# In Situ Stabilization of Inactive Low Level Waste Pipelines in the Melton Valley Watershed at Oak Ridge National Laboratory - 8455

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## ABSTRACT

The Melton Valley watershed at Oak Ridge National Laboratory (ORNL) contained an inactive waste pipeline system consisting of approximately 12 kilometers of buried waste pipelines and over 142 $m^3$ in surface/subsurface appurtenances (e.g., vents, valve pits, pump vaults, etc.). Historically, the system was used to transport liquid low level and process waste between generator facilities in Melton Valley, storage and disposal sites in Melton Valley, and storage/treatment facilities in Bethel Valley. The selected remedy in the Melton Valley Record of Decision (ROD) for inactive pipelines was isolation, removal, or stabilization. Pipeline remediation activities began in the summer of 2005 and were completed in the spring of 2006. The task entailed an iterative process of selecting pipeline access points, excavating and exposing pipelines, performing tapping, draining and cutting activities, either installing fittings for grouting or plugging and capping the lines. Grouting was accomplished using paired access points, with one location serving as the grout injection point and the other as vent/drain and grout confirmation point. Grouting was conducted by pumping a cement-bentonite grout into the specially installed fittings and typically proceeded from a low point to a high point to ensure complete filling of the pipeline (i.e., no void space). The project successfully grouted a total of 8,454 meters (linear distance) of pipeline; another 3,573 meters of pipeline was stabilized through isolation.

## INTRODUCTION

The U. S. Department of Energy's (DOE's) Oak Ridge Reservation (ORR) consistes of 13,970-hectares within and adjacent to the city limits of Oak Ridge, Tennessee, in Roane and Anderson counties. ORR hosts three major industrial research and production facilities originally constructed as part of the World War II (WWII)-era Manhattan Project: East Tennessee Technology Park (formerly the K-25 Site), Oak Ridge National Laboratory (ORNL), and the Oak Ridge Y-12 National Security Complex Plant. The Melton Valley (MV) watershed lies immediately south of the ORNL main campus.

Remediation activities in the watershed were completed in accordance with requirements and performance objectives specified in the Melton Valley Record of Decision (ROD) for Interim Actions in Melton Valley signed in September 2000 by the Federal Facilities Agreement (FFA) parties (DOE, the State of Tennessee, and U.S. Environmental Protection Agency [EPA]). The ROD and its subsequent changes (ROD amendment and four Explanations of Significant Differences) addressed contaminant releases and potential risks or hazards associated with 175 contaminated units scattered across an area of 430 hectares (1,062 acres) within the watershed. One of the units addressed by the Melton Valley ROD was the inactive waste pipeline system.

The inactive waste pipeline system in Melton Valley consisted of a complex series of buried waste pipelines and appurtenances (e.g., vents, valve pits, pump vaults, etc.) historically used to transport liquid process waste and low-level waste between generator facilities in Melton Valley, storage and disposal sites in Melton Valley, and storage/treatment facilities in Bethel Valley. The pipelines were constructed during the 1950's, 1960's and 1970's using various materials such as cast iron, carbon steel, and stainless steel. Pipeline diameters ranged from 3.8 to 15.2 cm, with the majority consisting of 5.1 cm (2-inch) lines, followed by those that were 15.2 cm in diameter. As-built drawings were not completed for the system, which complicated the planning and execution of the remediation work. The basic layout of the system is shown on Figure 1.

The selected remedy in the ROD for inactive process and LLW transfer pipelines was isolation, removal, or stabilization. Stabilization was defined as the in situ grouting of the pipelines and identified as the preferred option for completing the remediation, particularly for the LLW pipelines. Pipelines associated with process wastes or other waste streams with generally low levels of contamination were identified for isolation. An additional 1,524 meters of pipeline were isolated based on conditions encountered in the field. These conditions included the type and condition of the line, the level of contamination associated with it, the feasibility of grouting the line, the presence of previously documented problems regarding line integrity, and the relationship between the line and associated features such as valve boxes or manholes planned to be grouted. In addition to the grouting and isolation activities, the project included the grouting of valve boxes, pump pits, and other appurtenances associated with the pipeline system.

