Disposal for Canada….a Responsible Solution for 120 years of Waste Generation – 17052

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ABSTRACT

Disposal is coming to Canada. After decades of interim storage of radioactive wastes, Canadian Nuclear Laboratories (CNL) is preparing to build Canada's first facility for the permanent disposal of low-level and other suitable radioactive wastes that satisfy the waste acceptance criteria. A project was launched in 2015 to establish a Near Surface Disposal Facility (NSDF) and to place it into operation in 2020 for 50 years.

INTRODUCTION

Canadian Nuclear Laboratories, formerly known as Atomic Energy of Canada Limited (AECL), was initially established as a nuclear research facility in 1944. Operated by the National Research Council as part of the Second World War effort until AECL was created in 1952, CNL and its main Chalk River Laboratories (CRL) campus, has a long history of diverse nuclear operations and facilities, primarily related to scientific research and nuclear technology [1].

Chalk River Laboratories – the host site for the NSDF – is located on the shores of the Ottawa River in Renfrew County, Ontario, approximately 190 km northwest of Ottawa, ON (Figure 1). The CRL site has a total area of approximately 4,000 hectares (ha) and is the daily workplace for approximately 3200 employees.

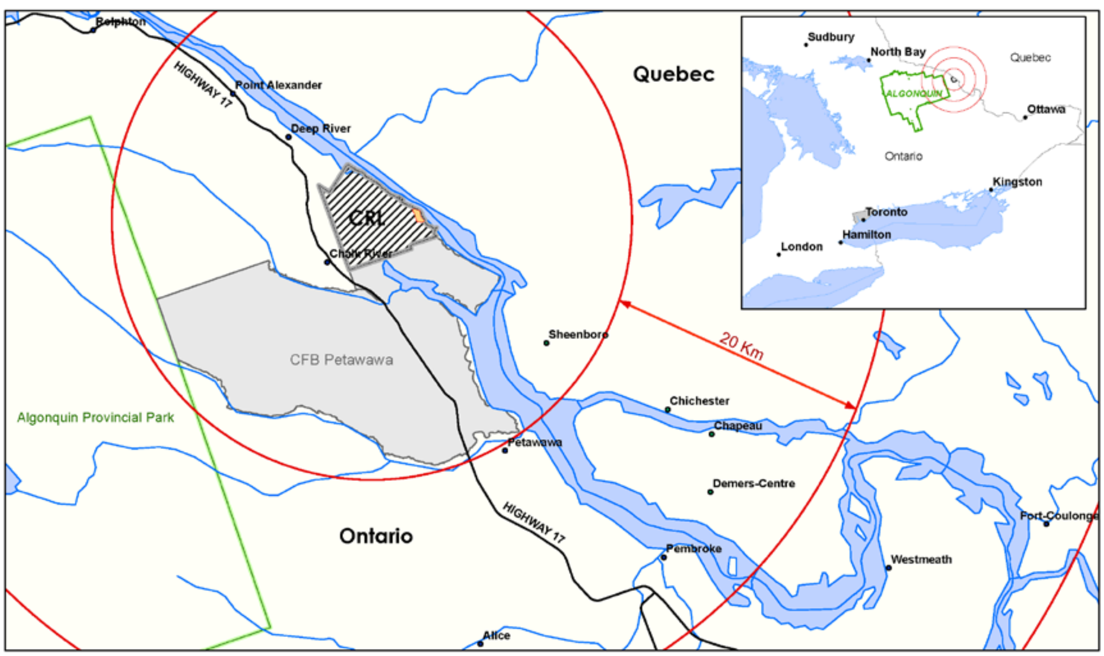

Figure 1 Location of Chalk River Laboratories

Since the 1950s CNL has effectively managed the majority of its wastes on an interim storage basis. Facilities have been built in dedicated waste management areas (WMAs) to hold waste including sand trenches, concrete tile holes (standpipes) and bunkers, traditional and engineered landfills, and most recently, shielded modular above ground storage (SMAGS) buildings where waste packaged in steel B-25 containers is stacked [2].

