Plant Habitability Assessment for Point Lepreau Generating Station during a Severe Accident Resulting From Station Blackout Conditions*

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Abstract

In response to the CNSC Fukushima Action Plan, the CANDU Owners Group (COG) developed a methodology for assessing nuclear power plant habitability under Joint Project 4426 and to determine if any improvement actions are necessary to provide a high degree of assurance that a severe accident can be managed from a human and organizational performance perspective. NB Power has applied the methodology considering a station black-out scenario (representative case), and assessed the effects of non-radiological hazards and radiological hazards in the context of operator dose relative to emergency dose limits. The paper will discuss the overall methodology, findings and recommendations.

1. Introduction

Following a hypothetical severe accident, there is a need for operators to perform mitigating actions from the Secondary Control Area (SCA). Such actions may occur over a day or many days following the accident. Following an industry COG methodology [1] developed under Joint Project 4426, NB Power has evaluated the habitability of its Secondary Control Area (SCA) and other key locations where operators may need to perform key mitigating actions, such as those for Severe Accident Sampling and Monitoring or for operation of Emergency Mitigating Equipment (EME), during severe accident conditions. Evaluation of Main Control Room (MCR) habitability is not considered in the assessment as it is presumed that the MCR becomes uninhabitable. In following the COG methodology, the habitability assessment evaluates the implications of non-radiological hazards and radiological hazards for dose comparison against habitability criteria.

According to the COG methodology [1], accident scenarios to be assessed in the habitability analysis can be selected from accident scenarios analyzed in the Level 2 Probabilistic Safety Assessment (PSA) of the CANDU station. A limited number of scenarios may be selected for the habitability analysis, for example, a limiting accident scenario and a representative accident scenario. A limiting scenario considers the severe accident event class resulting in the largest releases, the longest mission time and largest dose consequences. A representative scenario considers the severe accident class with the highest frequency (the most probable event) that will require mitigating actions. Although an assessment of the limiting case has been completed, it is extremely conservative. Therefore, this paper focuses on the representative case only as best estimate but draws upon recommendations from the limiting case where those are reasonable and practicable.

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The radioactive source terms following a postulated severe accident originate from the following sources:

- Radionuclides (fission products and actinides) released from fuel bundles; and
- Radionuclides (e.g., tritium, carbon-14) released from the primary heat transport system and moderator system; however, according to the COG methodology [1] these radionuclides do not need to be considered if the source term contains significant quantities of fission products.

The non-radiological hazard sources include the type of non-radiological hazards that pose a risk for the facility, their inventory, their locations, and the mechanisms for their release. They include:

- Chemical or toxic substances – Various chemical or toxic substances as used in and around the nuclear power plant facility which could cause habitability problems should they be released.
- Physical agents – Physical agents that could be involved include fire, steam releases, missiles from explosion/rupture of equipment with high potential energy.

More specifically;

- External hazards to which the site may be susceptible including;
    - External flooding caused by rainfall, storm surge, tsunami;
    - Extreme winds and tornadoes;
    - Seismic events;

  Other external hazards have been screened out based on the criteria that the event cannot occur close enough to the plant to affect it, that the predicted occurrence frequency is sufficiently low or that it may be bounded by Probabilistic Safety Assessment;
- Water line break in the SCA;
- Breaks of the steam and feedwater piping that runs near the MCR; and,
- Loss of Spent Fuel Bay heat sink.

2. Selection of Representative Case

The results of Point Lepreau G.S. 2008 Level 2 PSA expressed as external plant release categories (EPRC) frequencies, which are defined as follows:

EPRC0 =	Failure to shutdown + early external releases (containment failure)
EPRC1 =	External releases between 0 and 6 hours
EPRC2 =	External releases between 6 and 24 hours
EPRC3 =	External releases between 24 and 72 hours
EPRC4 =	Initial containment bypass + EPRC1
EPRC5 =	Initial containment bypass + EPRC2

EPRC6 = Initial containment bypass + EPRC (adjusted for containment bypass events through the emergency core cooling low pressure circuit)

The selection of the representative case is based on the case with the highest frequency that includes operator action to prevent containment failure. Therefore, since EPRC0 does not credit human mitigating actions, it was excluded from further consideration.

