Appendix # B
to
Report # WWW2017-007

**MEMORANDUM**

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**Date:** June 23, 2016

**To:** Shelley Durham. City of Kawartha Lakes

**From:** Mazahir Alidina, Maika Pellegrino. WSP

**Project No.:** 161-15613

**Location:** Lindsay Water Treatment Plant

**Subject:** Coagulant Testing for the Lindsay Water Treatment Plant

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# 1. Introduction

The Lindsay Water Treatment Plan is a conventional (full) 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. Operational and raw water parameters provided by the Plant staff are summarized in Table 1 Plant Operational and Raw Water Parameters.

**Table 1 Plant Operational and Raw Water Parameters**

| Parameter | Value | | Comments |
|---|---|---|---|
| | | | |
| Flow Rate | 80-185 | L/s | |
| Surface Area Clarifier | 21 | $m^2$ | From Drawing S-103 (4595 x 4595) $mm^2$ |
| Surface loading rate (rise rate) | 31.7 | m/hr | (185 L/s)/21 $m^2$ |
| | | | |
| ***Hydraulic Contact Time*** | | | |
| Coagulation tank | In-line | | Flash Mixers are used |
| Injection Tank | 2 | min | |
| Maturation Tank | 8 | min | |
| Settling Tank | 15 | min | |
| | | | |
| ***Operational Parameters*** | | | |
| Polymer in Use | LT22S | | Cationic in nature |
| Polymer Dose | 0.03 | mg/L | |
| SternPAC (Coagulant) Dose | 85 | mg/L | |
| $CO_2$ (pH suppression) Dose | | | |
| Microsand Dose | 20 | mL/1000 mL | |
| Alum (Coagulant) Dose | 120 - 180 | Mg/L | |
| Actiflo® Influent pH range | 6.8 - 7.0 | | |
| | | | |
| ***Raw Water Characteristics*** | | | |
| Raw water pH range | 7.5 – 8.0 | | |
| Raw water Turbidity | 1.5 – 2.0 | NTU | |
| Raw water Alkalinity | 160 - 190 | mg/L | |
| Raw water Hardness | 170 - 300 | mg/L | |
| Raw water Colour | 20 – 30 | TCU | |
| Raw water UVT | 50–Hi 60s | | |

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# 2. Objectives

WSP was retained by The City of Kawartha Lakes to explore optimum coagulants for the Lindsay Water Treatment Plant during Raw Water cold temperature conditions.

The aim of the jar test was to simulate a full scale ACTIFLO® process in order to determine alternative coagulants for cold water use. The jar test simulates 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.

The coagulants to be tested were to be compatible with the following:

- Source water characteristics.
- Other treatment chemicals used at the Plant
- Water characteristics in clearwells
- Water characteristics in the distribution system

Suppliers who were contacted to provide coagulant samples were informed that the coagulants to be provided should meet the above criteria.

# 3. Methodology

## 3.1 Coagulants to be tested

WSP contacted several suppliers for samples of coagulants to use in the jar testing. A total of ten (10) coagulant samples were received from four (4) suppliers as outlined in Appendix 1. Suppliers were asked to provide data for optimum pH range, basicity, typical dose, concentration of $Al_2O_3$ and confirmation that the product met ANSI/NSF standard 60 and all Ontario regulations. Input was obtained from the City during the kick-off meeting regarding any previous experience with any of the procured coagulants as well as any operational issues perceived with use of any of the coagulants. The following is a summary of factors considered in shortlisting the coagulants selected for testing:

- The City currently uses SternPAC and this was to be one of the coagulants to be tested.
- The RFQ indicated that DelPAC 2020 would be one of the tested coagulants
- PAX-18 was used previously by the plant and had led to red water issues, and was hence excluded from further consideration.
- WC 620 Polydadmac, WC 530 Polyamine & WC 585 Polyamine were polymeric coagulants that required much lower dosage. Current plant equipment did not allow dosing at such low rates and these coagulants were hence excluded from further consideration.
- Insufficient information was provided by the supplier of Magnasol 4000G to qualify it.
- PAX-XL50 & PAX-XL-54 were similar in composition and hence only one of these was selected (PAX-XL50)
- DeltaFloc 1118 & DeltaFloc 1123 were similar in composition and hence only one of these was selected (DeltaFloc 1118)

The coagulant dose tested was calculated based on the actual average dose of SternPAC currently used at the plant. The specific doses of the coagulants varied in order to have the $Al_2O_3$ content proportional and allow a direct comparison based on $Al_2O_3$ dose.

### 3.2 Jar Testing Procedure

The jar testing was carried out in accordance with the industry standard "Actiflo® Jar Testing Procedure" (Appendix 2). Since insufficient washed microsand was available for use, the jar testing was carried out over the course of two days: April 28, 2016 and April 29, 2016. The test was 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) 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 micro-sand was laid out to dry overnight and stored in a plastic jar.

Raw water was collected from the raw water sampling tap located after the screens to the plant (Figure 2). Four (4) 18L pails were filled with water on the morning of April 28, 2016. The raw water temperature, pH and turbidity as read from the on-line meters during collection were as follows:

- Temperature: 12.1$^{0}$C
- pH: 8.03
- Turbidity: 0.83

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 calculated to be approximately: 0.003 kg/L (3000 mg/L). The polymer dose in the Actiflo® was calculated for April 27, 2016 to be 0.54 mg/L.

**Figure 2 Raw Water Sampling Location**

## 3.3 pH Control

It was initially anticipated that the pH of the raw water would need to be adjusted to an optimum theoretical pH (as provided by the manufacturer). It was envisioned that the minimum and maximum doses would be adjusted for pH by recording the volume of acid or caustic required to bring the pH of solution into the optimum pH range by conducting a small scale titration. Amounts to be added to intermediate coagulant doses would then be interpolated.

Upon review of the technical product information for each of the products, it was noted that the optimum pH ranges for all the products lied between the range of 6 – 8. Since the raw water pH range supplied by the Plant was 7.5 – 8, it was noted that all the tested coagulants operate optimally at the raw water pH and pH adjustment was hence not required.

## 3.4 Temperature Control

Ambient temperature in the lab was around 20$^0$C. In order to maintain the tested water at a temperature below 12$^0$C, water was stored in the refrigerator/freezer before testing (Figure 3). Ice packs were placed within the jars during the course of the test to prevent temperature rise above 12$^0$C while the test was ongoing.

Due to space constraints only one pail could be stored in the refrigerator in the laboratory. The remaining three (3) pails of raw water were stored outside the water treatment plant. Ambient temperatures for Lindsay on the two days of the jar test are as follows:

- April 28, 2016: High: 10$^0$C, Low: -4$^0$C
- April 29, 2016: High: 13$^0$C, Low: -2$^0$C

Since the target was to carry out the jar test at temperatures below $12^0$C, storing the pails outside the water was deemed acceptable.

**Figure 3 Raw Water Storage During Jar Testing**

## 3.5 Jar Testing

Readings for the raw water pH, temperature, turbidity and UV absorbance were recorded. 2L of raw water was transferred into each of the square jars using a 1L measuring cylinder. The paddles were set a few centimetres from the bottom of the jars.

The respective coagulant to be tested was diluted in a ratio of 1:100 using a volumetric flask and transferred to a plastic bottle. The neat polymer was also diluted in a ratio of 1:100 using a volumetric flask and transferred to a plastic bottle. Each of these dilutions were prepared right before beginning the jar test. The required amount of coagulant to be added to jars 1 – 6 was measured using a micropipette and transferred to a glass vial. The amount of polymer to be added to each jar was divided equally into two glass vials. The amount of microsand to be transferred into each jar was placed into a plastic weigh boat in preparation for the beginning of the test.

The jar test apparatus was switched on and set to 150 ± 5 rpm. The coagulant was added to each of the jars and the timing started. At 2:40 mins the microsand followed by 50% of the polymer was added to each of the jars. At 5:20 mins, the remaining 50% of polymer was added to each of the jars. After 6 mins of maturation time, the stirring was stopped at 13:20 mins and the water was allowed to settle for 4 mins. At 17:20 mins, the supernatant from each of the jars were extracted using the tap for laboratory analysis and bottling for external analysis. Samples were kept cold before delivery to the lab. Images taken during jar testing of one of the coagulants are presented in Figure 4 below.

**Figure 4 Time Lapse of Jar Test for one coagulant**

The water quality parameters tested are summarized in Table 2 below:

**Table 2 Water Quality Parameters Tested**

| WSP (In Lab) | Commercial Lab |
|---|---|
| pH | Alkalinity |
| Temperature | Apparent Colour |
| Turbidity | True Colour |
| UVA | Residual Aluminum |
| | Total Hardness |
| | Calcium Hardness |
| | DOC |
| | TOC |

# 4. Results

## 4.1 Raw Water

The raw water quality results are summarized in Table 3 below.

**Table 3 Raw Water Quality Parameters**

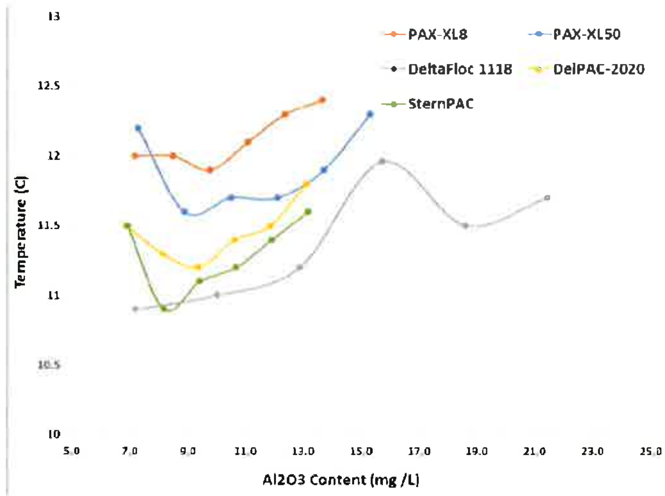
| Parameter | Value | Unit |
|---|---|---|
| pH | 8.09 | |
| Temperature | 10.28 | (°C) |
| Turbidity | 1.38 | (NTU) |
| UVA | 0.22 | |
| DOC | 7.4 | mg/L |
| TOC | 7.8 | mg/L |
| Alkalinity | 177 | (mg CaCO3/L) |
| True colour | 20 | |
| Apparent Colour | 38 | |
| Calcium Hardness | 73.6 | mg/L |
| Total Hardness | 220 | mg/L |
| Residual Aluminum | 7.4 | ug/L |

## 4.2 Jar Test Results

Lab results from SGS Canada Inc. and data sheets summarizing the jar test results for each of the coagulants are included in Appendix 3. Graphs illustrating performance of each of the coagulants with regards to the different water quality parameters are included in Appendix 4.

