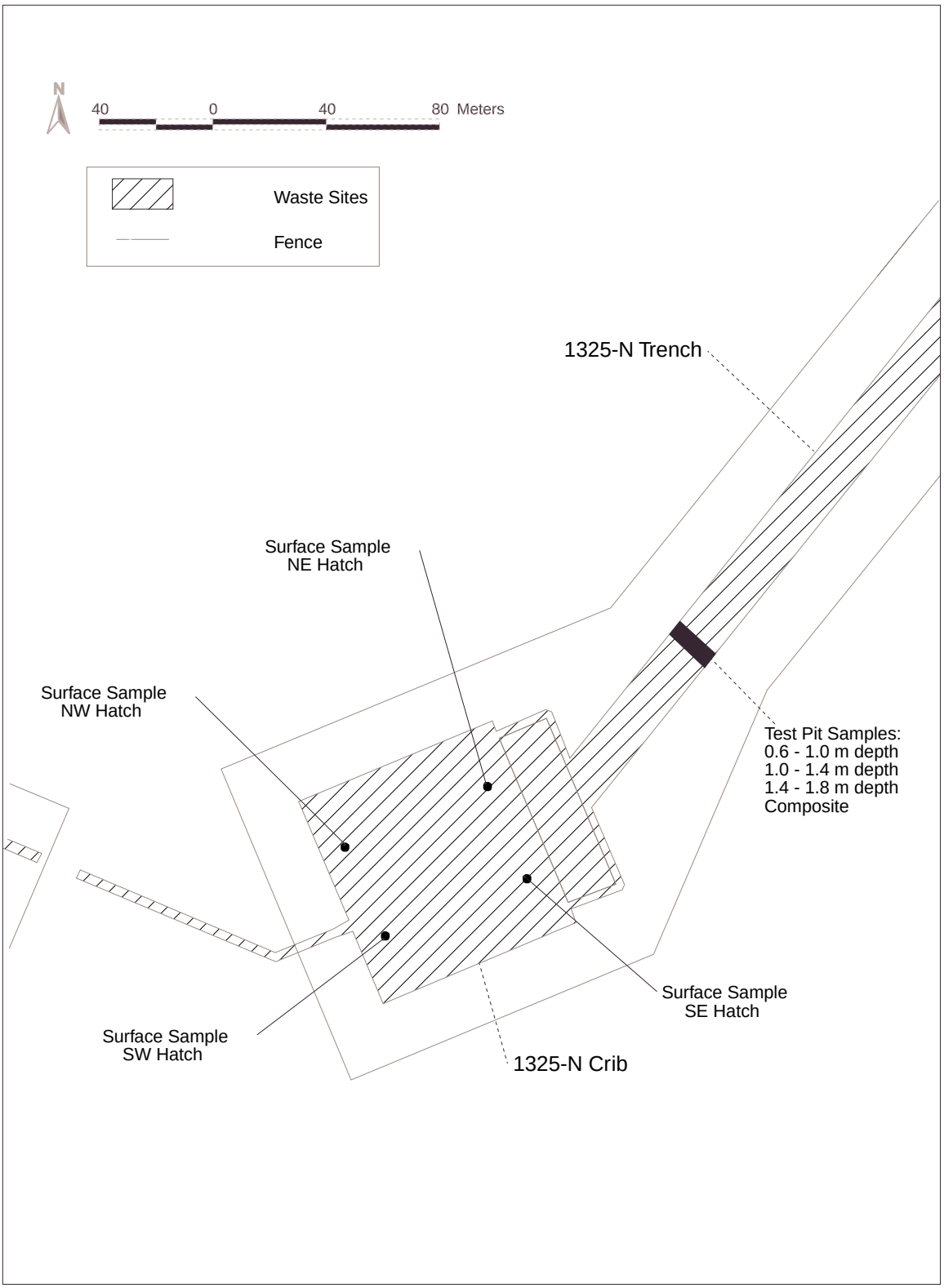


Figure 3.1-4. Map of the 1325-N Crib and Trench Showing the Locations of Samples Collected (adapted from BHI-01271, Rev. 0)

