AN ILLUSTRATION OF THE CORRECTIVE ACTION PROCESS, THE CORRECTIVE ACTION MANAGEMENT UNIT AT SANDIA NATIONAL LABORATORIES/NEW MEXICO

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ABSTRACT

Corrective Action Management Units (CAMUs) were established by the Environmental Protection Agency (EPA) to streamline the remediation of hazardous waste sites. Streamlining involved providing cost saving measures for the treatment, storage, and safe containment of the wastes. To expedite cleanup and remove disincentives, EPA designed 40 CFR 264 Subpart S to be flexible. At the heart of this flexibility are the provisions for CAMUs and Temporary Units (TUs). CAMUs and TUs were created to remove cleanup disincentives resulting from other Resource Conservation Recovery Act (RCRA) hazardous waste provisions —specifically, RCRA land disposal restrictions (LDRs) and minimum technology requirements (MTRs). Although LDR and MTR provisions were not intended for remediation activities, LDRs and MTRs apply to corrective actions because hazardous wastes are generated. However, management of RCRA hazardous remediation wastes in a CAMU or TU is not subject to these stringent requirements. The CAMU at Sandia National Laboratories in Albuquerque, New Mexico (SNL/NM) was proposed through an interactive process involving the regulators (EPA and the New Mexico Environment Department), DOE, SNL/NM, and stakeholders. The CAMU at SNL/NM has been accepting waste from the nearby Chemical Waste Landfill remediation since January of 1999. During this time, a number of unique techniques have been implemented to save costs, improve health and safety, and provide the best value and management practices.

In the spirit of continuous process improvement, examples of techniques that have evolved with the project include:

- Preparation of electronic waste disposal request (WDR) forms,
- Use of Sprung™ structure storage for PCB impacted soils management to comply with the Toxic Substance Control Act (TSCA) storage requirements,
- Installation of inflatable dome tents for soil pile management which significantly increased employee health and safety at the site and surrounding facilities,
- Implementation of a vadose zone monitoring system for active leak detection from the containment cell,
- Improved overall site storm water control through implementation of best management practices, and
- Development of a computerized CAMU operations data management system (CODMS) that includes algorithms for determining storage and treatment requirements at the CAMU.

As expected type and volumes of waste have changed, the flexibility of the CAMU has allowed management strategies to be revised. A total of over 37,000 cubic yards of contaminated soil and debris will be accepted and managed within the CAMU. A portion of these soils will be processed through a TU soil stabilization treatment unit, and another portion of the soils will also be treated using low-temperature thermal desorption (LTTD).

This presentation will take the audience through the corrective action process implemented at the CAMU facility, from the selection of the CAMU site to permitting and construction, waste management, waste treatment, and final waste placement. The presentation will highlight the key advantages that CAMUs and TUs offer in the corrective action process. These advantages include yielding a practical approach to regulatory compliance, expediting efficient remediation and site closure, and realizing potentially significant cost savings compared to off-site disposal. Specific examples of CAMU advantages realized by SNL/NM will be presented along with the above highlighted process improvements, Integrated Safety Management System (ISMS) performance, and associated lessons learned.

INTRODUCTION

SNL/NM has been involved in nuclear weapons research, component development, testing, assembly, and other weapons-related activities since 1949. As a result of these and other activities, several sites around the 17,540-acre facility have been contaminated with hazardous wastes or hazardous constituents, radioactive materials, and/or Toxic Substance Control Act (TSCA) regulated materials. These sites are being cleaned up under the SNL/NM

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Environmental Restoration (ER) Project. The clean-up of ER Projects at SNL/NM has been accelerated through the use of a CAMU, which was initiated, through the flexibility of RCRA Subpart S, Corrective Action Program.

To expedite cleanup and remove disincentives, EPA designed Subpart S to be flexible. At the heart of this flexibility are the provisions for corrective action management units (CAMUs) and temporary units (TUs). CAMUs and TUs were created to remove cleanup disincentives resulting from other RCRA hazardous waste provisions—specifically, RCRA land disposal restrictions (LDRs) and minimum technology requirements (MTRs). While the LDR and MTR provisions were never intended for cleanup applications and since corrective actions can "generate" hazardous wastes, LDRs and MTRs apply. To maximize the operational flexibility offered under Subpart S, SNL/NM solicited and received input from a variety of sources. The CAMU at SNL/NM was initiated through dialogue with local citizens' groups, regulators (EPA and the New Mexico Environmental Department), the Department of Energy (DOE), and SNL/NM. These groups worked together to achieve the EPA's goal of protecting human health and the environment. As the SNL/NM CAMU project evolved, participation from citizens groups, regulators, and project and operations personnel helped produce operational procedures that optimized the corrective action process. Strong team work between SNL/NM's management team and contracted operations personnel provides feedback that helps meet changing project requirements. The operational improvements realized were achieved through outstanding teaming between CAMU project staff, citizens groups, SNL/NM and URS staff without compromising project goals. The flexibility in Subpart S offered SNL/NM an opportunity to achieve the desired results using operational innovation to meet customer and regulatory requirements.

After the regulatory requirements were met, EPA Region VI permitted the CAMU as a RCRA unit on September 25, 1997. Construction of the CAMU began in 1998 and was completed in 1999. Waste managed at the CAMU currently includes 37,000 cubic yards of soil contaminated with metals, organics, and polychlorinated biphenyls (PCBs). The CAMU will be used to stage, treat, and protectively manage soils generated from the cleanup of SNL/NM ER sites. Treatment and placement of these soils into the CAMU containment cell is scheduled to begin in the summer of 2002.

HISTORY AND OPERATIONS OF THE CHEMICAL WASTE LANDFILL (CWL)

The CWL occupies approximately 1.9 acres of gently sloping terrain that from 1962 until 1985, held separate, shallow, unlined pits reportedly were used for disposal of chemicals that may have occasionally included PCBs. Separate pits were used in an attempt to segregate various waste types such as acids, oxidizers, organics, reactives, metals, salts, and bulky materials. In 1981, all liquid waste disposals were discontinued and in 1985, all pits were covered with soil backfill, and the CWL operated under RCRA interim status as a hazardous waste drum storage facility until 1989. The CWL is a site being remediated under Voluntary Corrective Measures (VCMs). To achieve timely risk reduction at the CWL, SNL/NM implemented VCM for source removal and exposure pathway elimination using vapor extraction and then landfill excavation. The functions of the VCMs were to control the organic vapor plume (trichloroethylene) in the vadose zone, prevent degradation of groundwater, and remove wastes for the buried disposal pits.

