ONTARIO POWER GENERATION

Report

Internal Use Only Commercially Sensitive	
Document Number: NK38-REP-09701-10080	Usage Classification:
Sheet Number: N/A	Revision: R000

Title:
DARLINGTON REFURBISHMENT: D_2O MANAGEMENT STRATEGY

© Ontario Power Generation Inc., 2012. This document has been produced and distributed for Ontario Power Generation Inc. purposes only. No part of this document may be reproduced, published, converted, or stored in any data retrieval system, or transmitted in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise) without the prior written permission of Ontario Power Generation Inc.

Darlington Refurbishment: D_2O Management Strategy

NK38-REP-09701-10080-
2012-09-10

Order Number: N/A
Other Reference Number:

Internal Use Only
Commercially Sensitive

Prepared by: Alan Cornthwaite 2012 OCT 10 — Date
Alan Cornthwaite
Operations
Nuclear Refurbishment

Reviewed by: 2012-10-12 — Date
Frank Cox
Operations
Nuclear Refurbishment

Reviewed by: 2012-10-11 — Date
Thomas Wong
Section Manager
TRF Life Cycle and Projects
Darlington Nuclear

Approved by: Ron Chatterton 2012-10-12 — Date
Ron Chatterton
Operations Project Manager
Nuclear Refurbishment

Table of Contents

Page

1.0 EXECUTIVE SUMMARY 5

2.0 INTRODUCTION 6

3.0 TRITIUM REMOVAL FACILITY AND HEAVY WATER MANAGEMENT OVERVIEW 6

4.0 MOD AND PHT SYSTEM TRITIUM ACTIVITIES 8

5.0 PROPOSED TRITIUM REDUCTION PRIOR TO REFURBISHMENT 10

6.0 HEAVY WATER MANAGEMENT STORAGE FACILITY - WEST ANNEX 10

6.1 Storage Capability 10
6.2 D_2O Transfers to the West Annex 10
6.3 West Annex Build and Commissioning 11

7.0 MODERATOR 11

7.1 Over Poisoned Guarantee Shutdown State (OPGSS) 11
7.2 Moderator Flushing Volume: 12
7.3 Moderator Purification 12

8.0 PRIMARY HEAT TRANSPORT 12

9.0 REACTOR PHT AND MOD D_2O VOLUMES: 13

9.1 Moderator 13
9.2 Heat Transport 13
9.3 PHT Maintenance Cooling (proposed) 13

10.0 D_2O TRANSFERS – PRE, POST REFURBISHMENT: 14

11.0 TRF AND HEAVY WATER MANAGEMENT WORK PROGRAM PLANNING 16

12.0 CHEMISTRY AND ENVIRONMENT 17

12.1 Chemistry Layup 17
12.2 Environmental Protection 17

13.0 REFURBISHMENT UNIT SHUTDOWN DATES: 18

14.0 OPEX 18

15.0 REFERENCES 19

Revision Summary

Revision Number	Date	Comments
R000	2012-09-10	Initial issue.

1.0 EXECUTIVE SUMMARY

Darlington will begin refurbishing its reactor units beginning with U2 in fall of 2016. Over the course of eight years, all four units will be refurbished.

Part of the refurbishment requires removal, and replacement, of all pressure and calandria tubes in the reactor core under a program titled Retube and Feeder Replacement (R&FR). This program will necessitate the draining of the Moderator (Mod) and Primary Heat Transport (PHT) systems in order to replace the tubes.

Mod and PHT D_2O will be transferred to the Darlington Tritium Removal Facility (DTRF) for storage in the new Heavy Water Management Building West Annex storage facility[1] (West Annex for short). Improvements to facilitate long term storage of unit D_2O is provided under Project Charter N-PCH-09701-10001 - Refurbishment, Operational Improvement & Long Term D_2O Storage (Project No: 16-31555).

Recommendations have been established to proceed with a storage facility capable of storing 2100 m^3 of D_2O to meet:

(a) Refurbishment

(b) TRF operational improvements

(c) Long term decommissioning.

Over the 8 year refurbishment period, D_2O transfers will require coordination between respective refurbishing units, operating units and managed D_2O sales/detritiation/upgrading.

Prior to refurbishment a tritium reduction program will be implemented to reduce unit tritium values to minimize environmental releases and to facilitate dose management.