In the past 20 years, CNL has increased the priority it places on the safe management of nuclear waste and the related reduction of risk to workers, the public and the environment. Accordingly, various programs have been put in place to: improve waste facility planning; better manage existing waste inventories (including utilization of off-site treatment of radioactive wastes); increase the level of waste characterization; implement environmental remedial investigations; reduce waste generation; and to separate clean waste from radioactive waste. The Nuclear Legacy Liabilities Program initiated in 2006 was the umbrella program that guided the efforts for nearly 10 years. Since 2015, when the Government-owned, Contractor-operated (GoCo) model came into effect at CNL, efforts to manage liabilities have been further escalated under the new Decommissioning and Waste Management Mission. Ten-year mission goals include the decommissioning of 100 buildings, closure of two CNL sites, remediation of various WMAs and licensing and construction of the NSDF, the subject of this paper.

WASTE INFORMATION

Integrated Waste Strategy

The NSDF is an important part of the new CNL-wide Integrated Waste Strategy (IWS). The strategy concisely details 'cradle to grave' pathways for all CNL waste streams, from generation to final disposition. The IWS is based on CNL's waste inventory and forecast data and founded on the fundamental principles of waste avoidance, minimization and re-use. It enables the assessment of the quantities and types of waste across the spectrum of waste that CNL manages, from clearable waste to used fuel. The NSDF will represent a key disposition route for waste arising from near term decommissioning and demolition and legacy waste clean-up activities; the low-level waste (LLW) debris and soils that will arise from these activities represent more than 80% of the total radioactive waste volume forecast to be generated through 2045.

Waste Volumes

The NSDF is proposed to have a total waste capacity of one million cubic metres (1,000,000 m^3). This capacity was established based on a review of existing inventories and future waste forecasts [3], as well as consideration of uncertainties and likelihood of clearance of some materials.

