Appendix # A

to

Report # WWW 2017-007

MEMORANDUM

Date:	July 17, 2017
To:	Amber Hayter. City of Kawartha Lakes
From:	Mazahir Alidina, Maika Pellegrino. WSP
Project No.:	161-15613
Location:	Lindsay Water Treatment Plant
Subject:	Follow Up Coagulant Testing for the Lindsay Water Treatment Plant

1. Introduction

The Lindsay Water Treatment Plan is a conventional treatment plant with an ACTIFLO® System that consists of two (2) ballasted flocculation/clarification units, two (2) sedimentation tanks and five (5) multi-media filters to handle the plant rated flow of 22,730 m^3/d. The source water for the plant is the Scugog River where water temperatures range between 0 and 30^{0}C. Currently polyaluminum chloride (PAC) is used when raw water is below 12^{0}C and alum is used above 12^{0}C.

WSP was retained by The City of Kawartha Lakes in the Spring of 2016 to explore alternative coagulants for the Lindsay Water Treatment Plant during Raw Water cold temperature conditions. WSP completed this jar testing at temperatures between 10.5^{0}C and 12.5^{0}C, and recommended that SternPAC (current coagulant in use at the plant) and DeltaFloc-1118 be tested further at lower temperatures of 2 - 4^{0}C, to investigate if DeltaFloc-1118 exhibits superior performance compared to SternPAC.

It was also recommended that when SternPAC and DeltaFloc-1118 were re-tested at cold temperatures, the following additional parameters be included in the analysis to assess for corrosivity: chloride, sulphate and total dissolved solids (TDS). This would allow the calculation of the following corrosion indices: Langelier Saturation Index (LSI), Ryznar Stability Index (RSI), Chloride to Sulphate Mass Ratio (CSMR).

Following the jar testing, WSP also recommended that an optimization jar test study be conducted to review the microsand dose, determine the optimum polymer dose and optimum pH since the dosing ranges used during the jar testing did not seem to be optimized.

2. Aim

The aims of the current jar tests were as follows:

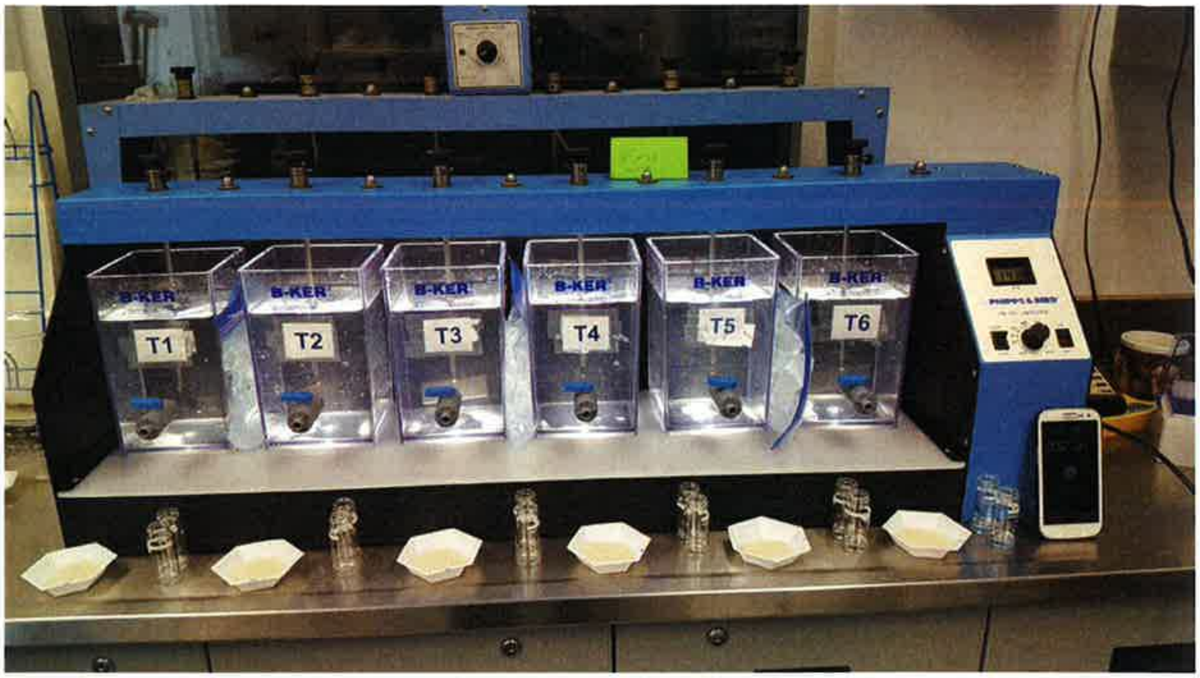
1. Determine optimum microsand dose
2. Determine optimum polymer dose
3. Determine optimum pH
4. Determine optimum coagulant dose

The jar testing simulated a full scale ACTIFLO® process by using similar contact times in each basin of the ACTIFLO® process and by adding the chemicals and micro-sand along the same sequence used in the full-scale unit.

3. Jar Testing Procedure

The jar testing was carried out in accordance with the industry standard "Actiflo® Jar Testing Procedure" (Appendix 1). The jar tests were performed using a Phipps & Bird PB-700™ Jar Test Apparatus (supplied by WSP, Figure 1) at the Lindsay Water Treatment Plant. The PB-700™ is a six-paddle model with regulated variable paddle speed control between a range of 1 – 300 rpm with a digital readout of the exact speed. The unit comes with six, square acrylic 2L jar testing jars and has a fluorescent lamp floc illuminator built into its base.

Figure 1 Jar Testing Apparatus used for testing the coagulants



The microsand to be used for the testing was washed thoroughly (by plant staff) before beginning of the jar testing. The microsand was washed until the supernatant was clear, in order to eliminate turbidity caused by micro-grains or any suspended particles that could be introduced into the water tested in the jar test. The microsand was laid out to dry overnight and stored in plastic jars.

Since these jar tests were to be carried out at cold temperatures around 4°C, plant staff were requested to collect raw water the afternoon before a jar testing event was scheduled. Actual raw water temperatures were noted to be in the 4°C to 5°C range, and to maintain the temperature at this level, collected water was stored in the refrigerator. Care was taken to leave the raw water in the refrigerator and fill the 2 L test jars just before beginning of the jar test to minimize temperature increase. Ice packs were also placed between the jars to try and keep the jars cold.

Ultimately however, where individual readings of the jars were required before beginning of the jar test (e.g. pH), there was some time period when the jars had to be kept at room temperature which resulted in slight increases in liquid temperature. During the jar tests as well, due to heat dissipation from the moving paddles as well as the large surface area of the jars exposed to atmospheric temperature, the temperature of the water inevitably increased. The experiment however was run such that these effects were minimized as much as possible.

Polymer solution utilized in the jar tests was obtained (by plant staff) from the bulk solutions prepared for the full-scale unit in the plant. The concentration of the bulk polymer was approximately: 0.003 kg/L (3000 mg/L).

The water quality parameters tested are summarized in Table 1 below:

Table 1 Water Quality Parameters Tested

WSP (In Lab)	Commercial Lab (SGS Canada Inc.)	
pH	Alkalinity	DOC
Temperature	Apparent Colour	TOC
Turbidity	True Colour	Calcium
UVA	Residual Aluminum	TDS
	Total Hardness	Chloride
	Calcium Hardness	Sulphate

Before undertaking the cold water jar test to compare performance of SternPAC and DeltaFloc-1118, the optimization jar tests were carried out. The microsand and polymer optimization jar tests were carried out using SternPAC as the coagulant. These optimal values were carried forward for future jar tests.

Optimum pH was tested separately for SternPAC and DeltaFloc-1118. These optimal pH values were used when the jar tests to compare performance of the two coagulants were carried out. Details of the different jar tests are presented below:

3.1 Optimum Microsand Dose Jar Test

With the aim of optimizing the coagulation/flocculation process, a jar test was carried out to investigate the optimal microsand dose. The difference in microsand dosage was achieved by adding different amounts of microsand into each jar. The amounts of the microsand added to each 2 L jar ranged between 10 and 35 g, representing doses of 5 – 17.5 g/L. Other parameters were kept constant as follows:

- Coagulant: SternPAC
- Coagulant Dose: 85 mg/L
- Polymer Dose: 0.35 mg/L
- pH: Unchanged from raw water (7.59)

3.2 Optimum Polymer Dose Jar Test

During the first round of jar testing investigating alternative cold water coagulants, a constant polymer dose was utilized. A jar test experiment was undertaken to investigate if this dose could be optimized. The polymer dose was varied between 0.2 and 0.7 mg/L by addition of different amounts of polymer into each jar. Other parameters were kept constant as follows:

- Coagulant: SternPAC
- Coagulant Dose: 85 mg/L
- pH: Unchanged from raw water (7.59)
- Microsand Dose: 10 g/L

3.3 Optimum pH Jar Test

During the first round of jar testing investigating alternative cold water coagulants, pH was not altered since the optimum pH ranges obtained from the data sheets for all the coagulants were between 6 and 8. The raw water pH was noted to be within this range and no pH control was hence implemented.

However, due to the impact pH has on efficacy of coagulants, during the current investigation; jar tests were undertaken to determine the optimal pH for SternPAC and DeltaFloc-1118.

A 10X dilution of the concentrated 19.2N Sulphuric acid available in the lab was used to achieve pH control. A test was carried out using raw water to investigate the amount of the diluted acid required to lower the pH of the 2 L jar in set intervals. From the results of this experiment, the determined amount of acid was added to each jar to achieve a pH as close as possible to the target value. pH readings were taken for each jar at the beginning and at the end of the jar test. Optimal pH jar tests were carried out separately for the two coagulants as presented below:

3.3.1 SternPAC pH Test

The initial pH in the SternPAC pH test was varied between 6.3 and 7.6. Other parameters were as follows:

- Coagulant Dose: 85 mg/L
- Polymer dose: 0.3 mg/L
- Microsand Dose: 10 g/L

3.3.2 DetalFloc pH Test

The initial pH in the DetlaFloc pH test was also varied within the same range as SternPAC, between 6.3 and 7.6. Other parameters were as follows:

- Coagulant Dose: 37 mg/L
- Polymer dose: 0.3 mg/L
- Microsand Dose: 10 g/L

3.4 Optimum Coagulant Dose Jar Test

Once the optimal microsand and polymer dose were determined and the optimal pH specific to the coagulant was established, a final jar test was done to determine the optimal coagulant dose.

3.4.1 SternPAC Dose Test

The SternPAC dose was varied between 55 and 105 mg/L. Other parameters were as follows:

- pH: 6.5
- Polymer dose: 0.3 mg/L
- Microsand Dose: 7.5 g/L

3.4.2 DeltaFloc-1118 Dose Test

The DeltaFloc-1118 dose was varied between 24 and 46 mg/L. Other parameters were as follows:

- pH: 6.45 (Target pH: 6.5)
- Polymer dose: 0.3 mg/L
- Microsand Dose: 7.5 g/L

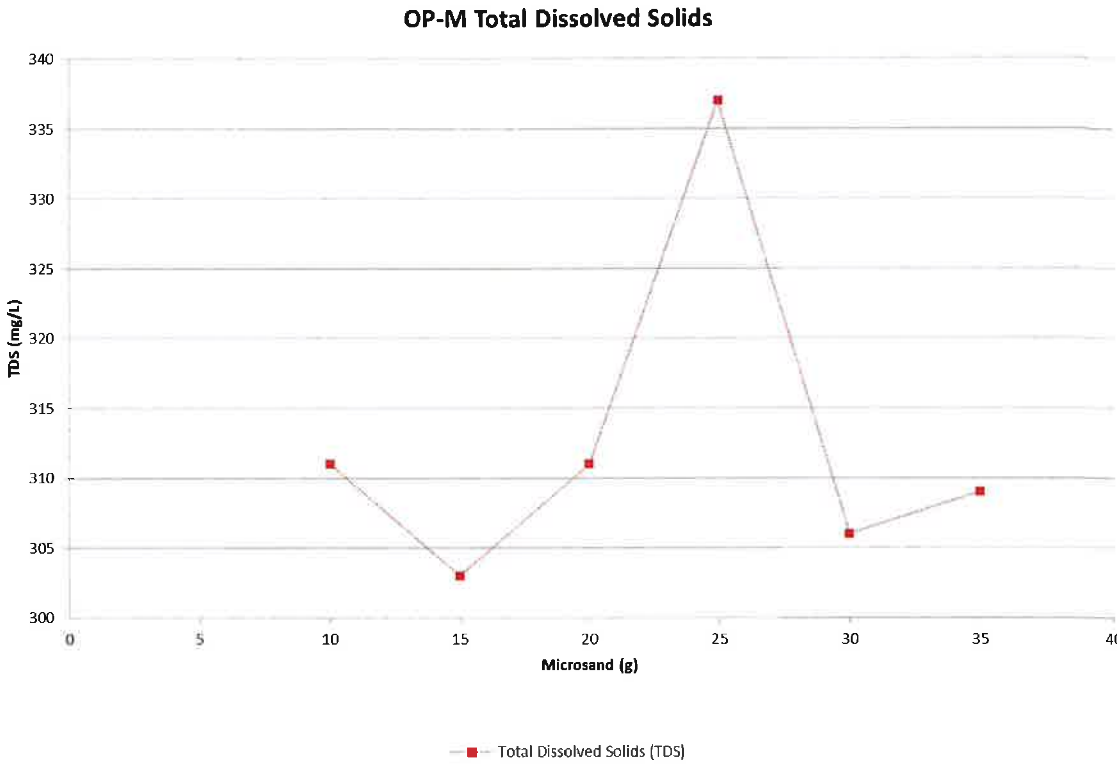
4. Results

4.1 Jar Test Results

Lab results from SGS Canada Inc. are presented in Appendix 2. Data sheets completed during and after the jar tests by WSP summarizing recorded jar test parameters and results for each of the jar tests are included in Appendix 3. Graphs summarizing the results from each of the jar tests are included in Appendix 4.

4.1.1 Optimal Microsand Dose

Turbidity values ranging between 0.339 and 0.369 NTU were observed with microsand doses of 10 -15 g. Turbidity was noted to increase at a dose of 20 g, and then decrease again at higher doses. Apparent colour of 12 CU noted at a microsand quantity of 10 g was noted to increase with increasing microsand amount, before reaching its lowest value at 30 g of microsand. There was a difference of only 2 CU between the microsand amounts of 10 g and 30 g. The lowest TDS of 303 mg/L was noted at a microsand amount of 15 g, though TDS values ranged between 306 and 311 mg/L for microsand amounts of 10, 20, 30 and 35 g.



TOC values of 6 mg/L were noted at 10 and 35 g of microsand, while slightly higher TOC values of 7 mg/L were noted at 15, 25 and 30 g of microsand.

Overall, the lower microsand doses of 10-15 g seem to yield better water quality results. Microsand amount of 15 g appeared to yield similar water quality results to higher microsand doses and was hence selected as the optimal microsand dose.

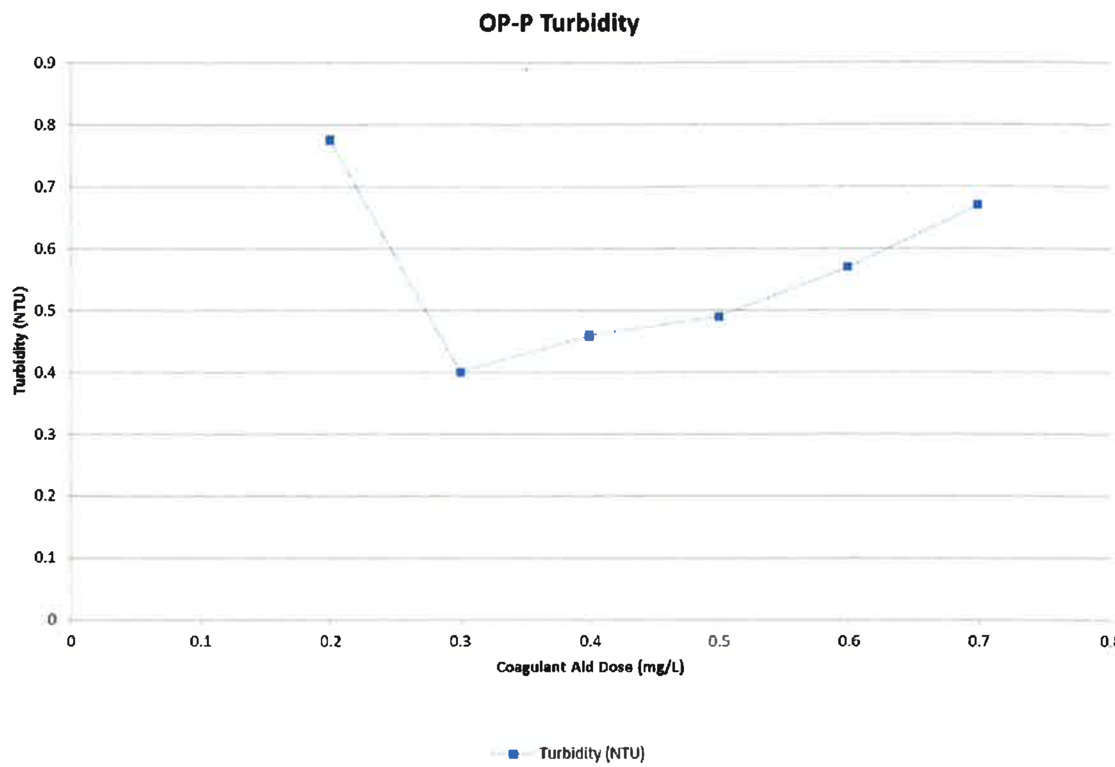
4.1.2 Optimal Polymer Dose

Results from some of the parameters, such as DOC, TOC and apparent colour did not exhibit a clear preference of one polymer dose over another. Turbidity was lowest at a polymer does of 0.3 mg/L, and turbidity increased with increasing polymer dose.

Similarly, TDS was lowest at a polymer dose of 0.3 mg/L and increased with increasing polymer dose. Turbidity and TDS were higher at a polymer dose of 0.2 mg/L compared to values at a dose of 0.3 mg/L, suggesting that lowering the polymer dose below 0.3 mg/L was not beneficial.

Alkalinity was also noted to be highest at a polymer dose of 0.3 mg/L, representing the least amount of alkalinity consumed at this dose.

Based on the above results, the obvious optimal polymer dose was noted to be 0.3 mg/L.

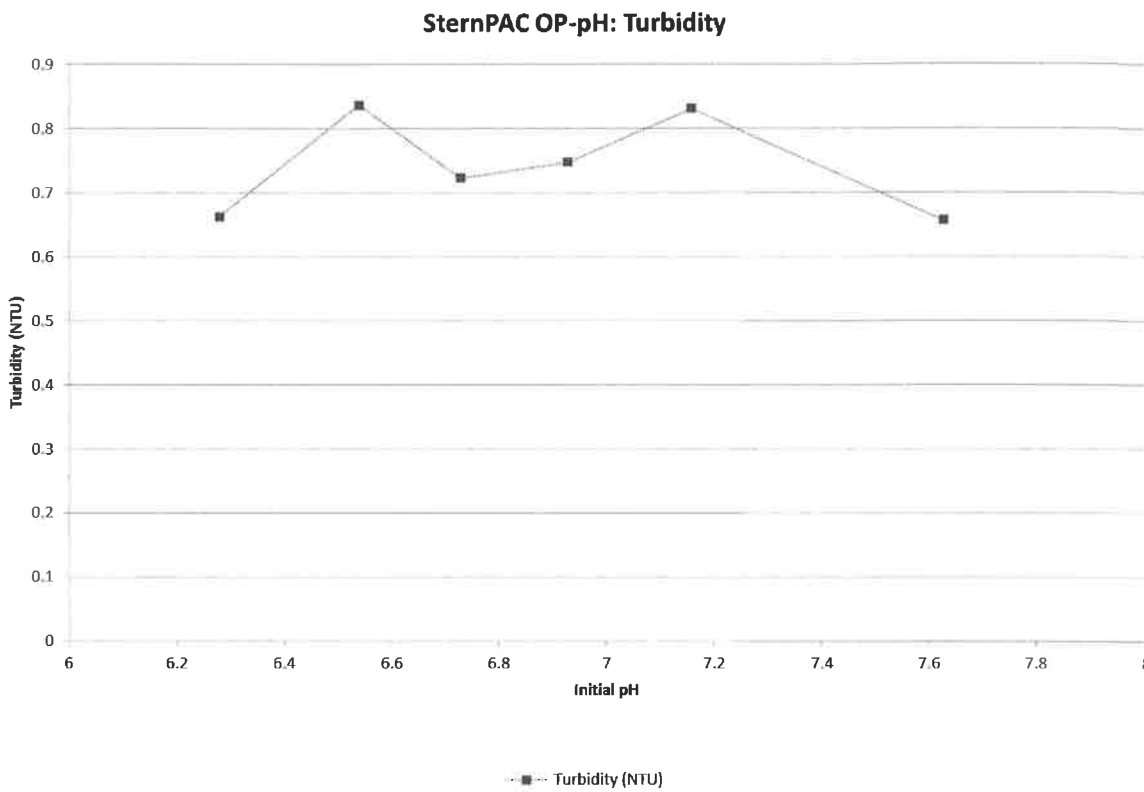


4.1.3 Optimal pH

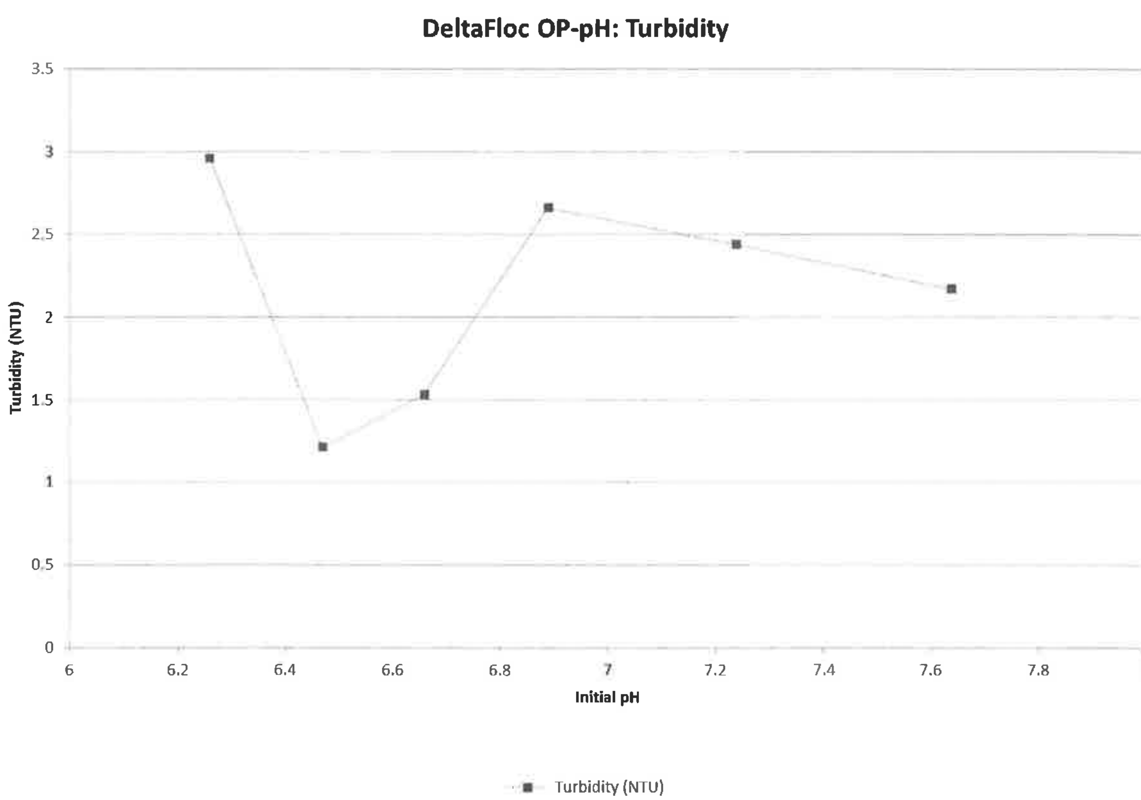
4.1.3.1 SternPAC: Optimal pH

Optimal water quality results for SternPAC were less clear compared to DeltaFloc-1118 when pH was altered. Turbidity, UVA and apparent colour were noted to have least values at the lower pH values and displayed an upward trend as pH was raised. TDS on the other hand seemed to decrease as pH was increased with a minimum value of 263 mg/L observed at a pH of around 7.2 mg/L. Lower values of DOC and TOC were noted at pH values less than 7 and 6.5 respectively.

