DEWATERING RADIOACTIVE PITCHBLENDE RESIDUES AT THE NIAGARA FALLS STORAGE SITE

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ABSTRACT

The U.S. Department of Energy (DOE), with Bechtel National, Inc. (BNI), as the Project Management Contractor (PMC), is responsible for the Niagara Falls Storage Site (NFSS) interim waste containment facility in Lewiston, New York. The NFSS contains approximately 190,000 m3 (250,000 yd3) of low-level radioactive waste resulting from the remediation of approximately 600 hectares (1,500 acres) of the U.S. Army's former Lake Ontario Ordnance Works. The remedial action is being performed as part of DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP).

Radioactive pitchblende residues stored on-site in a saturated condition required dewatering before final encapsulation within the containment facility. The successful dewatering operations, using both standard and innovative dewatering techniques, provide added confidence in the stability of the containment facility.

BACKGROUND

The NFSS, located in northwestern New York (Fig. 1), is a DOE surplus facility. As a remnant of the U.S. Army's original Lake Ontario Ordnance Works (LOOW), the 77-hectare (191-acre) NFSS was used by the Manhattan Engineer District (MED) for the storage and transshipment of radioactive materials, primarily pitchblende processing residues. As a result of these operations, some portions of the LOOW other than the present NFSS were also contaminated. DOE established the SFMP to plan and manage the ultimate disposition of surplus DOE-owned facilities including the NFSS. Remedial actions of off-site vicinity properties are the responsibility of FUSRAP, another DOE program.

In 1981, DOE selected BNI as the PMC for FUSRAP and the NFSS under SFMP. Interim remedial actions at the NFSS began in 1982.

Interim remedial actions completed at the site include (1) decontamination of the NFSS and vicinity properties; (2) decontamination and/or demolition of contaminated structures; (3) excavation, placement, and stabilization of contaminated soil, sediment, and rubble; (4) relocation of residues; (5) dewatering and stabilization of residues within the interim waste storage facility (WSF); and (6) completion and closure of the short-term WSF.

This paper addresses the dewatering and stabilization of residues within the WSF during the 1985-86 construction seasons.

TOWER DEMOLITION

Approximately 3,000 m^3 (4,000 yd^3) of high-grade pitchblende (K-65) residues were stored in a heavily reinforced concrete former water storage tower at the NFSS. It was necessary to transfer the residues from the tower to the WSF and subsequently demolish the 50-m- (165-ft-) tall, 12-m- (40-ft-) diameter tower, because its structural integrity was questionable. A hydraulic mining and slurry transfer

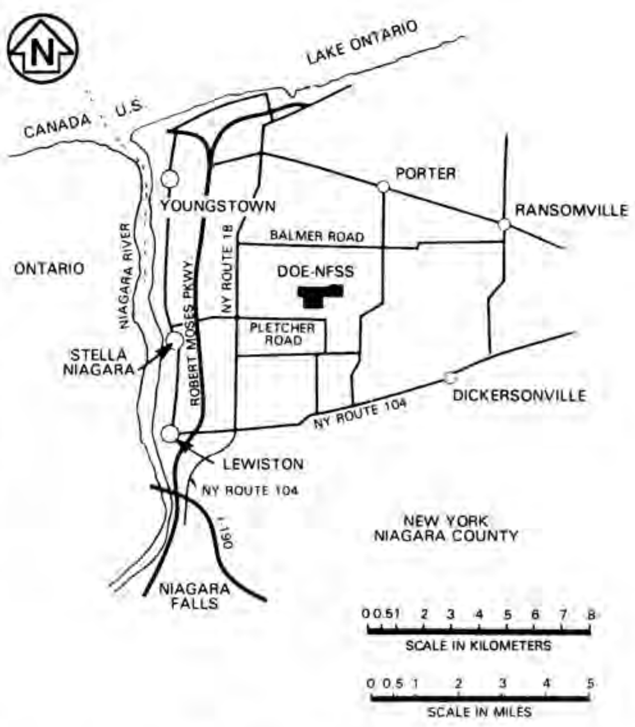

Fig. 1. Location of the NFSS.

system was used to transport the bulk of the K-65 residues from the tower to the WSF.

Once transferred, the K-65 residues settled out of suspension, and the transfer water was decanted for reuse as the hydraulic transfer medium. A water cover was maintained atop the K-65 and other residues to reduce radon emanation to the environment.

DEWATERING REQUIREMENTS

A dewatering program was implemented following the transfer of the residues. The objectives of this program were to:

- Reduce the potential for spread of radioactivity.
- Improve the long-term stability of the wastes.
- Accelerate consolidation.

Water in the residues was the most likely transport medium for migration of contaminants both in solution and in suspension. With sufficient time and overburden pressure, free water within the pore structure of the residues could have been forced from the residues, transporting contaminants with it.

