

## **Successful Characterization and Remedial Contour of Highly Contaminated Mercury Soil at the Y-12 National Security Complex – 13593**

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### **ABSTRACT**

An area known as the 81-10 pad within the footprint of the Y-12 National Security Complex, suspected to be heavily contaminated with mercury, was slated for characterization in support of a Federal Facilities Agreement (FFA) milestone to be accomplished by September 30, 2012. A full remedial design report (RDR) required the soil in Exposure Unit -9 (EU-9) to be fully characterized for a number of contaminants of concern including mercury. The goal of this characterization effort was to determine what soil, if any, would need to be removed for the protection of industrial workers and impacts to the surface and ground water. Funding for this project was made available using buy-back scope under the American Recovery and Reinvestment Act (ARRA).

The EU-9 soil unit involved 3 different classifications which were determined as follows: Class 1: Known to have been impacted, contamination is likely; Class 2: Suspected to have been impacted, contamination is unknown; Class 3: Area not known to have been impacted, contamination unlikely. Due to various sampling and analysis events since the 1980s, significant mercury contamination was expected under the concrete pad of an area known as 81-10. Mercury contamination outside of the boundary of this pad within the EU-9 footprint was not known and therefore an original planned estimate of 1,461 cubic meters of material were expected to be heavily contaminated with mercury requiring removal, treatment and disposal.

Through the use of a highly effective nature and extent sampling and analysis design that involved a hybrid of statistically-based and judgmental sampling, the actual remedial contour requiring removal was approximately 717 cubic meters, roughly 12% of the original estimate. This characterization approach was executed in full compliance with the Record of Decision (ROD) [1] documents that were agreed upon by the U.S. Department of Energy, Environmental Protection Agency and Tennessee Department of Environment and Conservation. In addition, the RDR was completed ahead of the FFA milestone date of September 30, 2012.

### **INTRODUCTION**

EU-9 is located in the southern portion of the Y-12 plant. The entire EU-9 boundary encompasses a total of 11.7 acres (47,348 square meters) and includes former and active warehouses, paved areas, grassy, and unpaved areas. While EU-9 includes several former facilities that had the potential for elevated soil contamination, the only area that contained contamination above the remediation levels was the Building 81-10 area.

Spills of mercury were well documented in and around the 81-10 area; therefore the planning team expectations were that the soils lying beneath the 81-10 pad were heavily contaminated with elemental mercury.

## **PURPOSE**

A technical solution determining the nature and extent of the characterization of a highly mercury contaminated area known as the 81-10 pad within a soil Exposure Unit 9 (EU-9) at the Oak Ridge Y-12 National Security Complex was required in an effort to support a Federal Facilities Agreement (FFA) milestone for a Remedial Design Report (RDR) due September 2012.

The goal of the characterization program was to accurately and efficiently determine boundaries of mercury contamination that would require future removal as determined by the Record of Decision (ROD) [1] for industrial worker and impacts to surface and ground water. The nature and extent characterization and remedial contour determination activities were captured in a RDR that was published in draft for regulatory concurrence by the U.S. Environmental Protection Agency (EPA) and Tennessee Department of Environment and Conservation (TDEC). This activity was completed using American Recovery and Reinvestment Act (ARRA) funds provided by the U.S. Department of Energy Environmental Management. Work was completed using Babcock and Wilcox (B&W) Technical Services via contractual agreement with the National Nuclear Safety Administration (NNSA). All work was governed by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and associated applicable or relevant and appropriate requirements (ARARs).

## **BACKGROUND**

Mercury contamination is widespread at the Y-12 site and has been identified in soil, sediment, surface water, groundwater, buildings, drains, and sumps. Mercury discharges to Upper East Fork Poplar Creek (UEFPC) originate from point and non-point sources within Y-12 including direct erosion of contaminated soil, migration of dissolved mercury through storm drains and several outfalls, and through shallow groundwater. EU-9 is a known source of mercury contamination primarily due to the former 81-10 mercury retort building.

