FINAL REPORT

Alternative Salt Guidelines for British Columbia Boreal Peatland Releases:

Scientific Derivation Document

Prepared for:
Steering Committee – BC OGRIS Salinity in Wetlands Research Project

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Re: **Alternative Salt Guideline for British Columbia Boreal Peatland Releases: Scientific Derivation Document**

I am pleased to present this final report to the Steering Committee for the BC OGRIS "Adapting Contaminated Sites Approaches for Produced Water Releases to Wetlands" Project aimed at developing a set of alternative salt guidelines for peatland ecosystems for possible adoption under the province's *Contaminated Sites Regulation.*

My thanks for your long-standing interest in this project and its intended outcomes.

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We would like to thank the British Columbia Oil and Gas Research and Innovation Society (BC OGRIS) for their generous funding and support, and to the BC OGRIS fund manager, Brian Thompson, for his patience.

We would also like to express our appreciation to the Project Steering Committee - comprised of representatives from the Canadian Association of Petroleum Producers, Oil and Gas sector knowledge experts at large, the BC Ministry of Environment, BC Oil and Gas Commission, and BC Environmental Laboratory Technical Advisory Committee. Individuals who have helped shape this project since its inception, through their participation on the Project Steering Committee include the following:

On behalf of the BC Ministry of Environment:

Dr. Glyn Fox
Lavinia Zanini
Peggy Evans
Dr. Lizzy Mos

On behalf of the BC Oil and Gas Commission:

Devin Scheck

On behalf of the Canadian Association of Petroleum Producers:

Robert Martens
Diana Almeida
Paul Hartzheim

On behalf of the BC Environmental Laboratory Technical Advisory Committee

Mark Hugdahl

Dr. Curtis Eikhoff and James Elphick, of Nautilus Environmental contributed to the design and execution of the laboratory toxicity testing, including development and refinement of methods for species of relevance to boreal peatland environments. Finally, we thank James Agate, CNRL, and Sean Willetts, Conoco-Phillips, for their help in our search for suitable field sites for mesocosm trials.

IMPORTANT NOTES FOR THE READER

The opinions, interpretations and conclusions herein are those of the author alone and are not necessarily endorsed by BC OGRIS or the entities who provided representatives to the Project Steering Committee. This report is provided as a project deliverable per conditions of the BC OGRIS grant provided for this project.

A key objective of this project was to enable the adoption of a new set of British Columbia Contaminated Sites Regulation (BC CSR) peatland salt soil matrix standards and application protocols; however, the solution- based chloride and sodium thresholds of biological effects derived herein have not been formally adopted into the BC CSR at the time of completion of this report. The possible future adoption of alternative salt standards in the province, specifically focussed on saline releases to peatland ecosystems, will require further internal BC MOE review, as well as consultations, and is further subject to enabling mechanisms for future alterations or additions to contaminated sites numerical standards as defined within the current version of the British Columbia *Environmental Management Act* and *Contaminated Sites Regulation.*

Above all, the ministry has to further review this document and the numerical thresholds discussed herein are not considered standards for demonstrating compliance with the BC CSR until further notice. In light of this larger context, the ecotoxicological thresholds derived and discussed herein are uniformly referred to as “guidelines” rather than “standards”.

We trust that the scientific data and interpretations provided herein will responsible parties and contaminated site assessment/environmental risk assessment practitioners with an improved ability to work through the assessment and remediation of peatland sites affected by produced water and other types of sodium and chloride environmental releases, regardless of the formal regulatory status of the derived environmental protection goals.

EXECUTIVE SUMMARY

The province of British Columbia adopted in the mid-2000s numerical “soil matrix standards” within the CSR for chloride (Cl) ion and sodium (Na) ion; however, NaCl assessment and remediation guidelines that are of direct relevance to the major portion of western Canadian wetlands, and especially peatlands, do not currently exist. This report describes the scientific basis for the derivation of an alternative suite of salt ion numerical soil guidelines for possible adoption within the British Columbia Contaminated Sites Regulation (BC CSR) framework that are better focused on a peatland environment as opposed to terrestrial upland soil systems. The newly derived guidelines are intended to be applicable for anthropogenic salt releases to boreal peatland environments, including fens and bogs, as opposed to terrestrial upland environments.

For the purpose of applying the provisional alternative salt guidelines, peatlands are defined as areas that are continuously or routinely water-saturated in their natural or reclaimed state such that water occurs, at least seasonally for a typical year, at or near (within 20 to 30 cm of) the upper land surface, including bryophyte cover. Furthermore, a peatland – by operational definition – will exhibit a surface accumulation of peat to a depth of ≥40 cm. Furthermore, peatland sites (bog or fen-type wetlands) exhibit organic soils (peat) with a total organic carbon content ≥17%.

The Na ion and Cl ion numerical soil standards that were adopted under the BC CSR in 2006 were based on the analysis of Cl and Na content in soil samples using saturated paste methods, as described in Section B of the British Columbia Environmental Laboratory Manual (2015). For Cl and other major salt anions such as sulfate, virtually the entire mass of Cl present will be associated with soil pore water (or interstitial water) to the extent that the soil matrix is substantially saturated under typical environmental conditions (as is the case for hygric soils). For simple cations such as Na, the major portion of the mass will be associated with the aqueous phase except in the case of soil types with a very high cation exchange capacity. The saturated paste methods prescribed for use with the existing BC CSR numerical matrix standards for Cl or Na are not appropriate for hygric, organic rich, and very low bulk density soils, given the associated expression of sample concentration on the basis of soluble/extractable mass of Cl ion and Na ion per dry mass of soil. This is because the soil bulk density of peat soils is far lower than the mineral soil types used to derive Na ion and Cl ion soil ecotoxicity data used in the earlier derivation. Alternative methods are proposed here for either the direct (preferred method) or indirect (via fixed ratio water extraction of soil) measurement of salt ions in soil solution (in mg/L), consistent with the field concentrations that are likely to occur in peat interstitial water within the upper biologically active zone.

The derivation of alternative salt guidelines for peatland environments is intended primarily for application to wildlands settings; however, it is recognized that occasionally peatlands will occur adjacent to or underneath sites with other land use types and the peatland protection goals as discussed herein are relevant.

In order to define acceptable Cl and Na concentration thresholds for the protection of peatland ecosystems based on solution-based exposure concentrations, the existing ecotoxicological information was critically evaluated, and new relevant data were developed based on laboratory ecotoxicity testing completed by Nautilus Environmental. New concentration-response type ecotoxicity data were developed, under laboratory conditions intended to approximate exposure conditions in salinized peatland ecosystems, for a collembolan (*Folsomia candida*), two plant species (paper birch: *Betula papyrifera*; bluejoint reedgrass (*Calamagrostis canadensis*), and a bryophyte (water moss: *Foninalis antipyretica*).

BC MOE protocols for the derivation of soil quality standards for the protection of soil invertebrates and plants, as updated in 2016, were used in conjunction with the larger set of adequate quality ecotoxicity data to develop a provisional set of alternative salt guidelines that are applicable to British Columbia peatland ecosystems.

The resulting alternate chloride guidelines are as follows:

- WL$_{N}$: 15th percentile chloride concentration = **1370 mg/L** chloride
- WL$_{R}$ / AL / RL$_{LDR}$ / PL: 25th percentile chloride concentration = **1680 mg/L** chloride
- RL$_{HDR}$ / CL / IL: 50th percentile chloride concentration = **2440 mg/L** chloride

The resulting alternative sodium guidelines are as follows:

- WL$_{N}$: 15th percentile chloride concentration = **890 mg/L** sodium
- WL$_{R}$ / AL / RL$_{LDR}$ / PL: 25th percentile chloride concentration = **1090 mg/L** sodium
- RL$_{HDR}$ / CL / IL: 50th percentile chloride concentration = **1580 mg/L** sodium

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DEFINITIONS AND ACRONYMS

Acrotelm: The upper layer of two semi-distinct layers in a peat bog or fen, which is generally partially saturated and contains the major portion of living plant and bryophyte biomass.

BC OGC: British Columbia Oil and Gas Commission.

BC ENV: British Columbia Ministry of Environment and Climate Change Strategy.

Catotelm: The lower layer of two semi-distinct layers in a peat bog or fen, which is generally fully saturated, anoxic, and contains mostly detrital organic matter.

Contaminant: Per Part 4, Div. 1, 39(1) of the BC *Environmental Management Act*, a substance prescribed for the purpose of definition of “contaminated site” in a quantity or concentration exceeding prescribed or risk-based numerical standards.

CSR: *Contaminated Sites Regulation.*

EMA: *Environmental Management Act.*

Emulsion: A mixture of two or more liquids that are normally immiscible. In conventional oil and gas operations, this often refers to a co-mingled solution of petroleum hydrocarbons and produced water. A typical product of oil wells, water-oil emulsion has also been used as a drilling fluid.

Hygric soil: A soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part.

Mesofauna: Invertebrates generally smaller than 2 mm in size that live in the soil or organic litter and matter on or in the soil, including (but not limited to) nematodes, mites, collembola, proturans, pauropods, rotifers, tardigrads, small areneidae, pseudoscorpions, opiliones, enchytraeid worsk, small isppods, myriopods and insect larvae. Mesofauna may play an important role in creating and maintaining soil structure and in the cycling and trophic transfer of energy, carbon, phosphorus, nitrogen, and sulfur.

Minerotrophic/Geogenic: Wetland that receives the major portion of its shorter to longer term water inputs via groundwater from below or laterally.

Ombrogenic:	Wetland that receives the major portion of its shorter to longer term water inputs through direct rainfall and snowfall to the surface.
Produced water:	Water with a complex chemistry and trapped in underground formations that is brought to the surface during oil and gas exploration and production

1.0 INTRODUCTION

Oil and gas (O&G) exploration and extraction activities in British Columbia and elsewhere routinely result in the withdrawal of saline water from the deeper geological reservoirs that host petroleum hydrocarbon resources. This saline "produced water" is the largest waste stream by volume that results from upstream O&G activities. Within typical host sedimentary basins, approximately seven to ten barrels of produced water are generated for every barrel of crude oil, or equivalent volume of natural gas (Santos and Wiesner, 1997; Benko and Drewes, 2008). The inorganic composition of produced water is typically similar to that of seawater: primarily sodium and chloride, with lesser amounts of sulfate, calcium, and other major ions. Salt concentration, however, can vary substantially between production fields from less than a few parts per thousand to more than 250 parts per thousand (>250,000 mg/L) (Benko and Drewes, 2008).

Most produced water from on-land O&G operations is disposed by re-injection into deep subterranean areas (or increasingly through de-salinization by reverse osmosis and re-use in oilfield operations); however, environmental releases may occur especially from the corrosion and rupture of emulsion and produced water pipelines. Accidental releases of saline produced water from oil and gas activities in northeastern BC are an important environmental issue especially in peatland (fen and bog) and other wetland ecosystems. Peatlands coincide with several major O&G operational areas within northeastern British Columbia and produced water releases to peatlands are common in temperate and taiga regions throughout all of western Canada.

Environmental quality guidelines and standards such as *British Columbia Approved Water Quality Guidelines* and soil numerical standards contained within the *British Columbia Contaminated Sites Regulation* (CSR) are important tools for regulators, responsible parties, and practitioners involved in the assessment and remediation of contaminant releases to the environment. The province of British Columbia adopted in the mid-2000s numerical "soil matrix standards" within the CSR for chloride ion and sodium ion. These were developed mainly to assist with the assessment and remediation of road salt storage facilities, especially at highways maintenance yards. Contaminant assessment and remediation guidelines that are of direct relevance to the major portion of western Canadian wetlands, and especially peatlands, do not currently exist.

Since the adoption of CSR soil numerical standards for sodium and chloride, various contaminated sites responsible parties, their consultants, and western Canadian analytical laboratory service providers have gained considerable experience in environmental sampling issues, chemical analyses, and interpretations associated with salt contamination issues in British Columbia. Among the insights gained - especially at northeastern BC oil and gas sites - are the following:

- A large proportion of salt releases enter boreal wetland systems, which can be classified as bogs, fens, marshes, and swamps. The existing CSR salt standards were not derived in consideration of these types of ecosystems, as opposed to hydrogeological and soil conditions more typical of the lower mainland formed through deltaic deposition.

- The CSR standards are based on a “saturated paste” soil extraction and analytical method. Such techniques were developed by agronomic researchers to measure the available fraction of nutrients, ions and trace elements to plant roots in agricultural systems with limited moisture content and are overly complex and potentially inaccurate measures of biological exposures in organic-rich and hygric soil types.
- The true effects on wetland mesofauna, plant roots, and other biota is likely to be better correlated with the soil salt solution results than analytical results expressed on a dry soil mass basis for soils (based in turn on saturated paste extract methods) that are almost completely saturated in their native state.
- The standardized CSR assumptions for back-calculation of soil chloride and sodium concentrations protective of aquatic life based on a groundwater-mediated transport scenario are likely overly conservative for the vast majority of peatland systems.

Overall, gaps in scientific knowledge and the regulatory/policy regime for the assessment, risk management, and remediation of saline water releases to boreal wetland ecosystems are perceived to be an impediment to the timely remediation and reclamation of these sites.

This report describes the scientific basis for the derivation of an alternative suite of salt ion numerical soil guidelines for possible adoption within the CSR framework that are better focused on a peatland environment as opposed to terrestrial upland soil systems. This project was funded through the British Columbia Upstream industry supported by the BC Ministry of Environment, BC Oil and Gas Commission, Canadian Association of Petroleum Producers (CAPP), BC Environmental Laboratory Technical Advisory Committee, and various members of the oil and gas industry at-large.

1.1 PROJECT OBJECTIVES

The overall objective of this project is to derive, for the consideration of the Ministry of Environment and Climate Change (BC ENV) and BC Oil and Gas Commission (BC OGC) a set of salt ion (chloride and sodium) matrix soil numerical guidelines for possible adoption within the BC *Contaminated Sites Regulation* (CSR) framework. The newly derived guidelines are intended to be applicable for anthropogenic salt releases to boreal peatland environments, including fens and bogs, as opposed to terrestrial upland environments. The derivation includes the development of ancillary guidance on conditions under which the alternative wetland numerical soil guidelines could be applied and precluding conditions related to their use.

While saline produced water releases from upstream O&G operations into BC wetland ecosystems present challenges for the appropriate assessment and remediation of operational and spill sites, there are other human activities that routinely result in the release of sodium and chloride as well as other salt ions to wetland ecosystems. Among these are road salt storage, handling and application. Thus, the development and adoption of alternative salt guidelines under the provincial *Contaminated Sites Regulation* is intended to increase the efficacy and ease of site remediation and reclamation for peatlands that have been affected by sodium and chloride environmental releases in general.

2.0 WHAT ARE PEATLANDS? AN OPERATIONAL DEFINITION

Peatlands comprise a subset of wetland ecosystem types. According to Mackenzie and Moran (2004), wetlands are –

> "*areas where soils are water saturated for a sufficient length of time such that excess water and resulting low oxygen levels are principal determinants of vegetation and soil development. Wetlands will have a relative abundance of hydrophytes in the vegetation community and/or soils featuring "hydric" characteristics.*"

The *Canadian Wetland Classification System* (2nd edition, 1997, Warner and Rubec, editors) (available online at http://www.gret-perg.ulaval.ca/fileadmin/fichiers/fichiersGRET/pdf/Doc_generale/Wetlands.pdf) defines five major classes of wetlands and various forms and subforms therein; i.e. bogs, fens, swamps, marshes, and shallow water wetlands. These are further divided into two broad categories: organic wetlands (more simply referred to as peatlands), and mineral wetlands.

According to Warner and Rubec (197) –

> "*Peatlands contain more than 40 cm of peat accumulation on which organic soils (excluding Folisols) develop. This depth limit is consistent with soil classification standards established by the Canada Soil Survey Committee (1978).*
>
> *Mineral wetlands are found in areas where an excess of water collects on the surface and which for geomorphic, hydrologic, biotic, edaphic (factors related to soil), or climatic reasons produce little or no organic matter or peat. Gleysolic soils or peaty phases of these soils are characteristics of these wetlands."*

The Alberta (October 2015) Peatland Reclamation Criteria provide a very useful discussion about desired functions of peatlands:

> *"Peatlands, like other wetlands, serve important functions on the landscape: namely, (1) water storage; (2) a filter for surface water as it moves into ground water; (3) a habitat for wildlife (Mitsch & Gosselink 2000) and (4) a carbon sink (Yu et al. 2001)."*

BC CSR alternative salt guidelines for peatlands should provide adequate protection of the sphagnidae mosses and other vegetation that are important for carbon sequestration and water storage and filtering, and for the growth of herbaceous and woody plants and trees that provide forage, tertiary structure, shelter, nesting and denning sites.

The Alberta Peatland Reclamation Criteria document further states:

> *"Vegetation is the long term indicator of biogeochemical conditions of a peatland; however, disturbance leads to chemical and/or water level changes that affect vegetation. In peatlands, the ground layer (i.e., bryophytes) is most strongly affected by these changes, leading to disruption of peat accumulation functions."*

The Alberta Peatland Reclamation Criteria further reinforce an operational definition of a peatland consistent with the Canadian Wetland Classification System:

> *"Peatlands are defined in North America as landscape covered by peat to a minimal depth of 40 cm (Tarnocai, 1980). Peat is a deposit of plant and animal remains that over time has accumulated under water-saturated conditions through incomplete decomposition."*

Characteristics of western Canadian peat soils are defined in Appendix A, p. 41 of the Alberta Peatland Reclamation Criteria:

> *"Important structural attributes for peat in western Canada are as follows: Bulk density of peatland peat from western Canada is 0.168 g/cm^3, much greater than the global average of 0.118g/cm^3. Organic matter content averages 91.6 per cent. Carbon content averages 45.0 per cent and nitrogen content 1.1 per cent, while C/N mass ratio averages 62.4 (all data from Loisel et al. (2014)."*

For the purpose of application of alternative salt guidelines, peatlands are defined herein as areas that are continuously or routinely water-saturated in their natural or reclaimed state such that water occurs, at least seasonally for a typical year, at or near (within 20 to 30 cm of) the upper land surface, including bryophyte cover. Furthermore, a peatland – by operational definition – will exhibit a surface accumulation of peat to a depth of ≥40 cm.

In British Columbia, the highest water elevations in peatlands typically occur during spring freshet, based on local recharge with snowmelt.

There may be instances in which peat accumulations arising from peatland development are encountered in the subsurface environment, beneath shallow anthropogenic or naturally occurring flood or landslide deposits. These relict peatland soils may be considered as peatlands for the purpose of applying alternative salt guidelines, to the extent that the soil characteristics within the peat strata are consistent with the expected range of variation in natural surface peatlands within the province.

The peat 'soils' that are the subject of this alternative salt guideline, furthermore, comprise accumulations of partially decayed vegetation accumulating under anoxic and often acidic conditions. The degree of decay of the detrital organic matter in the peat depends on the major biomass contributions (typically *Sphagnum* moss spp., but also sedges and ericaceous shrubs), hydrological conditions, and local/regional climatic conditions. Because of the ability of peat soils to hold water, peat accumulations may create wetter conditions locally, facilitating further lateral expansion, as well as development of raised bogs; for example, Burns Bog, along the lower Fraser River. Peat soils vary from being fibric (with minimally decomposed bryophyte and plant remains), to hemic (partially decomposed) to sapric (mostly decomposed).

Peatland soils are further defined herein as being rich in detrital organic matter, **having a total organic carbon (TOC) content of ≥17% and a total organic matter content of ≥30%**[1], and having a much lower bulk density than top soils formed in non-hygric environments or in surface and subsurface soils substantially formed through wind and water erosion, glaciation, hydrological processes, and commonly recognized pedogenic processes (i.e., **having a soil bulk density generally less than 0.2 g/cm^3**).

The soil bulk density upper threshold provided above is not intended to support formal categorizations of peatland versus non-peatland soils, in contrast to a definition based on TOC content, for the simple reason that field- or laboratory-based soil bulk density measurements are challenging to obtain with a reasonable degree of precision and accuracy, and therefore of lesser pragmatic value for defining peatland soils than TOC and site hydrology. A recognition of the low bulk densities of peatland soils is nonetheless important for understanding how salt ion exposure characteristics and biological effects thresholds are expected to be different between peatland and non-peatland soils.

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[1] Per BC MOE CSR Protocol 8, “organic soil” is formally defined as “*any soil containing at least 30% organic matter by weight and includes most of the soils commonly known as peat, muck or bog soils.”*

3.0 ENVIRONMENTAL FATE OF SALINE RELEASES TO PEATLANDS

Chloride and sodium are freely soluble in water, and the fate and effects of NaCl releases to wetlands are closely linked to site hydrology. Canadian (and British Columbian) wetlands may be loosely classified as systems with predominantly mineral soils/sediments (shallow water, marsh, some swamps) or peat accumulating systems (bogs, fens, some swamps) (Price and Waddington, 2000). Mackenzie and Moran (2004) provide a much more detailed biogeoclimatic classification of British Columbia bogs, fens, marshes, swamps and other major wetland types; however, for the purpose of developing alternative salt guidelines, we differentiate only between peat-accumulating wetlands (bogs, fens) and those that do not accumulate peat (mineral substrate types) such as marshes and swamps.

Marshes and swamps tend to exhibit greater surface water connectivity over extended areas in comparison with bogs and fens. Although potentially of small geographic scale, surface water accumulations in marshes and swamps have ecological characteristics that are similar to lotic systems (smaller scale to larger scale creeks, streams, and rivers, particularly in headwater areas) and lentic systems (still water ecosystems such as lakes and ponds). In addition, many marsh and swamp ecosystems in British Columbia transition into headwater and tributary areas of lotic systems and the transitions tend to be more gradual than punctuated. Thus, from a management perspective, wetlands other than fens or bogs may provide similar habitat for aquatic life as the broader range of lotic and lentic systems. From an ecological protection perspective, contaminant risk management objectives will generally be similar for shallow water, marsh and swamp wetlands as for lotic and lentic ecosystems. Such wetland types are not discussed further herein in any detail.

An obvious feature of peatlands is the macroscale and microscale ‘soil’ forms associated with the active growth of sphagnum mosses and other bryophytes and the extensive detrital organic matter that accumulates as a result. While there are instances and periods when open surface flows dominate ecohydrological processes, subsurface flow characteristics are generally of greater interest from an ecosystem functioning perspective over extended spatial and temporal scales (although emergent properties and functions reflect interactions between surface and subsurface flows, as discussed below). There have been very few published studies at the field scale of the transport and fate of ions such as chloride and sodium through peatlands (McCarter and Price 2017). One of the few available studies is on NaCl transport in a blanket bog by Baird and Gaffney (2000). The fate of salt ions in temperate bogs and fens is expected to vary based on the extent to which sources of water are primarily associated with direct rainfall and snowmelt (i.e. in the case of ombrogenic bogs and poor fens) or shallow ground discharge and/or lateral ingress from adjacent areas (geogenic or minerotrophic fens).

Classification systems tend to subdivide peatlands according to whether the dominant water input is via direct precipitation and snowmelt recharge to the peatland surface versus inputs from below or laterally of shallow groundwater. Geogenic peatlands are generally considered to exhibit higher pH owing to the ongoing inputs with groundwater of calcium and magnesium and other elements sourced from lithogenic weathering, while obrogenic peatlands – especially bogs – tend to exhibit pH < 4.5. Circumneutral fens buffered by calcium and magnesium inputs from groundwater ingress tend to exhibit a much higher diversity of plants and other species than more highly acidic fens and bogs.

Because of the appreciable seasonal variations in rainfall, snowfall, snowmelt, temperature, and evaporation in British Columbia, peatlands tend to exhibit strong seasonal variations in the water levels and secondarily of lateral transport rates. Particularly in shallow peatland systems (e.g. ~0.5 to ~2 m deep) that have evolved over top of low permeability tills and glaciolacustrine sediments, water levels may be near or above the height of living peat hummocks and features during the spring melt period, and may recede through dryer late summer periods to a half meter or more below the peatland surface. The seasonal variations in peatland water volumes also drive seasonal variations in salt ion concentrations in areas affected by saline water releases, since the total mass of salt ions that occurs locally will be dissolved in smaller volumes of water within the peatland during seasonally dry periods. Thus, we have observed at several produced water release sites in British Columbia, a temporary seasonal increase in fen water chloride concentrations under low precipitation late summer conditions, commensurate with the drop in the water table. Seasonal variations on peatland solute strength as a result of changes in the water table height and corresponding change in volume of water per hectare of wetland are also expected to occur naturally.

While seasonal variations in peatland water storage capacity are theoretically expected to alter solute concentrations if water losses occur through evapotranspiration, the actual quantification of peatland water storage capacity and its variability over space and time is technically challenging (Bourgault et al., 2016). Furthermore, past research has suggested that the effective water storage capacity (further influenced by air uptake, and peat matrix compression or expansion) can vary by two orders of magnitude in the upper 0.5 m of the peatland (Dettman and Bechtold 2016), and between the upper living portion of the peatland (acrotelm), which is typically a few decimeters thick, and the more anoxic, deeper detrital portion (catotelm) (Bourgault et al. 2017).

As discussed above, peatlands can be broadly categorized as ombrogenic or geogenic; however, seasonal and interannual evaporative water loss and water table drawdown has been shown to result in seasonal or longer-term groundwater flow reversals in some systems (Price *et al.* 2000). While the direct measurement of groundwater gradient and direction can provide useful information about the longer-term fate of soluble contaminants introduced in peatlands, it is important to consider the possibility of groundwater flow reversals that may be driven by natural or other processes. Local alterations in water volumes and height, e.g. as a result of saline water recovery efforts when actively pumping from bell holes or as a result of beaver dam construction and loss, can result in both an alteration in vertical groundwater flow direction (resulting in increased rates of downward or upward transport of salt ions) and capillary rise of salt ions in association with evapotranspiration.

Lateral water and salt ion transport rates vary according to water table elevation with differing conductivities of acrotelm and catotelm. During periods of higher water in many peatlands, net water and solute transport may increase substantially based on greater interconnectivity of open water channels. Under very high water conditions, lateral transport as sheet flow may occur. For the prevailing conditions in most fens and bogs in British Columbia, when there is no continuous or semi-continuous surface water present above the peat matrix, depth below the peat surface is a strong correlate of many ecohydrological variables such as saturation, redox potential, soil structure, soil pore characteristics, and hydraulic conductivity (Morris *et al.* 2011). Thus, several models of water and solute flow through peatlands assume a two-layer system comprised of a permanently saturated catotelm underlying a semi-saturated acrotelm. As discussed by Morris *et al.* (2011), this "diplotelmic" conceptual model of water transport through peatlands is approximately six decades old, but has not been rigorously examined experimentally. According to these authors, both spatial and vertical heterogeneity are important aspects of peatland ecohydrology, beyond the two-layer concept, with "hot spots" that "*exhibit fast processing rates in a number of mechanistically linked hydrological, ecological and biogeochemical processes".* Baird *et al* (2016) also provide experimental evidence that the acrotelm-catotelm model is simplistic for predictions of lateral conductivity with depth.

Peatlands tend to be low-gradient systems, and this - along with low saturated hydraulic conductivities for water levels that are less conducive to channelized and macropore flow – tends to limit the rates of lateral spread of salt ions introduced to the peatland. Nonetheless, there are abundant observations of rapid rates out lateral transport of saline water release within hours to a few days of a release to peatland ecosystems in northeast British Columbia. The rate of lateral spread is likely to be commensurate with the volume of the produced water or other type of saline water release: Large volumes introduced at the point of a spill or emulsion line/produced water line failure will result in local mounding of the water table, thus substantially increasing both the local hydraulic gradient and hydraulic conductivity. Once the released saline water infiltrates the peatland and hydraulic gradients return to the pre-spill condition, subsequent rates of lateral spread of salt contamination tend to be very slow.

While it is routinely assumed that chloride is conservatively transported with water, McCarter and Price (2017) provide empirical evidence for retardation factors for chloride ($R_{\text{peat Cl}}$) in the range of 1.1 based on field data and 2.7 to 7.3 based on laboratory core studies. Such retardation is thought to be associated with diffusion into inactive pores along the flow path. Experimentally derived retardation factors for sodium have generally been larger than for chloride ($R_{\text{peat Na}}$ = 2.2 based on field studies). Retardation of chloride and sodium transport rates through peatlands relative to the net transport velocities of wetland water are generally not associated with soil particle sorption-desorption kinetics, as is the case for the vast majority of organic and inorganic contaminants, but rather based on macropore versus micropore and solute diffusion into quiescent pore space, as discussed above.

4.0 ANALYTICAL APPROACH FOR MEASURING BIOLOGICAL EXPOSURES TO SALT IONS IN PEAT SETTINGS

The Na ion and Cl ion numerical soil standards that were adopted under the CSR in 2006 were based on the analysis of chloride and sodium content in soil samples using saturated paste methods, as described in Section B of the British Columbia Environmental Laboratory Manual (2015). For chloride and other major salt anions such as sulfate, virtually the entire mass of chloride present will be associated with soil pore water (or interstitial water) to the extent that the soil matrix is substantially saturated under typical environmental conditions (as is the case for hygric soils). For simple cations such as sodium, the major portion of the mass will be associated with the aqueous phase except in the case of soil types with a very high cation exchange capacity.

Recent experience has been gained in the evaluation of ecological risks in boreal wetland environments associated with residual NaCl contamination arising from a produced water release. Wetland plant and bryophyte community biodiversity (taxon richness) is more closely correlated with chloride (and electrical conductivity) measures obtained from samples of free water collected within the active growing zone than with other measures of contamination such as saturated paste concentrations obtained from soil samples (Bright, 2015).

The saturated paste methods prescribed for use with the existing BC CSR numerical matrix standards for chloride or sodium are not appropriate for hygric, organic rich, and very low bulk density soils, given the associated expression of sample concentration on the basis of soluble/extractable mass of chloride ion and sodium ion per dry mass of soil. This is because the soil bulk density of peat soils is far lower than the mineral soil types used to derive Na ion and Cl ion soil ecotoxicity data used in the earlier derivation (Bright and Addison, 2002). The same Cl (or Na) concentration in the interstitial water of a specific volume of peat versus mineral soil (interstitial water is the medium most relevant to soil invertebrate and plant salt exposures) would exhibit a far higher estimated concentration when converted to a mass per dry weight mass of soil.

Alternative methods are proposed for quantifying chloride and sodium concentrations in the upper peatland as follows:

(i) If feasible, the first preference is to sample standing water within upper 1.0 m of peatland and measure the concentrations of major ions including chloride and sodium directly (mg/L).

Given the operational definition to which this alterative guideline applies, we have found that free water can typically be collected in the field through advancing a small borehole into the upper peatland with a pre-cleaned peat corer or with a sharpened stainless steel long-nosed shovel for excavating a narrow, deep pit. Water will typically seep into the void created within a period of 0.5 h or less, and can be collected using non-contaminating methods such as via use of a dedicated bailer or use of a peristaltic pump. A coarse nylon screen can be used to limit entrainment of fibric and other suspended solids in the sample.

We have also observed that the electrical conductivity and chloride concentration in the upper-most mass of water that freely accumulates in voids introduced into the bog or fen is generally representative of the local concentration in water held within the peat matrix closer to the surface and which communicates with the deeper water mass especially via capillary movement.

(ii) If free water cannot be obtained (highly hygroscopic nature of peat sometimes makes this challenging at lower levels of hydration and during more dry seasons), the sampler and analyst will:

a. Collect a peat sample from top 50 cm of the peat profile (but avoiding active bryophyte growth and the uppermost portions of peat hummocks);

b. Determine the *in situ* water content (moisture content) on a representative sub-sample by oven drying at 105°C [BC Environmental Laboratory Manual, 2015. Section B – Physical, Inorganic and Miscellaneous Constituents];

c. Extract salt ions from another pre-weighed sub-sample using a fixed ratio extraction in the range of ~100 mL deionized water to 20 g fresh weight of peat (SynergyAspen, 2015). The sample and deionized water are thoroughly mixed, and a portion of the water is recovered from the sample through vacuum filtration or a suitable alternative;

d. Analyze chloride in aqueous extract[2] based on ion chromatography or colourimetric methods provided in the BC Environmental Laboratory Manual, or alternative performance-based methods approved by the Director. Analyze sodium in aqueous extract based on atomic absorption spectroscopy or atomic emission spectroscopy or inductively coupled plasma mass spectrometry methods provided in the BC Environmental Laboratory Manual, or alternative performance-based methods approved by the Director;

e. Adjust measured extract concentrations to reflect the concentrations in *in situ* water using volume of water initially present (step b, above) and volume added.

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[2] It is generally recommended that all major salt anions and cations be analyzed in the aqueous sample, including bromide, chloride, sulfate, potassium, sodium, calcium and magnesium. The free ion data from the sample can then be checked based on charge balance, allowing for some potential modest negative charge contribution from organic acids in the peat matrix. The analysis of all major salt ions is also beneficial for interpretations of the degree of natural salinization versus anthropogenic releases to the environment. Analysis of Electrical Conductivity (EC) especially in samples collected via method (i) is recommended to facilitate use of EC during field investigations for real-time contaminant plume delineation, and to provide a basis for demonstrating correlations between EC and sodium and chloride concentrations.

5.0 LAND USES AND RECEPTORS OF INTEREST

The alternative salt guidelines for peatland environments account for a form of direct contact exposure for ecological receptors that is best accounted for by exposures to soil solution. Thus, the general approach for deriving a set of risk-based soil solution effects thresholds is best applied to those contaminants of potential concern that have very little affinity for soil (or detrital organic matter) particles in a two-phase soil-water system and which predominantly partition into water, as is the case for chloride. This approach would not be applicable to contaminants of potential concern that strongly sorb to or are otherwise associated with the solid-phase portion of the soil-water system (e.g. for petroleum hydrocarbon constituents), except where it can be confidently demonstrated that partitioning from soil into the water phase is a precondition for bioavailability and adverse biological effects.

The alternative salt guidelines are also based on an assumption that the zone of exposure is saturated or partially saturated, at least seasonally, as is the case for hygric soils and peatland ecosystems in British Columbia. These alternative soil guidelines were not developed for use in assessment or management of salt contamination for upland ecosystems with plant and soil invertebrate communities potentially present in unsaturated soils.

The BC CSR (Stage 11 Amendments, October 2017) defines soil matrix standards for the following formally defined land uses:

- Wildlands land use (natural *or* reverted)
- Agricultural land use
- Urban park land use
- Residential land use (low density *or* high density)
- Commercial land use
- Industrial land use

The derivation of alternative salt guidelines for peatland environments is intended primarily for application to wildlands settings; however, it is recognized that occasionally peatlands that match the definitions provided in Section 2.0 herein and which fit within the intent of environmental protection goals that underpin the alternative salt guidelines will occur adjacent to or underneath sites with other land use types. As an example, peat bogs and fens are known to occur in areas within northeastern British Columbia that have been included within Agricultural Land Reserve areas.

It is important to note that the intent of the alternative salt guidelines for peatlands is not intended for protection of agronomic or other species and ecosystems, to the extent that the ecotoxicity data than underlie the peatland alternative guidelines are based on surrogate species for the broader suite of peatland flora and fauna. If additional soil (or sediment) biological communities are present at a site that would not generally be found in peatlands, the application of other biological effects thresholds may be required.

As discussed above, the alternative salt guidelines are not intended for application to non-saturated soil systems.

6.0 UPDATED COLLATION OF SCIENTIFIC KNOWLEDGE ABOUT SALT ION EFFECTS ON PEATLAND BIOTA

In order to define acceptable sodium and chloride concentration thresholds for the protection of peatland ecosystems based on solution-based exposure concentrations, the existing ecotoxicological information was critically evaluated (Sections 6.1 and 6.2 below), and new relevant data were developed based on laboratory ecotoxicity testing completed by Nautilus Environmental (Section 6.3).

6.1 RE-EVALUATION OF LABORATORY ECOTOXICITY DATA FROM BRIGHT AND ADDISON (2001)

The soil invertebrate and plant ecotoxicity data used to develop the existing CSR soil matrix standards is provided in Bright and Addison (2002). Relevant details of the experimental methods used to produce these data are provided in Addison (2002), *Addendum C: Soil Invertebrate Toxicity Tests: Lessons and Recommendations* which accompanies the main derivation report. Soil invertebrate toxicity tests were completed in an artificial OECD soil and three native BC soil types collected from Scotch Creek, Clinton, and Saanichton. Sufficient accessory measurements were obtained for the OECD soil, in particular, to convert ecotoxicological threshold values obtained from the studies based on saturated paste methods to sodium and chloride concentration in soil pore water (mg/L).

The OECD soil is composed of 70% sand, 20% kaolin clay, and 10% peat by dry mass. Experiments in the OECD soil were carried out at 30% moisture (by wet weight), or 43% moisture (by dry weight). The water holding capacity (WHC) of the OECD artificial soil was 115% of dry weight (determined according to Annex C of ISO 11267). Thus, the moisture level used in these laboratory toxicity tests corresponded to 37% of WHC. Based on these estimates, the various ecotoxicological thresholds established for exposures to NaCl in the OECD artificial soil, expressed as saturated paste concentrations (mg/kg dw) can be re-expressed on the basis of mg/L in soil solution in light of the expected presence in the test units of 0.43 mL water/g dw soil [i.e. based on 1.15 mL/g soil x 0.37 (37% WHC)].

No similar conversion is available for the soil invertebrate laboratory toxicity test results using field-collected Saanichton, Scotch Creek, or Clinton soil types since no estimate of overall WHC was provided for these.

The converted results of tests in OECD soil are provided in **Table 6-1**.

