KINECTRICS

Strategic Options Study for OPG Heavy Water Storage and Handling

Chapter A – Tritiated Heavy Water Storage and Handling

Kinectrics Report: K-011043-001-RA-0001-R00

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Chapter A – Tritiated Heavy Water Storage and Handling

A-1 SUMMARY

There are two main components of heavy water management at OPG:

- Heavy Water Recovery, Cleanup, Upgrading and Detritiation
- Heavy Water Storage and Handling

This study does not deal with improvements to heavy water recovery, cleanup, upgrading and detritiation. However, the recent poor reliability of the Darlington Tritium Removal Facility (TRF) has focused attention on the fact that the TRF is the main driver of heavy water management at OPG. It is an essential facility for all stakeholders as it is the only source of high isotopic, low Curie make up water for the PHT system and is essential to ensuring that the Stations meet their OP&P limits. The poor reliability of this aging facility has a large impact on storage, segregation and management of heavy water. As a result, the storage volumes recommended in this study are intended to compensate for the low reliability to a limited extent. Development of the TRF life cycle plan, aimed at improving the reliability of this facility is under way in a separate study.

The major issues with storage of tritiated water at Pickering and Darlington can be summarized as follows:

- Lack of adequate bulk storage for reactor grade and downgraded heavy water
- Inability to empty out, clean and dispose of surplus drums
- Inadequate storage space for drums and excessive space currently occupied by dirty drums
- Inability to ensure integrity of drums by pressure testing

The principal objective of this study is to develop an OPG Heavy Water Storage and Handling Strategy which can be implemented at the Stations to create significant improvements in the following areas:

- Virgin and Reactor Grade D_2O Storage – optimizing the storage requirements to support operational flexibility and meet operational needs by eliminating bottlenecks. These improvements should be designed to meet operational needs to the end of station life.
- Improving the ability to support outages requiring moderator or PHT system drains and better managing heavy water storage during extended outages of the Darlington TRF, thereby minimizing its impact
- Drum Management Program – i.e. reducing the backlog of drums at the Stations to a minimum manageable level by enabling cleaning, pressure testing and disposal of surplus empty drums combined with emptying and processing of drum contents,
- Reducing "dirty" D_2O storage at source thereby reducing the load on cleanup and D_2O storage.
- Improving the sites' ability to support external opportunities by more streamlined handling and storage of heavy water and containers received from external customers or by providing

more space for storage and handling of these drums. These commercial activities optimize the heavy water assets of OPG by providing low cost D_2O for loss make-up as well preserving the more valuable virgin D_2O inventories

The approach used in this study was to gather information from a wide number of stake holders, assess current D_2O storage practices and limitations at each station and thereby develop options and specific recommendations to remove bottlenecks or improve operations. The benefits that would result from implementation of the recommendations are clearly outlined together with an estimate of the major capital expenditures required for implementation of the recommendations.

For the portion of the study dealing with tritiated heavy water, there were 13 separate issues identified at Darlington and 18 issues identified at Pickering. These were grouped into various categories (e.g. bulk storage, drum handling, etc.).
A summary of the findings, options and recommendations of the study for Darlington and Pickering are presented below:

Bulk Storage

At Darlington, eight stainless steel tanks, with a total capacity of 747 m^3 are provided for storage; four tanks are for moderator heavy water and four tanks are for heat transport heavy water. In addition, two stainless steel weigh tanks, 10 m^3 and 30 m^3 are provided for heavy water make-up for the moderator and heat transport systems respectively. As a result of this study, a total of 750 m^3 of additional bulk storage is recommended at Darlington as follows:

Proposed Additional Bulk Storage at Darlington	
Purpose	**Capacity: m^3**
PHT Storage Tank	1x100
Upgrader Product Storage Tank	1x100
Moderator Drain Storage Tank	1x100
TRF External Feed	1x100
TRF External Product	1x100
Downgraded Dirty Tanks	2x25
Downgraded Clean Tanks	2x50
Downgraded D_2O from Emptied Drums	1x100

An alternate configuration of storage has been suggested at the recent review meeting by Darlington staff. This proposes the use of more, smaller tanks rather than large 100 m^3 tanks. This will allow easier segregation of different grades of water. The proposed alternate configuration is as follows:

Proposed Alternate Bulk Storage Configuration at Darlington	
Purpose	**Capacity: m^3**
PHT Storage Tanks	2x50
Upgrader Product Storage Tank	2x50
Moderator Drain Storage Tank	2x50
TRF External Feed	2x50
TRF External Product	1x100
Downgraded Dirty Tanks	2x50
Downgraded Clean Tanks	2x50
Downgraded D_2O from Emptied Drums	4x25

This alternate configuration requires almost double the number of tanks and a total capacity of 800 m^3. It will need more piping and valves as well as requiring a larger building. The cost of the new facility, therefore, is expected to be somewhat higher than shown below.

Proposed New Addition to Darlington HWMB Facility

A major recommendation of this study is to construct an addition to the Heavy Water Management Building (HWMB). The building will house facilities to improve drum handling as well as bulk storage. The original recommendation of the study was to construct and addition to the west of the HWMB. It was to have been an industrial structure with approximate floor area of 10m by 30m or greater, depending on confirmation of the space available. However, to accommodate the many more additional tanks in the alternate proposal, a new location with a bigger footprint is required. The design of the building will be such that ISO Container and drum unloading will be on the ground floor so that trucks can drive in for unloading. Also on this floor will be drum storage area and the drum cleaning and pressure testing facility. The drum cleaning and pressure testing facility will be common to Pickering and Darlington. The building will have a full basement which will contain all of the additional bulk storage tanks that have been proposed in this report. An order-of magnitude cost of the HWMB extension with the original proposal using 100 m^3 tanks has been estimated (±50%) as $ 10 million to $15 million. This includes the cost of tie-ins to existing systems in the reactors and in the HWMB.

The cost of the extension and additional facilities at Darlington can be roughly broken down as follows:

Equipment (Tanks, pumps, drum cleaning system, etc.)	$4,680,000
Engineering Design, Assembly, Administration, Accessories	$1,586,000
Sub-Total for Tanks, Drum Cleaning, Pressure Testing, Engineering, Assembly, Installation	**$6,266,000**
Cost of Building Extension	$1,100,000
Services, equipment within Building	$633,000
Engineering, etc.	$729,000
Sub-Total for Building and Services (including design, engineering, construction)	**$2,462,000**
Interfacing System Materials (piping, valves, etc.)	$460,000
Engineering	$360,000
Construction, installation	$905,000
Sub-Total for interfacing with existing systems	**$1,725,000**

The cost of the alternate configuration, with more tanks and bigger building is estimated to be about $ 5 million greater, i.e. a total of $15 to $20 million.

Currently, the total capacity for storing reactor grade water at Pickering consists of 11 stainless steel tanks with a total capacity of approximately 570 m^3. Two 150 m^3 tanks are used for Pickering B moderator water drains, Pickering A has dump tanks. As the station ages, there is a projected need to perform on average, one moderator drain per year. The Station cannot physically handle two drains concurrently. Storage of Moderator drains adversely affects the

station's maneuverability and the ability to perform on-line moderator D_2O swaps and hence eliminates or reduces the ability to send D_2O to the TRF.

At Pickering, installation of an additional two 150 m^3 storage tanks to accommodate moderator drains is recommended as a way of providing increased flexibiility.

Existing downgraded D_2O storage capacity at Pickering consists of 7 x 6 m^3 D_2O recovery tanks (4 Low Curie (Ci), 3 High Ci) at the Ion Exchange Clean Up (IXCU) system. The tanks are used to collect downgraded Primary Heat Transport (PHT) and moderator water. Additional storage capacity is required to address the need for segregation of PHT and moderator recoveries and to prevent an accumulation of drums resulting from the insufficient capacity to process high Ci water throughput the Sulzer-B upgrader. This segregation is required to ensure that the upgrader can be used to produce low curie D_2O suitable for use as PHT make-up, in the event of an extended, unplanned shutdown of the TRF. The TRF is the only source of PHT make-up and is an aging facility that could be subjected to unplanned outages as a result of unforeseen component failures. It is recommended that two 25 m^3 D_2O Recovery Tanks be installed. An order-of magnitude cost of the additional bulk storage at Pickering and the tie-ins to systems has been estimated ($\pm$50%) as $ 5 million.

A cost for the installation and commissioning of the UV Oxidation has also estimated as $520,000. A gross breakdown of the estimates for Pickering is shown below:

Bulk Storage Tanks

Equipment	$1,900,000
Engineering, Installation, Commissioning	$1,100,000
Sub-Total	**$3,000,000**

Interfacing and Tie-ins

Equipment	$450,000
Engineering, Installation, Commissioning	$1,550,000
Sub-Total	**$2,000,000**

The additional storage will provide the following significant benefits to Station and to TRF operations:

- Improve flexibility of operation by satisfying the storage demands during normal operation but particularly, during outages requiring draining of various systems. During these outages, segregation requirements will be met without having to resort to moving heavy water off-site
- Preserve the segregation of high and low Curie D_2O and improve the isotopics for the Units
- Allow unit moderators to be drained completely when required, e.g. during a Station Containment Outage (SCO)
- Provide the benefits of lower tritium concentrations by enabling the drained moderator to be processed through the TRF in a once-through mode of operation
- Additional downgraded D_2O storage capacity will enable the segregation of PHT and moderator recoveries during an extended outage of the TRF. This segregation is required to

ensure that the upgrader can be used to produce low curie D_2O suitable for use as PHT make-up, in the event of an extended, unplanned shutdown of the TRF.

- Additional storage for clean D_2O product from the Clean-up System would enable more efficient use of the UV Oxidation system and better TOC removal. Otherwise, if clean product is recycled through the Clean-up System in order to meet TOC specifications, this product water ends up being stored in the same tank as the "off-spec" water being recycled, thus mixing clean and dirty water.

- The extra storage would result in more efficient utilization of the TRF capacity, as DND's use of the TRF would be reduced.

- This also has transportation advantages as the transportation trucks (TDO's) would be more efficiently utilized and their use would not be tied to TRF availability.

- Additional TRF product storage would also allow the TRF to keep operating if the TDO's were not available for a period of time.

- The additional storage would also be beneficial in supporting OPG's commercial efforts to secure additional external heavy water for upgrading and detritiation, hence optimizing the heavy water assets.

Drum Handling and Management

The unavailability of an existing ultra-violet (UV) oxidation system at Pickering is a major impediment both in reducing the backlog of heavy water filled drums as well as in meeting the upgrader's feed specifications for TOC. It is strongly recommended that an oxidation system be commissioned on an urgent basis. Aside from the ability to effectively destroy elevated levels of TOCs, the adequacy of the throughput capacity of a single oxidation system in meeting both the ongoing processing needs at Pickering as well as the need for expeditiously treating the back logged HW inventory, must be evaluated. If the back logged inventory cannot be treated on a timely basis using a single oxidation system, then the option of hiring an external contractor should be considered. Otherwise, the recovery of real estate currently used for storage of drums will be unacceptably slow.

The nominally empty drums at Pickering contain a heel of material at the bottom, and as such do not meet Western Waste Management Facility (WWMF's) current waste acceptance criteria which requires that the concentration of tritiated water vapor within a drum does not exceed 100 MPCa.

A number of options were considered for disposal of the empty drums at Pickering. The simplest and least cost option involves the use of available binders to immobilize the small volume of sludge still present in the drums. These binders may be employed without the need for mixing the drum contents. After solidification, the largely empty drum should be compacted for efficient storage at WWMF. This option is feasible only if a safety case can be made to demonstrate compliance with NWMD's waste acceptance criteria.

As at Darlington, drum handling at Pickering involves a significant amount of manual effort. Further, facilities for drum cleaning and pressure testing which are pre-requisites for the re-use of drums in transportation and storage, do not exist. Thus, a key to reducing the backlog of stored drums is to have access to a drum cleaning and pressure testing facility. Because of the unavailability of drum cleaning equipment, surplus drums cannot be cleaned and sent to the WWMF and thus the backlog of drums would continue to increase. The increasingly reduced real estate combined with the inadequate drum handling equipment currently being utilized will result in an increasingly unsafe environment.

The appointment of a "Drum Management Program Champion" at Pickering and Darlington is recommended. This individual would be responsible for all aspects of drum handling, storage, cleaning, and disposal.

While the above recommendations require investment, the costs can be offset by providing the following benefits:

- Increased safety (reduced handling, lower radiation dose)
- More efficiently run operation
- Ability to keep stations within OP&P limits (regulatory requirement)
- Environmental stewardship (less tritium emissions)
- Increased revenues

A-2 INTRODUCTION AND BACKGROUND

There are two main components of heavy water management at OPG:

- Heavy Water Recovery, Cleanup, Upgrading and Detritiation
- Heavy Water Storage and Handling

The recent poor reliability of the Darlington Tritium Removal Facility (TRF) has focused attention on the fact that the TRF is the main driver of heavy water management at OPG. It is an essential system for all stakeholders as it is the only source of high isotopic, low Curie make up water for the PHT system and is essential to ensuring that the Stations meet their OP&P limits without excessive swapping with low Ci water from other sources. Thus, when the TRF is not operating, it affects all stakeholders. The poor reliability of this aging facility has a large impact on storage, segregation and management of heavy water. As a result, the storage volumes recommended in this study are intended to partly compensate for the low reliability of the TRF. Development of the TRF life cycle plan, aimed at improving the reliability of this facility is under way in a separate study.

The storage and handling of tritiated heavy water at Ontario Power Generation (OPG) has been driven by different stakeholders, each with their own particular issues and priorities – for example, Pickering has a backlog surplus of drums on site and needs to reduce these to a manageable number. A major issue for Darlington, on the other hand, is lack of enough bulk storage to deal with outages of the TRF and needs for isotopic segregation.

The major issues with storage of tritiated water at Pickering and Darlington can be summarized as follows:

- Lack of adequate bulk storage for reactor grade and downgraded heavy water
- Inability to empty out, clean and dispose of surplus drums
- Inadequate storage space for drums

A schematic of the heavy water management cycle is shown in Figure 1. This shows that the feed to the TRF is taken from the moderator system via on-line swaps. The general intent is to make up for losses in the PHT via the TRF product and to improve the isotopic of the Moderator via the Upgrader product. However, the system has to be necessarily flexible to balance the losses and meet OP&P limits. Therefore, both TRF and Upgrader product can go to the Moderator or PHT. The separate Heavy Water make-up input indicates the heavy water required to make-up for the net losses from the system via virgin (undesirable) or external heavy water sources.

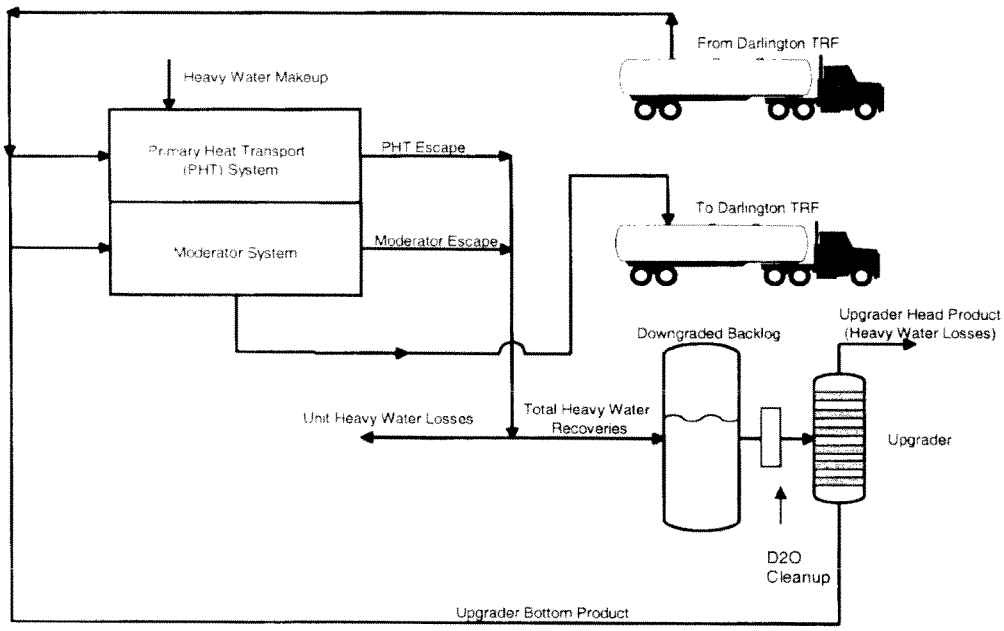

Figure 1. Simplified Nuclear Station Heavy Water Management Schematic

The various priorities of the OPG stakeholders are described in more detail below:

A-2.1 Station Priorities

Leakage or spills of D_2O from the Primary Heat Transport (PHT) or Moderator systems are recovered by Vapor Recovery Dryers or collected from floor drains. These result in "recovered", downgraded D_2O which is radioactive but also contaminated with emulsified oil and other organics. This recovered water is normally cleaned up and upgraded to reactor grade for re-use. However, historically, a large number of drums containing contaminated, downgraded D_2O have been stored at the Stations, particularly at Pickering. This is due to contamination of recovered heavy water by bulk quantities of oil which the existing D_2O Cleanup System could not handle. Note that Pickering uses hydraulically operated fueling machines which tended to leak oil and water whereas the newer plants have pneumatically operated fueling machines which largely avoids the oil contamination problem experienced at Pickering.

At Darlington and Pickering, the following priorities have been identified:

- Ensure adequate bulk storage capacity for reactor grade D_2O to facilitate draining of one or more moderator systems or to cope with an extended Tritium Removal Facility (TRF) outage

- Evaluate the adequacy of storage capacity of D_2O before feeding to the D_2O Clean Up System
- Increase storage of TRF feed and product at Darlington only
- Evaluate any possibility of adapting existing installed equipment (e.g. Off Gas Management System (OGMS) at Darlington) for D_2O storage.
- Reduce the number of drums on site containing dirty or off-spec D_2O by clean-up and upgrading and dispose of surplus drums or clean them up for re-use
- Ensure adequate availability of clean drums for reactor grade D_2O storage
- Ensure adequate storage space for filled drums

A-2.2 Commercial Priorities

OPG carries out commercial activities by selling or procuring heavy water in order to optimize its heavy water assets. These activities result in the following priorities:

- Maximize revenues through heavy water asset optimization and through provision of services to external clients
- Plan and implement strategies for future heavy water loss replacement for OPG
- Have enough clean IP-2 or IP-3 qualified drums available to sell D_2O to external clients or to transport between sites
- Optimize the storage, security and handling of OPG's virgin D_2O inventory

A-2.3 Overall Strategy

OPG has identified a need for an overall strategy for Heavy Water Storage and Handling such that the system can be optimized to meet the diverse interests of the various stakeholders. Implementation of this strategy will enable OPG to improve heavy water operations, remove bottlenecks and reduce costs.

This study will develop specific recommendations as part of an overall strategy to improve Heavy Water Storage and Handling. The strategy will be used to drive practices to achieve industrial leadership in areas such as:

1. Virgin Grade, Reactor Grade and Downgraded D_2O storage in tanks or drums
2. Drum Cleaning
3. Disposal of surplus drums
4. Reducing "dirty" D_2O storage at source
5. Improving sites' ability to support external commercial opportunities in heavy water

A-3 OBJECTIVE

The principal objective of this study is to develop an OPG Heavy Water Storage and Handling Strategy which can be implemented at the Stations to create significant improvements in the following areas:

- Virgin and Reactor Grade D_2O Storage – optimizing the storage requirements to support operational flexibility and meet operational needs by eliminating bottlenecks. These improvements should be designed to meet operational needs to the end of station life.
- Drum Management Program – i.e. reducing the backlog of drums at the Stations to a minimum manageable level by enabling cleaning and disposal of surplus empty drums combined with emptying and processing of drum contents
- Reducing "dirty" D_2O storage at source thereby reducing the load on cleanup facilities and D_2O storage
- Improving the sites' ability to support external opportunities by more streamlined handling and storage of heavy water and containers received from external customers or by providing more space for storage and handling of these drums.

