Development of a Site-Wide Water Management Strategy at the Portsmouth Gaseous Diffusion Plant – 22382

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ABSTRACT

The overall D&D Mission at the Portsmouth Gaseous Diffusion Plant (PORTS) includes demolition of the process buildings, placing the demolition debris in a new On-Site Waste Disposal Facility (OSWDF), excavating soils associated with historic groundwater plumes and unlined landfills, and using the impacted soil as engineered fill in the OSWDF. As planning and preparation of the D&D process progressed Fluor-BWXT Portsmouth (FBP) identified the need to capture, treat and discharge accumulated water at each of the sources identified. Specific sources of potentially contaminated water include leachate, stormwater runoff, truck washing, dust suppression, and groundwater from excavation dewatering.

Due to funding constraints and schedule considerations, DOE and FBP decided to shift from a centralized design to a phased/distributed/modular implementation strategy to establish the required water treatment capability during the D&D Mission at PORTS. FBP engaged Arcadis to develop both the centralized design and the phased/distributed/modular designs for collecting and treating water associated with locations and sources identified above during each phase of the D&D Mission starting with demolition of the first of three large process buildings at PORTS. Arcadis developed the first Conceptual Site Model (CSM) using available groundwater analytical data, Pump and Treat operational data, soil sampling data, X-326 Process Building material of construction characteristics, including results from Toxicity Characteristic Leaching Procedure tests, residual contamination source term data from the X-326 Processing Building and left in place process piping, and data from other historical environmental remediation activities. The data were used to identify and assess the potential contaminants of concern that may be present in the water sources. Specific challenges associated with the development of the first CSM included the inability to collect analytical data from the future water sources identified (as some sources did not exist during the design phase) and the lack of information relating to the potential concentration ranges of identified contaminants that would result during X-326 Process Building demolition, soil excavation, or OSWDF operation.

Following development of the CSM, water management evaluations were initially developed for a large centralized treatment facility, and subsequently for a smaller distributed/modular treatment facility at each location of water generation in the initial phase of D&D Mission that includes X-326 Process Building, X-740 Plume, X-231A/B Landfills, and ODWDF Cells 1, 4, and 5. The water management evaluation was intended to model a range of probable water generation rates that could be used to define an optimum flow rate for a treatment modular system and evaluate methods for storing large volumes of water pending treatment.

Modular treatment system sizing was optimized based on management of water at each point of generation. As mentioned previously, stormwater must be managed and treated from all identified locations. Specifically, any stormwater coming into direct contact with the demolition site, demolition debris, or impacted soil must be captured and treated. A back-to-back 25-year, 24-hour storm event was selected as the design basis to provide a sufficient factor of safety. Based on the size of the demolition site, active waste cells in the OSWDF or open soil excavation site, storm events result in the modeled production of large volumes of water. It is not feasible to design a treatment system capable of treating the instantaneous flow resulting from the design storm event. Therefore, the water management evaluation modelled temporary storage of water in the detention berm encompassing over 30-acres surrounding the X-326 Process Building demolition site. Similar water management approaches were used for the excavation sites and the OWSDF; and estimates of contractor downtime (due to standing water at the active job site) were used to quantify risk and water management options.

Once potential contaminants and flow rates were established a Technology Evaluation and Selection Report was prepared, which identified available technologies to treat the identified contaminants. Finally, a Design Criteria Package was developed that summarized design requirements for both the centralized and decentralized treatment systems and included National Pollutant Discharge Elimination System permit requirements from outfalls across the site as specified by the State of Ohio.

The original outcome of this process was the design of the Interim Leachate Treatment System (ILTS) which is intended to function as a centralized water treatment system for the treatment of all OSWDF leachate, demolition water and dewatering from excavations during the D&D Mission at PORTS. The system design contained 4 individual treatment modular trains each capable of treating up to 1,541 liters per minute (400 gallons per minute), including pretreatment for reduction of total suspended solids (TSS) and oil removal, metals treatment including clarification, multimedia filtration (for metal polishing and TSS removal), granular activated carbon (for trichloroethylene and polychlorinated biphenyls), and ion exchange (for removal of radionuclides).

As design of the ILTS system advanced to the 90 percent level, DOE and FBP determined that schedule and funding constraints required that the full-scale centralized treatment concept temporarily be set aside without impacting the initial and overall D&D schedules. Arcadis, FBP and DOE worked collaboratively on modular treatment systems with many inter-changeable components, and the site strategy evolved away from the initial concept of a centralized ILTS in Phase 1 of the D&D Mission. The outcome was a modular approach of three separate Modular Treatment Systems with many inter-changeable components for the initial demolition, soil excavation, and OSWDF operation. This approach took advantage of the modular nature of the ILTS and allowed for initial demolition, soil excavation, and OSWDF operations to proceed on schedule without waiting for completion of the full-scale centralized treatment system. The initial three modular systems were housed in two fabric structures and placed in close proximity to the source of generation during the first phase of the D&D Mission. This approach also standardized design of the modular systems across all projects as well as component fabrication and allowed one contractor to construct and startup all the initial three modular systems. Following completion of the first phase of the D&D Mission, the ILTS will then be fully implemented by integrating initial modules with an additional treatment module and other system components to support all subsequent demolition and excavation sites on the D&D Mission's life cycle baseline line.

Developing a comprehensive water management strategy, such as the one described here requires intensive collaboration. Early stakeholder involvement is critical given the aggressive design and procurement schedules. Many Arcadis technical experts and design engineers interacted with FBP and DOE stakeholders including central engineering, nuclear criticality safety, the X-326 Process Building Demolition, OSWDF, and Environmental Remediation. The resultant design optimizations and approach have led to construction and startup of 3 decentralized/modular treatment systems, allowing FBP to meet the schedule requirements associated with first waste placement of demolition debris in the OSWDF in May of 2021.