The presence of water in the residues increased susceptibility for contaminant migration by another, though somewhat indirect, means. Various chemicals can degrade the waste containment attributes of clay by increasing permeability, reducing ionic exchange capacity, etc. Without water, these deleterious chemicals cannot go into solution and cannot migrate through the clay encasement of the WSF.

Although the residues are stored in a small portion of the total WSF, subsidence within these residues can negatively influence the performance of the containment cap. Therefore, large amounts of free water in the residues would present a potential threat to the long-term stability of the WSF from a number of perspectives, including settlement, structural, and seismic concerns. Settlement was a major concern because of its adverse effect on the containment cover. Local distress due to settlement (e.g., cracks, localized subsidence, etc.) could result in increased water infiltration, increased radon emanation, surface water ponding, increased maintenance, and other problems. Structurally, the residues would have a reduced bearing capacity in a submerged condition due to loss of cohesion and reduced effective unit weight. During a seismic event, the residues, if saturated or submerged, could be subject to loss of strength, possibly resulting in localized distress of the containment cover.

The overall project schedule required that the residue stabilization operation be finalized to allow completion of the WSF and concurrent construction activities. To this end, the dewatering scheme was developed to accelerate the consolidation process.

ALTERNATE DEWATERING TECHNIQUES

Standard construction dewatering techniques were evaluated for dewatering the residues. These techniques were attractive because they allow in situ dewatering and require only minimal disturbance of the residues. The conventional deep well dewatering technique, using submersible pumps, was ruled out (except for the Bay A area of Building 411) due to the low production rates associated with the very fine-grained texture of the residues. A conventional vacuum wellpoint system was also ruled out because of difficulties in maintaining a vacuum seal around the wellpoint at all times during dewatering operations. Construction dewatering techniques considered appropriate for the site conditions included open pumping from sumps, vertical sand drains, vertical drainage strips, drainage blankets, and vacuum assisted eductor (ejector) systems.

Residue stabilization might also be effected by chemical fixation (grouting), cementitious solidification, and vitrification. Chemical fixation and cementation were eliminated because these would have increased the total volume of wastes and produced a harder, more solid mass either of these effects could have prejudiced future long-term actions involving the residues. Vitrification would also have produced a harder, more solid mass that would have been more difficult to remove in the future.

Mechanical dewatering techniques such as the belt filter press, plate and frame press, diatomaceous earth filter, and centrifuge were evaluated. These mechanical methods were not selected because of their relatively low effectiveness in this application and radiation safety concerns.

The electroosmosis method of dewatering was ruled out because of its comparatively high cost.

From this list of techniques, individualized dewatering system designs were prepared for each bay of the building to maximize dewatering efficiency and consequently maximize consolidation of the residues while still accommodating concurrent construction activities by several other subcontractors working in the same area.

DEWATERING TECHNIQUES USED

Bay A

Bay A, the smallest bay in Building 411 (Fig. 2), had the smallest volume and lowest moisture content of residues to dewater. A basal granular drainage blanket (sand layer) placed in this bay prior to emplacement of residues was used to provide drainage. Six perforated corrugated metal pipe sumps, wrapped with three layers of filter fabric, were installed in this drainage layer. The filter fabric was used to prevent the very fine-grained sand from entering the sump.

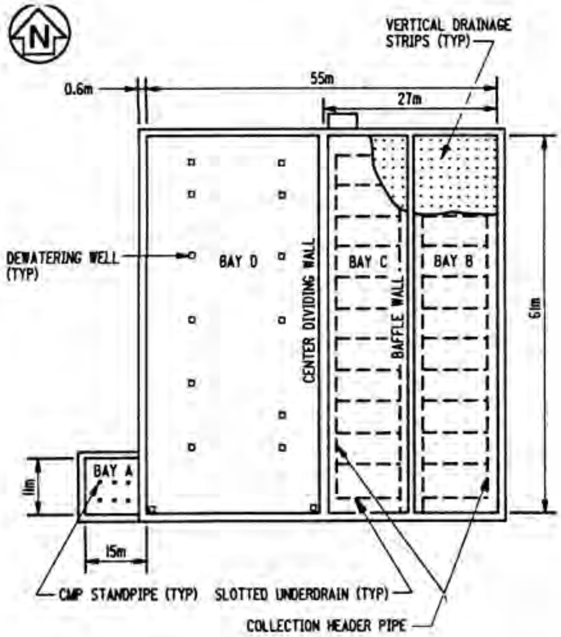

Fig. 2. Building 411 - Plan View.

Submersible pumps were installed in these sumps to dewater the residue. As soil surcharge was added to the top of the residues, the submersible pumps were used to dewater the basal drainage blanket which in turn acted to dissipate excess hydrostatic pressures generated during residue consolidation.

