



## The analysis of cation and anion trends from soil and water samples at the Norske Skog Tasman Pulp and Paper Mill dump site in Kawerau, New Zealand

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### Abstract

The main premise of this research is to identify spatial and temporal trends of leaching cations and anions in soil and water samples. The samples are from the Norske Skog Tasman Pulp and Paper Mill waste site in Kawerau, New Zealand. In addition, the consistency of collection and experimental techniques will be explored using statistical analysis of the samples. This investigation is conducted under the hypothesis that cations and anions are leaching from mill's waste and are contaminating both the land and river as a result. The hypothesis is based on past research performed by Cailly Howell. It was performed by monitoring ion concentrations over various transects and comparing them to ion concentrations found in adjoining water sources. This study found that ions do leach from the waste site and that even under the same procedure in-lab there can be discrepancies between specific samples. In conclusions, further studies should be performed to analyze the spatial trends using multiple sample sets.

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### 1. Introduction

Chemical leaching is one of the main problems encountered at landfills. The movement of ions depends on a multitude of factors, including waste composition, land permeability and water table level. Many wastes are treated before they are dumped into landfills to reduce harmful chemicals and to dilute the detritus. Land permeability is a concern because the rock composition and geologic outline of an area makes it more or less prone to absorption through bed rock and faults. Water is a

main source of transportation for ions, therefore the height of the water table is important to acknowledge. If the water table is low fluid transport may be less of a concern, but if it is high transport can be imminent.

The landfill in this study is used by Norske Skog Tasman Pulp and Paper Mill for the disposal of pulp production waste. Studies have been performed in regard to the leaching of ions from the waste into surrounding land and water features. One water feature of concern is the Tawerau

River, which is used by the local community for recreation and livelihood.

A study was performed in 2011 by Cailly Howell which showed that cations leach from soil sediments when the pH is lowered and the soil becomes more acidic (Howell, 2011). Sources of soil acidity include both rainfall and weathering (Sparks, 2003). Prompted by her work, a complementary study of the waste site was performed in 2012. Ions which leach from the sediments were compared to cations found in various water samples from sources both upstream and downstream of the waste under the hypothesis that ions are leaching from the central waste site to surrounding land and water features. This study used Atomic Absorption Spectrometry and Ion Chromatography to determine ion concentrations and results showed spatial trends throughout the site. The confirmation of ion transport is of concern because it means that the waste not only directly impacts the land on which it was situated, but also indirectly impacts the surrounding area.

In addition, the study used statistical analysis to determine the consistency of sampling practices both in the field and in the lab. Visual and calculated comparisons were employed in the investigation to find that the lab methods performed did not yield perfectly replicable results. This information promotes the use of more sample sets in order to reduce the significance of outliers.

## **2. Background**

The site being tested is a waste-ground for the Norske Skog Tasman Pulp and Paper Mill, located in Kawerau, Bay of Plenty, North Island, New Zealand (Figure 1). The mill was established in 1952 and initially disposed of waste into the Tarawera River until 1964 (Hikuroa, 2012). In 1964 the Tasman Pulp and Paper Company Enabling Act was passed as a means to promote industry through the subsidence of environmental regulations (Tasman, 1954). At this time the company used the Tasman Act to force the Maori landowners of Kawerau to either sell or lease the land as a waste site. The owners chose to lease the land rather than lose it completely. This lease is set to expire in 2013, at which time Ngati Rangitihi Iwi (the owners) will regain control of the grounds. Over the past 60 years, the land and adjoining Tarawera River have been contaminated and polluted under the blanket of social and economic benefits (Environment, 2009).

The land which waste was and is still being disposed on is permeable, faulted and geothermally active (Hikuroa, 2012). The water table in the area is high, and the site is between an artificial pond and the Tarawera River. The river is separated by an embankment, built in the 1980s. It has failed three times in its lifespan (Hikuroa, 2012). All of these attributes are clear indicators as to why it is possible for contaminants to spread from the paper waste. Permeable and faulted grounds offer pathways for transport over a wide area. Elevated water tables indicate that the ground water is shallow, meaning that if water is contaminated, it has the ability to continue flowing along the table. In addition, the three failures of the



Figure 1: Norske Skog Tasman Pulp and Paper Mill waste site. Transect 1 is represented in red, transect 2 in orange, and transect 3 in blue. Water site 311 is represented by a purple circle, 312 by a yellow circle, and 313 by a green circle.

embankment allowed unrestricted flow of waste from the field into the Tarawera, on top of the original 30 years of unobstructed flow.

In 1964 the land in question was home to both a lake and geothermal features. Today the land is covered by 20 meters of waste (Hikuroa, 2012). The Kawerau geothermal field receives fluids from Mesozoic basement rocks, 500 meters into the earth. An estimation of the resource is between 350 and 570 MWe (megawatts electric) (White, 2009). Surface features, including hot springs, seepages, steaming grounds and hot grounds, have declined rapidly over the past century. This reduction is linked to both natural diminishing and resource exploration; production is diminishing features that are already in a natural decline. As water is extracted from the ground sources, replenishment appears

to be from shallow, cooler ground water (Cronin, 2004). This has caused much of the field to become in-active.

Norske Skog Tasman Pulp and Paper Mill is powered directly by the Kawerau geothermal field, receiving 300 tons of steam per hour. This usage accounts for nearly half of New Zealand's direct geothermal heat use (White, 2009).

Norske Skog was entitled to create the waste site by the Tasman Act, which stood to promote increasing industry across the Bay of Plenty. This piece of law was registered by the New Zealand Legislation in 1954 to the Tasman Paper Company. During the 1950's, increasing employment was the main priority in New Zealand's government (Singleton, 2010). The mill provided jobs and brought industry to the Bay of Plenty. Over the past 60 years, the

mill has become the Norske Skog Tasman Pulp and Paper Mill, and is still providing jobs and industry in the bay area. Today the mill contributes over \$1 billion annually to the New Zealand economy. It is the largest single employer in the eastern Bay of Plenty (Hikuroa, 2012).

With the 60-year lease's expiration fast approaching, the Ngati Rangitihi Iwi has been planning a course of action. For matters concerning the land, the Iwi is represented by a group of trustees. The Trustees are currently working on a remediation plan. Their intention is an attempt to return the land to its natural Mauri condition upon lease expiration (Hikuroa, 2012). The plan will combine science with indigenous knowledge, using the Mauri Model. The Mauri Model is a decision-making framework that provides a culturally based template within which indigenous values are explicitly empowered alongside knowledge (Morgan, 2006). Our work, in analyzing soil and water samples, will be directly used to assess the impact on Mauri. The information on cations present across the plot will be compared to a retrospective of the time before the land was contaminated. The goal of remediation is to return the Mauri to the land, meaning to return the land to its condition before it was leased to Norske Skog. The contaminants therefore will be compared to initial concentrations rather than national environmental standards (Hikuroa, 2003).

Water sources in the vicinity of the waste site include the Tarawera River, Urupa Pond, A8 Pond, connecting canal (between the ponds), and Te Wai U o

Tuwharetoa. The last of which is upstream from the waste site, and the others are located around the site. These bodies facilitate water and sediment movement both as surface features and ground water.

### **3. Materials and Methods**

#### *3.1. Sediment*

A total of 42 sediment samples, along three separate transects, were taken from Norske Skog Tasman Pulp and Paper Mill's waste site in Kawerau, New Zealand. The samples were collected on February 2, 2012 from 12:15 until 12:50. Between 50 and 200 grams of sediment were taken from each site and placed into a plastic bag, which was then labeled, sealed, and transported to Auckland University for processing. To attain a more accurate representation of soil content, two samples were taken from each sample site, labeled A and B.

The first transect, labeled T1, consists of 12 sample sites and 24 samples. Each site is 2 meters apart along the transect line, originating 1 meter from Urupa Pond and extending a total of 23 meters from the pond, towards the landfill area. This transect was selected to show a spatial pattern starting from the water source and extending towards the actual waste bed. The second transect, labeled T2, consists of 3 sample sites and 6 samples. The first sample was located 2 meters to the west of the road, the second in the center of the road, and the third 2 meters to the east of the road. This transect was selected to monitor how well the road acted as a barrier between the waste and Urupa pond. The third transect, T3, consists of 6 sample

sites and 12 samples. Similar to transect 1, each sample is spaced 2 meters apart along the transect line. T3 originates 50 meters north of T2, further down the road, and extends 13 meters onto the landfill area. The last transect was used to determine how much of the waste leached from the middle of the waste bed extending away towards the road.

### *3.2. Water*

Three water samples were taken from three sample sites. The samples were collected on February 2, 2012, between 11:00 and 12:00. The first sample site, labeled AZ311, is called "Te Wai U o Tuwharetoa," which means "the life giving water of Tuwharetoa" (Council). This existing warm-water spring is located upstream from the pulp and paper dumping site, and can act as a control. The second site, AZ312, is Urupa pond, which is where transect 1 of the sediment samples began. Urupa pond is separated from the landfill by a road. The third site, AZ313, is the A8 pond, which is in very close proximity to a tail of the landfill.

Each sample was extracted by placing the plastic collection bottle directly in the water source, rinsing three times, and then filling completely. Then the sample was filtered, using .45 micrometer filters, and separated into labeled cation and anion bottles. These bottles were then bagged, according to site, and placed into a cooler for transport to Auckland University.

### *3.3. Experimental set-up*

All laboratory experiments took place in University of Auckland HSB water quality

laboratory. The samples were initially organized by transect and sample site, with the water samples separated from the soil samples. To prepare the sediment for analysis, 4 grams of each sample was measured and added to 40 mL of deionized water in a centrifuge tube, which was labeled with transect, site, and group (example: T1S1Amix). The tube was then shaken vigorously for 5 minutes and then placed on a sample stand to sit and separate for 4 hours. This procedure was repeated with all 42 sediment samples.

After the allotted 4 hours, each sample was decanted into a beaker. Using a syringe and a .45 micrometer filter, approximately 20 mL of the extracted liquid was then filtered and placed in a new labeled centrifuge tube (example: T1S1A). After all samples were processed in such manner, there were 42 liquid samples prepared for cation spectrometry and anion chromatography.

The water samples had previously been filtered in the field, immediately after collection. In the lab, 20 mL of each was measured in a graduated cylinder and poured into a labeled centrifuge tube, specified as either a cation or anion sample and separated into groups A and B (example: AZ311A-cation).

### *3.4. Cation concentrations*

Cation concentrations were measured Atomic Absorption Spectrometry. The cations in question were sodium, potassium, magnesium and calcium, and the concentrations were recorded in parts per million (ppm). The in-lab analysis occurred from May 7 through 22, 2012. During the experiment, the bulb in the

spectrometry machine that pertained to the analysis of potassium burned out and a replacement was not available. Therefore, potassium was removed from the observed cations.