INTRODUCTION

"For approximately 50 years, the Portsmouth Gaseous Diffusion Plant near Piketon, Ohio, supported federal government and commercial nuclear power missions. In the early 1950s, the Atomic Energy Commission sought to dramatically expand its production of enriched uranium for military purposes—nuclear submarines and weapons—and to provide fuel for a burgeoning nuclear power industry. From 1991 until production ceased in 2001, the Portsmouth plant produced only low-enriched uranium for commercial power plants. In 1993, uranium enrichment operations were turned over to United States Enrichment Corporation (USEC) in accordance with the Energy Policy Act of 1992. In 2000, uranium enrichment production was terminated at the Portsmouth Site. Some of the facilities were no longer required by USEC and subsequently returned to DOE. Uranium enrichment activities at Portsmouth concluded in May 2001. In 2011, USEC returned the gaseous diffusion plant facilities to DOE for decontamination and decommissioning".[1,2]

The Ohio Environmental Protection Agency (Ohio EPA) and the DOE entered *The April 13, 2010 Director's Final Findings and Orders for Removal Action and Remedial Investigation and Feasibility Study and Remedial Design and Remedial Action, including the July 16, 2012 Modification thereto* (DFF&O) (Ohio EPA 2012). This administrative order establishes the regulatory framework for conducting D&D activities at the Portsmouth Gaseous Diffusion Plant (PORTS) under the Comprehensive Environmental Response, Compensation, and Liability Action of 1980, as amended. The *Record of Decision for the Site-wide Waste Disposition Evaluation Project at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio* (Waste Disposition Record of Decision [ROD]) [3] selected on-site disposal with an off-site component, as the remedy for disposition of waste. The *Comprehensive On-Site Waste Disposal Facility Remedial Design/Remedial Action Work Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio* (Comprehensive On-Site Waste Disposal Facility [OSWDF] Remedial Design/Remedial Action [RD/RA] Work Plan) [4] presents the plan for developing the remedial design and remedial action for the on-site waste disposal component of the remedy, including information regarding the design, construction, operation and maintenance, closure, and reporting activities. The Comprehensive OSWDF RD/RA Work Plan states that two remedial design packages (i.e., Interim Leachate Treatment System [ILTS] Remedial Design Package and OSWDF Remedial Design Package) will be prepared in accordance with the DFF&O to implement the on-site disposal remedy at PORTS.

"The OSWDF is designed to accommodate all or any portion of the total volume of impacted material meeting the WAC that results from the PORTS D&D Project. It is anticipated that impacted material placed in the OSWDF will include material from D&D of the buildings and structures listed in the DFF&O as well as associated residual soils, a limited amount of debris from existing landfills at PORTS that may potentially be excavated as sources of fill, and fill that may come from clean or contaminated sources". [4, 5]

Various sources of water will come into contact with the D&D activities and OSWDF operations, resulting in potentially impacted wastewater; therefore, an ILTS has been designed and will be constructed to treat leachate and wastewater from the OSWDF, D&D (building demolition), and environmental remediation (soil excavations), and existing groundwater Pump and Treat (P&T) (future provisional) activities for discharge to surface waters of the State of Ohio under the substantive requirements of a renewed National Pollutant Discharge Elimination System (NPDES) permit (Ohio EPA 2020). The purpose of this paper is to present the methodology of the adaptive design process for treating potentially contaminated water and summarize the outcome of the design.

The ILTS system includes the components required to transfer, store, and treat leachate and wastewater prior to discharge. Wastewater includes impacted stormwater, dust suppression water, wheel wash water, and extracted groundwater (dewatering). Note at the onset of the water management site strategy the design approach was to utilize ILTS as a "centralized" water treatment facility for all water sources. As design of the ILTS system advanced to the 90 percent level, schedule and funding demands required that the centralized full-scale treatment concept temporarily be set aside without impacting the initial and overall D&D schedule. Arcadis, Fluor-BWXT Portsmouth (FBP) and DOE worked collaboratively on decentralized/modular treatment systems with many inter-changeable components, and the site strategy evolved away from the initial concept of a centralized ILTS. The outcome was a distributed modular approach of three separate water treatment systems with many inter-changeable components for the initial demolition, soil excavation, and waste disposal activities. An adaptive design approach allowed for maintaining design and treatment objectives, while providing a smooth transition from a centralized approach to a decentralized/modular approach. The resulting ILTS design approach includes the construction and operations phasing of ILTS Phase 1 – Modular Leachate Treatment System (MLTS) A-

Train associated with waste disposal at OWSDF, Modular Treatment Systems (MTS) C-Train dedicated to the X-326 Process Building demolition and D-Train dedicated to the soil excavation sites. This approach also standardized design of the modular systems across all projects as well as component fabrication and allowed one contractor to construct and startup all the initial three modular systems. It is anticipated ILTS Phase 2 will consolidate some combination of A-, C-, and D-Trains, and add a fourth train (B-Train) to provide additional capacity for the expansion of OWSDF operations from 3 active cells to 6 active cells. The 100 percent design package for ILTS included numerous documents described herein; as a phasing approach was developed those reports were updated or supplemental documents for C- and D- trains were developed. Figure 1 – Site Map [6] provides an overview of major site features. The ILTS location noted in Figure 1 is also the location of MLTS A-Train. The MLTS A-Train receives wastewater from OSWDF operations. The future ILTS is intended to receive wastewater from OSWDF and from process building demolition sites. C- and D- Trains (noted at the bottom of Figure 1) receive wastewater from X-326, X-740 or 5-Unit Plume Area excavations, these waste streams are segregated (X-326 wastewater is conveyed to C-Train and soil excavation wastewater is conveyed to D-Train). All wastewater is conveyed to the designated treatment location using buried double-walled High-Density Polyethylene pipe. Monitoring systems ensure no leaks exist in the conveyance system. Construction and startup of these three treatment trains were completed in spring of 2021. Subsequently, these three treatment trains successfully supported the demolition, excavation, and OSWDF operations in 2021 by treating approximately 17 million gallons of wastewater.

