High Angle Remediation of Legacy Mercury Contaminated Soil at LANL - 16276

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ABSTRACT

Mercury contaminated soil was left behind by The Manhattan Project and early Cold War era operations at Los Alamos National Laboratory (LANL) in Los Alamos, NM. TerranearPMC (TPMC) was the subcontractor that successfully completed this high-angle, legacy cleanup project on a steep, difficult-to-access canyon wall in Upper Los Alamos Canyon Aggregate Area south of a busy shopping center parking lot. A Menzi Muck (spider excavator) was used in concert with a high capacity telescoping crane to remove approximately 158 cubic yards of contaminated rock and soil from the steep slope. The crane was also used to safely move personnel and equipment into and off of the site, as well as to retrieve packaged waste. All soil excavated from the site was containerized in soft-sided 1.77 cubic yard IP-1 containers and shipped to an approved, licensed, off-site disposal facility. Once excavation was completed, sampling confirmed that human health concerns and environmental risk issues had been mitigated. This proven technical approach will become the preferred method for cleaning up other similar, difficult-to access/steep legacy waste sites across the Upper Los Alamos Canyon Aggregate Area.

INTRODUCTION

The purpose of the legacy cleanup project was to remove concentrations of mercury at levels greater than or equal to 5mg/kg to protect human health and the environment. Multiple technical approaches were evaluated for implementing the soil remediation and restoration on the steep, rugged slope at Solid Waste Management Unit (SWMU) 32-002(b2) located in former Technical Area 32 (TA-32) in Los Alamos, NM (Figure 1). Former TA-32 was a small medical research facility consisting of three laboratories; work at the facility included biological research involving radionuclides.

Given the technical complexity, high public visibility, and overall uniqueness of the Upper Los Alamos Canyon Remediation at SWMU 32-002(b2), TPMC selected the most competent, technically capable resources to support this remediation project. The TerranearPMC Team (The Team) included Envirocon in collaboration with All Mountain Construction Spider Excavation Service and Crane Service, Inc. of Albuquerque, NM. The Team’s collective expertise was critical to the overall success of the project.