Heavy Water Management is governed by N-PROG-AS-0008.

Heavy Water Programming D_2O Supply/Demand Plan and the 5 year Integrated Business Plan for OPG Detritiation Management detailed in N-REP-03800-10000.

Heavy Water Management Upkeep and Inventory Reporting detailed in D-INS-38000-10002

Due to the changing nature of the Refurbishment program and the TRF Life Cycle, this report will need future revision.

[1] NK38-REP-38000-10002 – Conceptual Design Report for the Heavy Water Management Building West Annex.

2.0 INTRODUCTION

The purpose of this report is to provide an overview of the D_2O Management Strategy pre, during, and post refurbishment (refurb). The TRF supports this program as indicated in correspondence; Tritium Removal Facility – Darlington D_2O Refurbishment Strategy[2]

Approximately one year prior to refurb, a tritium reduction program will begin. Two hundred Mg's of stored D_2O will be cycled through the TRF to reduce the tritium concentration to a low level, expected to be < 5 Ci/kg. This low curie D_2O will then be stored for a bulk swap at the beginning of refurb. This program will support As Low As Reasonably Achievable (ALARA) minimizing environmental releases and allowing better dose management during refurb.

During the defueling process, additional PHT water will be required to make up for the voids created during the spent fuel removal. With all fuel removed, the PHT system will be drained and vacuum dried prior to system maintenance.

The Mod system will be maintained in a hot state (61° C) during the PHT drain and dry program. Once completed, the Mod will be drained, partially refilled with demineralised water, flushed, re-drained, and then air dried prior to system maintenance.

Both Mod and PHT D_2O will be transferred to the West Annex for storage in a clean state.

On completion of the unit refurb, the Mod will be refilled with low curie (<2 Ci/kg) D_2O, circulated via purification, and analyzed to ensure no contaminants are present which could affect reactivity.

With cleanliness confirmed, Gadolinium Nitrate and / or Boron will be added to establish the Over Poisoned Guaranteed Shutdown State (OPGSS) in preparation for new fuel load.

Once new fuel load has been completed, the PHT will be refilled with D_2O in preparation for unit restart.

3.0 TRITIUM REMOVAL FACILITY AND HEAVY WATER MANAGEMENT OVERVIEW[3]

The DTRF is an integral part of the site design and has a critical role in Heavy Water Management (HWM) at Darlington Nuclear[2] (DN). The importance of the DTRF to the continued operation of the DN generating units is highlighted by the following three factors:

[2] Reference – NK38-CORR-38000-0417633 – Memorandum – TRF – Refurbishment Strategy
[3] Reference - NK38-REP-39000-10112 – Darlington Nuclear Tritium Removal Facility 2011 Annual Report

(a) The operating (OP&P) limits on the Mod and PHT system tritium activity levels at Darlington can only be maintained with the continued operation of the DTRF (in the absence of new virgin D_2O production capability)

(b) DTRF product is the only long-term source of PHT system recovery makeup at DN since the site has only one upgrader for mixed (i.e. PHT and Mod) heavy water recoveries.

(c) The DTRF is essential for the OPGN strategic goals of reducing tritium emissions and consequently contributing to reduction in occupational and public dose.

The DTRF reduces the tritium activity in both the Mod and PHT Systems.

PHT system activity is reduced by processing high activity Mod D_2O via the DTRF and returning the detritiated product to the PHT System.

Mod system activity is reduced by mixing the high activity Mod system recoveries with the lower activity PHT system recoveries. This mixing produces heavy water with an intermediate level activity that is returned to the Mod system after upgrading. Any DTRF product that is not used as PHT makeup is returned to the Mod system in order to maintain the mass balance. This strategy further reduces the Mod system activity.

