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Ministry of Environment

Finalization of Proposed 2007 Final Draft Matrix Soil Standards for Sodium (Na^+) and Chloride (Cl^-)

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1. Introduction

This report provides details related to the finalization of the proposed 2007 final draft matrix soil quality standards for sodium (Na^+) and chloride (Cl^-) presented in Exhibits 1 and 2 respectively.

In 2002, the ministry posted for comment draft matrix soil quality standards for sodium (Na^+) and chloride (Cl^-) for use under the Contaminated Sites Regulation (Appendices A and B).

Both the 2002 and the 2007 draft standards were developed in accordance with the Contaminated Sites Standards Task Group (CSST) Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites, (BC Environment, 1996).

The 2002 draft standards were developed Drs. Doug Bright and Jan Addison of Royal Roads University under the supervision of the Salt Standards Scientific Steering Committee (Appendix C).

Details related to the derivation of the 2002 draft standards are available in the following reports:

- Derivation of Matrix Soil Standards for Salt under the British Columbia Contaminated Sites Regulation., (Bright and Addison., 2002a)
- Derivation of Matrix Soil Standards for Salt under the British Columbia Contaminated Sites Regulation. Addendum A: Technical Options Analysis for a Soil Chloride Standard for Drinking Water Protection (Aesthetic)., (Bright and Addison., 2002b).
- Derivation of Matrix Soil Standards for Salt under the British Columbia Contaminated Sites Regulation. Addendum B: Protocol for the Estimation of Site-Specific Adsorption Co-efficients, Kd., (Bright and Addison., 2002c).
- Derivation of Matrix Soil Standards for Salt under the British Columbia Contaminated Sites Regulation. Addendum C: Soil Invertebrate Toxicity Tests: Lessons and Recommendations., (Bright and Addison., 2002d).
- Derivation of Matrix Soil Standards for Salt under the British Columbia Contaminated Sites Regulation. Addendum D: Prediction of Salt Ion Composition of Produced Water Releases in Northern British Columbia., (Bright and Addison., 2002e).

The 2002 draft standards and their derivation were subject to extensive scientific peer review and detailed public comment during the latter part of 2002. The final conclusion of this intensive review being that the 2002 draft standards were both scientifically defensible and appropriate for regulatory use under the Contaminated Sites Regulation.

Finalization and implementation of the 2002 draft standards has been delayed however, due to a number of factors related to implementing the standards, such as the need to complete requisite chemical analytical methods for use in the characterization of salt contaminated sites.

The ministry with the assistance of the British Columbia Laboratory Quality Assurance Advisory Committee (BCLQAAC) has now completed the following chemical analytical methods needed to support matrix soil standards for sodium and chloride:

- Saturated Paste Extraction for Soils, (B.C. Ministry of Environment, 2005a),
- Sodium and Chloride in Soil by Saturated Paste Extraction, (B.C. Ministry of Environment, 2005b), and
- Determination of Site-specific Soil-Water Partitioning Co-efficient (Kd) for Chloride (Prescriptive Method), (B.C. Ministry of Environment, 2006a).

In addition, the ministry with the assistance of the British Columbia Upstream Petroleum Environmental Committee, Salts Issues Technical Advisory Committee, (Appendix D) has now updated the previously derived 2002 draft standards to produce the proposed 2007 final draft matrix soil quality standards for sodium (Na^+) and (Cl^-).

2. Details Related to Finalizing the 2007 Final Draft Matrix Soil Standards

2.1 Synopsis of CSST, 1996 Matrix Soil Standard Derivation Process

Under the CSST, 1996 procedures, for any particular substance, matrix soil standards are developed following a three stage process. [1]

The first stage involves derivation of various toxicological-based, "preliminary" matrix soil quality standards to protect ecological receptors (i.e. the various environmental protection standards of a matrix)

The second stage involves derivation of the toxicological-based, "preliminary" matrix soil quality standards to protect human receptors (i.e. the various human health protection standards of a matrix).

The third stage consists of making a series of ancillary adjustments to the respective environmental and human health protection preliminary standards calculated in stages 1 and 2 of the process, to produce "final" matrix soil standards for a substance.[2]

For the most part, the proposed 2007 final draft matrix soil standards for sodium and chloride were finalized through application of third stage ancillary adjustments to the 2002 draft matrix soil standards previously derived by Bright and Addison, 2002a.

