A Geochemical Characterization of Streams Surrounding the Tom and Jason SEDEX Deposits of the MacMillan Pass, Yukon, Canada: Implications for Mineral Exploration and Toxicology

M.Sc. Earth Sciences Thesis

Stuart Edwin Bryson (M.Sc. Candidate)

Supervisor: Dr. Danielle Fortin

Department of Earth and Environmental Sciences, Advanced Research Complex,

University of Ottawa, Ottawa, Ontario

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Abstract

This study presents a geochemical characterization of stream waters draining the sedimentary exhalative (SEDEX) Tom and Jason Pb-Zn deposits and surroundings in the MacMillan Pass, Yukon. Streams sampled have wide ranging pH values of 3 to 8.2. Dissolved metal concentrations vary widely with water source and pH. Of note, streams draining the Tom and Jason deposits are acidic and neutral respectively, which greatly affects metal solubility. The Tom Deposit drainage is extremely high in dissolved and fine sediment fraction lead, as well as dissolved zinc. Neutral streams draining the Jason deposit have less dramatic metal concentrations, but do show elevated dissolved zinc and fine sediment fraction lead concentrations. Modelling using the thermodynamic equilibrium program PHREEQC and XRD analysis indicate that ferricrete hardpans underlying acidic drainages are formed where drainage water is saturated with respect to schwertmannite. Ferrihydrite is formed where the rapid mixing of waters increases the pH rapidly. An aluminium oxy-hydroxide, likely gibbsite, precipitates where pH levels exceed 4.5, however it appears to dissolve with decreasing pH. This study looks at dissolved, suspended and fine fraction sediments to provide a more complete view of metal movement under various conditions which may be useful to both exploration and environmental fields.

Keywords

Acid mine drainage, neutral mine drainage, metals, streams, Yukon

Résumé

Cette étude s'intéresse à la caractérisation géochimique des eaux d'un système de drainage provenant du gisement Pb-Zn sédimentaire exhalatif (SEDEX) Tom et Jason dans la passe MacMillan au Yukon. Les eaux échantillonnées ont une gamme de pH variant de 3 à 8.2. Leurs concentrations de métaux dissous varient en fonction de la source d'eau en amont et du pH. L'intérêt particulier de ce site porte sur l'éventail de pH des cours d'eau de la région, influençant directement la solubilité des métaux. Le bassin de drainage de la zone de minéralisation de Tom et Jason est particulièrement riche en métaux dissous (incluant le Zn) et en matériel particulaire fin. Les cours d'eau neutres provenant de la zone de minéralisation Jason ont des concentrations plus faibles de métaux dissous, mais possèdent tout de même des concentrations élevées de Zn dissout et de Pb particulaire fin. La modélisation thermodynamique, réalisée à l'aide du logiciel Phreeqc, ainsi que les analyses par diffraction des rayons-X indiquent que les croûtes ferrugineuse dans les cours d'eau acide ont été formées sous des conditions de saturation par rapport à la schwertmannite. La ferrihydrite se forme dans les zones de mélange d'eau lorsque le pH augmente rapidement. Il y a possiblement un oxyde d'aluminium, soit la gibbsite, qui se forme à des pH supérieurs à 4.5, mais ce minéral disparait lorsque des conditions acides prévalent. Cette étude porte sur la solubilité des métaux, les sédiments en suspension, et les matériels particulaires fins afin d'offrir une vue complète de la mobilité des métaux dans différentes conditions. Ces données peuvent venir appuyer la prospection minière et les études environnementales.

Mots clés

Drainage minier acide, drainage minier neutre, rivières, métaux, Yukon

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1.0 Introduction

1.1 Geochemical Exploration

Surficial geochemical exploration methods, such as surveys performed by the Geological Survey of Canada, have a history of recorded success. Much of this success has been attributable to mechanically transported glacial drift and stream sediments (Boyle, 1979; Levson, 2001). Mechanical dispersion is limited to ore bodies exposed to surface erosion during recent geological history. In contrast, groundwater can penetrate the earth, transporting constituents back to the surface through dissolution and dispersion, followed by potential mineral precipitation (Miller, 1979; Johnson, 2009). Thus, dispersion haloes created by aqueous transport have the potential to carry the geochemical signatures of ore bodies not visible in detrital sediments. While chemical weathering and mineral precipitation in stream sediments are well documented, the effects of varying environmental conditions on exploration samples are not always well accounted for. Additionally, documented geochemical signatures from undisturbed ore bodies, known as orientation surveys, are limited.

Mountainous areas are particularly promising for geochemical exploration since water can interact with buried geology and resurface along a generally downward flow-path. Metal mobility, however, is extremely dependent on the properties of the water (Hermann and Neumann-Mahlkau, 1985). This becomes important for exploration since the oxidation of pyrite associated with many mineral deposits can generate extremely acidic, metal rich conditions known as acid rock drainage (ARD), which may or may not be related to the presence of an economic ore deposit (Kelley and Taylor, 1997; Kwong *et al.*, 2009). Conversely, if sufficient carbonates are present within the ore body, waters

may remain pH neutral with low overall metal concentrations despite the presence of economic mineralization (Kwong *et al.*, 2009). As water surfaces and enters stream flow, pH, temperature and bulk chemistry can rapidly change, limiting or enhancing the ability of elements to be carried in the aqueous solution. The literature reveals few, if any, documented successes of ore bodies being located based on water chemistry alone. This limited success has not gone unnoticed and a need for method development has been a recurring theme. Refinements have been proposed such as thermodynamic modelling of the waters, analysis of oxide precipitates, and analysis of the suspended sediment fraction (Carpenter *et al.*, 1975; Miller, 1979; Telmer *et al.*, 2002; Huelin *et al.*, 2006; Leybourne and Cameron, 2010). These methods attempt to measure previously dissolved metals which have either precipitated into mineral form or adsorbed onto charged particulate material.

Clays, oxides and organics are particularly adept at adsorbing metal ions (Moore *et al.*, 1991; Hua *et al.*, 2012). Secondary metal-oxide minerals complicate inter-stream comparisons due to their susceptibility to varying thermodynamic conditions. As such, stream water chemistry can only meaningfully be directly compared to streams with similar conditions, particularly pH. Targeting these highly adsorptive particles by analyzing suspended sediments has the potential to both enhance the contrast of an anomaly, and increase the lateral extent of its dispersal (Telmer *et al.*, 2002). By targeting only stream deposited fine sediments, which act as a sink for suspended sediment, this effect may already be partially visible.

The aqua regia extraction commonly used in sediment sampling programs, is a partial digestion which dissolves most base metals, sulphides, oxides, and altered

silicates (Chen and Ma, 2001). Unfortunately, aqua regia extractions alone do not allow for the separation of those metals contained in mechanically transported primary ore minerals (such as metal-sulphides) from those precipitated with and absorbed to oxides, clays and organics. Instrumental neutron activation analysis (INAA) of sediments is commonly performed by the Geological Survey of Canada and is believed to represent a total concentration including structural silicates. Given the limited precision of INAA data, and that aqua regia digestions would be expected to extract most minerals present in the fine sediment fraction, these can be largely equivalent datasets (Bryson *et al.*, 2015).

Thus, the current methods for geochemical survey analysis provides excellent information on dissolved stream chemistry and bed load. Unfortunately it does little to address the natural progression of transported metals from dissolved to suspended particulate through to bed load. These mechanisms for metal transport and fate are also of concern to the environmental field. (Moore, 1991; Schaider *et al.,* 2014).

1.2 Environmental Considerations

ARD and metal toxicity is of particular concern in Canada due to the increasing focus on resource development. Within British Columbia alone the number of abandoned mines with the potential to generate significant metal leaching and ARD have exceeded the number of operating mines by approximately 10:1 (Price, 2003).

At a pH of 5 or lower, the combination of acidic waters, iron oxide precipitates, and high metal loads will be acutely toxic to most organisms (Wildeman *et al.*, 2007). This results in the upper reaches of ARD impacted streams commonly being devoid of all but the most acid and metal tolerant, specialized organisms (DeNicola *et al.*, 2001; Dsa *et al.*, 2008). At higher pH's, acidity will be less influential and toxicity will be primarily a

function of the sedimentary and dissolved metals (Wildeman *et al.*, 2007). Many metals associated with negative health effects such as Cd, Al, Hg, and Pb are commonly present (Byrne, 2011; Schaider *et al.*, 2014). Even essential metals such as Zn and Fe can be present in sufficient quantities to cause deleterious health affects to fish and microorganisms (Moore, 1991; Todd, 2007; Wood, 2011). Effects of these metals include the inhibition of numerous biologically important functions (Wood, 2011). In particular, Cu and Cd have been shown to accumulate in trout livers over 100 kilometers downstream from an ARD source with the exact transport mechanism and uptake paths being unknown (Moore, 1991). At the same time, abiotic sorption of nutrients, such as phosphate, by metal oxides can have a potentially limiting influence on lake and stream nutrient availability (Tate *et al.*, 1995).

Despite their extreme conditions, ARD waters have been found to contain algae, fungi and bryophyte mosses, indicating they may not be as inhospitable as commonly suggested but rather a novel environment (Tate *et al.*, 1995; Lawrence *et al.*, 1998; McKnight, 2001; Sevink *et al.*, 2015).

1.3 Previous Studies in this Region

The MacMillan Pass provides an interesting opportunity as the Tom and Jason Pb-Zn sedimentary exhalative (SEDEX) deposits are drained by acidic and neutral streams respectively. Nearby streams have a wide pH range while draining no known economic ore deposits. An overview of the regional ARD was provided by Kwong and Whitley (1992). Kwong later summarized the findings with reference to potential mining ARD mitigation strategies (1993). In 2006, Gartner Lee performed a regional water quality, sediment and benthic invertebrate assessment of the area as a baseline study to

establish water quality objectives prior to potential mining (Gartner Lee, 2007). Kwong *et al.* (2009) also studied selected streams in the MacMillan Pass due to their naturally acidic properties. This site is similar to the nearby Howard's Pass, where the waters were characterized for mineral exploration purposes (Goodfellow, 1983). Study of the acidic streams draining sedimentary exhalative deposits of the Howard's Pass has shown Zn to be highly mobile in these surficial environments while Pb rapidly accumulates in sediments causing dissolved concentrations to fall significantly. Conversely at the abandoned Sa Dena Hes mine in the southern Yukon, Zn was found to be virtually absent in a neutral spring shortly down gradient of a mineshaft with elevated zinc levels (Day and Bowell, 2005).

The dissolved and fine fraction sediment metal results of a Geological Survey of Canada geochemical survey performed during the current research program were discussed in Bryson *et al.* (2015) and those findings form the basis for this extended discussion.

1.4 Metal Leaching and Acid Rock Drainage

1.4.1 Mineral dissolution

The geochemistry of groundwater is a function of the mineral composition of the aquifer and local geology through which it flows (Rogers, 1989; Kwong, 1993). Silicate, carbonate and sulphide minerals in particular have been shown to exert a primary impact on groundwater chemistry (Rogers, 1989).

Within the silicates, plagioclase feldspars and mafic silicates such as amphiboles and biotite weather over time, while potassium feldspars and quartz can be considered essentially inert at ambient conditions (Rogers, 1989). These will primarily contribute Al,

Na, K, Ca, Si, Mg as well as some pH buffering capacity to the groundwater. Long residence times are required for water to reach equilibrium with these minerals and therefore reaction kinetics must be considered (Rogers, 1989).

Carbonates, by contrast, can react quite quickly, and the effects of silicate dissolution can be readily masked (Rogers, 1989). Carbonates are a primary control on water alkalinity, strongly buffering pH (Rogers, 1989; Kwong, 1993). They can also contribute large quantities of Ca and Mg to a system.

Sulphide minerals are thermodynamically unstable in oxygenated environments. They are consequently a much more reactive phase, both readily dissolving and precipitating within redox ranges present at the earth's surface with great impact on ground and surface waters (Kwong, 1993; Erickson and Barnes, 2005).

1.4.2 Acid Rock Drainage

Metal-sulphide minerals such as pyrite (FeS_2) are a particular case due to the quantity of protons released during their oxidation, resulting in the acidic, metal-rich waters known as ARD. When surficial materials are displaced it can greatly increase the exposure of material to oxidized fluids. Such mineral exposing processes can include natural phenomenon such as erosion by glaciation as well as anthropogenic actions such as highway construction, and mining (Huckabee *et al.*, 1975; Kwong, 1993; Fortner *et al.* 2011). Where this process has been enhanced by mining activities it is commonly known as acid mine drainage (AMD).

When iron bearing metal-sulphides are exposed to oxidized waters they are oxidized, releasing protons, ferrous iron, and other metals associated with the mineral [eq. 1] (Nordstrom, 1982; Sánchez España, 2007).

$$FeS_2 + \frac{7}{2} O_2 + H_2O \rightarrow Fe^{2+} + 2\ SO_4^{2-} + 2\ H^+$$

[1] Oxidation of FeS_2 by O_2 is slow under acidic conditions (Singer and Stumm, 1970). However, the initial acidic conditions generated by FeS_2 oxidation promote the growth of acid and metal tolerant microorganisms (Johnson and Hallberg, 2003). Amongst these are varieties which catalyse the oxidation of ferrous iron to ferric iron, a process known as bio-oxidation. In particular the iron-oxidizing bacteria *Acidothiobacillus ferrooxidans* and *Leptospirillium ferrooxidans* are common to ARD environments (Johnson and Hallberg, 2003; Rohwerder *et al.* 2003). There are two common pathways for bio-oxidation of iron depending on pH [eqs. 2 and 3] (Singer and Stumm, 1970; Sánchez España, 2007).

$$Fe^{2+} + \frac{1}{4} O_2(g) + \frac{5}{2} H_2O \rightarrow Fe(OH)_3(s) + 2\ H^+ \quad (pH > 3) \qquad [2]$$

$$Fe^{2+} + \frac{1}{4} O_2(g) + H^+ \rightarrow Fe^{3+} + \frac{1}{2} H_2O \quad (pH < 3) \qquad [3]$$

The oxidation of pyrite by ferric iron releases further ferrous iron and protons [eq. 4] (Sánchez España, 2007).

$$FeS_2 + 14\ Fe^{3+} + 8\ H_2O \rightarrow 15\ Fe^{2+} + 2\ SO_4^{2-} + 16\ H^+ \qquad [4]$$

Under acidic conditions, ferric iron can oxidize pyrite at rates that are one to two orders of magnitude higher than oxygen (pH < 3) (Ritchie, 1994). Since the ferrous iron released from pyrite is further subject to bio-oxidation and added protons decrease the pH, the positive feedback of equations [1] and [4] results in oxidation rates up to five orders of magnitude greater than the abiotic rate (Sánchez España, 2007). Note that the oxidative dissolution of non-iron bearing sulphides with metal-to-sulphur ratios greater than or equal to one is not normally considered acid generating, however, they will release heavy metals of concern (Kwong; 1993).

Other elements are commonly present at very high concentrations in ARD due to increased dissolution under acidic conditions (Blowes and Pacek, 1994; Cravotta, 1994). These include Al, Mg, and Ca from aluminosilicates, carbonates and sulfates; as well as Cu, Zn, Pb, Mn, As and Cd from sulphides and sulfosalts (Sánchez España, 2007).

Cold climates have the potential to limit weathering of sulphide minerals due to lack of biological activity and liquid water, particularly during winter. Note that pyrite oxidation is an exothermic process (Sracek *et al.,* 2006). Generated heat aids in the maintenance of liquid water as well as temperature conditions that promote microbial growth and iron oxidation. Elevated concentrations of dissolved ions further suppress the freezing point to below zero-temperatures (Meldrum *et al.*, 2001). Therefore liquid water is often present in sulphide-ore bodies and tailings impoundments in northern climates. Iron-oxidizing bacteria able to grow at near-zero temperatures have also been documented at many northern locations (Johnson *et al.*, 2001; Dopson *et al.*, 2007; Kupka *et al.*, 2007). The iron-oxidizing bacteria *L. ferrooxidans* is uncommon in cold-water ARD relative to *A. ferrooxidans* (Hallmann *et al.*, 1992).

1.4.3 Fe(III)-hydroxysulphate and -oxyhydroxide minerals

ARD has been described as ‘self-mitigating’ in some locations as the pH may be moderated and many of the detrimental elements removed from the waters by neutralization by carbonate minerals, dilution with pH neutral surface waters, and hydrolysis reactions (Sánchez España *et al.*, 2006). Neutralization by mixing with other stream or carbonate alkalinity, and oxygenation of surface and near surface waters will promote mineral precipitation as ferric iron hydrolyses and precipitates as Fe(III)-hydroxysulphates and Fe(III)-oxyhydroxides. Ferric iron is highly soluble at low pH (<2)

initially limiting this process (Sánchez España, 2007; Dopson *et al.*, 2007).

Low pH conditions (pH <3) limit the oxidation ferrous iron, (Johnson *et al.,* 2012). At pH >4, Fe(II) oxidation by O_2 is very fast and the precipitation of Fe(III)-minerals occurs rapidly (Johnson *et al.,* 2012). Note that Fe(II) present in water will remain soluble until very high pH levels (>8) if not exposed to oxidizing conditions (Sánchez España, 2007).

The most common Fe-hydroxysulphate and Fe-oxyhydroxide minerals associated with ARD are schwertmannite ($Fe_8O_8(SO_4)(OH)_6$), jarosite ($(H_3O,K,Na)Fe_3(SO_4)_2(OH)_6$) and goethite (α-FeOOH) (Bigham *et al.*, 1996b; Yu *et al.*, 1999). Jarosite may precipitate directly at lower pH (<2.1) if favourable monovalent cations, such as K^+, NH_4^+, Na^+, and H_3O^+, are present [eq. 5] (Barham, 1997; Regenspurg *et al.,* 2004; Wang *et al.*, 2006).

$$3\ Fe^{3+} + 2\ SO_4^{2-} + 7\ H_2O \leftrightarrow (H_3O)Fe_3(SO_4)_2(OH)_6 + 5\ H^+ \qquad [5]$$

Schwertmannite is favoured to precipitate at pH 2.8–3.2, with high sulphate (1000–3000 mg/L), and Fe(II)-oxidizing bacteria [eq. 6] (Bigham *et al.*, 1990; Bigham *et al.*, 1994; Bigham *et al.*, 1996b).

$$8\ Fe^{3+} + SO_4^{2-} + 14\ H_2O \leftrightarrow Fe_8O_8(OH)_6(SO_4) + 22\ H^+ \qquad [6]$$

Schwertmannite recrystallizes as both jarosite [eq. 7] and goethite [eq. 8]. Jarosite is favoured at lower pH's (<3) while geothite is favoured at modestly higher pH's (> 3.0) (Bigham *et al.*, 1996a,b; Kumpulainen *et al.*, 2008).

$$Fe_8O_8(OH)_6(SO_4) + H_2O + SO_4^{2-} + 17\ H^+ \leftrightarrow (H_3O)Fe_3(SO_4)_2(OH)_6 + 5\ Fe^{3+} + 8\ H_2O \qquad [7]$$

$$Fe_8O_8(OH)_6(SO_4) + 2\ H_2O_{(l)} \leftrightarrow 8\ FeOOH_{(s)} + 2\ H^+ + SO_4^{2-} \qquad [8]$$

Low temperatures will enhance the stability of schwertmannite while limiting jarosite formation due to the increased solubility of Fe(III) (Leduc and Ferroni, 1994; Jonsson *et al.*, 2005). Seasonal variability, however, favours the conversion of schwertmannite to goethite (Schroth and Parnell, 2005; Kumpulainen *et al.*, 2007).

As stream acidity is neutralized through dilution with other streams or dissolution of carbonates, the oxidation of any remaining ferrous iron will occur and ferric iron minerals precipitate very rapidly (Johnson *et al.,* 2012; Singer and Stumm, 1970). In waters with continuously evolving pH, dissolved iron will be eliminated from the waters by pH 4 (Kim *et al.*, 2002). Where pH increases dramatically to pH levels above five, typically at the confluence of acidic and neutral streams, ferrihydrite ($Fe^{3+}2O_3 \bullet 0.5H_2O$) may precipitate spontaneously (Bigham *et al.*, 1996b; Sánchez España, 2007).

Schwertmannite, jarosite and ferrihydrite are all metastable with regards to goethite which rarely precipitates directly since the low sulphate conditions required are uncommon in ARD systems (Bigham *et al.*, 1996b; Sánchez España, 2007). Goethite is generally therefore considered to be a minor component of the particulate fraction in relation to schwertmannite and ferrihydrite, forming instead in the stream bottom sediments (Sánchez España, 2007).

1.4.4 Al-hydroxysulphate and -oxyhydroxide minerals

The differing pH ranges at which iron and aluminium are soluble often result in spatial separation of the precipitates (Sánchez España *et al.*, 2006). Unlike iron, aluminium is highly soluble until pH approaches 4.5 (Sánchez España, 2007). Above this, highly amorphous aluminum-hydroxysulphate minerals such as hydrobasaluminite ($Al_4SO_4(OH)_{10}$-$4H_2O$), jurbanite ($AlOHSO_4$), alunite ($KAl_3(SO_4)_2(OH)_6$) and gibbsite

($Al(OH)_3$) may precipitate (Nordstrom and Ball, 1986; Bigham and Nordstrom, 2000; Sánchez España, 2007).

Jurbanite precipitation is favoured at pH below 4.6 [eq. 9] (Nordstrom, 1982; Nordstrom and Alpers, 1999).

$$Al^{3+} + SO_4^{2-} + H_2O \leftrightarrow Al(OH)SO_4 + H^+ \quad [9]$$

Hydrobasaluminite is favoured to precipitate at pH's above 5 [eq. 10], after which it dehydrates to basaluminite (Sánchez España, 2007; Nordstrom, 1982).

$$4\ Al^{3+} + SO_4^{2-} + 22 – 46\ H_2O \leftrightarrow Al_4(SO_4)(OH)_{10} \bullet 12 – 36\ H_2O + 10\ H^+ \quad [10]$$

The precipitation of gibbsite is favoured at pH levels above 5.7 [eq. 11] (Nordstrom, 1982; Munk *et al.*, 2002).

$$Al^{3+} + H_2O \leftrightarrow Al(OH)_3 + 3\ H^+ \quad [11]$$

Gibbsite can also form via equilibration with basaluminite [eq. 12] (Nordstrom, 1982).

$$Al_4(SO_4)(OH)_{10} + 2\ H_2O \leftrightarrow 4\ Al(OH)_3 + 2\ H^+ + SO_4^{2-} \quad [12]$$

Alunite has been found in some ARD environments, though rarely as a direct precipitate (Sánchez España, 2007).

In the pH 4.5 – 5 range, a poorly ordered mixture of hydrobasaluminite and basaluminite is likely the most common Al mineral form in these waters (Chapman *et al.*, 1983; Sánchez España, 2007; Sánchez España *et al.*, 2006).

1.4.5 Sequestration of metals and trace elements

With large, highly reactive surfaces and amorphous structures Al and Fe minerals are able to scavenge significant quantities of metals and trace elements from the water column through adsorption and coprecipitation (Sánchez España *et al.,* 2006).

During coprecipitation trace elements are physically incorporated into the mineral lattice. Adsorption is the process by which elements coordinate at the solid-water interface of a mineral precipitate. The presence of functional groups such as SO_4 and OH can cause metals to coordinate as surface complexes (Stumm and Morgan, 1995). Metals are commonly bound to one or two oxygen atoms at the mineral surface while other ligands, such as SO_4, complete the coordination sphere and form a ternary complex (Schindler, 1990).

At low pH, excess protons will cause most mineral surfaces to have a net positive charge (Stumm and Morgan, 1995). Under these conditions they will not be effective adsorbents for dissolved cations. Protonation of the binding sites will decrease with increasing pH, allowing for the adsorption of metal cations (Stumm and Morgan, 1995). Elevated sulphate concentrations (>1000 mg/L) can cause metal adsorption at protonated sites due to the formation of metal-sulfate complexes (Sánchez España *et al.*, 2006).

1.4.6 Trace element sequestration by Fe(III)-minerals

Fe(III)-hydroxysulphates and –oxyhydroxides are capable of accumulating high concentrations of trace elements. Enhanced adsorption of Pb and Cd on the surface of goethite at low pH occurs due to the formation of $PbSO_4$ and $CdSO_4$ ternary complexes (Acero *et al.*, 2006; Penilla *et al.*, 2005; Ostergren *et al.*, 2000; Webster *et al.*, 1998; Weesner and Bleam, 1998). Microbes associated with some of these precipitates

enhance adsorption either by providing an additional surface for adsorption or by changing the way in which precipitation occurs (Webster *et al.*, 1998).

Coprecipitation can also account for the removal of trace elements from ARD. Pb is known to substitute in jarosite minerals, forming plumbojarosite ($PbFe_6(SO_4)_4(OH)_{12}$) (Hochella *et al.*, 1999). Al is known to coprecipitate with jarosite, replacing Fe(III) (Dutrizac and Jambor, 2000). The resulting mineral is a solid solution between jarosite and alunite. Al can also replace Fe(III) in goethite, forming a solid solution with diaspore (αAlOOH) (Herbert, 1996). The removal of oxyanions, such as $AsSO_4^{2-}$ and VSO_4^{2-}, occurs by substitution for SO_4^{2-} in the schwertmannite structure (Regenspurg and Peiffer, 2004).

Metals present as aqueous free ions show a general trend of progressive sorption at increasing pH. The general sequence for adsorption and coprecipitation by Fe(III)-oxides is As > V > Pb > Cu, U > Zn > Cd > Ni (Dzombak and Morel, 1990; Lee *et al.*, 2002; Sánchez España *et al.*, 2006).

1.4.7 Trace element sequestration by Al(III)-minerals

Adsorption and coprecipitation mechanisms in Al(III)-hydroxysulphates are largely undocumented compared to the adsorption and coprecipitation of metals with Fe(III)-hydroxysulphates. Metals which undergo adsorption at pH levels similar to Al-hydroxysulphate precipitation, including Zn, Ni, Cd, and U, are often enriched (Munk *et al.*, 2002; Lee *et al.*, 2002; Sánchez España *et al.,* 2006). Uranium also has a high affinity for Al-hydroxysulphate minerals (Luo *et al.*, 2009). Si has a very high affinity for Al and SO_4; it is often associated with Al-hydroxysulphates, as well (Bigham and Nordstrom, 2000).

The adsorption sequence for Al-oxide minerals is less well defined than that for

Fe(III) but generally follows as As, V, Pb > Cu, Zn, Cd, Ni (Kinniburgh *et al.*, 1976; Lee et al 2002; Munk *et al.*, 2002; Sánchez España *et al.*, 2006). Both show variability between sites; however As, V, and Pb are generally attenuated at low pH; with Cu, Zn, Cd, and Ni following as pH increases.

Following the above discussion, the combined sequences for Fe and Al precipitation, coprecipitation, and adsorption appear as Fe(III) > As > V > Pb > Al > Cu,U > Zn > Cd > Ni.

Precise pH and extent of adsorption depends on prevailing geochemical conditions and temperature (Parker *et al.*, 2007; Lee *et al.*, 2002). Furthermore, microbes on the surface of these precipitates will provide additional surface area and may alter methods under which precipitation occurs (Webster *et al.,* 1998).

Evolving stream chemistry through physical transport, as well as diurnal or seasonal changes can cause redistribution or release of adsorbed metals through either dissolution or recrystallization. For instance, diurnal photoreduction of stream bed Fe-oxides can release Fe(II) and adsorbed species while the conversion of schwertmannite to goethite, favoured by seasonal variability, has been shown to convert bound schwertmannite sulfate ions into goethite surface complexes, and release a portion of the bound metals (such as Al, Cu and Zn) back into solution (Peretyazhko *et al.*, 2009; Kumpulainen *et al.*, 2007; McKnight *et al.,* 2001; Tate *et al.,* 1995).

2.0 Present Study

2.1 Site

Figure 1. Location of the MacMillan Pass area along the Canol Road on the Yukon side of the territorial border.

The MacMillan Pass is located along the south central portion of the Yukon-Northwest Territories border (Figure 1). It is on the eastern margin of the Selwyn Basin, an epicratonic marine basin developed during Proterozoic rifting of the North American western continental margin (Goodfellow, 2004). This rifting and associated hydrothermal activity created the Tom and Jason sedimentary exhalative (SEDEX) deposits opposite each other in the MacMillan Pass, 10 kilometres from the territorial border. The sedimentary exhalative (SEDEX) deposits, Tom Zn-Pb-Ag-barite and Jason Zn-Pb-barite, are hosted in inter-bedded carbonaceous mudstone, diamictite, siltstone and siliceous shales of Devonian Lower Earn Group rocks known as the Portrait Lake Formation

(Goodfellow, 1991; Goodfellow and Rhodes, 1991). Figure 2 illustrates the regional geology relative to the sampling locations.

Economic mineralization at the Tom and Jason deposits consists of sphalerite (ZnS), galena (PbS), tetrahedrite ($Cu_{12}Sb_4S_{13}$) and chalcopyrite ($CuFeS_2$). Accessory minerals include barite ($BaSO_4$), pyrite (FeS_2), pyrrhotite ($Fe_{(1-x)}S$), quartz (SiO_2), ankerite ($Ca(Fe,Mg,Mn)(CO_3)_2$) and siderite ($FeCO_3$) (Scott Wilson RPA, 2007). Mineralization is concordant with sedimentary stratigraphy. The Tom deposit contains four sulphide zones which are up to 40 meters thick, extending up to 1000 meters along strike and up to 450 meters up and down dip. The Jason deposit contains stratiform lenses up to 40 meters thick extending up to 1200 meters along strike (Scott Wilson RPA, 2007).

The site is accessible by the Canol Road, a summer access road following the valley sides. Peat-rich wetlands are common in the valley bottom, while slopes are scree covered. The South MacMillan River follows the steeply sided valley from the water divide in the MacMillan Pass for roughly 20 kilometres before entering a larger open drainage basin. Smaller tributary streams drain the surrounding mountains to the South MacMillan River at regular intervals (Figure 3).

Detrital stream sediments are composed of silt to boulder lag deposits. These are overlain by ferricretes in the most acidic waters (pH <3.2), red Fe-oxide rich precipitates in moderately acidic waters (pH 4-5) and white Al-oxides in slightly acidic waters (pH 5-6) (Figure 4). Neutral to basic waters without acidic tributaries have no visible precipitates. Tributaries to the main channel are either acidic (pH <3.5), or neutral to alkaline (pH >7). The bottom of the South MacMillan River was often covered in up to a centimetre of Fe-oxide and Al-oxide precipitates under clear, calmly flowing regions. While laterally

extensive and opaque, this material was typically very thin and highly mobile if disturbed. River reaches with faster flows suspended this finer material, clearing the riverbed of all but the largest boulders and giving the waters a rusty appearance. At the Tom deposit, exploration tunnelling has been performed and untreated waters from the adit feed Seckie Creek 2. No processing is known to have occurred on site.

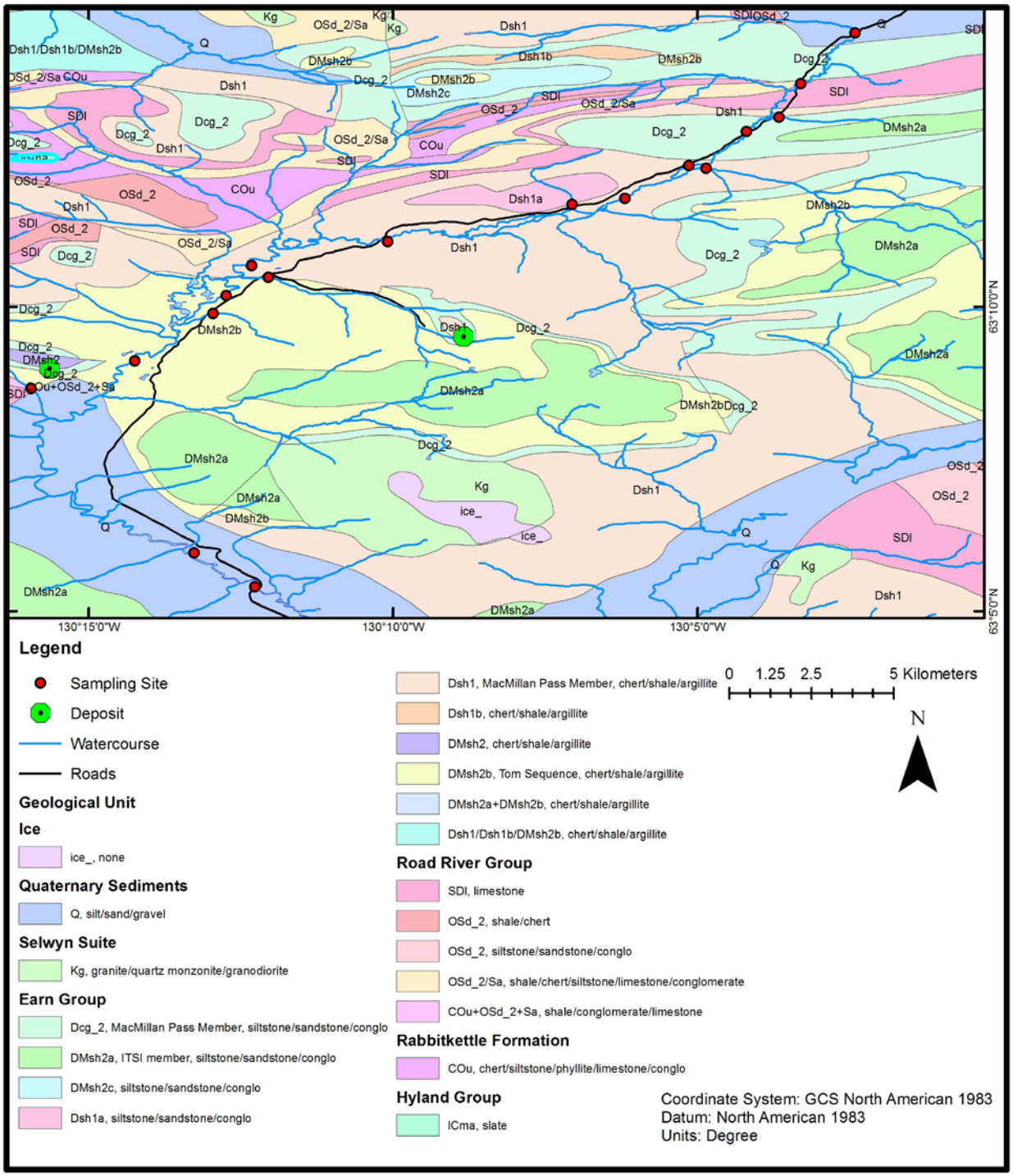

Figure 2. Geological map of the MacMillan Pass area showing stream network and sampling locations. (Modified from Gordey and Makepeace, 1999; National Topographic Data Base 105-O/1, 1990; Goodfellow and Rhodes, 1991).

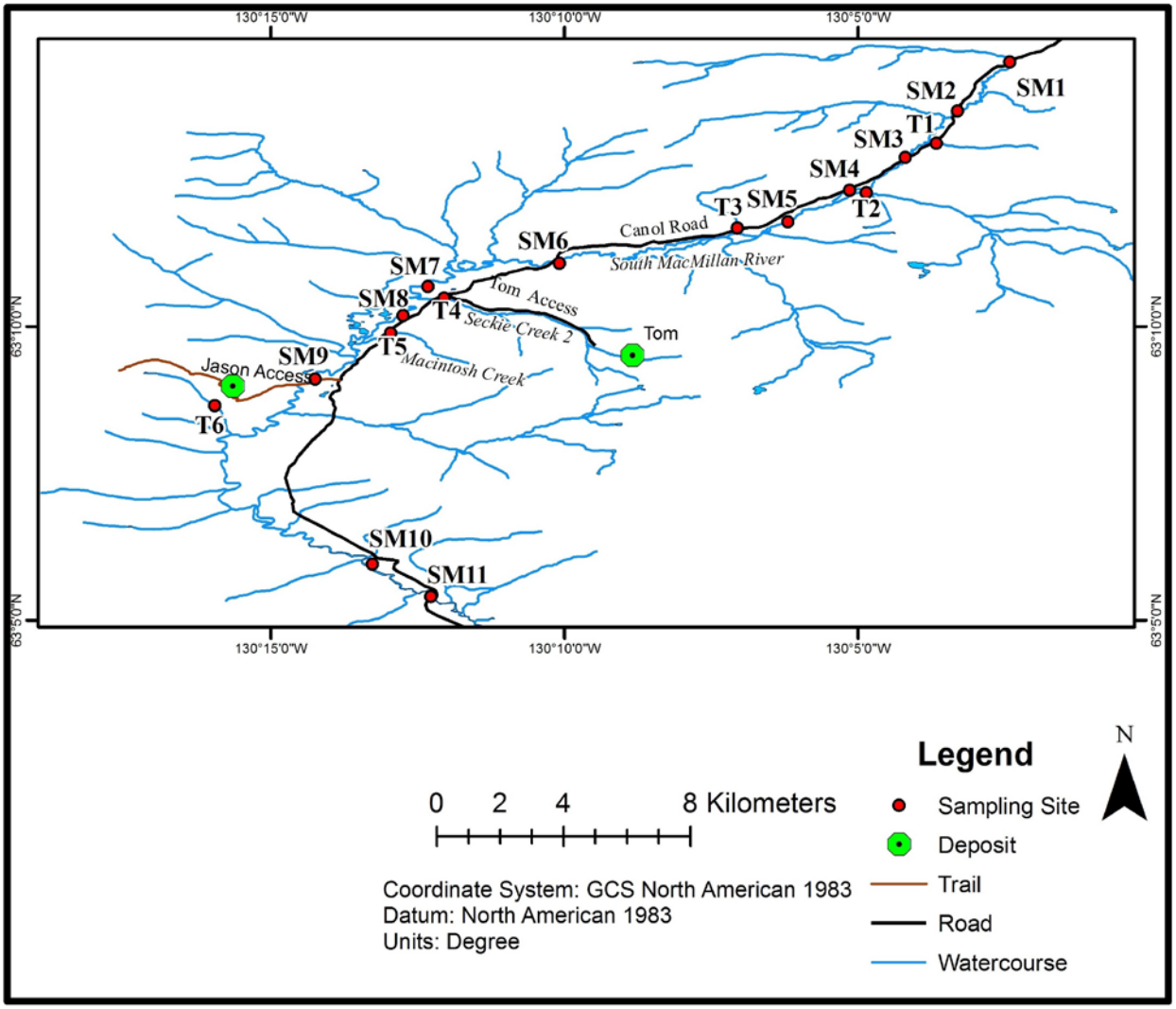

Figure 3. Site map showing sampling locations on the South MacMillan River (SM) and tributaries (T) as well as the Canol Road and Tom and Jason access roads. The South MacMillan River flows towards the bottom of the map (southwest). (Modified from the National Topographic Data Base 105-O/1, 1990).

Figure 4. Clockwise from top left 1) Acidic stream (pH 3.4) at site T1 showing ferricrete stream bottom and clear waters. 2) Moderately acidic stream (pH 4) at site SM5 showing heavy Fe-oxide precipitation. 3) Site SM7 on the South MacMillan River with mildly acidic waters (pH 5.3) showing Al-oxide precipitation with minor Fe-oxides. 4) Neutral tributary at site T6 downstream of the Jason deposit showing clear waters.

2.2 Thesis Objectives

Originally envisioned by Dr. Paul Gammon of the Geological Survey of Canada as an extension of a previous research thesis completed by Kristen (Feige) Gault to assess the potential for thermodynamic modeling in mineral exploration. The original project characterized a small acidic stream draining ~ 100 meters from the XY Pb-Zn SEDEX deposit at Howard's Pass (Feige, 2010; Gault *et al.*, 2015). The follow up was to continue the original research into more neutral waters further downstream. With changing field opportunities, equipment availability, and personnel, the original project has evolved into

a valley sized orientation survey with similar objectives.

This thesis aims to investigate the impacts of acid rock drainage geochemistry downstream of the Tom and Jason sedimentary exhalative Pb-Zn deposits and surrounding barren regions. Factors controlling mineral precipitate formation and the processes controlling trace metal attenuation in these precipitates will also be addressed.

3.0 Methods

Forty-five separate sampling events were performed at 17 sites along the South MacMillan River and its tributary streams during August 2013. Samples were always taken greater than 10 meters upstream of road and a bridge crossings beyond the area of road influence. All water samples and measurements were collected mid-stream. Sampling and analysis followed standard Geological Survey of Canada field and laboratory procedures for stream geochemical surveys unless otherwise specified (McCurdy *et al.*, 2012).

3.1 In-situ measurements

Water parameters including pH, conductivity (µS/cm), ORP (mV) and temperature (°C) were recorded on site immediately after sampling using a YSI multi-parameter meter calibrated daily. As the YSI took some time to stabilize, this meter was placed into the stream downstream of sampling locations to equilibrate with the waters, and then moved to the sampling location once sampling was completed. Sulphide was measured on a HACH field spectrophotometer using methylene blue reagent sachets.

3.2 Water Sampling

The sampling protocol called for one unfiltered and three syringe filtered (0.45µm) samples to be collected at each site. The unfiltered sample and one filtered sample were

acidified with HNO_3 for total and dissolved trace metals analysis respectively. Another filtered sample was acidified with HCl for determination of dissolved iron speciation at the University of Ottawa geochemistry laboratory, while the last filtered samples was unpreserved for anion analysis. A dissolved organic carbon (DIC) and dissolved inorganic carbon (DOC) sample was also collected. The first time each site was visited, an additional dissolved metal sample was collected for analysis by the Geological Survey of Canada. Unfortunately logistical considerations and limited supplies sometimes prevented a full suite of samples from being collected during each sampling event.

All samples were filtered with new 60 ml syringes rinsed with sample water through disposable 0.45 µm filters. The initial filter discharge was used as a rinse and was not collected. All bottles were new and rinsed three times with sample water. For the purposes of this analysis, 'dissolved' includes all materials passing through filtration while 'total' includes all those materials able to be dissolved or released by the nitric acid preservative such as Fe- and Al-oxides (Banks *et al.,* 2005). Due to logistical transportation challenges two varieties of filters and bottles were used.

The first variety of filter and bottles were sourced in Whitehorse. PAL brand filters were used with new, Environment Canada issue, 250 mL bottles provided by the Yukon Geological Survey. Fe- and Al-oxides in watercourses regularly caused blockages of the PAL filters and all attempts were made to change filters before excessive pressure was required to force water through the filter. Total and dissolved metal samples were acidified with pre-measured nitric acid (HNO_3) (1% v/v), while ferrous iron samples were preserved with pre-measured hydrochloric acid (HCl) (1% v/v), at the time of sample collection. ALS laboratories, Whitehorse, graciously provided both preservatives. Forty-four per cent of

samples were collected with this equipment.

The Geological Survey of Canada supplied the second set of filters and bottles. Durapore filters were used with new, 30 mL HDPE bottles, and samples for total elemental analysis were acidified with ultrapure HNO_3 (1% v/v) upon returning to basecamp. In addition, three acid washed 40 mL amber glass bottles were used to collect filtered DIC/DOC samples at each location. Fifty-six per cent of reported samples used the 30 mL bottles and Durapore filters.