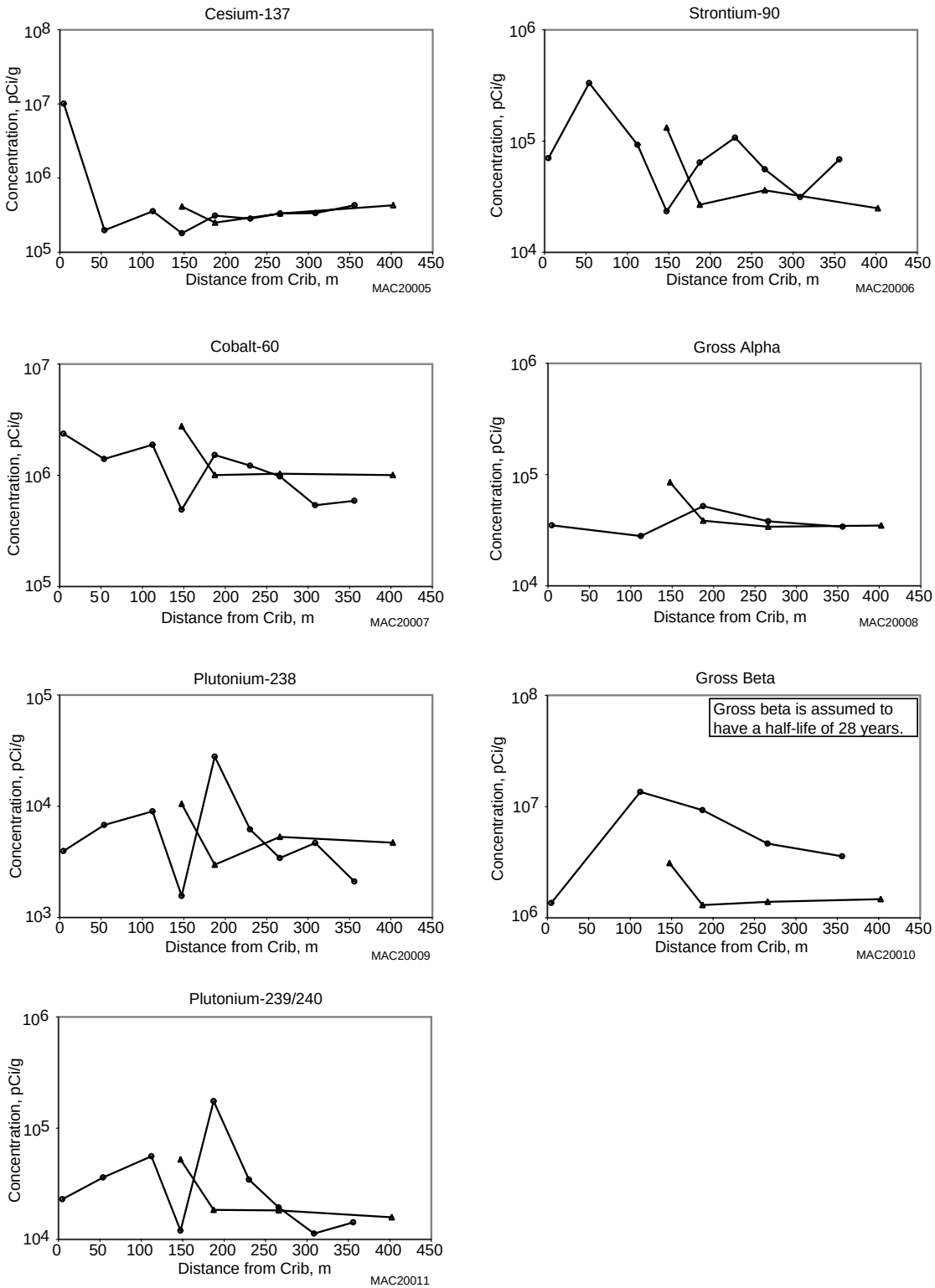


Figure 3.1-5. Concentration versus Distance from the 1301-N Crib for Selected Analytes in Samples from the 1301-N Trench. Triangles are 1999 data; circles are averaged 1980 to 1985 process data. Process data are decay corrected to January 1999 (adapted from BHI-01271, Rev. 0).