The heavy water flows described here are illustrated on the simplified heavy water management diagram shown in Figure 2.1.[4]

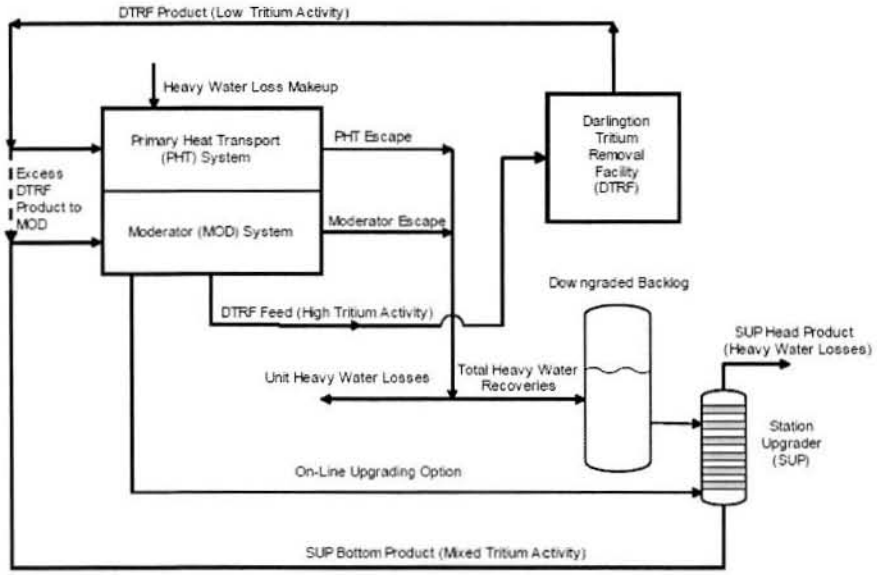

Figure 2.1. Darlington Nuclear Simplified Heavy Water Management Diagram

[4] Reference - NK38-REP-39000-10112

4.0 MOD AND PHT SYSTEM TRITIUM ACTIVITIES

The Mod tritium activity for each unit (based on 2011 data) is shown in Figure 2.2[5]. The average unit Mod tritium activity remained relatively constant during 2011 at an average of 7.83 Ci/kg. The DTRF is essential for keeping the Mod tritium activity level below the OP&P limit of 15 Ci/kg. DN Mod tritium activities are expected to remain stable with continued DTRF operation till 2015. Reduction activities for refurb will begin in 2015, post SCO/VBO outage, to minimize environmental releases and personnel dose.

The DN PHT tritium activity of each unit is shown in Figure 2.3[6]. The DTRF is also essential for keeping the PHT tritium activity level below the OP&P operating limit of 1.2 Ci/kg. Heavy Water Management strategies are used to limit the increase in PHT tritium activity level during DTRF Outages. The average unit PHT tritium activity remained relatively constant at about 0.62 Ci/kg during 2011. This was below the DTRF local action limit of 0.75 Ci/kg and below the OP&P limit of 1.2 Ci/kg.

The DTRF local tritium action limits for the Moderator and PHT systems are tighter than the official site action limits of 12 Ci/kg and 1.0 Ci/kg respectively (as provided in Chemical Control OM - NK38-OM-09160). This provides further assurance that tritium levels will remain within the OP&P limit.

