LESSONS LEARNED IN PLANNING THE CANADIAN NUCLEAR LEGACY LIABILITIES PROGRAM

M. Stephens, S. Brooks, J. Miller, P. Neal, R. Mason
Atomic Energy of Canada Limited
Chalk River, Ontario, Canada

ABSTRACT

In 2006, Atomic Energy of Canada Limited (AECL) and Natural Resources Canada (NRCan) began implementing a $7B CDN, 70-year Nuclear Legacy Liabilities Program (NLLP) to deal with legacy decommissioning and environmental issues at AECL nuclear sites. The objective of the NLLP is to safely and cost-effectively reduce the nuclear legacy liabilities and associated risks based on sound waste management and environmental principles in the best interest of Canadians.

The NLLP comprises a number of interlinked decommissioning, waste management and environmental restoration activities that are being executed at different sites by various technical groups. Many lessons about planning and executing such a large, diverse Program have been learned in planning the initial five-year "start-up" phase (concluded 2011 March), in planning the three-year second phase (currently being commenced), and in planning individual and interacting activities within the Program.

The activities to be undertaken in the start-up phase were planned by a small group of AECL technical experts using the currently available information on the liabilities. Several internal and external reviews of the Program during the start-up phase examined progress and identified several improvements to planning. These improvements included strengthening communications among the groups within the Program, conducting more detailed advance planning of the interlinked activities, and being cautious about making detailed commitments for activities for which major decisions had yet to be made.

The second phase was planned by a dedicated core team. More and earlier input was solicited from the suppliers than in the planning for the first phase. This was to ensure that the proposed program of work was feasible, and to be able to specify in more detail the resources that would be required to carry it out.

The NLLP has developed several processes to assist in the detailed planning of the numerous projects and activities. These include developing a more formal procedure for setting priorities of the different parts of the Program, preparing an Integrated Waste Plan to identify the optimal suite of support facilities to be constructed, the creation of a series of "pre-project initiation" procedures and documents to guide the development of well-founded projects, and the use of staged decision-making to incorporate more flexibility to adjust Program strategy and the details of implementation at planned decision points. Several Case Studies will be outlined to illustrate examples of the application of these planning techniques.

1. INTRODUCTION

In 2006, Atomic Energy of Canada Limited (AECL) and Natural Resources Canada (NRCan) began implementing a $7B CDN, 70-year Nuclear Legacy Liabilities Program (NLLP) on behalf of the Government of Canada to deal with legacy decommissioning and environmental issues at AECL nuclear sites. The "legacy" liabilities include shutdown research and prototype power reactors, fuel-handling facilities, radiochemical laboratories and support buildings, stored radioactive wastes, and lands that have been contaminated by past practices. These liabilities had resulted from activities to pursue the national goals of developing Canada's CANDU®[1] power reactor technology, producing medical isotopes that are used around the world, and conducting research into other peaceful applications of nuclear technology. The Program is overseen by an NRCan/AECL Joint Oversight Committee (JOC), and is managed by a Liability Management Unit (LMU) that was established for the purpose within AECL.

The liabilities are located at the Chalk River Laboratories (CRL) in Ontario, Whiteshell Laboratories (WL) and the Underground Research Laboratory (URL) in Manitoba, the sites of three prototype CANDU® power reactors in Ontario and Quebec, and the sites of former heavy water production plants at LaPrade, Québec and Glace Bay, Nova Scotia. CRL presents a particular challenge because nuclear operations are continuing at the site. The extensive suite of shutdown facilities occupying portions of the built-up areas of CRL must be decommissioned to remove the continuing risk and financial liability they represent, and historic waste storage practices need to be addressed. WL and the URL are currently in the process of being fully decommissioned, and the remaining sites are currently held in storage with surveillance until they are completely decommissioned.

The NLLP began with a five-year (2006-2011) "start-up" phase that was focused on four areas of activity:

- dealing with immediate health, safety and environmental issues;
- accelerating the decommissioning of the shutdown facilities and infrastructure;
- conducting groundwork studies and putting into place "enabling" waste management facilities that were essential to conducting the future phases of the Program; and
- ensuring care and maintenance of the legacy liabilities until each could be dealt with in turn.

