Operation of a Waste Management Area during Decommissioning - 14327

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ABSTRACT

AECL's Whiteshell Laboratories (WL) site in Eastern Manitoba, Canada is being actively decommissioned under the auspices of the Natural Resources Canada Nuclear Legacies Liability Program (NLLP). Developed in the 1960's WL consists of an organically cooled research reactor, radiological laboratories, hot and warm cells, active liquid waste treatment facility and assorted active and non-active support buildings. The main WL campus, other than security and radiological and environmental monitoring laboratories, is forecast to be largely decommissioned by 2028. Active operational waste and most of the active decommissioning waste from the site is stored in the Waste Management Area (WMA). Remediation efforts and storage and protection of the waste material will continue at the WMA beyond that timeframe. This paper outlines the WMA, its setting, planned remediation work and waste storage.

INTRODUCTION

Planned in the late 1950's to further develop Canada's nuclear research capability, and constructed beginning in the early 1960's, WL consists of an organically-cooled research reactor, radiological laboratories, hot and warm cells, active liquid waste treatment facility and assorted active and non-active support buildings. In 1997, a decision was made to cease operations at WL and in 1998 it was decided to decommission the WL site. Before the responsible federal authorities would permit the decommissioning of the WL site to begin, they determined a comprehensive study under the Canadian Environmental Assessment Act (CEAA) was required. The Comprehensive Study Report (CSR) [1] was published in 2001 and reviewed by federal authorities and the public. Based on the content of this report, the Federal government and the Canadian Nuclear Safety Commission (CNSC) gave their approval and AECL was granted a decommissioning license by the CNSC in 2002.

The main WL campus (Fig 1), other than possibly a security building and a radiological and environmental monitoring laboratories building, is forecast to be largely decommissioned by 2028 with work continuing on remediation activities at the WMA beyond that time according to the strategic plan developed for the site [2]. The WMA (Fig 2) is located approximately 2 km northeast of the main WL campus and covers an area of approximately 4.6 ha. The WMA hosts above-ground Low Level Waste (LLW) bunkers, in-ground Intermediate Level Waste (ILW) Bunkers, in-ground vertical concrete tubes called standpipes, waste trenches, steel storage structures, a liquid waste incinerator, a soil storage compound (SSC), a Shielded Modular Above Ground Storage

(SMAGS) building for LLW, and a small operations building (Fig 2). The WMA will continue to undergo remediation of the standpipes and ILW Bunkers and will continue to store waste beyond the 2028 timeframe until a repository is constructed to accept the waste materials. There is a 200 year institutional control period described in the CSR once the waste material that is to be moved to a repository is transported from the site [1]. Adjacent to the WMA is the Concrete Canister Storage Facility (CCSF) (Fig 1). The CCSF provides dry storage for used fuel from WR-1 Reactor and other fuel materials from research and testing. Once a disposal facility has been established for the fuel inventory, the fuel will be transferred for disposal.

As the main WL campus is decommissioned, work space will be required for WMA operations staff, and associated radiological and possibly environmental monitoring personnel and security (assuming removal of the main site buildings designated for this purpose) required to maintain the WMA and to ensure monitoring and compliance requirements are met for the regulators. The ongoing remediation at the main campus and the preparation for remediation activities at the WMA require that the WMA continues to accept waste from decommissioning but also that work is executed to maintain and enhance its capabilities.

SETTING

The WL site is in a mid-continental climate; temperatures range from daily mean of - 18.4°C in January to 18.8°C in July. Precipitation averages 56.2 cm including 127 cm of snowfall [1]. The location of the WMA was selected as it is a groundwater discharge zone in a topographic low. Thus any contamination escaping from the waste storage structures would not be transported through groundwater flow.

The WMA is underlain by 0.5 m of organic material, 1.5 m of silt, 2.5 m of plastic glacial lacustrine clay with a low in situ permeability ($<3x10^{-7}$ cm/s [1]). Below the clay layer is 5 m of low permeability clayey till, in turn underlain by a 3 to 5 m of a sand-based aquifer unconformably overlying the Lac du Bonnet Batholith bedrock. The sand layer recharges to the east of the WMA and horizontal flow ($8x10^{-4}$ cm/s) [1] is westward towards the Winnipeg River.

