ONTARIOPOWER GENERATION

Report

Internal Use Only	
Document Number: NK38-REP-09701-0265054	
Revision: R000	Retention: T 20

Title:
DARLINGTON REFURBISHMENT D2O STORAGE FACILITY EVALUATION

© Ontario Power Generation Inc., 2009. 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 D2O Storage Facility Evaluation

NK38-REP-09701-0265054--R000 T 20

2009-05-28

Order Number: N/A
Project ID: 10-27959

Internal Use Only

Prepared by: 28.05.09
Stefan Varga — Date
Senior Technical Engineer
Engineering Support
Nuclear Refurbishment

Prepared by: 28 May 2009
Margini Patel — Date
Senior Technical Engineer
Engineering Support
Nuclear Refurbishment

Reviewed by: 28 May 2009
Raju Chander — Date
Section Manager
Engineering Support
Nuclear Refurbishment

Concurred by: Jun 1/09
Denny Williams — Date
Section Manager
TRF/HW Operations & Maintenance

Approved by: Glenn Pringle 2 June 09
Glenn Pringle — Date
Department Manager
Engineering Support
Nuclear Refurbishment

Table of Contents

Page

List of Tables and Figures 3
Executive Summary 4

1.0 INTRODUCTION 5

2.0 NEED FOR ADDITIONAL D_2O STORAGE CAPACITY 6

2.1 Existing D_2O Storage & Inventory 6
2.2 Additional D_2O Storage Capacity Needs 6
2.2.1 Refurbishment 6
2.2.1.1 Refurbishment HTS and Moderator draining capacity needs 6
2.2.1.2 Decontamination capacity needs during Refurbishment 7
2.2.2 Operational Improvements additional storage capacity needs 8
2.3 Summary of Total Storage capacity needs 9

3.0 REVIEWED OPTIONS 10

3.1 New buildings 10
3.1.1 Build separate facility south of the existing storage 10
3.1.2 Build separate facility south of the SG storage tank and west of the SG 10
3.1.3 Extension to existing S&I 10
3.2 Using existing facilities with addition of new tanks 10

4.0 PREFFERED OPTION – NEW BUILDING - DESIGN REQUIREMENTS 11

4.1 Benefits of the proposed location 14
4.2 Disadvantages of the proposed location 14
4.3 Cost Estimate 15
4.3.1 Cost Estimate for the Operational Improvements 400 Mg D_2O Storage project 16
4.3.2 Conceptual Cost Estimate for the Refurbishment D_2O Storage of 845 Mg 17
4.3.3 Conceptual Cost Estimate for the Combined D_2O Storage of 1245 Mg 18
4.4 Schedule 20

5.0 REFURBISHMENT UPGRADING AND TRITIUM REMOVAL COST ESTIMATE 20

6.0 PROJECT RISKS 21

Appendix A: DNGS Refurbishment Outage and D_2O Managing Schedule 22
Appendix B: DNGS Refurbishment D_2O Process Flow 23
Appendix C: GE Email DNGS Refurbishment Decontamination D_2O Storage 24

Appendix D: Meeting Minutes DNGS Refurbishment Decontamination D_2O Storage 27
Appendix E: DNGS Project # 16-31555 Scope of Work.....28
Appendix F: DNGS Project # 16-31555 Exclusion from Additional Scope of Work.....31
Appendix G: DNGS Refurbishment D_2O Storage Conceptual Schematic 33
Appendix H: DNGS Refurbishment D_2O Storage Conceptual Tanks Arrangement Layouts..34
Appendix I: Cost Estimate Details for 400 Mg Storage & Drum Handling Project 31555 36
Appendix J: Refurbishment Upgrading and Tritium Removal Cost Estimate.....43
Reference List.....44
Glossary of Acronyms.....45

List of Tables and Figures

Figure 1: DNGS Refurbishment D_2O Process Flow 23
Figure 2: DNGS Refurbishment D_2O Storage Conceptual Schematic.....33
Figure 3: Proposed Conceptual Tanks Arrangement - Layout A 34
Figure 4: Proposed Conceptual Tanks Arrangement – Layout B 35

Table 1: DNGS Refurbishment D_2O Storage Need to drain 1 Unit 7
Table 2: DNGS Refurbishment D_2O Decontamination Storage Need (for 1 Unit) 7
Table 3: DNGS Operational Improvements D_2O Storage Need.....9
Table 4: DNGS Total D_2O Storage Need (for 1 Unit Refurb. & Op. Improvements).....9
Table 5: Cost Estimate Summary for 400 Mg & 845 Mg Storage 15
Table 6: Cost Estimate for Operational Improvements 400 Mg D_2O Project.....16
Table 7: Building Material Cost, Operational Improvements 400 Mg D_2O Project.....17
Table 8: Building Installation Cost, Operational Improvements 400 Mg D_2O Project 17
Table 9: Conceptual Cost Estimate for the Refurbishment D_2O Storage of 845 Mg.....18
Table 10: Conceptual Cost Estimate for the Combined D_2O Storage of 1245 Mg.....19
Table 11: Refurbishment Upgrading & Tritium Removal Cost Estimate.....21
Table 12: DNGS Refurbishment Outage and D_2O Managing Schedule 22

Executive Summary

Purpose and Scope

The overall objective of this project is to provide sufficient heavy water storage capacity at the Darlington site during the refurbishment period. The operational improvement needs have also been incorporated separately in this report.

According to the draft Darlington station refurbishment outage scheduling [Appendix A:] there is a minimum gap of ten weeks between the refilling of one unit and the dewatering of the next unit. As a result, the refurbishment storage capacity needs to meet the requirements of one Unit.

The main emphasis of this report is to identify the most appropriate solution for heavy water storage that will provide the best flexibility and least disturbance to the plant operations and to develop a cost estimate for the storage facility.

The various options investigated are presented as part of this report with benefits/shortfall rationalizations.

The estimated storage facility cost presented in this report will be part of the overall business case summary of the Nuclear Refurbishment Project - Darlington.

Conclusion

Build a new Heavy Water Storage Facility at Darlington NGS with 1245 Mg of Heavy Water storage capability located inside the Inner Security fence immediately west of the existing storage building. The 1245 Mg of D_2O storage capacity is for:

- 845 Mg in support of the refurbishment of the 4 DNGS units
- 400 Mg in support of the normal operation of the in-service DNGS units and the TRF

Estimated cost of the combined project is $ 138.5 Million when implemented over a period of 4 years.

When taking normal cost scaling factors into account, this estimate is nominally comparable with previous estimates produced for storage at Darlington.

1.0 INTRODUCTION

The overall objective for this project is to provide sufficient heavy water storage facilities at Darlington sites during the refurbishment period.

There are three drivers for the additional storage capacity planning, two required by Refurbishment (draining and decontamination) and one required by Operational Improvements (for continuous station operation at the Darlington site).

The requirements for Operational Improvements are reflected in a previous project (# 16-31555) for the addition of a 400 Mg HW storage and drum handling facility. This project was later deferred, in order to be implemented together with the Darlington refurbishment project, as being more cost effective to be carried-out together (Ref [16] and Ref [17]).

Based on the DNGS refurbishment screening level Draft Rev. 0, dated 27-Apr-2009 (DNGS 2/3-4 months - Engineering Mods – Level 1& 2 Activities) there is a 10 weeks gap between the end of refilling of one unit and start of dewatering of the next unit. This means that storage volume for one unit HW (Moderator and HTS) will be sufficient for refurbishment purposes.

The total refurbishment storage capacity needs to meet the requirements of one unit refurbishment is 845 Mg as follows:

- 350 Mg for D_2O from one unit Moderator Systems
- 345 Mg for D_2O from one unit Primary Heat transport (PHT) Systems
- 150 Mg designated for decontamination prior to refurbishment (medium risk - see section 2.2 for details)

The operational improvement needs for continuous station operation are:

- 400 Mg HW storage space for continuous operation improvements as per Ref [16] and Ref [17] (for details see Section 2.2.2). This quantity requirement could change in the future as new circumstances arise until the start of refurbishment.

The cost estimate for both projects will be presented separately in this report. The Refurbishment project cost estimate will be detailed, and the cost of the previous 400 Mg project will be presented as received from the project team.

The Heavy water management cycle at Darlington is different from that at Pickering due to the presence of a single, mixed recovery Upgrader. Upgrader product is utilized as addition/swap to the Moderator system keeping the isotopic at a very high level (approx. 99.98% D_2O). This results in significant fuel savings for the station. The TRF is integrated into the heavy water management cycle and is used to produce low-Curie make up to compensate for HTS losses, thus removing the requirement to segregate recoveries during normal operation of TRF. When the TRF is on outage for prolonged periods, recoveries must be segregated imposing additional storage (and manpower) requirements.

2.0 NEED FOR ADDITIONAL D_2O STORAGE CAPACITY

2.1 Existing D_2O Storage & Inventory

The existing Storage and Inventory has four objectives:

- normal operation of the units
- segregation of the high isotopic (> 99.98% D2O) and high curie (> 1.2 Ci/kg) reactor grade D2O (upgrader product) for the moderator systems
- segregation of the lower isotopic (< 99.96% D2O) and lower curie (< 0.7 Ci/kg) reactor grade D2O for the PHT systems, and
- support outages

The station existing Storage and Inventory System includes eight storage tanks with a total volume of 747 m3 and two weigh tanks:

(a) Four PHT tanks with a capacity of 100 m^3 each (i.e. 38110-TK7/8/9/10)

(b) One PHT weigh tank with a capacity of 30 m^3 (i.e. 38110-TK1)

(c) 3 Moderator tanks with a capacity of 3x100 m^3 each & 1moderator tank of 47 m^3 (i.e. 38110-TK3/4/6 & 38110-TK5 respectively)

(d) One Moderator weigh tank with a capacity of 10 m3 i.e. 38110-TK2

Details of the system can be found in references [18] and [19] and the details of the seismic qualification in references [5] and [19]

2.2 Additional D_2O Storage Capacity Needs

There are three drivers for the additional storage capacity planning, two required by refurbishment (draining and decontamination) and one required by operational improvement. The project for the latter was deferred, in order to be implemented together with the refurbishment project, since this approach would be more cost effective (Ref [16] and Ref [17]). This additional storage can also be used during TRF Refurbishment (see Ref [25] for details).

2.2.1 Refurbishment

There are two refurbishment drivers for the storage capacity planning:

- HTS and Moderator D_2O draining capacity during refurbishment
- D_2O capacity for decontamination during refurbishment

2.2.1.1 Refurbishment HTS and Moderator draining capacity needs

The refurbishment HW storage capacity needs are set by the volume of HTS and Moderator drained from one unit.

- 345 Mg for D_2O from one unit HTS (Ref [23]).
- 350 Mg for D_2O from one unit Moderator Systems (Ref [23], Ref [9], page 3 & Ref [10], page 2, Ref [1] Table 5.7)

	Total Required [Mg]		**Tanks Need**
HTS	1x343	345*	**3x115**
Moderator	1x343	350	**3.5x100**
	Total	**695**	**3x115+3.5x100**

Table 1: DNGS Refurbishment D_2O Storage Need to drain 1 Unit

- Note: Although Ref [8] (Table 1, page 528), and Ref [1] (Table 5.1) calls for a total inventory of 273 Mg storage space for the HTS, we selected the most conservative solution from Ref [23].

2.2.1.2 Decontamination capacity needs during Refurbishment

The Retube & Feeder Replacement Study is not yet completed at the time of issuing this report.

The Decontamination D_2O Storage needs are based on the preliminary judgment articulated through the email in Appendix C: and the minutes of meeting in Appendix D: and they are:

Decontamination Total Required [Mg]		
High Risk	**Medium Risk**	**Low Risk**
0	150	350

Table 2: DNGS Refurbishment D_2O Decontamination Storage Need (for 1 Unit)

The basis of the judgment is that the Darlington contamination levels are less than the Pickering B (Ref [2]), the HTS Tritium limit is 1.2 Ci/ kg D_2O and the Moderator Tritium Limit is 15.0 Ci/kg versus 2.5 Ci/ kg D_2O and 25.0 Ci/kg respectively (Ref [3]). In addition the operating levels are much lower than the OP&P levels.

We made the assumption that the existing SUP can handle (if needed) the quantity and in time processing of the downgraded D_2O from the decontamination of the unit under refurbishment.

<u>High Risk:</u>

The decontamination process is very unlikely since the contamination levels in DNGS is very low; as a result, no HW storage space is needed (see Appendix C: and Appendix D: option A).

Medium Risk

The next likely scenario (per Appendix D: option E) is a decontamination of the HTS, with no fuel in core, and up to the header level. Per the appendix the volume of low Curie HW needed is 120 m^3 (132 Mg).

The above quantity of 132 Mg low Ci HW is in addition to the quantity taken from the HTS system as explained in the following (based on Ref. [13]):

> The decontamination of the HTS main circuit header-to-header is done in principle by draining the main circuit above header to LLDS (130 Mg), keeping the rest of the inventory (140 Mg) in the main circuit header-to-header. After the fuel is removed the decontamination skid is installed between the inlet and outlet headers and circulating chemical reagents through the loop. The decontamination skid is equipped with pumps, filters, ion exchange columns and other equipment (Ref. [13]).
>
> The deuteration and de-deuteration of ion exchange resins will generate about 400 m^3 of downgraded HW having an isotopic content of about 60%. The HW in the 60%-isotopic would correspond to 231 m^3 of reactor grade HW (254 Mg). (These volumes were calculated scaling the volumes/quantities from Pickering B decontamination study, Ref. [13]). To provide this 254 Mg low Ci HW, 130 Mg can be used from the drained main circuit above header to LLDS and the rest needed is 124 Mg and has to be provided from additional station reserve. This conclusion is close to the quantity proposed per Appendix D: option E (132 Mg).

The 132 Mg station reserve low Ci HW has to be stored in additional tanks to the already planned storage tanks, because after decontamination the remainder of the of the HTS inventory (140 Mg) in the main circuit header-to-header needs to be drained to the refurbishment storage.

Low Risk

The safest scenario (per Appendix D: option D) is a decontamination of the entire HTS, with no fuel in core. The volume of low Curie HW needed is 305 m3 (335 Mg).

The major difference from the above scenario is that the draining of the main circuit above header to LLDS (130 Mg) will not be performed; as a result the quantity of 130 Mg HW from HTS is not available for deuteration and de-deuteration of ion exchange resins. This amount of low Ci HW needs to be provided in addition to the medium risk case. Even though the sum of the two is about 254 Mg, we need to consider the deuteration and de-deuteration of a larger quantity of ion exchange resins; as a result we increased the storage volume from 254 Mg to 350 Mg. It needs to be repeated that 350 Mg of additional low Ci HW needs to be provided by the station during decontamination.

2.2.2 Operational Improvements additional storage capacity needs

The needs for sufficient heavy water storage and segregation had been recognized for years in OPG and initiatives were taken since 2004 to improve the heavy water management process. As a result studies were initiated leading to, in November 2005, the project charter (Ref [16]) and the Kinectrics report (Ref [18]). The report,

examined in detail the heavy water and drum management issues for both Pickering and Darlington.

