PRE-PROJECT ACTIVITIES RELATED TO THE REMEDIATION OF FISSIONABLE MATERIALS CONTAINED IN STANDPIPES AT ATOMIC ENERGY OF CANADA LIMITED'S WHITESHELL LABORATORIES.

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ABSTRACT

AECL® is presently decommissioning Whiteshell Laboratories (WL), a former nuclear research site. Some Fissionable Materials (FM), arising from operation of Whiteshell Reactor-1, an experimental organic-cooled 60 MW reactor that ran from 1965 to 1985, are stored in 69 in-ground standpipes in the WL Waste Management Area (WMA). The standpipes (171 in total) were used to store mainly intermediate level waste over the period 1967 to 1986.

AECL has committed to remediate the 69 standpipes containing FM. This work, under the auspices of the Nuclear Legacy Liabilities Program, is presently in the pre-project phase, which is focussed on developing an optimum remediation strategy. It includes assessing the condition of the standpipes, the environment inside the standpipes, and possible remediation options. This paper describes the standpipe designs, approaches for determining their fitness for purpose, and steps being taken to determine what radiological or industrial issues may be associated with the stored material. In addition, potential remediation strategies identified to date, and technology that must be developed for conditioning the contents of the standpipes for remediation are discussed.

1. INTRODUCTION

In 1999, AECL received government concurrence to plan actions for closure of the Whiteshell Laboratories site. The goal is to safely and effectively transition the WL site to a shutdown and decommissioned state that meets regulatory and Federal policy requirements. Remediation of standpipes containing reactor fuels located in the WL WMA is required to meet this goal. The Standpipe Remediation Initiative was established to conduct the pre-project planning and development work necessary to address the need for remediating these standpipes.

2. STANDPIPES

The WL WMA contains 171 in-ground standpipes; 95 are covered by 50 cm of earth or less, and 76 have their top portions exposed about 50 cm above ground. Of these, 69 contain FM[1].

The standpipe area and the rest of the WL WMA is underlain by 0.5 m of organic rich soil horizons, then 1.5 m of silt, followed by 2.5 m of clay, 5 m of clayey glacial till and 3 to 5 m of stratified basal sands. The area lies in a groundwater discharge zone. Groundwater from the

[1] Broadly defined here to include thorium and all enrichment levels of uranium

basal sand aquifer flows vertically upwards, through the silts and clays and discharges at the ground surface. The water table is generally within 1-2 m of the surface.

2.1. Standpipe Design

There are two basic standpipe designs; the "Early" or prefabricated standpipes, and the "New" standpipes, which were poured-in-place. Early standpipes were prefabricated using 2-3 sections of unlined concrete pipe and a base (Figure 1, total length of the uncapped standpipe: 3.66 m). The sections were assembled with offset connections that were sealed with a gasket. Two steel strands run through the solid bottom section and through tubes embedded in the walls of the pipes (sections 2 and 3 in Figure 1). Upon assembly, these strands were tensioned and tied off in a recessed pocket at the top of the upper section. These standpipes were damp-proofed by coating with asphalt. They were suspended in augered holes on top of a freshly poured concrete base and kept in this position for 48 hours while the concrete base set (Figure 2). Common backfill was used to fill in the annulus of the augered hole.

After the full complement of waste was added, these standpipes were apparently filled with sand or gravel, sealed with bitumen and capped with concrete. Excavation work in 2009 on some standpipes to 1.2 m below grade showed that the shapes of the caps vary. Figure 3A shows a standpipe on which the cap covers only the interior diameter of the standpipe; the caps of other standpipes examined in 2009 were found to cover some of the standpipe top end wall, the entire top end of the standpipe, and in one case, extended beyond the outside diameter of the wall.

Figure 1. Standpipe sections 1: base; 2 and 3: unlined pipe (circa 1966).

Figure 2. Installation of an early standpipe (circa 1966). Note work in the background on augering another standpipe hole.