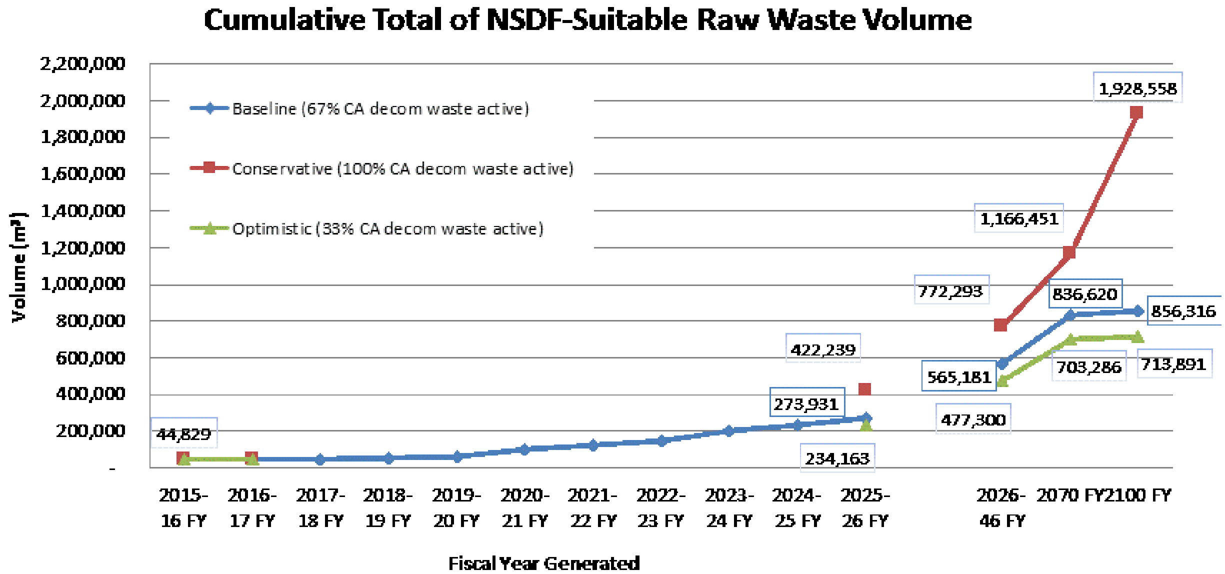

Figure 2: Cumulative Total of NSDF-Suitable Raw Waste Volume

The vast majority of the waste to be emplaced in the NSDF waste will be classified as LLW. Mixed waste and intermediate-level waste (ILW) are expected to represent approximately 1% of the NSDF's total waste volume. All waste to be emplaced in the NSDF must satisfy the Waste Acceptance Criteria (WAC). CNL recognizes the Canadian Standards Association waste classification guidance [4] for handling purposes, however for disposal purposes, the long-term safety case demonstrates the appropriate inventory. Since the total waste inventory either does not yet exist, or may not be fully characterized, a bounding approach is being taken for the purposes of defining the WAC, as well as to support the development of the performance assessment and safety case for the facility.

Waste Types

The nature of the waste to be disposed in the NSDF varies, consistent with the diverse operation of the laboratory over the period 1944 to 2070. It includes waste arising from the:

- demolition of existing and future buildings;
- remediation of impacted soils and related structures;
- operational and legacy wastes currently in interim storage;
- commercial sourced inventories; and
- wastes from the enduring laboratory operations and clean up missions

For NSDF operational handling and waste placement purposes, six waste types have been proposed as described below.

Type 1 – Soil and Soil-like Waste: Type 1 waste includes contaminated soils and other waste materials with characteristics similar to soil that can easily be placed within the mound with little to no handling requirements beyond what would be used for soil fill. Environmental remediation activities at CRL will be the main source of these wastes. Type 1 waste is forecast to represent 31% of the total NSDF volume.

Type 2 – Comingled Debris with Soil or Soil-like Waste: Type 2 waste includes wastes that are anticipated to be at least 50% soil or soil-like in nature, but will also contain varying amounts of radioactive wastes that require additional handling procedures beyond those required for Type 1 wastes. Type 2 waste is forecast to represent 6% of the total NSDF volume. Examples include environmental remediation wastes that are likely to contain materials such as metal, wood debris and trash. Additional handling procedures may include segregation of soil from non-soil like materials.

Type 3 – Non-soil-like Waste: Type 3 waste includes materials that can be excavated and handled as a bulk material, but do not have the physical characteristics of soil and soil-like materials. These include process wastes, highly organic or highly compressible wastes. Type 3 waste is forecast to represent <1% of the total NSDF volume. Examples include contaminated vegetation such as trees.

Type 4 – Decommissioning and Demolition Waste: Type 4 wastes include typical materials used in construction such as concrete, asphalt, brick, lumber, structural steel, process equipment, piping, and other building materials produced by decommissioning and demolition activities at CRL and other CNL sites. Type 4 waste will be the most prevalent and is forecast to represent 47% of the total NSDF volume.

Type 5 – Packaged Waste: Type 5 waste includes a variety of containerized wastes such as wastes contained in large shipping containers, B-25 containers, drums, buckets, and pails. These wastes typically require special handling procedures and protocols for placement and containment within the mound. Type 5 waste is forecast to represent 15% of the total NSDF volume. Examples include packaged personal protective equipment and clothing, laboratory glassware and equipment. A small percentage by volume of packaged wastes will be ILW such as spent ion-exchange resins, compacted trash, immobilized liquids and miscellaneous items. Some of the ILW containerized wastes may require special handling procedures such as provision of shielding to ensure protection of workers from elevated radiation fields. Forklifts and cranes may be required for handling and emplacement of large packages.

Type 6 – Miscellaneous Waste: Type 6 waste includes waste that does not fall within the definition of Waste Types 1 through 5 but otherwise meet the WAC. These wastes will also typically require special handling procedures and protocols for placement and containment within the mound. Type 6 waste is forecast to represent <1% of the total NSDF volume. Examples include oversized equipment, such as tanks that may require use of a crane for emplacement or animal droppings/remains that may require sterilization/sanitation prior to emplacement.