Previous characterization efforts in EU-9 have focused on subsurface mercury contamination associated with activities in the former 81-10 building area. Multiple soil sampling events have identified mercury contamination in the surface soils down to 6 meters (m) below ground surface (bgs). Typically mercury concentrations decrease with depth; however, there are distinct high concentration zones at depth. Laboratory analysis of soil screening samples collected from 2.1–2.7 m and 3.0–3.6 m below the former 81-10 building revealed mercury concentrations exceeding mercury TL (892 mg/kg). Small beads of elemental mercury were observed in soil

samples collected from 0.6 m bgs. Additionally, the analytical results revealed that the soil was also contaminated with polychlorinated biphenyls (PCBs), radionuclides and other heavy metals. Four groundwater monitoring wells were installed in the Bldg. 81-10 area. The depth to groundwater varies from 3.0–9.1 m bgs. The EU-9 parcel is underlain by the Maynardville Limestone geologic formation and is likely to have karst features which complicate groundwater flow rates and transport paths.

EU-9 is located in the southern portion of the Y-12 plant. The EU is bounded by the Perimeter Intrusion Detection Assessment System (PIDAS) to the north, corner 14 of the PIDAS corridor to the west, “E” Road to the east, and a boundary established across the north-facing slope of Chestnut Ridge to the south (Figure 1). The entire EU-9 boundary encompasses a total of 11.7 acres (47,348 square meters) and includes former and active warehouses, paved areas, grassy, and unpaved areas (Figure 2). While EU-9 includes several former facilities that had the potential for elevated soil contamination, the only area that contained contamination above the remediation levels was the Building 81-10 area.

Building 81-10 was originally constructed as a tin shop in 1943. In 1956, the site and structure were modified for the installation of a mercury extraction/recovery process also known as the Solvent Salvage Facility (SSF). The SSF was in operation from early 1957 until July 1962. A gas-fired multiple hearth furnace was used to recover mercury from carbon filtration media, sludge, process wastes, contaminated soil, scrap, and other similar materials used at Y-12. The SSF was removed from service in 1971. Building 81-10 was then used to store scrap material and drums of sludge until its demolition in March 1995 leaving only the concrete pad. The 9822 Settling Basin was cleaned, rubblized, and grouted in place in August 1998. [2]