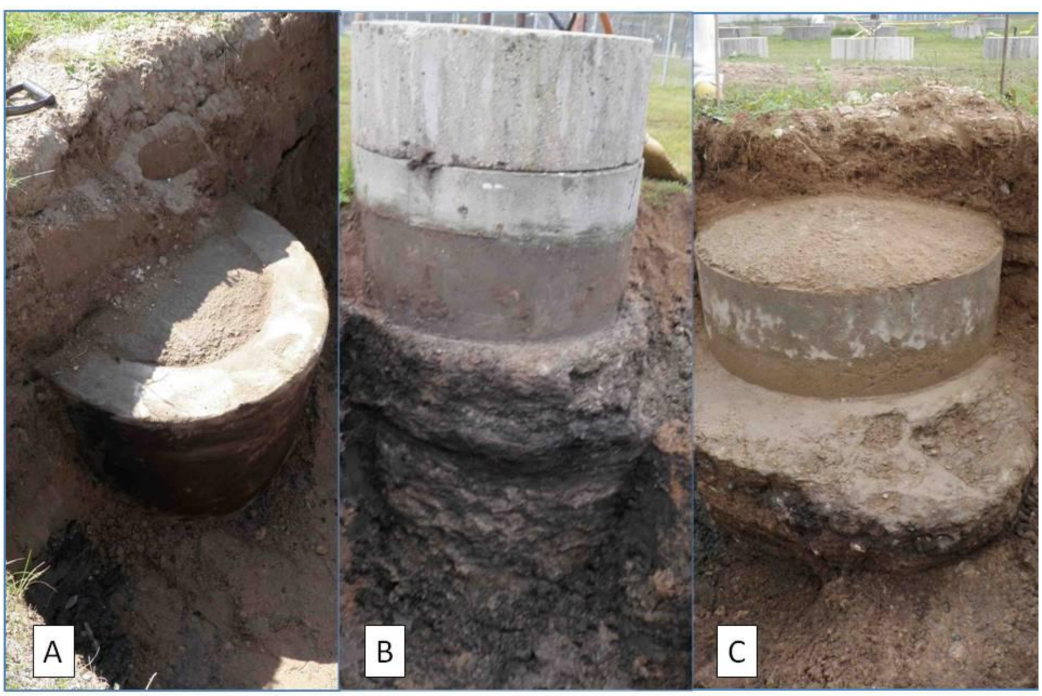

Figure 3. Standpipe Types: A- EARLY; B - exposed NEW; C - buried NEW (2009).

The 76 standpipes with tops exposed above ground are based on the new, poured-in-place, design shown in Figure 4. They were constructed by suspending a welded carbon steel pipe in an augered hole and backfilling around and under with concrete to a nominal thickness of 0.2 m. They are sealed with concrete shielding plugs that can be removed for inspecting the contents. Figure 3B shows one of these standpipes exposed to 1.2 m below grade. Some buried standpipes appear to be of this design (Figure 3C); however, instead of a plug, they are capped with concrete, like the early standpipes.