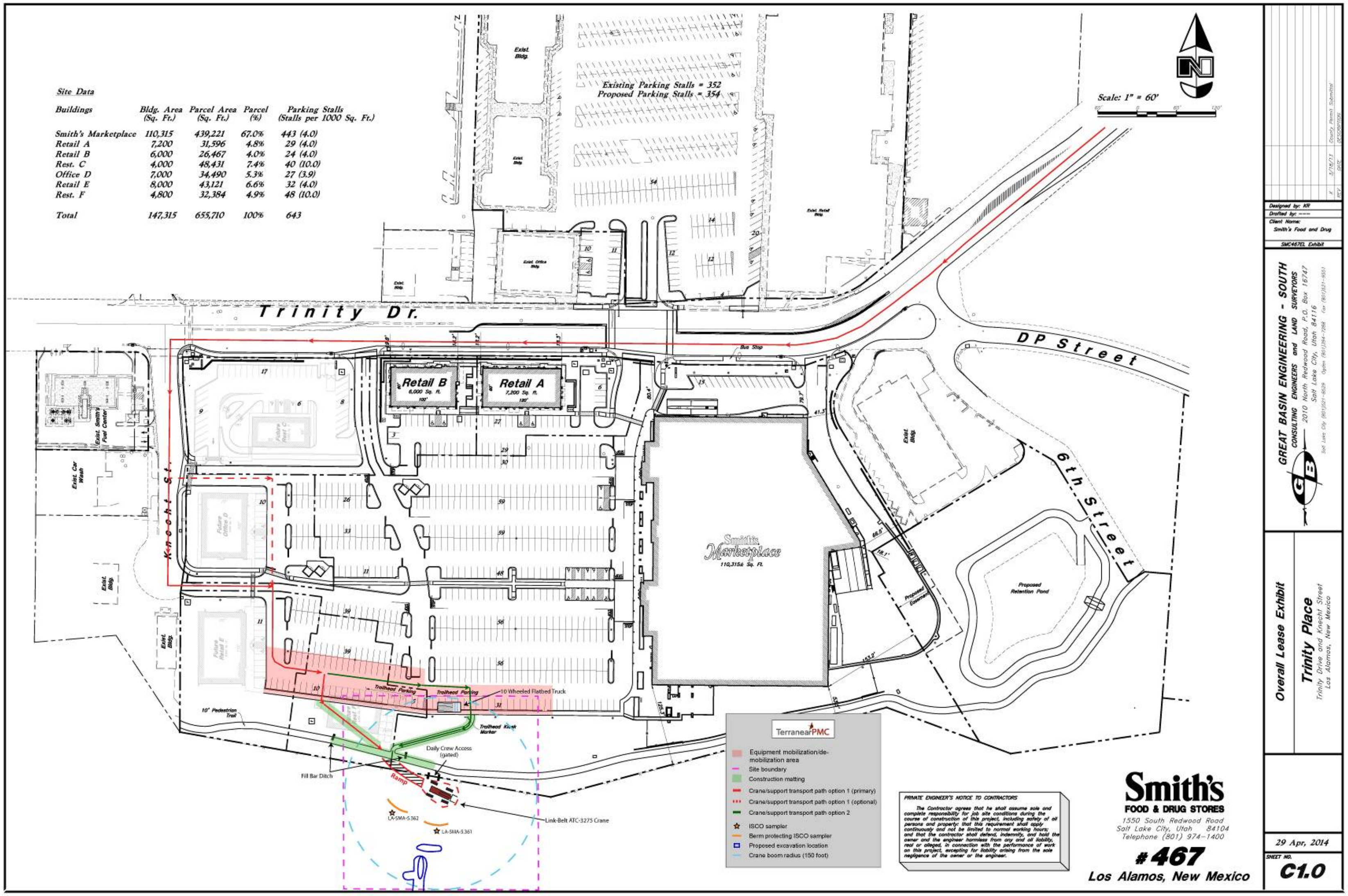

Figure 1. Location of SWMU 32-002(b2) excavation work site, Los Alamos, NM.

The successful execution of this remediation effort started early in the development of our technical approach. The Team's technical approach placed an absolute priority on worker health and safety while simultaneously facilitating the achievement of project technical objectives. Further, our approach minimized impacts to the work site, took the property owner's interests into consideration, and the overall approval of our approach.

The Team evaluated multiple approaches spanning the range of technical complexity for implementing the soil remediation and restoration at SWMU 32-002(b2). A 26,000 lb Menzi Muck A91-E spider excavator spider was the highly specialized piece of equipment selected for the steep and rugged remediation because it is rated for safe work on 100%+ grades without assistance. The maneuverability and safety of this machine on steep terrain allowed it to access the entire excavation area and to safely remove large boulders from the excavation site. The spider excavator was also used to load waste containers with contaminated soil, and supported final site restoration and stabilization of the excavation site. A telescoping crane was specifically selected because of its all-terrain capabilities and its lifting capacity and extended reach. The crane was equipped with a 223-foot main boom, capable of operating at less than 10-degree boom angles, and had a working radius of 115 feet and a rated weight capacity of over 32,000 pounds. The crane's capacity allowed safe placement of the spider excavator onto the otherwise inaccessible excavation site. Because of the extreme terrain and accessibility challenges, the project personnel and equipment used to perform work were also hoisted to and from the work site using the crane and a man-basket.

The planning and review phase was also critical to the overall success of the project and included a substantial document submittal and approval process between The Team and the Laboratory's Environmental Remediation (ER) Program, other Laboratory SMEs and Los Alamos County. To move this project from a planning phase to an execution phase, The Team submitted a multitude of Health and Safety documents, access agreements, and critical lift plans (required to hoist personnel to and from the site and to lower and lift the spider excavator) for approval to perform the work.

Waste characterization results indicated the regulatory status of the waste generated was Low Level Waste (LLW). All waste was shipped to an approved, licensed, off-site disposal facility. Once excavation was completed, sampling confirmed that human health concerns and environmental risk issues had been mitigated. This was the final step in transforming the site that can now be used for additional economic development in the area.