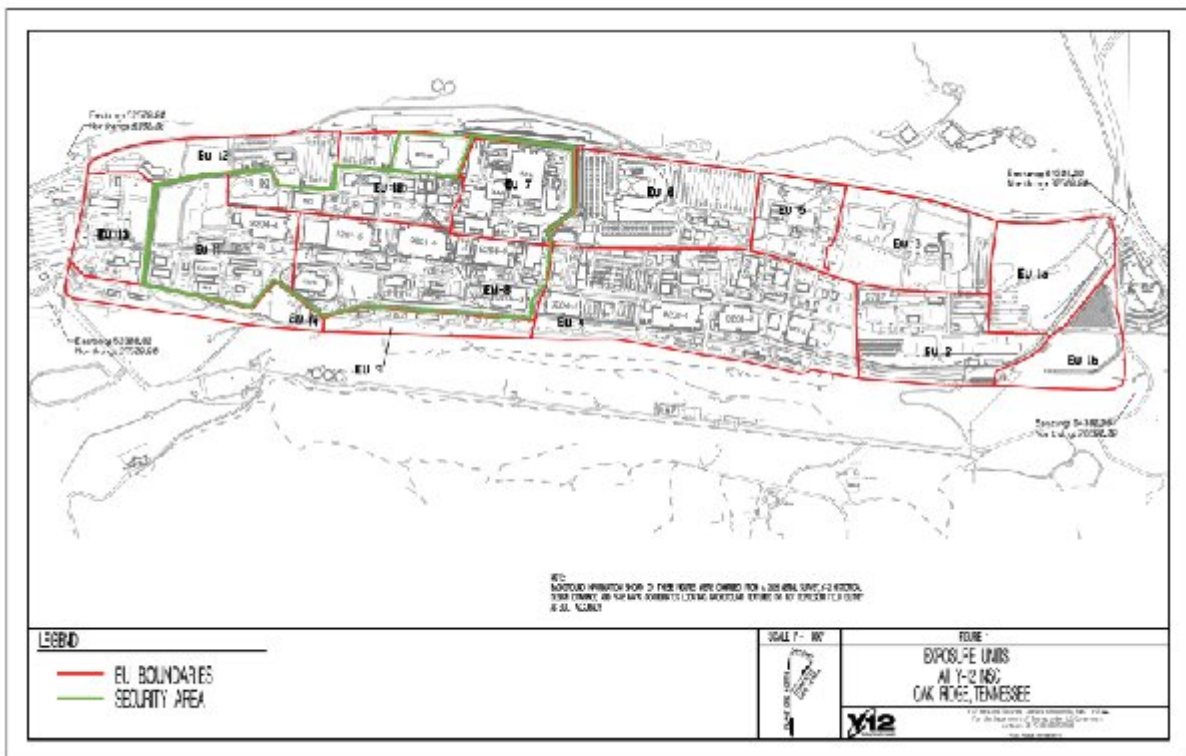


Figure 1. Oak Ridge Y-12 National Security Complex Plant Site Divided into Soil Exposure Units

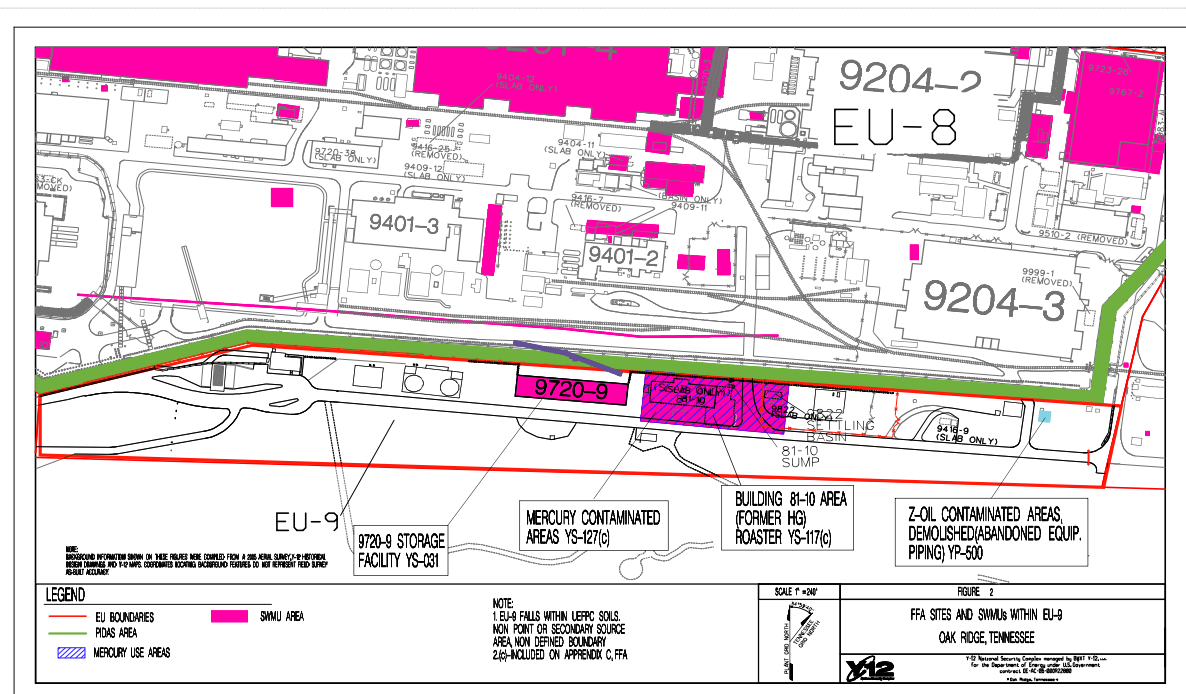


Figure 2. Exposure Unit 9 at the Oak Ridge Y-12 National Security Complex

## **SAMPLING AND CHARACTERIZATION OBJECTIVES**

There are three primary objectives for the EU-9 Soils Characterization Project:

- Assess the top 0.6 m of soil for worker protection as prescribed in the Phase II ROD [1].