A-4 APPROACH

It was recognized at the start of this study that the work groups that lived the issues daily and managed around the problems at the sites were also the key to the solutions. To this end the Kinectrics team met with the project sponsors – the Isotope Sales and Heavy Water Programming Group (ISG) – at the start of the project and ISG provided the context for the study and provided the contacts for the data gathering exercise.

Kinectrics then prepared a set of questions specific to the site and organized individual site meetings to obtain answers to these questions. Darlington provided a "backgrounder" (see Appendix 5) which anticipated many of the questions. The site meetings were formal and minutes were prepared which are included in the Appendices 2 to 7 inclusive. They were then reviewed by the meeting attendees for accuracy and approved for use as the primary source of data for the problem definition part of this study. As well, some relevant questions were also posted on the Candu Owners Group (COG) OPEX site to elicit information on best practices in the Candu industry. However it was recognized that single unit Candu stations would not experience the same D_2O management challenges as the multi-unit Ontario facilities.

Where appropriate site tours were also conducted for the Kinectrics team to see first hand the challenges being faced.

The determination of the numerous options associated with the drum management issue (cleaning, testing, handling, transporting, storing) was shared among the Kinectrics team members who met weekly to discuss progress and gaps. In this manner each team member provided a reality check on an ongoing basis for the feasibility of the options considered. Suppliers of equipment and services were contacted for advice and budgetary cost estimates.

At the request of the project sponsors the report for the study has been presented in two distinct chapters:

Chapter A focuses on the Tritiated Heavy Water Storage and Handling issues and Chapter B deals with Virgin Heavy Water Handling and Storage.

A-5 DARLINGTON FINDINGS

It was apparent from interviews with Station staff, early in this study, that the biggest impact on Darlington's operational flexibility could be achieved by making improvements to station capability in the following two key areas:

- Bulk heavy water storage
- Handling and cleaning of drums

It is the opinion of Darlington staff that the biggest improvement to operational flexibility of the station as well as the Darlington Tritium Removal Facility can be made by adding more storage tank capacity to various heavy water systems. The rationale for this as well as the recommended additional storage volumes are described in the next few sections of the report.

A-5.1 Bulk Reactor Grade and Downgraded D_2O Storage

D_2O storage needs at DND are driven by several different demands. These include storage needs to support DND reactors during normal operation and during outages. During a Station Containment Outage (SCO), for example, the moderator needs to be completely drained and stored. In addition, DND has the unique requirement of providing adequate storage to support TRF external detritiation demands and storage to support external heavy water services. These demands require segregation and handling of water of varying quality in tanks and in drums. The potential benefits of additional storage are as follows:

- Improve flexibility of operation by satisfying the storage demands during normal operation but particularly, during outages requiring draining of various systems. During these outages segregation requirements will be met without having to resort to moving heavy water off-site
- Allow unit moderators to be drained completely when required, e.g. during an SCO
- Provide the benefits of lower tritium concentrations by enabling the drained moderator to be processed through the TRF in a once-through mode of operation i.e. enable moderator swaps to be performed
- Preserve the segregation of high and low Curie D_2O and improve the isotopics for the Units
- Provide contingency storage of TRF feed should the TRF be in an outage for an extended period

A-5.1.1 Reactor Grade D_2O Requirements to Support DND Reactor Units

Existing D_2O S&I storage capacity available to support reactor unit operation and unit outages are as follows:

Table 1. Existing Reactor Grade D_2O Storage Tanks at Darlington

Purpose	Capacity: m^3
PHT S&I tanks	4x100
PHT Weigh Tank	1x30
Moderator S&I Tanks	3x100
Moderator Storage	1x47
Moderator Weigh Tank	1x10
Upgrader Product Tank	2x9
TRF Feed Day Tanks	2x10
TRF Product Day Tanks	2x10
TRF Product Return Tanks	2x25
TRF External Feed Tank	1x57
TRF External Product tanks	2x25

Eight stainless steel tanks, with a total capacity of 747 m^3 are provided for storage; four tanks are for moderator heavy water and four tanks are for heat transport heavy water. In addition, two stainless steel weigh tanks, 10 m^3 and 30 m^3 are provided for heavy water make-up for the moderator and heat transport systems respectively.

Reactor grade D_2O storage and segregation requirements to support normal reactor operation and outages are as follows:

A-5.3.1.1 High Isotopic (Moderator)

- Segregation of high isotopic (>99.98 % D_2O), high curie (>1.2 Ci/kg) reactor grade D_2O (Upgrader product) for DND moderator systems addition/swap for detritiation, etc ; a 100 m^3 D_2O Supply and Inventory (S&I) moderator storage tank is usually assigned to satisfy this requirement.

- Moderator D_2O S&I storage capacity is required to accommodate the complete drain of a poisoned moderator system during a single unit outage. A moderator D_2O drain requires the use of all moderator S&I storage (347 m^3) available. The 10 m^3 weigh tank is also reserved for contingency. Segregation of the different grades of reactor D_2O is still required during the drain. Typically 60 to 100 m^3 of reactor grade D_2O also needs to be moved off-site to satisfy the segregation requirements during the drain. As an alternative, In addition to the 3 x100 m^3 D_2O Supply and Inventory (S&I) moderator storage tanks, a 100 m^3 PHT D_2O S&I tank has to be assigned to satisfy this requirement during DND unit outages requiring a complete unit moderator drain.

- Execution of the recent SCO in 2003 has demonstrated that it would not be possible to satisfy the demand for a complete moderator drain with the existing storage capacity in the HWMB. Adequate storage capacity for a moderator drain, if available, can be used to detritiate the

moderator in a once-through mode (instead of feed and bleed) using the TRF. This has the potential for significantly lowering the tritium concentrations in a shorter period.

- In the past, it has been possible to temporarily store D_2O at Bruce A & B. With the lease of the stations to Bruce Power, this is no longer an option.

A-5.3.1.2 Low Isotopic (PHT)

- Segregation of low isotopic (<99.96% D_2O), low curie (<0.7 Ci/kg) reactor grade D_2O (TRF product) for make-up to DND PHT systems; one or two of the PHT D_2O S&I 100 m^3 tanks are generally assigned to satisfy this requirement. There is a chemistry concern with addition of a large quantity (>10 Mg) of non-lithiated TRF product to PHT systems.

- Segregation of lithiated PHT quality D_2O from the DND reactors to accommodate shrink and swell during unit shutdowns and start-ups (e.g. SCO); two 100 m^3 PHT D_2O S&I storage tanks are assigned to meet this requirement. This is also supplemented with TRF product, within the PHT lithium chemistry constraints, depending on the units' demand for PHT quality D_2O.

- A minimum inventory of PHT D_2O also needs to be maintained in the PHT storage tanks to satisfy the shrinkage requirement during simultaneous cooldown of all four units in the event of a four unit trip. This quantity was established to be 210 Mg as a result of a study conducted by Nuclear Safety, HWM and the PHT group in preparation for the 1997 Vacuum Building Outage (VBO). The HWM unit has maintained this requirement since 1997.

- Segregation of a small quantity (typically 30 – 50 Mg) of "multi-purpose" D_2O (TRF product with an isotopic >99.96 % D_2O) to be used for deuteration of both moderator and PHT purification systems ion-exchange resins. This is normally reserved in the 30 m^3 PHT weigh tank or in the 47 m^3 moderator storage tank.

- The initial demand to satisfy the 2003 SCO requirements was for 480 Mg of PHT quality D_2O. This demand was reduced to 420 Mg, due to the extended shutdown of the TRF in 2003. This requirement was satisfied by a lease of 77 Mg from AECL, a loan of 60 Mg from Bruce Power and a shipment of 40 Mg from PND. The remaining requirements were met from DND's inventory of Darlington Tritium Removal Facility (TRF) product. The need to have a 100 m^3 tank available to accommodate storage of upgrader product is still required in this case.

Issues with Bulk Reactor Grade D_2O Storage Requirements

D.1 There is inadequate storage to permit the draining of moderators, segregation of isotopics, storage of lithiated PHT D_2O, shrink/swell requirements, lack of reliability of the TRF.

A-5.1.2 Downgraded D_2O Requirements to Support DND Reactor Units

Existing downgraded D_2O storage capacity at DND consists of small D_2O recovery tanks in the units (2 X 1 m3 tanks in each unit) which are used to collect downgraded PHT and moderator D_2O. This is then pumped to the central processing area in the HWMB where the water is cleaned, prior to processing it through the Upgrader.

The storage capacity in the HWMB consists of 2 x 25 m^3 downgraded dirty tanks and 2 x 50 m^3 downgraded clean tanks which also serve as the feed tanks for the Upgrader. The downgraded recovery and clean-up system configuration allows for segregation of recoveries based on tritium concentration.

Table 2. Existing Downgraded D_2O Storage Tanks at Darlington

Purpose	Capacity: m^3
Downgraded Dirty Tanks	2x25
Downgraded Clean Tanks	2x50

Upgrader product is stored in 2 x 9 m^3 product tanks before it is returned to the moderator system or reserved in one of the moderator or PHT S&I storage tanks for use in future moderator on-line transfers. Normally all upgrader product is returned to the moderator system and TRF product is the source of make-up to the PHT system.

Downgraded D_2O storage and segregation requirements to support normal reactor operation and outages are as follows:

- During normal reactor operation the existing downgraded D_2O storage capacity is adequate and there is no need for segregation of moderator and heat transport recoveries if the TRF is operating. A planned upgrader outage of up to 4 weeks is acceptable under these conditions.

- During unit outages, downgraded D_2O recovery rates increase, but the existing storage capacity is still acceptable as long as there is sufficient TRF product available to replace PHT losses. Segregation of PHT and moderator recoveries is recommended if there is an extended TRF outage since mixing the recovered D_2O would make it unsuitable for returning to the PHT system.

- During a 4-unit outage and extended unavailability of the TRF, the existing downgraded D_2O storage capacity is not adequate to meet the storage demands. Again, segregation of moderator and PHT recoveries is required in this case. Unavailability of the upgrader under these conditions makes the situation even more difficult. This was the situation that the TRF/HWM Department was faced with for the 2003 SCO because of unavailability of the back-up heating steam supply for the station. This resulted in utilization of the 2 x 25 m^3 TRF product return tanks for storage of downgraded D_2O, storage of downgraded D_2O in 12 x 1 m^3 plastic totes and in drums. It vividly highlighted the need for additional downgraded storage capacity to adequately segregate PHT and Moderator downgraded D_2O recoveries. A D_2O S&I storage tank was downgraded during this period and it is thought that the downgrading was a result of activities related to transferring of the downgraded D_2O to reactor grade storage tanks.

Issues with Downgraded D_2O Storage Requirements

D.2 There is inadequate storage for downgraded D_2O during Unit outages and in particular during extended TRF outages.

A-5.1.3 Storage Requirements to Support TRF External Detritiation Demands

Existing storage capacity available to support external (outside of DND – e.g. Pickering, Bruce, non-OPG.) detritiation demands consist of 1 x 57 m^3 tank for storage of external TRF feed and 2 x 25 m^3 tanks for storage of TRF product to be shipped off-site.

There have been numerous requests (primarily from PND, but also from Bruce Power) for the TRF to accommodate acceptance of external feed during periods when the TRF is shutdown.

Issues with Storage Requirements to Support External Detritiation Demands

D.3 There is inadequate storage to handle external feeds and for heavy water contingency needs if the TRF is in an extended outage.

A-5.2 Drum Management Program

A-5.2.1 Drum Handling

In general, all drums are handled using some power assisted drum handling tools, but this still involves a large amount of manual effort. The drums are currently man-handled in many cases. Ergonomics of drum handling is an issue with a potential for injury to some of the operators. A facility is required to minimize the amount of manual effort involved with loading, unloading, emptying and filling of these drums. Better drum handling equipment that may be available in industry should be investigated as part of solving the drum handling issue.

For off-site transportation of drums, IP-2 drums are to be used. There is a requirement by NWMD that the drums must be shipped within an overpack (secondary containment). This is not a regulatory requirement but is intended to mitigate the risk of leakage during transportation. The overpacks occupy more room (10%). Labels are sometimes required to be placed both on the drum as well as on the overpack. Drums within the overpack have to be removed using slings because there is no other way to grapple them (no lip). External customers are not happy with the use of overpacks as it places an additional handling burden without being a regulatory requirement.

The drums from external customers are received and shipped in ISO containers and require the use of a crane for unloading and loading. Unloading of trucks is currently inadequate and presents unnecessary safety hazards. Presently, an external contractor is brought in to remove the lids from the ISO containers to allow the Operators to unload a truck at a cost of $4K to unload and $4K to load. The ramp leading into the HWMB is too steep and the back doors of the ISO container have to be opened prior to going down the ramp, this leaves us with drums stacked two high on a metal floor with only a rope to prevent them from sliding off if anything happened, leading to a potentially unsafe condition.

For the above reasons, the impact of "doing nothing" to address the present situation is not acceptable for the long term due to safety, spillage concerns, ergonomics and housekeeping.

Issues with Drum Handling at DND

D.6 There are potentially unsafe conditions with unloading of ISO containers and drums from external customers.

D.7 There is a potential for injury to operators due to manhandling of drums.

A-5.2.2 Drum Cleaning and Pressure Testing

During discussions with station personnel and others, it quickly became clear that a key to reducing the backlog of stored drums is to have a drum cleaning and pressure testing facility. Such a facility does not exist at Pickering, Darlington or at the Bruce Heavy Water Plant site but

Hydro Quebec does operate a facility successfully. A drum cleaning facility did exist at the Central Maintenance Facility (Bruce Site) but it has been decommissioned. The system was very labor intensive, and production was limited by the time it took to vent the tritium from the drums prior to cleaning. Venting seemed to take 24 hours. This was a system that purged the drums with air that was drawn off to active ventilation. When it was operational it could clean about 20 drums in an 8 hour shift with 2 persons.

A pressure testing facility to check and certify the integrity of drums by testing at a pressure of 5 psig is required (as per OPG procedure WM-0040, "Type A and Less Packaging, Receiving, Handling and Shipping") in making these drums available for re-use in transportation and storage. A decision would be required as to whether a centralized facility of this kind would be better than local facilities at Pickering and Darlington.

Issues with Drum Cleaning and Pressure Testing

D.8 A Drum Cleaning and Pressure Testing Facility is required but is not available at DND or elsewhere in OPG.

D.9 A decision is required as to whether a centralized Drum Cleaning and Pressure Testing facility would be better than local facilities at Pickering and Darlington.

D.10 A suitable location within the plant for such a Drum Cleaning and Pressure Testing facility needs to be identified.

A-5.2.3 Drum Disposal

At Darlington, the present criteria for drum disposal are not documented, but drums are disposed based on visible defects or known or visible leakage. All drums at the site are considered as "active" except for drums strictly containing virgin water for dispensing.

Drums received from external customers are not cleaned or compacted prior to return to customers but are returned in their original condition after emptying out of the contents.

There have been no drums shipped to the Western Waste Management Facility (WWMF) yet. This is believed to be due to the strict criteria imposed by OPG's Nuclear Waste Management Division (NWMD). The drums sent for disposal would need to be dry of any free-standing liquid and would need to show that the tritium emitted from the contents was below 100 MPCa ($1x10^{-3}$ Ci/m^3). It is not clear whether making the drums "dry" by filling them with the required quantity of absorbent material would be acceptable to NWMD. NWMD does not want to be in the drum cleaning business – so integration of cleaning/testing with storage/disposal is not an option. OPG-DND will need to develop a safety case to demonstrate that the NWMD-Waste Acceptance criteria can be met using this methodology.

Contracting out drum cleaning/testing may be a possibility. A proposal was received by OPG from AECL for "washing" of 12 empty drums. However, AECL were not willing to accept drums which had any "heels" of liquid or which had external gamma fields > 2.5 mrem/h. Thus, the AECL acceptance criteria appear to be very similar to those imposed by NWMD.

Issues with Drum Disposal

D.11 A decision is required by OPG/NWMD based on a safety case to be provided by DND whether filling the empty drums with absorbent material will be deemed to be acceptable in lieu of cleaning the drums for shipment to the WWMF.

A-5.2.4 Drums Storage Space

In general, there is a lack of space for storage of drums in the Heavy Water Management Building. Darlington also has the role, due to the presence and operation of the TRF, to handle heavy water which is received from external customers. This heavy water can be upgraded and detritiated. if required. It then can be used for providing loss make-up at OPG Stations, thereby alleviating the need to use valuable virgin heavy water for this purpose and optimizing use of OPG's heavy water assets.

However, if significant number of drums are received, they are stored in available space, which may include corridors and under stairways .Some typical examples of stored drums in corridors are shown below:

Figure 2. Stacked Drums in Overpacks Stored Next to Equipment at DND

Figure 3. Example of Temporary Storage in HWMB Corridors

Figure 4. Stainless Steel (Empty) Drums Stacked 2 High at Darlington Near Scaffolding

Drum handling at DND in 2004, resulting from ISG transactions will be as follows:

- 192 drums from Japan
- 216 drums to USA (NIST)
- 192 drums (42 Mg) from Europe (JET – Joint European Torus) in Nov. 2004

OPG is committed to receiving 40 Mg from Japan for the next 6 years. (2 X 20 Mg or 96 drums per shipment). In addition, 46.5 Mg (216 drums) are expected from NIST in 2005.

All the above transactions will involve handling D_2O drums contained in a 55 gal shipping overpack, an OPG-NWMD requirement. Drums received from off-shore sources are normally returned to the source after emptying of the contents.

A recent extended, unplanned TRF outage necessitated a lease of low Curie heavy water from AECL to accommodate station heavy water requirements. As a result, an additional approximately 300 drums of D_2O were received and returned to AECL over the period Sep 2003 to July 2004.

In August 2004, 96 drums (included in the above 192 drum schedule) of low Ci, downgraded heavy water have been received from Japan with their associated overpacks. This has necessitated storage of the drums in available space, e.g. in corridors, next to equipment, etc. Since the Upgrader is in an outage, it will take longer than normal time to empty out these drums and process this heavy water and return the drums. In addition to the drums received from external customers, DND has a significant inventory of its own drums to handle as well (in the order of ~300). An Excel database of the D_2O storage drums at Darlington has been prepared. This shows the drum type, contents, location, etc. for full drums, but does not include empty drums stored at Darlington. The drums at DND are predominantly stainless steel. There are only a few carbon steel drums with epoxy liners. (Operations indicate that DND only have one full non-stainless steel drum remaining).

There is a separate facility to handle virgin HW and the current inventory is 6 drums.

Issues with Drum Storage

D.4 There is a lack of space for storage of drums in HWMB.

D.5 Since Darlington is dealing with a significant amount of drum storage, cleaning and handling activities, there is a need to have a stronger focus on drum management than at present .

A-5.2.5 Other Issues

There is ongoing need for clean drums to store reactor grade D_2O during outages or moderator drains. Typically, about 40-50 clean drums are required to be available on stand-by. However, DND is continually building up an inventory of dirty drums, because the clean drums get contaminated as they end up being used for contaminated, downgraded water containing high total organic carbon (TOC). These are replaced with new ones. DND normally does not need to purchase new drums – can get clean drums from ISG or drums from Pickering for storing downgraded D_2O. These drums are visually checked to confirm cleanliness. Drums received from external clients, if unsuitable for transportation, end up being reused at DNGS.

Other Issues with Drums

D.12 A strategy for preventing contamination of clean drums needs to be identified by Station staff.

A-5.3 Reducing Dirty D_2O at Source

Production of downgraded and "dirty" D_2O is an inevitable but undesirable byproduct of heavy water management at the Stations. Most of the issues listed in this Section are common to Pickering and Darlington.

A-5.3.1 HW Collection

The general feeling at the Stations is that not much can be done to reduce collection rates from leakages and spills other than to perform maintenance and fix leaks promptly. If leaks are not promptly fixed, this can result in other problems such as trying to determine whether feeders leak when there is a chronic background of HW leakage from other sources such as leaking instrument lines, closure plugs or grayloc couplings.