The events considered that contribute to external releases include internal events, internal fires, internal floods and seismic events. It was considered that the severe accident progression for the events generated at full power conditions are more severe than for those that are generated during shutdown. For shutdown state cases, the time available is much longer. Therefore it is considered that the selected cases from full power will envelope the shutdown state cases.

The 2008 Level 2 PSA demonstrates that EPRC2 and EPRC3 sequences contribute 75.3% of the total summed EPRC frequencies. These are broken down further by analysed case in Table 2 below. The specific details of each case are not discussed except for the final representative case selected for the habitability assessment.

MAAP4-CANDU Case	EPRC2 and EPRC3 (%)
In-Core Loss of Coolant Accident (LOCA) Case A3	25.4
Station Blackout Case D1	29.1
In-Core LOCA Case C	10.6
Small LOCA Case E	2.98

Table 2: MAAP4-CANDU Cases and their Contribution to EPRC2 and EPRC3 Frequency

Based on Table 2, Station Blackout Case D1 was selected as the representative case for the plant habitability assessment. Station Blackout Case D1 can be describes as a Loss of Class IV and III power resulting in the loss of PHT pumps, moderator cooling, steam generator feedwater, shield cooling, recirculating cooling water and shutdown cooling. All three stages of emergency core cooling (ECC) are available together with boiler crash cooldown capability. The electrical power for ECC provided by emergency power supply, which is considered to be available for 72 hours; however, there is no cooling to the ECC heat exchanger. The dousing spray and passive autocatalytic recombiners are available. The emergency containment filtered venting system is assumed to be initiated around 20 hours after the event starts.

3. Assessment of Non-Radiological Hazards

Non-radiological hazards due to transportation accidents that result in toxic chemical release and for other potential threats are also addressed. In the bounding analysis for transportation accidents, possible transportation modes included highways, railroads and shipping traffic. Due to proximity, only shipping traffic was considered in detail. According to USNRC evaluation of external hazards to nuclear power plants [2], transportation accidents within 5 miles (8 kms) of a plant is used for the initial screening analysis. Various other distances were derived by different sources, ranging from 0.75 miles (1.2 kms) to 50.3 miles (81 kms). The screening criteria are consistent with USNRC Regulatory Guide 1.78 dealing with hazardous chemical releases and control room habitability [3]. Following these criteria and based on shipping lanes and the potential for shipping accidents resulting in ships veering off course, typical material shipped and the potential for explosions, shipping accidents were screened out from detailed analysis in the PSA as unlikely to cause significant damage to the plant. As a result and considering installation of the MCR HVAC system during plant refurbishment, it is judged that the MCR would remain habitable and such hazards could be excluded from scope of the habitability evaluation as the SCA would not be needed in that type of event for plant operation, stabilization or control.

In terms of chemical or toxic hazards that might occur due to damage of on-site sources due to an extreme external hazard, overall control of hazardous materials conforms to Station Instruction SI-01365-P80 [4] for handling and storage including responsibilities of various site staff to ensure the safe use, storage and transportation of hazardous products. Specific requirements are included for storage depending on the type of material to ensure that risks to plant staff are sufficiently low, which includes flammable material, corrosive/acid material, corrosive caustic material, oxidizing/reactive material, toxic/poisonous material and compressed gases. In the event of a spill or release, the chemical contingency procedure EP-78600-C070 [5] provides the steps necessary to deploy the Emergency Response Team (ERT) who have been trained to respond to various chemical/toxic hazards to ensure repair is expedited and material contained with minimum disruption to plant, equipment operation and minimum responder exposure. As a result, it was not deemed necessary for the habitability assessment to specifically address on-site chemical or toxic hazards. USNRC Regulatory Guide 1.78 has been reviewed and it does not provide any additional considerations beyond those already identified. There is, for example, no need to consider the response to releases of chemicals that are not applicable for a specific site.