Part of the safety case of the WMA against contamination migration requires no excavation below 4.5 m depth to prevent penetration of the clay layer, which with its low permeability acts to restrict water movement. Additionally, groundwater discharges towards the surface. This ensures that any radionuclides that may escape their storage location are not carried through the groundwater into the sand aquifer.

Discharge from the base of the clay till unit to surface is on the order of months to a few years. Water reaching the surface is transpired by plants or evaporates. The location of the WMA in this discharge zone does present challenges in terms of current storage and eventual remediation as waste materials that were placed below the groundwater level (ILW bunkers, standpipes and waste trenches) will have become saturated during their internment period. The earliest waste was placed in the mid 1960's and this is sufficient time for groundwater to have entered these structures.

Despite the saturated condition of the waste and their storage structures, the condition of the structures is acceptable. A fitness for service study was conducted on the ILW bunkers in 2007, and the concrete of the storage structures was found to be fit for service. While the groundwater chemistry is known to have elevated sulphates, the low permeability of the soil reduces the potential impact of sulphate attack to the concrete.

WASTE STORAGE STRUCTURES

Fitness for service of the waste storage structures located in the WMA (Fig 3) is maintained through the development and conduct of periodic inspections to guide ongoing maintenance on the concrete storage structures. Rigorous engineering change control processes ensure that required changes and modifications are documented and carried out according to applicable fire and building codes.

Trenches

The earliest waste placements in the WMA used underlined trenches for LLW materials. A minimum of four out of a total of the 23 trenches are planned to be remediated due to the presence of hazardous chemicals or higher level waste material [1]. The trench locations are marked by corner posts and some preliminary ground survey work has been done to better define the locations of material in those trenches. The trenches were used for LLW placement until 1985 when the use of above ground bunkers was initiated.

ILW Bunkers

All ILW bunkers at the WMA are variations on grade supported designs with varying approaches to water inflow control. The first three bunkers were divided into four cells (ILW Bunkers 1, 2 and 3) with concrete walls with water stopped keyways and were approximately 13.6 m by 5.6 m by 3.3 m in height. Temporary roofing was placed over the bunkers during operation and once filled with waste, sand was used to fill any remaining gaps and a monolithic roof slab up to 0.75 m thick was poured. ILW Bunkers 1, 2 and 3 had no sumps and as expected are now fully saturated.

ILW Bunkers 4 and 5 are of similar design, approximately 13.6 m by 6.3 m and 3.3 m in height, with a sump and four compartments. ILW Bunker 4 is still in operation and has a metal clad weather roof in place. An average of 360 litres per year is pumped from this bunker and the pumped water is classified as Intermediate Level Liquid Waste (ILLW). ILLW from the bunkers was formerly collected in a shielded tanker trailer that was transported to the main site and the water transferred to the Liquid Waste Treatment Centre at the main WL site. Until ten years ago solidification of the ILLW was performed, since then evaporation has been used to reduce the volume of fluid. The Waste Treatment Centre is in the early stages of decommissioning and is no longer accepting ILLW. Instead it will be collected in highway transport approved containers and sent to an offsite processing centre. The returned dry sludge will be stored in waste containers and routed to the appropriate ILW bunker or SMAGS.

ILW Bunker 5 was built raised approximately 1 m above grade and then soil was raised around it. ILW Bunker 5 is closed with a 0.75 m thick roof slab. While it has a sump, damage had occurred in the past to the pump out line, recent repairs to the line have shown that this bunker also contains water. The decision to remove this water and those of ILW Bunkers 1, 2 and 3, has not yet been made as large-scale pumping in the area could disturb the groundwater flow that is part of the safety case for the WMA.

ILW Bunker 6 is of a different design than the previous five ILW Bunkers. It is approximately 11.1 m by 6.6 m by 5.2 m in height, and is approximately one half below grade. The roof incorporates concrete beams spanning in the north-south and east-west directions to form a grid. Beams are 1000 mm deep and taper from top to bottom. The beams incorporate a drainage trough sloped to the exterior of the structure. The roof grid is closed by tapered reinforced concrete plugs that fit into the openings between the beams. ILW Bunker 6 averages approximately 1500 litres per year of water inflow, which also requires treatment as ILLW. Initially it had been thought that water entered between plugs on the roof. Sealing measures around these plugs did not reduce inflow so it is now believed water inflow occurs at or below grade.