As an outcome of the report it was concluded that there is inadequate S&I capacity to allow large volume bulk swap to be performed. A new storage facility building similar to the existing Heavy Water Storage Facility was recommended with a capacity of 400 m^3 as follows:

- 100 Mg (2x50 Mg) for Downgraded Dirty D_2O Tank/Drum Emptying Tank for SUP
- 100 Mg (2x50 Mg) for Downgraded Clean D2O Tanks for SUP
- 200 Mg for TRF operations support (2x50 Mg TRF Feed Tank/Moderator Drain Tank and 2x50 Mg TRF Product Tank/Upgrader Product Tank)
- Drum handling (storing, emptying, washing and testing) station for 300 drums

Operational Improvements	
Total Required [Mg]	Number of Tanks
400	4x100

Table 3: DNGS Operational Improvements D_2O Storage Need

A draft copy of the scope of work for the 400 Mg project is attached in Appendix E:. This was not approved since the project was deferred. The Kinetrics report was used and accepted by OPG as Scope of Work (ref. [18]).

Note: As per Appendix F: the addition of the New IXCU system was subsequently excluded from the Scope of Work.

2.3 Summary of Total Storage capacity needs

The total storage capacity needs at Darlington during refurbishment are calculated by adding the requirements from Table 1, Table 2, and Table 3. The results are summarized in the following table:

Total Required [Mg]			Tanks required
High Risk	**Medium Risk**	**Low Risk**	**Medium Risk**
1095	1245	1445	3x115+9x100 Mg

Table 4: DNGS Total D_2O Storage Need (for 1 Unit Refurb. & Op. Improvements)

Following are the details explaining the final numbers:

- High Risk: 695 Mg (Refurb. Mod & HTS) + 400 Mg (Op. Impr.) + 0 Mg (Refurb. Decont.)
- Medium Risk: 695 Mg (Refurb. Mod & HTS) + 400 Mg (Op. Impr.) + 150 Mg (Refurb. Decont.)
- Low Risk: 695 Mg (Refurb. Mod & HTS) + 400 Mg (Op. Impr.) + 350 Mg (Refurb. Decont.)

3.0 REVIEWED OPTIONS

3.1 New buildings

3.1.1 Build separate facility south of the existing storage

This option is unattractive, as the space should be reserved for a possible/likely new TRF. There is as well a Hydrogen supply station on this location. The underground soil as deep as 15 m is unexplored geologically.

3.1.2 Build separate facility south of the SG storage tank and west of the SG

This option is unattractive, as the space should be reserved for a possible/likely new TRF. In addition to this, we have to consider the environmental issue due to closeness to the lake. Also the soil conditions are unknown which is a risk for construction of a seismically qualified building such as the D_2O Storage facility. By comparison the projected new TRF building has no seismic requirements and its basement is expected to be only about 5 m below ground level, which may be acceptable.

3.1.3 Extension to existing S&I

This option seems the most practical. The main benefit is the closeness to existing storage and the lower cost for tying in to this system (even though the new storage facility will be provided with independent functionality).

3.2 Using existing facilities with addition of new tanks

The Kinetrics study (Ref [18]) examined several options where additional heavy water could be stored within the existing station structures to avoid the need for building extension or new building. The two explored options of the study were:

- Provision of Additional Storage at each Unit, one 50 m^3 tank located at each Reactor Unit (4x50 m^3 tanks in total).
- Locate Additional Tanks in the OGMS Room (could only accommodate a 100 m^3 tank or about 8 x 20 m^3 tanks)

The space available within the pre-existing structures was deemed inadequate for meeting the needs of additional heavy water storage defined in the report. It was concluded that for a building extension or new building, the incremental costs associated with the heavy water tanks are minor and the various options of providing additional storage for only one or two systems were deemed unnecessary.

Since the refurbishment requirements are much greater, we concluded that revisiting those options were not worth consideration.

The preferred option is to locate the storage facility in a new building.

4.0 PREFFERED OPTION – NEW BUILDING - DESIGN REQUIREMENTS

A total of 1245 Mg of storage tank capacity (made up of 3 x 115 + 9 x 100 Mg tanks) shall be provided for segregation of different streams of D_2O. This storage is for one unit Moderator drain (350 Mg), PHT drain (345 Mg), Decontamination (150 Mg) and the additional Operational Improvements requirement (400 Mg) as explained in details in section 2.2 and 2.3. All tanks with associated pump, piping, valves etc. will be located inside the new building.

Consideration shall be given to ensure maximum flexibility in storing and transferring different grades of D_2O to and from reactor units, TRF, Upgrader, etc

The storage facility should have provision for the treatment of the moderator drain (Gd removal prior to detritiation in the TRF and chemistry control prior to refill).

There shall be no negative impact to the performance of existing systems as the result of this project and the current mode of operation shall not be degraded.

System

All pressure boundary systems and components shall meet the requirement of CSA-N285.0-08.

CNSC approval of the proposed system code classification of "Class 3" and "Class 6" is required.

Most of the D_2O lines and storage tanks are expected to contain more than 74 GBq/kg (2 Ci/kg) tritium, hence all nuclear systems are classified as Class 3. Only the conventional part of the system is classified as Class 6.

Building

The building needs to meet the requirement of a Zone 3 area and shall meet the requirements of National Building Code of Canada 2005, the National Fire Code of Canada 2005, CSA-N293-07 (Fire Protection for CANDU Nuclear Power Plants), as well as all federal, provincial and local municipal regulations. (For costing purposes 2005 codes and standards are acceptable. However, the design should be based on the codes and standards in effect at the time of the design and construction.)

- The building to have heating system to maintain minimum OSHA ambient conditions during winter months with building sealing/insulating to minimize heat losses (see Ref [6] for details).
- The building to have ventilation system and kept under marginal negative pressure to maximize the recovery of D2O and isotope products in order to minimize release to the environment including radiation monitoring with alarm and exhaust through HEPA filters (see Ref [6] for details).
- Tritium monitoring, tritium emission reduction and D2O recovery from vent lines must be considered.
- It is not a safety related system

The D_2O storage tanks, transfer pumps and associated equipment shall be located in a pit at elevation depth of 87.000 m. The road elevation is at 100.000 m.

A platform shall be provided in the pit at El. 96.700 m to provide access to the top of the D_2O storage tanks for maintenance and inspection work.

The seismic qualification requirement for the proposed additional storage is similar to that of the existing storage facility (reference [4] & [5]). The substructure of the West Annex Building, enclosing the D_2O tanks, is to be seismically qualified to DBE category D (including the dyke around the tanks that would contain the D_2O inventory if the tanks were to fail during a seismic event and that would contain the spill of D_2O to the environment).

The concrete substructure of the dyke is sited on rock at elevation 87.000 m.

The superstructure of the building to be braced steel frame resting on a concrete structure. It does not need to be seismically qualified. However, it shall be analyzed for earthquake loads as per NBC 2005.

The suggested location for the building is inside the Inner Security Fence at immediate proximity of the existing HWMB to the West as indicated in Appendix H: (two variations of layouts). The approximate size of the building is 400 m2 (width between 13.3 m to 18 m and length between 22 m to 33 m, depending on the option) with a height of maximum 13 m below ground level of 100.000 m required by the refurbishment storage and a maximum height of 20 m above ground level of 100.000 m required by the 400 Mg Operational Improvement project.

Drainage shall be provided in the new building so that spills can be drained to the sumps in the D_2O Management Building.

Appendix G: shows the Conceptual D_2O Refurbishment Storage Schematic.

Material

The materials required to complete the project shall be procured as per OPG specifications/standards.

All equipment and piping shall be enclosed in a building to prevent freezing of system contents

Material of tanks and piping is Stainless Steel AISI 304L.

The new tanks shall be designed to Class 3. The orientation is vertical. The Design Pressure is 240 kPag (35 psig). The Design Temperature is 66 ^{0}C (150 ^{0}F) (ref [19]).

Each tank shall have a partition in the centre to divide it into two storage compartments. The capacity shall be at least 110% of the total storage capacity.

The tanks shall be inter-connected with piping (Size 2 inches) with provision for isolation, transfer and purification of the content. Piping shall include tank inlet and outlet headers, tank vent and drain lines and provision for tank recirculation, complete with sample points and quick disconnect fittings (or equivalent) for connection to a local IXCU.

All pipe fittings and valves are stainless steel. EPDM rubber is used for items such as gaskets, valve diaphragms and flexible hoses, which are in contact with D_2O.

Two 100% Nuclear Class 3 canned centrifugal type pumps with stainless steel internals. Capacity is 8 L/s at a total head of about 147 m. Design pressure is 2000

kPa(g) and Design Temperature is 68 ^{0}C (Ref [24] & Ref [19]). The pumps shall be connected to a common suction and discharge header. Manually operated isolation valves shall be designed to ensure a flow path can be established from any of the tanks to any of the pumps.

Instrumentation

The new storage tanks shall be designed to tie in to existing control/transfer systems, and still to have independent functionality.

Level and pressure indications shall be provided for the new D_2O storage tanks, both locally and in the Control Room. Alarms (locally and Control Room) shall be provided to alert operator of abnormality in the storage tanks. The existing control computers in the D_2O Management and TRF Building shall be utilized for any new equipment indicating alarms and control functions.

Fixed Area Alarming Tritium monitors shall be installed to detect the presence of tritiated water and/or vapour leakages.

Beetle alarms shall be provided to alert operator of leaks or spills. The new alarm system shall mirror the existing design for consistency

Cover gas shall be provided for the storage tanks from the existing system. The tanks shall be designed for a pressure equivalent to the cover gas pressure plus the static elevation of a water column in the tank.

Isolations and draining shall be provided to isolate/drain any individual tank for maintenance. Double block and bleed arrangements shall be used for isolation between tanks designated for PHT D2O and Moderator D2O, interconnecting lines between reactor grade and downgraded D2O.

Means of sampling and analyzing of the contents in the tanks shall be provided. In order to obtain a representative sample, the water present in the tanks must be re-circulated for several minutes using the appropriate recirculation line.

Tanks to be protected against overpressure by a pressure relief valve in the vent line.

Relocation of services: (List of pipes/sewer/cable ducts affected)

The following yard services are located within the construction area of the proposed location of the new storage building and have to be relocated (see ref [11] and [12]):

- A ½" diameter buried Helium Supply Piping 7554-L601-H1/2ANF (SCI 75540 Helium) (SCI 75000 Compressed Air, Gas & Vacuum Services) (SCI 75500 Miscellaneous Gas Services)
- A 10" diameter buried Fire Protection water Piping (7811-L18-W10APAA) (SCI 78110 Fire Protection Water Supply/Distribution)
- A Fire Protection water Piping of unknown size (SCI 78110)
- A 600 mm diameter buried yard drainage Piping (SCI 15200) (Sewer CSP - Corrugated Steel Pipe)
- A catch basin CB 483 (SCI 15200)
- A 6" diameter buried drain line from HWMB roof drain to catch basin (SCI 79110) (7911-W6APAB)

- A 300 mm diameter buried drain line from catch basin to yard drainage piping (SCI 15200)
- 7210-L921-W30A Low Pressure Service Water Open System Pipe (SCI 72100 – Liquid recovery)
- Cable Duct from Standby Gen OIL Tanks #1&2 to the Generators. (low probability to interfere)

All the yard services, except for the fire protection water piping of unknown size, will be relocated toward the west under the road. The fire protection water piping of unknown size will require further review relative to relocation.

There are four buried construction pipes (12" Steam, 3" C.R., 6" Air, 8" Water) running along the middle of the road west of the HWMB (see ref [11] and [12]). These pipes might not be in use and might not need to be relocated, only capped. The cost of these four pipes relocation should be included in contingency.

4.1 Benefits of the proposed location

- System tie-ins to the existing systems are less expensive than other farther location options
- Use of an extension to the HWMB reduces costs as it is already a Zone 3 building with a suitable ventilation and stack monitoring
- There are existing D2O transfer lines which simplifies piping installation needs
- Tanks can be monitored by existing HWMB operations staff
- Extra flexibility for segregation and management of D2O during the extended life of the plant reducing the outage duration and cost

4.2 Disadvantages of the proposed location

- The existing truck ramp and the loading dock will be affected and a temporary area needs to be provided on the north side of the existing HWMB to facilitate the loading and unloading operations of D2O drums during the construction of the HWMB West Annex.
- The proposed location is affecting the existing road that needs to be relocated toward west by about 2 meters.
- The closeness to the existing building imposes additional excavation and construction difficulties
- Since the HWMB West Annex systems are, in most cases, extensions of the existing systems in the HWMB, temporary design modifications to the following systems may be required to minimize the interruptions of their operation during system tie-ins: D_2O Supply System (SCI 38110); D_2O Cleanup System (SCI 38410); Downgraded D_2O Transfer System (SCI 38500); D_2O Sampling System (SCI 63800)
- The existing service pipes (firewater, helium, and storm water) and the 600 V electrical cables located on the west side of the existing HWMB need to be relocated or re-routed.

4.3 Cost Estimate

In the following sub-sections are presented the cost estimates for the Operational Improvement 400 Mg D_2O Storage and Drum Handling project, the cost estimate for the Refurbishment 845 Mg Storage, and the combined cost estimate for 1245 Mg Storage.

The Operational Improvement 400 Mg D_2O Storage project cost estimate was prepared by Project Management Office (PMO) on May 22, 2008 (section 4.3.1), and forms the basis for the Refurbishment 845 Mg Storage cost estimate (section 4.3.2).

The total cost of the combined storage of 1245 Mg is $ 138.5M (section 4.3.3). There is a cost reduction of 10% to 15% if both projects are completed together. This saving comes from space saving, PM, labour etc.

	Operational Improvements 400 Mg Storage	Refurbishment 845 Mg Storage	Combined 1245 Mg Storage
Cost w/o Contingency	$ 55.9M	$ 61.7M	$ 103.4M
Contingency	$ 19.0M	$ 21.0M	$ 35.1M
Total Cost	$ 74.8M	$ 82.7M	$ 138.5M

Table 5: Cost Estimate Summary for 400 Mg & 845 Mg Storage

Notes:

- All the estimates are in $ 2008
- Interest is not included
- Installation work is done by an external contractor
- All work is within the secured "protected area" with the incumbent restrictions
- Commissioning and Work Plans are prepared and managed by OPG Procedures
- External agency to provide design and construction documents for the facility
- Operating and Maintenance costs (excluding personnel) during the Refurbishment (approximately 7 years) is not included
- Costs related for approval procedures (CNSC, local municipality to obtain building permit) is included
- We made the assumption that the existing TRF and SUP can handle (if needed) the quantity and in time processing of the drained D2O from the unit under refurbishment
- Cost of detritiation and upgrading is separately indicated in section 5.0
- Cost of TRF refurbishment / new TRF is not included in this report (for this cost see Ref [25])
- Cost of D_2O Storage for TRF refurbishment is not included in this report

4.3.1 Cost Estimate for the Operational Improvements 400 Mg D_2O Storage project

The cost of the Operational Improvement 400 Mg D_2O Storage project is $ 74.8M, and it was prepared under Project 31555 by PMO (Ref [20]).

The scope of the project is given in section 2.2.2.