The NLLP thus comprises a large number of interlinked decommissioning, waste management and environmental restoration activities that are being executed at several sites by numerous technical groups as suppliers to the LMU.

The overall strategy behind the Program is shown in Figure 1. Until liabilities are reduced and eliminated, they must be controlled in a safe state, meeting site licence requirements.

To reach the end states, the liabilities are to be reduced as expeditiously as possible through a large set of decommissioning and environmental restoration activities. However, in some cases, these activities are constrained by a limited availability of the necessary waste management facilities.

[1] CANDU® is a registered trademark of Atomic Energy of Canada Limited.

The ultimate driver of the entire Program is to eliminate the liabilities, to the extent appropriate and possible, by bringing the affected sites to their respective final decommissioning end states, and placing the generated wastes in long-term management facilities.

The LMU has learned many lessons from planning the start-up phase of the NLLP, and from the current planning for the second three-year phase (2011-2014) of the Program. Additional lessons have been learned from internal and external reviews, and several techniques have been developed to manage various aspects. This paper presents the lessons learned to date about planning this large, complex Program, and provides selected case studies of some of the techniques that have been developed.

2. PLANNING THE START-UP PHASE (2006-2011)

Planning for the initial "start-up" phase (2006-2011) was led by a small group of AECL technical experts. They had to rely on the existing information on the state of the facilities to define a Program of projects to deal with the most immediate health, safety and environmental risks; to accelerate decommissioning of the stock of shutdown facilities; to begin cleaning up the contaminated lands; and to plan and construct the most urgent supporting, or "enabling", waste management facilities.

The Program began in a situation where the available resources were only sufficient to maintain the status quo in a safe, legally compliant state, so both internal and contracted resources had to be assembled to carry out the necessary work. The required increase in technical staff to support an aggressive Program was not fully appreciated. As well, some of the projects addressing immediate health, safety and environmental needs within the Program are one-of-a-kind, and the essential base information on which to prepare detailed execution plans was not available to plan the work accurately.

As a result, progress in executing the Program was slower than anticipated due to the limited available resources of the suppliers to execute the work, and a less than ideal alignment between some planned technical solutions and the actual requirements.

3. MID-PROGRAM REVIEW OF THE START-UP PHASE

At the mid-point of the start-up phase in 2008, at the request of the JOC LMU staff took stock of progress and examined the challenges that had been encountered. This review identified several necessary improvements to planning processes, including:

- The need to ensure that the groups executing the work had a good understanding not only of their own activities, but of how they fit into the NLLP's overall objectives and long-term strategy. They therefore needed strong guidance and direction on Program requirements and expectations;
- The need to conduct detailed advance planning of all work so that defined lower priority activities were available to substitute for stalled projects that had encountered difficulties;
- The need to learn as much as possible from the experience of other countries that had more mature decommissioning and environmental restoration programs. While the scale and detailed issues facing each country differ, many of the technical problems were shared by all, and much could be done to avoid "re-inventing the wheel";

- The need to include consideration of the value received (e.g., reduction in liability, lower ongoing care costs, avoided costs associated with breakdown maintenance) from the various possible ways to address a liability when setting priorities for taking action; and
- The need to expand provisions for managing risks in planning projects to foresee, forestall and mitigate potential difficulties that could be expected to arise.

4. COMPREHENSIVE LESSONS LEARNED OF THE START-UP PHASE

In early 2009, as the first step in an AECL initiative to improve delivery of the NLLP, the LMU carried out an internal review of general lessons that could be drawn from the experience to date. The review covered a variety of areas: overall planning; management of individual projects; cost estimating; procurement; execution of work; communications; human resources; and records and documentation. Forty-five documents from individual projects were examined, and over twenty interviews were conducted with supplier groups and staff of the Program management team.