Soil remediation concentrations corresponding to the average and maximum remediation levels (RLs) for target contaminants of concern (COCs) have been established for cadmium, mercury, uranium, polychlorinated biphenyls (PCBs), Cesium-137, Ra-226, Thorium-232, Uranium-235, and Uranium-238.

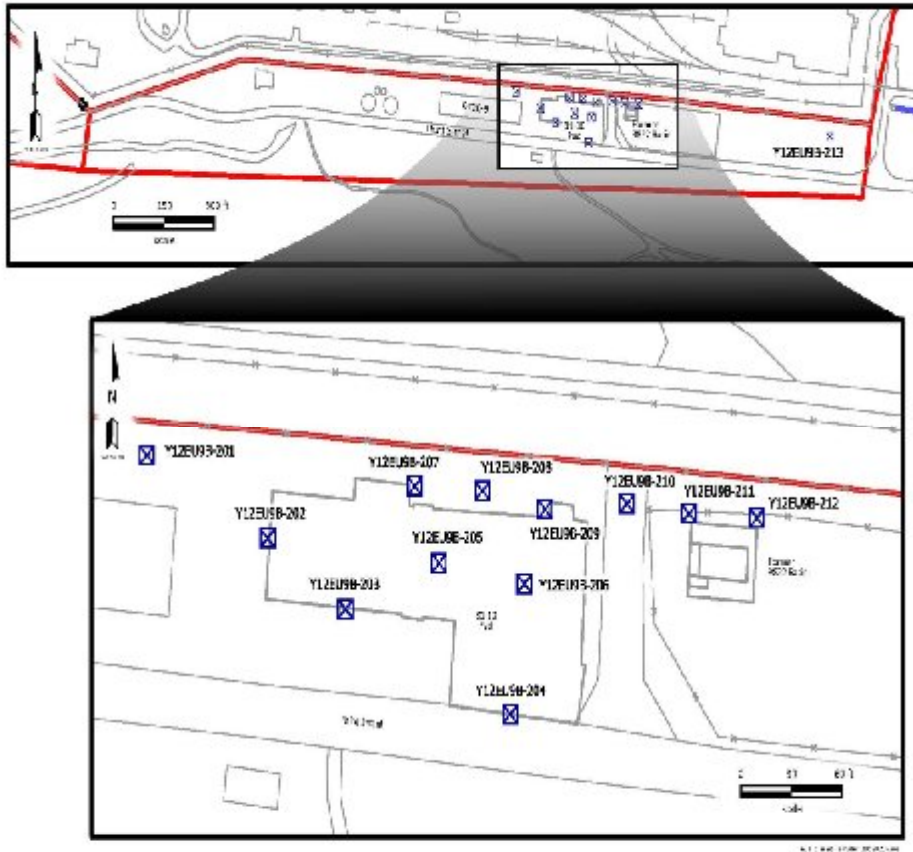
- Assess potential impacts from soil to groundwater.
- Assess potential impacts from soil to surface water.

Soil trigger levels (TLs) for protection of groundwater and surface water have been developed for the following 13 COCs: mercury, 1,1-dichloroethene (DCE), 1,2-dichloroethane, 1,2-DCE, bromoform, cis-1,2-DCE, carbon tetrachloride, chloroform, methylene chloride, tetrachloroethene, toluene, and vinyl chloride. The TLs are concentrations at which the COCs cause an elevated lifetime cancer risk (ELCR) to exceed  $1 \times 10^{-4}$  or a hazard index to exceed 1 at the point of exposure.