Since lower pH values appeared to yield better water quality results, the highest pH of 6.5 that also yielded lower TOC and DOC values was selected as the optimal pH for SternPAC.



The optimal pH range for DeltaFloc-1118 was hence noted to be between 6.4 and 6.6.



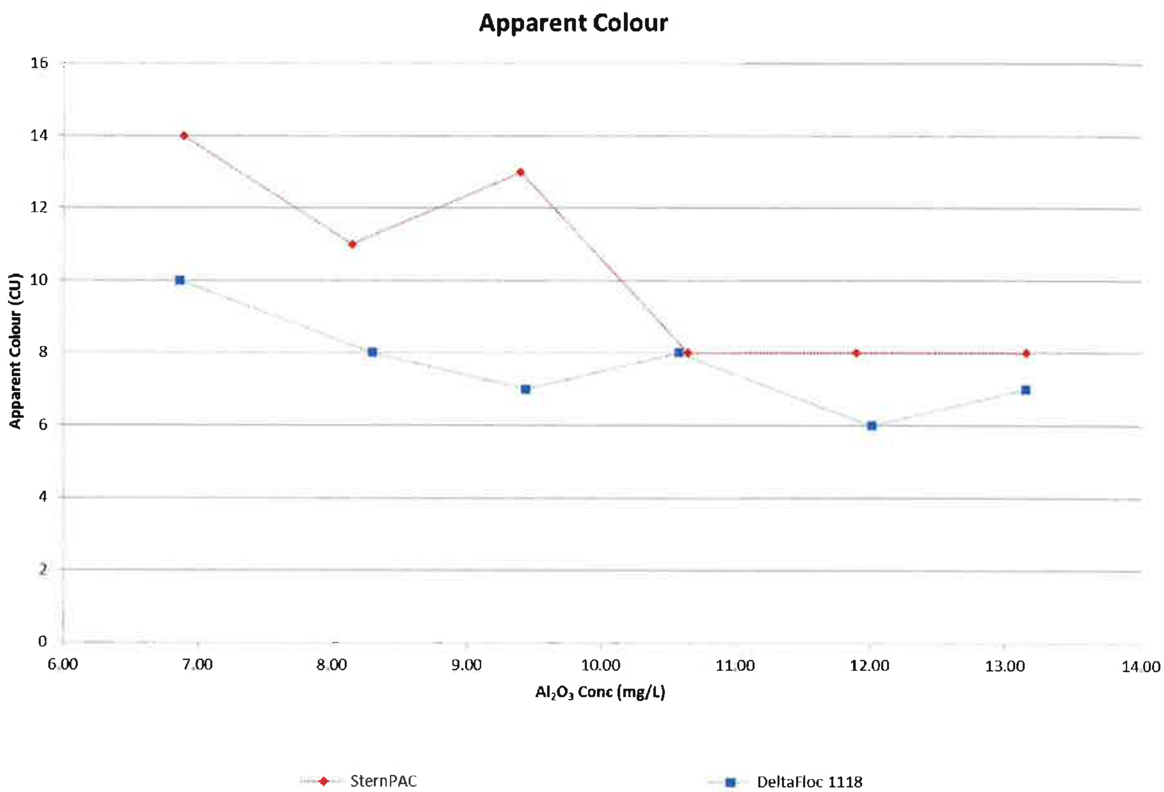
also has the benefit of providing a common baseline in terms of acid costs when comparing the two coagulants.

4.1.4 Optimal Coagulant Dose

4.1.4.1 Water Quality parameters

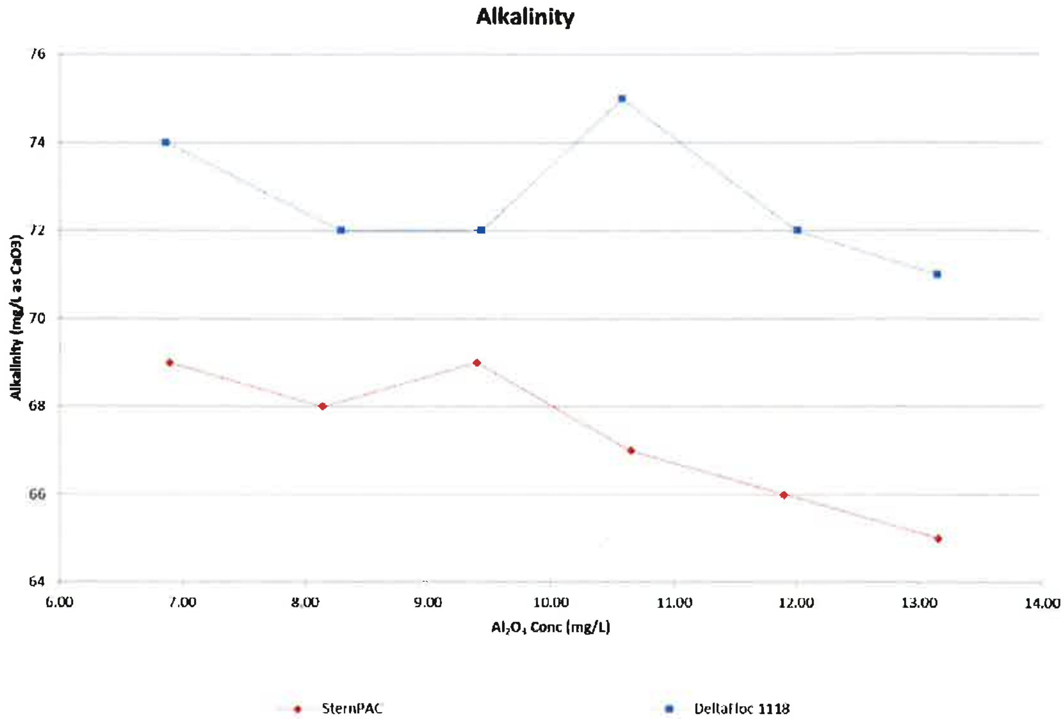
With the previously determined optimal microsand dose, optimal polymer dose and optimal pH, separate jar tests were carried out to determine the optimal coagulant doses for SternPAC and DeltaFloc-1118.

When the water quality parameters of turbidity, UVA, DOC and TOC were analyzed, the results for SternPAC and DeltaFloc-1118 did not exhibit significant differences. At doses above 8 mg/L of Al_2O_3, DeltaFloc-1118 was noted to yield lower TDS. Apparent colour on the other hand was always lower with DeltaFloc-1118 compared to SternPAC.



differences between the results of SternPAC and DeltaFloc-1118. The raw water alkalinity of 152 mg $CaCO_3$/L was depressed much more by SternPAC than by DeltaFloc-1118. Higher alkalinity means higher water stability suggesting more water stability with DeltaFloc-1118 than SternPAC.

Chloride was lower for DeltaFloc-1118, while sulphate was mainly higher. Water hardness and calcium were also lower when DeltaFloc-1118 was considered compared to SternPAC.



PAC and

Table 2 Corrosivity Indices for SternPAC and DeltaFloc-1118

	SternPAC (10 mg/L Al_2O_3)	DeltaFloc-1118 (12 mg/L Al_2O_3)	
CSMR	0.48	0.43	Higher CSMR: increase in galvanic corrosion of lead solder connected to copper pipe.
Langelier Saturation Index (LSI) Method 1	-1.39	-1.28	LSI < 0: water under saturated with calcium carbonate and will tend to be corrosive LSI > 0 water over saturated with calcium carbonate and will tend to deposit calcium carbonate forming scales If LSI close to zero, then water is just saturated with calcium carbonate and will neither be strongly corrosive nor scale forming.
Langelier Saturation Index (LSI) Method 2	-1.71	-1.60	
Ryznar Stability Index (RSI)	9.96	9.81	RSI < 6.5 the scale tendency increases as the index decreases. RSI > 7.0 under saturated

When CSMR was considered, SternPAC was noted to have a higher value indicating higher corrosivity towards lead solder when compared to DeltaFloc-1118.

The Langelier Saturation Index (LSI) for both SternPAC and DeltaFloc-1118 were less than 0 suggesting under saturation with calcium carbonate and corrosive water. Using both methods, the LSI of SternPAC was less than that of DeltaFloc-1118 indicating that DeltaFloc-1118 was less corrosive.

Similarly, the Ryznar Stability Index (RSI) for both coagulants were above 7 indicating under saturation. The SternPAC RSI was larger than the DeltaFloc-1118 RSI indicating the water was less saturated and hence more corrosive.

When all three indices are considered, the corrosivity tendency of DeltaFloc-1118 was noted to be similar to that of SternPAC i.e. both were noted to be under saturated with calcium carbonate and hence noted to be corrosive. When the magnitudes of corrosivity are considered however, DeltaFloc-1118 is noted to be slightly less corrosive than SternPAC. In light of these results, a switch to DeltaFloc-1118 from SternPAC is not expected to have an adverse impact on the distribution system in terms of corrosivity. Additional studies may be required to evaluate other impacts before making a switch.

4.1.4.3 Financial Analysis

The optimal dose determined for SternPAC and DeltaFloc-1118 were 85-88 mg/L (85 mg/L considered for the calculation) and 42 mg/L respectively. The City of Kawartha Lakes provided a current SternPAC cost of $0.47/liquid kg (one year term). The supplier of DeltaFloc-1118 provided a budgetary pricing of $0.994/liquid kg (assuming loads of 18,000 L).

Based on SCADA data provided by the City for 2016, the average SternPAC dose was 90 mg/L, and the estimated quantity of SternPAC required for 2017 as provided by the City was 504,360 kg. With the slightly lower optimal dose calculated of 85 mg/L the proposed consumption of SternPAC would actually be 476,340 kg, The proposed DeltaFloc-1118 consumption required at an optimal dose of 42 mg/L would hence be 235,368 kg. The calculated costs for each of the coagulants are presented in Table 3 below.

Table 3 Estimated Cost Comparison

Chemical	Supplier	Unit Price /kg	Proposed Consumption (kg)	Calculated Cost
SternPAC	Kemira	$0.47	476,340	$224,000
DeltaFloc-1118	Control Chem	$0.994	235,368	$234,000

Based on the amounts presented in Table 3, even though DeltaFloc-1118 has a higher unit price, since it contains a larger percentage of Al_2O_3, less is required compared to SternPAC. The total annual costs for SternPAC and DeltaFloc-1118 at their optimal doses are noted to be similar with values of $224,000 and $234,000 respectively.

5. Conclusion

Based on the results of the optimization jar tests, the microsand dose was lowered from the previously used amount of 20 g (10 g/L) to 15 g (7.5 g/L). The polymer dose was reduced slightly based on the optimization jar test from 0.35 mg/L to 0.3 mg/L. The optimal pH for both SternPAC and DeltaFloc-1118 were found to be between 6.4 and 6.6.

The findings from these optimization studies were used to provide the optimal conditions for the final jar tests in which SternPAC and DeltaFloc-1118 were tested to investigate the better cold water coagulant. Water quality results from this study indicated similar performance for the two coagulants. When corrosivity was considered, DeltaFloc-1118 was noted to be slightly less corrosive than SternPAC suggesting that a shift in coagulant would not adversely affect the distribution system. A financial analysis carried out for the supply of these two chemicals indicated similar costs, with an annual projected difference of only around $10,000.

In conclusion, from a water quality and financial standpoint, the use of DeltaFloc-1118 does not provide significant benefits over the current use of SternPAC. A change of coagulant would hence note be recommended at the current time.

Appendix 1

Actiflo® Laboratory Jar Test Procedure

N° method		Revision date
Reference	ACTIFLO LABORATORY JAR TEST PROCEDURE	2015-07-02

In order to simulate the ACTIFLO® process, a modified Jar test procedure was developed. The procedure can be used to find the adequate coagulant and polymer dosages to obtain a clarified water with a low turbidity. Furthermore, the modified jar test procedure has the capability of evaluating or predicting process performances of an existing ACTIFLO® unit and bring accurate diagnosis on operation troubleshooting.

The simulation method reproduces results that are very close to full-scale unit results. Such reproduction is achieved by simulating the same contact times in each basin and adding the chemicals and micro-sand along the same sequence used in the full-scale unit.

At the designed flow rate, the surface loading rate in a typical ACTIFLO® unit is 40 m/hr. This loading rate corresponds to hydraulic contact times of respectively 2, 2, 6 and 3 minutes in the coagulation, injection, maturation and settling tanks.

A. Material

- Jar test apparatus
- Raw water
- Circulating open bath for temperature control (optional).
- Square glass beakers or round beakers (1 Liter)
- Washed micro-sand
- Polymer
- Coagulant
- Acid or alkali, to adjust the pH (optional)
- Measurement apparatus (turbidimeter, spectrophotometer, etc.)
- Stopwatch

B. Chemicals Preparation

- Prepare the microsand dedicated to Jar-Test.

This microsand has to be already washed with distilled or tap water to remove sand dust causing turbidity. To prepare the microsand, follow the procedure below:

Rinse the new or used micro-sand thoroughly 10 times or until the supernatant is clear, in order to eliminate turbidity caused by micro-grains or any suspended particles that could be introduced into the water tested in the jar test. Dry in a 104°C oven overnight. Place in a identified microsand plastic jar.

- Prepare a polymer solution in the laboratory or use the polymer solution prepared for the full-scale unit in the WTP.

From dry polymer powder:

Prepare a 0.1% solution. Weight 0.1 g of dry polymer and slowly add in a 0.25L beaker filled with 0.1 L of distilled water. The beaker has to be mixed to avoid eye fish in the solution. Add the dry polymer weight into the vortex formed by mixing. Mix the solution for approximately 1 hour until complete dissolution of the polymer. 0.1 mL of this solution corresponds to 1 mg/L. 1mL of this prepared solution added in a 1000 L beaker corresponds to 1 mg/L of polymer dosage.

For better accuracy, it is recommended to dilute this solution prior injecting in the jar test beakers if the dosages to apply are less than 1 mg/L. Measure 10 mL of prepared polymer solution and complete at 100 mL with distilled water. 1mL of this diluted solution corresponds to 0.1 mg/L of polymer dosage.

Caution: the 0.1% solution is efficient for 1 day. The diluted polymer solution is efficient for approximately 1 hour. Prepare new diluted solution after 1hour use.

From polymer preparation tank:

For polymer at 1 g/L (0.1%), sample polymer from polymer metering pump or polymer preparation tank at the WTP.

Dilution to obtain a 0.1 g/L solution:

Concentration in the tank (g/L)	Dilution factor	Volume to add in the 100 ml cylinder (mL)
1.5	15	6.7
2.0	20	5
2.5	25	4
3.0	30	3.3

Fill the cylinder to 100 mL mark with distilled water and stir.

Caution: The polymer solution as prepared is efficient for approximately 1 hour. Prepare new dilution after 1 hour use.
Caution: Polymer solution is viscous and very slippery if dropped on the floor.

Polymer volume to inject for 1L water during the jar test is as follow:

Plant polymer diluted at 1.0 g/L (0.01%), for 1 L jar test.			
Dosage required (mg/L)	Total Volume (mL)	Polymer volume to add (mL)	
		1st injection	2nd injection
0.5	0.5	0.25	0.25
0.75	0.75	0.375	0.375
1.25	1.25	0.625	0.625
1.5	1.5	0.75	0.75
2.0	2.0	1.0	1.0
3.0	3.0	1.5	1.5

- Coagulant

Use coagulant from manufacturer bottle or sample coagulant metering pump skid in the WTP.

Caution: Dilution is not necessary if a micropipette is available (0-200 µL).
Caution: Change your tip or pipette between each jar tests series (risk of coagulant precipitation in the tip)
Caution: Never dilute PAC or PASS coagulants (risk of precipitation)

If no micropipette available, the following dilution

For organic coagulant, a dilution factor of 10 is recommended. Dilute 10 mL of neat coagulant into a 100 mL graduated cylinder using distilled water for dilution.

For inorganic coagulant, a dilution factor of 10 or 50 can be used.

The coagulant dosage may be expressed in different ways:

Volumetric dosage (µL /L)

mg/L of commercial product as sold = volume (µL /L) x specific gravity

mg/L of active ingredient = volume (µL /L) x specific gravity x concentration (%)

mg Fe or Al/L (recommended but not common)= volume (µL /L) x specific gravity x % Fe or Al

mg/L solid product (not recommended but very common in WTP) = volume (µL /L) x specific gravity x dry solids content (%)

To validate the calculation, please refer to the chemical technical specifications sheet.

C. Test Method

The optimal results will be achieved using the following jar test steps:

Step 1: Perform a series of jar test at fix coagulant dosage, fix polymer dosage and different pH (pH curve).

Step 2: Perform a series of jar tests at fix pH and using different coagulant dosages and fix polymer dosage (coagulant curve). You may review the pH curve at the optimal coagulant dosage found (optional).

Step 3: Perform a series of jar tests at different polymer dosage, with the optimal ph and coagulant found in the previous steps (polymer curve).

The Actiflo jar test method may be executed as follow:

Times given in the test method below are specific to a rise rate of 40 m/h.

Set the circulating bath to desired temperature (optional).

Measure the raw water parameters (pH, alkalinity, true and apparent colour, turbidity, UV absorbance, temperature). Measure parameters according to protocol and test objectives.

Fill up the 1-Liter beakers with raw water.

Set the beakers on the bench.

Make sure raw water temperature corresponds with the desired temperature (optional).

Set the paddle between 0.5 and 1.0 cm from the bottom of the beaker.

Start mixing and adjust speed at 150 RPM.

Add the acid or the alkali to adjust the pH (optional).

Add the coagulant (see timeline below).

Start the stopwatch or the sequential run in the Jar tester.

Two minutes after adding coagulant, add micro-sand (8-10 g/L of water) and 50% of the polymer dosage.

Two minutes (cationic polymer) or 5 minutes (anionic polymer) after adding the micro-sand and first polymer dosage, inject the remaining 50 % polymer dosage.

After a supplementary maturation contact time of 6 minutes (cationic polymer) or 3 minutes (anionic polymer), stop stirring and allow the water to settle for the next 3 minutes.

Use a 25-100 mL syringe, pipet or a pipe under vacuum to collect the supernatant (NOT collect the surface, due to microsand and microflocs that may float). Sample the clarified water.

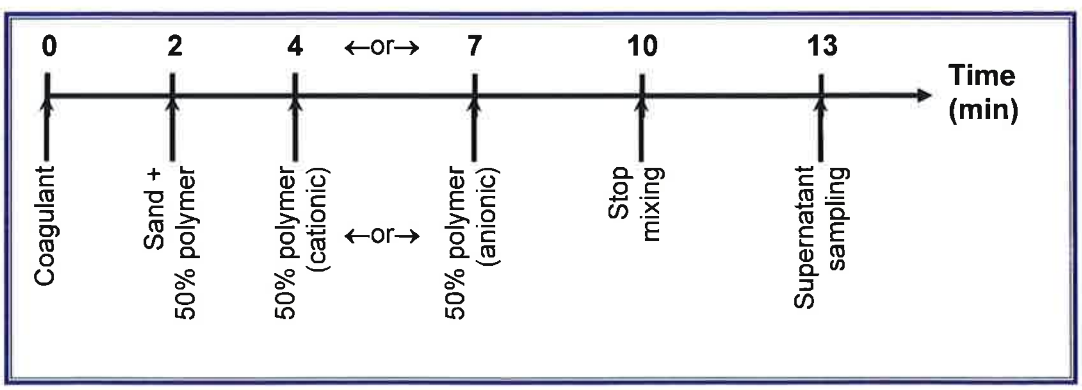
Measure the clarified water parameters important for the test objectives.

Note all the results and parameters on the ACTIFLO® jar test log sheet.

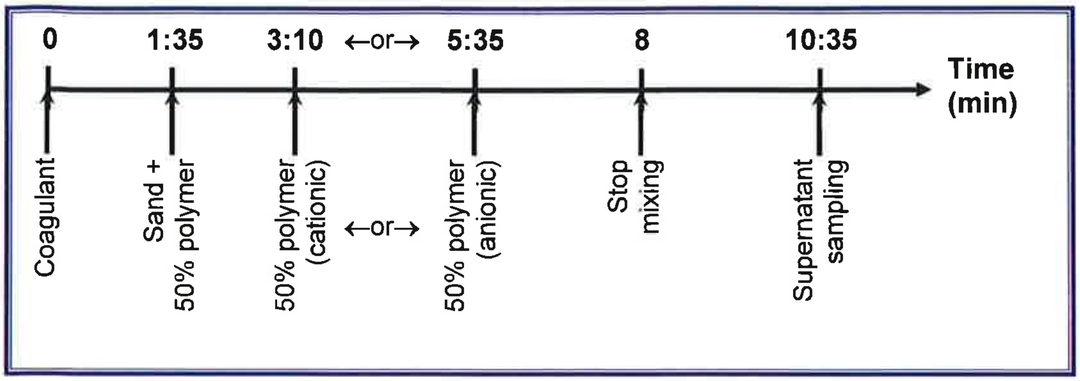
TIMELINE FOR SELECTED RISE RATES

20 m/h: twice the time for 40 m/h

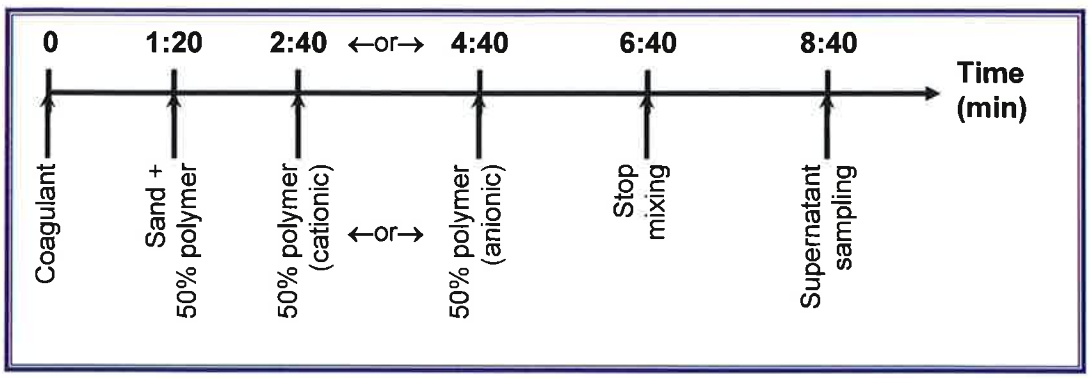
40 m/h



50 m/h



60 m/h



80 m/h: half the time for 40 m/h

C. Waste

Do not throw the sand in the wash bin. Collect sand and discard as stated by site regulation.