The water temperature was measured in samples from each of the jars following completion of a test. It was noted that the final water temperature was always below 12.5$^0$C as noted in Figure 5. This indicates that the objective of conducting the test at cold temperature was achieved. However since the jar test was carried out at the upper end of the cold water range, the results may not be the same at extreme cold water temperatures (2 - 4$^0$C).

**Figure 5 Water Temperatures following jar tests**




With increasing dose of SternPAC, DelPAC-2020 and PAX-XL50, the pH of the water was noted to decrease slightly (Appendix 4). The pH did not appear to change significantly with an increase in dosage of DeltaFloc-1118. It was unclear why the pH increased with increasing dose of PAX-XL8.

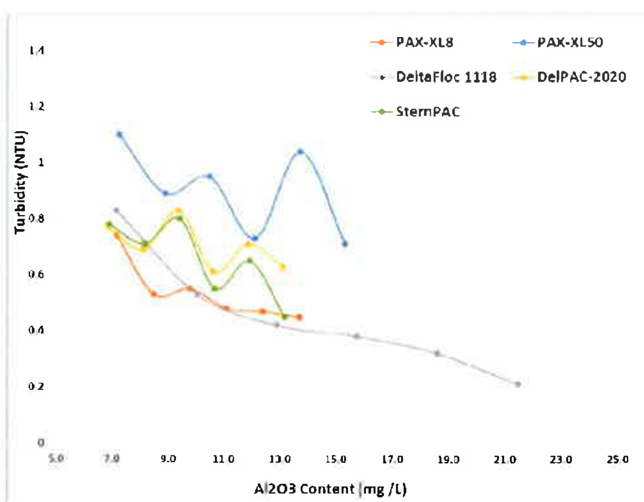
There were no identifiable trends in change of alkalinity, calcium hardness and total hardness between the coagulants tested (Appendix 4).

Apparent colour and true colour were both noted to decrease with increasing dose for all coagulants tested (Appendix 4). SternPAC and PAX-XL50 appeared to perform slightly better with regards to True colour removal, while DeltaFloc-1118 and SternPAC seemed to perform better with regards to Apparent colour removal.

UV absorbance, dissolved organic carbon and total organic carbon all decreased with increased coagulant dose (Appendix 4). Overall, all the coagulants performed very similar in regards to removal of these parameters. There appeared to be slightly better performance of SternPAC and PAX-XL50 regarding removal of total and dissolved organic carbon, and SternPAC and DeltaFloc-1118 regarding UVA. The differences noted between the coagulants however do not seem to be significant.

Turbidity was also noted to decrease with increasing coagulant dose as illustrated in Figure 6. PAX-XL50 exhibited significantly less turbidity removal than the other coagulants. PAX-XL8 and DeltaFloc-1118 exhibited slightly better turbidity removal than DelPAC-2020 and SternPAC.

**Figure 6 Jar Test results for Turbidity**



The aluminum residual was noted to be lowest with use of DeltaFloc-1118 as a coagulant (Appendix 4). The remaining coagulants resulted in similar residual aluminum generation.

# 5. Chemical Costs

The City of Kawartha Lakes issued a Request for Information (2016-46-RFI) seeking input from the suppliers of the five chemicals on estimated costs based on the 2015 consumption quantity of polyaluminum chloride of 630,000 kg. A summary of the responses received from the suppliers is presented in Table 4 below.

**Table 4 Summary of Chemical Costs**

| Chemical | Supplier | Proposed Consumption (kg) | Cost |
|---|---|---|---|
| SternPAC | Kemira | 630,000 | $277,000 |
| PAX-XL8 | Kemira | 620,000 | $297,000 |
| PAX-XL50 | Kemira | 510,000 | $250,000 |
| DelPAC 2020 | Control Chem | - | $300,000 |
| DeltaFloc-1118 | Control Chem | - | $300,000 |

# 6. Conclusion

Based on the results, the following conclusions are drawn:

- PAX-XL50 exhibited significantly lower turbidity removal compared to the other coagulants. Since turbidity is a critical parameter for water quality, PAX-XL50 is not recommended for further testing.
- PAX-XL8 resulted in an increase in pH with increasing dose. An increase in pH could result in increased scaling and PAX-XL8 is hence not recommended for further testing.
- Whereas the performance of DeltaFloc-1118 and DelPAC 2020 were noted to be similar for several parameters, DeltaFloc-1118 yielded better results compared to DelPAC 2020 for turbidity, apparent colour and aluminum. DelPAC 2020 is hence not recommended for further consideration.

Other than SternPAC which is currently used at the plant, the only other coagulant tested which may be considered further is DeltaFloc-1118. Under the conditions investigated in the current jar test, the results suggest that there is no obvious benefit in switching from SternPAC to DeltaFloc-1118.

It should be noted however that the jar test was carried out at a temperature between 11 and 12.5$^0$C, so the results obtained are valid at this temperature. Since the same results may not hold true at extremely low temperatures, it is recommended that SternPAC and DeltaFloc-1118 be tested further at a temperature of 2 - 4$^0$C, to investigate if DeltaFloc-1118 exhibits superior performance compared to SternPAC.

In the absence of any additional jar tests, since the plant is currently using SternPAC (and the staff are knowledgeable with its handling and use), our recommendation is that the Lindsay Water Treatment plant continue using SternPAC as the cold water coagulant.

Based on the cost estimates received from the chemical suppliers, DeltaFloc-1118 is more expensive than SternPAC. A switch in coagulant to DeltaFloc-1118 would hence imply a higher cost to the City. On the other hand, DeltaFloc-1118 consumed less alkalinity and resulted in a more stable pH, which could result in a lower consumption of carbon dioxide. The current results cannot hence determine the overall cost implication of switching coagulants. If the results for DeltaFloc-1118 are significantly better than SternPAC when re-tested at the extreme cold temperatures however, an increase in cost associated with a switch to DeltaFloc-1118 may be justified.

It is recommended that when SternPAC and DeltaFloc-1118 are re-tested at cold temperatures, the following additional parameters are included in the analysis to assess for corrosivity: chloride, sulphate and total dissolved solids (TDS). This will allow the calculation of the following corrosion indexes: Larsons-Skold Index, Langelier Index, Chloride to Sulphate Mass Ratio (CSMR) and their comparison with the full scale results. Additionally, before any change in coagulant is implemented, we recommend that an evaluation be carried out to highlight the effect of the change in coagulant on downstream processes.

Considering the current average dose of 80-85 mg/L SternPAC used at the plant (corresponding to an equivalent dose of 10 – 10.7 mg/L $Al_2O_3$), the dosage appears to be optimal. However, whether SternPAC continues to be used as the cold water coagulant or DeltaFloc-1118 is recommended to be adopted as an alternate coagulant, we recommend that an optimization jar test study be conducted to review the microsand dose, determine the optimum polymer dose and optimum pH since the current dosing ranges for these inputs do not seem to be optimized.

# Appendix 1

# Coagulant Options

## Lindsay Water Treatment Plant Jar Testing for Alternative Coagulants

| To be Tested | Name of Chemical | Constituent | Conc. Of Chemical | Supplier | Optimum pH Range | Basicity | Typical Dose | Conc. Of Al2O3 | ANSI/NSF Standard 60 certified and meets all Ontario Regulations (Y/N) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Y | DelPAC 2020 | Aluminum Chloride Hydroxide Sulfate Solution | - | ControlChem Canada Ltd. | 6 - 8 | 70% | 90% SternPAC - depending on raw water | 10.50% | Y | RFQ indicated DelPAC 2020 to be tested |
| Y | Delta-Floc 1118 | Aluminum Chloride Hydroxide, Aluminum chlorohydrate | - | ControlChem Canada Ltd. | 6 - 8 | 83% | 40% SternPAC - depending on raw water | 22% | Y | Selected for Testing |
| N | Delta-Floc 1123 | Aluminum Chloride Hydroxide Sulfate Solution, Blend | - | ControlChem Canada Ltd. | 6 - 8 | 78% | 40% SternPAC - depending on raw water | 16.70% | Y | Similar to Delta-Floc 1118 which was selected |
| Y | PAX-XL8 | Aluminum Chloride Hydroxide Sulfate | 30-35% | Kemira | 5.5 - 8 | 65 - 70 | - | 10.5 | Y | Selected for Testing |
| Y | PAX-XL50 | Aluminum Chloride Hydroxide Sulfate | 33-40% | Kemira | 5.5 - 8 | 60 | - | 13 | Y | Selected for Testing |
| N | PAX-XL54 | Aluminum Chloride Hydroxide Sulfate | 40-43% | Kemira | 5.5 - 8 | 75 | - | 19 | Y | Similar to PAX-XL50 which was selected |
| N | PAX-18 | Polyaluminum Chloride | 30-40% | Kemira | 5.5 - 8 | 42 | - | 17 | Y | Previous Red water issues when used at plant |
| Y | SternPAC | Polyaluminum Chloride | - | Kemira (From Plant Supply) | 5.5 - 8 | 50 | - | 10.4 | Y | SternPAC currently used & to be tested |
| N | WC 620 Polydadmac | Diallyldimethylammonium chloride homopolymer | - | Wescor | 6 - 9 | - | 0.7 - 5 ppm | - | Y | Plant does not have correct sized pumps to dose small qtys |
| N | WC 530 - Polyamine | Epichlorohydrin amine condensates polymer solution | - | Wescor | 6 - 9 | - | 0.5 - 3 ppm | - | Y | Plant does not have correct sized pumps to dose small qtys |
| N | WC 585 - polyamine | Epichlorohydrin amine condensates polymer solution | - | Wescor | 6 - 9 | - | 0.5 - 3 ppm | - | Y | Plant does not have correct sized pumps to dose small qtys |
| N | Magnasol 4000 G | Aluminum Salt | - | Canada Colors & Chemicals | - | - | - | - | - | Insufficient Information provided to make a decision |