Remediation of the CWL starts with buried waste materials being excavated and the soil separated from debris using a mechanically powered screen. The soils are taken by front-end loader to a sampling station where a sample is removed from the bucket. The soils are then loaded into a dump truck. The dump truck then takes the soil to a pile in the staging area of the CWL. Soil continues to be placed in this pile until an operationally efficient volume, nominally 100 cubic yards, is accumulated. Samples taken from each bucket are composited for analysis. Approximately 50,000 cubic yards have been excavated to date at the CWL. From the composite samples, the soil is characterized for RCRA and TSCA contaminants in an on-site laboratory. After the on-site analysis, the material is managed as replaceable material or treatable material, and for on-site containment or for off-site disposal. The treatable material and the direct on-site containment material are sent to the appropriate staging locations at the CAMU.

CAMU CONSTRUCTION AND SITE DESCRIPTION

To minimize concerns by local citizens groups and to all but eliminate transportation costs, the SNL/NM CAMU was constructed adjacent to the CWL. The CAMU is located on a 19-acre area immediately north and west of the CWL. CAMU operations are closely tied with operations at the CWL. Communication between project teams from the CWL and the CAMU coordinate site activities to allow both projects to progress towards completion.

The design of the CAMU was intended to allow for the efficient flow of contaminated material from staging to treatment to emplacement in the containment cell or staging for off-site disposal. Figure 1 details the layout of the CAMU.

The waste staging areas at the CAMU were constructed to provide space for the accumulation of sufficient hazardous remediation waste volumes to facilitate treatment, and to provide space for treated waste awaiting results of verification analyses. These waste staging areas have been designed to ensure contamination control by accommodating the potential forms in which hazardous remediation waste will be brought to the CAMU. The four waste staging areas include: a Containerized Waste Staging Area (CWSA) for containerized waste; four Sprung™ structures for staging containerized waste or bulk PCB-contaminated soils; a Bulk Waste Staging Area (BWSA) for uncontainerized soil and debris; and, treated waste staging area.

The CWSA is intended to provide temporary staging capacity for containerized waste. The CWSA consists of a one-acre site with compacted subgrade and aggregate base course surface. The treated waste staging area consists of prepared compacted soil.

Four Sprung™ structures were constructed for staging containerized waste or bulk waste. Each structure is generally 50 feet wide, 100 feet long, and 24 feet high, and is constructed of polyvinyl chloride (PVC)-coated, fire retardant polyester scrim stretched between aluminum ribbing. To prepare for PCB contaminated soils the Sprung structures were bermed and lined with a high density polyethelene (HDPE) liner to comply with TSCA requirements.

The BWSA provides the majority of the storage capacity at the CAMU and is primarily for uncontainerized soil and debris. The BWSA is divided into six compartments by 15-foot-high interior walls which provide physical barriers to segregate the bulk listed wastes from the bulk characteristic wastes. Constructed on a rectangular asphaltic concrete pad, the BWSA measures 300 feet long and 375 feet wide. The BWSA is divided into two symmetrical halves by a 75-foot-wide corridor used to access the BWSA compartments.

The waste staging areas were constructed to ensure the protection of human health and the environment prior to waste disposal. As part of the design, all waste staging areas are sloped to manage storm water flow into one of the four storm water retention ponds at the site. The storm water for three of the operational areas of the CAMU; the BWSA; the containment cell; and the treatment pad have individual retention ponds. There is also a site-wide retention pond to collect all other storm water from the site. To ensure protection of the environment, storm water from ponds in areas of the CAMU with active waste management operations is sampled and analyzed prior to discharging of this water from the site.

To protect groundwater and the environment during waste management operations, SNL/NM constructed and maintains the CAMU site in a manner that minimize contaminated materials from spreading from waste staging locations to other areas of the CAMU. Of particular concern was the management of storm water at the site. Use of Sprung ™ structures, inflatable tents, slope contouring, earthen berms, and silt fences was combined to direct storm water flow from coming in contact with contaminated materials. Site storm water control also prevents damage to CAMU structures by heavy run-off associated with the summer thundershowers common in the area.

Once waste has been staged, treatment of the contaminated soils is scheduled to begin. A treatment pad was constructed to accommodate low temperature thermal desorption (LTTD) and stabilization treatment (ST) technologies. The treatment pad consists of a bermed, asphaltic concrete foundation designed with minimal slope to facilitate positive runoff.

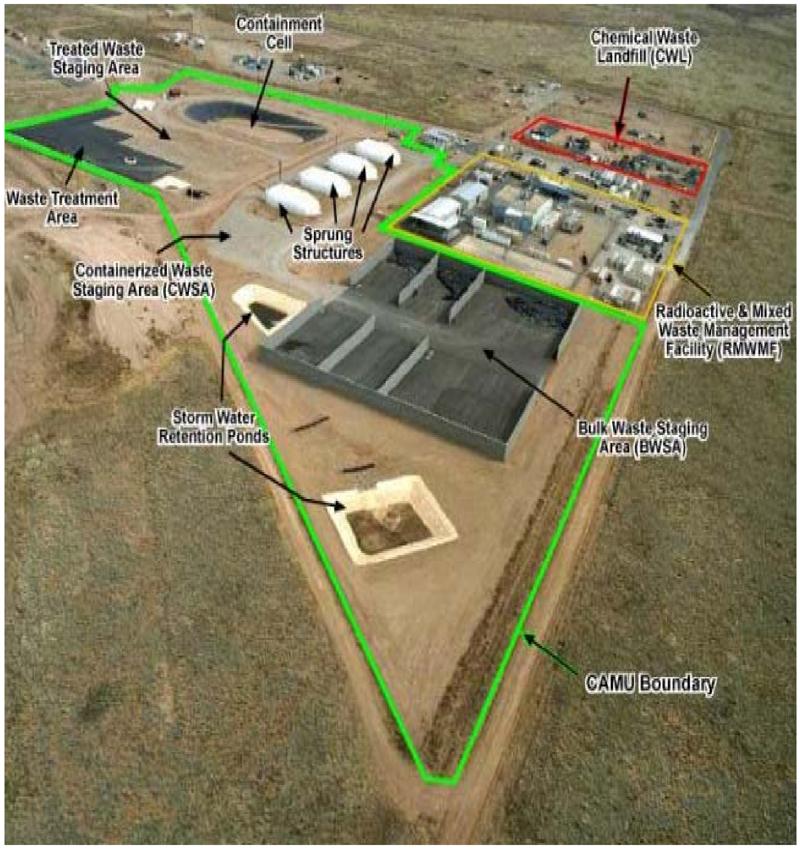

Fig. 1. CAMU Site Layout shows the locations of the waste management areas of the SNL/NM CAMU.