However, as described in more detail below, for chloride it was also necessary to re-calculate new second stage preliminary soil standards to protect aquatic life and livestock from soil to groundwater contaminant transfer, prior to third stage ancillary adjustments.

2.2 Review of 2002 to 2007 Toxicological Literature for Salt

A review (Bright and Meier, 2007) of the toxicological literature for salt was conducted for the period from 2002 to 2007.

The objective of this review was to determine if new data which may have become available between 2002 and 2007 could have the effect of substantively altering the 2002 draft soil quality matrix standards previously derived for sodium and chloride.

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[1] Full details related to the process by which the ministry derives matrix soil standards for use in Schedule 5 of the Contaminated Site Regulation (CSR) can be found in the CSST, 1996 overview document (B.C. Environment, 1996).

[2] See *Part E, Ancillary Issues* of the CSST, 1996 procedures.

The review concluded that toxicological data for salt which became available post-2002 would not substantively change the draft matrix soil standards derived in 2002 for either sodium (Na^+) or chloride (Cl^-).

2.3 Finalization of 2007 Final Draft Matrix Soil Standards for Sodium

2.3.1 CSST Background Adjustment

The CSST, 1996 procedures provide for a "background" adjustment of toxicologically derived standards in the case where a preliminary soil matrix standard represents a concentration which is less than the naturally occurring (background) concentration of the substance in soil.

As envisioned by CSST, the (Provincial) background soil concentrations for substances should represent "*contaminant concentrations equivalent to no less than the 90th percentile of the Lower Mainland background soil concentrations*", (CSST, 1996).

In practise the ministry has established, strictly for use in regulatory standards development, Provincial background soil quality estimates for only the selected inorganic substances listed in Table 1 of Protocol for Contaminated Sites 4, Determining Background Soil Quality, (B.C. Ministry of Environment, Lands and Parks, 1999). Furthermore, the ministry has established these Provincial background soil quality estimates as the 95th percentile background soil concentration of all regional background soil data for a substance contained in Technical Guidance on Contaminated Sites 17, Soil Quality Database, (B.C. Ministry of Environment, 2005c).

Sodium is not a listed substance in Table 1 of Protocol 4, and a Provincial background soil quality estimate for sodium has not been established. Furthermore, background soil quality concentrations provided in the regional data-bases of Technical Guidance 17 are based on strong acid digestion extraction methods, rather than the saturated paste extraction method now required for regulatory purposes under the Contaminated Sites Regulation (CSR).

Currently, the ministry has no data available related to sodium concentrations in background soil determined by the recently approved saturated paste analytical method. Consequently, the ministry is unable at this time to estimate a Provincial background soil quality estimate for sodium in soil

As no Provincial background soil quality estimate can be calculated for sodium, it is not possible to consider any background adjustment of the proposed 2007 final draft matrix soil standards for sodium (Na^+).

2.3.2 Application of CSST Rounding-off Rule

To assist scientific and public review, the draft matrix soil quality standards for sodium as posted by the ministry in 2002 (Appendix A) were not subject to the CSST "Rounding-off Rule", (B.C. Environment, 1996).

To finalize the 2007 matrix soil standards for sodium, the 2002 draft standards for sodium were updated based on application of the CSST Rounding-off Rule.

No other CSST, 1996 ancillary adjustments were required in finalizing the proposed 2007 final draft matrix soil quality standards for sodium (Na^+).

2.4 Finalization of 2007 Final Draft Matrix Soil Standards for Chloride

2.4.1. Kd-related Simplification of Soil to Groundwater Transfer Protective Standards

The 2002 draft matrix soil quality standards for chloride provided a set of chloride:soil adsorption co-efficient (Kd) range specific soil standards to protect against Cl^- transfer from soil to groundwater used for drinking water, aquatic life and irrigation watering (Appendix B).