## **NATURE AND EXTENT CHARACTERIZATION METHODOLOGIES**

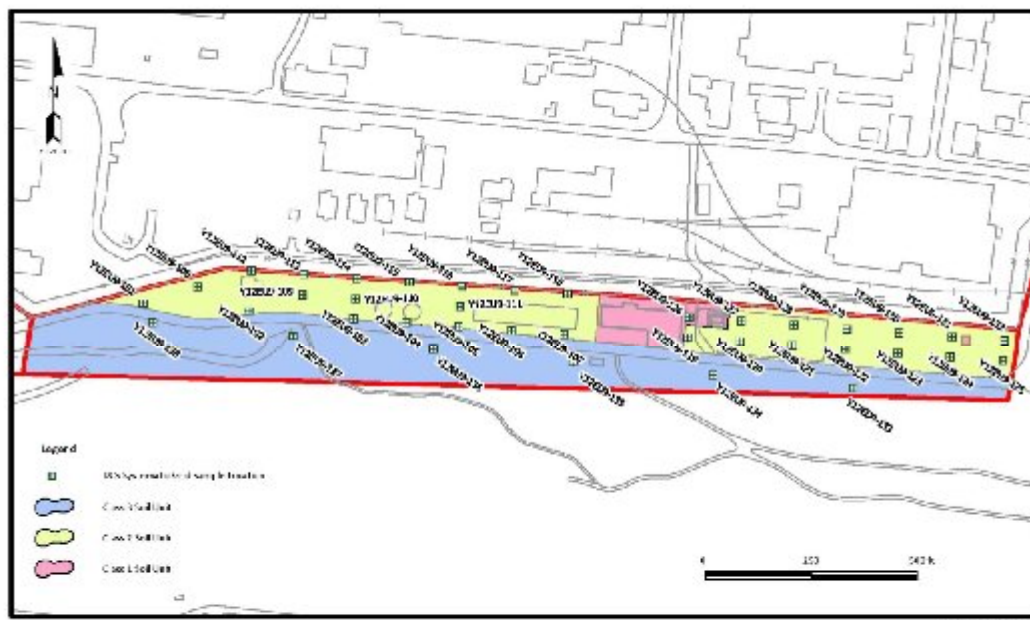
In accordance with the Phase II ROD [1], EU-9 was characterized to determine the need for remedial action. EU-9 was divided into three soil units (SU) based on criteria for soil unit classification presented in the UEFPC Remedial Action Work Plan [3]. SU classification is divided into three separate categories: Class 1 which are known to be impacted by industrial operations; Class 2 which are suspected to be impacted by industrial operations and Class 3 which are not expected to be impacted by industrial operations. These classification units were used to determine the number of samples for each area with more dense sampling activities in Class 1 areas, less dense in Class 2 areas and minimal sampling in Class 3 areas. Figure 3 depicts the sampling locations within the Class 1 area. Figure 4 depicts sampling locations within the Class 2 and 3 areas of EU-9.

There are two Class 1 SUs in EU-9, the 81-10 area and Z-Oil Tank area. Based on site knowledge and historical data, it was expected that areas of soil contamination in the former Building 81-10 vicinity would fail the requirements of the Phase II ROD Remedial Action Objectives (RAOs) and a remedial action in the Building 81-10 area will be needed. The Z-Oil Tank area was also been impacted and a remedial action may have been required. The area north of Third Street was classified as a Class 2 SU (EU-9 Northern Area) because the area was impacted and there was a high degree of uncertainty regarding the need for a remedial action in the area. The area south of Third Street, including Third Street, was a Class 3 SU (EU-9 Southern Area). This area had not been impacted and there was a high degree of certainty that it would not require a remedial action.