Treated soils will be sampled to determine treatment effectiveness. Once treated soil piles pass the treatment goals outline in the RCRA permit treated waste will be placed in the containment cell that was constructed adjacent to the waste treatment pad. The containment cell is designed according to RCRA Subtitle C standards to accommodate 1 million cubic feet of waste. The cell was excavated into the native subgrade with 2:1 (horizontal to vertical) sidewall slopes. The containment cell includes an engineered liner system designed to prevent migration of hazardous constituents, contaminated runoff, and hazardous waste decomposition products to adjacent geologic materials, and to groundwater during the post-closure period. The liner system components are designed of materials that are chemically resistant to the waste and to any leachate. The materials are of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying waste, waste compaction, waste cover materials, and equipment used in the containment cell.

Construction quality assurance of the containment cell, associated liner system, the leachate collection removal system (LCRS), and the final cover system were controlled by inspection and documentation of the quality of materials and the manner of their installation. These measures include control of construction activities, identification of organizational responsibilities and authorities, and personnel qualifications. Inspection and sampling activities, including observations and tests, were performed before, during, and after construction to ensure that construction materials and the installed containment cell components meet the design specifications.

The engineered containment cell liner system includes a bottom liner system and sidewall liner system components, which include the following:

- A geomembrane: consisting of 60-mil smooth high-density polyethylene.
- A geosynthetic clay liner (GCL): manufactured from nonwoven geotextile outer layers needle-punched through an inner layer of low-permeability sodium bentonite.

Additionally, the bottom of the containment cell has the following features to support the leachate collection and removal system:

- A protective cover: a minimum 18-inch-thick protective cover consisting of native, compacted on-site soil.
- A geocomposite drainage layer consisting of a geonet with a nonwoven geotextile bonded to the upper surface with drainage to a collection sump.

The containment cell contains a LCRS, designed to collect and remove fluid from the containment cell once waste placement and storage have begun. The LCRS overlies the 60 mil High Density Polyethylene (HDPE) synthetic liner and GCL. The 18-inch protective soil cover overlies the LCRS. Leachate from the containment cell is collected via gravity flow into the containment cell sump where it is pumped automatically using a pneumatic pump to the aboveground leachate collection tank. Prior to emplacement of any wastes into the containment cell, containment cell operations staff may temporarily replace the pneumatic pump with a submersible electric pump to more efficiently drain the LCRS. The leachate collection tank is a 20,000-gallon tank located immediately north of the containment cell. Following placement of waste in the containment cell, this tank will be operated as a less-than-90-day collection tank. As such, the tank will be inspected daily, comply with the applicable requirements, and leachate collected in the tank to be removed for disposal. The tank is equipped with a high-level sensor that shuts down the pneumatic pump if leachate collected in the tank reaches this level.

Regulation in RCRA requires that groundwater monitoring be sufficient to detect and characterize releases of hazardous constituents to groundwater that may originate from the containment cell after the closure of the CAMU. An innovative Vadose Zone Monitoring System (VZMS) was designed and installed to actively monitor for moisture releases in lieu of monitoring the groundwater, which is at a depth of approximately 500 feet. The VZMS consists of three subsystems, as follows:

- The Primary Subliner (PSL) Monitoring Subsystem;
- The Vertical Sensor Array (VSA) Monitoring Subsystem; and
- The CWL and Sanitary Sewer Line (CSS) Monitoring Subsystem.

The three subsystems have been designed to be used in an integrated fashion to achieve a high probability of detecting "real" leakage from the containment cell (low false negative rate) and to avoid false detections caused by environmental factors beyond the control of the proposed CAMU operation.

The PSL is the primary monitoring subsystem located beneath the bottom of the containment cell liner system for early leak-detection capability. The PSL has five subhorizontal access tubes that run longitudinally under the containment cell, which permit monitoring of moisture content beneath the cell by neutron probes. Should an unexplained increase in moisture content suggest a leak through the liner, a flexible everting membrane containing soil-water and soil-gas samplers can be deployed through the access tubes to ascertain the type or source of moisture.

The VSA monitoring subsystem is also located beneath the containment cell liner system and consists of 11 vertical, instrumented boreholes positioned beneath the liner subgrade around the perimeter of the cell. These boreholes do not penetrate the containment cell or the liner system. Analysis of data from these sensors, positioned at 5 and 15 feet below the base of the containment cell, will suggest whether any moisture increases sensed by the PSL monitoring subsystem originated from leakage through the containment cell liner or resulted from moisture migration through the native media. Active soil-gas samplers in the VSA system will aid in determining composition and source(s) of the infiltrate.

The CSS monitoring subsystem is located between the containment cell and the CWL and sanitary sewer line. It allows detection and identification of volatile organic compounds that could be migrating from the CWL toward the containment cell, as well as leakage from a sanitary sewer line running adjacent to the containment cell. The CSS monitoring subsystem consists of 6 vertical boreholes capable of being monitored with the neutron probe and is soil-vapor sampling points. Each borehole is 20 feet deep, contains a steel drive point (6 inches), and is connected to a 2-foot section of 2-inch diameter 10-slot (0.010 inch slots) galvanized steel screen.

Both the VSA and the CSS monitoring subsystems provides soil-gas monitoring capabilities (e.g., for volatile and semivolatile organic compounds). Soil-gas sampling is also available by deploying soil-gas samplers into the PSL monitoring subsystem access tubes, if needed. The soil-gas sampling capability serves several purposes:

- Characterization of the containment cell environment before waste emplacement;
- Monitoring soil-gas composition beneath the proposed containment cell;
- Monitoring for potential leaks from the sanitary sewer line adjacent to the proposed containment cell; and
- Monitoring for the CWL vapor plume that currently exists in the vicinity of the proposed containment cell.