## PIPELINE GROUTING

Pipeline grouting activities began in the summer of 2005 and continued through the spring of 2006. The work was conducted in accordance with the applicable work control package. The technical approach for pipeline grouting followed the general methodology presented in the Remedial Design Report/Remedial Action Work Plan (RDR/RAWP); however, a number of modifications concerning equipment and personnel protection were implemented based on the conditions encountered. These modifications dealt primarily with the adoption of specific measures designed to limit the potential for the spread of contamination or reduce worker exposures.

Pipeline remediation activities entailed an iterative process of selecting pipeline access points, excavating and exposing pipelines (Fig. 2), performing tapping, draining and cutting activities, and the pumping of a cement-bentonite grout into the lines. Pipeline access points were typically paired, with one location serving as the grout injection point and the other the vent/drain and grout confirmation point. All grouting was conducted from a low point to a high point to ensure complete filling of the pipeline (i.e., no void space). The distance between these locations varied depending on site conditions, including topography, the type and configuration of the pipelines, the potential for subsurface soil contamination, etc. A total of 78 excavations were completed for pipeline access during the course of the project.

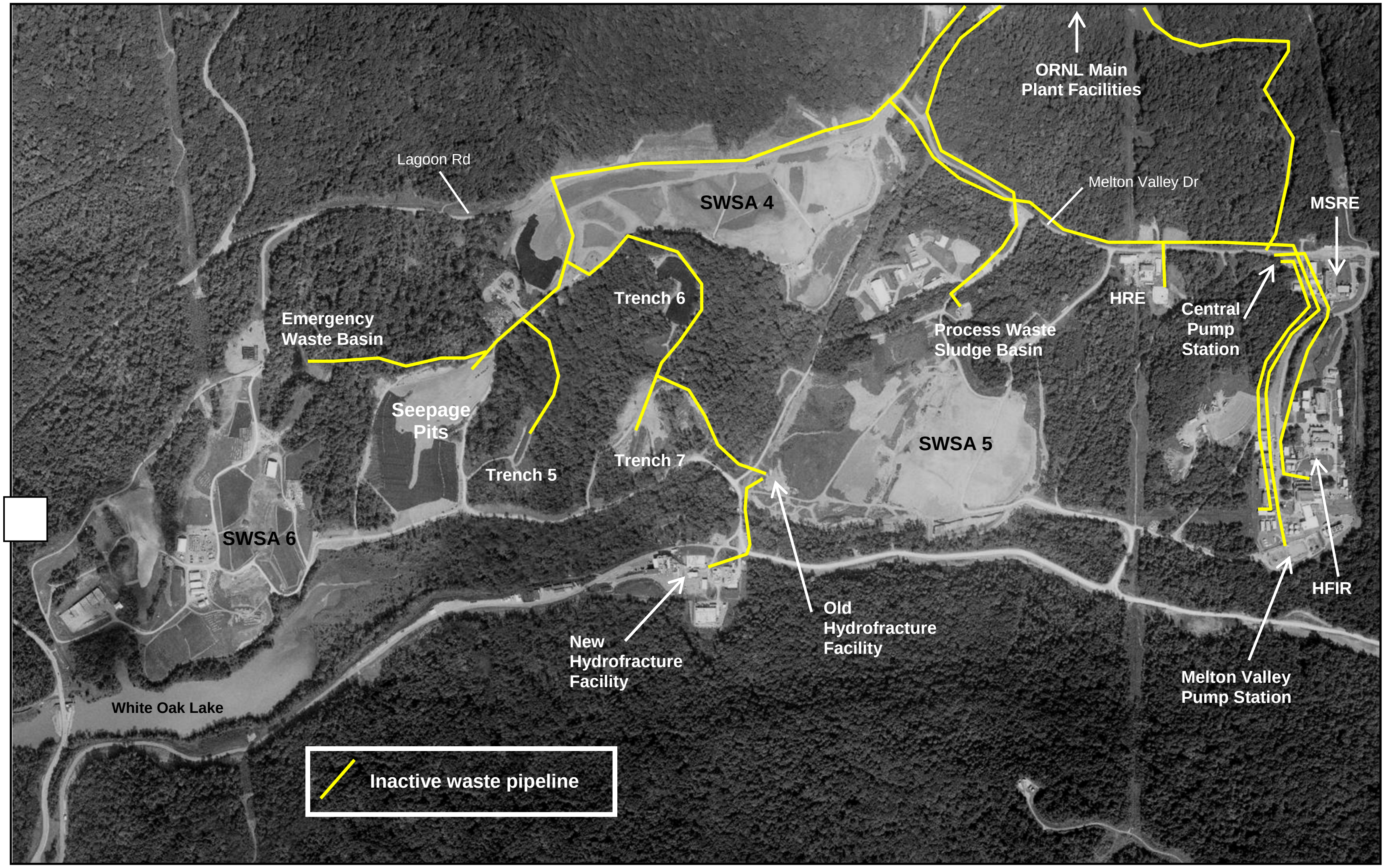


**Fig. 1. Aerial View of Melton Valley Showing Layout of Inactive Waste Pipeline System.**

Fig. 2. LLW Pipelines Exposed in Excavations (*left*) and Placing Lead Shielding on Pipeline (*right*)