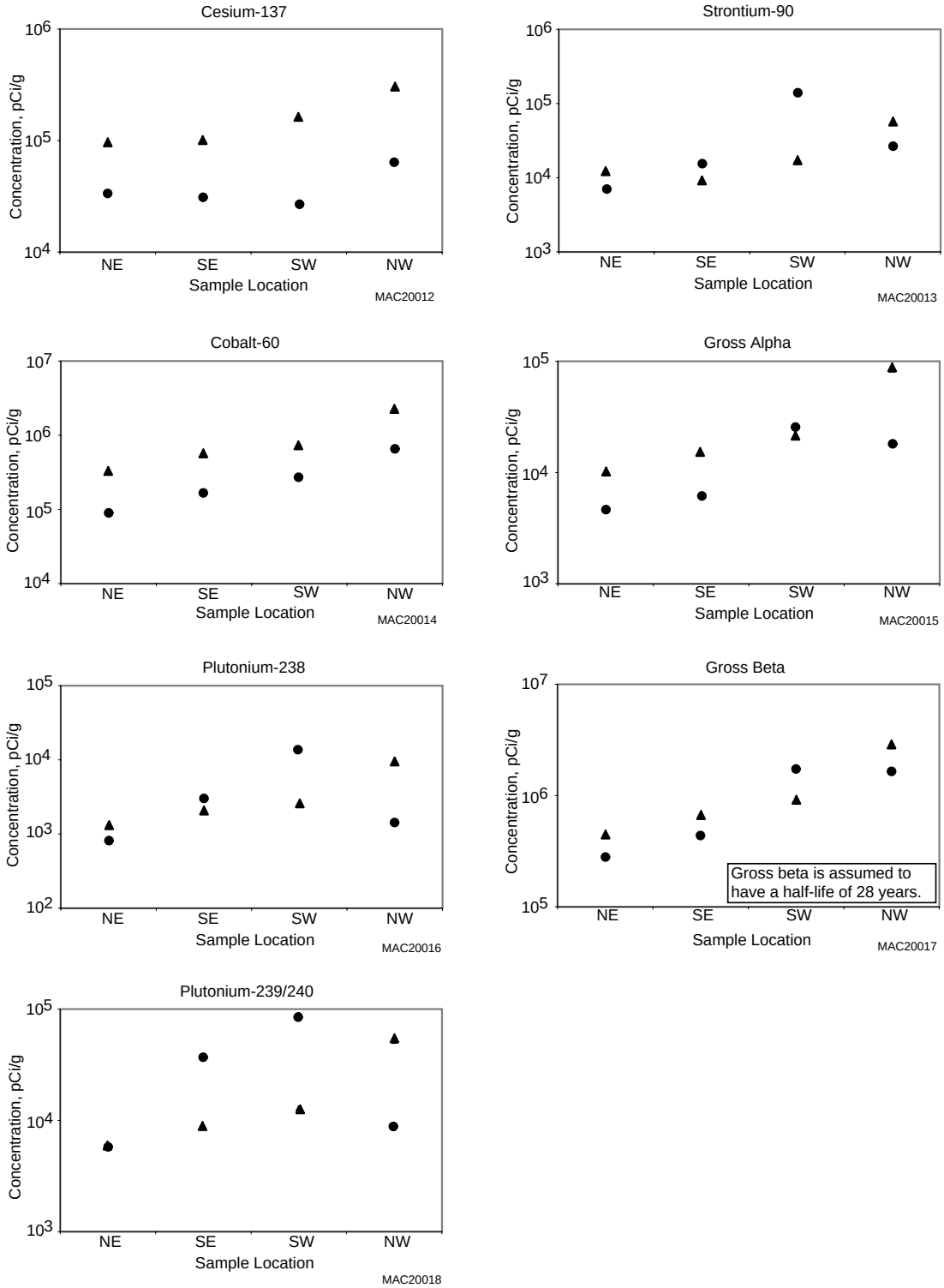


Figure 3.1-6. Concentration of Selected Analytes in Surface Samples from the 1325-N Crib (NE, SE, SW, and NW refer to the northeastern, southeastern, southwestern, and northwestern access hatches; see Figure 3.1-4). Triangles are 1999 data; circles are averaged 1985 to 1987 process data. Process data are decay corrected to January 1999 (adapted from BHI-01271, Rev. 0).

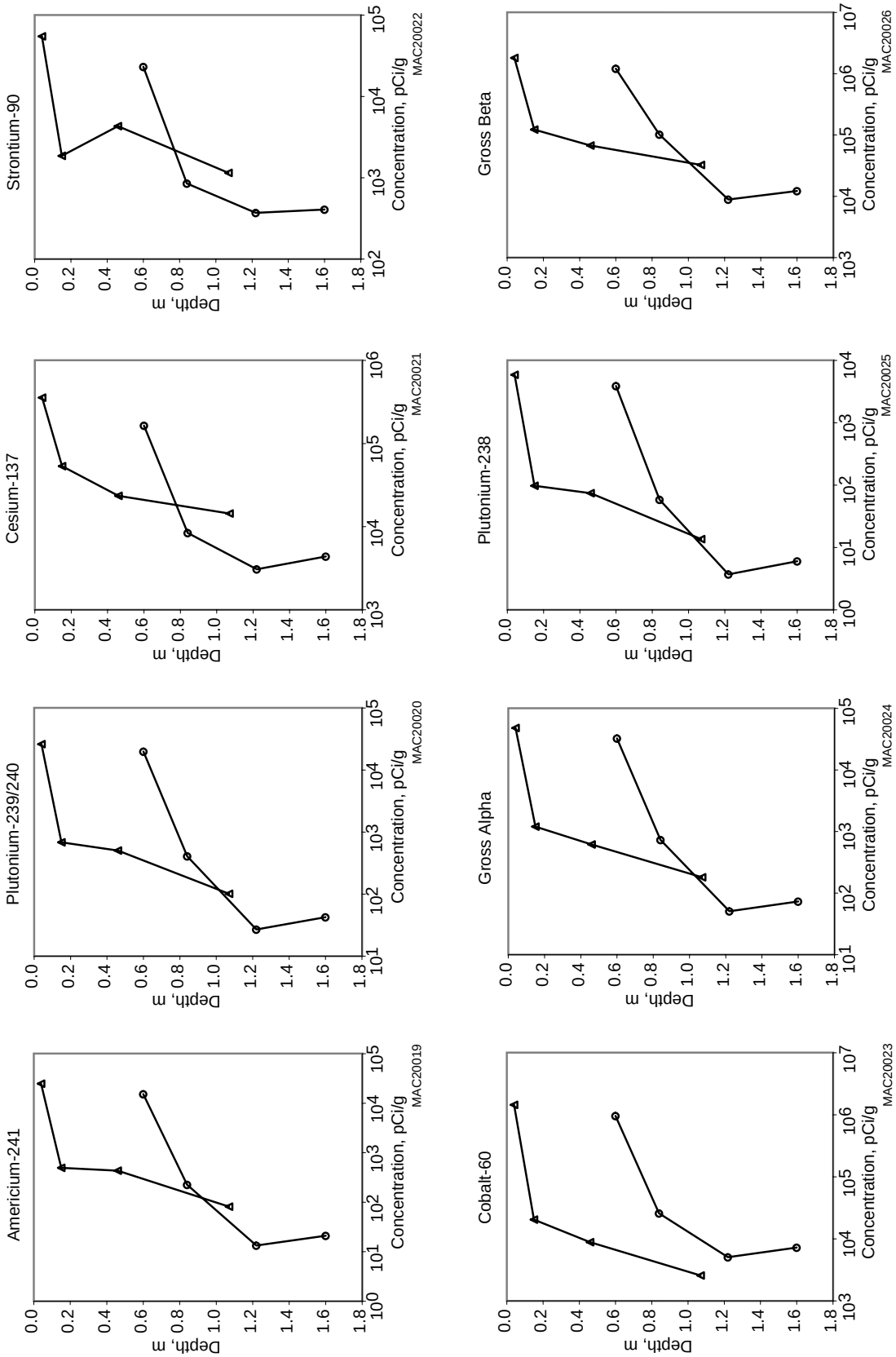


Figure 3.1-7. Activity versus Depth for Selected Analytes in Test Pit Samples from the 1301-N and 1325-N Trenches. Triangles are data from the 1301-N test pit; circles are data from the 1325-N test pit (adapted from BHI-01271, Rev. 0).