Other external hazards have been explicitly considered in the context of PSA in 87RF-03612-ASD-019 [15] as to whether they are likely to have an impact on the plant. For natural hazard re-assessments involving tsunami and high winds, work to date does not demonstrate a significant hazard for Point Lepreau. The work to re-evaluate seismic hazards and determine risks is on-going. In examining potential pathways for external flooding sources, it has been identified that critical areas such as the secondary control area (SCA) and SCA tunnel could be subjected to flooding from high rainfall. Therefore, the assessment of non-radiological hazards includes consideration of high rainfall.

Non-radiological hazards such as thermal stresses, steam environments, debris, etc., as a result of SSC damage along qualified access routes and areas where operators are required to perform post-accident actions have also been considered in the habitability assessment. Potential locations for these harsh environments outside containment have been previously identified by NB Power [6] largely due to Loss of Coolant Accidents or Main Steam Line Breaks that might affect accident mitigation actions. Under certain conditions, it is possible for the SCA tunnel temperature to increase up to 50ºC [7] and was, therefore, an area of potential harsh environment that was considered in the habitability assessment.

4. Assessment of Radiological Hazards

4.1 Habitability Criteria / Dose Limits

The acceptance criteria applied to consideration of radiological hazards is consistent with changes proposed to Canadian Radiation Protection Regulations [8] in CNSC discussion paper DIS-13-01 [9]. In establishing the acceptance criteria, the COG methodology [1] draws upon;

- interpretation of clause 5(1) of the current radiation protection regulations that the application of emergency dose limits applies during the control of an emergency and the consequent immediate and urgent remedial work;
- IAEA revised International Basic Safety Standard for Protection against Ionizing Radiation and for the Safety of Radiation Sources (2011) GSR Part 3 (interim) [10], Requirement 45;
- IAEA GSG-2 (2011), Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency [11];
- IAEA GS-R-2, Preparedness and Response for a Nuclear or Radiological Emergency [12]; and,
- ICRP 103 [13] recommendations
- Review of worker exposure at the Fukushima Daiichi Nuclear Power Plant

IAEA Guidance values for restricting exposure to emergency workers are provided in Table 1.

Tasks	Guidance Value[3] (mSv)
Type 1 Life-saving actions.	$H_p(10)$[4]<500 This value may be exceeded under circumstances in which the expected benefits to others clearly outweigh the emergency worker's own health risks, and the emergency worker volunteers to take the action understand and accept this health risk.
Type 2 Actions to prevent severe deterministic effects and actions to prevent the development of catastrophic conditions that could significantly affect people and the environment.	$H_p(10)<500$
Type 3 Actions to avert a large collective dose.	$H_p(10)<100$
Type 4 Longer term recovery operations. Work not directly connected with the control of an emergency and the consequent immediate and urgent remedial work.	Occupational exposure limit applies (100 mSv effective dose in five years and 50 mSv maximum effective dose in a year)

Table 1: IAEA Guidance Values for Restricting Exposure to Emergency Workers

On the above basis, the following approach was recommended in COG-JP-4426-009 [1]:

- For actions required to prevent severe deterministic effects and actions to prevent the development of catastrophic conditions that could significantly affect people and the environment, IAEA Type 2 dose limits apply (500 mSv).
- For actions required to avert a large collective dose, IAEA Type 3 dose limits apply (100 mSv).
- For all SAMG actions and potential beyond design basis modifications, ALARA (As Low As Reasonably Achievable) principles apply.

In general terms, the above can be represented as shown below in Table 2.