PROJECT TO ESTABLISH THE NSDF

The NSDF is the key enabling facility of the 10-year plan for the Decommissioning and Waste Management mission. It will enable accelerated decommissioning of buildings and remediation of the environment, and thus make possible the reduction of nuclear liabilities and the revitalization or re-use of lands. The ability to directly dispose of waste – without interim storage step - will preclude the handling of the waste a second time and improve safety for workers.

CNL established the NSDF project in 2015 October and undertook a six-month planning phase to define its scope and implementation strategy. The project was sanctioned to implement in early 2016, and is scheduled to be completed by 2020 September (Figure 3).

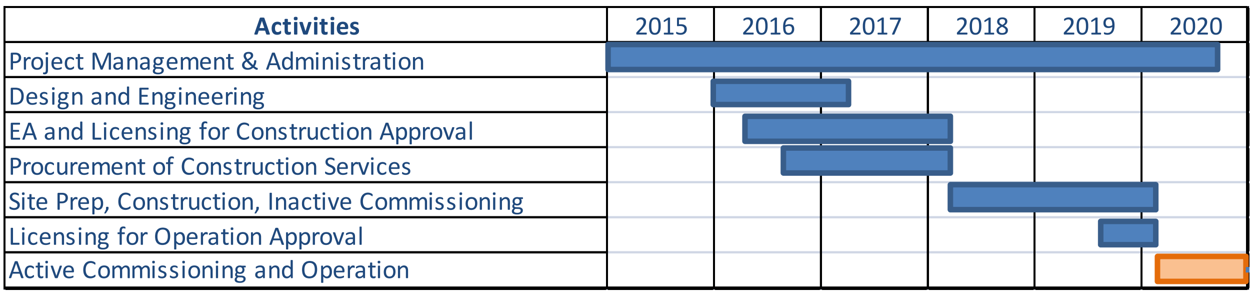

Figure 3: Overview Schedule for NSDF Project Implementation

A dedicated team has been formed to lead the project implementation. Some 25 CNL resources, a selected world class design team and several consultants are working together to deliver the outcomes on the accelerated timeline.

The NSDF is intended to be built in two primary phases. The NSDF project is concerned only with Phase 1 which will establish the initial 525,000 m^3 disposal waste capacity and build the infrastructure required to place the facility into operation. A Phase 2 will follow an estimated 20-25 years after Phase 1 is completed and expand the facility's waste capacity to 1,000,000 m^3.

The scope of the project is organized into three main work packages, each of which is described below.

Design and Engineering

The NSDF facility is proposed to be built at a green field location within the boundaries of the CRL site where the vast majority of waste is located. The location was selected to satisfy relevant technical, safety and environmental requirements (two options were evaluated). The location was confirmed in 2016 October following completion of subsurface investigations (e.g. geotechnical, hydrogeological), biodiversity studies, and archaeological assessments of both sites and following informal discussions with stakeholders. The site measures approximately 33 hectares (ha).

The design of the NSDF began with a concept modelled from facilities existing or under construction in North America. From there, following a competitive procurement, AECOM Canada Ltd. was retained by CNL in 2016 July to develop the full design. The design and safety analyses are being developed in parallel and reviewed in packages at the 30%, 60%, 90% and 100% completion points. As of the end of 2016 November, the design is 60% complete.

The NSDF is being designed for 550-years, including the 50-years of operation and 500 years post-closure. The design features four key elements:

- Engineered Containment Mound (ECM) for waste disposal;
- Waste Water Treatment Plant (WWTP) for processing of leachate and other aqueous waste streams;
- Support Facilities, including various buildings, weigh scales, etc.;
- Site Infrastructure, including roads, services, fencing and storm water ponds.

The elements above are laid out within the site to take full advantage of the natural slopes and groundwater gradients. The ECM, with a substantial structural berm defining its perimeter, will occupy approximately 16 ha, or nearly half of the total site area (Figure 4). The waste footprint will be considerably smaller, and displace less than 11 ha within the ECM. The WWTP and support facilities are positioned in the northern end of the site together, where operational synergies can be realized. Storm water ponds are located at the low elevations to optimize runoff capture.