For each cation, three standards were used with pre-determined concentrations. The standards were utilized to calibrate the machine and monitor irregularities. Once the machine was calibrated for the specific cation, the three transects and water samples were tested. The extraction tube of the machine was placed directly in each centrifuge tube and after the sample had been analyzed by the machine, the computer recorded a specific cation concentration. This process was repeated with all 48 samples for a specific cation, and then the next two cations were analyzed using the same procedure.

### *3.5. Anion concentrations*

Anion concentrations were measured using Ion Chromatography. The anions in question were chloride, sulphate, nitrate and phosphate, and the concentrations were recorded in parts per million (ppm). The in-lab analysis of anions occurred from May 7 through 22, 2012, as did the cations.

The samples were prepared for chromatography by extracting the liquid with a pipette and placing about 5 mL of each sample in a small, plastic tube. Five tubes fit together in a frame that would eventually be placed directly into the machine for analysis. Each tube was fitted with a rubber stopper that sealed the

samples completely. The samples were ordered by transect, with both sample A and B next to one another, followed by the water samples.

The chromatography ran overnight and analyzed each sample for anion concentrations. All recordable levels of anions were graphed on the computer. Each peak was manually identified and labeled as a specific anion, and the concentration was provided by the computer program.

### *3.6. Data interpretation*

After all of the raw data was collected, it was imported into excel for configuration. The two sets of data for each transect were separated in order to view each individually.

## **4. Results and Discussion**

### *4.1. Cation leaching trends*

Upon review of data collected through absorption spectrometry, trends were observed pertaining to the spatial distribution of cations in the sediment samples. Transects 1 and 3 were plotted as concentration (parts per million) verses distance down the transect line (meters), and then a linear trend line was added show the overall tendency of cation movement.

In transect 1, which ran from Urupa pond inland towards the landfill area, there was a clear increase in calcium-ion concentrations (figure 1), which averages

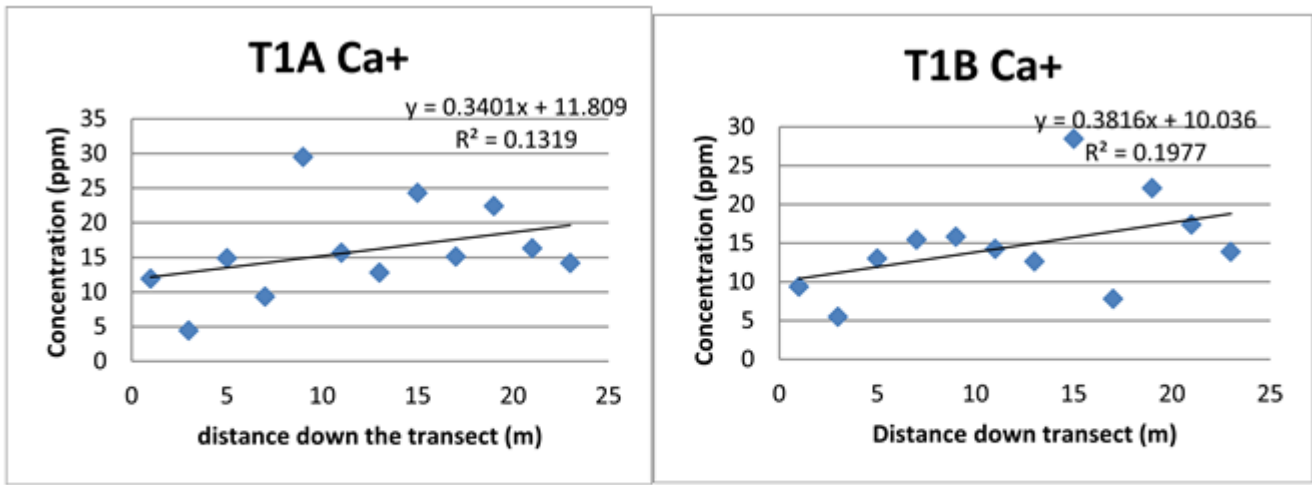


Figure 1: Calcium-ion concentrations down transect 1. The groupings (A+B) have been split apart and are graphed separately. Each set of data points is approximated with a trend line, whose equation is also given.

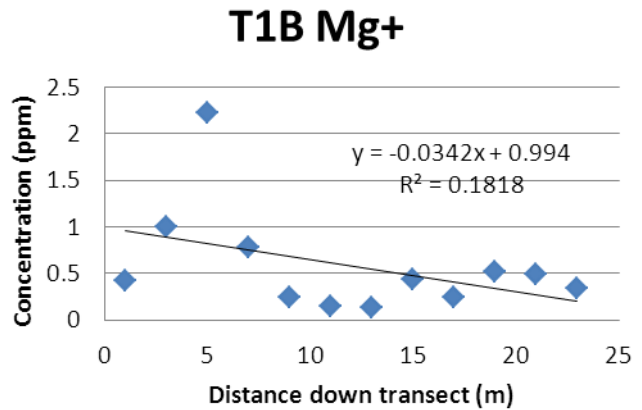
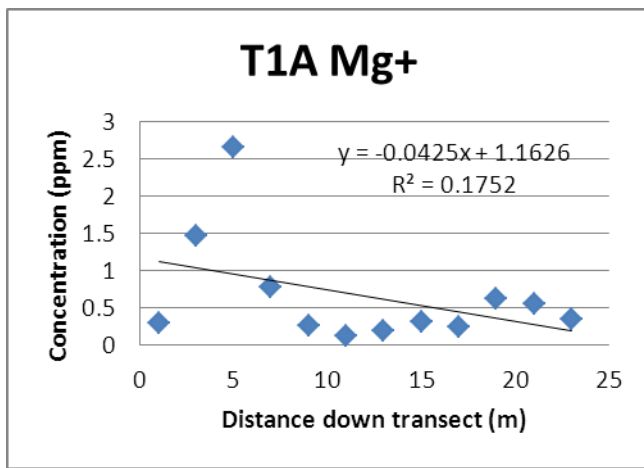


Figure 2: Magnesium-ion concentrations down transect 1. The groupings (A+B) have been split apart and are graphed separately. Each set of data points is approximated with a trend line, whose equation is also given.

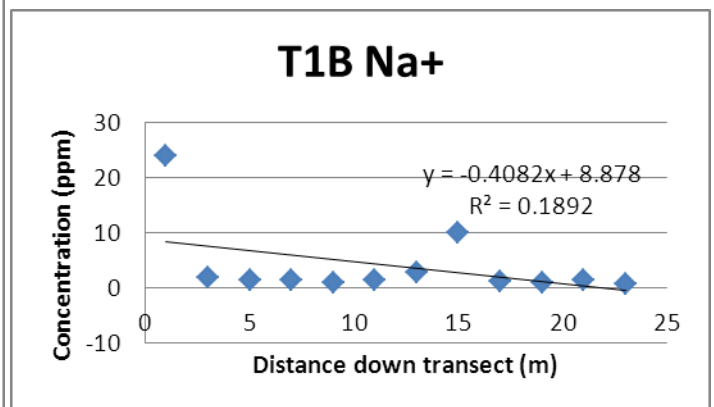
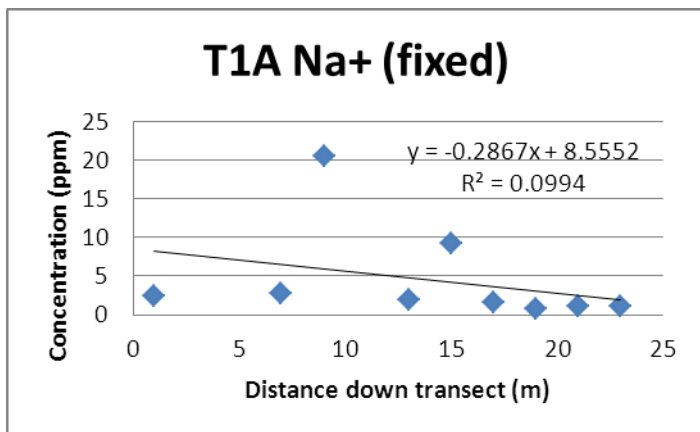


Figure 3: Sodium-ion concentrations down transect 1. The groupings (A+B) have been split apart and are graphed separately. Each set of data points is approximated with a trend line, whose equation is also given.

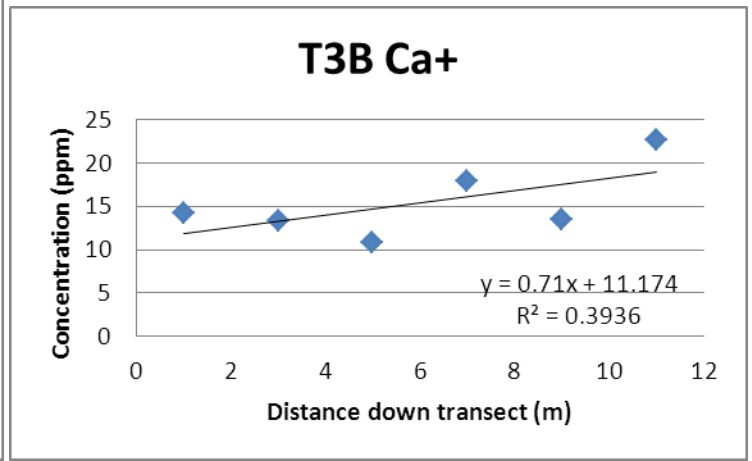
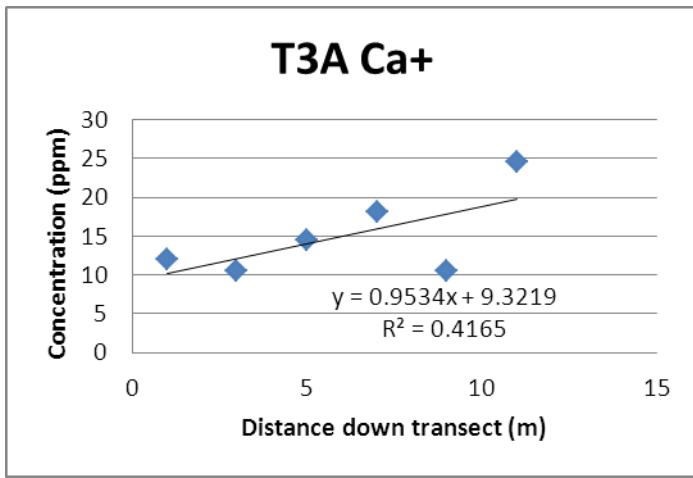


Figure 4: calcium-ion concentrations down transect 3. The groupings (A+B) have been split apart and are graphed separately. Each set of data points is approximated with a trend line, whose equation is also given.