Accident Progression	Accident Type	IAEA Task Type	Notes
Normal Operation	N/A	Type 4 (50 mSv)	Prior to accident
Transient	AOO	Type 4 (50 mSv)	Doses are expected to be low
EOP/APOP/CSPM	DBA/BDBA	Type 4 (50 mSv) to the extent practicable	Planned urgent protective actions
	EME Deployment		Actions such as boiler make-up using EME
	SA prevention		Deployment as a preventive action
SAMG	Severe Accident	Type 3 (100 mSv) to the extent practicable	SAMG actions to avert a large collective dose
		Type 2 (500 mSv) (apply ALARA)	SAMG actions to prevent severe deterministic effects and to prevent development of catastrophic conditions
Recovery/ Remediation	N/A	Type 4 (50 mSv)	Longer term efforts after plant stabilized

Table 2: Application of IAEA Dose Limits for CANDU Reactors

For the purposes of the habitability assessment, the maximum dose target was limited to 100 mSv with the caveat that reasonable improvements would be identified to achieve the normal occupational dose limit of 50 mSv if possible to maintain overall doses ALARA.

4.2 Conservative Assumptions

Given severe accidents are highly uncertain events, the habitability assessment includes some very conservative assumptions in terms of plume dispersion and plant state that serve to increase the potential for operator dose. The conservatisms include;

- Leakage into the SCA tunnel was assumed as a proportion of the leakage over the entire reactor building. Based on the calculated surface area of the reactor building and the inner surface area of the tunnel, approximately 3.6% of reactor building leakage will enter the tunnel. This leakage equates to an approximate volume of 15.4 m^3 in the tunnel of volume 973 m^3 over the entire release period.

According to the calculations for the leakage fraction (tunnel wall surface area divided by the R/B wall surface area), there is a major portion of the perimeter/tunnel wall that is above the water level in the basement and would be exposed to the vapor phase. It is conservatively assumed that the effect of water accumulation on impeding the flow of leakage is none, and therefore the entire wall is susceptible to leakage flow.

Note that assuming the walls and penetrations are leak tight in terms of water (or below the water line) then the total leakage of aerosols or noble gases will decrease with increasing water level in the Reactor Building. For example at a height of 7.6m of water in the Reactor Building (just below the emergency filtered containment vent inlet) it is assumed that the leakage of noble gases into the tunnel will be negligible.;

- No buoyancy effect is assumed for the hot plume released from the emergency filtered containment venting system (EVS), which results in the plume descending to ground level to maximize potential operator exposure and intake into the SCA (see Figure 1);

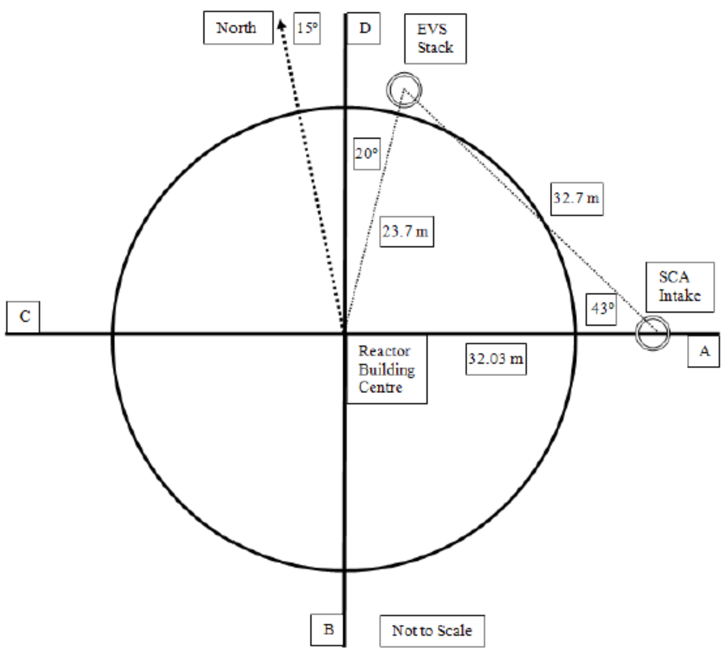

Figure 1: SCA Intake Relative to RB and EVS Exhaust

5. Emergency Preparedness

Issues surrounding emergency planning and sustenance for plant staff during an emergency should the plant site be isolated are beyond scope of the SCA habitability assessment. However, essential personnel requirements for contingencies are documented in emergency procedure EP-78600-T30 [14]. The procedure identifies sleeping facilities that may be used by plant staff for rest, inventory of beds/cots, emergency meals (MREs), water and beverages that are available and their locations.