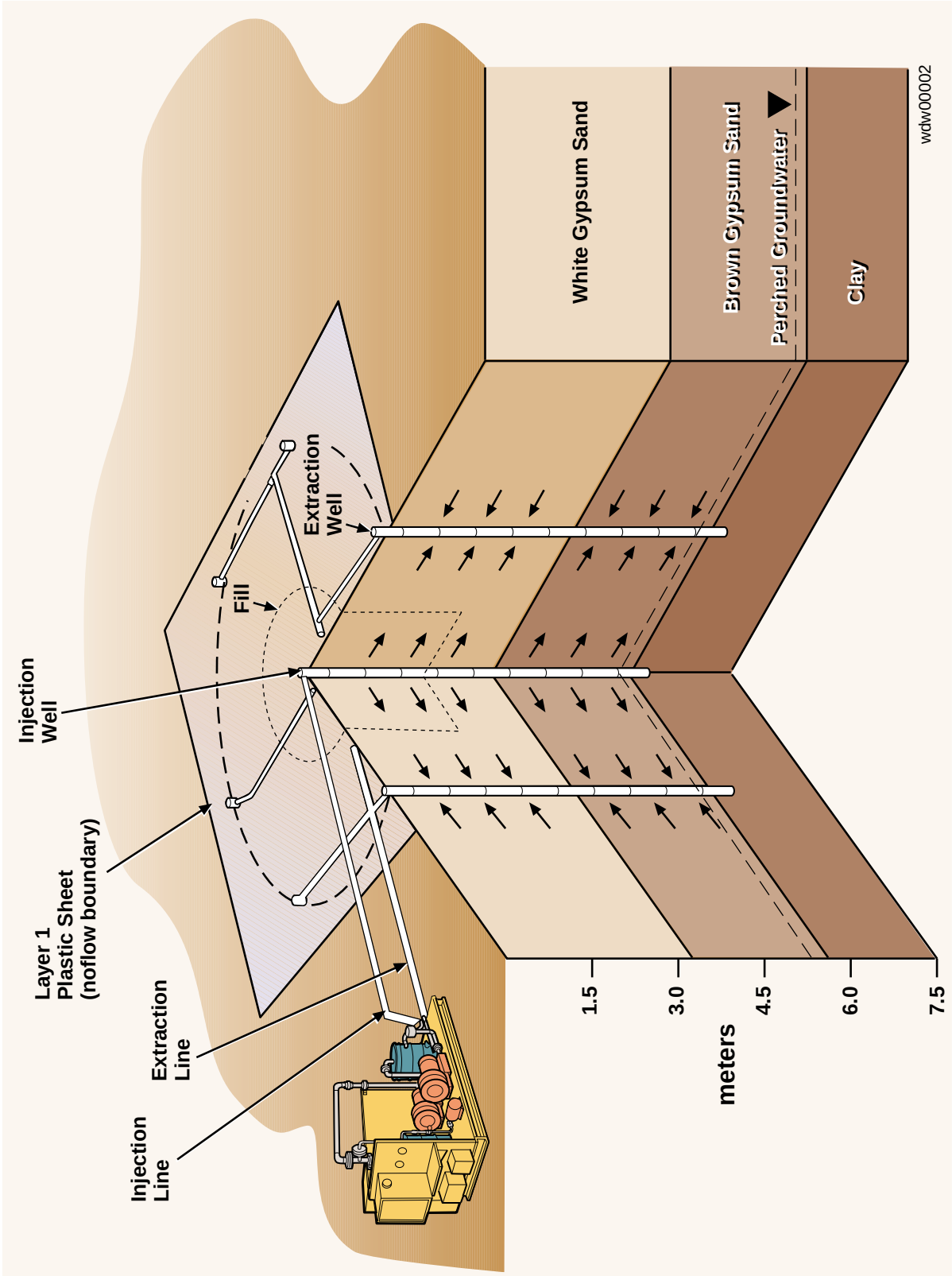


Figure 3.1-8. In Situ Gaseous Reduction