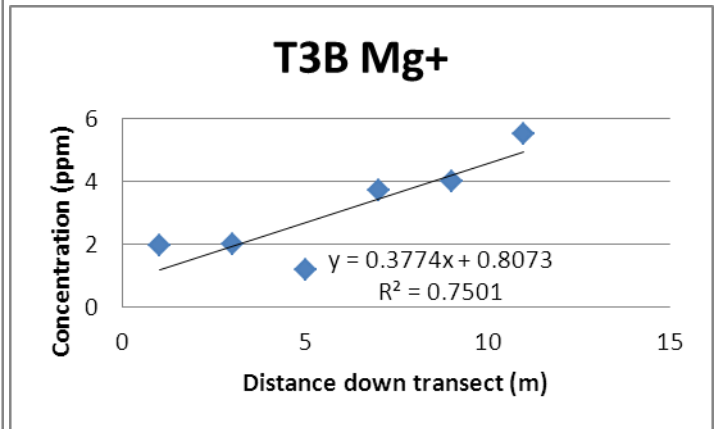
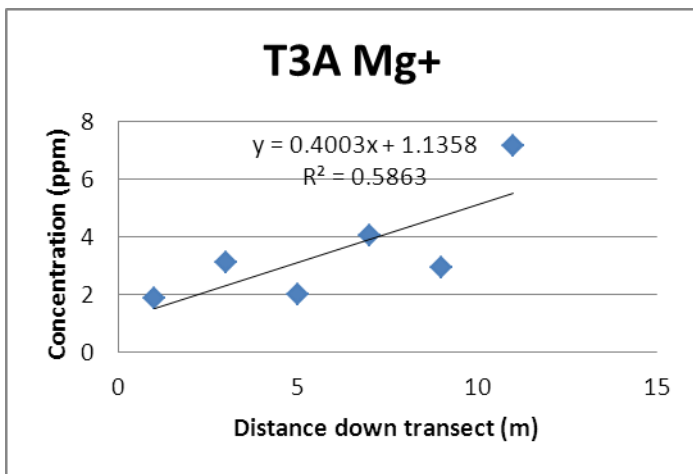


Figure 5: Magnesium-ion concentrations down transect 3. The groupings (A+B) have been split apart and are graphed separately. Each set of data points is approximated with a trend line, whose equation is also given.

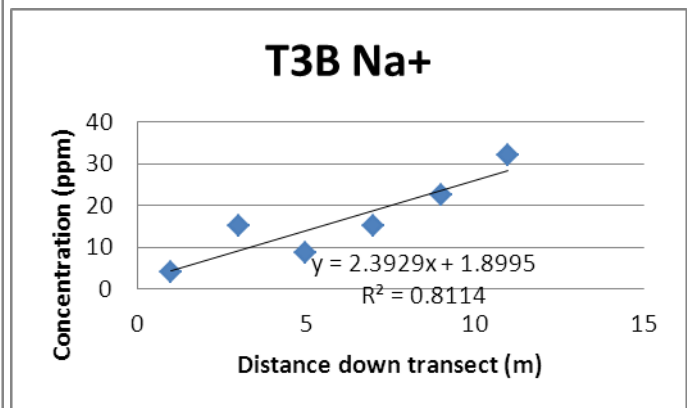
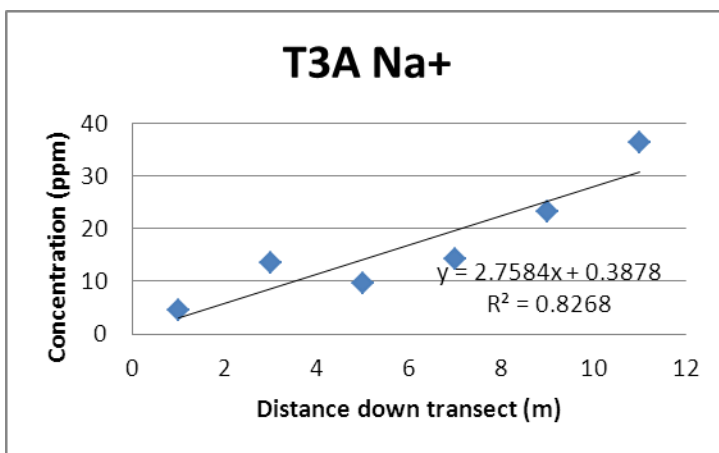


Figure 6: Sodium-ion concentrations down transect 3. The groupings (A+B) have been split apart and are graphed separately. Each set of data points is approximated with a trend line, whose equation is also given.



(between the two sample sets) to 7.94 ppm. There was a general decrease in the magnesium-ion concentration (figure 2) of 0.84 ppm, and also a decrease in the sodium-ion concentration (figure 3) of 7.64 ppm.

On transect 3, all three cations showed an increase from the road and advancing onto the landfill area. The calcium-ion concentration increased by 8.32 ppm (Figure 4), the magnesium-ion concentration by 3.89 ppm (Figure 5), and the sodium-ion concentration by 25.76 ppm (Figure 6). The same averaging technique used between the two sample groups in transect 1 was used to attain these results from transect 3.

Transect 2 consisted of three sample sites and therefore three data points. The data recorded in the field pertaining to the exact location of each sample and the spacing, both quantitatively and directionally, is minimal. Based on a lack of background knowledge and diversity of samples, transect two will not be analyzed for trends as transects one and three have.

#### 4.2. Cation statistical analysis

Through processing two separate sets of transects (A+B), the resulting data can be analyzed statistically and sets can be compared.

One method of analysis is the comparison of slopes of the data's' trend-lines. By calculating the percent error between the two slopes of a sample set (A+B), the relative consistency of the two are calculated. The error has been calculated for all of the cations on transect

2 and 3 to view the consistency of samples (table 1).

Transect, ion	Graph A (m)	Graph B (m)	% error
t1, Ca+	0.3401	0.3816	12.20229
t1, Mg+	-0.0425	-0.0342	19.52941
t1, Na+	-0.2867	-0.4082	42.37879
t3, Ca+	0.9534	0.71	25.52968
t3, Mg+	0.4003	0.3774	5.720709
t3, Na+	2.7584	2.3929	13.25044

Table 1: calculated percent error between datasets A+B for cations on transects 1 and 3.

The errors show that some of the sets have a high correlation, while others show much variation. As each of these samples was prepared in lab by the same individuals using the same method, the results are expected to be consistent. As there is discrepancy, many sources of inconsistency exist. Firstly, the spatial trend may not be linear, and therefore the trend-line may not be an accurate representation. If this is so, then the comparison of linear slopes would not show the consistency of samples. Secondly, lab error could account for some of the difference; in-lab practices and preparation would dictate the accuracy of results, and small mistakes have the ability to multiply. Thirdly, machine error could take a part in the discrepancy. The machine through which the results were acquired may have lost its calibration over the course of the experiment and therefore samples may have yielded different results. Lastly, there was a discrepancy in sample-homogeneity; some samples contained small roots and dirt clumps, which could have altered the consistency between sample-sets A and B.

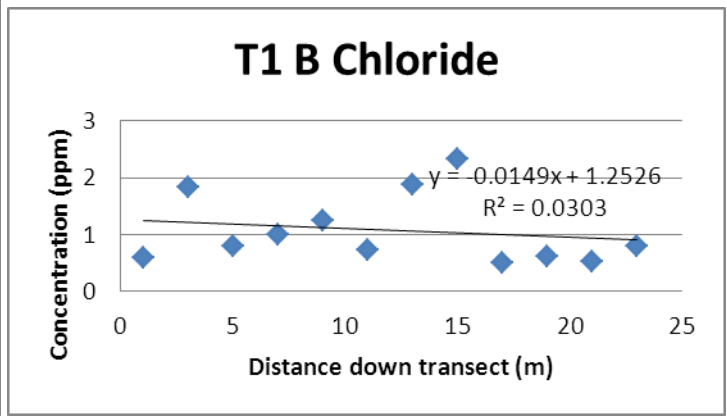
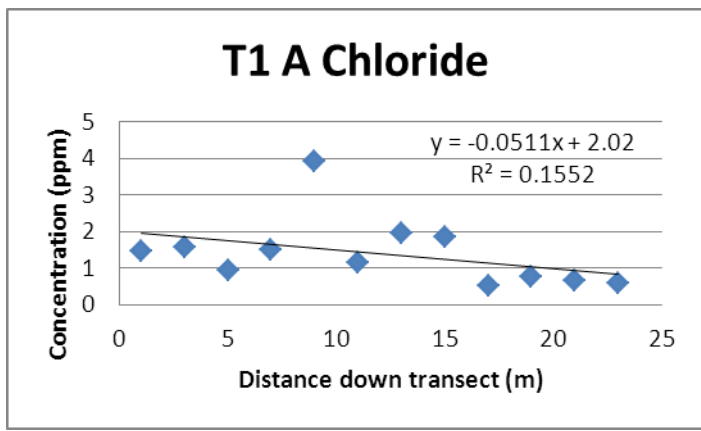


Figure 7: Chloride-ion concentrations down transect 1, with the groupings (A+B) split apart and graphed separately.

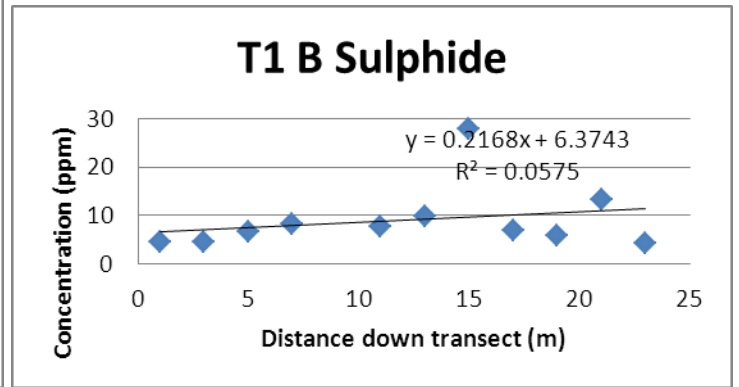
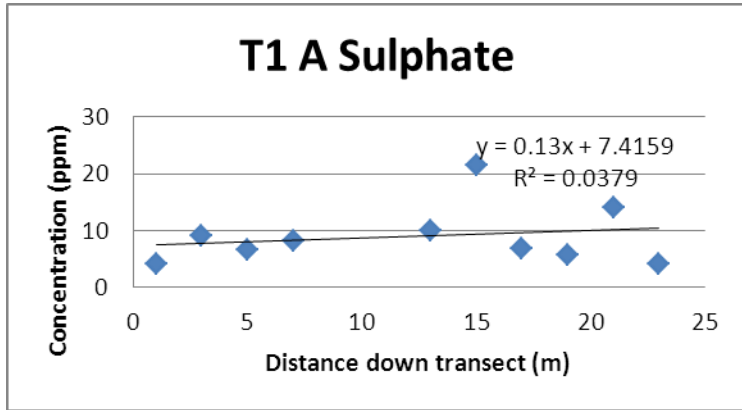


Figure 8: Sulphate-ion concentrations down transect 1, with the groupings (A+B) split apart and graphed separately.