Ref. Appendix I Tables	Description	Cost	% of total cost
	Process Systems incl. Tanks		
Table 1A	Material	$5,000,000	8.95%
Table 1B	Installation	$9,000,000	16.12%
	Sub total	**$14,000,000**	**25.07%**
	Building		
Table 2A	Material - 13 meter height (160 m^2)	$2,400,000	4.30%
Table 2A	Material - 6 meter height (820 m^2)	$5,600,000	10.03%
Table 2B	Construction - 13 meter height (160 m^2)	$4,335,000	7.76%
Table 2B	Construction - 6 meter height (820 m^2)	$10,115,000	18.11%
Table 2B	Relocation services	$1,000,000	1.79%
	Sub total	**$23,450,000**	**41.99%**
	Sub total Material & Installation	**$37,450,000**	**67.06%**
Table 3	**Design Engineering**	$8,500,000	15.22%
Table 4	**Project Management**	$5,862,364	10.50%
Table 5	**Installation OPG** (support during installation, commissioning & close out)	$4,035,669	7.23%
	Sub total	$18,398,033	32.94%
	Total before contingency	**$55,848,033**	**100%**
	Contingency @ 34%	$18,988,331	
	Total including contingency	**$74,836,364**	

Table 6: Cost Estimate for Operational Improvements 400 Mg D_2O Project

Since the cost breakdown of this project is not available in the PMO documents, the cost breakdown was derived as follows, to facilitate cost estimation of refurbishment storage costs:

The Table 1A, Appendix I: Material cost (tanks & process system) gives the cost of long lead items i.e. tanks & associated process system material cost as $ 5M.

One 100 Mg tank cost is $ 500k which is based on the Pickering B Refurbishment D_2O Storage estimate (ref [21]). Four tanks cost is $ 2M, therefore the process

systems cost is $ 3M. As a result, the process system cost is 1.5 times the cost of the tanks.

The Table 1B, Appendix I: gives the installation (tanks & process system) cost as $ 9M, which is 1.8 times the material cost.

In Table 2A, Appendix I: Material cost (building), the total cost of material for building is $ 8M. The cost is proportionately calculated for two different heights. The higher unit cost for the 13 m area takes in to consideration that the building is completely underground; it needs special foundation and isolation, and is seismically qualified. This method of proportionate allocation is used for both the building material and construction costs.

	Area	Unit Cost	Total Cost
Total Material Cost			$8,000,000
13 meter high area	160 m^2	$15,000 /$m^2$	$2,400,000
5/6 meter high area	820 m^2	$6,829 /$m^2$	$5,600,000

Table 7: Building Material Cost, Operational Improvements 400 Mg D_2O Project

In Table 2B, Appendix I: the total cost for construction of the building is $ 15.45M and includes the relocation of services.

The cost is proportionately calculated as mentioned above.

	Area	Unit Cost	Total Cost
Total Construction Cost			$15,450,000
13 meter high area	160 m^2	$27.094 /$m^2$	$4,335,000
5/6 meter high area	820 m^2	$12.335 /$m^2$	$10,115,000
Relocation of Services			$1,000,000

Table 8: Building Installation Cost, Operational Improvements 400 Mg D_2O Project

In Table 3, Appendix I: the Design Engineering cost is $ 8.5M, and it represents 23% of the total material and installation cost.

In Table 4, Appendix I: the Project Management cost is $ 5.86M, and it represents 16% of the total material and installation cost.

In Table 5, Appendix I: the OPG Installation cost is $ 4M. The cost includes OPG support during Design, Installation, Commissioning and Closeout; and it represents 11% of the total material and installation cost.

4.3.2 Conceptual Cost Estimate for the Refurbishment D_2O Storage of 845 Mg

The cost for the Refurbishment D_2O Storage of 845 Mg, alone, is $ 82.7M.

The conceptual cost estimate for the Darlington Refurbishment D_2O Storage project of 845 Mg is based on the cost estimates and notes provided in section 4.3.1, for the Operational Improvements 400 Mg D_2O Storage project.

The scope of the Refurbishment D_2O Storage of 845 Mg is presented in section 2.2.1.

Description	Cost (x1000)	% of total cost	Comment
Process Systems incl. Tanks			
Material	$10,000	16.20%	8 tanks at 500k$ (same for 115Mg & 100Mg tanks) 2.5 times to include pumps piping, valves
Installation	$17,778	28.80%	Back worked to get 64% installation of total
Sub total	**$27,778**	**45.00%**	
Building			
Material (300 m^2)	$4,500	7.29%	$15,000 / m^2
Construction (300 m^2)	$8,128	13.17%	$27,094 / m^2
Relocation services	$750	1.21%	
Sub total	**$13,378**	**21.67%**	
Sub total Material & Installation	$41,156	66.67%	
Design Engineering	$9,466	15.33%	23% of material & install.
Project Management	$6,585	10.67%	16% of material & install.
Installation OPG (support during installation, commissioning & close out)	$4,527	7.33%	11% of material & install.
Sub total	$20,578	33.33%	Planning & Eng. cost is 30% of total cost
Total before contingency	**$61,734**	**100%**	
Contingency @ 34 %	$20,990		
Total incl. contingency	**$82,724**		

Table 9: Conceptual Cost Estimate for the Refurbishment D_2O Storage of 845 Mg

4.3.3 Conceptual Cost Estimate for the Combined D_2O Storage of 1245 Mg

The cost for the Combined D_2O Storage of 1245 Mg is $ 138.5M.

The conceptual cost estimate for both projects (the Darlington refurbishment D_2O storage project for 845 Mg & the Operational Improvement Project of 400 Mg) are presented in parallel in Table 10.

There is a cost reduction between 10 to 15% if the two projects are implemented together mainly because there will be an area savings for the entire building from a more favourable tanks arrangement and other organizational costs savings.

Description	400 Mg Cost (x1000)	845 Mg Cost (x1000)	Total Cost (x1000)	Cost if implemented together (x1000)	
Process Systems incl. Tanks					
Material	$5,000	$10,000	$15,000		
Installation	$9,000	$17,778	$26,778		
Sub total	$14,000	$27,778	$41,778	$37,600	10% less
Building					
Material (13 m high)	$2,400	$4,500	$6,900		
Construction (13 m high)	$4,335	$8,128	$12,463		
Material (6 m high)	$5,600				
Construction (6 m high)	$10,115				
Relocation services (see note below)	$1,000	$750	$1,750		
Sub total	$23,450	$13,378	$36,828	$31,304	15% less
Total Material & Installation cost	$37,450	$41,156	$78,606	$68,904	
Design Engineering	$8,500	$9,466	$17,966	$15,848	
Project Management	$5,862	$6,585	$12,447	$11,025	
Installation OPG (support during install., commissioning & close out)	$4,036	$4,527	$8,563	$7,579	
Sub total	$18,398	$20,578	$38,976	$34,452	12% less
Total (before contingency)	$55,848	$61,734	$117,582	$103,356	
Contingency @ 34 %	$18,988	$20,990	$39,978	$35,141	
Total (including contingency)	$74,836	$82,724	$157,560	$138,497	12% less

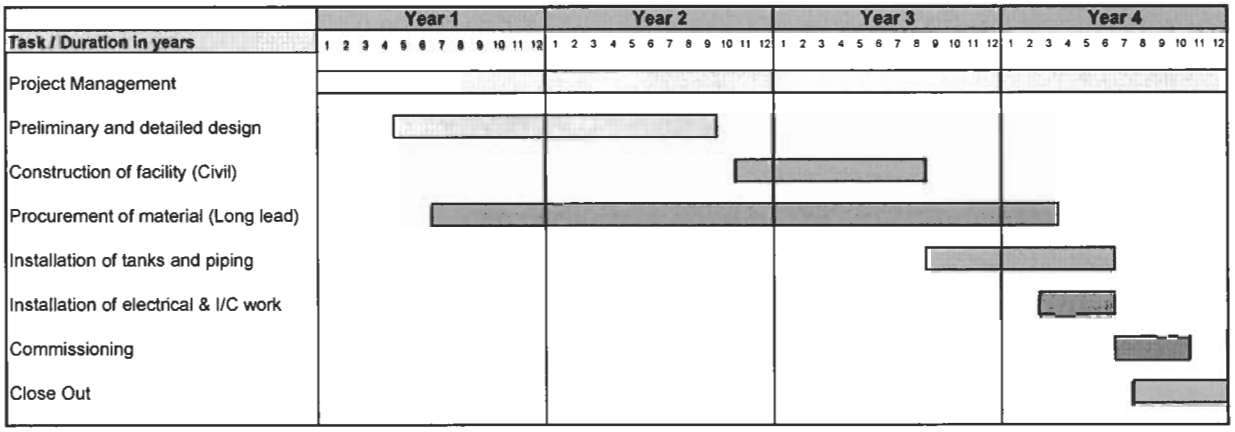
Table 10: Conceptual Cost Estimate for the Combined D_2O Storage of 1245 Mg

Note:

Relocation of services cost for 845 Mg project is in addition to the relocation services cost for 400 Mg project.

4.4 Schedule

Total project duration for 1245 Mg D_2O storage project is 4 years. The details for each activity can be found from the following schedule (based on Ref [26]):



The overall schedule for execution of the project includes time for approvals from municipality and CNSC.

5.0 REFURBISHMENT UPGRADING AND TRITIUM REMOVAL COST ESTIMATE

PHT Tritium limit is 1.2 Ci/ kg D_2O and Moderator Tritium limit is 15.0 Ci/kg as per the Darlington Operating Policies & Principles (Ref [2]).

The cost was calculated on the following judgments:

- Decontamination HW does not need de-tritiation
- PHT Ci level is 1 before refurbishment
- Moderator Ci level is 10 before refurbishment
- De-tritiation cost is $25/kg (Ref [22])
- Upgrading cost is $1,050 ($2,000 for decontamination HW at 60% isotopic). (Cost of upgrading is taken from the 1991 estimates provided by common services, Pickering B and adjusted to 2007) (Ref [22])
- Detritiated D_2O (Ci = 0.7) will be mixed to adjust the curie level by the following formula:

$$Qp = Qt * (Ca-Ct) / (Ca-Cp)$$

Where:

Qt = total quantity (273 Mg for PHT or 340 Mg for Moderator)

Ca= actual concentration (of PHT or Moderator D_2O)

Ct= target concentration

Cp=0.7 Ci/kg detritiated water from TRF

Following is the cost summary for Tritium Removal & Upgrading of the D_2O drained from units throughout Refurbishment:

	High Risk Cost	Med Risk Cost	Low Risk Cost
Tritium Removal Total 4 Units	$0	$ 29.25M	$ 32.90M
Upgrading Total 4 Units	$0	$ 1.78M	$ 3.95M
Tritium Removal & Upgrading Total	**$0**	**$ 31.03M**	**$ 36.85M**

Table 11: Refurbishment Upgrading & Tritium Removal Cost Estimate

Calculation details are presented in Appendix J:

6.0 PROJECT RISKS

The following list is created for both the refurbishment project and the operational improvement project.

- The current estimate is a conceptual level and unforeseen technical issues may arise that were not accommodated for in the proposed scope and not covered by the 34% contingency
- Correspondence with Regulators will require approvals from both the CNSC and TSSA. Obtaining approvals from outside parties can be time-consuming and may cause significant delays. In addition, it is possible that various levels of government may get involved, which have not been anticipated, such as the Ministry of the Environment.
- Scope Changes depending on the progress of the project and the information communicated over the course of the project. Scope changes may affect the schedule and/or price.
- The unavailability of design basis documentation that reflects the "as built" condition of the systems and/or equipment may cause additional processing and engineering effort in order to complete the engineering change packages.
- Effectiveness of OPG/Contractor team Interface, as the project process will require multiple interfaces between the design engineers and the approvers (OPG) for each design change (i.e. COMS review, issues resolution, document approvals, etc.).
- It is assumed that the refurbishment project D_2O upgrading and tritium removal can be accommodated during the refurbishment of one unit (this assumption is in conjunction with the requirements of the 400 Mg Operational Improvement project which must be satisfied). Some of the operational needs may require to be re-scheduled accordingly. Any non-conformance to this rule may affect the refurbishment schedule.
- The outage schedule as per 27 Apr 09 (10 weeks gap between the end of refilling of one unit and start of dewatering of the next unit) could change and there could be an overlap.

Appendix A: DNGS Refurbishment Outage and D_2O Managing Schedule

ID	Task Name	Start	Finish	Duration
1	Unit 1	10/1/2016	11/1/2018	762d
2	Unit 2	7/1/2018	8/2/2020	764d
3	Unit 3	4/1/2020	5/1/2022	761d
4	Unit 4	1/2/2022	2/1/2024	761d
5	Store U1	2/6/2017	8/17/2018	558d
6	Store U2	10/29/2018	5/16/2020	566d
7	Store U3	7/30/2020	2/15/2022	566d
8	Store U4	5/2/2022	11/10/2023	558d
9	OLap 1-2	7/1/2018	11/1/2018	124d
10	OLap 2-3	4/1/2020	8/2/2020	124d
11	OLap 3-4	1/2/2022	5/1/2022	120d
12	GAP 1-2	8/17/2018	10/29/2018	74d
13	GAP 2-3	5/16/2020	7/30/2020	76d
14	GAP 3-4	2/15/2022	5/2/2022	77d