It is also felt that there is not much flexibility in reducing heavy water collection from Vapor Recovery Systems other than ensuring that maintenance keeps gasket leaks, etc. to a minimum.

The TOC present in vapor recovery water is due to volatile organics in paints and degreasing solvents used in the reactor building. There may be opportunities for reducing the concentration of these contaminants by more judicious selection of paints and solvents used. Also the comparison of the collection rates from the various units will provide a measure of variance to guide leak location efforts. For example if the collection rate from one unit is significantly higher than the others, this should prompt an investigation into the causes and assist in developing corrective measures.

A-5.3.2 Processing of D_2O Contaminated with Arsenazo III.

The biggest bottleneck in reducing the number of these drums at Darlington is seen as disposal of the contents through the D_2O Clean-up System. This is not an issue of capacity of the D_2O Clean Up System which is judged to be adequate. The bottleneck is due to the fact that DND segregates water containing this arsenic containing organo-metallic reagent and characterization of the contents and strategy for clean-up is required for each drum, based on the contents, e.g. drums containing Arsenazo III require a different strategy than drums with just TOC. At Darlington, heavy water contaminated with Arsenazo has been segregated resulting in 24 drums which are filled with heavy water containing this reagent. This practice is different from that at other Stations, e.g. Pickering, Gentilly-2 and Bruce, where the heavy water contaminated with Arsenazo III is not segregated but since it is a small fraction of the total downgraded water volume, is mixed with the downgraded heavy water inventory, upgraded and re-used.

Issues with Reducing Dirty D_2O at Source

D.13 A strategy for dealing with the drums containing Arsenazo III needs to be identified by Station staff.

A-5.4 Options and Recommendations for Issues at Darlington

There are 13 significant findings with storage of heavy water at Darlington identified in the previous Sections. For clarity, the issues/findings are summarized here:

Table 3. Summary of the Darlington Tritiated Water Storage Issues at Darlington

Issue No.	Description
D.1	There is inadequate storage to permit the draining of moderators, segregation of isotopics, storage of lithiated PHT D_2O, shrink/swell requirements, lack of reliability of the TRF
D.2	There is inadequate storage for downgraded D_2O during Unit outages and in particular during extended TRF outages
D.3	There is inadequate storage to handle external feeds and for heavy water contingency needs if the TRF is in an extended outage
D.4	There is a lack of space for storage of drums in HWMB
D.5	Since Darlington is dealing with a significant amount of drum storage, cleaning and handling activities, there is a need to have a stronger focus on drum management
D.6	There are potentially unsafe conditions with unloading of ISO containers and drums from external customers
D.7	There is a potential for injury to operators due to manhandling of drums
D.8	A Drum Cleaning and Pressure Testing Facility is required but is not available at DND or elsewhere in OPG
D.9	A decision is required as to whether a centralized Drum Cleaning and Pressure Testing facility would be better than local facilities at Pickering and Darlington.
D.10	A suitable location for such a Drum Cleaning and Pressure Testing facility needs to be identified
D.11	A decision is required by OPG/NWMD whether filling the empty drums with absorbent material will be deemed to be acceptable in lieu of cleaning the drums for shipment to the WWMF.
D.12	A strategy for preventing contamination of clean drums needs to be identified by Station staff
D.13	A strategy for dealing with the drums containing Arsenazo needs to be identified by Station staff.

A-5.4.1 Bulk Reactor Grade D_2O Storage Requirements

This Section addresses item D.1in Table 3.

Recommendation for Issue D.1

In order to completely satisfy all of the demands for reactor grade D_2O storage as outlined in Section A-5.1.1, it is recommended that additional storage capacity be installed.

In addition, the D_2O PHT S&I transfer pumps need to be redesigned to double their capacity for the same head requirements.

The additional storage capacity that is recommended is as follows:

Table 4. Proposed Additional Reactor Grade Storage at Darlington

Purpose	Capacity: m^3
PHT Storage Tank	1x100
Upgrader Product Storage Tank	1x100
Moderator Drain Storage Tank	1x100

- 1x 100 m^3 PHT storage tank to ensure that there is sufficient storage to satisfy the PHT and Outage groups requirement to have >400 Mg of D_2O available for a 4-unit outage.
- 1 x 100 m^3 storage tank to be assigned for storage of upgrader product
- 1 x 100 m^3 storage tank to be assigned to accommodate moderator drains; the 1 x 47 m^3 moderator storage tank will be assigned for storage of multi-purpose water.

The additional storage will provide the following significant benefits to Station and to TRF operation:

- Improve flexibility of operation by satisfying the storage demands during normal operation but particularly, during outages requiring draining of various systems. During these outages segregation requirements will be met without having to resort to moving heavy water off-site
- Allow unit moderators to be drained completely when required, e.g. during an SCO
- Provide the benefits of lower tritium concentrations by enabling the drained moderator to be processed through the TRF in a once-through mode of operation
- Preserve the segregation of high and low Curie D_2O and improve the isotopics for the Units.

The impact of future drain requirements to support long term rehabilitation and life extension plans for the units has not been considered in the development of the above additional storage needs. For example, the simultaneous retubing of 2 Units has not been considered.

A-5.4.2 Downgraded D_2O Storage Requirements

This Section addresses items D.2 in Table 3.

Recommendation for Issue D.2

In order to completely satisfy all of the demands for downgraded D_2O storage as outlined in Section A-5.1.2, it is recommended that additional storage capacity be installed. This will provide the following significant benefits to Station and TRF operation:

- Additional downgraded D_2O storage capacity will enable the segregation of PHT and moderator recoveries during an extended outage of the TRF or the Upgrader. This segregation is required to ensure that the upgrader can be used to produce low curie D_2O suitable for use as PHT make-up, in the event of an extended, unplanned shutdown of the TRF. The TRF is the only source of PHT make-up for DND and is an aging facility that could be subjected to unplanned outages as a result of unforeseen component failures. Unavailability of the Upgrader makes the situation even worse. For example, during the 2003 SCO, back-up heating steam to the Upgrader was unavailable. All available storage had to be utilized, including 12 plastic totes of 1 m^3 each. The development of a life cycle management plan for the TRF is currently underway to address some of the existing and anticipated reliability issues expected to be faced by the TRF.

- Additional storage for clean D_2O product from the Clean-up System would enable more efficient use of the UV Oxidation system and better TOC removal by avoiding the possibility of mixing clean and dirty water if recirculation of clean product to the Feed Tanks of the Clean-up System is required to meet TOC specifications.

- The additional storage would also be beneficial in supporting the Isotope Sales & Heavy Water Programming Group's (ISG) efforts to secure additional D_2O for OPGN for upgrading and detritiation. This increased business would help underwrite the cost of improvements. In the proposed HWMB extension, the provision of bulk storage for downgraded D_2O from emptied drums (e.g. 1x100 m^3 Tank) is addressed. The tank could be multi-purpose and also be used also to supply additional feed storage for the D_2O Clean Up System and tie into the proposed 2x25 m^3 downgraded dirty tanks. These tanks together would take care of a shipment of 23 Mg in drums

The additional storage requirements are as follows:

Table 5. Proposed Additional Downgraded D_2O Storage Tanks at Darlington

Purpose	Capacity: m^3
Downgraded Dirty Tanks	2x25
Downgraded Clean Tanks	2x50
Downgraded D_2O from Emptied Drums	1x100

The 2x 50 m^3 clean downgraded D_2O storage tanks would also serve as upgrader feed tanks.

A-5.4.3 Storage Requirements to Support Off-site Detritiation Demands

This Section addresses items D.3 in Table 3.

Recommendation for Issue D.3

It is recommended that 2 x 50 m^3 tanks or a 1 x 100 m^3 tank is added for storage of external feed for the TRF. An equivalent amount of storage capacity will also be required for the product water. i.e. 2 x 50 m^3 tanks or 1 x 100 m^3 tank for TRF product.

The benefits accruing from addition of this extra storage are:

- The extra storage would result in more efficient utilization of the TRF capacity, as DND's use of the plant would be reduced.
- This also has transportation advantages as the TDOs would be more efficiently utilized and their use would not be tied to TRF availability.
- Additional TRF product storage would also allow the TRF to keep operating if the TDO's were not available for a period of time.

Table 6. Proposed Additional Storage to Support TRF External Customers at Darlington

Purpose	Capacity: m^3
TRF External Feed	1x100
TRF External Product	1x100

A-5.4.4 Drum Management

Drum management issues exist at Darlington as well as Pickering. A number of issues listed in Table 3 have been combined and will be addressed together since they fall under the umbrella of drum handling and management, particularly associated with drums received from external sources. These are items D.4, D.6, D.7, D.8, D.9 and D.10 in Table 3.

Radioactive drum handling has become an integral part of heavy water management at Darlington. OPG no longer produces heavy water. Hence, by necessity, radioactive drum handling will increase in the future as a means of optimizing and distributing heavy water assets across OPG and beyond. Because of location of the TRF, Darlington has become the heavy water management centre for OPG.

Therefore, while the option of "doing nothing" exists in theory – the impact of doing nothing will be an inability to reduce the backlog of drums at the Stations and an inability to send surplus drums to the WWMF site. In addition, some disruption to HWMB operations will be continue to be experienced due to lack of available storage space for drums and manipulation of drums in corridors, under stairwells etc. Most importantly, practices which are known to be potentially unsafe will continue.

A proper drum handling facility is recommended as a result of the above issues and OPG's long term commitment to process external D_2O. This facility could be located directly to the West of the HWMB. A new extension to the HWMB would be required. The facility could incorporate:

- Drum unloading/loading – e.g. access for trucks to come in to the building and a gantry crane to pick up the ISO container and put it on the floor,
- Provision of drum storage space,
- Bulk Storage of downgraded D_2O from emptied drums (e.g. 1x100 m^3 Tank) – these tanks could be multi-purpose and be used also to supply additional feed storage for the D_2O Clean Up System.
- Drum Cleaning and Pressure Testing - the facility would also serve to clean empty drums from Pickering and make these ready for disposal. A possible, alternate location of drum cleaning was suggested as being the room above the OGMS tanks (the Recombiner Room at 94' elevation). This room could be utilized if the equipment there could be removed and disposed. However, this alternate location would likely involve greater manipulation and movement of empty drums, and is therefore recommended only as a secondary option,
- Proper ventilation/drying.

The facility could serve all of OPG, including meeting Pickering's needs. The design of the facility would be intended to minimize manual handling of the drums by allocating storage space adjacent to the unloading area. In addition, it is recommended that current industrial practices in drum handling be investigated and incorporated into the designs to minimize ergonomic hazards associated with manual handling and movement of drums.

The rinse water from the facility would be monitored and go to Active Liquid Waste.

It is anticipated that the size of the addition to the HWMB would be approximately 10m by 30m in floor area.

Staff required for drum management may consist of 1 SNO + 2 NO's although they will not be required on a full time basis (estimate of 1 full time equivalent staff (FTE) needed).

A-5.4.5 Drum Management and Planning

This Section addresses items D.5, D.11 and D.12 in Table 3.

It is recommended that a "Drum Management Program Champion/Co-ordinator" at Darlington should be appointed. The accountabilities of this individual would be to proactively manage the drum issues at Darlington to ensure that issues D.5 and D.12 are addressed. For example, this individual would plan to receive drum shipments, and would also coordinate the delivery of empty drums from Pickering for cleaning, and then liaise with NWMD on disposal of empty drums after cleaning or filling with absorbent (issue D.11). The Drum Management Champion would be required to maintain an inventory of drums at the Stations and develop and implement a plan to dispose of surplus drums.

A-5.4.6 Reducing Dirty D_2O at Source

This Section addresses items D.13 in Table 3.

There are a number of options:

1 Do Nothing:

- The 24 drums containing heavy water contaminated with Arsenazo III will require continuing storage. This is recommended as a viable option for the short term only, since it does not resolve the fundamental issue. The pH of the drum contents is low, so that ongoing corrosion of the drums is an issue which will require that regular inspections be performed on the integrity of the drums.

2. Process the drums to destroy the Arsenazo:

- There is no effective clean up process identified for dealing with D_2O contaminated with Arsenazo III. There was a vague recollection that Bruce Power may have tested out the effectiveness of UV Oxidation process for destruction of Arsenazo. Harold Vogt (NOSS) questioned whether a simple, colorimetric bench test may be effective – e.g. mixing Arsenazo-contaminated water with hydrogen peroxide and passing UV light through the mixture and determining whether the color of the mixture dissipates. DND have issued a request through COG to investigate alternatives to Arsenazo, but since this is an issue which is specific to Darlington, it is not clear how much support will be generated from other COG members for this request.

- The UV Oxidation System at Darlington is hard piped downstream of the Clean Up System and it would be hard to carry out a test on it. In addition, it has been determined that it takes 1 L of IX resin to clean up 1 L of water contaminated with Arsenazo, i.e. the IX process is not very effective in removing Arsenazo.

3. Empty the Arsenazo drums into the downgraded D_2O tanks, one at a time over an extended period:

- In effect, this practice of dilution and desegregation is followed at the other Stations. Darlington has the advantage over Pickering of having the UV Oxidation system available. A trial emptying of one drum should be attempted while monitoring the TOC content downstream of the UV Oxidation System to determine if the specification of < 1 ppm is being maintained. If so, the practice of segregating drums containing Arsenazo should be discontinued.

- In the longer term, Arsenazo should be replaced as a reagent in the Chemistry Laboratory. There are likely alternative colorimetric reagents or perhaps with Inductively Coupled Plasma Spectrometry (ICP) capability the stations can do Gd analysis without the use of Arsenazo III. This is also a subject of a recent COG Statement of Requirement submitted by NOSS.

- Use of paints and degreasing solvents should be selected to minimize the degree of volatile organics content and hence the concentration of TOC in the recovered water.

A-5.4.7 Proposed Extension to the HWMB

To accommodate the increased storage capacity proposed in the preceding sections, an extension to the west of the HWMB is proposed. This will be an industrial building with approximate floor area of 10m by 30m or greater, depending on confirmation of the space available. The design of the building will be such that ISO Container and drum unloading will be on the ground floor so that trucks can drive in for unloading. Also on this floor will be drum storage area and the drum cleaning and pressure testing facility.

The building will have a full basement which will contain all of the additional bulk storage tanks that have been proposed in this report.

A-5.4.7.1 Functional Requirements of HWMB Extension

- The new storage area should be capable of accommodating an additional 300 m^3 of reactor grade S&I storage to support DND reactor operations, 200 m^3 of additional storage to support OPG and External detritiation demands (2 x 50 m^3 or 1 x 100 m^3 of TRF product storage and 2x 50 or 1 x 100 m^3 TRF feed storage), 150 m^3 of downgraded D_2O storage to support reactor operations and extended TRF unavailability and 100 m^3 of storage to empty drums received from external sources. In addition, the space should provide drum handling capability for up to 600 drums.

- All storage tanks added must have level instrumentation that displays on the System 6 computer and tie-in to the Plant Information (PI) system.

- All existing S& I level and weight instrumentation should also be displayed on the System 6 computer and tie-in to the PI system, as a part of this change.

- The building that houses this facility must tie-in to the existing HWMB D_2O liquid recovery system or have its own liquid recovery system.

- The building that houses this facility must tie-in to the existing HWMB D_2O ventilation system or have its own ventilation system.

- The storage tanks added must tie-in to the existing HWMB D_2O vent and cover gas system or have its own D_2O vent and cover gas system.

- An equipment vent dryer is required if the facility is to be housed in a new building.

- Tritium monitors are required to be located strategically in the building.

- New PHT S&I transfer pumps are to be installed with a design flow rate of 8 l/s and the same head capacity requirements as the existing units

- A weigh station is required for monitoring TDO payloads

- The storage tanks will have associated valves and pumps to transfer D_2O as required to their respective tie-in systems. Capability to transfer water from existing tanks to the new storage tanks and from the new storage tanks to existing tanks is required.

- The existing pit where the D_2O S&I storage tanks are housed is seismically qualified. Consideration of seismic qualification requirements for the additional storage area is required, since some of the new tanks will be used for storage of high tritium D_2O.

- A radiological dose assessment will be required to cover loss of the complete inventory of these tanks, similar to what was completed as part of the original design of the D_2O S&I system.

- The drum cleaning and pressure testing system must be tied into the active liquid waste system.

A-5.4.8 Other Options and Considerations

Utilization of existing space in the HWM Building should be optimized so as to reduce the load on the HWMB extension.

The Off Gas Management System (OGMS) equipment contained in the HWMB is no longer required as this system is to be permanently removed from service. Consideration should be given to the use of rooms containing OGMS equipment. Equipment that cannot be used would have to be scrapped for disposal, if it is to be contamination free. However, this option has a few drawbacks:

- There is a limited amount of space which would have to be retrofitted with equipment

- The location is not ideal for receiving and handling external drums (i.e. no direct access for unloading ISO containers)

- The space is not adequate for all of the equipment and systems proposed for the HWMB extension

- Removal of OGMS equipment would be costly and complicated.

On this basis, this is not recommended as the preferred option.

A-5.4.9 Summary of Existing and Proposed Bulk Storage

A summary of the existing bulk storage available at DND together with the additional proposed storage requirement is shown in the following Tables:

Table 7. Existing and Proposed Additional Reactor Grade Storage Capacity - DND

Existing Reactor Grade D_2O Storage Tanks		***Proposed Additional Reactor Grade Storage***	
Purpose	**Capacity: m^3**	**Purpose**	**Capacity: m^3**
PHT S&I tanks	4x100	PHT Storage Tank	1x100
PHT Weigh Tank	1x30	Upgrader Product Storage Tank	1x100
Moderator S&I Tanks	3x100	Moderator Drain Storage Tank	1x100
Moderator Storage	1x47	TRF External Feed	1x100
Moderator Weigh Tank	1x10	TRF External Product	1x100
Upgrader Product Tank	2x9		
TRF Feed Day Tanks	2x10		
TRF Product Day Tanks	2x10		
TRF Product Return Tanks	2x25		
TRF External Feed Tank	1x57		

Table 8. Existing and Proposed Additional Downgraded D_2O Storage Capacity - DND

Existing Downgraded D_2O Storage Tanks		*Proposed Additional Downgraded D_2O Storage Tanks*	
Purpose	**Capacity: m^3**	**Purpose**	**Capacity: m^3**
Downgraded Dirty Tanks	2x25	Downgraded Dirty Tanks	2x25
Downgraded Clean Tanks	2x50	Downgraded Clean Tanks	2x50
		Downgraded D_2O from Emptied Drums	1x100

An alternate configuration of storage has been suggested recently by Darlington staff. This proposes the use of more, smaller tanks rather than large 100 m^3 tanks. This will allow easier segregation of different grades of water. The proposed alternate configuration is as follows:

Table 9: Proposed Alternate Bulk Storage Configuration at Darlington

Proposed Alternate Bulk Storage Configuration at Darlington	
Purpose	**Capacity: m^3**
PHT Storage Tanks	2x50
Upgrader Product Storage Tank	2x50
Moderator Drain Storage Tank	2x50
TRF External Feed	2x50
TRF External Product	1x100
Downgraded Dirty Tanks	2x50
Downgraded Clean Tanks	2x50
Downgraded D_2O from Emptied Drums	4x25

This alternate configuration requires almost double the number of tanks and a total capacity of 800 m^3. It will need more piping and valves as well as requiring a larger building. The cost of the new facility, therefore, is expected to be somewhat higher than shown below. Because of its larger footprint, the new facility is unlikely to fit into the space available on the west side of the HWMB, and an alternate location for this facility will likely be required. This alternate location will be determined during the implementation phase of the project.

Furthermore, it would be beneficial if the downgraded tanks were provided with suitable connections for hooking up a portable clean up system on a skid. The design and implementation of this portable clean up skid should be investigated further in the next phase of the project.