EU-9 Based Sample Locations

Figure 3. Class 1 EU-9 Sampling Locations



EU-9 Class 2 and Class 3 Grid Sample Locations

**Figure 4. Class 2 and 3 Sampling Locations within EU-9**

A sampling subcontractor was hired for the execution of fieldwork discussed in the sample planning documentation. Soil sampling was performed using standard field methods and following U.S. Environmental Protection Agency Region 4 standard operating procedures. Field activities were also conducted in accordance with all applicable, approved CERCLA documentation.

Two types of sampling were utilized for the EU-9 characterization effort: (1) biased sampling to assess the potential impacts of soil contamination to groundwater and surface water and to define remedial action boundaries (RABs) and (2) dynamic characterization system (DCS)-based systematic grid sampling to determine if RLs are exceeded in Class 2 and Class 3 SUs. These characterization methodologies served as the primary tools to determine the nature and extent of mercury contamination within the EU-9 footprint.

Direct push technology (DPT) sampling was the predominant method of sample acquisition for subsurface soil. Surface and shallow interval soil sampling efforts were accomplished using DPT or hand augers.

The total original estimated quantity of mercury-contaminated soil required excavation, treatment and disposal was 1,461 cubic meters.

## **MERCURY CHARACTERIZATION NATURE AND EXTENT RESULTS**

The RAO for the EU-9 soil remediation is identified in the Phase II ROD and was developed to focus the planning of remedial alternatives addressing the containments of concern (COCs) at the site. Because Y-12 is an active industrial facility and because use of the buildings and facilities throughout the plant is anticipated for the foreseeable future, unrestricted (i.e., residential) land use is unlikely. The National Nuclear Security Administration (NNSA) has recommended that because of security concerns and the ongoing modernization program, the anticipated land use for the foreseeable future be controlled industrial throughout the entire facility. This decision considers soil, scrap metal, and buried waste as sources of contamination to groundwater but does not address remediation of the contaminated groundwater or adjacent surface water or sediments. Final remediation of these media will be addressed in future RODs.

The RAO for mercury-contaminated soil at EU-9 is to minimize risk to the industrial worker by remediating soil between the surface and 0.6 m bgs that exceeds a cumulative non-carcinogenic hazard index (HI) greater than 1.0. The HI for mercury is greater than 1.0 if it is present in discrete samples at concentrations at or above 3,250 milligrams per kilogram (mg/kg), the maximum remediation limit (MRL) or if the average mercury concentration across the entire EU exceeds an average remediation limit (ARL) of 325 mg/kg. The MRL limit for mercury equaled or exceeded the MRL limit in two soil boring locations: Y12EU9B-206 and Y12EU9B-206E (see Figure 5 and Figure 6). The average mercury concentration across EU-9 was 188 mg/kg, which is well below the mercury ARL limit. Additional details of the soil characterization project are included in a Technical Memorandum for Exposure Unit 9[4].

Trigger levels (TL) are specific soil concentration values that are indicative of potential threats to groundwater or surface water. When a TL is exceeded in a discrete sample location, the Phase II ROD requires that the subsurface contaminants be modeled to evaluate the threat to surface/groundwater. The TL limit for mercury was exceeded in six sampling locations; however the groundwater model indicated that mercury-contaminated groundwater would not reach UEFPC within the 1,000 year model simulation. In accordance with the Phase II ROD, no remedial actions are required for contaminated soils deeper than 0.6 m bgs.

## **REMEDIAL DESIGN**

The design for the EU-9 Remedial Action Area (RAA) includes removal of a 13.71 m by 21.33 m by 0.6 m deep excavation around sample locations Y12EU9B-206 and Y12EU9B-206E (**Figures 5 and 6**). The total estimated volume of mercury-contaminated soil was 171 cubic meters. This material will be packaged and shipped offsite for treatment and disposal. The site contains several abandon utilities; old building concrete slabs and several active storm drains. The excavation will be within 15.24 m of the PIDAS fence. The excavated remedial action area will be backfilled as follows:



1. Areas within the existing building slab will be filled with a Control Low Strength Material (flowable fill concrete) to provide a stabilized cover. Flowable fill will be contained laterally.
2. Areas that have surface slopes greater than 2:1 will be covered with a permeable geotextile filter fabric and then stabilized with machined rip-rap (Class A-3) varying in size from 5 to 15 centimeters (cm) with no more than 20% by weight being less than 10 cm. The geotextile fabric will provide a separation and erosion control between the subgrade and the new rip-rap slope.