# Appendix 2

# 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.

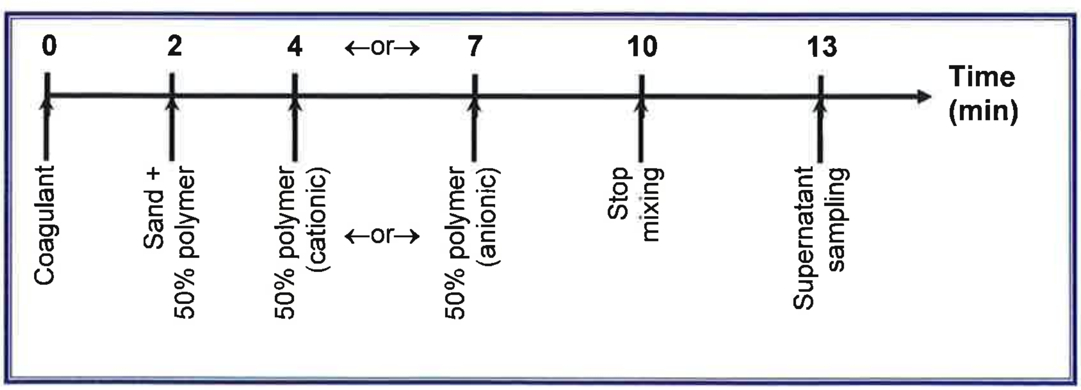
Measure the clarified water parameters important for the test objectives.

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

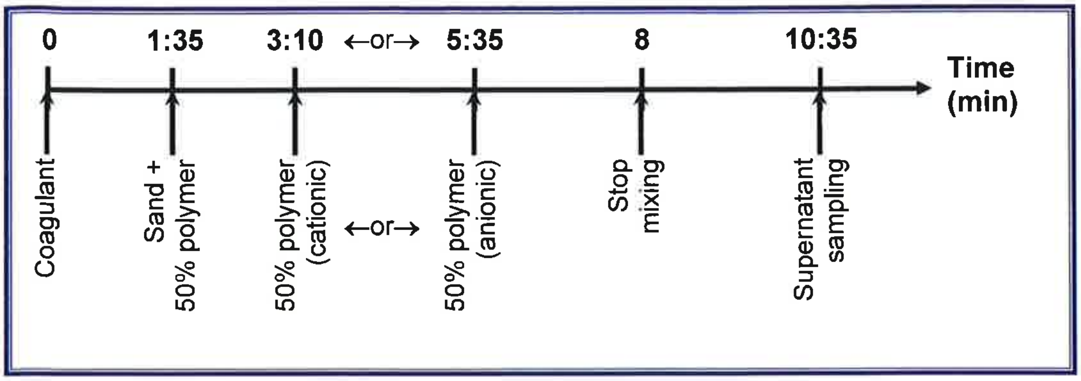
## TIMELINE FOR SELECTED RISE RATES

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

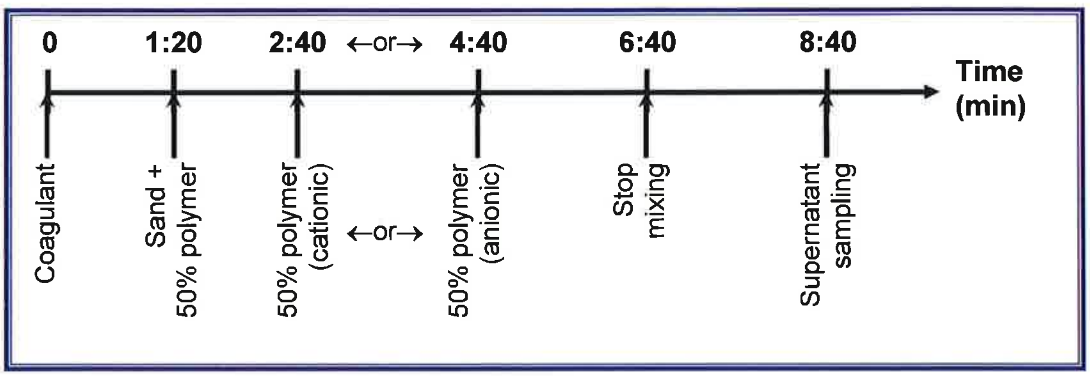
***40 m/h***



***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 3

# Result Data Sheets

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

10-May-2016

**City of Kawartha Lakes (Lindsay DWS)**
Attn : Rob Gamache

12 Peel Street
Lindsay, ON
K9V 3L8, Canada

Phone: 705-324-9411 Ext 1141
Fax:705-328-3054

**Date Rec. :** 29 April 2016
**LR Report:** **CA14580-APR16**

**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 | 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 | | --- | 29-Apr-16 | 02-May-16 | 02-May-16 | 03-May-16 | 03-May-16 | 03-May-16 | 29-Apr-16 | 29-Apr-16 |
| 2: Analysis Start Time | | --- | 21:44 | 15:12 | 13:53 | 09:11 | 09:11 | 07:48 | 22:19 | 22:19 |
| 3: Analysis Approval Date | | --- | 06-May-16 | 03-May-16 | 02-May-16 | 04-May-16 | 04-May-16 | 04-May-16 | 10-May-16 | 10-May-16 |
| 4: Analysis Approval Time | | --- | 12:32 | 11:29 | 15:25 | 10:18 | 10:18 | 10:19 | 13:05 | 13:05 |
| 7: AO/OG | | --- | 30-500 | 5 | | 80-100 | 100 | --- | 5 | --- |
| 8: MDL | | --- | 2 | 3 | | 0.05 | 0.3 | 0.01 | 0.2 | 0.2 |
| 9: NR DP-2020-T1 | 29-Apr-16 | 11.0 | 181 | 10 | 20 | 211 | 289 | 70.2 | 6.2 | 6.0 |
| 10: NR DP-2020-T2 | 29-Apr-16 | 11.0 | 180 | 9 | 18 | 215 | 257 | 71.3 | 5.0 | 5.6 |
| 11: NR DP-2020-T3 | 29-Apr-16 | 11.0 | 178 | 8 | 16 | 209 | 368 | 68.8 | 4.8 | 5.4 |
| 12: NR DP-2020-T4 | 29-Apr-16 | 11.0 | 178 | 8 | 16 | 213 | 267 | 70.6 | 5.4 | 5.8 |
| 13: NR DP-2020-T5 | 29-Apr-16 | 11.0 | 172 | 10 | 13 | 206 | 304 | 67.7 | 5.1 | 5.0 |
| 14: NR DP-2020-T6 | 29-Apr-16 | 11.0 | 172 | 7 | 12 | 218 | 231 | 72.6 | 5.1 | 5.1 |
| 15: NR PAX-XL50-T1 | 28-Apr-16 | 11.0 | 177 | 11 | 20 | 211 | 313 | 69.3 | 6.3 | 6.0 |
| 16: NR PAX-XL50-T2 | 28-Apr-16 | 11.0 | 185 | 9 | 18 | 213 | 296 | 70.9 | 5.1 | 6.0 |
| 17: NR PAX-XL50-T3 | 28-Apr-16 | 11.0 | 175 | 8 | 17 | 209 | 394 | 68.7 | 5.0 | 5.7 |
| 18: NR PAX-XL50-T4 | 28-Apr-16 | 11.0 | 172 | 7 | 17 | 217 | 286 | 72.2 | 4.9 | 5.5 |
| 19: NR PAX-XL50-T5 | 28-Apr-16 | 11.0 | 177 | 7 | 13 | 217 | 307 | 71.2 | 4.8 | 4.8 |
| 20: NR PAX-XL50-T6 | 28-Apr-16 | 11.0 | 180 | 6 | 12 | 213 | 250 | 70.5 | 4.1 | 4.4 |
| 21: NR SPAC-T1 | 29-Apr-16 | 11.0 | 177 | 11 | 21 | 214 | 301 | 71.3 | 5.7 | 5.9 |