The principal conclusions about overall planning of the Program were that:

- The NLLP needed to be recognized as being more complex, integrated and variable than a simple collection of independent, well-defined projects to be executed individually. It therefore was best planned and managed as a program of interacting activities, some of which could not be well defined at the outset, and many of which would continue to evolve and interact with other projects;
- It was vital to have effective communications among the different groups involved in the Program. The overall structure, ultimate objectives and linkages among the parts of the Program had to be communicated clearly to the executors of different parts, and they must not function in isolation ("silos"). They could then see how their activities related to those of others, and could identify ways to avoid conflicts in resource demands as well as opportunities to improve cost-effectiveness, by collaborating with other parts of the Program;
- It was important to involve the groups who would execute the individual projects in defining it. It was difficult, if not impossible, for a central planning group to prepare a detailed, cost-effective feasible Program in isolation;
- Flexibility needed to be incorporated into such a complex Program over a period as lengthy as five years (which is an administratively-defined fraction of the entire 70-year Program). It had to be expected that many changes would occur in personnel, legislation and regulatory and other requirements, available technologies, business goals and operational needs and opportunities; and
- The detailed objectives in dealing with individual liabilities would change as uncertainties about the liabilities were reduced, and as assessments and feasibility studies were completed to select the best solutions to be implemented.

5. PLANNING THE SECOND PHASE (2011-2014)

In mid-2009, planning began for the second phase of the NLLP. Several key changes were made to the approach that had been used in planning the initial phase. The planning effort itself was organized as a project, and a dedicated core planning team was created to orchestrate the planning activities. Great effort was devoted to ensuring that the execution groups knew and understood the key elements and required sequence of activities in their area in the upcoming decade (i.e., beyond the formally planned three-year period), and recognized the interdependences of the different elements of the Program. The LMU sought their input in

developing the plan. They were urged to use the experience they had gained in the first five years to propose work that would, above all, be feasible to execute in the second phase, and that would earn as much value as practicable in reducing the liabilities or the risks they posed. Several years of experience had been gained in the realities of executing decommissioning and cleanup work. Suppliers were urged not to propose simply to carry out the originally proposed activities for the second three-year period of the overall 70-year plan, if it was clear that changes were warranted from their experience. It was made clear that the 70-year plan would itself be updated to incorporate changes that were based on what could be accomplished with sufficient confidence.

Several further lessons were learned in planning the second phase. Experience had already shown that it was not possible to define in great detail all the activities to be carried out in such a large Program over such an extended period. Reasons for the uncertainty varied. For instance, characteristics of some facilities to be decommissioned remained uncertain due to difficulties in completing and evaluating the necessary field measurements. The characteristics of some wastes to be retrieved were not fully known - early records were incomplete, or no longer available.

Decommissioning work inevitably involves making a continuous series of adjustments to planned activities to cope with potentially hazardous surprises when opening up and dismantling closed systems and structures. Further, it was recognized that the Program had to have clearly defined and feasible final endstates defined for all the sites. In particular for CRL the original goal was to clean up all areas of the site to a condition that would be acceptable for "industrial re-use". It is not clear that this is actually the most appropriate objective. Additional consultation with the affected stakeholders will be required before the site endstate can be confirmed as acceptable to all parties having an interest and input in the matter.

As a result of these issues, the planning team recognized that an optimal process for detailed planning of the second multi-year phase of this large Program would require more than the time that was available. In addition, the planning effort that would be demanded of the execution groups would be in addition to the work they were already carrying out on the Program, and in addition to the short-term planning and reporting efforts to which they were already committed. Detailed instruction was needed of the execution groups on the different types of information that they would be called on to supply (e.g., budgeting principles to be adopted and the required level of detail and accuracy, the allowable degree of flexibility in delivery schedule, degree of commitment being made at various levels, guidance on the expected use of risk and contingency allowances, and common means for implementing risk management principles). The planning schedule had to include explicit allowances for the periods for the required reviews of the proposed Program by various levels of management, and for preparing the accompanying revisions of the main Program documents.

It was recognized that the limited available period to complete the plan would also constrain the development of resource-loaded scopes of work that were as detailed and supported as would be ideal. Therefore the overall schedule was developed only to level 3, with development of greater detail being reserved for the key portions on a prioritized basis.

To ensure that proposed timelines for various Program activities were realistic, it was found important to be clear on where the authority to make various key decisions for each activity would lie, as well as the processes that would be used to make them. Otherwise, uncertain decision and approval processes would risk delay to an activity or project.

It was found that immediate feedback had to be provided to the suppliers who were contributing planning information to prevent the planning effort from losing momentum and becoming confused with the planning exercise for the next 12-months (the final year of the start-up phase), which had to be executed at the same time.

Planning of the last year of the first phase was therefore carried out in conjunction with the planning of the three years of the second phase. This ensured consistency between the logic and timing of sequences of dependent activities in the two periods of time.