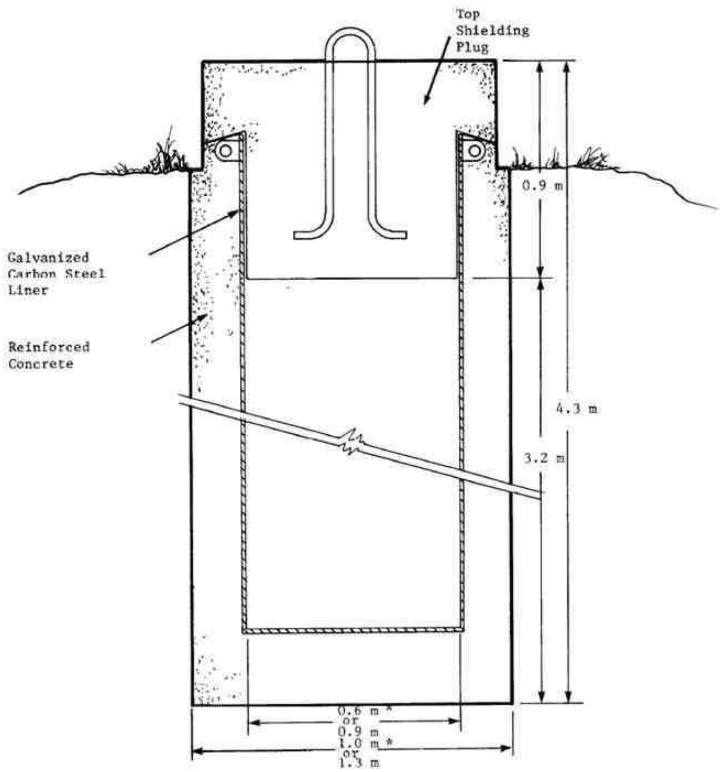

Figure 4. New, poured-in-place standpipe elevation drawing.

2.2. Standpipe Contents

The FM in the 69 standpipes selected for remediation include irradiated fuel from experiments and Post Irradiation Examination work conducted in the hot cells, surplus materials, and un-irradiated fuel materials used in some experiments. Most of the irradiated fuel originated from Whiteshell Reactor-1, with small contributions from several other Canadian experimental and power reactors. This material was in a variety of forms: cut sections, broken pieces, shavings, sludge, etc., and comprised 650 items of distinct FM. Some of these items were cut to fit into their transfer containers (e.g., fuel bundles cut into many element sections) before emplacement.

The waste consisted of uranium and thorium oxides, uranium carbide, uranium metal and various alloys, uranium silicide and uranium-silicon-aluminum and graphite-based composite materials. Most of the 69 FM-bearing standpipes contain two or more different fuel types.

In addition, some standpipes contain non-FM waste (e.g., scrap metals from experiments, filters).

The FM-bearing standpipes were filled between 1967 and 1977 except for two emplacements in 1985 and 1992. Thus, most of the FM has been in storage for 30 to 40 years. Due to the nature of the site and storage conditions, water ingress into the standpipes is expected to have occurred.

3. STANDPIPE REMEDIATION PRE-PROJECT PLAN

The WL Standpipe Remediation Initiative is in the pre-project phase. This phase involves gathering the information required to develop a plan for remediating the FM-bearing standpipes. The main foci are: 1) determining the condition of the standpipes and their contents to define the issues related to remediation, and; 2) assessing potential remediation options.

3.1. Condition Assessment

3.1.1. Past Activities

The following have led to the present understanding of standpipe conditions and potential issues:

- An electronic database of standpipe contents has been established.
- The chemical and physical properties of the emplaced FM have been documented.
- Burnup data have been compiled, with conservative estimates where necessary, for all irradiated FM, providing a basis for estimating radioactive inventories and hazards.
- The likely present conditions of the FM, the potential presence of combustible gases and pyrophoric material, and a relative hazard ranking have been assessed.
- Inspections of standpipes exposed to 1.2 m below grade indicated the condition of the concrete was very good. As no seals between sections of any early standpipes were exposed, deeper excavation is required for complete assessment.

3.1.2. Present Activities

Present activities include: 1) planning to conduct non-invasive material density profiling, and; 2) planning to drill through standpipe plugs/caps to sample for gas and water content.

3.1.2.1. Material Density Profiling Using Radiography

The objective is to locate emplaced material, sand, water, gas, and the approximate length of the poured-in-place concrete caps. The procedure involves installing investigation tubes on opposite sides of selected standpipes down to the same level as the bottom of the standpipe (Figure 5). A 100Ci Cobalt-60 gamma source will be placed in one tube; a detector configured with a narrow window to detect unscattered high-energy gamma rays from the Cobalt-60 source will be in the other tube. The detector and source will be raised and lowered such that when readings are taken, they will be located at the same relative depth. Background readings using the high-energy gamma ray window in the detector will be obtained prior to using the Co-60 source. Following compensation for background, data obtained using the Co-60 source will produce a profile of relative density as a function of depth. By comparison with similar data obtained using a mock standpipe (Figure 6), the material located at different depths may be identified.