A-5.4.10 Cost Estimate of HWMB Extension

An order-of-magnitude budgetary cost estimate (+/- 50% accuracy), has been prepared for the proposed HWMB extension. This cost estimate can serve as a starting point for preparing the BCS (Business Case Summary) for the extension project.

A bottoms-up cost estimate has been developed with detailed consideration of each individual component and task. The estimate includes the following items:

Storage System:

Equipment:
Bulk Storage Tanks (Nuclear Class III)
Drum Cleaning
Pressure Testing
Vent Dryers
Gantry Crane
Accessories
Design:
Process Design
Instrumentation & Control Design
Drafting & Sketches
Mechanical Design
Electrical Design
Fabrication:
Component Assembly
Pre-installation Testing
Administration:
Project Management,
Procurement,
Quality Assurance,
Project Expediting,
Regulatory Approvals

Formatted: Bullets and Numbering

Building:

Equipment:

Piping & Tubing Valves
- Process valves,
- Service valves,
- Relief valves,

Electrical Equipment Package
- Ancillary Equipment
- Chilled water package,
- Cooling water supply equipment,
- Steam/ condensate supply equipment,
- Insulation,

Design:
- CDD Preparation,
- Architectural Design,
- Eqpt. Specs.,
- Piping Specs.,
- Utility Requirements,
- Interface Requirements,
- Design Manual,
- Operating Manual,
- Installation Procedures,
- Commissioning Procedures,
- Drafting & Sketches,
- Architectural Drawings,

- Electrical Wiring Diagrams,
- Eqpt. Layout,
- Piping Layout & Isometrics,
- Mechanical Design,
- Post Order Engg.,
- Stress Analysis,
- Foundation/ Supports,
- Electrical Design

Interfacing and Tie-ins to Reactor Systems:

Piping & Tubing
Mechanical Design
Excavation & Trenching
Excavation & Trenching Labor

Estimate

The assumptions used in preparing the cost estimates are shown in Appendix 8.
On the basis of the above scope, the cost of the HWMB extension has been estimated as **$10 million to $15 million**. It should be noted that this cost does not include the cost of preparing the BCS or getting project approvals. Also, no contingency allowance has been included. Further, this is an order-of-magnitude budgetary cost only. This can be roughly broken down as follows:

Equipment (Tanks, pumps, drum cleaning system, etc.)	$4,680,000
Engineering Design, Assembly, Administration, Accessories	$1,586,000
Sub-Total for Tanks, Drum Cleaning, Pressure Testing, Engineering, Assembly, Installation	**$6,266,000**
Cost of Building Extension	$1,100,000
Services, equipment within Building	$633,000
Engineering, etc.	$729,000
Sub-Total for Building and Services (including design, engineering, construction)	**$2,462,000**
Interfacing System Materials (piping, valves, etc.)	$460,000
Engineering	$360,000
Construction, installation	$905,000
Sub-Total for interfacing with existing systems	**$1,725,000**

The alternate configuration of bulk storage tanks, as shown in Table 9, is expected to have a higher cost than shown above, primarily due to a greater number of tanks, a larger footprint and more piping and valves. The cost of the alternate configuration, with more tanks and bigger building is estimated to be about $ 5 million greater, i.e. **a total of $15 to $20 million.**

A-6 PICKERING FINDINGS

A-6.1 Bulk Reactor Grade and Downgraded D_2O Storage

D_2O storage needs are driven by several different demands. These include storage needs to support the reactors during normal operation and during outages. The various demands for D_2O require segregation and handling of water of varying quality in tanks and in drums.

The potential benefits of additional storage are similar to those at Darlington, and are as follows:

- Improve flexibility of operation by satisfying the storage demands during normal operation but particularly, also during outages requiring draining of various systems. During these outages, segregation requirements should be met without having to move heavy water off-site.
- Allow unit moderators to be drained completely when required.
- Provide the benefits of lower tritium concentrations by enabling the drained moderator to be processed through the TRF in a once-through mode of operation i.e. enable complete moderator swaps to be performed. This requires enough storage to avoid mixing of the feed and product from the TRF.
- Preserve the segregation of high and low Curie D_2O and improve the isotopics for the Units. Note that at the end of Aug/2004, the average Moderator isotopic at Pickering was 99.883% at PND-A and 99.890% at PND-B (in 2003, the average PHT isotopic was 98.623% at PND-A and 98.425% at PND-B). These isotopics are significantly lower than at Darlington with a resultant fuel burn-up penalty at Pickering.

A-6.1.1 Reactor Grade D_2O Requirements to Support Pickering Reactor Units

Existing D_2O Supply & Inventory (S&I) storage capacity available to support reactor unit operation and unit outages are shown in Table 9:

Table 10 Existing Reactor Grade D_2O Storage Tanks at Pickering

Purpose	Capacity (m^3)
PHT S&I tanks	2x100
Moderator S&I Tanks	2x150
Upgrader (UPP-B) Product Tank	2x5.5
Upgrader (Sulzer-B) Product Tank	2x1.8
PIOTS Receiving Tank	1x29
PIOTS Shipping Tank	1x15
PIOTS Surge Tank	1x11

Eleven stainless steel tanks, with a total capacity of approximately 570 m^3 are provided for storage; two tanks are for moderator (MOD) heavy water and two tanks are for primary heat transport (PHT) heavy water. The MOD tanks are used for Pickering B drains (Pickering A has MOD dump tanks). If the PHT tanks are full, TRF product is not easily received.

Reactor grade D_2O storage and segregation requirements to support normal reactor operation and outages are as follows:

- High isotopic (>99.9%D_2O), high curie (>1.2 Ci/kg) reactor grade D_2O (Upgrader product) for moderator systems must be segregated from low isotopic (<99.9% D_2O), low curie (<0.7 Ci/kg) reactor grade D_2O (TRF product) for make-up to PHT systems (a chemistry concern exists with adding a large quantity (>10 Mg) of non-lithiated TRF product to PHT systems).

- Moderator D_2O S&I storage capacity is required to accommodate the complete drain of a poisoned moderator system.

- As the station ages, there is a need to perform about 1 moderator drain per year (Unit 5 moderator drain is due in 2005). The Station can not physically handle two drains concurrently.

- When the two large tanks in S&I are full containing Moderator water from a drained unit, Pickering's maneuverability is extremely taxed: During a drain, one of the PHT Tanks has to be used for Moderator Upgrader product. This eliminates the possibility of performing large on-line Moderator swaps with the running units, therefore, reducing or eliminating the possibility of sending water to the TRF during the duration of the drain. Any TRF product delivered to Pickering must be placed in the same tank the PHT Upgrader product is going into which is not the best use of the TRF product. It also creates a greater risk of contaminating PHT water with Moderator water and creating the possible scenario of not having any suitable PHT water on site for make-up. Additional moderator tanks would provide greater flexibility in managing reactor grade water and maintaining segregation of Upgrader product and PHT make-up water under most circumstances.

- Lithiated PHT D_2O from the reactors has to be segregated to accommodate shrink and swell during unit shutdowns and start-ups.

- A minimum inventory of PHT D_2O must be maintained in the PHT storage tanks to satisfy the shrinkage requirement during simultaneous cool down of all four units in the event of a four unit trip.

- A small quantity of "multi-purpose" D_2O (TRF product with an isotopic >99.96 % D_2O) must be segregated for use in deuteration/de-deuteration of both moderator and PHT purification systems ion-exchange resins.

- For temporary bulk storage of D_2O, the Helium Storage Tank on Unit 2 has been used to store up to 95 m^3 of water. This is only possible in a shutdown unit.

- Draining of the PHT system directly into the S&I tanks is not allowed because the D_2O is lithiated and hence would contaminate the water in the tanks; also, the PHT water may downgrade the water in the tank. Therefore, the PHT water is either transferred to other Units via the inter-unit tie lines or purified via the IX Cleanup System and upgraded.

- Upgrader product is stored in 4 product tanks (tanks totaling 14.4 m^3) before it is returned to the moderator system or reserved in one of the moderator or PHT S&I storage tanks for use in future moderator on-line transfers. Normally all upgrader product is returned to the moderator system and TRF product is the source of make-up to the PHT system.

- The existing D_2O storage capacity for the PIOTS system is adequate for facilitating transfers between Pickering and the TRF. However, additional capacity would allow greater flexibility.

Issues

P.1 There is inadequate bulk storage for moderator grade water

A-6.1.2 Downgraded D_2O Requirements to Support Pickering Reactor Units

Existing downgraded D_2O storage capacity at Pickering consists of 7x 6 m^3 D_2O recovery tanks (4 Low Curie, 3 High Curie) at the IXCU which are used to collect downgraded PHT and moderator D_2O (the recovery tanks also receive collection from other sources, namely, (moderator D_2O collection, PHT collection, miscellaneous collection). This is then processed at the IXCU with the product water being stored in 2x2.5 m^3 tanks. This water is subsequently processed through the Upgrader. There are nine 50 m^3 feed tanks in the UPP (5 in UPP-A and 4 in UPP-B) and 4x15 m^3 Sulzer feed tanks.

Table 11. Existing Storage Tanks for Downgraded D_2O at Pickering

Purpose	Capacity (m^3)
D_2O Recovery Tanks (at IXCU) - High Curie	3x6
D_2O Recovery Tanks (at IXCU) - Low Curie	4x6
IXCU Product Tanks – High Curie	2x2.7
IXCU Product Tanks – Low Curie	2x5.5
UPP (A&B) Feed Tanks	9x50
Sulzer Feed Tanks	4x15

Upgrader product is stored in 2x5.4 and 2x1.8 m^3 product tanks (see Table 9) before being returned to the moderator system or reserved in one of the moderator or PHT S&I storage tanks for use in future moderator on-line transfers. Normally all Upgrader product is returned to the moderator system and TRF product is the source of make-up to the PHT system.

Additional downgraded D_2O storage capacity is required to address the need for segregation of PHT and moderator recoveries. This segregation is required to ensure that the upgrader can be used to produce low curie D_2O suitable for use as PHT make-up, in the event of an extended, unplanned shutdown of the TRF. The TRF is the only source of PHT make-up for Darlington and is an aging facility that could be subjected to unplanned outages as a result of unforeseen component failures.

The TOC spec of 1 ppm required by the Upgraders and the TRF is difficult to achieve with the IXCU. Normally the TOC level can be reduced to about 3-4 ppm. To achieve this level, however, the water is sent to an available tank at UPP-A where it is usually left to sit for a while and then recirculated through the columns of a temporary IXCU back into the same tank. It is believed that the venting of the UPP-A tanks allows the volatile TOC to naturally dissipate. Because the UPP-A tanks are carbon steel, rust and the conductivity and sometimes pH get out of spec and this requires further clean-up through the temporary columns.

The above complicated procedure currently being followed would likely be eliminated by commissioning and operation of the UV Oxidation System. It is possible that once the UV Oxidation system is commissioned, that there will be no further need to recirculate water through the UPP-A tanks and through the temporary clean up system. However, the additional storage

capacity available in the UPP-A tanks will be useful in all likelihood. Currently at UPP there are inter-connections to send water to UPP-A tanks from UPP-B, but not in the reverse direction. Thus, cleaned water in the UPP-A tanks cannot be sent to the UPP-B feed tanks without sending it back to the IXCU in 5 or 6 Mg batches for reprocessing. This is both time and resource consuming. Therefore, there is need to investigate the requirement for additional piping between UPP-A and UPP-B.

Issues

P.2 There is inadequate storage for down graded water

P.3 Some additional piping is required to interconnect UPP-A and UPP-B tanks.

P.4 Evaluate the need of a clean up system for UPP-A tanks after UV Oxidation system is commissioned

A-6.2 Drum Management Program

A-6.2.1 Processing of Downgraded Heavy Water

There are currently 3000 drums stored at PND of which 1629 are full drums, the balance being dirty empty drums. The empty drums contain an unknown quantity of D_2O and a sludge heel with very high TOC. They resulted partially from the recent processing of D_2O as discussed below.

The D_2O in the 1629 full drums has a TOC concentration of <100 ppm, and thus can be processed using a UV Oxidation system once this has been commissioned. For this reason, these full drums were not included in a recent Pacific Nuclear campaign which successfully processed D_2O with very high TOC (>1000 ppm)[1]. The processed D_2O, about 200 Mg in total and containing a residual TOC content of 100-200 ppm, is currently stored in tanks awaiting further processing using the UV Oxidation system. Because of Pacific Nuclear's success, no need is felt for the development of other treatment technologies.

In order to empty the 1629 full drums and further process the stored D_2O from the Pacific Nuclear campaign, the UV Oxidation System at Pickering will need to be commissioned. The present UV Oxidation system was procured in the mid-1990's but was never fully commissioned. Identical equipment is successfully in use at Darlington. Either this system or a new replacement, depending on the business case, is expected to be commissioned in 2005. The lessons learnt from the installation, commissioning and operation of the UV Oxidation system at Darlington can be applied at Pickering. The UV Oxidation system at Darlington has treated D_2O with a TOC content of up to 15-18 ppm (higher levels of TOC are also believed to be treatable) and reduced it to less than 1 ppm[2], the specification for feed to the Upgrader.

In the absence of a UV oxidation system at Pickering, the IXCU is unable to reduce TOC below 3 ppm[3]. Further, the reduction of TOC levels to about 3 ppm normally requires the UPP-A storage tanks to be utilized with a temporary IXCU on recirculation mode.

[1] The Pacific Nuclear campaign generated approximately 24 drums of filter waste, 24 drums of activated oil waste, 2 totes of resin and 1 tote of charcoal.

[2] Experience at Gentilly-2 shows that TOC of 1 ppm is achievable and has prevented Upgrader fouling since about 1994.

[3] The throughput capacity of D_2O Clean Up Systems is not a bottleneck in terms of processing dirty D_2O. The design rates of High and Low Curie Clean Up are adequate to supply Upgraders at their required throughputs.

In addition to the presence of TOC, the full drums contain varying levels of tritium. Of the 1629 full drums, 1300 contain D_2O at > 2 Ci/kg. These cannot be processed using the higher capacity UPP-B Upgrader and must be processed through the Sulzer-B Upgrader[4]. The low capacity[5] for processing high Curie D_2O through the Sulzer-B Upgrader is seen as one of the biggest bottlenecks in reducing the number of full drums at Pickering.

The reduced capacity of Sulzer-B is assessed to be caused by the unavailability of high pressure steam for the reboilers (due to the lay-up of Pickering A; high pressure steam is expected to be unavailable until Unit 1 returns to service) and also due to some plugged, leaking tubes in the condenser which reduces the condensation rate and consequentially limits the feed rate. Note that the distributors were last cleaned in about 2000 and hence, plugging of the distributors is not considered to be a factor in the reduced throughput. However, installation and commissioning of the UV Oxidation System, which is recommended in this report, will reduce the TOC levels in the feed and prevent or reduce future fouling of distributors. An investigation to improve the throughput of Sulzer "B" should be beneficial.

Other processing related findings include:

- Oil contamination from the Pickering fueling machines is under control. The two oil/water separators (one for high Curie and one for low Curie) appear to be working well.
- Meeting turbidity specifications in the recovery water is becoming an issue. This is possibly attributed to the presence of desiccant. Also, the TOC in the water does not meet specifications. If the water cannot be sufficiently cleaned, then it has to be drummed.
- Drained moderator water containing gadolinium cannot be sent to the TRF. A facility to remove gadolinium (present at 18 ppm in poisoned moderator water) is desirable.
- Unlike Darlington, Pickering does not segregate Arsenazo III waste hence there is no backlog of this type of water at PND.

Issues

P 5 The UV Oxidation System is not in operation

P 6 The throughput of Sulzer B upgrader needs improvement

P 7 Turbidity specifications of recovery water are not being met

P 8 There is a need for a facility to remove gadolinium from moderator water

A-6.2.2 Drum Handling

In general, although some power assisted equipment is utilized, drum handling still involves a significant amount of manual effort. Ergonomics of drum handling is an issue with a potential to cause injury to operators. A facility is required to minimize the amount of manual effort involved with loading, unloading, emptying and filling of these drums.

[4] Sulzer-A can not upgrade HW over 60% isotopic. Sulzer-A can not be restarted in it's current condition due to overpressure relief issues

[5] Based on an old NOSS memo, it appears that the single Recovery feedrate in the late 80's for Sulzer-B was about 160 kg/h with Bottom Product (BP) and Head Product (HP) isotopic of about 99 98 and 0 08%. Compared to this, the Sulzer-B feedrate from July 23 to Aug 13/2004 was 139 kg/h with BP and HP isotopics of 99.98 and 0.04%. Thus, the throughput appears to have declined by about 13%

IP-2 drums are used for off-site transportation. NWMD requires that drums be shipped within an overpack (secondary containment) in order to contain any potential leakage during transportation. This requirement is very onerous. Labels are sometimes required to be placed both on the drum as well as on the overpack. Drums are placed within the overpack with slings in place in order to facilitate their subsequent removal (the drums do not have a lip and hence cannot be grappled any other way) from the overpacks. They are filled after being placed within the overpacks. Pickering has no experience with lifting full drums out of overpacks using slings.

Stacking of drums is an option to alleviate shortage in storage space. At present, however, drums are not stacked on Elevation 274' near the IXCU or at the units because of concerns with floor loading. Floor loading should not exceed 300 psf at elevation 274' (in the vicinity of the IXCU) and 500 psf at elevation 254'. These limits do not allow for significant accumulation of full drums. A full drum of D_2O provides a load of 155psf.

There is no separate facility for handling virgin grade D_2O. Pickering needs 1-2 drums/year of virgin D_2O for laboratory use and to refill instrument lines for re-commissioning activities at Pickering-A.

Issues

P.9 There is a need for better drum handling equipment to avoid potentially unsafe work conditions

P.10 There is inadequate storage space for drums

A-6.2.3 Drum Cleaning and Pressure Testing

Drum cleaning and pressure testing (5 psig test pressure) are the pre-requisites for re-use of drums in transportation and storage. Thus, the empty drums at Pickering which contain a heel of sludge and heavy water cannot be transported, for volume reduction and storage at the WWMF, without first being cleaned. Further, the cleaned drums would need to be pressure tested to be re-used in transportation.

Thus, a key to reducing the backlog of stored drums at Pickering is to install a drum cleaning and pressure testing facility or contract for this service. Such a facility does not currently exist at Pickering, Darlington or at the Bruce Heavy Water Plant site. Either local facilities or a centralized facility, possibly located at Darlington but also serving Pickering's needs should be considered.

The optimum location for a drum cleaning/pressure testing facility at Pickering would be the Decon room on Elevation 254'. Locating it on Elevation 274' by the IXCU would require an assessment of the floor loading. Alternately, a centralized facility at Darlington could serve the needs for both Pickering and Darlington.

Issues

P.11 A Drum Cleaning and Pressure Testing facility is required either at Pickering or Darlington.

A-6.2.4 Drum Disposal

The present criteria for disposing drums at Pickering is typically based on visible damage, high fields and observed leaks. A failed pressure test may be utilized as a future criterion. All drums are considered to be active, i.e., inactive drums are not segregated from active drums.

As discussed earlier, Pickering has a significant backlog of empty drums. These drums do not meet WWMF's current waste acceptance criteria which require that the drums be cleaned to reduce radiation fields (it needs to be confirmed whether in lieu of cleaning and emptying drums, absorbent material may be placed in the drums to eliminate any free standing liquid). If the concentration of tritium within the cleaned empty drums exceeds 100 MPCa, then they are stored as is at the WWMF; otherwise, they can be compacted. Compaction of drums prior to shipment used to be practiced before but is no longer permitted by NWMD.

The current drum disposal practice is considered to be acceptable at Pickering. However, Pickering needs additional space to effectively manage drum disposal activities (approximately 200/year). Currently, drums, less than 15 at a time, are prepared in the IXCU area which is crowded at the best of times. The prepared drums are then transferred to the Solid Waste Handling Facility for shipment to WWMF. As an alternative to additional space for drum disposal activities at Pickering, a facility located at Darlington could also serve Pickering's needs. Such a facility would be part of a larger complex incorporating drum loading/ unloading, drum storage space, tanks for storage of downgraded D_2O (from emptied drums), drum cleaning, pressure testing and drum disposal.