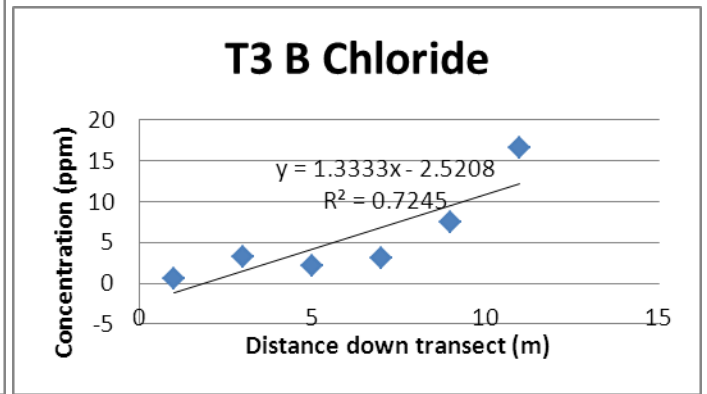
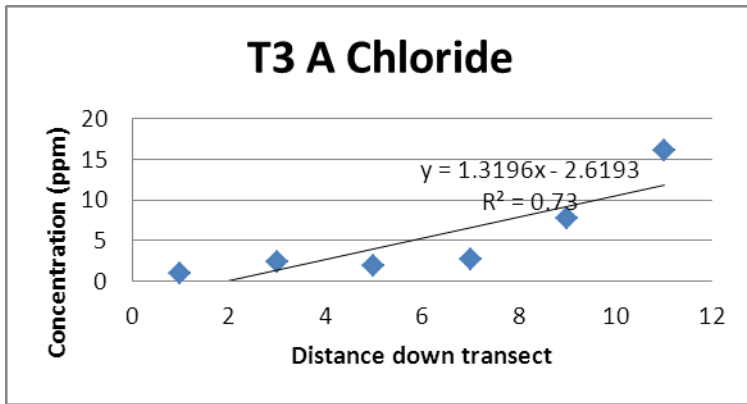


Figure 9: Chloride-ion concentrations down transect 3, with the groupings (A+B) split apart and graphed separately.

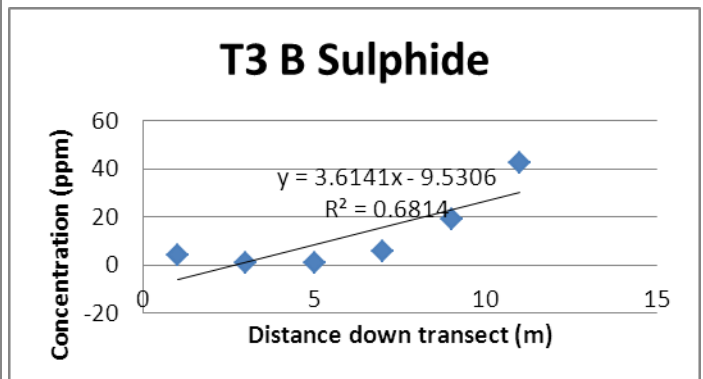
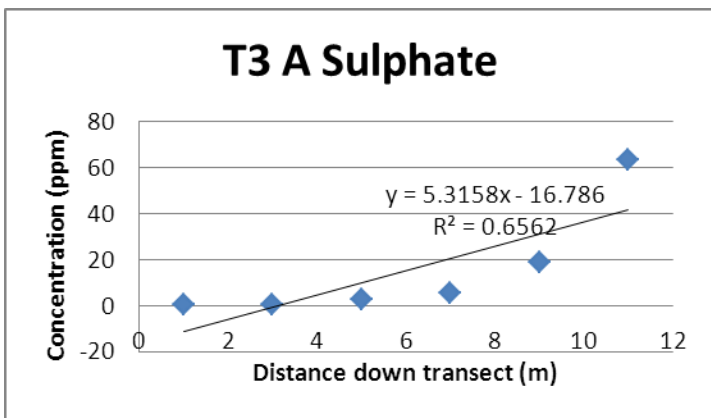


Figure 10: Sulphate-ion concentrations down transect 3, with the groupings (A+B) split apart and graphed separately.

#### 4.3. Anion leaching trends

As with the cations in the experiment, anion concentrations (ppm) were plotted against the distance down the transect (meters) and a linear trend line was added. The anions that were tested included chloride, sulphate, nitrate and phosphate. Of the data inquired about, nitrate and phosphate yielded inconsistent results; many concentrations were missing from the data sheets. Only chloride and sulphate yielded significant data which could be graphed and tabulated for trends. Therefore, only chloride and sulphate were used in the analysis of anion leaching trends.

On transect 1, there was a general decrease in chloride concentration (Figure 7) which averaged to 0.73 ppm. Sulphate showed a minimal increase down the transect of 3.81 ppm (Figure 8).

On transect 3, both chloride and Sulphate showed a more significant increasing trend. Chloride increased by 13.26 ppm (Figure 9) and Sulphate by 44.65 ppm (Figure 10). On both transect 1 and 3 the change in concentration was an average between the two datasets.

#### 4.4. Anion statistical analysis

To show the value of multiple statistical analyses, a different method will be used to compare anion datasets A+B from the cation analysis. Instead of a slope comparison, a visual alignment will be used to check for relative data consistency.

In transect 1, chloride concentration was plotted against distance down the transect. The two datasets were plotted on the same graph (Figure 11) to look for uniformity. Many points appear to be similar between the sets, but several have relative variance and one has a large discrepancy (1, 9 and 15 meters).

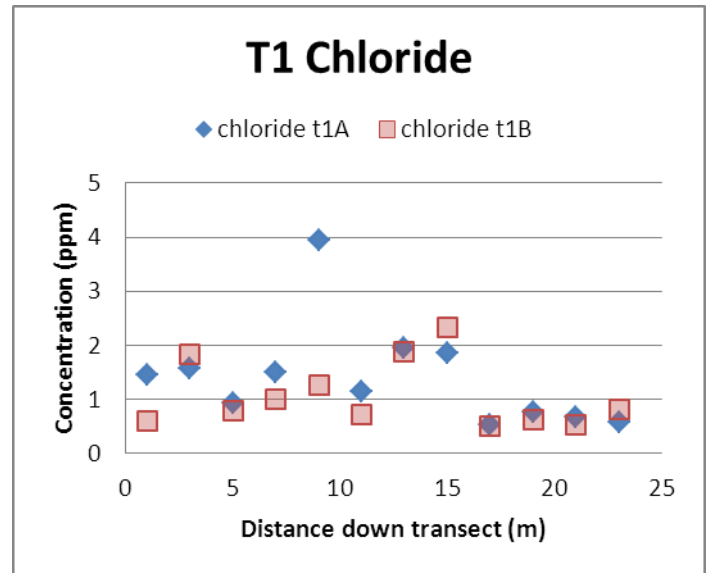


Figure 11: Dataset A+B plotted on a concentration verses distance graph.

When Sulphate was observed on the same graph (Figure 12), the majority of points were close to replicates, but three has some difference between sets (3, 11 and 15 meters).

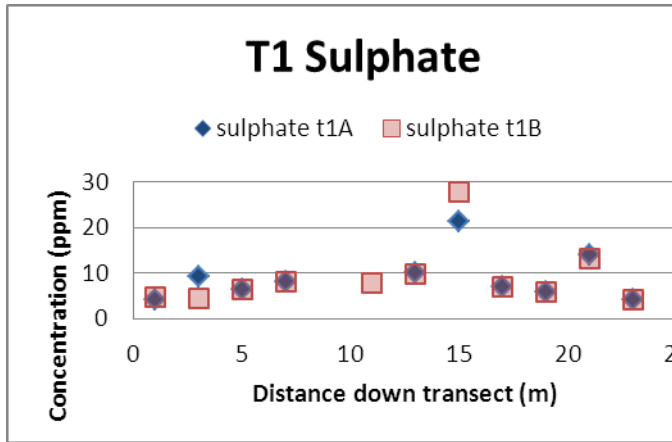


Figure 12: Dataset A+B plotted on a concentration versus distance graph.

On transect 3, the chloride samples were all plotted on the same graph (Figure 13). Visually, all of the points overlapped, which shows great consistency.

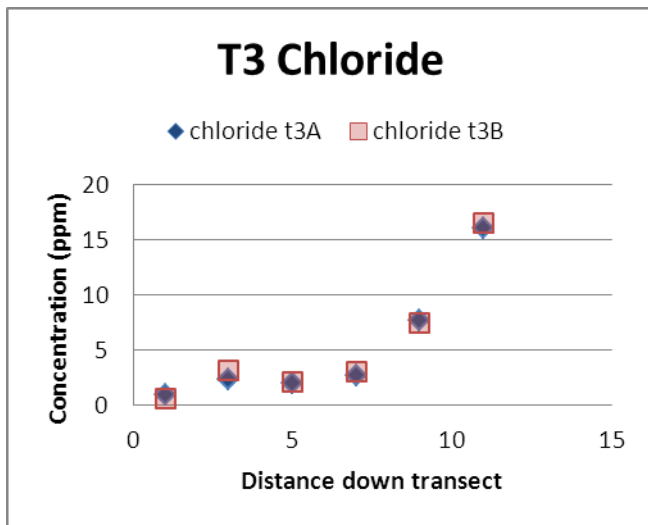


Figure 13: Dataset A+B plotted on a concentration versus distance graph.

When the Sulphate samples of transect three were plotted together (Figure 14), all but one of the data points overlapped (11 meters), showing that overall the points were consistent.

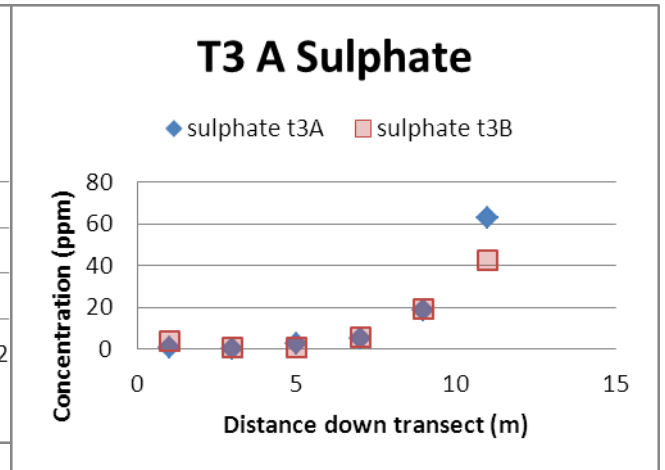


Figure 14: Dataset A+B plotted on a concentration versus distance graph.

### Conclusion

Overall, this experiment showed that both cation and anion concentrations change consistently over a site that contains leaching ions. In addition, when examining datasets statistically, it is more effective to overlay the points than to use a trend-approximation to gauge for consistency.

Much future work can be done to continue this study. Firstly, this experiment could be performed on a longer transect to view data from both on and around the waste site. Secondly, through varying the conditions of the sample (pH, temperature), the most opportune conditions for leaching can be identified. This technique was used in one study by Cailly Howell, and can be further investigated through the use of more sample sets. Thirdly, an investigation into the geologic setting of the waste site could be conducted. The type of rock present, along with its porosity and run-off rates, would build on the ability of the setting to further leach ions. Lastly, a

chemical analysis of the Norske Skog Tasman waste could be conducted to determine what exactly is being put into the land to possibly leach into surrounding grounds.