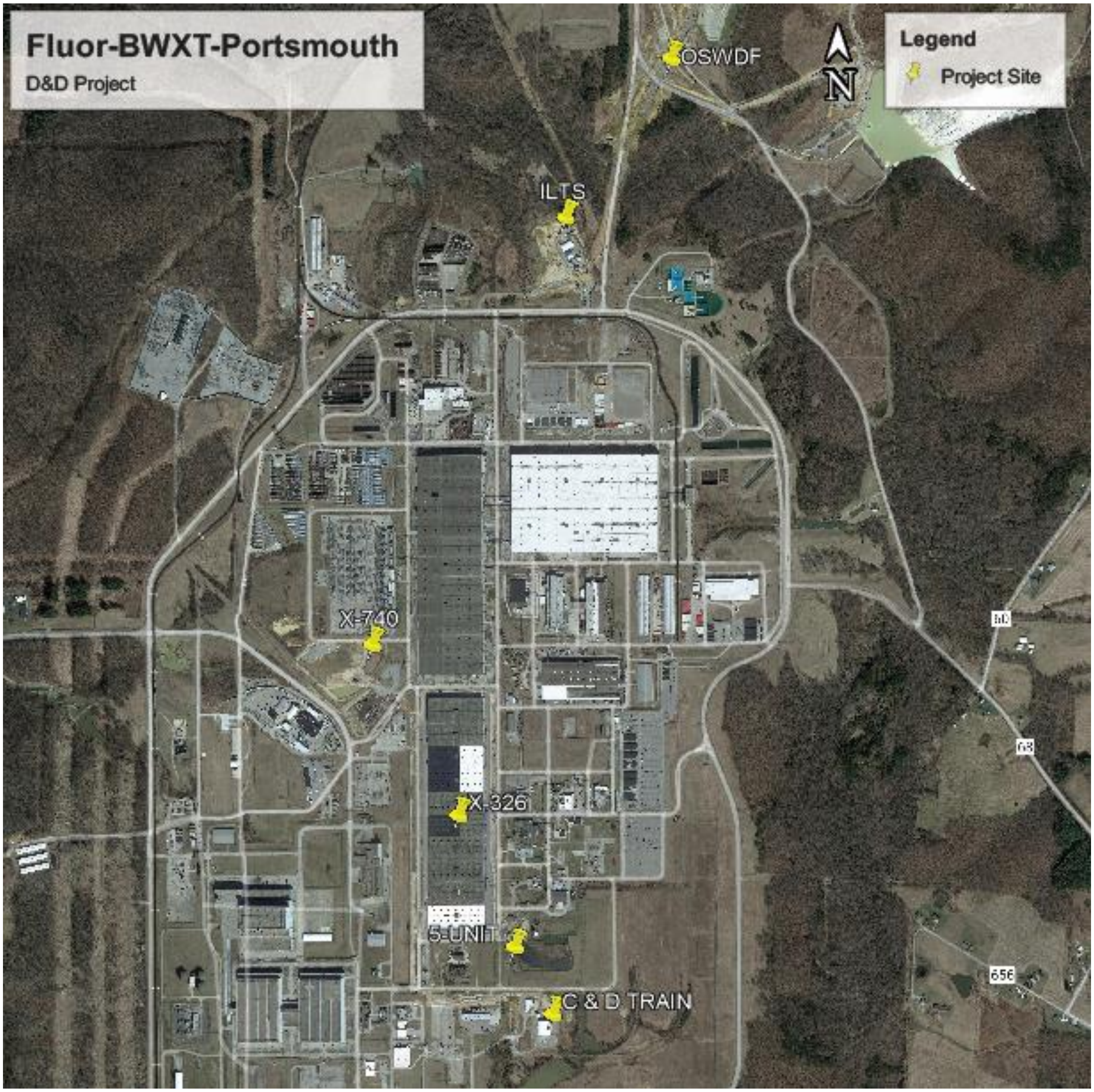

Figure 1. Site Map

METHODS

Conceptual Site Model

The *Conceptual Site Model for Influent Constituents of Concern* (CSM) was the starting point for the design process and provides an evaluation of the constituents of concern (COCs) that may be present in leachate and wastewater generated from D&D and soil excavation activities across the site and during waste placement in the OSWDF. The leachate and wastewater sources considered in the CSM are from the OSWDF and the Impacted Materials Transfer Area (IMTA), wastewater from D&D operations and ER soil excavation activities, and existing groundwater P&T extraction water, culminating at a centralized location for treatment and discharge. The CSM describes sources of COCs (e.g., waste materials planned for disposal in the OSWDF), identifies COCs likely to be present in the leachate and wastewater, and establishes a range of concentrations expected in leachate and wastewater designated for treatment in the ILTS and MLTS A-Train, and Modular Systems C- and D- Trains.

The initial CSM evaluates the COCs that may be present in leachate and wastewater generated across the site. This includes all potential demolition and excavation projects such as the X-326 Process Building demolition, and excavation of the X-740 Plume Area and X-231A Southeast Oil Biodegradation and X-231B Southwest Oil Biodegradation plots (X-231A/B). Therefore, a separate CSM is not developed for C and D Trains. The evaluation of COCs contained in this CSM is not affected by the configuration of the various trains during initial and final project phasing. This CSM is referenced as part of the design basis for X-326 Process Building D&D and X-740 Plume Area and X-231A/B soils excavation projects in the respective design packages.

The COCs expected to be present in wastewater conveyed to the ILTS are based on known COCs present in waste materials planned for demolition, excavation, and disposal. The concentration range for non-radiological COCs at ILTS is estimated based upon leach tests, concentrations measured in groundwater, influent concentrations at waste treatment facilities, and other DOE facilities. At the time of development of the first CSM specific source term information related to radiological COCs from the X-326 facility or the X-231A and B Oil Biodegradation Plots (contained within the 5-Unit Plume) was not available. This information was later added to specific design documents associated with Phase 1 implementation. As new COC concentrations are identified, the appropriate design basis are verified to ensure treatment objectives are still achievable.

Available data on COCs present in waste sources was compiled, including non-radiological COC concentrations detected in groundwater across the site. These data were screened for frequency of observations above the detection limit, as well as minimum and maximum concentrations. Compounds with less than 1% detections above the method detection limit (e.g., phthalates, pyrenes, chrysene, and anthracenes) were removed from consideration as COCs. The final list of COCs was adjusted based upon additional sources of data, including leaching tests of converters, as well as available PORTS groundwater treatment data.