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**Works #:** 220000175

**LR Report :** CA14580-APR16

| Sample ID | Sample Date & Time | Temperature Upon Receipt °C | Alkalinity mg/L as CaCO3 | Colour TCU | Apparent Colour CU | Hardness mg/L as CaCO3 | Aluminum ug/L | Calcium mg/L | Dissolved Organic Carbon mg/L | Total Organic Carbon mg/L |
|---|---|---|---|---|---|---|---|---|---|---|
| 22: NR SPAC-T2 | 29-Apr-16 | 11.0 | 190 | 9 | 18 | 215 | 266 | 71.5 | 5.4 | 5.9 |
| 23: NR SPAC-T3 | 29-Apr-16 | 11.0 | 177 | 10 | 17 | 216 | 393 | 71.7 | 5.6 | 5.6 |
| 24: NR SPAC-T4 | 29-Apr-16 | 11.0 | 188 | 8 | 14 | 213 | 196 | 70.0 | 5.0 | 5.0 |
| 25: NR SPAC-T5 | 29-Apr-16 | 11.0 | 167 | 8 | 15 | 213 | 247 | 70.3 | 4.7 | 5.2 |
| 26: NR SPAC-T6 | 29-Apr-16 | 11.0 | 173 | 7 | 12 | 211 | 224 | 69.6 | 5.2 | 4.8 |
| 27: NR DF1118-T1 | 29-Apr-16 | 11.0 | 182 | 14 | 23 | 213 | 211 | 70.1 | 5.7 | 6.0 |
| 28: NR DF1118-T2 | 29-Apr-16 | 11.0 | 181 | 8 | 14 | 209 | 83.1 | 69.2 | 5.4 | 6.0 |
| 29: NR DF1118-T3 | 29-Apr-16 | 11.0 | 187 | 9 | 10 | 210 | 65.8 | 69.4 | 5.0 | 5.0 |
| 30: NR DF1118-T4 | 29-Apr-16 | 11.0 | 182 | 8 | 9 | 212 | 77.2 | 70.2 | 4.6 | 4.6 |
| 31: NR DF1118-T5 | 29-Apr-16 | 11.0 | 190 | 6 | 7 | 214 | 50.8 | 71.4 | 3.8 | 4.2 |
| 32: NR DF1118-T6 | 29-Apr-16 | 11.0 | 193 | 4 | 6 | 210 | 57.3 | 69.8 | 4.1 | 4.0 |
| 33: NR PAX-XL8-T1 | 28-Apr-16 | 11.0 | 185 | 12 | 22 | 215 | 316 | 71.7 | 5.1 | 6.0 |
| 34: NR PAX-XL8-T2 | 28-Apr-16 | 11.0 | 174 | 10 | 17 | 215 | 250 | 71.1 | 5.5 | 5.4 |
| 35: NR PAX-XL8-T3 | 28-Apr-16 | 11.0 | 203 | 10 | 17 | 210 | 264 | 69.3 | 5.8 | 6.0 |
| 36: NR PAX-XL8-T4 | 28-Apr-16 | 11.0 | 173 | 10 | 15 | 213 | 210 | 70.9 | 5.1 | 5.5 |
| 37: NR PAX-XL8-T5 | 28-Apr-16 | 11.0 | 179 | 9 | 15 | 214 | 235 | 70.6 | 5.7 | 5.7 |
| 38: NR PAX-XL8-T6 | 28-Apr-16 | 11.0 | 175 | 7 | 14 | 210 | 197 | 69.7 | 4.8 | 5.2 |
| 39: NR Raw Water | 29-Apr-16 | 11.0 | 177 | 20 | 38 | 220 | 7.4 | 73.6 | 7.4 | 7.8 |

AO/OG - Aesthetic Objective / Operational Guideline
MDL - SGS Method Detection Limit
NR - Not reportable under applicable Provincial drinking water regulations as per client.

*Patti Stark*
*Project Specialist Environmental Services, Analytical*

OnLine LIMS

0000676074

| Coagulant | Sample | $Al_2O_3$ Dose | pH | Temp. (°C) | Turbidity (NTU) | UVA | Alkalinity mg/L as CaCO3 | True Colour TCU | Apparent Colour CU | Hardness mg/L as CaCO3 | Aluminum ug/L | Calcium Hardness mg/L | Dissolved Organic Carbon mg/L | Total Organic Carbon mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PAX-XL8 | *NR PAX-XL8-T1* | 7.16 | 7.41 | 12 | 0.74 | 0.161 | 185 | 12 | 22 | 215 | 316 | 71.7 | 5.1 | 6 |
| | *NR PAX-XL8-T2* | 8.46 | 7.55 | 12 | 0.53 | 0.137 | 174 | 10 | 17 | 215 | 250 | 71.1 | 5.5 | 5.4 |
| | *NR PAX-XL8-T3* | 9.77 | 7.62 | 11.9 | 0.55 | 0.139 | 203 | 10 | 17 | 210 | 264 | 69.3 | 5.8 | 6 |
| | *NR PAX-XL8-T4* | 11.07 | 7.65 | 12.1 | 0.46 | 0.126 | 173 | 10 | 15 | 213 | 210 | 70.9 | 5.1 | 5.5 |
| | *NR PAX-XL8-T5* | 12.37 | 7.69 | 12.3 | 0.47 | 0.127 | 179 | 9 | 15 | 214 | 235 | 70.6 | 5.7 | 5.7 |
| | *NR PAX-XL8-T6* | 13.67 | 7.68 | 12.4 | 0.45 | 0.116 | 175 | 7 | 14 | 210 | 197 | 69.7 | 4.8 | 5.2 |
| PAX-XL50 | *NR PAX-XL50-T1* | 7.25 | 8.08 | 12.2 | 1.1 | 0.162 | 177 | 11 | 20 | 211 | 313 | 69.3 | 6.3 | 6 |
| | *NR PAX-XL50-T2* | 8.87 | 8.01 | 11.6 | 0.89 | 0.147 | 185 | 9 | 18 | 213 | 296 | 70.9 | 5.1 | 6 |
| | *NR PAX-XL50-T3* | 10.48 | 7.94 | 11.7 | 0.95 | 0.138 | 175 | 8 | 17 | 209 | 394 | 68.7 | 5 | 5.7 |
| | *NR PAX-XL50-T4* | 12.09 | 7.92 | 11.7 | 0.73 | 0.127 | 172 | 7 | 17 | 217 | 286 | 72.2 | 4.9 | 5.5 |
| | *NR PAX-XL50-T5* | 13.70 | 7.88 | 11.9 | 1.04 | 0.122 | 177 | 7 | 13 | 217 | 307 | 71.2 | 4.8 | 4.8 |
| | *NR PAX-XL50-T6* | 15.31 | 7.8 | 12.3 | 0.71 | 0.108 | 180 | 6 | 12 | 213 | 250 | 70.5 | 4.1 | 4.4 |
| DeltaFloc 1118 | *NR DF1118-T1* | 7.15 | 7.87 | 10.9 | 0.83 | 0.181 | 182 | 14 | 23 | 213 | 211 | 70.1 | 5.7 | 6 |
| | *NR DF1118-T2* | 10.01 | 7.95 | 11 | 0.53 | 0.134 | 181 | 8 | 14 | 209 | 83.1 | 69.2 | 5.4 | 6 |
| | *NR DF1118-T3* | 12.87 | 7.95 | 11.2 | 0.42 | 0.11 | 187 | 9 | 10 | 210 | 65.8 | 69.4 | 5 | 5 |
| | *NR DF1118-T4* | 15.73 | 7.89 | 11.96 | 0.38 | 0.1 | 182 | 8 | 9 | 212 | 77.2 | 70.2 | 4.6 | 4.6 |
| | *NR DF1118-T5* | 18.59 | 7.91 | 11.5 | 0.32 | 0.087 | 190 | 6 | 7 | 214 | 50.8 | 71.4 | 3.8 | 4.2 |
| | *NR DF1118-T6* | 21.45 | 7.88 | 11.7 | 0.21 | 0.075 | 193 | 4 | 6 | 210 | 57.3 | 69.8 | 4.1 | 4 |
| DelPAC-2020 | *NR DP-2020-T1* | 6.86 | 8.09 | 11.5 | 0.77 | 0.156 | 181 | 10 | 20 | 211 | 289 | 70.2 | 6.2 | 6 |
| | *NR DP-2020-T2* | 8.11 | 7.99 | 11.3 | 0.69 | 0.144 | 180 | 9 | 18 | 215 | 257 | 71.3 | 5 | 5.6 |
| | *NR DP-2020-T3* | 9.36 | 7.92 | 11.2 | 0.83 | 0.138 | 178 | 8 | 16 | 209 | 368 | 68.8 | 4.8 | 5.4 |
| | *NR DP-2020-T4* | 10.61 | 7.89 | 11.4 | 0.61 | 0.128 | 178 | 8 | 16 | 213 | 267 | 70.6 | 5.4 | 5.8 |
| | *NR DP-2020-T5* | 11.86 | 7.85 | 11.5 | 0.71 | 0.125 | 172 | 10 | 13 | 206 | 304 | 67.7 | 5.1 | 5 |
| | *NR DP-2020-T6* | 13.10 | 7.79 | 11.8 | 0.63 | 0.113 | 172 | 7 | 12 | 218 | 231 | 72.6 | 5.1 | 5.1 |
| SternPAC | *NR SPAC-T1* | 6.89 | 8.07 | 11.5 | 0.78 | 0.157 | 177 | 11 | 21 | 214 | 301 | 71.3 | 5.7 | 5.9 |
| | *NR SPAC-T2* | 8.15 | 7.93 | 10.9 | 0.71 | 0.147 | 190 | 9 | 18 | 215 | 266 | 71.5 | 5.4 | 5.9 |
| | *NR SPAC-T3* | 9.40 | 7.85 | 11.1 | 0.8 | 0.143 | 177 | 10 | 17 | 216 | 393 | 71.7 | 5.6 | 5.6 |
| | *NR SPAC-T4* | 10.65 | 7.79 | 11.2 | 0.55 | 0.126 | 188 | 8 | 14 | 213 | 196 | 70 | 5 | 5 |
| | *NR SPAC-T5* | 11.91 | 7.75 | 11.4 | 0.65 | 0.123 | 187 | 8 | 15 | 213 | 247 | 70.3 | 4.7 | 5.2 |
| | *NR SPAC-T6* | 13.16 | 7.69 | 11.6 | 0.45 | 0.112 | 173 | 7 | 12 | 211 | 224 | 69.6 | 5.2 | 4.8 |
| | *NR Raw Water* | | 8.09 | 10.28 | 1.58 | 0.22 | 177 | 20 | 38 | 220 | 74 | 73.6 | 7.4 | 7.8 |