All samples were placed into coolers immediately after collection. Samples were kept cool with ice packs during sampling and air shipped to Ottawa in coolers.

Field method quality assurance was provided by equipment duplicates, field duplicates, and blanks used on a regular basis. The equipment duplicates comprised of two samples taken at the same time and location by two types of bottles and filters being used. These were collected at 7% of sampling events. Field duplicates were taken at the same time and location with the same style of bottle and filter; they were collected at 13% of sampling events.

Travel and acid blanks for the 250 mL sample bottles equipment collected in Whitehorse were filled with deionized water (DIW) transported from the Geological Survey of Canada geochemistry laboratory in Ottawa and filled in camp. Travel and acid blanks for 30 mL sample bottles were filled with DIW in Ottawa. Acid blanks consisted of unfiltered DIW acidified in the field. Filter blanks consisted of DIW transported in 1L HDPE bottles and filtered in the field. Due to a lack of deionized water, blanks were unavailable until the fifth day of sampling and were collected daily after that time. These blanks help identify potential contamination from transport, acidification and filtering respectively.

3.3 Sediment Sampling

Stream sediment samples were collected by gloved hand after water sampling and in-situ measurements were completed on the first occasion that a site was visited. Samples were collected from sorted stream sediments (verified by the sampler) at various locations over 5 to 20 m along the active stream channel in sediment sampling bags and allowed to drain and air dry on clean tarps. After being wrapped in individual plastic bags and taped shut, samples were shipped by truck to the Geological Survey of Canada, Booth Street laboratories in steel pails.

3.4 Laboratory Analyses of Water Samples

Water samples were analysed by inductively-coupled plasma emission spectroscopy (ICP-ES), inductively-coupled plasma mass spectroscopy (ICP-MS), and anion chromatography at the University of Ottawa, Department of Earth Sciences geochemistry labs. A Varian (Agilent) Vista Pro ICP-ES analysed for: Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, P, Pb, S, Si, Sr, Ti, V and Zn. An Agilent 7700x Quadrapole ICP-MS was used to analyse for: Sc, Ti, V, Cr, Mn, Co, Ni, Cu, As, Rb, Y, Zr, Nb, Mo, Ag, Cd, Sb, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm Yb, Lu, Hf, Ta, W, Au, Hg, Pb, Th and U. A DIONEX-ICS 2100 anion chromatograph was used to determine F, Cl, Br, SO_4, NO_3 and PO_4 by ion chromatography. Anion samples were first diluted by mass as required. No blind standards were used.

DIC/DOC analysis was performed at the University of Ottawa Hatch Lab using an OI Analytical Aurora Model 1030W TOC Analyser.

Iron speciation was determined at the University of Ottawa (Ottawa) colorimetrically by the Ferrozine method (Stookey *et al.*, 1970).

The additional dissolved metal samples collected at the first sampling of each site were analysed at the Geological Survey of Canada, Booth Street, Ottawa, laboratories. Analysis was done by ICP-OES and ICP-MS as per McCurdy *et al.*, (2012). Laboratory quality assurance for these samples was provided by two known standards analysed by the laboratory. No blind standards were used. These might be considered an agency duplicate, as all handling, sampling and analysis were completed by a separate agency once the samples left the field.

3.5 Sediment Laboratory Analysis

At the Geological Survey of Canada, Booth Street, Ottawa, laboratories the sediment samples were dry sieved to collect the -80 mesh (<177 microns) fraction. Three splits of the fine fraction were taken with one set being stored for later use. Three blind duplicates and two known reference standards were then inserted into the other two sample splits. One sample split was sent to Becquerel Laboratories, Mississauga, Ontario, for INAA analysis providing total concentrations of 35 elements. A second sample split was sent to ACME Analytical Laboratories, Vancouver, British Columbia, for analysis by aqua regia digestion followed by ICP-MS, providing concentrations of 65 elements.

3.6. Thermodynamic Modelling

Determination of expected equilibrium aqueous speciation and mineral saturation indices were performed using the geochemical calculations program PHREEQC version 3.3.7 (Parkhurst and Appelo, 2013). Thermodynamic data was provided by the MINTEQ database with the addition of the mineral phases schwertmannite and plumbojarosite (Hochella *et al.*, 1999; Yu *et al.*, 1999). The MINTEQ database was selected for

consistency with Kristen (Feige) Gault's previous work. The WATEQ4F database was also run as a sensitivity check, but not differences significant to this analysis were found.

Modelling was performed for one sampling event at each site between August 7th and 11th, 2013. These days were chosen as they had complete sets of in-situ and sample data, and as they were collected with the Durapore filters and 30 mL sample bottles in common usage by the Geological Survey of Canada. The input solution composition consisted of Al, Ba, Ca, Cd, Cu, Fe(II), Fe(III), K, Mg, Mn, Na, Ni, Pb, Si, Zn F, Cl, SO_4^{2-}, and NO^{3-} concentrations; as well as temperature, pH, and pE. Field ORP values adjusted for SHE and temperature were used to derive pe (Appendix 2). Where Fe(II) was measured in stream waters, redox potential was defined as being controlled by the Fe(II)/Fe(III) redox couple.

4.0 Results

4.1 Quality Control

Logistical complications during fieldwork created a significant possibility for quality control issues in this sampling program. The two brands of filters and sample bottles used create a lack of consistency that must be addressed. Tables 1 and 2 summarize the travel, acid and filter blanks analyzed at the University of Ottawa laboratories for both Whitehorse (PAL filters, 250 mL bottles) and Ottawa (Durapore filters, 30 mL bottles) sourced sampling equipment.

Note that the University of Ottawa geochemistry laboratory reported an instrument limit of detection (LOD) based on variability of laboratory blank measurements. Specifically the formula used is three times the standard deviation of the blanks. Conversely, the Geological Survey of Canada reports a concentration limit of detection

derived by analyzing the variability within a known standard or sample (J. Vaive, personal comm). The University of Ottawa LODs were typically much lower than the LODs reported by the Geological Survey of Canada. ICP-MS LODs reported at the University of Ottawa in particular were often 1-2 orders of magnitude lower than those of the Geological Survey of Canada.

Table 1. Average major element concentrations (ppm) found in blanks by type and bottle size. In both samples sets filtration appears to have scavenged some metals from the deionized water. LOD indicates samples are below the level of detection.

	Bottle	n	Al	Ca	Fe	K	Mg	Mn	Na	S	Si	Zn
LOD	(mL)		0.009	0.005	0.002	0.046	0.001	0.001	0.021	0.117	0.025	0.001
Travel Blank	250	2	0.115	0.011	0.177	LOD	0.018	LOD	LOD	0.347	LOD	0.004
Acid Blank	250	2	0.013	0.037	0.004	LOD	0.019	LOD	0.347	LOD	LOD	LOD
Filter Blank	250	2	0.009	LOD	LOD	LOD	0.001	LOD	LOD	LOD	LOD	LOD
Travel Blank	30	6	LOD	0.008	LOD	LOD	0.003	LOD	LOD	LOD	LOD	LOD
Acid Blank	30	6	LOD	LOD	LOD	LOD	0.001	LOD	LOD	LOD	LOD	LOD
Filter Blank	30	4	LOD	LOD	LOD	LOD	0.001	LOD	LOD	LOD	LOD	LOD

Blanks, which exceed these very low LODs reported at the University of Ottawa, do not automatically indicate contamination, but rather are a measure of natural and potentially unavoidable background levels of dissolved elements in both field and working laboratory settings.

The 250 mL travel blank collected on August 10th, 2013, does appear to have been contaminated with low levels of Al, Fe and other metals exceeding some values occurring

in the neutral drainages. It does not approach concentrations found in any of the acidic drainages or the South MacMillan River.

Table 2. Average minor element concentrations (ppb) found in blanks by type and bottle size. In both sample sets filtration appears to have scavenged some metals from the deionized water. LOD indicates samples are below the level of detection.

LOD	Bottle (mL)	n	Ni 0.0289	Cu 0.0046	As 0.0187	Cd 0.0020	Ba 0.0049	Pb 0.0036	U 0.0002
Travel Blank	250	2	0.354	0.0	0.02	0.04	0.03	0.004	0.0057
Acid Blank	250	2	0.0797	0.0705	LOD	0.01	0.12	0.013	0.0004
Filter Blank	250	2	0.035	0.027	LOD	0.00	0.18	0.004	LOD
Travel Blank	30	6	0.047	0.035	LOD	0.00	0.29	0.004	0.0002
Acid Blank	30	6	0.04	0.02	LOD	0.00	0.02	0.006	0.0002
Filter Blank	30	4	0.247	0.022	LOD	0.00	0.03	0.004	LOD

Field and laboratory duplicates were generally in good agreement with few exceeding 10% relative percent difference (RPD). The acid blanks and equipment duplicates showed a consistent enrichment in Na for the 250 mL bottles. This appears likely to be caused by the nitric acid preservative as seen in the acid blanks. Several dissolved stream samples had Na concentrations below that measured in the 250 mL acid blanks (0.347 ppm), usage of this data would require a project based LOD. Sodium data collected in this manner was not required for this assessment.

Relative percent error for cations and anions were in agreement with less than 10% error. Fe(II) concentrations were checked to ensure they did not exceed total dissolved iron concentrations. Dissolved metal analysis was also checked to ensure it did

not exceed total metal analysis, and water samples collected by the Geological Survey of Canada and analyzed at their laboratories were compared to those analyzed by the University of Ottawa. Full blank and duplicate data are available in Appendix 1.

4.2 Water Chemistry

Streams sampled had pH values ranging from 3 to 8.3 and moderate water temperatures of 8 to 15°C (Table 3). The primary driver of variability was pH, with acidic (pH<4) streams having high metal loads, and neutral to basic (pH>6.9) streams having relatively low metal loads. All but two streams had SO_4 concentrations exceeding 100 ppm. The mixing of diverse waters causes the South MacMillan River to be extremely precipitate-rich, with red Fe(III) and white Al precipitates visible throughout. The concentrations and parameters presented in the following results are mean values from the one to six sampling events that occurred at each site. The lack of rainfall and short time period of sampling resulted in much lower sampling and temporal variability than spatial variability; therefore usage of mean values is appropriate.

4.2.1 Physio-chemical parameters

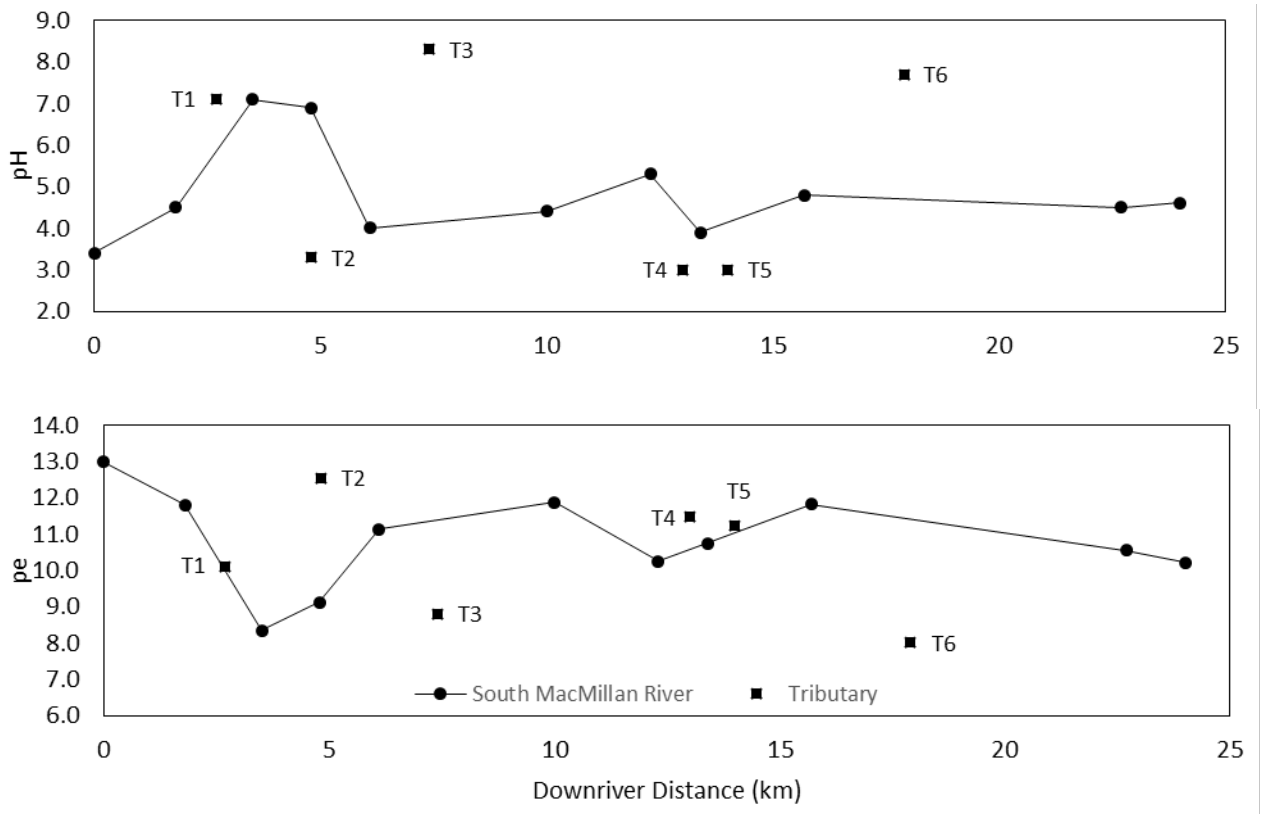

Figure 5. Highlighting the variability of the study sites, pH and pe (calculated from ORP values) with regards to distance from the most upstream site on the South MacMillan River (SM1). Sites along the South MacMillan River proper are connected while tributaries are individual squares. Sites T4 and T6 drain the Tom and Jason deposits respectfully.

A summary of field-collected parameters is presented in Table 3, for the full dataset please refer to Appendix 2.

Many tributaries were not sampled due to a short time frame and accessibility concerns; in at least one location the South MacMillan River appears to be significantly impacted by those tributaries that were missed. Groundwater is also certain to contribute to the stream flow, its relative impact cannot be determined with the information available. Due to mixing of the various contributing waters, mean pH at sampling locations of the main river channel fluctuated between 3.4 and 7.1 (Figure 5). The South MacMillan River

initially has a pH near 3 at site SM1 and SM2, but inputs between sites SM2 and SM3 neutralize the stream. Mixing from tributary site T2 returns the river to a pH of 4 by SM5. Inputs from inaccessible streams on the west side of the valley then return the pH above 5.3 at SM7. The two tributaries with the lowest pH are located midway down the east side of the valley and proximal to the Tom Deposit. These have a pronounced effect on the river, lowering the pH to 3.9 at SM8, even with the increased flow of the South MacMillan River this far down the valley. The main channel maintains a low pH downstream of these inputs and, despite reaching over 6 m wide, the most downstream sampling site (SM11) still has a pH of only 4.5. Redox potential (pe) generally shows an opposite trend to pH with low pH streams also being oxidized. The lowest pe value calculated is within the main channel at site SM3 below an unvisited stream from the west side of the valley. This illustrates the importance of the unreachable streams and potentially groundwater to stream chemistry. Barely detectable S^{2-} concentrations reflect the oxidizing nature of these waters.

Table 3. Field measurements from the South MacMillan River and tributaries. Where multiple sampling events occurred at the same location mean measurements were used. ORP values are corrected for SHE. Full data is available in Appendix 2.

Site	n	pH	Conductivity	Dissolved Oxygen	ORP	Temperature	S^{2-}
			µS/cm	mg/L	mV	˚C	µg/L
SM1	3	3.4	326.7	8.7	720.3	12.5	1
SM2	3	4.5	184.1	10.4	664.7	10.3	0
SM3	4	7.1	238.0	8.7	473.1	11.2	1
SM4	1	6.9	192.7	-	512.8	11.3	-
SM5	1	4.0	346.3	8.1	631.3	12.6	-
SM6	4	4.4	306.5	8.9	628.3	11.1	2
SM7	4	5.3	292.2	9.1	609.8	10.1	1
SM8	1	3.9	431.9	7.8	610.0	12.9	-
SM9	4	4.8	411.6	8.4	572.4	11.7	0
SM10	1	4.5	330.0	9.4	595.9	11.5	1
SM11	7	4.6	301.0	9.2	621.9	11.9	2
T1	2	7.1	34.5	9.3	572.5	9.5	0
T2	3	3.3	511.4	9.4	721.9	12.1	0
T3	1	8.3	359.8	8.8	496.3	10.7	-
T4	3	3.0	1398.9	9.6	654.5	10.2	0
T5	3	3.0	1746.4	8.3	651.7	10.8	0
T6	1	7.7	121.9	9.3	450.4	9.9	3

4.2.2. Dissolved constituents

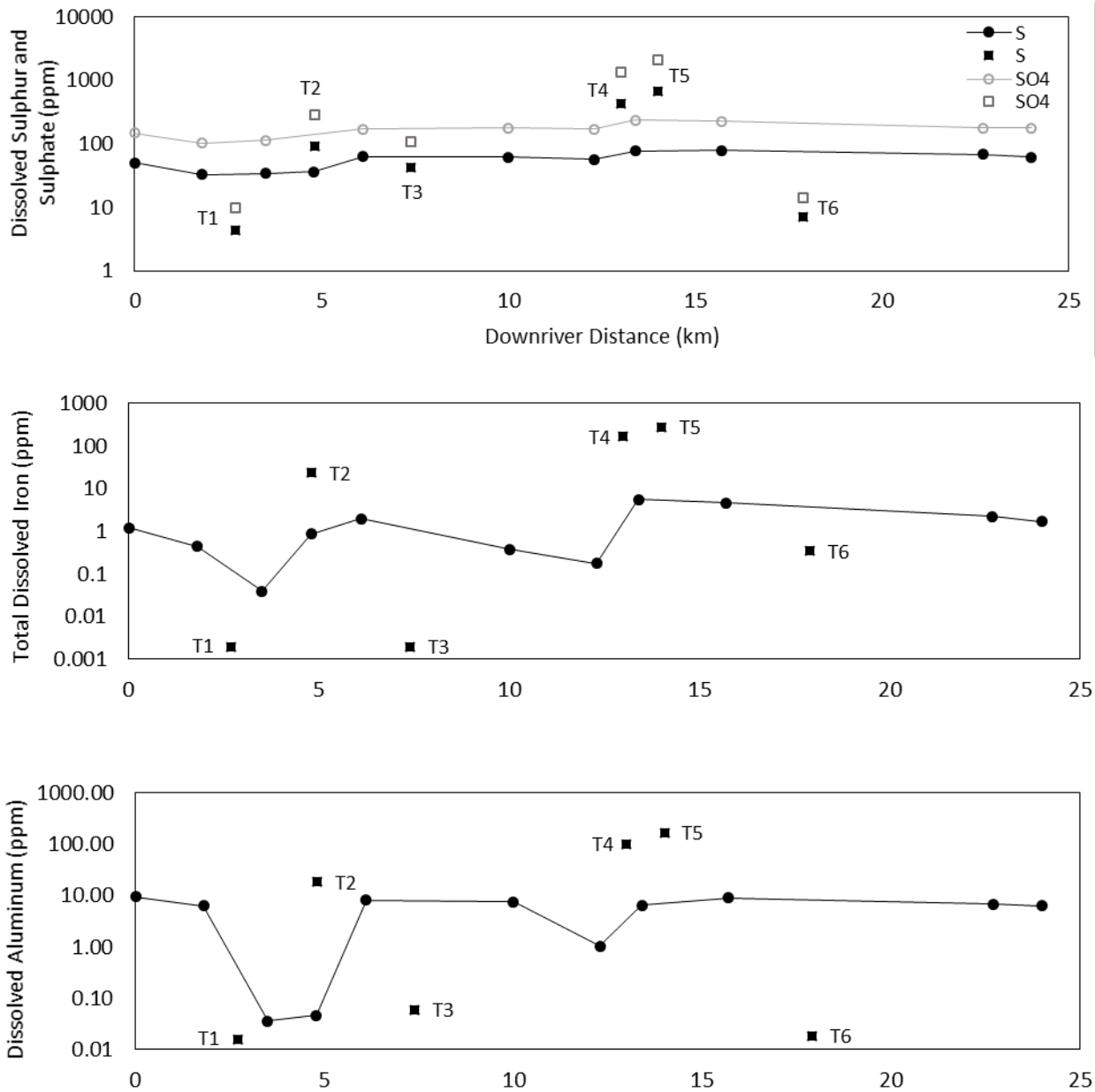

Figure 6. Iron, aluminum and sulphur with regards to distance from the most upstream site on the South MacMillan River (SM1). Sites along the South MacMillan River proper are connected circles while tributaries are individual squares. Sites T4 and T6 drain the Tom and Jason deposits respectfully.

A summary of major and trace element chemistry is presented in Tables 4 and 5,

the full data set can be found in Appendix 1. Sulphate (SO_4^{2-}) is the dominant anion with concentrations from 9.8 ppm (T1) to 2070 ppm (T5). All but two sites (T1 and T6) exceed 100 ppm. SO_4 closely correlates to dissolved S based on molarity (Figure 6). Dissolved S is addressed here as it was sampled at all sites and is available for comparison to the total (unfiltered) sample data. The dissolved S concentration of the main river is fairly stable, after dropping from an initial concentration of 50.1 ppm at SM1 to a low of 32.9 ppm at SM2, it increases over time to a high of 78.1 ppm at SM9, then decreases to 61.4 at SM11. T4 and T5 have very high S concentrations of 430 ppm and 670 ppm respectfully. T1 and T6 have the lowest S concentrations measured at 4.4 ppm and 7.1 ppm respectfully. T6 is somewhat surprising as it is directly down slope of the Jason deposit.

Dissolved metal concentrations along the South MacMillan River oscillate with the various stream inputs. Fe, Al, Mn, As, Cd, Co, Cr, Cu, Ni, Pb, U and Zn, all show initial peaks after inputs from low pH steams followed by diminishing concentrations (Figure 5 for Al, Fe and S). The concentrations of Fe and Al in particular have large-scale fluctuations. Ca and Mg show matching patterns; an initial increase in concentrations after the stream inputs between SM2 and SM3 followed by a generally stable but increasing trend (Table 4).

The low pH (pH 3) of Macintosh Creek's waters (T5) corresponds with the highest concentrations of Al, Fe, Mg, Ni, As, Si and S. Seckie Creek 2 (T4), draining the Tom deposit, has significantly higher concentrations of Mn, Cu, Zn, Cd and Pb. Dissolved Pb at this site is extremely high at 24.3 ppb. The only other sampling location to exceed a Pb concentration of 1 ppb was immediately downstream of the confluence of Seckie Creek

2 and the South MacMillan River (SM8).

Site T2 (pH 3.3) provides an interesting contrast to Seckie Creek 2 and Macintosh Creek where dissolved metal concentrations are closer to that found along the South MacMillan River. Site SM1 represents the acidic (pH 3.4) main channel of the South MacMillan River near its headwaters. It is the only low ph (pH <4) tributary with no ferricrete hardpan and metal concentrations are not notably high.

Neutral to basic streams T1, T3 and T6 have the lowest concentrations of dissolved Mn and Zn. T3 is the most basic stream sampled with a pH of 8.3. It is characterized by high Ca concentrations approaching 70 ppm, no detectable Fe or K, and low Al. It does, however, contain SO_4 (106.6 ppm). Site T1, also with neutral waters, has the lowest Ca concentration measured at just over 5 ppm.

Table 4. Mean concentrations (ppm) of dissolved major elements in the South MacMillan River and tributaries**.**

	n	pH	Al	Ca	Fe	Mg	S	Si	Zn	SO4
LOD			0.009	0.005	0.002	0.001	0.117	0.025	0.001	0.09
SM1	3	3.4	9.572	16.307	1.214	4.145	50.054	3.693	0.791	147.23
SM2	3	4.4	6.353	15.910	0.447	3.823	32.916	3.138	0.530	103.26
SM3	4	7.1	0.036	29.761	0.040	9.240	33.912	2.246	0.209	113.15
SM4	1	6.9	0.046	28.463	0.865	9.010	36.124	2.430	0.260	N/A
SM5	1	4.0	8.119	25.237	1.994	9.119	63.519	3.645	0.930	171.89
SM6	4	4.4	7.640	26.071	0.381	13.202	61.961	3.527	0.989	176.91
SM7	4	5.3	1.049	33.210	0.176	15.356	56.367	2.913	0.793	171.27
SM8	1	3.9	6.414	31.529	5.563	14.836	76.802	3.163	1.464	225.70
SM9	4	4.8	9.102	32.351	4.668	15.176	78.100	3.408	1.438	235.53
SM10	1	4.5	6.859	29.469	2.201	12.856	68.428	3.346	1.198	177.64
SM11	7	4.6	6.315	27.761	1.670	12.300	61.447	3.233	1.119	176.33
T1	2	7.1	0.016	4.600	0.002	1.445	4.405	2.123	0.016	9.77
T2	2	3.3	18.623	15.238	23.462	7.799	93.281	4.671	1.964	288.27
T3	1	8.3	0.061	63.256	0.002	13.018	42.179	1.611	0.016	106.60
T4	3	3.0	101.35	28.008	163.50	18.668	434.15	8.281	13.725	N/A
T5	2	3.0	169.83	22.999	274.97	31.028	670.14	14.575	7.511	2069.96
T6	1	7.7	0.019	18.699	0.346	4.195	7.106	2.624	0.052	14.05

Table 5. Mean concentrations (ppb) of dissolved trace elements in the South MacMillan River and tributaries

	n	pH	V	Mn	Co	Ni	Cu	As	Cd	Pb
LOD			0.037	0.014	0.0004	0.029	0.005	0.019	0.002	0.0036
SM1	3	3.4	0.06	262.6	22.11	145.8	31.9	0.13	7.79	0.140
SM2	3	4.4	0.21	211.9	16.95	116.3	25.0	0.13	5.97	0.088
SM3	4	7.1	0.37	107.5	8.84	65.7	1.2	0.04	3.53	0.005
SM4	1	6.9	0.12	124.5	10.51	75.0	2.0	0.04	3.80	0.008
SM5	1	4.0	0.10	341.9	24.99	152.5	42.7	0.10	20.60	0.062
SM6	4	4.4	0.21	397.1	22.57	156.9	37.0	0.08	21.91	0.076
SM7	4	5.3	0.20	272.2	15.58	128.8	21.9	0.08	15.47	0.016
SM8	1	3.9	0.55	321.1	22.20	180.5	32.5	0.21	39.78	1.082
SM9	4	4.8	0.08	346.9	23.87	198.4	33.4	0.16	39.38	0.489
SM10	1	4.5	0.04	254.5	16.77	147.1	22.0	0.13	27.82	0.239
SM11	7	4.6	0.05	265.8	17.31	151.5	22.4	0.12	28.26	0.248
T1	2	7.1	0.37	0.2	0.10	9.1	0.4	0.04	0.13	0.004
T2	2	3.3	11.95	419.5	45.74	281.7	116.9	1.87	55.06	0.150
T3	1	8.3	0.22	0.3	0.14	16.3	0.3	0.14	0.52	0.004
T4	3	3.0	307.87	1664.4	151.42	1212.1	241.0	17.30	484.92	24.327
T5	2	3.0	1057.51	943.4	173.36	1584.5	127.8	49.71	174.53	0.055
T6	1	7.7	0.05	44.9	0.20	3.6	0.3	0.48	0.14	0.029

4.2.3 Redox Chemistry, Ferrous Iron

Summarized Fe speciation measurements are presented in Table 6. Appendix 3 contains complete results. Concentrations of Fe(II) were highest in acidic tributaries T4 and T5 (26.9 ppm and 39.6 ppm). Sites T2, SM8 and SM9 also had elevated Fe(II) concentrations at 1.6 ppm,1.2 ppm and 1.1. Fe(II) made up the largest percentage of total iron where concentrations of both forms were low.

Table 6. Mean concentrations of total, ferrous and ferric iron.

Site	Total Fe ppm	Fe(II) ppm	Fe(III) ppm	Fe(II) %
SM1	1.214	0.121	1.093	9.9
SM2	0.447	0.065	0.383	14.5
SM3	0.040	0.011	0.027	28.4
SM6	0.381	0.104	0.277	27.3
SM7	0.176	0.026	0.150	14.6
SM8	5.563	1.161	4.402	20.9
SM9	4.668	1.093	3.575	23.4
SM10	2.201	0.539	1.662	24.5
SM11	1.727	0.380	1.347	22.0
T1	0.000	0.000	0.000	-
T2	23.462	1.581	22.408	6.7
T3	0.000	0.000	0.000	-
T4	163.496	26.887	136.610	16.4
T5	274.968	39.647	235.320	14.4
T6	0.346	0.034	0.312	9.9

4.3 Solid Sediment Chemistry

4.3.1 Suspended Sediment

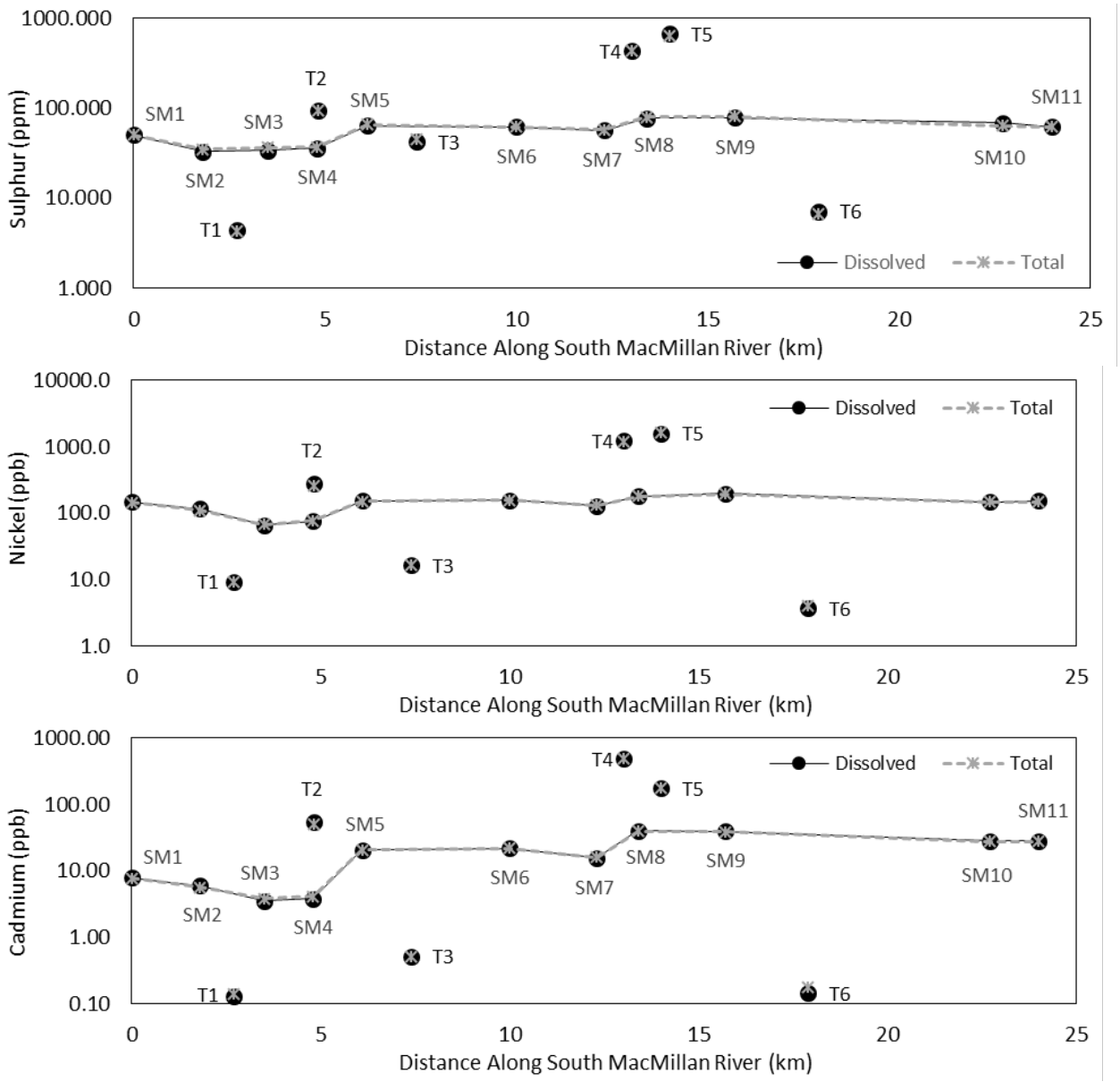

Figure 7. Total and dissolved concentrations along the South MacMillan River showing lack of adsorption and coprecipitation for sulphur, nickel and cadmium.

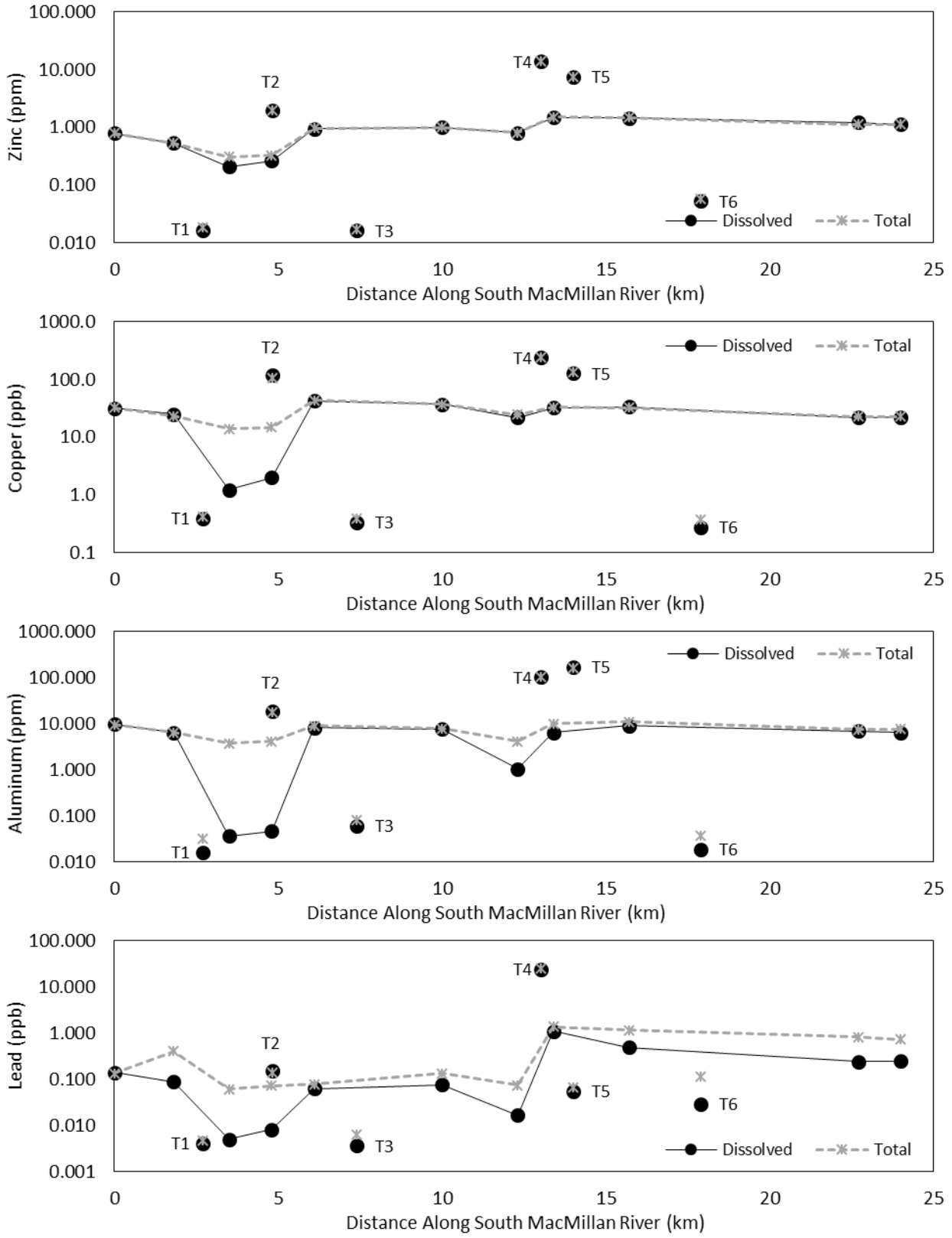

Figure 8. Total and dissolved concentrations along the South MacMillan River showing adsorption and coprecipitation of zinc, copper and aluminum and lead.

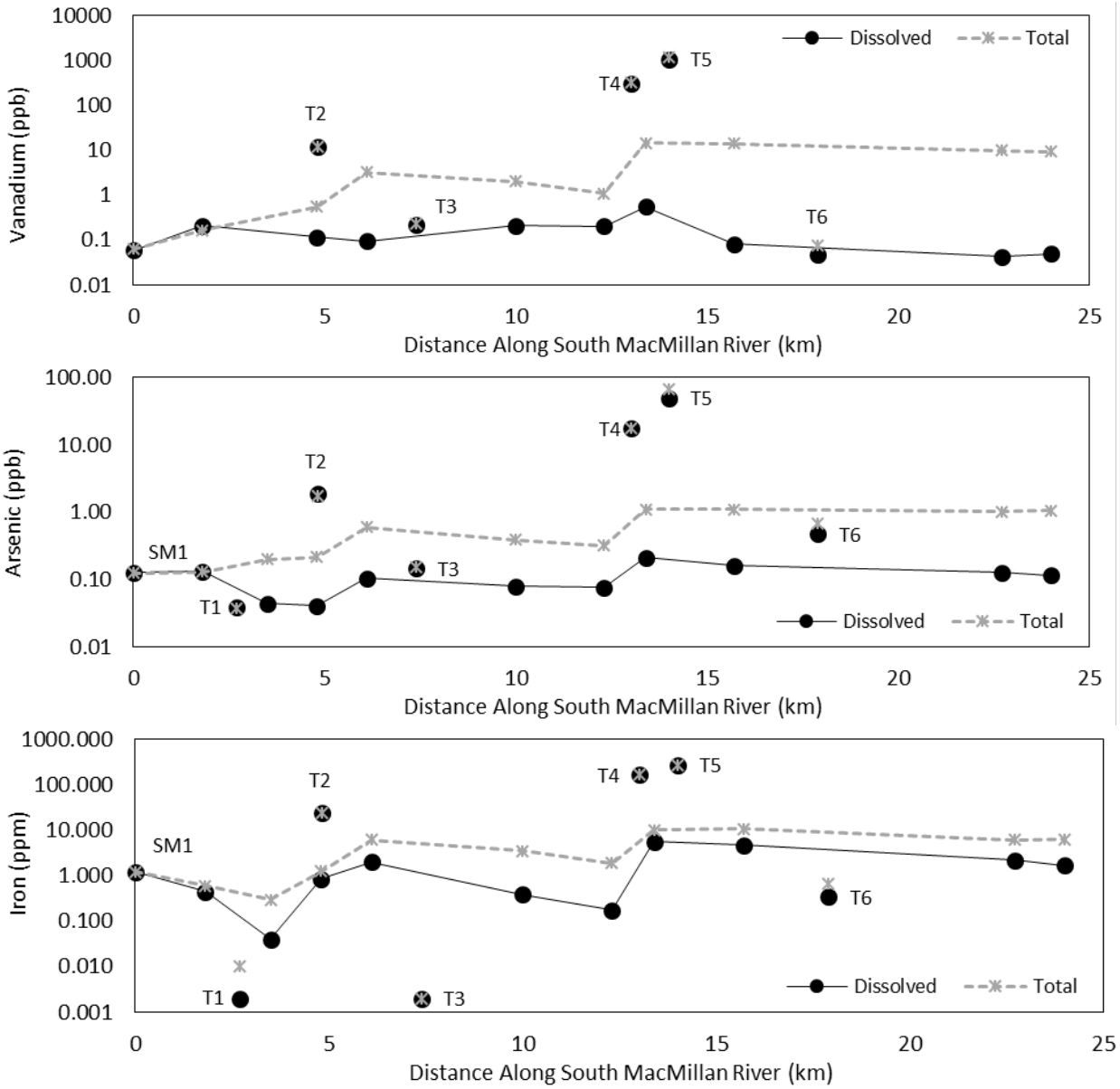

Figure 9. Total and dissolved concentrations along the South MacMillan River showing increasing sequestration of lead, iron, arsenic and vanadium.

Figures 7, 8 and 9 showing both dissolved and total metal loading illustrate how dissolved concentrations vary relative to the total load of the water column. The separation between the two becomes the suspended sediment fraction. Note that the figures are ordered according to the combined adsorption series for Al and Fe oxides. Measurements from the unfiltered samples are summarized in Tables 7 and 8. At the sites with the lowest pH, particularly T2, T4, T5, and SM1 total metal concentrations are

equivalent to the dissolved concentrations. A similar situation exists at tributaries T1, T3 and T6 where both dissolved and total concentrations of most metals are low. The main channel is far more dynamic particularly after confluences with tributaries where total and dissolved concentrations differ significantly due to increases in the suspended sediment fraction.

Fe shows fairly stable downward trends following tributary inputs, with dissolved Fe being depleted more quickly than total Fe (Figure 9). Total and dissolved Al concentrations are very closely matched after initial inputs, followed by drastic decreases in dissolved Al, then a return to similar concentrations at the next acidic input (Figure 8).

Total and dissolved Zn concentrations are similar (Figure 8), while Pb shows diverging and realigning concentrations that are intermediate between Al and Fe (Figure 8). The total S, Ni and Cd concentrations are dominantly dissolved and does not show the fluctuations experience by Fe and Al (Figure 7).

Due to the log scaling required for the above graphs, in all but the lowest concentrations the standard deviation is roughly the same size as the symbol and hidden. As such they are not presented on the figures. Summary statistics for the data presented in Figures 7, 8 and 9 are contained in Appendix 4.