6. Results

Several cases were analysed with varying configurations of the SCA emergency ventilation flow rate, examining dose rates at the 95th percentile with usage of self-contained breathing apparatus (SCBA) or alternatively with a portable filtered air supply unit, with and without an exhaust fan to remove noble gases from the SCA tunnel, and in consideration of possible containment emergency filtered venting setpoint changes that would retain a greater fraction of fission products within the containment envelope. These various options were investigated so that appropriate decisions could be made on what additional measures, if any, are needed to protect the operators and maintain doses ALARA.

Calculations provided in Table 3 below show the total individual doses in the SCA, including areas around the SCA, over 5 days are largely unaffected by varying the SCA emergency ventilation flow rate, and also provides additional combination of portable filtered air supply usage and SCBA usage. Retention values used in the dose calculations for the portable filtered air supply unit were obtained from the manufacturer.

SCA Emergency Ventilation Status	Cases	SCA Dose (mSv)			
		First 3 days (72h)	Day 4 (24h)	SCA Dose Day 5 (24h)	SCA Dose (mSv) Remainder
100% Flow	Filter, no SCBA	0.01	1.93	1.75	0.09
	No Filter, SCBA	0.01	1.94	1.76	0.09
	No Filter, no SCBA	0.03	15.43	12.54	0.93
25% Flow	Filter, no SCBA	0.01	1.93	1.75	0.09
	No Filter, SCBA	0.01	1.94	1.76	0.09
	No Filter, no SCBA	0.03	15.43	12.54	0.93

Table 3: Comparison of Doses for Various Configurations for SBO Scenario

As Table 3 demonstrates, the largest doses occur during days 4 and 5. This is due to operation of the emergency filtered containment venting system during those days and the dose contribution of noble gases that the system does not retain. The beneficial dose reduction of the portable filter and the usage of SCBA with a protection factor of 10,000 are virtually identical. This is because both methods of protection reduce the Iodine dose to the extent that immersion in noble gas becomes dominant (assuming the noble gas is drawn down to ground level). From an ALARA perspective, it makes sense to require the use of SCBA or a portable filtered air supply unit; however, during a severe accident it may be difficult to maintain a SCBA protection factor of 10,000 due to the potential for contamination when bottles need to be changed and early estimates are that prohibitively large number of SCBA bottles would be required throughout the accident period. A portable filtered air supply unit has the benefit of positively pressurizing the SCA slightly to provide improved contamination control of the entire SCA area and SCBA would only be needed when going into areas outside the SCA.

Table 4 below provides the dose consequences in the SCA tunnel with and without a 6000 CFM fan used to exhaust noble gases outside, and for the doses when performing actions outside the SCA. In addition, the benefit of either wearing (protection factor of 10,000) or not wearing SCBA has been assessed for each scenario. The SCA tunnel is specifically considered because it is the location where the controls for the emergency filtered containment vent system, emergency water supply pneumatic valves, and severe accident sampling equipment are located.