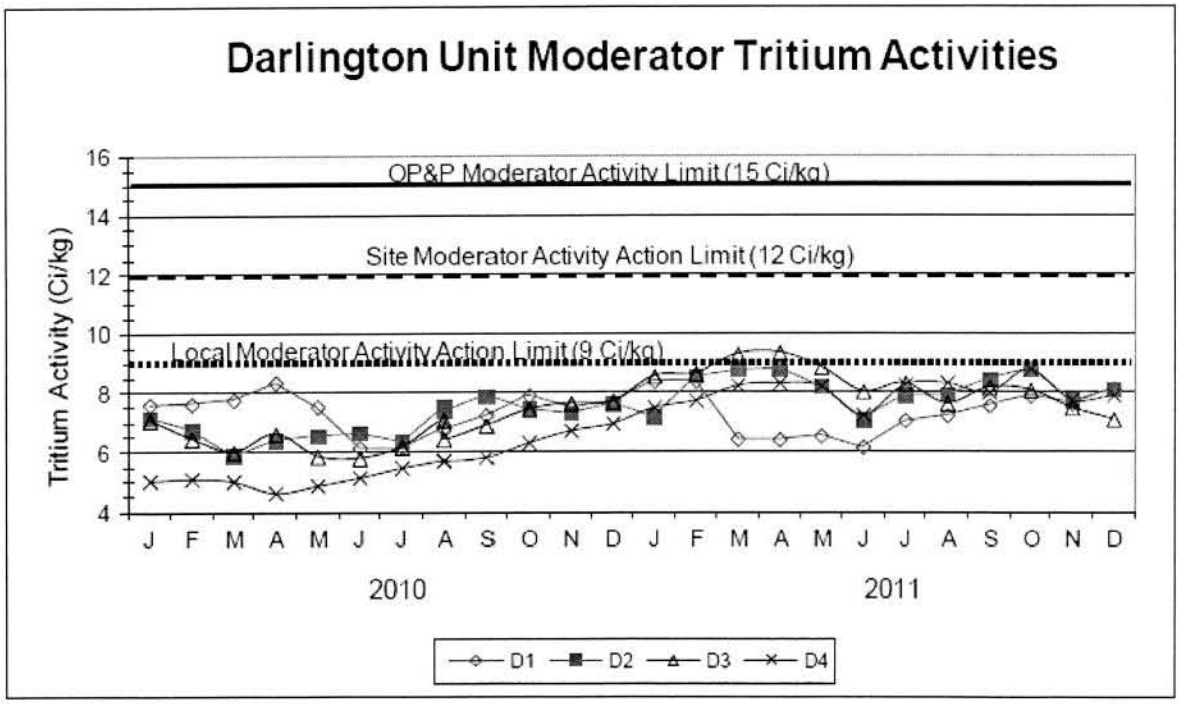

Fig 2.2 – Darlington Unit Moderator Activity Levels

[5] Reference - NK38-REP-39000-10112
[6] Reference - NK38-REP-39000-10112

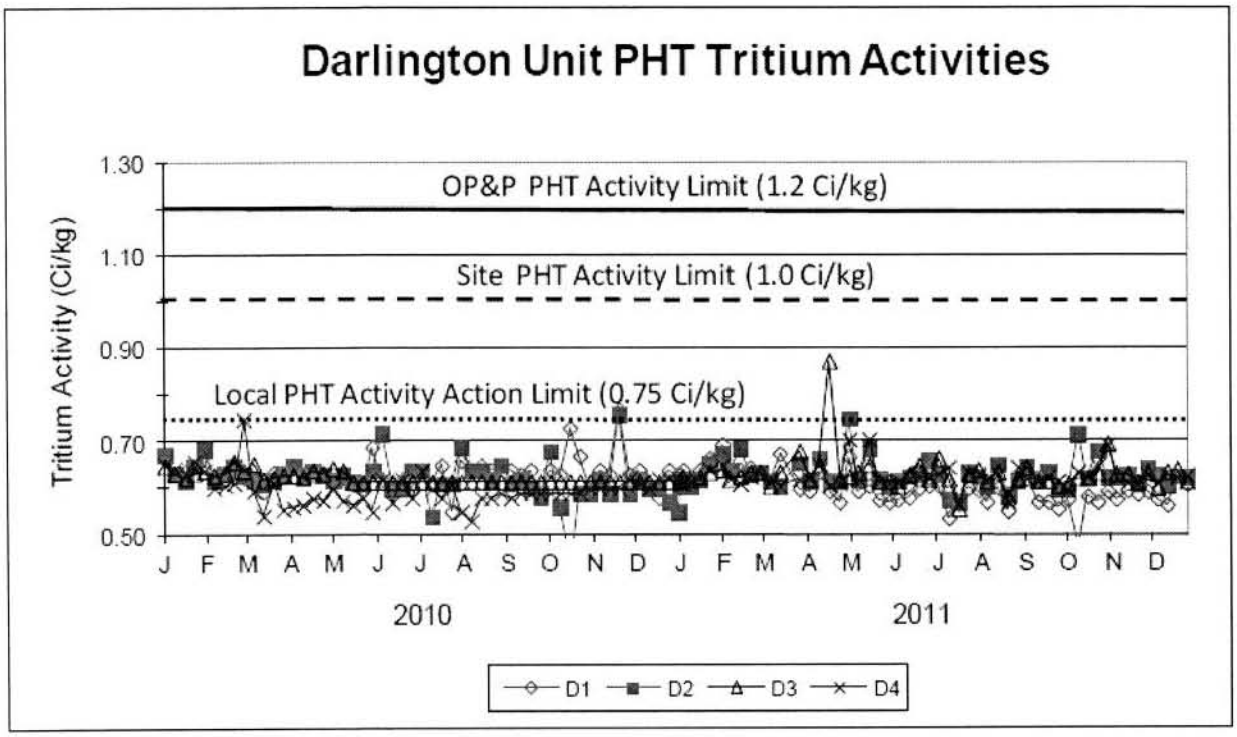

Fig 2.3 – Darlington Unit PHT Activity Levels

Current (Sept 2012) tritium activity in the Unit PHT and Mod systems are listed in Table 1.