Table 7. Mean concentrations (ppm) of dissolved major elements in the South MacMillan River and tributaries.

	n	pH	Al	Ca	Fe	Mg	S	Si	Zn
LOD			0.009	0.005	0.002	0.001	0.117	0.025	0.001
SM1	3	3.4	9.552	16.267	1.221	4.144	50.064	3.685	0.788
SM2	3	4.5	6.394	15.991	0.599	3.836	34.883	3.157	0.528
SM3	4	7.1	3.738	31.847	0.295	9.726	36.454	2.672	0.305
SM4	1	6.9	4.155	28.716	1.254	9.087	37.207	2.769	0.322
SM5	1	4.0	9.027	25.798	6.215	9.259	66.062	3.705	0.953
SM6	4	4.4	7.771	25.774	3.515	13.212	62.335	3.528	0.987
SM7	4	5.3	4.125	33.045	1.915	15.412	57.144	2.986	0.808
SM8	1	3.9	9.920	32.533	10.206	15.018	80.012	3.306	1.491
SM9	4	4.8	10.935	33.348	10.617	15.475	81.035	3.549	1.475
SM10	1	4.5	7.466	26.802	6.226	11.994	63.885	3.168	1.113
SM11	7	4.6	7.553	27.817	6.337	12.290	62.066	3.300	1.122
T1	2	7.1	0.031	4.490	0.010	1.415	4.287	2.086	0.019
T2	2	3.3	17.943	14.627	23.784	7.752	95.148	4.508	1.918
T3	1	8.3	0.079	63.282	0.002	13.943	44.772	1.706	0.017
T4	3	3.0	102.739	28.178	166.278	18.832	438.795	8.347	13.830
T5	2	3.0	164.235	22.625	277.351	30.866	630.812	14.424	7.437
T6	1	7.7	0.037	18.046	0.683	4.064	6.712	2.549	0.057

Table 8. Mean concentrations (ppb) of dissolved minor elements in the South MacMillan River and tributaries.

	n	pH	V	Mn	Co	Ni	Cu	As	Cd	Pb
LOD			0.0365	0.0138	0.0004	0.0289	0.0046	0.0187	0.0020	0.0036
SM1	3	3.4	0.06	260.5	21.92	145.4	32.0	0.12	7.65	0.132
SM2	3	4.5	0.17	201.3	15.87	109.9	23.3	0.13	5.65	0.399
SM3	4	7.1	0.06	107.9	8.99	66.9	13.8	0.20	3.78	0.060
SM4	1	6.9	0.55	127.6	10.84	77.3	14.8	0.22	4.10	0.072
SM5	1	4.0	3.26	338.1	24.78	150.6	43.5	0.59	20.37	0.078
SM6	4	4.4	2.00	396.3	22.34	155.5	37.2	0.39	21.79	0.132
SM7	4	5.3	1.08	276.3	15.79	131.4	24.4	0.32	15.93	0.074
SM8	1	3.9	14.57	317.3	21.67	178.5	32.8	1.10	39.17	1.360
SM9	4	4.8	14.12	338.8	23.22	192.5	32.3	1.11	38.54	1.152
SM10	1	4.5	9.88	256.1	16.83	146.3	22.7	1.00	27.58	0.821
SM11	7	4.6	9.36	260.3	16.82	147.4	22.7	1.06	27.68	0.720
T1	2	7.1	0.20	0.5	0.13	9.2	0.4	0.04	0.14	0.005
T2	2	3.3	11.66	384.8	41.74	255.1	106.6	1.73	50.16	0.141
T3	1	8.3	0.23	0.2	0.13	16.7	0.4	0.15	0.52	0.006
T4	3	3.0	317.07	1658.3	150.91	1208.8	240.1	17.72	486.29	24.633
T5	2	3.0	1175.27	958.7	176.74	1623.7	133.9	66.98	176.17	0.065
T6	1	7.7	0.08	50.1	0.24	4.1	0.4	0.68	0.18	0.112

4.3.2 Fine Fraction Sediment Samples

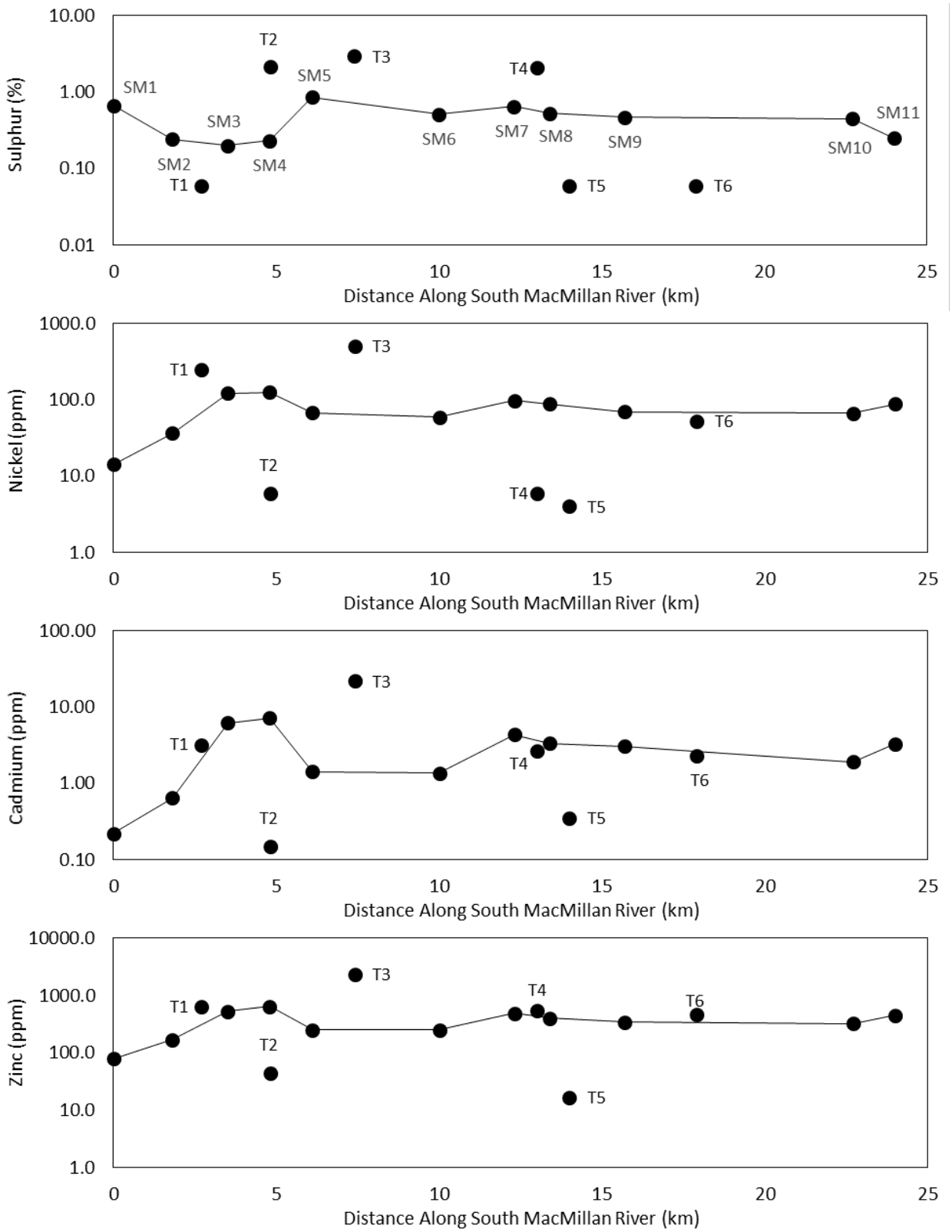

Figure 10. Fine fraction sediment concentrations along the South MacMillan River.

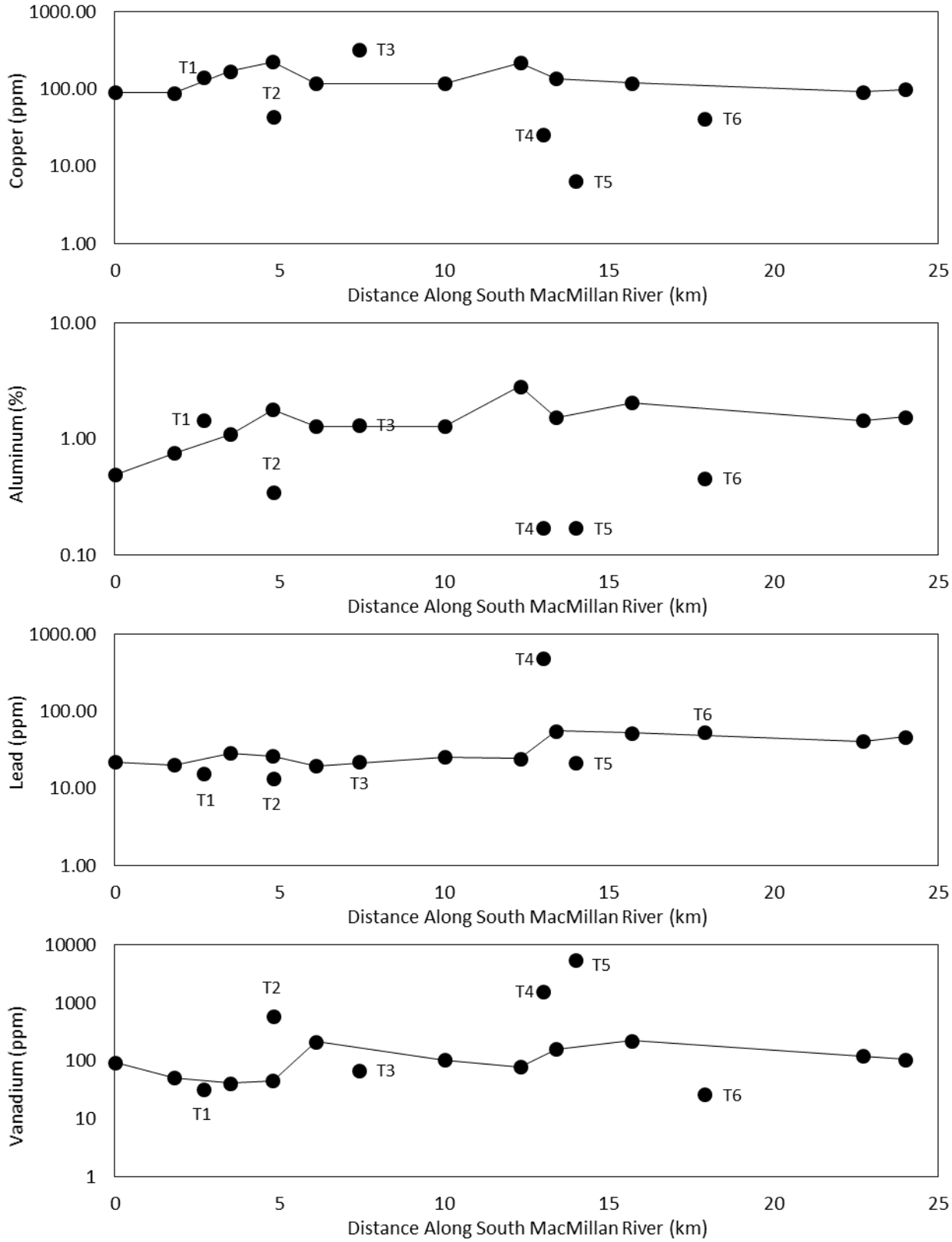

Figure 11. Fine fraction sediment concentrations along the South MacMillan River showing sequestration of metals.

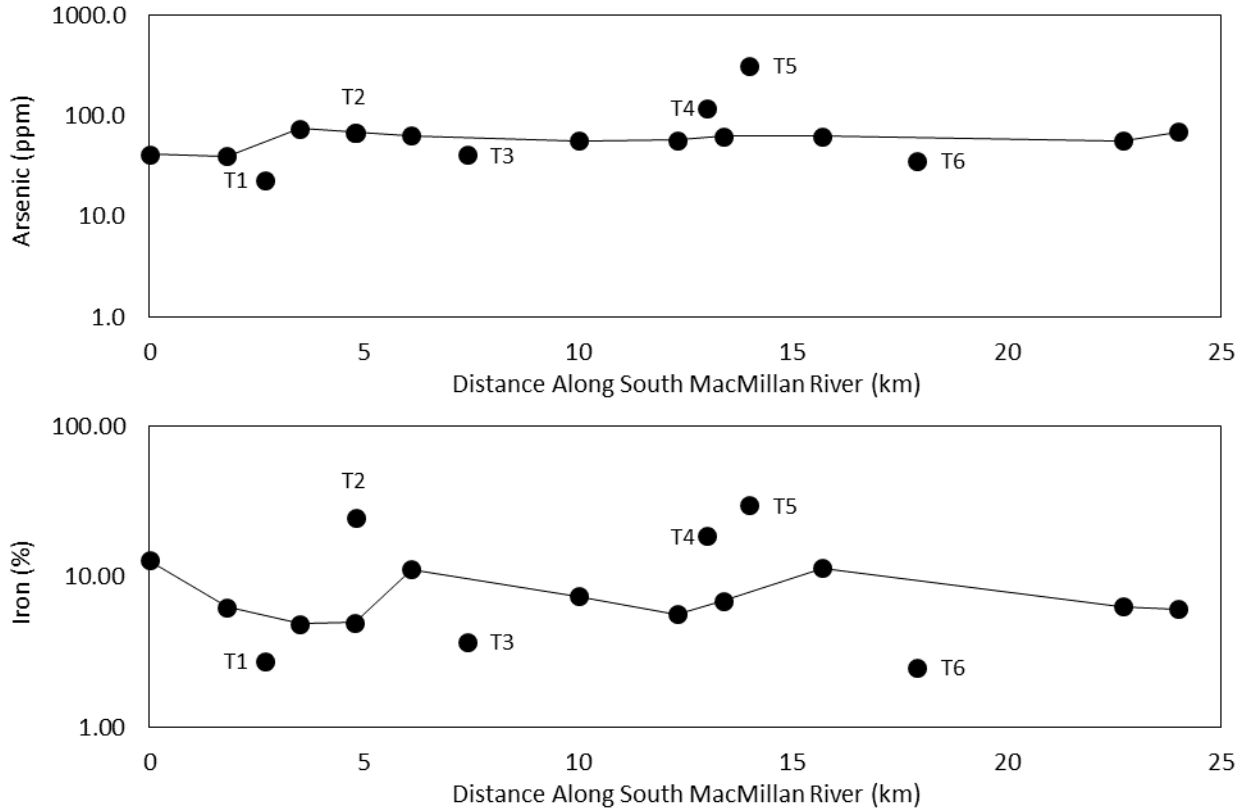

Figure 12. Fine fraction sediment concentrations along the South MacMillan River showing sequestration of metals.

With the exception of Cr, results by aqua regia/ICP-MS analysis show similar trends to those of total sediment concentration analysis conducted by INAA. Superior detection limits, precision, and data set size make aqua regia/ICP-MS the preferred method for this report. Full datasets are available in Appendix 5.

Figures 10, 11 and 12 highlight surging sediment concentrations downstream of acidic confluences. Many of these profiles take the inverse form of the total water column concentrations shown if Figures 7, 8 and 9. Iron concentrations are highest at T2, T4, and T5 (>18%), which are underlain by Fe-oxide ferricretes. The neutral tributaries T1, T3 and T6 are very low in iron (<5%) relative to the others. The South MacMillan River Fe concentrations oscillate similar to the dissolved Fe concentrations, with a peak after low pH tributary inputs followed by a gradual decline.

Al concentrations on the other hand have decreased concentrations immediately following an acid input, followed by an eventual rise. The rise appears to occur some distance downstream, being measured at the next site after the divergence of dissolved and total aluminium water samples. The highest Al values are found at site SM7 (2.7%), which had extensive white Al-oxide precipitates. The concentration of Al drops rapidly by SM8, which is right after low pH tributary T4 joins the South MacMillan River. The lowest Al concentrations were at low pH tributaries SM1, T2, T4, and T5 along with T6 (< 0.5%).

Pb and Zn are notable elements in the data set. Pb's profile is characterized by an extreme spike at sampling location T4 on Seckie Creek 2, immediately downstream of the Tom ore deposit. While no other sediment samples exceeded 60 ppm, the concentration measured at T4 is an elevated 483 ppm. Meanwhile, Zn has a peak at 2353 ppm at T3, downstream of carbonates where no known ore deposit exists (Figure 10).

Ca and Mg are highest at the neutral upstream sites T3, SM3 and SM4. Mn concentrations are highest at neutral drainage sites (1008 ppm at T1) and lowest at acidic sites (7 ppm at T5). Cu and Co concentrations have similar patterns to Mn, but are notably absent at site T6 and have an extreme spike at site T1. The highest Ni concentrations are found at neutral tributaries T1 and T3 (247 ppm and 508 ppm).

Table 9. Concentrations fine fraction sediment major elements in the South MacMillan River and tributaries.

	pH	Al	Ca	Fe	Mg	S	Zn
		%	%	%	%	%	PPM
LOD		0.01	0.01	0.01	0.01	0.02	0.1
SM1	3.4	0.49	0.03	12.85	0.07	0.67	78.0
SM2	4.5	0.76	0.10	6.26	0.09	0.24	168.0
SM3	7.1	1.10	0.68	4.85	0.26	0.20	530.0
SM4	6.9	1.80	0.55	4.98	0.24	0.23	635.4
SM5	4.0	1.28	0.17	11.19	0.10	0.85	252.0
SM6	4.4	1.29	0.15	7.42	0.09	0.51	250.2
SM7	5.3	2.86	0.32	5.66	0.09	0.65	485.8
SM8	3.9	1.54	0.23	6.92	0.07	0.53	398.2
SM9	4.8	2.06	0.24	11.40	0.06	0.47	341.5
SM10	4.5	1.44	0.29	6.37	0.09	0.45	320.9
SM11	4.6	1.55	0.31	6.12	0.10	0.25	447.2
T1	7.1	1.46	0.17	2.74	0.13	0.06	637.3
T2	3.3	0.35	<0.01	24.83	0.10	2.14	43.9
T3	3.0	1.32	1.38	3.70	0.31	0.06	2353.7
T4	3.0	0.17	0.02	18.74	0.01	2.08	549.4
T5	8.3	0.17	<0.01	29.91	0.02	2.97	16.8
T6	7.7	0.46	0.32	2.49	0.14	0.06	469.9

Table 10. Concentrations of fine fraction sediment minor elements in the South MacMillan River and tributaries.

	pH	V	Mn	Co	Ni	Cu	As	Cd	Pb
		PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
LOD		2	1	0.1	0.1	0.01	0.1	0.01	0.01
SM1	3.4	93	61	2.5	14.3	90.85	41.6	0.22	22.14
SM2	4.5	51	226	10.0	36.4	90.02	40.0	0.64	20.10
SM3	7.1	41	457	28.2	120.9	171.42	75.3	6.23	28.61
SM4	6.9	45	546	36.0	125.4	226.22	68.7	7.16	26.54
SM5	4.0	213	263	19.0	67.9	117.97	64.1	1.42	19.75
SM6	4.4	103	230	12.9	59.2	118.23	56.7	1.36	25.59
SM7	5.3	79	375	19.9	97.6	219.57	57.4	4.36	24.36
SM8	3.9	160	307	17.6	88.6	136.15	63.2	3.34	55.79
SM9	4.8	220	164	9.4	69.3	120.41	62.5	3.07	52.31
SM10	4.5	121	138	9.2	66.7	92.45	56.3	1.91	40.76
SM11	4.6	106	420	23.9	88.6	98.59	69.5	3.30	46.93
T1	7.1	32	1008	83.8	247.4	140.64	22.7	3.21	15.52
T2	3.3	587	36	1.0	6.0	43.89	67.3	0.15	13.46
T3	3.0	69	834	34.7	507.6	327.61	41.0	22.01	22.04
T4	3.0	1572	19	0.9	6.0	25.76	120.5	2.65	483.13
T5	8.3	5511	7	0.4	4.0	6.47	318.1	0.35	21.38
T6	7.7	26	804	8.8	52.7	41.88	36.1	2.31	53.13

4.3.3 X-Ray Diffraction

XRD analysis of ferricrete samples collected at T2, T4 and T5 suggest that schwertmannite is present at all three locations. Ferrihydrite is present at T2 and T5, T4 as well. Jarosite is present at the most acidic sampling location, T5. XRD profiles are available in Appendix 6

4.3.4 Thermodynamic Modelling

Saturation indices for selected minerals associated with acid rock drainage are presented in Appendix 7. T2, T4 and T5, are all saturated with respect to schwertmannite, with the exception of SM1. It is, however, saturated with respect to other iron ARD

minerals including jarosite, plumbojarosite, and goethite. The South MacMillan River was saturated with respect to ferrihydrite at sites SM7, SM8, SM9, SM10, and SM11, all sites above pH 4.5 with visible Fe precipitates. The streams were also saturated with respect ferrihydrite at sites T2, and T5, but not at low pH site T4. The stream water is only saturated with respect to gibbsite at sites SM3, SM7 and SM9. SM3 and SM7 are where large decreases in dissolved Al were present, and the only areas where white Al precipitates were visible. Basaluminite and hydrobasaluminite are not included in the database as appropriate thermodynamic data was not located.

5.0 Discussion

The stream system outlined in this paper is interesting and dynamic, unfortunately many pieces of the puzzle are missing. Many creeks which likely had a significant impact on water chemistry were inaccessible to sampling (Figure 3). Stream flow volume measurements were not possible with available equipment; therefore total loading and extent of dilution are unknown. The study area is large with a limited number of sampling sites spaced kilometers apart. It is likely that some of the inputs from unsampled drainages impact the South MacMillan River in ways not recorded in the data, particularly between sites SM5 and SM6, and between SM9 and SM10. Groundwater flow and inputs are also unable to be accounted for. With these caveats in mind, the system does conform to discussions found in the introductory literature.

5.1 Geology and Dissolved Water Chemistry

Low pH tributaries T2, T4 and T5, are closely associated with the Earn Group (D series), and its geological subsets containing shales; these include the Itsi Member (DMsh2a), and Tom Sequence (DMsh2b). The Tom Sequence in particular appears to

produce drainages with low pH. Under the South MacMillan River itself, unit (Dcg_2) appears to directly reduce pH as evidenced by visible in stream pyrite weathering at SM1, and decreased pH between sites SM3 and SM4 with no stream input.

Streams along the west side of the valley all appear to be neutral to basic. In the upper reaches, an un-sampled, inaccessible stream joins the South MacMillan River between sites SM2 and SM3. Its contribution causes a drop in pH between sites SM2 and SM4 with very fine white/bluish precipitates in the water column. This un-sampled stream along with tributaries T3 and T6 are underlain by the same acid generating Earn group shales as acidic tributaries T2, T4 and T5 (Figure 2). The non-acidic tributaries also drain the limestone bearing Rabbittkettle Formation, and Road River Group. It is notable that the stream sampled at location T1 does not appear to drain either shales or limestones, with its watershed located almost entirely within a chert pebble conglomerate known as the MacMillan Pass Member.

5.2 Fe(II) and Sulphide

Fe(II) concentrations are highest in the acidic tributaries due to the oxidation FeS_2 in their watersheds and the stability of Fe(II) at low pH. Fe(II) as a proportion of total Fe is actually higher in much of its main channel than the low pH streams feeding it. This is likely due to the rapid precipitation of Fe(III) as ferrihydrite under these conditions. There may also be contributions to Fe(II) from groundwater flow through the surrounding peats, soils and wetlands.

5.3 Mineral precipitation.

There are four low pH sites draining shales (SM1, T2, T4 and T5). Ferricretes underlie three of these streams, (T2, T4 and T5). While SM1 has a slightly higher pH (3.5)

and lower dissolved metals than the three other acidic sites draining shales, it is still saturated with respect to jarosite, goethite, ferrihydrite and hematite. It is, however, not saturated with respect to schwertmannite. At T2, T4 and T5, the stream is both saturated with respect to schwertmannite and it is identified in XRD analysis. This follows the pattern of schwertmannite as a precursor recrystallizing to the minerals jarosite and goethite previously described.

Characteristics of the South MacMillan River appear to be dominated by mixing dynamics of the various tributary streams rather than interactions with the underlying geology. Fe-oxides rapidly precipitate downstream of major confluences, as can be seen by the dissolved Fe concentrations showing sharp increases at confluences followed by declines (Figure 5). Co, Cu, Zn, Cd, Mn and Cr show similar patterns, likely due to their adsorption to Fe and Al-oxides.

The confluence of T2 and SM4, approximately two kilometers upstream of SM5 highlight this phenomenon. Here the low pH waters of T3 and the neutral waters flowing through SM4 meet and can be seen running parallel to each other with a narrow (<10 cm) rainbow pattern in the middle where slight mixing is occurring. By SM5, river morphology and flow have caused the two waters to mix and widespread amorphous yellow precipitates occur (Figure 13). A number of observations help to identify this precipitate: 1) the water is not saturated with respect to schwertmannite at this location 2) while dissolved Fe decreases relative to total Fe there is no corresponding decrease in dissolved S relative to total S, indicating this is not a hydroxysulphate, and 3) ferrihydrite, an oxyhydroxide, has been previously identified as being able to spontaneously precipitate under these conditions (Sánchez España, 2007). No other site was witnessed

to have had such a rapid mixing of two similarly sized streams, as the South MacMillan below this point appears to have enough flow to moderate the influence of incoming waters.

Figure 13. Ferrihydrite precipitation downstream of the confluence of low pH waters sampled at T3 and neutral waters sampled at SM4.

After this mixing and massive precipitation, both total and dissolved Fe concentrations decrease until reaching SM5. Suspended sediment makes up a large portion of the total Fe until site SM8. T4 and T5 cause the total and dissolved Fe levels to rapidly rise, to a peak at SM8. Sediment Fe levels rise more slowly, not peaking until SM9. This could be explained by the kinetically determined rate of ferrihydrite formation, and the subsequent deposition rate determined by the rivers ability to carry the suspended load.

A second possibility is that much of the increased sediment Fe concentration results directly from bedload inputs from the T2, T4 and T5 streams. There is no way to verify the exact nature of the sediment input without quantitatively characterizing the sediments for detrital ferricrete fragments.

At SM7, white precipitates visibly coat the riverbed. This same location shows a drop in dissolved Al relative to total as a portion is filtered out, and a rise in stream sediment Al. Once again, there is no drop in S concentrations, ruling out the hydroxysulfate hydro-basaluminite. Gibbsite, a hydroxide mineral, is saturated and is the likely candidate at this location. Downstream of SM7 at SM8, inputs from T4 have lowered the stream pH to 3.9. Stream sediment Al concentrations have dropped to pre-precipitate levels, and dissolved and total Al are once again closely aligned indicating that the portion of the mineral carried in suspended and bed load has likely dissolved under these conditions. It also indicates that for Al, bedload contributions from the tributaries to sediments are likely not a significant input.

5.4 Trace Elements

Matching the adsorption patterns identified for Al and Fe oxides, Ni and Cd are very mobile, remaining largely in the dissolved fraction of the water column. Fine fraction sediment concentrations do increase at locations experiencing gibbsite precipitation, indicating that some level of adsorption or coprecipitation must be taking place (Figure 10). Along the main channel Zn consistently begins to partition into the solid fraction when pH reaches 4.5 to 5. All sites with pH below 5 show very little if any Zn in the suspended sediment and fine fraction sediment. At SM3 and SM4, the only two sites along the main channel where pH is neutral (7.1 and 6.9), there is a marked decline in total Zn and an even greater decline in dissolved Zn. These correspond to a mirror increase in the fine fraction sediment Zn concentrations. By SM5, the river has returned to pH 4, and total Zn in the water column is almost entirely dissolved at approximately 1 ppm. The fine fraction sediment Zn also drops considerably. This process repeats itself at SM7 at pH 5.3.

Pb shows a somewhat similar pattern only with order of magnitude changes in concentration. There is an input of suspended sediment Pb between SM1 and SM2 that distorts the pattern. This is caused by the much higher proportion of Pb that fractions into the suspended sediment.

Referring back to the attenuation patterns for trace elements to absorption and co-precipitation (Fe(III) > As > V > Pb > Al > Cu, > Zn > Cd > Ni) this matches our pattern nicely. Fe is seen to begin partitioning to solid phases early, with Pb beginning to follow, then rapidly partitioning once Al oxides precipitate. Zn is more mobile than all Fe, Pb and Al and is only beginning to partition when Al undergoes wide scale fluctuations. As, Cu, Cd and Ni also appear to follow this trend.

Not entirely following the trend at this site are As and V. Large amounts of both fraction into the suspended sediment fragment just after SM2, and there they remain largely regardless of the relative amount of Fe in the dissolved and suspended fractions. This is likely due to the formation of oxyanions.

5.5 Waters from the Tom and Jason Deposits

Waters draining the Tom and Jason deposits are markedly different. The Tom deposit is drained by the low pH Seckie Creek 2, which was sampled at site T4. While this stream is low pH and metal rich, it is less so than the neighbouring Macintosh Creek sampled at site T5. Macintosh Creek may be geographically close to Seckie Creek 2, but it is draining a distinctly separate area from the Tom Deposit. The elevated levels of Pb in both water and sediment samples, with marginally higher Zn concentrations in the water, make Seckie Creek 2 distinct from the other acidic streams. Unfortunately the Seckie Creek 2 drainage is impacted with drainage from the exploration adit. Since the adit was not sampled separately with flow quantification, it is unknown how much impact it exerts on the stream drainage signature. The Tom deposit would have to be considered as an extreme end member for mineral deposit sources, where the unweathered deposit is at the immediate surface. A natural example of this could occur as a glacier retreats, exposing the fresh underlying material.

The stream draining the Jason deposit sampled at site T6 also drains significant portions of the acid generating Tom Sequence; however, the carbonates occurring within the Jason deposit and the nearby Road River Group appear to neutralize any acidity initially generated. This neutralization has allowed for the removal of metals released through weathering of the Jason Deposit, likely in the subsurface. While the waters of this

stream are somewhat distinct from waters sampled at sites T1 and T3, there is little to indicate that it is downstream of a significant ore body. In particular, Zn concentrations in the sediment are significantly lower than at the other two neutral tributaries and dissolved Pb values are roughly equal to those at other neutral tributary streams (T1). Pb concentrations are higher in the sediment, but it is doubtful this would attract enough attention to justify further exploration.

At streams in the nearby Howard's Pass, elevated dissolved and sedimentary Zn dispersal occur up to four kilometres from the source. Meanwhile, Pb is quickly scavenged from the dissolved phase onto charged surfaces, and as such, is not normally found in the dissolved phase downstream of an ore deposit (Goodfellow, 1983). This suggests that dissolved and sedimentary Zn could be traced back to a sedimentary Pb anomaly near the deposit.

Due to extreme metal loading, Seckie Creek 2 is close enough to the metal source for Pb to be anomalous in the dissolved fraction. Any Pb release from the Jason deposit, however, has already been scavenged and is primarily found in elevated sediment concentrations. Unfortunately, Zn levels can also remain high if acidic waters draining barren shales are neutralized due to its elevated mobility.

6.0 Conclusion

This geochemistry of the South MacMillan River is driven by mixing reactions. While other ARD systems precipitate Fe(III) and Al -hydroxysulphates such as schwertmannite and hydrobasaluminite as acidity is attenuated gradually, the rapid rise in pH from mixing appears to favour the precipitation of oxides and oxyhydroxides such as ferrihydrite and gibbsite.

The adsorption series identified at other sites appears to be largely in effect here, with the exception that once V and As are removed from the dissolved fraction, they do not appear to return. Fe concentrations are more dynamic and total and dissolved concentrations converge where acidity is re-introduced. It was also seen that while neutral pH streams do not contribute elevated concentrations of dissolved constituents, they still have a profound impact on the dynamics of the South MacMillan River.

Future studies may wish to assess the extent to which sediment inputs arrive via precipitation after mixing, and if bed load is a significant contributor to metal concentrations beyond the confluence of an acidic tributary.

7.0 Implications for Exploration

Thermodynamic modelling in itself appears to provide no specific vectors to an exploration target that cannot be found in dissolved, total and fine fraction sediment samples. What it does do is help support an understanding of the system so that the knowledge can be applied to future programs. Where it may be of benefit is where a company has recently located an anomaly and wants to advance its knowledge of metal mobility from similar sites.

Unfiltered samples to determine total metal concentrations provided useful stepping points between the dissolved and fine fraction sediments. For the minimal effort required to take an unfiltered sample it would appear to be an excellent return on investment. The expected sorption series developed within the environmental sector would also appear to be useful for exploration, as it expands upon the Zn-Pb couplet developed by Dr. Goodfellow over 30 years ago.

8.0 Environmental Considerations

The apparent ease of which the Al-oxide precipitates (gibbsite) were removed from the water column and sediments brings into question the term ‘self-mitigating’ with regard to ARD systems. If the Al-oxides dissipate they will release any bound metals back to the water column. It is not farfetched to envision other environments where these conditions may be present such as micro-environments within the substrate, or gastric fluids with the digestive system of aquatic life.

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Appendix 1: Water Chemistry Results

	Bottle	Timestamp	Al	As	B	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg
LOD:			0.009	0.017	0.009	0.001	0.005	0.003	0.006	0.002	0.004	0.002	0.046	0.001
ICP-ES			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Blanks														
Travel Blank	250	10-8-13	0.036	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	0.040	<0.046	0.004
Travel Blank	250	12-8-13	0.194	<0.017	<0.009	<0.001	0.016	<0.003	<0.006	<0.002	<0.004	0.314	<0.046	0.032
Acid Blank	250	10-8-13	0.011	<0.017	<0.009	0.002	0.040	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	0.019
Acid Blank	250	12-8-13	0.014	<0.017	<0.009	<0.001	0.034	<0.003	<0.006	<0.002	<0.004	0.006	<0.046	0.018
Field Blank	250	10-8-13	0.010	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Field Blank	250	12-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Travel Blank	30	7-8-13	<0.009	<0.017	<0.009	<0.001	0.022	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	0.012
Travel Blank	30	8-8-13	<0.009	<0.017	<0.009	<0.001	0.007	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	0.001
Travel Blank	30	9-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Travel Blank	30	10-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Travel Blank	30	11-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Travel Blank	30	12-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Acid Blank	30	7-8-13	<0.009	<0.017	<0.009	0.002	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	0.002
Acid Blank	30	8-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Acid Blank	30	9-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Acid Blank	30	10-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Acid Blank	30	11-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Acid Blank	30	12-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Field Blank	30	7-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Field Blank	30	9-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Field Blank	30	11-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Field Blank	30	12-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	0.001
TBlank	30	10-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
TBlank LD	30	10-8-13	<0.009	<0.017	<0.009	0.002	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	0.002
ABlank	30	9-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
ABLank LD	30	9-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
FBlank	30	11-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
FBlank LD	30	11-8-13	<0.009	<0.017	<0.009	<0.001	<0.005	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	<0.001
Filtered Samples														
SM1	250	3-8-13	9.228	<0.017	<0.009	0.023	15.830	0.008	0.025	<0.002	0.041	1.048	0.199	3.847
SM1	30	9-8-13	9.219	<0.017	<0.009	0.021	15.841	0.004	0.029	<0.002	0.049	1.259	0.055	4.117
SM1	30	11-8-13	10.268	<0.017	<0.009	0.029	17.251	0.005	0.032	<0.002	0.053	1.333	<0.046	4.469
SM2	250	4-8-13	6.498	<0.017	<0.009	0.036	16.177	0.005	0.015	<0.002	0.032	0.494	0.196	3.901
SM2	30	9-8-13	6.207	<0.017	<0.009	0.034	15.644	<0.003	0.016	<0.002	0.033	0.401	0.061	3.745
SM3	250	3-8-13	0.053	<0.017	<0.009	0.046	32.851	<0.003	0.010	<0.002	<0.004	0.045	0.284	9.940
SM3	250	6-8-13	0.045	<0.017	<0.009	0.040	28.259	0.003	0.010	<0.002	<0.004	0.051	0.202	8.801
SM3	30	8-8-13	0.015	<0.017	<0.009	0.039	27.715	<0.003	0.012	<0.002	<0.004	0.022	0.047	8.770

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	Al	As	B	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg
LOD:			0.009	0.017	0.009	0.001	0.005	0.003	0.006	0.002	0.004	0.002	0.046	0.001
ICP-ES			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SM3	30	10-8-13	0.032	<0.017	<0.009	0.042	30.218	<0.003	0.011	<0.002	<0.004	0.042	0.152	9.448
SM4	250	4-8-13	0.046	<0.017	<0.009	0.040	28.463	0.004	<0.006	<0.002	<0.004	0.865	0.307	9.010
SM5	30	7-8-13	8.119	<0.017	<0.009	0.031	25.237	0.025	0.040	<0.002	0.068	1.994	0.732	9.119
SM6	250	5-8-13	7.718	<0.017	<0.009	0.026	26.198	0.029	0.031	<0.002	0.056	0.402	0.794	13.057
SM6	250	6-8-13	7.384	<0.017	<0.009	0.026	25.995	0.031	0.030	<0.002	0.059	0.433	0.762	12.804
SM6	30	8-8-13	7.923	<0.017	<0.009	0.026	26.248	0.026	0.031	<0.002	0.061	0.334	0.814	13.443
SM6	30	10-8-13	7.534	<0.017	<0.009	0.026	25.844	0.030	0.034	<0.002	0.061	0.354	0.681	13.505
SM7	250	3-8-13	0.940	<0.017	<0.009	0.031	33.258	0.017	0.020	<0.002	0.029	0.218	0.564	15.249
SM7	30	8-8-13	1.273	<0.017	<0.009	0.030	32.126	0.015	0.025	<0.002	0.034	0.152	0.457	14.983
SM7	30	9-8-13	0.963	<0.017	<0.009	0.032	33.675	0.017	0.023	<0.002	0.037	0.176	0.535	15.915
SM7	30	11-8-13	1.021	<0.017	<0.009	0.030	33.781	0.015	0.015	<0.002	0.034	0.156	0.468	15.277
SM8	30	7-8-13	6.414	<0.017	<0.009	0.028	31.529	0.052	0.009	<0.002	0.050	5.563	0.626	14.836
SM9	250	5-8-13	8.631	<0.017	<0.009	0.028	30.124	0.051	0.009	<0.002	0.044	5.069	0.829	14.447
SM9	250	6-8-13	9.065	<0.017	<0.009	0.031	32.610	0.051	0.010	<0.002	0.053	5.101	0.866	15.452
SM9	30	9-8-13	8.799	<0.017	<0.009	0.031	33.155	0.049	0.015	<0.002	0.048	4.248	0.688	15.268
SM9	30	11-8-13	9.912	<0.017	<0.009	0.030	33.514	0.048	0.018	<0.002	0.053	4.254	0.719	15.538
SM10	30	8-8-13	6.859	<0.017	<0.009	0.032	29.469	0.039	0.027	<0.002	0.038	2.201	0.611	12.856
SM11	250	2-8-13	5.467	<0.017	<0.009	0.032	26.969	0.036	0.021	<0.002	0.031	2.181	0.691	11.718
SM11	250	3-8-13	6.620	<0.017	<0.009	0.032	27.604	0.037	0.015	<0.002	0.031	1.331	0.668	12.040
SM11	250	4-8-13	6.142	<0.017	<0.009	0.031	26.520	0.038	0.024	<0.002	0.031	1.672	0.696	11.697
SM11	250	6-8-13	5.874	<0.017	<0.009	0.032	27.254	0.037	0.024	<0.002	0.032	1.736	0.752	11.961
SM11	30	7-8-13	6.717	<0.017	<0.009	0.032	27.384	0.040	0.025	<0.002	0.034	1.569	0.679	13.645
SM11	30	9-8-13	6.264	<0.017	<0.009	0.033	27.790	0.032	0.033	<0.002	0.033	1.682	0.638	11.993
SM11	30	12-8-13	7.119	<0.017	<0.009	0.035	30.804	0.039	0.027	<0.002	0.038	1.522	0.646	13.043
T1	250	4-8-13	0.023	<0.017	<0.009	0.081	4.370	<0.003	<0.006	<0.002	<0.004	<0.002	0.058	1.316
T1	30	9-8-13	<0.009	<0.017	<0.009	0.088	4.830	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	1.575
T2	250	4-8-13	18.453	<0.017	<0.009	0.018	15.072	0.059	0.014	0.014	0.137	21.993	1.613	7.441
T2	250	7-8-13	18.453	<0.017	<0.009	0.017	14.848	0.072	0.017	0.013	0.165	23.593	1.670	7.403
T2	30	11-8-13	18.962	<0.017	<0.009	0.017	15.795	0.077	0.020	0.015	0.176	24.799	1.743	8.554
T3	30	7-8-13	0.061	<0.017	<0.009	0.050	63.256	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	13.018
T4	250	5-8-13	96.930	<0.017	0.115	0.012	26.638	0.665	<0.006	0.099	0.377	157.464	4.896	17.838
T4	30	8-8-13	104.658	<0.017	0.124	0.011	28.997	0.722	<0.006	0.107	0.406	168.211	4.723	19.253
T4	30	10-8-13	102.472	<0.017	0.128	0.010	28.389	0.710	<0.006	0.107	0.403	164.813	4.524	18.912
T5	250	5-8-13	164.984	0.062	0.215	0.005	21.672	0.227	<0.006	0.244	0.194	281.490	9.282	30.090
T5	30	8-8-13	181.316	0.059	0.203	0.005	23.665	0.256	<0.006	0.246	0.211	292.138	11.252	31.610
T5	30	12-8-13	163.188	0.067	0.232	0.004	23.660	0.260	<0.006	0.269	0.218	251.275	8.532	31.383
T6	30	10-8-13	0.019	<0.017	<0.009	0.110	18.699	<0.003	<0.006	<0.002	<0.004	0.346	<0.046	4.195