AECL is a potential contractor for alternative disposal services. However, a proposal received by OPG for "washing" of 12 empty drums indicated that AECL, similar to WWMF, was also unwilling to accept drums with heels of liquid and/or with external gamma fields exceeding 2.5 mRem/h.

Issues

P 12 There is a need to clarify NWMD's current waste acceptance criteria for nominally empty drums.

P 13 There is inadequate space to effectively manage drum disposal activities at Pickering.

P.14 There is a large backlogged inventory of empty drums which is not being disposed

A-6.2.5 Other Findings

- No database exists for the stored D_2O drums at Pickering. A drum bar coding system was once purchased but never used (inadequate resources to support this initiative) and its present whereabouts is unknown. All drums have individual serial numbers, but these have not been entered into a database. A bar coding system would be very beneficial for inventory tracking and control.

- Clean drums for storing reactor grade water (TRF product is used for loss make-up in the PHT system) are in short supply. There is an ongoing need for these drums during outages or moderator drains. PND currently have 15 clean drums on site but would prefer to have 50. However, the station is continually depleting its inventory of clean drums, because the clean drums get used for storing contaminated, TOC-laden, downgraded heavy water. New replacement drums are obtained from the Bruce Heavy Water Plant or from Darlington (Pickering does not purchase new drums normally). These drums are visually checked for cleanliness prior to use.

- Pickering does not have a proper facility for filling drums with reactor-grade D_2O. Currently, drums can be filled only via the PIOTS (TK18). A drum filling station, which could fill both high and low Curie water is desirable. An ECN (expanding the IXCU facility), for a drum filling station, had been prepared some time ago but was never implemented (this may have been due to issues with the HVAC system and lack of spill control capability).

Issues

P.15 There is a need to develop a database for stored HW drums and provide the necessary resources to support this endeavor.

P.16 There is a need to develop a strategy for preventing the contamination of clean drums

P.17 There is a requirement to increase supply of clean drums at Pickering

P.18 There is a need to install a drum filling station for high and low Curie reactor-grade D_2O.

A-6.3 Reducing Dirty D_2O Storage At Source

Production of downgraded and dirty D_2O is an inevitable but undesirable byproduct of heavy water management at the Stations. The Stations feel that not much can be done to reduce collection rates from leakages and spills other than to perform maintenance and fix leaks promptly. Comparison of the collection rates from the various units will provide a measure of variance to guide leak location efforts. It is also felt that there is not much flexibility in reducing heavy water collection from Vapor Recovery Systems other than ensuring that maintenance keeps gasket leaks, to a minimum.

The TOC present in vapor recovery water is due to volatile organics in paints and degreasing solvents used in the reactor building. There may be opportunities for reducing the concentration of these contaminants by more judicious selection of paints and solvents used.

A-6.4 Options and Recommendations for Findings at Pickering

The issues identified in Sections 6.1- 6.3 are summarized in Table 11 below. Options and recommendations for managing these issues are then discussed under various groupings.

A-6.4.1 Bulk Reactor Grade and Downgraded Storage Requirements

Issues P.1-P 4 are addressed in this section because they all pertain to bulk storage.

- It is recommended that two additional 150 m^3 tanks to store moderator water be installed. This will improve the flexibility of operation, allow units to be drained completely when required, provide the benefits of lower tritium concentrations and preserve the segregation and improve the isotopics for the Units.

  Unfortunately there isn't sufficient room to locate additional tanks near the existing S&I Tanks. The most probable location would be at the UPP. Tie ins to the existing reactor grade transfer lines would be required to transfer product from each of the upgraders to these tanks as well as for movement to and from the existing S&I Tanks; the latter are located on the east end of Pickering B.

The impact of future drain requirements to support long term rehabilitation and life extension projects such as the simultaneous retubing of 2 Units has not been considered in the development of the above additional storage needs.

- It is recommended that three 25 m^3 D_2O Recovery Tanks be installed to address the need for segregation of PHT and moderator recoveries (to store Low Curie, High Curie and High TOC water). This segregation is required to ensure the availability of low Curie Upgrader product for use as PHT make-up, in the event that TRF is shutdown. These tanks can possibly be installed on the 254' level below the IXCU, beside Unit 1.

- It is recommended that the two x 50 m^3 D_2O feed tanks to contain downgraded dirty feed for the D_2O Clean Up System should be added.

- The needs for additional piping to interconnect UPP-A and UPP-B tanks and for a clean-up system for UPP-A tanks should be evaluated and addressed by Pickering Engineering.

Table 12. Summary of the Pickering Tritiated Heavy Water Storage Issues

Issue No.	Description
P.1	There is inadequate bulk storage for moderator grade water
P.2	There is inadequate storage for down graded water
P.3	Some additional piping is required to interconnect UPP-A and UPP-B tanks.
P.4	Evaluate the need of a clean up system for UPP-A tanks after UV Oxidation system is commissioned
P.5	The UV Oxidation System is not in operation
P.6	The throughput of Sulzer B upgrader needs improvement
P.7	Turbidity specifications of recovery water are not being met
P.8	Three is a need for a facility to remove gadolinium from moderator water
P 9	There is a need for better drum handling equipment to avoid potentially unsafe work conditions
P.10	There is inadequate storage space for drums
P.11	A Drum Cleaning and Pressure Testing facility is required either at Pickering or Darlington.
P.12	There is a need to clarify NWMD's current waste acceptance criteria for nominally empty drums.
P.13	There is inadequate space to effectively manage drum disposal activities at Pickering
P.14	There is a large backlogged inventory of empty drums which is not being disposed
P.15	There is a need to develop a database for stored HW drums and provide the necessary resources to support this endeavor.
P.16	There is a need to develop a strategy for preventing the contamination of clean drums
P.17	There is a requirement to increase supply of clean drums at Pickering
P.18	There is a need to install a drum filling station for high and low Curie reactor-grade D_2O.

Table 13. Existing and Proposed Additional Reactor Grade Storage Capacity – PND

Existing Reactor Grade D_2O Storage Tanks		*Proposed Additional Reactor Grade Storage*	
Purpose	**Capacity: m^3**	**Purpose**	**Capacity: m^3**
PHT S&I tanks	2x100	Moderator Drain Storage Tanks	2x150
Moderator S&I Tanks	2x150		
Upgrader (UPP-B) Product Tank	2x5.4		
Upgrader (Sulzer-B) Product Tank	2x1.8		
PIOTS Receiving Tank	1x29		
PIOTS Shipping Tank	1x15		
PIOTS Surge Tank	1x11		

Table 14. Existing and Proposed Additional Downgraded D_2O Storage Capacity –PND

Existing Downgraded D_2O Storage Tanks		*Proposed Additional Downgraded D_2O Storage Tanks*	
Purpose	**Capacity: m^3**	**Purpose**	**Capacity: m^3**
D_2O Recovery Tanks (at IXCU) - High Curie	3x6	Dirty Downgraded D_2O Storage	3x25
D_2O Recovery Tanks (at IXCU) - Low Curie	4x6	D_2O Clean Up System Feed Tanks	2x50
IXCU Product Tanks – High Curie	2x2.7*		
IXCU Product Tanks – Low Curie	2x5.5		
UPP (A&B) Feed Tanks	9x50		
Sulzer Feed Tanks	4x15		

A-6.4.2 Processing of Downgraded Heavy Water

Issues P.5-P.9 are addressed together in this section because they all pertain to the processing of downgraded heavy water.

- As discussed earlier, the unavailability of a UV oxidation system at Pickering is a major impediment both in reducing the backlog of heavy water filled drums as well as in meeting the upgrader's feed specifications for TOC on an ongoing basis. To resolve these issues, an oxidation system should be commissioned on an urgent basis. Based on a recent business case assessment by Design Projects, the existing unit at Pickering is likely to be refurbished (versus the purchase of a new unit). This will require the equipment to be both functionally and performance tested. Based on the performance of the unit at Darlington, which is similar,

the ability of the oxidation system to reduce normal levels of TOC to 1 ppm or less is considered to be good. However, it must be recognized that the back logged inventory of heavy water contains TOC at levels of 100-200 ppm, which are substantially higher than the maximum levels encountered at Darlington. Therefore, it is imperative that the performance tests also evaluate the destruction of TOCs at such elevated levels.

Aside from the ability to effectively destroy elevated levels of TOCs, the adequacy of the throughput capacity of a single oxidation system in meeting both the ongoing processing needs at Pickering as well as the need for expeditiously treating the back logged D_2O inventory, must be evaluated. If the back logged inventory cannot be treated on a timely basis using a single oxidation system, then the option of hiring an external contractor (with additional equipment) should be considered. Otherwise, the recovery of real estate, currently used for storage of drums, will be unacceptably slow.

- The reduced capacity of Sulzer-B is primarily caused by the unavailability of high pressure steam for the reboilers. Supply of high pressure steam should be restored expeditiously following the return to service of Unit 1.

- Factors affecting the turbidity specifications of recovery water should be fully explored and corrective action taken.

- An ion exchange system should be installed for removing gadolinium from drained moderator water. Based on 18 ppm gadolinium and a moderator water volume of 300 m^3, a mixed bed (strong acid cation and strong base anion) column of about 0.19 m^3 is required.

A-6.4.3 Drum Handling, Storage, Cleaning and Pressure Testing

Issues P 9-11, P.13 and P.15-18 are addressed together in this section because they all pertain to drum management. Although P.8 and P.10 also pertain to drum management, they are discussed separately in Section A-6.4.3 because of the great significance of empty drum disposal at Pickering.

- "Doing nothing" will exacerbate the current situation vis-à-vis drum handling and storage. Because of the unavailability of drum cleaning equipment, surplus drums cannot be cleaned and sent to the WWMF for disposal and thus the backlog of drums would continue to increase. The increasingly reduced real estate combined with the inadequate drum handling equipment currently being utilized will result in an increasingly unsafe environment with the potential to cause serious injury to workers.

- The serious shortage of drum storage space at Pickering can be effectively alleviated by eliminating the inventory of 1629 heavy water filled drums and 1371 empty drums. This is discussed in Sections A-6.4.1 and A-6.4.3. Because of limitations on floor loadings, the available storage space cannot be utilized more efficiently by stacking.

- Although a drum cleaning and pressure test facility can be located at Pickering in the Decon room (Elevation 254') or by the IXCU (Elevation 274'), the recommended location is in the proposed new extension to the HWMB at Darlington. Further details of this facility are given in Section A-5.4.1. This would avoid duplication of facilities and avoid burdening Pickering where available space is already very limited.

- Unlike Darlington, Pickering does not have a database for stored HW drums. Having and maintaining a database is essential for the effective management of the HW drum inventory. The database should show the drum ID, type (IP-2/3, SS or CS etc), contents (empty or

extent full, type of heavy water, isotopic etc.), location, origin, age etc. Development of a database is strongly recommended.

- Pickering should acquire a bar coding system. Such a system would be useful for inventory tracking and control and to maintain the database. The associated software can be used for extracting and manipulating the gathered data. Gentilly-2 has such a system and may be willing to license or sell their technology.

- The appointment of a "Drum Management Program Champion/Co-ordinator" is recommended. The accountabilities of this individual would be to proactively manage all drum related issues at Pickering as itemized in Table 11. Thus, this individual would be responsible for drum handling, storage, cleaning, and disposal.

A-6.4.4 Disposal of Drums

Issues P.12and P.14 are addressed in this section. In particular, the focus is on the disposal of the 'Empty' drums at Pickering. These contain a heel of sludge and a layer of downgraded heavy water. The sludge is possibly a mixture of concrete debris and oil and oil oxidation products. The downgraded heavy water contains varying levels of tritium; based on the limited number of earlier measurements, the tritium level is expected to vary between 40 mCi/kg and 1.7 Ci/kg.

The practical options for disposal of the empty drums are:

1. Immobilize the heel at the bottom of the drum; ship the drums to WWMF for compaction and storage.

2. Ship the drums containing the heel to DSSI for incineration of the waste; DSSI will dispose the resulting ash and the empty drums in the US,

3. As in Option 2 except some of the drums would be cleaned with the secondary waste resulting from the cleaning consolidated within the empty space in the remaining drums; the cleaned drums would be shipped to WWMF for compaction and storage and the full drums would be shipped to DSSI for incineration,

4. Cut the bottom off each drum (for this purpose, the drum is positioned in a trough to collect the cut bottom and the associated sludge), compact the drum tops, immobilize the sludge in a suitable binder, ship compacted drum tops, the drum bottoms and the immobilized sludge for storage at WWMF

The above options were assessed based on preliminary proposals received from the service providers. The assumptions made and the details for each option are discussed in Appendix 1. The following conclusions were reached.

- Option 1 is the simplest and least cost option. Available binders may be employed without the need for mixing the drum contents. If the binders can be demonstrated to have good retention for tritium, no drying step would be required prior to immobilization. This option is feasible only if OPG-PND makes a safety case to demonstrate to NWMD that PND is meeting the intent of NWMD's Waste Acceptance Criteria.

- The costs of Options 2 and 3 are very sensitive to the elevated levels of tritium present in the sludge. For these options to be economically viable, the drum heels must be dried to remove the water and hence the tritium.

- Option 3 is expected to be significantly more expensive than Option 2. The higher cost for Option 3 is, however, offset by the potential savings arising from the re-use of cleaned drums. This would require the cleaned drums to be pressure tested.

- Option 4 is similar to Option 1 considering that both involve sludge solidification and drum compaction. With the added complexity of the cutting operation, Option 4 can be expected to be more expensive than Option 1. Good ventilation would be required to limit tritium exposure. Alternately, the sludge heels could be dried prior to the cutting operation.

- Options 1, 3 and 4 will, respectively, generate 275, 122 and 271 secondary waste overpacks, respectively. Option 3 produces secondary waste only if the cleaned drums are compacted instead of being reused. Option 2 also generates secondary waste consisting of crushed drums; however, these would be disposed by DSSI in the US. The relative amount of secondary waste produced in Options 1, 3 and 4 is of significance only if the stations are assigned a cost for waste storage at the WWMF.

Subject to the various caveats discussed above, the recommended choice is Option 1 followed by Option 2.

A-6.4.5 Cost Estimate for PND

An order-of-magnitude budgetary cost estimate (± 50% accuracy), has been prepared for the additional tankage required at Pickering and the cost of tie-ins to the systems . This cost estimate can serve as a starting point for preparing the BCS (Business Case Summary) for the project.

A bottoms-up cost estimate has been developed with consideration of each individual component and task. The estimate includes the following items:

Installation of UV Oxidation System
Peroxide Storage
Tie-ins to clean up systems, Active Drains
Venting, relief
Power supplies, other interfaces
Foundations & Supports

Storage System:
Bulk Storage Tanks (Nuclear Class III)
Accessories
Process Design
Instrumentation & Control Design
Drafting & Sketches
Mechanical Design
Electrical Design
Component Assembly
Pre-installation Testing
Installation & Commissioning
Administration:
- Project Management,
- Procurement,
- Quality Assurance,
- Project Expediting,
- Regulatory Approvals

Interfacing and Tie-ins to Reactor Systems:
Piping & Tubing
Mechanical Design

Cost Estimate

The assumptions used in preparing the cost estimates are shown in Appendix 8.
It is estimated that the additional storage tanks, engineered, installed and commissioned will cost $ 3 million. A considerable amount of effort is required for piping and valves to tie-in and interface with existing heavy water systems. Configuration management documents have to be updated. The cost of interfacing is estimated as $2 million.

A cost for the installation and commissioning of the UV Oxidation has also estimated as $520,000. A gross breakdown of the estimates is shown below:

Bulk Storage Tanks

Equipment	$1,900,000
Engineering, Installation, Commissioning	$1,100,000
Sub-Total	**$3,000,000**

Interfacing and Tie-ins

Equipment	$450,000
Engineering, Installation, Commissioning	$1,550,000
Sub-Total	**$2,000,000**

UV Oxidation System Installation & Commissioning

Sub-Total	**$520,000**

A-7 IMPLEMENTATION PLAN FOR RECOMMENDED OPTIONS

The significant benefits of providing additional bulk storage at Pickering and Darlington and improving the drum management by disposing of surplus drums have been clearly described in the previous sections. Although implementation of the recommendations requires capital expenditures and project resources, it is imperative that implementation of the recommendations start right away with preparation and approval of a Business Case, in order to maximize benefits over the remaining life of the Stations.

While the above recommendations require investment, the costs can be more than offset by providing the following benefits:

- Increased revenues
- Increased safety (handling,dosage)
- More efficiently run operation
- Ability to keep stations within OP&P limits (regulatory requirement)
- Environmental stewardship (less tritium emissions)

The implementation plan needs to be based on the priorities as well as the time required to complete an improvement initiative. The following priority of implementation is recommended:

- Design, build and commission a HWMB extension at Darlington with sufficient bulk and drum storage capacities and a drum cleaning and testing facility.
- Install and commission the UV peroxide system that is sitting idle at Pickering. It needs to be checked for operability, effectiveness put into service
- Design, build and commission additional bulk storage as recommended at Pickering

These initiatives are the ones that will require significant capital expenditures and dedicated project teams for execution. Because of the long lead times required to obtain internal management approvals, complete the engineering and procure and install systems, it is recommended that preparation of Business Case Summaries for these initiatives should proceed as soon as possible.

In parallel with initiation of these projects, there are other, modest, initiatives which are easy to implement and can be implemented immediately. These will have measurable positive impacts which will motivate production personnel as well as management to support and justify the expenditures associated with the larger initiatives.

Other Initiatives Recommended at Darlington

- Recognize that even though the stations were not designed with adequate drum storage, drums need to be handled safely and efficiently. Make drum management (storage, inventory and disposal) the responsibility of a single person in the Heavy Water Management organization (Drum Management Coordinator) and charge this individual with the development, implementation and monitoring of a drum management plan.
- In support of the above, it will be necessary to negotiate with NWMD to provide reasonable guidance and assistance for the volume reduction and disposal of contaminated, non useable

drums. Station Operations will need to conduct a safety assessment of the immobilization methodology to ensure the objectives of NWMD's WAC are complied with when the drums are volume reduced.

- Make drum storage space available by suspending the segregation of moderator laboratory samples that contain Arsenazo III reagent. Initiate clean up of the backlog Arsenazo III drums by IX or dilution.

- Provide the Drum Management Champion/Coordinator with the tools he/she will need to do his/her tasks. This includes a simple drum cleaning and pressure testing capability which will allow only a certain specified number of drums to be in circulation at any time and will preclude the accumulation of drums. This facility occupies a small footprint and is relatively easily moved

- Although potentially more expensive ($5600), consider in-station storage of heavy water in 950L stainless steel totes rather than drums. The reduction in footprint is about 30%.

- Conduct a Business Case Summary for the longer term improvement plan – design, build and commission an extension to the existing heavy water management building.

Other Initiatives Recommended at Pickering

- As at Darlington, a single Drum Management Coordinator is required to champion the issues and be responsible for implementing fixes to the drum management problems at Pickering.

- Pickering personnel should train at Darlington to write Pickering specific procedures for operating the UV peroxide system.

- To reduce the backlog of high TOC water, the option of buying service from an external supplier to destroy TOC should be investigated.

- As at Darlington, discussions need to start with NWMD to identify a reasonable path forward to move the empty drums containing small amounts of immobilized heel from Pickering to the waste storage facility at WWMF. A safety assessment of the preferred option will need to be conducted to ensure compliance with NWMD's Waste Acceptance Criteria.

- Reducing the inventory of backlog empty drums can be easily accomplished in this time frame and should be given high priority.

- If drum cleaning is a prerequisite for the large number of empty dirty drums disposal at WWMF, purchasing this service is likely to be a faster path forward than cleaning the drums in house. Pacific Nuclear may be able to provide this service.