System and Well Field Network

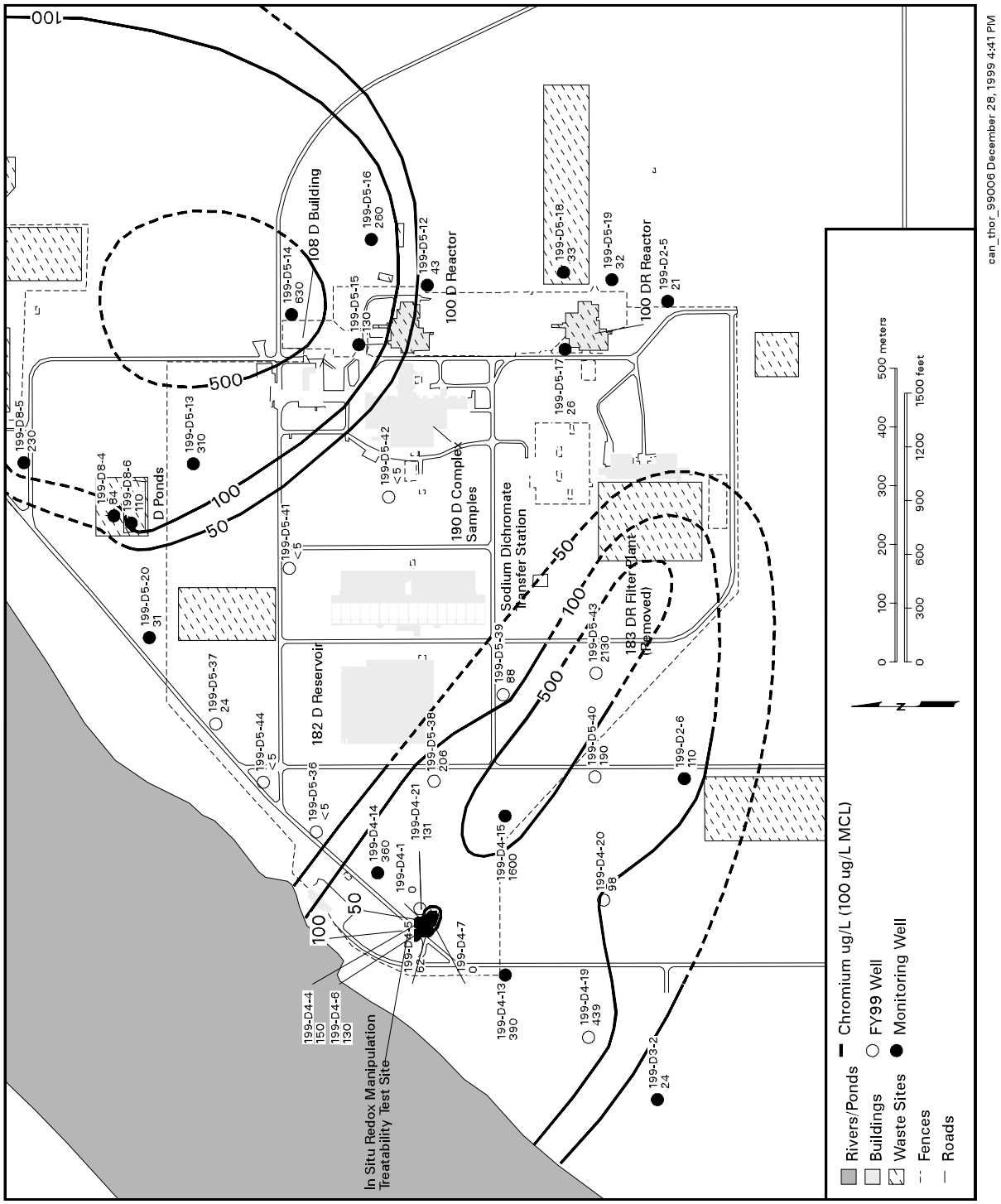