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	Al	As	B	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg
LOD:			0.009	0.017	0.009	0.001	0.005	0.003	0.006	0.002	0.004	0.002	0.046	0.001
ICP-ES			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
QA/QC														
SM5	30	7-8-13	8.119	<0.017	<0.009	0.031	25.237	0.025	0.040	<0.002	0.068	1.994	0.732	9.119
SM5	250	7-8-13	9.257	<0.017	<0.009	0.034	26.971	0.032	0.038	<0.002	0.074	2.420	0.946	9.693
T2	30	7-8-13	18.450	<0.017	0.010	0.017	14.959	0.061	0.017	0.013	0.158	23.547	1.508	7.366
T2	250	7-8-13	18.453	<0.017	<0.009	0.017	14.848	0.072	0.017	0.013	0.165	23.593	1.670	7.403
T3	30	7-8-13	0.061	<0.017	<0.009	0.050	63.256	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	13.018
T3	250	7-8-13	0.083	<0.017	<0.009	0.048	59.493	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	12.903
SM3	250	6-8-13	0.045	<0.017	<0.009	0.040	28.259	0.003	0.010	<0.002	<0.004	0.051	0.202	8.801
SM3 Field duplicate	250	6-8-13	0.049	<0.017	<0.009	0.048	33.326	0.004	0.011	<0.002	0.005	0.060	0.216	9.997
SM7 Field duplicate	250	3-8-13	0.940	<0.017	<0.009	0.031	33.258	0.017	0.020	<0.002	0.029	0.218	0.564	15.249
T1	250	4-8-13	0.023	<0.017	<0.009	0.081	4.370	<0.003	<0.006	<0.002	<0.004	<0.002	0.058	1.316
T1 Field duplicate	250	4-8-13	0.023	<0.017	<0.009	0.086	4.687	<0.003	<0.006	<0.002	<0.004	<0.002	0.090	1.399
T3	30	7-8-13	0.061	<0.017	<0.009	0.050	63.256	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	13.018
T3 Field duplicate	30	7-8-13	0.066	<0.017	<0.009	0.050	62.475	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	13.124
T3	250	7-8-13	0.083	<0.017	<0.009	0.048	59.493	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	12.903
T3 Field duplicate	250	7-8-13	0.086	<0.017	<0.009	0.054	66.447	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	14.101
T6	30	10-8-13	0.019	<0.017	<0.009	0.110	18.699	<0.003	<0.006	<0.002	<0.004	0.346	<0.046	4.195
T6 Field duplicate	30	10-8-13	0.014	<0.017	<0.009	0.102	17.426	<0.003	<0.006	<0.002	<0.004	0.253	<0.046	4.119
SM3	30	10-8-13	0.032	<0.017	<0.009	0.042	30.218	<0.003	0.011	<0.002	<0.004	0.042	0.152	9.448
SM3 Lab Duplicate	30	10-8-13	0.026	<0.017	<0.009	0.047	33.729	<0.003	0.010	<0.002	<0.004	0.045	0.202	10.454
SM7	30	11-8-13	1.021	<0.017	<0.009	0.030	33.781	0.015	0.015	<0.002	0.034	0.156	0.468	15.277
SM7 Lab Duplicate	30	11-8-13	1.072	<0.017	<0.009	0.031	34.692	0.016	0.023	<0.002	0.036	0.164	0.625	15.733
SM11	30	7-8-13	6.717	<0.017	<0.009	0.032	27.384	0.040	0.025	<0.002	0.034	1.569	0.679	13.645
SM11 Lab Duplicate	30	7-8-13	6.788	<0.017	<0.009	0.032	27.555	0.034	0.015	<0.002	0.033	1.378	0.639	12.004
Unfiltered Samples														
SM1	250	3-8-13	9.037	<0.017	<0.009	0.023	15.648	0.008	0.019	<0.002	0.041	1.034	0.179	3.788
SM1	30	9-8-13	9.723	<0.017	<0.009	0.022	16.510	0.005	0.031	<0.002	0.051	1.378	0.059	4.353
SM1	30	11-8-13	9.896	<0.017	<0.009	0.022	16.642	0.005	0.031	<0.002	0.049	1.250	<0.046	4.290
SM2	250	4-8-13	6.554	<0.017	<0.009	0.035	15.758	0.006	0.016	<0.002	0.031	0.886	0.220	3.864
SM2	30	9-8-13	5.989	<0.017	<0.009	0.033	15.049	<0.003	0.017	<0.002	0.031	0.486	0.093	3.634
SM2	30	11-8-13	6.640	<0.017	<0.009	0.038	17.165	<0.003	0.017	<0.002	0.036	0.423	0.067	4.011
SM3	250	3-8-13	3.776	<0.017	<0.009	0.046	32.941	0.004	0.010	<0.002	0.019	0.292	0.263	9.928
SM3	250	6-8-13	3.825	<0.017	<0.009	0.046	31.862	0.004	0.009	<0.002	0.021	0.309	0.254	9.723
SM3	30	8-8-13	3.636	<0.017	<0.009	0.044	31.191	<0.003	0.008	<0.002	0.019	0.261	0.154	9.606
SM3	30	10-8-13	3.717	<0.017	<0.009	0.044	31.396	<0.003	0.009	<0.002	0.019	0.319	0.150	9.646
SM4	250	4-8-13	4.155	<0.017	<0.009	0.041	28.716	0.004	<0.006	<0.002	0.019	1.254	0.323	9.087
SM5	30	7-8-13	9.027	<0.017	<0.009	0.032	25.798	0.027	0.012	<0.002	0.073	6.215	0.682	9.259
SM6	250	5-8-13	7.870	<0.017	<0.009	0.028	26.069	0.031	0.027	0.003	0.060	3.580	0.770	12.960

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	Al	As	B	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg
LOD:			0.009	0.017	0.009	0.001	0.005	0.003	0.006	0.002	0.004	0.002	0.046	0.001
ICP-ES			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SM6	250	6-8-13	7.171	<0.017	<0.009	0.025	24.210	0.029	0.027	<0.002	0.056	3.122	0.713	12.231
SM6	30	8-8-13	8.129	<0.017	<0.009	0.027	26.510	0.029	0.036	<0.002	0.062	3.563	0.810	13.638
SM6	30	10-8-13	7.912	<0.017	<0.009	0.026	26.306	0.029	0.034	<0.002	0.063	3.796	0.696	14.021
SM7	250	3-8-13	5.161	<0.017	<0.009	0.031	32.959	0.017	0.018	<0.002	0.033	2.442	0.575	15.049
SM7	30	8-8-13	4.960	<0.017	<0.009	0.029	30.027	0.014	0.028	<0.002	0.036	2.441	0.451	14.154
SM7	30	9-8-13	5.519	<0.017	<0.009	0.034	33.884	0.019	0.027	0.003	0.044	2.773	0.494	15.712
SM7	30	11-8-13	0.860	<0.017	<0.009	0.034	35.310	0.020	0.030	<0.002	0.036	0.003	0.526	16.733
SM8	30	7-8-13	9.920	<0.017	<0.009	0.029	32.533	0.051	<0.006	0.006	0.054	10.206	0.626	15.018
SM9	250	5-8-13	10.715	<0.017	<0.009	0.029	31.798	0.051	<0.006	0.005	0.045	11.185	0.830	14.984
SM9	250	6-8-13	11.623	<0.017	<0.009	0.033	34.816	0.054	0.007	0.004	0.053	11.505	0.876	16.108
SM9	30	9-8-13	10.501	<0.017	<0.009	0.034	33.711	0.052	<0.006	0.006	0.052	9.735	0.677	15.435
SM9	30	11-8-13	10.901	<0.017	<0.009	0.030	33.066	0.048	<0.006	0.004	0.051	10.044	0.745	15.372
SM10	30	8-8-13	7.466	<0.017	<0.009	0.030	26.802	0.036	<0.006	<0.002	0.035	6.226	0.523	11.994
SM11	250	2-8-13	7.249	<0.017	<0.009	0.035	27.522	0.039	<0.006	0.004	0.034	6.196	0.698	11.901
SM11	250	3-8-13	7.726	<0.017	<0.009	0.033	28.118	0.036	<0.006	0.003	0.032	6.055	0.721	12.239
SM11	250	4-8-13	6.925	<0.017	<0.009	0.030	25.387	0.035	<0.006	<0.002	0.031	5.755	0.685	11.331
SM11	250	6-8-13	7.464	<0.017	<0.009	0.033	27.963	0.036	<0.006	0.003	0.032	6.661	0.732	12.057
SM11	30	7-8-13	7.948	<0.017	<0.009	0.033	28.292	0.046	<0.006	<0.002	0.036	7.086	0.644	13.809
SM11	30	9-8-13	7.575	<0.017	<0.009	0.034	28.028	0.031	<0.006	<0.002	0.033	6.318	0.578	12.031
SM11	30	12-8-13	7.982	<0.017	<0.009	0.034	29.411	0.037	0.006	<0.002	0.038	6.285	0.559	12.666
T1	250	4-8-13	0.047	<0.017	<0.009	0.081	4.411	<0.003	<0.006	<0.002	<0.004	0.019	0.053	1.334
T1	30	9-8-13	0.015	<0.017	<0.009	0.084	4.569	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	1.496
T2	30	7-8-13	18.551	<0.017	0.014	0.019	15.104	0.064	0.018	0.014	0.159	23.919	1.491	7.400
T2	30	11-8-13	17.334	<0.017	<0.009	0.016	14.151	0.078	0.022	0.014	0.159	23.648	1.566	8.103
T3	30	7-8-13	0.079	<0.017	<0.009	0.052	63.282	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	13.943
T4	250	5-8-13	98.626	0.027	0.117	0.012	27.015	0.670	<0.006	0.100	0.381	159.769	4.984	18.020
T4	30	8-8-13	106.425	<0.017	0.127	0.011	29.062	0.737	<0.006	0.109	0.409	173.569	4.866	19.628
T4	30	10-8-13	103.166	0.029	0.134	0.012	28.459	0.703	<0.006	0.109	0.406	165.497	4.521	18.850
T5	250	5-8-13	164.537	0.079	0.228	0.005	21.599	0.224	<0.006	0.298	0.190	290.837	9.184	30.009
T5	30	12-8-13	163.933	0.089	0.246	0.005	23.650	0.264	<0.006	0.321	0.218	263.865	8.619	31.722
T6	30	10-8-13	0.037	<0.017	<0.009	0.110	18.046	<0.003	<0.006	<0.002	<0.004	0.683	<0.046	4.064
QA/QC														
T1	250	4-8-13	0.023	<0.017	<0.009	0.081	4.370	<0.003	<0.006	<0.002	<0.004	<0.002	0.058	1.316
T1	250	4-8-13	0.021	<0.017	<0.009	0.084	4.526	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	1.360
T3	250	7-8-13	0.083	<0.017	<0.009	0.048	59.493	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	12.903
T3	250	7-8-13	0.086	<0.017	<0.009	0.054	66.447	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	14.101
T5	250	5-8-13	164.984	0.062	0.215	0.005	21.672	0.227	<0.006	0.244	0.194	281.490	9.282	30.090
T5	250	5-8-13	171.005	0.060	0.219	0.005	23.195	0.262	<0.006	0.253	0.229	280.345	9.981	31.478

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	Al	As	B	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg
LOD:			0.009	0.017	0.009	0.001	0.005	0.003	0.006	0.002	0.004	0.002	0.046	0.001
ICP-ES			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SM5	30	7-8-13	9.027	<0.017	<0.009	0.032	25.798	0.027	0.012	<0.002	0.073	6.215	0.682	9.259
SM5	250	7-8-13	9.743	<0.017	<0.009	0.034	26.124	0.034	0.012	0.005	0.077	7.496	0.905	9.475
T2	30	7-8-13	18.551	<0.017	0.014	0.019	15.104	0.064	0.018	0.014	0.159	23.919	1.491	7.400
T2	250	4-8-13	18.851	<0.017	0.009	0.020	15.589	0.060	0.016	0.015	0.139	22.685	1.664	7.598
T3	30	7-8-13	0.079	<0.017	-0.009	0.052	63.282	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	13.943
T3	250	7-8-13	0.082	<0.017	-0.009	0.046	56.483	<0.003	<0.006	<0.002	<0.004	<0.002	0.103	12.406
T5	250	12-8-13	175.810	0.091	0.238	0.005	23.456	0.268	<0.006	0.321	0.216	304.108	10.398	32.180
T5	30	12-8-13	163.933	0.089	0.246	0.005	23.650	0.264	<0.006	0.321	0.218	263.865	8.619	31.722
SM3	250	6-8-13	3.825	<0.017	<0.009	0.046	31.862	0.004	0.009	<0.002	0.021	0.309	0.254	9.723
SM3	250	6-8-13	3.794	<0.017	<0.009	0.048	32.054	0.005	0.010	<0.002	0.023	0.308	0.205	9.717
SM7	250	3-8-13	6.304	<0.017	<0.009	0.030	30.515	0.018	0.015	<0.002	0.037	3.164	0.580	14.196
SM7	250	3-8-13	5.161	<0.017	<0.009	0.031	32.959	0.017	0.018	<0.002	0.033	2.442	0.575	15.049
T1	250	4-8-13	0.047	<0.017	<0.009	0.081	4.411	<0.003	<0.006	<0.002	<0.004	0.019	0.053	1.334
T1	250	4-8-13	0.040	<0.017	0.010	0.086	4.689	<0.003	<0.006	<0.002	<0.004	<0.002	0.049	1.401
T3	250	7-8-13	0.082	<0.017	<0.009	0.046	56.483	<0.003	<0.006	<0.002	<0.004	<0.002	0.103	12.406
T3	250	7-8-13	0.098	<0.017	<0.009	0.052	63.692	<0.003	<0.006	<0.002	<0.004	0.003	<0.046	13.557
T3	30	7-8-13	0.079	<0.017	<0.009	0.052	63.282	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	13.943
T3	30	7-8-13	0.076	<0.017	<0.009	0.049	59.520	<0.003	<0.006	<0.002	<0.004	0.004	<0.046	12.775
T6	30	10-8-13	0.037	<0.017	<0.009	0.110	18.046	<0.003	<0.006	<0.002	<0.004	0.683	<0.046	4.064
T6	30	10-8-13	0.033	<0.017	<0.009	0.109	17.912	<0.003	<0.006	<0.002	<0.004	0.716	<0.046	4.145
SM3	30	10-8-13	3.717	<0.017	<0.009	0.044	31.396	<0.003	0.009	<0.002	0.019	0.319	0.150	9.646
SM3 Lab Duplicate	30	10-8-13	3.852	<0.017	<0.009	0.045	32.493	<0.003	0.008	<0.002	0.019	0.301	0.224	10.035
SM7	30	11-8-13	0.860	<0.017	<0.009	0.034	35.310	0.020	0.030	<0.002	0.036	0.003	0.526	16.733
SM7 Lab Duplicate	30	11-8-13	0.889	<0.017	<0.009	0.037	38.038	0.023	0.031	<0.002	0.040	0.005	0.687	17.417
SM11	30	7-8-13	7.948	<0.017	<0.009	0.033	28.292	0.046	<0.006	<0.002	0.036	7.086	0.644	13.809
SM11 Lab Duplicate	30	7-8-13	8.061	<0.017	<0.009	0.033	28.402	0.035	<0.006	<0.002	0.035	6.376	0.669	12.144
T1	250	4-8-13	0.047	<0.017	<0.009	0.081	4.411	<0.003	<0.006	<0.002	<0.004	0.019	0.053	1.334
T1 Lab Duplicate	250	4-8-13	0.041	<0.017	<0.009	0.087	4.550	<0.003	<0.006	<0.002	<0.004	0.023	<0.046	1.379
T3	250	7-8-13	0.082	<0.017	<0.009	0.046	56.483	<0.003	<0.006	<0.002	<0.004	<0.002	0.103	12.406
T3 Lab Duplicate	250	7-8-13	0.079	<0.017	<0.009	0.049	59.749	<0.003	<0.006	<0.002	<0.004	<0.002	<0.046	12.982
T5	250	5-8-13	164.537	0.079	0.228	0.005	21.599	0.224	<0.006	0.298	0.190	290.837	9.184	30.009
T5 Lab Duplicate	250	5-8-13	170.392	0.086	0.229	0.006	23.016	0.261	<0.006	0.312	0.229	288.074	10.027	31.486

Appendix 1: Water Chemistry Results

Geological Surv. Can.		Timestamp	Al	As	B	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg
LOD							0.02					0.005	0.05	0.005
ICP-ES			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SM1 GSC	250	3-8-13					18.07					1.191	0.32	4.146
SM2 GSC	250	4-8-13					18.50					0.489	0.34	4.219
SM3 GSC	250	3-8-13					35.80					0.062	0.43	10.478
SM4 GSC	250	4-8-13					33.72					0.982	0.51	10.140
SM5 GSC	250	7-8-13					28.81					2.745	1.09	10.137
SM6 GSC	250	5-8-13					28.32					0.447	0.95	13.736
SM7 GSC	250	3-8-13					37.27					0.373	0.85	16.353
SM7 GSC	250	3-8-13					37.23					0.266	0.85	16.315
SM8 GSC	250	7-8-13					38.67					7.578	1.12	17.489
SM9 GSC	250	5-8-13					36.49					5.920	1.07	16.615
SM10 GSC	250	8-8-13					32.71					2.893	1.01	14.004
SM10 GSC	250	8-8-13					33.20					2.892	1.01	14.189
SM11 GSC	250	2-8-13					30.76					2.395	0.87	12.827
T1 GSC	250	4-8-13					5.15					< 0.005	0.19	1.444
T2 GSC	250	4-8-13					16.94					23.959	1.97	7.947
T3 GSC	250	7-8-13					69.63					< 0.005	0.22	14.339
T3 GSC	250	7-8-13					69.10					< 0.005	0.22	14.280
T4 GSC	250	5-8-13					30.48					193.781	5.52	19.685
T5 GSC	250	5-8-13					25.02					334.060	10.68	33.418
T6 GSC	250	10-8-13					20.74					0.319	0.22	4.377

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	Mn	Mo	Na	Ni	P	Pb	S	Si	Sr	Zn
LOD:			0.001	0.007	0.021	0.012	0.014	0.029	0.117	0.025	0.001	0.001
ICP-ES			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Blanks												
Travel Blank	250	10-8-13	<0.001	<0.007	<0.021	<0.012	0.028	<0.029	<0.0117	<0.025	<0.001	<0.001
Travel Blank	250	12-8-13	<0.001	<0.007	<0.021	<0.012	0.024	<0.029	0.683	<0.025	<0.001	0.006
Acid Blank	250	10-8-13	<0.001	<0.007	0.345	<0.012	0.018	<0.029	<0.0117	<0.025	0.002	<0.001
Acid Blank	250	12-8-13	<0.001	<0.007	0.349	<0.012	0.025	<0.029	<0.0117	<0.025	<0.001	<0.001
Field Blank	250	10-8-13	<0.001	<0.007	<0.021	<0.012	0.017	<0.029	<0.0117	<0.025	<0.001	<0.001
Field Blank	250	12-8-13	<0.001	<0.007	<0.021	<0.012	0.025	<0.029	<0.0117	<0.025	<0.001	<0.001
Travel Blank	30	7-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	0.026	<0.001	<0.001
Travel Blank	30	8-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Travel Blank	30	9-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Travel Blank	30	10-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Travel Blank	30	11-8-13	<0.001	<0.007	<0.021	0.014	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Travel Blank	30	12-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Acid Blank	30	7-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	0.002	<0.001
Acid Blank	30	8-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Acid Blank	30	9-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Acid Blank	30	10-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Acid Blank	30	11-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Acid Blank	30	12-8-13	<0.001	<0.007	<0.021	0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Field Blank	30	7-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Field Blank	30	9-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	0.001
Field Blank	30	11-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Field Blank	30	12-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
TBlank	30	10-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
TBlank LD	30	10-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	0.002	<0.001
ABlank	30	9-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
ABLank LD	30	9-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
FBlank	30	11-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
FBlank LD	30	11-8-13	<0.001	<0.007	<0.021	<0.012	<0.014	<0.029	<0.0117	<0.025	<0.001	<0.001
Filtered Samples												
SM1	250	3-8-13	0.378	<0.007	0.501	0.189	0.061	<0.029	39.847	3.582	0.088	0.741
SM1	30	9-8-13	0.402	<0.007	0.190	0.254	0.044	<0.029	53.158	3.640	0.089	0.785
SM1	30	11-8-13	0.434	<0.007	0.206	0.279	0.037	<0.029	57.158	3.855	0.097	0.847
SM2	250	4-8-13	0.281	<0.007	0.596	0.154	0.063	<0.029	32.617	3.225	0.076	0.544
SM2	30	9-8-13	0.275	<0.007	0.239	0.165	0.034	<0.029	33.214	3.051	0.074	0.516
SM3	250	3-8-13	0.150	<0.007	0.587	0.094	0.031	<0.029	33.347	2.426	0.106	0.214
SM3	250	6-8-13	0.141	<0.007	0.549	0.093	0.024	<0.029	34.381	2.206	0.092	0.208
SM3	30	8-8-13	0.135	<0.007	0.187	0.097	<0.014	<0.029	32.860	2.120	0.090	0.207

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	Mn	Mo	Na	Ni	P	Pb	S	Si	Sr	Zn
LOD:			0.001	0.007	0.021	0.012	0.014	0.029	0.117	0.025	0.001	0.001
ICP-ES			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SM3	30	10-8-13	0.144	<0.007	0.210	0.099	<0.014	<0.029	35.061	2.233	0.098	0.206
SM4	250	4-8-13	0.161	<0.007	0.573	0.105	0.026	<0.029	36.124	2.430	0.092	0.260
SM5	30	7-8-13	0.510	<0.007	0.260	0.259	0.031	<0.029	63.519	3.645	0.083	0.930
SM6	250	5-8-13	0.609	<0.007	0.599	0.251	0.093	<0.029	51.936	3.452	0.108	0.971
SM6	250	6-8-13	0.601	<0.007	0.630	0.261	0.067	<0.029	58.139	3.457	0.108	0.967
SM6	30	8-8-13	0.631	<0.007	0.274	0.284	0.061	<0.029	70.679	3.632	0.111	1.004
SM6	30	10-8-13	0.628	<0.007	0.261	0.294	0.081	<0.029	67.091	3.567	0.109	1.015
SM7	250	3-8-13	0.418	<0.007	0.579	0.188	0.051	<0.029	47.752	2.940	0.117	0.777
SM7	30	8-8-13	0.415	<0.007	0.235	0.225	0.037	<0.029	55.431	2.854	0.114	0.782
SM7	30	9-8-13	0.421	<0.007	0.249	0.235	0.024	<0.029	59.637	2.949	0.119	0.812
SM7	30	11-8-13	0.408	<0.007	0.242	0.228	0.024	<0.029	62.649	2.911	0.116	0.799
SM8	30	7-8-13	0.478	<0.007	0.238	0.310	0.054	<0.029	76.802	3.163	0.111	1.464
SM9	250	5-8-13	0.458	<0.007	0.649	0.292	0.088	<0.029	69.594	3.209	0.106	1.373
SM9	250	6-8-13	0.490	<0.007	0.709	0.308	0.106	<0.029	74.283	3.472	0.116	1.443
SM9	30	9-8-13	0.484	<0.007	0.330	0.317	0.065	<0.029	82.565	3.429	0.116	1.429
SM9	30	11-8-13	0.506	<0.007	0.340	0.333	0.064	<0.029	85.958	3.521	0.118	1.507
SM10	30	8-8-13	0.414	<0.007	0.430	0.273	0.047	<0.029	68.428	3.346	0.106	1.198
SM11	250	2-8-13	0.357	<0.007	0.795	0.218	0.099	<0.029	53.839	3.101	0.096	1.045
SM11	250	3-8-13	0.376	<0.007	0.764	0.234	0.118	<0.029	55.671	3.218	0.098	1.127
SM11	250	4-8-13	0.364	<0.007	0.756	0.228	0.093	<0.029	56.029	3.097	0.094	1.083
SM11	250	6-8-13	0.364	<0.007	0.814	0.227	0.101	<0.029	58.148	3.119	0.096	1.074
SM11	30	7-8-13	0.412	<0.007	0.450	0.284	0.081	<0.029	72.657	3.417	0.100	1.211
SM11	30	9-8-13	0.368	<0.007	0.449	0.234	0.028	<0.029	64.632	3.227	0.099	1.079
SM11	30	12-8-13	0.409	<0.007	0.476	0.266	0.064	<0.029	69.150	3.451	0.109	1.213
T1	250	4-8-13	<0.001	<0.007	0.564	<0.012	0.028	<0.029	3.581	2.020	0.014	0.015
T1	30	9-8-13	<0.001	<0.007	0.290	0.027	<0.014	<0.029	5.228	2.225	0.015	0.018
T2	250	4-8-13	0.542	<0.007	0.593	0.331	0.212	<0.029	79.357	4.609	0.049	1.880
T2	250	7-8-13	0.547	<0.007	0.641	0.404	0.214	<0.029	88.283	4.509	0.048	1.899
T2	30	11-8-13	0.623	0.011	0.325	0.491	0.200	<0.029	112.203	4.895	0.052	2.113
T3	30	7-8-13	<0.001	<0.007	0.220	0.037	<0.014	<0.029	42.179	1.611	0.218	0.016
T4	250	5-8-13	2.215	<0.007	0.724	1.869	1.381	0.050	388.540	8.016	0.107	13.164
T4	30	8-8-13	2.406	<0.007	0.405	2.012	1.473	0.046	460.770	8.488	0.115	14.167
T4	30	10-8-13	2.362	<0.007	0.388	1.978	1.492	0.054	453.129	8.340	0.114	13.843
T5	250	5-8-13	1.279	<0.007	0.982	2.327	4.353	<0.029	561.368	14.168	0.094	7.305
T5	30	8-8-13	1.359	<0.007	0.792	2.680	4.374	<0.029	748.082	14.951	0.101	7.641
T5	30	12-8-13	1.362	<0.007	0.733	2.698	5.421	0.031	700.976	14.607	0.102	7.588
T6	30	10-8-13	0.068	<0.007	0.346	0.014	<0.014	<0.029	7.106	2.624	0.064	0.052

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	Mn	Mo	Na	Ni	P	Pb	S	Si	Sr	Zn
LOD:			0.001	0.007	0.021	0.012	0.014	0.029	0.117	0.025	0.001	0.001
ICP-ES			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
QA/QC												
SM5	30	7-8-13	0.510	<0.007	0.260	0.259	0.031	<0.029	63.519	3.645	0.083	0.930
SM5	250	7-8-13	0.543	<0.007	0.716	0.256	0.054	<0.029	63.536	3.827	0.088	1.014
T2	30	7-8-13	0.542	<0.007	0.262	0.391	0.169	<0.029	85.256	4.444	0.048	1.850
T2	250	7-8-13	0.547	<0.007	0.641	0.404	0.214	<0.029	88.283	4.509	0.048	1.899
T3	30	7-8-13	<0.001	<0.007	0.220	0.037	<0.014	<0.029	42.179	1.611	0.218	0.016
T3	250	7-8-13	<0.001	<0.007	0.577	0.023	0.031	<0.029	36.032	1.557	0.208	0.016
SM3	250	6-8-13	0.141	<0.007	0.549	0.093	0.024	<0.029	34.381	2.206	0.092	0.208
SM3 Field duplicate	250	6-8-13	0.161	<0.007	0.634	0.106	<0.014	<0.029	38.574	2.514	0.108	0.236
SM7 Field duplicate	250	3-8-13	0.418	<0.007	0.579	0.188	0.051	<0.029	47.752	2.940	0.117	0.777
T1	250	4-8-13	<0.001	<0.007	0.564	<0.012	0.028	<0.029	3.581	2.020	0.014	0.015
T1 Field duplicate	250	4-8-13	<0.001	<0.007	0.585	<0.012	0.029	<0.029	3.708	2.148	0.014	0.017
T3	30	7-8-13	<0.001	<0.007	0.220	0.037	<0.014	<0.029	42.179	1.611	0.218	0.016
T3 Field duplicate	30	7-8-13	<0.001	<0.007	0.211	0.032	<0.014	<0.029	41.035	1.616	0.218	0.015
T3	250	7-8-13	<0.001	<0.007	0.577	0.023	0.031	<0.029	36.032	1.557	0.208	0.016
T3 Field duplicate	250	7-8-13	<0.001	<0.007	0.642	0.029	0.034	<0.029	39.092	1.717	0.235	0.017
T6	30	10-8-13	0.068	<0.007	0.346	0.014	<0.014	<0.029	7.106	2.624	0.064	0.052
T6 Field duplicate	30	10-8-13	0.065	<0.007	0.312	0.017	<0.014	<0.029	6.529	2.463	0.060	0.047
SM3	30	10-8-13	0.144	<0.007	0.210	0.099	<0.014	<0.029	35.061	2.233	0.098	0.206
SM3 Lab Duplicate	30	10-8-13	0.162	<0.007	0.263	0.120	<0.014	<0.029	48.311	2.522	0.110	0.230
SM7	30	11-8-13	0.408	<0.007	0.242	0.228	0.024	<0.029	62.649	2.911	0.116	0.799
SM7 Lab Duplicate	30	11-8-13	0.427	<0.007	0.259	0.235	0.031	<0.029	67.273	3.035	0.119	0.815
SM11	30	7-8-13	0.412	<0.007	0.450	0.284	0.081	<0.029	72.657	3.417	0.100	1.211
SM11 Lab Duplicate	30	7-8-13	0.378	<0.007	0.449	0.244	0.067	<0.029	68.102	3.243	0.099	1.108
Unfiltered Samples												
SM1	250	3-8-13	0.371	<0.007	0.497	0.191	0.060	<0.029	39.193	3.514	0.086	0.726
SM1	30	9-8-13	0.425	<0.007	0.204	0.272	0.043	<0.029	56.865	3.803	0.094	0.828
SM1	30	11-8-13	0.416	<0.007	0.191	0.265	0.048	<0.029	54.134	3.738	0.094	0.811
SM2	250	4-8-13	0.278	<0.007	0.577	0.150	0.064	<0.029	32.330	3.193	0.075	0.540
SM2	30	9-8-13	0.270	<0.007	0.221	0.154	0.022	<0.029	31.883	2.944	0.071	0.498
SM2	30	11-8-13	0.291	<0.007	0.278	0.175	0.021	<0.029	40.436	3.333	0.080	0.546
SM3	250	3-8-13	0.151	<0.007	0.563	0.092	0.056	<0.029	33.511	2.712	0.105	0.306
SM3	250	6-8-13	0.156	<0.007	0.630	0.100	0.073	<0.029	39.306	2.760	0.104	0.316
SM3	30	8-8-13	0.149	<0.007	0.206	0.107	0.037	<0.029	36.661	2.605	0.100	0.300
SM3	30	10-8-13	0.149	<0.007	0.208	0.103	0.034	<0.029	36.340	2.611	0.101	0.299
SM4	250	4-8-13	0.163	<0.007	0.582	0.104	0.058	<0.029	37.207	2.769	0.093	0.322
SM5	30	7-8-13	0.519	<0.007	0.265	0.259	0.091	<0.029	66.062	3.705	0.085	0.953
SM6	250	5-8-13	0.604	<0.007	0.604	0.258	0.079	<0.029	51.648	3.456	0.109	0.968

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	Mn	Mo	Na	Ni	P	Pb	S	Si	Sr	Zn
LOD:			0.001	0.007	0.021	0.012	0.014	0.029	0.117	0.025	0.001	0.001
ICP-ES			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SM6	250	6-8-13	0.570	<0.007	0.579	0.247	0.103	<0.029	55.554	3.313	0.101	0.921
SM6	30	8-8-13	0.643	<0.007	0.278	0.289	0.084	<0.029	71.629	3.669	0.111	1.015
SM6	30	10-8-13	0.649	<0.007	0.273	0.297	0.071	<0.029	70.508	3.675	0.111	1.047
SM7	250	3-8-13	0.412	<0.007	0.561	0.189	0.051	<0.029	48.184	3.026	0.115	0.778
SM7	30	8-8-13	0.391	<0.007	0.216	0.214	0.025	<0.029	52.876	2.813	0.107	0.751
SM7	30	9-8-13	0.420	<0.007	0.247	0.228	0.030	<0.029	60.584	3.079	0.121	0.821
SM7	30	11-8-13	0.446	<0.007	0.257	0.247	0.025	<0.029	66.929	3.027	0.125	0.881
SM8	30	7-8-13	0.484	<0.007	0.245	0.308	0.096	<0.029	80.012	3.306	0.114	1.491
SM9	250	5-8-13	0.477	<0.007	0.671	0.302	0.124	<0.029	73.305	3.402	0.111	1.434
SM9	250	6-8-13	0.511	<0.007	0.671	0.319	0.095	<0.029	79.474	3.718	0.123	1.518
SM9	30	9-8-13	0.493	<0.007	0.330	0.322	0.106	<0.029	84.916	3.546	0.120	1.453
SM9	30	11-8-13	0.501	<0.007	0.325	0.327	0.083	<0.029	86.444	3.532	0.117	1.497
SM10	30	8-8-13	0.384	<0.007	0.394	0.247	0.085	<0.029	63.885	3.168	0.098	1.113
SM11	250	2-8-13	0.364	<0.007	0.784	0.225	0.112	<0.029	55.346	3.224	0.100	1.063
SM11	250	3-8-13	0.381	<0.007	0.778	0.234	0.100	<0.029	57.018	3.331	0.100	1.143
SM11	250	4-8-13	0.352	<0.007	0.716	0.215	0.119	<0.029	54.136	3.024	0.090	1.046
SM11	250	6-8-13	0.369	<0.007	0.831	0.226	0.078	<0.029	59.539	3.220	0.098	1.089
SM11	30	7-8-13	0.419	<0.007	0.466	0.288	0.107	<0.029	74.537	3.535	0.103	1.235
SM11	30	9-8-13	0.369	<0.007	0.450	0.238	0.084	<0.029	65.721	3.327	0.100	1.081
SM11	30	12-8-13	0.400	<0.007	0.451	0.261	0.081	<0.029	68.164	3.439	0.105	1.196
T1	250	4-8-13	<0.001	<0.007	0.571	<0.012	<0.014	<0.029	3.690	2.030	0.014	0.019
T1	30	9-8-13	<0.001	<0.007	0.274	0.023	<0.014	<0.029	4.883	2.142	0.015	0.018
T2	30	7-8-13	0.548	<0.007	0.260	0.393	0.164	<0.029	84.780	4.454	0.051	1.857
T2	30	11-8-13	0.587	<0.007	0.315	0.461	0.173	<0.029	105.516	4.562	0.047	1.979
T3	30	7-8-13	<0.001	0.008	0.231	0.036	<0.014	<0.029	44.772	1.706	0.224	0.017
T4	250	5-8-13	2.242	<0.007	0.747	1.873	1.428	0.065	393.061	8.115	0.109	13.298
T4	30	8-8-13	2.432	<0.007	0.409	2.046	1.550	0.044	472.524	8.608	0.117	14.364
T4	30	10-8-13	2.358	<0.007	0.395	1.970	1.523	0.048	450.799	8.317	0.116	13.829
T5	250	5-8-13	1.274	<0.007	0.986	2.265	7.853	<0.029	554.766	14.107	0.093	7.242
T5	30	12-8-13	1.373	<0.007	0.729	2.734	8.774	0.047	706.859	14.741	0.102	7.632
T6	30	10-8-13	0.070	<0.007	0.328	<0.012	<0.014	<0.029	6.712	2.549	0.064	0.057
QA/QC												
T1	250	4-8-13	<0.001	<0.007	0.564	<0.012	0.028	<0.029	3.581	2.020	0.014	0.015
T1	250	4-8-13	<0.001	<0.007	0.622	<0.012	0.021	<0.029	3.978	2.062	0.014	0.017
T3	250	7-8-13	<0.001	<0.007	0.577	0.023	0.031	<0.029	36.032	1.557	0.208	0.016
T3	250	7-8-13	<0.001	<0.007	0.642	0.029	0.034	<0.029	39.092	1.717	0.235	0.017
T5	250	5-8-13	1.279	<0.007	0.982	2.327	4.353	<0.029	561.368	14.168	0.094	7.305
T5	250	5-8-13	1.346	<0.007	1.081	2.677	4.658	0.035	623.968	14.766	0.099	7.592

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	Mn	Mo	Na	Ni	P	Pb	S	Si	Sr	Zn
LOD: ICP-ES			0.001 ppm	0.007 ppm	0.021 ppm	0.012 ppm	0.014 ppm	0.029 ppm	0.117 ppm	0.025 ppm	0.001 ppm	0.001 ppm
SM5	30	7-8-13	0.519	<0.007	0.265	0.259	0.091	<0.029	66.062	3.705	0.085	0.953
SM5	250	7-8-13	0.532	<0.007	0.685	0.259	0.116	<0.029	63.244	3.743	0.087	0.997
T2	30	7-8-13	0.548	<0.007	0.260	0.393	0.164	<0.029	84.780	4.454	0.051	1.857
T2	250	4-8-13	0.558	<0.007	0.608	0.339	0.193	<0.029	80.414	4.736	0.052	1.913
T3	30	7-8-13	-0.001	0.008	0.231	0.036	<0.014	<0.029	44.772	1.706	0.224	0.017
T3	250	7-8-13	-0.001	<0.007	0.566	0.025	0.019	<0.029	34.753	1.507	0.200	0.015
T5	250	12-8-13	1.378	<0.007	1.090	2.734	8.781	0.037	641.007	14.842	0.102	7.683
T5	30	12-8-13	1.373	<0.007	0.729	2.734	8.774	0.047	706.859	14.741	0.102	7.632
SM3	250	6-8-13	0.156	<0.007	0.630	0.100	0.073	<0.029	39.306	2.760	0.104	0.316
SM3	250	6-8-13	0.158	<0.007	0.616	0.105	0.058	<0.029	37.412	2.733	0.106	0.315
SM7	250	3-8-13	0.390	<0.007	0.592	0.205	0.063	<0.029	52.657	2.922	0.107	0.754
SM7	250	3-8-13	0.412	<0.007	0.561	0.189	0.051	<0.029	48.184	3.026	0.115	0.778
T1	250	4-8-13	-0.001	<0.007	0.571	<0.012	<0.014	<0.029	3.690	2.030	0.014	0.019
T1	250	4-8-13	-0.001	<0.007	0.593	<0.012	0.021	<0.029	3.751	2.139	0.015	0.017
T3	250	7-8-13	-0.001	<0.007	0.566	0.025	0.019	<0.029	34.753	1.507	0.200	0.015
T3	250	7-8-13	-0.001	<0.007	0.614	0.024	0.035	<0.029	37.310	1.650	0.222	0.018
T3	30	7-8-13	-0.001	0.008	0.231	0.036	<0.014	<0.029	44.772	1.706	0.224	0.017
T3	30	7-8-13	-0.001	<0.007	0.204	0.035	<0.014	<0.029	39.696	1.579	0.211	0.017
T6	30	10-8-13	0.070	<0.007	0.328	<0.012	<0.014	<0.029	6.712	2.549	0.064	0.057
T6	30	10-8-13	0.068	<0.007	0.313	0.019	<0.014	<0.029	6.536	2.492	0.062	0.057
SM3	30	10-8-13	0.149	<0.007	0.208	0.103	0.034	<0.029	36.340	2.611	0.101	0.299
SM3 Lab Duplicate	30	10-8-13	0.156	<0.007	0.244	0.112	0.021	<0.029	46.100	2.761	0.105	0.312
SM7	30	11-8-13	0.446	<0.007	0.257	0.247	0.025	<0.029	66.929	3.027	0.125	0.881
SM7 Lab Duplicate	30	11-8-13	0.473	<0.007	0.301	0.267	0.037	<0.029	71.925	3.270	0.134	0.923
SM11	30	7-8-13	0.419	<0.007	0.466	0.288	0.107	<0.029	74.537	3.535	0.103	1.235
SM11 Lab Duplicate	30	7-8-13	0.383	<0.007	0.465	0.252	0.071	<0.029	70.379	3.363	0.100	1.127
T1	250	4-8-13	-0.001	<0.007	0.571	<0.012	<0.014	<0.029	3.690	2.030	0.014	0.019
T1 Lab Duplicate	250	4-8-13	-0.001	<0.007	0.638	<0.012	<0.014	<0.029	4.163	2.088	0.016	0.019
T3	250	7-8-13	-0.001	<0.007	0.566	0.025	0.019	<0.029	34.753	1.507	0.200	0.015
T3 Lab Duplicate	250	7-8-13	-0.001	<0.007	0.573	0.026	0.029	<0.029	35.366	1.578	0.211	0.015
T5	250	5-8-13	1.274	<0.007	0.986	2.265	7.853	<0.029	554.766	14.107	0.093	7.242
T5 Lab Duplicate	250	5-8-13	1.347	<0.007	1.091	2.683	8.505	<0.029	625.832	14.747	0.100	7.577

Appendix 1: Water Chemistry Results

Geological Surv. Can.		Timestamp	Mn	Mo	Na	Ni	P	Pb	S	Si	Sr	Zn
					0.05		0.05		0.05	0.02		
ICP-ES			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SM1 GSC	250	3-8-13			0.59		< 0.05		46.59	4.40		
SM2 GSC	250	4-8-13			0.64		< 0.05		35.00	3.94		
SM3 GSC	250	3-8-13			0.63		< 0.05		36.57	2.81		
SM4 GSC	250	4-8-13			0.62		< 0.05		38.03	3.03		
SM5 GSC	250	7-8-13			0.66		< 0.05		60.39	4.41		
SM6 GSC	250	5-8-13			0.64		< 0.05		58.41	4.08		
SM7 GSC	250	3-8-13			0.64		< 0.05		53.65	3.47		
SM7 GSC	250	3-8-13			0.70		< 0.05		53.69	3.49		
SM8 GSC	250	7-8-13			0.67		< 0.05		77.90	4.10		
SM9 GSC	250	5-8-13			0.71		< 0.05		75.00	4.09		
SM10 GSC	250	8-8-13			0.80		< 0.05		64.15	4.08		
SM10 GSC	250	8-8-13			0.83		< 0.05		64.24	4.08		
SM11 GSC	250	2-8-13			0.82		< 0.05		55.97	3.75		
T1 GSC	250	4-8-13			0.66		< 0.05		4.03	2.51		
T2 GSC	250	4-8-13			0.67		0.19		91.70	5.66		
T3 GSC	250	7-8-13			0.60		< 0.05		35.86	1.93		
T3 GSC	250	7-8-13			0.61		< 0.05		35.87	1.92		
T4 GSC	250	5-8-13			0.79		1.53		412.77	9.93		
T5 GSC	250	5-8-13			1.09		4.74		648.02	17.87		
T6 GSC	250	10-8-13			0.69		< 0.05		5.88	3.05		