BCLQAAC in the course of completing studies related to the development of a chemical analytical method to accurately determine the soil adsorption co-efficient (Kd) for chloride, noted that for the majority of soils (whether; sand, clay or loam) it would be very unusual to find a chloride Kd in excess of 0.1 in soil. This observation in conjunction with uncertainties associated with the precision of the chloride:soil adsorption co-efficient (Kd) for chloride method when determining chloride Kd near the method minimum detection limit (MDL) resulted in the following recommendation, (Downie, 2006):

- "*Recommendation 3: Raise the lowest KD-Cl range within the MNSS-Cl* [i.e. Matrix Numerical Soil Standards for Chloride Ion] *to a level that exceeds the MDL and Quantitation Limit of the KD-Cl method (under ideal circumstances). It is recommended that the lowest KD-Cl range be set to* < *0.1 mL/g.*"

For these reasons, it was decided to simplify the 2002 draft matrix soil quality standards by eliminating the series of chloride:soil adsorption co-efficient (Kd) range specific soil standards to protect against Cl^- transfer from soil to groundwater used for drinking water, aquatic life and irrigation watering.

In consequence, the proposed 2007 final draft matrix soil standards to protect groundwater used for drinking water, aquatic life and irrigation watering were

collapsed to single standards, appropriate to a chloride:soil Kd range of 0 - 0.1 mL/g. Note that provision for further Kd dependant adjustment of these soil to groundwater protective final standards is still provided by way of footnote 5 in the 2007 matrix. Thus a proponent may choose to determine the site-specific chloride:soil Kd for their site. If the Kd for chloride in the soil of their site is in fact greater than the chloride:soil Kd of 0 - 0.1 mL/g assumed for the 2007 matrix, the proponent can contact the Director to obtain a Kd adjusted soil standard appropriate for use at their specific site.

2.4.2 Recalculation of Soil to Groundwater Standards to Protect Aquatic Life

In 2002, there were no approved or working ministry or Canadian Council of Ministers of the Environment (CCME) aquatic life water quality guidelines for chloride.

Under the CCST procedures, matrix soil standards to protect aquatic life from soil to groundwater to surface water contaminant transfer are back-calculated using the ministry's approved groundwater transport model (B.C. Ministry of Environment, 2006b) and the CSR Schedule 6 aquatic life protective water quality standards (British Columbia, 2005). The CSR Schedule 6 aquatic life water quality standards are adopted directly from either ministry approved or working water quality criteria (B.C. Ministry of Environment, 2006c; 2006d) or CCME water quality guidelines (CCME, 1999) to protect aquatic life.

In view of the extreme solubility of chloride, provision of soil standards to protect aquatic life from soil to groundwater transfer was considered an essential element of the derivation of matrix soil standards. Dr. Bright was therefore directed by the Salt Standards Scientific Steering Committee to investigate options related to possible use of aquatic life protective water quality criteria drawn from other regulatory agencies, or *de novo* derivation of an "interim" aquatic life protective water quality guideline, for use in calculating aquatic life protective soil standards.

Ultimately, the ministry's 2002 draft matrix soil standards to protect aquatic life were based on back-calculation using an existing US Environmental Protection Agency ambient water quality criteria for chloride of 230 mg/L (US EPA, 1988; Bright and Addison, 2002a.).

Subsequently in 2003, the ministry published approved ambient water quality guidelines for chloride (B.C. Ministry of Environment, 2003). These 2003 guidelines included a 30-day average, freshwater aquatic life protective guideline of 150 mg/L. As the CSST procedures require use of ministry water quality criteria (guidelines) where such criteria exist, new preliminary matrix soil standards to protect aquatic life were back-calculated using the ministry groundwater transport model and the 2003 aquatic life 30-day average ambient water quality guideline for chloride. Details of the groundwater model parameter values used in this calculation appear in Appendix E. [3]

A new preliminary 2007 matrix soil standard of 532 ug/g, applicable to all land uses, was calculated to protect groundwater flow to surface water used by aquatic life.

2.4.3 Recalculation of Soil to Groundwater Standards to Protect Livestock

In 2002, no ministry or CCME water quality criteria to protect livestock existed for chloride. Under the CCST procedures, matrix soil standards to protect livestock from soil to water contaminant transfer are back-calculated using the ministry approved groundwater transport model (B.C. Ministry of Environment, 2006) and the CSR Schedule 6 livestock water quality standards (British Columbia, 2005). The CSR Schedule 6 livestock water quality standards are adopted directly from either ministry approved or working water quality criteria (B.C. Ministry of Environment, 2006c; 2006d) or CCME water quality guidelines (CCME, 1999) to protect livestock.