Much time was saved by planning the required series of successively more detailed descriptions of the second phase program of work in such a format that each document could serve as the core of the next document in the sequence. It was found to be well worth putting early focused effort on defining the content and format of the planning documents to be produced. To avoid reworking documents, it was important to have a clear understanding about the scope and contents of the documents to be produced, and of the "story line" to be told in each one. It was noted that planning for future multi-year phases could be reduced if a "rolling" five- or six-year plan were updated annually.

Building positive relationships and reducing the formality of interactions with other parties involved in developing the plan (e.g., by verbal briefings or face-to-face presentations rather than submission of formal documents) provided opportunities to save significant amounts of effort and time.

6. NRCAN EVALUATION AND AUDIT OF THE PROGRAM

Large Government of Canada programs are periodically subjected to independent evaluations and audits. In keeping with this practice, NRCan Evaluation and Audit Branches conducted an evaluation of the performance, and an audit of the management of the Program in early 2010. Both reviews identified strengths and areas for improvement within the Program. NRCan and AECL worked together to finalize their responses to these reviews when the final versions of the Evaluation and Audit reports became available.

7. THIRD PARTY REVIEW OF PLANNING FOR THE SECOND PHASE (2011-2014)

In early 2010, AECL's LMU engaged an independent third party to review the preliminary program of work planned for the second phase of the NLLP, and of the planning processes that were being used to develop it.

The independent review confirmed many of the conclusions from the preceding reviews, and action was already being taken on many of the recommendations. For example, the LMU had begun developing a detailed version of the 2011-2014 section of the Primavera P6 "Master Schedule" of all NLLP activities over the entire 70-year Program. The three-year schedule was fully resource-loaded, and showed the short-term linkages among the various activities.

The LMU was also already taking steps: to move to staged definition and decision-making for projects and activities, to develop an integrated waste management plan, to broaden and deepen international collaborations; to strengthen working arrangements with the Canadian Nuclear Safety Commission on licensing and other regulatory matters, to include return on investment in setting priorities for short-term action, to consult stakeholders and further define the final

endstates in which the Program should leave the different sites, and to establish the associated clean-up standards that would need to be met.

Additional recommendations from the third-party review are currently under consideration. Aspects relating to improved planning and execution of the Program include developing more thorough risk identification and management processes; and putting into place a performance measurement system that uses earned value to monitor progress towards the completion of milestones.

8. CASE STUDIES OF PLANNING TECHNIQUES

8.1 Planning in the Face of Uncertainty

The type of work conducted in the NLLP (and similar programs elsewhere) involves inherent risks to execution according to plan, due to the many unknowns at the outset of defining the Program. Historical records of wastes and hazards are sometimes incomplete. Radiological and non-radiological hazards in buildings, Waste Management Areas where wastes are stored, and other areas may also not be completely characterized and assessed at the outset of a project to improve the situation.

The work undertaken within the Program is now recognized as being a combination of activities that are well-defined with only a low risk to execution, activities that are relatively well-defined with moderate execution risk, and issues that will require investigation and analytical work even to reach initial decision points on the technical solutions to be adopted to deal with them. Accordingly, a level of certainty is now being assigned to each proposed Program activity.

Staged decision-making in defining problems, selecting solutions and implementing projects has been adopted so that tentative courses of action can be changed at recognized points to address issues involving any large uncertainties in a systematic manner. This provides a controlled manner for establishing an optimum technical approach, for successively narrowing the estimated range of implementation costs, and for defining a feasible implementation schedule. It is also a valuable tool for describing the nature of the commitments being made, and to portray a more realistic view of achievement.

8.2 Setting Priorities for Taking Action in the Short-Term

As noted above, the NLLP comprises a large number of interconnected activities. Although all of the liabilities must be dealt with eventually, they cannot all be addressed at once.

The liabilities are also interconnected, and cannot be dealt with independently at any time. For example, from a cost point of view, some aging, heavily-contaminated buildings should be decommissioned before other buildings because they cost more than the others to maintain in a safe state, and the costs of maintaining buildings are not recoverable. Militating against early decommissioning of a heavily contaminated building is the possible constraint of a lack of the necessary availability of sufficient waste management facilities to handle the resulting waste. Similarly, some areas of contaminated ground are more urgent to clean up than others due to the potential for the contamination to spread to additional areas and drive up the costs of eventually dealing with them, but again the necessary facilities to handle the waste must be available.

