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NSDF EFFLUENT DISCHARGE TARGETS

B1551-106499-TD-001

Revision 1

Accepted by: 

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2019-April-15
Date

Canadian Nuclear Laboratories
Near Surface Disposal Facility Design and Consulting Services

NSDF Effluent Discharge Targets
B1551-106499-TD-001
Deliverable G6, Revision 1

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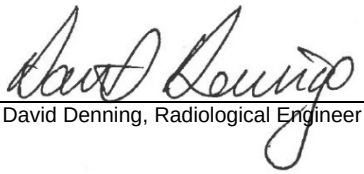
Reviewed by 
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2019 April 11

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Revision History

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C	2018/10/18	G. Merrell	Draft for review
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0	2019/01/25	G. Merrell	Final Submittal
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AECOM: 2015-04-13

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Acronyms

CBOD5	Carbonaceous Biochemical Oxygen Demand, 5-day
CCME	Canadian Council of Ministers of the Environment
CNL	Canadian Nuclear Laboratories
COD	Chemical Oxygen Demand
COPC	Contaminant of Potential Concern
CRL	Chalk River Laboratories
CS	COPC Screening Limit
DC	Dose Coefficient
ECM	Engineered Containment Mound
ICRP	International Commission on Radiological Protection
MAC	Maximum Allowable Concentration
NSDF	Near Surface Disposal Facility
PWQO	Provincial Water Quality Objectives
WAC	Waste Acceptance Criteria
WWTP	Wastewater Treatment Plant

1. Introduction

Canadian Nuclear Laboratories (CNL) proposes to develop the Near Surface Disposal Facility (NSDF) project to establish a safe, local, and permanent means for the disposal of radioactive waste and mixed waste at its Chalk River Laboratories (CRL) site. The NSDF is intended to dispose of historic waste now in interim storage as well as waste arising from building decommissioning and environmental remediation activities, enduring laboratory operations, and commercial sources. Waste acceptance criteria (WAC) will define the parameters for the waste that will be accepted for disposal in the NSDF.

The NSDF is being designed, licenced, and built as an engineered containment mound (ECM). The ECM will have an operational life of 50 years and a total waste capacity of 1,000,000 m^3. The development of the facility and the placement of waste within the ECM will be completed in a phased approach:

- Phase 1, with total waste capacity of 525,000 m^3, will accommodate waste now in storage and to be generated for a 20- to 25-year period beginning 2020.
- Phase 2, with total waste capacity of 475,000 m^3, will expand the mound to a total capacity of 1,000,000 m^3 and allow for wastes generated through 2070.

The main physical elements of the NSDF include the ECM that contains the waste; the wastewater treatment plant (WWTP), which treats leachate, contact water, and operational wastewater; various support facilities that enable operation; and site infrastructure. The WWTP, support facilities, and site infrastructure, and Phase 1 of the ECM are proposed for development as part of the NSDF project.

1.1 Purpose

The purpose of this document is to establish the effluent discharge targets for the WWTP. The effluent discharge targets are the maximum concentrations of each Contaminant of Potential Concern (COPC) in the WWTP effluent that can be discharged to the environment without adverse effects to human health or the environment. COPCs include both radionuclides and non-radioactive constituents. For each COPC, this report lists the effluent discharge targets and the basis for the target, including references.

2. Effluent Discharge Targets for Radionuclides

Effluent discharge targets for radionuclides are based on a 0.1 mSv/yr maximum drinking water dose. The dose calculation assumes an individual ingests two litres of drinking water per day. The limiting concentration is given by:

$$MAC\ (Bq/L) = (0.1\ mSv/yr) / [730\ L/yr \times DC\ (Sv/Bq) \times 1000\ mSv/Sv]$$

where,

MAC = maximum allowable concentration in effluent (Bq/L),

DC = adult committed effective dose coefficient for ingestion (Sv/Bq).

The dose coefficients are from International Commission on Radiological Protection (ICRP) Publication 119, Annex F [1]. The dose coefficients apply to ingestion of radionuclides by members of the public. Using these dose coefficients and the formula above, the limiting effluent release concentrations are as shown in Table 1.

Special adjustment was made for tritium due to the lack of treatment technologies and its propensity to disperse rapidly in the environment. The criterion for tritium is based on a limit of 7,000 Bq/L in Perch Creek, which currently has a tritium concentration of 3,500 Bq/L from other sources [2]. Inclusion of the effluent from the WWTP must not cause Perch Creek to exceed a total tritium concentration of 7,000 Bq/L. The flow rate of Perch Creek is 2.31E+06 m^3/yr [3] and the annual effluent output from the WWTP is 11,200 m^3/yr [4], leading to a dilution factor of 206. Using these flow rates, the tritium limit for the WWTP effluent would be 7.2E+05 Bq/L, which after mixing would produce a concentration of 3,500 Bq/L. However, since this is based on the annual flow in Perch Creek and the WWTP operates only six months of the year, the effluent release target must be cut in half in order to meet the Perch Creek total tritium criterion of 7,000 Bq/L at all times during the year. This results in a tritium criterion for the WWTP of 3.6E+05 Bq/L.