The projected COC influent concentrations for radionuclides are presented in Table I. Information in the table includes expected (maximum) radionuclide concentrations in picocuries per liter (pCi/L), the projected effluent quality (PEQ), and the contribution to sum of fractions of the Derived Concentration Standard (DCS) from each radionuclide. This provides a basis for developing a technology selection. Since soil from groundwater plumes accounts for over 70 percent of the OSWDF landfill volume, Anticipated Radionuclide Constituents of Concern for ILTS and MLTS A-Train, are identical to the X-231A/B concentrations within the 5-Unit Plume Excavation; therefore, a separate source term is not developed for OSWDF. As additional data is developed from future onsite sources, these assumptions will need to be verified. Since the leachate and impacted water concentrations are estimated for waste streams that did not exist before Phase 1 implementation, there were uncertainties inherent in the expected concentrations established for the COCs. Therefore, flexibility and adaptability in design were important considerations in the event COCs or their concentrations changed. In order to advance the design of the ILTS and subsequently Phase 1 treatment systems within the constraints of the uncertainties associated with influent COCs concentrations and regulatory compliance discharge limitations, PEQs were identified from the information available and were based upon the lowest concentration noted in the NPDES Fact Sheets (Ohio EPA 2015 and 2020)[7] and the Sum Of Fractions based on the DCS for water ingestion obtained from DOE STD-1196-2011 (DOE 2011)[8]. Discharge limits and mechanisms of compliance were established during the design process, and the design incorporated flexibility to adapt as decisions were made. Table II provides a summary of the non-radiological COCs at ILTS. A-Train, C-Train, and D-Train COCs are not included but are very similar to ILTS. Table II presents the PEQ, expected minimum and maximum COC concentrations, groundwater sampling statistics, and expected chemical speciation (where appropriate). This data provides a basis for defining potential treatment technologies.

TABLE I. Anticipated Radionuclide Constituents of Concern for ILTS and MLTS A-Train

COC	**Projected Influent Concentration[a] (pCi/L)**	**PEQ[b, d] (pCi/L)**	**Fraction of DCS[c]**
Technetium-99	1,958	59	0.00
Uranium-234	190	6	0.01
Uranium-235	9	0.3	0.00
Uranium-236	1	0.03	0.00
Uranium-238	12	0.4	0.00
Uranium total (mg/L)	0.04	0.001	--
Sum-of-Fractions	--	--	0.01

Footnotes:
a = Maximum Projected Influent Concentration from the Southwest Oil Biodegradation Plot (X-231A).
b = PEQs are based on 97% removal efficiency.
c = The PEQs for individual radionuclides are presented for information purposes. The PEQ presented are not required to achieve compliance, only the sum of the fractions. The proposed treatment technology, specifically Ion Exchange, for Uranium and Tc-99 is expected to result in a sum of the fractions that is less than 1.
d = PEQ is used for minimum design consideration and aligns with the most restrictive water quality standard or existing permit limit.
mg/L = milligram per liter
PEQ = projected effluent quality
Tc-99 = technetium-99

TABLE II. Anticipated Levels of Non-Radiological Constituents of Concern for ILTS

COC	**Projected Effluent Quality**	**Minimum Expected Concentration in Leachate**	**Maximum Expected Concentration in Leachate**	**Groundwater Detects/Analyses (% Detections)**	**Expected Chemical Speciation**
Physical Properties					
pH	6.5-9.0 [a]	5.8	9.13	NA	NA
Oil and Grease (mg/L)	10 [h]	<10	15	NA	NA
TSS (mg/L)	30 [a]	30	100	NA	NA

TABLE II. Anticipated Levels of Non-Radiological Constituents of Concern for ILTS (continued)

Metals					
COC	**Projected Effluent Quality**	**Minimum Expected Concentration in Leachate**	**Maximum Expected Concentration in Leachate**	**Groundwater Detects/Analyses (% Detections)**	**Expected Chemical Speciation**
Arsenic (mg/L)	0.1 [b]	0.003	0.25	102/587 (17%)	$HAsO_4^{2-}$, $H_2AsO_4^-$
Barium (mg/L)	2 [d, g]	0.032	0.75	495/564 (88%)	Ba^{2+}, $BaCO_3$ (s), $BaSO_4$ (s)

Cadmium (mg/L)	0.0031 [e]	0.0003	0.18	111/852 (13%)	Cd^{2+}
Chromium (mg/L)	0.1 [b]	0.011	13.5	334/1977 (17%)	Cr(VI): CrO_4^{2-}, $HCrO_4^-$
Cobalt (mg/L)	0.024 [e]	0.002	1.6	266/630 (42%)	Co^{2+}
Copper (mg/L)	0.012 [e]	0.002	0.33	92/565 (16%)	Cu^{2+}
Iron (mg/L)	5 [b]	0.49	5	454/645 (70%)	Fe^{2+}, Fe^{3+}, Fe_2O_3 (s)
Lead (mg/L)	0.0094 [e]	0.001	0.28	68/587 (12%)	Pb^{2+}
Mercury (mg/L)	0.000012 [c]	0.00003	0.003	10/535 (2%)	Hg^{2+}
Nickel (mg/L)	0.067 [e]	0.009	2	656/892 (74%)	Ni^{2+}
Selenium (mg/L)	0.005 [e]	0.001	0.035	8/587 (1%)	SeO_4^{3-}, $HSeO_3^-$
Silver (mg/L)	0.0013 [e]	0.00007	0.007	3/587 (1%)	Ag^+
Thallium (mg/L)	0.0063 [f]	0.0001	0.009	2/565 (0.4%)	Tl^{3+}
Vanadium (mg/L)	0.3 [h]	0.002	0.1	40/565 (7%)	$H_2VO_4^-$
Zinc (mg/L)	0.15 [d, e]	0.007	3.65	140/565 (25%)	Zn^{2+}
PCBs					
Total PCBs (mg/L)	0.0000017 [f]	<0.0000017	>0.0000017 [g]	1/2036 (0%)	NA
VOCs					
cis-1,2-DCE (mg/L)	18 [i]	0.0002	0.022 [j]	1022/2717 (38%)	NA
Trichloroethene (mg/L)	0.01 [a]	0.008	18 [k]	2046/3329 (61%)	NA
trans-1,2-DCE (mg/L)	0.066 [a]	0.0003	2.908 [j]	130/2717 (5%)	NA
Tetrachloroethene (mg/L)	0.089 [f]	0.0002	0.037 [j]	247/2717 (9%)	NA