The collaborative effort between the TPMC team, the Laboratory's ER Program, Los Alamos County and private property owner was impressive and resulted in a flawless execution. This paper will present the cleanup project process and lessons learned for other similar remediation efforts in difficult to access/high-hazard sites.

METHOD EVALUATION

The TPMC Team evaluated multiple approaches spanning the range of technical complexity and cost for implementing the soil sampling and removal work at SWMU 32-002(b2). The options assessed included a strictly manual labor operation, standard excavation methods using conventional heavy equipment and ground crews, ultra-long-reach excavators with ground support crews or operated in a two-tiered configuration, mini-excavators craned into the excavation area, soil vacuuming with ground support crews, conveyor systems, and manual and/or mechanized excavation work with a logging yarder and skyline system. Ultimately, the use of a high capacity crane to safely move personnel and equipment into and off of the site as well as to retrieve packaged waste, working in concert with a Menzi Muck (Spider) Excavator to remove the contaminated rock and soil, and collect confirmatory samples was selected.

The advantages of this approach were significant, and included first and foremost substantially reduced health and safety risks. Personnel were efficiently lifted onto and off of the excavation site using the crane with a certified man basket. This practice eliminated the requirement for ground crews to descend and ascend a steep footpath. Further, personnel were making multiple descents/ascents per day to manage materials movement and to allow for scheduled work breaks, this approach greatly decreasing worker risk exposures though use of the man basket. The advantages of the crane and certified man basket were particularly clear in the event of an illness or injury; personnel can be extracted from the site rapidly without outside support or additional specialty equipment.

The application and use of mechanized equipment allowed for the minimization of personnel required to support efficient site operations. Topside personnel, mostly managing crane rigging attachment/detachment operations and equipment deployments, and downside personnel (in addition to the Spider Excavator operator) supported setting up empty waste bags, closing and securing filled bags, and tending the excavator and operator. The small crew size significantly limited the overall amount of man-hours worked in a hazardous setting exposed to health and safety risks. In addition, the Spider Excavator safely operated over the entire excavation site including in the excavation locations near the cliff edge, and eliminated the need for personnel to approach these locations.

In contrast, all of the other considered options would have required far larger ground crews and/or would have caused significant environmental impact to the site and surrounding area. A strictly manual labor approach was quickly rejected due to unacceptable health and safety risks, principally associated with ingress and egress concerns and the inability to react effectively in the event of an emergency. Similarly, the use of compact or mini-excavators and loaders were not considered. While this type of equipment can be lowered onto the site with a lower capacity crane, they could not have safely operated on slopes over 40%. In general, there were four distinct slope angles at the site: 54% at the southern edge of the excavation area, 80% reducing to 60% in the mid-section of the excavation area, and over 100% in the uppermost reaches of the site, all well above operational slopes for mini-equipment. The safe operating ratio for this type of equipment diminishes further in rock-strewn terrain such as at SWMU 32-002(b2).

Based on our experience operating vacuuming equipment at other high-angle sites at LANL, ground crews would have had to manually loosen soil and break up rock using mechanized percussive tools to allow the vacuuming system to lift the contaminated materials at SWMU 32-002(b2). While successful at other sites with fewer hazards than SWMU 32-002(b2)this approach was physically challenging work, required a large team, and may ultimately not have be effective recovering all of the contaminated material from this site. Further, vacuuming operations complicate waste management practices and would have, at a minimum, posed some risk of release to non-contaminated DOE property above the excavation site if not to private property. Finally vacuuming equipment was not suitable for placing backfill materials and would have restricted the selection of backfill materials, or would have required the deployment of heavy equipment to place more appropriate materials.