	Bottle	Timestamp	45 Sc	47 Ti	51 V	52 Cr	55 Mn	59 Co	60 Ni	63 Cu	75 As	85 Rb	89 Y
LOD:			0.0029	0.0338	0.0365	0.0081	0.0138	0.0004	0.0289	0.0046	0.0187	0.0014	0.0003
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Blanks													
Travel Blank	250	10-8-13	0.02	<0.0338	<0.365	0.09	0.0216	0.01	0.1	0.0	<0.0187	0.0059	<0.0003
Travel Blank	250	12-8-13	0.02	0.0466	0.40	0.14	0.3183	0.06	0.7	0.1	0.03	0.0204	0.04
Acid Blank	250	10-8-13	0.03	0.0699	<0.365	0.12	0.0	0.00	0.1	0.1	<0.0187	0.0082	0.00
Acid Blank	250	12-8-13	0.03	0.0688	<0.365	0.12	0.0	0.00	0.1	0.1	<0.0187	0.0122	0.00
Field Blank	250	10-8-13	0.02	<0.0338	<0.365	0.08	0.1	0.00	0.0	0.0	<0.0187	0.011	<0.0003
Field Blank	250	12-8-13	0.02	<0.0338	<0.365	0.08	0.0	0.00	0.0	0.0	<0.0187	0.003	<0.0003
Travel Blank	30	7-8-13	0.01	<0.0338	<0.365	0.06	0.0	0.00	0.1	0.2	<0.0187	0.071	0.00
Travel Blank	30	8-8-13	0.01	<0.0338	<0.365	0.06	0.0	0.00	0.0	0.0	<0.0187	0.002	0.00
Travel Blank	30	9-8-13	0.01	<0.0338	<0.365	0.06	0.0	0.00	0.0	0.0	<0.0187	<0.0014	0.00
Travel Blank	30	10-8-13	0.01	<0.0338	<0.365	0.06	0.0	0.00	0.0	0.0	<0.0187	0.002	0.00
Travel Blank	30	11-8-13	0.01	<0.0338	<0.365	0.07	<0.0138	0.00	<0.0289	0.0	<0.0187	0.001	<0.0003
Travel Blank	30	12-8-13	0.02	<0.0338	<0.365	0.07	0.0	0.00	<0.0289	0.0	<0.0187	<0.0014	0.00
Acid Blank	30	7-8-13	0.01	0.068	<0.365	0.07	0.0	0.00	<0.0289	0.0	<0.0187	0.002	0.00
Acid Blank	30	8-8-13	0.01	0.109	<0.365	0.10	0.0	0.00	0.0	0.0	<0.0187	0.002	0.00
Acid Blank	30	9-8-13	0.02	0.047	<0.365	0.07	0.0	0.00	0.1	0.0	<0.0187	0.002	0.00
Acid Blank	30	10-8-13	0.01	0.046	<0.365	0.08	0.0	0.00	0.0	0.0	<0.0187	<0.0014	0.00
Acid Blank	30	11-8-13	0.01	0.043	<0.365	0.08	0.0	0.00	<0.0289	0.0	<0.0187	0.001	0.00
Acid Blank	30	12-8-13	0.02	0.080	<0.365	0.07	0.0	0.00	0.0	0.0	<0.0187	0.002	0.00
Field Blank	30	7-8-13	0.01	<0.0338	<0.365	0.07	<0.0138	0.00	<0.0289	0.0	<0.0187	0.002	<0.0003
Field Blank	30	9-8-13	0.01	<0.0338	<0.365	0.06	<0.0138	0.00	<0.0289	0.0	<0.0187	0.002	<0.0003
Field Blank	30	11-8-13	0.01	<0.0338	<0.365	0.07	0.0	0.00	0.9	0.1	<0.0187	0.010	<0.0003
Field Blank	30	12-8-13	0.01	<0.0338	<0.365	0.07	0.0	0.00	<0.0289	0.0	<0.0187	0.003	<0.0003
TBlank	30	10-8-13	0.01	<0.0338	<0.365	0.06	0.0	0.00	0.0	0.0	<0.0187	0.002	0.00
TBlank LD	30	10-8-13	0.00	<0.0338	<0.365	0.03	0.0	0.00	<0.0289	<0.0046	<0.0187	0.002	<0.0003
ABlank	30	9-8-13	0.02	0.047	<0.365	0.07	0.0	0.00	0.1	0.0	<0.0187	0.002	0.00
ABLank LD	30	9-8-13	0.01	0.071	<0.365	0.08	0.0	0.00	0.0	0.0	<0.0187	0.002	0.00
FBlank	30	11-8-13	0.01	<0.0338	<0.365	0.07	0.0	0.00	0.9	0.1	<0.0187	0.010	<0.0003
FBlank LD	30	11-8-13	0.01	<0.0338	<0.365	0.07	<0.0138	0.00	<0.0289	0.0	<0.0187	0.009	<0.0003
Filtered Samples													
SM1	250	3-8-13	0.66	0.325	0.06	0.60	262.8	22.28	147.6	33.0	0.12	0.908	23.08
SM1	30	9-8-13	0.66	0.316	0.06	0.58	259.8	21.94	144.1	31.4	0.13	0.744	22.92
SM1	30	11-8-13	0.67	0.290	0.05	0.55	265.2	22.10	145.5	31.3	0.13	0.765	23.26
SM2	250	4-8-13	0.67	0.358	0.05	0.41	230.4	18.74	127.6	27.9	0.15	0.969	19.23
SM2	30	9-8-13	0.55	0.326	<0.365	0.31	193.4	15.15	105.1	22.1	0.11	0.788	16.08
SM3	250	3-8-13	0.39	0.264	<0.365	0.09	104.4	8.72	65.1	1.2	0.05	0.843	0.48
SM3	250	6-8-13	0.43	0.216	<0.365	0.10	112.8	9.19	68.2	1.4	0.04	0.870	0.57
SM3	30	8-8-13	0.42	0.270	<0.365	0.07	103.9	8.56	63.5	1.1	0.04	0.821	0.56

	Bottle	Timestamp	45 Sc	47 Ti	51 V	52 Cr	55 Mn	59 Co	60 Ni	63 Cu	75 As	85 Rb	89 Y
LOD:			0.0029	0.0338	0.0365	0.0081	0.0138	0.0004	0.0289	0.0046	0.0187	0.0014	0.0003
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM3	30	10-8-13	0.43	0.262	<0.365	0.07	108.7	8.90	66.1	1.1	0.04	0.862	0.47
SM4	250	4-8-13	0.44	0.244	0.12	0.11	124.5	10.51	75.0	2.0	0.04	1.244	1.51
SM5	30	7-8-13	0.67	0.356	0.10	1.64	341.9	24.99	152.5	42.7	0.10	3.658	19.05
SM6	250	5-8-13	0.61	0.307	0.06	0.89	423.7	24.26	170.5	40.3	0.10	3.170	16.55
SM6	250	6-8-13	0.62	0.306	0.04	0.74	411.4	23.39	162.5	38.5	0.08	3.113	16.43
SM6	30	8-8-13	0.57	0.321	<0.365	0.56	378.1	21.23	146.6	34.2	0.07	2.851	14.93
SM6	30	10-8-13	0.57	0.272	<0.365	0.66	375.1	21.39	147.9	34.9	0.07	2.892	15.01
SM7	250	3-8-13	0.45	0.262	0.04	0.29	276.4	15.81	129.9	22.0	0.08	2.274	9.48
SM7	30	8-8-13	0.50	0.286	0.04	0.31	283.4	16.17	134.0	22.8	0.08	2.370	10.00
SM7	30	9-8-13	0.48	0.303	<0.365	0.29	271.4	15.65	129.6	22.1	0.08	2.282	9.70
SM7	30	11-8-13	0.45	0.284	<0.365	0.31	257.4	14.69	121.9	20.8	0.06	2.210	9.19
SM8	30	7-8-13	0.63	0.286	0.55	2.20	321.1	22.20	180.5	32.5	0.21	3.310	14.46
SM9	250	5-8-13	0.76	0.333	0.07	0.99	369.9	25.13	210.2	35.0	0.18	3.913	17.14
SM9	250	6-8-13	0.70	0.315	0.06	0.88	339.1	23.20	192.2	35.4	0.16	3.625	16.35
SM9	30	9-8-13	0.68	0.317	0.14	0.84	335.4	23.34	194.1	31.7	0.18	3.554	15.97
SM9	30	11-8-13	0.69	0.284	0.06	0.91	343.0	23.82	196.9	31.6	0.12	3.628	16.31
SM10	30	8-8-13	0.55	0.263	0.04	0.43	254.5	16.77	147.1	22.0	0.13	2.805	11.32
SM11	250	2-8-13	0.65	0.356	0.06	0.61	276.1	18.03	156.2	23.4	0.13	2.943	11.81
SM11	250	3-8-13	0.66	0.351	0.06	0.42	291.2	19.26	166.8	24.9	0.12	3.248	12.71
SM11	250	4-8-13	0.66	0.287	0.06	0.38	291.1	19.16	164.5	24.6	0.12	3.194	12.59
SM11	250	6-8-13	0.56	0.277	0.04	0.40	255.4	16.48	144.1	21.5	0.12	2.809	11.06
SM11	30	7-8-13	0.55	0.265	0.04	0.33	243.0	15.66	137.5	20.4	0.09	2.712	10.69
SM11	30	9-8-13	0.55	0.262	0.04	0.34	239.9	15.41	137.2	19.7	0.11	2.612	10.42
SM11	30	12-8-13	0.58	0.252	0.05	0.52	264.1	17.21	153.9	22.2	0.12	2.894	11.45
T1	250	4-8-13	0.36	0.224	<0.365	0.11	0.2	0.11	9.6	0.4	0.03	0.290	0.03
T1	30	9-8-13	0.35	0.252	<0.365	0.08	0.2	0.09	8.6	0.3	0.04	0.273	0.02
T2	250	4-8-13	1.23	0.658	11.24	10.86	423.6	46.15	286.5	118.4	1.86	9.306	38.50
T2	250	7-8-13	1.28	0.689	14.61	11.75	447.4	48.78	301.2	124.9	2.15	9.520	39.75
T2	30	11-8-13	1.06	0.610	10.01	9.66	387.4	42.28	257.3	107.4	1.60	8.247	34.43
T3	30	7-8-13	0.30	0.191	0.22	0.15	0.3	0.14	16.3	0.3	0.14	0.256	0.06
T4	250	5-8-13	4.67	1.851	320.86	78.00	1753.5	159.99	1282.6	256.2	18.33	25.086	104.66
T4	30	8-8-13	4.27	1.809	295.12	72.55	1637.9	149.18	1191.9	235.4	16.68	23.232	98.60
T4	30	10-8-13	4.14	1.788	307.64	71.78	1601.7	145.10	1161.7	231.5	16.89	22.354	95.84
T5	250	5-8-13	6.02	5.447	1145.86	191.34	1038.8	192.09	1759.2	149.2	53.98	41.237	153.49
T5	30	8-8-13	5.01	4.504	979.26	159.72	908.8	166.34	1514.5	117.1	45.67	36.930	137.46
T5	30	12-8-13	5.00	4.933	1047.41	167.33	882.6	161.66	1479.8	117.2	49.47	35.432	133.52
T6	30	10-8-13	0.40	0.233	0.05	0.07	44.9	0.20	3.6	0.3	0.48	0.417	0.03

	Bottle	Timestamp	45 Sc	47 Ti	51 V	52 Cr	55 Mn	59 Co	60 Ni	63 Cu	75 As	85 Rb	89 Y
LOD:			0.0029	0.0338	0.0365	0.0081	0.0138	0.0004	0.0289	0.0046	0.0187	0.0014	0.0003
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
QA/QC													
SM5	30	7-8-13	0.67	0.356	0.10	1.64	341.9	24.99	152.5	42.7	0.10	3.658	19.05
SM5	250	7-8-13	0.67	0.319	0.10	1.78	354.7	26.14	157.8	45.6	0.12	3.895	20.09
T2	30	7-8-13	1.28	0.731	14.74	11.51	438.4	47.87	297.0	123.4	2.06	9.224	39.04
T2	250	7-8-13	1.28	0.689	14.61	11.75	447.4	48.78	301.2	124.9	2.15	9.520	39.75
T3	30	7-8-13	0.30	0.191	0.22	0.15	0.3	0.14	16.3	0.3	0.14	0.256	0.06
T3	250	7-8-13	0.33	0.236	0.25	0.23	0.2	0.14	18.5	0.5	0.18	0.305	0.06
SM3	250	6-8-13	0.43	0.216	<0.365	0.10	112.8	9.19	68.2	1.4	0.04	0.870	0.57
SM3 Field duplicate	250	6-8-13	0.41	0.245	<0.365	0.09	108.5	8.90	65.7	2.7	0.04	0.854	0.55
SM7 Field duplicate	250	3-8-13	0.45	0.262	0.04	0.29	276.4	15.81	129.9	22.0	0.08	2.274	9.48
T1	250	4-8-13	0.36	0.224	<0.365	0.11	0.2	0.11	9.6	0.4	0.03	0.290	0.03
T1 Field duplicate	250	4-8-13	0.36	0.238	<0.365	0.11	0.2	0.10	9.2	0.4	0.03	0.287	0.03
T3	30	7-8-13	0.30	0.191	0.22	0.15	0.3	0.14	16.3	0.3	0.14	0.256	0.06
T3 Field duplicate	30	7-8-13	0.31	0.190	0.23	0.15	0.1	0.13	16.8	0.3	0.15	0.276	0.05
T3	250	7-8-13	0.33	0.236	0.25	0.23	0.2	0.14	18.5	0.5	0.18	0.305	0.06
T3 Field duplicate	250	7-8-13	0.34	0.235	0.25	0.19	0.1	0.15	18.7	0.4	0.15	0.308	0.07
T6	30	10-8-13	0.40	0.233	0.05	0.07	44.9	0.20	3.6	0.3	0.48	0.417	0.03
T6 Field duplicate	30	10-8-13	0.41	0.284	0.04	0.07	45.4	0.21	3.7	0.3	0.49	0.428	0.02
SM3	30	10-8-13	0.43	0.262	<0.365	0.07	108.7	8.90	66.1	1.1	0.04	0.862	0.47
SM3 Lab Duplicate	30	10-8-13	0.43	0.277	<0.365	0.06	106.4	8.63	63.7	1.0	0.03	0.832	0.47
SM7	30	11-8-13	0.45	0.284	0.04	0.31	257.4	14.69	121.9	20.8	0.06	2.210	9.19
SM7 Lab Duplicate	30	11-8-13											
SM11	30	7-8-13	0.55	0.265	0.04	0.33	243.0	15.66	137.5	20.4	0.09	2.712	10.69
SM11 Lab Duplicate	30	7-8-13	0.57	0.265	0.06	0.35	256.3	16.51	146.5	21.5	0.09	2.801	11.18
Unfiltered Samples													
SM1	250	3-8-13	0.62	0.310	0.07	0.58	256.1	21.59	143.6	32.3	0.13	0.868	22.35
SM1	30	9-8-13	0.67	0.337	0.07	0.61	271.5	23.05	152.4	33.4	0.13	0.794	23.84
SM1	30	11-8-13	0.63	0.317	0.05	0.53	253.8	21.12	140.3	30.2	0.11	0.749	22.24
SM2	250	4-8-13	0.64	0.332	0.10	0.40	230.4	18.64	128.4	27.6	0.15	0.942	19.24
SM2	30	9-8-13	0.54	0.313	0.04	0.31	192.2	14.86	102.8	21.7	0.13	0.766	15.91
SM2	30	11-8-13	0.51	0.281	<0.365	0.27	181.5	14.12	98.4	20.4	0.10	0.770	15.30
SM3	250	3-8-13	0.46	0.294	0.07	0.27	107.9	9.11	68.3	14.3	0.22	0.904	9.23
SM3	250	6-8-13	0.45	0.247	0.06	0.26	108.5	8.95	66.3	13.7	0.18	0.838	9.17
SM3	30	8-8-13	0.48	0.324	0.06	0.20	104.5	8.69	64.4	13.0	0.19	0.821	8.91
SM3	30	10-8-13	0.47	0.335	0.07	0.23	110.7	9.21	68.4	14.0	0.20	0.873	9.43
SM4	250	4-8-13	0.52	0.357	0.55	0.30	127.6	10.84	77.3	14.8	0.22	1.273	11.80
SM5	30	7-8-13	0.63	0.329	3.26	2.90	338.1	24.78	150.6	43.5	0.59	3.588	19.43
SM6	250	5-8-13	0.66	0.390	2.20	1.80	433.2	24.78	172.4	41.5	0.45	3.220	16.65

	Bottle	Timestamp	45 Sc	47 Ti	51 V	52 Cr	55 Mn	59 Co	60 Ni	63 Cu	75 As	85 Rb	89 Y
LOD:			0.0029	0.0338	0.0365	0.0081	0.0138	0.0004	0.0289	0.0046	0.0187	0.0014	0.0003
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM6	250	6-8-13	0.61	0.314	2.07	1.55	396.1	22.21	154.2	37.2	0.38	2.969	16.13
SM6	30	8-8-13	0.56	0.296	1.69	1.42	380.3	21.00	146.9	34.6	0.34	2.832	14.91
SM6	30	10-8-13	0.54	0.337	2.06	1.54	375.5	21.36	148.5	35.4	0.39	2.890	15.22
SM7	250	3-8-13	0.52	0.320	1.44	1.02	275.0	15.73	130.2	24.7	0.40	2.260	10.64
SM7	30	8-8-13	0.54	0.387	1.37	1.15	285.2	16.18	135.1	25.4	0.40	2.371	11.09
SM7	30	9-8-13	0.54	0.355	1.45	1.04	266.6	15.35	127.0	24.5	0.40	2.267	10.73
SM7	30	11-8-13	0.44	0.236	0.04	0.24	278.5	15.88	133.2	23.1	0.08	2.387	10.53
SM8	30	7-8-13	0.67	0.397	14.57	4.17	317.3	21.67	178.5	32.8	1.10	3.274	15.21
SM9	250	5-8-13	0.80	0.447	15.18	4.22	363.1	24.40	203.7	34.0	1.19	3.810	17.31
SM9	250	6-8-13	0.72	0.403	13.39	3.75	322.8	21.99	181.1	31.0	1.02	3.442	16.01
SM9	30	9-8-13	0.71	0.405	13.72	3.90	326.4	22.81	189.2	31.5	1.08	3.467	15.76
SM9	30	11-8-13	0.72	0.373	14.18	4.09	342.8	23.68	196.1	32.5	1.13	3.652	16.53
SM10	30	8-8-13	0.59	0.719	9.88	2.60	256.1	16.83	146.3	22.7	1.00	2.828	11.53
SM11	250	2-8-13	0.66	0.709	9.35	2.51	266.4	17.05	149.2	23.9	1.04	2.859	11.63
SM11	250	3-8-13	0.69	0.700	10.24	2.69	288.7	19.04	165.4	25.4	1.16	3.237	12.76
SM11	250	4-8-13	0.69	0.701	10.24	2.69	288.3	18.81	162.7	25.2	1.14	3.166	12.62
SM11	250	6-8-13	0.62	0.759	9.18	2.54	252.8	16.23	141.9	21.8	1.06	2.771	11.27
SM11	30	7-8-13	0.57	0.688	8.42	2.20	237.7	15.23	133.7	20.6	0.98	2.674	10.63
SM11	30	9-8-13	0.56	1.028	7.88	2.14	220.9	14.03	124.4	18.8	0.93	2.458	9.87
SM11	30	12-8-13	0.62	0.893	10.19	2.62	267.5	17.36	154.7	23.3	1.13	2.966	11.70
T1	250	4-8-13	0.36	0.239	0.04	0.11	0.6	0.14	9.7	0.5	0.05	0.298	0.04
T1	30	9-8-13	0.35	0.234	<0.365	0.07	0.5	0.12	8.8	0.4	0.03	0.271	0.03
T2	30	7-8-13	1.16	0.727	14.36	10.90	415.1	45.24	277.6	116.3	2.01	8.838	37.37
T2	30	11-8-13	0.90	0.502	8.96	8.77	354.5	38.24	232.6	96.9	1.46	7.601	31.94
T3	30	7-8-13	0.31	0.209	0.23	0.14	0.2	0.13	16.7	0.4	0.15	0.268	0.07
T4	250	5-8-13	4.55	1.907	328.68	76.84	1734.6	158.19	1271.3	252.5	18.70	25.075	104.26
T4	30	8-8-13	4.10	1.704	300.64	71.38	1606.7	146.03	1169.6	231.2	16.91	22.988	97.31
T4	30	10-8-13	4.19	1.782	321.88	73.51	1633.6	148.49	1185.6	236.5	17.55	22.755	98.07
T5	250	5-8-13	6.11	8.523	1229.76	232.14	1031.6	190.66	1755.5	149.3	71.57	40.661	152.37
T5	30	12-8-13	5.12	7.620	1120.78	199.61	885.7	162.83	1491.8	118.5	62.40	35.626	134.67
T6	30	10-8-13	0.44	0.388	0.08	0.07	50.1	0.24	4.1	0.4	0.68	0.459	0.05
QA/QC													
T1	250	4-8-13	0.36	0.224	<0.365	0.11	0.2	0.11	9.6	0.4	0.03	0.290	0.03
T1	250	4-8-13	0.38	0.293	<0.365	0.12	0.2	0.11	9.9	0.5	0.03	0.298	0.03
T3	250	7-8-13	0.33	0.236	0.25	0.23	0.2	0.14	18.5	0.5	0.18	0.305	0.06
T3	250	7-8-13	0.34	0.235	0.25	0.19	0.1	0.15	18.7	0.4	0.15	0.308	0.07
T5	250	5-8-13	6.02	5.447	1145.86	191.34	1038.8	192.09	1759.2	149.2	53.98	41.237	153.49
T5	250	5-8-13	5.61	5.118	1087.56	180.50	989.4	181.58	1662.3	141.2	51.21	39.119	146.02

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	45 Sc	47 Ti	51 V	52 Cr	55 Mn	59 Co	60 Ni	63 Cu	75 As	85 Rb	89 Y
LOD:			0.0029	0.0338	0.0365	0.0081	0.0138	0.0004	0.0289	0.0046	0.0187	0.0014	0.0003
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM5	30	7-8-13	0.63	0.329	3.26	2.90	338.1	24.78	150.6	43.5	0.59	3.588	19.43
SM5	250	7-8-13	0.68	0.372	3.54	3.28	356.7	25.81	158.0	47.0	0.64	3.859	20.58
T2	30	7-8-13	1.16	0.727	14.36	10.90	415.1	45.24	277.6	116.3	2.01	8.838	37.37
T2	250	4-8-13	1.11	0.592	11.17	10.56	414.4	45.04	276.2	114.8	1.83	9.090	37.59
T3	30	7-8-13	0.31	0.209	0.23	0.14	0.2	0.13	16.7	0.4	0.15	0.268	0.07
T3	250	7-8-13	0.34	0.241	0.26	0.20	0.3	0.15	18.4	0.7	0.17	0.301	0.07
T5	250	12-8-13	5.74	8.007	1255.09	224.03	997.1	182.87	1674.0	132.9	70.61	39.761	147.05
T5	30	12-8-13	5.12	7.620	1120.78	199.61	885.7	162.83	1491.8	118.5	62.40	35.626	134.67
SM3	250	6-8-13	0.45	0.247	0.06	0.26	108.5	8.95	66.3	13.7	0.18	0.838	9.17
SM3	250	6-8-13	0.48	0.320	0.06	0.25	110.2	9.07	66.9	13.9	0.20	0.861	9.32
SM7	250	3-8-13	0.60	0.534	2.09	1.47	299.9	16.95	138.8	28.2	0.68	2.450	11.89
SM7	250	3-8-13	0.52	0.320	1.44	1.02	275.0	15.73	130.2	24.7	0.40	2.260	10.64
T1	250	4-8-13	0.36	0.239	0.04	0.11	0.6	0.14	9.7	0.5	0.05	0.298	0.04
T1	250	4-8-13	0.36	0.245	<0.365	0.11	0.4	0.11	9.2	1.2	0.04	0.280	0.03
T3	250	7-8-13	0.34	0.241	0.26	0.20	0.3	0.15	18.4	0.7	0.17	0.301	0.07
T3	250	7-8-13	0.33	0.252	0.26	0.19	0.4	0.16	19.2	0.5	0.18	0.311	0.08
T3	30	7-8-13	0.31	0.209	0.23	0.14	0.2	0.13	16.7	0.4	0.15	0.268	0.07
T3	30	7-8-13	0.34	0.205	0.25	0.16	0.4	0.15	18.3	0.5	0.17	0.290	0.09
T6	30	10-8-13	0.44	0.388	0.08	0.07	50.1	0.24	4.1	0.4	0.68	0.459	0.05
T6	30	10-8-13	0.43	0.339	0.07	0.08	47.7	0.23	3.9	0.4	0.71	0.448	0.05
SM3	30	10-8-13	0.47	0.335	0.07	0.23	110.7	9.21	68.4	14.0	0.20	0.873	9.43
SM3 Lab Duplicate	30	10-8-13	0.44	0.259	0.06	0.21	100.2	8.21	60.8	12.5	0.19	0.801	8.76
SM7	30	11-8-13	0.44	0.236	0.04	0.24	278.5	15.88	133.2	23.1	0.08	2.387	10.53
SM7 Lab Duplicate	30	11-8-13	0.45	0.291	0.08	0.21	289.9	16.58	139.5	24.2	0.08	2.455	10.84
SM11	30	7-8-13	0.57	0.688	8.42	2.20	237.7	15.23	133.7	20.6	0.98	2.674	10.63
SM11 Lab Duplicate	30	7-8-13	0.60	0.664	9.20	2.36	257.3	16.58	146.4	22.3	1.03	2.839	11.38
T1	250	4-8-13	0.36	0.239	0.04	0.11	0.6	0.14	9.7	0.5	0.05	0.298	0.04
T1 Lab Duplicate	250	4-8-13	0.38	0.262	0.10	0.12	0.9	0.17	10.1	0.5	0.05	0.303	0.05
T3	250	7-8-13	0.34	0.241	0.26	0.20	0.3	0.15	18.4	0.7	0.17	0.301	0.07
T3 Lab Duplicate	250	7-8-13	0.34	0.229	0.26	0.18	0.2	0.15	18.7	0.5	0.16	0.302	0.07
T5	250	5-8-13	6.11	8.523	1229.76	232.14	1031.6	190.66	1755.5	149.3	71.57	40.661	152.37
T5 Lab Duplicate	250	5-8-13	5.86	8.187	1197.67	226.47	1005.4	184.82	1703.7	145.2	69.47	39.643	148.34

Appendix 1: Water Chemistry Results

Geological Surv. Can.		Timestamp	45 Sc	47 Ti	51 V	52 Cr	55 Mn	59 Co	60 Ni	63 Cu	75 As	85 Rb	89 Y
					0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.05	0.01
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM1 GSC	250	3-8-13			< 0.1	0.9	444.1	35.34	241.8	69.1	< 0.1	1.21	30.17
SM2 GSC	250	4-8-13			< 0.1	0.5	333.6	25.74	179.9	50.1	< 0.1	1.08	22.28
SM3 GSC	250	3-8-13			< 0.1	< 0.1	179.2	14.40	109.4	2.6	0.2	1.18	0.66
SM4 GSC	250	4-8-13			0.2	< 0.1	198.2	16.49	120.0	3.8	0.2	1.60	1.87
SM5 GSC	250	7-8-13			< 0.1	3.3	598.4	43.74	275.7	102.8	< 0.1	5.49	27.57
SM6 GSC	250	5-8-13			< 0.1	1.0	677.7	37.11	265.3	80.3	< 0.1	4.19	21.24
SM7 GSC	250	3-8-13			0.2	0.5	509.6	27.67	233.5	50.7	0.2	3.33	13.90
SM7 GSC	250	3-8-13			< 0.1	0.5	504.0	27.51	230.8	49.9	0.1	3.26	13.61
SM8 GSC	250	7-8-13			0.8	4.1	583.1	39.26	336.6	75.6	0.4	5.07	21.44
SM9 GSC	250	5-8-13			< 0.1	1.4	572.5	37.66	324.4	67.2	0.2	4.99	21.41
SM10 GSC	250	8-8-13			< 0.1	0.8	458.0	30.53	268.1	51.6	0.2	4.32	16.96
SM10 GSC	250	8-8-13			< 0.1	0.8	461.6	30.81	269.9	52.2	0.2	4.35	16.92
SM11 GSC	250	2-8-13			< 0.1	0.7	431.5	26.57	236.0	45.7	0.2	3.67	14.45
T1 GSC	250	4-8-13			< 0.1	< 0.1	0.3	0.15	13.6	0.8	< 0.1	0.33	0.04
T2 GSC	250	4-8-13			17.6	16.9	647.7	68.27	435.2	231.0	2.5	11.63	47.20
T3 GSC	250	7-8-13			0.4	0.2	0.2	0.10	30.6	0.8	0.4	0.42	0.08
T3 GSC	250	7-8-13			0.4	0.3	0.2	0.11	31.2	0.9	0.4	0.42	0.08
T4 GSC	250	5-8-13			554.9	122.5	2702.5	238.25	1912.8	507.0	25.6	33.19	138.09
T5 GSC	250	5-8-13			2040.6	322.5	1655.4	295.27	2674.4	305.6	78.2	58.22	214.32
T6 GSC	250	10-8-13			< 0.1	< 0.1	74.2	0.31	6.1	0.6	0.8	0.61	0.04

	Bottle	Timestamp	90 Zr	93 Nb	95 Mo	107 Ag	111 Cd	121 Sb	133 Cs	137 Ba	139 La	140 Ce	141 Pr
LOD:			0.0017	0.0007	0.0069	0.0016	0.0020	0.0012	0.0003	0.0049	0.0004	0.0003	0.0001
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Blanks													
Travel Blank	250	10-8-13	<0.0017	<0.0007	0.0098	<0.0016	0.00	<0.0012	0.001	0.04	<0.0004	<0.0003	<0.0001
Travel Blank	250	12-8-13	<0.0017	<0.0007	0.0078	<0.0016	0.07	<0.0012	0.004	0.02	0.001	0.002	0.001
Acid Blank	250	10-8-13	<0.0017	<0.0007	0.0406	0.0018	0.01	0.0028	0.000	0.11	0.000	0.001	<0.0001
Acid Blank	250	12-8-13	<0.0017	<0.0007	<0.0069	<0.0016	0.01	0.0014	<0.0003	0.14	0.001	0.001	0.000
Field Blank	250	10-8-13	<0.0017	<0.0007	0.0088	0.0018	0.01	0.0041	0.000	0.33	<0.0004	<0.0003	<0.0001
Field Blank	250	12-8-13	<0.0017	<0.0007	<0.0069	0.0016	<0.002	<0.0012	0.000	0.02	<0.0004	<0.0003	<0.0001
Travel Blank	30	7-8-13	<0.0017	<0.0007	<0.0069	0.0016	0.00	<0.0012	0.000	0.03	<0.0004	<0.0003	<0.0001
Travel Blank	30	8-8-13	<0.0017	<0.0007	<0.0069	<0.0016	0.01	<0.0012	<0.0003	0.01	<0.0004	0.000	<0.0001
Travel Blank	30	9-8-13	<0.0017	<0.0007	<0.0069	<0.0016	0.00	<0.0012	<0.0003	0.01	<0.0004	0.000	0.000
Travel Blank	30	10-8-13	<0.0017	<0.0007	<0.0069	<0.0016	<0.002	<0.0012	<0.0003	1.69	<0.0004	0.001	<0.0001
Travel Blank	30	11-8-13	<0.0017	<0.0007	<0.0069	<0.0016	<0.002	<0.0012	<0.0003	<0.0049	<0.0004	<0.0003	<0.0001
Travel Blank	30	12-8-13	<0.0017	<0.0007	<0.0069	<0.0016	<0.002	<0.0012	<0.0003	0.01	<0.0004	0.000	<0.0001
Acid Blank	30	7-8-13	<0.0017	<0.0007	0.0491	<0.0016	<0.002	<0.0012	<0.0003	0.02	<0.0004	0.001	<0.0001
Acid Blank	30	8-8-13	<0.0017	<0.0007	0.0146	<0.0016	<0.002	0.0014	<0.0003	0.01	<0.0004	0.001	<0.0001
Acid Blank	30	9-8-13	<0.0017	<0.0007	0.0166	<0.0016	0.00	<0.0012	<0.0003	0.03	<0.0004	0.001	0.000
Acid Blank	30	10-8-13	<0.0017	<0.0007	<0.0069	<0.0016	<0.002	0.0057	<0.0003	0.02	<0.0004	0.001	<0.0001
Acid Blank	30	11-8-13	<0.0017	<0.0007	0.0078	0.0019	<0.002	<0.0012	<0.0003	0.02	<0.0004	0.000	<0.0001
Acid Blank	30	12-8-13	<0.0017	<0.0007	<0.0069	0.0018	0.01	<0.0012	<0.0003	0.03	<0.0004	0.001	<0.0001
Field Blank	30	7-8-13	<0.0017	<0.0007	<0.0069	0.0019	<0.002	<0.0012	<0.0003	0.03	<0.0004	<0.0003	<0.0001
Field Blank	30	9-8-13	<0.0017	<0.0007	<0.0069	<0.0016	<0.002	<0.0012	<0.0003	0.03	<0.0004	<0.0003	<0.0001
Field Blank	30	11-8-13	<0.0017	<0.0007	<0.0069	<0.0016	<0.002	0.0020	0.000	0.03	<0.0004	<0.0003	<0.0001
Field Blank	30	12-8-13	<0.0017	<0.0007	<0.0069	<0.0016	<0.002	<0.0012	<0.0003	0.05	<0.0004	<0.0003	0.000
TBlank	30	10-8-13	<0.0017	<0.0007	<0.0069	<0.0016	<0.002	<0.0012	<0.0003	1.69	<0.0004	0.001	<0.0001
TBlank LD	30	10-8-13	<0.0017	<0.0007	<0.0069	<0.0016	<0.002	<0.0012	<0.0003	<0.0049	<0.0004	<0.0003	<0.0001
ABlank	30	9-8-13	<0.0017	<0.0007	0.0166	<0.0016	0.00	<0.0012	<0.0003	0.03	<0.0004	0.001	0.000
ABLank LD	30	9-8-13	<0.0017	<0.0007	0.0176	<0.0016	0.00	<0.0012	<0.0003	0.07	<0.0004	0.001	0.000
FBlank	30	11-8-13	<0.0017	<0.0007	<0.0069	<0.0016	<0.002	0.0020	0.000	0.03	<0.0004	<0.0003	<0.0001
FBlank LD	30	11-8-13	<0.0017	<0.0007	0.0775	<0.0016	<0.002	0.0020	<0.0003	0.02	<0.0004	<0.0003	<0.0001
Filtered Samples													
SM1	250	3-8-13	0.0086	<0.0007	0.0102	0.0805	8.18	0.0069	0.234	18.32	21.116	41.419	5.609
SM1	30	9-8-13	0.0121	<0.0007	<0.0069	0.0651	7.56	0.0046	0.180	16.12	20.579	40.274	5.429
SM1	30	11-8-13	0.0093	<0.0007	0.0071	0.0785	7.65	0.0080	0.193	21.36	21.141	41.351	5.558
SM2	250	4-8-13	0.0095	<0.0007	0.1520	0.0198	6.49	0.0206	0.134	31.84	16.242	31.175	4.209
SM2	30	9-8-13	0.0071	0.0010	0.1212	0.0089	5.44	0.0146	0.111	26.83	13.811	26.993	3.600
SM3	250	3-8-13	0.0025	<0.0007	0.7146	<0.0016	3.45	0.0520	0.094	34.56	1.476	1.421	0.139
SM3	250	6-8-13	0.0026	<0.0007	0.7248	0.0026	3.75	0.0519	0.100	36.26	1.764	1.692	0.163
SM3	30	8-8-13	0.0022	<0.0007	0.6659	0.0043	3.45	0.0428	0.088	33.34	1.687	1.600	0.152

	Bottle	Timestamp	90 Zr	93 Nb	95 Mo	107 Ag	111 Cd	121 Sb	133 Cs	137 Ba	139 La	140 Ce	141 Pr
LOD:			0.0017	0.0007	0.0069	0.0016	0.0020	0.0012	0.0003	0.0049	0.0004	0.0003	0.0001
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM3	30	10-8-13	0.0023	<0.0007	0.6642	0.0037	3.45	0.0531	0.092	34.67	1.454	1.376	0.136
SM4	250	4-8-13	0.0031	<0.0007	0.6300	0.0063	3.80	0.0531	0.138	34.87	2.183	2.330	0.237
SM5	30	7-8-13	0.0039	<0.0007	0.0132	0.0217	20.60	0.0119	0.717	23.02	10.820	21.099	3.248
SM6	250	5-8-13	0.0058	<0.0007	0.0254	0.0039	23.18	0.0146	0.529	20.28	8.501	15.500	2.438
SM6	250	6-8-13	0.0045	<0.0007	0.0179	0.0037	22.88	0.0117	0.528	20.53	8.583	15.704	2.461
SM6	30	8-8-13	0.0035	<0.0007	0.0122	0.0024	20.70	0.0179	0.492	18.31	7.712	14.276	2.246
SM6	30	10-8-13	0.0029	<0.0007	0.0088	<0.0016	20.87	0.0099	0.498	17.98	7.802	14.301	2.265
SM7	250	3-8-13	0.0041	<0.0007	0.1110	0.0029	15.47	0.0490	0.372	23.39	5.191	9.296	1.451
SM7	30	8-8-13	0.0027	<0.0007	0.0978	0.0021	15.83	0.0451	0.388	23.05	5.309	9.555	1.498
SM7	30	9-8-13	0.0019	<0.0007	0.1134	<0.0016	15.77	0.0426	0.388	23.31	5.283	9.487	1.465
SM7	30	11-8-13	0.0025	<0.0007	0.0985	<0.0016	14.82	0.0531	0.371	21.70	4.939	8.798	1.397
SM8	30	7-8-13	0.0044	<0.0007	0.0230	0.0043	39.78	0.0275	0.638	21.27	4.580	8.257	1.334
SM9	250	5-8-13	0.0055	<0.0007	0.0220	0.0029	42.09	0.0204	0.749	25.34	4.840	8.874	1.447
SM9	250	6-8-13	0.0049	<0.0007	0.0234	0.0032	39.03	0.0202	0.700	24.73	4.795	8.842	1.422
SM9	30	9-8-13	0.0048	<0.0007	0.0376	0.0029	37.02	0.0215	0.686	23.40	4.472	8.177	1.335
SM9	30	11-8-13	0.0032	<0.0007	0.0267	0.0032	39.38	0.0202	0.729	22.76	4.431	8.127	1.350
SM10	30	8-8-13	0.0030	<0.0007	0.0176	0.0026	27.82	0.0154	0.496	22.02	3.184	5.804	0.938
SM11	250	2-8-13	0.0040	<0.0007	0.0328	0.0019	28.48	0.0323	0.507	27.61	3.502	6.358	1.024
SM11	250	3-8-13	0.0082	<0.0007	0.0166	0.0027	31.21	0.0227	0.559	27.46	3.633	6.545	1.062
SM11	250	4-8-13	0.0041	<0.0007	0.0213	0.0029	31.19	0.0257	0.555	27.82	3.613	6.509	1.058
SM11	250	6-8-13	0.0048	<0.0007	0.0149	0.0037	27.00	0.0243	0.481	24.97	3.220	5.817	0.942
SM11	30	7-8-13	0.0032	<0.0007	0.0156	<0.0016	26.30	0.0206	0.478	23.67	3.106	5.606	0.906
SM11	30	9-8-13	0.0034	<0.0007	0.0132	0.0031	25.40	0.0288	0.461	24.25	2.972	5.371	0.879
SM11	30	12-8-13	0.0035	<0.0007	0.0200	0.0042	28.26	0.0156	0.510	24.19	3.148	5.676	0.919
T1	250	4-8-13	0.0066	<0.0007	0.1157	<0.0016	0.14	0.0732	0.004	74.39	0.003	0.002	0.001
T1	30	9-8-13	0.0061	<0.0007	0.1154	0.0037	0.13	0.0611	0.003	68.50	0.003	0.003	0.001
T2	250	4-8-13	0.0224	<0.0007	0.0694	0.0562	56.30	0.0213	2.151	15.05	21.261	43.282	7.046
T2	250	7-8-13	0.0254	<0.0007	0.0643	0.0351	58.73	0.0199	2.118	14.85	21.751	44.045	7.134
T2	30	11-8-13	0.0180	<0.0007	0.0531	0.0417	50.14	0.0172	1.913	12.65	18.864	38.722	6.243
T3	30	7-8-13	<0.0017	<0.0007	3.7537	<0.0016	0.52	0.1384	0.015	35.80	0.010	0.010	0.003
T4	250	5-8-13	0.1482	0.0007	0.5355	0.0475	512.31	0.1266	5.966	9.86	1.672	5.000	1.491
T4	30	8-8-13	0.1343	<0.0007	0.4620	0.0635	476.21	0.1146	5.563	8.26	1.544	4.645	1.398
T4	30	10-8-13	0.1324	0.0011	0.5091	0.0408	466.23	0.1193	5.312	7.22	1.512	4.524	1.355
T5	250	5-8-13	0.1017	0.0014	1.9059	0.0321	188.58	0.1453	10.030	4.48	2.543	8.181	2.411
T5	30	8-8-13	0.0751	0.0010	1.5670	0.0290	170.37	0.1229	8.928	3.71	2.134	6.994	2.102
T5	30	12-8-13	0.1090	0.0010	1.6968	0.0193	164.62	0.1222	8.428	3.31	2.090	6.784	2.043
T6	30	10-8-13	0.0114	<0.0007	0.7803	0.0024	0.14	0.0849	0.019	77.38	0.003	0.005	0.001

	Bottle	Timestamp	90 Zr	93 Nb	95 Mo	107 Ag	111 Cd	121 Sb	133 Cs	137 Ba	139 La	140 Ce	141 Pr
LOD:			0.0017	0.0007	0.0069	0.0016	0.0020	0.0012	0.0003	0.0049	0.0004	0.0003	0.0001
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
QA/QC													
SM5	30	7-8-13	0.0039	<0.0007	0.0132	0.0217	20.60	0.0119	0.717	23.02	10.820	21.099	3.248
SM5	250	7-8-13	0.0041	<0.0007	0.0196	0.0159	21.84	0.0140	0.774	24.40	11.458	22.379	3.452
T2	30	7-8-13	0.0252	0.0011	0.0931	0.0351	55.12	0.0186	2.047	14.15	20.829	42.264	6.812
T2	250	7-8-13	0.0254	<0.0007	0.0643	0.0351	58.73	0.0199	2.118	14.85	21.751	44.045	7.134
T3	30	7-8-13	<0.0017	<0.0007	3.7537	<0.0016	0.52	0.1384	0.015	35.80	0.010	0.010	0.003
T3	250	7-8-13	0.0037	<0.0007	4.1772	<0.0016	0.57	0.1625	0.016	39.75	0.008	0.004	0.002
SM3	250	6-8-13	0.0026	<0.0007	0.7248	0.0026	3.75	0.0519	0.100	36.26	1.764	1.692	0.163
SM3 Field duplicate	250	6-8-13	0.0134	<0.0007	0.6984	0.0034	3.53	0.0531	0.095	35.09	1.695	1.618	0.157
SM7 Field duplicate	250	3-8-13	0.0041	<0.0007	0.1110	0.0029	15.47	0.0490	0.372	23.39	5.191	9.296	1.451
T1	250	4-8-13	0.0066	<0.0007	0.1157	<0.0016	0.14	0.0732	0.004	74.39	0.003	0.002	0.001
T1 Field duplicate	250	4-8-13	0.0067	<0.0007	0.0995	<0.0016	0.14	0.0673	0.004	71.80	0.004	0.003	0.001
T3	30	7-8-13	<0.0017	<0.0007	3.7537	<0.0016	0.52	0.1384	0.015	35.80	0.010	0.010	0.003
T3 Field duplicate	30	7-8-13	0.0020	<0.0007	3.9038	0.0018	0.50	0.1414	0.014	36.52	0.007	0.003	0.002
T3	250	7-8-13	0.0037	<0.0007	4.1772	<0.0016	0.57	0.1625	0.016	39.75	0.008	0.004	0.002
T3 Field duplicate	250	7-8-13	0.0030	<0.0007	4.2044	0.0019	0.55	0.1703	0.015	40.57	0.009	0.004	0.002
T6	30	10-8-13	0.0114	<0.0007	0.7803	0.0024	0.14	0.0849	0.019	77.38	0.003	0.005	0.001
T6 Field duplicate	30	10-8-13	0.0106	<0.0007	0.8190	<0.0016	0.14	0.0829	0.021	79.48	0.003	0.004	0.001
SM3	30	10-8-13	0.0023	<0.0007	0.6642	0.0037	3.45	0.0531	0.092	34.67	1.454	1.376	0.136
SM3 Lab Duplicate	30	10-8-13	0.0017	<0.0007	0.6774	0.0032	3.51	0.0506	0.093	35.11	1.478	1.400	0.139
SM7	30	11-8-13	0.0025	<0.0007	0.0985	<0.0016	14.82	0.0531	0.371	21.70	4.939	8.798	1.397
SM7 Lab Duplicate	30	11-8-13											
SM11	30	7-8-13	0.0032	<0.0007	0.0156	<0.0016	26.30	0.0206	0.478	23.67	3.106	5.606	0.906
SM11 Lab Duplicate	30	7-8-13	0.0038	<0.0007	0.0118	0.0034	27.39	0.0179	0.495	24.39	3.173	5.794	0.942
Unfiltered Samples													
SM1	250	3-8-13	0.0088	<0.0007	0.0074	0.0955	7.80	0.0073	0.229	18.10	20.767	40.470	5.501
SM1	30	9-8-13	0.0119	<0.0007	0.0091	0.0743	7.88	0.0087	0.195	16.85	21.351	41.704	5.619
SM1	30	11-8-13	0.0081	<0.0007	0.0125	0.0888	7.27	0.0064	0.198	15.99	20.377	40.133	5.372
SM2	250	4-8-13	0.0131	<0.0007	0.1909	0.0428	6.54	0.0163	0.138	32.10	16.172	31.298	4.203
SM2	30	9-8-13	0.0101	<0.0007	0.1821	0.0438	5.33	0.0242	0.114	26.76	13.679	26.758	3.579
SM2	30	11-8-13	0.0053	<0.0007	0.1763	0.0527	5.08	0.0174	0.112	26.55	13.281	25.711	3.510
SM3	250	3-8-13	0.0068	<0.0007	0.7448	0.0330	3.92	0.0565	0.103	36.01	7.519	14.758	2.035
SM3	250	6-8-13	0.0058	<0.0007	0.7252	0.0306	3.77	0.0616	0.094	35.12	7.490	14.786	2.021
SM3	30	8-8-13	0.0051	<0.0007	0.7197	0.0293	3.68	0.0602	0.089	33.71	7.286	14.351	1.964
SM3	30	10-8-13	0.0054	0.0009	0.7262	0.0321	3.77	0.0590	0.098	35.46	7.588	15.009	2.050
SM4	250	4-8-13	0.0076	<0.0007	0.7024	0.0393	4.10	0.0492	0.140	35.91	7.541	14.974	2.083
SM5	30	7-8-13	0.0096	<0.0007	0.2992	0.0453	20.37	0.0254	0.707	22.69	10.970	21.769	3.329
SM6	250	5-8-13	0.0103	<0.0007	0.2535	0.0343	23.18	0.0277	0.536	20.27	8.560	15.580	2.460