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

WSP

| Jar Test Data Sheet | | Source Water: | | |
|---|---|---|---|---|
| Date: | 4/28/2016 | pH | | 7.61 |
| Time: | 12:15 PM | Temperature | (°C) | 9.8 |
| Performed By: | Mazahir Alidina | Turbidity | (NTU) | 1.41 |
| **Coagulant Type:** | **PAX-XL8** | UVA | | 0.227 |
| | | DOC | mg/L | 7.4 |
| | | TOC | mg/L | 7.8 |
| Coagulant Dosage: | 55 to 105 mg/L | Alkalinity | (mg CaCO3/L) | 177 |
| Coagulant Aid Type: | Cationic Polmer | True colour | | 20 |
| Coagulant Aid Dosage: | 0.54 mg/L | Apparent Colour | | 38 |
| Microsand Dose: | 20 g | Calcium Hardness | mg/L | 73.6 |
| Specific Gravity | 1.24 | Total Hardness | mg/L as CaCO3 | 220 |
| Conc. Of Alum ($Al_2O_3$) (%) | 10.50 | Residual Aluminum | ug/L | 7.4 |

| JAR NUMBER | T1 | T2 | T3 | T4 | T5 | T6 |
|---|---|---|---|---|---|---|
| **DOSAGES** | | | | | | |
| Raw Water Volume (mL) | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Coagulant Dose (mg/L) | 55 | 65 | 75 | 85 | 95 | 105 |
| $Al_2O_3$ Conc. (mg/L) | 7.16 | 8.46 | 9.77 | 11.07 | 12.37 | 13.67 |
| Volume of 1:10 diluted Coagulant added (mL) | 0.887 | 1.048 | 1.210 | 1.371 | 1.532 | 1.694 |
| Microsand added (g) | 20 | 20 | 20 | 20 | 20 | 20 |
| Initial Volume of 1:10 diluted Polymer added with microsand (mL) | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 |
| Remaining Volume of 1:10 diluted Polymer added (mL) | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 |
| **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 | 7.41 | 7.55 | 7.62 | 7.65 | 7.69 | 7.68 |
| Temperature (°C) | 12 | 12 | 11.9 | 12.1 | 12.3 | 12.4 |
| Turbidity (NTU) | 0.74 | 0.53 | 0.55 | 0.48 | 0.47 | 0.45 |
| UVA | 0.161 | 0.137 | 0.139 | 0.126 | 0.127 | 0.116 |
| Alkalinity as CaCO3 (mg/L) | 185 | 174 | 203 | 173 | 179 | 175 |
| Colour (TCU) | 12 | 10 | 10 | 10 | 9 | 7 |
| Apparent Colour (CU) | 22 | 17 | 17 | 15 | 15 | 14 |
| Hardness as CaCO3 (mg/L) | 215 | 215 | 210 | 213 | 214 | 210 |
| Aluminum (ug/L) | 316 | 250 | 264 | 210 | 235 | 197 |
| Calcium (mg/L) | 71.7 | 71.1 | 69.3 | 70.9 | 70.6 | 69.7 |
| Dissolved Organic Carbon (mg/L) | 5.1 | 5.5 | 5.8 | 5.1 | 5.7 | 4.8 |
| Total Organic Carbon (mg/L) | 6 | 5.4 | 6 | 5.5 | 5.7 | 5.2 |

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

WSP

| Jar Test Data Sheet | | Source Water: | | |
|---|---|---|---|---|
| Date: | 4/28/2016 | pH | | 7.81 |
| Time: | 2:45 PM | Temperature | (ºC) | 11.4 |
| Performed By: | Mazahir Alidina | Turbidity | (NTU) | 1.41 |
| Coagulant Type: | PAX-XL50 | UVA | | 0.227 |
| | | DOC | mg/L | 7.4 |
| | | TOC | mg/L | 7.8 |
| Coagulant Dosage: | 45 to 95 mg/L | Alkalinity | (mg CaCO3/L) | 177 |
| Coagulant Aid Type: | Cationic Polmer | True colour | | 20 |
| Coagulant Aid Dosage: | 0.54 mg/L | Apparent Colour | | 38 |
| Microsand Dose: | 20 g | Calcium Hardness | mg/L | 73.6 |
| Specific Gravity | 1.24 | Total Hardness | mg/L as CaCO3 | 220 |
| Conc. Of Alum ($Al_2O_3$) (%) | 13.00 | Residual Aluminum | ug/L | 7.4 |

| JAR NUMBER | T1 | T2 | T3 | T4 | T5 | T6 |
|---|---|---|---|---|---|---|
| **DOSAGES** | | | | | | |
| Raw Water Volume (mL) | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Coagulant Dose (mg/L) | 45 | 55 | 65 | 75 | 85 | 95 |
| $Al_2O_3$ Conc. (mg/L) | 7.25 | 8.87 | 10.48 | 12.09 | 13.70 | 15.31 |
| Volume of 1:10 diluted Coagulant added (mL) | 0.726 | 0.887 | 1.048 | 1.210 | 1.371 | 1.532 |
| Microsand added (g) | 20 | 20 | 20 | 20 | 20 | 20 |
| Initial Volume of 1:10 diluted Polymer added with microsand (mL) | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 |
| Remaining Volume of 1:10 diluted Polymer added (mL) | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 |
| **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 | 8.08 | 8.01 | 7.94 | 7.92 | 7.88 | 7.8 |
| Temperature (ºC) | 12.2 | 11.6 | 11.7 | 11.7 | 11.9 | 12.3 |
| Turbidity (NTU) | 1.1 | 0.89 | 0.95 | 0.73 | 1.04 | 0.71 |
| UVA | 0.162 | 0.147 | 0.138 | 0.127 | 0.122 | 0.108 |
| Alkalinity as CaCO3 (mg/L) | 177 | 185 | 175 | 172 | 177 | 180 |
| Colour (TCU) | 11 | 9 | 8 | 7 | 7 | 6 |
| Apparent Colour (CU) | 20 | 18 | 17 | 17 | 13 | 12 |
| Hardness as CaCO3 (mg/L) | 211 | 213 | 209 | 217 | 217 | 213 |
| Aluminum (ug/L) | 313 | 296 | 394 | 286 | 307 | 250 |
| Calcium (mg/L) | 69.3 | 70.9 | 68.7 | 72.2 | 71.2 | 70.5 |
| Dissolved Organic Carbon (mg/L) | 6.3 | 5.1 | 5 | 4.9 | 4.8 | 4.1 |
| Total Organic Carbon (mg/L) | 6 | 6 | 5.7 | 5.5 | 4.8 | 4.4 |

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

WSP

| Jar Test Data Sheet | | Source Water: | | |
|---|---|---|---|---|
| Date: | 4/29/2016 | pH | | 8.4 |
| Time: | 9:20 AM | Temperature | (°C) | 11.2 |
| Performed By: | Mazahir Alidina | Turbidity | (NTU) | 1.25 |
| **Coagulant Type:** | **DeltaFloc-1118** | UVA | | 0.223 |
| | | DOC | mg/L | 7.4 |
| | | TOC | mg/L | 7.8 |
| Coagulant Dosage: | 25 to 75 mg/L | Alkalinity | (mg CaCO3/L) | 177 |
| Coagulant Aid Type: | Cationic Polmer | True colour | | 20 |
| Coagulant Aid Dosage: | 0.54 mg/L | Apparent Colour | | 38 |
| Microsand Dose: | 20 g | Calcium Hardness | mg/L | 73.6 |
| Specific Gravity | 1.3 | Total Hardness | mg/L as CaCO3 | 220 |
| Conc. Of Alum ($Al_2O_3$) (%) | 22.00 | Residual Aluminum | ug/L | 7.4 |

| JAR NUMBER | T1 | T2 | T3 | T4 | T5 | T6 |
|---|---|---|---|---|---|---|
| **DOSAGES** | | | | | | |
| Raw Water Volume (mL) | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Coagulant Dose (mg/L) | 25 | 35 | 45 | 55 | 65 | 75 |
| $Al_2O_3$ Conc. (mg/L) | 7.15 | 10.01 | 12.87 | 15.73 | 18.59 | 21.45 |
| Volume of 1:10 diluted Coagulant added (mL) | 0.385 | 0.538 | 0.692 | 0.846 | 1.000 | 1.154 |
| Microsand added (g) | 20 | 20 | 20 | 20 | 20 | 20 |
| Initial Volume of 1:10 diluted Polymer added with microsand (mL) | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 |
| Remaining Volume of 1:10 diluted Polymer added (mL) | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 |
| **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 | 7.87 | 7.95 | 7.95 | 7.89 | 7.91 | 7.88 |
| Temperature (°C) | 10.9 | 11 | 11.2 | 11.96 | 11.5 | 11.7 |
| Turbidity (NTU) | 0.83 | 0.53 | 0.42 | 0.38 | 0.32 | 0.21 |
| UVA | 0.181 | 0.134 | 0.11 | 0.1 | 0.087 | 0.075 |
| Alkalinity as CaCO3 (mg/L) | 182 | 181 | 187 | 182 | 190 | 193 |
| Colour (TCU) | 14 | 8 | 9 | 8 | 6 | 4 |
| Apparent Colour (CU) | 23 | 14 | 10 | 9 | 7 | 6 |
| Hardness as CaCO3 (mg/L) | 213 | 209 | 210 | 212 | 214 | 210 |
| Aluminum (ug/L) | 211 | 83.1 | 65.8 | 77.2 | 50.8 | 57.3 |
| Calcium (mg/L) | 70.1 | 69.2 | 69.4 | 70.2 | 71.4 | 69.8 |
| Dissolved Organic Carbon (mg/L) | 5.7 | 5.4 | 5 | 4.6 | 3.8 | 4.1 |
| Total Organic Carbon (mg/L) | 6 | 6 | 5 | 4.6 | 4.2 | 4 |