Table 1
(Ci/Kg)

Unit	PHT	Mod
1	0.62	10.96
2	0.62	11.39
3	0.61	8.83
4	0.63	10.13

5.0 PROPOSED TRITIUM REDUCTION PRIOR TO REFURBISHMENT

In order to reduce dose to those working on the DN refurb project and minimize tritium releases to the environment, a tritium reduction program will commence prior to the start of this work. This program will include a bulk transfers of 200 Mg's of unit high curie moderator D_2O to the TRF, and return 200 Mg's of reduced curie D_2O back to the unit. It is anticipated that this program will occur during the HT Drain and Dry phase, after defueling and PHT drying has been completed.

Tritium reduction in the Moderator, based on calculations, will achieve < 5 Ci/kg.

During the bulk swap phase, operating unit on-line transfers will be suspended.

6.0 HEAVY WATER MANAGEMENT STORAGE FACILITY - WEST ANNEX

6.1 Storage Capability

The new West Annex will provide storage capability for two units moderator drained ($700m^3$), two units PHT drained including auxiliaries ($800m^3$), reactor grade D_2O for TRF efficiency improvements ($400m^3$), and any additional downgraded D_2O generated during refurb ($200m^3$).

Storage will be provided in stainless steel tanks matched to system specifications. West Annex tank layout is provided in the Conceptual Design Report for Heavy Water Management Building West Annex[7]

6.2 D_2O Transfers to the West Annex

During refurb, Mod D_2O and PHT D_2O will be drained[8] from the shutdown unit and transferred to the West Annex for storage. Once refurb is complete, D_2O will be transferred back to the unit.

This transfer program is recognized in the TRF and Heavy Water Management Yearly[9], Five Year and Twenty Five Year plans to be issued late 2013. Sufficient float shall be built into the one year and five year plans to ensure success of the transfer program.

Transfers will take into account the requirement to place other priority work on hold until refurb drain, or refill is complete.

Emergency unit actions will override transfers. Once the situation has been resolved, transfers may continue.

[7] NK38-REP-38000-10002 – Conceptual Design Report for the Heavy Water Management Building West Annex
[8] NK38-OM-32100-4.9 – Moderator Draining
[9] NK38-REP-39000-10112 – Darlington Nuclear Tritium Removal Facility 2011 Annual Report.

6.3 West Annex Build and Commissioning

The new D_2O storage facility Conceptual Design Report [10] is complete with a draft design overview provided in the report. As of Sept 2012, the Purchase Order has been issued to begin work on the West Annex design.

The execution of this work will be divided into 3 Phases. In order to ensure the earliest possible start, and to mitigate completion schedule risk, the phases overlap.

The contractual commitment of OPG under this release is to Phase 1 work only. The overall project schedule will be developed immediately following Phase 1 contract award. The work will be phased as below:

Phase 1,

Detailed Design.

Phase 2,

Site preparation and procurement of Long Lead materials. Site preparation includes activities such as demolition of existing truck dock and TRF trailers. With Environmental Assessment approval and completion of civil design packages, installation of caisson walls, start of excavation and miscellaneous civil substructure and relocation of existing buried services will begin in 2013.

The Environmental Assessment is expected to be completed by December 2012.

Phase 3

Completion of caisson wall installation and excavation, facility construction, tie-in to existing station services, commissioning and final close-out of project.

With the completion of the PO, and approval to build, a successful bidder will be chosen to build the new storage facility. Expected start date for West Annex new build is fall 2013 with an in-service date of spring 2015.

7.0 MODERATOR

7.1 Over Poisoned Guarantee Shutdown State (OPGSS)

Once shutdown, the refurb unit Mod will be placed in the OPGSS by over poisoning with gadolinium nitrate. When de-fuelling is complete, the mod poison will be removed by recirculation through the Mod Purification circuit. When the D_2O quality reaches values specified in Refurbishment Chemical Control: Main Moderator (NK38-OM-

[10] NK38-REP-38000-10002 – Conceptual Design Report for the Heavy Water Management Building West Annex

09701-3.0), the D_2O is deemed clean and may be transferred to the West Annex for storage.