Date de révision : 2015-07-02
Révisé par : CDM
Approuvé par : SV

Appendix 2

SGS Lab results

SGS
SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Works #: 220000175-NR

24-February-2017

City of Kawartha Lakes (Lindsay DWS)
Attn : Amber Hayter

12 Peel Street
Lindsay, ON
K9V 3L8, Canada

Phone: 705-324-9411 Ext 1120
Fax:705-328-3054

Date Rec. : 22 February 2017
LR Report: **CA14374-FEB17**

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	7: AO/OG	8: MDL	9: NR OP-M J1	10: NR OP-M J2	11: NR OP-M J3	12: NR OP-M J4	13: NR OP-M J5	14: NR OP-M J6
Sample Date & Time							21-Feb-17 14:00	21-Feb-17 14:00	21-Feb-17 14:00	21-Feb-17 14:00	21-Feb-17 14:00	21-Feb-17 14:00
Temperature Upon Receipt [°C]	---	---	--	--	--	---	5.0	5.0	5.0	5.0	5.0	5.0
Alkalinity [mg/L as CaCO3]	22-Feb-17	11:43	23-Feb-17	14:23	30-500	2	139	143	144	143	140	142
Colour [TCU]	22-Feb-17	10:10	22-Feb-17	16:03	5	3	4	4	4	4	4	4
Apparent Colour [CU]	22-Feb-17	10:10	22-Feb-17	16:03		3	12	15	15	13	10	14
Total Dissolved Solids [mg/L]	22-Feb-17	15:27	24-Feb-17	10:44	500	30	311	303	311	337	306	309
Chloride [mg/L]	23-Feb-17	17:34	24-Feb-17	12:22	250	0.04	53	54	53	54	56	56
Sulphate [mg/L]	23-Feb-17	17:34	24-Feb-17	12:22	500	0.04	19	19	20	20	19	19
Hardness [mg/L as CaCO3]	23-Feb-17	10:55	24-Feb-17	11:21	80-100	0.05	188	193	188	189	191	190
Aluminum [ug/L]	23-Feb-17	10:55	24-Feb-17	11:21	100	0.3	240	155	281	180	149	143
Calcium [mg/L]	23-Feb-17	10:55	24-Feb-17	11:21	---	0.01	58.8	60.5	57.9	58.5	59.2	58.4
Dissolved Organic Carbon [mg/L]	23-Feb-17	19:00	24-Feb-17	13:25	5	1	6	6	7	6	6	6
Total Organic Carbon [mg/L]	23-Feb-17	19:00	24-Feb-17	13:25		1	6	7	8	7	7	6

AO/OG - Aesthetic Objective / Operational Guideline
MDL - SGS Method Detection Limit

NR - Not regulated / reportable under applicable Provincial drinking water regulations as per client.

OnLine LIMS

000922542

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Works #: 220000175-NR

LR Report : **CA14374-FEB17**

Patti Stark
Project Specialist Environmental Services, Analytical

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Works #: 220000175-NR

24-February-2017

City of Kawartha Lakes (Lindsay DWS)
Attn : Amber Hayter

12 Peel Street
Lindsay, ON
K9V 3L8, Canada

Phone: 705-324-9411 Ext 1120
Fax:705-328-3054

Date Rec. : 22 February 2017
LR Report: **CA14375-FEB17**

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Temperature Upon Receipt °C	Alkalinity mg/L as CaCO3	Colour TCU	Apparent Colour CU	Total Dissolved Solids mg/L	Chloride mg/L	Sulphate mg/L	Hardness mg/L as CaCO3	Aluminum ug/L	Calcium mg/L	Dissolved Organic Carbon mg/L	Total Organic Carbon mg/L
1: Analysis Start Date		---	22-Feb-17	22-Feb-17	22-Feb-17	22-Feb-17	23-Feb-17	23-Feb-17	23-Feb-17	23-Feb-17	23-Feb-17	23-Feb-17	23-Feb-17
2: Analysis Start Time		---	11:43	10:10	10:10	15:27	17:34	17:34	10:55	10:55	10:55	19:00	19:00
3: Analysis Approval Date		---	23-Feb-17	22-Feb-17	22-Feb-17	24-Feb-17	24-Feb-17	24-Feb-17	24-Feb-17	24-Feb-17	24-Feb-17	24-Feb-17	24-Feb-17
4: Analysis Approval Time		---	14:36	16:04	16:04	10:44	10:08	10:08	11:21	11:21	11:21	13:25	13:25
7: AO/OG		---	30-500	5		500	250	500	80-100	100	---	5	---
8: MDL		---	2	3	3	30	0.04	0.04	0.05	0.3	0.01	1	1
9: NR OP-P J1	21-Feb-17 12:00	5.0	137	4	11	340	56	19	184	231	56.8	6	7
10: NR OP-P J2	21-Feb-17 12:00	5.0	149	6	12	291	57	19	189	179	58.8	6	6
11: NR OP-P J3	21-Feb-17 12:00	5.0	140	4	11	314	55	20	189	173	58.3	6	6
12: NR OP-P J4	21-Feb-17 12:00	5.0	137	3	12	317	53	19	187	152	58.0	6	7
13: NR OP-P J5	21-Feb-17 12:00	5.0	141	4	11	326	58	19	194	139	60.2	6	6
14: NR OP-P J6	21-Feb-17 12:00	5.0	141	4	14	317	58	19	188	247	58.1	6	6
15: Raw Water	21-Feb-17 12:00	5.0	152	11	25	326	48	18	189	13.1	58.9	8	9

AO/OG - Aesthetic Objective / Operational Guideline
MDL - SGS Method Detection Limit

NR - Not regulated / reportable under applicable Provincial drinking water regulations as per client.

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Works #: 220000175-NR

LR Report : **CA14375-FEB17**

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OnLine LIMS

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Works #: 220000175

07-March-2017

City of Kawartha Lakes (Lindsay DWS)
Attn : Amber Hayter

12 Peel Street
Lindsay, ON
K9V 3L8, Canada

Phone: 705-324-9411 Ext 1120
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Date Rec. : 02 March 2017
LR Report: **CA16113-MAR17**

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Sample ID	Sample Date & Time	Temperature Upon Receipt °C	Alkalinity mg/L as CaCO3	Colour TCU	Apparent Colour CU	Total Dissolved Solids mg/L	Chloride mg/L	Sulphate mg/L	Hardness mg/L as CaCO3	Aluminum ug/L	Calcium mg/L	Dissolved Organic Carbon mg/L	Total Organic Carbon mg/L
1: Analysis Start Date		---	02-Mar-17	02-Mar-17	02-Mar-17	02-Mar-17	02-Mar-17	02-Mar-17	03-Mar-17	03-Mar-17	03-Mar-17	03-Mar-17	03-Mar-17
2: Analysis Start Time		---	13:57	12:55	12:06	15:23	04:30	04:30	14:56	14:56	14:56	07:20	07:20
3: Analysis Approval Date		---	03-Mar-17	02-Mar-17	02-Mar-17	03-Mar-17	03-Mar-17	03-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	03-Mar-17	03-Mar-17
4: Analysis Approval Time		---	11:11	15:31	15:59	14:33	13:47	13:47	16:37	16:37	16:37	15:22	15:22
5: MAC		---	---	---		---	---	---	---	---	---	---	
6: Half MAC		---	---	---		---	---	---	---	---	---	---	
7: AO/OG		---	30-500	5		500	250	500	80-100	100	---	5	
8: MDL		---	2	3	3	30	0.04	0.04	0.05	0.3	0.01	1	1
9: RW DF-PH-1	01-Mar-17 02:45	6.0	127	10	32	266	27	44	202	1020	70.1	6	5
10: RW DF-PH-2	01-Mar-17 02:45	6.0	118	10	28	271	27	44	201	1440	69.4	6	5
11: RW DF-PH-3	01-Mar-17 02:45	6.0	102	10	46	263	27	60	203	1580	70.2	5	5
12: RW DF-PH-4	01-Mar-17 02:45	6.0	87	9	18	277	27	77	204	898	71.0	5	5
13: RW DF-PH-5	01-Mar-17 02:45	6.0	71	9	28	286	27	92	200	783	69.9	4	5
14: RW DF-PH-6	01-Mar-17 02:45	6.0	57	9	33	286	27	100	199	1090	69.0	5	5
15: RW Raw Water	01-Mar-17 02:45	6.0	132	33	53	254	24	29	204	68.4	71.1	8	8

MAC - Maximum Acceptable Concentration
AO/OG - Aesthetic Objective / Operational Guideline
MDL - SGS Method Detection Limit

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Works #: 220000175

LR Report : **CA16113-MAR17**

Method Descriptions

Units	Description	SGS Method Code
mg/L as CaCO3	Alkalinity by Titration	ME-CA-[ENV]EWL-LAK-AN-006
ug/L	Aluminum by ICP-MS Drinking Water	ME-CA-[ENV]SPE-LAK-AN-006
CU	Apparent Colour by colourmetric method	ME-CA-[ENV]EWL-LAK-AN-002
mg/L	Calcium by ICP-MS drinking water	ME-CA-[ENV]SPE-LAK-AN-006
mg/L	Chloride by Dionex - solution	ME-CA-[ENV]IC-LAK-AN-001
TCU	True Colour by colourmetric method	ME-CA-[ENV]EWL-LAK-AN-002
mg/L	DOC by Skalar	ME-CA-[ENV]SFA-LAK-AN-009
mg/L as CaCO3	Hardness (CaCO3) by ICP	ME-CA-[ENV]SPE-LAK-AN-003
mg/L	Sulphate by Dionex - solution	ME-CA-[ENV]IC-LAK-AN-001
mg/L	Total Dissolved Solids by Gravimetric	ME-CA-[ENV]EWL-LAK-AN-005
mg/L	TOC by Skalar	ME-CA-[ENV]SFA-LAK-AN-009

Patti Stark
Project Specialist Environmental Services, Analytical

OnLine LIMS

0000930594

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Works #: 220000175

09-March-2017

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Date Rec. : 02 March 2017
LR Report: **CA16114-MAR17**

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CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	7: AO/OG	8: MDL	9: RW SP-PH-1	10: RW SP-PH-2	11: RW SP-PH-3	12: RW SP-PH-4	13: RW SP-PH-5	14: RW SP-PH-6
Sample Date & Time							01-Mar-17 14:30	01-Mar-17 14:30	01-Mar-17 14:30	01-Mar-17 14:30	01-Mar-17 14:30	01-Mar-17 14:30
Temperature Upon Receipt [°C]	---	---	---	---	---	---	6.0	6.0	6.0	6.0	6.0	6.0
Alkalinity [mg/L as CaCO3]	02-Mar-17	11:56	03-Mar-17	11:36	30-500	2	133	114	99	87	71	53
Colour [TCU]	02-Mar-17	12:55	02-Mar-17	15:31	5	3	11	11	10	10	9	8
Apparent Colour [CU]	02-Mar-17	12:06	02-Mar-17	15:59		3	16	20	17	15	14	13
Total Dissolved Solids [mg/L]	02-Mar-17	15:23	03-Mar-17	14:33	500	30	269	263	271	271	274	274
Chloride [mg/L]	02-Mar-17	05:00	07-Mar-17	14:43	250	0.04	31	31	31	31	31	31
Sulphate [mg/L]	02-Mar-17	05:00	07-Mar-17	14:43	500	0.04	31	45	58	72	87	110
Hardness [mg/L as CaCO3]	03-Mar-17	14:56	06-Mar-17	16:38	80-100	0.05	211	202	200	198	210	205
Aluminum [ug/L]	03-Mar-17	14:56	06-Mar-17	16:38	100	0.3	337	714	360	325	580	356
Calcium [mg/L]	03-Mar-17	14:56	06-Mar-17	16:38	---	0.01	73.4	69.8	69.6	68.4	72.6	71.0
Dissolved Organic Carbon [mg/L]	03-Mar-17	07:20	03-Mar-17	15:22	5	1	5	5	4	4	4	4
Total Organic Carbon [mg/L]	03-Mar-17	07:20	03-Mar-17	15:22	---	1	5	5	5	5	4	4

AO/OG - Aesthetic Objective / Operational Guideline
MDL - SGS Method Detection Limit

Method Descriptions

Units	Description	SGS Method Code
mg/L as CaCO3	Alkalinity by Titration	ME-CA-[ENV]EWL-LAK-AN-006
ug/L	Aluminum by ICP-MS Drinking Water	ME-CA-[ENV]SPE-LAK-AN-006
CU	Apparent Colour by colourmetric method	ME-CA-[ENV]EWL-LAK-AN-002

OnLine LIMS

0000931887

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Works #: 220000175

LR Report : **CA16114-MAR17**

Units	Description	SGS Method Code
mg/L	Calcium by ICP-MS drinking water	ME-CA-[ENV]SPE-LAK-AN-006
mg/L	Chloride by Dionex - solution	ME-CA-[ENV]IC-LAK-AN-001
TCU	True Colour by colourmetric method	ME-CA-[ENV]EWL-LAK-AN-002
mg/L	DOC by Skalar	ME-CA-[ENV]SFA-LAK-AN-009
mg/L as CaCO3	Hardness (CaCO3) by ICP	ME-CA-[ENV]SPE-LAK-AN-003
mg/L	Sulphate by Dionex - solution	ME-CA-[ENV]IC-LAK-AN-001
mg/L	Total Dissolved Solids by Gravimetric	ME-CA-[ENV]EWL-LAK-AN-005
mg/L	TOC by Skalar	ME-CA-[ENV]SFA-LAK-AN-009

Kimberley Didsbury
Project Specialist
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Works #: 220000175

23-March-2017

City of Kawartha Lakes (Lindsay DWS)
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Date Rec. : 14 March 2017
LR Report: **CA18131-MAR17**

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	7: AO/OG	8: MDL	9: RW Raw Water	10: RW OP-SPD-1	11: RW OP-SPD-2	12: RW OP-SPD-3	13: RW OP-SPD-4	14: RW OP-SPD-5	15: RW OP-SPD-6
Sample Date & Time							13-Mar-17 12:00	13-Mar-17 12:00	13-Mar-17 12:00	13-Mar-17 12:00	13-Mar-17 12:00	13-Mar-17 12:00	13-Mar-17 12:00
Temperature Upon Receipt [°C]	---	---	---	---	---	---	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Alkalinity [mg/L as CaCO3]	15-Mar-17	08:02	16-Mar-17	16:03	30-500	2	152	69	68	69	67	66	65
Colour [TCU]	15-Mar-17	08:51	15-Mar-17	14:25	5	3	18	7	6	6	5	5	5
Apparent Colour [CU]	15-Mar-17	08:51	15-Mar-17	14:25		3	60	14	11	13	8	8	8
Total Dissolved Solids [mg/L]	14-Mar-17	17:53	15-Mar-17	16:10	500	30	263	277	294	306	300	294	297
Chloride [mg/L]	16-Mar-17	18:59	21-Mar-17	16:03	250	0.04	33	38	39	40	41	42	42
Sulphate [mg/L]	16-Mar-17	18:59	21-Mar-17	16:03	500	0.04	19	86	89	89	86	85	86
Hardness [mg/L as CaCO3]	15-Mar-17	14:34	17-Mar-17	08:52	80-100	0.05	192	193	195	196	202	195	198
Aluminum [ug/L]	15-Mar-17	14:34	17-Mar-17	08:52	100	0.3	163	338	197	185	173	138	157
Calcium [mg/L]	15-Mar-17	14:34	17-Mar-17	08:52	---	0.01	64.6	64.7	65.2	65.6	67.5	65.1	65.9
Dissolved Organic Carbon [mg/L]	15-Mar-17	06:45	15-Mar-17	13:29	5	1	7	6	5	4	4	4	4
Total Organic Carbon [mg/L]	15-Mar-17	06:45	15-Mar-17	13:29		1	8	6	5	5	5	4	4

AO/OG - Aesthetic Objective / Operational Guideline
MDL - SGS Method Detection Limit

OnLine LIMS

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Works #: 220000175

LR Report : **CA18131-MAR17**

Method Descriptions

Units	Description	SGS Method Code
mg/L as CaCO3	Alkalinity by Titration	ME-CA-[ENV]EWL-LAK-AN-006
ug/L	Aluminum by ICP-MS Drinking Water	ME-CA-[ENV]SPE-LAK-AN-006
CU	Apparent Colour by colourmetric method	ME-CA-[ENV]EWL-LAK-AN-002
mg/L	Calcium by ICP-MS drinking water	ME-CA-[ENV]SPE-LAK-AN-006
mg/L	Chloride by Dionex - solution	ME-CA-[ENV]IC-LAK-AN-001
TCU	True Colour by colourmetric method	ME-CA-[ENV]EWL-LAK-AN-002
mg/L	DOC by Skalar	ME-CA-[ENV]SFA-LAK-AN-009
mg/L as CaCO3	Hardness (CaCO3) by ICP	ME-CA-[ENV]SPE-LAK-AN-003
mg/L	Sulphate by Dionex - solution	ME-CA-[ENV]IC-LAK-AN-001
mg/L	Total Dissolved Solids by Gravimetric	ME-CA-[ENV]EWL-LAK-AN-005
mg/L	TOC by Skalar	ME-CA-[ENV]SFA-LAK-AN-009

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Works #: 220000175

20-March-2017

City of Kawartha Lakes (Lindsay DWS)
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Date Rec. : 14 March 2017
LR Report: **CA18134-MAR17**

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MAC	7: AO/OG	8: MDL	9: RW OP-DFD-1	10: RW OP-DFD-2	11: RW OP-DFD-3	12: RW OP-DFD-4	13: RW OP-DFD-5	14: RW OP-DFD-6
Sample Date & Time								13-Mar-17 14:00	13-Mar-17 14:00	13-Mar-17 14:00	13-Mar-17 14:00	13-Mar-17 14:00	13-Mar-17 14:00
Temperature Upon Receipt [°C]	---	---	--	--	--	--	---	6.0	6.0	6.0	6.0	6.0	6.0
Alkalinity [mg/L as CaCO3]	15-Mar-17	08:02	16-Mar-17	16:03	--	30-500	2	74	72	72	75	72	71
Colour [TCU]	15-Mar-17	08:51	15-Mar-17	14:25	--	5	3	7	5	5	6	5	5
Apparent Colour [CU]	15-Mar-17	08:51	15-Mar-17	14:25			3	10	8	7	8	6	7
Total Dissolved Solids [mg/L]	14-Mar-17	17:53	15-Mar-17	16:10	--	500	30	294	297	294	289	280	294
Chloride [mg/L]	16-Mar-17	18:59	20-Mar-17	08:50	--	250	0.04	35	35	36	36	37	37
Sulphate [mg/L]	16-Mar-17	18:59	20-Mar-17	08:50	--	500	0.04	87	88	88	88	87	87
Hardness [mg/L as CaCO3]	15-Mar-17	14:34	17-Mar-17	08:52	--	80-100	0.05	192	194	194	197	196	195
Aluminum [ug/L]	15-Mar-17	14:34	17-Mar-17	08:52	--	100	0.3	232	131	104	157	133	146
Calcium [mg/L]	15-Mar-17	14:34	17-Mar-17	08:52	---	---	0.01	63.6	64.7	64.9	65.8	65.0	64.9
Dissolved Organic Carbon [mg/L]	15-Mar-17	06:45	15-Mar-17	13:30	--	5	1	5	5	4	4	4	4
Total Organic Carbon [mg/L]	15-Mar-17	06:45	15-Mar-17	13:30			1	6	5	4	5	4	4

MAC - Maximum Acceptable Concentration
AO/OG - Aesthetic Objective / Operational Guideline
MDL - SGS Method Detection Limit

OnLine LIMS

000941926

SGS

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Works #: 220000175

LR Report : **CA18134-MAR17**

Method Descriptions

Units	Description	SGS Method Code	Reference Method Code
mg/L as CaCO3	Alkalinity by Titration	ME-CA-[ENV]EWL-LAK-AN-006	SM 2320
ug/L	Aluminum by ICP-MS Drinking Water	ME-CA-[ENV]SPE-LAK-AN-006	SM 3030/EPA 200.8
CU	Apparent Colour by colourmetric method	ME-CA-[ENV]EWL-LAK-AN-002	SM 2120
mg/L	Calcium by ICP-MS drinking water	ME-CA-[ENV]SPE-LAK-AN-006	SM 3030/EPA 200.8
mg/L	Chloride by Dionex - solution	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
TCU	True Colour by colourmetric method	ME-CA-[ENV]EWL-LAK-AN-002	SM 2120
mg/L	DOC by Skalar	ME-CA-[ENV]SFA-LAK-AN-009	SM 5310
mg/L as CaCO3	Hardness (CaCO3) by ICP	ME-CA-[ENV]SPE-LAK-AN-003	SM 3030/EPA 200.8
mg/L	Sulphate by Dionex - solution	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
mg/L	Total Dissolved Solids by Gravimetric	ME-CA-[ENV]EWL-LAK-AN-005	SM 2540C
mg/L	TOC by Skalar	ME-CA-[ENV]SFA-LAK-AN-009	SM 5310

P. Stark

Patti Stark
Project Specialist Environmental Services, Analytical

OnLine LIMS

0000941926

Appendix 3

WSP Result Data Sheets

161-05613-00 Coagulant Testing for Lindsay Water Treatment Plant

WSP

Jar Test Data Sheet		Source Water:		
Date:	2/21/2017	pH		7.59
Time:	12:00 PM	(°C)	(°C)	4.1
Performed By:	Mazahir Alidina	Turbidity (NTU)	(NTU)	0.855
Coagulant Type:	**SternPAC**	UVA		0.181
		Alkalinity as CaCO3 (mg/L)	mg/L	152
OPTIMIZE MICROSAND DOSE		Colour (TCU)	mg/L	11
Coagulant Dosage:	80 mg/L	Apparent Colour (CU)	(mg CaCO3/L)	25
Coagulant Aid Type:	Cationic Polmer	Tottal Dissolved Solids (TDS)		326
Coagulant Aid Dosage (mg/L)	0.35	Chloride		48
Coagulant Aid Conc.:	0.30%	Sulphate		18
Microsand Dose:		Hardness as CaCO3 (mg/L)	mg/L	189
Specific Gravity	1.205	Aluminum (ug/L)	mg/L as CaCO3	13.1
Conc. Of Alum (Al_2O_3) (%)	10.40	Calcium (mg/L)	ug/L	58.9
		Dissolved Organic Carbon (mg/L)		8
		Total Organic Carbon (mg/L)		9