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

WSP

| Jar Test Data Sheet | | Source Water: | | |
|---|---|---|---|---|
| Date: | 4/29/2016 | pH | | 8.31 |
| Time: | 11:20 AM | Temperature | (°C) | 9.5 |
| Performed By: | Mazahir Alidina | Turbidity | (NTU) | 1.41 |
| **Coagulant Type:** | **DelPAC 2020** | UVA | | 0.223 |
| | | DOC | mg/L | 7.4 |
| | | TOC | mg/L | 7.8 |
| Coagulant Dosage: | 55 to 105 mg/L | Alkalinity | (mg CaCO3/L) | 177 |
| Coagulant Aid Type: | Cationic Polmer | True colour | | 20 |
| Coagulant Aid Dosage: | 0.54 mg/L | Apparent Colour | | 38 |
| Microsand Dose: | 20 g | Calcium Hardness | mg/L | 73.6 |
| Specific Gravity | 1.2 | Total Hardness | mg/L as CaCO3 | 220 |
| Conc. Of Alum ($Al_2O_3$) (%) | 10.40 | Residual Aluminum | ug/L | 7.4 |

| JAR NUMBER | T1 | T2 | T3 | T4 | T5 | T6 |
|---|---|---|---|---|---|---|
| **DOSAGES** | | | | | | |
| Raw Water Volume (mL) | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Coagulant Dose (mg/L) | 55 | 65 | 75 | 85 | 95 | 105 |
| $Al_2O_3$ Conc. (mg/L) | 6.86 | 8.11 | 9.36 | 10.61 | 11.86 | 13.10 |
| Volume of 1:10 diluted Coagulant added (mL) | 0.917 | 1.083 | 1.250 | 1.417 | 1.583 | 1.750 |
| Microsand added (g) | 20 | 20 | 20 | 20 | 20 | 20 |
| Initial Volume of 1:10 diluted Polymer added with microsand (mL) | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 |
| Remaining Volume of 1:10 diluted Polymer added (mL) | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 |
| **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 | 8.09 | 7.99 | 7.92 | 7.89 | 7.85 | 7.79 |
| Temperature (°C) | 11.5 | 11.3 | 11.2 | 11.4 | 11.5 | 11.8 |
| Turbidity (NTU) | 0.77 | 0.69 | 0.83 | 0.61 | 0.71 | 0.63 |
| UVA | 0.156 | 0.144 | 0.138 | 0.128 | 0.125 | 0.113 |
| Alkalinity as CaCO3 (mg/L) | 181 | 180 | 178 | 178 | 172 | 172 |
| Colour (TCU) | 10 | 9 | 8 | 8 | 10 | 7 |
| Apparent Colour (CU) | 20 | 18 | 16 | 16 | 13 | 12 |
| Hardness as CaCO3 (mg/L) | 211 | 215 | 209 | 213 | 206 | 218 |
| Aluminum (ug/L) | 289 | 257 | 368 | 267 | 304 | 231 |
| Calcium (mg/L) | 70.2 | 71.3 | 68.8 | 70.6 | 67.7 | 72.6 |
| Dissolved Organic Carbon (mg/L) | 6.2 | 5 | 4.8 | 5.4 | 5.1 | 5.1 |
| Total Organic Carbon (mg/L) | 6 | 5.6 | 5.4 | 5.8 | 5 | 5.1 |

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

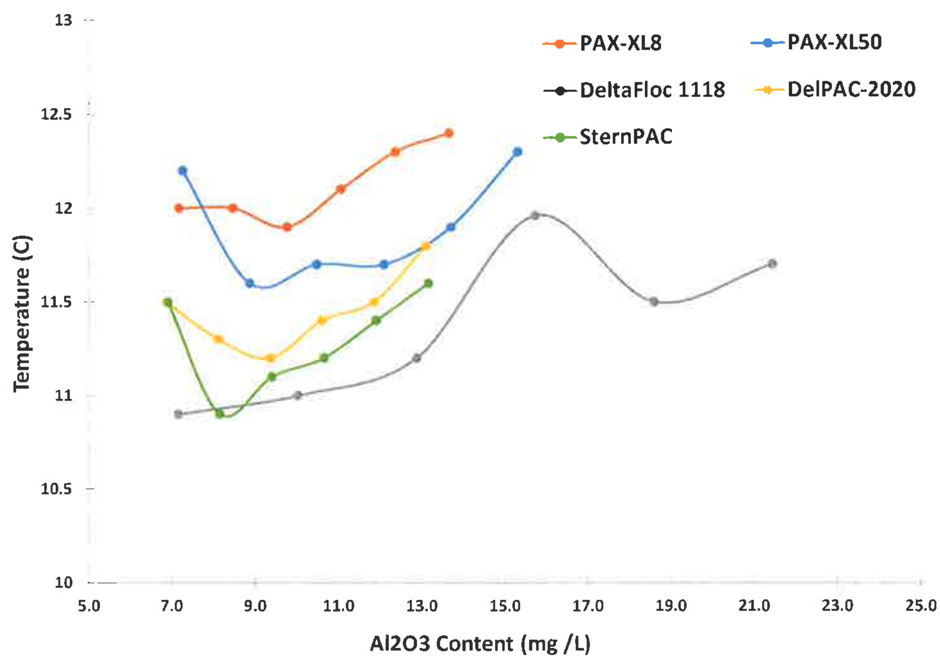
WSP

| Jar Test Data Sheet | | Source Water: | | |
|---|---|---|---|---|
| Date: | 4/29/2016 | pH | | 8.31 |
| Time: | 12:50 PM | Temperature | (°C) | 9.5 |
| Performed By: | Mazahir Alidina | Turbidity | (NTU) | 1.43 |
| **Coagulant Type:** | **SternPAC** | UVA | | 0.224 |
| | | DOC | mg/L | 7.4 |
| | | TOC | mg/L | 7.8 |
| Coagulant Dosage: | 55 to 105 mg/L | Alkalinity | (mg CaCO3/L) | 177 |
| Coagulant Aid Type: | Cationic Polmer | True colour | | 20 |
| Coagulant Aid Dosage: | 0.536 mg/L | Apparent Colour | | 38 |
| Microsand Dose: | 20 g | Calcium Hardness | mg/L | 73.6 |
| Specific Gravity | 1.205 | Total Hardness | mg/L as CaCO3 | 220 |
| Conc. Of Alum ($Al_2O_3$) (%) | 10.40 | Residual Aluminum | ug/L | 7.4 |

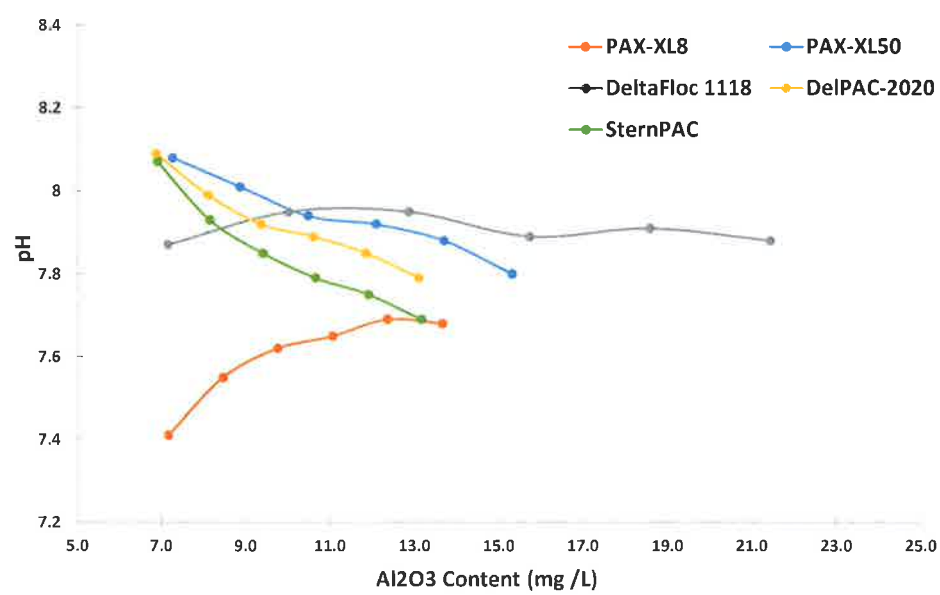
| JAR NUMBER | T1 | T2 | T3 | T4 | T5 | T6 |
|---|---|---|---|---|---|---|
| **DOSAGES** | | | | | | |
| Raw Water Volume (mL) | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Coagulant Dose (mg/L) | 55 | 65 | 75 | 85 | 95 | 105 |
| $Al_2O_3$ Conc. (mg/L) | 6.89 | 8.15 | 9.40 | 10.65 | 11.91 | 13.16 |
| Volume of 1:10 diluted Coagulant added (mL) | 0.913 | 1.079 | 1.245 | 1.411 | 1.577 | 1.743 |
| Microsand added (g) | 20 | 20 | 20 | 20 | 20 | 20 |
| Initial Volume of 1:10 diluted Polymer added with microsand (mL) | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 |
| Remaining Volume of 1:10 diluted Polymer added (mL) | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 | 1.667 |
| **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 | 8.07 | 7.93 | 7.85 | 7.79 | 7.75 | 7.69 |
| Temperature (°C) | 11.5 | 10.9 | 11.1 | 11.2 | 11.4 | 11.6 |
| Turbidity (NTU) | 0.78 | 0.71 | 0.8 | 0.55 | 0.65 | 0.45 |
| UVA | 0.157 | 0.147 | 0.143 | 0.126 | 0.123 | 0.112 |
| Alkalinity as CaCO3 (mg/L) | 177 | 190 | 177 | 188 | 167 | 173 |
| Colour (TCU) | 11 | 9 | 10 | 8 | 8 | 7 |
| Apparent Colour (CU) | 21 | 18 | 17 | 14 | 15 | 12 |
| Hardness as CaCO3 (mg/L) | 214 | 215 | 216 | 213 | 213 | 211 |
| Aluminum (ug/L) | 301 | 266 | 393 | 196 | 247 | 224 |
| Calcium (mg/L) | 71.3 | 71.5 | 71.7 | 70 | 70.3 | 69.6 |
| Dissolved Organic Carbon (mg/L) | 5.7 | 5.4 | 5.6 | 5 | 4.7 | 5.2 |
| Total Organic Carbon (mg/L) | 5.9 | 5.9 | 5.6 | 5 | 5.2 | 4.8 |