Case	SCBA	SCA Tunnel Dose (mSv)			
		First 3 days (72h)	**Day 4 (24h)[1]**	**Day 5 (24h)[2]**	**Remainder[1]**
Tunnel no Exhaust	None	6.61	779.83	2705.98	715.41
Tunnel no Exhaust	PF 10,000	6.06	759.17	2663.43	701.05
Tunnel with Exhaust	None	0.03	8.59	3.78	0.21
Tunnel with Exhaust	PF 10,000	0.03	8.48	3.76	0.20
Outside SCA	None	0.21	62.74	55.72	3.12
Outside SCA	PF 10,000	0.19	50.90	46.19	2.39

Table 4: Comparison of SCA Tunnel and Outside SCA Options

Notes:
1. Based on severe accident analysis, the assessment calculated that the operator needs to go to the SCA tunnel once during the period to operate the emergency filtered containment venting system, and needs to go outside to operate emergency mitigating equipment and calandria vault make-up when necessary
2. The operator goes into the tunnel 4 times during the period, and needs to go outside to operate emergency mitigating equipment and calandria vault make-up when necessary

In consideration of the conservative assumptions regarding noble gas leakage through the reactor building wall and build-up in the SCA tunnel, utilizing SCBA does not provide sufficient protection from immersion in noble gases. However, operating a 6000 CFM fan to exhaust the noble gases reduces projected individual doses by a significant amount and SCBA gear, which would inhibit movement on ladders in the SCA tunnel to access specific equipment, would not be required.

While operators are outside the SCA, noble gases are responsible for 77% of the dose and most of this dose occurs as a result of operation of the emergency filtered containment venting system.

7. Recommendations to Address Non-Radiological Hazards

After an extreme precipitation event (total of 21 inches / 533 mm) over a period of 6-hour duration, in order for the water to not infiltrate in the SCA building from the outside, the following recommendations were made:

- Site staff should examine in further detail installing watertight doors or install a 6” threshold in the SCA building if necessary to prevent water ingress.
- Site staff should examine in further detail and correct, as necessary, any deteriorating wall conditions up to the level of the EPS air intake louvres, including caulking and sealant as necessary to prevent water ingress.
- Site staff to further examine, in detail, natural draining pathways and identify design modifications that may be required to prevent water collection that would have an adverse impact on accident management and/or control room habitability.
- Site staff to examine methods and/or design modifications for pumping out any standing water in elevation 25' of the SCA tunnel to ensure accessibility to the Emergency Filtered Containment Vent system valves.

Site staff should examine further upgrading the selected doors to make them watertight, in order for the water not to reach the tunnel where the Emergency Filtered Containment Vent system equipment is located, after breaks in the feedwater lines and reheater drain lines. These doors have been identified between the service building (SB) and the tunnel as the last obstacle for the water not to enter the tunnel. In addition, site staff should examine in further detail to upgrade other doors to make them watertight in the SB stairways and control equipment room to prevent water to the SB basement, MCR and other elevations.

8. Recommendations to Address Radiological Hazards

In order for the calculated dose to be below the screening value limit of 50 mSv dose (or 100 mSv dose for planned BDBA actions) as set by the COG methodology, the following recommendations were made:

- Activate the Emergency Filtered Containment Vent system when containment pressure exceeds 200 kPa(g) or above, and deactivate it when containment pressure decreases below 100 kPa(g);
    - Note that the current setpoints are 200/150 kPa(g). It is judged that there would be no significant advantage to reducing the lower setpoint to 100 kPa(g) as it is desirable to retain as much fission product inventory inside containment as possible. Therefore, this recommendation will not be implemented.
- Remain inside the SCA during the Emergency Filtered Containment Vent releases. If the operator must go outside, wear Self-Containment Breathing Apparatus (SCBA);
- Install a 6000 CFM exhaust fan to prevent the build-up of radionuclides inside the SCA tunnel;

- Site staff to examine design modifications to provide a fresh air path between the SB and the SCA tunnel while the tunnel exhaust fan is running to vent noble gases; the path should be at an elevation higher than the flood level, to cater for the case where the door between the tunnel and Service Building is upgraded to make it a watertight door.
- The operator should minimize time spent outside
- Verify shielding calculations for sampling components and verify shielding is adequate

Implementation of the above recommendations is intended to provide a high degree of confidence that operators can perform needed actions that are credited in analysis by keeping doses as low as reasonably achievable and within applicable limits.