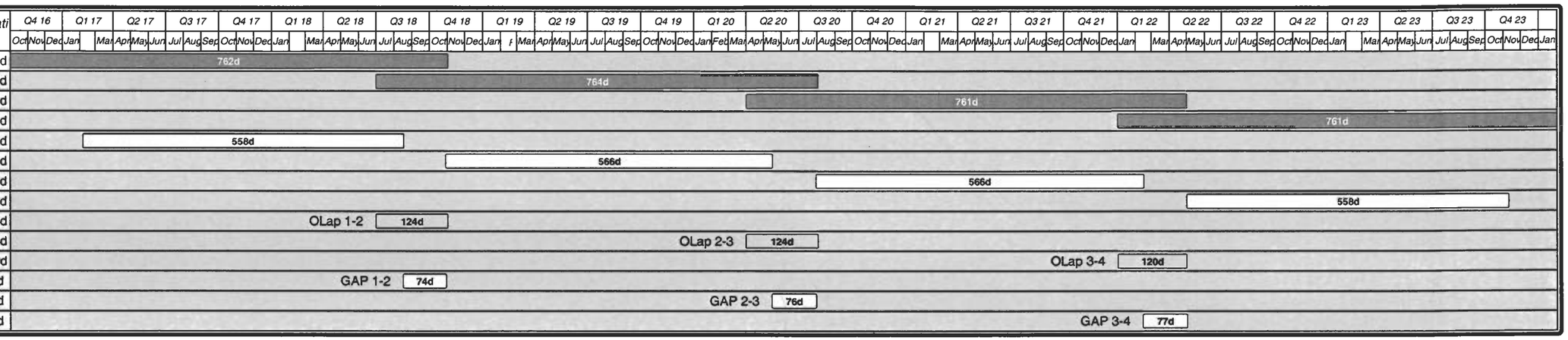
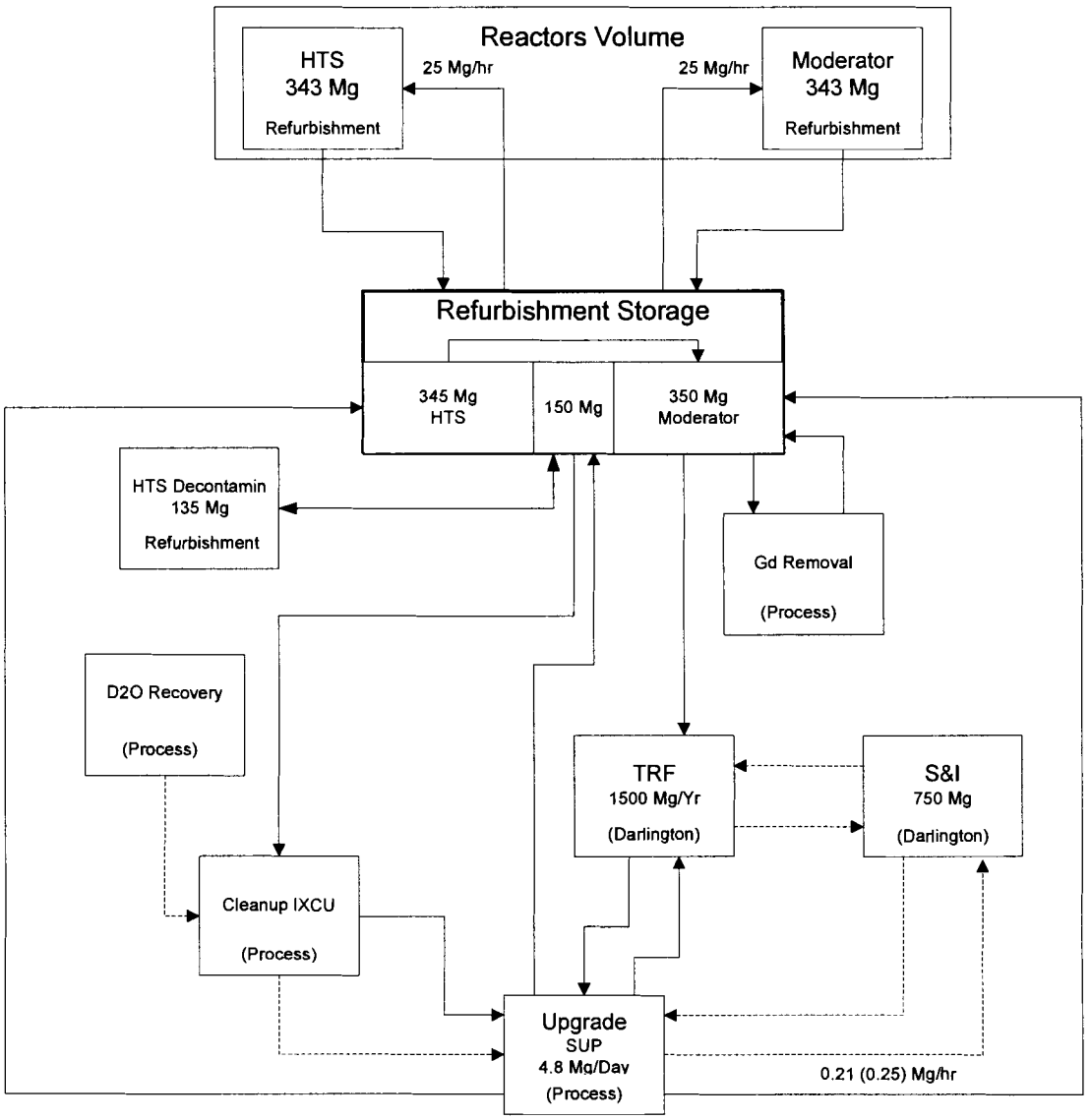


Table 12: DNGS Refurbishment Outage and D_2O Managing Schedule

Appendix B: DNGS Refurbishment D_2O Process Flow



Legend: → Refurbishment Activity

⇢ Normal Process Activity

Figure 1: DNGS Refurbishment D_2O Process Flow

Appendix C: GE Email DNGS Refurbishment Decontamination D_2O Storage

HITACHI

GE Hitachi
Nuclear Energy Canada Inc.

Graham MacDonald
Manager, Field Services

1160 Monaghan Road
Peterborough, Ontario K9J 7B5
Canada

T 705 748 7061
F 705 748 8187
M 705 872 2344
E graham.macdonald@ge.com

Job #: T4756
Ref #: N/A

Feb 27th, 2009

David Kurpjeweit, Ontario Power Generation
Nuclear Refurbishment Projects
889 Brock Rd., Pickering ON L1W 3J2

Subject: **Darlington Retube and Feeder Replacement D2O Considerations - Preliminary**

Attachments:
1. GEH-C Sketch, DNGS R&FR PHTS Chemical Decontamination Application Scenario Map.

References:
A. Meeting Notes, OPG Darlington R&FR Study, Status Update Meeting #4, 19-Feb-2009
B. OPG Doc. W-REP-03460-00015 R00 "Reference Plan for Management of Low- and Intermediate-Level Waste From Darlington Refurbishment"
C. OPG Doc. N-SPEC-09701-10001 R000 " Scope of Work – Darlington Retube and Feeder Replacement Study"
D. OPG Doc. NK38-SR-03500-10001 R002 "Darlington Safety Report – Part 2 Design Description"

Dear Mr. Kurpjeweit:

As discussed during our recent Status Update Meeting (Ref. A), we have prepared the following rough estimate of the D2O supply requirements for the various identified scenarios for Darlington Retube and Feeder Replacement (R&FR).

Regarding D2O requirements for chemical decontamination, please see the attached scenario map (Att. 1) that plots the various decon permutations. The table below provides preliminary, qualitative recommendations for each scenario, and a rough estimate of the D2O requirements:

ID	Scenario	Likelihood	Notes
A	No Decon	Recommended	No additional D2O req'd
B	Decon, Fuel in Core, D2O medium Full PHTS (+SGs)	Not Recomm.	~ 240 m^3 for IX deuteration ~ 40-50 m^3 for decon system volume ~ 7 m^3 make up for removed fuel volume de-deuteration water must be upgraded
C	Decon, Fuel in Core, D2O medium Up to Header Level	Not Recomm.	~ 120 m^3 for IX deuteration ~ 40-50 m^3 for decon system volume de-deuteration water must be upgraded

ALL RIGHTS RESERVED THIS MATERIAL MAY NOT BE USED OR REPRODUCED WITHOUT PRIOR WRITTEN CONSENT OF GE-HITACHI NUCLEAR ENERGY CANADA INC

ID	Scenario	Likelihood	Notes
D	Decon, No Fuel in Core, D2O medium Full PHTS (+SGs)	Not Recomm.	Bounding scenario for D2O. ~ 240 m^3 for IX deuteration ~ 40-50 m^3 for decon system volume ~ 15 m^3 make up for removed fuel volume de-deuteration water must be upgraded
E	Decon, No Fuel in Core, D2O medium Up to Header Level	Recommended Decon scenario	~ 120 m^3 for IX deuteration ~ 40-50 m^3 for decon system volume de-deuteration water must be upgraded
F	Decon, No Fuel in Core, H2O medium Full PHTS (+SGs), D2O removed	Not Recomm.	No additional D2O req'd Tritiated H2O an issue
G	Decon, No Fuel in Core, H2O medium Full PHTS (+SGs), D2O present	Not Recamm.	No additional D2O req'd Upgrading with high % H2O required
H	Decon, No Fuel in Core, H2O medium Up to Header Level, D2O removed	Not Recomm.	No additional D2O req'd Tritiated H2O an issue
I	Decon, No Fuel in Core, H2O medium Up to Header Level, D2O present	Not Recomm.	No additional D2O req'd Upgrading with high % H2O required

An additional consideration is that of flushing either the Primary Heat Transport System (PHTS) or Moderator System with low-Currie D2O prior to undertaking R&FR activities.

- Flushing the PHTS with low Currie D2O is not recommended for any scenario due to impact on schedule, assuming bulk drying of the PHTS is applied.
- Flushing the Moderator with low Currie D2O is not recommended, but should have no impact upon schedule and could be a useful tool for "soaking" out tritium from Moderator metallic components.

Note that condensed D2O product that is removed from both the PHTS and Moderator, during bulk drying, as per recommendations to come in the R&FR study, would need to be processed for upgrading and de-tritiation.

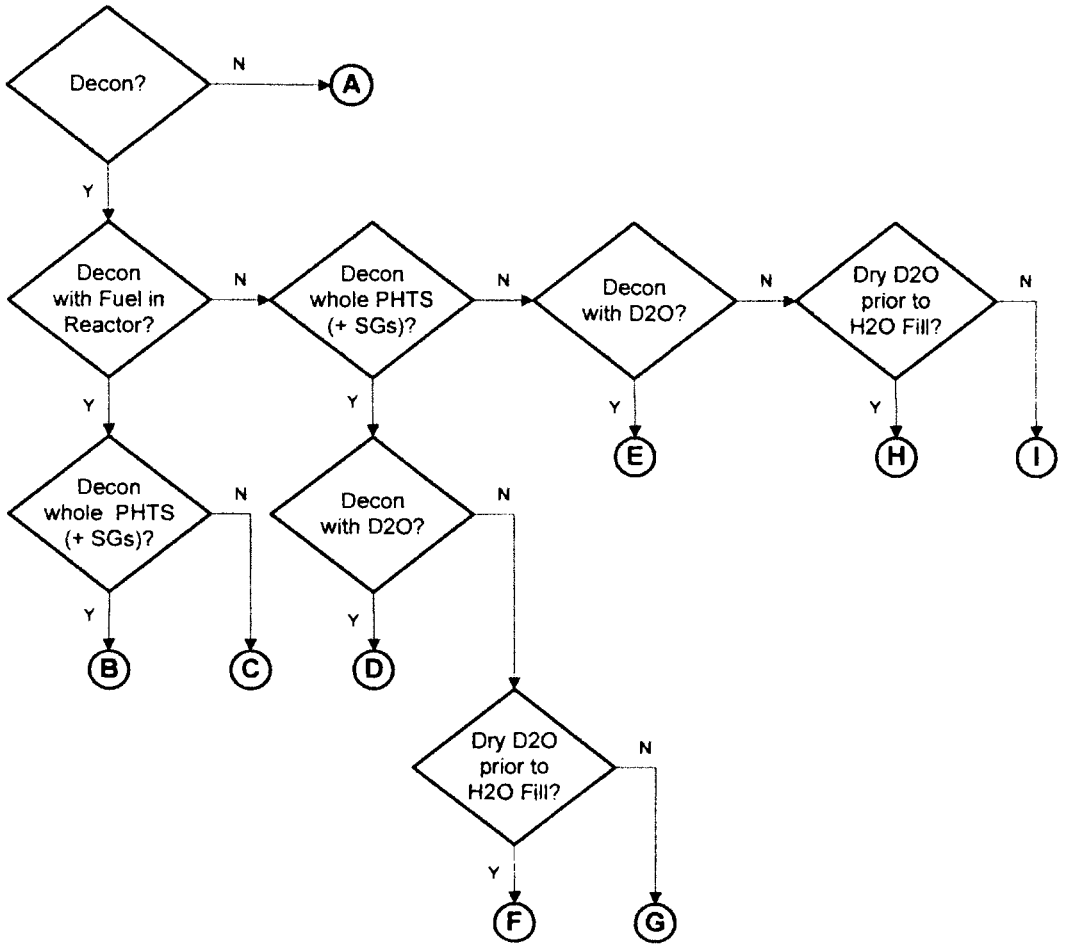
I trust this provides the preliminary assessment that your group requires.

Sincerely,

Graham MacDonald
Manager, Field Services

cc	R. Asadi	OPG
	M. Crawford	GEH-C
	M. Toland	GEH-C

Scenario Map for DNGS PHTS Chemical Decontamination as part of Retube and Feeder Replacement (R&FR)



NOTE: There is no plausible scenario for decon with fuel in core using H2O in the PHTS.

ALL RIGHTS RESERVED. THIS MATERIAL MAY NOT BE USED OR REPRODUCED WITHOUT PRIOR WRITTEN CONSENT OF GE-HITACHI NUCLEAR ENERGY CANADA INC.

HITACHI GE Hitachi Nuclear Energy Canada Inc.

TITLE:	DNGS Retube and Feeder Replcmt. Study PHTS Chemical Decontamination Application Scenario Map
DOC ID:	---
PREPARED:	G. MacDonald
REVIEWED:	---
APPROVED:	---
DATE: 21-Feb-2009	PROJECT: T4756
REV: D000	SHEET: 1 of 1

Appendix D: Meeting Minutes DNGS Refurbishment Decontamination D_2O Storage

Minutes of the meeting:

Subject: D2O Storage requirement for Decontamination during DNGS Refurbishment

Date: March 13, 2009

Participants:

David Kurpjuweit
Rafi Asadi
Stefan Varga
Raju Chander

Context:

D2O Storage for Refurbishment of DNGS needs to be finalized to develop the corporate HWM strategy. Volume of D2O for decontamination is one of the inputs required for determining the quantity of D2O storage during refurbishment. The strategy of decontamination of DNGS has not been finalized yet. Conclusion of this meeting is based on the information obtained from GE and the AECL assessment on Pickering B decontamination.

Conclusions:

1. Moderator system decontamination is not necessary. Hence there is no D2O storage required. There are no alternative options for moderator system decontamination.

2. PHT system decontamination: GE has recommended two options, out of this the preferred option is (A) i.e. – No Decontamination – No D2O storage required. The next preferred option is (E) i.e. – no fuel in core, D2O up to header level - D2O storage required is 120 Cu. M. Third preferred option is (D) i.e. – no fuel in core, PHTS full – D2O storage required is 305 Cu. M.

Minutes prepared by: Raju Chander

Appendix E: DNGS Project # 16-31555 Scope of Work

Important Note: This scope of work is a draft copy only and was not used for Technical Evaluation Packages or bids by the selected vendors.

The original scope of work (incorporated in RFP #2007804) was based on Kinetrics report (ref [18]). Their conceptual study was accepted by OPG as the basis for the design of the new D_2O Storage Facility. The document provides the information required to carry-out the additional storage and drum handling upgrades of the existing D_2O management system.

That original scope of work was supplemented subsequently by the "Clarification #7 – Scope Addition" (incorporated in RFP #2007204)

Original Scope of Work:

- A total of 400 Mg of storage tank capacity made up of 8 x 50Mg tanks shall be provided for segregation of different streams of D_2O. Consideration shall be given to the new "design/build" to ensure maximum flexibility in storing and transferring different grades of D_2O to and forth from reactor units, TRF, Upgrader, etc.
- The new storage tanks shall be designed to tie in to existing control/transfer systems. The current mode of operation shall not be degraded as the result of the new "design/build".
- Level and pressure indications shall be provided for the new D_2O storage tanks, both locally and in the Control Room. Alarms (locally and Control Room) shall be provided to alert operator of abnormality in the storage tanks. The existing control computers in the D_2O Management Building and TRF shall be utilized for any new equipment indicating alarms and control functions.
- Cover gas shall be provided for the storage tanks.
- Isolations and draining shall be provided to isolate/drain any individual tank for maintenance. Double block and bleed arrangements shall be used for isolation between tanks designated for PHT D_2O and Moderator D_2O, interconnecting lines between reactor grade and downgraded D_2O.
- Means of sampling and analyzing of the contents in the tanks shall be provided.
- Venting shall be provided where necessary. The design of the venting system shall maximize the recovery of D_2O and isotope products in order to minimize release to the environment.
- Vacuum Relief devices shall be installed on the tanks to minimize the risk of implosion during emptying
- Based on the Kinectrics report, the new tanks shall be designed to Class 3.
- All tanks shall be assumed to be filled to a maximum of 90% capacity.
- The pit in which the new D_2O storage tanks located shall be seismically qualified with dykes around that would contain the D_2O inventory if the tanks were to fail during a seismic event. This would limit the spill of D_2O to the environment. Beetle alarms shall be provided to alert operator of leaks or spills. The new alarm system shall mirror the existing design for consistency.