Table 1. Effluent Discharge Targets for Radionuclides

Constituent	Dose Coefficient (Sv/Bq)	Discharge Target (Bq/L) (rounded)
Ag-108m	2.3E-09	60
Am-241	2.0E-07	0.7
Am-243	2.0E-07	0.7
C-14	5.8E-10	200
Cl-36	9.3E-10	100
Co-60	3.4E-09	40
Cs-135	2.0E-09	70
Cs-137	1.3E-08	10
H-3	1.8E-11	360,000
I-129	1.1E-07	1
Mo-93	3.1E-09	40

Table 1. Effluent Discharge Targets for Radionuclides

Constituent	Dose Coefficient (Sv/Bq)	Discharge Target (Bq/L) (rounded)
Nb-94	1.7E-09	80
Ni-59	6.3E-11	2,000
Ni-63	1.5E-10	900
Np-237	1.1E-07	1
Pu-239	2.5E-07	0.6
Pu-241	4.8E-09	30
Pu-242	2.4E-07	0.6
Ra-226	2.8E-07	0.5
Se-79	2.9E-09	50
Sn-126	4.7E-09	30
Sr-90	2.8E-08	5
Tc-99	6.4E-10	200
Th-230	2.1E-07	0.7
Th-232	2.3E-07	0.6
U-233	5.1E-08	3
U-234	4.9E-08	3
U-235	4.7E-08	3
U-238	4.5E-08	3 (a)
Zr-93	1.1E-09	100
Gross alpha	n/a	0.2
Gross beta (based on Sr-90)	n/a	5
Gross gamma (based on Co-60)	n/a	40 (b)

(a) The limit shown is for drinking water protection from radiological effects; a more restrictive limit of 0.06 Bq/L (5 µg/L) is required for protection of aquatic life from chemical toxicity of uranium.
(b) The gross gamma limit applies to any gamma-emitting radionuclide not listed in Table 1.

3. Effluent Discharge Targets for Non-Radioactive Constituents

The effluent discharge targets for non-radioactive constituents are based on the protection of aquatic life and may be lower or higher than drinking water criteria. The effluent discharge targets for non-radioactive constituents are gathered from a variety of source documents including the Canadian Council of Ministers of the Environment (CCME) summary table [5] and the Ontario Provincial Water Quality Objectives (PWQO) [6]. If both Federal and Provincial values were available, the lower value was used to define the discharge target. The CCME water quality guidelines are for the protection of aquatic life and the PWQOs were developed to ensure that water quality is satisfactory for aquatic life and recreation. Other reference documents were used as noted when constituents were not listed in either of the primary references.

PWQOs were developed to ensure that water quality is satisfactory for aquatic life and recreation. Other reference documents were used as noted when constituents were not listed in any of the other references.The effluent discharge targets are listed in Table 2.

Table 2. Effluent Discharge Targets for Non-radioactive Constituents

Constituent	Discharge Target (mg/L) (a)	Reference
1,1,2,2-Tetrachloroethane	0.07	[6]
1,1,2-Trichloroethane	0.8	[6]
1,4-Dichlorobenzene	0.004	[6]
Acetone	1.5	[7]
Aluminum	**0.05**	[5]
Ammonia	0.02	[6]
Anthracene	8.0E-07	[6]
Antimony	0.02	[6]
Arsenic	0.005	[5]
Barium	**0.004**	[7]
Benzene	0.1	[6]
Benzo(a)pyrene	1.5E-05	[5]
Beryllium	0.011	[6]
Bis(2-ethylhexyl) phthalate	6.0E-04	[6]
Boron	0.2	[6]
Cadmium	**9.0E-05**	[5]
Calcium	116	[7]
Carbon tetrachloride	0.0133	[5]
Chloride	120	[5]
Chlorobenzene	0.0013	[5]
Chloroform	0.0018	[5]