Pending availability of the transfer header, D_2O in the calandria may remain on recirculation until it is ready to be transferred to the West Annex.

On completion of refurbishment, clean D_2O, as specific in NK38-OM-09701-3.0, will be transferred back to the unit. Gadolinium nitrate and / or boron will be added to establish the OPGSS condition prior to new fuel load.

7.2 Moderator Flushing Volume:

It is expected that the Mod will not be drained until the entire reactor core has been defueled and PHT vacuum dried.

In order to reduce tritium on moderator components during refurb, a light water flush will be completed after the moderator drain. Demineralised light water will be used creating approximately 50 Mg of low isotopic, tritiated water.

7.3 Moderator Purification

Once all the gadolinium poison has been removed from the moderator water through purification, the spent resin must be slurried to spent resin storage (resin sitting in IX columns for extended periods will become compacted and difficult to slurry).

D_2O entrained in the resin will be removed by the dedeuteration process, collected as downgraded D_2O, and then transferred to the TRF for upgrading. Dedeuteration of Mod and PHT resin will produce approximately 9 Mg's of downgraded D_2O.

Once the resin has been removed, the IX columns will be isolated, but not drained due to the difficulty in removing this D2O. The IX's will be refilled with fresh resin after refurb has been completed.

8.0 PRIMARY HEAT TRANSPORT

D_2O will remain in the PHT system circuit until defueling has been completed. Once all the fuel has been removed from the reactor core, D_2O will be transferred to the West Annex for storage.

The PHT will then be vacuum dried to remove all remaining trapped D_2O. The Mod system will remain at a high temperature, approximately 61° C, to aid in drying the PHT system

Transferring PHT D_2O must meet specifications as listed in Refurbishment Chemical Control – Main Heat Transport (NK38-OM-09701-5.0) to ensure that system parameters such as lithium, dissolved D_2, etc are in specification.

On completion of refurbishment, and after fuel load has been completed, clean D_2O, as specified in NK38-OM-09701-5.0, will be transferred back to the PHT system.

9.0 REACTOR PHT AND MOD D_2O VOLUMES:

Each running reactor unit contains a specific volume of D_2O to provide reactor fuel cooling and moderation of the nuclear fission process.

As part of shutdown/drain procedure, and to assist with PHT drying, the Mod will remain at an expected temperature of 61° C. Once the PHT is dried, the Mod will be drained, and then flushed with demineralised water to further reduce the tritium contamination of internal components.

Due to the extensive collection of pipework in both the Moderator and PHT systems, after draining is complete, drying will remove any remaining D_2O. The PHT will be vacuum dried while the Mod will be air purge dried. It is not feasible to vacuum dry the Mod.

9.1 Moderator

For the moderator drain, flush, refill and commissioning activities the following inventory requirements are expected for a single unit:

- Drain and refill inventory (includes auxiliaries) **350 m3**

9.2 Heat Transport

For the PHT drain, refill and commissioning activities the following inventory requirements are expected for a single unit:

- Drain and refill inventory (includes SDC, PI&C, etc) **310 m^3**
- Due to the defueling process, an additional D_2O make-up inventory will need to be added to the PHT system to compensate for fuel bundles that have been removed[11] **39 m^3 (approx)**

Note: On restart, the PHT system will not include a D_2O flush as this activity has been removed from the Refurb Scope.

9.3 Shutdown Cooling Modification

Presently in scope as of Sept 2012, the Shutdown Cooling system will be modified to improved redundancy by adding additional pumps. This is expected to add one to two **m^3** of PHT water to each unit inventory.

[11] NK38-REP-09701-10028 – 4.1 System Layup Technical Requirements – PHT System

10.0 D_2O TRANSFERS – PRE, POST REFURBISHMENT:

During refurbishment, unit D_2O will be transferred to the West Annex, stored for the duration of refurbishment and returned back to the unit once refurbishment is completed. Transfer dates are impacted by station outages. Outage dates are provided in Table 2 below.

The transfer program for this D_2O movement is identified in Table 3.