- Although potentially more expensive ($5600), consider in-station storage of heavy water in 950L stainless steel totes rather than drums. The reduction in footprint is about 30%.

- Conduct a Business Case Summary for the longer term improvement plan – design, build and commission additional storage tanks for moderator drains, D_2O recovery storage.

A-8 IMPACT OF THE RECOMMENDATIONS ON COMMERCIAL OPERATIONS

It is the opinion of the authors of this report, also shared by key stakeholders in this study that there are large benefits that would accrue to OPG by implementation of the recommendations of this report.

A-8.1 Impact on Station Operations

Implementation of the recommendations will provide improved bulk storage to cope with demands such as draining of moderators, segregation of isotopics, storage of lithiated PHT D_2O, shrink/swell requirements, lack of reliability of the TRF etc.

At Darlington and Pickering, the additional storage will provide the following significant benefits to Station and to TRF operation as well as meeting demands from external customers:

- Improve flexibility of operation by satisfying the storage demands during normal operation but particularly, during outages requiring draining of various systems. During these outages segregation requirements will be met without having to resort to moving heavy water off-site
- Allow unit moderators to be drained completely when required, e.g. during an SCO
- Provide the benefits of lower tritium concentrations by enabling the drained moderator to be processed through the TRF in a once-through mode of operation
- Preserve the segregation of high and low Curie D_2O and improve the isotopics for the Units.
- Additional downgraded D_2O storage capacity will enable the segregation of PHT and moderator recoveries during an extended outage of the TRF or the Upgrader. This segregation is required to ensure that the upgrader can be used to produce low curie D_2O suitable for use as PHT make-up, in the event of an extended, unplanned shutdown of the TRF. The TRF is the only source of PHT make-up for DND and is an aging facility that could be subjected to unplanned outages as a result of unforeseen component failures. Unavailability of the Upgrader makes the situation even worse. For example, during the 2003 SCO, back-up heating steam to the Upgrader was unavailable. All available storage had to be utilized, including 12 plastic totes of 1 m^3 each. The development of a life cycle management plan for the TRF is currently underway to address some of the existing and anticipated reliability issues expected to be faced by the TRF.
- Additional storage for clean D_2O product from the Clean-up System would enable more efficient use of the UV Oxidation system and better TOC removal by avoiding the possibility of mixing clean and dirty water if recirculation of clean product to the Feed Tanks of the Clean-up System is required to meet TOC specifications.
- The additional storage would also be beneficial in supporting the efforts to secure additional D_2O for OPGN for upgrading and detritiation. This increased business would help underwrite the cost of improvements. In the proposed HWMB extension, the provision of bulk storage for downgraded D_2O from emptied drums (e.g. 1x100 m^3 Tank) is proposed. The tank could be multi-purpose and also be used also to supply additional feed storage for the D_2O Clean Up System and tie into the proposed 2x25 m^3 downgraded dirty tanks. These tanks together would take care of a shipment of 23 Mg in drums

- The extra storage would result in more efficient utilization of the TRF capacity, as DND's use of the plant would be reduced.
- This also has transportation advantages as the TDOs would be more efficiently utilized and their use would not be tied to TRF availability.
- Additional TRF product storage would also allow the TRF to keep operating if the TDO's were not available for a period of time.

The impact of future drain requirements to support long term rehabilitation and life extension plans for the units has not been considered in the development of the above additional storage needs. For example, the simultaneous retubing of 2 Units has not been considered.

At present, there is not enough storage available to accommodate completion of a full moderator drain. At Darlington, the recent execution of an SCO has demonstrated that it is not possible to complete a moderator drain with the existing storage capacity. Hence, this requirement was removed from the Outage Scope. At Pickering "A", during the Unit 4 return-to-service project it has not been possible to take advantage of a once-through detritiation of the moderator due to inadequate storage availability.

At Pickering, the implementation of the UV Oxidation System is recommended as a high priority to be done immediately. It is viewed as important not only to meeting chemistry specifications, but also to preserving the physical assets, such as upgrader packing and reducing down time. It will also help in reducing the backlog of dirty water contained in 1629 drums at Pickering and aid in the overall goal of disposal of the 3000 drums at Pickering. A drum cleaning and pressure testing facility, when implemented, is the other key to disposal of these drums. Disposal of these drums will eliminate a long standing issue at Pickering, improve housekeeping, free-up valuable real estate at the Station, promote better World Association of Nuclear Operators (WANO) ratings and also add to OPG's inventory of reactor grade D_2O.

A-8.2 Impact on OPG's Commercial Operations

A significant positive impact would be realized by enabling D_2O shipments from external customers to be handled in a safe and efficient manner. The unloading of ISO containers and emptying of drums would be made much simpler. The temporary storage of external drums would not impose a burden on HWMB operations, thus saving labor costs and minimizing the manipulation of drums. Overall, the bottlenecks to OPG's D_2O business would be effectively removed.

Provision of additional storage for TRF feed and product would also increase revenue by allowing Darlington to continue receiving TDO shipments for some time if the TRF is out of service. There have been numerous requests (primarily from PND, but also from Bruce Power) for the TRF to accommodate acceptance of external feed during periods when the plant is shutdown. This would result in more efficient utilization of the TRF capacity, as DND's use of the plant would be reduced. Utilization of TDO's would also improve.

A-8.3 Impact on Operations during Implementation of Recommendations

Implementation of all of the recommendations involves capital and resource commitment as well as some short-term disruption to Operations when system tie-ins are made. A dedicated project team will require commitment of project resources.

In addition, tie-in to the S&I and other systems will require an outage for those systems. Further, significant documentation updates will be needed to reflect the revised system configuration in operating flowsheets, design flow diagrams, design manuals and operating manuals.

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A-10 APPENDIX 1 OPTIONS FOR DISPOSAL OF EMPTY DRUMS

The 'Empty' drums at Pickering contain a heel of sludge and a layer of downgraded heavy water. The sludge is possibly a mixture of concrete debris and organo-metallic additives which were originally associated with the oil contamination. The downgraded heavy water contains varying levels of tritium; based on the limited number of measurements in 1999, the tritium level varies from about 40 mCi/kg to 1.7 Ci/kg.

The practical options for disposal of the empty drums are:

1. Immobilize the heel at the bottom of the drum; ship the drums to WWMF for compaction and storage (alternately, the drums could be compacted prior to shipment),

2. Ship the drums containing the heel to DSSI for incineration of the waste; DSSI will dispose the resulting ash and the empty drums in the US,

3. As in Option 2 except the drums would be cleaned at PND prior to being shipped to DSSI; ship the cleaned drums to WWMF for compaction and storage (alternately, the drums could be compacted prior to shipment),

4. Cut the bottom off each drum (for this purpose, the drum is positioned in a trough to collect the cut bottom and the associated sludge), compact the drum tops, immobilize the sludge in a suitable binder, ship compacted drum tops, the drum bottoms and the immobilized sludge for storage at WWMF

The above options were assessed based on preliminary proposals received from the service providers and the following considerations:

- The dimensions of the 200 L drum were considered to be: OD 24 in, ID 21.1 in and Ht. 35 in.
- The heel in each drum was assumed to consist of a 2 inch layer of sludge containing downgraded heavy water. Thus, the volume of sludge per drum is on average 11.4 L.
- The average concentration of tritium in the water was assumed to be 500 mCi/L.
- For ease of comparison, all secondary waste was assumed to be contained within 250 L overpacks with dimensions: ID 22 in, Height 40 in.
- Typically, empty stainless steel 200 L drums may be compacted to a height of approximately 4 inch. Thus, the volume reduction factor for a drum is expected to be 35/4 or 8.75.
- Cleaning of drums was assumed to double the volume of the waste.
- Immobilization of the heels was assumed to double the volume of the waste.

Each option is briefly considered now.

Option 1:

- A limited characterization of the drum heels is required.
- Potential binders to immobilize the heels would need to be identified.
- A scoping level treatability study would be needed to identify the immobilization binder of choice. Binder must effectively immobilize the tritium to limit releases during shipment, compaction and storage.
- Ineffective binding of tritium would necessitate the removal of tritiated water from the drums by evaporation. This may be accomplished by passive heating of the drums and condensing the vapors. The recovered water could subsequently be upgraded to reactor grade water.
- Drums containing the immobilized solid would not meet WWMF's current waste acceptance criteria for an empty drum. The current WAC requires a drum to be empty with tritium limited to 10 MPCa. An exception to the WAC would be required.
- The overall height of each drum after compaction in the present case will be approximately 7.5 in. This is greater than the 4 inch corresponding to an empty drum as a result of the presence of the immobilized heel in the drum.
- Approximately 275 overpacks will be required to accommodate the 1371 compacted drums.
- Tri-Phase Environmental Inc., Mississauga have submitted a budgetary proposal for solidifying the sludge heels and subsequently compacting the drums. Their preliminary cost estimate for all the 1371 drums is $ 0.16 M. They propose to use a blend of cementitious materials called SSA (Soil Stabilizing Agent).

Option 2

- Contents of each drum would need to be characterized for shipment; compositing the samples for analysis would reduce the characterization cost. For composites of 10 samples each, the characterization cost would be approximately $ 0.15M.
- DSSI would assume responsibility for disposal of ash resulting from the incineration (and also the drums) provided OPG will not insist on dedicated burns.
- Price is very sensitive to tritium content. The potentially elevated levels of tritium in the drum heels may make it uneconomic to ship the drums as is to DSSI because surcharges for tritium would be significant. Therefore, it may be necessary to dry the drum contents (as described above). The recovered water would have a high isotopic and hence could be processed to reactor grade water.
- The total inventory of tritium associated with the 1371 drums is estimated to be 7,800 Ci. DSSI cannot accept more than 5000 Ci of tritium at any given time. Thus, the drums may need to be shipped in more than 1 batch.
- DSSI's current import license is restricted to 1000 Ci of H-3 per year and would need to be amended.
- OPG has an established relationship with DSSI and has routinely shipped other liquid wastes to DSSI.

- Cost of treatment at DSSI based on 500 mCi/L H-3 is expected to be approximately$ 8 M US. However, if the average concentration of tritium is only 1/10th, i.e., 50 mCi/L, the cost would be approximately $ 1M US. These costs include transportation and brokering.

- Without tritium surcharges, DSSI's cost would be approximately $ 0.17 M (US) only.

Option 3

- Of the 1371 drums, 1220 drums would need to be cleaned in order to consolidate the secondary waste into the remaining 151 dirty drums. Thus, only 151 full drums need to be shipped to DSSI for incineration.

- Contents of each full drum would need to be characterized for shipment; compositing the samples for analysis would reduce the characterization cost. For composites of 10 samples each, the characterization cost would be approximately $ 15,000.

- DSSI would assume responsibility for disposal of ash resulting from the incineration (and also the drums) provided OPG will not insist on dedicated burns.

- Price is very sensitive to tritium content. The potentially elevated levels of tritium in the drum heels may necessitate removal of tritium by drying prior to cleaning of the drums. The recovered water would have a high isotopic and hence could be processed to reactor grade water.

- The total inventory of tritium associated with the 1371 drums is estimated to be 7,800 Ci. DSSI cannot accept more than 5000 Ci of tritium at any given time. Thus, the drums may need to be shipped in more than 1 batch.

- DSSI's current import license is restricted to 1000 Ci of H-3 per year and would need to be amended.

- There is a significant potential for the 1220 cleaned drums to be reused at OPG stations.

- Compaction would be required if the cleaned drums cannot be reused. The number of overpacks required to store the compacted drums is approximately 122.

- Pickering does not have a capability for drum cleaning. Hence, an external contractor would be required. The cost to Pickering would include sponsoring the cleanup work, characterizing the secondary waste and shipment of the waste to DSSI and shipment of empty drums to WWMF for compaction if these cannot be reused.

- Based on the average tritium concentration in the heel of 500 mCi/L, the corresponding concentration in the secondary waste after cleaning is estimated to be 260 mCi/L. Cost of treatment at DSSI based on 260 mCi/L H-3 is expected to be approximately$ 8 M US. However, if the average concentration of tritium in the secondary waste is only 50 mCi/L, the cost would be approximately $ 1.8 M US. These costs include transportation and brokering.

- Without tritium surcharges, DSSI's cost would be approximately $ 0.27 M (US) only.

Option 4

- Services will be provided on-site by an external contractor.

- Cutting the bottom of each drum is expected to take about 5 mins.

- The cutting operations will need to be carried out in a well ventilated facility to minimize tritium emissions. The potentially elevated levels of tritium in the drum heels may necessitate removal of tritium by drying prior to cutting the drums. The recovered water would have a high isotopic and hence could be processed to reactor grade water.

- It is desirable to separate the cut bottoms from the sludge in order to separately package them.

- The sludge will need to be immobilized. Binder must effectively immobilize the tritium in the sludge to limit releases during shipment and subsequent storage.

- Approximately, 271 overpacks will be required to accommodate the 1371 compacted drum shells, the 1371 drum bottoms and the immobilized sludge.

- Hawman Containers, Barry who initially proposed this concept have declined to provide an estimate based on their concern with the management of tritium emissions.

A-11 APPENDIX 2 NOTES FROM MEETING WITH CHARLES FOSTER AND ALFRED MO (JULY 28TH, 2004)

- Pacific Nuclear have successfully processed 800 drums of contaminated (2000 ppm TOC, 10% isotopic) heavy water (HW) at Pickering. The process included oil separation and IX columns. Other drums were not processed because of budget. Common Services (Tom Henderson) were responsible.
- Need to develop a drum inventory at DNGS
    - Gadolinium is used at DNGS; contaminated HW drums contain dye
    - Denny Williams contact
- TDO is a 10 Mg (2X5 Mg) trailer; there is 1 TDO system at each station
- Bulk storage (200-400 Mg) is required at the TRF; the existing feed tank (FT) and product tank (PT) are not large enough. 50 Mg capacity. Tritiated feed water arrives in drums but because the feed tank is not large enough, the water cannot be emptied from the drums. Hence, the drums occupy space. Size of bulk storage must accommodate 20-40 Mg of external HW plus water from PNGS and BNGS.
- No drum cleaning facility exists at OPG. Facility at CMF is not functioning. Drum cleaning procedures available. AECL have a drum cleaning facility. At Laprade, the heavy water plant across G2 also has a drum cleaning facility. Because contaminated drums are not IP-2 drums, any water present must be removed in order to ship the drums to a cleaning facility.
- IP-2 drums cost $ 600-800 each.
- Because of restriction on plywood use (fire hazard), drums cannot be easily stacked. Metal palettes are not convenient to use.
- TOC is a bigger problem at PNGS because of the use of hydraulic oil in FMs
- Bruce Power is considering to install storage tanks to minimize TRF costs. TRF can treat water containing up to 30 Ci/kg. It costs the same to treat low Ci water as high Ci water. By having storage tanks, possibly only high Ci water goes out to the TRF for processing.
- Drum crushing facility at WWMF; 5 crushed drums to a m3.
- Sales opportunity typically involve at least 100 drums
- IP-2 drums are not needed for virgin HW
- Don't need virgin HW for loss replacement
- At Bruce, the two buildings have about 1000 Mg stored HW (equivalent to 5000 drums). Plant B (F2) have a storage capacity of 6x115 Mg (6 tanks) while Plant D has a storage capacity of 800-900 Mg (10 tanks). The tanks are 30-40 ft long and 10 ft high; these are not Class 3 vessels. Tanks are made of SS or Aluminum (Plant D has some aluminum tanks).
    - Too expensive to consolidate HW elsewhere (part of study objectives to assess this).

- No weighing scale at plant D
- Buildings are 25 years old, have never been upgraded. Plant B office half occupied by NWMD (NWMD plans to vacate). Little or no data on condition assessment of buildings.
- Costs $ 300, 000 (steam from BP) to heat buildings. Not much traffic through buildings but comfortable work environment has to be maintained.
- Work procedures are described in License.
- There is a sump recovery system; however, there have been no leaks.
- Low pressure N2 blanket system over liquid interface.
- Tankers move up to 20 Mg HW (no blanketing)

- There is a 1200 sq ft facility at DNGS for handling virgin grade HW. Serves external clients and OPG stations. Storage capacity 20 Mg. Any drums in this facility do not contribute to the overall drum problem at DNGS.

A-12 APPENDIX 3 NOTES OF MEETING AT PICKERING ND AUGUST 11, 2004

Attendees:

Fred Drepaul
Glenn Walker
John Krasznai
Aamir Husain
Armando Antoniazzi
Sav Sood

The meeting was held to review Pickering's priorities and needs for HW storage and handling such that Pickering's needs can be incorporated and integrated into the overall OPG strategy for heavy water storage and management. There are 3 broad areas of interest to Pickering:

- Drum Handling and Storage
- Bulk D_2O Storage
- Virgin D_2O Handling

Drum Handling

Q1 Are there previous reports or a database summarizing the drum inventory, type of drums, location and state of the drums at Pickering? Is there a SPOC for drum issues?

A1 A database of the HW storage drums at Pickering showing the drum type, contents, location, etc. was requested but such a database does not exist at PND. The SPOC for drum handling issues at PND is Glen Walker (x3573).

There are currently 3000 drums stored at PND. Of these, 1629 are full drums, the balance being dirty empty drums. The empty drums contain an unknown quantity of D_2O and sludge heel with very high TOC.

A drum bar coding system was once purchased at PND, but was never used and its present whereabouts is unknown. All drums have individual serial numbers, but these have not been entered into a database. A bar coding system could be a great tool for inventory measurement.

Q2 What is the status of the UV Oxidation System? Are there existing plans to use the PNGS UV Oxidation system to treat and clean-up some of the TOC-contaminated water in drums, so that these drums can be emptied prior to clean-up?

A2 The lessons learnt from the installation, commissioning and operation of the UV Oxidation system at Darlington can also be applied at Pickering. The present UV Oxidation system at PND was installed in mid-1990s but was never commissioned. It was originally planned to be commissioned by Nov 2004: now it is expected to be commissioned in 2005 following a business case assessment.

Q3 Was the treatment service provided by Pacific Nuclear satisfactory? Are there drums of water that are amenable to treatment by Pacific Nuclear? How many drums are in this category?

Q4 Are there drums of water that are not treatable by Pacific Nuclear technology? How many drums are in this category?

Q3/4 The 3000 drums are partially a result of the processing of D_2O with very high TOC (>1000 ppm) by Pacific Nuclear Inc. The processing decreased the TOC content of the D_2O to about 100-200 ppm. The processed D_2O, about 200 Mg in total, is currently stored in tanks and will be further processed using a UV Oxidation system once the latter has been commissioned.

The D_2O in the 1629 full drums has a TOC concentration of <100 ppm, and thus can also be further processed using the UV Oxidation system.

Q5 Do you see a need to develop other treatment technologies?

A5 No

Q6 What would be the optimum location for a drum cleaning facility at Pickering?

A6 Preferred location of drum cleaning equipment is the Decon room on Elevation 254'. Locating it on Elevation 274' by the IXCU would require an assessment of the floor loading.

Q7 In your view, what is the biggest bottleneck in reducing the number of drums at Pickering?

A7 The biggest bottleneck in reducing the number of drums at Pickering is seen as the low capacity for processing high Curie D_2O through the Sulzer-B Upgrader[5]. Of the 1629 full drums, 1300 contain D_2O at > 2 Ci/kg; these cannot be processed using the higher capacity UPP "B" Upgrader. Therefore, an investigation to improve the throughput of Sulzer -B may be beneficial (e.g. would distributor cleaning boost throughput, how does Sulzer -B operate as compared to predictions from the simulator UGDYNSIM?). The Chemistry Dept. in NOSS may be able to help in de-bottlenecking of Sulzer-B.

Q8 Are there any other drum handling issues that are high priority for Pickering and that have not been identified here?

A8 The key to reducing the backlog of stored drums is to have a drum cleaning and pressure testing facility in addition to having the UV Oxidation system in service. A centralized drum cleaning and pressure testing facility located at Darlington, but which could also serve Pickering's needs should be considered. The pressure testing facility to check and certify the integrity of drums would make these drums available for transportation.