Residual liquids removed from the lines were collected in HEPA-ventilated tanks and eventually transferred to the ORNL Process Waste Treatment Plant or LLW Evaporator, depending on the activity levels of the liquids. Liquids collected from the vent/drain fittings during grouting were similarly managed. The quantity of liquids collected from a given segment of pipeline varied greatly, depending on pipeline diameter, length of segment being drained or grouted, the elevation (profile) of invert elevations along the segment, and the condition of the pipeline, specifically whether there were leaks that allowed for groundwater to flow into the line.

Grouting of the pipelines was accomplished using a ChemGrout pump (Model CG-500GH) and associated hoses (3.2 cm dia.) with valves and Camlock connection fittings. Grout injection was accomplished in a measured, methodical manner tied to the type and diameter of the pipeline as well as the conditions between the injection point and vent. Grout pressures were typically maintained well below 103 kPa (15 psi) although higher pressures (138-276 kPa [20 – 40 psi]) were tolerated on runs with significant uphill portions. On average, the rate of grout injection was less than 37.8 liters per minute (lpm). Higher injection rates (up to 76 lpm) were used on larger diameter pipes when conditions allowed. Lower rates were used in areas where there were indications (based on pressure observations) that the integrity of the pipeline was uncertain.

The grout recipe basically followed the specification in the RDR/RAWP, consisting of the following:

- 189 liters of water
- 2 sacks (42.6 kg each) of Portland Type II cement
- 1.4 kg. of bentonite powder

Compressive strength tests of the grout indicated a 28-day strength test of 4,137 kPa, well above the minimum specification of 689 kPa (the objective of grouting was filling the void space of the pipelines rather than acting as structural fill). The grout was easily mixed and pumped with a minimum of separation ("bleed water") on all but the longest runs in the 15.2-cm diameter pipes. In situations where bleed water was potentially an issue, 0.5-1 kg of additional bentonite was added to the mixture.

Confirmation of successful grouting was based entirely on visual evidence of grout in the vent hoses. These hoses were tied into the HEPA-ventilated tanks used to collect displaced liquids pushed out of the pipelines ahead of the grout. Once grout was observed in the hoses between the fitting and the tank, grouting pumping was terminated and the valve on the downhill end of the segment (i.e., the grout injection point) was closed. Figure 3 shows typical grout fittings and the set-up used at the grout injection access point.


**Fig. 3. Grout Fittings (*left*) and Grout Set-Up (*right*)**

Following the completion of grouting along a given segment of pipeline, the equipment was demobilized and the holes were backfilled. All pipelines were civil surveyed after they were exposed. Following the backfill operations, final verification surveys were conducted to verify that the restored area did not require any soil remediation.

Pipeline grouting began on June 15, 2005 after an extensive planning and field demonstration period. The initial efforts to refine field techniques were focused on a 7.6-cm LLW pipeline that had been exposed through excavation of soils at the HRE facility (see Fig. 1). The line was tapped and cut in several places and fittings were attached; however, the first actual grouting activity occurred in early July on pipeline formerly used to transfer LLW from the Central Pump Station (CPS) to the LLW evaporator facility in Bethel Valley.

Pipeline grouting continued throughout 2005 and was completed on April 27, 2006. A total of 8,454 meters of pipeline was successfully grouted during the 10 months of field work. A comparison of the actual vs. planned pipeline grouting activities is presented in Table I.