In addition to implementing the specific recommendations listed above, NB Power intends to provide a portable filtered air supply unit for the SCA that will provide fresh air and will further reduce exposure of the operators to fission products. The portable filtered air supply unit would be powered from a portable diesel generator so that it can operate under pro-longed station black-out conditions. NB Power believes such a portable filter air supply unit, which can be deployed on demand as necessary, is a reasonable measure that ensures our approach is not overly dependent on the computational assumptions made in the habitability assessment. Provision of self-contained breathing apparatus (SCBA) had also been considered as opposed to a portable filtered air supply unit; however, determination of the number of SCBA packs and bottles that would have been necessary and decontamination facilities to maintain an analyzed protection factor of 10,000 was deemed cost prohibitive and problematic from a maintenance perspective.

9. Summary of Accumulated Doses with Implemented Recommendations

Assuming implementation of the above-noted recommendations, the total accumulated operator doses in the SCA, SCA tunnel and outside as a result of performing mitigating actions during a severe accident are provided in Table 5. The doses have been split between 12-hour shifts to assist in operator resource decision-making during an accident.

	Accumulated Dose (mSv)						
Locations	**First 3 days (72h)**	**Day 4 (24h)**		**Day 5 (24h)**		**Remainder**	
		Shift 1	**Shift 2**	**Shift 1**	**Shift 2**	**Shift 1**	**Shift 2**
Operator in SCA only	0.03	7.14	7.14	6.20	6.20	0.46	0.46
Operator in SCA and tunnel (with exhaust)	0.00	7.50	7.50	5.62	5.62	0.465	0.465
Operator in SCA and outside	0.00	5.38	5.38	18.3	18.3	3.00	3.00

Table 5: Total Accumulated Doses (95th Percentile Dispersion)

10. Sensitivity Case

A sensitivity analysis has been performed to identify the impact on the dose assessment in the SCA, in the tunnel and outside the Reactor Building if the atmospheric dispersion is calculated at 50th percentile as opposed to 95th percentile (the base representative case). All other assumptions, configurations and scenarios as were used for the 95th percentile case were used for the sensitivity case.

While reducing the percentile for atmospheric dispersion resulted in no improvement to the dose calculations for the SCA tunnel (since no air is assumed coming in from outside) or for areas outside the SCA, an improvement to the dose calculations inside the SCA was noted. However, the dose is dominated by the SCA tunnel and areas outside the SCA.

11. Conclusions

The habitability assessment incorporates some conservative assumptions. In particular, in terms of Reactor Building leakage through the wall to the SCA tunnel, the assumption that the effect of water accumulation on impeding the flow of through-wall noble gas leakage is none and, therefore, the entire wall is susceptible to leakage flow, is extremely conservative and drives up dose contribution in the SCA tunnel considerably. In reality, there would be a significant amount of water on the reactor building floor during a severe accident, which would impede the flow of noble gases through that water into the SCA tunnel and, therefore, the total effective surface area permitting noble gas leakage through the wall would be much smaller than assumed in the study. With potential addition of water from external sources via emergency mitigating equipment (e.g. portable diesel pump), the water level could be raised high enough that noble gas leakage into the SCA tunnel would be negligible. As a result, NB Power has confidence that a severe accident progressing from station blackout conditions can be effectively managed.

To maintain doses ALARA; to provide a higher degree of assurance that the plant will remain habitable; and, to ensure that key areas where severe accident mitigating actions are needed remain accessible, site design services has been requested to implement the recommendations for radiological and non-radiological hazards. Preliminary engineering has been progressing to implement the above recommendations and full implementation is currently scheduled for May 2017.

With efforts to distribute dose over Operations resources between shifts, the habitability assessment for the representative case concludes that the normal occupational individual dose limit of 50 mSv can be met. Implementation of the recommendations from the assessment will provide a higher degree of assurance that a severe accident can be reasonably and effectively managed, including those progressing from other initiating events.

12. References

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