ILW Bunker 7 is of a six cell design and is approximately 12 m by 6 m by 3.3 m in height, and is approximately one half below grade. It employs concrete roof slabs that are removable. It experienced minor amounts of inflow until temporary seals between the slabs were installed, showing that the water incursion was from rainfall or snowmelt. The bunker is still operational.

The inflow into ILW Bunker 6 and the subsequent determination that ILW Bunkers 1, 2, 3 and 5 contain water has led to the initiation of planning for characterization in the immediate vicinity of the ILW bunkers and the start of planning for remediation options for these bunkers. The characterization effort will determine the pace and input into the approach for eventual remediation of these bunkers.

The Above-Ground Storage Bunker (AGSB) (ILW Bunker 8) was constructed for the storage of waste from the Active Liquid Waste (ALW) cementation project. The bunker stores all of the cemented Amine and Thorium Fuel Reprocessing (TFRE) wastes and a small amount of TFRE waste that was calcined in stainless steel containers during an earlier solidification experiment. Amine waste had been previously stored in underground amine tanks at the WMA. That waste had been pumped out and cemented in drums. ILW Bunker 8 is small, approximately 3 m by 4.4 m, and was cast with six locations to insert the cementation drums. Each location has a carbon steel sleeve. An aluminum roof was installed over the bunker to shed rain from the storage locations. Space remains in the bunker for any liquid heel that may exist in the amine tanks. The tanks are due to be remediated in 2015/16.

Standpipes

The standpipes are an array of 171 in-ground waste-storage concrete tubular structures, 69 of which contain fissionable materials (FM). The 171 standpipes are of two main designs. The older version was two pre-cast pipes segments with a third bottom section. These were tensioned together with two steel cables in channels located 90° apart. The joints were sealed with a gasket. The exterior was coated in bitumen and the assembly was lowered into an augered hole. Interior dimensions were 0.46, 0.61, 0.76 and 0.91 m inner diameter and they were approximately 3.7 m in height. Waste material was transported from the main WL site using a flask, the material was removed from the flask using a small crane and lowered over the standpipe and released. Later a bottom release flask was used. Layers of sand separated placements of waste. Once a standpipe was full, a layer of bitumen was placed and the top sealed by a concrete cap of varying thickness.

The newer style standpipes consisted of a hot dip galvanized liner suspended in a rebar cage inside of a pre-excavated hole. The top of the standpipe was formed but the bottom conformed to the excavation perimeter. Concrete was poured in place. These standpipes were either 0.61 or 0.91 m inner diameter and approximately 4.3 m in height. At first these standpipes were sealed in manner similar to the older standpipes, although a bitumen layer may not have always been present. For later placements a removable plug was installed rather than a poured-in-pace cap.

Standpipe walls are approximately 0.2 m thick. It is expected that all the older standpipes and at least a portion of the more recent standpipes will be water filled. Removal of two empty standpipe plugs showed one to be full of water and the second to be nearly empty.

The standpipes contain, among other intermediate level waste such as filters, material from Post Irradiation Experiments (PIE) in the WL Hot Cell Facility. AECL had committed to remediate the 69 FM containing standpipes [1] [3]. Benchmarking efforts to assist in a path forward for remediation were undertaken in 2012. From these exercises, the preferred approach was determined to be a purpose built facility situated adjacent to the standpipe area. With the construction of such a facility, the remediation of all standpipes to limit future liabilities became the preferred option. The facility is also envisaged to be suitable for remediation of the adjacent ILW bunker material. This facility would be one of the areas identified to conduct remediation operations beyond the 2028 timeline of the main WL campus. Removal and re-packaging of the ILW from the bunkers and standpipes may require the construction of an above ground storage building at the WMA to contain the re-packaged ILW until an offsite repository is in operation.

LLW Bunkers

With evolving outlooks on the handling LLW in Canada, the use of trenches was discontinued at WL in 1985 and the use of slab-on-grade, above ground LLW bunkers were adopted. These LLW bunkers are poured-in-place concrete with essentially flat concrete roofs (Fig 4). The LLW bunkers at WL were constructed in two sections. The bunkers were expanded as waste was generated and additional storage space was required. Each section includes a floor, walls, and roof poured in turn. When the second section was added to each bunker, a rubber weatherstop was installed at the joint. The footprint of the bunkers is approximately 7.2 m by 27 m by 5.3 m in height. When a LLW bunker was filled, the access wall was sealed. This type of bunker is not ventilated, so internal moisture may be an issue for the materials stored within the bunkers. Sample ports exist on the east wall to allow air sampling if required. All these bunkers have sumps. Five have been sealed, the most recent in 2013. The sixth bunker of this type is still operating.