Figure 4: Aerial Rendering of NSDF with Final Cap Installed (from North)

The ECM will be constructed essentially at the existing surface elevation and will have a total height of approximately 20 metres (m). Ten waste cells are proposed (Phases 1 and 2 combined), with an average surface area of 10,000-11,000 m^2 each.

The design of the ECM will withstand a 1 in 10,000 year earthquake, winds of 240 km/hour, and back-to back, 24-hour 100-year storm events. The design features defense in depth with multiple engineered barriers to contain and isolate the waste from the environment using a double base liner system and cover system (Figure 5). Both systems are composite in that they feature natural and synthetic materials. Test wells with sensors will be installed around the perimeter of the ECM to monitor the performance of the waste containment.

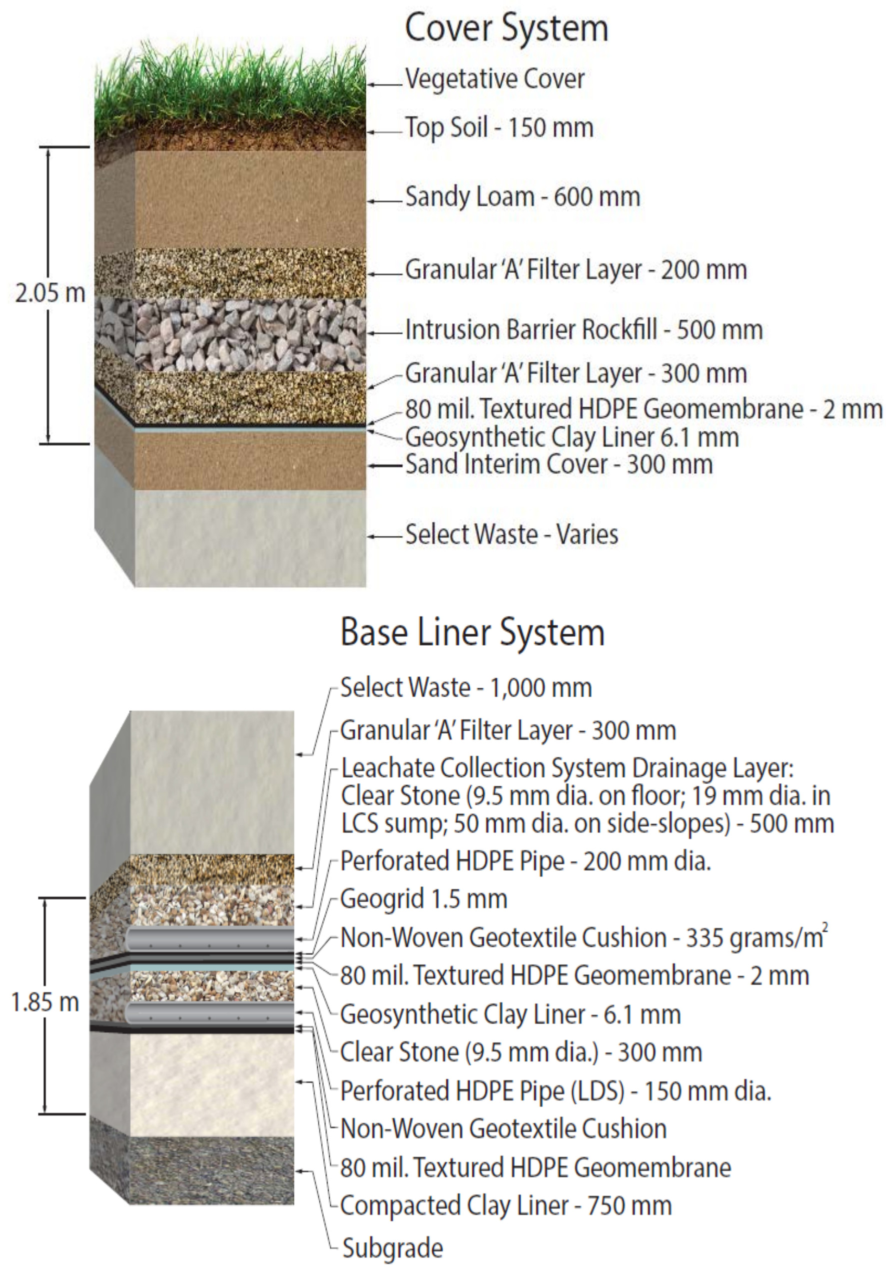

Figure 5: NSDF Base Liner and Cover Systems Rendering

Water draining through the wastes (generally prior to final cover installation) will be collected within High Density Poly-Ethylene (HDPE) piping that is installed within the base liner. There is both a primary leachate collection system (LCS) and a secondary leak detection system (LDS) to ensure all liquid is collected and removed. The LCS and LDS both drain by gravity to a series of sumps and from there, the water is pumped to the WWTP. Therefore, leachate and contact waters along with operational waste water from truck wash and personal showers will be directed to the WWTP.

All water to be processed in the WWTP will be first mixed in the equalization tanks. The tanks and other elements of the WWTP process train have the capacity to manage back to back, 24-hour 100-year storms occurring during a spring thaw. Liquids will be routed from the tanks through