At present, the mock up work has been successfully completed, and investigation tubes have been installed at selected standpipes in the WMA. Radiography work is scheduled for 2011.

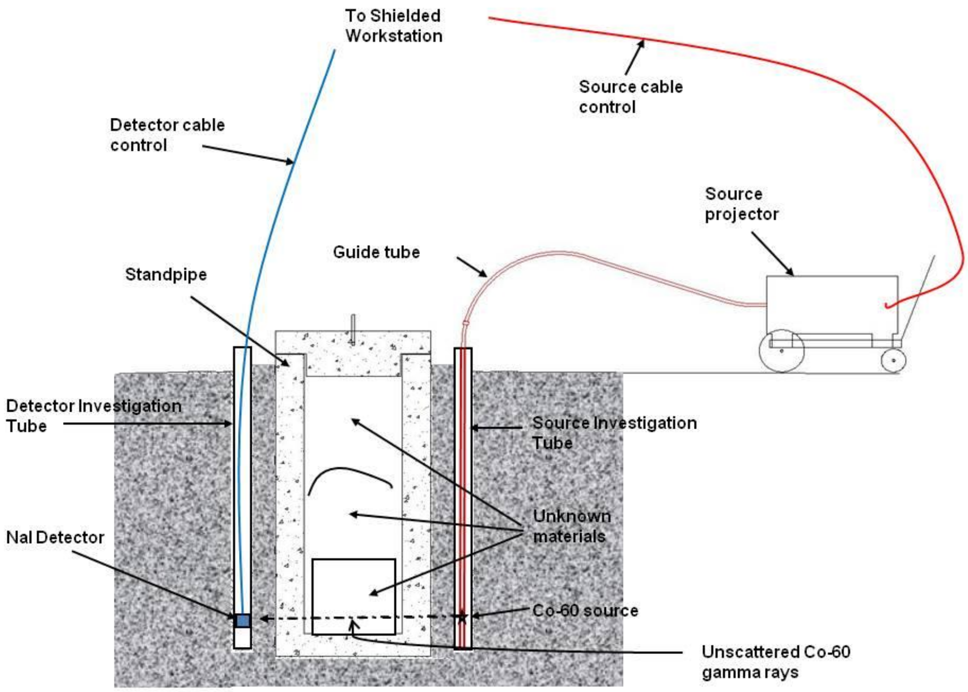

Figure 5. Set-up for axial material density profiling of standpipes.

Figure 6. Mock standpipe and shielded enclosure set-up for axial radiography trials.

3.1.2.2. Drilling Through Standpipe Plugs/Caps to Sample for Gas and Water

No empirically-derived data exists on the current physical or chemical conditions of the FM, the extent of gas accumulation within the standpipes, or the presence of water. Expectations based on inference from available data are:

- Fuel corrosion will generate hydrogen gas, and/or methane and other hydrocarbons;
- Anoxic corrosion of metallic objects such as steel cans and the aluminum-based cladding materials from some fuels can produce hydrogen;
- Radiolysis of water and organic compounds may be another gas generation source;
- Certain radionuclides, such as Cs-137 and Sr-90, in oxide fuels will have been significantly leached by water intruding into the standpipes.

Uncertainties regarding the extent of gas accumulation after 30-40 years storage and the extent of Cs-137 and Sr-90 dissolution into water in the standpipes need to be resolved before a remediation option can be chosen.

Available data shows the buried standpipes contain poured-in-place caps, which do not contain lifting bolts. The standpipes do not contain any ports for sampling or venting. Thus, drilling through the cap appears to be the best alternative for accessing the internal environment.

A diamond drill will be used to drill through the standpipe caps/plugs. Figure 7 shows a trial conducted on a mock concrete cap/plug (for work on actual standpipes, the drill will be on a mobile platform and not in direct contact with a standpipe).