Due to the cast-in-place nature of this type of bunker wall, they have a tendency to crack from thermal stresses as there were insufficient expansion gaps in their design. Regular maintenance helps to ensure the serviceability of these bunkers.

SMAGS

More recently, the WMA saw the construction of a SMAGS (Fig 5) in 2010 with the first waste accepted in 2012. The building is approximately 30.5 m by 47.2 m by 7.9 m in height. The building is constructed using pre-fabricated concrete technology for walls, columns, beams and roof panels. The SMAGS concrete wall panels have a thickness of approximately 0.36 m, which provides adequate radiation shielding. The concrete roof panels have a minimum thickness of approximately 0.05 m. The buildings are unheated, and are provided with internal and external lighting, fire detection, and a ventilation system. The ventilation system is provided to exhaust fumes from waste handling equipment and to moderate seasonal heat fluctuations. It consists of two intake louvers installed on one of the end walls, and an intake louver and an exhaust fan installed on the opposite wall.

This style of storage facility is in use in several locations in Canada. The SMAGS building has a large thick-edged slab underlain by compacted fill and a geotextile to collect leachate. The roof is slightly angled to encourage run off of rainwater. Waste is placed in B25 or B1000 steel dry waste storage containers. All the containers will be emplaced in the building following a specific loading strategy designed to optimize use of the available storage space while minimizing radiation fields and operator exposure. The SMAGS is capable of storing up to 4000 m^3 of waste material with approximately 67.5 m^3 currently in storage as of fall 2013.

Soil Storage Compound

A SSC was constructed in the WMA to accommodate radiologically contaminated soil materials from the WL site. The SSC consists of: a base built above ground level consisting of approximately 1 m of re-compacted clay sandwiched between layers of stone, geotextile and liner materials, and an anchor trench system to terminate the liner components (~1.5 m total thickness); an approximately 2 m high perimeter berm with an internal dimension of 34 m by 22 m, a 0.5 m deep ditch around the perimeter berm; and a stormwater and leachate collection and monitoring system.

The soil will be placed in 1 m^3 bags in the SSC and will be layered to create a pyramid shape for placement. Once filled at an estimated 2000 m^3 of soil, a soil layer will be placed over top. The first soil destined for the SSC is soil from the Cesium Pond, an experiment to study the migration of Cs in a representative marsh biome. The Cesium Pond has been remediated and the soil stored adjacent to the WMA for processing into clean and contaminated material. Further soil material will come from the foundation of SMAGS building, an area adjacent to the liquid waste storage building, and from crawlspaces of some of the active labs.

Warehouse Storage

Four steel Quonset warehouses provide flexibility for storage of materials such as soil recovered for environmental monitoring, equipment used in the WMA, and Phase 1 decommissioning waste from the WR-1 reactor. The Phase 1 material was removed from the reactor building after shutdown of the reactor in 1985. The material is stored in wood crates that were steel banded. Some of the material contained remnant organic coolant from WR-1 and vermiculite, that is now known to contain asbestos, was added to absorb excess coolant. Other material includes pipe insulation that is known to be asbestos containing.

One of these Quonsets, which formerly contained a compaction and baler unit, is being re-purposed to be a sorting and remediation facility for the Phase 1 WR-1 reactor decommissioning waste. The handling facility will allow this waste to be processed to remove the asbestos and to perform a survey of the waste to determine its routing; release for recycling, metal melt, or routing to storage in the WMA.

FUNCTIONAL GROUPS AT WL

To ensure the WL site as a whole is maintained and remediation work executed in accordance with the Site License and Federal and Provincial legislation, responsibilities are divided between three functional groups on site.

- WL Facilities, which includes General Site Services (GSS) and Nuclear Facilities (NF). GSS includes provision of landlord and property management, utility services (e.g., sewer & water, heating, taxes, insurance), grounds and roads, transportation, stores, shipping & receiving and information technology. NF includes provision of waste handling and storage and operation of listed nuclear facilities.
- Project Delivery includes work planning and management, provision of skilled trades, project management and work execution. This can include the use of external resources through the recruitment of knowledgeable and experienced contractors specialized in the work.