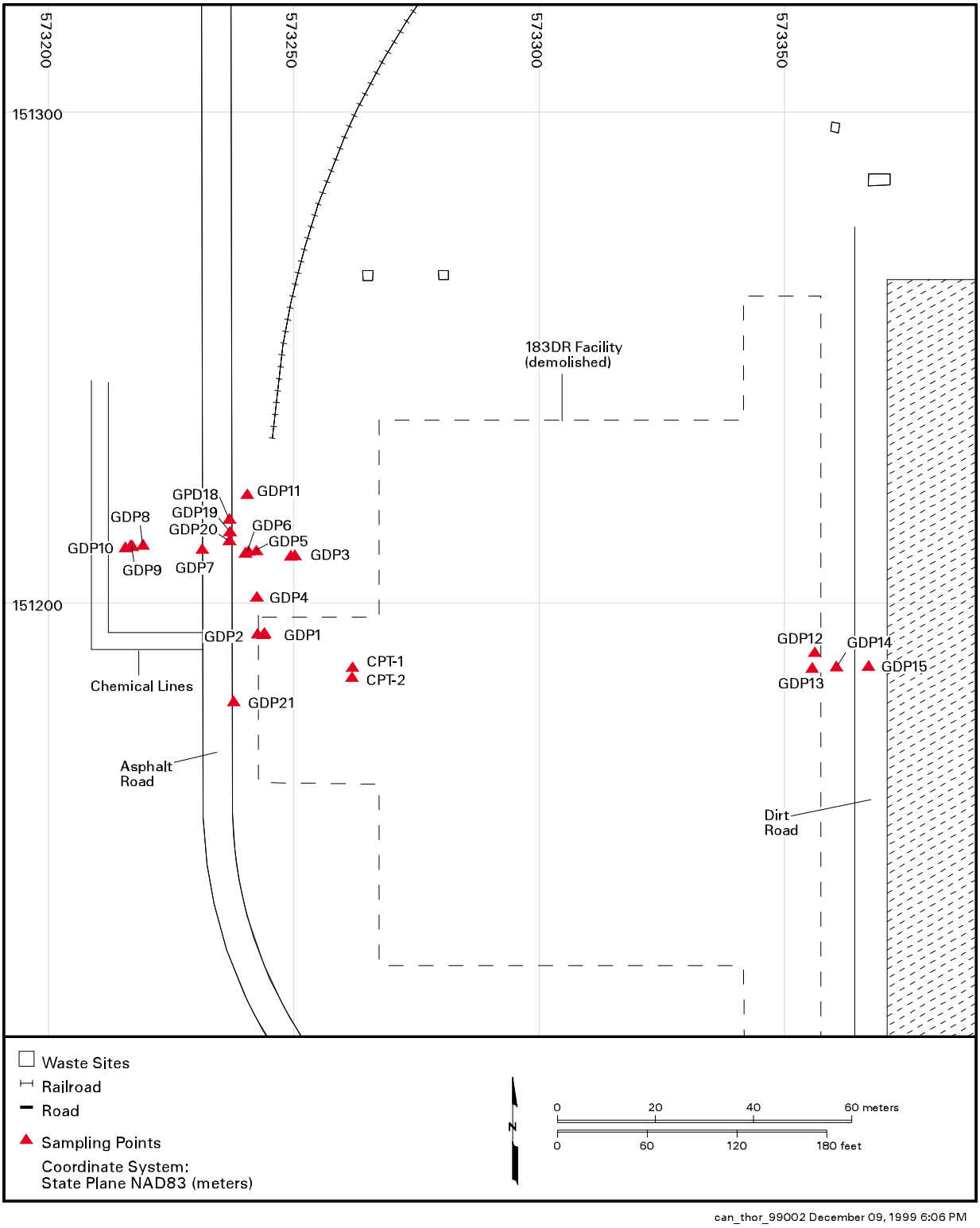
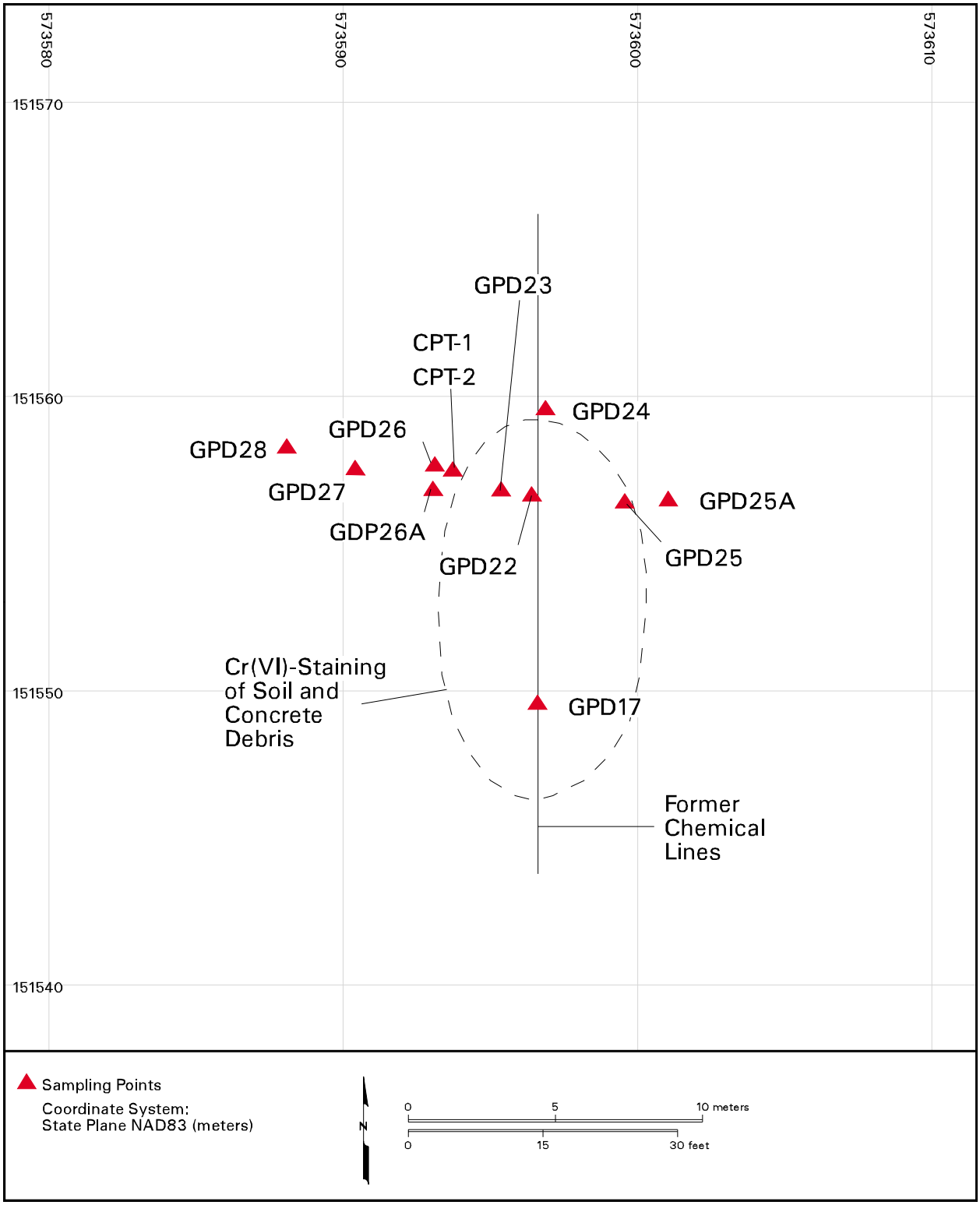