	Bottle	Timestamp	90 Zr	93 Nb	95 Mo	107 Ag	111 Cd	121 Sb	133 Cs	137 Ba	139 La	140 Ce	141 Pr
LOD:			0.0017	0.0007	0.0069	0.0016	0.0020	0.0012	0.0003	0.0049	0.0004	0.0003	0.0001
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM6	250	6-8-13	0.0075	<0.0007	0.2244	0.0290	22.09	0.0265	0.505	19.89	8.298	15.145	2.415
SM6	30	8-8-13	0.0081	<0.0007	0.2112	0.0375	20.98	0.0259	0.503	18.32	7.750	14.276	2.268
SM6	30	10-8-13	0.0085	<0.0007	0.2082	0.0354	20.91	0.0289	0.496	18.06	7.854	14.440	2.283
SM7	250	3-8-13	0.0082	<0.0007	0.5287	0.0226	15.56	0.0677	0.373	23.39	5.403	9.896	1.566
SM7	30	8-8-13	0.0103	<0.0007	0.5802	0.0217	16.06	0.0671	0.392	23.45	5.535	10.108	1.608
SM7	30	9-8-13	0.0076	<0.0007	0.5741	0.0238	15.60	0.0616	0.388	22.96	5.383	9.917	1.572
SM7	30	11-8-13	<0.0017	<0.0007	0.0247	0.0034	16.50	0.0339	0.398	23.34	5.385	9.687	1.531
SM8	30	7-8-13	0.0125	<0.0007	0.5091	0.0226	39.17	0.0684	0.634	21.26	4.638	8.541	1.396
SM9	250	5-8-13	0.0182	<0.0007	0.5027	0.0261	41.16	0.0705	0.740	25.00	4.809	8.890	1.462
SM9	250	6-8-13	0.0146	<0.0007	0.4895	0.0287	37.80	0.0659	0.675	23.81	4.669	8.699	1.424
SM9	30	9-8-13	0.0131	<0.0007	0.5233	0.0266	36.26	0.0542	0.677	23.03	4.406	8.183	1.324
SM9	30	11-8-13	0.0154	<0.0007	0.4932	0.0255	38.94	0.0611	0.721	22.63	4.484	8.216	1.345
SM10	30	8-8-13	0.0119	0.0023	0.3855	0.0219	27.58	0.0504	0.500	22.55	3.249	5.912	0.959
SM11	250	2-8-13	0.0161	0.0021	0.4255	0.0164	27.39	0.0551	0.491	27.07	3.419	6.243	1.006
SM11	250	3-8-13	0.0159	0.0021	0.3903	0.0182	31.12	0.0645	0.567	27.70	3.614	6.599	1.072
SM11	250	4-8-13	0.0172	0.0014	0.3852	0.0201	30.66	0.0755	0.551	27.80	3.625	6.604	1.069
SM11	250	6-8-13	0.0161	0.0019	0.4058	0.0182	26.70	0.0577	0.494	25.33	3.256	5.973	0.982
SM11	30	7-8-13	0.0117	0.0019	0.3117	0.0188	26.03	0.0474	0.476	23.36	3.069	5.598	0.918
SM11	30	9-8-13	0.0131	0.0032	0.3452	0.0159	23.63	0.0471	0.437	22.82	2.822	5.166	0.854
SM11	30	12-8-13	0.0129	0.0028	0.4184	0.0200	28.26	0.0547	0.518	24.79	3.205	5.837	0.955
T1	250	4-8-13	0.0068	<0.0007	0.1310	<0.0016	0.15	0.0767	0.004	75.00	0.007	0.010	0.002
T1	30	9-8-13	0.0047	<0.0007	0.1262	0.0026	0.13	0.0618	0.003	69.00	0.011	0.020	0.003
T2	30	7-8-13	0.0212	0.0018	0.1273	0.0428	53.40	0.0240	1.990	13.88	20.175	41.010	6.617
T2	30	11-8-13	0.0134	<0.0007	0.0460	0.0536	46.93	0.0172	1.776	11.85	17.644	35.847	5.821
T3	30	7-8-13	0.0057	<0.0007	3.7402	0.0056	0.52	0.1327	0.015	36.11	0.009	0.007	0.003
T4	250	5-8-13	0.1459	<0.0007	0.5667	0.0694	510.27	0.1423	5.976	9.95	1.669	4.991	1.492
T4	30	8-8-13	0.1279	<0.0007	0.4871	0.0712	473.28	0.1311	5.540	8.29	1.534	4.618	1.389
T4	30	10-8-13	0.1391	0.0010	0.5501	0.0512	475.31	0.1362	5.403	7.44	1.526	4.634	1.392
T5	250	5-8-13	0.1489	0.0015	2.3881	0.0404	187.31	0.1776	9.969	4.58	2.502	8.106	2.386
T5	30	12-8-13	0.1385	0.0013	2.1674	0.0245	165.04	0.1566	8.548	3.45	2.096	6.814	2.041
T6	30	10-8-13	0.0154	0.0009	0.8962	0.0019	0.18	0.0963	0.022	84.66	0.009	0.015	0.003
QA/QC													
T1	250	4-8-13	0.0066	<0.0007	0.1157	<0.0016	0.14	0.0732	0.004	74.39	0.003	0.002	0.001
T1	250	4-8-13	0.0078	<0.0007	0.1246	<0.0016	0.14	0.0701	0.003	73.79	0.004	0.002	0.001
T3	250	7-8-13	0.0037	<0.0007	4.1772	<0.0016	0.57	0.1625	0.016	39.75	0.008	0.004	0.002
T3	250	7-8-13	0.0030	<0.0007	4.2044	0.0019	0.55	0.1703	0.015	40.57	0.009	0.004	0.002
T5	250	5-8-13	0.1017	0.0014	1.9059	0.0321	188.58	0.1453	10.030	4.48	2.543	8.181	2.411
T5	250	5-8-13	0.0969	0.0015	1.7324	0.0324	181.04	0.1387	9.439	4.22	2.383	7.737	2.285

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	90 Zr	93 Nb	95 Mo	107 Ag	111 Cd	121 Sb	133 Cs	137 Ba	139 La	140 Ce	141 Pr
LOD:			0.0017	0.0007	0.0069	0.0016	0.0020	0.0012	0.0003	0.0049	0.0004	0.0003	0.0001
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM5	30	7-8-13	0.0096	<0.0007	0.2992	0.0453	20.37	0.0254	0.707	22.69	10.970	21.769	3.329
SM5	250	7-8-13	0.0097	<0.0007	0.3588	0.0417	22.05	0.0311	0.773	24.53	11.753	23.160	3.583
T2	30	7-8-13	0.0212	0.0018	0.1273	0.0428	53.40	0.0240	1.990	13.88	20.175	41.010	6.617
T2	250	4-8-13	0.0172	<0.0007	0.0805	0.0598	55.17	0.0217	2.104	14.75	20.979	42.594	6.974
T3	30	7-8-13	0.0057	<0.0007	3.7402	0.0056	0.52	0.1327	0.015	36.11	0.009	0.007	0.003
T3	250	7-8-13	0.0026	<0.0007	4.1911	<0.0016	0.54	0.1677	0.016	40.06	0.011	0.007	0.003
T5	250	12-8-13	0.1577	0.0017	2.4570	0.0288	183.22	0.1755	9.525	3.91	2.328	7.608	2.264
T5	30	12-8-13	0.1385	0.0013	2.1674	0.0245	165.04	0.1566	8.548	3.45	2.096	6.814	2.041
SM3	250	6-8-13	0.0058	<0.0007	0.7252	0.0306	3.77	0.0616	0.094	35.12	7.490	14.786	2.021
SM3	250	6-8-13	0.0049	<0.0007	0.7847	0.0379	3.89	0.0602	0.099	36.05	7.622	15.055	2.046
SM7	250	3-8-13	0.0254	0.0008	0.6977	0.0309	16.28	0.0805	0.404	26.32	5.872	10.848	1.715
SM7	250	3-8-13	0.0082	<0.0007	0.5287	0.0226	15.56	0.0677	0.373	23.39	5.403	9.896	1.566
T1	250	4-8-13	0.0068	<0.0007	0.1310	<0.0016	0.15	0.0767	0.004	75.00	0.007	0.010	0.002
T1	250	4-8-13	0.0065	<0.0007	0.1066	0.0018	0.13	0.0721	0.004	72.07	0.006	0.007	0.002
T3	250	7-8-13	0.0026	<0.0007	4.1911	<0.0016	0.54	0.1677	0.016	40.06	0.011	0.007	0.003
T3	250	7-8-13	0.0039	<0.0007	4.1718	<0.0016	0.61	0.1646	0.017	40.57	0.013	0.009	0.003
T3	30	7-8-13	0.0057	<0.0007	3.7402	0.0056	0.52	0.1327	0.015	36.11	0.009	0.007	0.003
T3	30	7-8-13	0.0040	<0.0007	4.0540	<0.0016	0.53	0.1481	0.016	38.56	0.015	0.011	0.005
T6	30	10-8-13	0.0154	0.0009	0.8962	0.0019	0.18	0.0963	0.022	84.66	0.009	0.015	0.003
T6	30	10-8-13	0.0153	-0.0007	0.8393	0.0034	0.17	0.0913	0.024	83.02	0.009	0.017	0.003
SM3	30	10-8-13	0.0054	0.0009	0.7262	0.0321	3.77	0.0590	0.098	35.46	7.588	15.009	2.050
SM3 Lab Duplicate	30	10-8-13	0.0043	<0.0007	0.6889	0.0346	3.60	0.0609	0.092	33.38	7.201	14.305	1.959
SM7	30	11-8-13	<0.0017	<0.0007	0.0247	0.0034	16.50	0.0339	0.398	23.34	5.385	9.687	1.531
SM7 Lab Duplicate	30	11-8-13	<0.0017	<0.0007	0.0311	0.0045	17.19	0.0437	0.408	24.18	5.567	9.981	1.580
SM11	30	7-8-13	0.0117	0.0019	0.3117	0.0188	26.03	0.0474	0.476	23.36	3.069	5.598	0.918
SM11 Lab Duplicate	30	7-8-13	0.0117	0.0016	0.3656	0.0211	27.45	0.0595	0.502	24.80	3.237	5.898	0.970
T1	250	4-8-13	0.0068	<0.0007	0.1310	<0.0016	0.15	0.0767	0.004	75.00	0.007	0.010	0.002
T1 Lab Duplicate	250	4-8-13	0.0070	<0.0007	0.1553	0.0042	0.27	0.0604	0.005	75.06	0.006	0.005	0.002
T3	250	7-8-13	0.0026	<0.0007	4.1911	<0.0016	0.54	0.1677	0.016	40.06	0.011	0.007	0.003
T3 Lab Duplicate	250	7-8-13	0.0041	<0.0007	4.1684	0.0019	0.56	0.1600	0.017	39.89	0.010	0.006	0.003
T5	250	5-8-13	0.1489	0.0015	2.3881	0.0404	187.31	0.1776	9.969	4.58	2.502	8.106	2.386
T5 Lab Duplicate	250	5-8-13	0.1413	0.0012	2.3820	0.0398	182.36	0.1966	9.590	4.45	2.415	7.828	2.304

Appendix 1: Water Chemistry Results

Geological Surv. Can.		Timestamp	90 Zr	93 Nb	95 Mo	107 Ag	111 Cd	121 Sb	133 Cs	137 Ba	139 La	140 Ce	141 Pr
			0.05	0.01	0.05	0.005	0.02	0.01	0.01	0.2	0.01	0.01	0.005
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM1 GSC	250	3-8-13	< 0.05	< 0.01	< 0.05	0.076	10.81	< 0.01	0.29	25.3	26.73	51.28	7.139
SM2 GSC	250	4-8-13	< 0.05	< 0.01	0.18	0.008	7.85	0.01	0.15	39.5	18.43	34.99	4.843
SM3 GSC	250	3-8-13	< 0.05	< 0.01	1.03	< 0.005	4.77	0.05	0.12	49.2	1.92	1.82	0.182
SM4 GSC	250	4-8-13	< 0.05	< 0.01	0.88	< 0.005	4.95	0.06	0.17	46.6	2.63	2.74	0.284
SM5 GSC	250	7-8-13	< 0.05	< 0.01	< 0.05	0.015	31.41	< 0.01	1.03	35.0	15.17	29.18	4.648
SM6 GSC	250	5-8-13	< 0.05	< 0.01	< 0.05	< 0.005	30.60	< 0.01	0.66	27.9	10.63	19.08	3.096
SM7 GSC	250	3-8-13	< 0.05	< 0.01	0.19	< 0.005	22.27	0.05	0.51	34.9	7.07	12.43	1.976
SM7 GSC	250	3-8-13	< 0.05	< 0.01	0.16	< 0.005	21.92	0.05	0.51	34.9	7.03	12.32	1.956
SM8 GSC	250	7-8-13	< 0.05	< 0.01	< 0.05	< 0.005	61.55	0.02	0.91	33.1	6.57	11.66	1.926
SM9 GSC	250	5-8-13	< 0.05	< 0.01	< 0.05	< 0.005	54.04	0.01	0.91	33.5	5.82	10.47	1.744
SM10 GSC	250	8-8-13	< 0.05	< 0.01	< 0.05	< 0.005	42.26	< 0.01	0.70	34.5	4.60	8.14	1.350
SM10 GSC	250	8-8-13	< 0.05	< 0.01	< 0.05	< 0.005	42.69	< 0.01	0.71	34.3	4.58	8.20	1.362
SM11 GSC	250	2-8-13	< 0.05	< 0.01	< 0.05	< 0.005	35.75	0.01	0.60	36.3	4.12	7.37	1.214
T1 GSC	250	4-8-13	< 0.05	< 0.01	0.14	< 0.005	0.17	0.08	< 0.01	89.7	< 0.01	< 0.01	< 0.005
T2 GSC	250	4-8-13	< 0.05	< 0.01	0.08	0.036	70.83	0.02	2.57	19.7	25.39	51.18	8.467
T3 GSC	250	7-8-13	< 0.05	< 0.01	6.26	< 0.005	0.74	0.18	0.02	54.5	< 0.01	< 0.01	< 0.005
T3 GSC	250	7-8-13	< 0.05	< 0.01	6.41	< 0.005	0.76	0.18	0.02	55.6	< 0.01	< 0.01	< 0.005
T4 GSC	250	5-8-13	0.20	< 0.01	0.80	0.046	701.78	0.13	7.59	13.6	2.11	6.20	1.918
T5 GSC	250	5-8-13	0.15	< 0.01	2.89	0.027	265.24	0.16	13.31	6.6	3.36	10.68	3.231
T6 GSC	250	10-8-13	< 0.05	< 0.01	1.28	< 0.005	0.20	0.10	0.03	115.5	< 0.01	0.01	< 0.005

	Bottle	Timestamp	146 Nd	147 Sm	153 Eu	157 Gd	159 Tb	163 Dy	165 Ho	166 Er	169 Tm	172 Yb	175 Lu
LOD:			0.0006	0.0005	0.0001	0.0005	0.0001	0.0003	0.0000	0.0001	0.0000	0.0002	0.0001
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Blanks													
Travel Blank	250	10-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
Travel Blank	250	12-8-13	0.006	0.004	0.002	0.009	0.001	0.008	0.002	0.004	0.001	0.004	0.001
Acid Blank	250	10-8-13	0.001	<0.0005	<0.0001	<0.0005	<0.0001	0.000	0.000	<0.0001	0.000	<0.0002	<0.0001
Acid Blank	250	12-8-13	0.001	<0.0005	0.000	0.001	0.000	0.000	0.000	0.000	0.000	<0.0002	<0.0001
Field Blank	250	10-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
Field Blank	250	12-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	0.000	0.000	<0.0002	<0.0001
Travel Blank	30	7-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	0.000	0.000	<0.0002	<0.0001
Travel Blank	30	8-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	0.000	0.000	<0.0002	<0.0001
Travel Blank	30	9-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	0.000	0.000	0.000	<0.0001
Travel Blank	30	10-8-13	<0.0006	0.001	<0.0001	<0.0005	<0.0001	<0.0003	0.000	0.000	0.000	<0.0002	<0.0001
Travel Blank	30	11-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
Travel Blank	30	12-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
Acid Blank	30	7-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
Acid Blank	30	8-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	0.000	0.000	<0.0002	<0.0001
Acid Blank	30	9-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	0.000	0.000	<0.0002	<0.0001
Acid Blank	30	10-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
Acid Blank	30	11-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
Acid Blank	30	12-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	0.000	0.000	0.000	0.000	<0.0002	<0.0001
Field Blank	30	7-8-13	<0.0006	<0.0005	0.000	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
Field Blank	30	9-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
Field Blank	30	11-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
Field Blank	30	12-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
TBlank	30	10-8-13	<0.0006	0.001	0.000	<0.0005	<0.0001	<0.0003	0.000	0.000	0.000	<0.0002	<0.0001
TBlank LD	30	10-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
ABlank	30	9-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	0.000	0.000	<0.0002	<0.0001
ABLank LD	30	9-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	0.000	0.000	<0.0001	0.000	<0.0002	<0.0001
FBlank	30	11-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
FBlank LD	30	11-8-13	<0.0006	<0.0005	<0.0001	<0.0005	<0.0001	<0.0003	0.000	<0.0001	0.000	<0.0002	<0.0001
Filtered Samples													
SM1	250	3-8-13	23.527	4.501	1.022	5.042	0.719	3.815	0.770	2.104	0.267	1.664	0.266
SM1	30	9-8-13	22.520	4.328	0.992	4.880	0.693	3.642	0.734	2.020	0.254	1.571	0.248
SM1	30	11-8-13	23.291	4.474	1.014	4.990	0.709	3.724	0.758	2.062	0.267	1.633	0.258
SM2	250	4-8-13	17.557	3.374	0.782	3.868	0.554	2.934	0.590	1.609	0.205	1.236	0.199
SM2	30	9-8-13	15.157	2.962	0.686	3.412	0.490	2.581	0.516	1.418	0.179	1.115	0.178
SM3	250	3-8-13	0.482	0.054	0.020	0.078	0.008	0.038	0.009	0.023	0.002	0.013	0.002
SM3	250	6-8-13	0.581	0.065	0.021	0.096	0.010	0.045	0.011	0.026	0.003	0.015	0.002
SM3	30	8-8-13	0.535	0.060	0.020	0.084	0.010	0.041	0.010	0.027	0.003	0.013	0.002

	Bottle	Timestamp	146 Nd	147 Sm	153 Eu	157 Gd	159 Tb	163 Dy	165 Ho	166 Er	169 Tm	172 Yb	175 Lu
LOD:			0.0006	0.0005	0.0001	0.0005	0.0001	0.0003	0.0000	0.0001	0.0000	0.0002	0.0001
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM3	30	10-8-13	0.466	0.052	0.018	0.075	0.007	0.038	0.008	0.022	0.002	0.013	0.002
SM4	250	4-8-13	0.944	0.111	0.038	0.202	0.021	0.112	0.026	0.068	0.008	0.034	0.006
SM5	30	7-8-13	14.651	3.158	0.780	3.780	0.561	3.021	0.621	1.722	0.222	1.429	0.236
SM6	250	5-8-13	11.001	2.430	0.626	3.113	0.454	2.493	0.506	1.428	0.180	1.151	0.192
SM6	250	6-8-13	11.151	2.449	0.630	3.126	0.462	2.472	0.510	1.418	0.181	1.174	0.196
SM6	30	8-8-13	10.135	2.268	0.573	2.909	0.424	2.338	0.475	1.306	0.169	1.086	0.184
SM6	30	10-8-13	10.229	2.240	0.575	2.890	0.430	2.329	0.473	1.333	0.169	1.087	0.180
SM7	250	3-8-13	6.466	1.362	0.350	1.793	0.259	1.396	0.287	0.788	0.102	0.616	0.103
SM7	30	8-8-13	6.737	1.438	0.365	1.876	0.277	1.470	0.304	0.837	0.106	0.653	0.112
SM7	30	9-8-13	6.626	1.399	0.365	1.839	0.270	1.434	0.297	0.825	0.102	0.639	0.107
SM7	30	11-8-13	6.281	1.321	0.341	1.766	0.259	1.389	0.286	0.779	0.097	0.601	0.101
SM8	30	7-8-13	6.332	1.757	0.546	2.834	0.430	2.318	0.468	1.283	0.167	1.060	0.183
SM9	250	5-8-13	6.970	2.033	0.639	3.234	0.504	2.742	0.561	1.530	0.199	1.307	0.219
SM9	250	6-8-13	6.830	1.941	0.614	3.124	0.482	2.652	0.529	1.473	0.192	1.236	0.209
SM9	30	9-8-13	6.388	1.863	0.581	2.979	0.461	2.552	0.507	1.396	0.183	1.182	0.200
SM9	30	11-8-13	6.425	1.891	0.593	3.083	0.473	2.608	0.528	1.440	0.190	1.229	0.210
SM10	30	8-8-13	4.569	1.272	0.413	2.161	0.330	1.813	0.367	1.017	0.133	0.868	0.145
SM11	250	2-8-13	4.860	1.367	0.431	2.184	0.336	1.848	0.380	1.042	0.134	0.858	0.146
SM11	250	3-8-13	5.090	1.430	0.466	2.330	0.357	1.996	0.399	1.110	0.145	0.935	0.156
SM11	250	4-8-13	5.078	1.439	0.458	2.363	0.360	2.000	0.407	1.111	0.144	0.944	0.159
SM11	250	6-8-13	4.511	1.293	0.403	2.051	0.317	1.760	0.353	0.970	0.127	0.822	0.138
SM11	30	7-8-13	4.385	1.256	0.408	2.038	0.313	1.755	0.356	0.973	0.127	0.828	0.141
SM11	30	9-8-13	4.230	1.195	0.390	2.013	0.307	1.713	0.347	0.949	0.124	0.806	0.138
SM11	30	12-8-13	4.444	1.280	0.411	2.116	0.325	1.783	0.363	1.001	0.128	0.841	0.143
T1	250	4-8-13	0.007	0.002	0.016	0.004	0.001	0.003	0.001	0.003	0.000	0.003	0.001
T1	30	9-8-13	0.006	0.002	0.015	0.003	0.001	0.003	0.001	0.002	0.000	0.002	0.000
T2	250	4-8-13	32.356	7.226	1.743	8.100	1.215	6.600	1.331	3.757	0.492	3.242	0.534
T2	250	7-8-13	32.384	7.286	1.765	8.203	1.225	6.676	1.339	3.729	0.499	3.206	0.535
T2	30	11-8-13	28.415	6.316	1.551	7.203	1.085	5.857	1.182	3.348	0.440	2.864	0.476
T3	30	7-8-13	0.015	0.004	0.009	0.006	0.001	0.006	0.001	0.003	0.001	0.002	0.000
T4	250	5-8-13	13.631	10.527	4.480	22.485	3.562	19.473	3.768	10.204	1.386	9.200	1.557
T4	30	8-8-13	12.795	9.890	4.199	21.236	3.381	18.488	3.575	9.655	1.296	8.663	1.479
T4	30	10-8-13	12.485	9.594	4.108	20.706	3.279	18.043	3.487	9.476	1.270	8.521	1.439
T5	250	5-8-13	21.542	16.577	6.983	30.297	4.847	27.181	5.446	15.266	2.087	14.162	2.414
T5	30	8-8-13	19.047	14.990	6.284	27.658	4.459	25.035	5.013	13.996	1.910	12.994	2.255
T5	30	12-8-13	18.304	14.366	5.982	26.468	4.256	23.837	4.765	13.365	1.844	12.531	2.156
T6	30	10-8-13	0.006	0.002	0.017	0.005	0.000	0.003	0.001	0.002	0.000	0.002	0.000

	Bottle	Timestamp	146 Nd	147 Sm	153 Eu	157 Gd	159 Tb	163 Dy	165 Ho	166 Er	169 Tm	172 Yb	175 Lu
LOD:			0.0006	0.0005	0.0001	0.0005	0.0001	0.0003	0.0000	0.0001	0.0000	0.0002	0.0001
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
QA/QC													
SM5	30	7-8-13	14.651	3.158	0.780	3.780	0.561	3.021	0.621	1.722	0.222	1.429	0.236
SM5	250	7-8-13	15.508	3.389	0.824	3.913	0.587	3.174	0.651	1.796	0.233	1.462	0.245
T2	30	7-8-13	31.013	6.911	1.659	7.910	1.171	6.330	1.264	3.564	0.474	3.045	0.513
T2	250	7-8-13	32.384	7.286	1.765	8.203	1.225	6.676	1.339	3.729	0.499	3.206	0.535
T3	30	7-8-13	0.015	0.004	0.009	0.006	0.001	0.006	0.001	0.003	0.001	0.002	0.000
T3	250	7-8-13	0.015	0.003	0.010	0.004	0.001	0.005	0.001	0.003	0.000	0.004	0.001
SM3	250	6-8-13	0.581	0.065	0.021	0.096	0.010	0.045	0.011	0.026	0.003	0.015	0.002
SM3 Field duplicate	250	6-8-13	0.555	0.061	0.021	0.091	0.010	0.043	0.009	0.029	0.003	0.014	0.002
SM7 Field duplicate	250	3-8-13	6.466	1.362	0.350	1.793	0.259	1.396	0.287	0.788	0.102	0.616	0.103
T1	250	4-8-13	0.007	0.002	0.016	0.004	0.001	0.003	0.001	0.003	0.000	0.003	0.001
T1 Field duplicate	250	4-8-13	0.006	0.004	0.016	0.004	0.001	0.003	0.001	0.003	0.000	0.002	0.001
T3	30	7-8-13	0.015	0.004	0.009	0.006	0.001	0.006	0.001	0.003	0.001	0.002	0.000
T3 Field duplicate	30	7-8-13	0.012	0.004	0.010	0.006	0.001	0.005	0.001	0.003	0.001	0.003	0.000
T3	250	7-8-13	0.015	0.003	0.010	0.004	0.001	0.005	0.001	0.003	0.000	0.004	0.001
T3 Field duplicate	250	7-8-13	0.013	0.003	0.009	0.005	0.001	0.005	0.001	0.003	0.000	0.004	0.001
T6	30	10-8-13	0.006	0.002	0.017	0.005	0.000	0.003	0.001	0.002	0.000	0.002	0.000
T6 Field duplicate	30	10-8-13	0.005	0.002	0.017	0.005	0.000	0.002	0.001	0.002	0.000	0.003	0.001
SM3	30	10-8-13	0.466	0.052	0.018	0.075	0.007	0.038	0.008	0.022	0.002	0.013	0.002
SM3 Lab Duplicate	30	10-8-13	0.487	0.051	0.019	0.077	0.008	0.037	0.009	0.025	0.002	0.010	0.002
SM7	30	11-8-13	6.281	1.321	0.341	1.766	0.259	1.389	0.286	0.779	0.097	0.601	0.101
SM7 Lab Duplicate	30	11-8-13											
SM11	30	7-8-13	4.385	1.256	0.408	2.038	0.313	1.755	0.356	0.973	0.127	0.828	0.141
SM11 Lab Duplicate	30	7-8-13	4.529	1.316	0.416	2.136	0.328	1.775	0.370	1.019	0.133	0.853	0.146
Unfiltered Samples													
SM1	250	3-8-13	22.975	4.433	0.996	5.003	0.705	3.742	0.754	2.090	0.267	1.629	0.260
SM1	30	9-8-13	23.516	4.503	1.012	5.028	0.712	3.784	0.760	2.100	0.267	1.632	0.262
SM1	30	11-8-13	22.425	4.341	0.990	4.922	0.689	3.665	0.732	2.025	0.259	1.599	0.255
SM2	250	4-8-13	17.609	3.409	0.788	3.847	0.555	2.947	0.598	1.637	0.208	1.271	0.201
SM2	30	9-8-13	15.034	2.916	0.669	3.372	0.474	2.543	0.518	1.416	0.178	1.089	0.173
SM2	30	11-8-13	14.809	2.849	0.673	3.353	0.473	2.510	0.503	1.397	0.174	1.081	0.174
SM3	250	3-8-13	8.605	1.678	0.401	1.930	0.277	1.485	0.298	0.825	0.103	0.655	0.102
SM3	250	6-8-13	8.527	1.706	0.386	1.897	0.273	1.455	0.291	0.803	0.102	0.640	0.098
SM3	30	8-8-13	8.318	1.644	0.383	1.876	0.270	1.436	0.292	0.805	0.101	0.629	0.100
SM3	30	10-8-13	8.691	1.692	0.396	1.982	0.283	1.496	0.300	0.845	0.105	0.647	0.102
SM4	250	4-8-13	9.009	1.851	0.448	2.224	0.326	1.775	0.367	1.027	0.126	0.811	0.131
SM5	30	7-8-13	14.939	3.254	0.796	3.839	0.565	3.015	0.623	1.730	0.226	1.438	0.241
SM6	250	5-8-13	11.098	2.454	0.623	3.116	0.471	2.516	0.519	1.424	0.181	1.172	0.194

	Bottle	Timestamp	146 Nd	147 Sm	153 Eu	157 Gd	159 Tb	163 Dy	165 Ho	166 Er	169 Tm	172 Yb	175 Lu
LOD:			0.0006	0.0005	0.0001	0.0005	0.0001	0.0003	0.0000	0.0001	0.0000	0.0002	0.0001
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM6	250	6-8-13	10.906	2.425	0.606	3.044	0.453	2.452	0.503	1.393	0.178	1.140	0.191
SM6	30	8-8-13	10.311	2.280	0.579	2.928	0.436	2.339	0.480	1.347	0.169	1.095	0.182
SM6	30	10-8-13	10.349	2.278	0.576	2.885	0.434	2.329	0.476	1.335	0.172	1.078	0.181
SM7	250	3-8-13	7.151	1.560	0.408	2.034	0.306	1.676	0.341	0.943	0.123	0.776	0.131
SM7	30	8-8-13	7.265	1.616	0.421	2.083	0.307	1.684	0.344	0.970	0.126	0.801	0.131
SM7	30	9-8-13	7.121	1.586	0.403	2.043	0.306	1.641	0.339	0.944	0.123	0.777	0.129
SM7	30	11-8-13	6.933	1.490	0.383	1.963	0.290	1.593	0.327	0.904	0.115	0.708	0.119
SM8	30	7-8-13	6.697	1.865	0.573	2.916	0.449	2.496	0.489	1.377	0.182	1.173	0.198
SM9	250	5-8-13	7.009	2.010	0.638	3.267	0.504	2.765	0.561	1.562	0.206	1.322	0.225
SM9	250	6-8-13	6.835	1.942	0.611	3.077	0.472	2.633	0.529	1.464	0.195	1.254	0.212
SM9	30	9-8-13	6.476	1.859	0.587	2.966	0.463	2.532	0.510	1.418	0.186	1.185	0.200
SM9	30	11-8-13	6.522	1.943	0.603	3.129	0.474	2.631	0.529	1.480	0.194	1.244	0.210
SM10	30	8-8-13	4.660	1.334	0.424	2.197	0.338	1.873	0.383	1.027	0.139	0.889	0.149
SM11	250	2-8-13	4.829	1.374	0.420	2.172	0.333	1.823	0.374	1.028	0.134	0.873	0.149
SM11	250	3-8-13	5.128	1.465	0.471	2.367	0.363	2.004	0.409	1.122	0.146	0.948	0.165
SM11	250	4-8-13	5.151	1.474	0.454	2.382	0.364	2.032	0.408	1.126	0.145	0.968	0.159
SM11	250	6-8-13	4.670	1.313	0.416	2.140	0.328	1.804	0.368	1.010	0.132	0.867	0.147
SM11	30	7-8-13	4.395	1.268	0.402	2.073	0.318	1.750	0.357	0.988	0.130	0.831	0.139
SM11	30	9-8-13	4.051	1.177	0.378	1.899	0.290	1.629	0.334	0.913	0.120	0.791	0.132
SM11	30	12-8-13	4.589	1.326	0.419	2.171	0.332	1.818	0.377	1.036	0.136	0.879	0.148
T1	250	4-8-13	0.015	0.004	0.016	0.006	0.001	0.004	0.001	0.003	0.001	0.003	0.001
T1	30	9-8-13	0.016	0.002	0.015	0.006	0.001	0.004	0.001	0.003	0.000	0.003	0.001
T2	30	7-8-13	30.063	6.738	1.651	7.674	1.148	6.214	1.260	3.516	0.465	3.018	0.500
T2	30	11-8-13	26.719	5.974	1.459	6.787	1.023	5.584	1.121	3.152	0.420	2.732	0.451
T3	30	7-8-13	0.015	0.006	0.009	0.006	0.001	0.006	0.001	0.003	0.001	0.004	0.001
T4	250	5-8-13	13.537	10.524	4.479	22.457	3.584	19.494	3.756	10.195	1.368	9.212	1.560
T4	30	8-8-13	12.671	9.797	4.191	21.070	3.365	18.409	3.543	9.674	1.297	8.662	1.468
T4	30	10-8-13	12.668	9.899	4.178	21.235	3.383	18.431	3.544	9.633	1.293	8.655	1.482
T5	250	5-8-13	21.284	16.404	6.886	29.990	4.814	27.090	5.396	15.043	2.060	14.044	2.390
T5	30	12-8-13	18.391	14.381	5.996	26.644	4.255	24.024	4.780	13.381	1.834	12.488	2.165
T6	30	10-8-13	0.010	0.005	0.020	0.006	0.001	0.006	0.002	0.004	0.000	0.004	0.001
QA/QC													
T1	250	4-8-13	0.007	0.002	0.016	0.004	0.001	0.003	0.001	0.003	0.000	0.003	0.001
T1	250	4-8-13	0.007	0.002	0.015	0.004	0.001	0.004	0.001	0.002	0.000	0.002	0.001
T3	250	7-8-13	0.015	0.003	0.010	0.004	0.001	0.005	0.001	0.003	0.000	0.004	0.001
T3	250	7-8-13	0.013	0.003	0.009	0.005	0.001	0.005	0.001	0.003	0.000	0.004	0.001
T5	250	5-8-13	21.542	16.577	6.983	30.297	4.847	27.181	5.446	15.266	2.087	14.162	2.414
T5	250	5-8-13	20.421	15.791	6.612	28.727	4.613	26.036	5.156	14.529	1.980	13.387	2.302

	Bottle	Timestamp	146 Nd	147 Sm	153 Eu	157 Gd	159 Tb	163 Dy	165 Ho	166 Er	169 Tm	172 Yb	175 Lu
LOD:			0.0006	0.0005	0.0001	0.0005	0.0001	0.0003	0.0000	0.0001	0.0000	0.0002	0.0001
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM5	30	7-8-13	14.939	3.254	0.796	3.839	0.565	3.015	0.623	1.730	0.226	1.438	0.241
SM5	250	7-8-13	16.099	3.471	0.845	4.083	0.603	3.286	0.670	1.843	0.242	1.558	0.253
T2	30	7-8-13	30.063	6.738	1.651	7.674	1.148	6.214	1.260	3.516	0.465	3.018	0.500
T2	250	4-8-13	31.687	7.107	1.724	8.012	1.193	6.533	1.320	3.699	0.486	3.198	0.532
T3	30	7-8-13	0.015	0.006	0.009	0.006	0.001	0.006	0.001	0.003	0.001	0.004	0.001
T3	250	7-8-13	0.019	0.005	0.008	0.006	0.001	0.006	0.001	0.004	0.001	0.003	0.001
T5	250	12-8-13	20.460	15.896	6.663	29.075	4.655	26.046	5.234	14.622	2.009	13.582	2.340
T5	30	12-8-13	18.391	14.381	5.996	26.644	4.255	24.024	4.780	13.381	1.834	12.488	2.165
SM3	250	6-8-13	8.527	1.706	0.386	1.897	0.273	1.455	0.291	0.803	0.102	0.640	0.098
SM3	250	6-8-13	8.714	1.692	0.400	1.959	0.284	1.485	0.305	0.828	0.107	0.634	0.101
SM7	250	3-8-13	7.816	1.753	0.453	2.226	0.331	1.818	0.372	1.034	0.136	0.871	0.147
SM7	250	3-8-13	7.151	1.560	0.408	2.034	0.306	1.676	0.341	0.943	0.123	0.776	0.131
T1	250	4-8-13	0.015	0.004	0.016	0.006	0.001	0.004	0.001	0.003	0.001	0.003	0.001
T1	250	4-8-13	0.009	0.003	0.016	0.004	0.001	0.003	0.001	0.003	0.000	0.003	0.000
T3	250	7-8-13	0.019	0.005	0.008	0.006	0.001	0.006	0.001	0.004	0.001	0.003	0.001
T3	250	7-8-13	0.019	0.005	0.010	0.008	0.001	0.006	0.002	0.005	0.001	0.004	0.001
T3	30	7-8-13	0.015	0.006	0.009	0.006	0.001	0.006	0.001	0.003	0.001	0.004	0.001
T3	30	7-8-13	0.023	0.006	0.012	0.009	0.002	0.007	0.002	0.005	0.001	0.005	0.001
T6	30	10-8-13	0.010	0.005	0.020	0.006	0.001	0.006	0.002	0.004	0.000	0.004	0.001
T6	30	10-8-13	0.014	0.005	0.020	0.008	0.001	0.007	0.001	0.004	0.001	0.004	0.001
SM3	30	10-8-13	8.691	1.692	0.396	1.982	0.283	1.496	0.300	0.845	0.105	0.647	0.102
SM3 Lab Duplicate	30	10-8-13	8.321	1.632	0.391	1.941	0.278	1.476	0.300	0.830	0.101	0.645	0.100
SM7	30	11-8-13	6.933	1.490	0.383	1.963	0.290	1.593	0.327	0.904	0.115	0.708	0.119
SM7 Lab Duplicate	30	11-8-13	7.078	1.568	0.400	2.032	0.303	1.609	0.326	0.898	0.117	0.715	0.124
SM11	30	7-8-13	4.395	1.268	0.402	2.073	0.318	1.750	0.357	0.988	0.130	0.831	0.139
SM11 Lab Duplicate	30	7-8-13	4.655	1.344	0.417	2.141	0.337	1.824	0.371	1.028	0.137	0.861	0.145
T1	250	4-8-13	0.015	0.004	0.016	0.006	0.001	0.004	0.001	0.003	0.001	0.003	0.001
T1 Lab Duplicate	250	4-8-13	0.010	0.005	0.016	0.007	0.001	0.008	0.001	0.005	0.001	0.005	0.001
T3	250	7-8-13	0.019	0.005	0.008	0.006	0.001	0.006	0.001	0.004	0.001	0.003	0.001
T3 Lab Duplicate	250	7-8-13	0.016	0.005	0.010	0.006	0.001	0.005	0.001	0.005	0.000	0.003	0.001
T5	250	5-8-13	21.284	16.404	6.886	29.990	4.814	27.090	5.396	15.043	2.060	14.044	2.390
T5 Lab Duplicate	250	5-8-13	20.574	15.893	6.662	29.073	4.658	26.082	5.193	14.552	1.991	13.629	2.322

Appendix 1: Water Chemistry Results

Geological Surv. Can. ICP-MS		Timestamp	146 Nd 0.005 ppb	147 Sm 0.005 ppb	153 Eu 0.005 ppb	157 Gd 0.005 ppb	159 Tb 0.005 ppb	163 Dy 0.005 ppb	165 Ho 0.005 ppb	166 Er 0.005 ppb	169 Tm 0.005 ppb	172 Yb 0.005 ppb	175 Lu 0.005 ppb
SM1 GSC	250	3-8-13	28.501	5.752	1.265	6.088	0.848	4.578	0.915	2.438	0.314	1.837	0.274
SM2 GSC	250	4-8-13	19.434	3.942	0.889	4.400	0.607	3.282	0.656	1.754	0.226	1.320	0.195
SM3 GSC	250	3-8-13	0.628	0.069	0.016	0.088	0.010	0.048	0.011	0.029	< 0.005	0.014	< 0.005
SM4 GSC	250	4-8-13	1.085	0.136	0.034	0.215	0.025	0.128	0.028	0.072	0.008	0.038	0.006
SM5 GSC	250	7-8-13	20.030	4.467	1.074	5.251	0.741	4.076	0.822	2.207	0.293	1.760	0.274
SM6 GSC	250	5-8-13	13.396	3.068	0.777	3.970	0.550	3.046	0.617	1.657	0.216	1.324	0.203
SM7 GSC	250	3-8-13	8.522	1.889	0.474	2.449	0.342	1.867	0.382	1.019	0.129	0.748	0.116
SM7 GSC	250	3-8-13	8.515	1.859	0.460	2.396	0.333	1.805	0.371	0.982	0.125	0.745	0.114
SM8 GSC	250	7-8-13	8.829	2.472	0.764	4.168	0.573	3.204	0.644	1.713	0.226	1.342	0.213
SM9 GSC	250	5-8-13	8.101	2.399	0.760	4.086	0.583	3.193	0.640	1.734	0.232	1.401	0.217
SM10 GSC	250	8-8-13	6.240	1.833	0.581	3.146	0.447	2.464	0.499	1.338	0.175	1.089	0.171
SM10 GSC	250	8-8-13	6.271	1.867	0.579	3.210	0.445	2.510	0.497	1.353	0.177	1.091	0.172
SM11 GSC	250	2-8-13	5.577	1.624	0.492	2.685	0.380	2.133	0.427	1.151	0.152	0.928	0.145
T1 GSC	250	4-8-13	0.009	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
T2 GSC	250	4-8-13	36.917	8.643	2.062	9.748	1.374	7.550	1.516	4.137	0.556	3.461	0.530
T3 GSC	250	7-8-13	0.014	< 0.005	< 0.005	0.006	< 0.005	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
T3 GSC	250	7-8-13	0.016	< 0.005	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
T4 GSC	250	5-8-13	16.912	13.208	5.588	30.577	4.303	23.788	4.550	12.165	1.646	10.418	1.622
T5 GSC	250	5-8-13	27.907	21.915	9.076	43.480	6.172	34.966	6.957	19.141	2.645	16.897	2.695
T6 GSC	250	10-8-13	0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