Conventional excavation equipment could have been placed on benches or tiers above the site and on the excavation area to work in tandem to raise waste sequentially up the canyon from one tier to the next. TPMC also had success with this approach at another LANL site; however, that site had a substantial soil layer, was far less rock strewn and was far more amenable to the placement of backfill, stabilization, and an overall successful site restoration. It was TPMC’s assessment that SWMU 32-002(b2) would have required the installation of at least one, if not two, intermediate benches to allow safe access to the site, essentially amounting to road construction, and would cause such impact to the site that it could not be properly restored. Erosion caused by the benching work and tracked equipment movements would have also been difficult to control at SWMU 32-002(b2). Ultra-long-reach equipment could somewhat reduce the amount of benching work required but the distances and elevation change at the site would have still required significant reworking of the site to gain safe access for this type of equipment as well. The use of a crane or logging skyline equipment in conjunction with conventional excavation equipment could have also improved waste handling and contamination control as well as reduced tracked equipment traffic in and out of the site; however, we ultimately rejected the use of any conventional excavation equipment on the excavation area due to the associated environmental damage and the compounded challenges for effective site restoration.

TPMC also considered a number of soil conveyor systems including bucket elevators, drag elevators, and screw augers. These approaches were rejected principally because of the significant dust production associated with this kind of equipment and difficulties conveying rocky materials and soils wetted with dust suppression water. Further, conveyor systems require frequent maintenance and are subject to mechanical failure in harsh environments. In the event of a breakdown, we would not have had a safe and efficient means for transporting repair parts to the work area. Finally, using an auger or conveyor would still require some means of excavating the contaminated material, adding equipment to an already small, steep, and crowded work zone.

EXECUTION

Prior to initiating excavation work, the downside ground crew surveyed the site and demarcate the boundaries of the excavation locations. The downside team established best management practices (BMPs) to restrict potential surface water impacts, erosion, and contaminant migration. The BMPs (e.g. wattles and gravel bags) installed at natural storm water run on/runoff pathways that may be impacted by operations. The BMPs were inspected and maintained in accordance with the Storm Water Pollution Prevention Plan (SWPPP) throughout the project.

Between May 4, 2015 and May 12, 2015 a total of 22 confirmation samples were collected from 11 locations in former TA-32 using hand auger methods. These confirmation samples were collected “in-situ”, prior to any excavation activities to build in project efficiencies and eliminate any stand-by or remobilization costs.

Prior to mobilization of heavy equipment (May 5, 2015 to May 11, 2015), two temporary access ramps and a crane pad were built to support crane mobilization (Figure 2). Industrial matting was installed atop the access ramp to further support the crane and to protect the landscaping and asphalt pedestrian path located on private property (Figure 2). After the access ramps were built and approved by crane experts from our crane subcontractor, The Team mobilized a Crane Service, Inc. owned and operated Link-Belt ATC-3275 275-ton hydraulic-boom all-terrain crane and rigging with full counterweights (156,000 lbs) Figure 3. A Critical Lift Plan (CLP) meeting and associated checklist were completed prior to the “critical” lift of the spider excavator. The spider excavator was successfully lifted and placed at the work site on May 11, 2015 (Figure 4). A second CLP was implemented to hoist personal to and from the work site using the crane and certified man-basket.

Equipment necessary to perform the job were also lowered to the site using the crane. Topside ground personnel attached tag lines and rigged the loading frame for the soft-sided waste containers to the crane and lowered the frame to the SWMU. Waste bags were also rigged and lowered to the SWMU as needed. Downside ground personnel unrigged the loading frame waste containers.

The Spider Excavator began by working over the entire site to remove 12- to 24-inch boulders exposed at the ground surface. The majority of the harvested boulders were reserved in a stockpile outside of the main excavation area for replacement during site restoration activities. Due to the extreme steepness of the site, there was significant potential to dislodge rock and boulders during excavation and while relocating equipment, posing a significant health and safety risk to ground crews and the area below the cliff. All Mountain Construction is deeply familiar with these conditions from their mining reclamation and ski lift construction work. Practices based on this experience were employed and no issues were encountered.