Table 6-1 Relevant soil invertebrate toxicity data from Bright and Addison (2002)

Test Species	Test Duration	Biological Endpoint	Dose-response Model	NaCl Effect Size (EC_X, LC_X)	NaCl Conc. (mg/kg dw) (95% Conf. Limits)	Na Conc. (mg/L soil solution)	Cl Conc. (mg/L soil solution)
Collembola - *Folsomia candida*	28 d	Reproduction (# of neonates)	Non-linear regression-logistic (r^2=0.788)	EC_{50}	2770 (1900-3640)	2560	3940
	7 d	Mortality	Non-linear regression-logistic (r^2=0.886)	LC_{20}	9590 (8830-10340)	8860	13700
Collembola - *Onychiurus folsomi*	28 d	Reproduction (# of neonates)	Non-linear regression-logistic (r^2=0.935)	EC_{50}	6520 (5520-7520)	6020	9280
		Mortality	Linear regression (0.666)	LC_{20}	5520 n/a-n/a)	5100	7860
Collembola - *Proisotoma minuta*	14 d	Reproduction (# of neonates)	Non-linear regression-logistic (r^2=0.903)	EC_{50}	6420 (5220-7610)	6020	9280
Collembola – *Protaphorura armata*	7 d	Mortality	Linear regression (r^2=0.903)	LC_{20}	16110 (n/a-n/a)	14900	22900
*Earthworms - *Eisenia andrei/fetida*	28 d	Reproduction (cocoon prod'n)	Non-linear regression-logistic (r^2=0.776)	EC_{50}	1880 (1480-2280)	1740	2680
	56 d	Reproduction (hatched cocoons)	Non-linear regression-logistic (r^2=0.553)	EC_{50}	906 (237-1580)	837	1290
	28 d	Growth	Non-linear regression-logistic (r^2=0.682)	EC_{50}	4680 (1980-4390)	4320	6660
		Mortality	Non-linear regression-logistic (r^2=0.990)	LC_{20}	5530 (n/a-n/a)	5110	7870

*Lumbriculid worms such as *E. andrei* are more generally associated with agricultural soils in western Canada, and the vast majority of earthworms in Canada are introduced species. Nonetheless, there is growing interest in earthworm invasions into western Canadian boreal forest ecosystems with peat soils (especially for *Dendrobaena octaedra*). In addition, some northern European peatlands are known to support populations of enchtraeid worms. Thus, *E. andrei* is included here as a non-native species that is nonetheless a relatively salt intolerant, surrogate species for various soft-bodied invertebrates that may occur in fens and bogs.

6.2 ADDITIONAL SOLUTION-BASED SALT ECOTOXICITY DATA FROM THE SCIENTIFIC LITERATURE

A detailed literature search of NaCl effects on soil invertebrates and plants of was completed by Bright and Addison (2002). The data collated in Appendix B of this report were reviewed to identify any relevant laboratory or field ecotoxicity data for soil invertebrates, bryophytes or plants that may serve as surrogate taxa for BC peatland taxa, based on effects thresholds definable on the basis of Na and Cl concentrations in solution (i.e. on the basis of mg/L concentrations). No relevant data were located.

Bright and Meier (2007) completed an updated review of the literature on salt ecotoxicity published between the time of completion of draft salt matrix standards by Bright and Addison (2007) and September 2007. This was completed on behalf of BC ENV in support of the formal adoption into the CSR of the Schedule 5 soil matrix standards for sodium and chloride. Seventeen studies were reviewed, including six separate studies on plants exposed to NaCl hydroponically (in solution). Four of these studies were completed on terrestrial agronomic plant species (e.g. barley, corn, cowpea, bean, soybean) and are not considered relevant to peatland vegetation. Two separate studies (Franklin *et al.* 2002; Apostol *et al.* 2002) examined NaCl effects on jack pine seedlings (*Pinus banksia*). According to NRCan (https://tidcf.nrcan.gc.ca/en/trees/factsheet/43), jack pine is the mostly widely distributed species of pine in Canada, and is commonly found in both muskeg (peatland) and upland habitats. While jack pine can be readily found in boreal peatlands in northern Alberta and the southeastern Yukon, the westerly distribution does not extend into the major portion of northeastern BC (Cunningham et al. 2012). Nonetheless, the species is probably a reasonable surrogate species for lodgepole pine (*Pinus contorta*), which occurs throughout northern BC, as well as for other coniferous plants. Data extracted from these two studies on jack pine are summarized in **Table 6-2** below.

Additional relevant data on plant species likely to be representative of BC peatland species were found in Croser *et al.* (2001), and Renault *et al.* (2005). The relevant data are also presented in **Table 6-2**. Relevant data from Nguyen *et al.* (2006) on growth responses of black spruce, white spruce or jack pine seedlings to 25 mM NaCl with or without prior ectomycorrhizal introduction are not included herein since the paper provided experimental results only as figures, from which quantitative estimates of effect size were challenging to obtain.

Many of these studies (Apostol *et al.* 2002; Franklin *et al.* 2002) used only a single NaCl exposure concentration, along with a control. Thus the full dose-response relationship was not assessed.

Princz *et al.* (2012) described the relative sensitivities of different boreal forest soil invertebrate and plant test species and effects endpoints to salinized soils from a produced water release site in Alberta. This study provides a summary of efforts to develop soil invertebrate and plant toxicity tests that are particularly relevant to Canadian wildlands ecosystems, with an emphasis on boreal forest ecosystems. The salt ion exposure concentrations in this study were quantified as soil electrical conductivity (EC: dS/m).

Table 6-2 NaCl toxicity to peatland and boreal plant species

Species	**Effect Endpoint**	**Effect Size**	**NaCl conc. (mg/L)**	**Na (mg/L)**	**Cl (mg/L)**
Apostol *et al.*, 2002					
Jack pine (*Pinus banksia)* (28 d)	Seedling survival	LC_{30}	3510 (60 nM)	1380	2130
	New shoot length	EC_{28}	*As above*		
	No. of new roots	EC_{85}			
Franklin *et al.*, 2002					
Jack pine (*Pinus banksia)* (10 wk)	Shoot dry mass	EC_{19}	3510 (60 nM)	1380	2130
	Chlorophyll *a*	EC_{15}	*As above*		
Croser *et al.*, 2001					
Jack pine (*Pinus banksia*) (6 wk)	Seed germination	NOEC (LC_0)	5840 (100 mM)	2300	3550
		LC_{83}	14600 (250 mM)	5750	8860
	Seedling survival	LC_7	2920 (50 mM)	1150	1770
		LC_{64}	5840 (100 mM)	2300	3550
White spruce (*Picea glauca*) (6 wk)	Seed germination	LC_8	1179 (20 mM)	460	709
		LC_{28}	2920 (50 mM)	1150	1770
		LC_{88}	5840 (100 mM)	2300	3550
	Seedling survival	LC_5	585 (10 mM)	230	355
		LC_{11}	1170 (20 mM)	460	710
		LC_{50}	2920 (50 mM)	1150	1770
Black spruce (*Picea mariana*) (6 wk)	Seed germination	LC_2	2920 (50 mM)	1150	1770
		LC_{21}	5840 (100 mM)	2300	3550
	Seedling survival	LC_3	585 (10 mM)	230	355
		LC_7	1170 (20 mM)	460	710
		LC_{28}	2920 (50 mM)	1150	1770
		LC_{87}	5840 (100 mM)	2300	3550
Renault *et al.*, 2005					
Tamarack (*Larix laricina*) (40 d)	New shoot length	EC_{59}	1750 (30 mM)	690	1060
		EC_{74}	3510 (60 nM)	1380	2130
	Shoot dry mass	EC_{22}	1750 (30 mM)	690	1060
		EC_{33}	3510 (60 nM)	1380	2130
	Root dry mass	EC_{19}	1750 (30 mM)	690	1060
		EC_{38}	3510 (60 nM)	1380	2130
	Chlorophyll *a* (old needles)	EC_{60}	1750 (30 mM)	690	1060
		EC_{87}	3510 (60 nM)	1380	2130

The expression of exposure concentration as soil EC imposes some limitations on the use of these data to derive a solution based environmental quality guideline for protection against saline releases expressed on the basis of sodium and chloride concentrations. Nonetheless, there is expected to be a strong relationship between the measured EC in saturated or partially saturated soil samples and the solution salt ion concentrations, since EC should be influenced more by cation and anion concentrations in soil solution than in association with the non-aqueous soil phase. Princz *et al.* (2012) constructed an estimated species sensitivity distribution (ESSD) for eight boreal forest plant species and seven soil invertebrate species. The 25th percentile of this combined ESSD was in the range of 0.25 dS/m

6.3 NEW LABORATORY TOXICITY TEST DATA

Nautilus Environmental Inc., Burnaby, was engaged to develop new ecotoxicity data for representative peatland bryophytes, plants and soil invertebrates, based on exposures to sodium chloride in solution within peat soils. A detailed description of study design, methods, results, and interpretations is provided in Appendix A.

The existing Canadian, OECD, or other standardized toxicity test procedures have not been developed for testing biological responses in peat soils, or under hygric conditions, and substantial effort was directed towards a set of study designs that adequately approximate biological exposure conditions in BC peatland areas following a produced water or other type of salinity release. Our efforts to develop test methods relevant to the taxa of interest and expected exposure conditions were assisted by efforts over the last decade to develop laboratory terrestrial toxicity test methods relevant for Canadian boreal ecosystems (Environment Canada, 2103; Environment Canada and Saskatchewan Research Council, 2007).

A concise summary of the test methods and results is provided in this section.

The following toxicity tests were completed by Nautilus:

- Springtail (collembolan) *Folsomia candida* 28-day survival and reproduction test. This was based on an adaptation of Environment Canada test method EPS1/RM/47 (February 2014). *F. candida* is intended to be broadly representative of various other wildlands collembolans and soil invertebrates such as oribatid mites and small-bodied enchytraeid worms.
- Paper birch (*Betula papyrifera*) 35-day seedling emergence and growth. This was based on an adaptation of Environment Canada test method EPS1/RM/56 (2013).
- Bluejoint Reedgrass (*Calamagrostis canadensis*) 28-day emergence and growth. This was based on an adaptation of Environment Canada test method EPS1/RM/56 (2013).
- Greater water moss (*Fontinalis antipyretica*) 21-day growth test. Since there are no standardized sphagnidae or brown moss tests available for species found in peatland environments, the aquatic moss *F. antipyretica* was used as an indicator of overall bryophyte sensitivity to salt ions in areas that are not naturally saline.

Each of these test organisms except *F. antipyretica* was exposed in test units comprised of peat that were then saturated with a sodium chloride solution over a range of concentrations of 0 mg/L (control), 320 mg/L, 490 mg/L, 750 mg/L, 1200 mg/L, 1800 mg/L, 2700 mg/L, 4200 mg/L, 6500 mg/L and 10000 mg/L.

The toxicity tests are summarized in Tables 6-1 through 6-4.

Table 6-3: NaCl effects on springtail (*F. candida*) survival and reproduction over 28 days

Effect Size	**Interpolated Exposure Level (mg/L) (95% Confidence Limits)**		
	NaCl	**Na^+**	**Cl^-**
Survival Rate *(Linear interpolation curve-fitting method)*			
LC5	**722** (535 - > 10,000)	284	438
LC10	>10,000	>3900	>6100
Reproduction: number of neonates *(Non-linear interpolation curve-fitting method: Log-Gompertz: R^2adj = 0.84)*			
IC5	**309** (n/a – 708)	122	187
IC10	**601** (228-979)	236	365
IC15	**896** (496-1310)	352	544
IC20	**1200** (759-1670)	472	728
IC25	**1520** (1040-2040)	598	922
IC40	**2580** (2000-3220)	1015	1565
IC50	**3420** (2750-4190)	1345	2075

** Exposures conducted at soil solution NaCl concentrations of 0 mg/L (control), 320 mg/L, 490 mg/L, 750 mg/L, 1200 mg/L, 1800 mg/L, 2700 mg/L, 4200 mg/L, 6500 mg/L and 10000 mg/L*

Table 6-4: NaCl effects on paper birch seedling emergence and growth over 35 days

Effect Size	**Interpolated Exposure Level (mg/L) (95% Confidence Limits)**		
	NaCl	**Na^+**	**Cl^-**
Germination *(untrimmed Spearman-Karber)*			
EC50	**4810** (3960 - 5830)	1890	2920
Growth: Shoot Length *(Log-Logistic with Hormesis)*			
IC5	**1690** (n/a – 2110)	665	1025
IC10	**1900** (n/a - 2320)	747	1153
IC15	**2100** (1650-2540)	826	1274
IC20	**2300** (1860-2750)	905	1395
IC25	**2500** (2060-2970)	983	1517
IC40	**3150** (2680-3700)	1239	1911
IC50	**3660** (3140-4340)	1440	2220
Growth: Shoot Dry Mass *(Linear Interpolation)*			
IC5	**2660** (n/a - 2840)	1046	1614
IC10	**2780** (1370-3190)	1094	1686
IC15	**2900** (2050-3500)	1141	1759
IC20	**3030** (2470-3830)	1192	1838
IC25	**3170** (2620-4190)	1247	1923
IC40	**3590** (2940-5140)	1412	2178
IC50	**3900** (3080-5630)	1534	2366
Growth: Root Length *(Two-point Interpolation)*			
IC5	**2620** (n/a-2790)	1031	1589
IC10	**2740** (n/a-2930)	1078	1662
IC15	**2860** (n/a-3130)	1125	1735
IC20	**2990** (2370-3320)	1176	1814
IC25	**3120** (2530-3510)	1227	1893
IC40	**3530** (2970-4220)	1389	2141
IC50	**3830** (3240-4890)	1507	2323
Growth: Root Dry Mass *(Two-point Interpolation)*			
IC5	**2740** (n/a-2820)	1078	1662
IC10	**2880** (n/a-3130)	1133	1747
IC15	**3030** (1190-3480)	1192	1838
IC20	**3180** (2420-4060)	1251	1929
IC25	**3340** (2550-4700)	1314	2026
IC40	**3860** (2920-5360)	1519	2341
IC50	**4240** (3070-5750)	1668	2572

** Exposures conducted at soil solution NaCl concentrations of 0 mg/L (control), 340 mg/L, 560 mg/L, 930 mg/L, 1600 mg/L, 2600 mg/L, 4300 mg/L, 7200 mg/L,12000 mg/L and 20000 mg/L.*

Table 6-5: NaCl effects on Bluejoint Reedgrass (*Calamagrostis canadansis*) emergence and growth over 28 days

Effect Size	**Interpolated Exposure Level (mg/L) (95% Confidence Limits)**		
	NaCl	**Na^+**	**Cl^-**
Germination *(Linear Regression, MLE: Log-Gompertz)*			
EC5	**1220** (0.3-2910)	480	740
EC10	**1790** (3.0-3630)	704	1086
EC15	**2250** (10-4160)	885	1365
EC20	**2670** (25-4611)	1050	1620
EC25	**3060** (50-5020)	1204	1856
EC40	**4160** (247-6150)	1637	2523
EC50	**4890** (566-6960)	1924	2966
Growth: Shoot Length *(Linear Interpolation)*			
IC5	**2930** (n/a-3050)	1153	1777
IC10	**3300** (n/a-3550)	1298	2002
IC15	**3690** (n/a-4250)	1452	2238
IC20	**4130** (n/a-4660)	1625	2505
IC25	**4470** (848-4860)	1758	2712
IC40	**5380** (4240-5690)	2116	3264
IC50	**6060** (5060-6320)	2384	3676
Growth: Shoot Dry Mass *(Nonlinear Regression:Log-Logistic with Hormesis)*			
IC5	**907** (n/a-1470)	357	550
IC10	**1020** (n/a-1640)	401	619
IC15	**1140** (n/a-1820)	448	692
IC20	**1270** (816-2010)	500	770
IC25	**1420** (941-2320)	559	861
IC40	**2140** (1370-3310)	842	1298
IC50	**2690** (1690-5100)	1058	1632
Growth: Root Length *(Nonlinear Regression:Log-Logistic with Hormesis)*			
IC5	**2500** (n/a-3920)	983	1517
IC10	**3000** (n/a-4260)	1180	1820
IC15	**3360** (n/a-4620)	1322	2038
IC20	**3660** (n/a-4970)	1440	2220
IC25	**3930** (n/a-5300)	1546	2384
IC40	**4660** (3010-6350)	1833	2827
IC50	**5160** (3600-7400)	2030	3130
Growth: Root Dry Mass *(Linear Interpolation)*			
IC5	**2860** (n/a-3020)	1125	1735
IC10	**3130** (n/a-4780)	1231	1899
IC15	**3430** (n/a-5030)	1349	2081
IC20	**3750** (n/a-5060)	1475	2275
IC25	**4090** (n/a-5090)	1609	2481
IC40	**4720** (n/a-5430)	1857	2863
IC50	**6000** (n/a-5720)	2360	3640

** Exposures conducted at soil solution NaCl concentrations of 0 mg/L (control), 340 mg/L, 560 mg/L, 930 mg/L, 1600 mg/L, 2600 mg/L, 4300 mg/L, 7200 mg/L,12000 mg/L and 20000 mg/L.*

Table 6-6: NaCl effects on aquatic moss (*F. antipyretica*) growth over 21 days

Effect Size	**Interpolated Exposure Level (mg/L) (95% Confidence Limits)**		
	NaCl	**Na^+**	**Cl^-**
Growth: Chlorophyll a content *(Nonlinear Regression:Log-Logistic)*			
IC5	**568** (303-706)	223	345
IC10	**727** (570-846)	286	441
IC15	**847** (705-966)	333	514
IC20	**950** (816-1070)	374	576
IC25	**1040** (916-1170)	409	631
IC40	**1310** (1190-1430)	515	795
IC50	**1500** (1380-1630)	590	910
Growth: Total Dry Mass *(Linear Interpolation: Log-Linear Regression)*			
IC5	**1590** (n/a-1950)	625	965
IC10	**1790** (553-2080)	704	1086
IC15	**2000** (867-2230)	787	1213
IC20	**2230** (1330-2400)	877	1353
IC25	**2470** (2040-2590)	972	1498
IC40	**>20000**	>7900	>12100
IC50	**>20000**	>7900	>12100
Growth: Mean Length *(Nonlinear Regression:Log-Logistic)*			
IC5	**313** (n/a-517)	123	190
IC10	**442** (194-609)	174	268
IC15	**548** (348-713)	216	332
IC20	**643** (454-815)	253	390
IC25	**734** (549-915)	289	445
IC40	**1010** (824-1220)	397	613
IC50	**1290** (1020-1460)	507	783

** Exposures conducted at soil solution NaCl concentrations of 0 mg/L (control), 340 mg/L, 560 mg/L, 930 mg/L, 1600 mg/L, 2600 mg/L, 4300 mg/L, 7200 mg/L,12000 mg/L and 20000 mg/L.*

7.0 DERIVATION OF ALTERNATIVE SALT GUIDELINES

7.1 EXISTING POLICIES AND PROCEDURES RELEVANT TO THE ESTABLISHMENT OF *BC CONTAMINATED SITES REGULATION* NUMERICAL STANDARDS

The derivation of BC CSR soil matrix standards based on ecological receptor direct contact pathways have historically been based on single species laboratory toxicity test data, in parallel with Canadian Council of Ministers of the Environment (CCME) (2003) Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines, and the CCME (1996) precursory derivation protocols. The use of field plots to derive relevant ecotoxicity data as part of this study is a departure from this practice.

The newly collected data are intended to support the derivation of alternative chloride and sodium site assessment and remediation guidelines for possible adoption under the *British Columbia Contaminated Sites Regulation* (CSR). As such, the data are intended to satisfy ecotoxicity data needs for the derivation of CSR Soil Matrix Standards (Soil Invertebrates and Plants) per derivation protocols documented in -

- BC MOE (January 31, 1996). Overview of CSST Procedures for the Derivation of Soil Quality Matrix Standards (available online at http://www.env.gov.bc.ca/epd/remediation/standards_criteria/standards/overview_of_csst.htm; and
- SABCS, November 2009. Review of CST (1996) Soil Matrix Derivation Approach and Related Policy Decisions (http://www.sabcs.chem.uvic.ca/review%20CSST-1996.html)
    - 2009a. Volume I: Review and Recommendations for Revision of the CSST 91996) Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites (123 pp).
    - 2009b. Volume II: SABCS Review and Recommendations for Revision of the CSST (1996) Policy Decision Summary (85 pp).
- BC MOE (Remi Odense/Glyn Fox) (February 2016). CSR OMNIBUS UPDATING: Protocol Summary – Amendments to Schedule 5 Environmental Protection, Matrix Soil Standards (5 pp).

MOE (February 2016) provides two alternative methods for the development of soil invertebrate and plant standards. The preferred of Method 1 and Method 2 is Method 1: Modified CSST (1996):

> "*Substance specific linear regression based Effects Concentration estimates are calculated using geometric means of quartile or quintile data bins of combined EC (non-lethal) and LC (lethal) toxicity data as follows:*
>
> 1. *All available toxicity data for a substance is compiled and assessed for acceptability against data quality assurance/quality control criteria and data bias checks.*

2. *No Observed Effect Concentration (NOEC) data lacking an associated percent effect are binned in the first quartile (or quintile) data bin.*

3. *All data are combined into a single data set comprising non-lethal Effect Concentration (EC) and Lethal Effect Concentration (LC) data.*

4. *Calculate a linear regression line for the resulting combined EC and LC effects substance specific distribution based on quartile geometric means for the following classes:*

    a. *1st quartile – EC and LC effects in the range of 0% to 24% (inclusive)*

    b. *2nd quartile – EC and LC effects in the range of 25% to 49% (inclusive)*

    c. *3rd quartile – EC and LC effects in the range of 50% to 74% (inclusive)*

    d. *4th quartile – EC and LC effects in the range of 75% to 100% (inclusive)*

5. *If the quartile regression returns an regression correlation coefficient, $r^2 > 0.75$, calculate from the regression line, land use soil invertebrate and plants soil standards as follows:*

    a. *WLN: standard is the predicted 15th percentile concentration*

    b. *WLR /AL/RL_{LDR}/PL: standard is the predicted 25th percentile concentration*

    c. *RL_{HDR} /CL/IL: standard is the predicted 50th percentile concentration*

6. *If the quartile regression does not meet data quality criteria, e.g. returns an r2 < 0.75, recalculate the regression using quintile data bins:*

    a. *1st quintile – EC and LC effects in the range of 0% to 19% (inclusive)*

    b. *2nd quintile – EC and LC effects in the range of 20% to 39% (inclusive)*

    c. *3rd quartile – EC and LC effects in the range of 40% to 59% (inclusive)*

    d. *4th quartile – EC and LC effects in the range of 60% to 79% (inclusive*

    e. *5th quintile – EC and LC effects in the range of 80% to 100% (inclusive)*

7. *If the quintile regression returns an r2 > 0.75, calculate from the regression line, land use soil invertebrate and plants soil standards as follows:*

    a. *WLN: standard is the predicted 15th percentile concentration*

   b. *WLR /AL/RL$_{LDR}$/PL: standard is the predicted 25th percentile concentration*

   c. *RL$_{HDR}$/CL/IL: standard is the predicted 50th percentile concentration*

8. *If the quintile regression does not meet data quality criteria, e.g. returns an r2 <0.75, do not use Method 1. Instead use Method 2 to derive the standard."*

MOE (2016) does not define either minimum data quality needs or data quality objectives for support of the derivation, based either on proposed Method 1 (modified CSST 1996 method) or Method 2 (SABCS 2009), as discussed further below. SABCS (2009), however, specifies:

- Ecotoxicity data for at least three distinct taxa for each of plants (including bryophytes) and soil invertebrates. Relevant endpoints might include mortality/survivorship, growth/yield, and reproduction (germination, seed production, etc.).

7.2 ALTERNATIVE GUIDELINES FOR SOIL INVERTEBRATE AND PLANT PROTECTION

As summarized in **Tables 6-1** through **6-7,** relevant laboratory toxicity data on NaCl, expressed on the basis of solution concentration (as soil solution or in hydroponic exposures) were obtained for the following five soil invertebrate species:

Collembola:

Folsomia candida - mortality, reproduction (Bright and Addison, 2002; Nautilus, 2017)

Onychiurus folsomi - mortality, reproduction (Bright and Addison, 2002)

Proisotoma minuta - reproduction (Bright and Addison, 2002)

Protophorura armata - mortality (Bright and Addison, 2002)

Oligochates:

Eisenia fetida/Andrei – reproduction (Bright and Addison, 2002)

Similarly, relevant NaCl laboratory toxicity data were obtained for the following seven plant and bryophypte species:

Jack pine *(Pinus banksia*) germination, seedling survival, growth (Croser *et al.* 2001; Apostol *et al.* 2002; Franklin et al. 2002)

White spruce (*Picea glauca*) – seed germination, seedling survival (Croser *et al.* 2001)

Black spruce (*Picea mariana*) – seed germination, seedling survival (Croser *et al.* 2001)

Tamarack *(Larix laricina*) – growth and photosynthesis (Renault *et al.* 2005)

Paper birch (*Betula papyrifera*) – seedling emergence and growth (Nautilus 2017)

Greater water moss (*Fontinalis antipyretica*) – seedling emergence and growth (Nautilus 2017)

Bluejoint Reedgrass (*Calamagrostis canadensis*) – seedling emergence and growth (Nautilus 2017)

The relationship between chloride exposure concentration and effect size based on these studies is illustrated in **Figure 7-1**.

Per MOE (February 2016), a summary of the geometric mean chloride concentration associated with each quartile of the overall effect size range is provided in **Table 7-1**. The data for soil invertebrates and plants were combined to generate the quartile geometric means, as were data for mortality type and non-lethal endpoints.

Table 7-1 Summary of NaCl ecotoxicity data by effects size quartile

Quartile of EC/LC$_X$ Estimates	Number of Data Points	Effect Size Geomean	Quartile Midpoint	Chloride Geomean (mg/L)
1st quartile (0 ≤ X ≤ 24)	70	10.9	12	1259
2nd quartile (25 ≤ X ≤ 49)	32	31.4	37	1788
3rd quartile (50 ≤ X ≤ 74)	25	52.0	62	2651
4th quartile (75 ≤ X ≤ 100)	5	86.0	87.5	3475

The resulting linear regression estimate is provided in **Figure 7-2**.

The simplified relationship between chloride exposure concentration and size of the predicted adverse toxicological effect across a total of 12 different species and various lethal and non-lethal effect types, is as follows:

$$\text{[chloride] (mg/L)} = 30.5 \times \text{defined effect size (X)} + 915 \text{ mg/L} \quad [1]$$

$$(r^2 = 0.988)$$

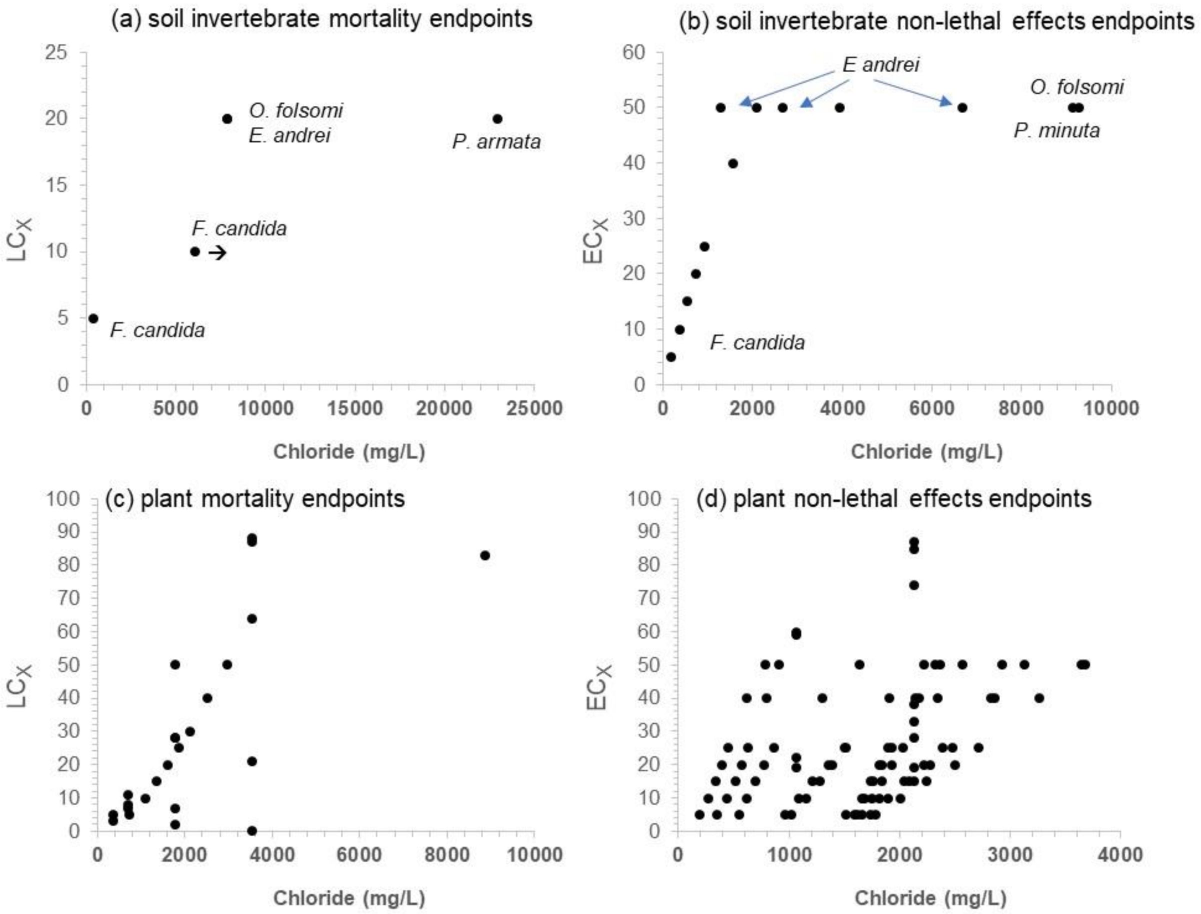

Figure 7-1 Summary of ecotoxicity data for laboratory exposures to NaCl in solution

From this equation, the following alternate chloride guidelines are proposed:

- WL$_N$: 15th percentile chloride concentration = **1370 mg/L** chloride
- WL$_R$ / AL / RL$_{LDR}$ / PL: 25th percentile chloride concentration = **1680 mg/L** chloride
- RL$_{HDR}$ / CL / IL: 50th percentile chloride concentration = **2440 mg/L** chloride

The laboratory ecotoxicity data that underpin these calculated alternative solution-based chloride guidelines were developed based on exposing various plants, moss, and soil invertebrates to solutions of NaCl and it is reasonable to assume exposures to equimolar concentrations of the chloride and sodium ion. While it is not possible to confidently ascribe the observed adverse effects to either the cation or anion based on the study designs, it is assumed that an equivalent set of solution-based sodium guidelines will be adequately protective of peatland vegetation and invertebrates, based on the ratio of the molecular weight of sodium and chloride (i.e. 22.99 and 35.45 respectively).

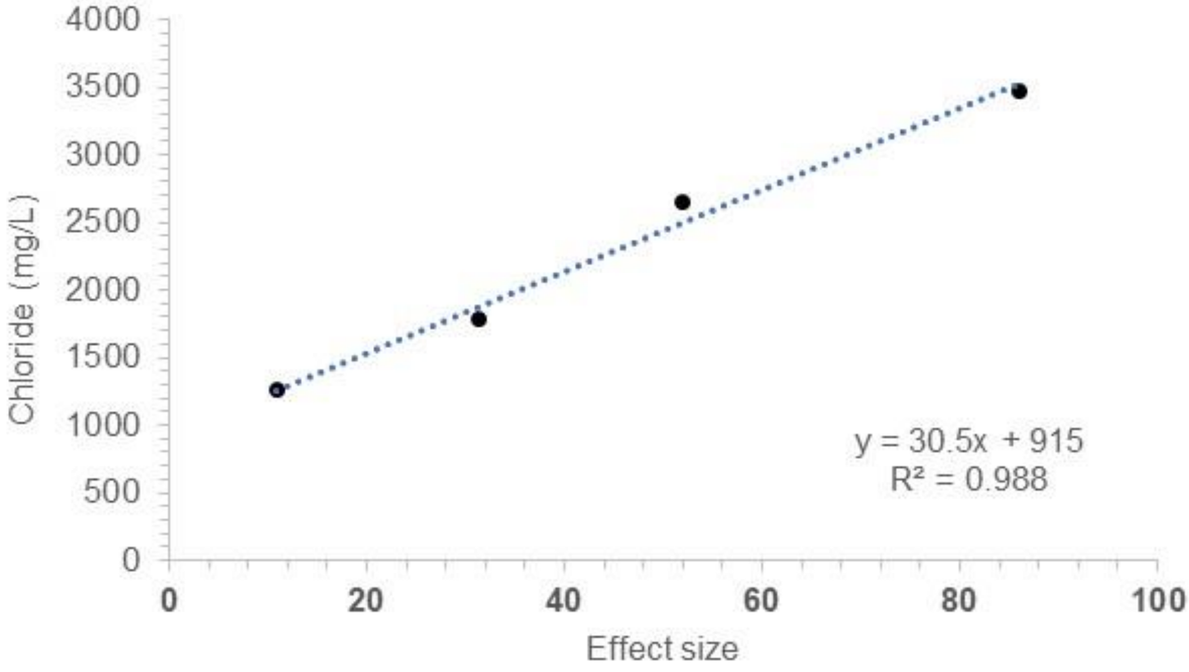

Figure 7-2 Linear regression of chloride concentration (mg/L) geometric means by effects size quartile on the geometric mean effect size

Thus, the following alternative sodium guidelines are proposed:

- WL$_N$:	15th percentile chloride concentration = **890 mg/L** sodium
- WL$_R$ / AL / RL$_{LDR}$ / PL:	25th percentile chloride concentration = **1090 mg/L** sodium
- RL$_{HDR}$ / CL / IL:	50th percentile chloride concentration = **1580 mg/L** sodium

7.3 HUMAN HEALTH PROTECTION

Since sodium chloride is generally recognized as safe for human consumption (Bright and Addison 2002), no alternative solution-based sodium or chloride guidelines have been derived in consideration of human health protection for peatlands.

The absence of a human health based peatland sodium or chloride standard notwithstanding, site assessment and risk management / remediation efforts still need to take into account the possible contamination of potable water supplies beyond the pre-existing standards for human health protection – drinking water ingestion.

7.4 AQUATIC LIFE PROTECTION

Use of the alternative sodium and chloride guidelines for peatland environments does not remove the requirement for the responsible party/parties to recognize surface water habitats that may support aquatic life, and to appropriately apply existing aquatic life protection standards and guidelines or to evaluate and manage the potential ecological risks based on a site-specific risk assessment approach.

8.0 CONCLUSIONS AND APPLICATION NOTES

The alternative sodium and chloride guidelines developed herein are intended to be applicable for anthropogenic salt releases to boreal peatland environments, including fens and bogs, as opposed to terrestrial upland environments. BC CSR alternative salt guidelines for peatlands should provide adequate protection of the sphagnidae mosses, other moss types, and vascular plants that are important for carbon sequestration and water storage and filtering, and for the growth of herbaceous and woody plants and trees that provide forage, tertiary structure, shelter, nesting and denning sites.

Peatlands are defined herein as areas that are continuously or routinely water-saturated in their natural or reclaimed state such that water occurs, at least seasonally for a typical year, at or near (within 20 to 30 cm of) the upper land surface, including bryophyte cover. Furthermore, a peatland – by operational definition – will exhibit a surface accumulation of peat to a depth of ≥40 cm and will have a total organic carbon (TOC) content of 17% or more. There may be instances in which peat accumulations arising from peatland development are encountered in the subsurface environment, beneath shallow anthropogenic or naturally occurring flood or landslide deposits. These relict peatland soils may be considered as peatlands for the purpose of applying alternative salt guidelines, to the extent that the soil characteristics within the peat strata are consistent with the expected range of variation in natural surface peatlands within the province.

The alternative sodium and chloride guidelines have been derived in a manner that permits a more straightforward assessment of ecological risks in peatlands through the collection and direct analysis of near-surface water (free water; e.g. collected within one meter or less from the peatland surface using a shallow test pit or piezometer). In cases where no free water is available for sampling, a pragmatic and defensible alternative to the use of saturated paste methods with peat soil samples is provided (Section 4 herein).

The utility of environmental quality guidelines or standards for achieving important environmental protection goals while avoiding undue inefficiencies in societal resource allocation that have little environmental benefit depends on the quantity and quality of the available scientific data, a good understanding of the particulars of environmental fate and effects, and the robustness of the prescribed derivation protocols. The available ecotoxicity data for NaCl effects on peatland plants and soil invertebrates is deemed adequate for developing a good appreciation of the variation in sensitivities of the taxa of interest to saline water exposures. The alternative sodium and chloride guidelines provided herein are based on extensive laboratory toxicity data for five soil invertebrate species, seven vascular plant species, and one aquatic moss species.

The ecotoxicity data or peatland biota based on aqueous exposures to NaCl (measured or quantified as Na and Cl) are complementary to various threshold of effects estimates based especially on measurements of wetland or soil salinity on the basis of electrical conductivity. The two approaches should generally achieve an equivalent level of environmental protection.