Assumptions:

(1) HT Drain and Dry will begin 84 days after unit shutdown (end of defueling)

(2) HT Drain and Dry is expected to take 74 days

(3) Mod Bulk Swap/Drain/Flush will occur during the last 15 days of the PHT Drain/Dry program

(i) Mod Bulk Swap expected to be the first 5 days

(ii) Mod Drain will occur at the end of the Bulk Swap. Five day window but expected to be shorter

(iii) Mod Flush will occur after the Mod Drain, 5 day window but expected to be shorter

(4) PHT Refill expected to occur 5 months before unit turnover.

TABLE 2

Future Outage Dates			
TRF	09-2016 to 01-2017	**Unit 1**	24 Mar 2017 to 30 May 2017
	02-2018 to 07-2018		03 Dec 2021 to 20 Dec 2021
	09-2019 to 01-2020		02 Dec 2022 to 23 Dec 2022
	02-2021 to 07-2021	**Unit 2**	03 Jul 2020 to 24 Jul 2020
	09-2022 to 01-2023		02 Jul 2021 to 19 Jul 2021
	02-2024 to 07-2024	**Unit 3**	23 Mar 2018 to 29 May 2018
		Unit 4	22 Mar 2019 to 30 May 2019

TABLE 3

Unit Refurbishment Drain/Dry/Bulk Swap/Refill Timeline (Estimate)									
Unit	Shutdown Date	PHT Drain and Dry Start	Mod Bulk Swap Start	Mod Bulk Swap End	Mod Drain End	PHT Drain and Dry End	Mod Refill	PHT Refill	Unit Turnover
2	15-Oct-16	7-Jan-17	7-Mar-17	12-Mar-17	18-Mar-17	22-Mar-17	24-Feb-19	24-Jul-19	24-Dec-19
				Mod Drain Start	Mod Flush In	Mod Flush Out			
				12-Mar-17	18-Mar-17	22-Mar-17			
Unit	Shutdown Date	PHT Drain and Dry Start	Mod Bulk Swap Start	Mod Bulk Swap End	Mod Drain End	PHT Drain and Dry End	Mod Refill	PHT Refill	Unit Turnover
1	25-May-18	17-Aug-18	15-Oct-18	20-Oct-18	25-Oct-18	30-Oct-18	1-Aug-20	1-Jan-21	1-Jun-21
				Mod Drain Start	Mod Flush In	Mod Flush Out			
				20-Oct-18	25-Oct-18	30-Oct-18			
Unit	Shutdown Date	PHT Drain and Dry Start	Mod Bulk Swap Start	Mod Bulk Swap End	Mod Drain End	PHT Drain and Dry End	Mod Refill	PHT Refill	Unit Turnover
3	28-Jan-20	21-Apr-20	19-Jun-20	24-Jun-20	29-Jun-20	4-Jul-20	30-Jan-22	30-Jun-22	30-Nov-22
				Mod Drain Start	Mod Flush In	Mod Flush Out			
				24-Jun-20	29-Jun-20	4-Jul-20			
Unit	Shutdown Date	PHT Drain and Dry Start	Mod Bulk Swap Start	Mod Bulk Swap End	Mod Drain End	PHT Drain and Dry End	Mod Refill	PHT Refill	Unit Turnover
4	6-Jul-21	28-Sep-21	26-Nov-21	1-Dec-21	6-Dec-21	11-Dec-21	15-Apr-23	15-Sept-23	15-Feb-24
				Mod Drain Start	Mod Flush In	Mod Flush Out			
				1-Dec-21	6-Dec-21	11-Dec-21			

11.0 TRF AND HEAVY WATER MANAGEMENT WORK PROGRAM PLANNING

The TRF and Heavy Water work programs are defined in their Yearly, Five Year[12] and Twenty Five year plans.

This planning process is critical to the success of refurbishment both for storage of unit D_2O and for the necessary reduction in unit tritium levels to minimize releases to the environment and to support dose reduction efforts. Long term plans are being developed to support these programs and will be reflected in future reports.

Issues of concern for work programs include:

- Transfers to, and from running units
- Transfers into the TRF from outside contracts
- Availability of TDO and transport packages
- TRF maintenance outages, planned maintenance on TRF loading bay equipment (cranes and radioactive material transfers) and unplanned events

Information on future TRF outages over the next five years is provided in Table 4. Information on TRF Feed assumptions for the next five years is provided in Table 5.