- Sufficient storage space for 300 drums, with drum pressure test capabilities shall be provided. A drum requires pressure testing prior to re-use. Consideration shall be given to the new "design/build" to maximize the space available for drum storage and handling. Empty drums may be stacked to maximize the use of space.
- The new "design/build" shall take into consideration the movement of drums between storage and the loading bay to ensure easy access and drum handling. Human factors shall be considered in the new "design/build" to minimize operator efforts in operating and maintaining the facilities. Provision for hoist to lift drum shall be considered.
- Pressure test facility shall be provided to pneumatically test the drum to 90 kPag (13 psig) to ensure the integrity of the drum before re-use. The drum testing shall be located in the vented area to prevent release into the room.
- For high dose areas, proper shielding shall be required.
- Drainage shall be provided in the new building so that spills can be drained to the sumps in the D_2O Management Building.
- There shall be no negative impact to the performance of existing systems as the result of this project.
- The new "design/build" shall take into consideration means to minimize any interruptions to the existing infrastructures and Station operations during construction, installation, commissioning, etc.
- The technical package shall include sufficient descriptions / directions to enable a firm fixed price bid for the EPC contract. The technical package will be reviewed by OPG which may ask for additional supporting drawings and documents.

<u>Additional Scope of Work:</u>

(1) **Drum Emptying Station.**

- Design of a new Drum Emptying Station in the same area as the new Drum Washing/Rinsing Station.
- Basis of design:
  1. Emptying D_2O from the drums to the Dirty Downgraded D_2O Tanks via the existing filtering system.
  2. Incorporate a small pump to pump out the drums during the emptying process instead of using air pressure (existing process).
  3. The estimated capacity shall be 25 drums per shift.

(2) **New IXCU System.**

- Design a new IXCU System with the dual task of supporting the new Drum system and to act as an emergency back up for the existing system
- Basis of design:
  1. Estimated capacity to be 50% of the existing IXCU System.
  2. Shall include its own in-line filter (for quick replacement), charcoal filter and 2 (two) IX with connections to the existing activated charcoal and spent resin tanks, and all the necessary services for the clean-up operation
  3. Shall operate as much independently as possible with the new system, but shall have the flexibility to take over the functions (not operation) of the existing IXCU

system in case of any shut down (emergency or maintenance) of the existing IXCU system.

- It is expected that this new IXCU System together with the associated piping, shielding and maintenance access will reduce some of the drum storage area capacity. The design shall be such as the impact is minimal.

Note: As per Appendix F: the addition of the New IXCU system was excluded from the Scope of Work

(3) **Two of the tanks from the current design submitted shall be split into halves.**

The design work shall be supplemented to include:

- Split 1 Dirty Downgraded D_2O Tank into half.
- Split 1 Clean Downgraded D_2O Tank into half.
- All in and out piping, part of the 2 tanks original design, shall now have a simple split with all required valves.

Appendix F: DNGS Project # 16-31555 Exclusion from Additional Scope of Work

JOK Eric -NUCLEAR (Scope Addition)

From: SULLIVAN Aileen -DARLINGTON
Sent: Monday, March 10, 2008 2:12 PM
To: JOK Eric -NUCLEAR; THAM Stephanie -NUCLEAR; MARTIN Brent -DARLINGTON; WILLIAMS Denny -DARLINGTON; CORNACCHIA Mario -NUCLEAR; FOSTER Charles -NUCLEAR; FUNG Ian -NUCLEAR; VELAYUTHAN Mano -NUCLEAR
Cc: GAINE Dianne -NUCLEAR
Subject: RE: D2O Storage - Scope Addition meeting with Stakeholders.

As actioned below, please move forward with the project including the following scope addition(s)
1) drum emptying station
2) splitting 2 tanks into havles.

As discussed with and confirmed with TRF Ops, please do NOT include the scope addition for the New IXCU system.

Thank You

Aileen Sullivan
TRF Manager, Darlington
ESSB 324, x 1361
cell/pager - 416-526-4381
aileen.sullivan@opg.com

-----Original Message-----
From: JOK Eric -NUCLEAR
Sent: Monday, March 03, 2008 3:09 PM
To: THAM Stephanie -NUCLEAR; SULLIVAN Aileen -DARLINGTON; MARTIN Brent -DARLINGTON; WILLIAMS Denny -DARLINGTON; CORNACCHIA Mario -NUCLEAR; FOSTER Charles -NUCLEAR; FUNG Ian -NUCLEAR; VELAYUTHAN Mano -NUCLEAR
Cc: GAINE Dianne -NUCLEAR
Subject: D2O Storage - Scope Addition meeting with Stakeholders.

The Conference Call meeting was called off at 11:40am due to missing key participants.
However, Aileen Sullivan called Stephanie Tham at 11:45am to re-start the meeting:

Present:
Aileen Sullivan, Brent Martin, Stephanie Tham, Eric Jok.

Objective of meeting:
This meeting was NOT intended to SELECT vendor A or B for the Scope Addition. It was intended for questions and discussions about the Quotes for the Scope Additions and any Schedule Impact from them - so that a management decision can be made to move forward with 1, 2 or all 3 Scope Addition Items.

Scope Addition Quote Update – quotes received on Feb.11, 2008 from both vendors (NSS and Wardrop) regarding:
Scope Addition # 1: Drum Emptying Station
Scope Addition # 2: New IXCU System
Scope Addition # 3: Divide 2 of the tanks into halves.

Discussions:
The Scope Additions, schedule impact and some cost issues were discussed. It was noted that for the vendor with longer schedule impact, OPG overhead cost would have to be added to reflect the total cost, and therefore, reducing the cost gap between the 2 vendors.
The project team will continue the vendor selection process, and the chosen Scope Addition Items will then be added to the Overall Project Scope with the selected vendor.

Based on the Total Project Quote received in late January/2008 from the vendors, the preliminary NPV re-visit has indicated it changes from +4.4M to the -ve zone without the Scope Addition Costs. An exact NPV re-calculation will be conducted later.

Due to the tight timeline of the project, the Scope Addition choices will have to be made by Mar.17, 2008.

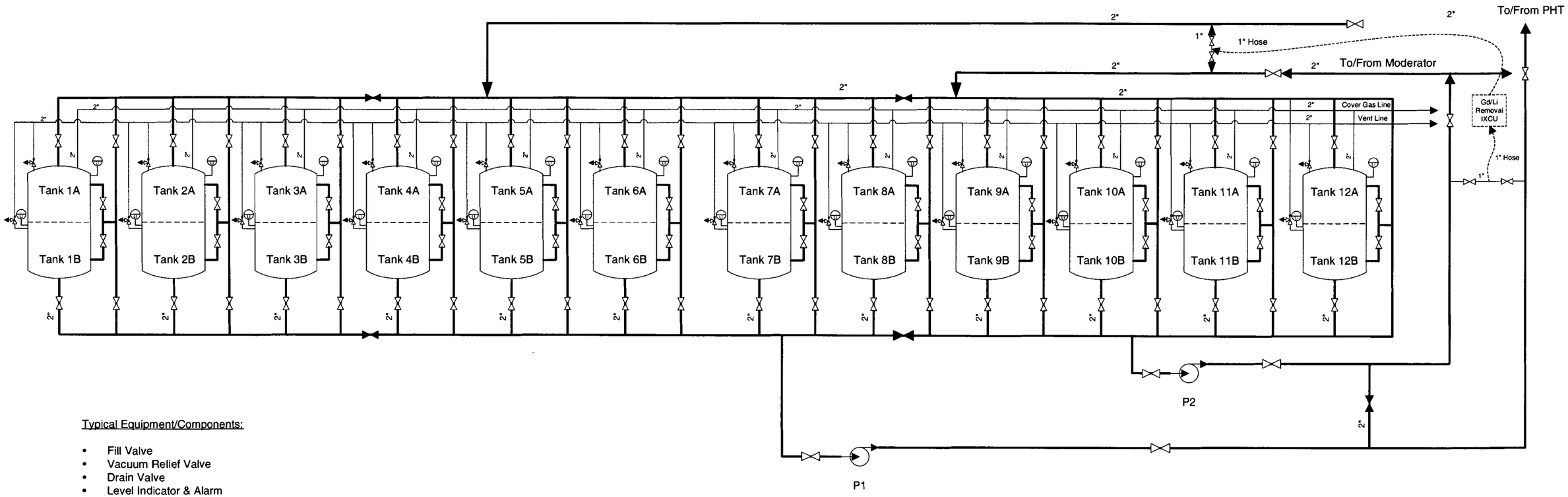
Note: The choice for the Scope Addition Item(s) should not be based on the less price of the 2 vendors, because the

final vendor selected may mean the higher cost for that Item.

Action:
Aileen S. will forward an e-mail to Stephanie T. by Mar.17/2008, indicating which Scope Addition(s) will be chosen to move forward.

Regards,
Eric Jok P.Eng PMP
Design Projects, Proj & Mods
905-839-1151 x8550
Pager 416-442-6612

Appendix G: DNGS Refurbishment D_2O Storage Conceptual Schematic



Typical Equipment/Components:

- Fill Valve
- Vacuum Relief Valve
- Drain Valve
- Level Indicator & Alarm
- PRV on the cover gas air line
- Sampling lines
- Recirculation lines