Footnotes:

Minimum expected concentration is based upon the median value of the groundwater data (2011-2014).
Maximum expected concentration (except where notes) is based upon one-half of the maximum reported value for groundwater or adjusted concentration calculated to leach from wastes.
a = NPDES Permit (Ohio EPA 2015a).
b = Outside Mixing Zone: Average Agricultural (Ohio EPA 2015b).
c = Outside Mixing Zone: Average Human Health (Ohio EPA 2015b).
d = Outside Mixing Zone: Maximum Aquatic Life (Ohio EPA 2015b).
DCE = dichloroethene
e = Outside Mixing Zone: Average Aquatic Life (Ohio EPA 2015b).
f = Federal Human Health, Nondrink.
g = Federal Human Health, Drink.
h = Expected to be present in concrete demolition debris, light ballasts, equipment and structures painted with PCB-containing paint, and materials containing PCBs in a non-free-liquid form, such as PCB-impregnated insulation in electrical equipment or cabling, PCB-impregnated gaskets and ducts, and contaminated duct work.
i = Inside Mixing Zone: Maximum Aquatic Life (Ohio EPA 2015).
j = 95%upper confidence limit of groundwater data (2011-2014).

k = Maximum concentration reporting to PORTS water treatment facilities.
mg/L = milligrams per liter
NA = not applicable
PCB = Polychlorinated biphenyls
PEQ = Projected Effluent Quality
TSS = total suspended solids
VOCs = volatile organic compounds

For the non-radiological COCs, minimum expected concentrations were established based upon an evaluation of site groundwater data; the median of the data was used for this value. This approach was chosen because the groundwater data provide an approximation of a leaching test for soils, which is the single largest component of materials to be included in the OSWDF at 72.1%.[9] Additionally, for compounds that are hydrophobic (i.e., sparingly soluble in water), the groundwater data provides a reasonable estimate of what might be mobilized from soils and into the leachate. For non-radiological COCs, the maximum expected concentrations were set based upon an evaluation of leaching data and site groundwater data, and all other information sources reviewed in the CSM. Generally, maximum concentrations of metals were set at one-half of the maximum reported concentration for groundwater or calculated through an evaluation of leaching of waste materials.

Water Management Evaluations (WMEs)

The *Water Management Study for Influent Flow Rates* (WMS) evaluates the various sources that will require treatment for the ILTS and MLTS) A-Train. The result of these evaluations is used to develop the flow rate design basis for the ILTS and MLTS A-Train. WMEs provide a similar evaluation for the individual sources conveying water to the C- and D- Trains, which are discussed in Modular Treatment Approach Documentation. The results from those studies verified the modular approach to individual treatment trains (which had already been designed in the ILTS system with many inter-changeable components) were adequately sized to treat the volume of water generated from building demolition or soil excavation. These studies are used to supplement and advance the detailed engineering design, and confirm the adaptive design approach is appropriate to meet the design objectives of both phases of the ILTS and to ensure that the treatment trains are appropriately sized. The sources of water during Phase 1 of the D&D Mission include leachate, wheel and truck wash, dust control, excavation groundwater, and stormwater for the following locations.

During D&D, ER, and OSWDF waste disposal activities, wastewater will be generated from several different areas, including:

- Wheel Washes
  - IMTA
  - D&D (X-326 Process Building)
  - Excavation (X-740 Plume)
  - Excavation (X-231B Landfill, 5-Unit Area Plume).
- Dust Suppression
  - OSWDF
  - IMTA
  - D&D Area (X-326 Process Building)
  - Excavation Area (X-740 Plume, X-231A/B Landfills, and 5-Unit Area Plume)
  - Haul Roads.
- Leachate from OSWDF Cells
- Excavation Groundwater (X-740 Plume, X-231A/B Landfills, and 5-Unit Area Plume)
- Extraction Groundwater from Existing groundwater P&T Operations (future provisional).
- Stormwater
  - OSWDF

- IMTA
- D&D Area (X-326 Process Building)
- Excavation Area (X-740 Plume, X-231A/B Landfills, and 5-Unit Area Plume)
- Provisional – Controlled Haul Roads.

GoldSim® modeling software was used to evaluate multiple water sources with dynamic characteristic (i.e., stormwater events). The results of the GoldSim® modeling demonstrated that a 25-year (yr), 24-hour storm event and an ILTS treatment flow of 3,028 liter per minute (lpm) (800 gallons per minute [gpm]), treating the stormwater from the OSWDF 6 active cells and IMTA Tanks drainage areas will result on 2.1 days of stored water at the cells. An additional 1,514 lpm (400 gpm) of treatment capacity would be dedicated to D&D, which results in 0.5 days of stored water above the X-326 Process Building slab; similarly, an additional 1,514 lpm (400 gpm) of treatment capacity would be dedicated to excavation, which results in 1.7 days of stored water in the active soil excavation area.[10] Those design objectives would be carried forward in the WMEs. Storage volumes are iteratively designed during this process to achieve a feasible detention basin and treatment system size, which minimizes risk of operation shut down. The days of stored water represents the number of days that the treatment system may not be operational.

Technology Selection and Evaluation Report

The *Interim Leachate Treatment System Technology Evaluation and Selection Report* (TESR) presents an evaluation of the technologies considered viable for treating leachate and wastewater associated with the design of the OSWDF, D&D, and ER activities. The TESR describes the technologies that have been selected. [11] The most effective technologies were selected for treating the OSWDF leachate and wastewater associated with D&D and ER activities in an ILTS. The technology selection was based on primary site COCs (developed in the CSM), regulatory and DOE treatment requirements, estimated leachate and wastewater flows (resulting from the WMS evaluation). Other considerations included health and safety, technical, economic, regulatory, implementability, process reliability, flexibility, management of treatment residuals, ease of operations and maintenance, and lessons learned from other DOE waste disposal facilities (e.g., DOE's Fernald, Oak Ridge, and Hanford Sites).