JAR NUMBER	OP-M1	OP-M2	OP-M3	OP-M4	OP-M5	OP-M6
DOSAGES						
Raw Water Volume (mL)	2000	2000	2000	2000	2000	2000
Coagulant Dose (mg/L)	85	85	85	85	85	85
Al_2O_3 Conc. (mg/L)	10.65	10.65	10.65	10.65	10.65	10.65
Volume of 1:10 diluted Coagulant added (mL)	1.411	1.411	1.411	1.411	1.411	1.411
Microsand added (g)	10	15	20	25	30	35
Coagulant-Aid Dose (mg/L)	0.35	0.35	0.35	0.35	0.35	0.35
Initial Volume of 1:10 diluted Polymer added with microsand (mL)	1.167	1.167	1.167	1.167	1.167	1.167
Remaining Volume of 1:10 diluted Polymer added (mL)	1.167	1.167	1.167	1.167	1.167	1.167
FLOCCULATION (0 - 2:40 mins)						
Duration (min)	2:40	2:40	2:40	2:40	2:40	2:40
Speed (rpm)	150	150	150	150	150	150
MATURATION (2:40 - 13:20 mins)						
Duration (min)	10:40	10:40	10:40	10:40	10:40	10:40
Speed (rpm)	150	150	150	150	150	150
SETTLING (13:20 - 17:20 mins)						
Duration (min)	4:00	4:00	4:00	4:00	4:00	4:00
Speed (rpm)	0	0	0	0	0	0
FINAL RESULTS						
pH	7.70	7.61	7.59	7.52	7.48	7.34
Temperature (°C)	6.90	7.00	7.00	7.00	7.00	7.00
Turbidity (NTU)	0.369	0.339	0.424	0.315	0.310	0.364
UVA	0.113	0.107	0.112	0.109	0.109	0.106
Alkalinity as CaCO3 (mg/L)	139	143	144	143	140	142
Colour (TCU)	4	4	4	4	4	4
Apparent Colour (CU)	12	15	15	13	10	14
Tottal Dissolved Solids (TDS)	311	303	311	337	306	309
Chloride	53	54	53	54	56	56
Sulphate	19	19	20	20	19	19
Hardness as CaCO3 (mg/L)	188	193	188	189	191	190
Aluminum (ug/L)	240	155	281	180	149	143
Calcium (mg/L)	58.8	60.5	57.9	58.5	59.2	58.4
Dissolved Organic Carbon (mg/L)	6	6	7	6	6	6
Total Organic Carbon (mg/L)	6	7	8	7	7	6

161-05613-00 Coagulant Testing for Lindsay Water Treatment Plant

WSP

Jar Test Data Sheet		Source Water:		
Date:	2/21/2017	pH		7.59
Time:	2:00 PM	(°C)	(°C)	4.1
Performed By:	Mazahir Alidina	Turbidity (NTU)	(NTU)	0.855
Coagulant Type:	**SternPAC**	UVA		0.181
		Alkalinity as CaCO3 (mg/L)	mg/L	152
OPTIMIZE POLYMER DOSE		Colour (TCU)	mg/L	11
Coagulant Dosage:	80 mg/L	Apparent Colour (CU)	(mg CaCO3/L)	25
Coagulant Aid Type:	Cationic Polmer	Tottal Dissolved Solids (TDS)		326
Coagulant Aid Dosage (mg/L)	0.2-.06	Chloride		48
Coagulant Aid Conc.:	0.30%	Sulphate		18
Microsand Dose:	20 g	Hardness as CaCO3 (mg/L)	mg/L	189
Specific Gravity	1.205	Aluminum (ug/L)	mg/L as CaCO3	13.1
Conc. Of Alum (Al_2O_3) (%)	10.40	Calcium (mg/L)	ug/L	58.9
		Dissolved Organic Carbon (mg/L)		8
		Total Organic Carbon (mg/L)		9

JAR NUMBER	OP-P1	OP-P2	OP-P3	OP-P4	OP-P5	OP-P6
DOSAGES						
Raw Water Volume (mL)	2000	2000	2000	2000	2000	2000
Coagulant Dose (mg/L)	85	85	85	85	85	85
Al_2O_3 Conc. (mg/L)	10.65	10.65	10.65	10.65	10.65	10.65
Volume of 1:10 diluted Coagulant added (mL)	0.913	1.079	1.245	1.411	1.577	1.743
Microsand added (g)	20	20	20	20	20	20
Coagulant-Aid Dose (mg/L)	0.2	0.3	0.4	0.5	0.6	0.7
Initial Volume of 1:10 diluted Polymer added with microsand (mL)	0.667	1.000	1.333	1.667	2.000	2.333
Remaining Volume of 1:10 diluted Polymer added (mL)	0.667	1.000	1.333	1.667	2.000	2.333
FLOCCULATION (0 - 2:40 mins)						
Duration (min)	2:40	2:40	2:40	2:40	2:40	2:40
Speed (rpm)	150	150	150	150	150	150
MATURATION (2:40 - 13:20 mins)						
Duration (min)	10:40	10:40	10:40	10:40	10:40	10:40
Speed (rpm)	150	150	150	150	150	150
SETTLING (13:20 - 17:20 mins)						
Duration (min)	4:00	4:00	4:00	4:00	4:00	4:00
Speed (rpm)	0	0	0	0	0	0
FINAL RESULTS						
pH	7.46	7.37	7.34	7.34	7.27	7.23
Temperature (°C)	7.3	8	8.5	9	9	9
Turbidity (NTU)	0.775	0.4	0.46	0.49	0.57	0.67
UVA	0.107	0.109	0.108	0.107	0.107	0.109
Alkalinity as CaCO3 (mg/L)	137	149	140	137	141	141
Colour (TCU)	4	6	4	3	4	4
Apparent Colour (CU)	11	12	11	12	11	14
Tottal Dissolved Solids (TDS)	340	291	314	317	326	317
Chloride	56	57	55	53	58	58
Sulphate	19	19	20	19	19	19
Hardness as CaCO3 (mg/L)	184	189	189	187	194	188
Aluminum (ug/L)	231	179	173	152	139	247
Calcium (mg/L)	56.8	58.8	58.3	58	60.2	58.1
Dissolved Organic Carbon (mg/L)	6	6	6	6	6	6
Total Organic Carbon (mg/L)	7	6	6	7	6	6

161-05613-00 Coagulant Testing for Lindsay Water Treatment Plant

WSP

Jar Test Data Sheet		Source Water:		
Date:	3/1/2017	pH		7.63
Time:	11:00 AM	(°C)	(°C)	5
Performed By:	Mazahir Alidina	Turbidity (NTU)	(NTU)	2.45
Coagulant Type:	**SternPAC**	UVA		0.314
		Alkalinity as CaCO3 (mg/L)	mg/L	
OPTIMIZE pH		Colour (TCU)	mg/L	
Coagulant Dosage:	55 to 105 mg/L	Apparent Colour (CU)	(mg CaCO3/L)	
Coagulant Aid Type:	Cationic Polmer	Toltal Dissolved Solids (TDS)		
Coagulant Aid Dosage:	0.3 mg/L	Chloride		
Coagulant Aid Conc.:	0.30%	Sulphate		
Microsand Dose:	15 g	Hardness as CaCO3 (mg/L)	mg/L	
Specific Gravity	1.205	Aluminum (ug/L)	mg/L as CaCO3	
Conc. Of Alum (Al_2O_3) (%)	10.40	Calcium (mg/L)	ug/L	
		Dissolved Organic Carbon (mg/L)		
		Total Organic Carbon (mg/L)		

JAR NUMBER	T1	T2	T3	T4	T5	T6
DOSAGES						
Raw Water Volume (mL)	2000	2000	2000	2000	2000	2000
Acid/Base addition	0	0.3	0.6	0.9	1.2	1.5
Coagulant Dose (mg/L)	85	85	85	85	85	85
Al_2O_3 Conc. (mg/L)	10.65	10.65	10.65	10.65	10.65	10.65
Volume of 1:10 diluted Coagulant added (mL)	1.411	1.411	1.411	1.411	1.411	1.411
Microsand added (g)	15	15	15	15	15	
Coagulant-Aid Dose (mg/L)	0.3	0.3	0.3	0.3	0.3	0.3
Initial Volume of 1:10 diluted Polymer added with microsand (mL)	1.000	1.000	1.000	1.000	1.000	1.000
Remaining Volume of 1:10 diluted Polymer added (mL)	1.000	1.000	1.000	1.000	1.000	1.000
FLOCCULATION (0 - 2:40 mins)						
Duration (min)	2:40	2:40	2:40	2:40	2:40	2:40
Speed (rpm)	150	150	150	150	150	150
MATURATION (2:40 - 13:20 mins)						
Duration (min)	10:40	10:40	10:40	10:40	10:40	10:40
Speed (rpm)	150	150	150	150	150	150
SETTLING (13:20 - 17:20 mins)						
Duration (min)	4:00	4:00	4:00	4:00	4:00	4:00
Speed (rpm)	0	0	0	0	0	0
FINAL RESULTS						
Initial pH	7.63	7.16	6.93	6.73	6.54	6.28
Final pH	7.35	7.13	6.88	6.73	6.6	6.25
Temperature (°C)	6	6	6	6	6	6
Turbidity (NTU)	0.657	0.831	0.748	0.723	0.837	0.663
UVA	0.159	0.161	0.157	0.146	0.141	0.13
Alkalinity as CaCO3 (mg/L)	133	114	99	87	71	53
Colour (TCU)	11	11	10	10	9	8
Apparent Colour (CU)	16	20	17	15	14	13
Total Dissolved Solids (mg/L)	269	263	271	271	274	274
Chloride (mg/L)	31	31	31	31	31	31
Sulphate (mg/L)	31	45	58	72	87	110
Hardness as CaCO3 (mg/L)	211	202	200	198	210	205
Aluminum (ug/L)	337	714	360	325	580	356
Calcium (mg/L)	73.4	69.8	69.6	68.4	72.6	71
Dissolved Organic Carbon (mg/L)	5	5	4	4	4	4
Total Organic Carbon (mg/L)	5	5	5	5	4	4

161-05613-00 Coagulant Testing for Lindsay Water Treatment Plant

Jar Test Data Sheet		Source Water:		
Date:	3/1/2017	pH		7.63
Time:	1:00 PM	(°C)	(°C)	5
Performed By:	Mazahir Alidina	Turbidity (NTU)	(NTU)	2.45
Coagulant Type:	**DeltaFloc-1118**	UVA		0.314
		Alkalinity as CaCO3 (mg/L)	mg/L	132
OPTIMIZE pH		Colour (TCU)	mg/L	33
Coagulant Dosage:	25 to 75 mg/L	Apparent Colour (CU)	(mg CaCO3/L)	53
Coagulant Aid Type:	Cationic Polmer	Tottal Dissolved Solids (TDS)		254
Coagulant Aid Dosage:	0.3 mg/L	Chloride		24
Coagulant Aid Conc.:	0.30%	Sulphate		29
Microsand Dose:	20 g	Hardness as CaCO3 (mg/L)	mg/L	204
Specific Gravity	1.3	Aluminum (ug/L)	mg/L as CaCO3	68.4
Conc. Of Alum (Al_2O_3) (%)	22.00	Calcium (mg/L)	ug/L	71.1
		Dissolved Organic Carbon (mg/L)		8
		Total Organic Carbon (mg/L)		8

JAR NUMBER	T1	T2	T3	T4	T5	T6
DOSAGES						
Raw Water Volume (mL)	2000	2000	2000	2000	2000	2000
Acid/Base addition (mL)	0	0.3	0.6	0.9	1.2	1.5
Coagulant Dose (mg/L)	37	37	37	37	37	37
Al_2O_3 Conc. (mg/L)	10.58	10.58	10.58	10.58	10.58	10.58
Volume of 1:10 diluted Coagulant added (mL)	0.538	0.538	0.538	0.538	0.538	0.538
Microsand added (g)						
Coagulant-Aid Dose (mg/L)	0.3	0.3	0.3	0.3	0.3	0.3
Initial Volume of 1:10 diluted Polymer added with microsand (mL)	1.000	1.000	1.000	1.000	1.000	1.000
Remaining Volume of 1:10 diluted Polymer added (mL)	1.000	1.000	1.000	1.000	1.000	1.000
FLOCCULATION (0 - 2:40 mins)						
Duration (min)	2:40	2:40	2:40	2:40	2:40	2:40
Speed (rpm)	150	150	150	150	150	150
MATURATION (2:40 - 13:20 mins)						
Duration (min)	10:40	10:40	10:40	10:40	10:40	10:40
Speed (rpm)	150	150	150	150	150	150
SETTLING (13:20 - 17:20 mins)						
Duration (min)	4:00	4:00	4:00	4:00	4:00	4:00
Speed (rpm)	0	0	0	0	0	0
FINAL RESULTS						
Initial pH	7.64	7.24	6.89	6.66	6.47	6.26
Final pH	7.27	7.29	6.97	6.86	6.66	6.24
Temperature (°C)	5.5	5.5	5.5	5.5	5.5	5.5
Turbidity (NTU)	2.17	2.44	2.66	1.53	1.21	2.96
UVA	0.2	0.212	0.23	0.165	0.164	0.218
Alkalinity as CaCO3 (mg/L)	127	118	102	87	71	57
Colour (TCU)	10	10	10	9	9	9
Apparent Colour (CU)	32	28	46	18	28	33
Total Dissolved Solids (mg/L)	266	271	263	277	286	286
Chloride (mg/L)	27	27	27	27	27	27
Sulphate (mg/L)	44	44	60	77	92	100
Hardness as CaCO3 (mg/L)	202	201	203	204	200	199
Aluminum (ug/L)	1020	1440	1580	898	783	1090
Calcium (mg/L)	70.1	69.4	70.2	71	69.9	69
Dissolved Organic Carbon (mg/L)	6	6	5	5	4	5
Total Organic Carbon (mg/L)	5	5	5	5	5	5

161-05613-00 Coagulant Testing for Lindsay Water Treatment Plant

WSP

Jar Test Data Sheet		Source Water:		
Date:	3/13/2017	pH		7.96
Time:	11:00 AM	Temperature (°C)	(°C)	3.5
Performed By:	Mazahir Alidina	Turbidity (NTU)	(NTU)	4.14
Coagulant Type:	SternPAC	UVA		0.231
		Alkalinity as CaCO3 (mg/L)	mg/L	152
OPTIMIZE STERNPAC DOSE		Colour (TCU)	mg/L	18
Coagulant Dosage:	55 to 105 mg/L	Apparent Colour (CU)	(mg CaCO3/L)	60
Coagulant Aid Type:	Cationic Polmer	Tottal Dissolved Solids (TDS)		263
Coagulant Aid Dosage:	0.3 mg/L	Chloride		33
	0.30%	Sulphate		19
Microsand Dose:	15 g	Hardness as CaCO3 (mg/L)	mg/L	192
Specific Gravity	1.205	Aluminum (ug/L)	mg/L as CaCO3	163
Conc. Of Alum (Al_2O_3) (%)	10.40	Calcium (mg/L)	ug/L	64.6
		Dissolved Organic Carbon (mg/L)		7
		Total Organic Carbon (mg/L)	(°C)	8

JAR NUMBER	SP-D1	SP-D2	SP-D3	SP-D4	SP-D5	SP-D6
DOSAGES						
Raw Water Volume (mL)	2000	2000	2000	2000	2000	2000
Acid/Base addition (mL)	1.3	1.3	1.3	1.3	1.3	1.3
Coagulant Dose (mg/L)	55	65	75	85	95	105
Al_2O_3 Conc. (mg/L)	6.89	8.15	9.40	10.65	11.91	13.16
Volume of 1:10 diluted Coagulant added (mL)	0.913	1.079	1.245	1.411	1.577	1.743
Microsand added (g)	15	15	15	15	15	15
Coagulant-Aid Dose (mg/L)	0.3	0.3	0.3	0.3	0.3	0.3
Initial Volume of 1:10 diluted Polymer added with microsand (mL)	1.000	1.000	1.000	1.000	1.000	1.000
Remaining Volume of 1:10 diluted Polymer added (mL)	1.000	1.000	1.000	1.000	1.000	1.000
FLOCCULATION (0 - 2:40 mins)						
Duration (min)	2:40	2:40	2:40	2:40	2:40	2:40
Speed (rpm)	150	150	150	150	150	150
MATURATION (2:40 - 13:20 mins)						
Duration (min)	10:40	10:40	10:40	10:40	10:40	10:40
Speed (rpm)	150	150	150	150	150	150
SETTLING (13:20 - 17:20 mins)						
Duration (min)	4:00	4:00	4:00	4:00	4:00	4:00
Speed (rpm)	0	0	0	0	0	0
FINAL RESULTS						
Initial pH	6.51	6.47	6.49	6.49	6.5	6.48
Final pH	6.56	6.6	6.64	6.54	6.51	6.5
Initial Temperature (°C)	3.6	3.4	3.4	3.2	3.4	3.1
Final Temperature (°C)	6.9	7.2	6.7	6.4	6.5	6.7
Turbidity (NTU)	0.586	0.377	0.361	0.311	0.318	0.312
UVA	0.131	0.105	0.1	0.09	0.083	0.077
Alkalinity as CaCO3 (mg/L)	69	68	69	67	66	65
Colour (TCU)	7	6	6	5	5	5
Apparent Colour (CU)	14	11	13	8	8	8
Total Dissolved Solids (mg/L)	277	294	306	300	294	297
Chloride (mg/L)	38	39	40	41	42	42
Sulphate (mg/L)	86	89	89	86	85	86
Hardness as CaCO3 (mg/L)	193	195	196	202	195	198
Aluminum (ug/L)	338	197	185	173	138	157
Calcium (mg/L)	64.7	65.2	65.6	67.5	65.1	65.9
Dissolved Organic Carbon (mg/L)	6	5	4	4	4	4
Total Organic Carbon (mg/L)	6	5	5	5	4	4

161-05613-00 Coagulant Testing for Lindsay Water Treatment Plant

WSP

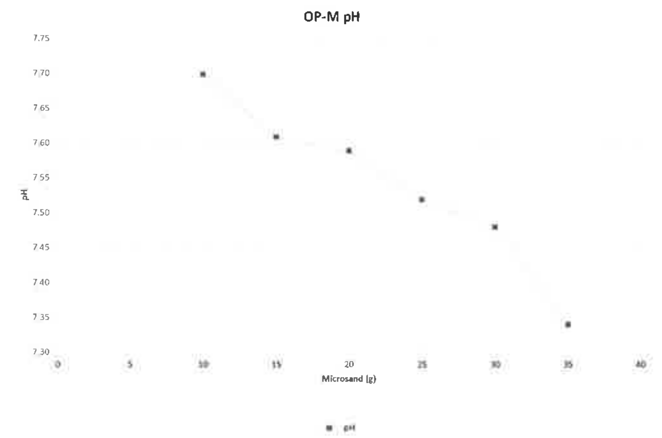
Jar Test Data Sheet			Source Water:		
Date:	3/13/2017		pH		7.96
Time:	1:00 PM		Temperature (°C)	(°C)	3.5
Performed By:	Mazahir Alidina		Turbidity (NTU)	(NTU)	4.14
Coagulant Type:	DeltaFloc-1118		UVA		0.231
			Alkalinity as CaCO3 (mg/L)	mg/L	152
OPTIMIZE DELTAFLOC-1118 DOSE			Colour (TCU)	mg/L	18
Coagulant Dosage:	25 to 75 mg/L		Apparent Colour (CU)	(mg CaCO3/L)	60
Coagulant Aid Type:	Cationic Polmer		Tottal Dissolved Solids (TDS)		263
Coagulant Aid Dosage:	0.3 mg/L		Chloride		33
Coagulant Aid Conc.:	0.30%		Sulphate		19
Microsand Dose:	20 g		Hardness as CaCO3 (mg/L)	mg/L	192
Specific Gravity	1.3		Aluminum (ug/L)	mg/L as CaCO3	163
Conc. Of Alum (Al_2O_3) (%)	22.00		Calcium (mg/L)	ug/L	64.6
			Dissolved Organic Carbon (mg/L)		7
			Total Organic Carbon (mg/L)	(°C)	8

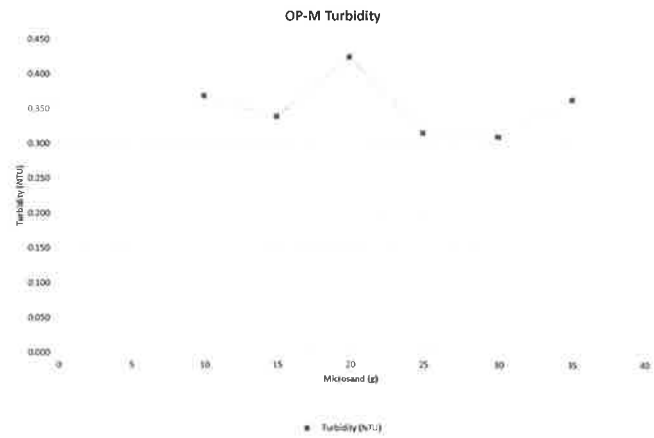
JAR NUMBER	DF-D1	DF-D2	DF-D3	DF-D4	DF-D5	DF-D6
DOSAGES						
Raw Water Volume (mL)	2000	2000	2000	2000	2000	2000
Acid/Base addition (mL)	1.3	1.3	1.3	1.3	1.3	1.3
Coagulant Dose (mg/L)	24	29	33	37	42	46
Al_2O_3 Conc. (mg/L)	6.86	8.29	9.44	10.58	12.01	13.16
Volume of 1:10 diluted Coagulant added (mL)	0.369	0.446	0.508	0.569	0.646	0.708
Microsand added (g)	15	15	15	15	15	15
Coagulant-Aid Dose (mg/L)	0.3	0.3	0.3	0.3	0.3	0.3
Initial Volume of 1:10 diluted Polymer added with microsand (mL)	1.000	1.000	1.000	1.000	1.000	1.000
Remaining Volume of 1:10 diluted Polymer added (mL)	1.000	1.000	1.000	1.000	1.000	1.000
FLOCCULATION (0 - 2:40 mins)						
Duration (min)	2:40	2:40	2:40	2:40	2:40	2:40
Speed (rpm)	150	150	150	150	150	150
MATURATION (2:40 - 13:20 mins)						
Duration (min)	10:40	10:40	10:40	10:40	10:40	10:40
Speed (rpm)	150	150	150	150	150	150
SETTLING (13:20 - 17:20 mins)						
Duration (min)	4:00	4:00	4:00	4:00	4:00	4:00
Speed (rpm)	0	0	0	0	0	0
FINAL RESULTS						
Initial pH	6.45	6.43	6.44	6.45	6.44	6.44
Final pH	6.59	6.57	6.57	6.54	6.61	6.61
Initial Temperature (°C)	5.4	3.8	3.2	3.1	3.2	3.3
Final Temperature (°C)	9.4	7.8	7.4	7.4	7.5	7.6
Turbidity (NTU)	0.622	0.45	0.368	0.386	0.295	0.25
UVA	0.131	0.112	0.1	0.095	0.084	0.079
Alkalinity as CaCO3 (mg/L)	74	72	72	75	72	71
Colour (TCU)	7	5	5	6	5	5
Apparent Colour (CU)	10	8	7	8	6	7
Total Dissolved Solids (mg/L)	294	297	294	289	280	294
Chloride (mg/L)	35	35	36	36	37	37
Sulphate (mg/L)	87	88	88	88	87	87
Hardness as CaCO3 (mg/L)	192	194	194	197	196	195
Aluminum (ug/L)	232	131	104	157	133	146
Calcium (mg/L)	63.6	64.7	64.9	65.8	65	64.9
Dissolved Organic Carbon (mg/L)	5	5	4	4	4	4
Total Organic Carbon (mg/L)	6	5	4	5	4	4