Bays B and C The residues in Bays B and C were, for the most part, dewatered using a vacuum-assisted underdrain system as shown in Fig. 3.

The collection pipe network consisted of a series of parallel slotted PVC drain pipes with PVC collection headers at each end. The collection headers emptied into carbon steel pump cans from which the water was removed. The drain pipe slots were sized to prevent entry of sand into the piping system. Preventing the removal of ultra-fine residue particles with the water during dewatering operations was a critical design consideration. The filter components (e.g., sand layers, filter fabric, and vertical drainage strips) were selected to minimize the amount of residue particles entering the system.

The residue vacuum seal provided a highly impermeable layer atop the residues to facilitate drawing a vacuum on the residues and to prevent water from reentering the residues. Several different materials/configurations were field tested. The materials included dry bentonite, slurried bentonite, cationic and anionic asphalt emulsion, asphalt cold mastic mix, geosynthetic liners, and various combinations of these materials. Dry granular bentonite was chosen as the residue vacuum seal material because of its effectiveness as a water and vacuum seal, its capacity for application through standing water, its self-healing characteristics, its ease of application, the minimal additional treatment of water necessary after application of the vacuum seal, its minimal reaction with residues, its capacity to maintain integrity during settlement, and cost effectiveness.

Because the hydration of bentonite can be adversely affected by contaminants, the bentonite was tested using water taken from atop the residues. It was found that chemical contaminants in the water decreased the hydration capacity of the bentonite to approximately 60 percent of the hydration that could be achieved using clean water.

The purpose of the vacuum system was to provide the functional equivalent of approximately 5 m (17 ft) of soil overburden, thus increasing the pore water pressure within the residues and accelerating the dewatering/consolidation process.

Upon completion of slurry transfer operations, a soil overburden was placed over the Building 411 area to provide a disposal location needed by other site operations for contaminated soil and rubble. In addition, the soil overburden provided an additional surcharge that increased the pore water pressure in the residues, thereby accelerating the dewatering/consolidation process. The soil overburden also displaced and permitted removal of the water over the residues.

To remove water from the residues in a timely manner, the dewatering system provided the driving force and accessible channels for removal of the water. The driving force was provided by the surcharge load of soil overburden and vacuum. Water in the vicinity of the sand underdrain flowed directly into the underdrain layer; elsewhere, the water entered the sand underdrain via the vertical drainage strips. Once in the sand layers, the water flowed to the slotted drain pipes and then to the collection headers. From there, the water entered the pump cans from which it was removed.

Bay D

Bay D, the largest bay in Building 411 (Figs. 4, 5), did not have an existing basal drainage blanket prior to residue emplacement. To accomplish dewatering, a series of filter-packed dewatering wells was installed through the residues in situ using a hole puncher and jet casing. Eductors were installed in the dewatering wells. Filter fabric was then placed over the residues and a thick, granular drainage blanket was placed on the filter fabric. The filter fabric was used to ensure that the granular drainage blanket would not sink into the saturated residues and thus suffer a significant decrease in permeability. This dewatering system functioned in two ways. First, the filter packs around the wells acted as vertical sand drains to reduce the effective drainage distances around the wells. Second, as the surcharge was applied above the drainage blanket, the excess hydrostatic pressure generated by residue consolidation was dissipated

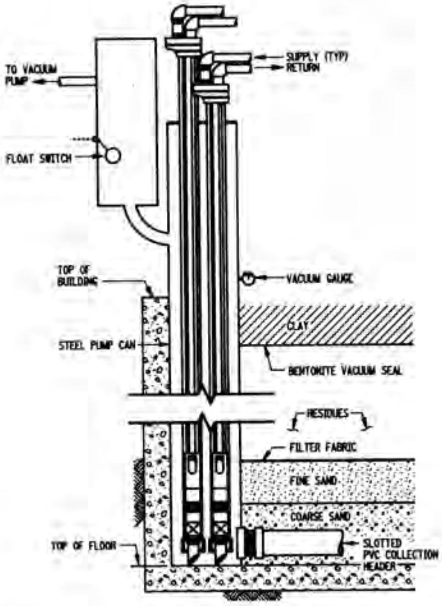

Fig. 3. Vacuum - Assisted Underdrain System.