In 2003, the ministry published approved ambient water quality guidelines for chloride (B.C. Ministry of Environment, 2003). These 2003 guidelines included a livestock watering guideline of 600 mg/L.

As the CSST procedures require use of ministry water quality criteria (guidelines) where such criteria exist, the 2007 final draft matrix soil standards include a standard to protect livestock watering for agricultural land use. This livestock watering protective soil standard was back-calculated using the ministry groundwater transport model and the 2003 livestock watering guideline. Details of the groundwater model parameter values used in this calculation appear in Appendix E. [3]

A new preliminary 2007 matrix soil standard of 213 ug/g, for agricultural land use, was calculated to protect groundwater used for livestock watering.

2.4.4 CSST Background Adjustment

The CSST, 1996 procedures provide for a "background" adjustment of toxicologically derived soil standards in the case where a derived preliminary soil matrix standard represents a concentration which is less than the naturally occurring (background) concentration of the substance in soil.

As envisioned by CSST, the (Provincial) background soil concentrations for substances should represent "contaminant concentrations equivalent to no less than the 90th percentile of the Lower Mainland background soil concentrations", (CSST, 1996).

In practise the ministry has established, strictly for use in regulatory standards development, Provincial background soil quality estimates for only the selected

[3] CSST, 1996 equations were used in calculating soil to groundwater protective standards.

inorganic substances listed in Table 1 of Protocol for Contaminated Sites 4, Determining Background Soil Quality, (B.C. Ministry of Environment, Lands and Parks, 1999). Furthermore, the ministry has established these Provincial background soil quality estimates as the 95th percentile background soil concentration of all regional background soil data for a substance contained in Technical Guidance on Contaminated Sites 17, Soil Quality Database, (B.C. Ministry of Environment, 2005c).

Chloride is not a listed substance in Table 1 of Protocol 4, and a Provincial background soil quality estimate for chloride has not been established. Furthermore, background soil quality concentrations provided in the regional data-bases of Technical Guidance 17 are based on strong acid digestion extraction methods, rather than the saturated paste extraction method now required for regulatory purposes under the CSR.

Currently, the ministry has no data available related to chloride concentrations in background soil determined by the recently approved saturated paste analytical method. Consequently, the ministry is unable at this time to estimate a Provincial background soil quality estimate for chloride in soil.

As no Provincial background soil quality estimate can be calculated for chloride, it is not possible to consider any background adjustment of the proposed 2007 final draft matrix soil standards for chloride (Cl^-).

2.4.5 Application of CSST Rounding-off Rule

To assist scientific and public review, the draft matrix soil quality standards for chloride as posted by the ministry in 2002 (Appendix B) were not subject to the "CSST Rounding-off Rule", (B.C. Environment, 1996).

As a final updating step, the new preliminary matrix soil standards to protect aquatic life and livestock calculated in sub-sections 2.4.2 and 2.4.3 above and the remaining previously derived 2002 draft matrix soil quality standards for chloride were rounded in accordance with the CSST Rounding-off Rule.

No other CSST, 1996 ancillary adjustments were required in finalizing the proposed 2007 final draft matrix soil quality standards for chloride (Cl^-).

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4. Exhibits

Exhibit 1. Proposed 2007 Final Draft Matrix Soil Standards for Sodium (Na^+)

Exhibit 2. Proposed 2007 Final Draft Matrix Soil Standards for Chloride (Cl^-)

Exhibit 1. Proposed 2007 Final Draft Matrix Soil Standards for Sodium (Na^+)

SCHEDULE 5

MATRIX NUMERICAL SOIL STANDARDS[1]

SODIUM Ion (Na^+) (CAS # 7440-23-5)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
Site-specific Factor	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g		3
Groundwater used for drinking water	15 000	15 000	15 000	15 000	15 000	
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	200	200	200	1 000	1 000	
Livestock ingesting soil and fodder	NS					4
Major microbial functional impairment	NS					4
Groundwater flow to surface water used by aquatic life	NS	NS	NS	NS	NS	5
Groundwater used for livestock watering	NS					5
Groundwater used for irrigation	NS	NS	NS			5

Notes

1. All values in ug/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.
2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.
3. Intake pathway of exposure modeled is inadvertent ingestion of soil.
4. NS – no standard. Insufficient acceptable scientific data exists, so no standard is calculated.
5. NS – no standard. No appropriate standard, guideline of criterion exists to use to develop a soil quality standard.