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### References

- Bruere, Andy. "Pulp and Paper Mills in the Bay of Plenty." . Environment Bay of Plenty Regional Council, April 2003. Web. 2 Apr 2012.  
<<http://monitoring.boprc.govt.nz/Reports/Report-0304-PulpAndPaperMillsInTheBOP.pdf>>.
- Cronin, John. "Geothermal Resources." *Tarawera River Catchment Plan*. Bay of Plenty Regional Council, 1 February 2004. Web. 26 May 2012.  
<[http://monitoring.boprc.govt.nz/Plans/Plan-040201-RegionalPlanForTheTaraweraRiverCatchmentChapter\\_17.pdf](http://monitoring.boprc.govt.nz/Plans/Plan-040201-RegionalPlanForTheTaraweraRiverCatchmentChapter_17.pdf)>.
- Davison, Isaac. "Mill gets 25-year pollution consent." *New Zealand Herald* 16 11 2009, n. pag. Web. 2 Apr. 2012.  
<[http://www.nzherald.co.nz/nz/news/article.cfm?c\\_id=1&objectid=10603488](http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10603488)>.
- "Environment permit decision upsets mill's detractors." *i-grafix*. 17 oct 2009: n. page. Web. 2 Apr. 2012.  
<<http://www.i-grafix.com/index.php/news/new-zealand/environment-permit-decision-upsets-mills-detractors.html>>.
- Hikuroa, Daniel, Angela Slade, and Darren Gravley. "Implementing Māori indigenous knowledge." *MAI Journal*. (2003): n. page. Print.
- Howell, Cailly. *Determining the concentration of calcium, potassium, magnesium, and zinc cations leached from solid waste generated by the Norske Skog Tasman Pulp and Paper Mill under varying pH conditions*. University of Auckland, 2011. Print.
- Morgan, T. K. K. B. (2006). Decision-support tools and the indigenous paradigm. *Engineering Sustainability*, 159(ES4), 169–177.  
New Zealand. Parliamentary Counsel Office.  
*Tasman Pulp and Paper Company Enabling Act* . 1954. Print.  
<[http://www.nzlii.org/nz/legis/hist\\_act/tpa\\_pcea19541954n82374/](http://www.nzlii.org/nz/legis/hist_act/tpa_pcea19541954n82374/)>.
- Norske Skog. Annual Report: Norwegian Paper Tradition. Norske Skog, 2010.
- Hikuroa, Daniel. "Norske Skog Pulp and Paper Mill." *New Zealand Earth Systems Course Book*. Frontiers Abroad, 2012. 123-125. Print.
- Singleton, John. "An Economic History of New Zealand in the Nineteenth and Twentieth Centuries." *EH.Net*. 2 May 2010. Economic History Association, Web. 3 Apr 2012.  
<<http://eh.net/encyclopedia/article/Singleton.NZ>>.
- Sparks, Donald; Environmental Soil Chemistry. 2003, Academic Press, London, UK

"Tasman Pulp and Paper Company Enabling Act 1954: ANALYSIS." *LegislationNZ*. The Knowledge Basket, 1954. Web. 2 Apr 2012. <<http://legislation.knowledge-basket.co.nz/gpacts/actlists.html>>.

"The Ten Principles." *United Nations Global Impact*. United Nations, n.d. Web. 2 Apr

2012.

<<http://www.unglobalcompact.org/AboutTheGC/TheTenPrinciples/index.html>>.

White, Brian. "New Zealand Geothermal Fields." *New Zealand Geothermal Association*. East Harbour Energy, 2009. Web. 26 May 2012. <[http://www.nzgeothermal.org.nz/nz\\_geo\\_fields.html](http://www.nzgeothermal.org.nz/nz_geo_fields.html)>.

## Appendix

### Anions

chloride

sample	concentration (ppm)
T1S1A	0.5935
T1S1B	1.5708 x
T1S2A	1.8325 x
T1S2B	0.9295 xx
T1S3A	0.7882 xx
T1S3B	1.5091
T1S4A	0.9974
T1S4B	3.9306
T1S5A	1.2563
T1S5B	1.1435 xxxx
T1S6A	0.7184 xxxx
T1S6B	1.9534 xxx
T1S7A	1.8874 xxx
T1S7B	1.8515 xx
T1S8A	2.3356 x
T1S8B	0.5317 x
T1S9A	0.512 x
T1S9B	0.7689 xx
T1S10A	0.624 xx
T1S10B	0.6726 xxx
T1S11A	0.5339 xxx
T1S11B	0.5709
T1S12A	0.8056
T1S12B	0.9526
T2S1A	0.9466
T2S1B	0.4362
T2S2A	0.4063
T2S2B	1.1907

Sulfate

sample	concentration (ppm)
T1S1A	4.5952
T1S1B	9.1745
T1S2A	4.4566
T1S2B	6.4958
T1S3A	6.5463
T1S3B	8.128
T1S4A	8.1602
T1S4B	*peak
T1S5A	*peak
T1S5B	*peak
T1S6A	7.7228
T1S6B	9.9551
T1S7A	9.9202
T1S7B	21.4312
T1S8A	27.8437
T1S8B	6.9365
T1S9A	6.9182
T1S9B	5.7825
T1S10A	5.752
T1S10B	14.0756
T1S11A	13.2314
T1S11B	4.2162
T1S12A	4.235
T1S12B	23.1251
T2S1A	30.69
T2S1B	10.9605
T2S2A	10.6438
T2S2B	18.5129

T2S3A	1.0479	T2S3A	16.8695
T2S3B	0.961	T2S3B	0.468
T3S4A	0.589	T3S4A	3.9576
T3S4B	2.3541	T3S4B	0.3187
T3S5A	3.1582	T3S5A	0.7272
T3S5B	1.9808	T3S5B	2.4745
T3S6A	2.1326	T3S6A	0.9793
T3S6B	2.6781	T3S6B	5.3453
T3S7A	3.0552	T3S7A	5.4913
T3S7B	7.7695	T3S7B	18.8519
T3S8A	7.4353	T3S8A	19.1993
T3S8B	16.0469	T3S8B	63.1953
T3S9A	16.505	T3S9A	42.5695
T3S9B		T3S9B	
AZ311A	6.0491	AZ311A	4.8374
AZ311B	6.0417	AZ311B	4.8173
AZ312A	6.2226	AZ312A	5.3102
AZ312B	6.174	AZ312B	5.1685
AZ313A	6.2967	AZ313A	5.4197
AZ313B	0.1285	AZ313B	0.1141

chloride

Sulfate

sample concentration (ppm)

concentration (ppm)

T1S1A	1.4521	T1S1A	4.0775
T1S1B	0.5935	T1S1B	4.5952
T1S2A	1.5708	T1S2A	9.1745
T1S2B	1.8325	T1S2B	4.4566
T1S3A	0.9295	T1S3A	6.4958
T1S3B	0.7882	T1S3B	6.5463
T1S4A	1.5091	T1S4A	8.128
T1S4B	0.9974	T1S4B	8.1602
T1S5A	3.9306	T1S5A	*peak
T1S5B	1.2563	T1S5B	*peak
T1S6A	1.1435	T1S6A	*peak
T1S6B	0.7184	T1S6B	7.7228
T1S7A	1.9534	T1S7A	9.9551
T1S7B	1.8874	T1S7B	9.9202
T1S8A	1.8515	T1S8A	21.4312
T1S8B	2.3356	T1S8B	27.8437
T1S9A	0.5317	T1S9A	6.9365
T1S9B	0.512	T1S9B	6.9182
T1S10A	0.7689	T1S10A	5.7825

T1S10B	0.624	T1S10B	5.752
T1S11A	0.6726	T1S11A	14.0756
T1S11B	0.5339	T1S11B	13.2314
T1S12A	0.5709	T1S12A	4.2162
T1S12B	0.8056	T1S12B	4.235
T2S1A	0.9526	T2S1A	23.1251
T2S1B	0.9466	T2S1B	30.69
T2S2A	0.4362	T2S2A	10.9605
T2S2B	0.4063	T2S2B	10.6438
T2S3A	1.1907	T2S3A	18.5129
T2S3B	1.0479	T2S3B	16.8695
T3S4A	0.961	T3S4A	0.468
T3S4B	0.589	T3S4B	3.9576
T3S5A	2.3541	T3S5A	0.3187
T3S5B	3.1582	T3S5B	0.7272
T3S6A	1.9808	T3S6A	2.4745
T3S6B	2.1326	T3S6B	0.9793
T3S7A	2.6781	T3S7A	5.3453
T3S7B	3.0552	T3S7B	5.4913
T3S8A	7.7695	T3S8A	18.8519
T3S8B	7.4353	T3S8B	19.1993
T3S9A	16.0469	T3S9A	63.1953
T3S9B	16.505	T3S9B	42.5695
AZ311A	6.0491	AZ311A	4.8374
AZ311B	6.0417	AZ311B	4.8173
AZ312A	6.2226	AZ312A	5.3102
AZ312B	6.174	AZ312B	5.1685
AZ313A	6.2967	AZ313A	5.4197
AZ313B	0.1285	AZ313B	0.1141

chloride A			Sulfide A		
sample		concentration (ppm)	sample		concentration (ppm)
T1S1A	1	1.4521	T1S1A	1	4.0775
T1S2A	3	1.5708	T1S2A	3	9.1745
T1S3A	5	0.9295	T1S3A	5	6.4958
T1S4A	7	1.5091	T1S4A	7	8.128
T1S5A	9	3.9306	T1S5A	9	
T1S6A	11	1.1435	T1S6A	11	
T1S7A	13	1.9534	T1S7A	13	9.9551
T1S8A	15	1.8515	T1S8A	15	21.4312
T1S9A	17	0.5317	T1S9A	17	6.9365



T1S10A	19	0.7689	T1S10A	19	5.7825
T1S11A	21	0.6726	T1S11A	21	14.0756
T1S12A	23	0.5709	T1S12A	23	4.2162
T2S1A		0.9526	T2S1A		23.1251
T2S2A		0.4362	T2S2A		10.9605
T2S3A		1.1907	T2S3A		18.5129
T3S4A	1	0.961	T3S4A	1	0.468
T3S5A	3	2.3541	T3S5A	3	0.3187
T3S6A	5	1.9808	T3S6A	5	2.4745
T3S7A	7	2.6781	T3S7A	7	5.3453
T3S8A	9	7.7695	T3S8A	9	18.8519
T3S9A	11	16.0469	T3S9A	11	63.1953
AZ311A		6.0491	AZ311A		4.8374
AZ312A		6.2226	AZ312A		5.3102
AZ313A		6.2967	AZ313A		5.4197