At a worst-case leak location (i.e., at a point farthest from a PSL access tube), a point leak as small as 600 gallons will cause a moisture-content increase of approximately 4 percent over antecedent conditions at one or both of the adjacent access tubes. Reliable detection of this increase in moisture (probability greater than 95 percent) will be accomplished with the neutron probe/access tube PSL monitoring subsystem. If a leak in the containment cell occurs, the VZMS access tube(s) in the affected area could potentially be used to remediate the leak.

The monitoring frequency of the VZMS varies depending on the operational status of the containment cell. Figure 2 shows a cross section of the CAMU containment cell monitoring system. During active cell operations, the VZMS requires monthly monitoring. The VZMS is capable of providing real-time information on the proposed containment cell performance, allowing early detection of leaks from the containment cell.

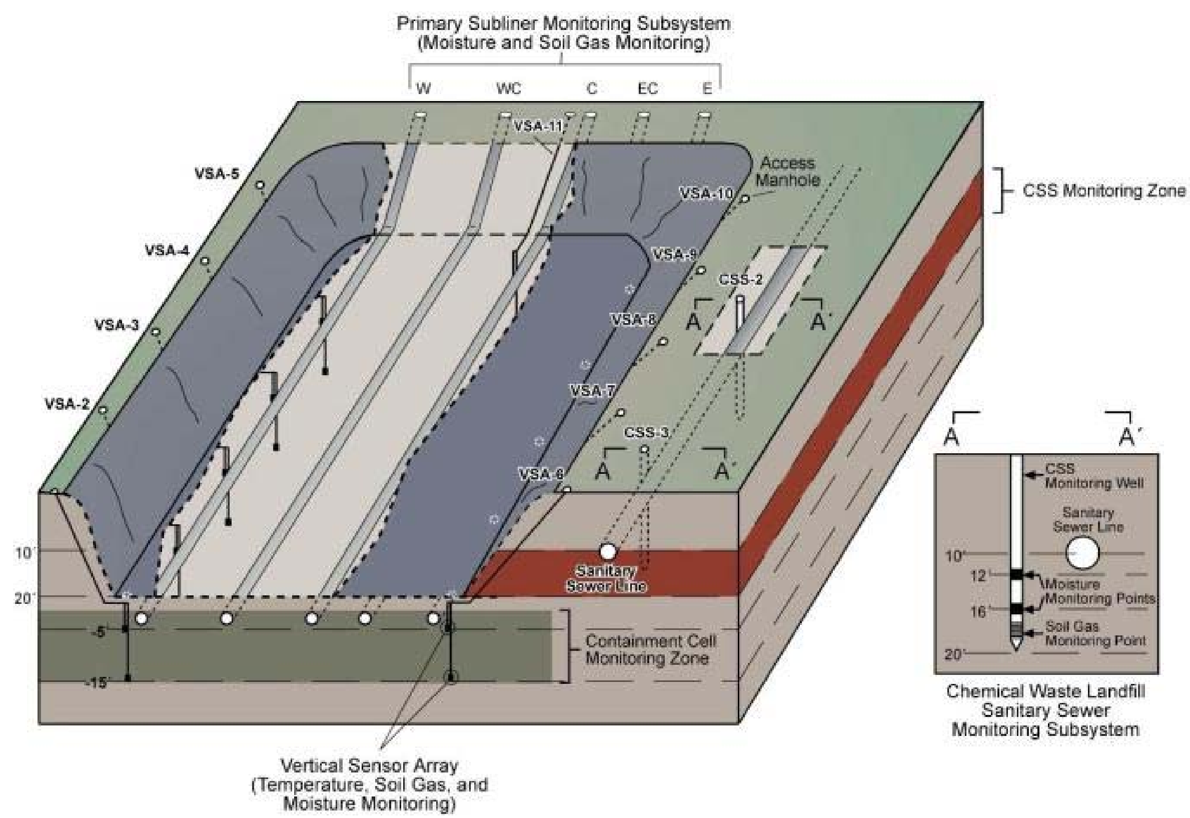

Fig. 2. CAMU Containment Cell VZMS Monitoring System

Once the containment cell has been filled, an engineered cover system will be put in place to cover the treated waste. The cover was designed to meet the following performance standards:

- Provide long-term minimization of migration of liquids through the closed containment cell.
- Accommodate for settling and subsidence so that the integrity of the containment cell cover is maintained.
- Have an unsaturated hydraulic conductivity less than or equal to that of the bottom liner system.
- Promote drainage and minimize erosion or abrasion of the containment cell cover.

These standards are intended to ensure protection of human health and the environment in the CAMU post closure period.

CAMU WASTE MANAGEMENT

Waste managed at the CAMU includes bulk soil, debris, and containerized materials from the CWL. Waste is accepted into the CAMU based on specific waste acceptance criteria. Wastes are characterized and appropriately segregated at the site of generation. The volume and potential constituents of concern for the waste are recorded, and the hazardous remediation waste is taken to the appropriate location at the bulk waste staging area, the treatment area or other appropriate waste staging location. Once the waste has been approved for acceptance into the CAMU, teams from the CWL and CAMU work together to transport the waste to the appropriate staging location. The CAMU is inspected routinely for malfunctions, deterioration, operator errors, and/or discharges that could cause or lead to a release of hazardous waste constituents to the environment, or pose a threat to human health. An inspection schedule is followed for inspecting potential problems with monitoring equipment, safety and emergency equipment, security devices, and operating and structural equipment that are important to preventing, detecting, or responding to hazards. Inspection results are recorded in an inspection log and maintained as part of the project documentation.

CAMU MAINTENANCE AND OPERATIONS

In order to maximize efficiency, CAMU operations are divided into three phases. The first phase includes staging of waste prior to treatment with no activities in the containment cell. The second phase includes treatment of waste and placement of waste into the containment cell. The third includes the construction of the cover system over the containment cell and long term monitoring operations.

In the first phase of operations, activities are initially restricted to staging operations, during which time hazardous remediation wastes are accumulated and segregated at the CAMU. The majority of the waste received at CAMU is staged in the BWSA. At the BWSA, bulk RCRA-regulated listed and characteristic hazardous wastes are segregated to eliminate cross-contamination. The bulk waste remains covered while awaiting treatment to reduce fugitive dust and potential exposure by human or environmental receptors.