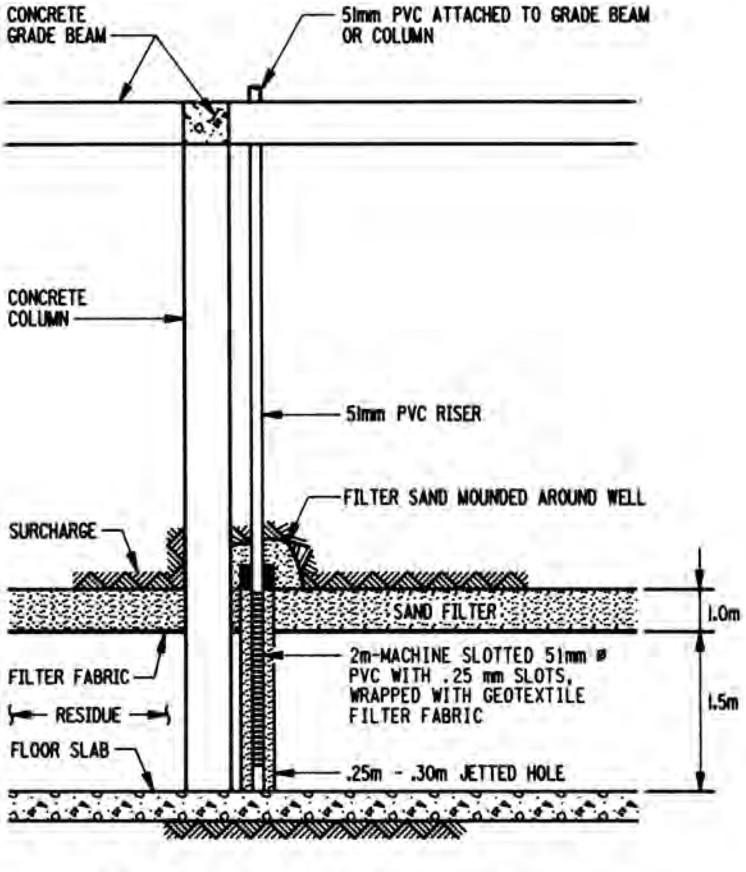

Fig. 4. Well Installatiom for Bay D Dewatering.

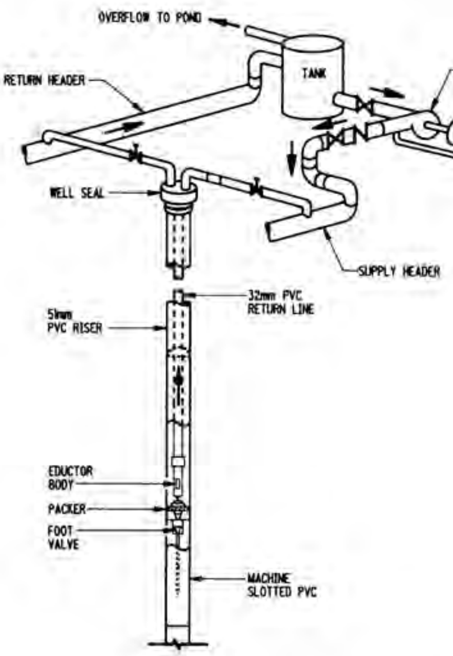

Fig. 5. Well Components.

into the drainage blanket. The granular drainage blanket was drained by the eductors installed in the dewatering wells.

System Closure

Upon completion of the dewatering operations, above grade dewatering system components were removed and disposed of elsewhere in the containment area. The below grade components were grouted to fill the voids and left in place.

EFFECTIVENESS OF DEWATERING TECHNIQUES

The effectiveness of the dewatering techniques was estimated during engineering design and monitored throughout field operations. A battery of tests was devised to measure dewatering progress (e.g., shear vane, settlement, water level, vacuum, piezometer, and water flow measurements were taken). Because direct settlement measurements were not practical, the settlement was verified by noting the height of the voids that developed beneath the concrete cross beams that formed the upper boundary in each bay of the building. These voids were later grouted.

The objectives of the dewatering scheme were successfully accomplished with regard for worker safety, economy, and constructibility. Further, the methods utilized did not prejudice future actions.

A comprehensive monitoring program is in place for the entire WSF. The program includes vibrating wire and pneumatic pressure transducers within the containment cell, groundwater and air monitoring, settlement monitoring, infrared aerial photography, and walkover inspections.

WASTEWATER PROCESSING

Approximately 19 million liters (5 million gallons) of contaminated wastewater were accumulated during slurry transfer, tower demolition dust suppression, and residue dewatering operations. The wastewater required treatment to meet stringent DOE and New York State Pollution Discharge Elimination System (SPDES) permit criteria.

A treatment process developed at the Oak Ridge National Laboratory in Oak Ridge, Tennessee, reduced the radium and uranium levels in the water to concentrations within DOE criteria and also reduced the levels of approximately 25 chemical constituents to concentrations within the SPDES permit criteria.

The treatment, a calcium chloride precipitation process, was performed in outdoor ponds in 7.5- to 10-million-liter (2- to 2.5-million-gallon) batches. As a result of the process, impurities precipitated and settled to the bottom of the pond as solids, and the purified supernatant liquid was decanted to a treated water pond for sampling and analysis.

LESSONS LEARNED

Despite the unusual nature of this type of dewatering project, the procedures for system installation, maintenance, tuning, and operation developed in conventional construction dewatering projects are still applicable.