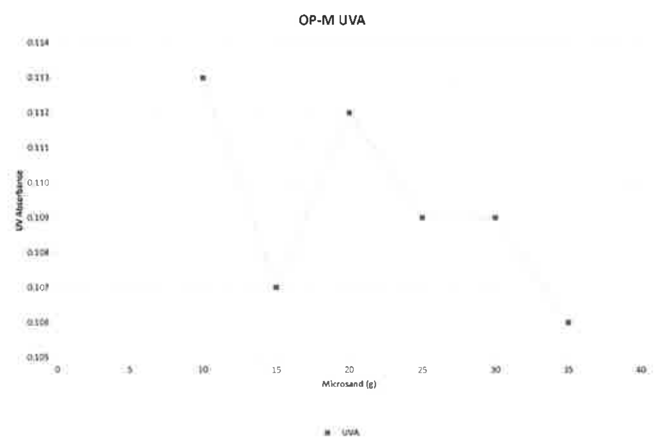
Appendix 4

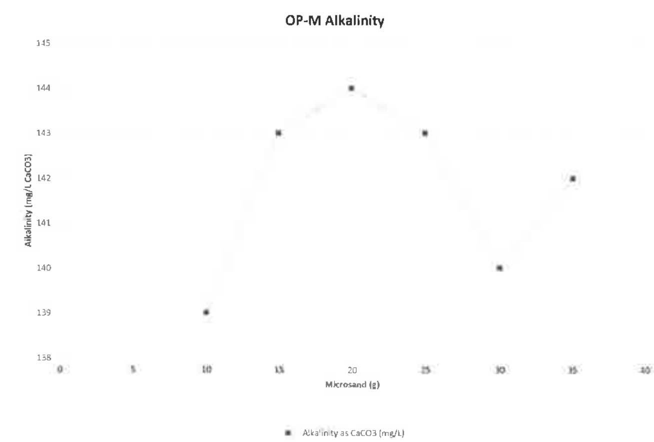
Result Graphs

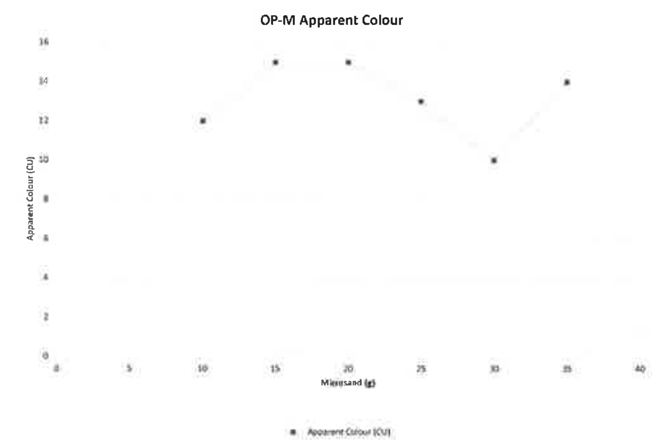
1. Optimum Microsand Dose Jar Test

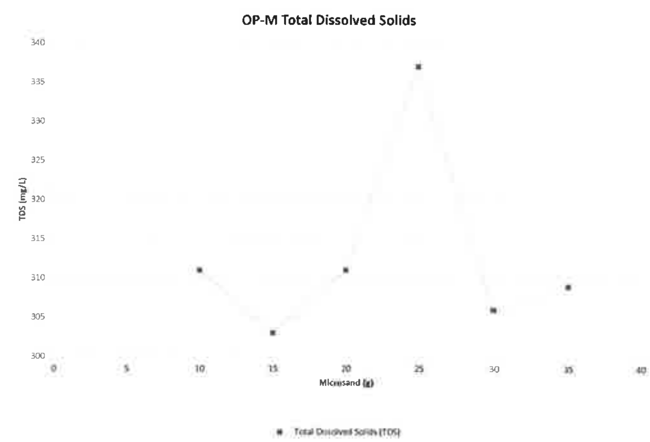


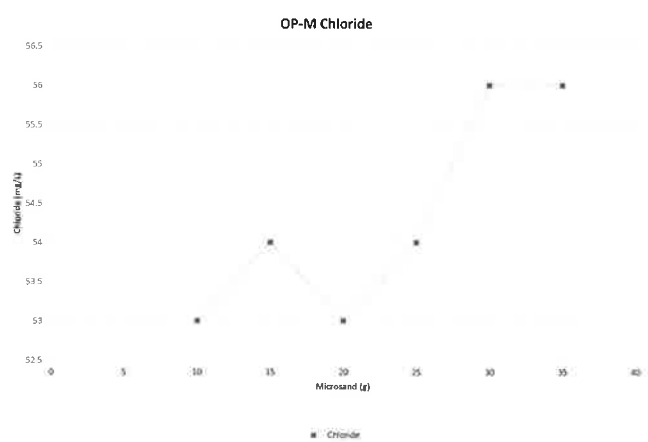


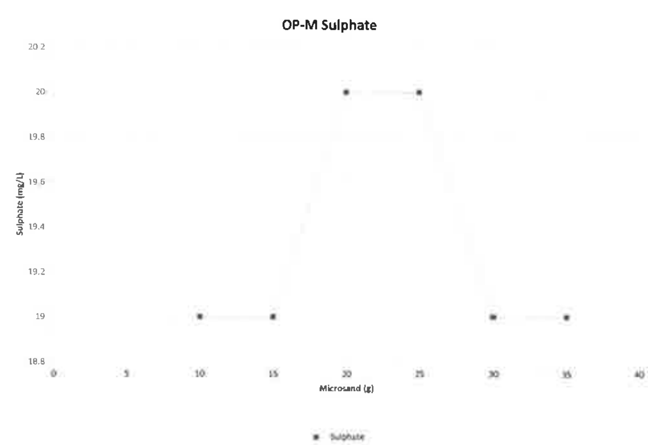


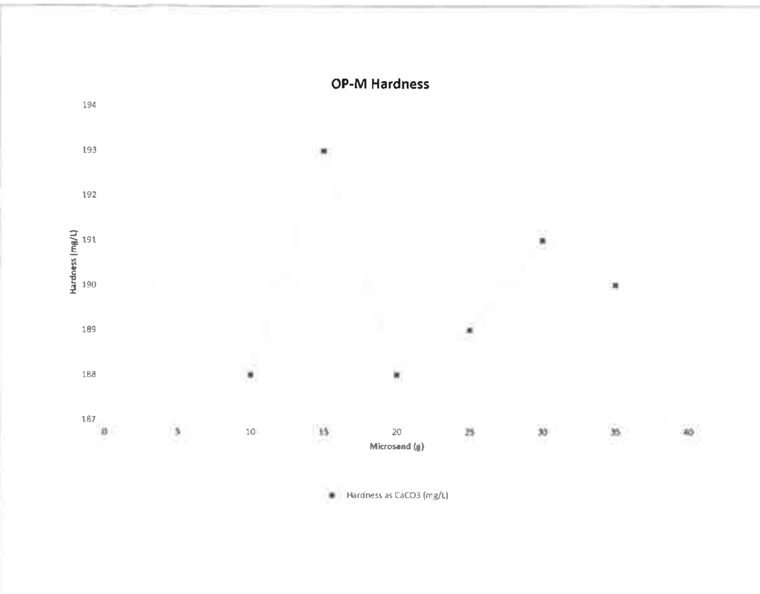


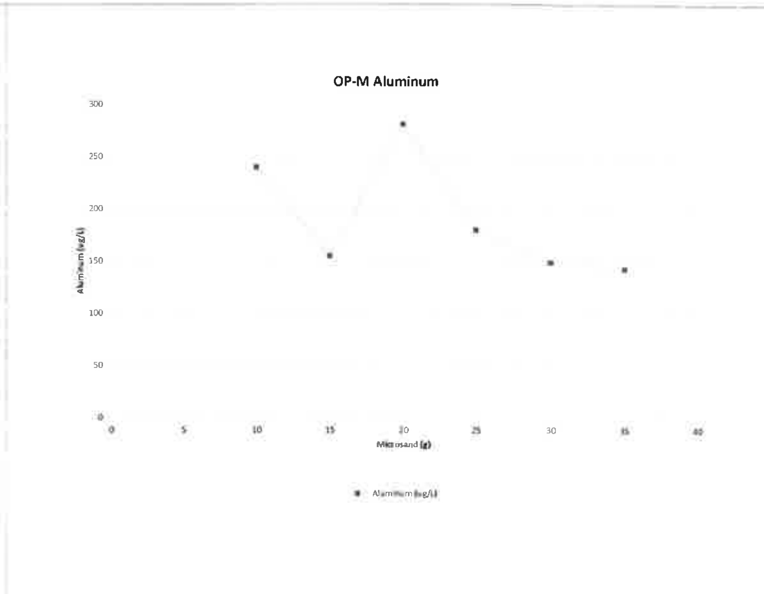

OP-M Apparent Colour
Apparent Colour (CU)
Microsand (g)
Apparent Colour (CU)

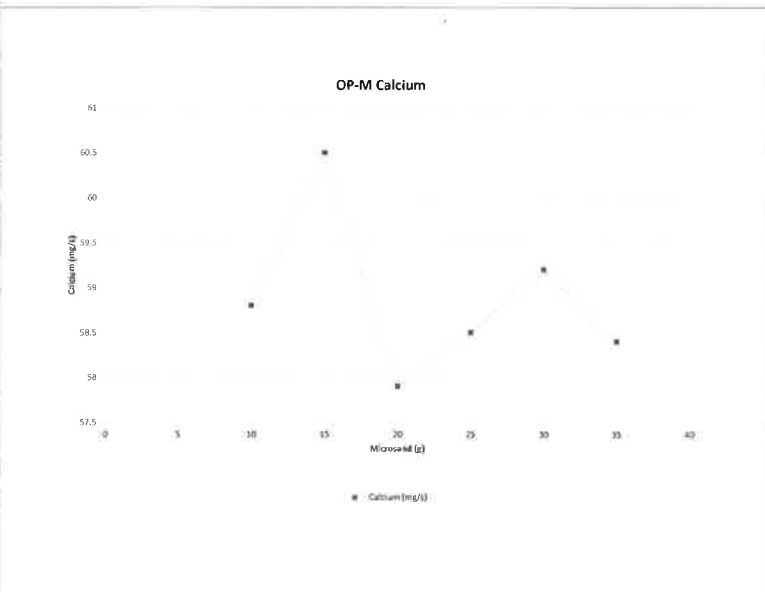

OP-M Total Dissolved Solids
TDS (mg/L)
Microsand (g)
Total Dissolved Solids (TDS)

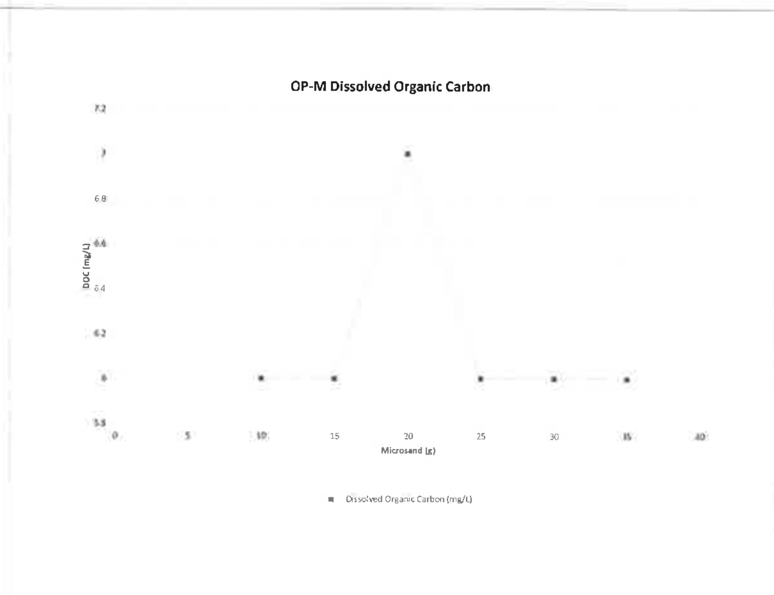

OP-M Chloride
Chloride (mg/L)
Microsand (g)
Chloride

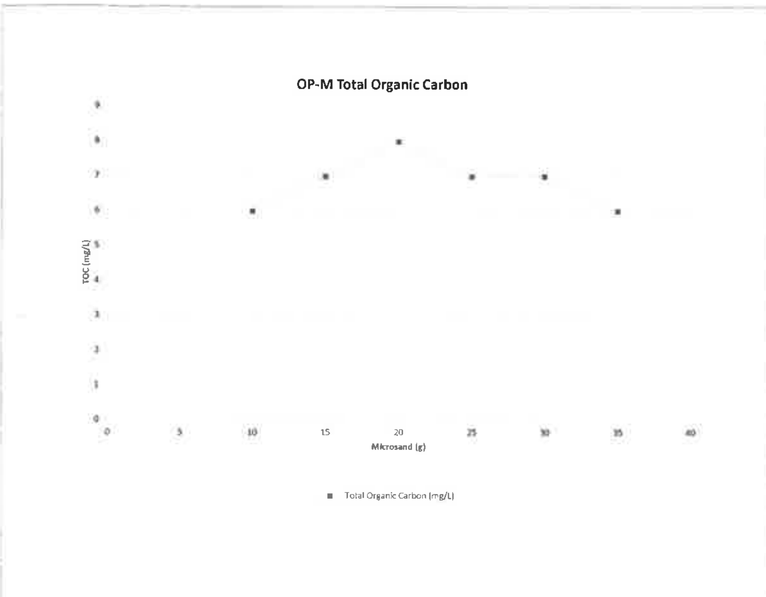

OP-M Sulphate
Sulphate (mg/L)
Microsand (g)
Sulphate


OP-M Hardness
194
193
192
191
190
189
188
187
Hardness (mg/L)
0
5
10
15
20
25
30
35
40
Microsand (g)
Hardness as CaCO3 (mg/L)


OP-M Aluminum
300
250
200
150
100
50
0
Aluminum (ug/L)
0
5
10
15
20
25
30
35
40
Microsand (g)

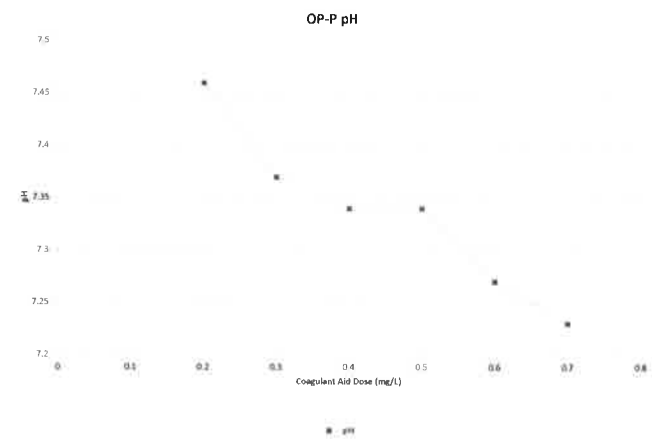

OP-M Calcium
61
60.5
60
59.5
59
58.5
58
57.5
Calcium (mg/L)
0
5
10
15
20
25
30
35
40
Microsand (g)
Calcium (mg/L)

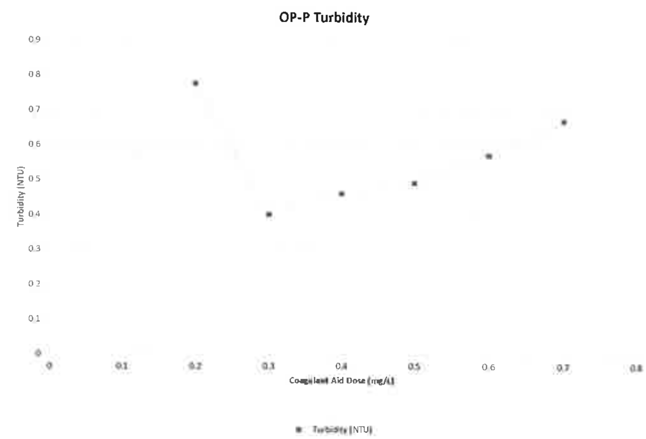

OP-M Dissolved Organic Carbon
7.2
7
6.8
6.6
6.4
6.2
6
5.8
DOC (mg/L)
0
5
10
15
20
25
30
35
40
Microsand (g)
Dissolved Organic Carbon (mg/L)

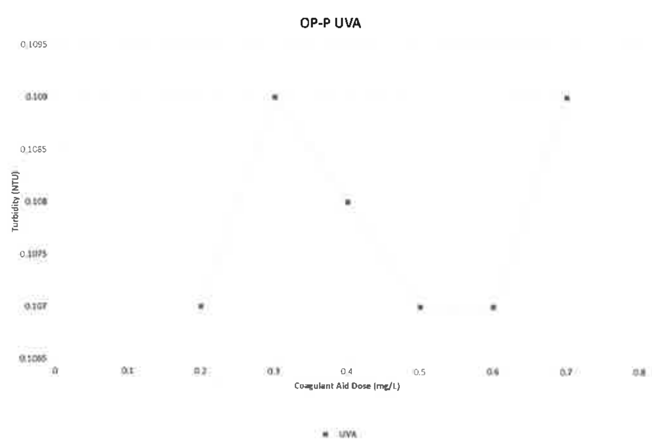


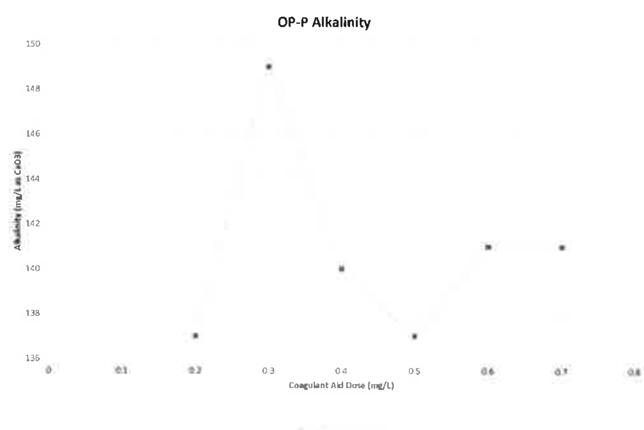
OP-M Total Organic Carbon
TOC (mg/L)
Microsand (g)
Total Organic Carbon (mg/L)