WASTE TREATMENT

In the second phase of operations, waste with minimal contaminant concentrations not requiring treatment is placed in the containment cell and untreated waste requiring treatment is moved from the staging areas to the treatment area. As waste is treated, each batch is segregated at the treated waste staging area. If the treated waste meets treatment standards, the treated waste will be moved to the containment cell. If the waste does not meet the treatment standards, the waste may be re-treated to attempt meet the treatment standards. If the treatment standards cannot be achieved, the waste may be placed in the cell if it meets a higher set of standards and is containerized. Otherwise, the waste will be transported off-site for disposal.

The process flow for the treatment operations is depicted in Figure 3, CAMU Treatment Operations Flow Diagram, below. As depicted in Figure 3, trucks are loaded at the waste staging area with segregated bulk waste. The trucks then transport the untreated bulk waste to the untreated waste staging area. A small stockpile, referred to as a day pile, is accumulated on the treatment pad. The day pile is used to provide the treatment process with an uninterrupted source of material for treatment.

Waste treatment at the CAMU will be performed to meet the criteria provided in 40 CFR §264.552(c)(6). Treatment technologies have been selected to enhance the long-term effectiveness of remedial actions by reducing the contaminant levels, toxicity, and mobility of wastes that will be placed into the containment cell after closure of the CAMU. Treatment operations include treatment of soils contaminated with volatile and semivolatile organic compounds (VOCs and SVOCs) using an LTTD treatment unit and treatment of heavy metals using an ST process. The overall treatment goals and decision logic flow diagram are described in Figure 4 below with the explanation of keyed notes in Table I.