The alternative sodium and chloride guidelines for toxicity to soil invertebrates and plants in peat soils developed as part of this project are summarized below:

Land Use	Peat Sodium Guideline	Peat Chloride Guideline
Wildlands - natural	890 mg/L	1370 mg/L
Wildlands – reverted Agricultural Residential – Low Density Urban Parkland	1090 mg/L	1680 mg/L
Residential – High Density Commercial Industrial	1580 mg/L	2240 mg/L

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APPENDIX A

Nautilus 2017 Laboratory NaCl Ecotoxicity Reports

Soil Test Summary Sheet

Client: Hemmera

Start Date: 11-Aug-17

Work Order No.: 170520

Set up by: JW / MLT

Sample Information:

Sample ID: Sodium chloride JW ~~Chloride~~ - made in-house
Sample Date: 11-Aug-17
Date Received: n/a
Stock Solution ID: 17Na02

Test Organism Information:

Species: *Folsomia candida*
Source: Environment Canada
Age 12 days

JW ~~Copper~~ Reference Toxicant Results:

Reference Toxicant ID: FC01
Stock Solution ID: Boric Acid
Date Initiated: 11-Aug-17
14-d EC50 (95% CL): 648.3 (582.6 - 721.3) mg/kg boric acid

EC50 Reference Toxicant Mean (Acceptable Range) : n/a* CV (%): n/a*
JW ~~IC50 Reference Toxicant Mean (Acceptable Range) : n/a* CV (%): n/a*~~

* : Insufficient data points to calculate a reference toxicant historical mean, range and CV

Test Results:

g/L NaCl	Survival	Reproduction
EC50 (95% CL)	>10	
IC25 (95% CL)		1.5 (1.0 - 2.0)
IC50 (95% CL)		3.4 (2.7 - 4.2)

Reviewed by:

Date reviewed: Dec. 5, 2017

Nautilus Environmental
Environmental Quality Data

Client: Hemmera
WO #: 170520

Organism Tested: Folsomia candida
Start Date/Time: Aug 11 / 17 @ 1700h
End Date/Time: ~~A~~ sept 8 / 17 @ 1600

Test Day	Temp (°C)	Tech Initials
0	1 JW 2~~3~~.0	JW
1	21.0	JW
2	22.0	JW
3	21.5	JW
4	21.0	JW
5	21.0	JW
6	21.0	JW
7	20.0	JW
8	21.0	JW
9	21.0	JW
10	21.0	JW
11	21.0	JW
12	21.0	JW
13	21.0	JW
14	21.0	JW
15	21.0	JW
16	21.0	JW
17	21.0	JW
18	21.0	JW
19	21.0	JW
20	20.5	JW
21	20.5	JW
22	21.0	JW
23	21.0	JW
24	21.0	JW
25	21.0	JW
26	21.0	JW
27	21.0	JW
28	21.0	JW

g/L NaCl Sample ID	Rep.	% Moisture		pH (units)		Conductivity (µS/cm)		Survival		# of young
		initial	final	initial	final	initial	final	initial	final	
control	1	32.9	24.9	6.5	7.3	—	—	10	10	472
soil	2							10	9	225
	3							10	10	230
	4							10	9	443
	5							10	10	425
control	1	281.2	243.5	6.5	6.6	—	—	10	10	250
Peat moss	2							10	9	233
	3							10	8	236
	4							10	7	317
	5							10	10	273
0.32	1	264.5	216.4	6.5	6.6	—	—	10	10	309
	2							10	10	200
	3							10	10	161
	4							~~10~~		
	5							~~10~~		
0.49	1	278.0	310.2	6.5	6.5	—	—	10	10	260
	2							10	10	280
	3							10	10	219
	4							~~10~~		
	5							~~10~~		
0.75	1	267.8	290.0	6.5	6.5	—	—	10	9	236
	2							10	9	220
	3							10	9	227
	4									
	5									
1.2	1	258.9	282.0	6.5	6.5	—	—	10	10	205
	2							10	8	167
	3							10	9	179
	4									
	5									
Tech Init		JW	JW	JW	JW	JW	JW	JW	JW	JW

Reviewed by:

Review Date: Dec 5, 2017

Nautilus Environmental
Environmental Quality Data

Client: Hemmera
WO #: 170526

Organism Tested: Folsomia candida
Start Date/Time: Aug 11/17 @ 1700h
End Date/Time: ~~A~~ sept 8/17 @ 1600

Test Day	Temp (°C)	Tech Initials
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		

JW

g/L NaCl

Sample ID	Rep.	% Moisture initial	% Moisture final	pH (units) initial	pH (units) final	Conductivity (µS/cm) initial	Conductivity (µS/cm) final	Survival initial	Survival final	# of young
1.8	1	285.7	261.4	6.5	6.6	—	—	10	8	167
	2							10	9	138
	3							10	9	145
	4							10		
	5							10		
2.7	1	274.9	295.9	6.5	6.5	—	—	10	10	158
	2							10	8	149
	3							10	9	177
	4							10		
	5							10		
4.2	1	299.7	286.7	6.5	6.6	—	—	10	10	125
	2							10	9	152
	3							10	10	170
	4							10		
	5							10		
6.5	1	272.4	191.7	6.5	6.5	—	—	10	10	65
	2							10	9	56
	3							10	7	43
	4							10		
	5							10		
10	1	256.0	211.7	6.5	6.5	—	—	10	10	0
	2							10	8	0
	3							10	9	0
	4									
	5									
	1							10		
	2							10		
	3							10		
	4									
	5									
Tech Init		JW	JW	JW	JW	JW	JW	JW	JW	JW

Reviewed by:

Review Date: Dec-5, 2017

Nautilus Environmental
Environmental Quality Data - Day 0 Soil Test

Client: ~~Hemerra~~ Hemmera JW
WO #: 170520

Organism Tested: Folsomia candida
Start Date/Time: Aug 11 / 17 @ 1700h
End Date/Time: Sept 8 / 17 @ 1600h

g/L NaCl Sample ID	Rep.	ST Blue Pan No.	Pan weight ~~(g)~~ mg JW	Pan + Wet soil weight JW ~~(g)~~ mg	Pan + dry soil JW weight ~~(g)~~ mg	% Moisture
Control soil	1	1	1276.71	5433.30	4405.37	32.9
	2					
	3					
	4					
	5					
control Peat Moss	1	2	1275.71	4330.46	2077.01	281.2
	2					
	3					
	4					
	5					
0.32	1	3	1275.79	4384.17	2128.65	264.5
	2					
	3					
	4					
	5					
0.49	1	4	1278.11	4422.50	2109.86	278.0
	2					
	3					
	4					
	5					
0.75	1	5	1276.60	4391.01	2123.33	267.8
	2					
	3					
	4					
	5					
1.2	1	6	1283.52	4314.78	2128.00	258.9
	2					
	3					
	4					
	5					
1.8	1	7	1283.15	4417.20	2095.75	285.7
	2					
	3					
	4					
	5					
Tech Init			JW	JW	JW	JW

Reviewed by:

Review Date: Dec 5, 2017

Nautilus Environmental
Environmental Quality Data - Day 0 Soil Test

Client: ~~Hemerra~~ JW Hemmera
WO #: 170520

Organism Tested: Folsomia candida
Start Date/Time: Aug 11 / 17 @ 1700h
End Date/Time: sept 8 / 17 @ 1600h

g/L NaCl

Sample ID	Rep.	ST Blue Pan No.	Pan weight ~~(g)~~ mg JW	Pan + Wet soil weight ~~(g)~~ mg JW	Pan + dry soil JW weight ~~(g)~~ mg	% Moisture
2.7	1	8	1283.11	4400.87	2114.66	274.9
	2					
	3					
	4					
	5					
4.2	1	9	1280.96	4419.32	2066.22	299.7
	2					
	3					
	4					
	5					
6.5	1	10	1279.30	4280.20	2085.20	272.4
	2					
	3					
	4					
	5					
10	1	11	1279.22	4459.61	2172.54	256.0
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
Tech Init			JW	JW	JW	JW

Reviewed by:

Review Date: Dec. 5, 2017

Nautilus Environmental JW
Environmental Quality Data - Day ~~0~~ 28 Soil Test

Client: JW ~~Hemerra~~ Hemmera
WO #: 170520

Organism Tested: Folsomia candida JW
Start Date/Time: Aug 11/17 @ ~~1600h~~ 1700h
End Date/Time: Sept 8/17 @ 1600h

SPT BLOCK

Sample ID	Rep.	Pan No.	Pan weight (mg)	Pan + wet soil weight (mg)	Pan + dry soil weight (mg)	% Moisture
control	1	1	1283.41	5753.20	4863.46	24.9
soil	2					
	3					
	4					
	5					
control	1	2	1279.50	2845.00	173~~4~~5.25	243.5
Peat moss	2				JW	
	3					
	4					
	5					
0.32	1	3	1277.28	3~~4~~212.51	1888.89	216.4
	2			JW		
	3					
	4					
	5					
0.49	1	4	1273.76	3188.91	1740.59	310.2
	2					
	3					
	4					
	5					
0.75	1	5	1273.18	3533.03	1852.68	290.0
	2					
	3					
	4					
	5					
1.2	1	6	1277.96	3267.28	1798.73	282.0
	2					
	3					
	4					
	5					
1.8	1	7	1285.79	3317.27	1847.86	261.4
	2					
	3					
	4					
	5					
Tech Init			JW	JW	JW	JW

Reviewed by:

Review Date: Dec-5, 2017

Nautilus Environmental
Environmental Quality Data - Day 0 Soil Test

Client: ~~Hemerra~~ Hemmera JW
WO #: 170520

Organism Tested: Folsomia candida JW
Start Date/Time: Aug 11 / 17 @ ~~1600h~~ 1700h
End Date/Time: ~~X~~ sept 8 / 17 @ 1600h.

SPT Black

Sample ID	Rep.	Pan No.	Pan weight (mg)	Pan + wet soil weight (mg)	Pan + dry soil weight (mg)	% Moisture
2.7	1	8	1281.49	3518.21	1846.44	295.9
	2					
	3					
	4					
	5					
4.2	1	9	1279.43	3452.~~87~~07	~~1840.~~	286.7
	2				1841.25	
	3					
	4					
	5					
6.5	1	10	1277.93	2796.45	1798.48	191.7
	2					
	3					
	4					
	5					
10	1	11	1283.61	3770.15	2081.24	211.7
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
Tech Init			JW	JW	JW	JW

Reviewed by:

Review Date: Dec. 5, 2017

CETIS Analytical Report

F. candida 28-d

Report Date:	04 Dec-17 12:31 (p 1 of 2)
Test Code:	170520 | 02-3676-8175

JW **~~Ceriodaphnia 7-d~~ Survival and Reproduction Test** **Nautilus Environmental**

Analysis ID:	01-0504-9904	**Endpoint:**	~~7d~~ Survival Rate 28-d JW	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 12:29	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	11-5986-5624	**Test Type:**	Reproduction-Survival (~~7d~~) 28-d JW	**Analyst:**	Jeslin Wijaya
Start Date:	11 Aug-17 17:00	**Protocol:**	EC/EPS 1/RM/47	**Diluent:**	Dechlorinated Tap Water
Ending Date:	08 Sep-17 16:00	**Species:**	~~Ceriodaphnia dubia~~ Folsomia candida	**Brine:**	
Duration:	27d 23h	**Source:**	Environment Canada JW	**Age:**	12d

Sample ID:	21-3239-6231	**Code:**	7F19C8C7	**Client:**	Hemmera
Sample Date:	11 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	11 Aug-17	**Source:**	Hemmera		
Sample Age:	17h	**Station:**	Chloride		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1823025	200	Yes	Two-Point Interpolation

Point Estimates

Level	gm/L	95% LCL	95% UCL
EC5	0.7221	0.5347	N/A
EC10	>10	N/A	N/A
EC15	>10	N/A	N/A
EC20	>10	N/A	N/A
EC25	>10	N/A	N/A
EC40	>10	N/A	N/A
EC50	>10	N/A	N/A

7d Survival Rate Summary

			Calculated Variate(A/B)								
C-gm/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0	Reference Sed	5	8.8	7	10	0.5831	1.304	14.82%	0.0%	44	5
0.32		3	10	10	10	0	0	0.0%	-13.64%	30	3
0.49		3	10	10	10	0	0	0.0%	-13.64%	30	3
0.75		3	9	9	9	0	0	0.0%	-2.27%	27	3
1.2		3	9	8	10	0.5774	1	11.11%	-2.27%	27	3
1.8		3	8.667	8	9	0.3333	0.5774	6.66%	1.52%	26	3
2.7		3	9	8	10	0.5774	1	11.11%	-2.27%	27	3
4.2		3	9.667	9	10	0.3333	0.5774	5.97%	-9.85%	29	3
6.5		3	8.667	7	10	0.8819	1.528	17.63%	1.52%	26	3
10		3	9	8	10	0.5774	1	11.11%	-2.27%	27	3

7d Survival Rate Detail

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	Reference Sed	10	9	8	7	10
0.32		10	10	10		
0.49		10	10	10		
0.75		9	9	9		
1.2		10	8	9		
1.8		8	9	9		
2.7		10	8	9		
4.2		10	9	10		
6.5		10	9	7		
10		10	8	9		

Dec-5/17

Analyst: JW QA:

CETIS Analytical Report

F. candida 28-d JW

Report Date: 04 Dec-17 12:31 (p 2 of 2)
Test Code: 170520 | 02-3676-8175

~~Ceriodaphnia 7-d~~ Survival and Reproduction Test

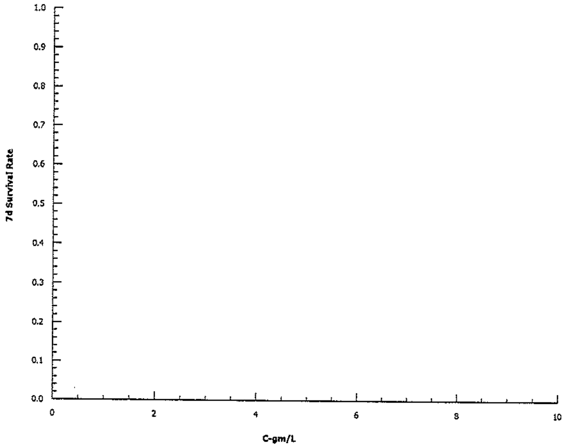
Nautilus Environmental

Analysis ID: 01-0504-9904
Analyzed: 04 Dec-17 12:29
Endpoint: ~~7d~~ Survival Rate 28-d JW
Analysis: Linear Interpolation (ICPIN)
CETIS Version: CETISv1.8.7
Official Results: Yes

7d Survival Rate Binomials

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	Negative Control	10/1	9/1	10/1	9/1	10/1
0	Reference Sed	10/1	9/1	8/1	7/1	10/1
0.32		10/1	10/1	10/1		
0.49		10/1	10/1	10/1		
0.75		9/1	9/1	9/1		
1.2		10/1	8/1	9/1		
1.8		8/1	9/1	9/1		
2.7		10/1	8/1	9/1		
4.2		10/1	9/1	10/1		
6.5		10/1	9/1	7/1		
10		10/1	8/1	9/1		

Graphics



Analyst: JW QA: Dec-5/17

CETIS Analytical Report

F. candida 28-d

Report Date:	04 Dec-17 12:31 (p 1 of 3)
Test Code:	170520 | 02-3676-8175

~~Ceriodaphnia 7-d~~ Survival and Reproduction Test JW

Nautilus Environmental

Analysis ID:	11-6041-8345	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 12:29	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes

Batch ID:	11-5986-5624	**Test Type:**	Reproduction-Survival (~~7d~~) 28d JW	**Analyst:**	Jeslin Wijaya
Start Date:	11 Aug-17 17:00	**Protocol:**	EC/EPS 1/RM/47	**Diluent:**	Dechlorinated Tap Water
Ending Date:	08 Sep-17 16:00	**Species:**	~~Ceriodaphnia dubia~~ Folsomia candida JW	**Brine:**	
Duration:	27d 23h	**Source:**	Environment Canada	**Age:**	12d

Sample ID:	21-3239-6231	**Code:**	7F19C8C7	**Client:**	Hemmera
Sample Date:	11 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	11 Aug-17	**Source:**	Hemmera		
Sample Age:	17h	**Station:**	Chloride		

Non-Linear Regression Options

Model Function	X Transform	Y Transform	Weighting Function	PTBS Function
3P Log-Gompertz EV [Y=A*exp(log(0.5)(X/D)^C)]	None	None	Normal [W=1]	Off [Y*=Y]

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
9	-128.5	263.8	267.3	0.8339	Yes	2.133	2.464	0.0827	Non-Significant Lack of Fit

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	0.3094	N/A	0.7079
IC10	0.601	0.2281	0.9792
IC15	0.8962	0.496	1.313
IC20	1.201	0.7591	1.669
IC25	1.518	1.037	2.036
IC40	2.577	1.998	3.224
IC50	3.415	2.746	4.185

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
A	254.5	13.33	228.4	280.6	19.09	<0.0001	Significant Parameter
C	1.084	0.2094	0.674	1.495	5.179	<0.0001	Significant Parameter
D	3.415	0.4869	2.46	4.369	7.012	<0.0001	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	196432.8	196432.8	1	157.6	<0.0001	Significant
Lack of Fit	14608.74	2086.963	7	2.133	0.0827	Non-Significant
Pure Error	21530.13	978.6424	22			
Residual	36138.88	1246.168	29			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variances	Mod Levene Equality of Variance	2.117	2.796	0.1128	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9671	0.9338	0.4225	Normal Distribution
	Anderson-Darling A2 Normality	0.4345	2.492	0.3051	Normal Distribution

Analyst: JW QA: Dec 5/17

CETIS Analytical Report

F. candida 28-d JW

Report Date: 04 Dec-17 12:31 (p 2 of 3)
Test Code: 170520 | 02-3676-8175

~~Ceriodaphnia 7-d~~ Survival and Reproduction Test

Nautilus Environmental

Analysis ID: 11-6041-8345
Analyzed: 04 Dec-17 12:29
Endpoint: Reproduction
Analysis: Nonlinear Regression
CETIS Version: CETISv1.8.7
Official Results: Yes

Reproduction Summary

			Calculated Variate						
C-gm/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0	Reference Sed	5	261.8	233	317	15.5	34.67	13.24%	0.0%
0.32		3	223.3	161	309	44.29	76.71	34.35%	14.69%
0.49		3	253	219	280	17.95	31.1	12.29%	3.36%
0.75		3	227.7	220	236	4.631	8.021	3.52%	13.04%
1.2		3	183.7	167	205	11.22	19.43	10.58%	29.84%
1.8		3	150	138	167	8.737	15.13	10.09%	42.7%
2.7		3	161.3	149	177	8.253	14.29	8.86%	38.38%
4.2		3	149	125	170	13.08	22.65	15.2%	43.09%
6.5		3	54.67	43	65	6.386	11.06	20.23%	79.12%
10		3	0	0	0	0	0		100.0%

Reproduction Detail

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	Reference Sed	250	233	236	317	273
0.32		309	200	161		
0.49		260	280	219		
0.75		236	220	227		
1.2		205	167	179		
1.8		167	138	145		
2.7		158	149	177		
4.2		125	152	170		
6.5		65	56	43		
10		0	0	0		

Dec 5/17

Analyst: JW QA:

CETIS Analytical Report

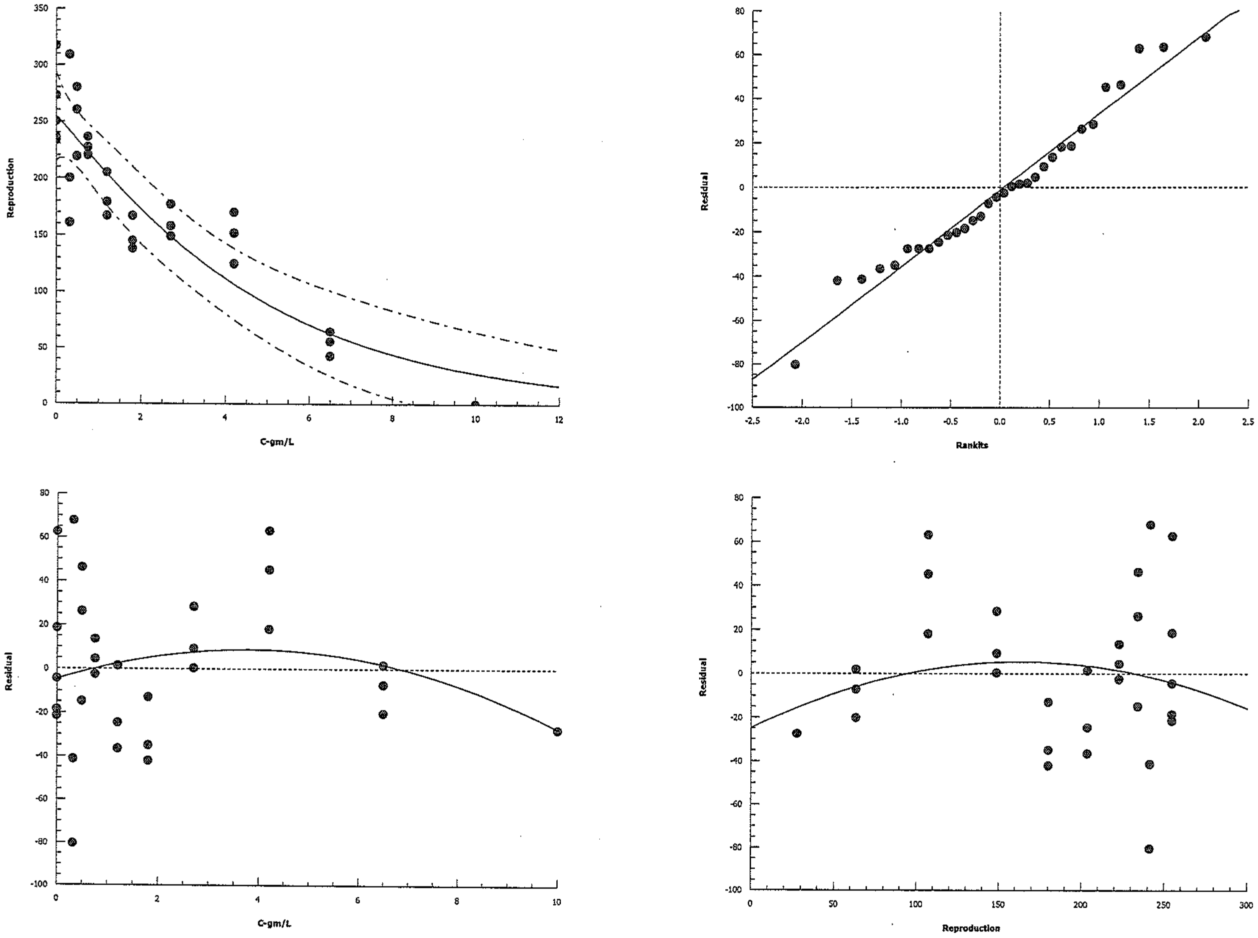
F. candida 28-d JW

Report Date:	04 Dec-17 12:31 (p 3 of 3)
Test Code:	170520 | 02-3676-8175

~~Ceriodaphnia 7-d~~ Survival and Reproduction Test **Nautilus Environmental**

Analysis ID:	11-6041-8345	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 12:29	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes

Graphics 3P Log-Gompertz EV [Y=A*exp(log(0.5)(X/D)^C)]



Dec-5/17

Analyst: JW QA:

Soil Test Summary Sheet

Client: Hemmera

Start Date: 4-Aug-17

Work Order No.: 170519

Set up by: JW / MLT

Sample Information:

Sample ID: Sodium chloride JW ~~Chloride~~ - made in-house
Sample Date: 4-Aug-17
Date Received: n/a
Stock Solution ID: 17Na02

Test Organism Information:

Species: *Betula papyrifera*
Source: BC Ministry of Forest, Lands and Natural Resources
Date Received: 8-Mar-17

Copper Reference Toxicant Results:

Reference Toxicant ID: CC01
Stock Solution ID: Boric Acid
Date Initiated: 4-Aug-17
28-d EC50 (95% CL): 508.1 (347.5 - 615.5) mg/kg boric acid
28-d IC50 (95% CL): 491.9 (385.0 - 799.4) mg/kg boric acid

EC50 Reference Toxicant Mean (Acceptable Range) : n/a* CV (%): n/a*
IC50 Reference Toxicant Mean (Acceptable Range) : n/a* CV (%): n/a*

* : Insufficient data points to calculate a reference toxicant historical mean, range and CV

Test Results:

g/L NaCl	Emergence	Shoot Length	Shoot Weight	Root Length	Root Weight
EC50 (95% CL)	4.8 (4.0 - 5.8)				
IC25 (95% CL)		2.5 (2.1 - 3.0)	3.2 (2.6 - 4.2)	3.1 (2.5 - 3.5)	3.3 (2.6 - 4.7)
IC50 (95% CL)		3.7 (3.1 - 4.3)	3.9 (3.1 - 5.6)	3.8 (3.2 - 4.9)	4.2 (3.1 - 5.8)

Reviewed by:

Date reviewed: Dec 5, 2017

page 1 of 2

Nautilus Environmental
Environmental Quality Data - 28-Day Soil Test

Client: ~~Hemerra~~ JW Hemmera
WO #: 170519

Organism Tested: Paper Birch
Start Date/Time: Aug 4 / 17 @ 1700h
End Date/Time: Sept 8 / 17 @ 1600h

Test Day	Temp (°C)	Tech Initials
0	23.0	JW
1	22.5	EMM
2	22.5	JS
3	23.0	MLT
4	23.0	JW
5	23.0	JW
6	23.0	JW
7	23.0	JW
8	21.0	EC
9	22.0	JS
10	21.0	MLT
11	21.0	MLT
12	21.0	MLT
13	21.0	MLT
14	21.0	JW
15	21.0	JW
16	21.0	EC
17	21.0	MLT
18	21.0	JW
19	21.0	JW
20	21.0	MLT
21	21.0	YML
22	21.0	EC
23	21.0	JS
24	~~20~~ KS 21.0	K
25	21.0	MLT
26	21.0	MLT
27	21.0	JW
28	21.0	JW

g/L NaCl

Sample ID	Rep.	% Moisture		pH (units)		Conductivity (µS/cm)		Survival	
		initial	final	initial	final	initial	final	initial	final
Control	1	31.9	29.7	7.0	7.0	/	/	5	3
Soil	2							5	4
	3							5	5
	4							5	4
	5								
Control	1	265.1	238.5	6.5	6.7	/	/	5	4
Peat moss	2							5	5
	3							5	1
	4							5	5
	5								
0.34	1	289.4	307.8	6.5	6.8	/	/	5	5
	2							5	5
	3							5	2
	4							5	4
	5								
0.56	1	286.4	298.3	6.6	6.7	/	/	5	2
	2							5	4
	3							5	4
	4							5	4
	5								
0.93	1	304.4	303.5	6.7	6.9	/	/	5	4
	2							5	2
	3							5	3
	4							5	5
	5								
1.6	1	299.9	270.4	6.7	6.8	/	/	5	3
	2							5	3
	3							5	3
	4							5	4
	5								
Tech Init		JW	JW	K	K	JW	JW	JW	JW

Reviewed by:

Review Date: Oct. 24, 2017

Nautilus Environmental
Environmental Quality Data - 28-Day Soil Test

JW
Client: ~~Hemerra~~ Hemmera
WO #: 170519

Organism Tested: Paper Birch
Start Date/Time: Aug 4/17 @ 1700h
End Date/Time: Sept 8 /17 @ 1600h.

Test Day	Temp (°C)	Tech Initials
JW ~~0~~ 29	21.0	JW
~~1~~ 30	21.0	MLT
~~2~~ 31	21.0.	JW
~~3~~ 32	21.0	JW
~~4~~ 33	21.0	JW
~~5~~ 34	21.0	JW
~~6~~ 35	21.0	JW
~~7~~		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		

JW

Sample ID	Rep.	% Moisture		pH (units)		Conductivity (µS/cm)		Survival	
		initial	final	initial	final	initial	final	initial	final
2.6	1	291.0	295.5	6.6	6.8	/	/	5	5
	2							5	3
	3							5	3
	4							5	5
	5								
4.3	1	275.5	~~293.5~~ 287.4 JW	6.5	6.7	/	/	5	3
	2							5	2
	3							5	3
	4							5	3
	5								
7.2	1	269.1	295.5	6.4	6.7	/	/	5	1
	2							5	2
	3							5	1
	4							5	1
	5								
12	1	243.7	293.5	6.3	6.6	/	/	5	0
	2							5	0
	3							5	0
	4							5	0
	5								
20	1	256.0	260.1	6.4	6.4	/	/	5	0
	2							5	0
	3							5	0
	4							5	0
	5								
	1								
	2								
	3								
	4								
	5								
Tech Init		JW	JW	K	K	JW	JW	JW	JW

Reviewed by:

Review Date: Oct. 24, 2017

1/2

Nautilus Environmental
Environmental Quality Data - Day 0 Soil Test

Client: ~~Hemerra~~ JW Hemmera

WO #: 170519

Organism Tested: Paper Birch

Start Date/Time: Aug 4 / 17 @ 1700h

End Date/Time: Sept 8 / 17 @ 1600h

g/L NaCl Sample ID	Rep.	MC Pan No.	Pan weight ~~(g)~~ K (mg)	Pan + Wet soil weight JW ~~(g)~~ mg	Pan + dry soil JW weight ~~(g)~~ mg	% Moisture
Control Soil	1	1	1011.85	~~49584.47~~ K	4044.56	31.9
	2			5011.42		
	3					
	4					
	5					
Peat Moss Control	1	2	1005.54	~~4894.10~~ K	2060.57	265.1
	2			4857.46		
	3					
	4					
	5					
0.34	1	3	1017.38	~~4943.60~~ K	2028.40	289.4
	2			4954.47		
	3					
	4					
	5					
0.56	1	4	996.38	~~4906.95~~ K	2005.01	286.4
	2			4894.10		
	3					
	4					
	5					
0.93	1	5	1029.62	4943.60	1997.33	304.4
	2					
	3					
	4					
	5					
1.6	1	6	1015.65	4906.95	1988.63	299.9
	2					
	3					
	4					
	5					
2.6	1	7	1002.00	K 49084.76	2000.10	291.0
	2					
	3					
	4					
	5					
Tech Init			K	K	JW	JW

Reviewed by:

Review Date: Oct. 24, 2017

2/2

Nautilus Environmental
Environmental Quality Data - Day 0 Soil Test

Client: ~~Hemerra~~ Hemmera JW
WO #: 170519

Organism Tested: Paper Birch
Start Date/Time: Aug 4 / 17 @ 1700h
End Date/Time: ~~Au~~ Sept 8 / 17 @ 1600h JW

g/L NaCl Sample ID	Rep.	MC Pan No.	Pan weight ~~(g)~~ mg JW	Pan + Wet soil weight JW ~~(g)~~ mg	Pan + dry soil JW weight ~~(g)~~ mg	% Moisture
4.3	1	8	1006.58	4908.94	2045.83	275.5
	2					
	3					
	4					
	5					
7.2	1	9	1022.02	4943.14	2084.36	269.1
	2					
	3					
	4					
	5					
12	1	10	1009.69	4874.24	2134.15	243.7
	2					
	3					
	4					
	5					
20	1	11	K ~~1004~~. 1005.00	4922.38	2105.46	256.0
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
Tech Init			K	K	JW	JW

Reviewed by:

Review Date: Oct. 24, 2017

Nautilus Environmental JW
Environmental Quality Data - Day ~~0~~ 35 Soil Test

Client: ~~Hemerra~~ JW Hemmera
WO #: 170519

Organism Tested: Paper Birch
Start Date/Time: Aug 4 / 17 @ 1700h
End Date/Time: Sept 8 / 17 @ 1600h

g/L NaCl PM Red

Sample ID	Rep.	Pan No.	Pan weight (mg)	Pan + wet soil weight (mg)	Pan + dry soil weight (mg)	% Moisture
Control	1	1	1274.92	5087.50	~~2~~4213.71	29.7
Soil	2				JW	
	3					
	4					
	5					
Control	1	2	1285.37	516~~8~~7.80	~~2431.~~ JW	238.5
Peat Moss	2				2432.19	
	3					
	4					
	5					
0.34	1	3	1278.18	5071.73	2208.34	307.8
	2					
	3					
	4					
	5					
0.56	1	4	1280.00	5116.32	2243.08	298.3
	2					
	3					
	4					
	5					
0.93	1	5	1279.33	5119.64	22301.15	303.5
	2					
	3					
	4					
	5					JW
1.6	1	6	1282.96	4022.20	2022.51	270.04
	2					
	3					
	4					
	5					
2.6	1	7	1286.36	5476.67	2345.90	295.5
	2					
	3					
	4					
	5					
Tech Init			JW	JW	JW	JW

Reviewed by:

Review Date: Oct. 24, 2017

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Nautilus Environmental JW
Environmental Quality Data - Day ~~0~~ 35 Soil Test

Client: ~~Hemerra~~ JW Hemerra
WO #: 170519

Organism Tested: Paper Birch
Start Date/Time: Aug 4 / 17 @ 1700h
End Date/Time: Sept 8 / 17 @ 1600h

g/L NaCl PM Red

Sample ID	Rep.	Pan No.	Pan weight (mg)	Pan + wet soil weight (mg)	Pan + dry soil weight (mg)	% Moisture
4.3	1	8	1281.41	5089.14	2264.39	287.4
	2					
	3					
	4					
	5					
7-2	1	9	1277.58	5325.77	~~2300~~.	295.5
	2				2301.17	
	3					
	4					
	5					
12	1	10	1276.35	5130.50	2255.74	293.5
	2					
	3					
	4					
	5					
20	1	11	1275.95	5118.53	2343.14	260.1
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
Tech Init			JW	JW	JW	JW

Reviewed by:

Review Date: Oct - 24, 2017

page 1 of 2

Client: ~~Hemerra~~ JW Hemmera
WO#: 170519
g/L NaCl

Nautilus Environmental
No. of Emergence - ~~21~~ 35 JW -day Soil Test

Organism Tested: Paper Birch
Start Date: Aug 4 /17
End Date: ~~X~~ Sept 8 / 17 JW

Sample ID	Rep	Day 6	Day 10	Day 12	Day 14	Day 17	Day 19	Day 21	Day 24	Day 26	Day 28	Day 31	Day 33
Control Soil	1	3	3	3	3	3	3	3	3	3	3	3	3
	2	4	4	4	4	4	4	4	4	4	4	4	4
	3	3	5	5	5	5	5	5	5	5	5	5	5
	4	JW ~~4~~ 3	4	4	4	4	4	4	4	4	4	4	4
control Peat Moss	1	2	4	4	4	5	5	5	5	k ~~5~~ 4	4	4	4
	2	2	4	5	5	5	5	5	5	5	5	5	5
	3	1	JW ~~2~~ 1	JW ~~2~~ 1	JW ~~2~~ 1	JW ~~2~~ 1	JW ~~2~~ 1	JW ~~2~~ 1	JW ~~2~~ 1	1 ~~2~~ k	1	1	1
	4	4	5	5	5	5	5	5	5	5	5	5	5
0.34	1	3	5	5	5	5	5	5	5	5	5	5	5
	2	4	5	5	5	5	5	5	5	5	5	5	5
	3	1	2	2	2	2	2	2	2	2	2	2	2
	4	3	3	3	3	3	3	3	3	3	4	4	4
0.56	1	2	2	2	2	2	2	2	2	2	2	2	2
	2	3	4	4	4	4	4	4	4	4	4	4	4
	3	2	4	4	4	4	4	4	4	4	4	4	4
	4	2	4	4	4	4	4	4	4	4	4	4	4
0.93	1	2	4	4	4	4	4	4	4	4	4	4	4
	2	1	2	2	2	2	2	2	2	2	2	2	2
	3	1	3	3	3	3	3	3	3	3	3	3	3
	4	2	4	4	5	5	5	5	5	5	5	5	5
1.6	1	JW ~~3~~ 1	2	3	3	3	3	3	3	3	3	3	3
	2	3	JW ~~4~~ 3	JW ~~4~~ 3	JW ~~4~~ 3	JW ~~4~~ 3	JW ~~4~~ 3	JW ~~4~~ 3	JW ~~4~~ 3	k ~~4~~ 3	3	3	3
	3	1	2	3	3	3	3	3	3	3	3	3	3
	4	0	1	3	4	4	4	4	4	4	4	4	4
2.6	1	1	5	5	5	5	5	5	5	5	5	5	5
	2	2	3	3	3	3	3	3	3	3	3	3	3
	3	2	3	4	4	4	4	4	4	k ~~4~~ 3	3	3	3
	4	2	5	5	5	5	5	5	5	5	5	5	5
4.3	1	2	3	3	JW ~~4~~ 3	JW ~~4~~ 3	JW ~~4~~ 3	JW ~~4~~ 3	JW ~~4~~ 3	k ~~4~~ 3	3	3	3
	2	0	1	2	2	2	2	2	2	2	2	2	2
	3	0	JW ~~1~~ 2	3	3	3	3	3	3	3	3	3	3
	4	1	3	3	3	3	3	3	3	3	3	3	3
7.2	1	0	1	MLT ~~4~~ ~~3~~ 1	~~3~~ JW 1	~~4~~ 1	~~4~~ 1	~~4~~ 1	~~4~~ 1	k ~~4~~ 1	1	1	1
	2	0	0	1 JW	1	1 JW	1 JW	1 JW	1 JW	2	2	2	2
	3	0	0	1	1	1	1	1	1	1	1	1	1
	4	0	0	0	0	0	0	0	1	1	1	1	1
Tech Init		JW	JW	MLT	MLT	MLT	JW	JW	JW	MLT	JW	JW	JW

Oct. 25, 2017

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JW
Client: ~~Hemerra~~ Hemmera
WO#: 170519
g/L NaCl

Nautilus Environmental
No. of Emergence - ~~21~~ 35 JW -day Soil Test

Organism Tested: Paper Birch
Start Date: Aug 4 /17
End Date: Sept 8/17

Sample ID	Rep	Day 6	Day 10	Day 12	Day 14	Day 17	Day 19	Day 21	Day 24	Day 26	Day 28	Day 31	Day 33
~~Control~~ JW	1	0	0	0	0	0	0	0	0	0	0	0	0
12	2	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0
20	1	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0
	1												
	2												
	3												
	4												
	1												
	2												
	3												
	4												
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	2												
	3												
	4												
	1												
	2												
	3												
	4												
	1												
	2												
	3												
	4												
Tech Init		JW	JW	MLJ	MLJ	MLJ	JW	JW	JW	MLJ	JW	JW	JW

Oct. 25, 2017

Nautilus Environmental Toxicology Laboratory
Weight Monitoring Data

Client/ Project ID: ~~Hemerra~~ JW Hemmera
WO #: 170519
g/L NaCl

Organism Tested: Paper Birch.
Start Date/Time: Aug 4 / 17 @ 1700 h
End Date/Time: Sept 8 / 17 @ 1600 h