Table 4
TRF Outages Assumptions – Start/Finish Time Line

	2011	2012	2013	2014	2015	2016
Outage Start Date:	N/A	January 20th	August 22nd	N/A	February 8th	September 2nd
Outage End Date:	N/A	June 20th	December 24th	N/A	July 3rd	December 5th
Outage Duration (Days):	N/A	152 Gas Outage	125 CRS Outage	N/A	145 Gas Outage	95 CRS Outage
Available for Service (Days):	365	213	240	365	220	270

[12] HW Programming D_2O Supply/Demand Plan (N-REP-03800-10000)

Table 5
TRF Feed Assumptions

	2011	2012	2013	2014	2015	2016
Operating Time (Months)	12	7	8	12	7	9
Operating Time (Days)	365	213	240	365	220	270
Feed Rate (Kgs/Hr)	400	400	400	400	400	400
Availability Factor (%):	85%	85%	85%	85%	85%	85%
TRF Production (Mgs)	2,978	1,738	1,958	2,978	1,795	2,203
TRF Production 5 Year Average	2,264	2,132	2,098	2,244	2,207	2,135

12.0 CHEMISTRY AND ENVIRONMENT

12.1 Chemistry Layup

During the refurb process, D_2O will be transferred in a clean state from the reactor to the West Annex, where it will be stored for a period of up to three years. During this time period, regular sampling will occur to ensure no change in water quality.

Sampling will occur monthly to confirm D_2O specifications remain within the limits provided in NK38-OM-09701, Refurbishment - Chemical Control.

If conditions of the D_2O change unexpectedly, actions will be taken to return the water quality back to its original stored condition.

12.2 Environmental Protection

In order to monitor and reduce tritium releases to the environment:

(a) A 200 Mg bulk swap will take place during the HT drain and dry program. This will be a proactive opportunity to reduce the bulk moderator tritium concentration in anticipation of potential tritium releases to the vault.

(b) A tritium in ground water monitoring program has been established. Through the development of onsite wells, monitoring of station ground water will take place to trend tritium levels around the station during refurbishment.

13.0 REFURBISHMENT UNIT SHUTDOWN DATES:

Based on the present (June 2012) approved refurbishment timeline, the expected shutdown of Darlington units will occur in the rotation – Unit 2, Unit 1, Unit 3, and Unit 4.

- Unit 2 will begin refurb in October 2016, with return to service in December 2019
- Unit 1 will begin refurb in May 2018, with return to service in June 2021
- Unit 3 will begin refurb in January 2020, with return to service in November 2022
- Unit 4 will begin refurb in July 2021, with return to service in February 2024

14.0 OPEX

There are significant advantages to reducing the PHT and Moderator Tritium source terms from both environmental emissions to air and water, and from a worker safety perspective.

Point Lepreau showed significant increases in tritium emission to the atmosphere at the start of their refurbishment. Wolsong detritiated to 0.25 and 0.14 Ci/kg for Moderator and PHT respectively and actually reduced their emissions.

Based on original thought, Mod D_2O would be transferred to the West Annex in a poisoned state. OPEX from Bruce and Pt. Lepreau refurb has reshaped this idea and it is now understood that D_2O can be transferred out of the reactor core for storage in a clean state. In this condition, there should be no need to chemically adjust the water during the storage period.

Once refurbishment is completed, D_2O will be returned back to the calandria in the same condition as it was removed.

15.0 REFERENCES

[R-1] D-INS-38000-10002-R000
Heavy Water Management Upkeep and Inventory Reporting

[R-2] NK38-OM-09701
Refurbishment – Chemical Control

[R-3] NK38-REP-09701-10029-R000
System Lay-Up Technical Requirement – Moderator

[R-4] NK38-REP-09701-10028-R000
System Lay-Up Technical Requirement – Primary Heat Transport System

[R-5] NK38-REP-03800-10000-R006
Ontario Power Generation Nuclear - Heavy Water Supply and Demand Year End 2009

[R-6] NK38-REP-38000-10002-R000
Conceptual Design Report for the Heavy Water Management Building West Annex

[R-7] NK38-REP-39000-10077-R000
Darlington Nuclear Tritium Removal Facility 2010 Annual Report

[R-8] N-PCH-09071-10001-R00
Refurbishment, Operational Improvement & Long Term D_2O Storage.

[R-9] N-PROG-AS-0008-R002
Heavy Water Management.