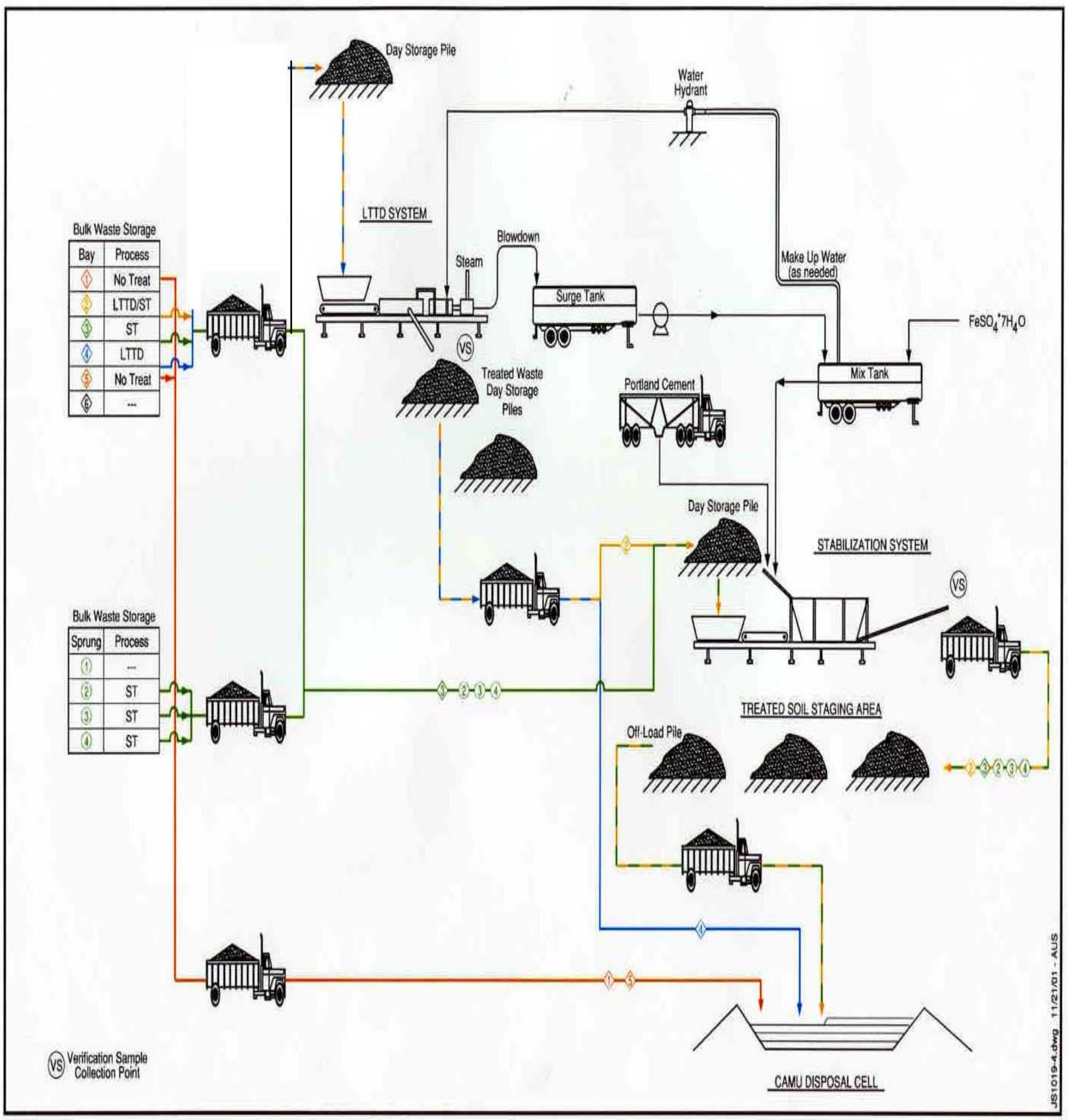

Fig. 3. CAMU Treatment Operations Process Flow Diagram

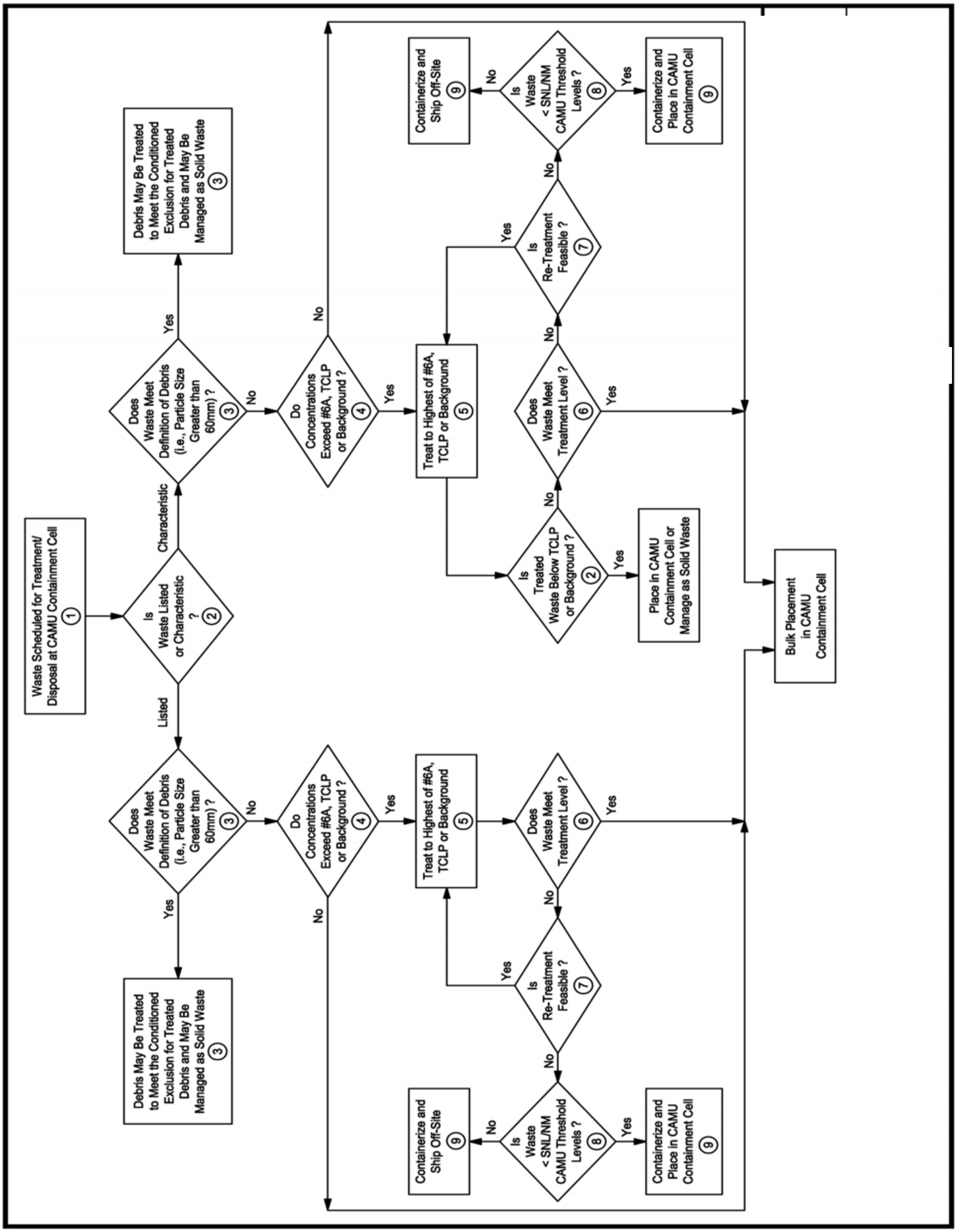

Fig. 4. CAMU Treatment Goals Decision Logic Flow Diagram

Table I
Explanation of Keyed Notes in Figure 4

No.	Keyed Note
1	Waste characterization prior to treatment will be performed as part of a voluntary corrective measure (VCM) in the SNL/NM ER Project. Waste characterization performed during the VCM will be subject to the requirements of the Sampling and Analysis Plan for that VCM and will be consistent with the CAMU waste acceptance criteria data needs. The VCM waste characterization data are imported into SNL/NM's waste tracking system and will be used at the CAMU for waste acceptance, staging, treatment, and disposal decision-making. Wastes having similar contaminant profiles will be placed in a BWSA or other storage area for storage prior to treatment or disposal. Statistical analyses of laboratory analytical results for wastes staged in each BWSA will be used to estimate an upper tolerance limit (UTL) or similar statistic to be used for making waste management decisions.
2	For waste tracking purposes, RCRA-hazardous waste streams entering the CAMU for treatment and/or disposal will be classified as listed or characteristic wastes. Listed hazardous wastes will only be managed in the CAMU or shipped off site to an appropriate RCRA facility. Characteristic hazardous wastes will also be managed in the CAMU or will be shipped off site to an appropriate facility. If the characteristic (e.g., toxicity, reactivity) has been removed through treatment, the waste may also be managed at a solid waste facility or recycled for reuse. However, the classification (i.e., listed vs. characteristic) will not impact treatment (see 4) since management in a CAMU is not subject to LDRs and other RCRA requirements.
3	40 CFR §268.2(g) defines debris as any solid material exceeding a 60mm particle size that is intended for disposal and that is either a manufactured object, plant or animal matter, or natural geologic material. For hazardous debris [40 CFR §268.2(h)], the treatment standards in 40 CFR §268.45 specify that such debris can be treated, or decontaminated, by technologies such as abrasive blasting (e.g., sand blasting) or water washing or spraying to achieve a "clean debris surface." A clean debris surface is achieved when the surface, when viewed without magnification, is free of all visible contaminated soil and waste except for residual stains (light shadows, slight streaks, or minor discoloration) and small amounts of material in cracks, crevices, and pits, provided that such residuals account for no more than 5% of each square inch of surface area. After treatment, the debris is not subject to RCRA Subtitle C and can be recycled/reused. At the CAMU, wastes with an average particle size exceeding 60 mm will be managed as debris.
4	Remediation wastes will be evaluated for treatment using three concentration-based decision criteria: *Superfund LDR Guide #6A* performance levels, TCLP levels, and SNL/NM background levels (metals only). If the waste concentrations are below any of these criteria, the waste will not be treated prior to disposal. If the waste concentrations are not below any of these criteria, the waste will be treated as specified in 5.
5	If the waste concentrations exceed the decision criteria in 4, the waste will be treated via low-temperature thermal desorption to the highest level specified by these criteria. For example, assume a waste shipment arrives at the CAMU containing 1,4-dichlorobenzene at a concentration of 500 milligrams per kilogram (mg/kg). The decision criteria are as follows: #6A=90% reduction (50 mg/kg), TCLP=150 mg/kg (using the 20x rule-of-thumb to convert from an acceptable leachate level to an acceptable level in solid materials, the TCLP limit of 7.5 milligrams per liter (mg/L) is equivalent to 150 mg/kg). Background is an inappropriate criterion for this organic constituent. The waste exceeds the decision criteria and, therefore, would be treated. The treatment level is the highest of these levels—in this case, 150 mg/kg.
6	A determination whether the required reduction in contaminant concentration has been achieved for each batch of treated wastes will be made based on the UTL (or similar statistic) for that group of wastes and the post-treatment analytical results for that treatment batch. Analyses may be performed in SNL/NM's on-site environmental laboratory or at an approved off-site laboratory. Wastes that have been successfully treated will be placed in the CAMU's containment cell or managed appropriately.
7	If any treated waste fails to meet the treatment levels specified in 5, the feasibility and economic viability of re-treating the waste will be assessed. Typically, re-treatment will be the preferred approach. However, any waste materials that are viewed to be incapable of meeting the treatment levels through re-treatment or that would require an exorbitant amount of treatment due to physical, chemical, or other characteristics, will be placed in containers for disposal as specified in 8 and 9.
8	SNL/NM has adopted protective CAMU threshold levels. These threshold levels will be used to determine when wastes that failed to meet the treatment levels in 5 can be containerized (see note #9) and placed in the CAMU or sent to the SNL/NM Hazardous Waste Management Facility for shipment off site.
9	Any waste that does not meet the treatment levels specified in 5 will be containerized. This volume is expected to be small and wastes will typically be placed in 55-gallon drums or similar containers. However, the appropriate container type will be selected based on waste volume. All containers will be labeled and tracked accordingly.