Chloride B			Sulfide B		
sample		concentration (ppm)	sample		concentration (ppm)
T1S1B	1	0.5935	T1S1B	1	4.5952
T1S2B	3	1.8325	T1S2B	3	4.4566
T1S3B	5	0.7882	T1S3B	5	6.5463
T1S4B	7	0.9974	T1S4B	7	8.1602
T1S5B	9	1.2563	T1S5B	9	
T1S6B	11	0.7184	T1S6B	11	7.7228
T1S7B	13	1.8874	T1S7B	13	9.9202
T1S8B	15	2.3356	T1S8B	15	27.8437
T1S9B	17	0.512	T1S9B	17	6.9182
T1S10B	19	0.624	T1S10B	19	5.752
T1S11B	21	0.5339	T1S11B	21	13.2314
T1S12B	23	0.8056	T1S12B	23	4.235
T2S1B		0.9466	T2S1B		30.69
T2S2B		0.4063	T2S2B		10.6438
T2S3B		1.0479	T2S3B		16.8695
T3S4B	1	0.589	T3S4B	1	3.9576
T3S5B	3	3.1582	T3S5B	3	0.7272
T3S6B	5	2.1326	T3S6B	5	0.9793
T3S7B	7	3.0552	T3S7B	7	5.4913
T3S8B	9	7.4353	T3S8B	9	19.1993
T3S9B	11	16.505	T3S9B	11	42.5695

AZ311B	6.0417	AZ311B	4.8173
AZ312B	6.174	AZ312B	5.1685
AZ313B	0.1285	AZ313B	0.1141

Nitrate

sample concentration (ppm)

T1S1A	24.2113
T1S1B	n/a
T1S2A	11.907
T1S2B	78.1385
T1S3A	60.796
T1S3B	37.6012
T1S4A	37.9403
T1S4B	n/a
T1S5A	25.9135
T1S5B	15.0333
T1S6A	15.0934
T1S6B	10.9682
T1S7A	9.5109
T1S7B	1.7078
T1S8A	5.5153
T1S8B	0.414
T1S9A	0.3702
T1S9B	n/a
T1S10A	n/a
T1S10B	n/a
T1S11A	n/a
T1S11B	0.3787
T1S12A	0.3335
T1S12B	15.9321
T2S1A	19.1018
T2S1B	11.3709
T2S2A	10.3252
T2S2B	24.1179
T2S3A	21.7173
T2S3B	0.5101
T3S4A	7.6815
T3S4B	0.4761
T3S5A	0.1721
T3S5B	n/a
T3S6A	0.5091
T3S6B	0.1897
T3S7A	0.1646

Phosphate

concentration

sample	(ppm)
T1S1A	64.964
T1S1B	n/a
T1S2A	11.8811
T1S2B	n/a
T1S3A	n/a
T1S3B	53.9347
T1S4A	n/a
T1S4B	n/a
T1S5A	*peak
T1S5B	*peak
T1S6A	n/a
T1S6B	15.4417
T1S7A	*peak
T1S7B	n/a
T1S8A	n/a
T1S8B	n/a
T1S9A	32.2089
T1S9B	*peak
T1S10A	*peak
T1S10B	*peak
T1S11A	n/a
T1S11B	n/a
T1S12A	n/a
T1S12B	n/a
T2S1A	n/a
T2S1B	n/a
T2S2A	n/a
T2S2B	n/a
T2S3A	n/a
T2S3B	n/a
T3S4A	n/a
T3S4B	n/a
T3S5A	n/a
T3S5B	n/a
T3S6A	n/a
T3S6B	n/a
T3S7A	n/a

T3S7B 0.3694  
 T3S8A 0.4086  
 T3S8B  
 T3S9A 0.3539  
 T3S9B  
 AZ311A 1.3306  
 AZ311B 1.151  
 AZ312A 0.0342  
 AZ312B  
 AZ313A 0.0313  
 AZ313B 0.0037  
 Nitrate

T3S7B n/a  
 T3S8A n/a  
 T3S8B n/a  
 T3S9A n/a  
 T3S9B n/a  
 AZ311A n/a  
 AZ311B n/a  
 AZ312A n/a  
 AZ312B n/a  
 AZ313A n/a  
 AZ313B n/a  
 Phosphate

sample concentration (ppm)

T1S1A 22.984  
 T1S1B 24.2113  
 T1S2A n/a  
 T1S2B 11.907  
 T1S3A 78.1385  
 T1S3B 60.796  
 T1S4A 37.6012  
 T1S4B 37.9403  
 T1S5A n/a  
 T1S5B 25.9135  
 T1S6A 15.0333  
 T1S6B 15.0934  
 T1S7A 10.9682  
 T1S7B 9.5109  
 T1S8A 1.7078  
 T1S8B 5.5153  
 T1S9A 0.414  
 T1S9B 0.3702  
 T1S10A n/a  
 T1S10B n/a  
 T1S11A n/a  
 T1S11B n/a  
 T1S12A 0.3787  
 T1S12B 0.3335  
 T2S1A 15.9321  
 T2S1B 19.1018  
 T2S2A 11.3709  
 T2S2B 10.3252  
 T2S3A 24.1179

concentration

sample (ppm)

T1S1A n/a  
 T1S1B 64.964  
 T1S2A n/a  
 T1S2B 11.8811  
 T1S3A n/a  
 T1S3B n/a  
 T1S4A 53.9347  
 T1S4B n/a  
 T1S5A n/a  
 T1S5B \*peak  
 T1S6A \*peak  
 T1S6B n/a  
 T1S7A 15.4417  
 T1S7B \*peak  
 T1S8A n/a  
 T1S8B n/a  
 T1S9A n/a  
 T1S9B 32.2089  
 T1S10A \*peak  
 T1S10B \*peak  
 T1S11A \*peak  
 T1S11B n/a  
 T1S12A n/a  
 T1S12B n/a  
 T2S1A n/a  
 T2S1B n/a  
 T2S2A n/a  
 T2S2B n/a  
 T2S3A n/a

T2S3B	21.7173	T2S3B	n/a
T3S4A	0.5101	T3S4A	n/a
T3S4B	7.6815	T3S4B	n/a
T3S5A	0.4761	T3S5A	n/a
T3S5B	0.1721	T3S5B	n/a
T3S6A	n/a	T3S6A	n/a
T3S6B	0.5091	T3S6B	n/a
T3S7A	0.1897	T3S7A	n/a
T3S7B	0.1646	T3S7B	n/a
T3S8A	0.3694	T3S8A	n/a
T3S8B	0.4086	T3S8B	n/a
T3S9A	0.3539	T3S9A	n/a
T3S9B		T3S9B	n/a
AZ311A	1.3306	AZ311A	n/a
AZ311B	1.151	AZ311B	n/a
AZ312A	0.0342	AZ312A	n/a
AZ312B		AZ312B	n/a
AZ313A	0.0313	AZ313A	n/a
AZ313B	0.0037	AZ313B	n/a

*Cations*

Element Ca,  
Date Thu May 17 13:50:27 2012

Full Calibration  
Calibration Mode Conc Least Squares Max Error : 1.616 R<sup>2</sup> : 0.587  
Error Standard has negative absorbance

Full Calibration

Conc.  
Sample Label (µg/ml) %RSD Mean Abs.

Full Calibration

Sample Label	Conc. (µg/ml)	%RSD	Mean Abs.
Table Blank	----	----	0
Standard 1	2.5	----	0.0652
Standard 2	5	----	0.1171
Standard 3	15	----	0.3259
T1S1A	11.916	0.06	0.2665
T1S1B	9.352	3.16	0.2159
T1S2A	4.429	1.03	0.109
T1-S2-B	5.481	2.94	0.133
T1S3A	High	3.89	0.3992
T1S3B	High	1.51	0.3642
T1S4A	9.325	1.17	0.2154
T1S4B	15.412	3.8	0.3306
STD	2.533	3.46	0.064
STD	5.173	1.07	0.1261
T1S5A	High	0.41	0.6754
T1S5B	High*	2.59	0.4118
T1S6A	15.646	2.14	0.3347
T1S6B	High	1.53	0.3892
T1S7A	High	0.61	0.3709
T1S7B	High	1.49	0.3615
T1S8A	High	0.92	0.5498
T1S8B	High	1.79	0.6338

2b

Analysis  
Filename

C:\Program Files\GBC Avanta Ver 1.33\Analysis1.anl

Element Ca,  
 Date Thu May 17 14:29:08 2012  
 Full Calibration  
 Calibration Mode Conc Least Squares Max Error : 0.645 R<sup>2</sup> : 0.999  
 Full Calibration

Sample Label	Conc. (µg/ml)	%RSD	Mean Abs.
Cal Blank	-----	0.9	0.0621
Standard 1	5	0.55	0.1301
Standard 2	15	0.97	0.3472
Standard 3	50	1.33	0.7574
Sample 2	2.613	0.35	0.0717 *
T1S3A	14.885	3.74	0.3383
T1S3B	12.971	0.88	0.3029
STD	47.478	1.97	0.7417
T1S5A	29.461	6.7	0.5564
T1S5B	15.785	1.05	0.3543
T1S6B	14.248	3.61	0.3268
T1S7A	12.802	1.45	0.2997
T1S7B	12.631	0.32	0.2964
T1S8A	24.286	2.63	0.488
T1S8B	28.437	1.41	0.5436
T1S9A	15.076	1.64	0.3418
STD	48.949	2.31	0.7541
T1S9B	7.787	6.82	0.1965
T1S10A	22.408	0.78	0.4609
T1S10B	22.068	1.4	0.4559
T1S11A	16.275	5.14	0.3629
T1S11B	17.371	0.65	0.3816
T1S12A	14.178	6.62	0.3255
T1S12B	13.84	3.78	0.3192
T2S1A	30.789	1.86	0.5727
T2S1B	29.805	3.12	0.5607
std	46.382	3.57	0.7323
T2S2A	17.235	0.65	0.3793
T2S2B	18.065	5.74	0.3932
T2S3A	27.616	3.25	0.533
T2S3B	22.263	4.67	0.4588
T3S4A	11.958	2.54	0.2834
T3S4B	14.238	1.39	0.3266

T3S5A	10.549	1.63	0.2552
T3S5B	13.369	3.24	0.3105
T3S6A	14.515	2.58	0.3316
std	49.25	0.35	0.7565
T3S6B	10.867	3.9	0.2617
T3S7A	18.141	4.89	0.3944
T3S7B	17.964	0.7	0.3915
T3S8A	10.451	4.65	0.2532
T3S8B	13.464	4.36	0.3122
T3S9A	24.639	2.57	0.4929
T3S9B	22.701	2.5	0.4652
AZ311A	0.802	2.28	0.0227
AZ311B	0.901	9.07	0.0254
std	40.556	8.72	0.6787
AZ312A	0.857	2.86	0.0242
AZ312B	0.968	12.56	0.0273
AZ313A	2.57	6.04	0.0705
AZ313B	2.563	1.14	0.0704