a three-stage process (Figure 6) that was developed following benchtop and pilot-scale testing using simulated leachate. In the first stage, suspended and dissolved solids will be removed by precipitation and filtration. In the second stage, organics will be removed in an activated charcoal bed while radionuclides and residual metals will be stripped via ion exchange. Finally, in the third stage, pH will be adjusted through polishing. Treated water (effluent) will be held in a tank and tested prior to its release to the environment to ensure all discharge criteria have been met. An infiltration area has been identified for the effluent discharge within the NSDF site.

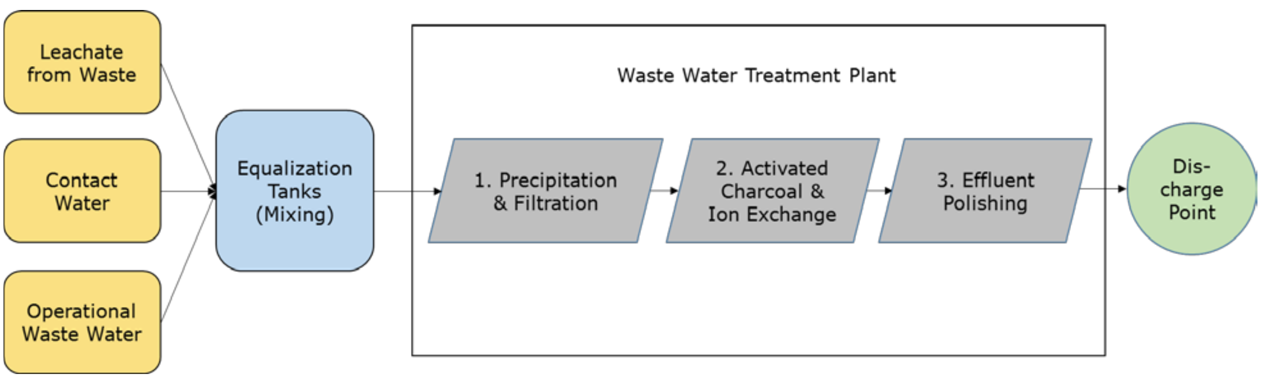

Figure 6: WWTP Simplified Process Flow Diagram

The NSDF features several Support Facilities. These include entrance control kiosks and weigh scales to measure loads in delivery trucks on the way in and out of the facility. Facility operations staff who are not based in the WWTP will use the main office and change room. There will additionally be a vehicle decontamination facility to wash delivery trucks that are pick up contamination while within the ECM. Most of the Support Facilities will be prefabricated and installed at the NSDF site.

Site Infrastructure includes several civil engineering features that effectively make the NSDF function. These include the road system both into and out of the facility, and surrounding the ECM itself, as well as parking and lay-down areas. Services supplied from the main CRL campus and distributed throughout the NSDF include Class IV power, telephone and fibre optics, natural gas, process/fire water and sanitary sewer. Additionally, there is security fencing and three storm water management ponds to receive run-off that can be diverted from the ECM.