Figure 2: DNGS Refurbishment D_2O Storage Conceptual Schematic

Appendix H: DNGS Refurbishment D_2O Storage Conceptual Tanks Arrangement Layouts

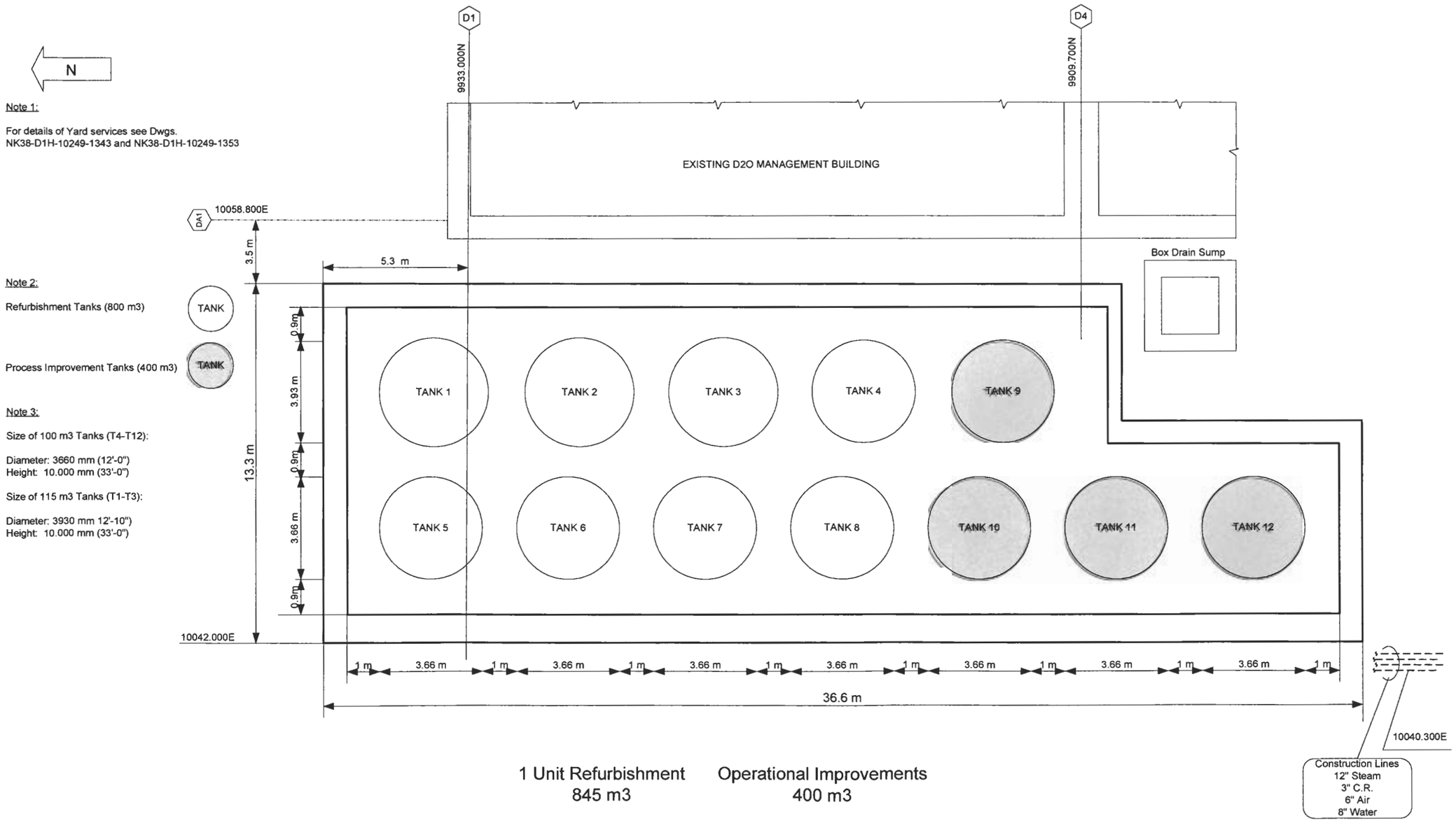


Figure 3: Proposed Conceptual Tanks Arrangement - Layout A

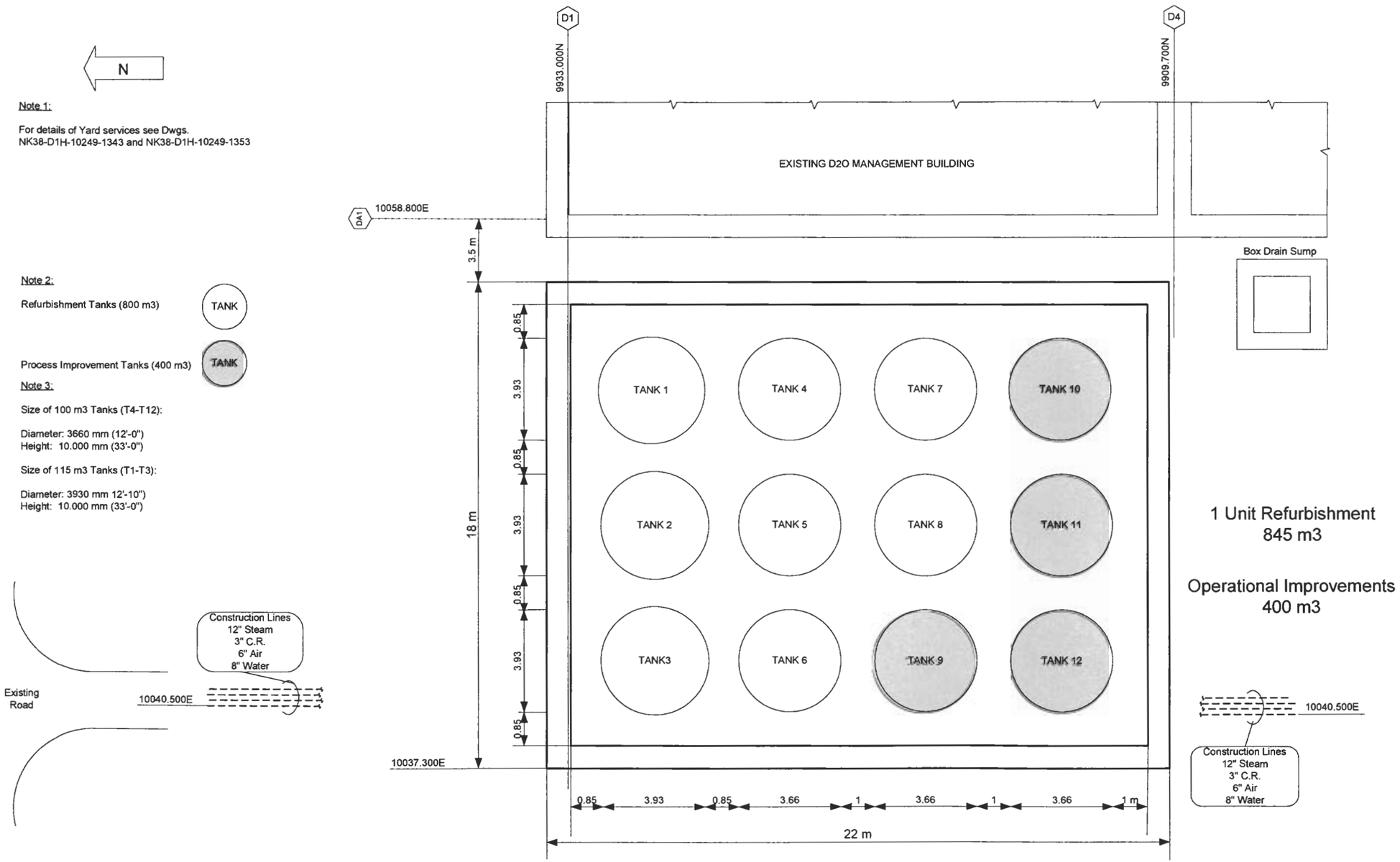


Figure 4: Proposed Conceptual Tanks Arrangement – Layout B

Appendix I: Cost Estimate Details for 400 Mg Storage & Drum Handling Project 31555

Table 1A

ID	Activity Description	LWBS	Planned Start	Planned Finish	Resource	RC	No. FTE	Year	Hours/ Year /FTE	total hours	Rate	SubTotal
P131555715	Long Lead Items 2009	99810	7/30/2009	12/24/2009	ZMATPER	EM_2896 Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2009				3000000
P131555718	Long Lead Items 2010	99810	1/2/2010	5/13/2010	ZMATPER	EM_2896 Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2010				2000000
	Total											5000000

Table 1B

ID	Activity Description	LWBS	Planned Start	Planned Finish	Resource	RC	No. FTE	Year	Hours/ Year /FTE	total hours	Rate	SubTotal
P131555303	Contractor - Installation (tanks)	39930	1/2/2010		ZEXT_G2 External Contractor - Generic 2	EM_2896 Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2010				9000000
	Total											9000000

Table 2A

ID	Activity Description	LWBS	Planned Start	Planned Finish	Resource	RC	No. FTE	Year	Hours/ Year /FTE	total hours	Rate	SubTotal
P131555721	Material - HWMB Addition	99810	7/20/2010	12/24/2010	ZMATPER	EM_2896 Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2010				4000000
P131555721zz	Material - HWMB Addition	99810	7/20/2011	12/24/2011	ZMATPER	EM_2896 Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2011				4000000
P131555712	Material-Issue PO & Delivery- Relocate Servic	99710	4/29/2009	12/24/2009	ZMATPER	EM_2896 Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2009				0
	Total											8000000

Table 2B

ID	Activity Description	LWBS	Planned Start	Planned Finish	Resource	RC	No. FTE	Year	Hours/ Year /FTE	total hours	Rate	SubTotal
P131555472	Installation - HWMB Addition	49811	1/1/2011	10/5/2011	ZEXT_G3 External Contractor - Generic 3	EM_2896 Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2011				9900000
P131555472	Installation - HWMB Addition	49811	1/1/2012	10/5/2012	ZEXT_G3 External Contractor - Generic 3	EM_2896 Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2012				4500000
P131555457	Installation - Relocate Services 2010	49711	9/1/2010	12/24/2010	ZEXT_G3 External Contractor - Generic 3	EM_2896 Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2010				1000000
P131555236	Contract - core samples	29011	11/1/2008	12/15/2008	ZEXT_G4 External Contractor - Generic 4	EM_2896 Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2008				50000
	Total											15450000

Table 3

ID	Activity Description	LWBS	Planned Start	Planned Finish	Resource	RC	No. FTE	Year	Hours/ Year /FTE	total hours	Rate	SubTotal
P131555230	Contract - Detailed Engineering	39930	10/1/2008	12/31/2008	ZEXT_G5 External Contractor - Generic 5	EM_2896 Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2008				500000
P131555303	Contractor - Detailed Engineering	39930	1/2/2009	7/31/2009	ZEXT_G2 External Contractor - Generic 2	EM_2896 Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2009				8000000
	Total											8500000

Table 4 (continuation on next sheet)

ID	Activity Description	LWBS	Planned Start	Planned Finish	Resource		RC		No. FTE	Year	Hours/ Year /FTE	total hours	Rate	SubTotal
LTD06-07	Life to Date 2007 Actuals	19999	12/1/2006	12/31/2007										1564000
P131555012	Project Management 2008 - Str 4	19010	1/3/2008	12/31/2008	BANDG_X	Band G	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	0.1	2008	1600	160	123.7	19792
P131555027	Project Management 2009 - Str 4	19010	1/2/2009	12/31/2009	BANDG_X	Band G	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	0.1	2009	1600	160	128.18	20508.8
P131555037	Project Management 2010 - Str 4	19010	1/2/2010	12/24/2010	BANDG_X	Band G	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	0.1	2010	1600	160	132.66	21225.6
P131555049	Project Management 2011 - Str 4	19010	1/4/2011	12/23/2011	BANDG_X	Band G	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	0.1	2011	1600	160	137.14	21942.4
P131555056	Project Management 2012 - Str 4	19010	1/3/2012	12/22/2012	BANDG_X	Band G	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	0.1	2012	1600	160	141.62	22659.2
P131555014	Work Control 2008 - PMO	19020	1/3/2008	12/31/2008	BANDH_E	Band H - Engineering	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.2	2008	1600	320	95.3	30496
P131555029	Work Control 2009 - PMO	19020	1/2/2009	12/31/2009	BANDH_E	Band H - Engineering	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.2	2009	1600	320	98.76	31603.2
P131555039	Work Control 2010 - PMO	19020	1/2/2010	12/24/2010	BANDH_E	Band H - Engineering	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.2	2010	1600	320	102.22	32710.4
P131555051	Work Control 2011 - PMO	19020	1/4/2011	12/23/2011	BANDH_E	Band H - Engineering	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.2	2011	1600	320	105.68	33817.6
P131555057	Work Control 2012 - PMO	19020	1/3/2012	12/22/2012	BANDH_E	Band H - Engineering	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.2	2012	1600	320	109.14	34924.8
P131555012	Project Management 2008 - PM	19010	1/3/2008	12/31/2008	BANDH_E	Band H - Engineering	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	0.5	2008	1600	800	95.3	76240
P131555027	Project Management 2009 - PM	19010	1/2/2009	12/31/2009	BANDH_E	Band H - Engineering	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	0.5	2009	1600	800	98.76	79008
P131555037	Project Management 2010 - PM	19010	1/2/2010	12/24/2010	BANDH_E	Band H - Engineering	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	0.5	2010	1600	800	102.22	81776
P131555049	Project Management 2011 - PM	19010	1/4/2011	12/23/2011	BANDH_E	Band H - Engineering	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	0.5	2011	1600	800	105.68	84544
P131555056	Project Management 2012 - PM	19010	1/3/2012	12/22/2012	BANDH_E	Band H - Engineering	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	0.5	2012	1600	800	109.14	87312
P131555035	3rd Party Review Budget Cost Estimate	19011	4/1/2008	5/31/2008	ZEXT_HLY	External Contractor - Helyar Es	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2008				50000
P131555035	3rd Party Review Budget Cost Estimate	19011	11/1/2009	12/31/2009	ZEXT_HLY	External Contractor - Helyar Es	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2009				55000
P131555035	3rd Party Fire Protection System Review	19011	3/1/2009	4/30/2009	ZEXT_HLY	External Contractor - Helyar Es	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2009				30000
P131555032	Non Project Specific 2009	19050	1/2/2009	12/31/2009	ZEXPENSE		EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2009				50000
P131555042	Non Project Specific 2010	19050	1/2/2010	12/24/2010	ZEXPENSE		EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2010				195000
P131555016	Training 2008	19070	1/3/2008	12/31/2008	ZEXPENSE		EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2008				10000
P131555031	Training 2009	19070	1/2/2009	12/31/2009	ZEXPENSE		EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2009				20000
P131555041	Training 2010	19070	1/2/2010	12/24/2010	ZEXPENSE		EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2010				62000
P131555053	Training 2011	19070	1/4/2011	12/23/2011	ZEXPENSE		EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2011				33000
P131555054	Non Project Specific 2011	19050	1/4/2011	12/23/2011	ZEXPENSE		EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2011				118000
	Training 2012				ZEXPENSE		EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2012				10000
	Non Project Specific 2012				ZEXPENSE		EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2012				25000
P131555017	Non Project Specific 2008 - Travel	19050	1/3/2008	12/31/2008	ZEXPENSE		EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2008				5000
P131555012	Project Management 2008 - PL	19010	1/3/2008	12/31/2008	ENGOP_E	Nuclear Operations	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	0.5	2008	1600	800	73.93	59144
P131555027	Project Management 2009 - PL	19010	1/2/2009	12/31/2009	ENGOP_E	Nuclear Operations	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2009	1700	1700	77.61	131937
P131555037	Project Management 2010 - PL	19010	1/2/2010	12/24/2010	ENGOP_E	Nuclear Operations	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2010	1800	1800	81.29	146322
P131555049	Project Management 2011 - PL	19010	1/4/2011	12/23/2011	ENGOP_E	Nuclear Operations	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2011	1800	1800	84.97	152946
P131555056	Project Management 2012 - PL	19010	1/3/2012	12/22/2012	ENGOP_E	Nuclear Operations	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2012	1800	1800	88.65	159570
P131555014	Work Control 2008 - CSA	19020	1/3/2008	12/31/2008	PPCSA_B	Analyst - Cost/Schedule	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.33	2008	1600	528	76.2	40233.6
P131555029	Work Control 2009 - CSA	19020	1/2/2009	12/31/2009	PPCSA_B	Analyst - Cost/Schedule	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.33	2009	1600	528	79.97	42224.16
P131555039	Work Control 2010 - CSA	19020	1/2/2010	12/24/2010	PPCSA_B	Analyst - Cost/Schedule	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.33	2010	1600	528	83.74	44214.72
P131555051	Work Control 2011 - CSA	19020	1/4/2011	12/23/2011	PPCSA_B	Analyst - Cost/Schedule	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.33	2011	1600	528	87.51	46205.28
P131555057	Work Control 2012 - CSA	19020	1/3/2012	12/22/2012	PPCSA_B	Analyst - Cost/Schedule	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.33	2012	1600	528	91.28	48195.84
P131555014	Work Control 2008 - other support	19020	1/3/2008	12/31/2008	PPCST_T	Tech Cost/Schedule	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.1	2008	1600	160	61.17	9787.2
P131555029	Work Control 2009 - other support	19020	1/2/2009	12/31/2009	PPCST_T	Tech Cost/Schedule	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.1	2009	1600	160	64.01	10241.6
P131555039	Work Control 2010 - other support	19020	1/2/2010	12/24/2010	PPCST_T	Tech Cost/Schedule	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.1	2010	1600	160	66.85	10696
P131555051	Work Control 2011 - other support	19020	1/4/2011	12/23/2011	PPCST_T	Tech Cost/Schedule	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.1	2011	1600	160	69.69	11150.4
P131555057	Work Control 2012 - other support	19020	1/3/2012	12/22/2012	PPCST_T	Tech Cost/Schedule	EM_2894	Eng & Mods-Mods-Proj Mgmt Office	0.1	2012	1600	160	72.53	11604.8
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2011	150	150	84.97	12745.5
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2012	350	350	88.65	31027.5
P131555603	Design ECs Close Out- Relocate Services	89710	2/23/2012	8/30/2012	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2012	100	100	88.65	8865

Table 4 (continuation from previous sheet)

P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2009	500	500	77.61	38805
P131555400	Work Planning RS	49710			ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2010	800	800	81.29	65032
P131555418	Work Planning HWMB Addition	49810			ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2010	800	800	81.29	65032
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2010	400	400	81.29	32516
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2011	1100	1100	84.97	93467
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2011	2200	2200	84.97	186934
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2012	550	550	88.65	48757.5
P131555615	Design ECs Close Out- HWMB Addition 2012	89810	1/3/2012	5/26/2012	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2012	400	400	88.65	35460
P131555013	Project Engineering 2008 - MTL	19010	1/3/2008	12/31/2008	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2008	1600	1600	73.93	118288
P131555013	Project Engineering 2008 - Proj Eng	19030	1/3/2008	12/31/2008	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	0.5	2008	1600	800	73.93	59144
P131555027	Project Management 2009 - MTL	19010	1/2/2009	12/31/2009	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2009	1700	1700	77.61	131937
P131555028	Project Engineering 2009 - Proj Eng	19030	1/2/2009	12/31/2009	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2009	1700	1700	77.61	131937
P131555037	Project Management 2010 - MTL	19010	1/2/2010	12/24/2010	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2010	1800	1800	81.29	146322
P131555038	Project Engineering 2010 - Proj Eng	19030	1/2/2010	12/24/2010	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2010	1800	1800	81.29	146322
P131555049	Project Management 2011 - MTL	19010	1/4/2011	12/23/2011	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2011	1800	1800	84.97	152946
P131555050	Project Engineering 2011 - Proj Eng	19030	1/4/2011	12/23/2011	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2011	1800	1800	84.97	152946
P131555056	Project Management 2012 - MTL	19010	1/3/2012	12/22/2012	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2012	1800	1800	88.65	159570
P131555056	Project Engineering 2012 - Proj Eng	19030	1/3/2012	12/22/2012	ENGPE_E	Project Engineer	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2012	1800	1800	88.65	159570
P131555206	Engineering Support - DTL	29000	1/3/2008	12/31/2008	ENGPE_E	Project Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	0.4	2008	1600	640	73.93	47315.2
P131555206	Engineering Support - Civil	29000	11/1/2008	12/15/2008	ENGPE_E	Project Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2008	100	100	73.93	7393
	Total													5862364.3

Table 5 (continuation on next 4 sheets)