- Programs and Regulatory Compliance includes provision of analytical services, environmental monitoring, work safety & occupational health, radiation protection (surveyors, decontamination crew), health physics, records and information management, emergency services, physical security, design and engineering, safety and licensing, and quality assurance/control.

These groups work together to decommission the WL site, remediate the waste and ensure safe operations and ongoing monitoring.

WASTE GENERATION, ACCEPTANCE AND STORAGE

During the operational phase of WL waste was generated from multiple sources, primarily experimental work and reactor and facilities operations. Gain/loss records provide the primary traceability for FM and to ensure waste placement remained subcritical and facilities remained in compliance with Criticality Safety Documents. Non-FM waste material, from experimental and operational sources was recorded on waste transfer slips prior to placement in the WMA.

In the early years of site operations, some of the non-FM waste would be emplaced with a more general description (e.g. package, bag) rather than details on the material stored in the given package. This early information was hand transcribed in a database. In preparation for standpipe remediation, waste listed as in the standpipes has been checked versus the waste transfer slips to ensure the most detail possible on each standpipe is available. This process has been initiated for the ILW bunkers as well.

In order to better track the decommissioning waste being generated, a barcoding system with details on type and contents of waste packages was implemented. This system allows waste packages to be tracked to its container, and the location of the container to be similarly tracked. This allows for greater safety in retrieval in the future and also allows for waste with a higher field to be strategically placed to be on the inside of an array of lower field waste containers for shielding. In the case of the offsite ILLW shipments, the transport totes will also be barcoded. The returned sludge container will contain multiple barcodes for the totes it received waste from.

When a decommissioning project is started, a detailed decommissioning plan is developed and then general work plans are prepared to cover major systems or components. Job scopes and hazard assessments are used to ensure safety during the work. Work plans must include a Waste Management Plan (WMP).

The WMP is used to estimate volumes and to help plan for alternate routes for waste where possible. Currently a large radiological laboratory building is being decommissioned generating a large volume of material ranging from active drain lines and ventilation ducting, to ceiling tiles and drywall. The waste material and other building related materials are initially surveyed during decommissioning. Contaminated material is processed and packaged in the Waste Handling Area (WHA) and routed to the WMA. The WHA is an onsite characterization and processing area that includes waste volume reduction capabilities. Likely clean waste is processed through the Waste Clearance Facility (WCF) in which an additional clearance survey is performed and the waste is categorized to determine its routing; re-use, recycling or non-active disposal. Every effort is made to prevent and reduce waste at the source to reduce costs for storage and for eventual disposal. The approach is visualized as an inverted pyramid with prevention of waste as the first line of action, then reduction, reuse, recycling and finally disposal (storage) as the least favourable option. Where waste is generated the estimated cost is $60 per tonne to recycle. It costs approximately $250 per cubic metre to clear clean waste. The estimated life-cycle costs for LLW range from $14,000 to $27,000 per cubic metre for storage in SMAGS and final disposal in a repository.

The waste is accepted for storage at the WMA after it has been properly characterized and found to meet the waste acceptance criteria. The majority of contaminated waste generated in current campaigns of decommissioning is considered LLW and can be accepted into the SMAGS building. Currently approximately 20,565 m^3 of low level waste and 1,045 m^3 of ILW are stored at the WMA. Canada does not have a central, national waste disposal facility for radioactive waste, although regional solutions exist for some historic and waste from some waste generators [4]. Currently plans are for waste stored at the WMA to remain there until a final repository solution is developed in part through development of an integrated waste management plan. The plan will be refined through inputs from various studies to better define the waste processing, treatment and long-term management facilities required [4].

The waste storage structures are monitored to ensure they remain fit-for-service. Repairs are made as required and structures will be replaced as necessary to ensure the stored waste remains properly secured, protected, and intact and immobilized until such time that a suitable disposal facility is available for transfer of the waste containers.

REMEDIATION AND FUTURE WORK AT THE WMA

Some of the waste storage structures, notably the standpipes, ILW bunkers, and some trenches require remediation of the materials they contain in order to sort, characterize, dry and package them for eventual disposal. While the wastes are currently safely stored, the time before disposal extends beyond the expected functional lifetime of these structures. Given the mixed nature of the waste and the onsite expertise present, it is considered the best and least expensive option to remediate this waste and have the material in a state that is ready to move to a repository when one becomes available.