Sample		Total Wet Weight (jar + soil + organisms) (g) - Before and after hydration, Day of Test															
		Initial	Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		
ID	Rep.	Day 0	Day 4	Day 4	Day 6	Day 6.	Day 10	Day 10	Day 12	Day 12	Day 14	Day 14	Day 17	Day 17	Day 19	Day 19	
Control	1	409.38	408.57	409.41	408.43	409.47	409.06	409.45	409.31	409.39	408.50	409.39	408.83	409.45	409.36	409.36	
Soil	2	367.73	367.3316	367.88	367.44	367.73	367.36	367.78	367.58	367.74	366.40	367.70	367.30	367.75	~~373.50~~ KL ①	373.50	①365.73
	3	390.42	389.42	390.68	390.21	390.50	390.14	390.55	390.36	390.48	389.68	390.41	389.76	390.45	389.03	390.04	
	4	403.75	403.85 JW	403.81	403.37	403.82	403.31	403.73	403.51	403.81	403.08	403.80	403.14	403.81	402.58	403.70	
Control	1	205.99	204.41	206.12	205.77	206.11	205.55	206.07	205.83	206.01	205.11	206.08	204.52	206.03	204.77	206.07	
Peat moss	2	242.44	240.72	242.56	242.01	242.52	242.40	242.46	242.24	242.44	241.89	242.54	240.59	242.45	240.97	242.45	
	3	260.55	258.81	260.83	260.34	260.89	260.23	260.57	260.33	260.62	260.13	260.66	258.73	260.65	259.26	260.51	
	4	236.41	234.71	236.52	236.25	236.45	236.11	236.50	236.21	236.43	235.67	236.53	234.81	236.44	234.94	236.47	
0.34	1	226.12	224.34	226.37	225.86	226.15	225.78	226.14	225.92	226.13	~~232~~ 225.31 MLT	226.20	225.40	226.30	225.34	226.10	
	2	237.81 JW	236.01	238.04	237.56	237.85	237.25	237.93	237.64	237.91	237.09	237.89	237.17	237.98	236.72	238.00	
	3	231.05	229.32	231.13	230.46	231.10	230.60	231.10	230.81	231.05	230.19	231.08	229.97	231.24	230.03	231.09	
	4	240.48	238.78	240.58	240.01	240.52	240.06	240.53	240.33	240.55	239.77	240.64	239.71	240.48	239.06	240.65	
0.56	1	239.77	237.94	240.22	239.69	239.95	239.02	239.84	239.62	239.88	239.01	239.90	238.41	240.01	239.75	239.88	
	2	237.95	236.07	238.39	237.90	238.06	237.54	237.96	237.63	237.97	237.44	238.03	236.83	237.99	237.08	237.93	
	3	230.80	228.92	231.18	230.74	230.91	230.23	230.84	230.61	230.81	230.31	230.82	229.19	230.85	229.75	230.84	
	4	245.07	243.08	245.22	244.90	245.21	244.89	245.07	244.72	245.10	244.24	245.11	243.89	245.14	243.97	245.27	
0.93	1	232.91	231.16	232.95	232.68	232.91	232.11	232.91	232.71	232.96	232.04	232.94	231.40	232.89	231.59	232.58	
	2	225.87	224.14	225.94	225.46	225.90	225.27	225.84	225.61	225.89	224.86	225.81	224.30	225.90	224.65	225.81	
	3	245.84	244.09	246.18	245.61	245.90	245.40	245.93	245.73	245.91	245.11	245.90	244.31	245.99	244.76	246.08	
	4	233.71	231.92	234.20	233.68	233.91	233.20	233.80	233.53	233.71	233.01	233.81	232.09	233.74	232.26	233.71	
1.6	1	224.46	226.63	224.68	224.42	224.55	223.93	224.51	224.31	224.51	223.91	224.50	222.64	224.39	222.57	224.26	
	2	237.11	235.01	237.25	236.64	237.11	236.42	237.10	236.82	237.12	236.14	237.12	235.77	237.19	235.24	237.25	
	3	228.91	227.10	229.04	228.31	229.04	228.29	228.90	228.66	228.92	228.05	228.98	227.09	228.93	227.44	228.86	
	4	236.41	234.53	236.46	236.03	236.61	235.96	236.59	236.35	236.54	235.98	236.44	234.50	236.40	235.00	236.47	
2.6	1	246.83	245.13	246.91	246.42	246.88	246.17	246.88	246.61	246.83	246.08	246.85	245.63	246.91	245.44	246.80	
	2	234.00	232.33	234.46	233.70	234.15	233.60	234.00	233.74	234.02	233.23	234.03	233.01	234.01	232.89	234.06	
	3	242.25	240.52	242.71	241.96	242.32	241.64	242.29	242.04	242.25	241.56	242.26	240.95	242.33	240.93	242.27	
	4	225.31	223.63	225.38	225.30	225.54	224.94	225.60	225.28 MLT	225.41	224.85	225.36	224.21	225.35	224.03	225.34	
4.3	1	250.66	249.03	250.86	250.41	250.80	250.33	250.64	250.44	250.67	250.10	250.65	249.43	250.60	249.24	250.72	
	2	216.78	215.17	216.96	216.11	216.78	216.36	216.80	216.54	216.83	215.93	216.72	215.62	216.84	215.40	216.68	
	3	243.11	241.14	243.47	243.06	243.29	242.81	243.35	243.09	243.17	242.64	243.20	242.05	243.14	241.97	243.12	
	4	223.68	222.24	223.85	223.04	223.69	223.03	223.70	223.48	223.73	222.61	223.81	222.77	223.70	222.21	223.76	
Tech Init		JW	JW	JW	MLT	MLT	JW	JW	MLT	MLT	MLT	MLT	MLT	MLT	KL	KL	

QA Review/Date: Dec. 28, 2017

Nautilus Environmental Toxicology Laboratory
Weight Monitoring Data

Client/ Project ID: ~~Hemerra~~ JW Hemmera
WO #: 170519

Organism Tested: Paper Birch
Start Date/Time: Aug 4 / 17 @ 1700h
End Date/Time: Sept 8 / 17 @ 1600h

g/L NaCl

Total Wet Weight (jar + soil + organisms) (g) - Before and after hydration, Day of Test

Sample ID	Rep.	Initial Day 0	Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		
			Day 4	Day 4	Day 6	Day 6	Day 10	Day 10	Day 12	Day 12	Day 14	Day 14	Day 17	Day 17	Day 19	Day 19	
7.2	1	245.02	243.60	245.46	245.00	245.16	244.61	245.03	244.81	245.10	244.48	245.08	243.34	245.00	244.08	245.12	
	2	228.57	227.11	228.91	228.21	228.72	227.92	228.65	228.42	228.60	227.91	228.55	227.59	228.60	227.74	228.46	
	3	226.04	224.49	226.11	225.33	226.11	225.86	226.12	225.96	226.15	225.74	226.09	224.65	226.10	224.91	226.09	
	4	235.48	233.88	235.81	235.12	235.49	234.78	235.49	235.27	235.50	234.84	235.51	234.71	235.60	234.65	235.45	
12	1	234.29	232.91	234.53	233.91	234.31	233.67	234.27	234.07	234.29	233.55	234.37	233.17	234.22	232.96	234.37	
	2	244.62	243.09	224.63	244.15	244.63	244.38	244.88	244.60	244.71	243.84	244.63	243.28	244.60	243.32	244.69	
	3	233.10	231.61	233.24	232.51	233.19	232.60	233.12	232.96	233.21	232.60	233.10	231.88	233.11	231.70	233.08	
	4	237.84	236.44	238.05	237.55	237.86	239.25	237.83	237.61	237.84	236.94	237.89	236.88	237.88	236.65	237.92	
20	1	235.81	234.47	236.02	235.23	235.87	235.41	235.82	235.54	235.84	235.42	235.91	234.78	235.80	234.63	235.90	
	2	234.97	233.72	235.18	234.41	234.97	234.51	234.99	234.76	234.99	234.36	234.99	233.46	234.91	234.23	235.06	
	3	248.81	247.64	249.17	248.68	249.01	248.40	248.97	248.7.6	248.91	248.39	238.85	247.32	248.90	247.98	248.79	
	4	231.62	230.26	231.73	231.20	231.76	231.21	231.67	231.38	231.64	230.98	231.63	230.19	231.64	230.29	231.63	
	1																
	2																
	3																
	4																
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	3																
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Tech Init			JW	JW	MLT	MLT	JW	JW	MLT	MLT	MLT	MLT	MLT	MLT	k	k	

QA Review/Date: Oct. 25, 2017

page ~~1 of 2~~ JW
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Nautilus Environmental Toxicology Laboratory
Weight Monitoring Data

Client/ Project ID: ~~Hemerra~~ JW Hemmera
WO #: 170519

Organism Tested: Paper Birch
Start Date/Time: Aug 4 /17 @ 1700h
End Date/Time: Sept 8 /17 @ 1600 h

.g/L NaCl

Sample		Total Wet Weight (jar + soil + organisms) (g).- Before and after hydration, Day of Test														
		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Final ~~Pre & Post Hydration~~ JW		
ID	Rep.	Day 21	Day 21	Day24	Day24	Day26	Day26	Day 28	Day 28	Day 31	Day 31	Day 33	Day 33	Day 35		
control	1	408.56	409.43	408.89	409.33	407.88	409.30	404.51	409.80	408.89	409.52	409.17	409.31	408.63		
soil	2	367.40	367.83	371.~~11~~03	371.03	370.28	370.40	366.36	369.25	367.58	367.76	367.09	367.84	367.51		
	3	389.52	390.40	389.49	390.50	389.59	390.47	386.30	391.73	390.18	390.47	389.63	390.51	390.19		
	4	402.81	403.81	403.09	403.84	402.88	403.71	398.25	404.30	404.35	404.71	404.16	404.15	403.63		
Control	1	204.97	205.99	204.86	206.02	204.77	206.03	200.97	206.65	204.05	206.04	205.59	205.97	205.25		
Peat Moss	2	241.32	242.47	241.69	242.53	241.00	242.45	237.13	242.78	241.57	242.49	242.06	242.44	241.69		
	3	259.28	260.61	259.59	260.65	258.93	260.53	256.35	261.06	259.10	260.59	259.78	260.59	260.05		
	4	235.41	236.50	235.60	236.50	235.63	236.50	231.53	236.73	235.34	236.41	235.81	236.39	235.77		
0.34	1	224.76	226.19	225.08	226.08	224.83	226.15	220.96	226.36	224.43	226.14	224.84	226.07	225.67		
	2	236.62	237.81	237.23	237.86	236.10	237.81	232.21	237.81	236.30	237.95	237.21	237.88	237.01		
	3	229.84	231.03	230.15	231.20	229.86	231.10	228.56	232.61	231.04	231.04	230.38	231.06	230.28		
	4	239.54	240.48	239.52	240.52	239.18	240.50	235.62	240.67	238.99	240.38	239.74	240.50	239.78		
0.56	1	238.80	239.85	239.05	239.77	237.96	239.80	236.60	239.~~64~~91	237.68	239.67	238.61	239.71	238.80		
	2	235.46	237.93	237.08	238.01	236.42	237.99	234.34	① ~~238.51~~	235.21	238.04	237.29	238.01	237.15		
	3	229.46	230.77	229.71	230.82	229.47	230.79	227.22	230.46	228.40	230.78	② ~~227.29~~	230.85	230.06		
	4	244.29	245.14	244.46	245.03	243.45	245.08	241.57	245.~~62~~55	242.66	245.05	243.52	245.08	244.44		
0.93	1	231.71	232.94	231.99	232.99	231.26	232.99	229.69	233.05	231.41	232.94	232.32	232.93	232.31		
	2	224.93	225.95	225.25	22~~8~~6.02	224.62	225.93	222.05	226.11	224.37	225.87	225.25	225.92	225.29		
	3	245.25	245.89	244.88	245.95	244.71	245.86	242.34	245.88	244.29	245.84	245.23	245.87	245.25		
	4	232.80	233.69	232.76	233.79	232.53	233.74	230.14	233.91	232.40	233.73	233.24	233.83	233.32		
1.6	1	223.55	224.54	~~22~~223.64	224.43	223.26	224.52	221.15	224.58	223.11	224.50	223.79	224.48	223.93		
	2	236.50	237.09	236.36	237.19	235.45	237.22	233.53	237.68	236.14	237.10	236.47	237.16	236.66		
	3	227.99	228.99	227.99	228.95	227.93	228.99	225.37	228.80	226.70	228.96	228.43	229.04	228.49		
	4	235.72	236.50	235.85	236.36	233.91	236.49	233.73	236.62	234.75	236.40	235.35	236.49	236.06		
2.6	1	245.96	246.89	245.81	246.85	245.78	246.95	243.56	246.89	244.52	246.79	246.07	246.88	246.32		
	2	233.34	234.07	233.16	234.02	232.38	234.02	230.71	234.02	232.57	234.08	233.72	234.12	233.63		
	3	241.44	242.29	241.48	242.27	240.52	242.26	238.71	242.29	240.65	242.32	241.64	242.32	241.67		
	4	224.57	225.31	223.98	225.27	223.50	225.32	221.66	225.72	224.09	225.28	224.72	225.34	224.89		
4.3	1	249.93	250.71	249.92	250.64	249.03	250.60	246.98	251.13	249.93	250.60	250.10	250.69	250.21		
	2	215.71	216.78	216.02	216.69	214.86	216.68	213.00	216.83	215.50	216.86	216.31	216.74	216.32		
	3	242.59	243.16	242.42	243.11	241.33	243.09	239.64	243.41	241.81	243.19	242.23	243.11	242.80		
	4	223.19	223.63	221.70	~~22~~ 223.64	222.25	223.67	220.11	223.69	221.89	223.69	222.82	223.69	223.12		
Tech Init		YML	YML	K	K	MLT	MLT	JS	JS	K	K	K	K	K		

①238.51

②229.89

QA Review/Date: Oct-25, 2017

page ~~2 of 2~~ JW
4 of 4

Nautilus Environmental Toxicology Laboratory
Weight Monitoring Data

Client/ Project ID: ~~Hemerra~~ JW Hemmera
WO #: 170519
9/L NaCl

Organism Tested: Paper Birch
Start Date/Time: Aug 4 /17 @ 1700h
End Date/Time: Sept 8 /17 @ 1600 h.

Sample		Total Wet Weight (jar + soil + organisms) (g) - Before and after hydration, Day of Test														
		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Final ~~Pre & Post Hydration~~ JW		
ID	Rep.			Day24	Day24	Day26	Day26	Day 28	Day 28	Day 31	Day 31	Day 33	Day 33	Day 35		
7.2	1	244.50	245.05	244.52	245.05	242.62	245.08	242.42	245.55	243.67	244.97	244.18	244.95	244.66		
	2	227.77	228.67	227.72	228.49	227.41	228.60	226.18	228.78	227.09	228.78	228.13	228.59	228.23		
	3	225.40	226.08	225.50	226.03	224.32	226.01	223.24	226.49	225.28	226.10	225.38	226.00	225.53		
	4	234.80	235.47	234.61	235.53	233.76	235.43	~~23~~ 232.33	235.76	234.25	235.43	234.81	235.42	234.92		
12	1	233.66	234.39	233.52	234.41	232.78	234.21	231.99	234.50	233.56	234.22	233.81	234.29	233.71		
	2	244.00	244.62	244.05	248.11	244.41	244.75	242.37	244.78	243.37	244.75	244.15	244.69	244.23		
	3	232.54	233.11	232.24	233.16	231.57	233.05	229.44	233.83	231.75	233.12	232.34	233.15	232.86		
	4	237.29	237.88	237.19	237.92	236.36	237.79	③ ~~233.15~~	237.97	236.09	237.72	237.27	237.85	237.38		
20	1	235.22	235.90	235.04	235.85	234.55	235.80	233.15	236.75	235.27	235.90	235.34	235.81	235.49		
	2	234.46	235.01	233.99	234.92	233.29	234.99	231.55	234.74	233.30	234.90	234.34	235.02	234.64		
	3	~~230.85~~①	~~231.50~~②	248.38	248.79	247.19	248.77	245.91	248.51	247.22	248.80	248.33	248.84	248.54		
	4	230.85	231.59	230.55	231.64	230.17	231.59	228.68	231.65	230.10	231.56	231.05	231.68	231.31		
	1															
	2															
	3															
	4															
	1															
	2															
	3															
	4															
	1															
	2															
	3															
	4															
	1															
	2															
	3															
	4															
	1															
	2															
	3															
	4															
Tech Init		YM	YM	K	K	MLT	MLT	JS	JS	K	K	K	K	K		

①248.16 ②248.89 ③234.29

QA Review/Date: Oct. 25, 2017

1/3

Client: ~~Hemerra~~ JW Hemmera
WO#: 170519

Nautilus Environmental
No. of Emergence - 2~~1~~-day Soil Test
35 JW

Organism Tested: Paper Birch
Start Date: Aug 4 / 17
End Date: Sept 8 / 17

Post Germination Shoot and Root Length (mm)

g/L NaCl

Date	Sample	Rep A	Length (mm)		Rep B	Length (mm)		Rep C	Length (mm)		Rep D	Length (mm)	
		Plant #	Shoot	Root	Plant #	Shoot	Root	Plant #	Shoot	Root	Plant #	Shoot	Root
Sept 8/17	Control Soil	1	50	58	1	48	34	1	45	38	1	53	34
		2	43	38	2	50	30	2	48	37	2	49	29
		3	45	50	3	50	30	3	45	35	3	43	29
		4			4	51	31	4	50	33	4	50	28
		5			5			5	53	30	5		
	Control Peat Moss	1	59	64	1	78	117	1	53	48	1	54	36
		2	55	75	2	65	46	2			2	56	109
		3	60	70	3	64	34	3			3	61	52
		4	62	82	4	34	JW ~~37~~ 27	4			4	50	34
		5			5	48	JW ~~40~~ 70	5			5	46	33
	0.34	1	68	81	1	72	120	1	67	148	1	81	150
		2	80	99	2	63	88	2	90	120	2	62	82
		3	70	93	3	77	100	3			3	75	74
		4	55	76	4	75	102	4			4	76	85
		5	33	34	5	80	80	5			5		
	0.56	1	87	130	1	51	70	1	71	115	1	95	130
		2	76	85	2	100	185	2	65	102	2	51	80
		3			3	92	80	3	50	95	3	34	58
		4			4	10	JW ~~0~~ 71	4	41	101	4	56	93
		5			5			5			5		
	0.93	1	63	43	1	92	98	1	72	74	1	55	61
		2	62	38	2	50	50	2	56	53	2	64	46
		3	61	JW ~~56~~ 45	3			3	54	96	3	42	55
		4	80	56	4			4			4	56	105
		5			5			5			5	44	34
Tech Init			JW	JW		JW	JW		JW	JW		JW	JW

Oct. 25, 2017

2/3

Client: ~~Hemerra~~ JW Hemmera
WO#: 170519

Nautilus Environmental
No. of Emergence - ~~21~~-day Soil Test
35 JW

Organism Tested: Paper Birch
Start Date: Aug 4 / 17
End Date: Sept 8 / 17

Post Germination Shoot and Root Length (mm)

g/L NaCl

Date	Sample	Rep A	Length (mm)		Rep B	Length (mm)		Rep C	Length (mm)		Rep D	Length (mm)	
		Plant #	Shoot	Root	Plant #	Shoot	Root	Plant #	Shoot	Root	Plant #	Shoot	Root
Sept 8/17	1.6	1	62	90	1	65	103	1	67	80	1	88	95
		2	58	85	2	55	80	2	45	87	2	60	80
		3	42	63	3	31	20	3	23	37	3	43	38
		4			4			4			4	100	73
		5			5			5			5		
	2.6	1	59	55	1	53	66	1	60	62	1	48	35
		2	21	22	2	40	65	2	36	55	2	58	62
		3	76	78	3	JW ✓ 34	57	3	49	68	3	64	67
		4	51	45	4			4			4	50	35
		5	49	55	5			5			5	26	15
	4.3	1	56	19	1	15	15	1	15	12	1	52	55
		2	32	28	2	25	22	2	13	3	2	30	55
		3	20	18	3			3	7	3	3	11	2
		4			4			4			4		
		5			5			5			5		
	7.2	1	3	20	1	7	4	1	4	2	1	16	5
		2			2	13	10	2			2		
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
	12	1			1			1			1		
		2			2			2			2		
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
Tech Init			JW	JW		JW	JW		JW	JW		JW	JW

Oct. 25, 2017

Client: ~~Hemerra~~ Hemmera
WO#: 170519

Nautilus Environmental
No. of Emergence - ~~21~~-day Soil Test
35 JW

Organism Tested: Paper Birch
Start Date: Aug 4 / 17
End Date: Sept 8 / 17

Post Germination Shoot and Root Length (mm)

g/L NaCl

Date	Sample	Rep A	Length (mm)		Rep B	Length (mm)		Rep C	Length (mm)		Rep D	Length (mm)	
		Plant #	Shoot	Root	Plant #	Shoot	Root	Plant #	Shoot	Root	Plant #	Shoot	Root
Sept 8/17	20	1			1			1			1		
		2			2			2			2		
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
		1			1			1			1		
		2			2			2			2		
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
		1			1			1			1		
		2			2			2			2		
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
		1			1			1			1		
		2			2			2			2		
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
		1			1			1			1		
		2			2			2			2		
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
Tech Init			JW	JW		JW	JW		JW	JW		JW	JW

Oct 25, 2017

35-d Paper Birch
JW ~~7-d *Lemna minor*~~ Weight Data Sheet

Client: JW ~~Hemerra~~ Hemmera
Sample ID: NaCl (Shoot)
WO #: 170519

Start Date: Aug 4 /17
Termination Date: Sept 8 /17
Balance ID: Bal - 1

g/L NaCl Concentration	Rep	PS Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
Control Soil	A	1	1274.30	1297.54	JW
	B	2	1277.23	1299.22	↓
	C	3	1280.83	1306.00	
	D	4	127~~2~~ JW 1.96	1296.16	
Control Peat Moss	A	5	1271.84	1351.85	
	B	6	1279.60	1381.54	
	C	7	1273.76	1293.62	
	D	8	1280.41	1365.92	
0.34	A	9	1280.58	1479.48	
	B	10	1280.00	1477.22	
	C	11	1274.54	1422.33	
	D	12	1273.54	1396.04	
0.56	A	13	1276.86	1441.74	
	B	14	1276.92	1453.01	
	C	15	1276.77	1428.99	
	D	16	1276.61	1440.81	
0.93	A	17	1278.18	1422.99	
	B	18	1276.66	1383.96	
	C	19	1274.95	1374.03	
	D	20	1272.95	1390.71	
1.6	A	21	1276.60	1366.91	
	B	22	1276.10	1360.59	
	C	23	1275.73	1339.22	
	D	24	1280.09	1441.47	
2.6	A	25	1274.81	1371.27	
	B	26	1279.55	1332.21	
	C	27	1282.09	1351.22	
	D	28	1285.22	1362.45	↓

Comments: 10% Re-weigh = #8. 1365.09 # 24. 1441.35
(mg) #17. 1422.05 # 32. 1304.46

Reviewed by: Ell

Date Reviewed: Oct. 25, 2017

35-d Paper Birch ~~7-d Lemna minor~~ Weight Data Sheet

JW

Client: ~~Hemerra~~ JW Hemmera

Sample ID: NaCl (shoot)

WO #: 170519

Start Date: Aug 4 /17

Termination Date: Sept 8 /17

Balance ID: Bal - 1

g/L NaCl

PS

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
4.3	A	29	1282.06	1331.06	JW
	B	30	1274.56	1280.50	
	C	31	1280.96	1284.38	
	D	32	1277.89	1304.82	
7.2	A	33	1280.99	1282.56	
	B	34	1276.42	1278.41	
	C	35	1276.54	1276.78	
	D	36	1272.36	1273.99	
12	A				
	B				
	C				
	D				
20	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				

JW

Comments:

Reviewed by:

Date Reviewed: Oct. ~~26~~ 25, 2017

35-d Paper Birch

JW ~~7-d *Lemna minor*~~ Weight Data Sheet

Client: ~~Hemerra~~ JW Hemmera

Sample ID: NaCl (Root)

WO #: 170519

Start Date: Aug 4 / 17

Termination Date: Sept 8 / 17

Balance ID: Bal - 1

g/L NaCl

PR Purple

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
Control Soil	A	1	1276.71	1283.71	JW
	B	2	1275.43	1281.84	
	C	3	1278.40	1296.34	
	D	4	1278.90	1302.38	
Control Peat Moss	A	5	1281.58	1290.48	
	B	6	1286.97	1296.97	
	C	7	1281.81	1283.39	
	D	8	1282.97	1292.44	
0.34	A	9	1282.98	1307.47	
	B	10	1282.21	1302.43	
	C	11	1279.23	1303.02	
	D	12	1273.48	1290.49	
0.56	A	13	~~1274.27~~ JW 1290.17	1306.90	
	B	14	1274.26	1296.07	
	C	15	1281.20	1300.82	
	D	16	1277.47	1295.71	
0.93	A	17	1274.71	1285.09	
	B	18	1283.89	1295.15	
	C	19	1279.50	1292.79	
	D	20	1277.87	1290.92	
1.6	A	21	1278.22	1285.98	
	B	22	1279.14	1288.91	
	C	23	1273.29	1279.84	
	D	24	1275.14	1289.04	
2.6	A	25	1272.84	1282.31	
	B	26	1273.32	1280.18	
	C	27	1274.20	1283.43	
	D	28	1278.72	1286.02	↓

10 % Re-weigh (mg)

Comments:

#6 . 1296.81 # 24 . 1288.96

14 . 1295.98 # 3~~0~~ 2 JW . 1275.63

Reviewed by:

Date Reviewed: Oct. 25, 2017

35-d Paper Birch ~~7-d Lemna minor~~ Weight Data Sheet

Client: ~~Hemerra~~ JW Hemmera
Sample ID: NaCl (Root)
WO #: 170519

Start Date: Aug 4 /17
Termination Date: Sept 8 /17
Balance ID: Bal - 1

g/L NaCl
PR Purple

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
4.3	A	29	1276.07	1280.86	JW
	B	30	1270.80	1272.07	↓
	C	31	1271.03	1271.66	
	D	32	1271.81	1275.68	
7.2	A	33	1277.60	1278.03	
	B	34	1276.75	1277.00	
	C	35	1272.96	1273.05	
	D	36	1276.34	1276.38	
12	A				
	B				
	C				
	D				
20	A		JW		
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				

Comments:

Reviewed by:

Date Reviewed: Oct 25, 2017

CETIS Analytical Report

Report Date:	05 Dec-17 11:31 (p 1 of 2)
Test Code:	170519-S | 14-2805-6538

JW ~~Eisenia 28-d Survival and Growth Soil~~ **Test** 35-d

Nautilus Environmental

Analysis ID:	14-2696-7856	**Endpoint:**	~~Survival~~ Rate (germination) JW	**CETIS Version:**	CETISv1.8.7
Analyzed:	05 Dec-17 11:24	**Analysis:**	Untrimmed Spearman-Kärber	**Official Results:**	Yes

Batch ID:	12-1325-2703	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	04 Aug-17	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	08 Sep-17	**Species:**	Betula papyrifera	**Brine:**	
Duration:	35d 0h	**Source:**	BC Ministry of Forest, Lands and Natural R	**Age:**	

Sample ID:	01-2024-9676	**Code:**	72ADD4C	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	NA	**Station:**	Sodium Chloride		

Spearman-Kärber Estimates

Threshold Option	Threshold	Trim	Mu	Sigma	EC50	95% LCL	95% UCL
Control Threshold	0.25	0.00%	0.6818	0.04209	4.806	3.959	5.834

JW ~~Survival~~ Rate Summary
germination

			Calculated Variate(A/B)								
C-gm/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0	Reference Sed	4	0.75	0.2	1	0.1893	0.3786	50.48%	0.0%	15	20
0.34		4	0.8	0.4	1	0.1414	0.2828	35.36%	-6.67%	16	20
0.56		4	0.7	0.4	0.8	0.1	0.2	28.57%	6.67%	14	20
0.93		4	0.7	0.4	1	0.1291	0.2582	36.89%	6.67%	14	20
1.6		4	0.65	0.6	0.8	0.05	0.1	15.38%	13.33%	13	20
2.6		4	0.8	0.6	1	0.1155	0.2309	28.87%	-6.67%	16	20
4.3		4	0.55	0.4	0.6	0.05	0.1	18.18%	26.67%	11	20
7.2		4	0.25	0.2	0.4	0.05	0.1	40.0%	66.67%	5	20
12		4	0	0	0	0	0		100.0%	0	20
20		4	0	0	0	0	0		100.0%	0	20

JW ~~Survival~~ Rate Detail
germination

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	0.8	1	0.2	1
0.34		1	1	0.4	0.8
0.56		0.4	0.8	0.8	0.8
0.93		0.8	0.4	0.6	1
1.6		0.6	0.6	0.6	0.8
2.6		1	0.6	0.6	1
4.3		0.6	0.4	0.6	0.6
7.2		0.2	0.4	0.2	0.2
12		0	0	0	0
20		0	0	0	0

JW ~~Survival~~ Rate Binomials
germination

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Negative Control	3/5	4/5	5/5	4/5
0	Reference Sed	4/5	5/5	1/5	5/5
0.34		5/5	5/5	2/5	4/5
0.56		2/5	4/5	4/5	4/5
0.93		4/5	2/5	3/5	5/5
1.6		3/5	3/5	3/5	4/5
2.6		5/5	3/5	3/5	5/5
4.3		3/5	2/5	3/5	3/5
7.2		1/5	2/5	1/5	1/5
12		0/5	0/5	0/5	0/5
20		0/5	0/5	0/5	0/5

Dec-5/17

Analyst: JW QA:

CETIS Analytical Report

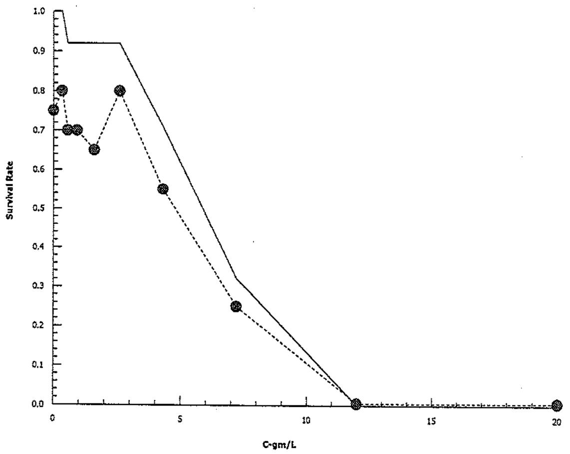
Report Date: 05 Dec-17 11:31 (p 2 of 2)
Test Code: 170519-S | 14-2805-6538

JW ~~Eisenia 28-d Survival and Gro~~wth Soil Test 35-d

Nautilus Environmental

Analysis ID: 14-2696-7856
Analyzed: 05 Dec-17 11:24
Endpoint: ~~Survival~~ Rate (germination) JW
Analysis: Untrimmed Spearman-Kärber
CETIS Version: CETISv1.8.7
Official Results: Yes

Graphics



Analyst: JW

QA: Dec-5/17

CETIS Analytical Report

Report Date: 05 Dec-17 11:44 (p 1 of 2)
Test Code: 170519-S | 14-2805-6538

JW ~~Eisenia 28-d Survival and Growth~~ Soil Test 35-d

Nautilus Environmental

Analysis ID:	18-3322-9011	**Endpoint:**	Mean Length-mm (shoot)	**CETIS Version:**	CETISv1.8.7
Analyzed:	05 Dec-17 11:43	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes

Batch ID:	12-1325-2703	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	04 Aug-17	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	08 Sep-17	**Species:**	Betula papyrifera	**Brine:**	
Duration:	35d 0h	**Source:**	BC Ministry of Forest, Lands and Natural R	**Age:**	

Sample ID:	01-2024-9676	**Code:**	72ADD4C	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	NA	**Station:**	Sodium Chloride		

Non-Linear Regression Options

Model Function	X Transform	Y Transform	Weighting Function	PTBS Function
4P Log-Logistic+Hormesis EV [Y=A(1+EX)/(1+(2ED+1)(X/D)^C)]	None	None	Normal [W=1]	Off [Y*=Y]

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
25	-83.81	177.1	181.5	0.8355	Yes	1.748	2.776	0.1724	Non-Significant Lack of Fit

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	1.689	N/A	2.107
IC10	1.903	N/A	2.324
IC15	2.104	1.646	2.538
IC20	2.302	1.855	2.753
IC25	2.5	2.057	2.971
IC40	3.146	2.682	3.695
IC50	3.664	3.142	4.327

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
A	60.89	3.933	53.18	68.6	15.48	<0.0001	Significant Parameter
C	2.403	0.386	1.646	3.159	6.225	<0.0001	Significant Parameter
D	3.664	0.321	3.035	4.293	11.42	<0.0001	Significant Parameter
E	0.1612	0.1769	-0.1854	0.5079	0.9117	0.3697	Non-Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	12705.52	12705.52	1	160.5	<0.0001	Significant
Lack of Fit	500.1089	125.0272	4	1.748	0.1724	Non-Significant
Pure Error	1716.335	71.51396	24			
Residual	2216.444	79.15871	28			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variances	Bartlett Equality of Variance	7.651	14.07	0.3644	Equal Variances
	Mod Levene Equality of Variance	0.7598	2.423	0.6256	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9586	0.9338	0.2511	Normal Distribution
	Anderson-Darling A2 Normality	0.5155	2.492	0.1949	Normal Distribution

Analyst: JW QA: Dec-5/17

CETIS Analytical Report

Report Date: 05 Dec-17 11:44 (p 2 of 2)
Test Code: 170519-S | 14-2805-6538

JW ~~Eisenia 28-d Survival and Growth~~ Soil Test 35-d

Nautilus Environmental

Analysis ID:	18-3322-9011	**Endpoint:**	Mean Length-mm (shoot)	**CETIS Version:**	CETISv1.8.7
Analyzed:	05 Dec-17 11:43	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes

Mean Length-mm Summary

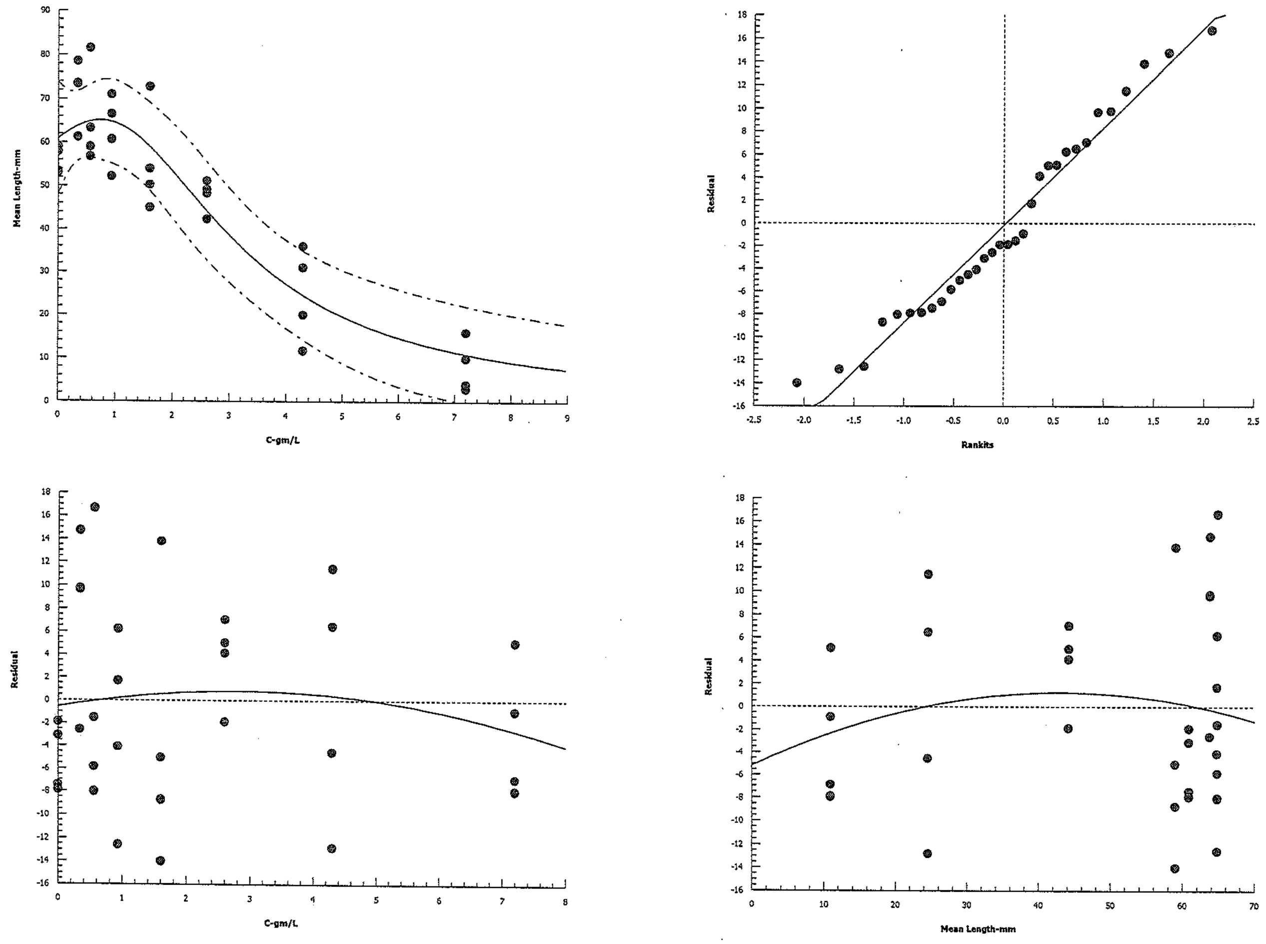
			Calculated Variate						
C-gm/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0	Reference Sed	4	55.8	53	59	1.523	3.046	5.46%	0.0%
0.34		4	71.65	61.2	78.5	3.681	7.362	10.28%	-28.41%
0.56		4	65.15	56.8	81.5	5.615	11.23	17.24%	-16.76%
0.93		4	62.6	52.2	71	4.057	8.115	12.96%	-12.19%
1.6		4	55.53	45	72.8	6.047	12.09	21.78%	0.49%
2.6		4	47.75	42.3	51.2	1.915	3.83	8.02%	14.43%
4.3		4	24.67	11.7	36	5.466	10.93	44.3%	55.78%
7.2		4	8.25	3	16	3.01	6.021	72.98%	85.22%

Mean Length-mm Detail

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	59	57.8	53	53.4
0.34		61.2	73.4	78.5	73.5
0.56		81.5	63.3	56.8	59
0.93		66.5	71	60.7	52.2
1.6		54	50.3	45	72.8
2.6		51.2	42.3	48.3	49.2
4.3		36	20	11.7	31
7.2		3	10	4	16

Graphics

4P Log-Logistic+Hormesis EV [Y=A(1+EX)/(1+(2ED+1)(X/D)^C)]



Dec 5/17

Analyst: JW QA:

CETIS Analytical Report

Report Date: 05 Dec-17 11:31 (p 1 of 2)
Test Code: 170519-S | 14-2805-6538

JW ~~Eisenia 28-d Survival and Growth~~ **Soil Test** 35-d Shoot **Nautilus Environmental**

Analysis ID:	08-7944-7794	**Endpoint:**	Mean Dry Weight-mg (~~Bed~~) JW	**CETIS Version:**	CETISv1.8.7
Analyzed:	05 Dec-17 11:29	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	12-1325-2703	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	04 Aug-17	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	08 Sep-17	**Species:**	Betula papyrifera	**Brine:**	
Duration:	35d 0h	**Source:**	BC Ministry of Forest, Lands and Natural R	**Age:**	

Sample ID:	01-2024-9676	**Code:**	72ADD4C	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	NA	**Station:**	Sodium Chloride		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1174228	200	Yes	Two-Point Interpolation

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	0.8703	0.4563	2.103
IC10	1.074	0.4194	2.14
IC15	1.262	0.3945	2.207
IC20	1.468	0.3621	2.272
IC25	1.66	0.3409	2.352
IC40	2.155	0.9933	2.957
IC50	2.536	1.578	3.436