The LTTD system consists of a primary thermal desorption trailer, a secondary treatment trailer, and control systems. The primary thermal desorption trailer consists of a feed hopper, cold-feed conveyor, weigh belt conveyor, rotary drum (equipped with a gas-fired burner that produces low levels of nitrogen oxides [NO_x]), baghouse, induced draft blower, and moisturizing discharge auger. The feed rate capacity of the LTTD system ranges from 10 to 25 cubic yards per hour. Soils are heated in the LTTD rotary drum to volatilize contaminants into an air stream that can be removed for further treatment. After the particulates are filtered from this air stream in the baghouse, the filtered air stream is sent to the secondary treatment trailer that consists of a heat exchanger, catalyst preheater, catalytic oxidizer, quench, acid gas scrubber, recycle pump, induced draft blower, and exhaust stack. The secondary treatment system destroys the volatile and semi-volatile contaminants in the air stream.

The ST system is a stand-alone, mobile treatment unit designed to effectively remediate soils contaminated with metals. The ST process consists of several integrated unit operations. Stabilization and solidification of the fine-grained soil is accomplished by using a combination of Portland cement, ferrous sulfate (if soil is contaminated with Cr+6), and water. Stabilization of the fine-grained fraction and metals is accomplished using a design mix that is formulated for the specific waste characteristics to ensure effective chemical fixation and microencapsulation of the metals. Portland cement and water (or process water) are mixed with the fine fraction to microencapsulate and stabilize the soil particles and metals in a monolithic solid, which has minimal structural strength and low potential for leaching. Soils contaminated with hexavalent chromium (Cr+6) are treated by adding ferrous sulfate (or equivalent) to the mixture to chemically reduce the Cr+6 to the less toxic, nonmobile trivalent form.

Bench-scale tests of SNL/NM soils have demonstrated that Portland cement and ferrous sulfate are effective for reducing the solubility of Cr and increasing the strength of the materials. Soils containing Cr+6 concentrations of 1,212 mg/kg that were stabilized using a combination of 10% Portland cement and 1% ferrous sulfate had a TCLP-extractable Cr concentration of less than 0.5 mg/L and an unconfined compressive strength (UCS) of greater than 100 pounds per square inch (psi). The extractable Cr concentration is well below the RCRA TCLP standard of 5 mg/L total Cr specified in 40 CFR 261.24. The data confirm that this mix design is effective for solidifying metal-contaminated media. The quantity of cement and additives will be adjusted in the field for each source based on waste characterization data and trial mix tests.

WASTE PLACEMENT

The containment cell is designed to accommodate 1 million cubic feet of treated waste and measures approximately 200 feet wide by 300 feet long. The containment cell is subdivided into surveyed and numbered subcells, creating a grid pattern based on the cell dimensions. As bulk waste soils will comprise the majority of the waste placed in the cell, each treated and untreated batch placed will be surveyed with x, y and z coordinates related to permanent monuments placed at each corner of the containment cell. Placement of waste into the containment cell will be recorded in the CAMU Operations Data Management System (CODMS). Markers (e.g., stakes) will be maintained to assist in identifying the approximate boundaries of each placed batch. LTTD-treated soil, stabilized soil, and bulk soil that meet the CAMU waste acceptance criteria will be placed into the CAMU containment cell. The CAMU cell has an engineered liner system designed for long-term waste containment. After waste emplacement is complete, an engineered cover will be constructed. A vadose zone monitoring system (VZMS) has been constructed for leak detection monitoring of the containment cell.

Bulk materials generally are placed in the containment cell directly from dump trucks or front-end loaders used to haul the waste. A tracked vehicle (such as a bulldozer) is used to spread and compact bulk waste within the cell. Bulk wastes are applied in compacted lifts of 8 to 12 inches, and compacted with a compaction equipment suitable for granular soils.

Debris that cannot be decontaminated or recycled may be placed in the containment cell. Such debris is crushed, flattened, or cut up to minimize void space, thus reducing the potential for settlement problems. Any material that cannot meet the treatment goals is containerized prior to placement in the containment cell. Empty containers not suitable for recycling will be crushed or flattened prior to land disposal in order to reduce volume and prevent subsidence.

CAMU OPERATIONAL INNOVATIONS AND LESSONS LEARNED

The CAMU at SNL/NM was the first CAMU administered by the DOE. As the operation of the CAMU continues, many process improvements have and continue to be applied. The operational requirements of the CAMU are flexible, as long as the protection of human health and the environment are ensured. This flexibility increases the need for careful decision making and documentation.