Analysis

Filename C:\Program Files\GBC Avanta Ver 1.33\Analysis1.anl

Element Mg,

Date Fri May 18 09:38:18 2012

Full Calibration

Calibration Mode Conc Least Squares Max Error : 0.130 R<sup>2</sup> : 1.000

Full Calibration

Sample Label	Conc. (µg/ml)	%RSD	Mean Abs.
Cal Blank	----	HIGH	0.0001
Standard 1	6.67	0.04	0.337
Standard 2	17.91	0.56	0.7936
Standard 3	35.74	0.16	1.3496
T1S1A	0.289	11.33	0.0157
T1S1B	0.417	7.13	0.0226
T1S2A	1.475	0.74	0.0791
T1S2B 38.2% of Expected	0.382 **	9.27	0.0208

1

Element

Mg,

Date

Fri May 18 09:42:53 2012

Full Calibration  
Calibration Mode  
Full Calibration

Conc Least Squares Max Error : 0.130 R<sup>2</sup> : 1.000

Sample Label	Conc. (µg/ml)	%RSD	Mean Abs.
Table Blank	-----	-----	0
Standard 1	6.67	-----	0.337
Standard 2	17.91	-----	0.7936
Standard 3	35.74	-----	1.3496
T1S3A	2.66	0.37	0.1405
T1S3B	2.233	1.2	0.1186
T1S4A	0.773	1.14	0.0418
T1S4B	0.788	3.16	0.0426
STD	1.725	1.84	0.0922
T1S5A	0.25	1.45	0.0136
T1S5B	0.248	8.04	0.0135
T1S6A	0.121	16.5	0.0066
T1S6B	0.151	4.02	0.0082
T1S7A	0.182	8.77	0.0099
T1S7B	0.132	12.19	0.0072
T1S8A	0.318	7.34	0.0173
T1S8B	0.435	5.55	0.0236
T1S9A	0.238	5.3	0.013
STD	0.238	9.03	0.013
STD	6.894	0.69	0.3463
T1S9B	0.245	6.04	0.0134
T1S10A	0.618	1.76	0.0335
T1S10B	0.521	3.08	0.0283
T1S11A	0.551	4.93	0.0298
T1S11B	0.497	2.82	0.027
T1S12A	0.352	7.67	0.0192
T1S12B	0.338	6.03	0.0184
T2S1A	0.49	19.77	0.0266
T2S1B	0.633	4.87	0.0343
std	6.982	1.05	0.3504
T2S2A	0.141	8.04	0.0077
T2S2B	0.119	6.41	0.0065
T2S3A	0.722	3.44	0.039
T2S3B	0.656	1.23	0.0355
T3S4A	1.883	0.66	0.1004
T3S4A	1.91	2.63	0.1018
T3S4B	1.968	0.54	0.1048



T3S5A	3.13	0.52	0.1644
T3S5B	1.998	1.21	0.1064
T3S6A	2.008	0.67	0.1069
std	6.774	0.62	0.3408
T3S6B	1.187	1.57	0.0638
T3S7A	4.07	1.03	0.2114
T3S7B	3.725	0.48	0.1942
T3S8A	2.955	0.25	0.1555
T3S8B	4.025	1.12	0.2092
T3S9A	7.18	0.36	0.3595
T3S9B	5.528	0.82	0.2822
AZ311A	1.188	0.74	0.0639
AZ311B	1.201	2.88	0.0646
std	6.918	0.59	0.3475
AZ312A	1.336	1.61	0.0717
AZ312B	1.333	0.39	0.0716
AZ313A	1.611	0.41	0.0862
AZ313B	1.606	0.92	0.086

Analysis

Filename C:\Program Files\GBC Avanta Ver 1.33\Analysis1.anl

Element Na,

Date Fri May 18 10:07:11 2012

Full Calibration

Calibration Mode Conc Least Squares Max Error : 2.067 R<sup>2</sup> : 0.840

Full Calibration

Sample Label	Conc. (µg/ml)	%RSD	Mean Abs.
Table Blank	-----	-----	0
Standard 1	1.49	-----	0.337
Standard 2	6.85	-----	0.7936
Standard 3	11.2	-----	1.3496

Analysis

Filename C:\Program Files\GBC Avanta Ver 1.33\Analysis1.anl

Element Na,

Date Fri May 18 10:09:44 2012

Full Calibration

Calibration Mode Conc Least Squares Max Error : 0.031 R<sup>2</sup> : 1.000

Full Calibration

Sample Label	Conc. (µg/ml)	%RSD	Mean Abs.
Cal Blank	-----	HIGH	0.0033
Standard 1	1.49	5.42	0.1035
Standard 2	6.85	1.21	0.5026

Standard 3	11.2	0.57	0.8497
T1S1A	1.294	1.83	0.0899
T1S1B	High	0.25	1.631
T1S2A	High	HIGH	0.9389

Analysis

Filename C:\Program Files\GBC Avanta Ver 1.33\Analysis1.anl

Element K,

Date Fri May 18 10:15:36 2012

Full Calibration

Calibration Mode Conc Least Squares Max Error : 0.303 R<sup>2</sup> : 0.995

Full Calibration

Sample Label	Conc. (µg/ml)	%RSD	Mean Abs.
Cal Blank	----	HIGH	-0.0041
Standard 1	2.71	4.54	0.3058
Standard 2	4.57	----	0.5026
Standard 3	10.84	----	0.8497

Analysis

Filename C:\Program Files\GBC Avanta Ver 1.33\Analysis1.anl

Element Na,

Date Tue May 22 10:47:20 2012

Full Calibration

Calibration Mode Conc Least Squares Max Error : 0.352 R<sup>2</sup> : 0.998

Full Calibration

Sample Label	Conc. (µg/ml)	%RSD	Mean Abs.
Cal Blank	----	4.73	0.0152
Standard 1	6.85	----	0.3058
Standard 2	11.285	----	0.5026
Standard 3	22	----	0.8497

Analysis

Filename C:\Program Files\GBC Avanta Ver 1.33\Analysis1.anl

Element Na,

Date Tue May 22 10:49:02 2012

Full Calibration

Calibration Mode Conc Least Squares Max Error : 0.548 R<sup>2</sup> : 0.996

Full Calibration

Sample Label	Conc. (µg/ml)	%RSD	Mean Abs.
Cal Blank	----	HIGH	0.002
Standard 1	6.85	1.44	0.3151
Standard 2	11.285	0.91	0.5798
Standard 3	22	0.69	1.1242

T1S1A	0.243	11.91	0.0112		
T1S1B	2.395	1.15	0.1114		
T1S2A	High	0.55	1.3023		
T1S2A	18.157	0.96	0.9226	20%	multiply by 20
T1S2a	18.246	0.17	0.9276	20% dill	
T1S3A	0.282	15.76	0.013		
T1S3B	0.177	HIGH	0.0081		
T1S4A	2.047	0.79	0.0951		
T1S4B	0.135	13.83	0.0062		
STD	7.149	0.52	0.3413		
T1S5A	High	0.99	2.2512	30%	
T1S5A	16.774	1.21	0.8455	30% dill	multiply by 30
T1S5B	0.134	13.56	0.0061		
T1S6A	0.191	18.37	0.0088		
T1S6B	0.087	HIGH	0.004		
T1S7A	0.92	15.35	0.0425		
T1S7B	0.146	HIGH	0.0067		
T1S8A	0.155	7.78	0.0071		
T1S8B	0.28	HIGH	0.0129		
T1S9A	0.076	HIGH	0.0035		
STD	7.355	0.92	0.3515		
T1S9B	0.99	2.14	0.0457		
T1S10A	0.102	HIGH	0.0047		
T1S10B	0.121	HIGH	0.0055		
T1S11A	0.1	14.95	0.0046		
T1S11B	0.096	HIGH	0.0044		
T1S12A	0.072	HIGH	0.0033		
T1S12B	0.136	18.2	0.0062		
T2S1A	0.128	HIGH	0.0059		
T2S1B	0.078	HIGH	0.0036		
std	7.568	1.04	0.3621		
T2S2A	0.133	5.73	0.0061		
T2S2B	0	HIGH	-0.0007		
T2S3A	0.102	HIGH	0.0047		
T2S3B	0.144	18.31	0.0066		
T3S4A	0.444	4.01	0.0204		
T3S4B	0.409	18.81	0.0188		
T3S5A	1.362	2.42	0.063		
T3S5B	1.527	1.71	0.0707		
T3S6A	0.971	6.32	0.0448		
std	7.728	1.67	0.3701		
T3S6B	0.865	4.04	0.0399		
T3S7A	1.421	1.01	0.0658		

T3S7B	1.5	6.5	0.0694
T3S8A	2.33	0.29	0.1083
T3S8B	2.262	1.69	0.1052
T3S9A	3.635	1.02	0.1702
T3S9B	3.191	0.69	0.1491
AZ311A	0.927	4.71	0.0428
AZ311B	2.294	1.45	0.1067
std	7.899	0.72	0.3787
AZ312A	0.847	1.23	0.0391
AZ312B	0.868	3.74	0.04
AZ313A	0.865	2.4	0.0399
AZ313B	0.857	8.49	0.0395

Ca

Sample Label	Conc. (µg/ml)	%RSD	Mean Abs.
Standard 1	5	0.55	0.1301
Standard 2	15	0.97	0.3472
Standard 3	50	1.33	0.7574
T1S1A	11.916	0.06	0.2665
T1S1B	9.352	3.16	0.2159
T1S2A	4.429	1.03	0.109
T1S2B	5.481	2.94	0.133
T1S3A	14.885	3.74	0.3383
T1S3B	12.971	0.88	0.3029
T1S4A	9.325	1.17	0.2154
T1S4B	15.412	3.8	0.3306
T1S5A	29.461	6.7	0.5564
T1S5B	15.785	1.05	0.3543
T1S6A	15.646	2.14	0.3347
T1S6B	14.248	3.61	0.3268
T1S7A	12.802	1.45	0.2997
T1S7B	12.631	0.32	0.2964
T1S8A	24.286	2.63	0.488
T1S8B	28.437	1.41	0.5436
T1S9A	15.076	1.64	0.3418
T1S9B	7.787	6.82	0.1965
T1S10A	22.408	0.78	0.4609
T1S10B	22.068	1.4	0.4559
T1S11A	16.275	5.14	0.3629
T1S11B	17.371	0.65	0.3816
T1S12A	14.178	6.62	0.3255
T1S12B	13.84	3.78	0.3192

Mg

Sample Label	Conc. (µg/ml)	%
Standard 1	6.67	
Standard 2	17.91	
Standard 3	35.74	
T1S1A	0.289	
T1S1B	0.417	
T1S2A	1.475	
T1S2B 38.2% of Expected	0.382 **	
T1S3A	2.66	
T1S3B	2.233	
T1S4A	0.773	
T1S4B	0.788	
T1S5A	0.25	
T1S5B	0.248	
T1S6A	0.121	
T1S6B	0.151	
T1S7A	0.182	
T1S7B	0.132	
T1S8A	0.318	
T1S8B	0.435	
T1S9A	0.238	
T1S9B	0.245	
T1S10A	0.618	
T1S10B	0.521	
T1S11A	0.551	
T1S11B	0.497	
T1S12A	0.352	
T1S12B	0.338	