Mean Dry Weight-mg Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Reference Sed	4	19.34	17.1	20.39	0.7537	1.507	7.8%	0.0%
0.34		4	45.94	30.63	73.89	9.558	19.12	41.61%	-137.5%
0.56		4	51.39	38.05	82.44	10.42	20.84	40.55%	-165.8%
0.93		4	36.61	23.55	53.65	6.284	12.57	34.33%	-89.3%
1.6		4	29.94	21.16	40.35	3.963	7.926	26.47%	-54.84%
2.6		4	18.83	15.45	23.04	1.608	3.217	17.08%	2.61%
4.3		4	7.355	1.14	16.33	3.429	6.858	93.24%	61.97%
7.2		4	1.109	0.24	1.63	0.323	0.6461	58.27%	94.27%

Mean Dry Weight-mg Detail

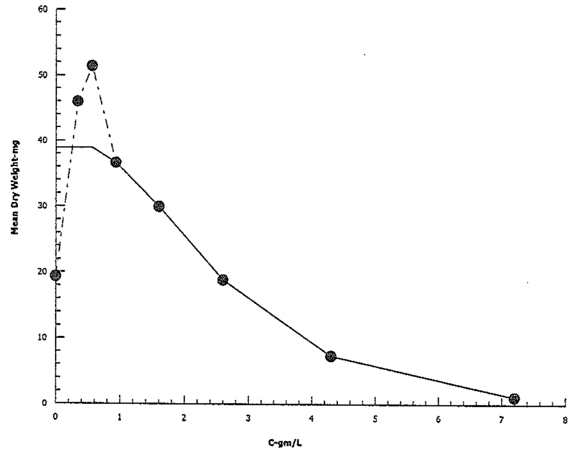
C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	20	20.39	19.86	17.1
0.34		39.78	39.44	73.89	30.63
0.56		82.44	44.02	38.05	41.05
0.93		36.2	53.65	33.03	23.55
1.6		30.1	28.16	21.16	40.35
2.6		19.29	17.55	23.04	15.45
4.3		16.33	2.97	1.14	8.977
7.2		1.57	0.995	0.24	1.63

Analyst: JW QA: Dec-5/17

JW ~~**Eisenia 28-d Survival and Growth**~~ **Soil Test** 35-d **Nautilus Environmental**

Analysis ID: 08-7944-7794 **Endpoint:** Mean Dry Weight-mg (shoot) **CETIS Version:** CETISv1.8.7
Analyzed: 05 Dec-17 11:29 **Analysis:** Linear Interpolation (ICPIN) **Official Results:** Yes

Graphics



Dec 5/17

Analyst: JW QA:________

CETIS Analytical Report

JW

Report Date: 05 Dec-17 11:40 (p 1 of 2)
Test Code: 170519-S1 | 16-8569-4353

~~Eisenia 28-d Survival and Growth~~ Soil Test 35-d

Nautilus Environmental

Analysis ID:	07-1469-1761	**Endpoint:**	Mean Dry Weight-mg (Shoot)	**CETIS Version:**	CETISv1.8.7
Analyzed:	05 Dec-17 11:40	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	12-1325-2703	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	04 Aug-17	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	08 Sep-17	**Species:**	Betula papyrifera	**Brine:**	
Duration:	35d 0h	**Source:**	BC Ministry of Forest, Lands and Natural R	**Age:**	

Sample ID:	02-2289-4098	**Code:**	D491812	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	NA	**Station:**	Sodium Chloride		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	365804	200	Yes	Two-Point Interpolation

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	2.657	N/A	2.841
IC10	2.778	1.367	3.194
IC15	2.903	2.051	3.5
IC20	3.032	2.472	3.827
IC25	3.165	2.622	4.192
IC40	3.593	2.939	5.139
IC50	3.902	3.079	5.626

Mean Dry Weight-mg Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Reference Sed	4	19.34	17.1	20.39	0.7537	1.507	7.8%	0.0%
0.34		4	19.34	17.1	20.39	0.7537	1.507	7.8%	0.0%
0.56		4	19.34	17.1	20.39	0.7537	1.507	7.8%	0.0%
0.93		4	19.34	17.1	20.39	0.7537	1.507	7.8%	0.0%
1.6		4	19.34	17.1	20.39	0.7537	1.507	7.8%	0.0%
2.6		4	18.83	15.45	23.04	1.608	3.217	17.08%	2.61%
4.3		4	7.355	1.14	16.33	3.429	6.858	93.24%	61.97%
7.2		4	1.109	0.24	1.63	0.323	0.6461	58.27%	94.27%

Mean Dry Weight-mg Detail

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	20	20.39	19.86	17.1
0.34		20	20.39	19.86	17.1
0.56		20	20.39	19.86	17.1
0.93		20	20.39	19.86	17.1
1.6		20	20.39	19.86	17.1
2.6		19.29	17.55	23.04	15.45
4.3		16.33	2.97	1.14	8.977
7.2		1.57	0.995	0.24	1.63

Dec 5/17

Analyst: JW QA:

CETIS Analytical Report
JW

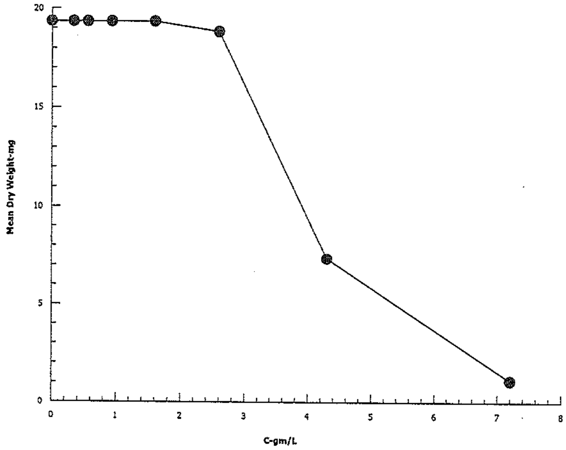
Report Date: 05 Dec-17 11:40 (p 2 of 2)
Test Code: 170519-S1 | 16-8569-4353

~~Eisenia 28-d Survival and Growth~~ Soil Test 35-d

Nautilus Environmental

Analysis ID: 07-1469-1761
Analyzed: 05 Dec-17 11:40
Endpoint: Mean Dry Weight-mg (shoot)
Analysis: Linear Interpolation (ICPIN)
CETIS Version: CETISv1.8.7
Official Results: Yes

Graphics



Dec-5/17

Analyst: JW QA:

CETIS Analytical Report

Report Date:	05 Dec-17 12:40 (p 1 of 2)
Test Code:	170519-R | 05-9925-0056

JW ~~Eisenia 28-d Survival and Growth~~ **Soil Test** 35-d

Nautilus Environmental

Analysis ID:	04-6395-7743	**Endpoint:**	Mean Length-mm (Root)	**CETIS Version:**	CETISv1.8.7
Analyzed:	05 Dec-17 12:39	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	11-5215-0357	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	04 Aug-17	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	08 Sep-17	**Species:**	Betula papyrifera	**Brine:**	
Duration:	35d 0h	**Source:**	BC Ministry of Forest, Lands and Natural R	**Age:**	

Sample ID:	01-2024-9676	**Code:**	72ADD4C	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	NA	**Station:**	Sodium Chloride		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	840271	200	Yes	Two-Point Interpolation

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	0.646	0.6033	0.8248
IC10	0.7368	0.6474	2.164
IC15	0.8325	0.6922	2.506
IC20	1.61	0.3316	2.576
IC25	1.928	0.2512	2.984
IC40	2.807	2.11	3.261
IC50	3.179	2.722	3.817

Mean Length-mm Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Reference Sed	4	58.65	48	72.8	5.175	10.35	17.65%	0.0%
0.34		4	96.65	73.5	134	14.05	28.09	29.06%	-64.79%
0.56		4	100.6	90.2	107.5	3.689	7.379	7.34%	-71.53%
0.93		4	65.15	45.5	74.3	6.776	13.55	20.8%	-11.08%
1.6		4	71.63	67.7	79.3	2.7	5.4	7.54%	-22.12%
2.6		4	56.3	49.8	62.7	3.421	6.843	12.15%	4.01%
4.3		4	20.88	6	37.3	6.438	12.88	61.68%	64.41%
7.2		4	8.5	2	20	3.969	7.937	93.38%	85.51%

Mean Length-mm Detail

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	72.8	56	48	57.8
0.34		76.6	102.5	134	73.5
0.56		107.5	101.5	103.2	90.2
0.93		45.5	74	74.3	66.8
1.6		79.3	67.7	68	71.5
2.6		51	62.7	61.7	49.8
4.3		21.7	18.5	6	37.3
7.2		20	7	2	5

Dec-5/17

Analyst: JW QA:________

CETIS Analytical Report

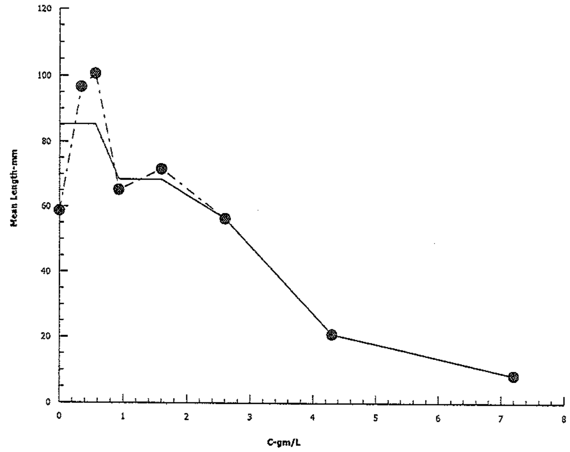
Report Date: 05 Dec-17 12:40 (p 2 of 2)
Test Code: 170519-R | 05-9925-0056

JW ~~Eisenia 28-d Survival and Growth~~ Soil Test 35-d

Nautilus Environmental

Analysis ID: 04-6395-7743
Analyzed: 05 Dec-17 12:39
Endpoint: Mean Length-mm (Root)
Analysis: Linear Interpolation (ICPIN)
CETIS Version: CETISv1.8.7
Official Results: Yes

Graphics



Analyst: JW QA: Dec-5/17

CETIS Analytical Report

Report Date: 05 Dec-17 12:48 (p 1 of 2)
Test Code: 170519-R1 | 03-2159-0526

JW ~~Eisenia 28-d Survival and Growth~~ Soil Test 35-d

Nautilus Environmental

Analysis ID:	12-9497-1552	**Endpoint:**	Mean Length-mm (Root)	**CETIS Version:**	CETISv1.8.7
Analyzed:	05 Dec-17 12:48	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	06-2115-2074	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	04 Aug-17	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	08 Sep-17	**Species:**	Betula papyrifera	**Brine:**	
Duration:	35d 0h	**Source:**	BC Ministry of Forest, Lands and Natural R	**Age:**	

Sample ID:	01-2024-9676	**Code:**	72ADD4C	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	NA	**Station:**	Sodium Chloride		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1147931	200	Yes	Two-Point Interpolation

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	2.623	N/A	2.787
IC10	2.741	N/A	2.934
IC15	2.863	N/A	3.13
IC20	2.988	2.373	3.316
IC25	3.118	2.534	3.51
IC40	3.533	2.971	4.221
IC50	3.833	3.239	4.888

Mean Length-mm Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Reference Sed	4	58.65	48	72.8	5.175	10.35	17.65%	0.0%
0.34		4	58.65	48	72.8	5.175	10.35	17.65%	0.0%
0.56		4	58.65	48	72.8	5.175	10.35	17.65%	0.0%
0.93		4	58.65	48	72.8	5.175	10.35	17.65%	0.0%
1.6		4	58.65	48	72.8	5.175	10.35	17.65%	0.0%
2.6		4	56.3	49.8	62.7	3.421	6.843	12.15%	4.01%
4.3		4	20.88	6	37.3	6.438	12.88	61.68%	64.41%
7.2		4	8.5	2	20	3.969	7.937	93.38%	85.51%

Mean Length-mm Detail

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	72.8	56	48	57.8
0.34		72.8	56	48	57.8
0.56		72.8	56	48	57.8
0.93		72.8	56	48	57.8
1.6		72.8	56	48	57.8
2.6		51	62.7	61.7	49.8
4.3		21.7	18.5	6	37.3
7.2		20	7	2	5

Dec-5/17

Analyst: JW QA:

CETIS Analytical Report

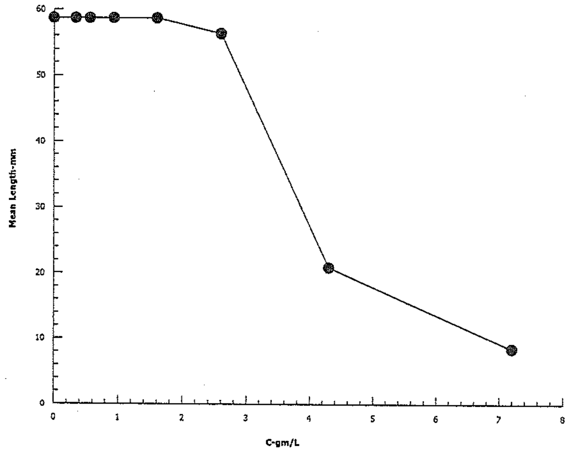
Report Date: 05 Dec-17 12:48 (p 2 of 2)
Test Code: 170519-R1 | 03-2159-0526

JW ~~Eisenia 28-d Survival and Growth~~ Soil Test 35-d

Nautilus Environmental

Analysis ID:	12-9497-1552	**Endpoint:**	Mean Length-mm (Root)	**CETIS Version:**	CETISv1.8.7
Analyzed:	05 Dec-17 12:48	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



Analyst: JW QA: Dec 5/17

CETIS Analytical Report

Report Date: 05 Dec-17 12:40 (p 1 of 2)
Test Code: 170519-R | 05-9925-0056

JW ~~Eisenia 28-d Survival and Growth~~ Soil Test 35-d

Nautilus Environmental

Analysis ID:	20-5457-6536	**Endpoint:**	Mean Dry Weight-mg (Root)	**CETIS Version:**	CETISv1.8.7
Analyzed:	05 Dec-17 12:39	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	11-5215-0357	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	04 Aug-17	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	08 Sep-17	**Species:**	Betula papyrifera	**Brine:**	
Duration:	35d 0h	**Source:**	BC Ministry of Forest, Lands and Natural R	**Age:**	

Sample ID:	01-2024-9676	**Code:**	72ADD4C	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	NA	**Station:**	Sodium Chloride		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1809007	200	Yes	Two-Point Interpolation

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	0.6533	0.5117	1.324
IC10	0.7521	0.5463	1.698
IC15	0.8569	0.5542	2.046
IC20	0.9784	0.5413	2.286
IC25	1.13	0.521	2.437
IC40	1.689	0.3877	3.443
IC50	2.345	0.7656	3.649

Mean Dry Weight-mg Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Reference Sed	4	1.925	1.58	2.225	0.1341	0.2681	13.93%	0.0%
0.34		4	6.272	4.044	11.9	1.883	3.766	60.04%	-225.9%
0.56		4	5.821	4.56	8.365	0.8678	1.736	29.82%	-202.4%
0.93		4	3.816	2.595	5.63	0.7423	1.485	38.9%	-98.27%
1.6		4	2.875	2.183	3.475	0.2982	0.5964	20.74%	-49.39%
2.6		4	2.179	1.46	3.077	0.3435	0.6869	31.52%	-13.23%
4.3		4	0.9329	0.21	1.597	0.3135	0.627	67.21%	51.53%
7.2		4	0.1713	0.04004	0.4301	0.088	0.176	102.7%	91.1%

Mean Dry Weight-mg Detail

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	2.225	2	1.58	1.894
0.34		4.898	4.044	11.9	4.253
0.56		8.365	5.452	4.905	4.56
0.93		2.595	5.63	4.43	2.61
1.6		2.587	3.257	2.183	3.475
2.6		1.894	2.287	3.077	1.46
4.3		1.597	0.6349	0.21	1.29
7.2		0.4301	0.125	0.09009	0.04004

Dec.5/17

Analyst: JW QA:

CETIS Analytical Report

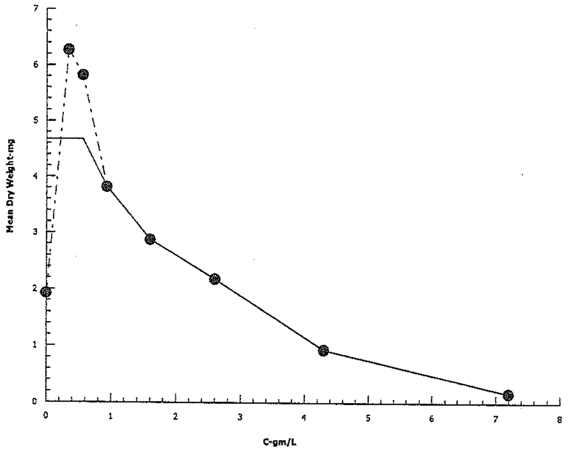
Report Date: 05 Dec-17 12:40 (p 2 of 2)
Test Code: 170519-R | 05-9925-0056

JW ~~**Eisenia 28-d Survival and Growth**~~ **Soil Test** 35-d

Nautilus Environmental

Analysis ID: 20-5457-6536
Analyzed: 05 Dec-17 12:39
Endpoint: Mean Dry Weight-mg (Root)
Analysis: Linear Interpolation (ICPIN)
CETIS Version: CETISv1.8.7
Official Results: Yes

Graphics



Analyst: JW QA: Dec 5/17

CETIS Analytical Report

Report Date:	05 Dec-17 12:52 (p 1 of 2)
Test Code:	170519-R2 | 01-8760-0991

JW **~~Eisenia 28-d Survival and Growth~~ Soil Test** 35-d **Nautilus Environmental**

Analysis ID:	05-0304-4058	**Endpoint:**	Mean Dry Weight-mg (Root)	**CETIS Version:**	CETISv1.8.7
Analyzed:	05 Dec-17 12:52	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	04-8043-5599	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	04 Aug-17	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	08 Sep-17	**Species:**	Betula papyrifera	**Brine:**	
Duration:	35d 0h	**Source:**	BC Ministry of Forest, Lands and Natural R	**Age:**	

Sample ID:	01-2024-9676	**Code:**	72ADD4C	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	NA	**Station:**	Sodium Chloride		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1568665	200	Yes	Two-Point Interpolation

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	2.738	N/A	2.82
IC10	2.881	N/A	3.129
IC15	3.029	1.187	3.476
IC20	3.183	2.424	4.062
IC25	3.343	2.553	4.712
IC40	3.861	2.916	5.359
IC50	4.239	3.069	5.751

Mean Dry Weight-mg Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Reference Sed	4	1.925	1.58	2.225	0.1341	0.2681	13.93%	0.0%
0.34		4	1.925	1.58	2.225	0.1341	0.2681	13.93%	0.0%
0.56		4	1.925	1.58	2.225	0.1341	0.2681	13.93%	0.0%
0.93		4	1.925	1.58	2.225	0.1341	0.2681	13.93%	0.0%
1.6		4	1.925	1.58	2.225	0.1341	0.2681	13.93%	0.0%
2.6		4	1.925	1.58	2.225	0.1341	0.2681	13.93%	0.0%
4.3		4	0.9329	0.21	1.597	0.3135	0.627	67.21%	51.53%
7.2		4	0.1713	0.04004	0.4301	0.088	0.176	102.7%	91.1%

Mean Dry Weight-mg Detail

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	2.225	2	1.58	1.894
0.34		2.225	2	1.58	1.894
0.56		2.225	2	1.58	1.894
0.93		2.225	2	1.58	1.894
1.6		2.225	2	1.58	1.894
2.6		2.225	2	1.58	1.894
4.3		1.597	0.6349	0.21	1.29
7.2		0.4301	0.125	0.09009	0.04004

Dec.5/17

Analyst: JW QA:

CETIS Analytical Report

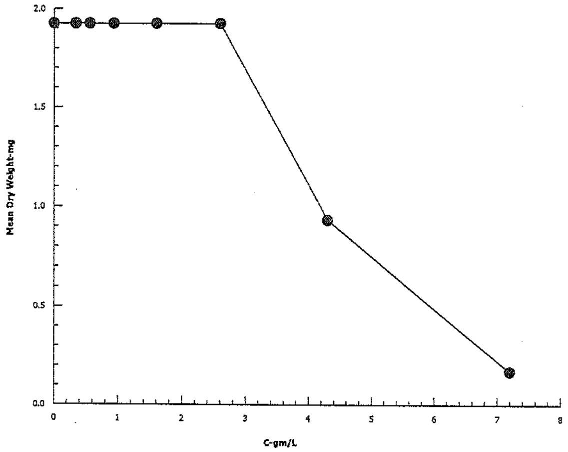
Report Date: 05 Dec-17 12:52 (p 2 of 2)
Test Code: 170519-R2 | 01-8760-0991

JW ~~Eisenia 28-d Survival and Growth~~ Soil Test 35-d

Nautilus Environmental

Analysis ID: 05-0304-4058
Analyzed: 05 Dec-17 12:52
Endpoint: Mean Dry Weight-mg (Root)
Analysis: Linear Interpolation (ICPIN)
CETIS Version: CETISv1.8.7
Official Results: Yes

Graphics



Analyst: JW QA: Dec 5/17

Soil Test Summary Sheet

Client: Hemmera

Start Date: 4-Aug-17

Work Order No.: 170518

Set up by: JW / MLT

Sample Information:

Sample ID: sodium chloride JW ~~Chloride~~ - made in-house

Sample Date: 4-Aug-17

Date Received: n/a

Stock Solution ID: 17Na02

Test Organism Information:

Species: *Camalogrostis canadensis*

Source: Premier Pacific Seeds Ltd., BC

Date Received: 13-Mar-17

Copper Reference Toxicant Results:

Reference Toxicant ID: CC01

Stock Solution ID: Boric Acid

Date Initiated: 4-Aug-17

14-d EC50 (95% CL): 381.6 (38.7 - 596.6) mg/kg boric acid

7-d IC50 (95% CL): 138.1 (53.7 - 297.3) mg/kg boric acid

EC50 Reference Toxicant Mean (Acceptable Range) : n/a* CV (%): n/a*

IC50 Reference Toxicant Mean (Acceptable Range) : n/a* CV (%): n/a*

* : Insufficient data points to calculate a reference toxicant historical mean, range and CV

Test Results:

g/L NaCl	Emergence	Shoot Length	Shoot Weight	Root Length	Root Weight
EC50 (95% CL)	4.9 (0.6 - 7.0)				
IC25 (95% CL)		4.5 (0.8 - 4.9)	1.4 (0.9 - 2.2)	3.9 (n/a - 5.3)	4.1 (n/a - 5.1)
IC50 (95% CL)		6.1 (5.1 - 6.3)	2.7 (1.7 - 5.1)	5.2 (3.6 - 7.4)	5.1 (n/a - 5.7)

n/a = not available.

Reviewed by:

Date reviewed: Dec. 5, 2017

Nautilus Environmental
Environmental Quality Data - 28-Day Soil Test

Client: ~~Hemerra~~ JW Hemmera
WO #: 170518

Organism Tested: Bluejoint Reedgrass
Start Date/Time: Aug 4 / 17 @ 1700h
End Date/Time: Sept 1 / 17 @ 1600h

Test Day	Temp (°C)	Tech Initials
0	23.0	JW
1	22.5	EMM
2	22.5	JS
3	23.0	MLT
4	23.0	JW
5	23.0	JW
6	23.0	JW
7	23.0	JW
8	21.0	EC
9	22.0	JS
10	21.0	MLT
11	21.0	MLT
12	21.0	MLT
13	21.0	MLT
14	21.0	JW
15	21.0	JW
16	21.0	EC
17	21.0	MLT
18	21.0	JW
19	21.0	JW
20	21.0	MLT
21	21.0	YML
22	21.0	EC
23	21.0	JS
24	~~20~~ 21.0	K
25	21.0	MLT
26	21.0	MLT
27	21.0	JW
28	21.0	JW

g/L NaCl

Sample ID	Rep.	% Moisture initial	% Moisture final	pH (units) initial	pH (units) final	Conductivity (µS/cm) initial	Conductivity (µS/cm) final	Survival initial	Survival final
Control	1	31.9	34.7	7.0	6.1	/	/	5	2
Soil	2							5	4
	3							5	3
	4							5	3
	5								
Control	1	265.1	207.5	6.5	6.2	/	/	5	4
Peat moss	2							5	3
	3							5	3
	4							5	2
	5								
0.34	1	289.4	170.1	6.5	6.3	/	/	5	4
	2							5	0
	3							5	3
	4							5	2
	5								
0.56	1	286.4	111.1	6.6	6.3	/	/	5	1
	2							5	1
	3							5	5
	4							5	1
	5								
0.93	1	304.4	185.6	6.7	6.5	/	/	5	2
	2							5	1
	3							5	3
	4							5	1
	5								
1.6	1	299.9	153.9	6.7	6.5	/	/	5	3
	2							5	1
	3							5	2
	4							5	3
	5								
Tech Init		JW	JW	K	K	JW	JW	JW	JW

Reviewed by:

Review Date: Oct. 25, 2017

Nautilus Environmental
Environmental Quality Data - 28-Day Soil Test

Client: ~~Hemerra~~ Hemmera JW
WO #: 170518

Organism Tested: Bluejoint Reedgrass
Start Date/Time: Aug 4/17 @ 1700h
End Date/Time: Sept 1/17 @ 1600h

Test Day	Temp (°C)	Tech Initials
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		

JW

Sample ID	Rep.	% Moisture initial	% Moisture final	pH (units) initial	pH (units) final	Conductivity (µS/cm) initial	Conductivity (µS/cm) final	Survival initial	Survival final
2.6	1	291.0	164.1	6.6	6.4	/	/	5	2
	2							5	2
	3							5	1
	4							5	2
	5								
4.3	1	275.5	123.7	6.5	6.3	/	/	5	0
	2							5	1
	3							5	2
	4							5	2
	5								
7.2	1	269.1	256.5	6.4	6.4	/	/	5	1
	2							5	0
	3							5	2
	4							5	0
	5								
12	1	243.7	273.0	6.3	6.6	/	/	5	0
	2							5	0
	3							5	0
	4							5	0
	5								
20	1	256.0	247.4	6.4	6.5	/	/	5	0
	2							5	0
	3							5	0
	4							5	0
	5								
	1								
	2								
	3								
	4								
	5								
Tech Init		JW	JW	KL	k	JW	JW	JW	JW

Reviewed by:

Review Date: Oct. 25, 2017

Nautilus Environmental
Environmental Quality Data - Day 0 Soil Test

Client: ~~Hemerra~~ JW Hemmera
WO #: 170518

Organism Tested: Bluejoint Reedgrass
Start Date/Time: Aug 4 / 17 @ 1700h
End Date/Time: Sept 1 / 17 @ 1600h

g/L NaCl Sample ID	Rep.	MC Pan No.	(mg) Pan weight ~~(g)~~ K	Pan + Wet soil weight JW ~~(g)~~ mg	Pan + dry soil JW weight ~~(g)~~ mg	% Moisture
Control Soil	1	1	1011.85	~~49584.47~~ K	4044.56	31.9
	2			5011.42		
	3					
	4					
	5					
Peat Moss	1	2	1005.54	~~4894.10~~ K	2060.57	265.1
Control	2			4857.46		
	3					
	4					
	5					
0.34	1	3	1017.38	~~4943.60~~ K	2028.40	289.4
	2			4954.47		
	3					
	4					
	5					
0.56	1	4	996.38	~~4906.95~~ K	2005.01	286.4
	2			4894.10		
	3					
	4					
	5					
0.93	1	5	1029.62	4943.60	1997.33	304.4
	2					
	3					
	4					
	5					
1.6	1	6	1015.65	4906.95	1988.63	299.9
	2					
	3					
	4					
	5					
2.6	1	7	1002.00	K 49084.76	2000.10	291.0
	2					
	3					
	4					
	5					
Tech Init			K	KL	JW	JW

Reviewed by:

Review Date: Oct - 25, 2017

Nautilus Environmental
Environmental Quality Data - Day 0 Soil Test

Client: ~~Hemmera~~ JW Hemmera

WO #: 170518

Organism Tested: BlueJoint Reedgrass

Start Date/Time: Aug 4 / 17 @ 1700h

End Date/Time: Sept 1 / 17 @ 1600h

g/L NaCl Sample ID	Rep.	MC Pan No.	Pan weight ~~(g)~~ JW mg	Pan + Wet soil weight JW ~~(g)~~ mg	Pan + dry soil JW weight ~~(g)~~ mg	% Moisture
4.3	1	8	1006.58	4908.94	2045.83	275.5
	2					
	3					
	4					
	5					
7.2	1	9	1022.02	4943.14	2084.36	269.1
	2					
	3					
	4					
	5					
12	1	10	1009.69	4874.24	2134.15	243.7
	2					
	3					
	4					
	5					
20	1	11	K ~~1004~~. 1005.0	4922.38	2105.46	256.0
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
Tech Init			K	K	JW	JW

Reviewed by:

Review Date: Oct. 25, 2017

Nautilus Environmental JW
Environmental Quality Data - Day ~~0~~ Soil Test
28

Client: JW ~~Hemerra~~ Hemmera
WO #: 170518

Organism Tested: Bluejoint Reedgrass
Start Date/Time: Aug 4 /17 @ 1700h
End Date/Time: Sept 1 /17 @ 1600h

g/L NaCl J orange

Sample ID	Rep.	Pan No.	Pan weight (~~g~~) mg JW	Wet soil weight JW (~~g~~) mg	Pan + dry soil JW weight (~~g~~) mg	% Moisture
control	1	1.	1285.46	5031.50	4065.51	34.7
soil	2					
	3					
	4					
	5					
control	1	2	1286.90	5156.10	2545.31	207.5
Peat Moss	2					
	3					
	4					
	5					
0.34	1	3	1281.99	5104.01	2696.84	170.1
	2					
	3					
	4					
	5					
0.56	1	4	1280.03	5109.05	0 JW 3~~2~~94.04	JW ~~90.1~~ 111.1
	2					
	3					
	4					
	5					
0.93	1	5	1280.86	5075.36	2609.66	185.6
	2					
	3					
	4					
	5					
1.6	1	6	1282.01	5266.24	2851.09	153.9
	2					
	3					
	4					
	5					
2.6	1	7	1282.71	4981.30	2683.27	164.L
	2					
	3					
	4					
	5					
Tech Init			JW	JS	JW	JW

Reviewed by:

Review Date: Oct. 25, 2017

Nautilus Environmental JW
Environmental Quality Data - Day ~~0~~ 28 Soil Test

Client: ~~Hemerra~~ JW Hemmera
WO #: 170518

Organism Tested: Bluejoint Reedgrass
Start Date/Time: Aug 4/17 @ 1700h
End Date/Time: Sept 1/17 @ 1600h

g/L NaCl   J orange   Pan +

Sample ID	Rep.	Pan No.	Pan weight mg (~~g~~) JW	Wet soil weight mg (~~g~~) JW	Pan + dry soil JW weight (~~g~~) mg	% Moisture
4.3	1	8	1278.82	5070.95	2974.28	123.7
	2					
	3					
	4					
	5					
7.2	1	JW ~~8~~ 9	1279.25	5086.05	2346.97	256.5
	2					
	3					
	4					
	5					
12	1	JW ~~9~~ 10	1279.36	4809.71	2225.72	273.0
	2					
	3					
	4					
	5					
20	1	11	1283.01	4858.64	2312.38	247.4
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
	1					
	2					
	3					
	4					
	5					
Tech Init			JW	JS	JW	JW

Reviewed by:

Review Date: Oct. 25, 2017

page 1 of 2

Client: ~~Hemerra~~ JW Hemmera
WO#: 170518
g/L NaCl

Nautilus Environmental
No. of Emergence - ~~21~~ 28 JW -day Soil Test

Organism Tested: Bluejoint Reedgrass
Start Date: Aug 4 / 17
End Date: ~~Aug~~ Sept 1 / 17

Sample ID	Rep	Day 6	Day 10	Day 12	Day 14	Day 17	Day 19	Day 21	Day 24	Day 26	Day 28	Day	Day
Control Soil	1	2	2	2	2	2	2	2	2	2	2		
	2	3	3	3	MLT ~~3~~ 4	4	4	4	4	4	4		
	3	3	3	3	3	3	3	3	3	3	3		
	4	2	3	3	3	3	3	3	3	3	3		
control Peat Moss	1	4	4	4	4	4	4	4	4	4	4		
	2	1	1	1	JW ~~3~~ 2	2	3	3	3	3	3		
	3	1	1	1	JW ~~3~~ 2	2	3	3	3	3	3		
	4	2	2	2	2	2	2	2	2	2	2		
0.34	1	3	4	4	4	4	4	4	4	4	4		
	2	0	0	0	0	0	0	0	0	~~3~~ MLT 0	0		
	3	2	3	3	3	3	3	3	3	3	3		
	4	2	2	2	2	2	2	2	2	2	2		
0.56	1	1	1	1	1	1	1	1	1	1	1		
	2	1	1	1	1	1	1	1	1	1	1		
	3	5	5	5	5	5	5	5	5	5	5		
	4	1	1	1	1	1	1	1	1	1	1		
0.93	1	2	2	2	2	2	2	2	2	2	2		
	2	0	1	1	1	1	1	1	1	1	1		
	3	3	3	3	3	3	3	3	3	3	3		
	4	JW ~~2~~ 1	1	1	1	1	1	2	2	1	1		
1.6	1	2	3	3	3	3	3	3	3	MLT ~~4~~ 3	MLT ~~4~~ 3		
	2	0	1	1	1	1	1	1	1	1	1		
	3	2	3	3	3	3	3	3	3	2	2		
	4	2	3	3	3	3	3	3	3	3	3		
2.6	1	2	2	2	2	2	2	2	2	2	2		
	2	0	2	2	2	2	2	2	2	2	2		
	3	0	1	1	1	1	1	1	1	1	1		
	4	2	~~3~~ 2	~~3~~ 2	~~3~~ 2	~~3~~ 2	~~3~~ 2	~~3~~ 2	~~3~~ 2	~~3~~ 2	~~3~~ 2		
4.3	1	0	0	0	0	0	0	0	0	0	0		
	2	1	1	1	1	1	1	1	1	1	1		
	3	1	2	2	2	2	2	2	2	2	2		
	4	1	1	1	2	2	2	2	2	MLT ~~1~~ 2	2		
7.2	1	0	1	1	MLT ~~2~~ 1	1	1	1	1	1	1		
	2	0	0	0	0	0	0	0	0	0	0		
	3	0	1	2	2	2	2	2	2	2	2		
	4	0	0	0	0	0	0	0	0	0	0		
Tech Init		JW	JW	MLT	MLT	MLT	JW.	JW	JW	K	MLT		

Oct. 25, 2017

page 2 of 2

Client: ~~Hemerra~~ JW Hemmera
WO#: 170518
g/L NaCl

Nautilus Environmental
No. of Emergence - ~~21~~-day Soil Test JW

Organism Tested: Bluejoint Reedgrass
Start Date: Aug ~~14~~ 4/17 JW
End Date: Sept 1 / 17

Sample ID	Rep	Day 6	Day 10	Day 12	Day 14	Day 17	Day 19	Day 21	Day 24	Day 26	Day 28	Day	Day
~~Control~~ JW	1	0	0	0	0	0	0	0	0	0	0		
12	2	0	0	0	0	0	0	0	0	0	0		
	3	0	0	0	0	0	0	0	0	0	0		
	4	0	0	0	0	0	0	0	0	0	0		
20	1	0	0	0	0	0	0	0	0	0	0		
	2	0	0	0	0	0	0	0	0	0	0		
	3	0	0	0	0	0	0	0	0	0	0		
	4	0	0	0	0	0	0	0	0	0	0		
	1												
	2												
	3												
	4												
	1												
	2												
	3												
	4												
	1												
	2												
	3												
	4												
	1												
	2												
	3												
	4												
	1												
	2												
	3												
	4												
	1												
	2												
	3												
	4												
	1												
	2												
	3												
	4												
Tech Init		JW	JW	MLJ	MLJ	MLJ	JW	JW	JW	KL	MLJ		

Oct. 25, 2017

page 1 of ~~2~~ 4 JW

Nautilus Environmental Toxicology Laboratory
Weight Monitoring Data

Client/ Project ID: ~~Hemerra~~ JW Hemmera
WO #: 170518
9/L NaCl

Organism Tested: Bluejoint Reedgrass
Start Date/Time: Aug 4 / 17 @ 1700h
End Date/Time: Sept 1 / 17 @ 1600h

Total Wet Weight (jar + soil + organisms) (g) - Before and after hydration, Day of Test