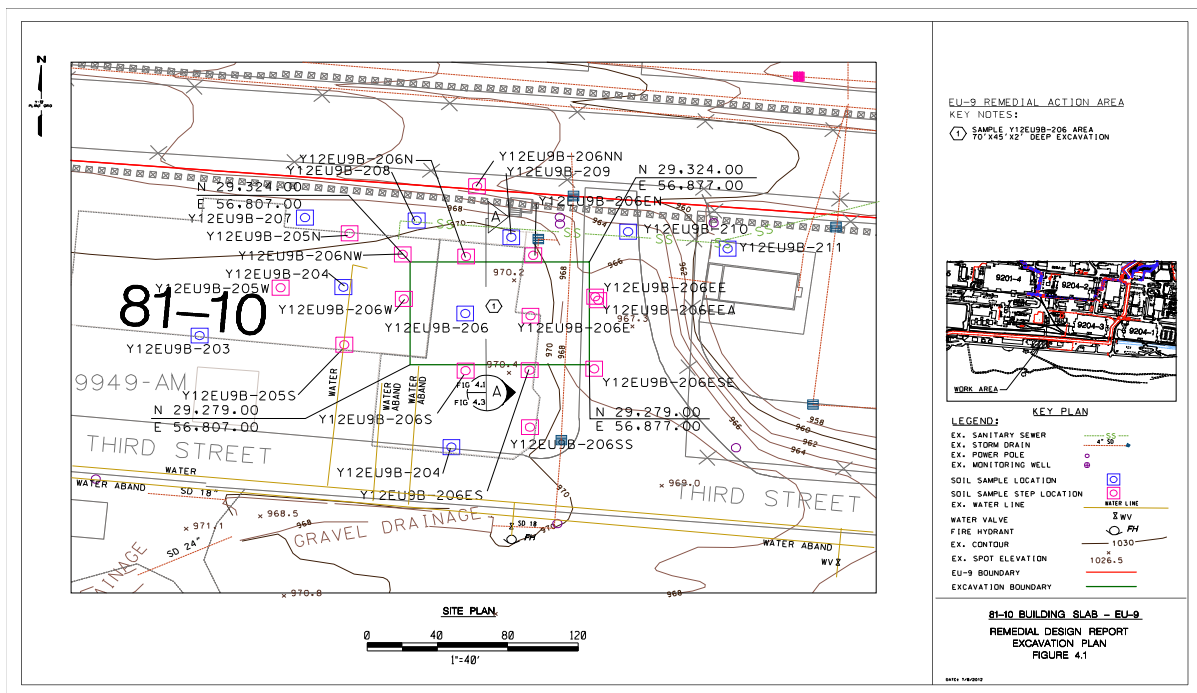


Figure 5. EU-9 81-10 Area Soil Excavation Map

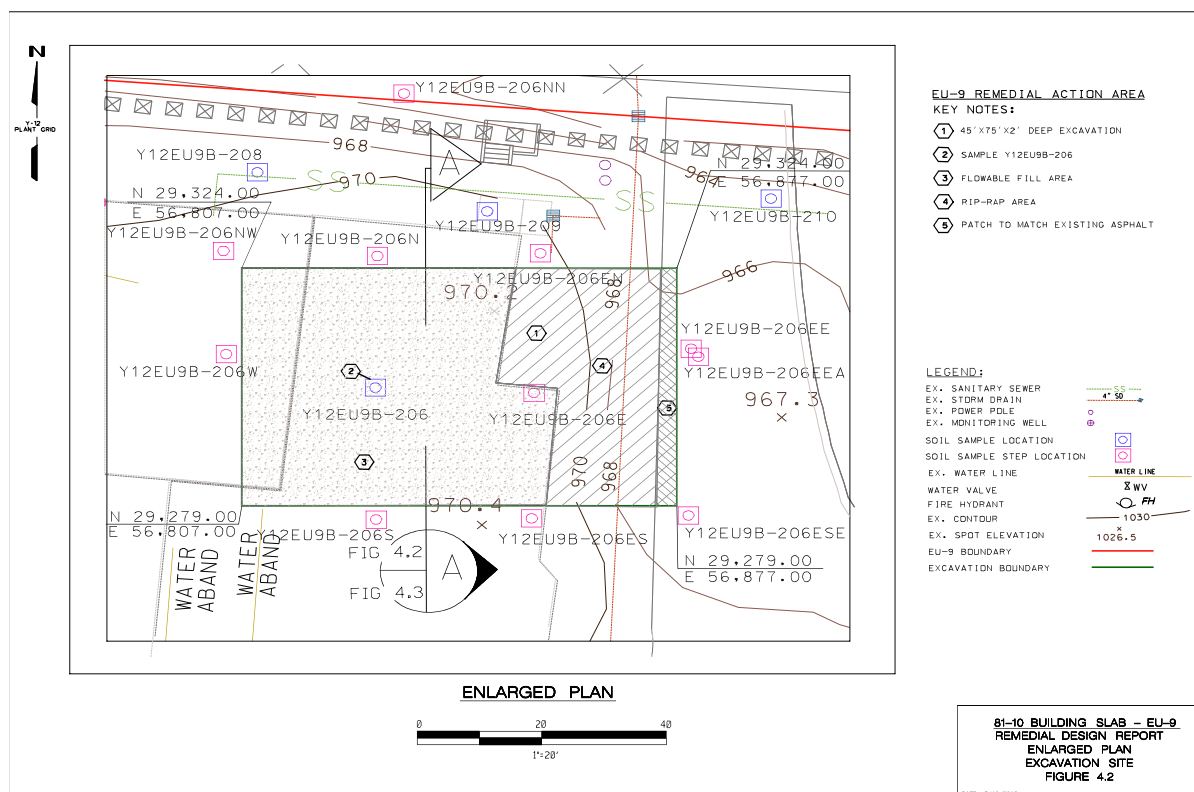


Figure 6. Enlarged EU-9 81-10 Area Excavation Map

## CONCLUSION

Through the use of effective nature and extent characterization planning and methodologies for mercury, the original estimated quantity of contaminated soil shrunk from 1,461 to 171 cubic meters. This represents a reduction of 88% of the affected area, resulting in a major cost reduction for future remediation of the 81-10 pad within the EU-9 soil unit of the Y-12 National Security Complex in Oak Ridge, Tennessee.

## REFERENCES

1. U.S. Department of Energy, *Record of Decision for Phase II Interim Remedial Actions for Contaminated Soils and Scrapyard in Upper East Fork Poplar Creek, Oak Ridge, Tennessee*, DOE/OR/01-2229&D3, 2006.
2. U.S. Department of Energy, *Technical Memorandum for Exposure Unit 9 of the Upper East Fork Poplar Creek (UEFPC) Characterization Area*. Oak Ridge, Tennessee: Y-12 National Security Complex, Attachment B.2 to the Upper East Fork Poplar Creek Soils Remedial Action Work Plan DOE/OR/01-2423&D1, 2012.

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3. U.S. Department of Energy, *Upper East Fork Poplar Creek Soils Remedial Action Work, Oak Ridge, Tennessee*, DOE/OR/01-2423&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN, 2010.
4. U.S. Department of Energy, *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*. DOE/OR/01-1641/V1-V4&D2, 1998.