Figure 3.1-9. Facilities, Wells, and Hexavalent Chromium Groundwater Plumes in 100 D Area



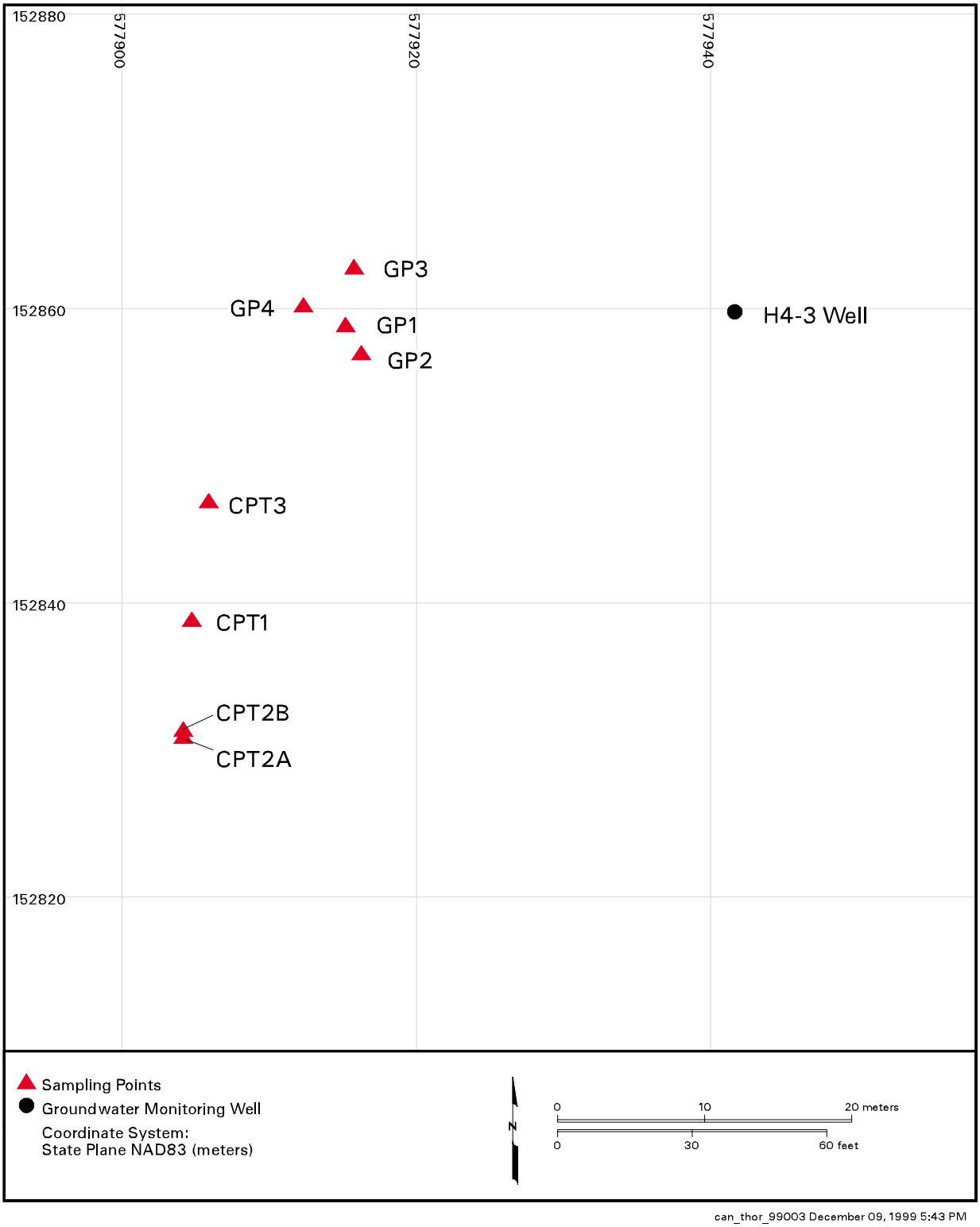
can_thor_99002 December 09, 1999 6:06 PM

Figure 3.1-10. Map of Sample Locations at the 183-DR Head House and Filter Plant Site. Sample locations beginning with GP are Geoprobe™ sites; locations beginning with CPT are cone penetrometer sites.



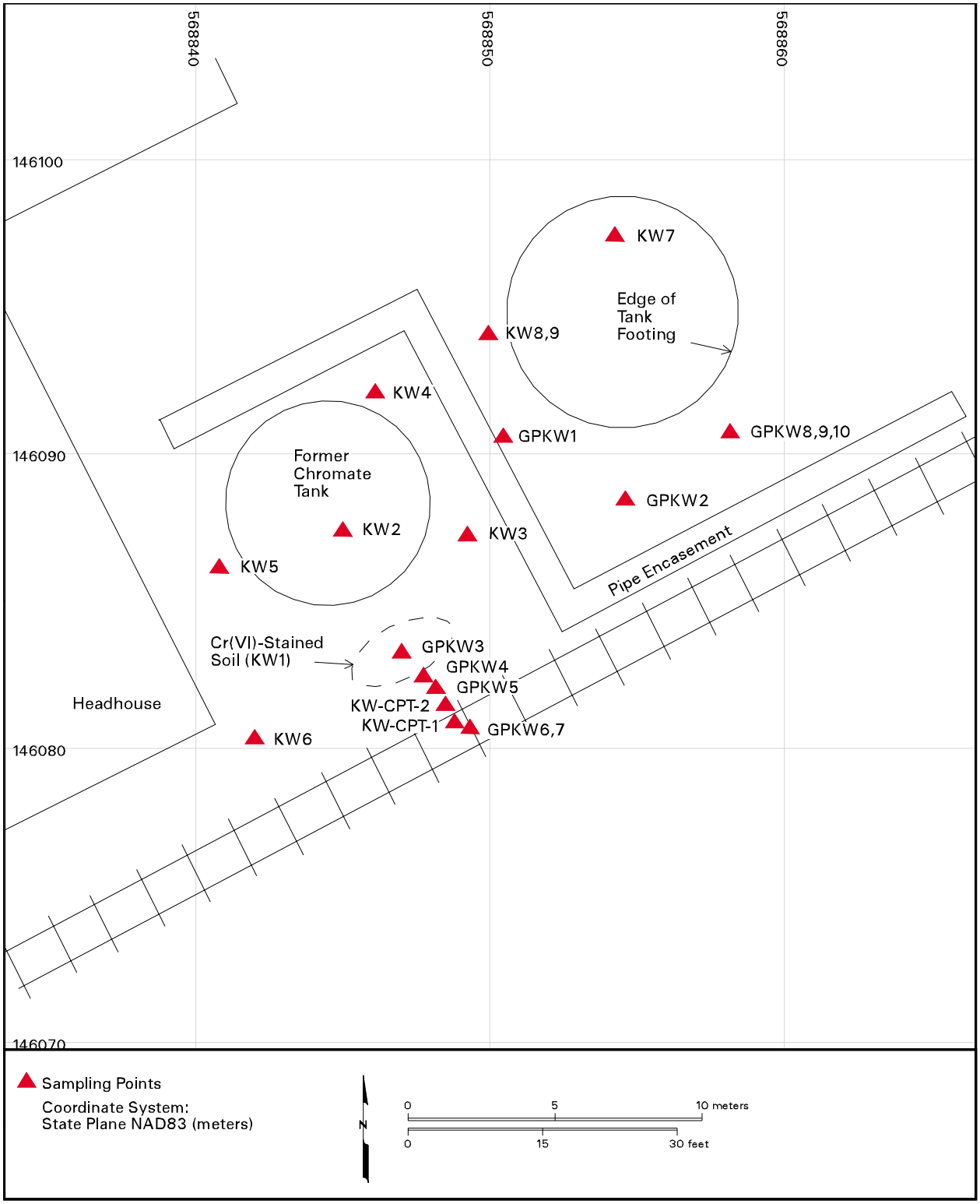
can_thor_99001 December 09, 1999 6:22 PM