**Table I. Pipeline Grouting Performance Summary**

| Activity | Actual | Plan | Δ |
|---|---|---|---|
| Start | 6/15/05 | 5/28/05 | -- |
| Finish | 4/27/06 | 11/23/05 | -- |
| Duration (work days) | 213 | 125 | + 70% |
| Total quantity (linear m) | 8,454 | 8,218 | + 3% |
| Avg. productivity (linear m/day) | 38.4 | 48.8 | - 21% |
| Days of grouting | 50 | 104 | - 52% |
| Daily production per grout day (linear m) | 169 | 58.5 | + 189% |

Many of the complications associated with completion of the pipeline work were due to that the fact that there were no as-built drawings for the pipelines and related systems. Consequently, the scope of the grouting effort (and other pipeline remediation activities) evolved over time as a better understanding of the configuration of the system and actual site conditions were obtained. Thus, at the time the remediation contract was awarded to Sevenson, the scope of the grouting was assumed to consist of approximately 6,096 linear meters of pipeline. Soon after the work began, at which time the plan for completion of the work was revised to reflect a more accurate assessment of the scope, the quantity of pipelines to be grouted was increased in September 2005 to 8,218 meters. In March 2006, additional information concerning the pipelines inside HFIR led to another upward revision of the estimate to 8,583 meters. The final quantity grouted, as shown in Table I, was 8,454 meters, about mid-way between the September 2005 and March 2006 estimates.

The longer duration and lower productivity for the pipeline grouting activities were due almost entirely to the unexpectedly high levels of radiation and radioactive contamination encountered at many of the pipeline access points. Worker safety and contamination control dictated the development and implementation of rigorous work controls that impacted the pace of the work, and as shown in the table, the duration was considerably longer than originally planned. These efforts were successful in minimizing dose to the workers and preventing any releases of contamination from the controlled areas associated with the pipelines.

## ISOLATION OF PIPELINES

The procedures for isolation of pipelines was essentially the same as that followed for exposure and preparation of the lines prior to grouting (Fig. 4). As specified in the RDR/RAWP, isolation was planned for 2,074 meters of pipeline. The bulk of this footage was associated with the Process Waste Sludge Basin Line (1,296 m) and the unused 15.2-cm Process Waste Line between the Lagoon Rd valve box and the Emergency Waste Basin (599 m). A number of short segments of pipelines (on average 12 m or less) at HRE were also planned for isolation as these lines originated and terminated in facilities that were grouted in place (e.g., pump pits at HRE).


Fig. 4. Tapping LLW Line Using Drill Press (*left*) and Cutting Line With Reciprocating Saw (*right*)

As shown in Table II, nearly 1,524 additional meters of pipeline were isolated based on conditions encountered in the field. These conditions included the type and condition of the line, the level of contamination associated with it, the feasibility of grouting the line, the presence of previously documented problems regarding line integrity, and the relationship between the line and associated features such as valve boxes or manholes planned to be grouted.

Isolation of these lines was accomplished by one of the following methods:

- Installation of a plug and cap on both ends of a line after it was tapped, drained, and cut; the lines were plugged with expanding foam and the capped end of the line was grouted in place.
- Grouting a portion of the line from one end and plugging/capping the other end (e.g., if there was a blockage in the line, the position of which either could not be determined or it was located in an inaccessible area)
- Installation of a plug and cap on one end of line when the other line was previously cut and capped by others or the line terminated in a grouted structure
- Filling void spaces such as diversion boxes or manholes associated with both ends of the line.

It is important to note that with few exceptions, the lines that were isolated were considered secondary waste lines, as opposed to primary waste transfer lines. The only isolation activities on the primary waste lines (such as the lines along Melton Valley Drive or between HFIR and the CPS) occurred on segments of these lines where site conditions prevented it from being grouted. As discussed earlier, isolation of the lines complies with the ROD requirements for remediation of the inactive waste pipeline system.

Table II shows the duration and quantity of the pipeline isolation work. The isolation work was completed in tandem with the grouting, and typically grouting took precedence over pipeline isolation work due to the complexity of the grouting operation.

**Table II. Pipeline Isolation Performance Summary**

| Activity | Actual | Plan | Δ |
|---|---|---|---|
| Start | 6/15/05 | 5/28/05 | -- |
| Finish | 4/27/06 | 11/23/05 | -- |
| Duration (work days) | 213 | 125 | + 70% |
| Total quantity isolated (linear m) | 3,573 | 2,074 | + 68% |
| Avg. productivity (linear m/day) | 16.8 | 16.5 | + 2% |

## GROUTING OF VOID SPACES

Void spaces associated with subsurface valve boxes, pump pits, manholes, diversion boxes, vents, and related structures were grouted as part of the IWPS remediation task. A listing of the structures and grout quantities are shown in Table III.