T2S1A	30.789	1.86	0.5727	T2S1A	0.49
T2S1B	29.805	3.12	0.5607	T2S1B	0.633
T2S2A	17.235	0.65	0.3793	T2S2A	0.141
T2S2B	18.065	5.74	0.3932	T2S2B	0.119
T2S3A	27.616	3.25	0.533	T2S3A	0.722
T2S3B	22.263	4.67	0.4588	T2S3B	0.656
T3S4A	11.958	2.54	0.2834	T3S4A	1.883
T3S4B	14.238	1.39	0.3266	T3S4B	1.968
T3S5A	10.549	1.63	0.2552	T3S5A	3.13
T3S5B	13.369	3.24	0.3105	T3S5B	1.998
T3S6A	14.515	2.58	0.3316	T3S6A	2.008
T3S6B	10.867	3.9	0.2617	T3S6B	1.187
T3S7A	18.141	4.89	0.3944	T3S7A	4.07
T3S7B	17.964	0.7	0.3915	T3S7B	3.725
T3S8A	10.451	4.65	0.2532	T3S8A	2.955
T3S8B	13.464	4.36	0.3122	T3S8B	4.025
T3S9A	24.639	2.57	0.4929	T3S9A	7.18
T3S9B	22.701	2.5	0.4652	T3S9B	5.528
AZ311A	0.802	2.28	0.0227	AZ311A	1.188
AZ311B	0.901	9.07	0.0254	AZ311B	1.201
AZ312A	0.857	2.86	0.0242	AZ312A	1.336
AZ312B	0.968	12.56	0.0273	AZ312B	1.333
AZ313A	2.57	6.04	0.0705	AZ313A	1.611
AZ313B	2.563	1.14	0.0704	AZ313B	1.606

data set A  
Ca

Sample Label	Conc. (µg/ml)	%RSD	Mean Abs.	
Standard 1	5	0.55	0.1301	
Standard 2	15	0.97	0.3472	
Standard 3	50	1.33	0.7574	
T1S1A	1	11.916	0.06	0.2665
T1S2A	3	4.429	1.03	0.109
T1S3A	5	14.885	3.74	0.3383
T1S4A	7	9.325	1.17	0.2154
T1S5A	9	29.461	6.7	0.5564
T1S6A	11	15.646	2.14	0.3347
T1S7A	13	12.802	1.45	0.2997
T1S8A	15	24.286	2.63	0.488
T1S9A	17	15.076	1.64	0.3418
T1S10A	19	22.408	0.78	0.4609

data set a  
Mg

Sample Label	Conc. (µg/ml)	%
Standard 1	6.67	
Standard 2	17.91	
Standard 3	35.74	
T1S1A	1	0.289
T1S2A	3	1.475
T1S3A	5	2.66
T1S4A	7	0.773
T1S5A	9	0.25
T1S6A	11	0.121
T1S7A	13	0.182
T1S8A	15	0.318
T1S9A	17	0.238
T1S10A	19	0.618

T1S11A	21	16.275	5.14	0.3629
T1S12A	23	14.178	6.62	0.3255
T2S1A		30.789	1.86	0.5727
T2S2A		17.235	0.65	0.3793
T2S3A		27.616	3.25	0.533
T3S4A	1	11.958	2.54	0.2834
T3S5A	3	10.549	1.63	0.2552
T3S6A	5	14.515	2.58	0.3316
T3S7A	7	18.141	4.89	0.3944
T3S8A	9	10.451	4.65	0.2532
T3S9A	11	24.639	2.57	0.4929
AZ311A		0.802	2.28	0.0227
AZ312A		0.857	2.86	0.0242
AZ313A		2.57	6.04	0.0705

T1S11A	21	0.551
T1S12A	23	0.352
T2S1A		0.49
T2S2A		0.141
T2S3A		0.722
T3S4A	1	1.883
T3S5A	3	3.13
T3S6A	5	2.008
T3S7A	7	4.07
T3S8A	9	2.955
T3S9A	11	7.18
AZ311A		1.188
AZ312A		1.336
AZ313A		1.611

data set B  
Ca

Sample Label		Conc. (µg/ml)	%RSD	Mean Abs.
Standard 1		5	0.55	0.1301
Standard 2		15	0.97	0.3472
Standard 3		50	1.33	0.7574
T1S1B	1	9.352	3.16	0.2159
T1S2B	3	5.481	2.94	0.133
T1S3B	5	12.971	0.88	0.3029
T1S4B	7	15.412	3.8	0.3306
T1S5B	9	15.785	1.05	0.3543
T1S6B	11	14.248	3.61	0.3268
T1S7B	13	12.631	0.32	0.2964
T1S8B	15	28.437	1.41	0.5436
T1S9B	17	7.787	6.82	0.1965
T1S10B	19	22.068	1.4	0.4559
T1S11B	21	17.371	0.65	0.3816
T1S12B	23	13.84	3.78	0.3192
T2S1B		29.805	3.12	0.5607
T2S2B		18.065	5.74	0.3932
T2S3B		22.263	4.67	0.4588
T3S4B	1	14.238	1.39	0.3266
T3S5B	3	13.369	3.24	0.3105
T3S6B	5	10.867	3.9	0.2617
T3S7B	7	17.964	0.7	0.3915
T3S8B	9	13.464	4.36	0.3122
T3S9B	11	22.701	2.5	0.4652

data set b  
Mg

Sample Label		Conc. (µg/ml)	%
Standard 1		6.67	
Standard 2		17.91	
Standard 3		35.74	
T1S1B	1	0.417	
T1S2B	3	1	
T1S3B	5	2.233	
T1S4B	7	0.788	
T1S5B	9	0.248	
T1S6B	11	0.151	
T1S7B	13	0.132	
T1S8B	15	0.435	
T1S9B	17	0.245	
T1S10B	19	0.521	
T1S11B	21	0.497	
T1S12B	23	0.338	
T2S1B		0.633	
T2S2B		0.119	
T2S3B		0.656	
T3S4B	1	1.968	
T3S5B	3	1.998	
T3S6B	5	1.187	
T3S7B	7	3.725	
T3S8B	9	4.025	
T3S9B	11	5.528	

AZ311B	0.901	9.07	0.0254	AZ311B	1.201
AZ312B	0.968	12.56	0.0273	AZ312B	1.333
AZ313B	2.563	1.14	0.0704	AZ313B	1.606
Na		new			
Sample Label	Conc. (µg/ml)	Conc. (µg/ml)	%RSD	Mean Abs.	
Standard 1	6.85	1.44	0.3151		
Standard 2	11.285	0.91	0.5798		
Standard 3	22	0.69	1.1242		
T1S1A	0.243	11.91	0.0112		
T1S1B	2.395	1.15	0.1114		
T1S2A	18.157	0.96	0.9226	0.2	
T1S2a	18.246	0.17	0.9276	20% dill	
T1S3A	0.282	15.76	0.013		
T1S3B	0.177	HIGH	0.0081		
T1S4A	2.047	0.79	0.0951		
T1S4B	0.135	13.83	0.0062		
T1S5A	16.774	1.21	0.8455	0.3	
T1S5B	0.134	13.56	0.0061	30% dill	
T1S6A	0.191	18.37	0.0088		
T1S6B	0.087	HIGH	0.004		
T1S7A	0.92	15.35	0.0425		
T1S7B	0.146	HIGH	0.0067		
T1S8A	0.155	7.78	0.0071		
T1S8B	0.28	HIGH	0.0129		
T1S9A	0.076	HIGH	0.0035		
T1S9B	0.99	2.14	0.0457		
T1S10A	0.102	HIGH	0.0047		
T1S10B	0.121	HIGH	0.0055		
T1S11A	0.1	14.95	0.0046		
T1S11B	0.096	HIGH	0.0044		
T1S12A	0.072	HIGH	0.0033		
T1S12B	0.136	18.2	0.0062		
T2S1A	0.128	HIGH	0.0059		
T2S1B	0.078	HIGH	0.0036		
T2S2A	0.133	5.73	0.0061		
T2S2B	0	HIGH	-0.0007		
T2S3A	0.102	HIGH	0.0047		
T2S3B	0.144	18.31	0.0066		
T3S4A	0.444	4.01	0.0204		
T3S4B	0.409	18.81	0.0188		
T3S5A	1.362	2.42	0.063		
T3S5B	1.527	1.71	0.0707		

T3S6A	0.971	6.32	0.0448
T3S6B	0.865	4.04	0.0399
T3S7A	1.421	1.01	0.0658
T3S7B	1.5	6.5	0.0694
T3S8A	2.33	0.29	0.1083
T3S8B	2.262	1.69	0.1052
T3S9A	3.635	1.02	0.1702
T3S9B	3.191	0.69	0.1491
AZ311A	0.927	4.71	0.0428
AZ311B	2.294	1.45	0.1067
AZ312A	0.847	1.23	0.0391
AZ312B	0.868	3.74	0.04
AZ313A	0.865	2.4	0.0399
AZ313B	0.857	8.49	0.0395

Water			
Sample	[Ca+]	[Mg+]	[Na+]
AZ311A	0.802	1.188	0.927
AZ311B	0.901	1.201	2.294
AZ311			
(avg.)	0.8515	1.1945	1.6105
AZ312A	0.857	1.336	0.847
AZ312B	0.968	1.333	0.868
AZ312			
(avg.)	0.9125	1.3345	0.8575
AZ313A	2.57	1.611	0.865
AZ313B	2.563	1.606	0.857
AZ313			
(avg.)	2.5665	1.6085	0.861

Transect,	Graph A	Graph B	
ion	(m)	(m)	% error
t1, Ca+	0.3401	0.3816	12.20229
t1, Mg+	-0.0425	-0.0342	19.52941
t1, Na+	-0.2867	-0.4082	42.37879
t3, Ca+	0.9534	0.71	25.52968
t3, Mg+	0.4003	0.3774	5.720709
t3, Na+	2.7584	2.3929	13.25044

t1aCa	y = 0.3401x + 11.809	7.4822	7.9387
t1bCa	y = 0.3816x + 10.036	8.3952	
t1aMg	y = -	-0.935	-0.8437



	0.0425x + 1.1626		
	y = -		
t1bMg	0.0342x + 0.994	-0.7524	
	y = -		
t1aNa	0.2867x + 8.5552	-6.3074	-7.6439
	y = -		
t1bNa	0.4082x + 8.878	-8.9804	
t3aCa	y = 0.9534x + 9.3219	9.534	8.317
t3bCa	y = 0.71x + 11.174	7.1	
t3aMg	y = 0.4003x + 1.1358	4.003	3.8885
t3bMg	y = 0.3774x + 0.8073	3.774	
t3aNa	y = 2.7584x + 0.3878	27.584	25.7565
t3bNa	y = 2.3929x + 1.8995	23.929	