Following is a summary of the technologies selected for the treatment trains:

- A skimmer pump and influent clarifier for oil separation and skimming.
- Metals precipitation/coagulation/sedimentation/filtration to remove metal COCs.
- PCBs treatment will occur as a byproduct of the selected metals and oil/water separation technologies.
- Granular-activated carbon adsorption for VOCs.
- The primary radionuclide COCs, uranium, thorium and Tc-99, will be primarily treated as a byproduct of the technologies selected for the metals treatment, with ion exchange used for uranium and Tc-99 polishing of these COCs.
- A solids thickening process (including a clarifier tank, slurry conditioning, and a solids thickening tank) and a plate and frame filter press for solids dewatering.

Figure 2 below provides an example of media vessels installed for C-Train. These vessels provide multimedia filtration for removal of suspended solids, granular activated carbon for removal of PCBs or VOCs, and ion exchange for removal of radionuclides.

Figure 2. C-Train Process Equipment

The primary classes of COCs that will be treated at the ILTS facility are expected to be total suspended solids (TSS), oil, metals, PCBs, VOCs, and radionuclides. The CSM provided input to the TESR to evaluate and select treatment technologies. After a review of applicable technologies (in the TESR), the treatment technologies were selected that could meet the target effluent qualities anticipated for the COCs. The selected technologies are shown on Figure 3.

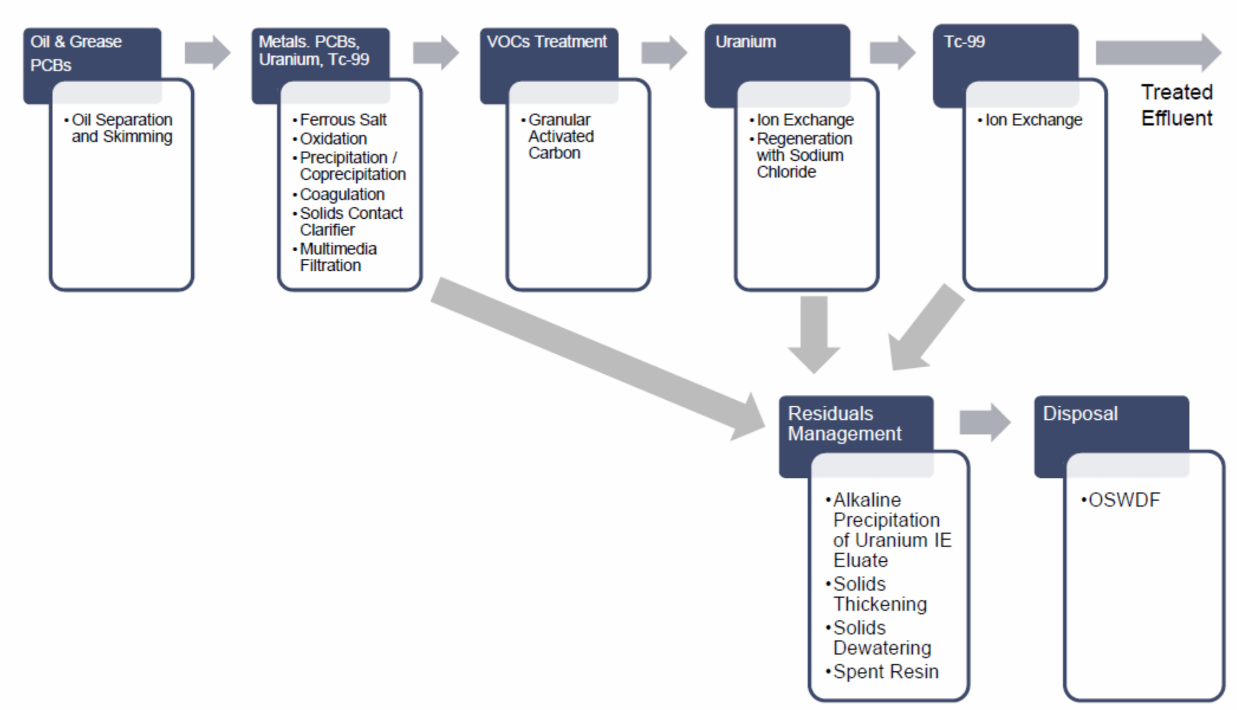

Figure 3. Selected Treatment Technologies for ILTS and MLTS A-Train

Minor variations are made to the C- and D-Train systems as defined by unique operational considerations. As an example, oil may be presented in the excavation at X-231A/B and 5-Unit Plume area; therefore, an Oil Water Separator is provided at the headworks, while C-Train does not provide that technology.

Design Criteria Package (DCP)

The DCP provides the design basis for the ILTS Phase 1 – MLTS and the ILTS Phase 2, which is utilized during full-scale OSWDF operations. Initial and full-scale operations are described in the DCP. ILTS Phase 1 – MLTS utilizes a single treatment train. ILTS Phase 2 consists of up to four (4) treatment trains. For reference purposes related to construction and operations phasing, these four trains are referred to as A, B, C, and D Trains. [12] The primary components of these four treatment trains are inter-changeable. The ILTS Phase 2 represents the original design which was advanced to 100 percent and reflect and adaptive design, providing flexibility.