	Bottle	Timestamp	178 Hf	181 Ta	182 W	197 Au	202 Hg	208 Pb	232 Th	238 U
LOD:			0.0006	0.0007	0.0512	0.0061	0.0117	0.0036	0.0012	0.0002
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Blanks										
Travel Blank	250	10-8-13	<0.0006	<0.0007	0.45	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
Travel Blank	250	12-8-13	<0.0006	<0.0007	0.10	<0.0061	<0.0117	0.004	<0.0012	0.0111
Acid Blank	250	10-8-13	<0.0006	<0.0007	0.19	<0.0061	<0.0117	0.009	<0.0012	<0.0002
Acid Blank	250	12-8-13	<0.0006	<0.0007	0.30	<0.0061	<0.0117	0.018	<0.0012	0.0005
Field Blank	250	10-8-13	<0.0006	<0.0007	0.16	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
Field Blank	250	12-8-13	<0.0006	<0.0007	0.17	<0.0061	0.0123	<0.0036	<0.0012	<0.0002
Travel Blank	30	7-8-13	<0.0006	<0.0007	0.07	<0.0061	<0.0117	0.005	<0.0012	<0.0002
Travel Blank	30	8-8-13	<0.0006	<0.0007	0.11	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
Travel Blank	30	9-8-13	<0.0006	<0.0007	0.16	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
Travel Blank	30	10-8-13	<0.0006	<0.0007	0.10	<0.0061	<0.0117	<0.0036	<0.0012	0.0002
Travel Blank	30	11-8-13	<0.0006	<0.0007	0.08	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
Travel Blank	30	12-8-13	<0.0006	<0.0007	0.09	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
Acid Blank	30	7-8-13	<0.0006	<0.0007	0.23	<0.0061	0.0165	0.004	<0.0012	0.0004
Acid Blank	30	8-8-13	<0.0006	<0.0007	0.27	<0.0061	0.0172	0.010	<0.0012	<0.0002
Acid Blank	30	9-8-13	<0.0006	<0.0007	0.26	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
Acid Blank	30	10-8-13	<0.0006	<0.0007	0.39	<0.0061	0.0129	0.006	<0.0012	0.0002
Acid Blank	30	11-8-13	<0.0006	<0.0007	0.23	<0.0061	0.0172	<0.0036	<0.0012	<0.0002
Acid Blank	30	12-8-13	<0.0006	<0.0007	0.25	<0.0061	0.0123	0.011	<0.0012	<0.0002
Field Blank	30	7-8-13	<0.0006	<0.0007	0.38	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
Field Blank	30	9-8-13	<0.0006	<0.0007	0.22	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
Field Blank	30	11-8-13	<0.0006	<0.0007	0.22	<0.0061	0.0123	<0.0036	<0.0012	<0.0002
Field Blank	30	12-8-13	<0.0006	<0.0007	0.17	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
TBlank	30	10-8-13	<0.0006	<0.0007	0.10	<0.0061	<0.0117	<0.0036	<0.0012	0.0002
TBlank LD	30	10-8-13	<0.0006	<0.0007	<0.0512	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
ABlank	30	9-8-13	<0.0006	<0.0007	0.26	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
ABLank LD	30	9-8-13	<0.0006	<0.0007	0.27	<0.0061	<0.0117	<0.0036	<0.0012	0.0002
FBlank	30	11-8-13	<0.0006	<0.0007	0.22	<0.0061	0.0123	<0.0036	<0.0012	<0.0002
FBlank LD	30	11-8-13	<0.0006	<0.0007	0.28	<0.0061	<0.0117	<0.0036	<0.0012	<0.0002
Filtered Samples										
SM1	250	3-8-13	0.016	0.005	1.89	<0.0061	0.0129	0.147	0.0391	1.7902
SM1	30	9-8-13	0.016	0.004	1.69	<0.0061	<0.0117	0.120	0.0327	1.6094
SM1	30	11-8-13	0.016	0.004	2.12	<0.0061	<0.0117	0.154	0.0328	1.6689
SM2	250	4-8-13	0.013	0.004	1.45	<0.0061	<0.0117	0.091	0.0121	1.3272
SM2	30	9-8-13	0.013	0.003	1.76	<0.0061	0.0141	0.085	0.0085	1.1782
SM3	250	3-8-13	0.002	0.001	0.28	0.0083	0.0172	0.008	0.0032	0.0561
SM3	250	6-8-13	0.001	<0.0007	0.45	<0.0061	<0.0117	0.005	<0.0012	0.0480
SM3	30	8-8-13	0.001	<0.0007	0.50	<0.0061	<0.0117	<0.0036	<0.0012	0.0427

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	178 Hf	181 Ta	182 W	197 Au	202 Hg	208 Pb	232 Th	238 U
LOD:			0.0006	0.0007	0.0512	0.0061	0.0117	0.0036	0.0012	0.0002
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM3	30	10-8-13	0.001	0.001	0.76	<0.0061	<0.0117	<0.0036	0.0017	0.0537
SM4	250	4-8-13	0.001	<0.0007	0.52	<0.0061	<0.0117	0.008	0.0013	0.0563
SM5	30	7-8-13	0.014	0.003	1.88	<0.0061	<0.0117	0.062	0.0134	3.3763
SM6	250	5-8-13	0.011	0.004	1.99	0.0075	0.0202	0.076	0.0073	2.4609
SM6	250	6-8-13	0.011	0.003	1.50	<0.0061	<0.0117	0.074	0.0031	2.5206
SM6	30	8-8-13	0.012	0.003	1.68	<0.0061	<0.0117	0.072	0.0022	2.3989
SM6	30	10-8-13	0.009	0.002	1.33	<0.0061	<0.0117	0.083	0.0030	2.4069
SM7	250	3-8-13	0.007	0.003	2.77	0.0084	0.0178	0.020	0.0033	1.5450
SM7	30	8-8-13	0.008	0.003	0.95	<0.0061	<0.0117	0.015	<0.0012	1.6219
SM7	30	9-8-13	0.008	0.002	1.09	<0.0061	<0.0117	0.012	0.0013	1.7515
SM7	30	11-8-13	0.006	0.002	0.87	<0.0061	<0.0117	0.019	<0.0012	1.8243
SM8	30	7-8-13	0.009	0.003	1.54	<0.0061	<0.0117	1.082	0.0185	2.9805
SM9	250	5-8-13	0.012	0.003	1.71	<0.0061	<0.0117	0.535	0.0049	3.3426
SM9	250	6-8-13	0.011	0.004	1.42	<0.0061	<0.0117	0.468	0.0032	3.2165
SM9	30	9-8-13	0.010	0.003	1.38	<0.0061	<0.0117	0.421	0.0029	3.0406
SM9	30	11-8-13	0.012	0.003	1.69	<0.0061	<0.0117	0.531	0.0029	3.2291
SM10	30	8-8-13	0.007	0.002	1.28	<0.0061	<0.0117	0.239	0.0017	2.2848
SM11	250	2-8-13	0.008	0.002	1.40	<0.0061	<0.0117	0.266	0.0036	2.3198
SM11	250	3-8-13	0.008	0.003	1.31	<0.0061	<0.0117	0.284	0.0040	2.4939
SM11	250	4-8-13	0.009	0.002	1.20	<0.0061	0.0153	0.301	0.0036	2.5157
SM11	250	6-8-13	0.007	0.003	1.76	<0.0061	<0.0117	0.214	0.0028	2.1731
SM11	30	7-8-13	0.008	0.002	1.15	<0.0061	<0.0117	0.253	0.0016	2.2715
SM11	30	9-8-13	0.008	0.002	0.97	<0.0061	<0.0117	0.201	0.0016	2.1689
SM11	30	12-8-13	0.007	0.002	1.11	<0.0061	<0.0117	0.216	0.0023	2.2895
T1	250	4-8-13	<0.0006	0.001	0.60	<0.0061	<0.0117	<0.0036	0.0029	0.0129
T1	30	9-8-13	<0.0006	<0.0007	0.23	<0.0061	<0.0117	0.047	0.0017	0.0104
T2	250	4-8-13	0.027	0.008	3.14	0.0062	<0.0117	0.163	0.1870	8.2488
T2	250	7-8-13	0.027	0.007	6.23	<0.0061	<0.0117	0.145	0.1825	8.2893
T2	30	11-8-13	0.023	0.007	3.14	<0.0061	<0.0117	0.141	0.1557	7.4322
T3	30	7-8-13	<0.0006	<0.0007	0.68	<0.0061	<0.0117	<0.0036	<0.0012	6.3468
T4	250	5-8-13	0.074	0.020	8.45	<0.0061	<0.0117	26.409	0.7809	24.2765
T4	30	8-8-13	0.073	0.015	7.79	<0.0061	<0.0117	24.350	0.7125	23.0881
T4	30	10-8-13	0.070	0.017	6.94	<0.0061	<0.0117	22.223	0.6944	22.5322
T5	250	5-8-13	0.106	0.030	11.73	<0.0061	<0.0117	0.059	0.4220	40.3985
T5	30	8-8-13	0.098	0.024	10.80	<0.0061	0.0153	0.055	0.3570	36.2441
T5	30	12-8-13	0.090	0.022	9.75	<0.0061	<0.0117	0.052	0.3453	34.9293
T6	30	10-8-13	<0.0006	<0.0007	0.15	<0.0061	<0.0117	0.029	0.0022	0.7691

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	178 Hf	181 Ta	182 W	197 Au	202 Hg	208 Pb	232 Th	238 U
LOD:			0.0006	0.0007	0.0512	0.0061	0.0117	0.0036	0.0012	0.0002
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
QA/QC										
SM5	30	7-8-13	0.014	0.003	1.88	<0.0061	<0.0117	0.062	0.0134	3.3763
SM5	250	7-8-13	0.014	0.003	1.84	<0.0061	<0.0117	0.063	0.0148	3.6643
T2	30	7-8-13	0.027	0.009	3.48	<0.0061	<0.0117	0.132	0.1742	7.7848
T2	250	7-8-13	0.027	0.007	6.23	<0.0061	<0.0117	0.145	0.1825	8.2893
T3	30	7-8-13	<0.0006	<0.0007	0.68	<0.0061	<0.0117	<0.0036	<0.0012	6.3468
T3	250	7-8-13	0.001	0.001	0.50	<0.0061	<0.0117	0.006	<0.0012	6.7212
SM3	250	6-8-13	0.001	<0.0007	0.45	<0.0061	<0.0117	0.005	<0.0012	0.0480
SM3 Field duplicate	250	6-8-13	0.001	<0.0007	0.34	<0.0061	<0.0117	0.006	0.0014	0.0474
SM7 Field duplicate	250	3-8-13	0.007	0.003	2.77	0.0084	0.0178	0.020	0.0033	1.5450
T1	250	4-8-13	<0.0006	0.001	0.60	<0.0061	<0.0117	<0.0036	0.0029	0.0129
T1 Field duplicate	250	4-8-13	0.001	0.001	0.25	0.0084	<0.0117	0.004	0.0028	0.0112
T3	30	7-8-13	<0.0006	<0.0007	0.68	<0.0061	<0.0117	<0.0036	<0.0012	6.3468
T3 Field duplicate	30	7-8-13	<0.0006	<0.0007	0.70	<0.0061	0.0135	0.004	<0.0012	6.2648
T3	250	7-8-13	0.001	0.001	0.50	<0.0061	<0.0117	0.006	<0.0012	6.7212
T3 Field duplicate	250	7-8-13	<0.0006	<0.0007	0.26	<0.0061	<0.0117	0.010	<0.0012	6.8685
T6	30	10-8-13	<0.0006	<0.0007	0.15	<0.0061	<0.0117	0.029	0.0022	0.7691
T6 Field duplicate	30	10-8-13	0.001	<0.0007	0.31	<0.0061	<0.0117	0.017	0.0019	0.7707
SM3	30	10-8-13	0.001	0.001	0.76	<0.0061	<0.0117	<0.0036	0.0017	0.0537
SM3 Lab Duplicate	30	10-8-13	<0.0006	<0.0007	0.64	<0.0061	<0.0117	0.004	<0.0012	0.0608
SM7	30	11-8-13	0.006	0.002	0.87	<0.0061	<0.0117	0.019	<0.0012	1.8243
SM7 Lab Duplicate	30	11-8-13								
SM11	30	7-8-13	0.008	0.002	1.15	<0.0061	<0.0117	0.253	0.0016	2.2715
SM11 Lab Duplicate	30	7-8-13	0.008	0.002	1.17	<0.0061	<0.0117	0.261	0.0019	2.3351
Unfiltered Samples										
SM1	250	3-8-13	0.017	0.005	1.92	<0.0061	0.0184	0.141	0.0353	1.7564
SM1	30	9-8-13	0.019	0.004	1.85	<0.0061	<0.0117	0.123	0.0333	1.6591
SM1	30	11-8-13	0.017	0.003	2.05	<0.0061	<0.0117	0.131	0.0305	1.6429
SM2	250	4-8-13	0.012	0.004	2.03	<0.0061	<0.0117	0.098	0.0150	1.3607
SM2	30	9-8-13	0.013	0.003	1.39	<0.0061	<0.0117	1.012	0.0130	1.1824
SM2	30	11-8-13	0.011	0.004	1.42	<0.0061	<0.0117	0.089	0.0080	1.1907
SM3	250	3-8-13	0.006	0.003	1.20	0.0083	<0.0117	0.072	0.0111	2.3025
SM3	250	6-8-13	0.007	0.002	0.87	<0.0061	<0.0117	0.054	0.0068	2.1583
SM3	30	8-8-13	0.007	0.002	0.92	<0.0061	<0.0117	0.055	0.0069	2.1949
SM3	30	10-8-13	0.008	0.002	0.84	<0.0061	<0.0117	0.061	0.0086	2.2688
SM4	250	4-8-13	0.009	0.003	1.09	<0.0061	<0.0117	0.072	0.0095	2.2317
SM5	30	7-8-13	0.014	0.004	1.94	<0.0061	<0.0117	0.078	0.0480	3.5200
SM6	250	5-8-13	0.012	0.003	2.08	0.0081	0.0270	0.133	0.0382	2.5002

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	178 Hf	181 Ta	182 W	197 Au	202 Hg	208 Pb	232 Th	238 U
LOD:			0.0006	0.0007	0.0512	0.0061	0.0117	0.0036	0.0012	0.0002
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM6	250	6-8-13	0.010	0.003	1.97	<0.0061	<0.0117	0.130	0.0324	2.4988
SM6	30	8-8-13	0.011	0.003	1.22	<0.0061	<0.0117	0.128	0.0273	2.4238
SM6	30	10-8-13	0.011	0.003	1.30	<0.0061	<0.0117	0.138	0.0315	2.4416
SM7	250	3-8-13	0.008	0.003	0.96	0.0073	0.0165	0.089	0.0257	2.4336
SM7	30	8-8-13	0.007	0.002	1.40	<0.0061	<0.0117	0.100	0.0219	2.4786
SM7	30	9-8-13	0.007	0.002	1.02	<0.0061	<0.0117	0.093	0.0211	2.4927
SM7	30	11-8-13	0.005	0.002	0.58	<0.0061	<0.0117	0.013	<0.0012	1.1972
SM8	30	7-8-13	0.011	0.003	1.26	<0.0061	<0.0117	1.360	0.0609	3.3581
SM9	250	5-8-13	0.015	0.003	1.62	<0.0061	<0.0117	1.272	0.0655	3.5118
SM9	250	6-8-13	0.012	0.003	1.80	<0.0061	<0.0117	1.116	0.0627	3.3732
SM9	30	9-8-13	0.012	0.003	1.28	<0.0061	<0.0117	1.034	0.0590	3.1695
SM9	30	11-8-13	0.010	0.004	1.44	<0.0061	<0.0117	1.186	0.0570	3.3199
SM10	30	8-8-13	0.008	0.002	2.28	<0.0061	<0.0117	0.821	0.0496	2.4571
SM11	250	2-8-13	0.007	0.002	2.81	<0.0061	<0.0117	0.770	0.0510	2.4222
SM11	250	3-8-13	0.009	0.002	2.56	<0.0061	<0.0117	0.755	0.0506	2.6134
SM11	250	4-8-13	0.011	0.003	2.65	<0.0061	<0.0117	0.806	0.0494	2.6065
SM11	250	6-8-13	0.009	0.003	2.34	<0.0061	<0.0117	0.711	0.0529	2.4415
SM11	30	7-8-13	0.008	0.002	2.22	<0.0061	<0.0117	0.676	0.0434	2.3634
SM11	30	9-8-13	0.008	0.003	2.42	<0.0061	<0.0117	0.631	0.0481	2.2412
SM11	30	12-8-13	0.009	0.002	2.22	<0.0061	<0.0117	0.690	0.0477	2.4018
T1	250	4-8-13	<0.0006	<0.0007	0.20	<0.0061	<0.0117	0.005	0.0028	0.0150
T1	30	9-8-13	<0.0006	<0.0007	0.28	<0.0061	0.0129	0.004	0.0014	0.0132
T2	30	7-8-13	0.027	0.007	3.36	<0.0061	<0.0117	0.140	0.1665	7.7093
T2	30	11-8-13	0.023	0.007	3.47	<0.0061	<0.0117	0.142	0.1412	7.1821
T3	30	7-8-13	<0.0006	<0.0007	0.28	<0.0061	<0.0117	0.006	<0.0012	6.4045
T4	250	5-8-13	0.076	0.019	8.16	<0.0061	<0.0117	26.572	0.7742	24.2640
T4	30	8-8-13	0.077	0.019	7.64	<0.0061	<0.0117	24.273	0.7095	23.1249
T4	30	10-8-13	0.069	0.018	7.83	<0.0061	<0.0117	23.055	0.7153	23.1588
T5	250	5-8-13	0.106	0.025	11.83	<0.0061	<0.0117	0.070	0.4729	39.7681
T5	30	12-8-13	0.091	0.023	10.44	<0.0061	<0.0117	0.059	0.3946	35.0467
T6	30	10-8-13	0.001	<0.0007	0.39	<0.0061	<0.0117	0.112	0.0044	0.8120
QA/QC										
T1	250	4-8-13	<0.0006	0.001	0.60	<0.0061	<0.0117	<0.0036	0.0029	0.0129
T1	250	4-8-13	<0.0006	<0.0007	0.24	<0.0061	<0.0117	0.008	0.0018	0.0126
T3	250	7-8-13	0.001	0.001	0.50	<0.0061	<0.0117	0.006	<0.0012	6.7212
T3	250	7-8-13	<0.0006	<0.0007	0.26	<0.0061	<0.0117	0.010	<0.0012	6.8685
T5	250	5-8-13	0.106	0.030	11.73	<0.0061	<0.0117	0.059	0.4220	40.3985
T5	250	5-8-13	0.095	0.023	10.27	<0.0061	<0.0117	0.062	0.3901	38.5228

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	178 Hf	181 Ta	182 W	197 Au	202 Hg	208 Pb	232 Th	238 U
LOD: ICP-MS			0.0006 ppb	0.0007 ppb	0.0512 ppb	0.0061 ppb	0.0117 ppb	0.0036 ppb	0.0012 ppb	0.0002 ppb
SM5	30	7-8-13	0.014	0.004	1.94	<0.0061	<0.0117	0.078	0.0480	3.5200
SM5	250	7-8-13	0.015	0.004	1.76	<0.0061	<0.0117	0.090	0.0547	3.8361
T2	30	7-8-13	0.027	0.007	3.36	<0.0061	<0.0117	0.140	0.1665	7.7093
T2	250	4-8-13	0.029	0.007	3.21	<0.0061	0.0153	0.164	0.1745	8.1746
T3	30	7-8-13	<0.0006	<0.0007	0.28	<0.0061	<0.0117	0.006	<0.0012	6.4045
T3	250	7-8-13	<0.0006	<0.0007	1.48	<0.0061	<0.0117	0.006	<0.0012	6.7004
T5	250	12-8-13	0.101	0.023	11.18	<0.0061	<0.0117	0.069	0.4304	38.4407
T5	30	12-8-13	0.091	0.023	10.44	<0.0061	<0.0117	0.059	0.3946	35.0467
SM3	250	6-8-13	0.007	0.002	0.87	<0.0061	<0.0117	0.054	0.0068	2.1583
SM3	250	6-8-13	0.006	0.002	4.03	<0.0061	<0.0117	0.065	0.0067	2.2629
SM7	250	3-8-13	0.009	0.002	1.26	<0.0061	<0.0117	0.198	0.0428	2.9475
SM7	250	3-8-13	0.008	0.003	0.96	0.0073	0.0165	0.089	0.0257	2.4336
T1	250	4-8-13	<0.0006	<0.0007	0.20	<0.0061	<0.0117	0.005	0.0028	0.0150
T1	250	4-8-13	<0.0006	0.001	0.50	0.0072	<0.0117	0.005	0.0038	0.0134
T3	250	7-8-13	-0.001	<0.0007	1.48	<0.0061	<0.0117	0.006	<0.0012	6.7004
T3	250	7-8-13	0.001	<0.0007	0.30	<0.0061	<0.0117	0.005	0.0013	6.8216
T3	30	7-8-13	<0.0006	<0.0007	0.28	<0.0061	<0.0117	0.006	<0.0012	6.4045
T3	30	7-8-13	<0.0006	<0.0007	0.26	<0.0061	<0.0117	0.007	<0.0012	6.5662
T6	30	10-8-13	0.001	<0.0007	0.39	<0.0061	<0.0117	0.112	0.0044	0.8120
T6	30	10-8-13	0.001	<0.0007	0.24	<0.0061	<0.0117	0.140	0.0069	0.7944
SM3	30	10-8-13	0.008	0.002	0.84	<0.0061	<0.0117	0.061	0.0086	2.2688
SM3 Lab Duplicate	30	10-8-13	0.006	0.002	22.81	<0.0061	<0.0117	0.061	0.0069	2.3326
SM7	30	11-8-13	0.005	0.002	0.58	<0.0061	<0.0117	0.013	<0.0012	1.1972
SM7 Lab Duplicate	30	11-8-13	0.006	0.002	0.88	<0.0061	<0.0117	0.016	<0.0012	1.6363
SM11	30	7-8-13	0.008	0.002	2.22	<0.0061	<0.0117	0.676	0.0434	2.3634
SM11 Lab Duplicate	30	7-8-13	0.009	0.002	2.11	<0.0061	0.0141	0.706	0.0469	2.4673
T1	250	4-8-13	<0.0006	<0.0007	0.20	<0.0061	<0.0117	0.005	0.0028	0.0150
T1 Lab Duplicate	250	4-8-13	<0.0006	0.001	0.33	<0.0061	<0.0117	0.013	0.0016	0.0180
T3	250	7-8-13	<0.0006	<0.0007	1.48	<0.0061	<0.0117	0.006	<0.0012	6.7004
T3 Lab Duplicate	250	7-8-13	<0.0006	<0.0007	0.26	<0.0061	<0.0117	0.009	<0.0012	6.6960
T5	250	5-8-13	0.106	0.025	11.83	<0.0061	<0.0117	0.070	0.4729	39.7681
T5 Lab Duplicate	250	5-8-13	0.101	0.023	11.65	<0.0061	<0.0117	0.072	0.4523	38.7329

Appendix 1: Water Chemistry Results

Geological Surv. Can.		Timestamp	178 Hf	181 Ta	182 W	197 Au	202 Hg	208 Pb	232 Th	238 U
			0.01	0.01	0.02			0.01		0.005
ICP-MS			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
SM1 GSC	250	3-8-13	< 0.01	< 0.01	< 0.02			0.19		1.826
SM2 GSC	250	4-8-13	< 0.01	< 0.01	0.02			0.11		1.334
SM3 GSC	250	3-8-13	< 0.01	< 0.01	< 0.02			0.01		0.054
SM4 GSC	250	4-8-13	< 0.01	< 0.01	< 0.02			< 0.01		0.056
SM5 GSC	250	7-8-13	< 0.01	< 0.01	< 0.02			0.08		4.042
SM6 GSC	250	5-8-13	< 0.01	< 0.01	< 0.02			0.09		2.603
SM7 GSC	250	3-8-13	< 0.01	< 0.01	< 0.02			0.02		1.716
SM7 GSC	250	3-8-13	< 0.01	< 0.01	< 0.02			0.02		1.711
SM8 GSC	250	7-8-13	< 0.01	< 0.01	< 0.02			1.55		3.486
SM9 GSC	250	5-8-13	< 0.01	< 0.01	< 0.02			0.63		3.310
SM10 GSC	250	8-8-13	< 0.01	< 0.01	< 0.02			0.34		2.648
SM10 GSC	250	8-8-13	< 0.01	< 0.01	< 0.02			0.34		2.620
SM11 GSC	250	2-8-13	< 0.01	< 0.01	< 0.02			0.38		2.293
T1 GSC	250	4-8-13	< 0.01	< 0.01	< 0.02			< 0.01		0.011
T2 GSC	250	4-8-13	< 0.01	< 0.01	< 0.02			0.20		8.157
T3 GSC	250	7-8-13	< 0.01	< 0.01	< 0.02			< 0.01		6.818
T3 GSC	250	7-8-13	< 0.01	< 0.01	< 0.02			0.03		6.843
T4 GSC	250	5-8-13	0.02	< 0.01	0.03			33.61		25.273
T5 GSC	250	5-8-13	0.04	0.01	< 0.02			0.08		49.923
T6 GSC	250	10-8-13	< 0.01	< 0.01	< 0.02			0.03		0.838

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	DIC	DOC	Fluoride	Chloride	Sulfate	Bromide	Nitrate	Phosphate
LOD:					0.0286	0.0040	0.094	0.0025	0.0151	0.0118
			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Blanks										
Travel Blank										
Travel Blank										
Acid Blank										
Acid Blank										
Field Blank										
Field Blank										
Travel Blank										
Travel Blank	30	8-8-13			<0.0286	<0.0040	0.0461	<0.0025	<0.0151	<0.118
Travel Blank	30	9-8-13								
Travel Blank	30	10-8-13								
Travel Blank	30	11-8-13								
Travel Blank	30	12-8-13								
Acid Blank	30	7-8-13								
Acid Blank	30	8-8-13								
Acid Blank	30	9-8-13								
Acid Blank	30	10-8-13								
Acid Blank	30	11-8-13			0.033	<0.0040	0.02	0.004	<0.0151	0.021
Acid Blank	30	12-8-13								
Field Blank	30	7-8-13								
Field Blank	30	9-8-13								
Field Blank	30	11-8-13								
Field Blank	30	12-8-13								
TBlank	30	10-8-13								
TBlank LD	30	10-8-13								
ABlank	30	9-8-13								
ABLank LD	30	9-8-13								
FBlank	30	11-8-13								
FBlank LD	30	11-8-13								
Filtered Samples										
SM1	250	3-8-13	1.44	2.18						
SM1	30	9-8-13	1.86	2.47	0.405	0.030	145.2	<0.002	0.07	<0.0118
SM1	30	11-8-13	1.76	2.51	0.406	0.027	149.2	<0.002	0.07	<0.0118
SM2	250	4-8-13	1.03	2.40						
SM2	30	9-8-13	0.52	1.81	0.364	0.041	103.3	<0.002	<0.0151	<0.0118
SM3	250	3-8-13	4.67	2.24						
SM3	250	6-8-13	4.55	1.83						
SM3	30	8-8-13	4.77	1.53	0.134	0.037	112.2	<0.002	0.02	<0.0118

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	DIC	DOC	Fluoride	Chloride	Sulfate	Bromide	Nitrate	Phosphate
LOD:					0.0286	0.0040	0.094	0.0025	0.0151	0.0118
			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SM3	30	10-8-13	4.61	2.31	0.141	0.048	114.1	<0.002	0.21	<0.0118
SM4	250	4-8-13								
SM5	30	7-8-13			0.127	0.024	171.9	<0.002	0.117	<0.0118
SM6	250	5-8-13	1.10	1.88						
SM6	250	6-8-13	1.40	2.22						
SM6	30	8-8-13	0.67	1.89	0.127	0.041	176.9	<0.002	0.169	<0.0118
SM6	30	10-8-13	0.92	1.84						
SM7	250	3-8-13	2.66	1.90						
SM7	30	8-8-13	2.27	2.01	0.222	0.023	169.4	<0.002	0.166	0.022
SM7	30	9-8-13								
SM7	30	11-8-13			0.205	0.043	173.1	<0.002	0.177	<0.0118
SM8	30	7-8-13	3.18	2.29	0.127	0.041	225.7	<0.002	0.169	<0.0118
SM9	250	5-8-13	1.77	1.81						
SM9	250	6-8-13								
SM9	30	9-8-13	1.53	1.99						
SM9	30	11-8-13	1.49	2.22	0.121	0.046	235.5	<0.002	0.136	<0.0118
SM10	30	8-8-13	0.74	2.23	0.093	0.045	177.6	<0.002	0.163	<0.0118
SM11	250	2-8-13	1.45	2.55						
SM11	250	3-8-13								
SM11	250	4-8-13								
SM11	250	6-8-13	0.67	1.81						
SM11	30	7-8-13	0.99	2.47	0.090	0.043	173.4	<0.002	0.160	<0.0118
SM11	30	9-8-13								
SM11	30	12-8-13			0.056	0.035	179.3	<0.002	0.175	<0.0118
T1	250	4-8-13	2.16	2.64						
T1	30	9-8-13			<0.0286	0.027	9.8	<0.002	<0.0151	<0.0118
T2	250	4-8-13	0.24	0.07						
T2	250	7-8-13			0.156	0.063	288.27	<0.002	0.540	<0.0118
T2	30	11-8-13	6.19	3.18	0.267	0.063	288.3	<0.002	0.362	<0.0118
T3	30	7-8-13	37.11	2.67	0.114	0.033	106.6	<0.002	<0.0151	<0.0118
T4	250	5-8-13	8.60	2.90						
T4	30	8-8-13	23.32	4.81	0.096	0.093	1344.68	<0.002	0.451	<0.0118
T4	30	10-8-13	1.65	2.52	0.105	0.125	1347.8	<0.002	0.380	<0.0118
T5	250	5-8-13	22.83	4.26						
T5	30	8-8-13	20.52	5.57						
T5	30	12-8-13			0.090	0.031	2070.0	<0.002	0.563	0.327
T6	30	10-8-13	14.31	4.01	0.055	0.026	14.05	<0.002	0.055	<0.0118

Appendix 1: Water Chemistry Results

	Bottle	Timestamp	DIC	DOC	Fluoride	Chloride	Sulfate	Bromide	Nitrate	Phosphate
LOD:					0.0286	0.0040	0.094	0.0025	0.0151	0.0118
ICP-MS			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
QA/QC										
SM5	30	7-8-13								
SM5	250	7-8-13	1.66	2.43						
T2	30	7-8-13								
T2	250	7-8-13								
T3	30	7-8-13	37.11	2.67						
T3	250	7-8-13	37.58	2.62						
SM3	250	6-8-13	4.55	1.83						
SM3 Field duplicate	250	6-8-13	4.24	1.81						
SM7 Field duplicate	250	3-8-13	2.66	1.90						
T1	250	4-8-13	2.16	2.64						
T1 Field duplicate	250	4-8-13	1.65	0.29						
T3	30	7-8-13	37.11	2.67						

Appendix 2: Field Measurements

Site	Timestamp	Barometer kpa	Conductivity µS/cm	Dissolved Oxygen mg/L	ORP mV	pH	Temperature ˚C
SM11	2013-08-02 15:02	91.55	325.4	9.3	362.3	4.59	12.0
SM7	2013-08-03 11:29	90.87	225.4	9.7	423.1	5.34	8.5
SM1	2013-08-03 14:28	88.94	285.4	8.4	510.2	3.40	14.6
SM3	2013-08-03 17:38	89.94	197.3	8.7	335.1	6.97	12.3
SM11	2013-08-03 21:04	91.30	256.6	8.8	431.9	4.54	13.3
SM7	2013-08-03 21:32	90.65	241.2	8.5	435.1	5.37	11.5
SM2	2013-08-04 11:29	89.41	149.9	11.3	478.8	4.36	9.2
T1	2013-08-04 14:25	89.60	29.7		378.0	7.26	9.6
SM4	2013-08-04 15:42	90.09	192.7		312.8	6.85	11.3
T2	2013-08-04 17:25	90.03	448.3	10.9	552.3	3.24	12.2
SM11	2013-08-04 21:02	91.28	259.3	10.2	492.1	4.51	12.4
SM6	2013-08-05 12:14	90.57	234.3	9.6	393.5	4.44	8.9
SM9	2013-08-05 14:28	90.81	298.8	8.9	341.5	4.66	10.2
T5	2013-08-05 15:36	90.49	1607.5	8.2	435.6	2.96	11.5
T4	2013-08-05 16:54	90.62	1158.8	9.4	444.2	2.97	10.7
SM11	2013-08-06 11:56	91.67	297.2	9.6	349.9	4.62	9.9
SM9	2013-08-06 12:55	91.12	370.5	9.0	327.9	4.76	10.4
SM6	2013-08-06 14:32	90.86	310.5	8.7	380.5	4.61	11.1
SM3	2013-08-06 18:09	90.16	250.2	7.3	215.9	7.15	12.0
T2	2013-08-07 11:46	90.49	484.5	9.0	498.1	3.26	10.8
T3	2013-08-07 13:55	90.24	359.8	8.8	296.3	8.34	10.7
SM5	2013-08-07 16:13	90.50	346.3	8.1	431.3	4.04	12.6
SM8	2013-08-07 18:07	90.92	431.9	7.8	410.0	3.90	12.9
SM11	2013-08-07 21:14	91.47	334.1	8.1	381.1	4.46	13.5
SM7	2013-08-08 11:51	90.74	299.6	9.5	375.7	5.28	9.1
SM10	2013-08-08 13:57	91.17	330.0	9.4	395.9	4.55	11.5
T5	2013-08-08 17:09	90.38	2136.8	7.9	437.4	2.99	12.1
SM11	2013-08-08 17:55	90.56	1571.0	9.1	450.1	3.00	11.9
T4	2013-08-08 17:55	90.56	1565.0	9.1	450.1	3.00	11.8
SM6	2013-08-08 20:34	90.46	324.1	8.7	463.2	4.39	11.5
M22	2013-08-08 21:48	89.81	236.8	9.5	269.5	7.02	8.8
SM1	2013-08-09 12:00	88.63	331.1	9.5	510.1	3.40	9.7
SM2	2013-08-09 13:17	89.25	196.4	9.4	462.3	4.42	9.7
T1	2013-08-09 14:28	89.50	39.2	9.3	367.1	6.96	9.3
SM7	2013-08-09 15:39	90.69	305.1	9.0	418.0	5.28	9.5
SM11	2013-08-09 16:49	91.28	308.2	9.2	448.6	4.61	10.5
SM9	2013-08-09 20:34	89.70	544.7	7.7	346.3	5.40	12.1
T4	2013-08-10 11:27	90.74	1473.0	10.3	469.4	3.04	8.0
T6	2013-08-10 13:55	90.28	121.9	9.3	250.4	7.66	9.9
SM3	2013-08-10 18:02	90.03	267.8	9.3	272.0	7.09	11.5
SM6	2013-08-10 18:55	90.64	356.9	8.6	475.9	4.32	13.0
SM1	2013-08-11 12:43	89.20	363.7	8.1	540.7	3.42	13.2
SM2	2013-08-11 13:28	89.79	205.9	0.2	452.9	4.63	12.0
T2	2013-08-11 16:17	90.44	601.3	8.4	515.5	3.30	13.4
SM7	2013-08-11 17:45	91.01	338.9	8.2	422.6	5.34	13.3
SM9	2013-08-11 19:19	91.14	432.3	8.0	474.0	4.51	14.1
T5	2013-08-12 10:35	90.99	1495.0	8.6	482.3	3.05	8.9
SM11	2013-08-12 12:53	91.77	326.1	0.2	487.2	4.61	11.4

Appendix 3: Iron Speciation

Site	Date	Tot Fe ppm	Fe(II) ppm	Fe(III) ppm
SM1	2016-08-03	1.048	0.144	0.905
SM1	2016-08-09	1.259	0.102	1.157
SM1	2016-08-11	1.333	0.116	1.217
SM2	2016-08-04	0.494	0.082	0.412
SM2	2016-08-09	0.401	0.048	0.353
SM3	2016-08-03	0.045	0.068	-
SM3	2016-08-06	0.051	0.034	0.017
SM3	2016-08-08	0.022	0.000	0.022
SM3	2016-08-10	0.042	0.000	0.042
SM6	2016-08-05	0.402	0.130	0.272
SM6	2016-08-06	0.433	0.143	0.289
SM6	2016-08-08	0.334	0.116	0.218
SM6	2016-08-10	0.354	0.027	0.327
SM7	2016-08-03	0.218	0.034	0.184
SM7	2016-08-08	0.152	0.000	0.152
SM7	2016-08-09	0.176	0.048	0.129
SM7	2016-08-11	0.156	0.020	0.136
SM8	2016-08-07	5.563	1.161	4.402
SM9	2016-08-05	5.069	1.134	3.935
SM9	2016-08-06	5.101	1.147	3.954
SM9	2016-08-09	4.248	1.052	3.196
SM9	2016-08-11	4.254	1.038	3.216
SM10	2016-08-26	2.201	0.539	1.662
SM11	2016-08-02	2.181	0.553	1.628
SM11	2016-08-04	1.672	0.396	1.276
SM11	2016-08-06	1.736	0.335	1.402
SM11	2016-08-07	1.569	0.253	1.317
SM11	2016-08-09	1.682	0.362	1.320
SM11	2016-08-12	1.522	0.382	1.140
T1	2016-08-04	0.000	0.000	0.000
T1	2016-08-09	0.000	0.000	0.000
T2	2016-08-04	21.993	1.564	20.429
T2	2016-08-07	23.593		23.593
T2	2016-08-11	24.799	1.598	23.201
T3	2016-08-07	0.000	0.000	0.000
T4	2016-08-05	157.464	25.471	131.993
T4	2016-08-08	168.211	27.212	140.999
T4	2016-08-10	164.813	27.977	136.836
T5	2016-08-05	281.490	44.830	236.660
T5	2016-08-08	292.138	25.375	266.762
T5	2016-08-12	251.275	48.736	202.539
T6	2016-08-10	0.346	0.034	0.312

Appendix 4: Summary Statistics for Figures 7, 8 and 9

	Bottle	Timestamp	Al	Fe	S	Zn	51 V	60 Ni	63 Cu	75 As	208 Pb
LOD:			0.009 ppm	0.002 ppm	0.117 ppm	0.001 ppm	0.0365 ppb	0.0289 ppb	0.0046 ppb	0.0187 ppb	0.0036 ppb
Filtered Samples											
SM1	250	3-8-13	9.228	1.048	39.847	0.741	0.06	147.6	33.0	0.12	0.147
SM1	30	9-8-13	9.219	1.259	53.158	0.785	0.06	144.1	31.4	0.13	0.120
SM1	30	11-8-13	10.268	1.333	57.158	0.847	0.05	145.5	31.3	0.13	0.154
Mean			9.572	1.214	50.054	0.791	0.06	145.8	31.9	0.13	0.140
Standard Deviation			0.493	0.121	7.400	0.044	0.00	1.4	0.8	0.00	0.015
SM2	250	4-8-13	6.498	0.494	32.617	0.544	0.05	127.6	27.9	0.15	0.091
SM2	30	9-8-13	6.207	0.401	33.214	0.516	0.37	105.1	22.1	0.11	0.085
Mean			6.353	0.447	32.916	0.530	0.21	116.3	25.0	0.13	0.088
Standard Deviation			0.145	0.046	0.299	0.014	0.16	11.3	2.9	0.02	0.003
SM3	250	3-8-13	0.053	0.045	33.347	0.214	0.37	65.1	1.2	0.05	0.008
SM3	250	6-8-13	0.045	0.051	34.381	0.208	0.37	68.2	1.4	0.04	0.005
SM3	30	8-8-13	0.015	0.022	32.860	0.207	0.37	63.5	1.1	0.04	0.004
SM3	30	10-8-13	0.032	0.042	35.061	0.206	0.37	66.1	1.1	0.04	0.004
Mean			0.036	0.040	33.912	0.209	0.37	65.7	1.2	0.04	0.005
Standard Deviation			0.014	0.011	0.861	0.003	0.00	1.7	0.1	0.01	0.002
SM4	*250*	*4-8-13*	*0.046*	*0.865*	*36.124*	*0.260*	*0.12*	*75.0*	*2.0*	*0.04*	*0.008*
SM5	*30*	*7-8-13*	*8.119*	*1.994*	*63.519*	*0.930*	*0.10*	*152.5*	*42.7*	*0.10*	*0.062*
SM6	250	5-8-13	7.718	0.402	51.936	0.971	0.06	170.5	40.3	0.10	0.076
SM6	250	6-8-13	7.384	0.433	58.139	0.967	0.04	162.5	38.5	0.08	0.074
SM6	30	8-8-13	7.923	0.334	70.679	1.004	0.37	146.6	34.2	0.07	0.072
SM6	30	10-8-13	7.534	0.354	67.091	1.015	0.37	147.9	34.9	0.07	0.083
Mean			7.640	0.381	61.961	0.989	0.21	156.9	37.0	0.08	0.076
Standard Deviation			0.202	0.039	7.373	0.020	0.16	10.1	2.5	0.01	0.004
SM7	250	3-8-13	0.940	0.218	47.752	0.777	0.04	129.9	22.0	0.08	0.020
SM7	30	8-8-13	1.273	0.152	55.431	0.782	0.04	134.0	22.8	0.08	0.015
SM7	30	9-8-13	0.963	0.176	59.637	0.812	0.37	129.6	22.1	0.08	0.012
SM7	30	11-8-13	1.021	0.156	62.649	0.799	0.37	121.9	20.8	0.06	0.019
Mean			1.049	0.176	56.367	0.793	0.20	128.8	21.9	0.08	0.016
Standard Deviation			0.133	0.026	5.596	0.014	0.16	4.4	0.7	0.01	0.003
SM8	*30*	*7-8-13*	*6.414*	*5.563*	*76.802*	*1.464*	*0.55*	*180.5*	*32.5*	*0.21*	*1.082*
SM9	250	5-8-13	8.631	5.069	69.594	1.373	0.07	210.2	35.0	0.18	0.535
SM9	250	6-8-13	9.065	5.101	74.283	1.443	0.06	192.2	35.4	0.16	0.468
SM9	30	9-8-13	8.799	4.248	82.565	1.429	0.14	194.1	31.7	0.18	0.421
SM9	30	11-8-13	9.912	4.254	85.958	1.507	0.06	196.9	31.6	0.12	0.531
Mean			9.102	4.668	78.100	1.438	0.08	198.4	33.4	0.16	0.489
Standard Deviation			0.493	0.417	6.492	0.048	0.03	7.1	1.8	0.02	0.047
SM10	*30*	*8-8-13*	*6.859*	*2.201*	*68.428*	*1.198*	*0.04*	*147.1*	*22.0*	*0.13*	*0.239*