Exhibit 2. Proposed 2007 Final Draft Matrix Soil Standards for Chloride (Cl^-)

SCHEDULE 5

MATRIX NUMERICAL SOIL STANDARDS[1]

CHLORIDE Ion (Cl^-) (CAS # 7647-14-5)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
Site-specific Factor	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g		3,4
Groundwater used for drinking water	90	90	90	90	90	5
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	350	350	350	2 500	2 500	
Livestock ingesting soil and fodder	NS					6
Major microbial functional impairment	NS					7
Groundwater flow to surface water used by aquatic life	550	550	550	550	550	5,8
Groundwater used for livestock watering	200					5
Groundwater used for irrigation	35	35	35			5

Notes

1. All values in ug/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.
2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.
3. Intake pathway of exposure modeled is inadvertent ingestion of soil.
4. Standard established based on toxic reference dose (Tolerable Daily Intake) derived for NaCl. Toxicity attributed primarily to cation (Na^+) not anion (Cl^-).
5. Standard varies with Kd for Chloride ion in the soil of a site. Standard is appropriate to a chloride:soil Kd range of 0 to 0.1 mL/g. Consult Director for further advice.
6. NS – no standard. No appropriate standard, guideline of criterion exists to use to develop a soil quality standard.
7. NS – no standard. Insufficient acceptable scientific data exists, so no standard is calculated.
8. Standard to protect freshwater aquatic life.

5. Appendices

Appendix A.	2002 Draft Matrix Soil Standards for Sodium (Na^+)
Appendix B.	2002 Draft Matrix Soil Standards for Chloride (Cl^-)
Appendix C.	Members of the Salt Standards Scientific Steering Committee
Appendix D.	Members of the Salts Issues Technical Advisory Committee
Appendix E.	Groundwater Model Parameter Values Used in Calculation of Preliminary 2007 Matrix Soil Standards to Protect Groundwater Used by Aquatic Life and for Livestock Watering

Appendix A. 2002 Draft Matrix Soil Standards for Sodium (Na^+)

SCHEDULE 5

MATRIX NUMERICAL SOIL STANDARDS[1]

SODIUM Ion (Na^+)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
Site-specific Factor	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g		3
Groundwater used for drinking water	13 000	13 000	13 000	13 000	13 000	
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	190	190	190	1 200	1 200	
Livestock ingesting soil and fodder	NS					4
Major microbial functional impairment	NS					4
Groundwater flow to surface water used by aquatic life	NS	NS	NS	NS	NS	5
Groundwater used for livestock watering	NS					5
Groundwater used for irrigation	NS	NS	NS			5

Notes

1. All values in ug/g unless otherwise stated. Substances must be analyzed using methods specified in protocols approved under section 53 or alternate methods acceptable to the director.
2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.
3. Intake pathway of exposure modeled is inadvertent ingestion of soil.
4. NS – no standard. Insufficient acceptable scientific data exists, so no standard is calculated.
5. NS – no standard. No appropriate standard, guideline of criterion exists to use to develop a soil quality standard.

Appendix B. 2002 Draft Matrix Soil Standards for Chloride (Cl^-)

SCHEDULE 5

MATRIX NUMERICAL SOIL STANDARDS[1]