Since the DCP addresses ILTS Phase 2 (all four trains) and the primary components of all four trains are inter-changeable, a separate DCP was not required for C- and D- Trains. Design parameters for non-primary treatment components C- or D- Trains which may differ from the DCP are accounted for in the Calculations Packages for the respective train. MTS treatment Trains C and D will initially be constructed and operated to treat wastewater from demolition of the X-326 Process Building and X-740 Plume Area and X-231A Southeast Oil Biodegradation and X-231B Southwest Oil Biodegradation (X-231A/B) plot excavation projects. Trains C and/or D may be incorporated into ILTS Phase 2 to support OSWDF full-scale operations and demolition of the remaining two Process Buildings north of the X-326.[12]

During initial operations, only leachate from the OSWDF is treated by the ILTS Phase 1 – MLTS (A-Train), which is constructed at the location of the future ILTS Phase 2 facility. The A-Train is housed in a temporary tensioned fabric structure within the earthen containment berm of the future ILTS Phase 2. During initial operations, water from dust control and stormwater at D&D sites (which provide demolition debris for placement in the OSWDF) and excavation dewatering and stormwater at excavation sites (which provide soil as engineered fill in the OSWDF) is treated by C-Train and D-Train respectively. Treatment trains C and D will be co-located in a separate facility, X-622-1, and are not connected to ILTS Phase 1 – MLTS components.

The effluent pipelines from treatment trains A, C, and D connect to an existing outfall line which discharges to the regulated NPDES Outfall 4 to the Scioto River.

Before full-scale OSWDF operations with up to 6 active/open cells can begin, ILTS Phase 2 must be operational. A drawing package specific to the ILTS Phase 2 facility and components is included as part of the ILTS Final (100%) Design Package. The ILTS Phase 2 facility will be constructed by first starting up newly constructed B-Train in a permanent metal building. After B-Train is operational, treatment of leachate from the OSWDF will be transferred from A-Train to B-Train. A-Train will then be relocated to the ILTS Phase 2 facility and re-started. Once A-Train is installed and operational inside the ILTS Phase 2 facility along with B-Train, full-scale OSWDF operations can commence.

When treatment of wastewater from demolition of the X-326 Process Building is no longer necessary, C-Train will be relocated to the ILTS Phase 2 facility and re-started to treat waste water from demolition of the remaining Process Buildings. The ILTS Phase 2 facility has the capacity to accept D-Train if future operational constraints related to soils excavation projects require its relocation.

Design Drawings and Specifications

Initially, the ILTS design package was prepared to the 90 percent design level. This design includes a full-scale centralized treatment system with 4 individual treatment trains (providing 3,028 lpm [800 gpm]) capacity for ILTS, 1,514 lpm (400 gpm) for demolition activities and 1,541 lpm (400 gpm) for excavation activities). At this design stage, schedule and funding constraints required that the centralized treatment concept temporarily be set aside without impacting the initial and overall D&D schedule. With 4 individual treatment trains in the ILTS design with many inter-changeable components, modularity was inherent in the design. Collaboration with all stakeholders allowed for the development of the Modular Treatment Systems, easily extracting the design elements from what had already been developed with the ILTS 90 percent design. At this point the site strategy evolved away from the initial concept of a centralized ILTS. The modular approach took advantage of the inherent flexible nature of the ILTS and allowed for demolition, soil excavation, and disposal operations to proceed without waiting for full construction of the large ILTS. The modular systems were housed in fabric structures and placed near the sources of generation. Three separate design packages were developed, on each for A-, C- and D- Trains.

Figure 4 below shows outdoor process equipment that will be used for both Phase 1 and Phase 2 ILTS activities. The foreground shows a portion of the containment berm that provided secondary containment and the pretreatment clarifier to the left, while in the background the equalization and 1-million-gallon storage tank are shown.

Figure 4. ILTS Pretreatment Equipment

Modular Treatment Approach Documentation

ILTS design activities began in 2015 with an approach of developing a centralized water treatment system. This approach initially included development of a CSM and a WMS. As noted previously the CSM development process included the review of all available data related to potential COCs that may be present in leachate and wastewater generated from D&D activities, while the WMS reviewed multiple locations where impacted water could be generated and the resulting water volume from those locations. This approach proved to be very critical to the overall site strategy. Since the CSM and WMS considered data from a variety of sources (excavation and demolition sites), an approach that deviated from a centralized system required only small revisions to the design approach. WMEs were generated to document the differences in the design basis. As detailed data was generated from the individual sources, the basis of designs developed merely required a check against the original DCP to ensure treatment objectives could be obtained.

Specifically, the *X-326 Demolition Water Management Evaluation (WME)*, Final Report, evaluated the management of stormwater, water used for truck wash, and dust suppression water during demolition of the X-326 Process Building. The *X-326 Demolition WME* evaluation included modeling four scenarios with various storage volumes within the containment berm. Subsequently, the design of the berm continued, and the geometry of the berm and detention basin were modified to account for subsurface obstructions. Under this scenario, the storage volume within the berm, below the elevation of the building slab, is 2,381,000 gallons, and will be the basis for this WME water management related to D&D. During the development of the X-326 WME, the source term (radiological) data became available. That information in combination with water volume generation allows for the calculation of potential radiological concentrations in wastewater generated at the demolition site. This information is compared to the DCP to ensure the selected equipment and sizing (developed much earlier in the design process) is still valid.

Figure 5 below shows C- (to the right) and D- (to the left) Train process vessels during construction at X-622-1. The fabric structure housing the equipment is open on one end providing a view of the equipment. Once closed, the fabric structure provides protection from freezing and precipitation.

Figure 5. C- and D-Trains

Similarly, to D&D, the *X-740 and 5-Unit Area Plume Excavation Water Management Evaluation (WME), Final Report*, evaluated the management of stormwater, water used for wheel wash, dust suppression, and excavation groundwater. The *X-740 and 5-Unit Plume WME* evaluated four scenarios of various sizes of excavated areas including the plumes being excavated concurrently and separately. For this evaluation, the X-740 Plume, X-231A/B Landfills, and 5-Unit Plume excavations have been divided into "active", "inactive", "stockpile" and "soil conditioning" areas. The active area is the area where soil is being removed and transported to the OSWDF; therefore, this area is a priority for removal of stormwater to minimize production delays or downtime. The inactive area is the area in the excavation footprint where soil removal is not occurring (either because maximum depth has been reached or the area is being used as a bench). The inactive area will be pumped down secondary to the active area using treatment capacity that remains after accounting for wheel wash, dust control and excavation groundwater. The overburden stockpile area is located at X-740 and contains soil that will be placed back into the excavation (backfill). Stormwater from the overburden stockpile area has the potential to be impacted with low level trichloroethene; therefore, requires collection, testing, and/or treatment. The soil conditioning area located at the 5-Unit Plume Area contains an area for drying and mixing soils before loading into the haul trucks and transported to OSWDF.