ID	Activity Description	LWBS	Planned Start	Planned Finish	Resource		RC		No. FTE	Year	Hours/ Year /FTE	total hours	Rate	SubTotal
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	BANDH_E	Band H - Engineering	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2011	20	20	105.68	2113.6
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	BANDH_E	Band H - Engineering	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2012	40	40	109.14	4365.6
P131555603	Design ECs Close Out- Relocate Services	89710	2/23/2012	8/30/2012	BANDH_E	Band H - Engineering	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2012	40	40	109.14	4365.6
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	BANDH_E	Band H - Engineering	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2009	40	40	98.76	3950.4
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	BANDH_E	Band H - Engineering	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2010	50	50	102.22	5111
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	BANDH_E	Band H - Engineering	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2011	25	25	105.68	2642
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	BANDH_E	Band H - Engineering	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2011	50	50	105.68	5284
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	BANDH_E	Band H - Engineering	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2012	20	20	109.14	2182.8
P131555615	Design ECs Close Out- HWMB Addition 2012	89810	1/3/2012	5/26/2012	BANDH_E	Band H - Engineering	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2012	50	50	109.14	5457
P131555206	Engineering Support - Design SM	29000	1/3/2008	12/31/2008	BANDH_E	Band H - Engineering	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	0.2	2008	1600	320	95.3	30496
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	BANDH_E	Band H - Engineering	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2011	20	20	105.68	2113.6
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	BANDH_E	Band H - Engineering	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2012	40	40	109.14	4365.6
P131555603	Design ECs Close Out- Relocate Services	89710	2/23/2012	8/30/2012	BANDH_E	Band H - Engineering	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2012	40	40	109.14	4365.6
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	BANDH_E	Band H - Engineering	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2009	40	40	98.76	3950.4
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	BANDH_E	Band H - Engineering	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2010	50	50	102.22	5111
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	BANDH_E	Band H - Engineering	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2011	25	25	105.68	2642
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	BANDH_E	Band H - Engineering	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2011	50	50	105.68	5284
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	BANDH_E	Band H - Engineering	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2012	20	20	109.14	2182.8
P131555615	Design ECs Close Out- HWMB Addition 2012	89810	1/3/2012	5/26/2012	BANDH_E	Band H - Engineering	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2012	50	50	109.14	5457
P131555206	Engineering Support - Elec	29000	11/1/2008	12/15/2008	BANDH_E	Band H - Engineering	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2008	100	100	95.3	9530
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	BANDH_E	Band H - Engineering	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2011	20	20	105.68	2113.6

Table 5 (continuation 1 from previous sheet)

P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	BANDH_E	Band H - Engineering	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2012	40	40	109.14	4365.6
P131555603	Design ECs Close Out- Relocate Services	89710	2/23/2012	8/30/2012	BANDH_E	Band H - Engineering	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2012	40	40	109.14	4365.6
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	BANDH_E	Band H - Engineering	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2009	40	40	98.76	3950.4
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	BANDH_E	Band H - Engineering	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2010	50	50	102.22	5111
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	BANDH_E	Band H - Engineering	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2011	25	25	105.68	2642
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	BANDH_E	Band H - Engineering	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2011	50	50	105.68	5284
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	BANDH_E	Band H - Engineering	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2012	20	20	109.14	2182.8
P131555615	Design ECs Close Out- HWMB Addition 2012	89810	1/3/2012	5/26/2012	BANDH_E	Band H - Engineering	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2012	50	50	109.14	5457
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	CTCCM_T	Contract Monitor	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2011	150	150	55.79	8368.5
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	CTCCM_T	Contract Monitor	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2012	350	350	58.06	20321
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	CTCCM_T	Contract Monitor	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2009	80	80	51.25	4100
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	CTCCM_T	Contract Monitor	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2011	600	600	55.79	33474
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	CTCCM_T	Contract Monitor	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2011	2300	2300	55.79	128317
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	CTCCM_T	Contract Monitor	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2012	600	600	58.06	34836
P131555206	Engineering Support - PE	29000	11/1/2008	12/15/2008	CTCCM_T	Contract Monitor	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2008	80	80	48.98	3918.4
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	CTCVL_T	Construction Tech Civil	EM_2891	Eng & Mods-Mods-Field Engineering	1	2011	50	50	73.56	3678
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	CTCVL_T	Construction Tech Civil	EM_2891	Eng & Mods-Mods-Field Engineering	1	2012	100	100	76.55	7655
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	CTCVL_T	Construction Tech Civil	EM_2891	Eng & Mods-Mods-Field Engineering	1	2009	50	50	67.58	3379
P131555400	Work Planning RS	49710			CTCVL_T	Construction Tech Civil	EM_2891	Eng & Mods-Mods-Field Engineering	1	2010	120	120	70.57	8468.4
P131555418	Work Planning HWMB Addition	49810			CTCVL_T	Construction Tech Civil	EM_2891	Eng & Mods-Mods-Field Engineering	1	2010	120	120	70.57	8468.4
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	CTCVL_T	Construction Tech Civil	EM_2891	Eng & Mods-Mods-Field Engineering	1	2010	350	350	70.57	24699.5
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	CTCVL_T	Construction Tech Civil	EM_2891	Eng & Mods-Mods-Field Engineering	1	2011	500	500	73.56	36780
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	CTCVL_T	Construction Tech Civil	EM_2891	Eng & Mods-Mods-Field Engineering	1	2011	1000	1000	73.56	73560
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	CTCVL_T	Construction Tech Civil	EM_2891	Eng & Mods-Mods-Field Engineering	1	2012	300	300	76.55	22965
P131555206	Engineering Support - FE	29000	11/1/2008	12/15/2008	CTCVL_T	Construction Tech Civil	EM_2891	Eng & Mods-Mods-Field Engineering	1	2008	160	160	64.59	10334.4
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	CTELC_T	Construction Tech EC	EM_2891	Eng & Mods-Mods-Field Engineering	1	2011	50	50	73.56	3678
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	CTELC_T	Construction Tech EC	EM_2891	Eng & Mods-Mods-Field Engineering	1	2012	100	100	76.55	7655
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	CTELC_T	Construction Tech EC	EM_2891	Eng & Mods-Mods-Field Engineering	1	2009	50	50	67.58	3379
P131555400	Work Planning RS	49710			CTELC_T	Construction Tech EC	EM_2891	Eng & Mods-Mods-Field Engineering	1	2010	120	120	70.57	8468.4
P131555418	Work Planning HWMB Addition	49810			CTELC_T	Construction Tech EC	EM_2891	Eng & Mods-Mods-Field Engineering	1	2010	120	120	70.57	8468.4
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	CTELC_T	Construction Tech EC	EM_2891	Eng & Mods-Mods-Field Engineering	1	2010	175	175	70.57	12349.75
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	CTELC_T	Construction Tech EC	EM_2891	Eng & Mods-Mods-Field Engineering	1	2011	500	500	73.56	36780
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	CTELC_T	Construction Tech EC	EM_2891	Eng & Mods-Mods-Field Engineering	1	2011	1000	1000	73.56	73560
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	CTELC_T	Construction Tech EC	EM_2891	Eng & Mods-Mods-Field Engineering	1	2012	300	300	76.55	22965
P131555206	Engineering Support - FE	29000	11/1/2008	12/15/2008	CTELC_T	Construction Tech EC	EM_2891	Eng & Mods-Mods-Field Engineering	1	2008	160	160	64.59	10334.4
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	CTMEC_T	Construction Tech Mechan	EM_2891	Eng & Mods-Mods-Field Engineering	1	2011	100	100	73.56	7356
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	CTMEC_T	Construction Tech Mechan	EM_2891	Eng & Mods-Mods-Field Engineering	1	2012	150	150	76.55	11482.5
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	CTMEC_T	Construction Tech Mechan	EM_2891	Eng & Mods-Mods-Field Engineering	1	2009	50	50	67.58	3379
P131555400	Work Planning RS	49710			CTMEC_T	Construction Tech Mechan	EM_2891	Eng & Mods-Mods-Field Engineering	1	2010	120	120	70.57	8468.4
P131555418	Work Planning HWMB Addition	49810			CTMEC_T	Construction Tech Mechan	EM_2891	Eng & Mods-Mods-Field Engineering	1	2010	120	120	70.57	8468.4
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	CTMEC_T	Construction Tech Mechan	EM_2891	Eng & Mods-Mods-Field Engineering	1	2010	175	175	70.57	12349.75
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	CTMEC_T	Construction Tech Mechan	EM_2891	Eng & Mods-Mods-Field Engineering	1	2011	500	500	73.56	36780
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	CTMEC_T	Construction Tech Mechan	EM_2891	Eng & Mods-Mods-Field Engineering	1	2011	1000	1000	73.56	73560
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	CTMEC_T	Construction Tech Mechan	EM_2891	Eng & Mods-Mods-Field Engineering	1	2012	300	300	76.55	22965
P131555206	Engineering Support - FE	29000	11/1/2008	12/15/2008	CTMEC_T	Construction Tech Mechan	EM_2891	Eng & Mods-Mods-Field Engineering	1	2008	160	160	64.59	10334.4
P131555603	Design ECs Close Out- Relocate Services	89710	2/23/2012	8/30/2012	DTCVL_T	Drafting Civil	DA_2644	DA-Drawing office	1	2012	800	800	70.87	56696
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	DTCVL_T	Drafting Civil	DA_2644	DA-Drawing office	1	2009	60	60	62.56	3753.6
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	DTCVL_T	Drafting Civil	DA_2644	DA-Drawing office	1	2010	288	288	65.33	18815.04
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	DTCVL_T	Drafting Civil	DA_2644	DA-Drawing office	1	2011	100	100	68.1	6810

Table 5 (continuation 2 from previous sheet)

P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	DTCVL_T	Drafting Civil	DA_2644	DA-Drawing office	1	2011	200	200	68.1	13620
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	DTCVL_T	Drafting Civil	DA_2644	DA-Drawing office	1	2012	0	0	70.87	0
P131555615	Design ECs Close Out- HWMB Addition 2012	89810	1/3/2012	5/26/2012	DTCVL_T	Drafting Civil	DA_2644	DA-Drawing office	1	2012	700	700	70.87	49609
P131555206	Engineering Support	29000	11/1/2008	12/15/2008	DTCVL_T	Drafting Civil	DA_2644	DA-Drawing office	1	2008	20	20	59.79	1195.8
P131555603	Design ECs Close Out- Relocate Services	89710	2/23/2012	8/30/2012	DTELC_T	Drafting Electrical	DA_2644	DA-Drawing office	1	2012	800	800	70.87	56696
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	DTELC_T	Drafting Electrical	DA_2644	DA-Drawing office	1	2009	60	60	62.56	3753.6
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	DTELC_T	Drafting Electrical	DA_2644	DA-Drawing office	1	2010	288	288	65.33	18815.04
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	DTELC_T	Drafting Electrical	DA_2644	DA-Drawing office	1	2011	100	100	68.1	6810
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	DTELC_T	Drafting Electrical	DA_2644	DA-Drawing office	1	2011	200	200	68.1	13620
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	DTELC_T	Drafting Electrical	DA_2644	DA-Drawing office	1	2012	0	0	70.87	0
P131555615	Design ECs Close Out- HWMB Addition 2012	89810	1/3/2012	5/26/2012	DTELC_T	Drafting Electrical	DA_2644	DA-Drawing office	1	2012	700	700	70.87	49609
P131555206	Engineering Support	29000	11/1/2008	12/15/2008	DTELC_T	Drafting Electrical	DA_2644	DA-Drawing office	1	2008	20	20	59.79	1195.8
P131555603	Design ECs Close Out- Relocate Services	89710	2/23/2012	8/30/2012	DTMEC_T	Drafting Mechanical	DA_2644	DA-Drawing office	1	2012	800	800	70.87	56696
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	DTMEC_T	Drafting Mechanical	DA_2644	DA-Drawing office	1	2009	60	60	62.56	3753.6
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	DTMEC_T	Drafting Mechanical	DA_2644	DA-Drawing office	1	2010	288	288	65.33	18815.04
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	DTMEC_T	Drafting Mechanical	DA_2644	DA-Drawing office	1	2011	100	100	68.1	6810
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	DTMEC_T	Drafting Mechanical	DA_2644	DA-Drawing office	1	2011	200	200	68.1	13620
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	DTMEC_T	Drafting Mechanical	DA_2644	DA-Drawing office	1	2012	0	0	70.87	0
P131555615	Design ECs Close Out- HWMB Addition 2012	89810	1/3/2012	5/26/2012	DTMEC_T	Drafting Mechanical	DA_2644	DA-Drawing office	1	2012	700	700	70.87	49609
P131555206	Engineering Support	29000	11/1/2008	12/15/2008	DTMEC_T	Drafting Mechanical	DA_2644	DA-Drawing office	1	2008	20	20	59.79	1195.8
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	ENCVL_E	Civil Engineer	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2011	20	20	84.97	1699.4
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	ENCVL_E	Civil Engineer	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2012	40	40	88.65	3546
P131555603	Design ECs Close Out- Relocate Services	89710	2/23/2012	8/30/2012	ENCVL_E	Civil Engineer	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2012	400	400	88.65	35460
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	ENCVL_E	Civil Engineer	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2009	250	250	77.61	19402.5
P131555400	Work Planning RS	49710			ENCVL_E	Civil Engineer	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2010	120	120	81.29	9754.8
P131555418	Work Planning HWMB Addition	49810			ENCVL_E	Civil Engineer	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2010	120	120	81.29	9754.8
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	ENCVL_E	Civil Engineer	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2010	380	380	81.29	30890.2
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	ENCVL_E	Civil Engineer	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2011	175	175	84.97	14869.75
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	ENCVL_E	Civil Engineer	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2011	350	350	84.97	29739.5
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	ENCVL_E	Civil Engineer	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2012	100	100	88.65	8865
P131555615	Design ECs Close Out- HWMB Addition 2012	89810	1/3/2012	5/26/2012	ENCVL_E	Civil Engineer	EV_1880	Eng & Mods-Eng Srvs-Eng'g Mechanics	1	2012	450	450	88.65	39892.5
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	ENELC_E	Electrical Engineer	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2011	20	20	84.97	1699.4
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	ENELC_E	Electrical Engineer	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2012	40	40	88.65	3546
P131555603	Design ECs Close Out- Relocate Services	89710	2/23/2012	8/30/2012	ENELC_E	Electrical Engineer	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2012	400	400	88.65	35460
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	ENELC_E	Electrical Engineer	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2009	250	250	77.61	19402.5
P131555400	Work Planning RS	49710			ENELC_E	Electrical Engineer	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2010	120	120	81.29	9754.8
P131555418	Work Planning HWMB Addition	49810			ENELC_E	Electrical Engineer	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2010	120	120	81.29	9754.8
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	ENELC_E	Electrical Engineer	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2010	380	380	81.29	30890.2
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	ENELC_E	Electrical Engineer	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2011	175	175	84.97	14869.75
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	ENELC_E	Electrical Engineer	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2011	350	350	84.97	29739.5
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	ENELC_E	Electrical Engineer	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2012	100	100	88.65	8865
P131555615	Design ECs Close Out- HWMB Addition 2012	89810	1/3/2012	5/26/2012	ENELC_E	Electrical Engineer	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2012	450	450	88.65	39892.5
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	ENINC_E	Instrumentation/Control Eng	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2009	250	250	77.61	19402.5
P131555400	Work Planning RS	49710			ENINC_E	Instrumentation/Control Eng	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2010	120	120	81.29	9754.8
P131555418	Work Planning HWMB Addition	49810			ENINC_E	Instrumentation/Control Eng	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2010	120	120	81.29	9754.8
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	ENINC_E	Instrumentation/Control Eng	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2010	380	380	81.29	30890.2
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	ENINC_E	Instrumentation/Control Eng	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2011	20	20	84.97	1699.4
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	ENINC_E	Instrumentation/Control Eng	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2012	40	40	88.65	3546