Figure 7. Demonstration of drilling through a mock standpipe cap/plug (2009).

The drilling procedure is based on one used at AECL's Underground Research Laboratory for concrete buffer interface gas sampling [1]. A 96 mm-diameter hole will be drilled part way into the cap/plug (the radiography work discussed in Section 3.1.2.1 should provide information on the depth of the poured-in-place caps). A modified 38 mm drill bit will then be used to drill the remaining distance through the standpipe cap/plug. The modified bit will include a packer assembly (Figure 8 A and B), which will capture used cooling water and maintain a barrier between the atmospheres inside and above the standpipe. The outer 45 mm tube will contain and direct the used cooling water to a collection tank. The compressible rubber sleeve will provide a pressure seal against the walls of the 96 mm-diameter hole; this will constitute the barrier between atmospheres inside and above the standpipe.

A stainless steel tube will span the rubber sleeve (Figure 8 A and B). This tube will be attached to an inert gas supply, a pressure transducer, and a tube leading to an evacuated gas sampling system. When the standpipe cap/plug is breached, any gas pressure inside the standpipe is expected to be relieved by expansion along the path taken by the used cooling water, which leads to a cooling water collection tank. Once pressure inside the standpipe is deemed acceptable, a valve on the line leading to the gas sampling system will be opened and the vacuum inside the sampling system will assist in collecting up to four replicate gas samples.