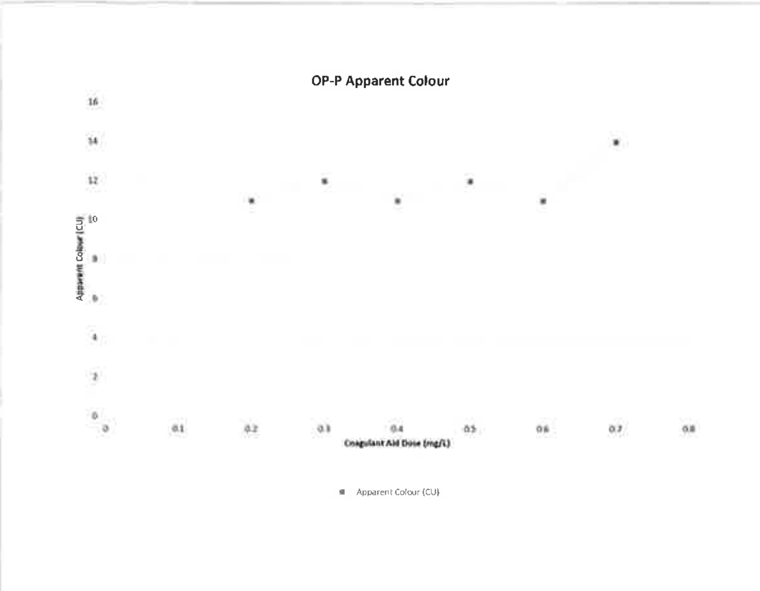
2. Optimum Polymer Dose Jar Test

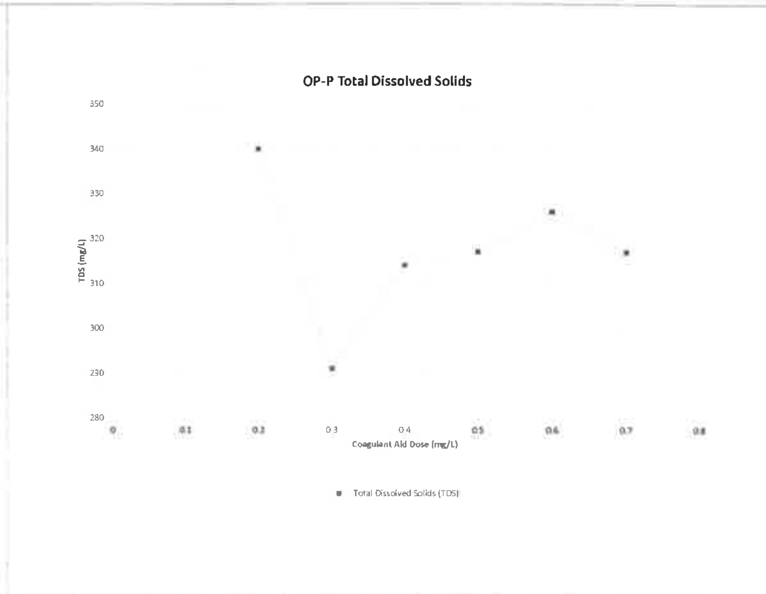


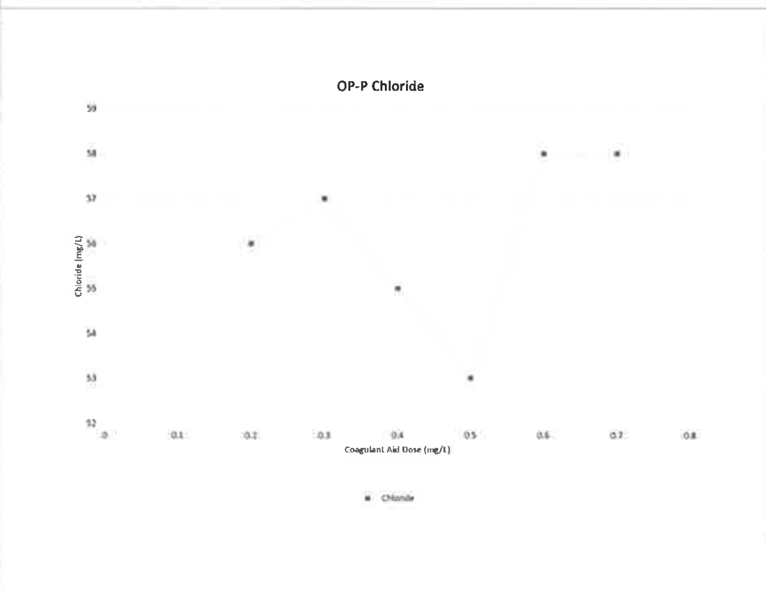


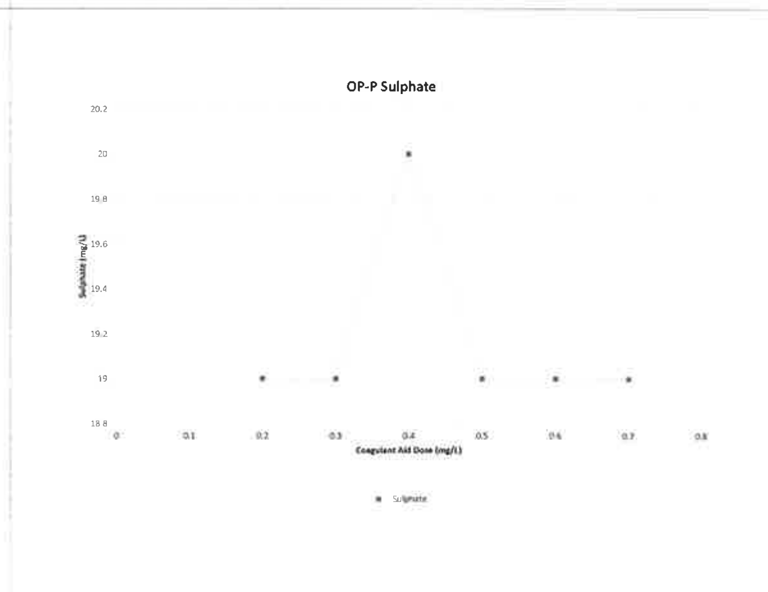


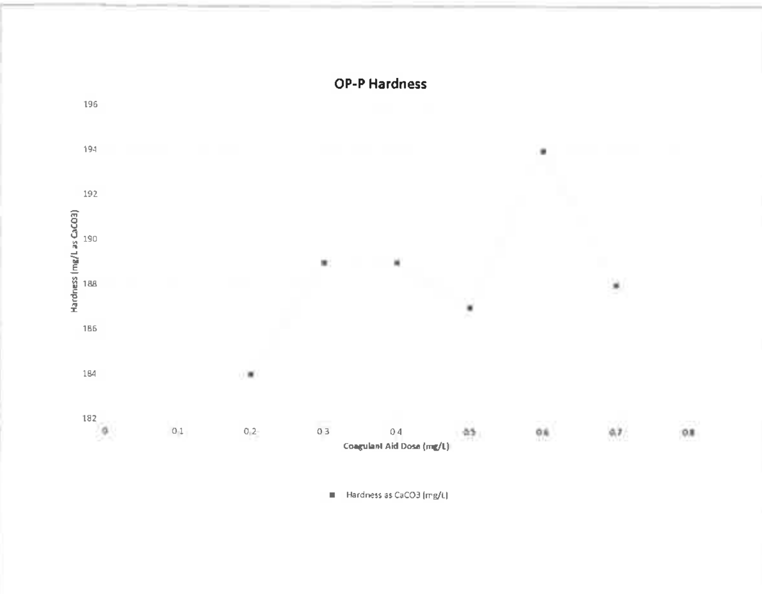


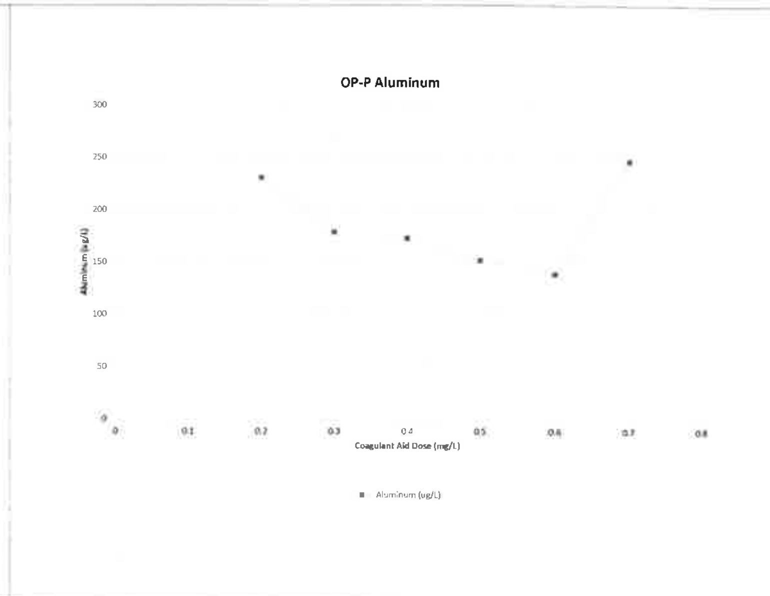

OP-P Apparent Colour
Apparent Colour (CU)
Coagulant Aid Dose (mg/L)
Apparent Colour (CU)

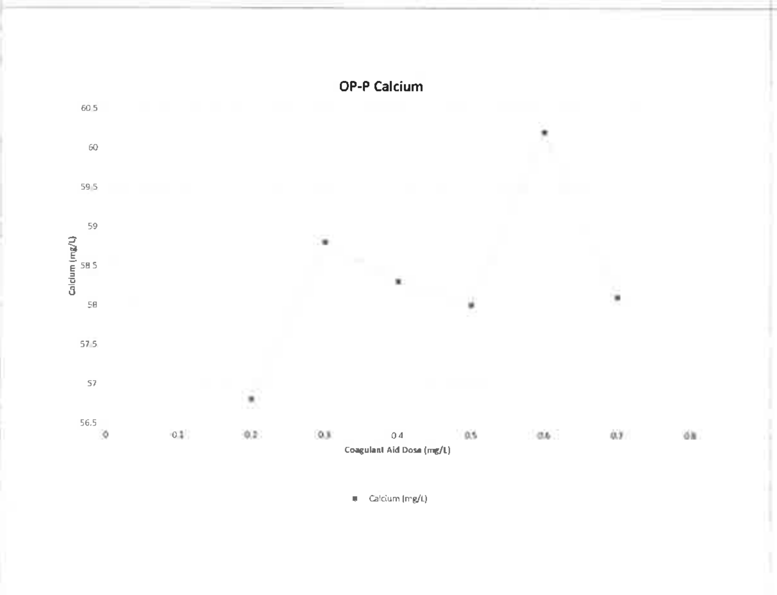

OP-P Total Dissolved Solids
TDS (mg/L)
Coagulant Aid Dose (mg/L)
Total Dissolved Solids (TDS)

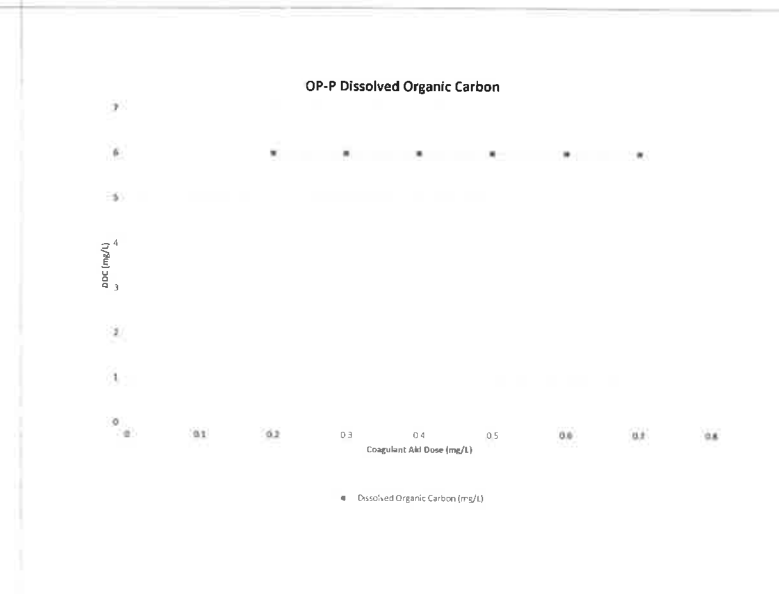

OP-P Chloride
Chloride (mg/L)
Coagulant Aid Dose (mg/L)
Chloride

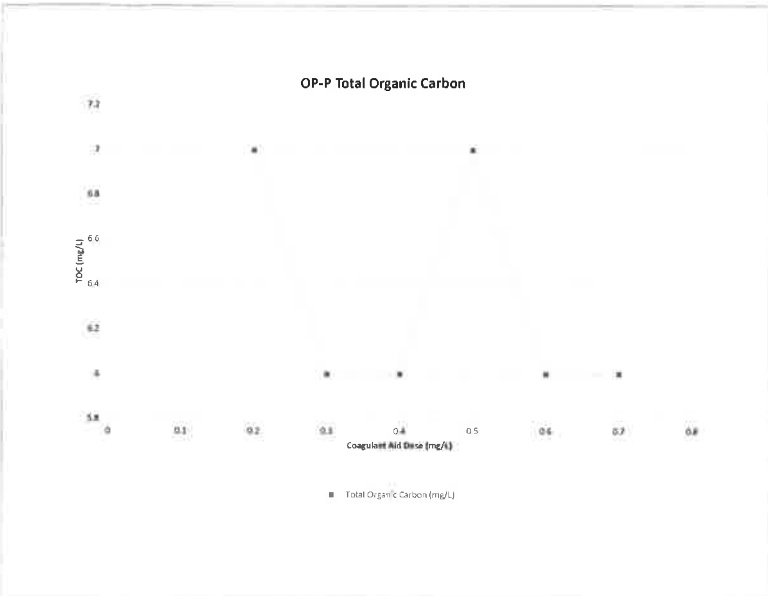

OP-P Sulphate
Sulphate (mg/L)
Coagulant Aid Dose (mg/L)
Sulphate


OP-P Hardness
Hardness (mg/L as CaCO3)
Coagulant Aid Dose (mg/L)
Hardness as CaCO3 (mg/L)


OP-P Aluminum
Aluminum (ug/L)
Coagulant Aid Dose (mg/L)
Aluminum (ug/L)

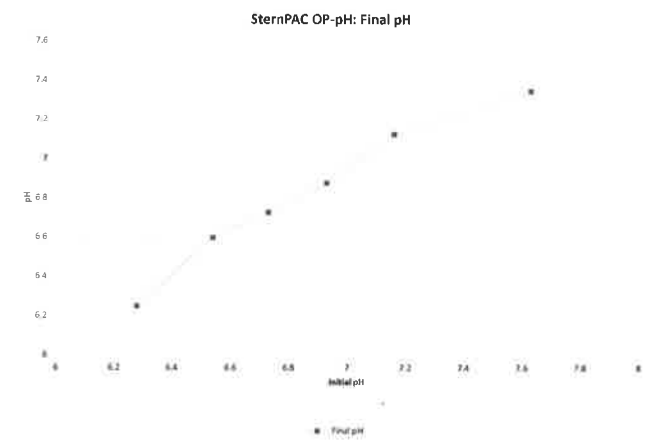

OP-P Calcium
Calcium (mg/L)
Coagulant Aid Dose (mg/L)
Calcium (mg/L)

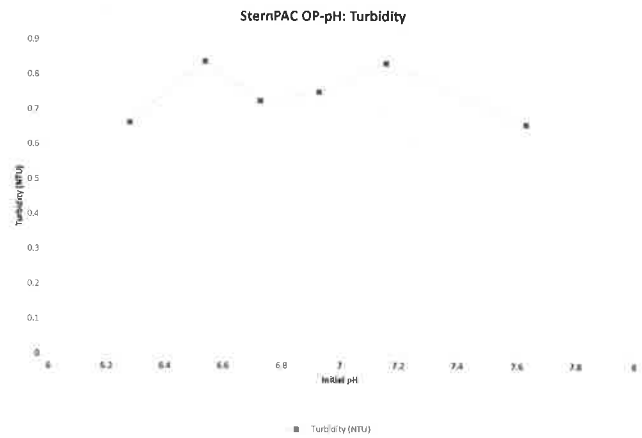

OP-P Dissolved Organic Carbon
DOC (mg/L)
Coagulant Aid Dose (mg/L)
Dissolved Organic Carbon (mg/L)

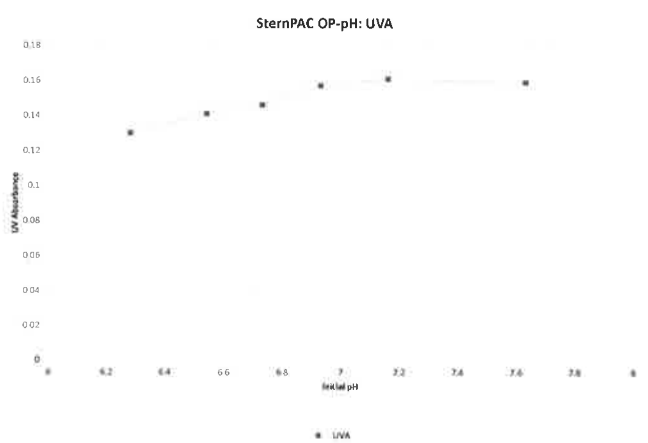


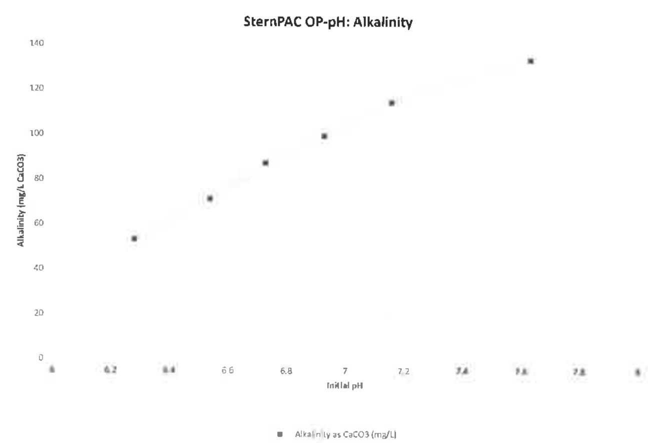
OP-P Total Organic Carbon
7.2
7
6.8
6.6
6.4
6.2
6
5.8
TOC (mg/L)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Coagulant Aid Dose (mg/L)
Total Organic Carbon (mg/L)

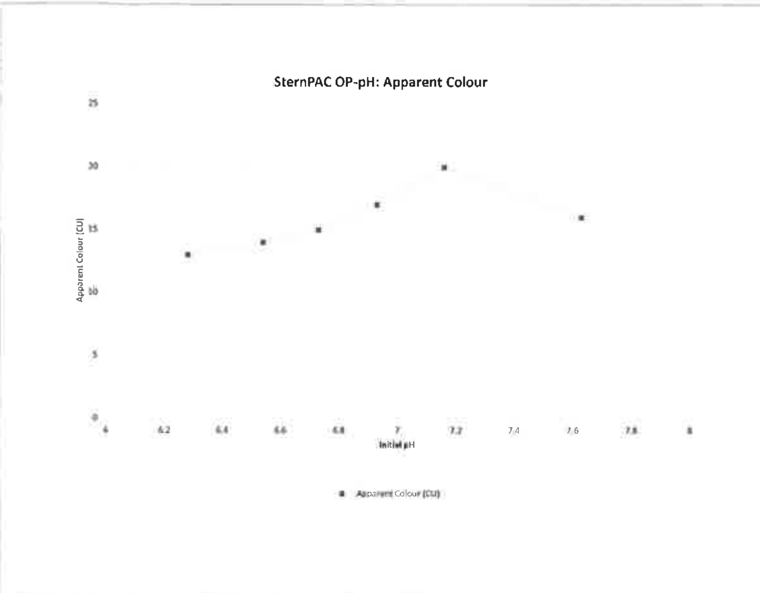
3. Optimum pH Jar Test

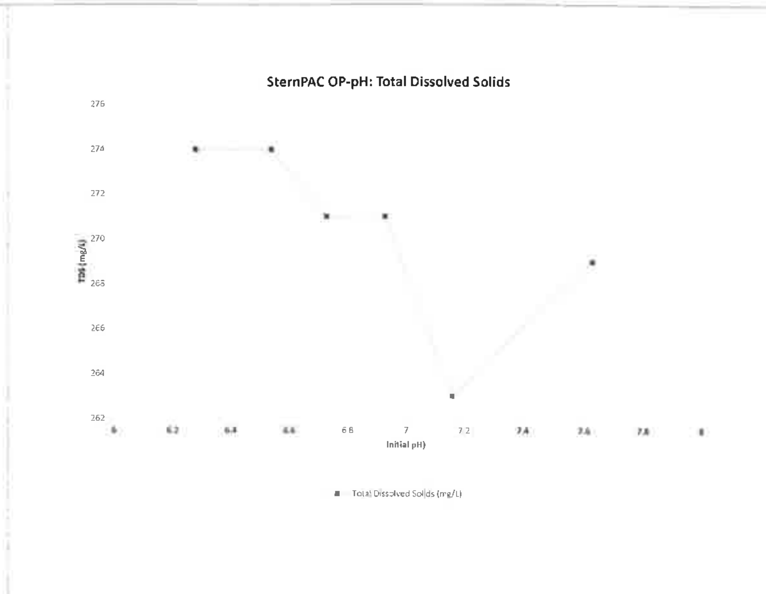


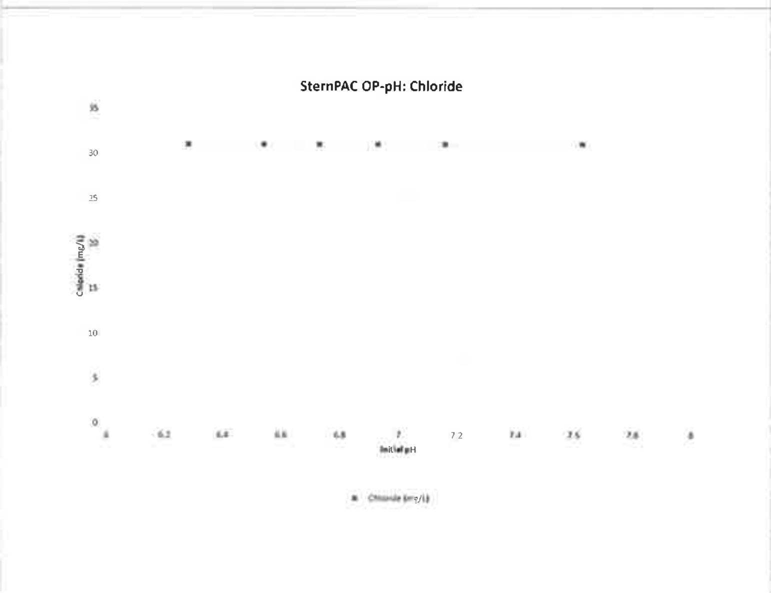


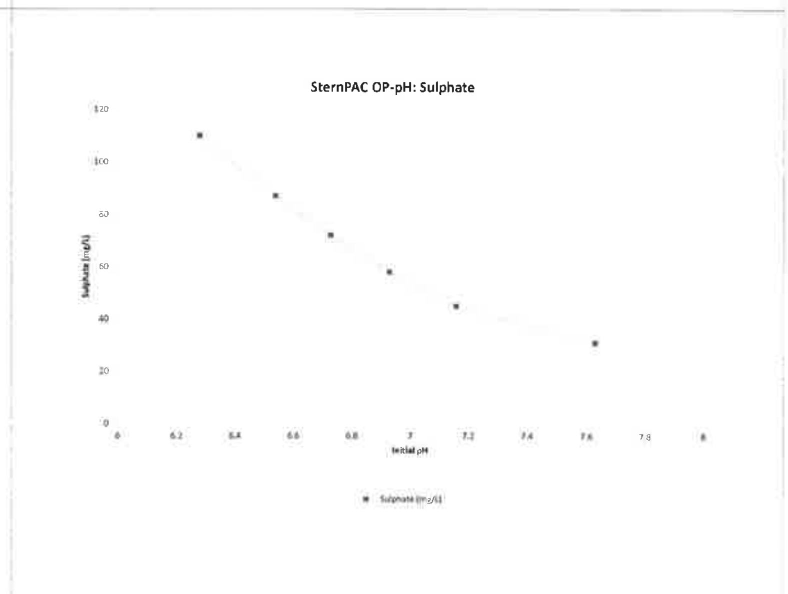


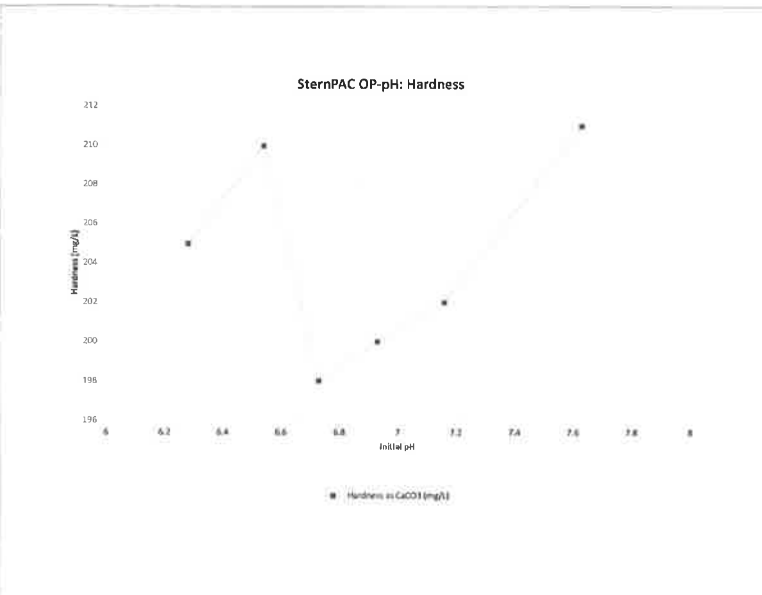


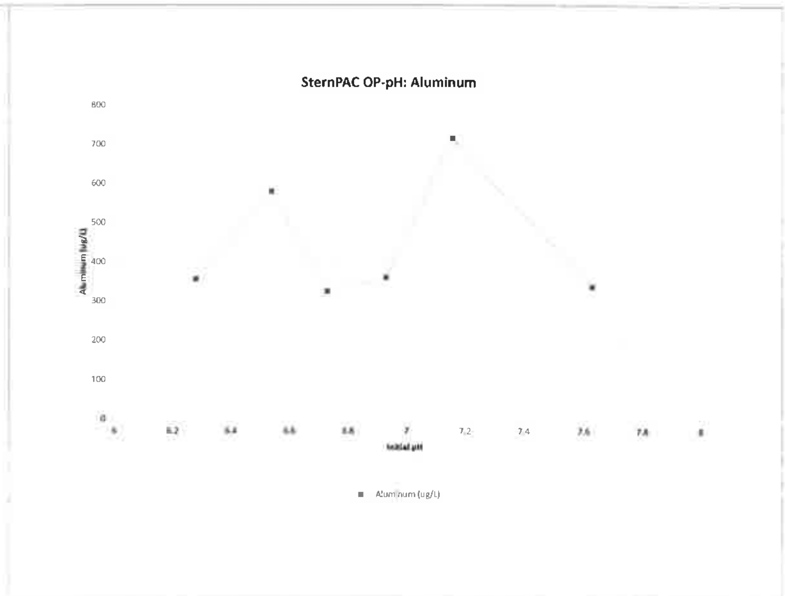

SternPAC OP-pH: Apparent Colour
Apparent Colour (CU)
Initial pH
Apparent Colour (CU)