These conflicting driving forces need to be reconciled in deciding how to allocate available resources in dealing with the various liabilities. The LMU therefore developed a process for setting priorities biennially that was based on the risks associated with the different liabilities [3].

Panels of experts rate the liabilities with respect to their relative current or potential risk to human health and safety, to the environment, and to AECL's business (i.e., regulatory compliance, public reputation, etc.).

Several lessons have been learned in the course of repeated applications of the prioritization process. First, it is important to differentiate between ranking the relative risks presented by various liabilities (e.g., a contaminated building or area of land), versus selecting amongst the solutions (i.e., different ways) for dealing with each liability. If the risks from the liabilities are ranked as to the importance of dealing with them, then the results will not take into account how much is to be gained by an equal investment in tackling different liabilities, or in adopting different approaches to dealing with each liability. If single solutions for individual problems are ranked and a problem arises in implementing the ranked solution (e.g., a new and better estimate of cost shows it to be much more expensive than foreseen and than other available solutions), then pursuing the solution may "crowd out" other worthwhile actions on other problems. It was thus recognized that another factor should be added to the prioritization process: Explicit consideration of the return on the investment in adopting a particular solution to a problem (e.g., how much would care and maintenance costs and the liability represented by different buildings be reduced by decommissioning one versus another of them, or by cleaning up one area of contamination rather than another one).

In general, it is preferable from cost and other perspectives to decommission a facility promptly rather than hold it under a static care and maintenance regime because of the "lost" care and maintenance costs incurred in holding it. However, it may be better to apply available funds to reducing partially the threat from a high risk building to a lower, better controlled level rather than to apply the funds to dealing with lower risk buildings definitively.

From a practical point of view, it was found that when setting priorities, it was important to present to the decision-makers background information on each liability in a standard format. This might take the form of answering questions such as, "What is the worst case scenario if control over this liability is lost?", or "What is the probability of this becoming a worst case scenario?" and "How acceptably is the liability being managed now?" Without such standardization, presentations of different issues can be viewed as more or less significant simply as a function of perception.

(A substantial side benefit of the prioritization was that simply executing the prioritization process was a powerful tool for sharing information amongst the entire team that manages and executes the different parts of the Program. Long after the prioritization is completed, panel members act as knowledgeable advocates of the Program in other quarters and are more sensitized to the relative merits of resources that are devoted to areas other than their own.)

Finally, from the outset it was recognized that there is no magic approach to define an unarguable fixed set of quantified priorities to plan a broad range of potential activities and projects. Any formal scheme that generates quantitative rankings of problems (or solutions) can only serve as a guide to management, who must take a broader view of the entire Program and its drivers in deciding how best to proceed.

8.3 Defining Problems in Detail before Committing to Action

Final Endstates, and Soil and Groundwater Clean-up Criteria A key lesson learned in the area of problem definition was that it is imperative to have a clear understanding of the final

endstate in which the NLLP plans to leave each site before firm decisions can be taken about how far cleanup activities must go to complete the job. For example, it was initially decided that the CRL site would best be left in a state that is suitable for "industrial re-use" throughout, as it is foreseen that some level of industrial use of the site will continue for the indefinite future.

Additional stakeholder input from the surrounding communities and other stakeholders will be needed to clarify whether the clean-up should proceed to levels suitable for industrial, residential, agricultural or unrestricted uses. Only then can the definitive clean-up criteria be finalized.

At the outset of the Program, although not all of the liabilities were well characterized and well understood, an initial "reference strategy" had to be defined for dealing with each of them. Later, when more effort could be devoted to defining the problems in detail and to comparing alternative possible strategies, one of the alternative approaches not originally adopted might be chosen instead. Three examples described below are: The approach used to deal with stored liquid wastes at CRL; for characterizing wastes at CRL; and for using existing waste processing services rather than AECL developing a full suite of facilities itself.

Stored Liquid Wastes One significant liability at CRL is ~300 m^3 of stored radioactive liquid wastes. The original reference strategy was to transfer the liquids from aging tanks into newly-constructed tanks that meet modern design standards. After several decades of storage, the wastes would be immobilized in a vitrification facility to be constructed.