# Appendix 4

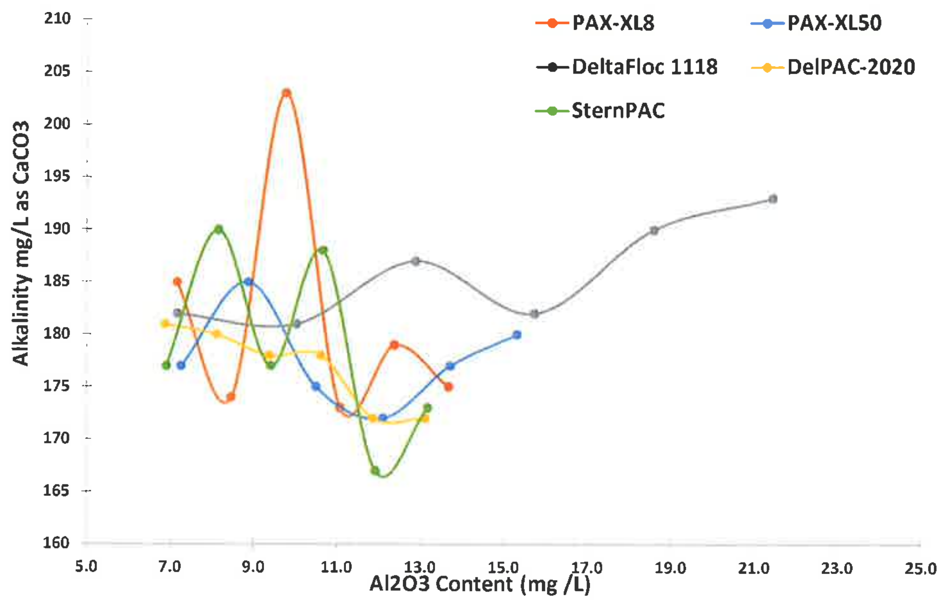
# Result Graphs

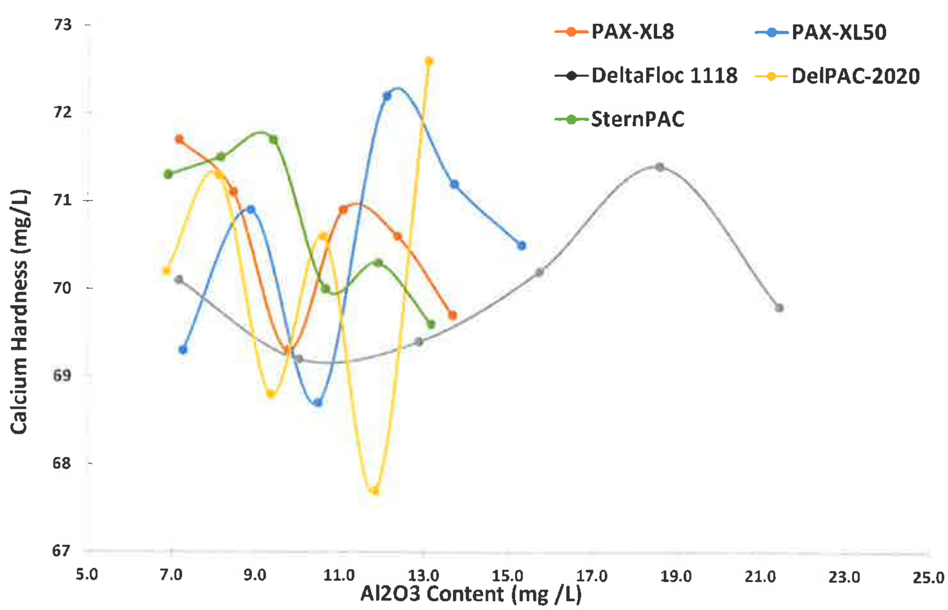


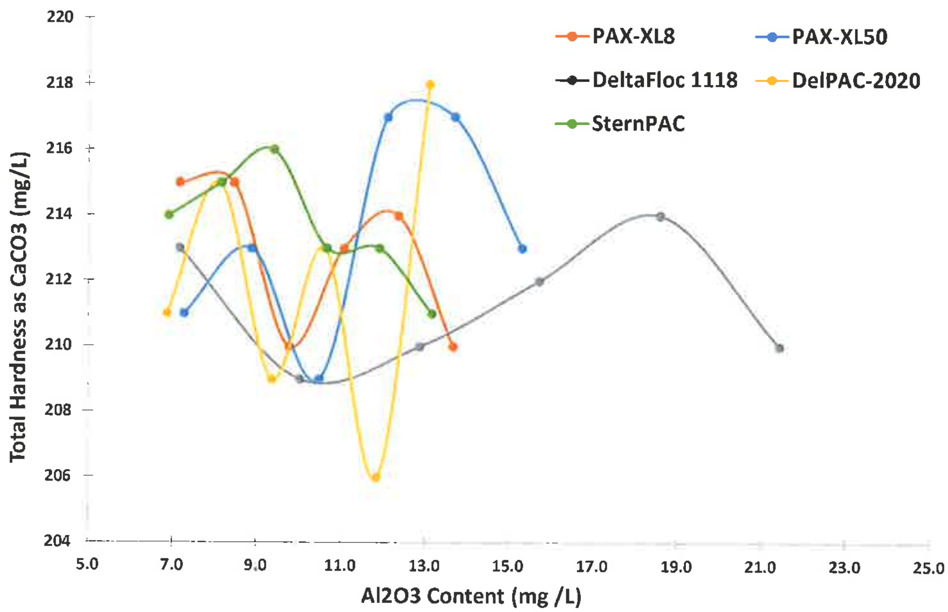
PAX-XL8
PAX-XL50
DeltaFloc 1118
DelPAC-2020
SternPAC
Temperature (C)
13
12.5
12
11.5
11
10.5
10
5.0
7.0
9.0
11.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0
Al2O3 Content (mg /L)

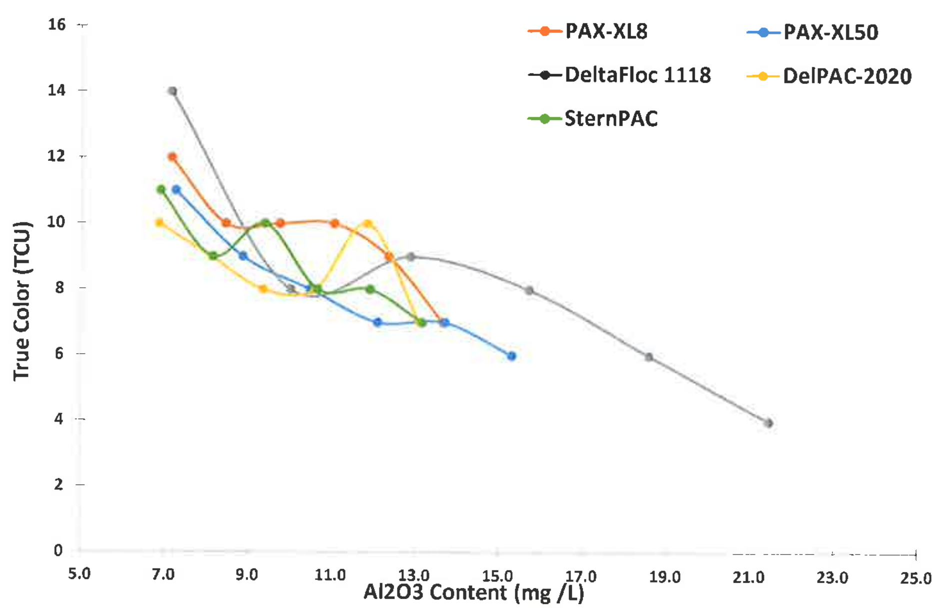



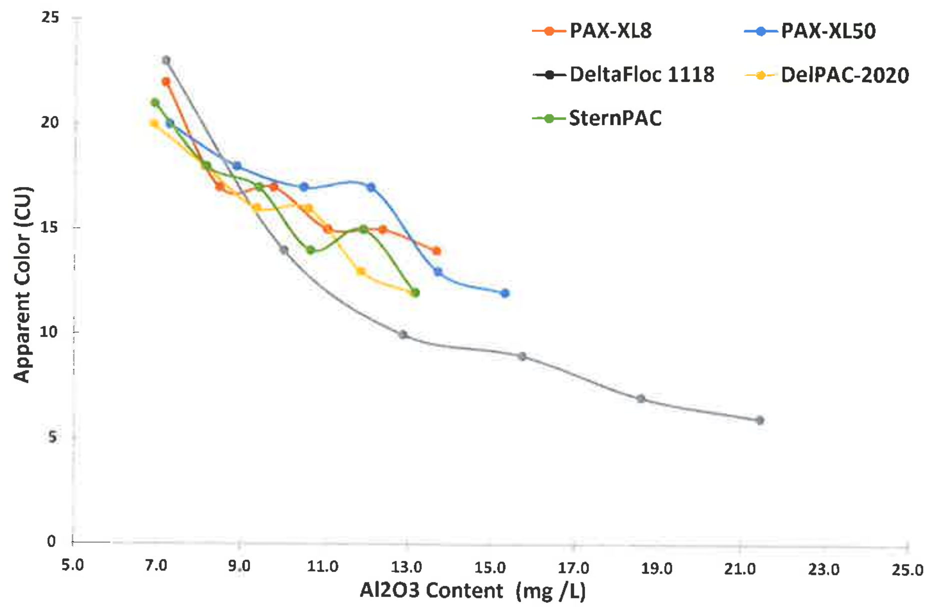
PAX-XL8
PAX-XL50
DeltaFloc 1118
DelPAC-2020
SternPAC
pH
8.4
8.2
8
7.8
7.6
7.4
7.2
5.0
7.0
9.0
11.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0
Al2O3 Content (mg /L)