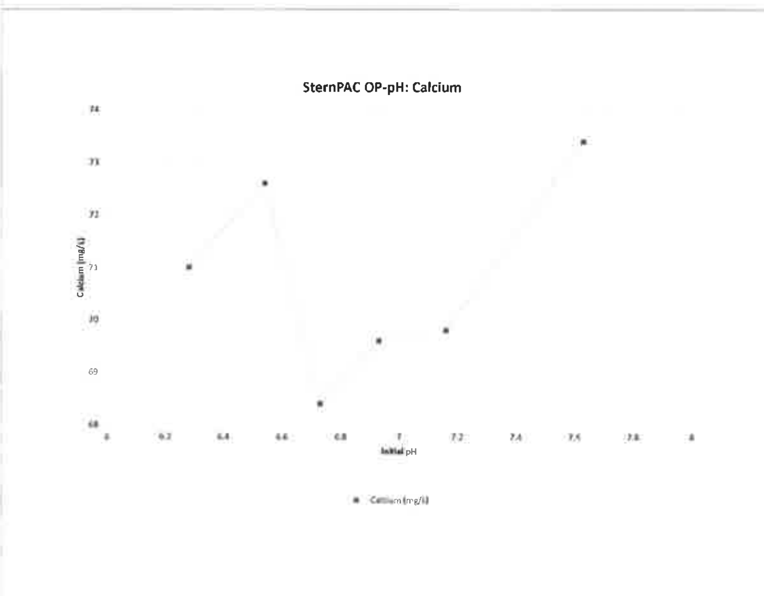

SternPAC OP-pH: Total Dissolved Solids
TDS (mg/L)
Initial pH
Total Dissolved Solids (mg/L)

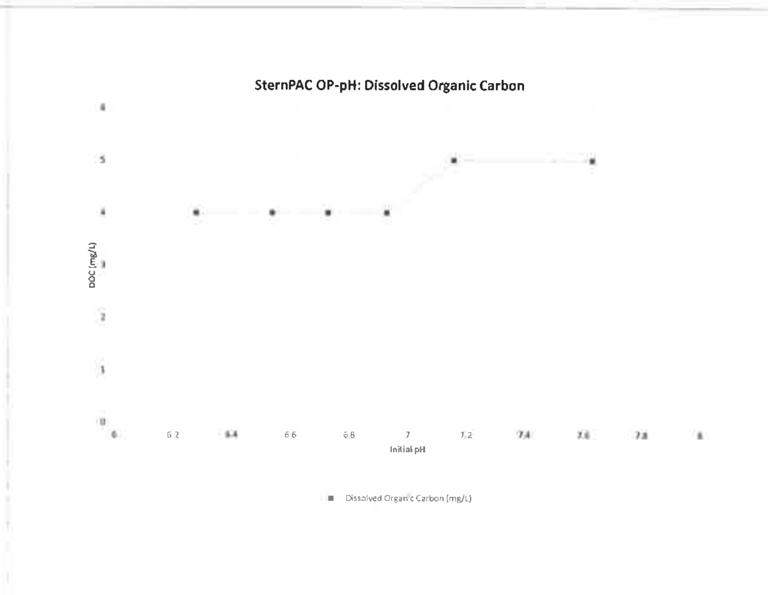

SternPAC OP-pH: Chloride
Chloride (mg/L)
Initial pH
Chloride (mg/L)

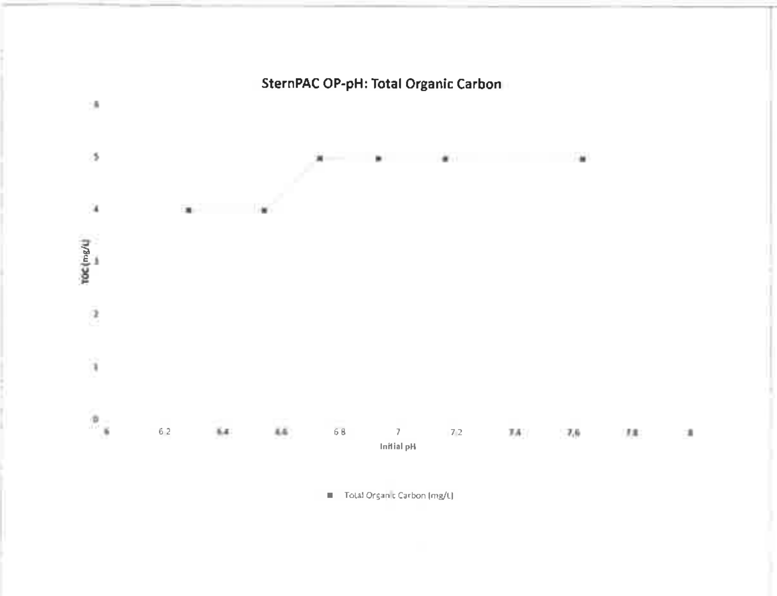

SternPAC OP-pH: Sulphate
Sulphate (mg/L)
Initial pH
Sulphate (mg/L)

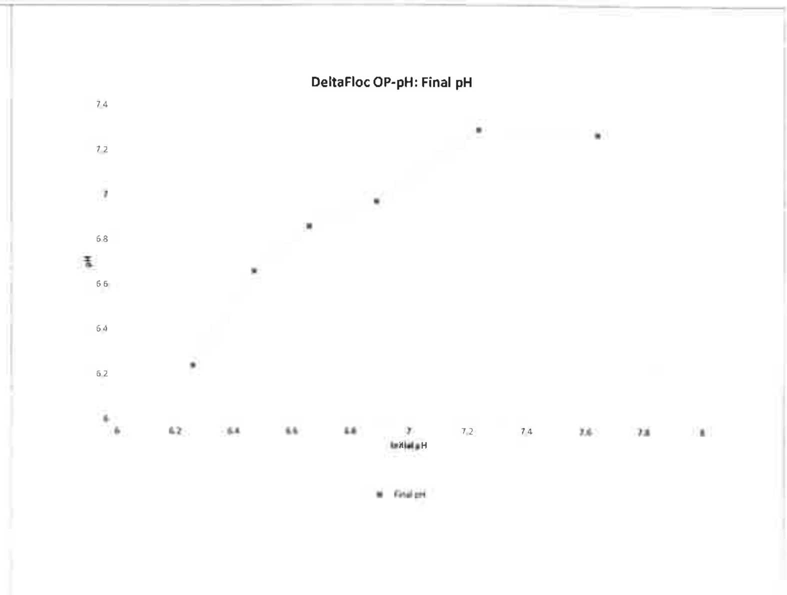

SternPAC OP-pH: Hardness
212
210
208
206
204
202
200
198
196
Hardness (mg/L)
6
6.2
6.4
6.6
6.8
7
7.2
7.4
7.6
7.8
8
Initial pH
Hardness as CaCO3 (mg/L)

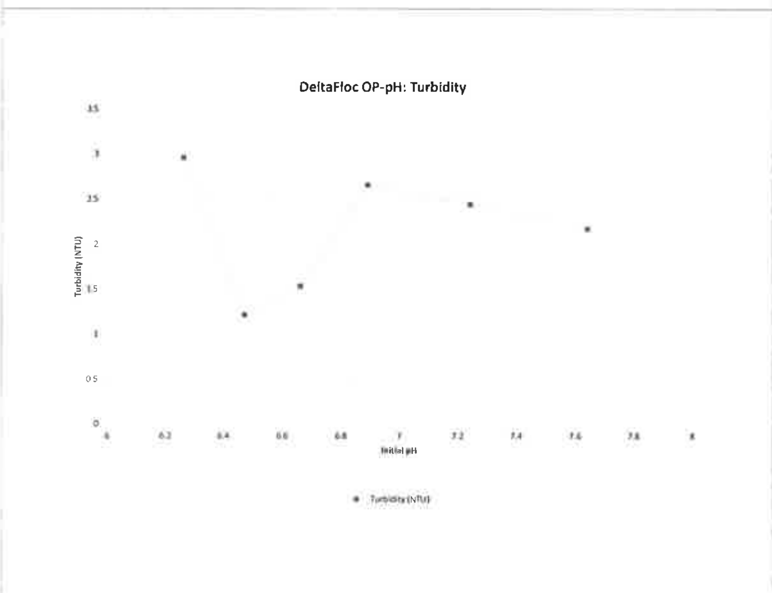

SternPAC OP-pH: Aluminum
800
700
600
500
400
300
200
100
0
Aluminum (ug/L)
6
6.2
6.4
6.6
6.8
7
7.2
7.4
7.6
7.8
8
Initial pH
Aluminum (ug/L)

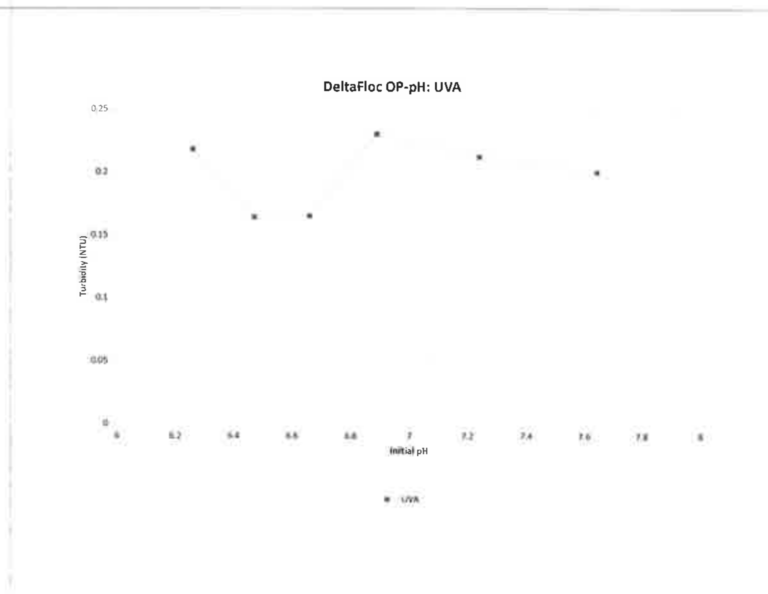

SternPAC OP-pH: Calcium
74
73
72
71
70
69
68
Calcium (mg/L)
6
6.2
6.4
6.6
6.8
7
7.2
7.4
7.6
7.8
8
Initial pH
Calcium (mg/L)

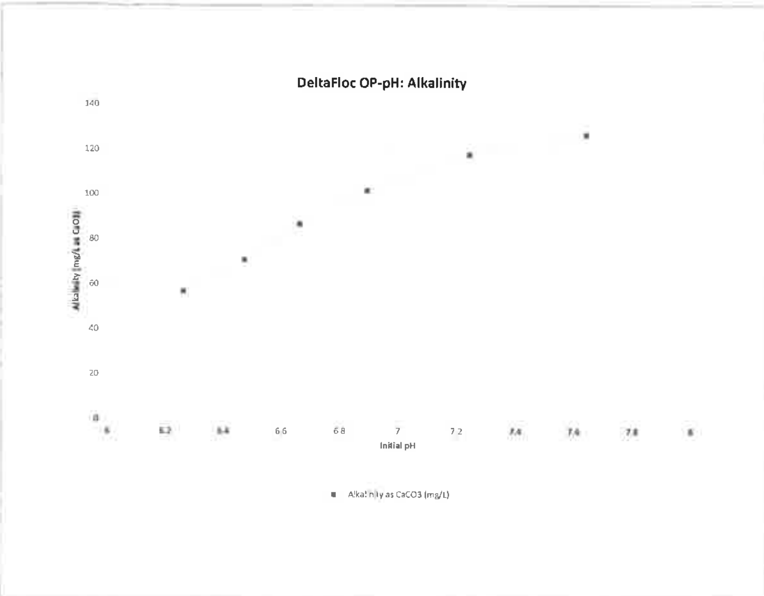

SternPAC OP-pH: Dissolved Organic Carbon
6
5
4
3
2
1
0
DOC (mg/L)
6
6.2
6.4
6.6
6.8
7
7.2
7.4
7.6
7.8
8
Initial pH
Dissolved Organic Carbon (mg/L)

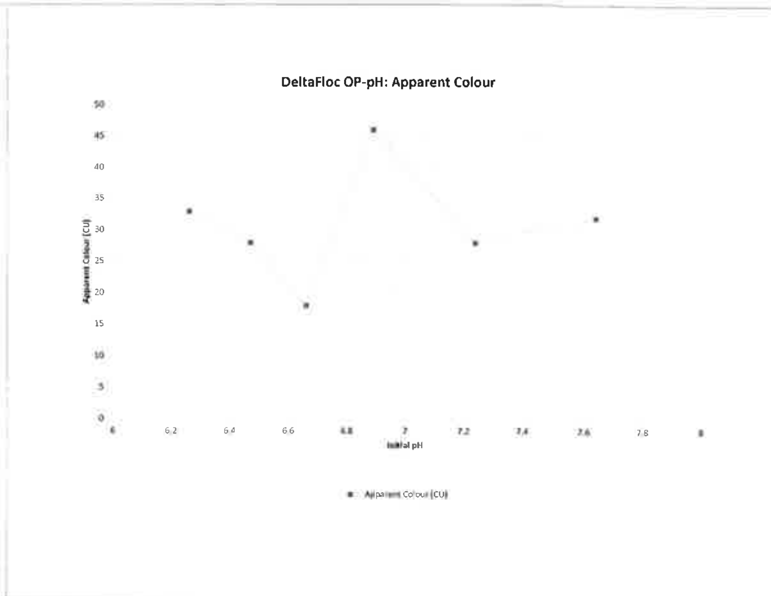

SternPAC OP-pH: Total Organic Carbon
TOC (mg/L)
Initial pH
Total Organic Carbon (mg/L)

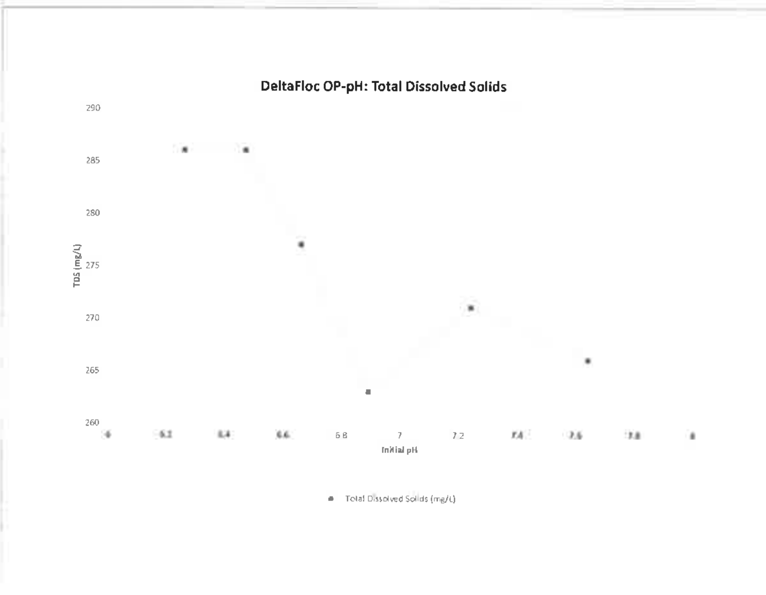

DeltaFloc OP-pH: Final pH
pH
Initial pH
Final pH

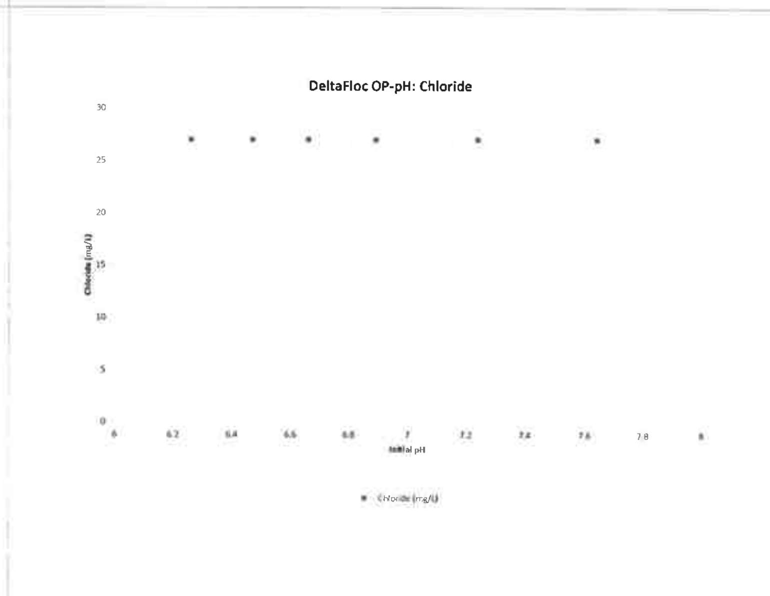

DeltaFloc OP-pH: Turbidity
Turbidity (NTU)
Initial pH
Turbidity (NTU)

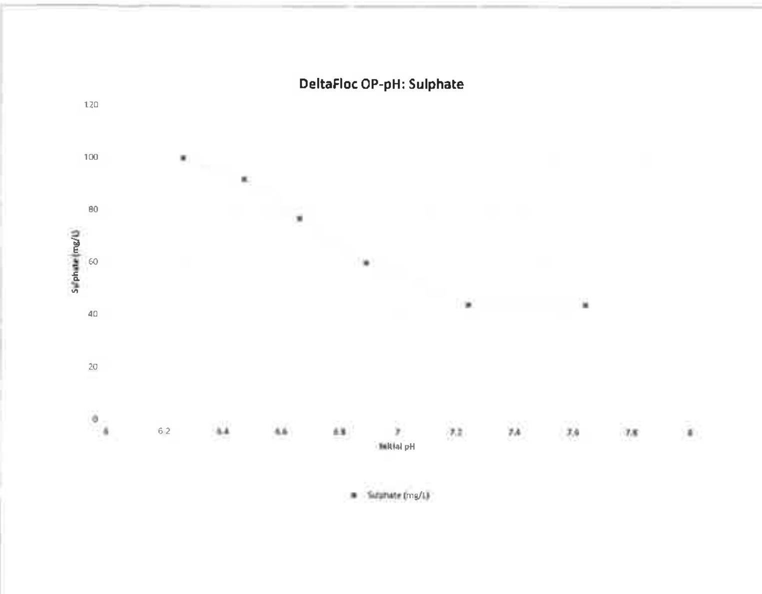

DeltaFloc OP-pH: UVA
Turbidity (NTU)
Initial pH
UVA

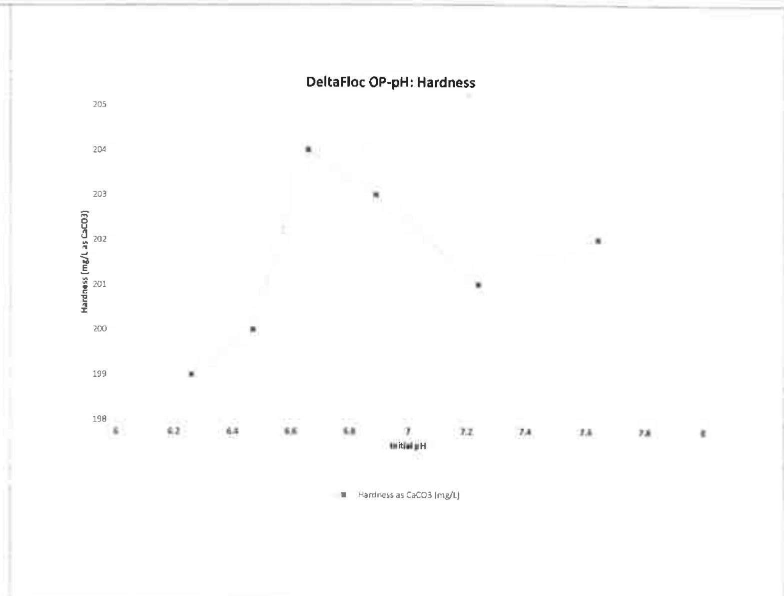

DeltaFloc OP-pH: Alkalinity
140
120
100
80
60
40
20
0
Alkalinity (mg/L as CaCO3)
6
6.2
6.4
6.6
6.8
7
7.2
7.4
7.6
7.8
8
Initial pH
Alkalinity as CaCO3 (mg/L)

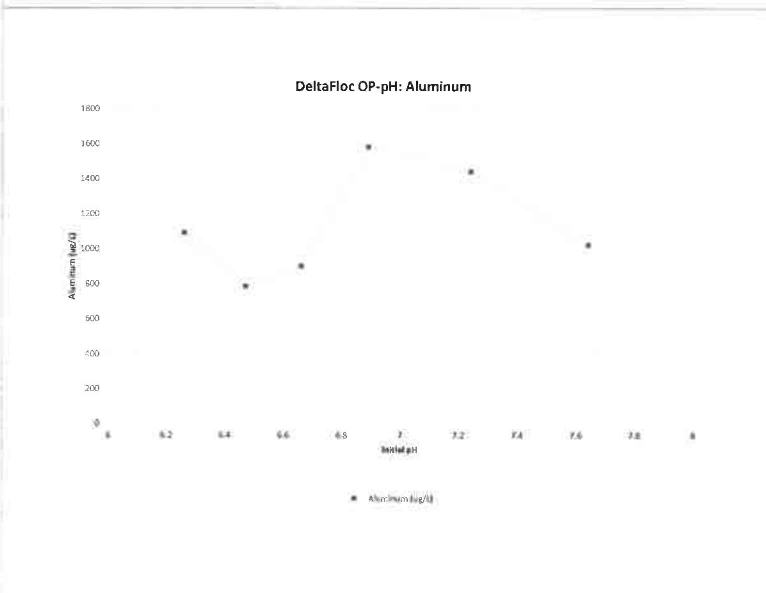

DeltaFloc OP-pH: Apparent Colour
50
45
40
35
30
25
20
15
10
5
0
Apparent Colour (CU)
6
6.2
6.4
6.6
6.8
7
7.2
7.4
7.6
7.8
8
Initial pH
Apparent Colour (CU)