Q9 We understand that clean drums for reactor grade water are in short supply. How many drums are required on stand-by? Are these drums required for storage, transportation or both?

There is ongoing need for clean drums to store reactor grade HW during outages or moderator drains. PND currently have 15 clean drums on site but would prefer to have 50 clean drums on site at any time.

[5] Sulzer-A can not upgrade HW over 60% isotopic. Sulzer-A can not be restarted in it's current condition due to overpressure relief issues.

There is no proper facility at PND for filling drums with reactor-grade D_2O. This can currently be performed only via the PIOTS system (TK18). A drum filling station, which could fill high and low Ci drums would be useful. An ECN, expanding the IXCU facility, had been prepared some time ago for a drum filling station but was never implemented (there was a sense that this may have been due to issues with the HVAC system and lack of spill control capability).

Q10 We understand that there is a separate facility for handling virgin grade HW. What is the inventory of clean drums in this facility. Are some of these drums used elsewhere in the plant when clean drums are hard to find.

There is no separate facility for handling virgin grade HW. PND needs 1-2 drums/year of virgin D_2O for laboratory use. TRF product is used for loss make-up.

Q11 Does Pickering buy clean drums on an ongoing basis? If so how many are purchased and what types?

A11 PND does not purchase new drums. These are obtained from the inventory of clean drums at the Bruce HWP facility or from Darlington. PND has a problem in keeping drums clean.

Q12 Why can't drums be stacked to alleviate shortage in storage space ?

A12 Drums are not stacked on Elevation 274' near the IXCU or at the units because of concerns with floor loading.

Bulk Storage

Q1 What is the state of present space usage and future space availability or restrictions for HW storage?

A1 Lack of enough bulk storage at PND is seen as an issue similar to Darlington. Shutdown of the IXCU results in an instant backlog of drums.

Q2 Bulk storage of HW – what is Pickering's view on required amount of storage and what are the potential locations?

A2 If 3 new Class 3 tanks of 25 Mg capacity each were available to store High Curie, Low Curie and High TOC feed water for the IXCU, respectively, then drums could be emptied into these tanks and the drum inventory at PND could be drastically reduced. Two new 150 Mg tanks could accommodate moderator swaps but this would not affect drum storage

It is anticipated that provision of additional bulk storage will be constrained by availability of space and will require significant capital expenditures.

Q3 Are there any existing plans for future moderator drains at Pickering? Is this possible without additional storage?

A3 As the station ages, there is a need to perform about 1 moderator drain per year. The Station can not physically handle two drains concurrently. Moderator drains adversely affect the stations ability to perform on-line moderator D_2O swaps and hence the volume of water which the station can send to the TRF. The next moderator drain is due next year on Unit 5.

The S&I tank capacity at PND is as follows:
2 x 100 Mg tanks for PHT storage
2 x 150 Mg tanks for MOD storage

The MOD tanks are used for Pick "B" drains. Pick "A" has MOD dump tanks.
If the PHT tanks are full, TRF product cannot be received easily.

Q4 Is there existing equipment (e.g. Helium cover gas tanks) that would be available to be adapted for bulk storage of HW? What was the outcome of the attempt to use the helium cover gas tanks for storing moderator drains?

A4 For temporary, bulk storage of D_2O, the Helium Storage Tank on Unit 2 has been used to store up to 95 Mg of water. This is only possible in a Unit that is shutdown.

Q5 Are there any other bulk storage issues that are high priority for Pickering and that have not been identified here?

A5 For D_2O Cleanup, currently there are 7 x 6 Mg feed tanks, (4 Low Ci, 3 High Ci) available to store dirty water. The capacity of the feed tanks needs to be increased by 2X50 Mg to be consistent with the capacity of the Clean Product Tanks that are available as well as to allow more surge capacity for storing untreated, downgraded D20.

Q6 Will adequate provision of bulk storage alleviate all the problems currently faced with drum storage. What would the residual issues be?

A6 It would decrease the problem but not alleviate it entirely.

Q7 Is the HW storage capacity for the PIOTS system adequate for facilitating transfers to the TRF and return from the TRF?

A7 We can manage with existing storage capacity but additional capacity would give greater flexibility.

Other Issues

1. Draining of the PHT system directly into the S&I tanks is not allowed because the D_2O is lithiated and hence would contaminate the water in the tanks; also, the PHT water may downgrade the water in the tank. Therefore the PHT water is either transferred to other Units via the inter-unit tie lines or purified via the IX Cleanup System and upgraded.

2. Oil contamination from the PND fuelling machines is under control. There are 2 Oil/Water Separators (one for high Ci and one for low Ci) which appear to be working well. However, a UV oxidation system is still required to attain feed water specifications for the upgrader.

3. The TOC spec of 1 ppm required by the Upgraders and the TRF is difficult to achieve with the IXCU. Normally the TOC level can be reduced to about 3-4 ppm. Even for this, the UPP "A" storage tanks are utilized together with a temporary IXCU on recirculation to bring the TOC levels down from 5 ppm to 3 ppm. This adds further justification for commissioning of the UV Oxidation System. There was a previous ECN to expand the capability of the IXCU (approx. worth $5 million). **Action:** Glenn Walker to get a copy for information.

4. In the past, drums have been shipped in overpacks with the empty drums being first placed within the overpacks and then filled. Pickering has no experience with lifting full drums out of overpacks using slings.

5 Turbidity in the recovery water is becoming an issue – it is passing chemical specs but failing turbidity spec. this is possibly attributed to the desiccant. If the water cannot is not sufficiently clean then it has to be drummed. The TOC in the water does not meet specifications.

6 Full drums cannot be transported without first being tested. Empty drums can, however, be transported.

7 Moderator water containing gadolinium cannot be sent to the TRF. A facility to remove gadolinium (present at 18 ppm in poisoned moderator water) is desirable.

8. There are 9 tanks in the UPP (5 in UPP-A and 4 in UPP-B).

9 Unlike Darlington, Pickering does not segregate Arsenazo waste.

10. Virgin D_2O is required in the Chem. Lab and is also used to refill instrument lines for recommissioning activities at Pickering-A.

A-13 APPENDIX 4 NOTES OF MEETING AT DARLINGTON ND

OPG Heavy Water Storage and Handling Strategy

Darlington ND
August 6, 2004

Attendees:

Denny Williams
Thomas Wong
Jerry Ernewein
John Krasznai
Aamir Husain
Sav Sood

The meeting was held to review Darlington's priorities and needs for HW storage and handling such that Darlington's needs can be incorporated and integrated into the overall OPG strategy for heavy water storage and management. There are 3 broad areas of interest to Darlington:

- Drum Handling and Storage
- Bulk D_2O Storage
- Virgin D_2O Handling

A draft document "Backgrounder on DND D_2O Storage Requirements for OPGN's D_2O Options Study" was distributed by Denny Williams prior to the meeting. This is a very useful summary of DND's needs. Denny will obtain comments form DND stakeholders, finalize this document and issue it to the meeting attendees **(Action)**.

Following the meeting, a tour of the HW Management Building was undertaken. A useful discussion was held with Peter Smith (HWMB Operator) which reinforced many of the storage bottlenecks and issues. The tour highlighted the lack of storage space available. For this reason, for example, drums are now being stacked on top of each other which is a departure from previous DND practice (only empty drums are stacked).

Drum Handling

Q1. Are there previous reports or a database summarizing the drum inventory, type of drums, location and state of the drums at Darlington? Is there a SPOC for drum issues?

A1. An Excel database of the HW storage drums at Darlington has been prepared by Steve Hackett. This shows the drum type, contents, location, etc. Denny will get an electronic copy of this database and distribute it to the attendees **(Action - Complete)**. The drums at DND are predominantly stainless steel. There are only a few carbon steel drums with epoxy liners. (Ops indicate that DND only have one full non-stainless steel drum remaining).
For off-site transportation of drums, IP-2 drums are to be used. There is a requirement by NWMD that the drums must be shipped within an overpack (secondary containment) in order to contain any leakage during transportation. This requirement is very onerous. The overpacks occupy more room. Labels are sometimes required to be placed both on

the drum as well as on the overpack. Drums within the overpack have to be removed using slings because there is no other way to grapple them (no lip). Empty drum/overpack combination is manually handled in the plant

For drums received from external sources (e.g. Japan), the SPOC is Diego (Dick) Fabris (Alternate is Steve Hackett).

Q2. What is the status of the UV Oxidation System? Are there existing plans to use the DNGS UV Oxidation system to treat and clean-up some of the TOC-contaminated water in drums, so that these drums can be emptied prior to clean-up?

A2. The UV Oxidation system has been installed, commissioned and is in operation. It has been used to treat HW with a TOC content of up to 15-18 ppm and is intended to be used to clean-up TOC in existing drums. It is believed that water containing higher TOC levels than 15-18 ppm can also be treated successfully.

Q3. What would be the optimum location for a drum cleaning facility at Darlington?

A3. It was agreed that a key to reducing the backlog of stored drums is to have a drum cleaning and pressure testing facility. A centralized facility which could also serve Pickering's needs could be considered. A good location of a drum cleaning facility would be in the HWMB building, close to the TRF. The rinse water from the facility would go to Active Liquid Waste. A pressure testing facility to check and certify the integrity of drums by testing at a pressure of 5 psig would also be useful in making these drums available for re-use in transportation and storage.

Q4. In your view, what is the biggest bottleneck in reducing the number of drums at Darlington?

A4 The biggest bottleneck in reducing the number of drums at Darlington is seen as disposal of the contents through the D_2O Clean-up System. Characterization of the contents and strategy for clean-up is required for each drum, based on the contents, e.g. drums containing Arsenazo require a different strategy than drums with just TOC. Also, there is a need to demonstrate Arsenazo removal on IX resins.

Q5 What is the current status/plan for disposal or cleanup of drums that have been previously received from off-shore or external customers via Isotope Sales & Heavy Water Programming? How much of an encumbrance do these particular drums impose?

A5 Drums received from off-shore sources are normally returned to the source after emptying of the contents.

Q6 In your view, what are the bottlenecks for receiving off-shore shipments of HW?

A6. Lack of space is seen as a major issue at DND. This is a bottleneck for receiving shipments of drums from external sources, particularly if the drums arrive at short notice. For example, at the end of August, 108 drums are expected from Japan. These will probably have to be stored for a while before processing. Better co-ordination between ISD and DND would be of benefit. OPG is committed to taking 216 drums/year from Japan for the next 6 years. Juggling of drums at DND has become an issue.

Q7. Are there any other drum handling issues that are high priority for Darlington and that have not been identified here?

A7. Body mechanics of drum handling is another issue. The drums are currently man-handled in many cases. Better drum handling equipment that may be available in industry should be investigated.

Q8. We understand that clean drums for reactor grade water are in short supply. How many drums are required on stand-by ? Are these drums required for storage, transportation or both?

A8. There is ongoing need for clean drums to store reactor grade HW during outages or moderator drains. Typically, about 40-50 clean drums are required to be available on stand-by. However, DND is continually building up an inventory of dirty drums, because the clean drums get contaminated because they end up being used for contaminated downgraded water containing TOC and new ones are purchased or obtained form the ISD inventory at Bruce. Denny Williams suggested that there is a need to identify and nominate a "Drum Management Program Champion" at Darlington to manage issues like these.

Q9. We understand that there is a separate facility for handling virgin grade HW. What is the inventory of clean drums in this facility. Are some of these drums used elsewhere in the plant when clean drums are hard to find

A10. There is a separate facility to handle virgin HW and the current inventory is 6 drums.

Q11 Does Darlington buy clean drums on an ongoing basis. If so how many are purchased and what types.

A11. DND normally does not need to purchase new drums – can get clean drums from ISD or drums from Pickering for storing downgraded D_2O. These drums are visually checked to confirm cleanliness. Page: 64
Drums received from external clients, if unsuitable for transportation, end up being reused at DNGS.

Bulk Storage

Q1. What is the state of present space usage and future space availability or restrictions for HW storage?
Q2. Bulk storage of HW – what is Darlington's view on required amount of storage and what are the potential locations?

A1&A2. Lack of enough bulk storage at DND is seen as a "much bigger issue". There is not enough tankage to keep various grades of reactor water segregated. Details of the requirement are outlined in the document "Backgrounder on DND D_2O Storage Requirements for OPGN's D_2O Options Study". This document was reviewed in detail during the meeting.

It is anticipated that provision of additional bulk storage will be constrained by availability of space and will require significant capital expenditures. For example, one way of providing additional space would be to extend the HWMB along its west wall.

Q3. Are there any existing plans for future moderator drains at Darlington? Is this possible without additional storage?
A3. As the station ages, there will probably be a need to perform 1 moderator drain per year (Although Outages indicate that there are currently no plans to perform any future

moderator drains currently showing on DND's long term outage plans. This is yet to be verified with the Primary Systems Engineers) .

Also, 480 Mg of TRF product will be required to support:
Containment outage (SCO): Once/5years (to be confirmed by Outages)
Vacuum Building Outage (VBO) Once/10 years (frequency to be confirmed by Outages)

(Current plans for 4-unit outages are VBO – 2009, SCO – 2015)

Q4 Are the present 2X10 Mg Feed and Product Tanks at the TRF adequate for smooth operation of the TRF or is additional buffer storage seen as beneficial?

Q5. Is there existing equipment (e.g. OGMS tanks) that would be available to be adapted for bulk storage of HW?

A5. The space occupied by the Off-Gas Management System (OGMS) which has never been commissioned could possibly be used if this system is dismantled. The OGMS tanks appear to carbon steel, hence they are not suitable for storage of heavy water.

Q6. Are there any other bulk storage issues that are high priority for Darlington and that have not been identified here?

A6. In the past, off-site bulk storage of 60 – 80 Mg of HW has been used (e.g. at Bruce "A") in order to provide sufficient storage space to accommodate a moderator drain and segregate the different grades of D_2O that has to be maintained in S&I. This is not guaranteed to be available in the future.

Q7. Will adequate provision of bulk storage alleviate all the problems currently faced with drum storage. What would the residual issues be?

A7 For D_2O Cleanup, currently there are 2x25 Mg feed tanks available to store dirty water. These need to be increased to 2X50 Mg to be consistent with the capacity of the Clean Product Tanks that are available as well as to allow more surge capacity to store untreated, downgraded D_2O. Details of all the needs in this area are outlined in the document "Backgrounder on DND D_2O Storage Requirements for OPGN's D_2O Options Study".

Virgin D_2O

Q1. If virgin heavy water were to be stored at DNGS would a new storage facility be required? Where would the facility be likely situated? Would the storage of the virgin heavy water at DNGS be welcomed?

A1. It was agreed that since DND has become the central facility for detritiation services, upgrading services and virgin D_2O sales, consideration should also be given to relocating the remaining OPGN inventory of virgin D_2O from BHWP to Darlington.

Q2. What has been the historical need for virgin heavy water brought into DNGS (exclusive of filling new reactors)? What is the anticipated future need for virgin heavy water at DNGS?

A2. Generally, DND does not need virgin D_2O for loss make-up. Detritiated reactor grade D_2O (e.g. from externally received water) is used for loss make-up, thus making available an equivalent amount of the more valuable virgin D_2O for sales.
Virgin D_2O is transported to Darlington in drums for re-packaging as required for external sales. The SPOC for this is Dick Fabris.

A-14 APPENDIX 5 BACKGROUNDER ON DND D_2O STORAGE REQUIREMENTS FOR OPGN'S D_2O STORAGE OPTIONS STUDY

Draft for Review

Introduction

D_2O storage needs at DND are driven by several different demands. These include storage needs to support DND reactors during normal operation and during outages, to support TRF external detritiation demands and storage to support external heavy water services. These demands require segregation and handling of water of varying quality in tanks and in drums.

Reactor Grade D_2O Requirements to Support DND Reactor Units

Existing D_2O S&I storage capacity available to support reactor unit operation and unit outages consist of 4 x 100 m3 PHT storage tanks, 1 x 30 m3 PHT weigh tank, 3 x 100 m3 moderator storage tanks, 1 x 47 m3 moderator storage tank, and 1 x 10 m3 moderator weigh tank.

Reactor grade D_2O storage and segregation requirements to support normal reactor operation and outages are as follows:

- Segregation of high isotopic (>99.98 % D_2O), high curie (>1.2 Ci/kg) reactor grade D_2O (upgrader product) for DND moderator systems addition/swap; a 100 m3 D_2O Supply and Inventory (S&I) moderator storage tank is usually assigned to satisfy this requirement. A 100 m3 PHT D_2O S&I tank has to be assigned to satisfy this requirement during DND unit outages requiring a complete unit moderator drain.

- Segregation of low isotopic (<99.96% D_2O), low curie (<0.7 Ci/kg) reactor grade D_2O (TRF product) for make-up to DND PHT systems; one or two of the PHT D_2O S&I 100 m3 tanks are generally assigned to satisfy this requirement. There is a chemistry concern with addition of a large quantity (>10 Mg) of non-lithiated TRF product to PHT systems.

- Segregation of lithiated PHT quality D_2O from the DND reactors to accommodate shrink and swell during unit shutdowns and start-ups; two 100 m3 PHT D_2O S&I storage tanks are assigned to meet this requirement. This is also supplemented with TRF product, depending on the units' demand for PHT quality D_2O.

- Segregation of a small quantity (typically 30 – 50 Mg) of "multi-purpose" D_2O (TRF product with an isotopic >99.96 % D_2O) to be used for deuteration/dedeuteration of both moderator and PHT purification systems ion-exchange resins. This is normally reserved in the PHT weigh tank or in the 47 m3 moderator storage tank.

- Moderator D_2O S&I storage space is required to accommodate the complete drain of a poisoned moderator system during a single unit outage. There was a request from the Moderator Unit and Outages for the TRF/HWM unit to satisfy this requirement for the Station Containment Outage (SCO) outage also. However, the requirement for maintenance requiring a unit moderator drain was removed from the outage scope. A moderator D_2O drain requires the use of all the moderator S&I storage (347 m3) available. The 10 m3 weigh tank is also reserved for contingency. Segregation of the different grades of reactor D_2O is still required during the drain. Typically 60 to 100 Mg of reactor grade D_2O also needs to be moved off-site to satisfy the segregation requirements during the drain.

- The initial demand from Outages and Performance Engineering to satisfy the 2003 SCO requirements was for 480 Mg of PHT quality D_2O. This demand was reduced to a minimum of 420 Mg, due to the extended shutdown of the TRF in 2003. This requirement was satisfied by a lease of 77 Mg from AECL, a loan of 60 Mg from Bruce Power and a shipment of 40 Mg from PND. The remaining requirements were met from DND's inventory of TRF product. The need to have a 100 m3 tank available to accommodate storage of upgrader product is still required in this case.

- A minimum inventory of PHT D_2O also needs to be maintained in the PHT storage tanks to satisfy the requirement for simultaneous cooldown of all four units in the event of a four unit trip. This quantity was established to be 210 Mg as a result of a study conducted by Nuclear Safety, HWM and the PHT group in preparation for the 1997 Vacuum Building Outage (VBO). The HWM unit has maintained this requirement since 1997, but there have been instances when the inventory has been allowed to go below this level.

- Recent analysis of a LOCA event involving a PHT system break outside of containment has also uncovered the need for transfer of PHT water from S&I to the units' PHT storage tanks at a rate greater than the present design flow rate of the D_2O S&I PHT transfer pumps. This issue has been covered in the Davis Bessie Aggregate Assessment report and in TOE #.

- A modification was recently completed to install a pressure reducing station to address the fact that the units PHT transfer piping has a design pressure of 2000 KPag while the interfacing piping in the PHT D_2O S&I system has a design pressure of only 1400 KPag. This design deficiency which was discovered in 1996 had restricted transfers from the units to the HWMB to gravity drain only and this resulted in a significant increase in unit outage time. During commissioning of the modification, it was discovered that there was a pressure spike of ~2500 KPag for a period of one second. PHT transfers from the units are again restricted to gravity drain only during normal operation, until this issue is dispositioned.