Once the surface of the site was prepared, excavation was completed in one sustained effort. A total of approximately 158 yd^3 of mercury-contaminated soil was removed from the site at depths ranging from 2 ft bgs to 5 ft bgs using the spider excavator between May 12, 2015 and May 19, 2015 (Figures 5 and 6). To ensure worker safety, downside ground personnel remained a safe distance from the edge of the excavation during excavation and the filling of waste containers. The spider excavator was used to place material excavated from the site into IP-1 rated 1.77 yd^3 soft-side waste bags at the point of generation (Figure 5). A loading frame was used to easily and safely load the waste bags. The downside team collected the specified waste characterization samples as each waste container was filled. The containers were closed and secured in accordance with manufacturer specified procedures and made ready for transport to the selected off-site disposal facilities in accordance with LANL waste packaging and shipping procedures and off-site facility WACs. The crane was used to hoist the bags from the excavation site and place them on a flatbed truck for immediate delivery to the LANL waste staging area at TA-21 off public property (Figure 7). At the end of each work period, excavation was secured and the downside team returned to the topside staging area using the crane and man-basket (Figure 8). Unpackaged waste was not handled outside of the DOE excavation area. This process resulted in handling the waste containers a single time from the point of generation to transport to the waste storage area reducing the materials handling risks.

Figure 2. Lower access ramp and crane pad (left) Industrial matting over pedestrian path and upper access ramp (right). Photos courtesy of Los Alamos National Laboratory.

Figure 3. Linkbelt ATC 3275 being mobilized to the Upper Los Alamos Canyon Aggregate Area Remediation Site.

Figure 4. Photos of Linkbelt ATC 3275 lifting and lowering the Menzi Muck Spider Excavator to the excavation site. Photos courtesy of Los Alamos National Laboratory.

Figure 5. Menzi Muck 91-E spider excavator positioned on the SWMU 32-002(b2) excavation site.

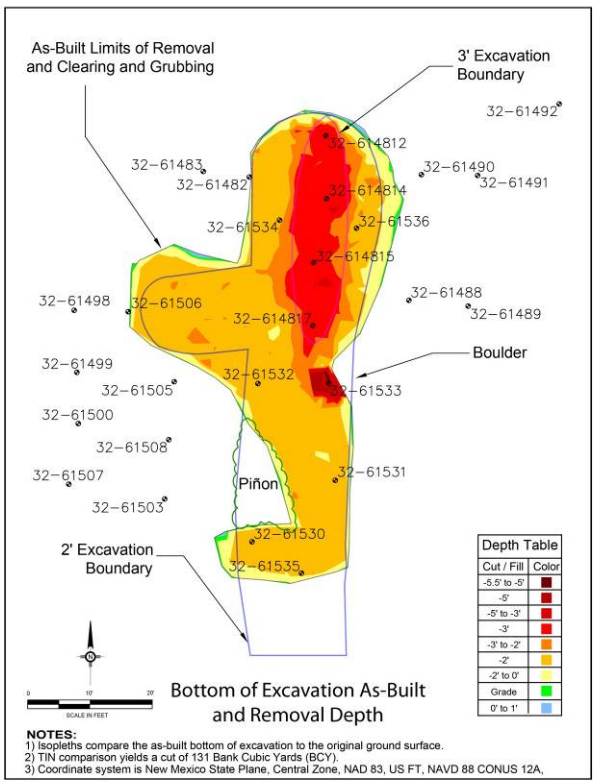

Figure 6. SWMU 32-002(b2) excavated area topography

Backfilling and site restoration of the excavation site, crane pad, and temporary access ramps were planned in accordance with the SWPPP and in collaboration with LANL SWPPP experts. The crane and a 2 cubic yard cement bucket were used to transport backfill materials to the excavation site. Approximately 107 yd^3 of certified clean backfill material was used to fill the excavation area (Figures 9 and 10). Backfill was installed in 6” lifts, wheel-rolled, and compacted. Approximately 24 yd^3 of topsoil was placed atop the backfill and 24 yd^3 of angular rip rap ranging between 6 in. and 2 ft was placed at the break in slope at the northern end of the excavation (Figures 9 and 10). Additional rip rap was placed in areas disturbed by remediation activities. The area was fertilized, reseeded, and 400 yd^2 of erosion control matting was placed on top of the site. Four rows of coconut erosion control logs (Coir Logs) were installed to further prevent and/or control erosion (Figures 9 and 10).