Sample ID	Rep.	Initial	Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		
		Day 0	Day 4	Day 4	Day 6	Day 6	Day 10	Day 10	Day12	Day12	Day14	Day14	Day ~~14~~ 17	Day17	Day19	Day19	
Control	1	396.86	396.41	397.15	396.76	397.03	396.52	396.89	396.68	396.88	396.56	396.84	395.59	396.86	394.71 JW	396.37	
Soil	2	433:79	433.22	433.83	433.40	433.93	433.55	433.94	433.65	433.86	433.60	433.81	432.20	433.81	~~366.47~~ ②	433.84	② 433.00
	3	399.37	398.87	399.41	399.06	399.44	399.03	399.58	399.26	399.45	399.18	399.46	398.08	399.35	397.86	399.26	
	4	383.49	382.92	383.52	383.08	383.61	383.25	383.59	383.37	383.58	383.06	383.52	382.60	383.45	~~366.47~~ ①	383.34	① 380.56
Control	1	242.34	241.19	242.40	242.05	242.44	242.05	242.37	242.12	242.39	242.03	242.40	241.12	242.35	240.28	242.42	
Peat moss	2	245.59	244.36	245.74	245.19	245.62	245.40	246.04	244.92	245.63	245.19	245.61	243.68	245.61	242.92	245.55	
	3	216.99	215.81	217.06	216.21	217.04	216.66	217.05	216.81	217.11	216.90	217.21	216.01	217.00	214.84	216.92	
	4	232.06	230.95	232.12	231.82	232.07	231.61	232.03	231.70	~~232~~ MLJ 232.08	231.06	232.05	230.49	232.05	229.27	232.03	
0.34	1	237.08	235.52	237.21	236.64	237.21	236.72	237.02	236.71	237.10	236.71	237.15	23~~6~~5.98	237.21	235.38	237.22	
	2	240.08	238.87	240.17	239.61	240.14	239.24	240.05	239.72	240.13	239.44	240.08	MLJ 238.20	240.10	237.92	240.02	
	3	232.71	231.34	232.72	232.12	232.84	232.30	232.90	232.61	232.91	230.81	232.84	231.20	232.78	229.63	232.71	
	4	229.33	228.08	229.37	228.82	229.40	228.62	229.40	229.01	229.35	228.14	229.40	228.78	229.50	227.77	229.38	
0.56	1	230.04	228.80	230.07	229.31	230.21	229.69	230.03	229.84	230.10	229.77	230.20	229.10	230.15	229.39	230.28	
	2	227.81	226.40	227.81	227.24	227.89	227.44	227.80	227.75	227.90	227.40	227.92	226.90	227.88	227.46	227.73	
	3	227.36	226.10	227.38	226.34	227.38	226.98	227.58	227.21	227.50	227.18	227.49	226.57	227.50	224.52	227.25	
	4	234.04	232.80	234.10	233.39	234.18	233.62	234.14	233.90	234.10	233.80	234.15	23~~8~~3.93	234.10	234.42	235.12	
0.93	1	233.01	231.95	233.04	232.41	233.20	232.78	233.07	232.75	233.05	232.66	233.18	231.10 MLJ	233.05	221.03	233.10	
	2	231.39	230.15	231.49	230.83	231.46	231.08	231.47	231.26	231.46	230.99	231.40	229.36	231.40	229.80	231.22	
	3	237.82	236.64	237.89	237.38	238.15	237.84	237.84	237.26	237.82	237.64	237.90	235.61	237.85	235.08	237.70	
	4	232.18	231.01	232.34	231.73	232.31	231.82	232.37	231.99	232.21	231.86	232.20	230.35	232.21	228.96	232.54	
1.6	1	235.94	234.74	236.08	235.24	236.01	235.57	236.15	235.84	236.11	235.83	235.99	234.46	235.94	233.21	235.86	
	2	243.28	242.07	243.36	242.44	243.31	242.66	243.26	242.83	243.29	242.98	243.35	241.75	243.30	240.97	243.38	
	3	232.77	231.54	232.82	232.24	232.78	231.97	232.79	232.52	232.79	232.25	232.85	230.78	232.91	230.13	232.72	
	4	236.82	234.95	236.87	236.21	236.93	236.44	236.86	236.61	236.87	236.53	236.90	235.13	236.82	234.74	236.83	
2.6	1	244.73	243.64	244.73	243.92	244.79	244.10	244.74	244.50	244.77	243.77	244.80	242.58	244.74	242.25	244.73	
	2	226.75	225.66	226.80	226.33	226.80	226.22	226.82	~~2~~ MLJ 225.29	226.78	226.30	226.80	224.37	226.71	223.84	226.62	
	3	240.38	238.99	240.48	239.92	240.42	240.04	240.36	240.08	240.39	239.84	240.33	238.21	240.31	238.04	240.30	
	4	209.77	208.62	209.88	209.10	209.81	209.32	209.82	209.53	209.84	209.50	209.90	207.90	209.77	208.06	209.70	
4.3	1	237.70	236.33	237.89	237.14	237.83	236.89	237.94	237.68	237.88	237.32	237.75	235.51	237.71	235.72	237.60	
	2	243.80	242.71	243.85	243.37	243.93	243.43	243.82	243.54	243.91	243.41	243.83	242.45	243.81	241.48	243.95	
	3	240.87	239.77	240.99	240.32	240.88	240.26	240.89	240.74	240.98	240.36	240.91	239.22	240.86	237.98	240.82	
	4	223.19	222.01	223.24	222.70	223.33	222.64	223.39	223.13	223.34	222.84	223.34	221.40	223.21	221.47	223.18	
Tech Init		JW	JW	JW	MLJ	MLJ	JW	JW	MLJ	MLJ	MLJ	MLJ	MLJ	MLJ	K	K	

① K

QA Review/Date: Oct. 25, 2017

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JW

Nautilus Environmental Toxicology Laboratory
Weight Monitoring Data

Client/ Project ID: ~~Hemerra~~ JW Hemmera
WO #: 170518

Organism Tested: Bluejoint Reedgrass
Start Date/Time: Aug 4 / 17 @ 1700h
End Date/Time: sept 1 / 17 @ 1600h

9/L NaCl

Sample			Total Wet Weight (jar + soil + organisms) (g) - Before and after hydration, Day of Test														
ID	Rep.	Initial Day 0	Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		
			Day4	Day4	Day6	Day6	Day10	Day10	Day12	Day12	Day14	Day14	Day17	Day17	Day19	Day19	
7.2	1	237.21	236.18	237.34	236.72	237.40	236.99	237.24	237.00	237.22	236.84	237.21	235.33	237.21	234.93	237.43	
	2	220.54	219.59	220.65	219.83	220.66	219.68	220.51	220.31	220.58	220.26	220.55	218.71	220.56	218.44	220.52	
	3	239.20	238.02	239.21	238.24	239.24	239.01	239.56	239.15	239.49	238.41	239.18	237.06	239.15	236.40	239.31	
	4	243.54	242.58	243.56	242.73	243.70	243.17	243.64	243.26	243.68	243.34	243.65	241.44	243.59	240.90	243.68	
12	1	239.52	238.61	239.63	238.72	239.60	238.95	239.59	239.40	239.58	239.25	239.56	237.11	239.48	237.28	239.62	
	2	234.08	233.13	234.15	233.40	234.23	233.80	234.18	233.82	234.15	233.86	234.11	231.65	234.07	231.82	234.44	
	3	229.88	228.91	229.~~84~~ MG 89	229.16	229.90	229.54	229.99	229.74	229.93	229.00	229.80	226.01	229.95	228.06	229.95	
	4	230.10	229.09	230.68	229.82	230.32	229.77	230.10	229.93	230.21	228.31	230.11	227.13	230.05	227.50	230.11	
20	1	231.26	230.40	231.26	230.87	231.30	230.94	231.23	231.01	231.29	230.96	231.40	229.41	231.27	227.81	231.27	
	2	231.85	230.92	231.88	230.92	231.85	231.39	231.90	231.84	231.97	231.70	231.90	230.32	231.80	229.70	231.97	
	3	241.22	240.36	241.22	240.45	241.23	240.75	241.56	241.20	241.36	241.18	241.33	238.55	241.14	239.24	241.34	
	4	230.56	229.27	230.63	229.70	230.67	230.24	230.65	230.42	230.61	230.38	230.86	228.76	230.51	227.65	230.63	
	1																
	2																
	3																
	4																
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Tech Init			MLT	MLT	MLT	MLT	JW	JW	MLT	MLT	MLT	MLT	MLT	MLT	u	u	

QA Review/Date: Oct. 25, 2017

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Nautilus Environmental Toxicology Laboratory
Weight Monitoring Data

Client/ Project ID: ~~Hemeffa~~ JW Hemmera

WO #: 170518

g/L NaCl

Organism Tested: Bluejoint Reedgrass

Start Date/Time: Aug 4 /17 @ 1700h

End Date/Time: Sept 1 / 17 @ 1600h

Sample ID	Rep.	Total Wet Weight (jar + soil + organisms) (g) - Before and after hydration, Day of Test														
		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		~~Pre & Post Hydration~~ JW		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		
		Day 21	Day 21	Day 24	Day 24	Day 26	Day 26	Day 28	Final							
Control soil	1	395.97	396.96	394.79	3~~8~~96.86 K	~~36~~ MLT 394.85	396.80	345.36								
	2	432.80	433.75	432.81	433.91	432.69	433.79	432.59								
	3	379.77	399.32	368.04	399.48	372.20	399.35	352.18								
	4	355.75	383.48	352.35	383.68	352.98	383.41	336.53								
Control Peat Moss	1	219.87	242.33	194.32	242.30	194.21	242.16	184.10								
	2	216.72	245.63	203.35	245.57	211.95	245.60	209.21								
	3	185.85	216.98	187.35	216.92	212.35	217.03	191.63								
	4	209.74	232.12	198.64	232.25	193.29	232.08	189.60								
0.34	1	198.57	237.05	187.85	237.69	190.28	237.29	187.06								
	2	239.33	240.10	238.93	240.06	235.18	240.05	238.34								
	3	195.03	232.80	182.05	234.24	184.34	232.22	172.56								
	4	205.34	229.37	188.03	229.55	182.58	229.45	180.76								
0.56	1	197.52	230.06	187.95	230.11	193.99	230.15	191.57								
	2	199.49	227.80	189.00	227.89	195.86	228.10	200.34								
	3	193.47	227.39	179.01	227.36	171.61	227.50	174.66								
	4	209.37	234.08	192.98	236.~~8~~26	200.50	234.10	220.96								
0.93	1	200.16	233.07	188.01	232.99	191.42	233.20	189.42								
	2	231.02	231.44	229.97	231.30	227.33	231.47	205.06								
	3	205.64	237.77	~~192 23~~ K ①	241.16	198.55	237.91	181.46								
	4	200.99	232.24	192.23	240.11	207.81	232.30	212.81								
1.6	1	205.00	235.93	184.62	245.76	200.63	235.99	180.69								
	2	243.17	243.32	241.40	243.35	239.01	243.20	211.80								
	3	199.99	232.77	194.47	235.76	196.12	233.01	190.42								
	4	210.20	236.84	195.76	237.35	193.85	236.91	189.57								
2.6	1	214.68	244.72	207.51	244.90	211.63	244.45	210.23								
	2	198.50	226.77	192.65	226.92	186.72	226.59	188.91								
	3	239.25	240.40	211.08	245.25	212.75	240.90	210.02								
	4	189.77	209.83	186.97	209.68	182.31	209.81	176.03								
4.3	1	236.98	237.77	235.81	237.74	234.99	237.57	~~240~~ K 235.01								
	2	243.44	243.90	242.56	243.74	213.35	243.60	210.55								
	3	209.55	240.93	206.59	241.05	210.63	240.90	208.83								
	4	204.10	223.25	193.57	225.54	190.46	223.30	190.80								
Tech Init		VW	YW	K	K	MLT	MLT	K								

① 187.85

QA Review/Date: Oct. 25, 2017

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Nautilus Environmental Toxicology Laboratory
Weight Monitoring Data

Client/ Project ID: ~~Hemerra~~ Hemmera
WO #: 170518

Organism Tested: Bluejoint Reedgrass
Start Date/Time: Aug 4 /17 @ 1700h
End Date/Time: Sept 1 / 17 @ 1600h

9/L NaCl

Sample		Total Wet Weight (jar + soil + organisms) (g) - Before and after hydration, Day of Test													
		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration		~~Pre & Post Hydration~~ JW		Pre & Post Hydration		Pre & Post Hydration		Pre & Post Hydration	
ID	Rep.	Day 21	Day 21	Day 24	Day 24	Day 26	Day 26	Final							
7.2	1	237.00	237.29	235.83	237.42	233.69	237.21	234.60							
	2	220.19	220.64	219.12	220.57	216.37	220.65	218.09							
	3	238.76	239.28	237.13	239.18	234.75	239.10	236.51							
	4	243.14	243.53	241.52	243.67	239.65	243.91	241.28							
12	1	239.~~8~~20	239.54	237.79	239.64	235.53	239.51	237.30							
	2	233.64	234.08	232.39	234.27	229.93	234.12	232.37							
	3	229.44	229.89	228.63	229.87	225.23	229.91	227.68							
	4	229.70	230.18	228.52	230.10	225.24	230.16	227.38							
20	1	230.93	231.36	229.57	231.25	226.91	231.28	228.72							
	2	231.51	231.89	231.09	231.80	227.75	231.90	229.95							
	3	240.97	241.30	240.31	241.48	236.94	241.20	238.73							
	4	230.19	230.66	228.62	230.62	226.23	230.30	228.09							
	1														
	2														
	3														
	4														
	1														
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	3														
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	3														
	4														
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	3														
	4														
Tech Init		GM	GM	K	K	MLT	MLT	K							

QA Review/Date: Oct-25, 2017

Client: ~~Hemerra~~ JW Hemmera
WO#: 170518

Nautilus Environmental
No. of Emergence - 28-day Soil Test

Organism Tested: Bluejoint Reedgrass
Start Date: Aug 4 / 17
End Date: Sept 1 / 17

Post Germination Shoot and Root Length (mm)

JW mg/L NaCl

Date	Sample	Rep A Plant #	Length (mm) Shoot	Length (mm) Root	Rep B Plant #	Length (mm) Shoot	Length (mm) Root	Rep C Plant #	Length (mm) Shoot	Length (mm) Root	Rep D Plant #	Length (mm) Shoot	Length (mm) Root
Sept 1 / 17													
	control	1	KL ~~168~~ 170	60	1	144	52	1	229	33	1	KL ~~238~~ 240	110
	soil	2	136	66	2	154	85	2	220	72	2	148	62
		3			3	174	64	3	226	86	3	KL ~~179~~ 181	91
		4			4	233	84 ~~84~~ KL	4			4		
		5			5			5			5		
	control	1	191	117	1	262	138	1	141	92	1	334	165
	Peat Moss	2	278	152	2	222	122	2	119	82	2	161	88
		3	188	114 ~~90~~ KL	3	302	154	3	163	102	3		
		4	302	133	4			4			4		
		5			5			5			5		
	0.34	1	292	281	1	-	-	1	222	211	1	296	166
		2	144	124	2			2	312	160	2	285	174
		3	262	204	3			3	248	124	3		
		4	260	156	4			4			4		
		5			5			5			5		
	0.56	1	KL ~~202~~ 283	202	1	282	152	1	297	200	1	256	185
		2			2			2	205	123	2		
		3			3			3	151	120	3		
		4			4			4	289	127	4		
		5			5			5	~~250~~ KL 258	152	5		
	0.93	1	276	207	1	-	-	1	245	129	1	236	135
		2	250	182	2	159	70	2	247	134	2		
		3			3			3	217	172	3		
		4			4			4			4		
		5			5			5			5		
Tech Init			JW/KL	JW/KL		JW/KL	JW/KL		JW/KL	JW/KL		JW/KL	JW/KL

Oct. 25, 2017

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Client: ~~Hemerra~~ JW Hemmera
WO#: 170518

Nautilus Environmental
No. of Emergence - 28-day Soil Test

Organism Tested: Bluejoint Reedgrass
Start Date: Aug 4 / 17
End Date: Sept 1 / 17

Post Germination Shoot and Root Length (mm)

JW
mg/L NaCl

Date	Sample	Rep A	Length (mm)		Rep B	Length (mm)		Rep C	Length (mm)		Rep D	Length (mm)	
		Plant #	Shoot	Root	Plant #	Shoot	Root	Plant #	Shoot	Root	Plant #	Shoot	Root
Sept 1 / 17	1.6	1	258	151	1	126	80	1	265	159	1	177	115
		2	272	130	2	173	137	2			2	305	240
		3	231	179	3			3			3	252	202
		4			4			4			4		
		5			5			5			5		
	2.6	1	260	120	1	261	182	1	235	152	1	187	100
		2	235	135~~8~~ KL	2	249	125	2			2	239	110
		3	~~261~~ KL	~~182~~ KL	3			3			3		
		4			4			4			4		
		5			5			5			5		
	4.3	1	–	–	1	180	90	1	243	120	1	77	69
		2			2			2	123	83	2	240	125
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
	7.2	1	79	33	1			1	69	12	1	~~77~~ KL	~~69~~ KL
		2			2			2	88	33	2		
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
	12	1			1			1			1		
		2			2			2			2		
		3		JW	3		JW	3		JW	3		JW
		4			4			4			4		
↓		5			5			5			5		
Tech Init			JW/KL	JW/KL		JW/KL	JW/KL		JW/KL	JW/KL		JW/KL	JW/KL

Oct 25, 2017

JW
Client: ~~Hemetta~~ Hemmera
WO#: 170518

Nautilus Environmental
No. of Emergence - 28-day Soil Test

Organism Tested: Bluejoint Reedgrass
Start Date: Aug 4 / 17
End Date: Sept 1 / 17

Post Germination Shoot and Root Length (mm)

g/L NaCl

Date	Sample	Rep A	Length (mm)		Rep B	Length (mm)		Rep C	Length (mm)		Rep D	Length (mm)	
		Plant #	Shoot	Root	Plant #	Shoot	Root	Plant #	Shoot	Root	Plant #	Shoot	Root
Sept 1/17	20	1			1			1			1		
		2			2			2			2		
		3		JW	3		JW	3		JW	3		JW
		4			4			4			4		
		5			5			5			5		
		1			1			1			1		
		2			2			2			2		
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
		1			1			1			1		
		2			2			2			2		
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
		1			1			1			1		
		2			2			2			2		
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
		1			1			1			1		
		2			2			2			2		
		3			3			3			3		
		4			4			4			4		
		5			5			5			5		
Tech Init			JW / KL	JW / KL		JW/KL	JW/KL		JW/ KL	JW / KL		JW/KL	JW/KL

Oct. 25, 2017

28-d Bluejoint Reedgrass

JW ~~7-d Lemna minor~~ Weight Data Sheet

Client: JW ~~Hemeffa~~ Hemmera

Sample ID: NaCl (Shoot)

WO #: 170518

Start Date: JW ~~Bluejoint~~ Aug 4 / 17

Termination Date: Sept 1 / 17

Balance ID: Bal - 1

g/L NaCl

SB Red

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
control soil	A	1	1280.15	1342.47	JW
	B	2	1281.82	1373.97	
	C	3	1281.83	1403.60	
	D	4	1284.08	1403.99	
Control Peat Moss	A	5	1284.74	1703.48	
	B	6	1285.49	1674.89	
	C	7	1280.86	1606.23	
	D	8	1285.49	1582.45	
0.34	A	9	1286.28	1735.58	
	B	10	1285.90	—	
	C	11	1284.~~7~~ 67 JW	1770.94	
	D	12	1282.63	1604.05	
0.56	A	13	1281.37	1485.85	
	B	14	1275.10	1410.02	
	C	15	1271.40	1788.68	
	D	16	1276.68	1442.84	
0.93	A	17	1278.08	1533.99	
	B	18	1277.45	1289.13	
	C	19	1274.06	1576.43	
	D	20	1275.30	1408.73	
1.6	A	21	1275.02	1669.98	
	B	22	1276.30	1285.90	
	C	23	1003.87	1223.08	
	D	24	1018.13	1368.29	
2.6	A	25	1018.66	1162.12	
	B	26	1032.01	1226.48	
	C	27	1025.08	1106.31	
	D	28	1040.60	1170.85	↓

Comments: 10 % Re-weigh = # 1. 1342.85 # 20. 1408.87
(mg) # 12. 1604.11 # 26. 1227.00

Reviewed by:

Date Reviewed: Oct. 25, 2017

28-d Bluejoint Reedgrass

JW ~~7-d *Lemna minor*~~ Weight Data Sheet

Client: JW ~~Hemerra~~ Hemmera
Sample ID: NaCl (shoot)
WO #: 170518
Start Date: Aug 4/17
Termination Date: Sept 1/17
Balance ID: Bal - 1

g/L NaCl

SB Red

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
4.3	A	29	1016.68	—	JW
	B	30	1034.56	1098.88	
	C	31	1030.48	1109.90	
	D	32	988.89	1049.19	
7.2	A	33	1008.70	1012.45	
	B	34	1028.32	—	
	C	35	1039.34	1043.22	
	D	36	1011.63	—	↓
12	A				
	B				
	C				
	D		JW		
20	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				

Comments:

Reviewed by:

Date Reviewed: Oct. 25, 2017

28-d Bluejoint Reedgrass

JW ~~7-d *Lemna minor*~~ Weight Data Sheet

Client: JW ~~Hemerra~~ Hemmera

Sample ID: NaCl (Root)

WO #: 170518

Start Date: Aug 4/17

Termination Date: Sept 1 / 17

Balance ID: Bal - 1

g/L NaCl

RB green

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
control soil	A	1	1284.40	1306.85	JW
	B	2	1279.92	1308.53	
	C	3	1279.94	1323.40	
	D	4	1283.08	1330.61	
Control Peat moss	A	5	1283.93	1458.63	
	B	6	1279.98	1310.21	
	C	7	1276.35	1287.20	
	D	8	1274.97	JW 1336.19	
0.34	A	9	1276.81	~~1458.62~~ ~~1500.32~~ JW 1500.32	
	B	10	1281.80	JW ~~1503.84~~ —	
	C	11	1285.83	1503.84	
	D	12	1278.~~91~~ JW 56	1411.52	
0.56	A	13	1285.71	1363.89	
	B	14	1279.40	1365.17	
	C	15	1279.86	1641.59	
	D	16	1281.98	1369.55	
0.93	A	17	1280.90	1398.25	
	B	18	1279.27	1282.87	
	C	19	1281.06	1454.18	
	D	20	1279.78	1356.87	
1.6	A	21	1282.30	1511.36	
	B	22	1286.47	1293.31	
	C	23	1282.54	1387.75	
	D	24	1281.56	1474.05	
2.6	A	25	1280.25	1337.39	
	B	26	1280.76	1349.72	
	C	27	1281.27	1314.16	
	D	28	1283.64	1336.12	↓

Comments: 10 % Re-weigh : # 9. 1499.51 #. 22 1293.13
(mg) # 19. 1455.95 # 31. 1318.24

Reviewed by:

Date Reviewed: Oct-25, 2017

28-d Bluejoint Reedgrass
JW ~~7-d *Lemna minor*~~ Weight Data Sheet

Client: JW ~~Hemerra~~ Hemmera
Sample ID: NaCl (Root)
WO #: 170518
Start Date: Aug 4 /17
Termination Date: Sept ~~X~~ 1 / 17 JW
Balance ID: Bal - 1

g/L NaCl RB green

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
4.3	A	29	1282.39	—	JW
	B	30	1282.867 JW	1295.82	
	C	31	1277.78	1318.24	
	D	32	1276.47	1304.72	
7.2	A	33	1277.78	1278.88	
	B	34	1279.49	—	
	C	35	1282.57	1283.37	
	D	36	1277.78	—	↓
12	A				
	B				
	C				
	D				
20	A		JW		
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				

Comments:

Reviewed by:

Date Reviewed: Oct. 25, 2017

CETIS Analytical Report

Report Date:	04 Dec-17 15:03 (p 1 of 3)
Test Code:	170518-S | 08-5914-0908

JW ~~**Eisenia 28-d Survival and Growth**~~ **Soil Test** 28-d

Nautilus Environmental

Analysis ID:	10-2165-1921	**Endpoint:**	~~Survival~~ Rate (germination)	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 13:48	**Analysis:**	JW Linear Regression (MLE)	**Official Results:**	Yes

Batch ID:	07-5675-8645	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	04 Aug-17 17:00	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	01 Sep-17 16:00	**Species:**	Camalogrostis canadensis	**Brine:**	
Duration:	27d 23h	**Source:**	Premier Pacific Seeds Ltd.	**Age:**	

Sample ID:	01-2024-9676	**Code:**	72ADD4C	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	17h	**Station:**	Control Soil		

Linear Regression Options

Model Function	Threshold Option	Threshold	Optimized	Pooled	Het Corr	Weighted
Log-Gompertz [log(-log(1-P)=A+B*log(X)]	Control Threshold	0.4	Yes	No	No	Yes

Regression Summary

Iters	LL	AICc	BIC	Mu	Sigma	Adj R2	F Stat	Critical	P-Value	Decision(α:5%)
26	-101.8	210.2	214.6	0.7744		0.4442	0.5297	2.334	0.8050	Non-Significant Lack of Fit

Point Estimates

Level	gm/L	95% LCL	95% UCL
EC5	1.217	0.0003965	2.908
EC10	1.788	0.003011	3.632
EC15	2.254	0.01018	4.164
EC20	2.669	0.02474	4.612
EC25	3.057	0.05031	5.017
EC40	4.155	0.2468	6.151
EC50	4.891	0.5658	6.964

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
Threshold	0.5404	0.05781	0.4271	0.6537	9.348	<0.0001	Significant Parameter
Slope	4.31	1.784	0.8136	7.807	2.416	0.0207	Significant Parameter
Intercept	-3.338	1.551	-6.379	-0.297	-2.151	0.0380	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	31.51636	31.51636	1	33.17	<0.0001	Significant
Lack of Fit	3.866728	0.5523897	7	0.5297	0.8050	Non-Significant
Pure Error	31.28358	1.042786	30			
Residual	35.15031	0.9500083	37			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Goodness-of-Fit	Pearson Chi-Sq GOF	35.15	52.19	0.5560	Non-Significant Heterogenity
	Likelihood Ratio GOF	40.83	52.19	0.3060	Non-Significant Heterogenity
Variances	Mod Levene Equality of Variance	1.185	2.211	0.3399	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9645	0.9447	0.2385	Normal Distribution
	Anderson-Darling A2 Normality	0.6291	2.492	0.1019	Normal Distribution

Dec 5/17

JW ~~Eisenia 28-d Survival and Growth~~ Soil Test 28-d

Nautilus Environmental

Analysis ID:	10-2165-1921	**Endpoint:**	JW ~~Survival~~ Rate (germination)	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 13:48	**Analysis:**	Linear Regression (MLE)	**Official Results:**	Yes

JW ~~Survival~~ Rate Summary
germination

			Calculated Variate(A/B)								
C-gm/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0	Reference Sed	4	0.6	0.4	0.8	0.08165	0.1633	27.22%	0.0%	12	20
0.34		4	0.45	0	0.8	0.1708	0.3416	75.9%	25.0%	9	20
0.56		4	0.4	0.2	1	0.2	0.4	100.0%	33.33%	8	20
0.93		4	0.35	0.2	0.6	0.09574	0.1915	54.71%	41.67%	7	20
1.6		4	0.45	0.2	0.6	0.09574	0.1915	42.55%	25.0%	9	20
2.6		4	0.35	0.2	0.4	0.05	0.1	28.57%	41.67%	7	20
4.3		4	0.25	0	0.4	0.09574	0.1915	76.59%	58.33%	5	20
7.2		4	0.15	0	0.4	0.09574	0.1915	127.7%	75.0%	3	20
12		4	0	0	0	0	0		100.0%	0	20
20		4	0	0	0	0	0		100.0%	0	20

JW ~~Survival~~ Rate Detail
germination

* Reference sed = control peat moss *

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	0.8	0.6	0.6	0.4
0.34		0.8	0	0.6	0.4
0.56		0.2	0.2	1	0.2
0.93		0.4	0.2	0.6	0.2
1.6		0.6	0.2	0.4	0.6
2.6		0.4	0.4	0.2	0.4
4.3		0	0.2	0.4	0.4
7.2		0.2	0	0.4	0
12		0	0	0	0
20		0	0	0	0

JW ~~Survival~~ Rate Binomials
germination

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Negative Control	2/5	4/5	3/5	3/5
0	Reference Sed	4/5	3/5	3/5	2/5
0.34		4/5	0/5	3/5	2/5
0.56		1/5	1/5	5/5	1/5
0.93		2/5	1/5	3/5	1/5
1.6		3/5	1/5	2/5	3/5
2.6		2/5	2/5	1/5	2/5
4.3		0/5	1/5	2/5	2/5
7.2		1/5	0/5	2/5	0/5
12		0/5	0/5	0/5	0/5
20		0/5	0/5	0/5	0/5

Dec 5/17

Analyst: JW QA:

CETIS Analytical Report

Report Date: 04 Dec-17 15:03 (p 3 of 3)
Test Code: 170518-S | 08-5914-0908

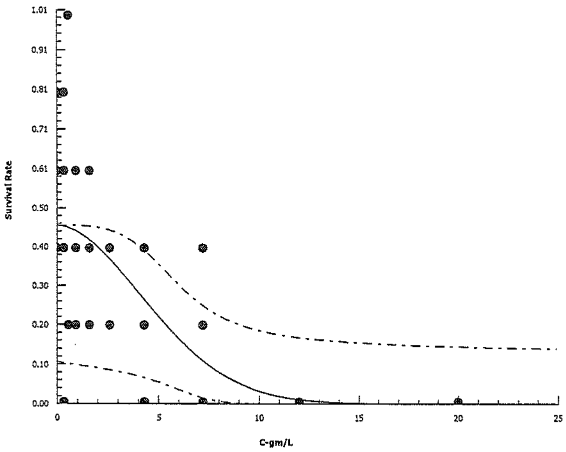
JW ~~**Eisenia 28-d Survival and Growth**~~ **Soil Test** 28-d

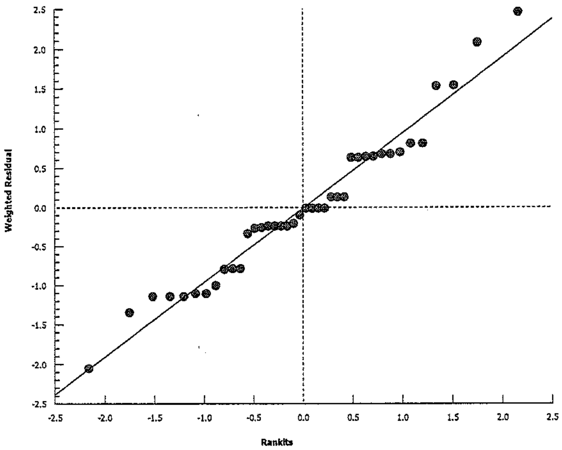
Nautilus Environmental

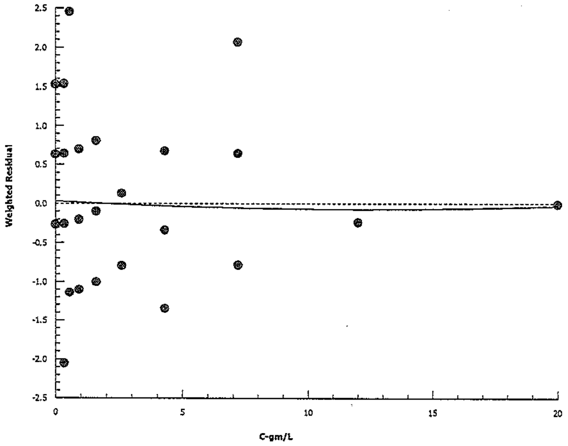
Analysis ID:	10-2165-1921	**Endpoint:**	~~Survival~~ Rate (germination) JW	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 13:48	**Analysis:**	Linear Regression (MLE)	**Official Results:**	Yes

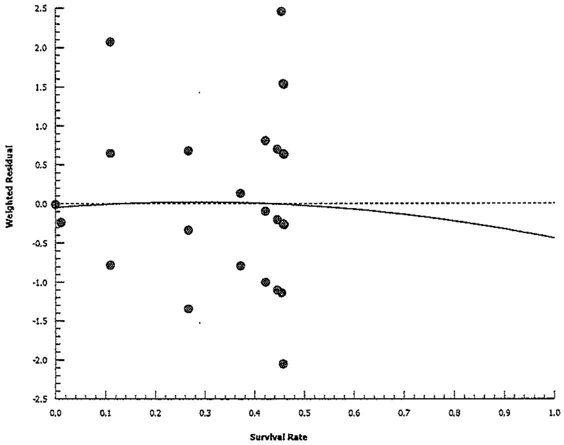
Graphics

Log-Gompertz [log(-log(1-P)=A+B*log(X)]









Dec 5/17

CETIS Analytical Report
JW

Report Date: 04 Dec-17 15:03 (p 1 of 2)
Test Code: 170518-S | 08-5914-0908

~~Eisenia 28-d Survival and Growth~~ Soil Test 28-d

Nautilus Environmental

Analysis ID: 04-3778-5410
Analyzed: 04 Dec-17 15:02
Endpoint: Mean Length-mm (shoot)
Analysis: Linear Interpolation (ICPIN)
CETIS Version: CETISv1.8.7
Official Results: Yes

Batch ID: 07-5675-8645
Start Date: 04 Aug-17 17:00
Ending Date: 01 Sep-17 16:00
Duration: 27d 23h
Test Type: Survival-Growth
Protocol: EC/EPS 1/RM/56 (2013)
Species: Camalogrostis canadensis
Source: Premier Pacific Seeds Ltd.
Analyst: Jeslin Wijaya
Diluent: Dechlorinated Tap Water
Brine:
Age:

Sample ID: 01-2024-9676
Sample Date: 04 Aug-17
Receive Date: 04 Aug-17
Sample Age: 17h
Code: 72ADD4C
Material: Sodium chloride
Source: Hemmera
Station: Control Soil
Client: Hemmera
Project:

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	256132	200	Yes	Two-Point Interpolation

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	0.766	0.3514	5.073
IC10	2.691	N/A	3.605
IC15	3.03	N/A	4.039
IC20	3.4	N/A	4.7
IC25	3.804	2.324	5.092
IC40	4.905	3.874	5.745
IC50	5.625	4.727	6.331

Mean Length-mm Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Reference Sed	4	222.6	141	262	27.58	55.16	24.78%	0.0%
0.34		3	263.6	239.5	290.5	14.79	25.62	9.72%	-18.42%
0.56		4	265.3	240	283	10.48	20.97	7.9%	-19.17%
0.93		4	223.6	159	263	22.44	44.87	20.07%	-0.45%
1.6		4	228.2	149.5	265	26.57	53.14	23.28%	-2.54%
2.6		4	235.1	213	255	8.613	17.23	7.33%	-5.64%
4.3		3	173.8	158.5	183	7.715	13.36	7.69%	21.9%
7.2		2	78.75	78.5	79	0.25	0.3536	0.45%	64.62%

Mean Length-mm Detail

* Reference Sed = Control peat moss

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	239.8	262	141	247.5
0.34		239.5	260.7	290.5	
0.56		283	282	240	256
0.93		263	159	236.3	236
1.6		253.7	149.5	265	244.7
2.6		237.5	255	235	213
4.3		180	183	158.5	
7.2		79	78.5		

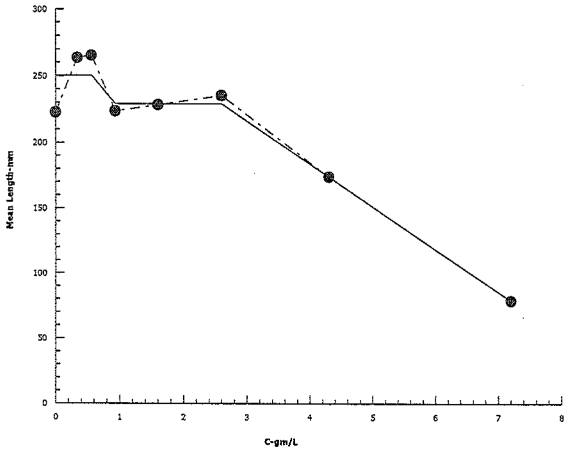
Analyst: JW
QA: Dec 5/17

~~Eisenia 28-d Survival and Growth~~ **Soil Test** 28-d JW

Nautilus Environmental

Analysis ID: 04-3778-5410 **Endpoint:** Mean Length-mm (Shoot) **CETIS Version:** CETISv1.8.7
Analyzed: 04 Dec-17 15:02 **Analysis:** Linear Interpolation (ICPIN) **Official Results:** Yes

Graphics



Analyst: JW QA: Dec 5/17

CETIS Analytical Report

Report Date: 04 Dec-17 15:27 (p 1 of 2)
Test Code: 170518-S1 | 17-8597-9604

~~Eisenia 28-d Survival and Growth~~ Soil Test 28-d JW

Nautilus Environmental

Analysis ID:	02-5659-9325	**Endpoint:**	Mean Length-mm (shoot)	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 15:26	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	07-5675-8645	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	04 Aug-17 17:00	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	01 Sep-17 16:00	**Species:**	Camalogrostis canadensis	**Brine:**	
Duration:	27d 23h	**Source:**	Premier Pacific Seeds Ltd.	**Age:**	

Sample ID:	02-2289-4098	**Code:**	D491812	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	17h	**Station:**	Control Soil		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1654870	200	Yes	Two-Point Interpolation

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	2.932	N/A	3.046
IC10	3.295	N/A	3.546
IC15	3.692	N/A	4.245
IC20	4.125	N/A	4.655
IC25	4.471	0.848	4.863
IC40	5.377	4.242	5.688
IC50	6.062	5.059	6.316

Mean Length-mm Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Reference Sed	4	222.6	141	262	27.58	55.16	24.78%	0.0%
0.34		4	222.6	141	262	27.58	55.16	24.78%	0.0%
0.56		4	222.6	141	262	27.58	55.16	24.78%	0.0%
0.93		4	222.6	141	262	27.58	55.16	24.78%	0.0%
1.6		4	222.6	141	262	27.58	55.16	24.78%	0.0%
2.6		4	222.6	141	262	27.58	55.16	24.78%	0.0%
4.3		3	173.8	158.5	183	7.715	13.36	7.69%	21.9%
7.2		2	78.75	78.5	79	0.25	0.3536	0.45%	64.62%

Mean Length-mm Detail

* Reference Sed = control peat moss

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	239.8	262	141	247.5
0.34		239.8	262	141	247.5
0.56		239.8	262	141	247.5
0.93		239.8	262	141	247.5
1.6		239.8	262	141	247.5
2.6		239.8	262	141	247.5
4.3		180	183	158.5	
7.2		79	78.5		

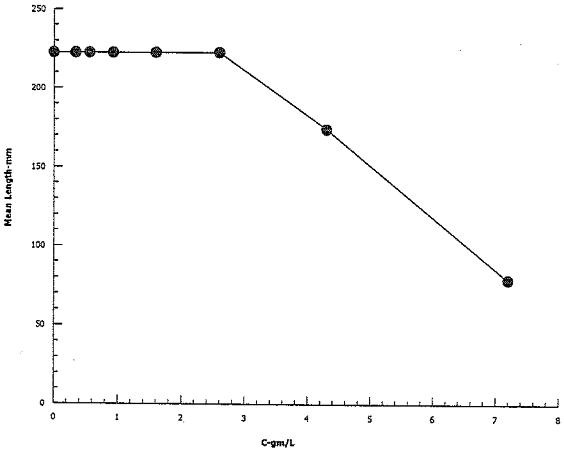
Analyst: JW QA: Dec 5/17

~~Eisenia 28-d Survival and Growth~~ Soil Test 28-d

Nautilus Environmental

Analysis ID: 02-5659-9325
Analyzed: 04 Dec-17 15:26
Endpoint: Mean Length-mm (shoot)
Analysis: Linear Interpolation (ICPIN)
CETIS Version: CETISv1.8.7
Official Results: Yes

Graphics



CETIS Analytical Report

Report Date:	04 Dec-17 15:03 (p 1 of 2)
Test Code:	170518-S | 08-5914-0908

JW ~~Eisenia 28-d Survival and Growth~~ Soil Test 28-d

Nautilus Environmental

Analysis ID:	16-1010-0378	**Endpoint:**	Mean Dry Weight-mg (shoot)	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 13:58	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes

Batch ID:	07-5675-8645	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	04 Aug-17 17:00	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	01 Sep-17 16:00	**Species:**	Camalogrostis canadensis	**Brine:**	
Duration:	27d 23h	**Source:**	Premier Pacific Seeds Ltd.	**Age:**	

Sample ID:	01-2024-9676	**Code:**	72ADD4C	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	17h	**Station:**	Control Soil		

Non-Linear Regression Options

Model Function	X Transform	Y Transform	Weighting Function	PTBS Function
4P Log-Logistic+Hormesis EV [Y=A(1+EX)/(1+(2ED+1)(X/D)^C)]	None	None	Normal [W=1]	Off [Y*=Y]

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
10	-113.4	236.6	240.2	0.5075	Yes	0.9718	2.866	0.4448	Non-Significant Lack of Fit

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	0.9074	N/A	1.467
IC10	1.017	N/A	1.638
IC15	1.136	N/A	1.818
IC20	1.27	0.8163	2.012
IC25	1.421	0.941	2.231
IC40	2.039	1.374	3.309
IC50	2.69	1.689	5.102

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
A	122.5	18.81	85.66	159.4	6.513	<0.0001	Significant Parameter
C	1.642	0.2683	1.116	2.168	6.12	<0.0001	Significant Parameter
D	2.69	0.9525	0.8231	4.557	2.824	0.0094	Significant Parameter
E	2.218	3.455	-4.553	8.989	0.642	0.5269	Non-Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	43669.94	43669.94	1	30.82	<0.0001	Significant
Lack of Fit	5533.441	1383.36	4	0.9718	0.4448	Non-Significant
Pure Error	28469.73	1423.486	20			
Residual	34003.17	1416.799	24			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variances	Bartlett Equality of Variance	12.87	14.07	0.0754	Equal Variances
	Mod Levene Equality of Variance	0.5679	2.577	0.7724	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9386	0.9264	0.1016	Normal Distribution
	Anderson-Darling A2 Normality	0.6384	2.492	0.0965	Normal Distribution

Dec 5/17

Analyst: JW QA:

CETIS Analytical Report

JW

Report Date: 04 Dec-17 15:03 (p 2 of 2)
Test Code: 170518-S | 08-5914-0908

~~Eisenia 28-d Survival and Growth~~ Soil Test 28-d

Nautilus Environmental

Analysis ID:	16-1010-0378	**Endpoint:**	Mean Dry Weight-mg (shoot)	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 13:58	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes

Mean Dry Weight-mg Summary

			Calculated Variate						
C-gm/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0	Reference Sed	4	122.9	104.7	148.5	10.17	20.35	16.56%	0.0%
0.34		3	145	112.3	162.1	16.36	28.34	19.54%	-18.06%
0.56		4	152.3	103.5	204.5	21.61	43.22	28.38%	-23.93%
0.93		4	93.46	11.68	133.4	28.18	56.36	60.3%	23.92%
1.6		4	91.89	9.6	131.7	27.81	55.63	60.53%	25.2%
2.6		4	78.83	65.13	97.23	6.969	13.94	17.68%	35.84%
4.3		3	44.73	30.15	64.32	10.18	17.63	39.41%	63.59%
7.2		2	2.845	1.94	3.75	0.905	1.28	44.99%	97.68%

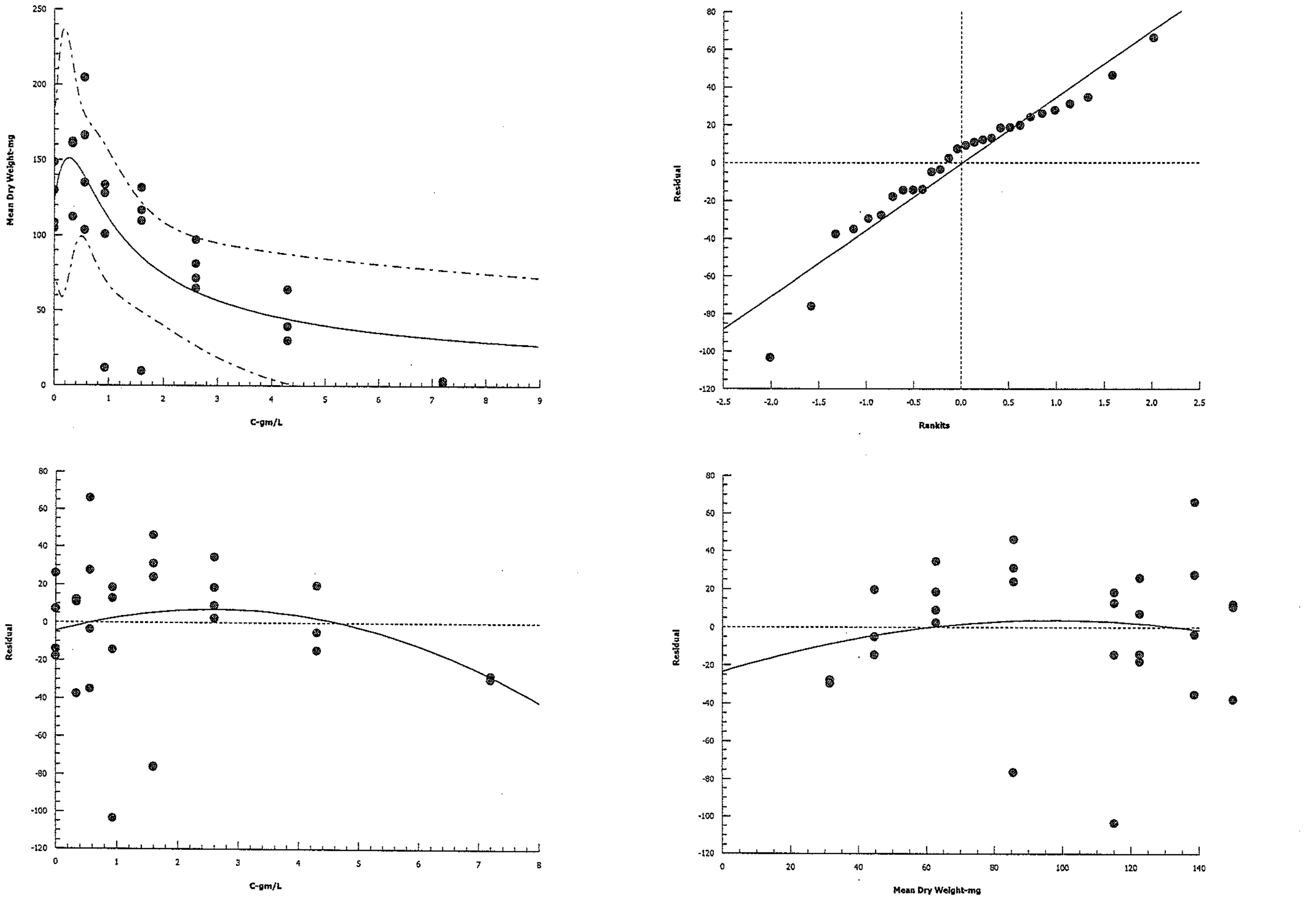
Mean Dry Weight-mg Detail

* Reference Sed = control peat moss *

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	104.7	129.8	108.5	148.5
0.34		112.3	162.1	160.7	
0.56		204.5	134.9	103.5	166.2
0.93		128	11.68	100.8	133.4
1.6		131.7	9.6	109.6	116.7
2.6		71.73	97.23	81.23	65.13
4.3		64.32	39.71	30.15	
7.2		3.75	1.94		

Graphics

4P Log-Logistic+Hormesis EV [Y=A(1+EX)/(1+(2ED+1)(X/D)^C)]



Analyst: JW QA: Dec 5/17

CETIS Analytical Report
JW

Report Date: 04 Dec-17 15:20 (p 1 of 2)
Test Code: 170518-R | 02-6853-3928

~~Eisenia 28-d Survival and Growth~~ Soil Test 28-d

Nautilus Environmental

Analysis ID:	06-7133-8253	**Endpoint:**	Mean Length-mm (Root)	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 15:18	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes

Batch ID:	07-5675-8645	**Test Type:**	Survival-Growth	**Analyst:**	
Start Date:	04 Aug-17 17:00	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	01 Sep-17 16:00	**Species:**	Camalogrostis canadensis	**Brine:**	
Duration:	27d 23h	**Source:**	Premier Pacific Seeds Ltd.	**Age:**	

Sample ID:	20-9960-3271	**Code:**	7D256747	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	17h	**Station:**	Control Soil		

Non-Linear Regression Options

Model Function	X Transform	Y Transform	Weighting Function	PTBS Function
4P Log-Logistic+Hormesis EV [Y=A(1+EX)/(1+(2ED+1)(X/D)^C)]	None	None	Normal [W=1]	Off [Y*=Y]

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
31	-114	237.7	241.3	0.3543	Yes	1.596	2.866	0.2143	Non-Significant Lack of Fit

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	2.502	N/A	3.917
IC10	2.999	N/A	4.262
IC15	3.359	N/A	4.62
IC20	3.659	N/A	4.967
IC25	3.929	N/A	5.302
IC40	4.664	3.014	6.353
IC50	5.158	3.599	7.404

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
A	142	13.71	115.2	168.9	10.36	<0.0001	Significant Parameter
C	4.016	2.807	-1.485	9.518	1.431	0.1654	Non-Significant Parameter
D	5.158	0.814	3.562	6.753	6.336	<0.0001	Significant Parameter
E	0.001	0.1041	-0.203	0.205	0.009607	0.9924	Non-Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	26302.39	26302.39	1	17.82	0.0003	Significant
Lack of Fit	8571.362	2142.841	4	1.596	0.2143	Non-Significant
Pure Error	26860.31	1343.015	20			
Residual	35431.67	1476.319	24			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variances	Bartlett Equality of Variance	12.11	14.07	0.0969	Equal Variances
	Mod Levene Equality of Variance	1.629	2.577	0.1905	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.948	0.9264	0.1768	Normal Distribution
	Anderson-Darling A2 Normality	0.5675	2.492	0.1451	Normal Distribution

Analyst: JW QA: Dec 5/17

CETIS Analytical Report
JW

Report Date: 04 Dec-17 15:20 (p 2 of 2)
Test Code: 170518-R | 02-6853-3928

~~Eisenia 28-d Survival and Growth~~ Soil Test 28-d

Nautilus Environmental

Analysis ID: 06-7133-8253 **Endpoint:** Mean Length-mm (Root) **CETIS Version:** CETISv1.8.7
Analyzed: 04 Dec-17 15:18 **Analysis:** Nonlinear Regression **Official Results:** Yes

Mean Length-mm Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Reference Sed	4	121.4	92	138	10.1	20.2	16.64%	0.0%
0.34		3	164.9	133.5	191.3	16.86	29.21	17.71%	-35.87%
0.56		4	170.4	142.5	202	13.93	27.86	16.35%	-40.37%
0.93		4	129.5	70	194.5	25.68	51.37	39.67%	-6.69%
1.6		4	121.8	39.8	185.7	31.59	63.18	51.86%	-0.37%
2.6		4	134.5	105	153.5	11.5	23	17.1%	-10.81%
4.3		3	96.17	90	101.5	3.346	5.795	6.03%	20.77%
7.2		2	27.75	22.5	33	5.25	7.425	26.76%	77.14%

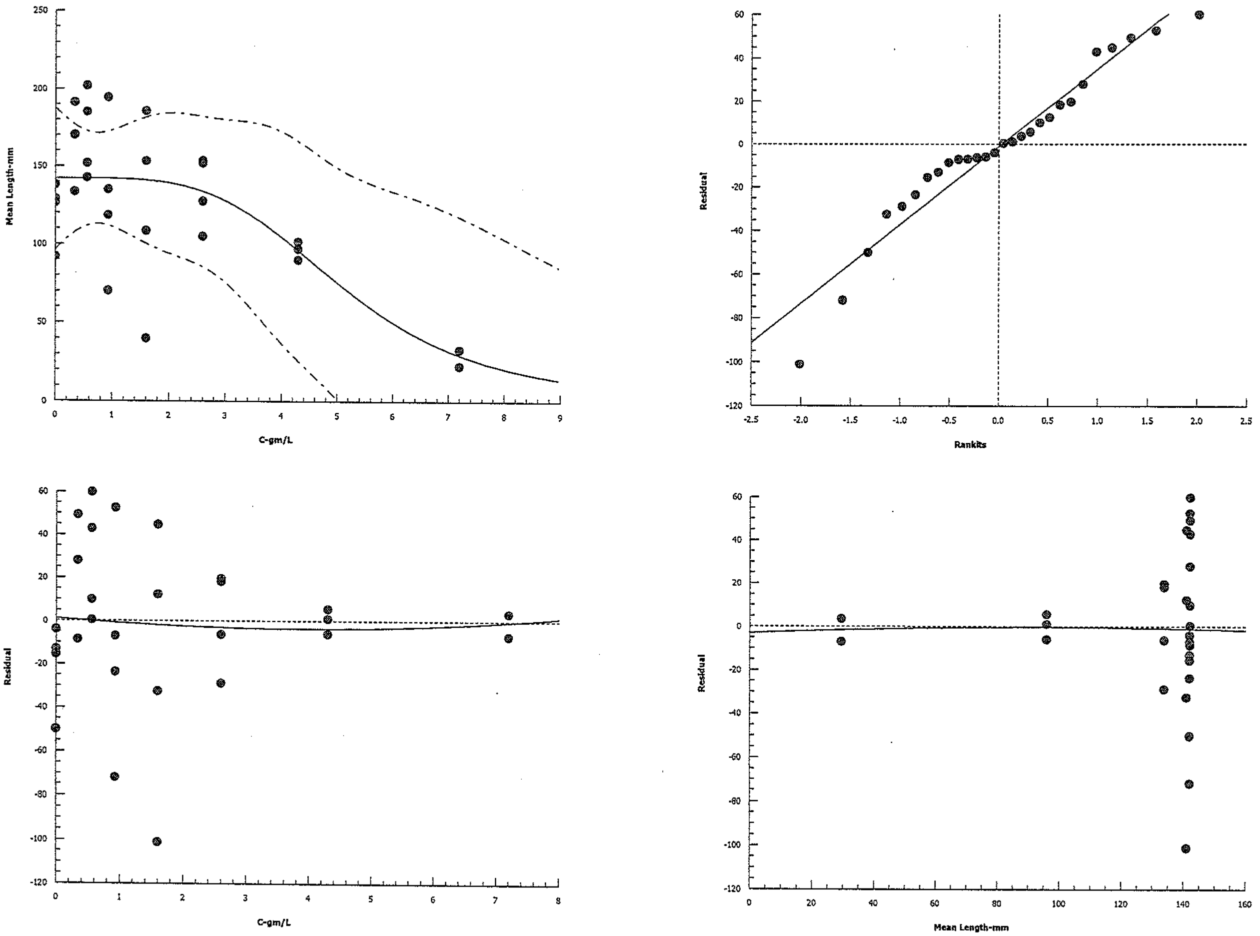
Mean Length-mm Detail

* Reference sed = control peat moss

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	129	138	92	126.5
0.34		191.3	133.5	170	
0.56		202	152	142.5	185
0.93		194.5	70	118.5	135
1.6		153.3	108.5	39.8	185.7
2.6		127.5	153.5	152	105
4.3		90	101.5	97	
7.2		33	22.5		

Graphics

4P Log-Logistic+Hormesis EV [Y=A(1+EX)/(1+(2ED+1)(X/D)^C)]



Dec 5/17

Analyst: JW QA:

CETIS Analytical Report

Report Date: 04 Dec-17 15:20 (p 1 of 2)
Test Code: 170518-R | 02-6853-3928

JW ~~Eisenia 28-d Survival and Growth~~ Soil Test 28-d

Nautilus Environmental

Analysis ID: 06-1519-5454
Analyzed: 04 Dec-17 15:18
Endpoint: Mean Dry Weight-mg (Root)
Analysis: Linear Interpolation (ICPIN)
CETIS Version: CETISv1.8.7
Official Results: Yes

Batch ID: 07-5675-8645
Start Date: 04 Aug-17 17:00
Ending Date: 01 Sep-17 16:00
Duration: 27d 23h
Test Type: Survival-Growth
Protocol: EC/EPS 1/RM/56 (2013)
Species: Camalogrostis canadensis
Source: Premier Pacific Seeds Ltd.
Analyst:
Diluent: Dechlorinated Tap Water
Brine:
Age:

Sample ID: 20-9960-3271
Sample Date: 04 Aug-17
Receive Date: 04 Aug-17
Sample Age: 17h
Code: 7D256747
Material: Sodium chloride
Source: Hemmera
Station: Control Soil
Client: Hemmera
Project:

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	800626	200	Yes	Two-Point Interpolation

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	0.7132	0.4772	2.784
IC10	0.8814	0.38	2.815
IC15	1.692	N/A	2.19
IC20	1.824	N/A	2.295
IC25	1.962	N/A	2.402
IC40	2.418	N/A	3.066
IC50	2.85	0.07107	3.68

Mean Dry Weight-mg Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Reference Sed	4	21.99	3.617	43.67	9.238	18.48	84.0%	0.0%
0.34		3	65.01	55.88	72.67	4.903	8.492	13.06%	-195.6%
0.56		4	80.97	72.35	87.57	3.521	7.042	8.7%	-268.1%
0.93		4	49.27	3.6	77.09	15.86	31.72	64.39%	-124.0%
1.6		4	49.99	6.84	76.35	15.18	30.36	60.73%	-127.3%
2.6		4	30.54	26.24	34.48	1.902	3.804	12.45%	-38.88%
4.3		3	15.83	13.15	20.23	2.215	3.837	24.23%	28.01%
7.2		2	0.75	0.4	1.1	0.35	0.4949	65.99%	96.59%

Mean Dry Weight-mg Detail

* Reference sed = control peat moss

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	43.67	10.08	3.617	30.61
0.34		55.88	72.67	66.48	
0.56		78.18	85.77	72.35	87.57
0.93		58.67	3.6	57.71	77.09
1.6		76.35	6.84	52.6	64.16
2.6		28.57	34.48	32.89	26.24
4.3		13.15	20.23	14.13	
7.2		1.1	0.4		

Dec 5/17

Analyst: JW QA:

CETIS Analytical Report

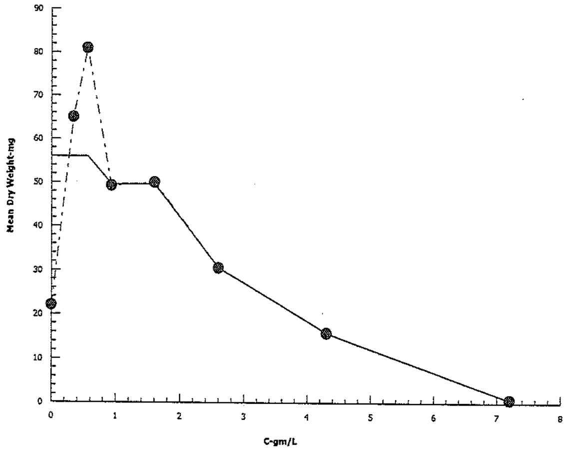
Report Date: 04 Dec-17 15:20 (p 2 of 2)
Test Code: 170518-R | 02-6853-3928

JW ~~Eisenia 28-d Survival and Growth~~ Soil Test 28-d

Nautilus Environmental

Analysis ID: 06-1519-5454
Analyzed: 04 Dec-17 15:18
Endpoint: Mean Dry Weight-mg (Root)
Analysis: Linear Interpolation (ICPIN)
CETIS Version: CETISv1.8.7
Official Results: Yes

Graphics



Analyst: JN QA:

Dec 5/17

CETIS Analytical Report

JW

Report Date: 04 Dec-17 15:33 (p 1 of 2)
Test Code: 170518-R1 | 09-0294-4963

~~Eisenia 28-d Survival and Growth~~ Soil Test 28-d

Nautilus Environmental

Analysis ID:	02-1502-0882	**Endpoint:**	Mean Dry Weight-mg (Root)	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 15:33	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	07-5675-8645	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	04 Aug-17 17:00	**Protocol:**	EC/EPS 1/RM/56 (2013)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	01 Sep-17 16:00	**Species:**	Camalogrostis canadensis	**Brine:**	
Duration:	27d 23h	**Source:**	Premier Pacific Seeds Ltd.	**Age:**	

Sample ID:	02-3778-0929	**Code:**	E2C3FC1	**Client:**	Hemmera
Sample Date:	04 Aug-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	04 Aug-17	**Source:**	Hemmera		
Sample Age:	17h	**Station:**	Control Soil		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1334585	200	Yes	Two-Point Interpolation

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	2.857	N/A	3.021
IC10	3.133	N/A	4.776
IC15	3.429	N/A	5.032
IC20	3.745	N/A	5.064
IC25	4.085	N/A	5.088
IC40	4.72	N/A	5.426
IC50	5.096	N/A	5.72

Mean Dry Weight-mg Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Reference Sed	4	21.99	3.617	43.67	9.238	18.48	84.0%	0.0%
0.34		4	21.99	3.617	43.67	9.238	18.48	84.0%	0.0%
0.56		4	21.99	3.617	43.67	9.238	18.48	84.0%	0.0%
0.93		4	21.99	3.617	43.67	9.238	18.48	84.0%	0.0%
1.6		4	21.99	3.617	43.67	9.238	18.48	84.0%	0.0%
2.6		4	21.99	3.617	43.67	9.238	18.48	84.0%	0.0%
4.3		3	15.83	13.15	20.23	2.215	3.837	24.23%	28.01%
7.2		2	0.75	0.4	1.1	0.35	0.4949	65.99%	96.59%

Mean Dry Weight-mg Detail

* Reference sed = control peat moss

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Reference Sed	43.67	10.08	3.617	30.61
0.34		43.67	10.08	3.617	30.61
0.56		43.67	10.08	3.617	30.61
0.93		43.67	10.08	3.617	30.61
1.6		43.67	10.08	3.617	30.61
2.6		43.67	10.08	3.617	30.61
4.3		13.15	20.23	14.13	
7.2		1.1	0.4		

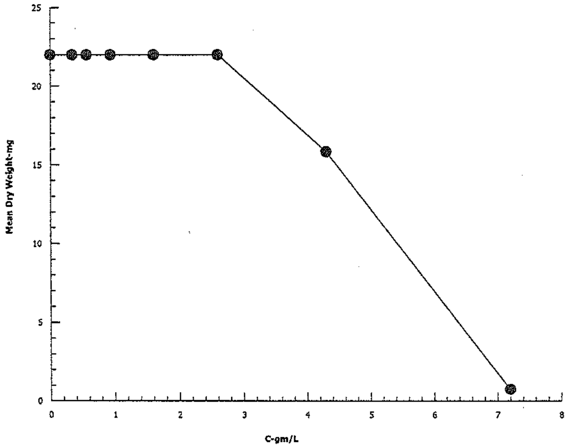
Dec 5/17

~~Eisenia 28-d Survival and Growth~~ Soil Test 28-d

Nautilus Environmental

Analysis ID: 02-1502-0882
Analyzed: 04 Dec-17 15:33
Endpoint: Mean Dry Weight-mg (Root)
Analysis: Linear Interpolation (ICPIN)
CETIS Version: CETISv1.8.7
Official Results: Yes

Graphics



Analyst: JW

QA: Dec 5/17

Fontinalis antipyretica Summary Sheet

Client: Hemmera
Work Order No.: 170521
Start Date: 29-Jun-17
Set up by: JW/MLT

Sample Information:

Sample ID: NaCl - made in-house
Sample Date: 29-Jun-17
Date Received: 29-Jun-17
Sample Volume: n/a

Reference Toxicant Results:

Reference Toxicant ID: FA01
Stock Solution ID: 17SO01
Date Initiated: 29-Jun-17
Length 21-d EC50 (95% CL): 1012 (781.4 - 1492) mg/L SO4
Dry Wt 21-d EC50 (95% CL): >1600 mg/L SO4

EC50 Reference Toxicant Mean (Acceptable Range) : n/a*
CV (%): n/a*

* : Insufficient data points to calculate a reference toxicant historical mean, range and CV

Test Results:

g/L NaCl	IC25 (95% CL)	IC50 (95% CL)
Dry weight (mg)	2.5 (2.0 - 2.6)	>20
Chlorophyll a	1.0 (0.9 - 1.2)	1.5 (1.4 - 1.6)
Length (mm)	0.7 (0.5 - 0.9)	1.2 (1.0 - 1.5)

Reviewed by:

Date reviewed: Dec 6, 2017

Aquatic Moss Fresh Water Toxicity Test
Water Quality Measurements

Client: m JW Hemerra
Sample ID: Sodium Chloride
Work Order #: 170521

Start Date & Time: June 29/17 @ 1500h
Stop Date & Time: July 20/17 @ 1400h
Test Species: *Fontinalis antipyretica*

g/L NaCl Concentration control	Days													
	0	5		10		15		20		Final				
	init.	new	old	new	old	new	old	new	old	~~new~~	old	new	old	new
Temperature (°C)	14.5	15.0	16.0	15.0	16.0	15.0	~~15.0~~ ① MLT	16.0	16.0	16.0				
DO (mg/L)	10.2	9.9	9.4	10.0	9.7	9.9	9.7	10.0	9.6	9.5				
pH	7.2	7.4	7.4	7.2	7.3	7.2	7.2	7.3	7.1	7.4				
Cond. (µS/cm)	41	43		41		42		49		43				
Initials	JW	MLT		YYL		MLT		MLT		MLT				

Concentration 0.34	Days													
	0	5		10		15		20		Final				
	init.	new	old	new	old	new	old	new	old	~~new~~	old	new	old	new
Temperature (°C)	15.0	15.0	16.0	15.5	16.0	15.0	~~15.0~~ ① MLT	15.0	16.0	16.0				
DO (mg/L)	10.2	9.9	9.4	9.9	9.7	9.8	9.7	10.1	9.7	9.5				
pH	7.3	7.3	7.3	7.3	7.2	7.2	7.2	7.3	7.2	7.4				
Cond. (µS/cm)	765	773		730		744		744		738				
Initials	JW	MLT		YYL		MLT		MLT		MLT				

Concentration 0.56	Days													
	0	5		10		15		20		Final				
	init.	new	old	new	old	new	old	new	old	~~new~~	old	new	old	new
Temperature (°C)	15.0	15.0	~~21~~ MLT 16.0	15.5	16.0	15.0	~~15.0~~ ① MLT	15.0	16.0	16.0				
DO (mg/L)	10.2	9.9	9.4	9.8	9.8	9.8	9.6	10.1	9.8	9.5				
pH	7.2	7.3	7.3	7.3	7.2	7.2	7.3	7.4	7.2	7.4				
Cond. (µS/cm)	1208	1202		1161		1182		1160 ~~1150~~ MLT		1161				
Initials	JW	MLT		YYL		MLT		MLT		MLT				

Concentration 0.93	Days													
	0	5		10		15		20		Final				
	init.	new	old	new	old	new	old	new	old	~~new~~	old	new	old	new
Temperature (°C)	15.0	15.0	16.0	15.5	16.0	15.0	16.0	15.0	16.0	16.0				
DO (mg/L)	10.2	9.9	9.3	9.8	9.6	9.8	9.7	10.1	9.8	9.5				
pH	7.2	7.3	7.3	7.3	7.3	7.2	7.3	7.3	7.2	7.4				
Cond. (µS/cm)	1917	1923		1888		1901		1884		1893				
Initials	JW	MLT		YYL		MLT		MLT		MLT				

① 16.0

DO meter: 1
pH meter: 1
Conductivity meter: 2

	Control			
Hardness*	17			
Alkalinity*	15			

* mg/L as CaCO3

Analysts: JW, MLT, YYL
Reviewed by:
Date reviewed: Oct 18, 2017

Sample Description: Stock solution : 17Na02. Thermometer : CER #2. Light meter : Lit - 1

Comments: Light intensity = 1500 - 2000 lux

Aquatic Moss Fresh Water Toxicity Test
Water Quality Measurements

Client: Hemmera JW
Sample ID: Sodium chloride
Work Order #: 170521
Start Date & Time: June 29/17 @ 1500h
Stop Date & Time: July 20/17 @ 1400h
Test Species: *Fontinalis antipyretica*

g/L NaCl Concentration 1.6	Days													
	0	5		10		15		20		Final				
	init.	new	old	new	old	new	old	new	old	~~new~~	old	new	old	new
Temperature (°C)	15.0	15.0	16.0	15.5	16.0	15.0	16.0	15.0	16.0	16.0				
DO (mg/L)	10.2	9.9	9.3	10.0	9.7	9.8	9.6	10.1	9.8	9.5				
pH	7.2	7.3	7.3	7.3	7.2	7.2	7.2	7.3	7.2	7.3				
Cond. (µS/cm)	3230	3180		3190		3130		3170		3150				
Initials	JW	MLT		YML		MLT		MLT		MLT				

Concentration 2.6	Days													
	0	5		10		15		20		Final				
	init.	new	old	new	old	new	old	new	old	~~new~~	old	new	old	new
Temperature (°C)	15.0	15.0	16.0	15.5	16.0	15.0	16.0	15.0	16.0	16.0				
DO (mg/L)	10.2	9.9	9.1	9.9	9.7	9.8	9.6	10.1	9.8	9.5				
pH	7.1	7.2	7.2	7.2	7.1	7.2	7.2	7.3	7.2	7.3				
Cond. (µS/cm)	5120	4980		5000		4940		4970		4930				
Initials	JW	MLT		YML		MLT		MLT		MLT				

Concentration 4.3	Days													
	0	5		10		15		20		Final				
	init.	new	old	new	old	new	old	new	old	~~new~~	old	new	old	new
Temperature (°C)	15.0	15.0	16.0	15.5	16.0	15.0	16.0	15.0	16.0	16.0				
DO (mg/L)	10.2	9.9	8.7	9.9	9.8	9.8	9.7	10.1	9.8	9.5				
pH	7.1	7.2	7.0	7.2	7.0	7.1	7.1	7.2	7.2	7.3				
Cond. (µS/cm)	7880	7640		7810		8030		7920		7890				
Initials	JW	MLT		YML		MLT		MLT		MLT				

Concentration 7.2	Days													
	0	5		10		15		20		Final				
	init.	new	old	new	old	new	old	new	old	~~new~~	old	new	old	new
Temperature (°C)	15.0	15.0	16.0	15.5	16.0	15.0	16.0	15.0	16.0	16.0				
DO (mg/L)	10.2	9.9	8.5	9.8	9.7	9.8	9.6	10.1	9.8	9.5				
pH	7.0	7.1	7.0	7.1	6.9	7.0	7.0	7.2	7.1	7.2				
Cond. (µS/cm)	12710	12740		12770		12830		12680		12640				
Initials	JW	MLT		YML		MLT		MLT		MLT				

DO meter: 1
pH meter: 1
Conductivity meter: 2

	Control			
Hardness*	17			
Alkalinity*	15			

* mg/L as CaCO3

Analysts: JW, MLT, YML

Reviewed by:

Date reviewed: Oct-18, 2017

Sample Description:

Comments:

Aquatic Moss Fresh Water Toxicity Test
Water Quality Measurements

Client: m JW
Heme~~y~~ra

Sample ID: Sodium chloride

Work Order #: 170521

Start Date & Time: June 29/17 @ 1500h

Stop Date & Time: July 20/17 @ 1400h

Test Species: *Fontinalis antipyretica*

g/L NaCl Concentration 12	Days													
	0	5		10		15		20		Final				
	init.	new	old	new	old	new	old	new	old	~~new~~	old	new	old	new
Temperature (°C)	15.0	15.0	16.0	15.5	16.0	15.0	16.0	15.0	16.0	16.0				
DO (mg/L)	10.2	9.9	8.5	9.8	9.6	9.8	9.6	10.1	9.8	9.6				
pH	7.0	7.1	6.8	7.0	6.8	7.0	6.9	7.1	7.0	7.0				
Cond. (µS/cm)	20600	20500		20600		20500		20500		20400				
Initials	JW	MLT		YYL		MLT		MLT		MLT				

Concentration 20	Days													
	0	5		10		15		20		Final				
	init.	new	old	new	old	new	old	new	old	~~new~~	old	new	old	new
Temperature (°C)	15.0	15.0	16.0	15.5	16.0	15.0	16.0	15.0	16.0	16.0				
DO (mg/L)	10.2	9.9	8.4	9.8	9.7	9.8	9.6	10.1	9.6	9.6				
pH	6.9	7.0	6.7	6.9	6.7	6.9	6.7	7.0	6.9	7.0				
Cond. (µS/cm)	32400	32900		33000		32600		32700		32400				
Initials	JW	MLT		YYL		MLT		MLT		MLT				

Concentration	Days													
	0													
	init.	new	old	new	old	new	old	new	old	new	old	new	old	new
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Concentration	Days													
	0													
	init.	new	old	new	old	new	old	new	old	new	old	new	old	new
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

DO meter: 1 **pH meter:** 1 **Conductivity meter:** 2

	Control			
Hardness*	17			
Alkalinity*	15			

* mg/L as CaCO3

Analysts: JW, MLT, YYL

Reviewed by:

Date reviewed: Oct. 18, 2017

Sample Description:

Comments:

Moss Toxicity Test Data Sheet - Length Measurements

Client: Hemmera
Work Order #: 170521
Sample ID: NaCl

Start Date: June 29 / 17
Termination Date: July 20 / 17
Test set up by: JW

Concentration g/L NaCl	Rep	Plant #	Length (cm)	Chlorosis	Necrosis	Yellow	Comments	Initials
Control	A	1	22					JW
		2	24					
		3	23					
		4	K ~~27~~ 21					
		5	22					
		6	21					
		7	22					
		8	21					
		9	22					
		10	23					
	B	1	23					
		2	22					
		3	22					
		4	22					
		5	24					
		6	23					
		7	25					
		8	21					
		9	23					
		10	22					
	C	1	25					
		2	24					
		3	23					
		4	24					
		5	21					
		6	23					
		7	22					
		8	25					
		9	23					
		10	23					

Comments:

Reviewed by:

Date Reviewed: Oct. 18, 2017

Moss Toxicity Test Data Sheet - Length Measurements

Client: Hemmera
Work Order #: 170521
Sample ID: NaCl

Start Date: June 29 / 17
Termination Date: July 20 / 17
Test set up by: JW

Concentration g/L NaCl	Rep	Plant #	Length (cm)	Chlorosis	Necrosis	Yellow	Comments	Initials
0.34	A	1	22					JW
		2	24					
		3	24					
		4	22					
		5	24					
		6	22					
		7	22					
		8	22					
		9	21					
		10	23					
	B	1	23					
		2	23					
		3	h ~~23~~ 22					
		4	22					
		5	25					
		6	23					
		7	24					
		8	22					
		9	23					
		10	23					
	C	1	22					
		2	23					
		3	22					
		4	h ~~20~~ 22					
		5	24					
		6	22					
		7	22					
		8	22					
		9	23					
		10	23					

Comments:

Reviewed by:

Date Reviewed: Oct - 18, 2017

Moss Toxicity Test Data Sheet - Length Measurements

Client: Hemmera
Work Order #: 170521
Sample ID: NaCl

Start Date: June 29 / 17
Termination Date: July 20 / 17
Test set up by: JW

Concentration g/L NaCl	Rep	Plant #	Length (cm)	Chlorosis	Necrosis	Yellow	Comments	Initials
0.56	A	1	25					JW
		2	24					
		3	23					
		4	23					
		5	23					
		6	24					
		7	21					
		8	22					
		9	25					
		10	22					
	B	1	k ~~24~~ 22					
		2	~~23~~ 21					
		3	~~22~~ 22					
		4	~~23~~ 23					
		5	~~23~~ 22					
		6	~~22~~ 23					
		7	~~22~~ 23					
		8	~~22~~ 21					
		9	~~20~~ 21					
		10	20					
	C	1	24					
		2	24					
		3	21					
		4	22					
		5	23					
		6	22					
		7	20					
		8	20					
		9	k ~~20~~ 22					
		10	23					

Comments:

Reviewed by:

Date Reviewed: Oct - 18, 2017

Moss Toxicity Test Data Sheet - Length Measurements

Client: Hemmera
Work Order #: 170521
Sample ID: NaCl

Start Date: June 29 / 17
Termination Date: July 20 / 17
Test set up by: JW

Concentration g/L NaCl	Rep	Plant #	Length (cm)	Chlorosis	Necrosis	Yellow	Comments	Initials
0.93	A	1	22					JW
		2	22					
		3	20					
		4	22					
		5	21					
		6	22					
		7	22					
		8	23					
		9	21					
		10	22					
	B	1	22					
		2	23					
		3	22					
		4	20					
		5	23					
		6	25					
		7	22					
		8	20					
		9	21					
		10	21					
	C	1	21					
		2	21					
		3	21					
		4	24					
		5	22					
		6	20					
		7	23					
		8	21					
		9	21					
		10	22	✓				

Comments:

Reviewed by:

Date Reviewed: Oct-18, 2017

Moss Toxicity Test Data Sheet - Length Measurements

Client: Hemmera
Work Order #: 170521
Sample ID: NaCl

Start Date: June 29 / 17
Termination Date: July 20 / 17
Test set up by: JW

Concentration g/L NaCl	Rep	Plant #	Length (cm)	Chlorosis	Necrosis	Yellow	Comments	Initials
1.6	A	1	21	✓				JW
		2	~~22~~ 21					
		3	20					
		4	21	✓				
		5	20	✓				
		6	21	✓	✓			
		7	21	✓	✓			
		8	20	✓				
		9	20	✓				
		10	23	✓				
	B	1	22					
		2	22					
		3	21					
		4	22	✓				
		5	21	✓				
		6	22	✓				
		7	21	✓				
		8	20	✓	✓			
		9	21	✓				
		10	20	✓	✓			
	C	1	22	✓				
		2	20					
		3	23					
		4	23					
		5	21	✓				
		6	20	✓				
		7	21	✓	✓			
		8	20	✓				
		9	22	✓	✓			
		10	20	✓	✓			

Comments:

Reviewed by:

Date Reviewed: Oct. 18, 2017

Moss Toxicity Test Data Sheet - Length Measurements

Client: Hemmera
Work Order #: 170521
Sample ID: NaCl

Start Date: June 29 / 17
Termination Date: July 20 / 17
Test set up by: JW

Concentration g/L NaCl	Rep	Plant #	Length (cm)	Chlorosis	Necrosis	Yellow	Comments	Initials
2.6	A	1	20	✓	✓			JW
		2	21	✓	✓			
		3	20	✓	✓			
		4	21	✓	✓			
		5	k ~~20~~ 21	✓	✓			
		6	19	✓	✓			
		7	20	✓				
		8	20	✓	✓			
		9	20	✓	✓			
		10	k ~~20~~ 21	✓	✓			
	B	1	20	✓	✓			
		2	~~2~~ k 18	✓	✓			
		3	21	✓	✓			
		4	22	✓	✓			
		5	20	✓	✓			
		6	18	✓	✓			
		7	21	✓	✓			
		8	20	✓	✓			
		9	20	✓	✓			
		10	20	✓	✓			
	C	1	20	✓	✓			
		2	21	✓	✓			
		3	20	✓	✓			
		4	21	✓	✓			
		5	20	✓	✓			
		6	20	✓				
		7	20	✓	✓			
		8	21	✓				
		9	21	✓	✓			
		10	20	✓	✓			

Comments:

Reviewed by:

Date Reviewed: Oct-18, 2017

Moss Toxicity Test Data Sheet - Length Measurements

Client: Hemmera
Work Order #: 170521
Sample ID: NaCl

Start Date: June 29 / 17
Termination Date: July 20 / 17
Test set up by: JW

Concentration g/L NaCl	Rep	Plant #	Length (cm)	Chlorosis	Necrosis	Yellow	Comments	Initials
4.3	A	1	21	✓	✓			JW
		2	22	✓				
		3	21	✓	✓			
		4	20	✓	✓			
		5	20	✓	✓			
		6	20	✓	✓			
		7	20	✓	✓			
		8	22	✓	✓			
		9	20	✓	✓			
		10	20	✓	✓			
	B	1	20	✓	✓			
		2	20	✓	✓			
		3	k ~~20~~ 22	✓	✓			
		4	17	✓	✓			
		5	21	✓	✓			
		6	20	✓	✓			
		7	20	✓	✓			
		8	20	✓	✓			
		9	20	✓	✓			
		10	20	✓	✓			
	C	1	22	✓	✓			
		2	21	✓	✓			
		3	20	✓	✓			
		4	20	✓	✓			
		5	20	✓	✓			
		6	20	✓	✓			
		7	20	✓	✓			
		8	20	✓	✓			
		9	22	✓	✓			
		10	20	✓	✓			

Comments:

Reviewed by:

Date Reviewed: Oct. 18, 2017

Moss Toxicity Test Data Sheet - Length Measurements

Client: Hemmera
Work Order #: 170521
Sample ID: NaCl

Start Date: June 29 / 17
Termination Date: July 20 / 17
Test set up by: JW

Concentration g/L NaCl	Rep	Plant #	Length (cm)	Chlorosis	Necrosis	Yellow	Comments	Initials
7.2	A	1	20		✓			JW
		2	20		✓			
		3	~~2~~ JW 17		✓			
		4	20		✓			
		5	20		✓			
		6	20		✓			
		7	20		✓			
		8	20		✓			
		9	20		✓			
		10	15		✓			
	B	1	22		✓			
		2	20		✓			
		3	23		✓			
		4	20		✓			
		5	20		✓			
		6	20		✓			
		7	21		✓			
		8	20		✓			
		9	20		✓			
		10	21		✓			
	C	1	21		✓			
		2	20		✓			
		3	22		✓			
		4	17		✓			
		5	20		✓			
		6	20		✓			
		7	20		✓			
		8	20		✓			
		9	20		✓			
		10	20		✓			

Comments:

Reviewed by:

Date Reviewed: Oct. 18, 2017

Moss Toxicity Test Data Sheet - Length Measurements

Client: Hemmera
Work Order #: 170521
Sample ID: NaCl

Start Date: June 29 / 17
Termination Date: July 20 / 17
Test set up by: JW

Concentration g/L NaCl	Rep	Plant #	Length (cm)	Chlorosis	Necrosis	Yellow	Comments	Initials
12	A	1	20		✓			JW
		2	21		✓			
		3	17		✓			
		4	21		✓			
		5	20		✓			
		6	20		✓			
		7	20		✓			
		8	20		✓			
		9	20		✓			
		10	21		✓			
	B	1	21		✓			
		2	21		✓			
		3	21		✓			
		4	20		✓			
		5	21		✓			
		6	20		✓			
		7	20		✓			
		8	20		✓			
		9	20		✓			
		10	20		✓			
	C	1	20		✓			
		2	20		✓			
		3	20		✓			
		4	20		✓			
		5	20		✓			
		6	22		✓			
		7	17		✓			
		8	21		✓			
		9	20		✓			
		10	20		✓			↓

Comments:

Reviewed by:

Date Reviewed: Oct-18, 2017

Moss Toxicity Test Data Sheet - Length Measurements

Client: Hemmera
Work Order #: 170521
Sample ID: NaCl

Start Date: June 29/17
Termination Date: July 20/17
Test set up by: JW

Concentration g/L NaCl	Rep	Plant #	Length (cm)	Chlorosis	Necrosis	Yellow	Comments	Initials
20	A	1	20		✓			JW
		2	21		✓			
		3	20		✓			
		4	20		✓			
		5	21		✓			
		6	19		✓			
		7	20		✓			
		8	20		✓			
		9	20		✓			
		10	20		✓			
	B	1	18		✓			
		2	20		✓			
		3	20		✓			
		4	20		✓			
		5	20		✓			
		6	21		✓			
		7	20		✓			
		8	21		✓			
		9	20		✓			
		10	20		✓			
	C	1	20		✓			
		2	20		✓			
		3	21		✓			
		4	20		✓			
		5	20		✓			
		6	20		✓			
		7	20		✓			
		8	20		✓			
		9	20		✓			
		10	21		✓			

Comments:

Reviewed by:

Date Reviewed: Oct. 18, 2017

21-d Moss Dry Weight Data Sheet

Client: Hemmera

Sample ID: NaCl

Work Order No.: 170521

Start Date: June 29 / 17

Termination Date: July 20 / 17

g/L NaCl

Concentration	Rep	Pan No. MT	Pan weight (mg)	Pan + moss (mg)	No. of moss tips	Initials
Control	A	1	1026.81	1040.98	10	JW/JW
	B	2	1027.77	1042.28	10	
	C	3	1026.60	1042.00	10	
0.34	A	4	1031.50	1046.94	10	
	B	5	1005.23	1020.31	10	
	C	6	1000.30	1015.25	10	
0.56	A	7	1014.88	1030.25	10	
	B	8	1002.83	1018.06	10	
	C	9	1013.17	1027.17	10	
0.93	A	10	1027.74	1041.65	10	
	B	11	1011.50	1026.23	10	
	C	12	1021.30	1036.07	10	
1.6	A	13	1020.72	1033.03	10	
	B	14	1033.95	1049.50	10	
	C	15	1009.45	1024.11	10	
2.6	A	16	1026.05	1036.94	10	
	B	17	1021.62	1032.43	10	
	C	18	999.60	1010.30	10	
4.3	A	19	1013.21	1023.35	10	
	B	20	1022.71	1032.18	10	
	C	21	1023.51	1033.70	10	

Comments: 10% re-weigh: #1: 1041.00mg, #13: 1032.81mg, #21: 1033.57mg.

Reviewed by:

Date Reviewed: Oct. 18, 2017

21-d Moss Dry Weight Data Sheet

Client: Hemmera
Sample ID: NaCl
Work Order No.: 170521

Start Date: June 29 /17
Termination Date: July 20 / 17

g/L NaCl

Concentration	Rep	Pan No. MT	Pan weight (mg)	Pan + moss (mg)	No. of moss tips	Initials
~~Control~~ JW 7.2	A	22	1019.49	1027.96	10	JW/ JW
	B	23	1023.68	1033.47	10	
	C	24	1017.28	1026.81	10	
12	A	25	1027.23	1036.81	10	
	B	26	1025.32	1035.11	10	
	C	27	1028.84	1038.87	10	
20	A	28	1009.56	1019.54	10	
	B	29	1037.89	1047.62	10	
	C	30	1044.15	1054.42	10	
	A					
	B					
	C					
	A					
	B					
	C					
	A					
	B					
	C					
	A					
	B					
	C					

Comments: 10% re-weigh: #30: 1054.19 mg

Reviewed by:

Date Reviewed: Oct 18, 2017

Nominal	Day 0 Analytical				**Average Analytical Values**	
NaCl (g)	Cl (mg)	Na (mg)	NaCl (mg)	NaCl (g)	**NaCl (g)**	**Cl (g)**
0	2.38	1.77	4.15	0.00415	**0.004**	**0.00**
0.34	226	149	375	0.375	**0.379**	**0.22**
0.56	361	240	601	0.601	**0.594**	**0.35**
0.93	588	389	977	0.977	**0.975**	**0.58**
1.6	981	675	1656	1.656	**1.667**	**1.01**
2.6	1650	1050	2700	2.7	**2.783**	**1.68**
4.3	2750	1620	4370	4.37	**4.513**	**2.79**
7.2	4380	2760	7140	7.14	**7.280**	**4.47**
12	7450	4680	12130	12.13	**12.267**	**7.51**
20	12200	7830	20030	20.03	**20.033**	**12.20**

Nominal	Day 10 Analytical			
NaCl (g)	Cl (mg)	Na (mg)	NaCl (mg)	NaCl (g)
0	2.27	1.46	3.73	0.00373
0.34	234	152	386	0.386
0.56	347	234	581	0.581
0.93	588	382	970	0.97
1.6	1030	660	1690	1.69
2.6	1810	1140	2950	2.95
4.3	2980	1820	4800	4.8
7.2	4720	2840	7560	7.56
12	8050	4490	12540	12.54
20	12100	7940	20040	20.04

Nominal	Day 21 Analytical			
NaCl (g)	Cl (mg)	Na (mg)	NaCl (mg)	NaCl (g)
0	2.48	1.86	4.15	0.00415
0.34	210	137	375	0.375
0.56	340	221	601	0.601
0.93	575	369	977	0.977
1.6	1010	642	1656	1.656
2.6	1580	1010	2700	2.7
4.3	2650	1690	4370	4.37
7.2	4320	2530	7140	7.14
12	7030	4760	12130	12.13
20	12300	7730	20030	20.03

Oct. 18, 2017

Concentrations (g/L NaCl)	Rep	Plant #	Initial Length (mm)	Length (mm)	Growth (mm)	Mean growth (mm)
Control	A	1	20	22	2	2.1
		2	20	24	4	
		3	20	23	3	
		4	20	21	1	
		5	20	22	2	
		6	20	21	1	
		7	20	22	2	
		8	20	21	1	
		9	20	22	2	
		10	20	23	3	
	B	1	20	23	3	2.7
		2	20	22	2	
		3	20	22	2	
		4	20	22	2	
		5	20	24	4	
		6	20	23	3	
		7	20	25	5	
		8	20	21	1	
		9	20	23	3	
		10	20	22	2	
	C	1	20	25	5	3.3
		2	20	24	4	
		3	20	23	3	
		4	20	24	4	
		5	20	21	1	
		6	20	23	3	
		7	20	22	2	
		8	20	25	5	
		9	20	23	3	
		10	20	23	3	
0.34	A	1	20	22	2	2.6
		2	20	24	4	
		3	20	24	4	
		4	20	22	2	
		5	20	24	4	
		6	20	22	2	
		7	20	22	2	
		8	20	22	2	
		9	20	21	1	
		10	20	23	3	
	B	1	20	23	3	3
		2	20	23	3	
		3	20	22	2	
		4	20	22	2	
		5	20	25	5	
		6	20	23	3	
		7	20	24	4	
		8	20	22	2	
		9	20	23	3	
		10	20	23	3	
	C	1	20	22	2	2.5
		2	20	23	3	
		3	20	22	2	
		4	20	22	2	
		5	20	24	4	
		6	20	22	2	
		7	20	22	2	
		8	20	22	2	
		9	20	23	3	
		10	20	23	3	
0.56	A	1	20	25	5	3.2
		2	20	24	4	
		3	20	23	3	
		4	20	23	3	
		5	20	23	3	
		6	20	24	4	
		7	20	21	1	
		8	20	22	2	
		9	20	25	5	
		10	20	22	2	
	B	1	20	22	2	1.8
		2	20	21	1	
		3	20	22	2	
		4	20	23	3	
		5	20	22	2	
		6	20	23	3	
		7	20	23	3	
		8	20	21	1	
		9	20	21	1	
		10	20	20	0	
	C	1	20	24	4	2.1
		2	20	24	4	
		3	20	21	1	
		4	20	22	2	
		5	20	23	3	
		6	20	22	2	
		7	20	20	0	
		8	20	20	0	
		9	20	22	2	
		10	20	23	3	
0.93	A	1	20	22	2	1.7
		2	20	22	2	
		3	20	20	0	
		4	20	22	2	
		5	20	21	1	
		6	20	22	2	
		7	20	22	2	
		8	20	23	3	
		9	20	21	1	
		10	20	22	2	
	B	1	20	22	2	1.9
		2	20	23	3	
		3	20	22	2	
		4	20	20	0	
		5	20	23	3	
		6	20	25	5	
		7	20	22	2	
		8	20	20	0	
		9	20	21	1	
		10	20	21	1	
	C	1	20	21	1	1.6
		2	20	21	1	
		3	20	21	1	
		4	20	24	4	
		5	20	22	2	
		6	20	20	0	
		7	20	23	3	
		8	20	21	1	
		9	20	21	1	
		10	20	22	2	

Dec-5/17

Concentrations (g/L NaCl)	Rep	Plant #	Initial Length (mm)	Length (mm)	Growth (mm)	Mean growth (mm)
1.6	A	1	20	21	1	0.8
		2	20	21	1	
		3	20	20	0	
		4	20	21	1	
		5	20	20	0	
		6	20	21	1	
		7	20	21	1	
		8	20	20	0	
		9	20	20	0	
		10	20	23	3	
	B	1	20	22	2	1.2
		2	20	22	2	
		3	20	21	1	
		4	20	22	2	
		5	20	21	1	
		6	20	22	2	
		7	20	21	1	
		8	20	20	0	
		9	20	21	1	
		10	20	20	0	
	C	1	20	22	2	1.2
		2	20	20	0	
		3	20	23	3	
		4	20	23	3	
		5	20	21	1	
		6	20	20	0	
		7	20	21	1	
		8	20	20	0	
		9	20	22	2	
		10	20	20	0	
2.6	A	1	20	20	0	0.3
		2	20	21	1	
		3	20	20	0	
		4	20	21	1	
		5	20	21	1	
		6	20	19	-1	
		7	20	20	0	
		8	20	20	0	
		9	20	20	0	
		10	20	21	1	
	B	1	20	20	0	0
		2	20	18	-2	
		3	20	21	1	
		4	20	22	2	
		5	20	20	0	
		6	20	18	-2	
		7	20	21	1	
		8	20	20	0	
		9	20	20	0	
		10	20	20	0	
	C	1	20	20	0	0.4
		2	20	21	1	
		3	20	20	0	
		4	20	21	1	
		5	20	20	0	
		6	20	20	0	
		7	20	20	0	
		8	20	21	1	
		9	20	21	1	
		10	20	20	0	

Concentrations (g/L NaCl)	Rep	Plant #	Initial Length (mm)	Length (mm)	Growth (mm)	Mean growth (mm)
4.3	A	1	20	21	1	0.6
		2	20	22	2	
		3	20	21	1	
		4	20	20	0	
		5	20	20	0	
		6	20	20	0	
		7	20	20	0	
		8	20	22	2	
		9	20	20	0	
		10	20	20	0	
	B	1	20	20	0	0
		2	20	20	0	
		3	20	22	2	
		4	20	17	-3	
		5	20	21	1	
		6	20	20	0	
		7	20	20	0	
		8	20	20	0	
		9	20	20	0	
		10	20	20	0	
	C	1	20	22	2	0.5
		2	20	21	1	
		3	20	20	0	
		4	20	20	0	
		5	20	20	0	
		6	20	20	0	
		7	20	20	0	
		8	20	20	0	
		9	20	22	2	
		10	20	20	0	
7.2	A	1	20	20	0	-0.8
		2	20	20	0	
		3	20	17	-3	
		4	20	20	0	
		5	20	20	0	
		6	20	20	0	
		7	20	20	0	
		8	20	20	0	
		9	20	20	0	
		10	20	15	-5	
	B	1	20	22	2	0.7
		2	20	20	0	
		3	20	23	3	
		4	20	20	0	
		5	20	20	0	
		6	20	20	0	
		7	20	21	1	
		8	20	20	0	
		9	20	20	0	
		10	20	21	1	
	C	1	20	21	1	0
		2	20	20	0	
		3	20	22	2	
		4	20	17	-3	
		5	20	20	0	
		6	20	20	0	
		7	20	20	0	
		8	20	20	0	
		9	20	20	0	
		10	20	20	0	

Dee 5/17

Concentrations (g/L NaCl)	Rep	Plant #	Initial Length (mm)	Length (mm)	Growth (mm)	Mean growth (mm)
12	A	1	20	20	0	0
		2	20	21	1	
		3	20	17	-3	
		4	20	21	1	
		5	20	20	0	
		6	20	20	0	
		7	20	20	0	
		8	20	20	0	
		9	20	20	0	
		10	20	21	1	
	B	1	20	21	1	0.4
		2	20	21	1	
		3	20	21	1	
		4	20	20	0	
		5	20	21	1	
		6	20	20	0	
		7	20	20	0	
		8	20	20	0	
		9	20	20	0	
		10	20	20	0	
	C	1	20	20	0	0
		2	20	20	0	
		3	20	20	0	
		4	20	20	0	
		5	20	20	0	
		6	20	22	2	
		7	20	17	-3	
		8	20	21	1	
		9	20	20	0	
		10	20	20	0	
20	A	1	20	20	0	0.1
		2	20	21	1	
		3	20	20	0	
		4	20	20	0	
		5	20	21	1	
		6	20	19	-1	
		7	20	20	0	
		8	20	20	0	
		9	20	20	0	
		10	20	20	0	
	B	1	20	18	-2	0
		2	20	20	0	
		3	20	20	0	
		4	20	20	0	
		5	20	20	0	
		6	20	21	1	
		7	20	20	0	
		8	20	21	1	
		9	20	20	0	
		10	20	20	0	
	C	1	20	20	0	0.2
		2	20	20	0	
		3	20	21	1	
		4	20	20	0	
		5	20	20	0	
		6	20	20	0	
		7	20	20	0	
		8	20	20	0	
		9	20	20	0	
		10	20	21	1	

Dec 5/17

CETIS Analytical Report

Report Date:	04 Dec-17 17:07 (p 1 of 2)
Test Code:	170521a | 20-7341-9798

JW ~~EC Alga Growth Inhibition Test~~ 21-d Moss Toxicity test **Nautilus Environmental**

Analysis ID:	09-0486-5950	**Endpoint:**	Chlorophyll a	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 17:07	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes

Batch ID:	00-9889-1901	**Test Type:**	~~Cell~~ Growth JW	**Analyst:**	Jeslin Wijaya
Start Date:	29 Jun-17	**Protocol:**	Davies (2007)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	20 Jul-17	**Species:**	Fontinalis antipyretica	**Brine:**	
Duration:	21d 0h	**Source:**	University of BC	**Age:**	

Sample ID:	14-3310-0097	**Code:**	556B5F41	**Client:**	Hemmera
Sample Date:	29 Jun-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	29 Jun-17	**Source:**	Hemmera		
Sample Age:	NA	**Station:**	Sodium Chloride		

Non-Linear Regression Options

Model Function	X Transform	Y Transform	Weighting Function	PTBS Function
3P Log-Logistic EV [Y=A/(1+(X/D)^C)]	None	None	Normal [W=1]	Off [Y*=Y]

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
9	-9.73	29.46	26.37	0.9914	Yes				Lack of Fit Not Tested

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	0.5684	0.3032	0.706
IC10	0.7271	0.5695	0.8462
IC15	0.8468	0.7051	0.9655
IC20	0.9498	0.8156	1.07
IC25	1.044	0.9157	1.165
IC40	1.312	1.194	1.434
IC50	1.5	1.38	1.63

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
A	47	1.31	44.43	49.57	35.88	<0.0001	Significant Parameter
C	3.035	0.3834	2.284	3.787	7.916	<0.0001	Significant Parameter
D	1.5	0.07485	1.353	1.646	20.04	<0.0001	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	3803.936	3803.936	1	1034	<0.0001	Significant
Residual	25.75362	3.679089	7			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Distribution	Shapiro-Wilk W Normality	0.9645	0.7607	0.8353	Normal Distribution
	Anderson-Darling A2 Normality	0.2412	2.492	0.8003	Normal Distribution

Chlorophyll a Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	1	44.3	44.3	44.3	0	0	0.0%	0.0%
0.34		1	47.1	47.1	47.1	0	0	0.0%	-6.32%
0.56		1	47.6	47.6	47.6	0	0	0.0%	-7.45%
0.93		1	37.5	37.5	37.5	0	0	0.0%	15.35%
1.6		1	20.6	20.6	20.6	0	0	0.0%	53.5%
2.6		1	7.61	7.61	7.61	0	0	0.0%	82.82%
4.3		1	3.33	3.33	3.33	0	0	0.0%	92.48%
7.2		1	2.58	2.58	2.58	0	0	0.0%	94.18%
12		1	1.45	1.45	1.45	0	0	0.0%	96.73%
20		1	0.669	0.669	0.669	0	0	0.0%	98.49%

Dec-5/17

Analyst: JW QA:

CETIS Analytical Report

Report Date: 04 Dec-17 17:07 (p 2 of 2)
Test Code: 170521a | 20-7341-9798

JW ~~**EC Alga Growth Inhibition Test**~~ 21-d Moss toxicity test

Nautilus Environmental

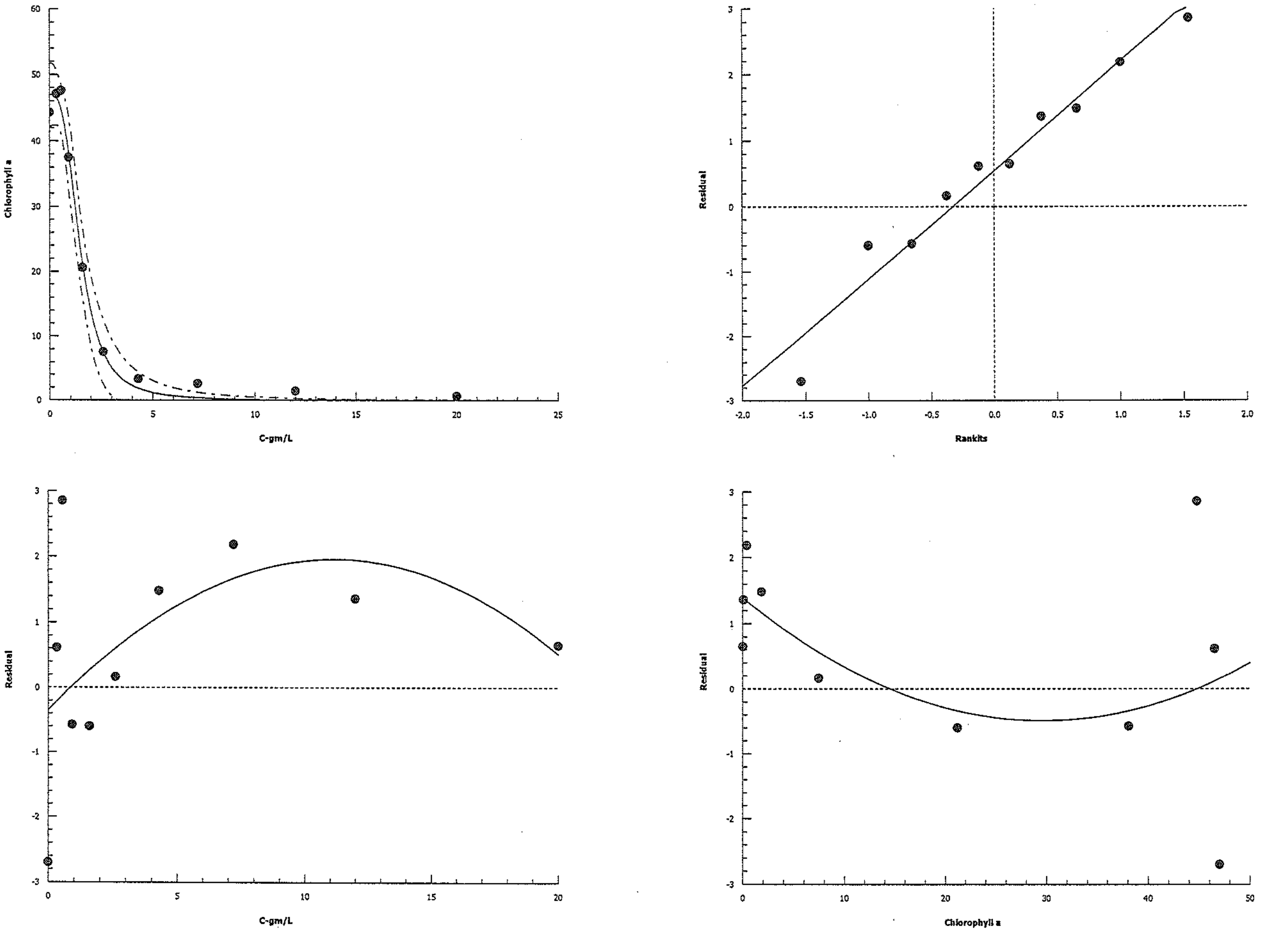
Analysis ID: 09-0486-5950 **Endpoint:** Chlorophyll a **CETIS Version:** CETISv1.8.7
Analyzed: 04 Dec-17 17:07 **Analysis:** Nonlinear Regression **Official Results:** Yes

Chlorophyll a Detail

C-gm/L	Control Type	Rep 1
0	Negative Control	44.3
0.34		47.1
0.56		47.6
0.93		37.5
1.6		20.6
2.6		7.61
4.3		3.33
7.2		2.58
12		1.45
20		0.669

Graphics

3P Log-Logistic EV [Y=A/(1+(X/D)^C)]



Dec.5/17

Analyst: JW QA:

CETIS Analytical Report
JW

Report Date: 04 Dec-17 17:14 (p 1 of 2)
Test Code: 170521c | 21-2194-8059

~~Lemna Growth Inhibition Test~~ 21-d Moss toxicity Test

Nautilus Environmental

Analysis ID: 18-9577-7625
Analyzed: 04 Dec-17 17:13
Endpoint: Total Dry Weight-mg
Analysis: Linear Interpolation (ICPIN)
CETIS Version: CETISv1.8.7
Official Results: Yes

Batch ID: 06-4112-0551
Start Date: 29 Jun-17
Ending Date: 20 Jul-17
Duration: 21d 0h
Test Type: Lemna Growth
Protocol: Davies (2007)
Species: Fontinalis antipyretica
Source: University of BC
Analyst: Jeslin Wijaya
Diluent: Dechlorinated Tap Water
Brine:
Age:

Sample ID: 05-8389-5437
Sample Date: 29 Jun-17
Receive Date: 29 Jun-17
Sample Age: NA
Code: 22CD898D
Material: Sodium chloride
Source: Hemmera
Station: Sodium Chloride
Client: Hemmera
Project:

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	181791	200	Yes	Two-Point Interpolation

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	1.586	N/A	1.948
IC10	1.793	0.5532	2.079
IC15	2.001	0.8674	2.231
IC20	2.225	1.33	2.404
IC25	2.466	2.042	2.594
IC40	>20	N/A	N/A
IC50	>20	N/A	N/A

Total Dry Weight-mg Summary

			Calculated Variate						
C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	3	14.69	14.17	15.4	0.3667	0.6352	4.32%	0.0%
0.34		3	15.16	14.95	15.44	0.1465	0.2538	1.68%	-3.15%
0.56		3	14.87	14	15.37	0.4352	0.7538	5.07%	-1.18%
0.93		3	14.47	13.91	14.77	0.2802	0.4853	3.35%	1.52%
1.6		3	14.17	12.31	15.55	0.9664	1.674	11.81%	3.54%
2.6		3	10.8	10.7	10.89	0.05505	0.09535	0.88%	26.5%
4.3		3	9.933	9.47	10.19	0.2321	0.402	4.05%	32.4%
7.2		3	9.263	8.47	9.79	0.4037	0.6992	7.55%	36.96%
12		3	9.8	9.58	10.03	0.13	0.2251	2.3%	33.3%
20		3	9.993	9.73	10.27	0.156	0.2703	2.71%	31.99%

Total Dry Weight-mg Detail

C-gm/L	Control Type	Rep 1	Rep 2	Rep 3
0	Negative Control	14.17	14.51	15.4
0.34		15.44	15.08	14.95
0.56		15.37	15.23	14
0.93		13.91	14.73	14.77
1.6		12.31	15.55	14.66
2.6		10.89	10.81	10.7
4.3		10.14	9.47	10.19
7.2		8.47	9.79	9.53
12		9.58	9.79	10.03
20		9.98	9.73	10.27

Dec 5/17

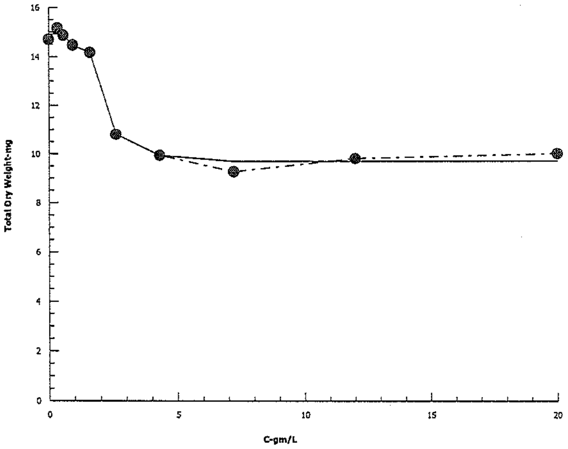
Analyst: JW QA:

~~Lemna Growth Inhibition Test~~ 21-d Moss Toxicity Test

Nautilus Environmental

Analysis ID: 18-9577-7625
Endpoint: Total Dry Weight-mg
CETIS Version: CETISv1.8.7
Analyzed: 04 Dec-17 17:13
Analysis: Linear Interpolation (ICPIN)
Official Results: Yes

Graphics



Analyst: JW
QA: Dec-5/17

CETIS Analytical Report

JW

Report Date:	04 Dec-17 17:32 (p 1 of 3)		
Test Code:	170521b1 | 19-4763-2049		

~~Eisenia 21-d Survival and Growth Soil Test~~ 21-d Moss Toxicity test

Nautilus Environmental

Analysis ID:	07-9440-9678	**Endpoint:**	Mean Length-mm	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Dec-17 17:32	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes
Batch ID:	05-6322-3923	**Test Type:**	Survival-Growth	**Analyst:**	Jeslin Wijaya
Start Date:	29 Jun-17	**Protocol:**	Davies (2007)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	20 Jul-17	**Species:**	Fontinalis antipyretica	**Brine:**	
Duration:	21d 0h	**Source:**	University of BC	**Age:**	
Sample ID:	05-8389-5437	**Code:**	22CD898D	**Client:**	Hemmera
Sample Date:	29 Jun-17	**Material:**	Sodium chloride	**Project:**	
Receive Date:	29 Jun-17	**Source:**	Hemmera		
Sample Age:	NA	**Station:**	Sodium Chloride		

Non-Linear Regression Options

Model Function	X Transform	Y Transform	Weighting Function	PTBS Function
3P Log-Logistic EV [Y=A/(1+(X/D)^C)]	None	None	Normal [W=1]	Off [Y*=Y]

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
8	17.98	-29.03	-25.75	0.9007	Yes	0.4846	2.514	0.8345	Non-Significant Lack of Fit

Point Estimates

Level	gm/L	95% LCL	95% UCL
IC5	0.3133	N/A	0.5169
IC10	0.4423	0.1938	0.6089
IC15	0.5475	0.3477	0.7127
IC20	0.643	0.4537	0.8153
IC25	0.7342	0.5485	0.9151
IC40	1.011	0.824	1.22
IC50	1.219	1.018	1.46

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
A	2.777	0.1711	2.442	3.113	16.23	<0.0001	Significant Parameter
C	2.167	0.4297	1.325	3.01	5.044	<0.0001	Significant Parameter
D	1.219	0.1458	0.9331	1.505	8.359	<0.0001	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	32.70017	32.70017	1	265.2	<0.0001	Significant
Lack of Fit	0.4828253	0.0689751	7	0.4846	0.8345	Non-Significant
Pure Error	2.846667	0.1423333	20			
Residual	3.329492	0.1233145	27			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variances	Bartlett Equality of Variance	10.55	16.92	0.3079	Equal Variances
	Mod Levene Equality of Variance	0.8819	3.02	0.5701	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9723	0.9303	0.6024	Normal Distribution
	Anderson-Darling A2 Normality	0.5106	2.492	0.2003	Normal Distribution

Analyst: JW QA: Dec-5/17

CETIS Analytical Report

JW

~~Eisenia 21-d Survival and Growth Soil Test~~ 21-d Moss Toxicity Test

Nautilus Environmental

Analysis ID: 07-9440-9678
Analyzed: 04 Dec-17 17:32
Endpoint: Mean Length-mm
Analysis: Nonlinear Regression
CETIS Version: CETISv1.8.7
Official Results: Yes

Mean Length-mm Summary

C-gm/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
			Calculated Variate						
0	Negative Control	3	2.7	2.1	3.3	0.3464	0.6	22.22%	0.0%
0.34		3	2.7	2.5	3	0.1528	0.2646	9.8%	0.0%
0.56		3	2.367	1.8	3.2	0.4256	0.7371	31.15%	12.35%
0.93		3	1.733	1.6	1.9	0.08819	0.1528	8.81%	35.8%
1.6		3	1.067	0.8	1.2	0.1333	0.2309	21.65%	60.49%
2.6		3	0.2333	0	0.4	0.1202	0.2082	89.21%	91.36%
4.3		3	0.3667	0	0.6	0.1856	0.3215	87.67%	86.42%
7.2		3	0.2333	0	0.7	0.2333	0.4041	173.2%	91.36%
12		3	0.1333	0	0.4	0.1333	0.2309	173.2%	95.06%
20		3	0.1	0	0.2	0.05774	0.1	100.0%	96.3%

Mean Length-mm Detail

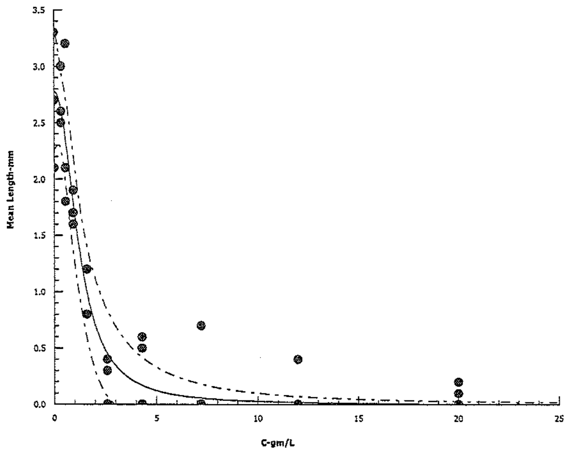
C-gm/L	Control Type	Rep 1	Rep 2	Rep 3
0	Negative Control	2.1	2.7	3.3
0.34		2.6	3	2.5
0.56		3.2	1.8	2.1
0.93		1.7	1.9	1.6
1.6		0.8	1.2	1.2
2.6		0.3	0	0.4
4.3		0.6	0	0.5
7.2		0	0.7	0
12		0	0.4	0
20		0.1	0	0.2

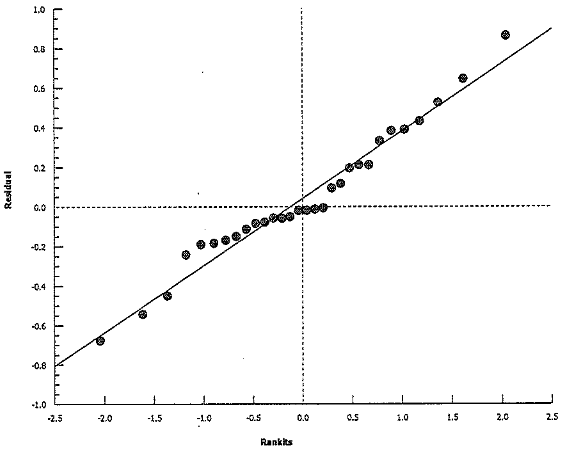
Analyst: JW QA: Dec5/17

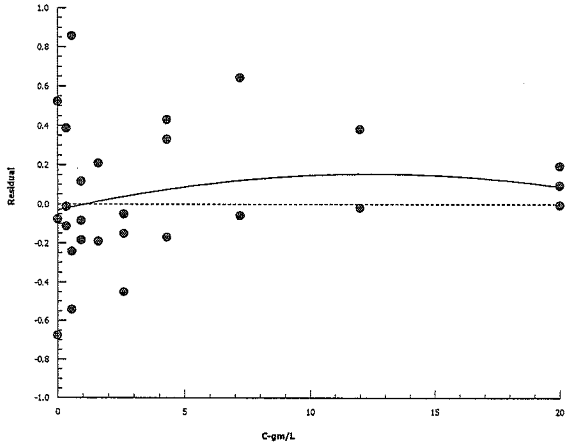
~~Eisenia 21-d Survival and Growth Soil Test~~ 21-d Moss toxicity Test **Nautilus Environmental**

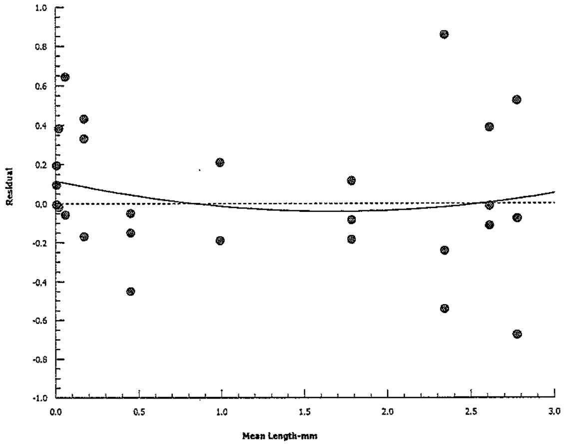
Analysis ID: 07-9440-9678 **Endpoint:** Mean Length-mm **CETIS Version:** CETISv1.8.7
Analyzed: 04 Dec-17 17:32 **Analysis:** Nonlinear Regression **Official Results:** Yes

Graphics 3P Log-Logistic EV [Y=A/(1+(X/D)^C)]









Dec-5/17