When a detailed design was completed for the new storage facility, it was realized that that facility would be much more expensive than had been foreseen and the schedule would be significantly longer. An assessment team was formed to step back and re-assess the problem and examine alternative solutions. A formal Multi-Attribute Decision Analysis was carried out, and visits were paid to other sites to confirm that liquid waste treatment systems currently offered by various vendors performed as publicized. At the completion of the exercise, it was decided to change the basic strategy for dealing with the problem to adopt a combination of solutions that could be executed in the short term: Some of the less hazardous liquids could be treated in the site's Waste Treatment Centre without making any modifications to the facility, and the remainder of the liquids could be extracted from their current tanks and treated at the site by a mobile cementation skid that could be moved from tank to tank as required.

Waste Characterization Facility/Capability Another example of changed strategy is a move away from the initial reference strategy of constructing early in the Program a central facility at CRL for characterizing all types of radioactive wastes to qualify them for long-term management in repositories. Instead, it was recognized that greater initial benefit would be gained by strengthening the capability to characterize wastes in more detail at the locations where they were generated. A central characterization facility may eventually be constructed, but only after specific purposes and requirements are better specified, as a "one size fits all" facility would be extremely expensive to construct.

Use of Offsite Waste Processing Services Yet another lesson learned was the need for flexibility in planning how to obtain key supporting waste processing services. AECL has long used outside capabilities for dealing with some of its wastes (e.g., PCB wastes are sent to an offsite incineration service, and recyclable metals are sent to a scrap dealer). At the start of the NLLP, it was planned to rely heavily on constructing AECL's own "enabling" facilities to process and disposition the larger volumes of many types of wastes that the Program would

generate. (Two exceptions were used fuel waste and PCB-contaminated mixed wastes, which would be sent to specialized organizations.)

Cost-effective opportunities were later identified to send incinerable wastes to facilities operated by large US service providers. To date much radioactive waste, both solid and liquid, has been sent to the US for processing. Even so, it is recognized that risk is inherent in devolving key waste management capabilities entirely to outside suppliers. NLLP plans need to include assurance that internal processing and long-term waste management capabilities are available in case the external services are no longer accessible (attractive though they may be from purely a cost perspective).

Integrated Waste Plan (IWP) One continuing challenge to the Program has been the identification of the optimal set of "enabling" waste management facilities to be constructed at CRL to serve the Program. Originally, the selection of facilities was based on an overall estimate of the different types of wastes expected to be produced or already held in storage. When more detailed assessments were carried out in several areas it was found that the assumptions underlying the original plan had overestimated the needs. As noted above, in some cases, existing waste processing services elsewhere could readily handle the wastes, rather than AECL having to construct and operate additional facilities at its sites.

It was decided that a more transparent and robust decision-making process was needed to define and plan the enabling facilities. A process that has been used extensively by the UK Nuclear Decommissioning Authority is currently being adapted to produce an "Integrated Waste Plan" (IWP) for wastes managed at AECL sites [4,5]. Development of the IWP will involve evaluating detailed information on waste types, volumes and time of generation to determine when key decisions about processing, storage and long-term waste management facilities must be made, and will also facilitate making those decisions. The IWP will be the roadmap for selecting and defining waste management enabling facilities and capabilities in both the short and long term. It will also provide the basis for policy decisions on refinement of the long-term NLLP strategy, and the funding of major enabling facilities.

The process to create the IWP has started; an initial version of the IWP was produced in 2011. Maintenance and refinement of the IWP will be an iterative process, with reviews and updates occurring regularly, or whenever significant changes or new developments occur.

Environmental Restoration Plan An integrated approach is now also being adopted to planning environmental restoration activities at CRL. A Steering Committee and Working Groups are being established to examine the various landfills, plumes of contaminated groundwater, and buried sources of radioactivity that require restoration to decide on the appropriate approach in each case (e.g., management *in-situ* with continued monitoring of the situation, non-intrusive or intrusive detailed characterization of the contamination to define the extent of contamination more clearly, enhanced containment and isolation of the contamination, or removal of the contaminated material for processing and management elsewhere). Conceptual site models of the current and expected future behaviour of the various contaminated locations will be enhanced or developed to guide the selection of the most urgent issues for action and the most appropriate steps to take in each case. This integrated approach incorporates all of the site environmental monitoring information and ecological risk assessments, and the development of the overall site end state.