CAMU Operational Data Management System

To support documentation and waste management decision-making at the CAMU, CODMS, a data base that tracks waste handling and associated operations. CODMS allows for tracking of each unit of waste (e.g., bulk soils, drum, roll-off box, etc.) from its entrance into the CAMU through staging, treatment, re-staging, and final placement in the containment cell (or exit from the CAMU should the waste require off-site disposal). As such, CODMS allows for real-time querying of the waste location for each cataloged unit of waste along with records of the current chemical make-up and other associated data (e.g., volume, containerized/covered, other wastes that it is stockpiled with, treatment results, etc.). CODMS is also being used to track waste generated on site at the CAMU, such as storm water, and accumulating hazardous waste such as soiled personal protection equipment, used liners and sandbags from the BWSA.

The data management system also includes an administrative user interface created in Microsoft Access software and a web-based client interface. CODMS also has an intelligent infrastructure employing the CAMU waste acceptance criteria and treatment goal decision logic to help CAMU maintenance and operations staff make decisions regarding proper waste management. For example, information tracked by CODMS can help determine:

- Whether the incoming waste can be accepted at the CAMU;
- Where the incoming unit of waste should be staged (acceptable staging locations);
- Whether treatment is required, and if so, what type(s) of treatment is required;
- Whether treatment has been effective and soil may be moved to the containment cell;
- What other wastes the particular unit of waste can be bulked with for treatment.

CODMS is also used to track other information, which may include, but not be limited to:

- Whether treated waste passes the treatment goals or needs to be containerized, and
- Containment cell leachate generation, analysis, and disposal.

Dedicated Haul Route

Documentation of waste management activities is not only required, but can also be useful in receiving approvals from regulatory agencies. An example is the management of decontamination water. A major waste stream at SNL/NM CAMU is decontamination water generated from the decontamination of equipment used to transport waste from the CWL to CAMU staging locations. To help minimize the volume of decontamination water, the construction of a dedicated waste transport route connecting the CAMU and CWL was proposed by SNL. Through decontamination water analysis records, SNL/NM was able to show that the dry decontamination methods used at waste staging locations provided adequate protection against the spread of contaminants from waste staging locations to other CAMU operation areas. The approval to construct the dedicated waste transport route provided cost saving through reduced wastewater generation, sampling requirements and reducing the time required to transport waste from the CWL to the CAMU.

Minimization of Waste Management Areas

Reducing costs and improving operations was also realized through the two phase approach to CAMU operations. By separating the treatment and containment cell operations from the waste staging operations, a substantial portion of the CAMU site was excluded from many permit requirements. Freedom from the personal protection equipment requirements, storm water sampling requirements, and equipment and personnel decontamination requirements, helped reduce costs and allowed the set up of treatment equipment and containment cell monitoring activities to be performed independent from waste staging activities.

Inflatable Soil Pile Covers

As part of cost reduction initiatives, operational innovations are primarily measured against maintaining health and safety requirements and the protection of the environment. The flexibility of Subpart S, along with program such as SNL's Integrated Safety Management System (ISMS) make it possible for operational improvements to be implemented. ISMS provides the framework for continuous process improvement by using work planning and hazard analysis and control, followed by feedback from personnel involved in performing the work. For example, the CAMU permit requires bulk waste in the BWSA to be covered when waste management activities have stopped. Originally, this requirement was met by using 12 millimeter HDPE liner panels that ranged in size from 50' x 50' to 100' x 100'. The liners covering the waste were secured by placing sand bags on top of the panels. As the segregated bulk waste piles grew larger, covering and uncovering the wastes became increasingly difficult. This process also required a large number of workers in Level B respiratory protection to manipulate the liners on the waste piles. During inclement weather, workers were required to traverse the steep soil piles with level B PPE on wet sheets of plastic.

The health and safety concerns associated with the BWSA waste management activities became a strong driver in selecting an alternative method for meeting this CAMU permit requirement. The method selected for meeting the bulk waste management requirements was the installation of frameless inflatable tents, which not only improved health and safety conditions for workers, but also benefited waste management operations.

The inflatable tents improved health and safety conditions by eliminating the need for respiratory protection during the waste covering and uncovering operations. The number of personnel required to cover or uncover the bulk waste was reduced to two, and contact between bulk waste materials and personnel was reduced.

Waste management operations were improved by providing inflatable tents, which yielded a more secure cover. The need for sandbags was virtually eliminated, greatly reducing waste generated as a result of damaged used sandbags. Damaged, used liners were also virtually eliminated as a generated waste. The operation was also improved by reducing the time required to prepare the piles of bulk waste for acceptance of additional waste. The only requirement in regards to covering the soil piles is that they be protectively managed. This flexibility allows the use of alternative methods such as the inflatable tents used at the SNL/NM-CAMU.

Vadose Zone Monitoring System

Like the waste management requirements at the BWSA, the method for meeting groundwater monitoring requirements for SNL/NM CAMU were also modified. SNL/NM developed the VZMS to meet the CAMU permit requirements while providing project personnel with useful real time information on the containment cell performance. Advantages of the VZMS include:

- More rigorous and useful results
- Capability to provide real-time data on containment cell performance
- More timely leak detection than is possible with a typical groundwater monitoring system
- Ability to detect a leak that is orders of magnitude less in volume than a leak required for detection via groundwater monitoring
- Ability to help remediate or contain a potential leak
- Ability to differentiate between contaminant sources

CONCLUSION

With any environmental restoration project, proper planning is the best tool to insure a smooth operational process once the project is underway. However, plans can only be made on the information available. When dealing with unknown conditions, the flexibility of CAMU regulations coupled with a dedicated project team can mitigate issues not addressed during the project-planning phase. At the SNL/NM CAMU, changes in waste volumes, contaminants, and treatment and storage requirements were encountered and resolved with input from citizens groups, regulators, management, and operational personnel. Currently, over 37,000 cubic yards of bulk hazardous wastes have been accepted into the SNL/NM CAMU. While the procedures used in management and staging of these wastes at the SNL/NM CAMU have changed, the mechanism that created those changes remains in place. The flexibility built in to the CAMU regulations is valuable, but without an equally flexible management and operation strategy, the full potential for process efficiency cannot be realized.

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