Table 5 (continuation 3 from previous sheet)

P131555603	Design ECs Close Out- Relocate Services	89710	2/23/2012	8/30/2012	ENINC_E	Instrumentation/Control Eng	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2012	400	400	88.65	35460
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	ENINC_E	Instrumentation/Control Eng	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2011	175	175	84.97	14869.75
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	ENINC_E	Instrumentation/Control Eng	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2011	350	350	84.97	29739.5
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	ENINC_E	Instrumentation/Control Eng	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2012	100	100	88.65	8865
P131555615	Design ECs Close Out- HWMB Addition 2012	89810	1/3/2012	5/26/2012	ENINC_E	Instrumentation/Control Eng	EV_1870	Eng & Mods-Eng Srvs-Elect & Inst Design	1	2012	450	450	88.65	39892.5
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	ENMEC_E	Mechanical Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2011	150	150	84.97	12745.5
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	ENMEC_E	Mechanical Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2012	350	350	88.65	31027.5
P131555603	Design ECs Close Out- Relocate Services	89710	2/23/2012	8/30/2012	ENMEC_E	Mechanical Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2012	400	400	88.65	35460
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	ENMEC_E	Mechanical Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2009	1100	1100	77.61	85371
P131555400	Work Planning RS	49710			ENMEC_E	Mechanical Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2010	120	120	81.29	9754.8
P131555418	Work Planning HWMB Addition	49810			ENMEC_E	Mechanical Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2010	120	120	81.29	9754.8
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	ENMEC_E	Mechanical Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2010	770	770	81.29	62593.3
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	ENMEC_E	Mechanical Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2011	600	600	84.97	50982
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	ENMEC_E	Mechanical Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2011	1200	1200	84.97	101964
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	ENMEC_E	Mechanical Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2012	300	300	88.65	26595
P131555615	Design ECs Close Out- HWMB Addition 2012	89810	1/3/2012	5/26/2012	ENMEC_E	Mechanical Engineer	EV_1860	Eng & Mods-Eng Srvs-Mechanical Design	1	2012	450	450	88.65	39892.5
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	ENMUL_E	Multi-Discipline Eng	DA_2681	DA-Chem/TRF Technical	1	2011	70	70	84.97	5947.9
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	ENMUL_E	Multi-Discipline Eng	DA_2681	DA-Chem/TRF Technical	1	2012	150	150	88.65	13297.5
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	ENMUL_E	Multi-Discipline Eng	DA_2681	DA-Chem/TRF Technical	1	2009	250	250	77.61	19402.5
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	ENMUL_E	Multi-Discipline Eng	DA_2681	DA-Chem/TRF Technical	1	2010	380	380	81.29	30890.2
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	ENMUL_E	Multi-Discipline Eng	DA_2681	DA-Chem/TRF Technical	1	2011	200	200	84.97	16994
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	ENMUL_E	Multi-Discipline Eng	DA_2681	DA-Chem/TRF Technical	1	2011	400	400	84.97	33988
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	ENMUL_E	Multi-Discipline Eng	DA_2681	DA-Chem/TRF Technical	1	2012	100	100	88.65	8865
P131555206	Engineering Support	29000	11/1/2008	12/15/2008	ENMUL_E	Multi-Discipline Eng	DA_2681	DA-Chem/TRF Technical	1	2008	160	160	73.93	11828.8
P131555206	Engineering Support	29000	11/1/2008	12/15/2008	ENMUL_E	Multi-Discipline Eng	DA_2631	DA-Perf Eng'g Primary Sys	1	2008	70	70	73.93	5175.1
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	MCONF_M	FLMA Control	DA_2682	DA-Chem/TRF Operations	1	2011	180	180	71.15	12807
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	MCONF_M	FLMA Control	DA_2682	DA-Chem/TRF Operations	1	2012	350	350	74.05	25917.5
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	MCONT_M	Maintainer Control	DA_2682	DA-Chem/TRF Operations	1	2011	180	180	71.15	12807
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	MCONT_M	Maintainer Control	DA_2682	DA-Chem/TRF Operations	1	2012	350	350	74.05	25917.5
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	MMECF_M	FLMA Mechanical	DA_2682	DA-Chem/TRF Operations	1	2011	375	375	71.67	26876.25
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	MMECF_M	FLMA Mechanical	DA_2682	DA-Chem/TRF Operations	1	2012	725	725	74.59	54077.75
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	MMECF_M	FLMA Mechanical	DA_2682	DA-Chem/TRF Operations	1	2011	200	200	71.67	14334
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	MMECF_M	FLMA Mechanical	DA_2682	DA-Chem/TRF Operations	1	2011	400	400	71.67	28668
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	MMECF_M	FLMA Mechanical	DA_2682	DA-Chem/TRF Operations	1	2012	100	100	74.59	7459
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	MSCVF_M	FLMA Civil	DA_2682	DA-Chem/TRF Operations	1	2011	180	180	57.8	10404
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	MSCVF_M	FLMA Civil	DA_2682	DA-Chem/TRF Operations	1	2012	350	350	60.15	21052.5
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	MSCVF_M	FLMA Civil	DA_2682	DA-Chem/TRF Operations	1	2011	200	200	57.8	11560
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	MSCVF_M	FLMA Civil	DA_2682	DA-Chem/TRF Operations	1	2011	400	400	57.8	23120
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	MSCVF_M	FLMA Civil	DA_2682	DA-Chem/TRF Operations	1	2012	100	100	60.15	6015
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	NMODF_N	FLM Modifications	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2011	150	150	92.51	13876.5
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	NMODF_N	FLM Modifications	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2012	350	350	96.49	33771.5
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	NMODF_N	FLM Modifications	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2009	125	125	84.55	10568.75
P131555400	Work Planning RS	49710			NMODF_N	FLM Modifications	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2010	120	120	88.53	10623.6
P131555418	Work Planning HWMB Addition	49810			NMODF_N	FLM Modifications	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2010	120	120	88.53	10623.6
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	NMODF_N	FLM Modifications	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2010	175	175	88.53	15492.75
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	NMODF_N	FLM Modifications	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2011	600	600	92.51	55506
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	NMODF_N	FLM Modifications	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2011	1200	1200	92.51	111012
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	NMODF_N	FLM Modifications	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2012	300	300	96.49	28947

Table 5 (continuation 4 from previous sheet)

P131555206	Engineering Support - CMO	29000	11/1/2008	12/15/2008	NMODF_N	FLM Modifications	EM_2898	Eng & Mods-Mods-Trades Darlington	1	2008	80	80	80.57	6445.6
P131555503	Commissioning Support Common	59000	10/1/2011	12/31/2011	OPNUC_O	Operator Nuclear	DA_2682	DA-Chem/TRF Operations	1	2011	120	120	70.65	8478
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	OPNUC_O	Operator Nuclear	DA_2682	DA-Chem/TRF Operations	1	2012	250	250	73.52	18380
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	OPNUC_O	Operator Nuclear	DA_2682	DA-Chem/TRF Operations	1	2009	40	40	64.91	2596.4
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	OPNUC_O	Operator Nuclear	DA_2682	DA-Chem/TRF Operations	1	2010	40	40	67.78	2711.2
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	OPNUC_O	Operator Nuclear	DA_2682	DA-Chem/TRF Operations	1	2011	200	200	70.65	14130
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	OPNUC_O	Operator Nuclear	DA_2682	DA-Chem/TRF Operations	1	2011	400	400	70.65	28260
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	OPNUC_O	Operator Nuclear	DA_2682	DA-Chem/TRF Operations	1	2012	100	100	73.52	7352
P131555206	Engineering Support	29000	11/1/2008	12/15/2008	OPNUC_O	Operator Nuclear	DA_2682	DA-Chem/TRF Operations	1	2008	160	160	62.04	9926.4
P131555503	Commissioning Support Common	59000	6/1/2012	11/24/2012	RADTN_T	Tech Radiation	DA_3152	DA-Rad Safety Materials	1	2012	80	80	65.14	5211.2
P131555309	Engineering Support Common 2009	39930	1/3/2009	12/24/2009	RADTN_T	Tech Radiation	DA_3152	DA-Rad Safety Materials	1	2009	40	40	57.52	2300.8
P131555309	Engineering Support Common 2010	39930	1/3/2010	6/30/2010	RADTN_T	Tech Radiation	DA_3152	DA-Rad Safety Materials	1	2010	40	40	60.06	2402.4
P131555412	Installation Support Common RS 2011	49000	1/2/2011	12/24/2011	RADTN_T	Tech Radiation	DA_3152	DA-Rad Safety Materials	1	2011	500	500	62.6	31300
P131555469	Installation Support Common 2011	49000	1/4/2011	12/23/2011	RADTN_T	Tech Radiation	DA_3152	DA-Rad Safety Materials	1	2011	1000	1000	62.6	62600
P131555469	Installation Support Common 2012	49000	1/4/2012	12/23/2012	RADTN_T	Tech Radiation	DA_3152	DA-Rad Safety Materials	1	2012	300	300	65.14	19542
P131555206	Engineering Support	29000	11/1/2008	12/15/2008	RADTN_T	Tech Radiation	DA_3152	DA-Rad Safety Materials	1	2008	80	80	54.98	4398.4
P131555512	Commissioing - HWMB	59810			ZEXT_G4	External Contractor - Generi	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2012				300000
P131555500	Commissioing - Relocate Services	59710			ZEXT_G4	External Contractor - Generi	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2011				100000
P131555610	Contract Design EC Close-out HWMB 2012	89810			ZEXT_G5	External Contractor - Generi	EM_2896	Eng & Mods-Mods-Dsgn Proj Crit Equip	1	2012				200000
	Total													4035668.67

Appendix J: Refurbishment Upgrading and Tritium Removal Cost Estimate

Tritium Removal										
	Average Actual [Ci/kg]	Target [Ci/kg]		Cost $/Mg	Volume [Mg]			Total Cost [$/unit]		
		ALARA	Realistic		ALARA (Low Risk)	Realistic (Medium Risk)	High Risk	Low	Med	High
PHT*	**1**	0.7	0.9	$25,000	273	91	0	$0	$0*	$0*
Moderator	**10**	1.0	2.0	$25,000	329	292	0	$0	$7,311,828	$8,225,806
Decontamination				$25,000	0	0	0	$0	$0	$0
							Tritium Removal Cost for one unit	$0	$7,311,828	$8,225,806
							Tritium Removal Total 4 Units	**$0**	**$29,247,312**	**$32,903,224**

Upgrading									
	Actual Isotopic [Mass %D_2O]	Target Isotopic [Mass %D_2O]	Cost $/Mg	Volume [Mg]			Total Cost [$/unit]		
				Low Risk	Medium Risk	High Risk	Low	Med	High
PHT	95	99.96	$1,050	273	137	0	$0	$143,850	$286,650
Moderator*	99.9	99.98	$1,000	340	170	0	$0	$0*	$0*
Decontamination	60	99.98	$2,000	350	150	0	$0	$300,000	$700,000
						Upgrading Cost for one unit	$0	$443,850	$986,650
						Upgrading Total 4 Units	**$0**	**$1,775,400**	**$3,946,600**

Tritium Removal & Upgrading Total	**$0**	**$31,022,712**	**$36,849,824**

*Assumptions: 1. PHT D_2O does not require detritiation;
2. Moderator D_2O does not require upgrading

Reference List

[1] NK38-SR-03500-10001... Darlington Safety Report - Part 1: Plant/site Description And Part 2: Design Description

[2] NK38-OPP-03600 ..... Operating Policies And Principles

[3] NK30-OPP-03600 ..... Operating Policies And Principles (PB)

[4] NK38-DG-03650.2B.... Nuclear Safety Design Guide – Common Mode Incidents - Seismic Design

[5] NK38-REP-D1274014..... Darlington GS A Heavy Water Management Building Seismic Analysis

[6] NK38-DM-73690 ..... TRF and D_2O Management Building Ventilation

[7] NA44-DRT-32310-00004-U2 ..... Modification Design Report - DCP 70548 / DCN 70549 Assessment of Piping Modification

[8] NK38-DM-33100 ..... Main Heat Transport Circuit - Design Manual

[9] NK38-OM-32100-04.09 ..... Moderator Draining – Operating Manual

[10] NK38-OM-32100-04.10..... Moderator Filling - Drained To Overpoisoned GSS

[11] NK38-D1H-10249-1343 ..... Yard Services Area No. 1343 (Drawing)

[12] NK38-D1H-10249-1353 ..... Yard Services Area No. 1353 (Drawing)

[13] NK30-REF-09701-0185104 .. AECL Retube & Feeder Replacement Study – Input to Environmental Assessment (AECL # 30RF-09700-ASD-001 Rev. 1)

[14] NK30-REP-09701-0236734 ..... Pickering B Assessment Document: Retube and Feeder Study–Technical Assessment (AECL # 30RF-09700-ASD-002)

[15] NK38-39000-T5 ..... TRF Plant Life Extension Assessment – R02, Sep 11, 2006

[16] N-PCH-03800-10000 ..... Adding Heavy Water Storage/Drum Handling Facilities

[17] D-BCS-38000-10001-001 ... BCS DNGS D_2O Storage and Drum Handling Project

[18] K-012667-001-RA-0001 ..... Kinetrics Report - OPG Heavy Water Storage Management and Drum Handling – Study of Preferred Solution

[19] NK38-DM-38110 ..... D_2O SUPPLY - Design Manual

[20] NK38-CORR-09701-0264963 DNGS 400 Mg D2O Storage Project Cost Estimate Supporting Documents

[21] NK30-REP-09701-0185093 ..... D_2O PLEP Storage Facility Evaluation

[22] N-REP-03800-10002 .. Heavy Water Management Strategy For Pickering B Plant Life Extension Project

[23] NK38-CORR-38000-0150457 ..... Memo Dnd Heavy Water D_2O Annual Physical Inventory Results For 2004

[24] NK38-TS-38112-10001 ..... D_2O Supply Pumps

[25] NK38-CORR-09701-0249012 .. Cost and Schedule for DTRF Plant Life Extension Options

[26] NK30-CORR-09701-0185091 ..... Pickering B PLEP HW Storage Facility – Conceptual Quality Estimate by Altus Helyar

Glossary of Acronyms

ASME	American Society of Mechanical Engineers
CNSC	Canadian Nuclear safety Commission
DBE	Design Basis Earthquake
DNGS	Darlington Nuclear Generating Station
EA	Environmental Assessment
ECC	Engineering Change Control
EOL	End of Life
HTS	Heat Transport System
HW	Heavy Water
HWMB	Heavy Water Management Building
HWSF	Heavy Water Storage Facility
Igpm	Imperial gallon per minute
IXCU	Ion Exchange Column Unit
LLDS	Low Level Drained State
NBC	National Building Code
NGS	Nuclear Generating Station
OGMS	Off-Gas Management System
OPEX	Operating Experience
OPG	Ontario Power Generation
PB	Pickering B
PHT	Primary Heat Transport
PLEP	Plant Life Extension Project
S&I	Storage & Inventory
SUP	Station UPgrader
TRF	Tritium Removal Facility