Approaches to this remediation effort have been studied and an on-site remediation facility is seen as the most favorable option for the standpipes and ILW bunkers. The design of this facility is planned to begin in the next three-year time frame. The facility is seen to include a purpose-built hot cell facility as the current hot cells at the main WL site are not suited for waste transfer in a processing environment. The need to develop additional storage facilities will be considered in light of these remediation efforts, in particular an above ground ILW storage building may be required.

As the main campus is decommissioned, operational space will be required for WMA operations staff, and associated radiological and environmental monitoring personnel and security. The use of modular easily-removed structures is expected to be employed for these services to minimize future efforts during eventual decommissioning of the WMA. Once repositories for the waste are available, the waste will be transported from the WMA and final remediation of the area will commence.

SUMMARY

The WL site is being actively decommissioned with the main campus forecast to be largely completed by 2028. Remediation projects will continue at the WMA beyond that timeline to prepare waste stored in the ILW bunkers, standpipes and some trenches for eventual disposal. The WMA will remain in operation, safely storing waste generated from WL operations and decommissioning, until disposal facilities are constructed elsewhere in Canada. At that time waste materials from the WL WMA will be shipped to those locations and final decommissioning of the WMA will be conducted.

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Fig 1. An Aerial View of the WL Main Campus

Fig 2. An Aerial View of the Waste Management Area (right) and Concrete Canister Storage Facility (left)

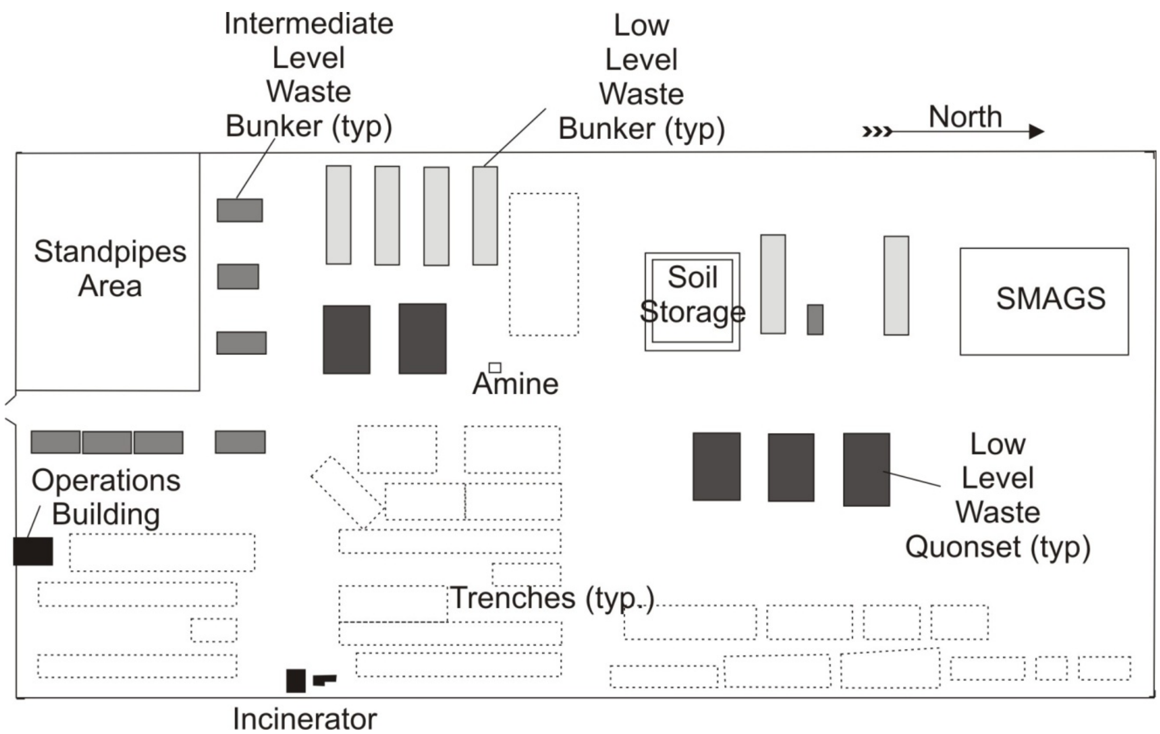

Fig. 3. Layout of the WL WMA Indicating Waste Storage Structures

Fig. 4. Low Level Waste Bunker

Fig. 5. Shielded Modular Above Ground Storage Building