Pre-Project Initiation Process Even when a clear picture of the relative importance of dealing with different issues has been achieved, the linkage still must be made between the specification of the problem and the selection and detailed definition of the best solution to resolve it. At the outset of the Program, the importance of this linkage was not fully recognized. In some cases, the appropriate waste management facility to fill a need appeared to be intuitively obvious, and it was planned to construct a wide range of facilities. However, when individual needs were looked at more closely, it was recognized that the assumed solutions were not necessarily the best possible approaches. One example has already been given: The original approach for dealing with stored liquid wastes (prolonged continued storage and eventual vitrification) was replaced by prompt immobilization of the liquids using a combination of existing fixed and new portable processing facilities.

An updated examination of volumes of inactive waste being generated at CRL showed that a new landfill would not be required until much later than foreseen because waste reduction efforts were succeeding better than expected. Anticipated volumes of incinerable radioactive waste were found to be much lower than would be needed to provide sufficient fuel to support reliable operation of a radioactive waste incinerator. Similarly, it had been assumed that volume reduction equipment (e.g. shredders and compactors) for processing inactive wastes would be worth acquiring. However, closer analysis of the anticipated types and volumes of waste coming from the Program showed that the only equipment worth considering was a crusher for large volumes of "likely clean" concrete, and even that equipment could likely be more cost effectively leased than purchased.

Finally, the original strategy had not included a specific facility for the long-term management of very-low-level decommissioning waste. Initial assessments suggest that it would be more cost-effective to construct such a facility rather than rely on waste management routes based on clearance of likely-clean waste materials and a large geologic waste management facility for all low and intermediate-level wastes. We are now seeking to learn from the experience of the French ANDRA and Spanish ENRESA waste management organizations in constructing and operating very-low-level waste facilities.

It was decided that the processes used to perform such pre-project studies should be standardized for internal use. Accordingly, a three-part approach to pre-project studies was created. First, a Business Case is prepared to document that a well-founded need exists. A Feasibility Study then delineates and compares the various options for filling the need. Finally, a Project Concept document sets out in detail the requirements that must be met by the selected option. This process is now in common use.

9. CONCLUSIONS

Planning for the 70-year Canadian Nuclear Legacy Liabilities Program has evolved greatly since the initial planning for the first five-year phase of the Program. Planning for the initial phase was centralized and conducted largely by a small group. Current planning for the second phase has involved a much broader range of well-informed direct contributors, including heavy involvement of those who will execute the work. Much more detailed advance planning will be carried out in future to provide flexibility to define projects well, and to be able to substitute new work when existing parts of the Program encounter difficulties. Greater effort will be devoted to managing the significant levels of risk involved in the diverse program of activities.

It is now better appreciated that the Program is more effectively managed as a program of integrated activities that will evolve as uncertainties about the liabilities are reduced and better technical options are identified, rather than as a set of relatively unchanging and independent activities with fixed scopes.

Finally, the NLLP is committed to strive for continual improvement of its activities and to learning lessons from all available sources. Information obtained from programs with similar goals in other countries has made it clear that the relatively young Canadian NLLP can benefit from the lessons learned by the more mature programs. Canada will seek to benefit from the techniques that the other programs have developed and to avoid the mistakes they have made and had to deal with. Accordingly, efforts continue to expand the contacts between the NLLP and these other programs through conferences, participation in IAEA and OECD-NEA networks, working groups and other activities. The NLLP has also engaged contractors and hired experienced staff from other countries, and is in the process of establishing framework agreements with organizations that manage similar programs in other countries to facilitate more extensive ongoing exchanges at the working level.

Planning for the NLLP has had to accommodate changes to technical approaches and assumptions as more was learned about the liabilities and more experience was gained in dealing with them. The Program will certainly continue to evolve as issues arise, and the plan for the next phase incorporates several management changes to provide flexibility, including: staged decision-making in defining decommissioning and environmental restoration activities, iterative development and implementation of an Integrated Waste Plan, use of conceptual site models to rank environmental restoration priorities, standard techniques for better pre-project selection of solutions and definition of facilities to be put into place, and more formal risk management processes.