CHLORIDE Ion (Cl^-)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
Site-specific Factor	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g		3,4
Groundwater used for drinking water						
Kd < 0.05	50	50	50	50	50	5
Kd 0.05 - < 0.1	90	90	90	90	90	5
Kd 0.1 - < 0.15	130	130	130	130	130	5
Kd 0.15 - < 0.2	170	170	170	170	170	5
Kd $\geq$ 0.2	210	210	210	210	210	5
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	370	370	370	2 500	2 500	
Livestock ingesting soil and fodder	NS					6
Major microbial functional impairment	NS					7
Groundwater flow to surface water used by aquatic life						
Kd < 0.05	440	440	440	440	440	5,8
Kd 0.05 - < 0.1	820	820	820	820	820	5,8
Kd 0.1 - < 0.15	1 200	1 200	1 200	1 200	1 200	5,8
Kd 0.15 - < 0.2	1 600	1 600	1 600	1 600	1 600	5,8
Kd $\geq$ 0.2	2 000	2 000	2 000	2 000	2 000	5,8
Groundwater used for livestock watering	NS					6
Groundwater used for irrigation						
Kd < 0.05	20	20	20			5
Kd 0.05 - < 0.1	35	35	35			5
Kd 0.1 - < 0.15	50	50	50			5
Kd 0.15 - < 0.2	70	70	70			5

Kd $\geq$ 0.2	85	85	85			5

Notes

1. All values in ug/g unless otherwise stated. Substances must be analyzed using methods specified in protocols approved under section 53 or alternate methods acceptable to the director.
2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.
3. Intake pathway of exposure modeled is inadvertent ingestion of soil.
4. Standard established based on toxic reference dose (tolerable Daily Intake) derived for NaCl. Toxicity attributed primarily to cation (Na^+), not anion (Cl^-).
5. The Kd is the Kd of the soil at a site.
6. NS – no standard. No appropriate standard, guideline of criterion exists to use to develop a soil quality standard.
7. NS – no standard. Insufficient acceptable scientific data exists, so no standard is calculated.
8. Standard to protect freshwater aquatic life, based on USEPA (1988) chloride water quality guideline of 230 mg/L.

Appendix C. Members of the Salt Standards Scientific Steering Committee

Glyn R. Fox, Ph.D. (Committee Chair)
Ministry of Water, Land, and Air Protection

Doug Walton, Ph.D.
Ministry of Water, Land, and Air Protection

Narender Nagpal, Ph.D.
Ministry of Water, Land, and Air Protection

Linda Elder, B.Sc.
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Nazir Jessa, P.Eng., CMA
British Columbia Buildings Corporation

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John Ashworth, Ph.D.
Norwest Laboratories,

Doug Keyes,
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Canadian Association of Petroleum Producers

Alan Kennedy,
Canadian Association of Petroleum Producers

Neil W. Drummond,
Canadian Association of Petroleum Producers

Doug Bright, Ph.D.
Royal Roads University

Appendix D. Members of the Salts Issues Technical Advisory Committee

James Agate (Committee Chair)
Canadian Natural Resources Limited

Glyn Fox
BC Ministry of Environment

Peggy Evans
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Appendix E. Groundwater Model Parameter Values Used in Calculation of Chloride Preliminary 2007 Matrix Soil Standards to Protect Groundwater Used by Aquatic Life and for Livestock Watering

Model Component	Parameter	Definition	Value	Units	Notes
Source Properties	X	Source length	5	m	
	Y	Source width	30	m	
	Xr	Distance to receptor	10	m	
Aquifer Properties	N	Total porosity (saturated zone)	0.3		
	n_e	Effective porosity (saturated zone)	0.2		
	n_a	Air porosity (unsaturated zone)	0.2		
	n_w	Water porosity (unsaturated zone)	0.1		
	f_{oc}	Fraction organic carbon	0.006	dimensionless	
	P_b	Density	1.75	g/cm^3	
	K	Hydraulic conductivity	0.0001	m/s	
	i	Hydraulic gradient	0.004	m/m	
	d_a	Aquifer thickness	5	m/yr	
	I	Infiltration rate	0.55	m/yr	
Contaminant Properties	Kd	Chloride:soil dissociation coefficient	0.05	mL/g	chemical specific
	H'	Henry's constant	0	dimensionless	
	$t_{1/2}$	Biodegradation half-life	0	Days	
	Solubility	Pure-phase solubility	216652.73	mg/L	chemical specific [1]
Water Quality Standards	$C_{schedule\ 6\ AW}$	CSR Schedule 6 Aquatic Life standard	150	mg/L	
	$C_{schedule\ 6\ LW}$	CSR Schedule 6 Livestock Watering standard	600	mg/L	

[1] Based on NaCl solubility of 357 g/L (Merck, 1976) and calculated Cl- solubility of 216.65 g/L