Figure 3.1-11. Map of Sample Locations at the 190-D Complex. Sample locations beginning with GP are Geoprobe™ sites; locations beginning with CPT are cone penetrometer sites.



can_thor_99003 December 09, 1999 5:43 PM

Figure 3.1-12. Map of Sample Locations at the 183-H Solar Evaporation Basins (see Plate 1 for location of well H4-3). Sample locations beginning with GP are Geoprobe™ sites; locations beginning with CPT are cone penetrometer sites.



can_thor_99004 December 09, 1999 6:10 PM

Figure 3.1-13. Map of Sample Locations at the 183-KW Chromate Transfer Station. GP indicates Geoprobe™ samples, CPT indicates cone penetrometer samples, and KW indicates surface soil samples.

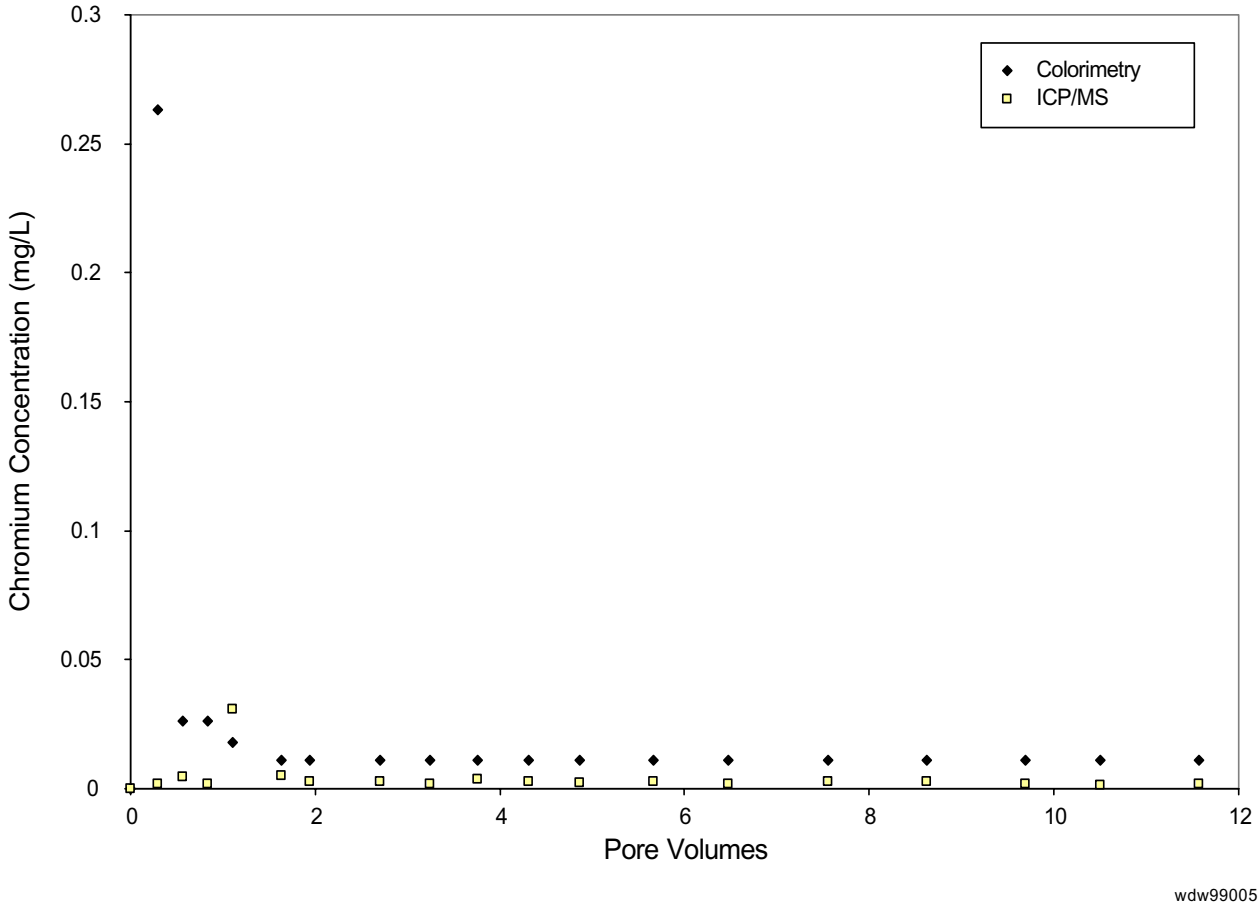


Figure 3.1-14. Effluent Hexavalent Chromium Concentrations (mg/L) versus Pore Volumes for Leach Test Samples