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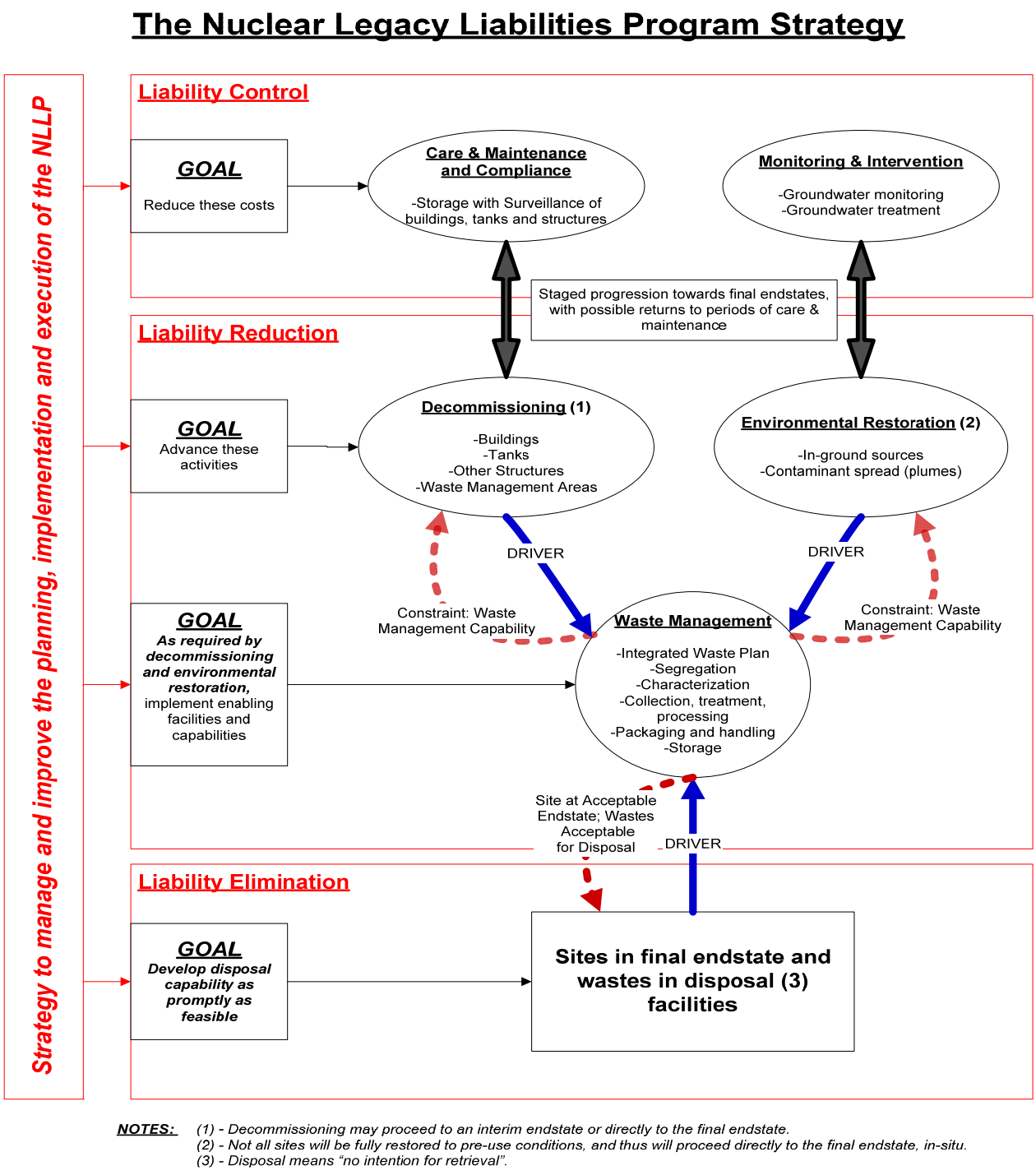

NOTES: *(1) - Decommissioning may proceed to an interim endstate or directly to the final endstate.*
(2) - Not all sites will be fully restored to pre-use conditions, and thus will proceed directly to the final endstate, in-situ.
(3) - Disposal means "no intention for retrieval".

Figure 1: The Nuclear Legacy Liabilities Program Strategy