In deploying the decentralized/modular approach, the original equipment sizing and specifications from the ILTS design were used, which included skid mounted equipment. The modular systems were assumed to have a design life of 5 years or less, while the ILTS design life was 25 years. Aside from some minor components all equipment placed in the modular systems can be unbolted at flange connection points, transported, and reassembled at ILTS in the future. Polyvinyl Chloride (PVC) pipe is used for interconnecting piping at the modular systems, while carbon steel pipe is provided in the design for ILTS. The adaptive design approach provides versatility and efficiency related to system construction and reuse of multiple equipment components.

CONCLUSION

Water management is a very significant consideration as part of the overall D&D Mission at PORTS or any DOE Environmental Management site. The size of this D&D Mission presented multiple technical challenges emphasizing the importance of early planning. These technical challenges include:

- Based on desired schedule outcomes, design activities need to commence long before all design input values are available.
- The inability to sample water that may require collection and treatment once demolition activities begin.
- Determining design basis discharge objectives without having the renewed NPDES permit in place until late 2020.
- Managing a large volume of historical data (groundwater monitoring, process building specific source terms, historical site operating and remediation data, etc.).
- The timing of when new data may become available and its incorporation into the design.
- The number and complexity of discrete sources across the site that generate potentially impacted water and the distance between these demolition, excavation, and disposal sites.
- Constraints on schedule and funding required a significant design approach change, resulting in the development of a phased and modular treatment strategy, at the 90 percent ILTS design phase under the original centralized treatment strategy. The approach also standardized design of the modular systems across all projects as well as component fabrication and allowed one contractor to construct and startup all the initial three modular systems. The design change preserved the design basis and treatment objectives, while optimizing initial demolition preparation activities and schedule.
- Balancing treatment system design throughput with volume of water generated per rain event at each source site.
- Coordination between multiple projects. The design of water treatment facilities involves 4 separate subprojects, including ILTS, A-Train, C-Train, and D-Train. In addition, numerous other large design efforts associate with D&D Mission are also ongoing that directly impact the outcome of water collection, transmission, and treatment designs, including OSWDF design, X-326 Process Building demolition design, soil excavation designs, and utility isolations/installation.

Early development of the CSM and an adaptive design approach provided the ability to overcome these design challenges and maintain project schedule. Adaptive design, flexibility and modularity were concepts that were incorporated into the development of the ILTS from a very early stage. Development of a water management and treatment strategy without analytical data of the wastewater to be treated poses several design developmental hurdles. Design based on theoretical wastewater requires continual verification in the design process. Adaptive design provided minimal impacts to the design as new data became available. Furthermore, adaptive design allows for an easy transition from a centralized water treatment facility to a phased/distributed/modular treatment system dispersed across the site.

In addition to incorporating adaptability the importance of developing a CSM in the early stage of the project was critical to understand potential contaminants that may be encountered, that could manifest themselves in the wastewater generated during future D&D and excavation activities.

Many Arcadis technical experts and design engineers interacted with FBP and DOE stakeholders including

Central Engineering, Nuclear Criticality Safety, the D&D, OSWDF, and ER. The resultant design optimizations and approach have led to regulatory approvals by Ohio EPA, construction and startup of 3 individual modular treatment systems initially, thus allowing DOE and FBP to meet the schedule requirements associated with first waste placement of demolition debris in the OSWDF under the annual funding constraints. Furthermore, based on the influent design concentrations being achieved, these treatment systems have maintained the discharge objectives continuously since startup in early spring of 2021.

REFERENCES

1. https://www.energy.gov/pppo/portsmouth-site/portsmouth-background
2. https://portsdemo.com/
3. Record of Decision for the Site-wide Waste Disposition Evaluation Project at the Portsmouth Gaseous Diffusion Plant, U.S. Department of Energy, Piketon, OH, DOE/PPPO/03-0513&D2. June 2015
4. Comprehensive On-site Waste Disposal Facility Remedial Design/Remedial Action Work Plan for the Portsmouth Gaseous Diffusion Project, Piketon, Ohio. U.S. Department of Energy, DOE/PPPO/03-0346&D1. March 2018.
5. DOE 2014. On-Site Waste Disposal Facility (OSWDF) Design Criteria Package (DCP *at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio.* U.S. Department of Energy, DOE/PPPO/03-0336&D3. August 2015.
6. Google Maps, 2021. Piketon Ohio, 1:4,000. Goggle Maps [online].
7. Ohio EPA 2015a. *National Pollutant Discharge Elimination System (NPDES) Permit Program FACT SHEET Regarding an NPDES Permit To Discharge to Waters of the State of Ohio For United States Department of Energy (DOE) Portsmouth Gaseous Diffusion Plant – Fluor-B&W Portsmouth, LLC. U.S. Department of Energy, Ohio EPA Permit No. 0IO00000*LD,* Application No. OH0006092, March 2015 and 2020.
8. *Derived Concentration Technical Standard. DOE-STD-1196-2011. U.S. Department of Energy, Washington, D.C. 20585. April 2011.*
9. Remedial Investigation and Feasibility Study Report for the Site-Wide Waste Disposition Evaluation Project at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio. U.S. Department of Energy, DOE/PPPO/03-0246&D3. February 2014.
10. Water Management Study for Influent Flow Rates, Portsmouth Gaseous Diffusion Plant Decontamination and Decommissioning Project Piketon, Ohio, June 2020
11. Interim Leachate Treatment System Technology Evaluation and Selection Report Portsmouth Gaseous Diffusion Plant Decontamination and Decommissioning Project Piketon, FBP-ER-OSDC-WD-ENG-0063, Revision O. Ohio, June 2020
12. Interim Leachate Treatment System Design Criteria Package (DCP) Portsmouth Gaseous Diffusion Plant Decontamination and Decommissioning Project Piketon, FBP-ER-OSDC-WD-ENG-0064June 2020