Grouting of the appurtenance void spaces was accomplished using one of two methods. For the smaller spaces, grout was mixed using the grout pump and pumped into the structure using a 3.8 cm grout hose. For the larger void spaces, Ready-Mix trucks from an offsite batch plant were used. These trucks would then either dump the mixture directly into the void space or if necessary, transfer the moisture to the grout pump which then pumped the grout into the structure. The same grout mixture used for the pipelines was used for the void spaces.

The large difference between the plan and actual quantity of void spaces was due to the absence of as-built drawings as well as uncertainty at the time of the design with regard to the status of certain process waste appurtenances inside HFIR. In addition, the need to create grout monoliths in 2 of the highly contaminated excavations at the CPS was not anticipated. These monoliths were constructed to isolate areas with residual soil contamination in addition to stabilizing the broken pipes that were encountered..

**Table III. Grouting of appurtenances associated with the Inactive Waste Pipeline System**

| Area | Unit | Plan ($m^3$) | Actual ($m^3$) |
|---|---|---|---|
| Pits & Trenches | Trench 5 Valve Box & Overflow | 1.4 | 3.5 |
| | Chemical Rd Valve Box | 1.6 | 1.4 |
| Lagoon Rd/ MV Dr | Lagoon Rd Valve B ox | 0 | 1.8 |
| Melton Valley Drive | Line G/A Valve Box on MV Dr | 0 | 2.3 |
| | Vents in Line F/A on MV Dr | 4.2 | 4.3 |
| HRE | Isolation of broken pipeline | 0 | 0.3 |
| Central Pump Station Area | Diversion Box | 3.7 | 6.1 |
| | Line H Valve Box | 1.3 | 3.2 |
| | WC 20 Valve Box – Bldg 7569 | 17.6 | 22.5 |
| | Isolation of broken pipes | 0 | 6.9 |
| HFIR Facility | Valve Box #2 | 0 | 8.4 |
| | Valve Box #3/4 | 0 | 15.6 |
| | TRU Valve Box (*not TRU waste*) | 2.1 | 7.6 |
| | TURF Diversion Box East | 2.1 | 6.8 |
| | Turf Diversion Box West | 2.1 | 6.8 |
| | Valve Box 53 (*NW of 7952*) | 2.1 | 6.7 |
| | Manhole MH P9 | 0 | 4.7 |
| | Manhole MH P8 | 0 | 4.3 |
| | Manhole MH P7 | 0 | 2.9 |
| | Manhole MH UP105 | 0 | 1.4 |
| | HFIR LLW Tank Pump Pit | 12.7 | 23.2 |
| | Manhole MH UP106 | 0 | 1.7 |
| | Manhole MH P3 | 0 | 0 |
| Total | | 50.9 | 142 |

Confirmation of the successful grouting of the appurtenance void spaces was based on visual observations. Most of the structures had an open top or hatch which could be opened to observe the grout level. Three of the structures at the CPS were sealed (i.e., could not be opened). Confirmation of successful grouting at these locations was accomplished through the installation of visual site glasses created by drilling a hole in the sidewall of the box and installing the necessary pipes and fittings to monitor water or grout levels in the structure. All water displaced from the void spaces as a consequence of grouting was captured in the HEPA-filtered wastewater tanks and transferred to the appropriate facility for treatment at ORNL.

## SUMMARY AND CONCLUSIONS

Remediation of the inactive waste pipeline system was accomplished through the in situ grouting or isolation of underground waste lines and the grouting of valve boxes, pump pits, etc. associated with the pipeline system. A summary of the remediation accomplishments for the pipeline system is shown in Table IV.

**Table IV. Performance Summary for Inactive Waste Pipeline Remediation**

| Pipelines Grouted (m) | | Pipelines Isolated (m) | | Total Remediated (m) | | Void Spaces Grouted ($m^3$) | |
|---|---|---|---|---|---|---|---|
| **Plan** | **Actual** | **Plan** | **Actual** | **Plan** | **Actual** | **Plan** | **Actual** |
| 8,218 | 8,454 | 2,074 | 3,573 | 10,292 | 12,026 | 50.9 | 142 |

Successful completion of the pipeline remediation task resulted in the effective removal of a potentially significant source of groundwater and soil contamination from the watershed. The work was accomplished safely and well-below the predicted radiation exposures for the workers.