Table 2. Effluent Discharge Targets for Non-radioactive Constituents

Constituent	Discharge Target (mg/L) (a)	Reference
Chromium (III)	0.0089	[5]
Chromium (VI)	0.001	[5]
Chrysene	1.0E-07	[6]
Cobalt	9.0E-04	[6]
Copper	**0.002**	[5]
Dioxin	1.0E-08	[7]
Ethylene dibromide	0.005	[6]
Fluoranthene	8.0E-07	[6]
Fluorene	2.0E-04	[6]
Fluoride (aqueous)	0.12	[5] (b)
Furan	1.0E-08	Same as dioxin (c)
Iron	**0.3**	[5]
Lead	**0.001**	[5]
Magnesium	82	[7]
Manganese	0.12	[7]
Mercury (aqueous)	**2.6E-05**	[5]
Methylene chloride	0.0981	[5]
Molybdenum	0.04	[6]
Nickel	0.025	[5]
Nitrate	13	[5]
Nitrite	0.06 (as N)	[5] (b)
Petroleum hydrocarbons, C6-C10	0.15	[8]
Phenol	0.004	[5]
Phenolic compounds, non-chlorinated	0.004	Same as phenol (d)
Phosphorus	**0.01**	[6] (e)
PCB	1.0E-06	[6]
Potassium	53	[7]
Selenium	**0.001**	[5]
Silver	**1.0E-04**	[6]
Sodium	680	[7]
Sulphate	128	[8] (b) (f)
Tetrachloroethylene	0.05	[6]
Thallium	3.0E-04	[6]
Tin	0.073	[7]

Table 2. Effluent Discharge Targets for Non-radioactive Constituents

Constituent	Discharge Target (mg/L) (a)	Reference
Trichloroethylene	0.02	[6]
Uranium	0.005	[6] (g)
Vanadium	0.006	[6]
Zinc	**0.007**	[5]
pH, standard units	**6.5-9**	[5]
CBOD5	25	[9]
COD	125	[10]
Dissolved oxygen, >15-20 Celsius	≥6	[5]
Dissolved oxygen, <15-20 Celsius	≥9.5	[5]

(a) The **bolded** values indicate constituents where historic background concentrations from the Perch Lake watershed exceed the discharge targets listed in this table.
(b) Effluent discharge targets for fluoride, nitrite, and sulphate apply at the perimeter of the mixing zone in Perch Lake. For exfiltration gallery discharges the discharge targets apply at the point of groundwater discharge to East Swamp Stream.
(c) The dioxin limit is used for furans because furans have similar, or slightly lower, toxicity than dioxins and the mechanism of toxicity is the same as dioxins, namely disruption of protein synthesis by binding to the aryl hydrocarbon receptor.
(d) Since no specific non-chlorinated phenols were identified in CNL's non-radioactive inventory, the limit for phenol is considered adequate to represent this class of compounds.
(e) The phosphorus discharge target is an investigation level triggering analysis on impacts if exceeded. An analysis has been completed indicating minimal impacts on Perch Lake and East Swamp for the projected phosphorus loading [11]. The results of the analysis will be verified by monitoring Perch Lake water quality under winter conditions [11].
(f) A dilution factor of 10 may be credited for dilution along the groundwater flow path and mixing at the discharge to East Swamp Stream.
(g) Uranium discharge target based on chemical toxicity to aquatic life.

4. References

[1] ICRP. 2012. *Compendium of Dose Coefficients Based on ICRP Publication 60*, ICRP Publication 119, Annals of the ICRP Volume 41 Supplement.

[2] CNL. 2016. *Environmental Monitoring in 2016 at Chalk River Laboratories*, CRL-509243-ASR-2016.

[3] Arcadis. 2018. *Performance Assessment for Near Surface Disposal Facility*, Addendum 1, 232-509240-ASD-002, Revision 0.

[4] CNL. 2018. *Leachate and Wastewater Characterization (Quantity and Quality)*, B1551-508600-REPT-001, Revision 3.

[5] Canadian Council of Ministers of the Environment (CCME) summary table, http://st-ts.ccme.ca/en/index.html?chems=154,162.

[6] Ontario Provincial Water Quality Objectives (PWQO). https://www.ontario.ca/page/water-management-policies-guidelines-provincial-water-quality-objectives#section-13

[7] Suter II, G.W., and Tsao, C.L. 1996. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota*, Table 1, Tier II Secondary Chronic Values.

[8] Alberta Government. 2018. *Environmental Quality Guidelines for Alberta Surface Waters*. https://open.alberta.ca/dataset/5298aadb-f5cc-4160-8620-ad139bb985d8/resource/38ed9bb1-233f-4e28-b344-808670b20dae/download/environmentalqualitysurfacewaters-mar28-2018.pdf.

[9] Canadian Council of Ministers of the Environment (CCME). 2008. *Canada-wide Strategy for the Management of Municipal Wastewater Effluent*, Technical Supplement 3.

[10] Canadian Water Network. 2018. *Wastewater Treatment Practice and Regulations in Canada and Other Jurisdictions*, Supporting Document 2.

[11] CNL. 2018. *Increased Loading of Phosphorus to Perch Lake from NSDF Operations*, File #153-121221-021-000-0006, ESB-18-024, 2018 November 12.