- There was an initial requirement from Outages and Performance Engineering for the TRF/HWM group to satisfy the D_2O storage and supply demands to fulfill completion of a unit moderator drain and the SCO. The requirement for completion of a unit moderator drain during the SCO was eventually removed from scope. Execution of the SCO has demonstrated that it would not be possible to satisfy this demand with the existing storage capacity in the HWMB.

In summary, additional storage capacity is required in order to completely satisfy all the above demands. In addition, the D_2O PHT S&I transfer pumps need to be redesigned to double their capacity for the same head requirements.

The additional storage requirements are as follows:

- 1x 100 m3 PHT storage tank to ensure that there is sufficient storage to satisfy the PHT and Outage groups requirement to have >400 Mg of D_2O available for a 4-unit outage.

- 1 x 100 m3 storage tank to be assigned for storage of upgrader product

- 1 x 100 m3 storage tank to be assigned to accommodate moderator drains; the 1 x 47 m3 moderator storage tank will be assigned for storage of multi-purpose water.

This requirement is based on the needs identified above, but consideration should also be given to the impact of future drain requirements to support long term rehabilitation and life extension plans for the units

Downgraded D_2O Requirements to Support DND Reactor Units

Existing downgraded D_2O storage capacity at DND consists of small D_2O recovery tanks in the units and the FFAAs (2 X 1 m3 tanks in each unit) which are used to collect downgraded PHT and moderator D_2O. This is then transferred to the central processing area in the HWMB where the water is cleaned, prior to processing it through the upgrader. The storage capacity in the HWMB consists of 2 x 25 m3 downgraded dirty tanks and 2 x 50 m3 downgraded clean tanks which also serve as the feed tanks for the upgrader. The downgraded recovery and clean-up system configuration allows for segregation of recoveries based on tritium concentration. Upgrader product is stored in 2 x 9 m3 product tanks before it is returned to the moderator system or reserved in one of the moderator or PHT S&I storage tanks for use in future moderator on-line transfers. Normally all upgrader product is returned to the moderator system and TRF product is the source of make-up to the PHT system.

Downgraded D_2O storage and segregation requirements to support normal reactor operation and outages are as follows:

- During normal reactor operation the existing downgraded D_2O storage capacity is adequate and there is no need for segregation of moderator and heat transport recoveries if the TRF is operating. A planned upgrader outage of up to 4 weeks is acceptable under these conditions.

- During unit outages downgraded D_2O recovery rates increase, but the existing storage capacity is still acceptable as long as there is sufficient TRF product available. Segregation of PHT and moderator recoveries is recommended if there is an extended TRF outage.

- During a 4-unit outage and extended unavailability of the TRF, the existing downgraded D_2O storage capacity is not adequate to meet the storage demands. Again, segregation of moderator and PHT recoveries is required in this case. Unavailability of the upgrader under these conditions makes the situation even more difficult. This was the situation that the TRF/HWM Department was faced with for the 2003 SCO because of unavailability of the back-up heating steam supply for the station. This resulted in utilization of the 2 x 25 m3 TRF product return tanks for storage of downgraded D_2O, storage of downgraded D_2O in 12 x 1 m3 plastic totes and in drums. It vividly highlighted the need for additional downgraded storage capacity to adequately segregate PHT and Moderator downgraded D_2O recoveries. A D_2O S&I storage tank was downgraded during this period and it is thought that the downgrading was a result of activities related to transferring of the downgraded D_2O to reactor grade storage tanks.

In summary, additional downgraded D_2O storage capacity is required to address the need for segregation of PHT and moderator recoveries. This segregation is required to ensure that the upgrader can be used to produce low curie D_2O suitable for use as PHT make-up, in the event of an extended, unplanned shutdown of the TRF. The TRF is the only source of PHT make-up for DND and is an aging facility that could be subjected to unplanned outages as a result of unforeseen component failures.

The additional storage would also be beneficial in supporting the efforts to secure additional D_2O for OPGN for upgrading and detritiation.

The additional storage requirements are as follows:

- 2 x 25 m3 dirty downgraded D_2O storage tanks

- 2 x 50 m3 clean downgraded D_2O storage tanks that would also serve as upgrader feed tanks

Requirements to Support TRF External Detritiation Demands

Existing storage capacity available to support external detritiation demands consist of 1 x 57 m3 tank for storage of external TRF feed and 2 x 25 m3 tanks for storage of TRF product to be shipped off-site.

There has been numerous requests (primarily from PND, but also from Bruce Power) for the TRF to accommodate acceptance of external feed during periods when the plant is shutdown. This would result in more efficient utilization of the TRF capacity, as DND's use of the plant would be reduced. This also has Transportation advantages as the TDOs would be more efficiently utilized.

It is recommended that 2 x 50 m3 tanks or a 1 x 100 m3 tank is added for storage of external feed for the TRF. An equivalent amount of storage capacity will also be required for the product water. i e. 2 x 50 m3 tanks or 1 x 100 m3 tank for TRF product.

Drum Storage and Handling Requirements

Consideration should be given to providing a drum storage and handling facility due to the increased demand for upgrading and detritiation of D_2O contained in drums, as a result of additional business secured by ISG.

Drum handling at DND in 2004, resulting from ISG transactions will be as follows:

- 216 drums from Japan
- 216 drums from NIST
- 190 drums from JET

All the above transactions will involve handling D2O drums contained in a 55 gal shipping overpack. External drum handling requirements for the next five years will be in the order of 216 drums. These drums are receipted and shipped in ISO containers and require the use of a crane for unloading and loading.

In addition approximately 300 drums of D_2O was received and returned to AECL over the period Sep 2003 to July 2004.

DND also has a significant inventory of drums to handle as well (in the order of ~300).

These drums are handled using some power assisted drum handling tools, but still involves a large amount of manual effort. A facility is required to minimize the amount of manual effort involved with loading, unloading, emptying and filling of these drums

OPGN's Virgin D_2O Inventory

As DND has become the central facility for detritiation services, upgrading services, and virgin D_2O sales, consideration should be given to relocating the remaining OPGN inventory of virgin D_2O at BHWP to Darlington.

Functional Requirements for Additional D_2O Storage

- The new storage area should be capable of accommodating an additional 300 m3 of reactor grade S&I storage to support DND reactor operations, 200 m3 of additional storage to support OPGN and External detritiation demands (2 x 50 m3 or 1 x 100 m3 of TRF product storage and 2x 50 or 1 x 100 m3 TRF feed storage), 150 m3 of downgraded D_2O storage to

support reactor operations and extended TRF unavailability, and drum handling capability for up to 600 drums.

- All storage tanks added must have level instrumentation that displays on the System 6 computer and tie-in to the Plant Information (PI) system.
- All existing S& I level and weight instrumentation should also be displayed on the System 6 computer and tie-in to the PI system, as a part of this change.
- The building that houses this facility must tie-in to the existing HWMB D_2O liquid recovery system or have its own liquid recovery system.
- The building that houses this facility must tie-in to the existing HWMB D_2O ventilation system or have its own ventilation system.
- The storage tanks added must tie-in to the existing HWMB D_2O vent and cover gas system or have it's own D_2O vent and cover gas system.
- An equipment vent dryer is required if the facility is to be housed in a new building.
- Tritium monitors are required to be located strategically if the facility is housed in a new building.
- New PHT S&I transfer pumps are to be installed with a design flow rate of 8 l/s and the same head capacity requirements as the existing units
- A weigh station is required for monitoring TDO payloads if the facility is housed in a new building.
- Capability to transfer water from existing tanks to the new storage tanks and from the new storage tanks to existing tanks is required.
- A hoist is required for removing and installing the ISO containers from trailers
- Sufficient headroom is required for installation/removal of the ISO containers
- A drum cleaning facility is required
- A facility for pressure testing of empty IP2 drums is required.
- The existing pit where the D_2O S&I storage tanks are housed is seismically qualified. Consideration of seismic qualification requirements for the additional storage area is required, since some of the new tanks will be used for storage of high tritium D_2O.
- A radiological dose assessment will be required to cover loss of the complete inventory of these tanks, similar to what was completed as part of the original design of the D_2O S&I system.

Other Considerations

Utilization of Existing space in the HWM Building should be optimized. The Off Gas Management System (OGMS) equipment contained in the HWMB is no longer required as this system is to be permanently removed from service. Consideration should be given to the use of rooms containing OGMS equipment, in addition to use of the equipment. Equipment that cannot be used would have to be scrapped for disposal, if they are verified to be contamination free.

A budgetary estimate together with a conceptual design will be required, if the study determines that a Business Case can be made to justify the additional storage. Estimates of potential savings can be obtained from the DND Outage Department.

Additional justification that is not readily quantifiable is the fact that the additional storage capability would provide contingency planning to address the risk of an extended unplanned TRF outage.

Consideration should be given to completion of this work in phases.

Comparison with Other Facilities

- Bruce A has added additional S&I storage capacity and Bruce B are currently preparing a Business case for addition of extra storage capacity. Any relevant OPEX related to the previous and ongoing work in this area at Bruce Power should be incorporated in the recommendations resulting from this study. Comparisons of the downgraded and reactor grade storage capacities a Bruce Power should also be completed. Bruce Power HWM contacts are Ed Kuratcyz and Tim Elliot.

- Similar comparisons of downgraded and reactor grade storage capacities should also be made with PND. PND contacts HWM are John Law and Glen Walker.

- Similar comparisons with other CANDU facilities would also be useful. Contacts for this information are Frank Fusca and COG.

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References

1. Process flow diagrams for SCI 38110, 38500, 38410, 33850, 38430
2. Design Manuals for the above SCIs
3. DND Safety Report (LOCA Outside Containment)
4. DND Drum Inventory Report
5. DND HWM Resource Sheet
6. DND HWM Strategy Sheet
7. Davis Bessie Aggregate Assessment Report (Finding re D_2O Transfer rates)
8. PHT System TOE on D_2O Transfer Rates
9. Report on D_2O Coordination for the 1997 VBO prepared by Steve Macgee of DND.
10. DND D_2O Management Overview operational flowsheet
11. Contingency Planning to Address Long Term Unavailability of the TRF

A-15 APPENDIX 6 DRAFT NOTES OF MEETING #2 AT DND

OPG Heavy Water Storage and Handling Strategy

Darlington NGS
September 9, 2004

Attendees:

Denny Williams
Ali Leilabadi
Diego (Dick) Fabris
Sav Sood

The meeting was held to ensure that input from the Operations SPOC, Dick Fabris and Ali Leilabadi, Senior Engineer, TRF & HWMB was incorporated in the study. The following areas of interest to Darlington were reviewed:

- Drum Handling and Storage
- Bulk D_2O Storage
- Virgin D_2O Handling

Drum Handling

- Dick Fabris noted that since the previous meeting of August 6, an additional 108 drums of low Ci, downgraded heavy water have been received from Japan with their associated overpacks. This has necessitated storage of the drums in any available space, e.g. in corridors, next to equipment, etc. and has caused a tremendous strain on resources. Photographs of typical storage of drums are attached to this document, showing the status as of August 18, 2004. Since the Upgrader is in an outage, it will take longer than normal time to empty out these drums and process this heavy water and return the drums.

- On an ongoing basis, OPG has made a commitment to receive 46 Mg/yr of heavy water from Japan for the next 6 years. In addition, there are other possible sources of heavy water from external sources, e.g. NIST, Italy, etc.

- Unloading of trucks is currently inadequate and presents unnecessary safety hazards. Presently, an external contractor is brought in to remove the Lids from the ISO containers to allow the Operators to unload a truck at a cost of $4K to unload and $4K to load. The ramp leading into the HWMB is very steep and the back doors of the ISO container (not the Truck)has to be opened prior to going down the ramp, this leaves us with drums stacked two high on a metal floor with only a rope to prevent them from sliding off if anything happened, leading to a potentially unsafe condition.

- The original intent behind processing of external heavy water was that this upgraded D_2O would be used for loss replacement by all 3 sites (DND, PND and Bruce). In reality, this is not occurring. As a result DND is overstocked in D2O (unofficial estimate of 100 Mg). This D_2O needs to be distributed to the other 2 sites.

- A proper drum handling facility is recommended as result of the above issues and OPG's long term commitment to process external D_2O. this could be located directly to the West of the HWMB. The facility could incorporate:

  1. Drum unloading/loading – e.g. access for trucks to come in to the building and a gantry crane to pick up the Iso container and put it on the floor

  2. Drum Storage space

  3. Bulk Storage of downgraded D_2O from emptied drums (e.g. 2x100 Mg Tanks) – these tanks could be multi-purpose and be used also to supply additional feed storage for the D_2O Clean Up System

  4. Drum Cleaning and Pressure Testing - the facility would also serve to clean empty drums from Pickering and lake these ready for disposal. A possible, alternate location of this facility was suggested as being the room above the OGMS tanks (the Recombiner Room at 94' elevation). This room could be utilized if the equipment there could be removed and disposed.

  5. Proper ventilation/drying

Bulk Storage

- Ali suggested that in the S&I system, a "double-block and bleed" valve arrangement should be implemented. This arrangement would make the S&I system much more flexible and possibly allow it to be used for alternately storing PHT or moderator D_2O.

- Denny recommended that the long term Life Cycle Plans for the reactors need to be considered in the study – e.g. is there a possible scenario for retubing 2 reactors in parallel? This could be part of the business case for additional storage. Fred Dermarkar was suggested as a SPOC for the Life Cycle Plan.

- Denny will shortly finalize and issue the document "Backgrounder on DND D_2O Storage Requirements for OPGN's D_2O Options Study" so that it can be used as a reference for the study.

Virgin D_2O

Q1. If virgin heavy water were to be stored at DNGS would a new storage facility be required? Where would the facility be situated? Would the storage of the virgin heavy water at DNGS be welcomed?

A1. Further to the responses on August 6, it was felt that moving virgin heavy water from BHWP to DND would be a costly affair and that consolidation into OBD would be more economical. However, inspection, maintenance and drum filling in OBD would still need to be contracted out

Virgin D_2O is transported to Darlington in drums for re-packaging as required for external sales. The SPOC for this is Dick Fabris. No major issues are seen with re-packaging for sales.

Questions for Round 2 , Objective iii) Drum Disposal

In Addition to the above, the "Questions for Round 2", submitted by Aamir Hussain to Thomas Wong were discussed and answered as far as practicable. These will represent the response form Darlington and a further response is not anticipated. The responses are summarized below or already included in the notes above:

- The present criteria for drum disposal are not documented, but drums are disposed based on visible defects or known or visible leakage
- All drums at the site are considered as "active"
- Drums are not cleaned or compacted prior to return to customers
- There have been no drums shipped to the WWMF – but the acceptance criteria would need to be met – e.g. cleaning, drying.
- Staff required for drum management may consist of 1 SNO + 2 NO's, although they will not be required on a full time basis
- Capital & Operating costs – not known
- Impact of "doing nothing" is not acceptable – potential safety concerns, ergonomics, housekeeping, etc. as outlined above.
- NWMD does not want to be in the drum cleaning business – so integration of cleaning/testing with disposal is not an option
- Contracting out drum cleaning/testing may be a possibility. Charles Foster is investigating. Thomas Wong will visit AECL at La Prade to check out their facility.

A-16 APPENDIX 7_REDUCING DIRTY D_2O AT SOURCE AND IMPROVING PROCESSING OF DOWNGRADED D_2O

Notes of Meeting with H. Vogt, B. Tanaka, K. Kalyanam

August 25, 2004

HW Collection

Not much can be done to reduce collection rates from leakages and spills other than to performance maintenance and fix leaks promptly.

It was also felt that there is not much flexibility in reducing heavy water collection from Vapor Recovery Systems other than ensuring that maintenance keeps gasket leaks, etc. to a minimum.

Capacity of D_2O Clean Up Systems

AT PND, the throughput capacity of D_2O Clean Up Systems is not a bottleneck in terms of processing dirty D_2O. The design rates Hi and Lo Ci Clean Up are adequate to supply Upgraders at their required demand. The bottleneck is the inability of the Clean UP Systems to reduce TOC to below 3 ppm. This again points to need for the UV Oxidation System. Reducing turbidity to the required levels is also an issue occasionally.

To get below 3 ppm water is sent to the UPP-A feed tanks and recirculated until the TOC is below 3 ppm. This demonstrates that the TOC is volatile.

Trade-off between TOC levels and Upgrader maintenance is not required since the TOC level of 1 ppm is a Chemistry Specification for Upgrader feed and has been determined after careful deliberation. Experience at Gentilly-2 shows that TOC of 1 ppm is achievable and has prevented Upgrader fouling since about 1994. Therefore, the optimum level of TOC should be < 1ppm and ALARA

Capacity of Upgraders

The capacity of the High-Ci Sulzer "B" Upgrader is limiting the rate of processing of downgraded D_2O. This reduced capacity is caused by the unavailability of high pressure steam for the Sulzer "B" reboilers (due to the lay-up of Pickering "A") and also due to some plugged, leaking tubes in the product condenser which reduces the product condensation rate and consequentially limits the feed rate. High pressure steam is expected to be unavailable until Unit 1 at Pickering returns to service

The distributors at Sulzer "B" were cleaned about 2 years ago and should be in fair condition (To be confirmed – check with Frank Fusca).

Processing of D_2O Contaminated with Arsenazo

There is no effective clean up process available for dealing with D_2O contaminated with Arsenazo. There was a vague recollection that Bruce Power may have tested out the effectiveness of UV Oxidation process for destruction of Arsenazo. Harold Vogt questioned whether a simple, colorimetric bench test may be effective – e.g. mixing Arsenazo-contaminated water with hydrogen peroxide and passing UV light through the mixture (would need TiO2 as a catalyst? Is GdNO3 required?) and determining whether the color of the mixture dissipates.

The UV Oxidation System at Darlington is hard piped downstream of the Clean UP System and it would be hard to carry out a test on it.

Bob Tanaka suggested contacting SAIC Canada, who may have done some assessments in the past.

Bar Coding System for Drums

A Bar Coding System for Drums should be considered as means of taking inventory quickly. This could be done as a part of the upgrade of HWMIS which is understood to be planned (check with Charles Foster). The bar coding system requires associated software which can be used for extracting and manipulating the gathered data. Gentilly-2 have such a system with which they may be willing to license or sell. (Check with Frank Fusca)

Recorded by

Sav Sood

A-17 APPENDIX 8 ASSUMPTIONS USED IN COST ESTIMATES

General Assumptions:

- All cost estimates given in 2004 dollars.
- Costs due to seismic qualification requirements have not been incorporated into cost estimate.
- Cost estimates subject to applicable taxes, duties, shipping costs, and fluctuations in supplier prices.
- Contingency costs are not included in cost estimate.
- Costs associated with work at the site are included in cost estimate.
- Components are assumed to be designed, fabricated, and tested in accordance with the requirements of ASME Section VIII, Division 1, and in compliance with Canadian Standards Association Quality Assurance Program CSA-Z 299.3, or equivalent, unless otherwise stated. The majority of the storage tanks and pumps are to be built to the requirements of ASME Section III due to the tritium content of the heavy water.
- Costs associated with liaisons with regulators and preparation of regulatory submissions included in cost estimate.
- Interest cost on capital borrowed for construction are not included

Assumptions Associated with Drum Cleaning and Pressure Testing:

General:

- Cost estimate assumes no nuclear code requirements other than specified in estimate.
- Cost estimate assumes coolant water activity is less than 10 Ci/kg. Therefore, treated water activity is also assumed to be less than 10 Ci/kg.

Heavy Water Tanks and Equipment:

- Cost estimate based on 304L or 316L stainless steel tanks which can withstand the following design parameters: Pressure = 200 kPa; Temperature = 38°C.

Accessories:

- Cost estimate based on non-corrosive piping which can withstand the following design parameters: Pressure = 200 kPa; Temperature = 38°C.