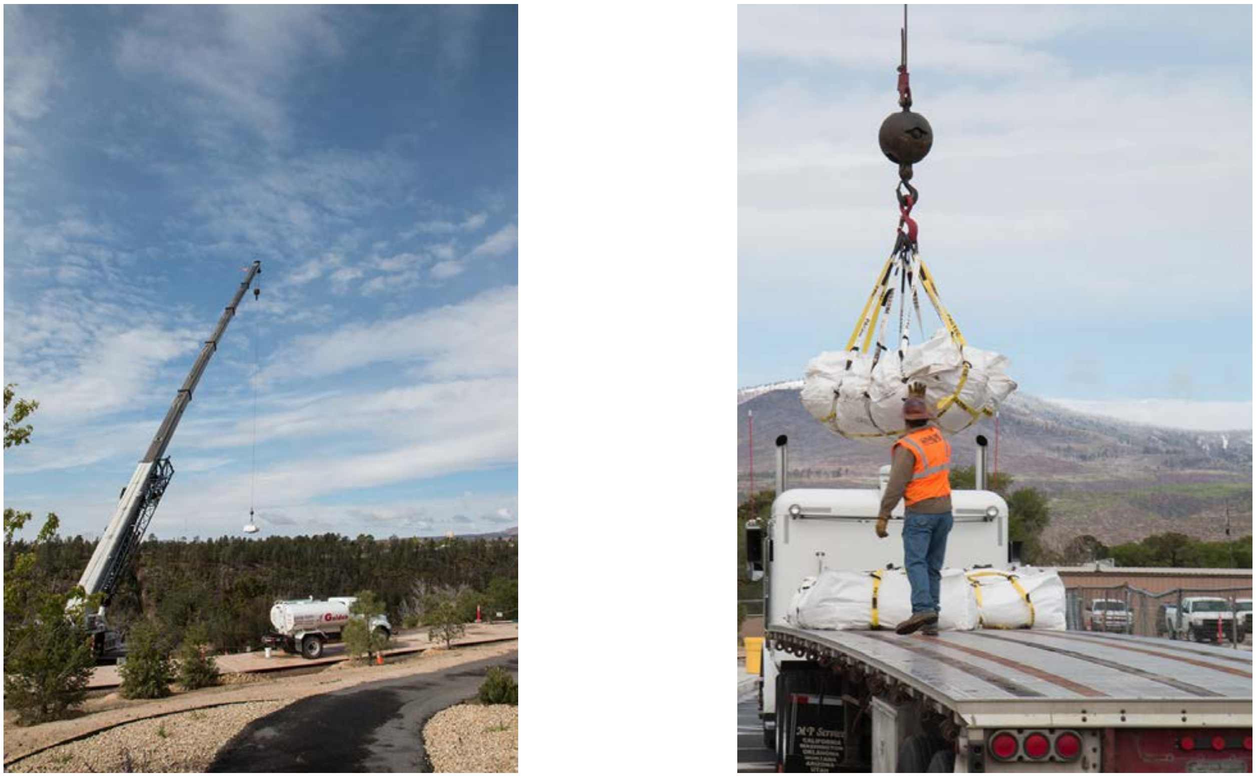

Figure 7. Hoisting from the excavation site and placement on flatbed for immediate delivery to the LANL waste staging area off public property.

Figure 8. Hoisting personnel in man-basket at SWMU 32-002(b2) excavation site.

Figure 9. Site restoration at SWMU 32-002(b2) excavation site.