Regulatory Approvals

Based on its waste inventory, the NSDF will be regulated as a Class 1B facility, and its construction and operation will be subject to licensing and environmental approvals from the Canadian Nuclear Safety Commission (CNSC). All approvals are being sought as part of the Phase 1 development.

The environmental approval is required pursuant to the *Canadian Environmental Assessment Act* (2012) [5] and must be in place before site preparation work can commence. The proponent, CNL, must undertake an environmental assessment (EA) and determine the potential impacts on the natural and socio-economic environments and identify measures to mitigate the effects to levels that are deemed to be acceptable. CNL has engaged Golder Associates to prepare the Environmental Impact Statement (EIS) for the NSDF, with significant input from CNL resources and contributing consultants. The EIS and other supporting documents required in support of the EA decision are on track to be submitted to the CNSC by the end of 2017 March (Figure 7). Public comment on the EIS will be invited for 60 days in parallel with the planned regulatory reviews.

The licensing approval is required in accordance with the *Nuclear Safety & Control Act* [6] and under the existing licence held by CNL for CRL site activities [2]. CNL will seek CNSC approval for the NSDF in conjunction with CNL's broader application to renew the CRL site licence. Several documents are required in support of the NSDF licensing decision, notably the Safety Analysis Report which is being produced by AECOM Canada Ltd. as part of the design scope, and almost all must be submitted to the CNSC by end of 2017 March (Figure 7).

As the proponent for the NSDF, CNL will present its applications to the CNSC's panel of Commissioners in a public hearing process, tentatively in 2018 January.

Figure 7: Regulatory Decisions and Required Supporting Documentation

Construction

The activities to prepare the site, build the NSDF and complete inactive commissioning are expected to take two years to complete. The procurement to hire the contractor(s) to undertake this work has already commenced. In 2016 December, a pre-qualification process was launched to identify the subset of companies that have the requisite qualifications and experience to undertake the construction. Following the completion of the detailed design, the pre-qualified companies will be invited to submit proposals. CNL will evaluate the offers received and ultimately select a successful bidder to undertake the construction.

The construction itself will entail extensive removal of trees (estimated at 95% of the site footprint), grubbing, rock blasting and crushing and grading. The ECM itself will require import and placement of significant quantities (Table 1) of clay, granular and synthetic materials [7]. The installation of all ECM materials will be under a comprehensive quality assurance program.

Table 1: Indicative Material Quantities for ECM Base Liner Construction

Material	Quantity
HDPE Geomembrane	225,000 m^2
Geosynthetic Clay Liner	130,000 m^2
Non-Woven Geotextile	225,000 m^2
Perforated HDPE Pipe	2,320 m
Natural Clay	88,500 m^3
Granular 'A'	28,300 m^3
Clear Stone	80,000 m^3
Perimeter Berm Rock/Fill	215,000 m^3

In parallel with the ECM construction, the WWTP and other buildings will be built. Skids of process equipment and tanks will be installed on prepared foundations and then plumbed and wired in place. A supervisory control and data acquisition (SCADA) system will connect all instrumentation and equipment to enable full control of the WWTP from the operator control stations.

Following substantial completion of construction, inactive commissioning of the various components and systems will be undertaken to validate that the as-built plant functions as was intended by the design. Due to the Class 1B nature of the facility formal commissioning plans, procedures and records will be required for all component and system tests. Future facility operators will, to the extent feasible, be engaged in the commissioning tasks.

The Construction work package will end with the formal acceptance of the NSDF.

CONCLUSIONS

The NSDF is an essential new facility for CNL which will utilize proven technologies for containment and waste water treatment. It will provide Canada's first disposal facility and with its 1,000,000 m^3 capacity, will enable significant reduction of legacy nuclear waste liabilities as CNL transitions from decades of safe interim storage of LLW to permanent disposal. Implemented on a fast-tracked basis, under a high performance project organization, the main work scopes include design and engineering, regulatory approvals and construction. The project is on track to complete design in 2017 March, defend regulatory applications in 2018 January, and to have the facility ready for active commissioning and operation by 2020 March. Canada's multiple solutions for future waste management are on the move from strategies to implementation. Watch this space…….

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