Appendix 4: Summary Statistics for Figures 7, 8 and 9

	Bottle	Timestamp	Al	Fe	S	Zn	51 V	60 Ni	63 Cu	75 As	208 Pb
LOD:			0.009 ppm	0.002 ppm	0.117 ppm	0.001 ppm	0.0365 ppb	0.0289 ppb	0.0046 ppb	0.0187 ppb	0.0036 ppb
SM11	250	2-8-13	5.467	2.181	53.839	1.045	0.06	156.2	23.4	0.13	0.266
SM11	250	3-8-13	6.620	1.331	55.671	1.127	0.06	166.8	24.9	0.12	0.284
SM11	250	4-8-13	6.142	1.672	56.029	1.083	0.06	164.5	24.6	0.12	0.301
SM11	250	6-8-13	5.874	1.736	58.148	1.074	0.04	144.1	21.5	0.12	0.214
SM11	30	7-8-13	6.717	1.569	72.657	1.211	0.04	137.5	20.4	0.09	0.253
SM11	30	9-8-13	6.264	1.682	64.632	1.079	0.04	137.2	19.7	0.11	0.201
SM11	30	12-8-13	7.119	1.522	69.150	1.213	0.05	153.9	22.2	0.12	0.216
Mean			6.315	1.670	61.447	1.119	0.05	151.5	22.4	0.12	0.248
Standard Deviation			0.514	0.243	6.831	0.063	0.01	11.2	1.9	0.01	0.036
T1	250	4-8-13	0.023	0.002	3.581	0.015	0.37	9.6	0.4	0.03	0.004
T1	30	9-8-13	0.009	0.002	5.228	0.018	0.37	8.6	0.3	0.04	0.047
Mean			0.016	0.002	4.405	0.016	0.37	9.1	0.4	0.04	0.025
Standard Deviation			0.007	0.000	0.824	0.002	0.00	0.5	0.1	0.01	0.022
T2	250	4-8-13	18.453	21.993	79.357	1.880	11.24	286.5	118.4	1.86	0.163
T2	250	7-8-13	18.453	23.593	88.283	1.899	14.61	301.2	124.9	2.15	0.145
T2	30	11-8-13	18.962	24.799	112.203	2.113	10.01	257.3	107.4	1.60	0.141
Mean			18.623	23.462	93.281	1.964	11.95	281.7	116.9	1.87	0.150
Standard Deviation			0.240	1.149	13.867	0.105	1.94	18.3	7.3	0.23	0.009
T3	*30*	*7-8-13*	*0.061*	*0.002*	*42.179*	*0.016*	*0.22*	*16.3*	*0.3*	*0.14*	*0.004*
T4	250	5-8-13	96.930	157.464	388.540	13.164	320.86	1282.6	256.2	18.33	26.409
T4	30	8-8-13	104.658	168.211	460.770	14.167	295.12	1191.9	235.4	16.68	24.350
T4	30	10-8-13	102.472	164.813	453.129	13.843	307.64	1161.7	231.5	16.89	22.223
Mean			101.353	163.496	434.147	13.725	307.87	1212.1	241.0	17.30	24.327
Standard Deviation			3.253	4.485	32.399	0.418	10.51	51.4	10.8	0.73	1.709
T5	250	5-8-13	164.984	281.490	561.368	7.305	1145.86	1759.2	149.2	53.98	0.059
T5	30	8-8-13	181.316	292.138	748.082	7.641	979.26	1514.5	117.1	45.67	0.055
T5	30	12-8-13	163.188	251.275	700.976	7.588	1047.41	1479.8	117.2	49.47	0.052
Mean			169.829	274.968	670.142	7.511	1057.51	1584.5	127.8	49.71	0.055
Standard Deviation			8.155	17.308	79.283	0.147	68.39	124.3	15.1	3.40	0.003
T6	*30*	*10-8-13*	*0.019*	*0.346*	*7.106*	*0.052*	*0.05*	*3.6*	*0.3*	*0.48*	*0.029*
Unfiltered Samples											
SM1	250	3-8-13	9.037	1.034	39.193	0.726	0.07	143.6	32.3	0.13	0.141
SM1	30	9-8-13	9.723	1.378	56.865	0.828	0.07	152.4	33.4	0.13	0.123
SM1	30	11-8-13	9.896	1.250	54.134	0.811	0.05	140.3	30.2	0.11	0.131
Mean			9.552	1.221	50.064	0.788	0.06	145.4	32.0	0.12	0.132
Standard Deviation			0.371	0.142	7.768	0.044	0.01	5.1	1.3	0.01	0.007

Appendix 4: Summary Statistics for Figures 7, 8 and 9

	Bottle	Timestamp	Al	Fe	S	Zn	51 V	60 Ni	63 Cu	75 As	208 Pb
LOD:			0.009 ppm	0.002 ppm	0.117 ppm	0.001 ppm	0.0365 ppb	0.0289 ppb	0.0046 ppb	0.0187 ppb	0.0036 ppb
SM2	250	4-8-13	6.554	0.886	32.330	0.540	0.10	128.4	27.6	0.15	0.098
SM2	30	9-8-13	5.989	0.486	31.883	0.498	0.04	102.8	21.7	0.13	1.012
SM2	30	11-8-13	6.640	0.423	40.436	0.546	0.37	98.4	20.4	0.10	0.089
Mean			6.394	0.599	34.883	0.528	0.17	109.9	23.3	0.13	0.399
Standard Deviation			0.289	0.205	3.931	0.021	0.14	13.3	3.1	0.02	0.433
SM3	250	3-8-13	3.776	0.292	33.511	0.306	0.07	68.3	14.3	0.22	0.072
SM3	250	6-8-13	3.825	0.309	39.306	0.316	0.06	66.3	13.7	0.18	0.054
SM3	30	8-8-13	3.636	0.261	36.661	0.300	0.06	64.4	13.0	0.19	0.055
SM3	30	10-8-13	3.717	0.319	36.340	0.299	0.07	68.4	14.0	0.20	0.061
Mean			3.738	0.295	36.454	0.305	0.06	66.9	13.8	0.20	0.060
Standard Deviation			0.070	0.022	2.052	0.007	0.01	1.6	0.5	0.01	0.007
SM4	*250*	*4-8-13*	*4.155*	*1.254*	*37.207*	*0.322*	*0.55*	*77.3*	*14.8*	*0.22*	*0.072*
SM5	*30*	*7-8-13*	*9.027*	*6.215*	*66.062*	*0.953*	*3.26*	*150.6*	*43.5*	*0.59*	*0.078*
SM6	250	5-8-13	7.870	3.580	51.648	0.968	2.20	172.4	41.5	0.45	0.133
SM6	250	6-8-13	7.171	3.122	55.554	0.921	2.07	154.2	37.2	0.38	0.130
SM6	30	8-8-13	8.129	3.563	71.629	1.015	1.69	146.9	34.6	0.34	0.128
SM6	30	10-8-13	7.912	3.796	70.508	1.047	2.06	148.5	35.4	0.39	0.138
Mean			7.771	3.515	62.335	0.987	2.00	155.5	37.2	0.39	0.132
Standard Deviation			0.360	0.245	8.851	0.048	0.19	10.1	2.7	0.04	0.004
SM7	250	3-8-13	5.161	2.442	48.184	0.778	1.44	130.2	24.7	0.40	0.089
SM7	30	8-8-13	4.960	2.441	52.876	0.751	1.37	135.1	25.4	0.40	0.100
SM7	30	9-8-13	5.519	2.773	60.584	0.821	1.45	127.0	24.5	0.40	0.093
SM7	30	11-8-13	0.860	0.003	66.929	0.881	0.04	133.2	23.1	0.08	0.013
Mean			4.125	1.915	57.144	0.808	1.08	131.4	24.4	0.32	0.074
Standard Deviation			1.896	1.112	7.178	0.049	0.60	3.1	0.8	0.14	0.035
SM8	*30*	*7-8-13*	*9.920*	*10.206*	*80.012*	*1.491*	*14.57*	*178.5*	*32.8*	*1.10*	*1.360*
SM9	250	5-8-13	10.715	11.185	73.305	1.434	15.18	203.7	34.0	1.19	1.272
SM9	250	6-8-13	11.623	11.505	79.474	1.518	13.39	181.1	31.0	1.02	1.116
SM9	30	9-8-13	10.501	9.735	84.916	1.453	13.72	189.2	31.5	1.08	1.034
SM9	30	11-8-13	10.901	10.044	86.444	1.497	14.18	196.1	32.5	1.13	1.186
Mean			10.935	10.617	81.035	1.475	14.12	192.5	32.3	1.11	1.152
Standard Deviation			0.422	0.745	5.160	0.034	0.67	8.4	1.2	0.06	0.088
SM10	*30*	*8-8-13*	*7.466*	*6.226*	*63.885*	*1.113*	*9.88*	*146.3*	*22.7*	*1.00*	*0.821*

Appendix 4: Summary Statistics for Figures 7, 8 and 9

	Bottle	Timestamp	Al	Fe	S	Zn	51 V	60 Ni	63 Cu	75 As	208 Pb
LOD:			0.009 ppm	0.002 ppm	0.117 ppm	0.001 ppm	0.0365 ppb	0.0289 ppb	0.0046 ppb	0.0187 ppb	0.0036 ppb
SM11	250	2-8-13	7.249	6.196	55.346	1.063	9.35	149.2	23.9	1.04	0.770
SM11	250	3-8-13	7.726	6.055	57.018	1.143	10.24	165.4	25.4	1.16	0.755
SM11	250	4-8-13	6.925	5.755	54.136	1.046	10.24	162.7	25.2	1.14	0.806
SM11	250	6-8-13	7.464	6.661	59.539	1.089	9.18	141.9	21.8	1.06	0.711
SM11	30	7-8-13	7.948	7.086	74.537	1.235	8.42	133.7	20.6	0.98	0.676
SM11	30	9-8-13	7.575	6.318	65.721	1.081	7.88	124.4	18.8	0.93	0.631
SM11	30	12-8-13	7.982	6.285	68.164	1.196	10.19	154.7	23.3	1.13	0.690
Mean			7.553	6.337	62.066	1.122	9.36	147.4	22.7	1.06	0.720
Standard Deviation			0.351	0.398	7.030	0.066	0.87	14.0	2.3	0.08	0.056
T1	250	4-8-13	0.047	0.019	3.690	0.019	0.04	9.7	0.5	0.05	0.005
T1	30	9-8-13	0.015	0.002	4.883	0.018	0.37	8.8	0.4	0.03	0.004
Mean			0.031	0.010	4.287	0.019	0.20	9.2	0.4	0.04	0.005
Standard Deviation			0.016	0.008	0.597	0.000	0.16	0.5	0.0	0.01	0.000
T2	30	7-8-13	18.551	23.919	84.780	1.857	14.36	277.6	116.3	2.01	0.140
T2	30	11-8-13	17.334	23.648	105.516	1.979	8.96	232.6	96.9	1.46	0.142
Mean			17.943	23.784	95.148	1.918	11.66	255.1	106.6	1.73	0.141
Standard Deviation			0.609	0.135	10.368	0.061	2.70	22.5	9.7	0.28	0.001
T3	*30*	*7-8-13*	*0.079*	*0.002*	*44.772*	*0.017*	*0.23*	*16.7*	*0.4*	*0.15*	*0.006*
T4	250	5-8-13	98.626	159.769	393.061	13.298	328.68	1271.3	252.5	18.70	26.572
T4	30	8-8-13	106.425	173.569	472.524	14.364	300.64	1169.6	231.2	16.91	24.273
T4	30	10-8-13	103.166	165.497	450.799	13.829	321.88	1185.6	236.5	17.55	23.055
Mean			102.739	166.278	438.795	13.830	317.07	1208.8	240.1	17.72	24.633
Standard Deviation			3.198	5.661	33.532	0.435	11.94	44.6	9.0	0.74	1.458
T5	250	5-8-13	164.537	290.837	554.766	7.242	1229.76	1755.5	149.3	71.57	0.070
T5	30	12-8-13	163.933	263.865	706.859	7.632	1120.78	1491.8	118.5	62.40	0.059
Mean			164.235	277.351	630.812	7.437	1175.27	1623.7	133.9	66.98	0.065
Standard Deviation			0.302	13.486	76.046	0.195	54.49	131.9	15.4	4.58	0.005
T6	*30*	*10-8-13*	*0.037*	*0.683*	*6.712*	*0.057*	*0.08*	*4.1*	*0.4*	*0.68*	*0.112*

Appendix 5: Sediment Chemistry Results

	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	Fe	As	U	Au
	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM
LOD	0.01	0.01	0.01	0.1	0.002	0.1	0.1	1	0.01	0.1	0.1	0.0002
SM1	17.72	90.85	22.14	78	2.442	14.3	2.5	61	12.85	41.6	3	0.0008
SM2	17.81	90.02	20.1	168	1.482	36.4	10	226	6.26	40	4.8	0.0026
SM3	15.2	171.42	28.61	530	0.928	120.9	28.2	457	4.85	75.3	7	0.0006
SM4	17.39	226.22	26.54	635.4	1.17	125.4	36	546	4.98	68.7	10.4	0.0009
SM5	16.44	117.97	19.75	252	1.051	67.9	19	263	11.19	64.1	8.3	0.0008
SM6	15.34	118.23	25.59	250.2	1.054	59.2	12.9	230	7.42	56.7	7.7	<0.0002
SM7	21.48	219.57	24.36	485.8	0.992	97.6	19.9	375	5.66	57.4	16.6	0.0003
SM7	18.51	178.81	24.07	475.2	0.849	97.9	18.9	333	5.03	57.1	12	<0.0002
SM7	19.09	178.5	26.19	594.7	0.844	108.6	21	384	5.56	59.1	12.2	0.0008
SM8	19.48	136.15	55.79	398.2	1.112	88.6	17.6	307	6.92	63.2	10.5	0.0005
SM9	28.69	120.41	52.31	341.5	0.866	69.3	9.4	164	11.4	62.5	10.3	<0.3
SM10	15.95	92.45	40.76	320.9	0.577	66.7	9.2	138	6.37	56.3	9.6	<0.0002
SM10	16.21	93.56	41.53	315.3	0.579	69.8	10	155	5.78	54.1	9.2	0.0008
SM11	18.04	98.59	46.93	447.2	0.832	88.6	23.9	420	6.12	69.5	10	0.0018
T1	10.25	140.64	15.52	637.3	2.658	247.4	83.8	1008	2.74	22.7	4.7	0.0005
T2	9.78	43.89	13.46	43.9	0.865	6	1	36	24.83	67.3	1.8	0.0013
T5	21.89	6.47	21.38	16.8	0.934	4	0.4	7	29.91	318.1	2.7	0.0016
T4	16.85	25.76	483.13	549.4	1.827	6	0.9	19	18.74	120.5	1.6	<0.0002
T3	31.86	327.61	22.04	2353.7	0.94	507.6	34.7	834	3.7	41	15.9	<0.0002
T3	28.39	451.72	20.29	3114.9	0.944	608.5	40.3	999	3.69	40.3	17.4	0.0005
T6	9.25	41.88	53.13	469.9	0.489	52.7	8.8	804	2.49	36.1	4.1	0.0007

Appendix 5: Sediment Chemistry Results

	Th	Sr	Cd	Sb	Bi	V	Ca	P	La	Cr	Mg	Ba
	PPM	PPM	PPM	PPM	PPM	PPM	%	%	PPM	PPM	%	PPM
LOD	0.1	0.5	0.01	0.02	0.02	2	0.01	0.001	0.5	0.5	0.01	0.5
SM1	5.4	43.3	0.22	5.89	0.23	93	0.03	0.146	12.8	19.5	0.07	330.6
SM2	3.8	35.8	0.64	4.45	0.19	51	0.1	0.159	15.9	16	0.09	348.3
SM3	5	40.6	6.23	4.87	0.27	41	0.68	0.231	32	10.7	0.26	291.2
SM4	4.8	39.8	7.16	4.78	0.22	45	0.55	0.194	53.7	10.9	0.24	243.5
SM5	4.2	21.8	1.42	4.35	0.2	213	0.17	0.248	14	32.9	0.1	132
SM6	3.9	27.3	1.36	4.35	0.19	103	0.15	0.179	12.8	26.2	0.09	274.1
SM7	4.2	43.5	4.36	4.85	0.2	79	0.32	0.234	21.3	22.1	0.09	254.7
SM7	4.3	46.7	4.61	5.04	0.22	77	0.33	0.227	22.7	17.4	0.09	434
SM7	4.5	50.2	5.45	5.47	0.25	80	0.36	0.264	24.8	18.8	0.1	577.1
SM8	3.9	37.3	3.34	5.34	0.17	160	0.23	0.255	14.6	24	0.07	295.4
SM9	3.7	35.2	3.07	5.04	0.15	220	0.24	0.241	11.9	39.4	0.06	346.2
SM10	3.8	41.5	1.91	4.78	0.18	121	0.29	0.245	11.4	21.6	0.09	340.9
SM10	4	41.9	1.86	4.66	0.16	111	0.29	0.224	12.3	19.9	0.1	419
SM11	4.3	43.8	3.3	5.21	0.2	106	0.31	0.26	15.8	23.1	0.1	743.8
T1	2.4	23.4	3.21	2.95	0.16	32	0.17	0.108	14.8	12.7	0.13	410.2
T2	3.7	7.6	0.15	4.1	0.12	587	<0.01	0.35	5.4	55.7	0.1	79.7
T5	1.6	10.4	0.35	5.59	0.07	5511	<0.01	1.819	1.2	219.9	0.02	75.2
T4	2.1	14.5	2.65	9.21	0.07	1572	0.02	0.372	1.9	53.4	0.01	78.6
T3	3.6	74.8	22.01	5.99	0.14	69	1.38	0.275	32.7	17.3	0.31	418.9
T3	3.8	89.2	27.29	5.37	0.14	66	1.77	0.272	30.1	15.8	0.25	310.8
T6	2.8	33.7	2.31	2.9	0.14	26	0.32	0.128	13.1	8.3	0.14	1175.8

Appendix 5: Sediment Chemistry Results

	Ti	B	Al	Na	K	W	Sc	Tl	S	Hg	Se	Te
	%	PPM	%	%	%	PPM	PPM	PPM	%	PPB	PPM	PPM
LOD	0.001	20	0.01	0.001	0.01	0.1	0.1	0.02	0.02	5	0.1	0.02
SM1	0.007	<20	0.49	0.004	0.05	0.1	2.7	0.42	0.67	159	8.5	0.31
SM2	0.006	<20	0.76	0.002	0.04	0.1	2.6	0.3	0.24	102	5.9	0.19
SM3	0.006	<20	1.1	0.001	0.06	0.1	2.2	0.51	0.2	116	3.5	0.13
SM4	0.005	<20	1.8	<0.001	0.06	0.1	2.6	0.55	0.23	143	3	0.03
SM5	0.006	<20	1.28	<0.001	0.05	<0.1	2.6	0.31	0.85	88	3.7	0.03
SM6	0.004	<20	1.29	<0.001	0.04	0.1	2.8	0.31	0.51	130	3.7	0.05
SM7	0.006	<20	2.86	<0.001	0.04	0.3	2.9	0.41	0.65	188	4.8	0.17
SM7	0.006	<20	1.6	<0.001	0.05	<0.1	2.6	0.39	0.31	128	4.2	0.08
SM7	0.006	<20	1.74	<0.001	0.05	0.1	2.6	0.39	0.3	183	4.1	0.03
SM8	0.005	<20	1.54	<0.001	0.05	0.2	2.7	0.45	0.53	248	5.4	0.1
SM9	0.005	<20	2.06	<0.001	0.04	0.2	3.3	0.36	0.47	189	4.6	0.04
SM10	0.006	<20	1.44	<0.001	0.05	0.2	2.6	0.31	0.45	130	3.5	0.12
SM10	0.007	<20	1.38	<0.001	0.05	0.2	2.5	0.34	0.38	153	4.6	0.07
SM11	0.008	<20	1.55	<0.001	0.05	0.2	2.4	0.39	0.25	184	4.7	<0.02
T1	0.005	<20	1.46	<0.001	0.06	<0.1	2	0.46	0.06	170	4.2	0.1
T2	0.009	<20	0.35	0.003	0.04	0.1	1	0.1	2.14	69	4.6	0.05
T5	0.013	<20	0.17	0.004	0.1	0.1	2	<0.02	2.97	93	5.4	<0.02
T4	0.006	<20	0.17	0.003	0.05	0.2	1.1	0.06	2.08	933	5.8	<0.02
T3	0.005	<20	1.32	0.002	0.06	0.1	4.3	1.02	0.06	166	5.7	0.11
T3	0.004	<20	1.74	<0.001	0.05	0.1	4.6	1.12	0.07	183	5	0.03
T6	0.006	<20	0.46	0.002	0.04	0.1	1.3	0.53	0.06	167	2.5	<0.02

Appendix 5: Sediment Chemistry Results

	Ga	Cs	Ge	Hf	Nb	Rb	Sn	Ta	Zr	Y	Ce	In
	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
LOD	0.1	0.02	0.1	0.02	0.02	0.1	0.1	0.05	0.1	0.01	0.1	0.02
SM1	2.6	3.02	<0.1	0.06	0.2	4	0.3	<0.05	2.4	5.78	23.9	0.05
SM2	1.8	2.16	0.2	<0.02	0.12	4.3	<0.1	<0.05	1.2	9.4	34.4	<0.02
SM3	1.4	2.44	0.1	0.04	0.13	4.8	<0.1	<0.05	3	30.93	60.1	0.06
SM4	1.3	2.54	<0.1	0.08	0.14	4.9	0.1	<0.05	3.8	62.74	102.2	0.04
SM5	1.8	2.43	<0.1	0.09	0.13	3.8	<0.1	<0.05	3.6	14.29	32.6	0.04
SM6	1.6	2.49	0.2	0.06	0.07	4.3	0.1	<0.05	3	11.78	26.2	0.03
SM7	1.5	2.45	<0.1	0.1	0.09	4.1	0.2	<0.05	5.3	35.3	46	0.04
SM7	1.7	2.43	<0.1	0.12	0.12	4.7	<0.1	<0.05	3.5	31.61	44.2	<0.02
SM7	1.5	2.49	<0.1	0.09	0.07	4.5	0.1	<0.05	4.3	30.91	47.9	<0.02
SM8	1.6	2.41	<0.1	0.05	0.08	4	<0.1	<0.05	3	20.69	30	0.05
SM9	1.6	2.09	0.2	0.06	0.11	4.2	<0.1	<0.05	4.7	18.38	24.5	0.07
SM10	1.6	2.23	<0.1	0.06	0.13	4.3	<0.1	<0.05	2.9	14.83	22.3	0.06
SM10	1.3	2.32	<0.1	0.07	0.12	4.4	<0.1	<0.05	3	14.54	23.3	0.03
SM11	1.7	2.33	0.2	0.06	0.21	4.8	<0.1	<0.05	3.6	17.79	30	0.03
T1	1.6	1.4	<0.1	0.09	0.13	5.4	0.1	<0.05	1.5	15.74	27.6	<0.02
T2	3.7	1.54	0.1	0.08	0.11	2.6	<0.1	<0.05	4	2.43	9.4	0.03
T5	1.7	1.1	0.2	0.12	0.09	3.6	<0.1	<0.05	3.4	1.25	2.3	<0.02
T4	2	1.03	0.5	0.04	0.07	2.1	0.2	<0.05	2.9	1.36	3.6	0.08
T3	1.1	2.07	<0.1	0.07	0.06	4.4	<0.1	<0.05	2.6	63.76	45.2	0.03
T3	1.1	2	<0.1	0.12	0.08	3.5	0.1	<0.05	5	79.14	42.1	0.03
T6	1.2	1.16	<0.1	<0.02	0.11	3.9	<0.1	<0.05	0.7	6.23	24.3	0.03

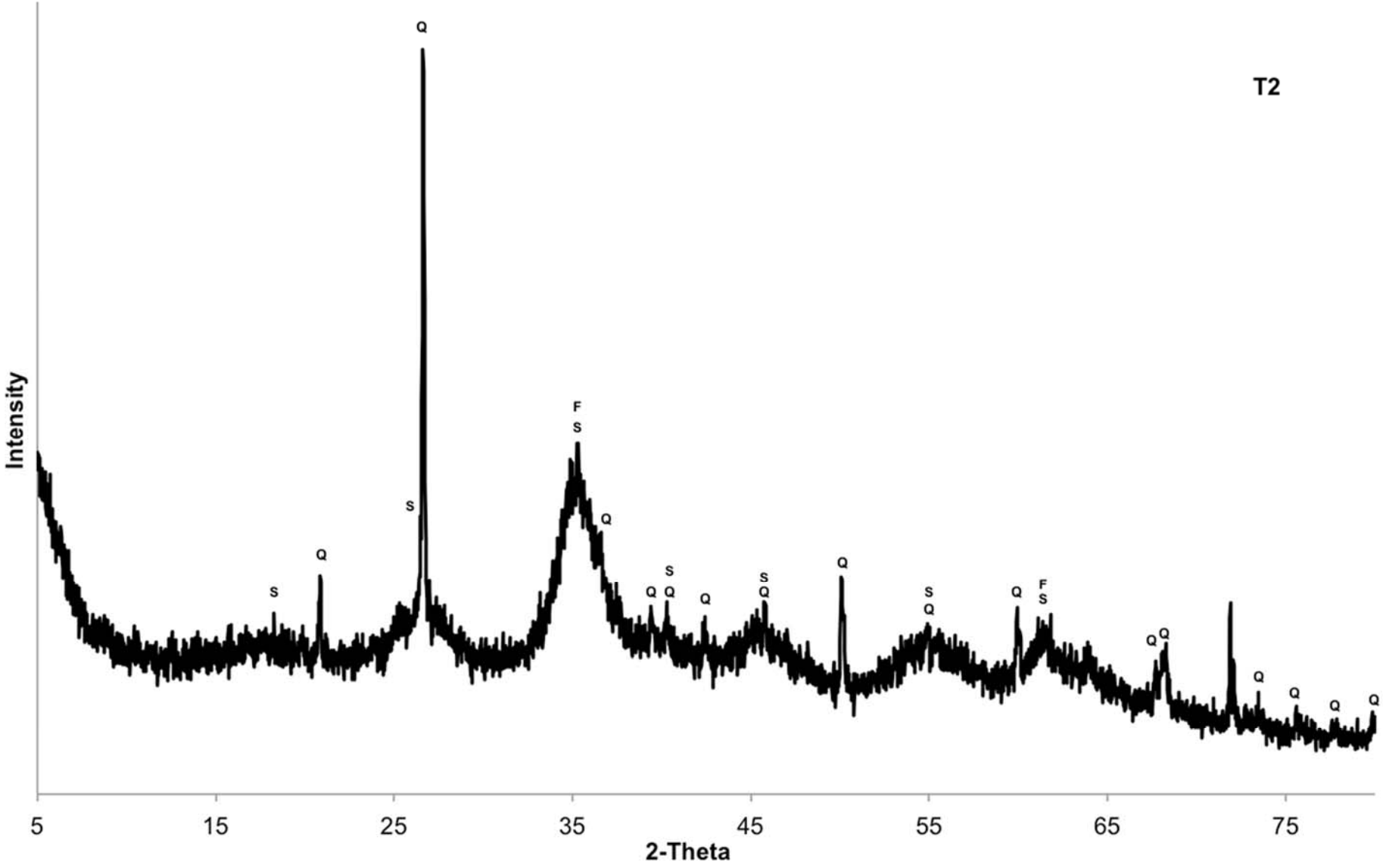
Appendix 5: Sediment Chemistry Results

	Re	Be	Li	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er
	PPB	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
LOD	1	0.1	0.1	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
SM1	8	0.2	4	3.25	12.21	2.6	0.65	1.94	0.32	1.32	0.27	0.45
SM2	6	0.5	8	4.9	18.55	3.54	0.94	2.84	0.38	2.44	0.43	0.91
SM3	2	1.3	8.8	8.65	33.57	7.03	1.57	7.47	1.03	5.23	0.87	2.6
SM4	13	1.1	8.5	14.12	60.98	12.33	2.93	13.24	1.82	9.59	1.84	5.33
SM5	<1	0.8	7.1	4.54	19.19	5.41	1.17	4.21	0.64	3.13	0.61	1.82
SM6	3	0.9	8.1	3.81	16.45	3.76	0.99	3.66	0.5	2.61	0.48	1.12
SM7	4	1.3	8.1	7.51	32.04	7.64	2.2	8.62	1.24	6.6	1.24	3.4
SM7	4	1.5	8.9	7	30.58	7.15	1.91	6.94	1.02	5.76	1	2.84
SM7	8	1.4	7.5	7.14	30.78	6.73	1.76	8.31	1.09	5.21	1.12	2.8
SM8	3	0.9	7.6	4.61	20.37	5.02	1.53	5.39	0.74	4.07	0.74	2.26
SM9	3	0.6	5.3	3.79	17.59	4.72	1.05	5.02	0.73	4.01	0.7	1.66
SM10	5	1.2	7.8	3.42	14.62	4.03	0.87	3.84	0.63	3.15	0.64	1.53
SM10	5	1.7	8.2	3.6	15.87	4.13	1.02	4.16	0.62	2.98	0.57	1.38
SM11	9	1	10.6	4.43	18.23	3.79	1.12	4.72	0.72	3.7	0.67	1.84
T1	4	1.9	12.5	3.84	15.42	3.89	0.81	3.98	0.49	2.43	0.43	1.31
T2	5	<0.1	6.4	1.28	4.66	0.99	0.34	1.01	0.15	0.86	0.1	0.27
T5	3	<0.1	0.9	0.36	1.77	0.67	0.09	0.56	0.09	0.34	0.08	0.14
T4	13	0.2	1	0.48	2.42	0.56	0.15	0.43	0.07	0.44	0.04	0.15
T3	5	0.8	4.2	9.56	45.87	11.64	2.97	12.63	1.69	9.38	1.77	4.64
T3	9	2.2	3.6	9.48	48.77	12.71	3.47	16.9	2.14	11.45	2.19	6.13
T6	<1	0.2	6.4	2.96	11.15	2.74	0.55	2.13	0.27	1.39	0.23	0.52

Appendix 5: Sediment Chemistry Results

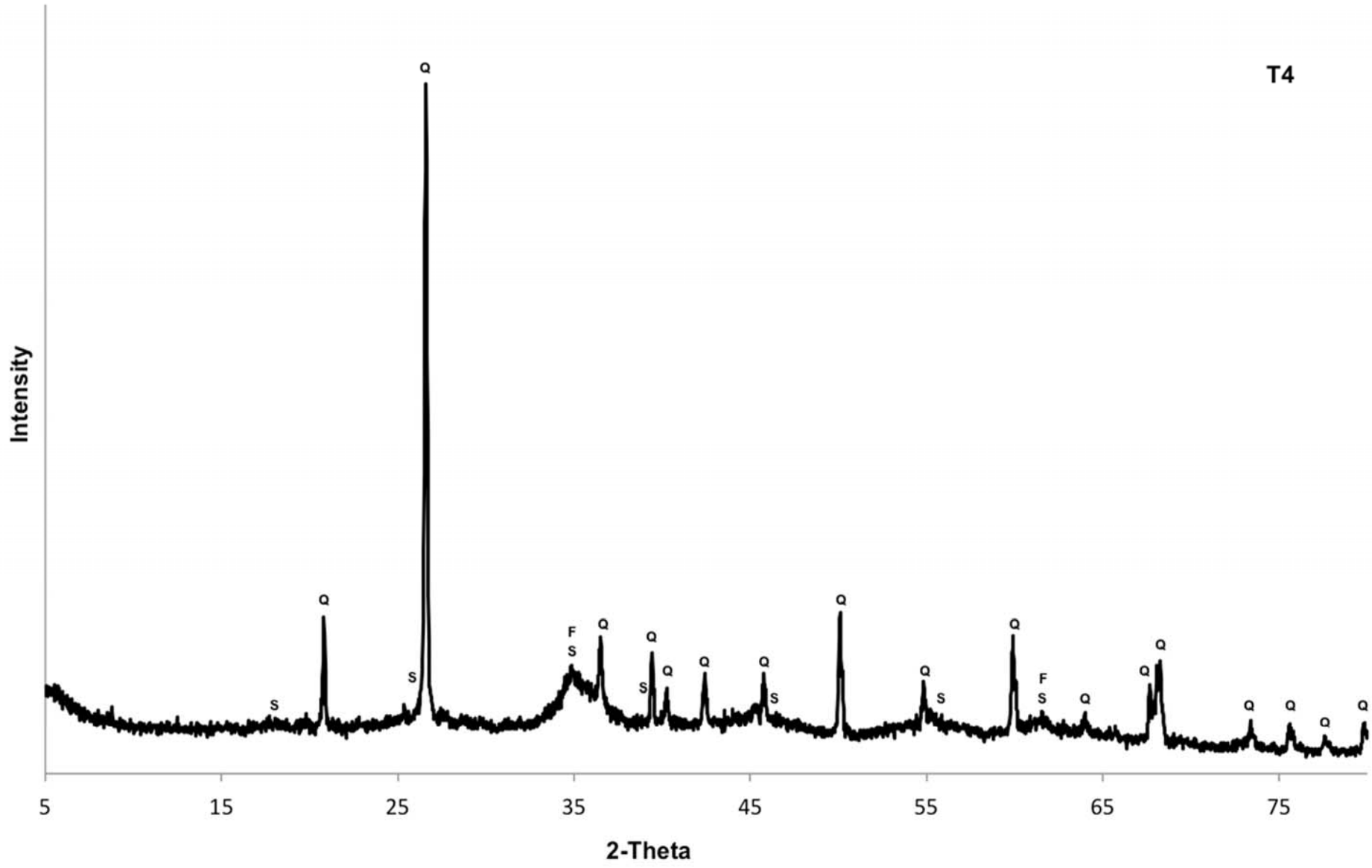
	Tm	Yb	Lu	Pd	Pt
	PPM	PPM	PPM	PPB	PPB
LOD	0.02	0.02	0.02	10	2
SM1	0.1	0.5	0.05	13	<2
SM2	0.17	0.86	0.15	<10	<2
SM3	0.33	2.08	0.3	<10	<2
SM4	0.67	4.28	0.51	<10	<2
SM5	0.23	1.58	0.21	<10	3
SM6	0.22	1.32	0.22	<10	<2
SM7	0.52	2.93	0.51	<10	<2
SM7	0.42	2.51	0.36	<10	4
SM7	0.41	2.53	0.32	13	<2
SM8	0.32	1.91	0.35	<10	<2
SM9	0.26	1.65	0.23	<10	<2
SM10	0.2	1.53	0.22	<10	4
SM10	0.24	1.44	0.21	<10	<2
SM11	0.21	1.49	0.24	16	5
T1	0.21	1.11	0.21	<10	<2
T2	0.03	0.25	0.04	<10	<2
T5	0.02	0.18	<0.02	<10	<2
T4	0.02	0.14	<0.02	<10	<2
T3	0.6	4.14	0.61	14	3
T3	0.78	4.78	0.74	<10	<2
T6	0.08	0.59	0.07	<10	<2

Appendix 6: XRD Spectra

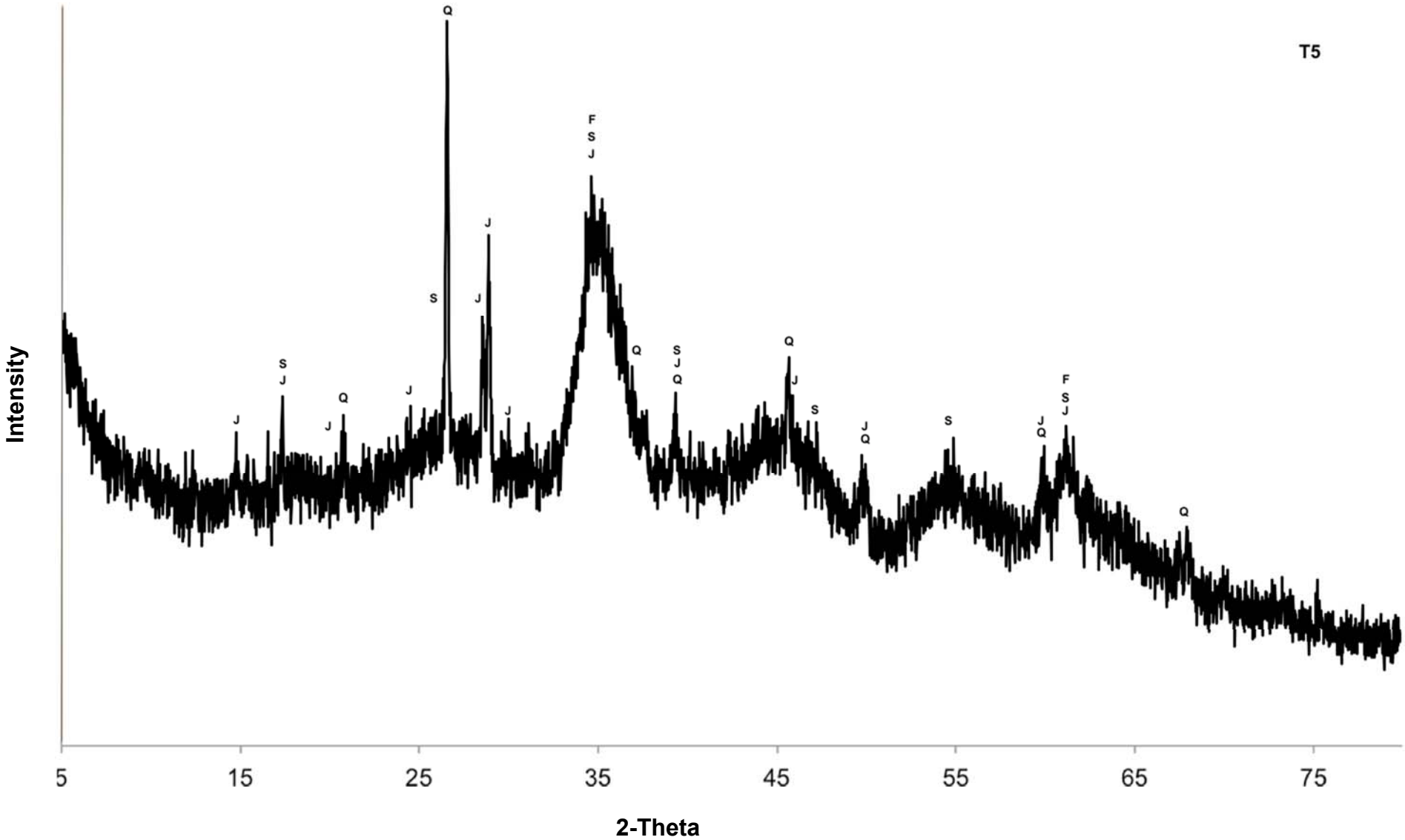


X-ray diffraction pattern of precipitate sample at site T2. S = schwertmannite, F = two-line ferrihydrite, and Q = quartz.

Appendix 6: XRD Spectra



X-ray diffraction pattern of precipitate sample at site T4. S = schwertmannite, F = two-line ferrihydrite, and Q = quartz.



X-ray diffraction pattern of precipitate sample at site T5. S = schwertmannite, F = two-line ferrihydrite, J = jarosite, and Q-quartz.

Appendix 7: Mineral Saturation Indices

	Date	Alunite	Gibbsite	Ferrihydrite	Goethite	Hematite	Jarosite-H	Jarosite-K	Jarosite-Na	Lepido-crosite	Plumbo-jarosite	Schwert-mannite
SM1	09-Aug	-1.84	-3.4	-1.73	2.08	9.1	-0.24	0.88	-2.1	1.79	0.99	-10.4
SM2	09-Aug	3.71	-0.48	-0.05	3.76	12.46	0.49	2.71	-0.25	3.47	2.69	-0.84
SM3	10-Aug	-1.3	0.47	1.55	5.54	16.03	-4.72	0.46	-2.94	5.18	-0.9	3.29
SM5	07-Aug	2.94	-1.41	0.26	4.19	13.33	3.73	6.46	2.49	3.78	5.01	3.34
SM6	10-Aug	4.38	-0.62	-0.21	3.74	12.42	1.28	4.24	0.3	3.31	2.85	-1.39
SM7	09-Aug	6.33	0.78	0.38	4.17	13.27	-1.35	2.64	-1.22	3.9	1.38	-0.11
SM8	07-Aug	1.72	-2.05	0.41	4.35	13.65	5.19	7.69	3.76	3.93	6.86	5.41
SM9	11-Aug	6.05	0.12	0.98	4.97	14.9	4.45	7.56	3.69	4.5	6.6	7.63
SM10	08-Aug	5.63	-0.05	0.75	4.63	14.21	3.01	6.25	2.56	4.27	5.26	5.43
SM11	10-Aug	5.09	-0.2	0.55	4.51	13.98	3.05	6.11	2.42	4.07	4.92	4.14
T1	09-Aug	-	-0.17	-	-	-	-	-	-	-	-	-
T2	11-Aug	0	-3.3	0.12	4.08	13.11	6.68	8.99	4.75	3.64	7.25	5.13
T3	07-Aug	-	0.54	-	-	-	-	-	-	-	-	-
T4	08-Aug	0.6	-3.92	-0.16	3.74	12.43	7.68	10.19	5.59	3.36	9.17	4.81
T5	08-Aug	1.52	-3.78	0.01	3.92	12.79	8.41	11.25	6.58	3.53	8.49	6.29
T6	10-Aug	-6.5	0.16	2.92	6.75	18.43	-5.14	-0.46	-2.48	6.44	-0.3	9.83