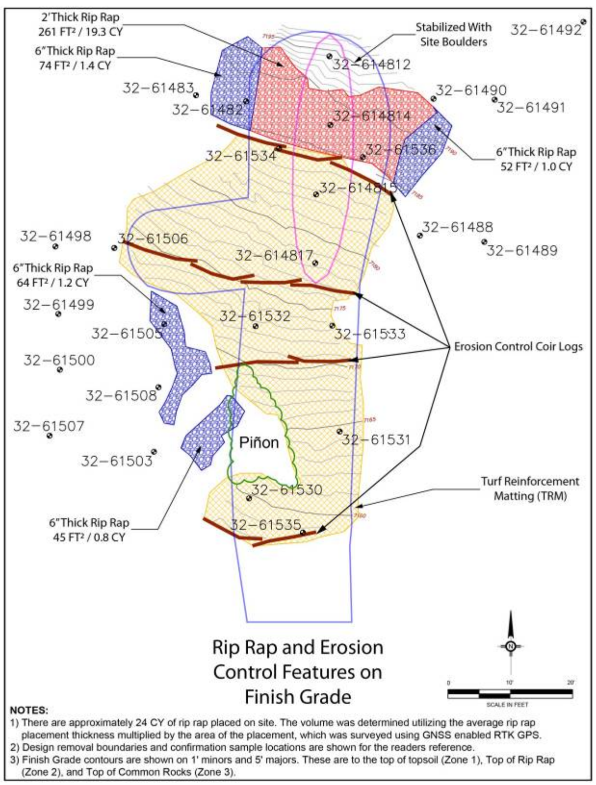

Figure 10. SWMU 32-002(b2) rip rap and erosion control features on final grade

The crane pad area was re-contoured and a berm was built using base coarse spoils from the upper and lower ramp to prevent storm water run-on to the site below. Erosion control matting was placed on top of the berm. A rip rap spill way was added to the eastern end of the berm.

The remaining base course that was used to build the upper ramp was removed and trucked off site. After base course was removed exposing the original surface, all irrigation pipes were restored and tested. After confirming that the irrigation system was fully functional, topsoil was spread across the former upper ramp. The upper ramp area was then re-seeded, fertilized, and jute matting was placed on top.

The waste arrived (Figure 11) at the LANL owned waste storage area at TA-21 for staging while the waste samples were being analyzed. The waste bags were lifted off the transport using the custom designed lifting frame and stored on bermed visqueen to prevent storm water run-on/run-off from the waste storage area. The bagged waste was also covered with heavy tarps in order to minimize exposure to the elements and possible subsequent waste bag degradation.

Once the analyses were received and evaluated, waste characterization was conducted and final off-site disposal facility selection was made. The waste profile was drafted by TPMC and approved for disposal by the off-site disposal facility. Waste bags were then packaged into IP-1 roll-off containers for ease of transport/disposal and to add an extra degree of protection for the waste en route to the disposal facility.

Figure 11. Waste staging at TA-21.

DISCUSSION

The use of the crane significantly improved the efficiency and safety of transporting other site support equipment such as waste containers, loading and lifting frames, and straw wattles and BMP materials. The crane was also used to supply day-quantities of fuel and allowed for the efficient transport of any necessary equipment-repair parts and tools.

The use of the crane and Spider Excavator offered a clear advantage for successfully restoring the site. The Spider Excavator caused significantly less ground disturbance, particularly in environmentally sensitive areas, than conventional excavation equipment or heavy foot traffic. In addition, the crane allowed the specified backfill and site restoration materials to be placed safely and efficiently directly onto the excavation site and in the quantities necessary to be effective. The Spider Excavator was also superior to manual site re-grading methods, reworking backfill materials, and stabilizing applied materials. Overall, the combined use of the crane and Spider Excavator was required to ensure the effectiveness of the range of site restoration choices.

Finally, the application of mechanized equipment reduced fatigue and other human performance factors that may have limited overall project quality and ensured the technical and data objectives of the project were comprehensively achieved. This is in contrast to an approach that relies too heavily on physically demanding manual labor, particularly on rough terrain and with increased health and safety risk and the associated personal protective equipment fundamentally reducing worker commitment to technical execution.

SUMMARY

The overall success of this project can be attributed to a superior technical approach for performing such a unique scope of work, unparalleled project planning and collaboration between The Team and the Laboratory, careful selection of the highest qualified and skilled subcontractors available to perform the job, meticulous attention to detail, an unwavering focus on Health and Safety, and finally The Team's "boots on the ground" project team members. We all had an extreme respect for one another, understood and valued our individual expertise, and were all highly motivated to perform for our client. The Team is prepared to provide support for DOE's commitment to reduce the Laboratory's historical footprint and continual progress on environmental legacy cleanup.