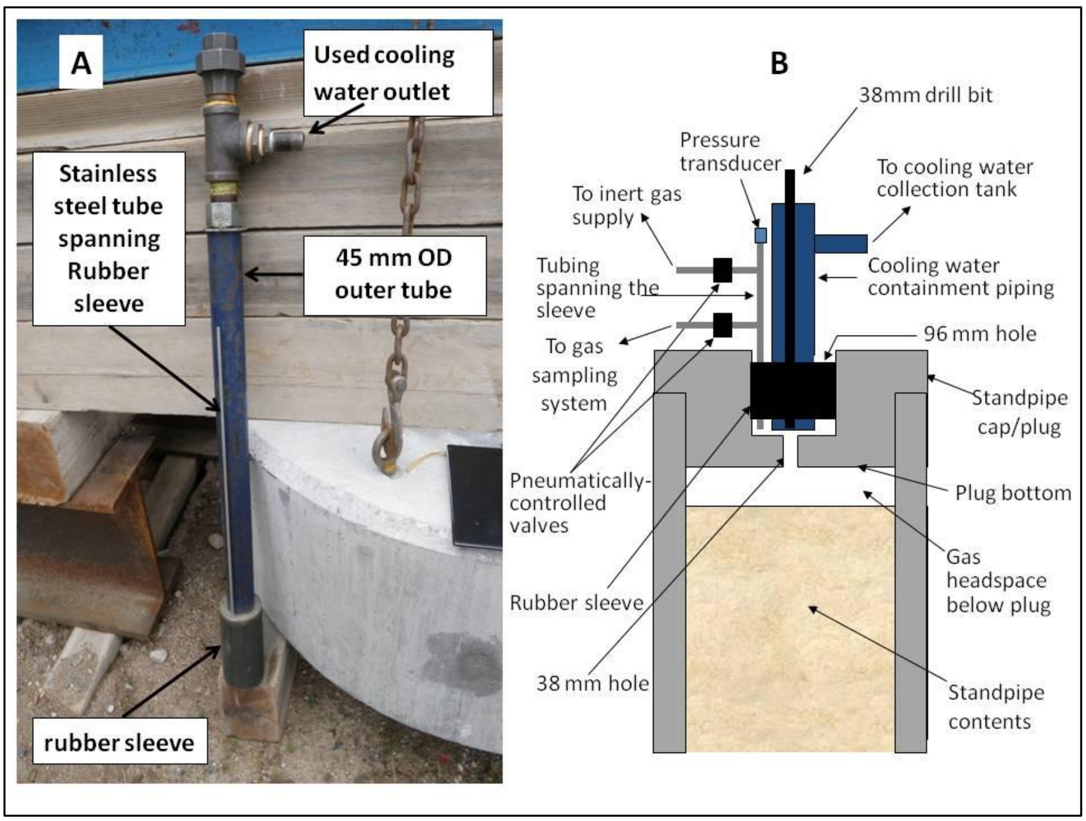

Figure 8. A: 38mm drill bit modified with a packer assembly. B: Schematic of the modified 38mm drill bit in the standpipe cap with tubing connected to inert gas source, pressure transducer and gas sampling system (Note: Drawing not to scale).

After gas sampling is complete, an inert gas atmosphere will be established inside the top part of the standpipe and in the 96 mm- and 38 mm-holes in the plug/cap. The condition of the interior walls of the standpipe near the bottom of the cap/plug will be examined using a bore scope. A probe will then be used to detect water in the top 10 cm of the contents of the standpipe. If present, water will be sampled only from that top 10 cm so no potentially reactive material is disturbed. A vacuum-assisted procedure will be used to collect a water sample. Finally, equipment will be installed in the 38 mm- and 96 mm-diameter holes to allow venting, flushing and sampling in the future, if required. This equipment will be protected by a removable all-weather cover.

At present, a detailed design of the components involved in the drilling and sampling and a safety analysis of the proposed procedure are in progress.

3.1.3. <u>Future Activities</u>

Dewatering is anticipated to be a major component of any final remediation strategy. The equipment inserted under the removable all-weather protective cover after the drilling and sampling process (see previous section) will provide the portal for dewatering fieldwork.

Dewatering technology used at AECL's Chalk River Laboratories (CRL) will be assessed in 2011. At CRL, vacuum assistance is used to remove water from tile holes (similar to standpipes), circulate it through a filter and ion-exchange column, and then pump the water into drums for processing at the Waste Treatment Centre.

Technology will need to be developed for safely inserting water removal equipment into the standpipe without disturbing potentially reactive material.

3.2. Assessing Remediation Options

A survey of remediation work conducted in Europe and North America indicated that the remediation of tile holes at Bruce Power in Ontario was the only technology with potential for use with the WL standpipes. This technology involved encapsulating tile holes in concrete, *in situ*, then lifting and transporting them to a storage location [2]. Evaluations of the different soil conditions at WL, and of the worst-case radioactive fields anticipated to be encountered at WL, indicated that, with some modification, this technology had potential. Currently, work is in progress to determine costs and requirements for testing this technology at WL.

Another potential remediation option involves using WL's Shielded Facilities to separate, characterize, passivate and package the contents of the FM-bearing standpipes for long-term storage. A preliminary evaluation was conducted on the possibility of extracting the standpipe's contents *in situ*, transferring the contents to the Shielded Facilities, sorting and repackaging the waste, and decommissioning the empty standpipe.

The third remediation option identified involves using a new, possibly mobile, shielded facility located at the WMA. A preliminary assessment of this option has been completed. Once information has been collected on costs and requirements for testing the tile hole remediation technology used at Bruce Power, a comparison of the three options will be conducted to define all the issues and prioritize the options for further assessment.

4. SUMMARY

Standpipe Remediation Initiative pre-project activities involve evaluation of standpipe condition, potential issues that may be faced during remediation, dewatering techniques, and potential remediation options. Work is underway to examine concrete surfaces outside and inside the standpipes. Plans for drilling through standpipe caps/plugs are underway to test for gas and water, and to examine the interior walls at the top of the standpipe. Development of suitable dewatering techniques will begin next year. Finally, a comparison of the three potential remediation options identified to date will be completed in 2012.

The output of this pre-project work will be a recommendation of a remediation technology, definition of the requirements for the remediation project, and provision of a clear set of expectations and acceptance criteria.

5. REFERENCES

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