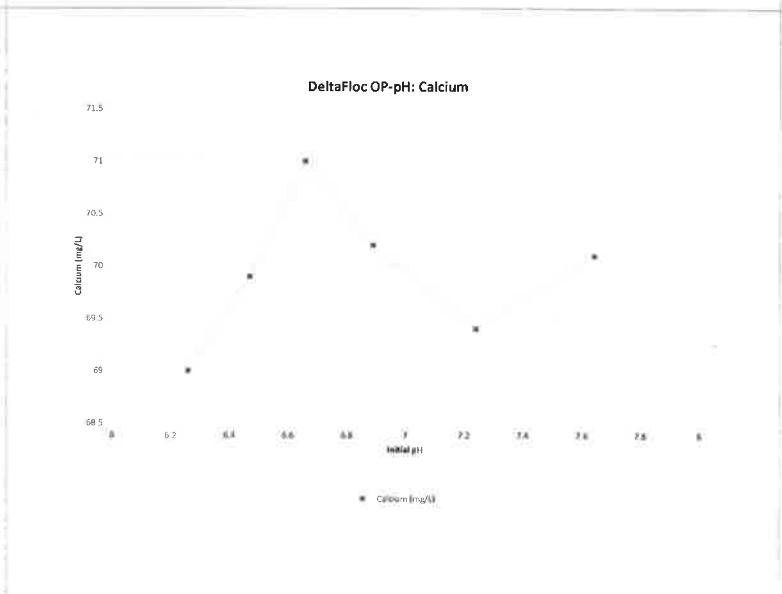

DeltaFloc OP-pH: Total Dissolved Solids
290
285
280
275
270
265
260
TDS (mg/L)
6
6.2
6.4
6.6
6.8
7
7.2
7.4
7.6
7.8
8
Initial pH
Total Dissolved Solids (mg/L)

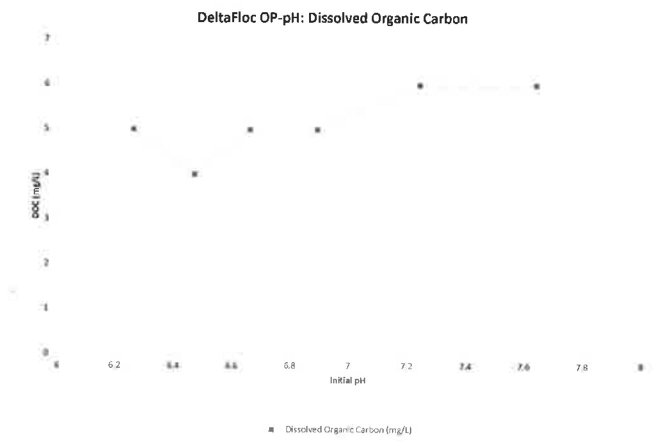

DeltaFloc OP-pH: Chloride
30
25
20
15
10
5
0
Chloride (mg/L)
6
6.2
6.4
6.6
6.8
7
7.2
7.4
7.6
7.8
8
Initial pH
Chloride (mg/L)


DeltaFloc OP-pH: Sulphate
Sulphate (mg/L)
Initial pH
Sulphate (mg/L)

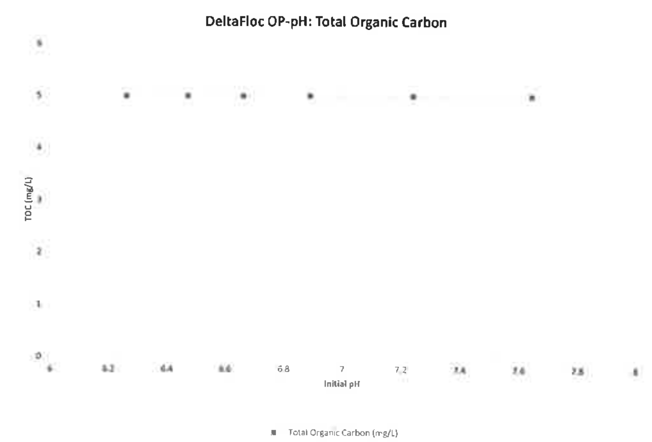

DeltaFloc OP-pH: Hardness
Hardness (mg/L as CaCO3)
Initial pH
Hardness as CaCO3 (mg/L)


DeltaFloc OP-pH: Aluminum
Initial pH


DeltaFloc OP-pH: Calcium
Calcium (mg/L)
Initial pH
Calcium (mg/L)

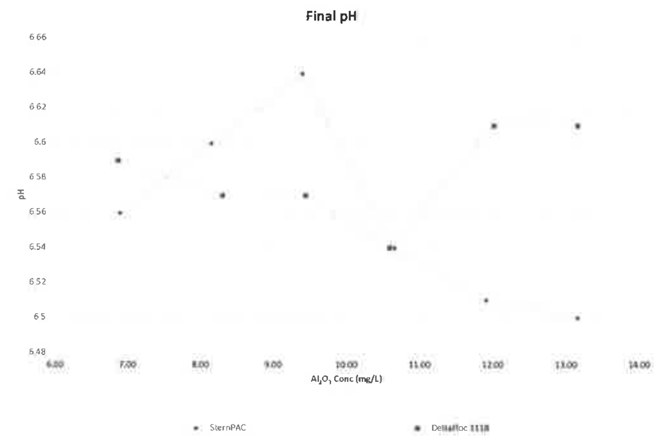


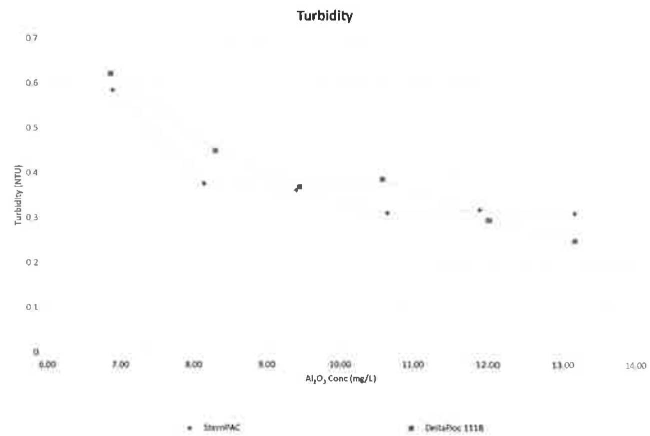
DeltaFloc OP-pH: Dissolved Organic Carbon
DOC (mg/L)
Initial pH
Dissolved Organic Carbon (mg/L)

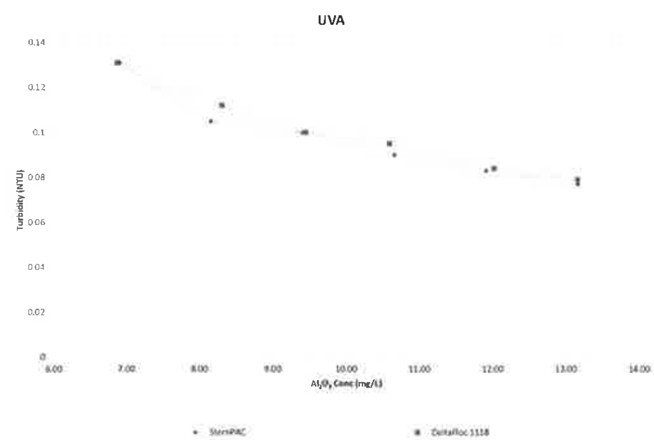


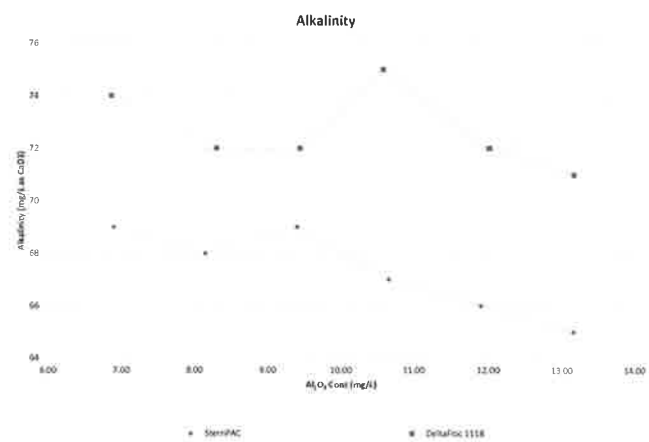
DeltaFloc OP-pH: Total Organic Carbon
TOC (mg/L)
Initial pH
Total Organic Carbon (mg/L)

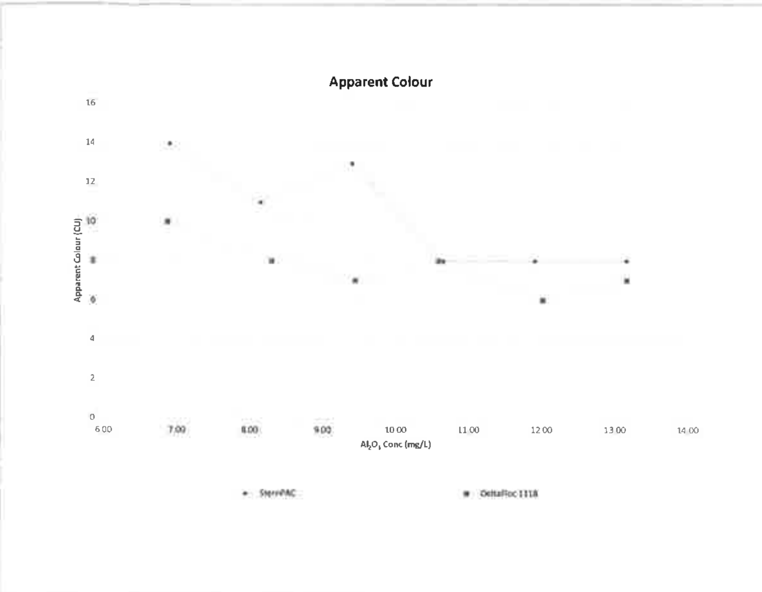
4. Optimum Coagulant Dose Jar Test

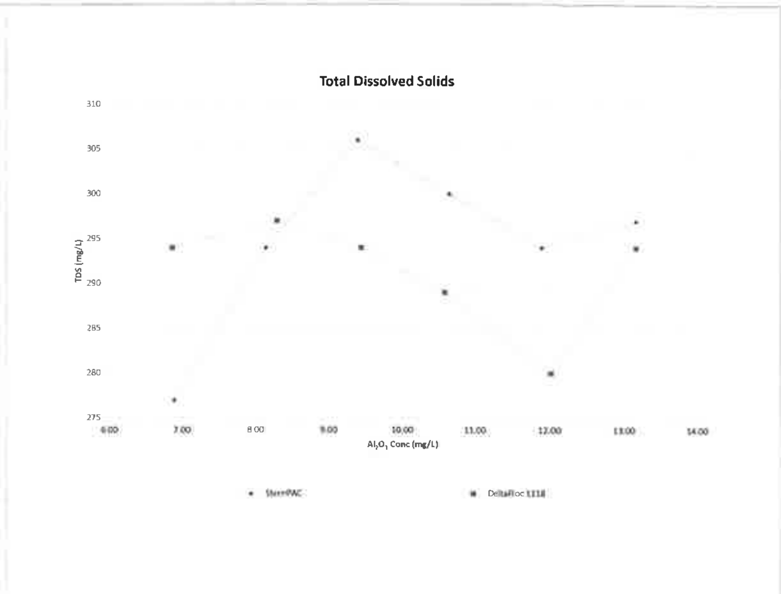


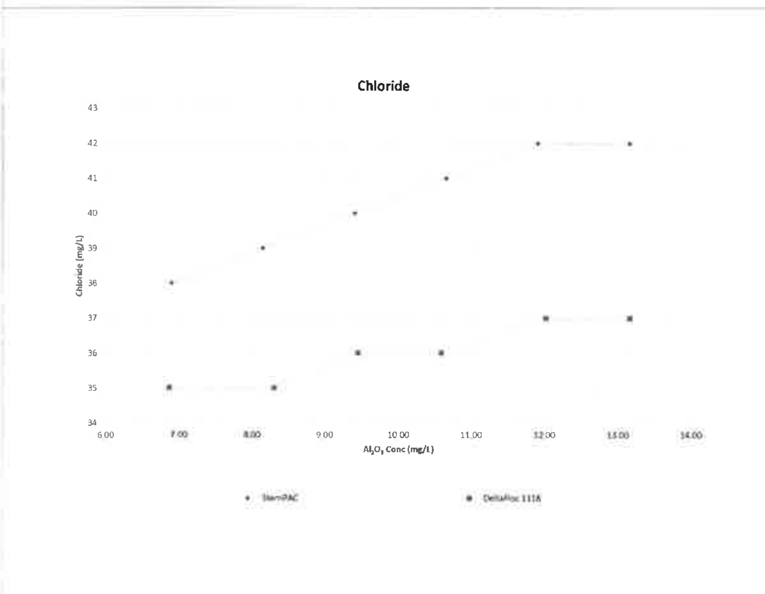


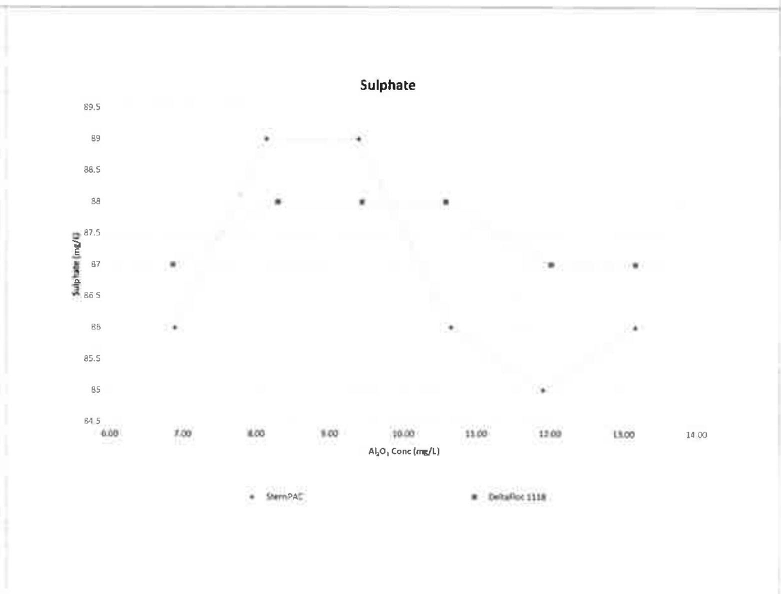


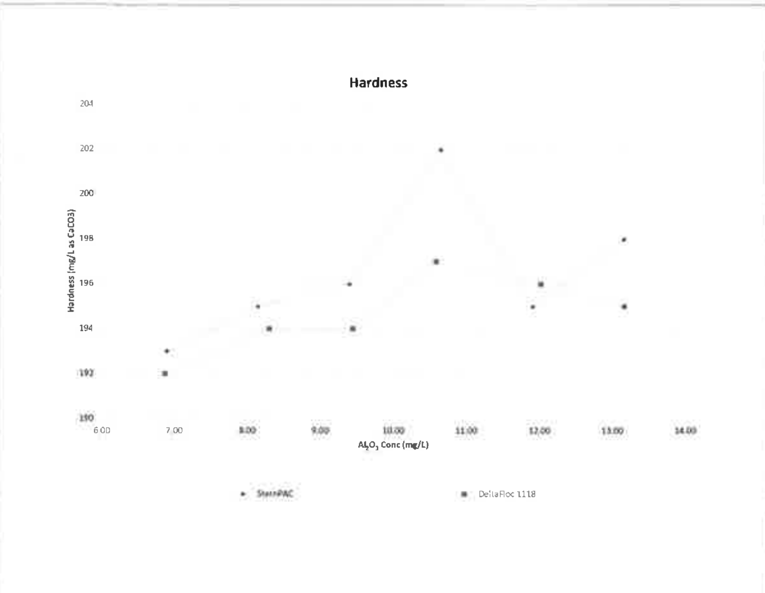


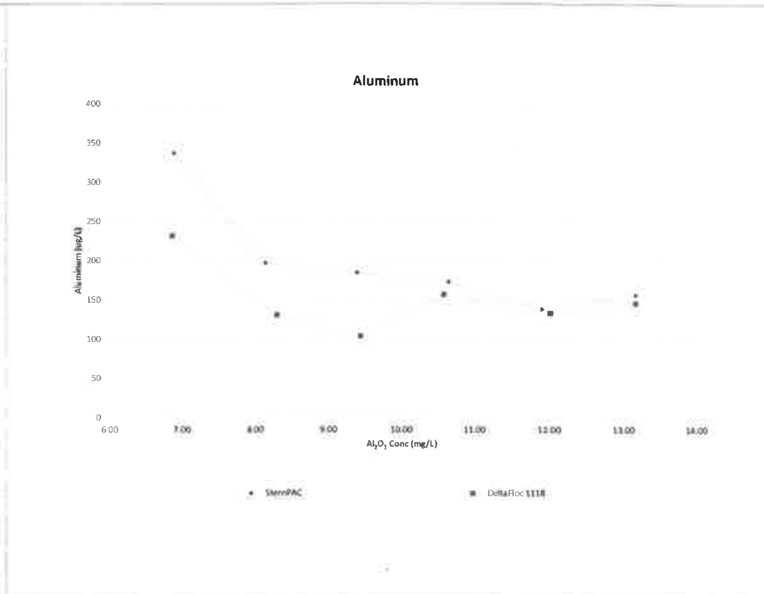

Apparent Colour
Apparent Colour (CU)
Al2O3 Conc (mg/L)
SternPAC
DeltaFloc 1118

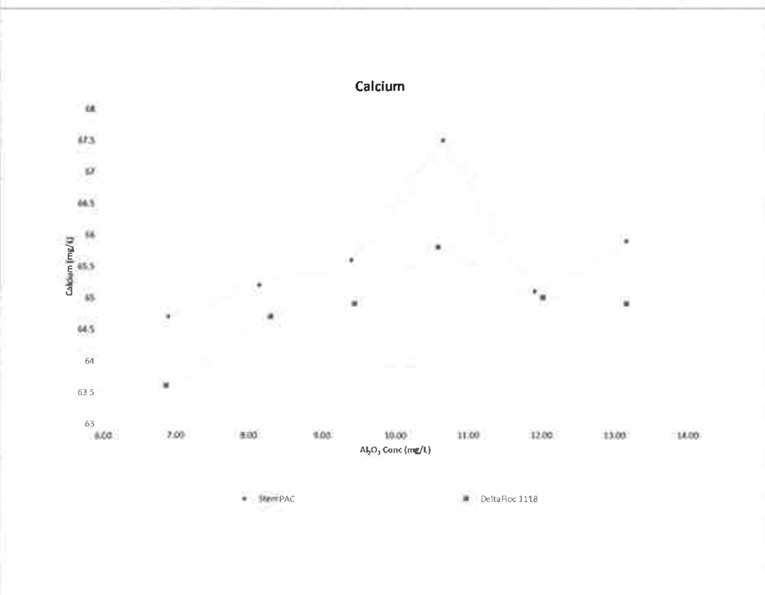

Total Dissolved Solids
TDS (mg/L)
Al2O3 Conc (mg/L)
SternPAC
DeltaFloc 1118

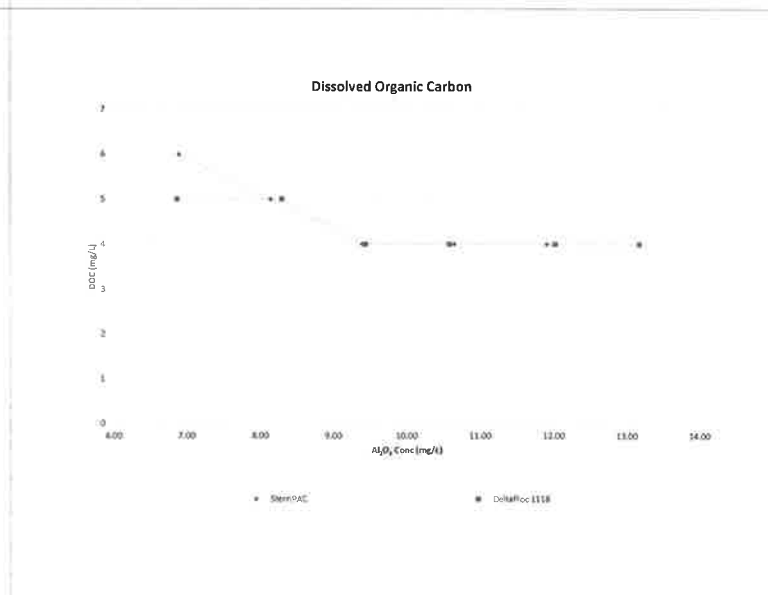

Chloride
Chloride (mg/L)
Al2O3 Conc (mg/L)
SternPAC
DeltaFloc 1118

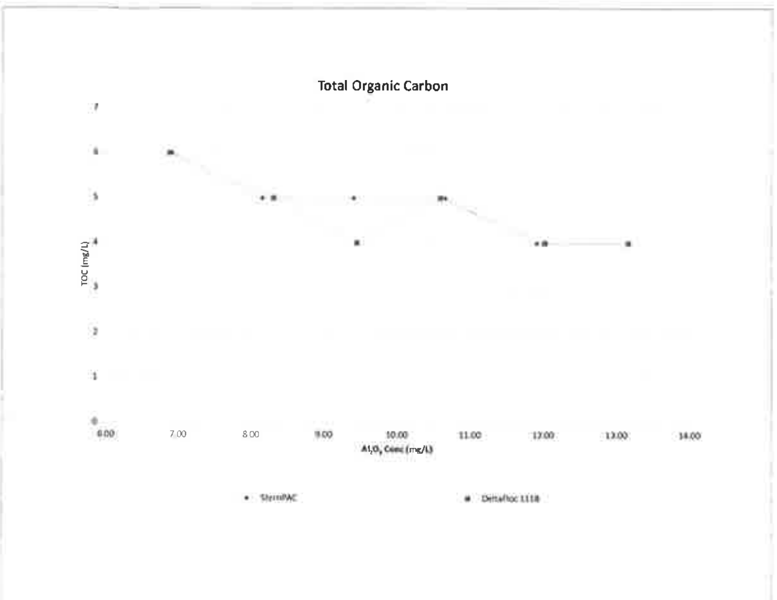

Sulphate
Sulphate (mg/L)
Al2O3 Conc (mg/L)
SternPAC
DeltaFloc 1118


Hardness
Hardness (mg/L as CaCO3)
204
202
200
198
196
194
192
190
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
Al2O3 Conc (mg/L)
SternPAC
DeltaFloc 1118


Aluminum
Aluminum (ug/L)
400
350
300
250
200
150
100
50
0
6.00
7.00
8.00
9.00
10.00
11.00
11.00
13.00
14.00
Al2O3 Conc (mg/L)
SternPAC
DeltaFloc 1118


Calcium
Calcium (mg/L)
68
67.5
67
66.5
66
65.5
65
64.5
64
63.5
63
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
Al2O3 Conc (mg/L)
SternPAC
DeltaFloc 1118


Dissolved Organic Carbon
DOC (mg/L)
7
6
5
4
3
2
1
0
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
Al2O3 Conc (mg/L)
SternPAC
DeltaFloc 1118


Total Organic Carbon
TOC (mg/L)
0
1
2
3
4
5
6
7
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
Al_2O_3 Conc (mg/L)