PAX-XL8
PAX-XL50
DeltaFloc 1118
DelPAC-2020
SternPAC
Alkalinity mg/L as CaCO3
210
205
200
195
190
185
180
175
170
165
160
5.0
7.0
9.0
11.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0
Al2O3 Content (mg /L)

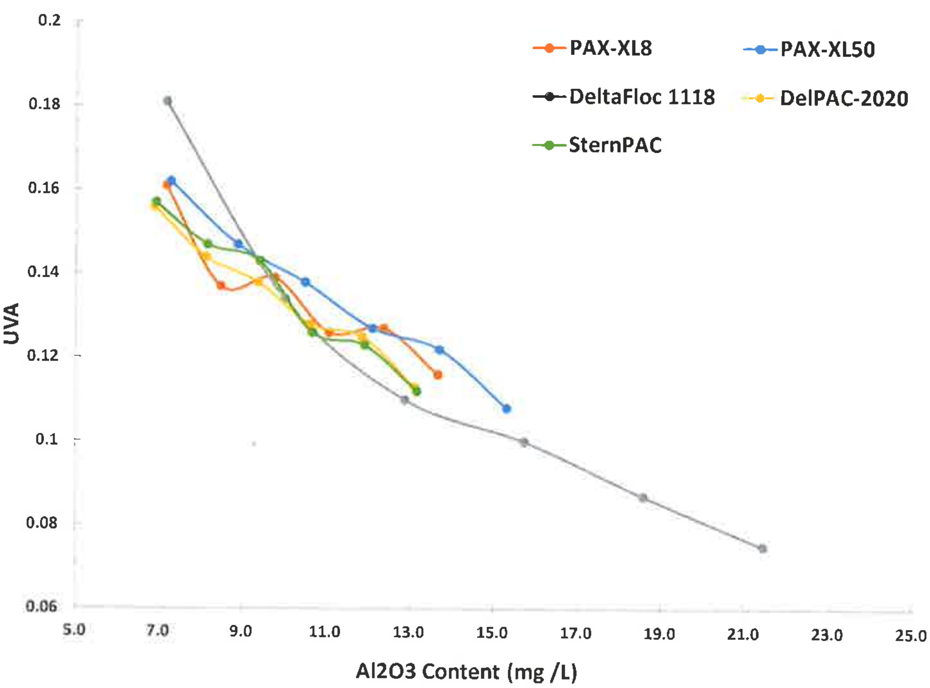

PAX-XL8
PAX-XL50
DeltaFloc 1118
DelPAC-2020
SternPAC
Calcium Hardness (mg/L)
73
72
71
70
69
68
67
5.0
7.0
9.0
11.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0
Al2O3 Content (mg /L)


PAX-XL8
PAX-XL50
DeltaFloc 1118
DelPAC-2020
SternPAC
Total Hardness as CaCO3 (mg/L)
220
218
216
214
212
210
208
206
204
5.0
7.0
9.0
11.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0
Al2O3 Content (mg /L)

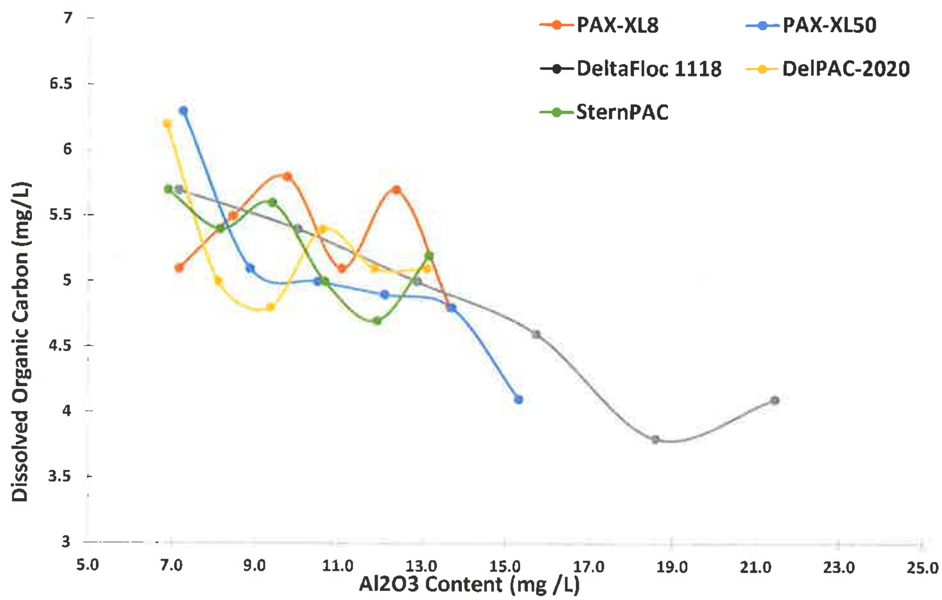

PAX-XL8
PAX-XL50
DeltaFloc 1118
DelPAC-2020
SternPAC
True Color (TCU)
16
14
12
10
8
6
4
2
0
5.0
7.0
9.0
11.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0
Al2O3 Content (mg /L)

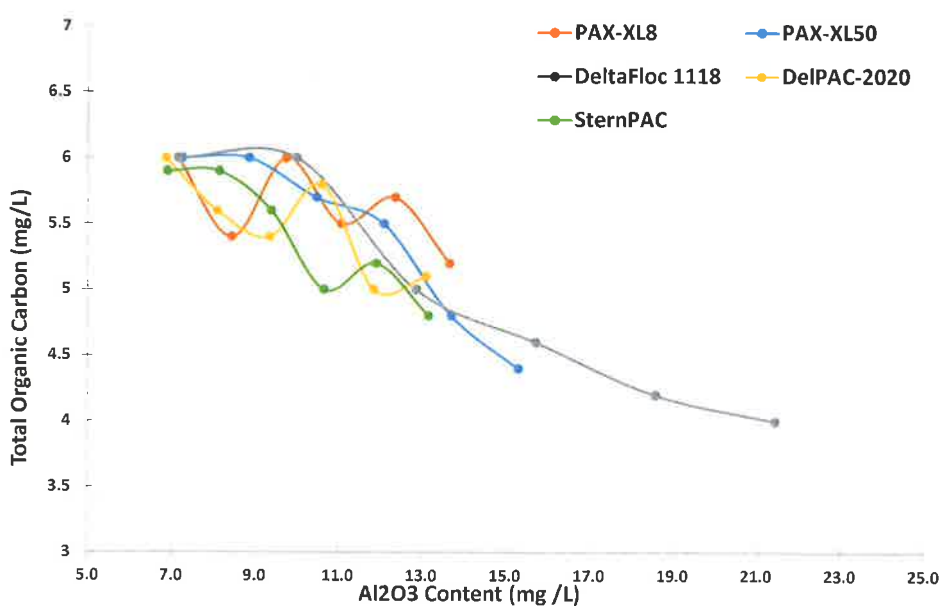


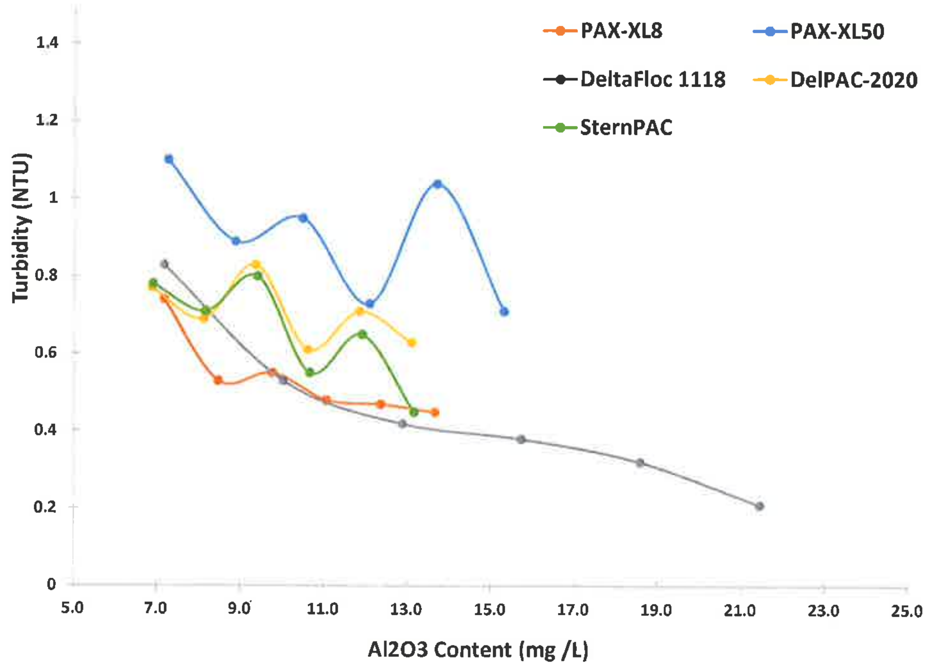
PAX-XL8
PAX-XL50
DeltaFloc 1118
DelPAC-2020
SternPAC
Apparent Color (CU)
25
20
15
10
5
0
5.0
7.0
9.0
11.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0
Al2O3 Content (mg /L)

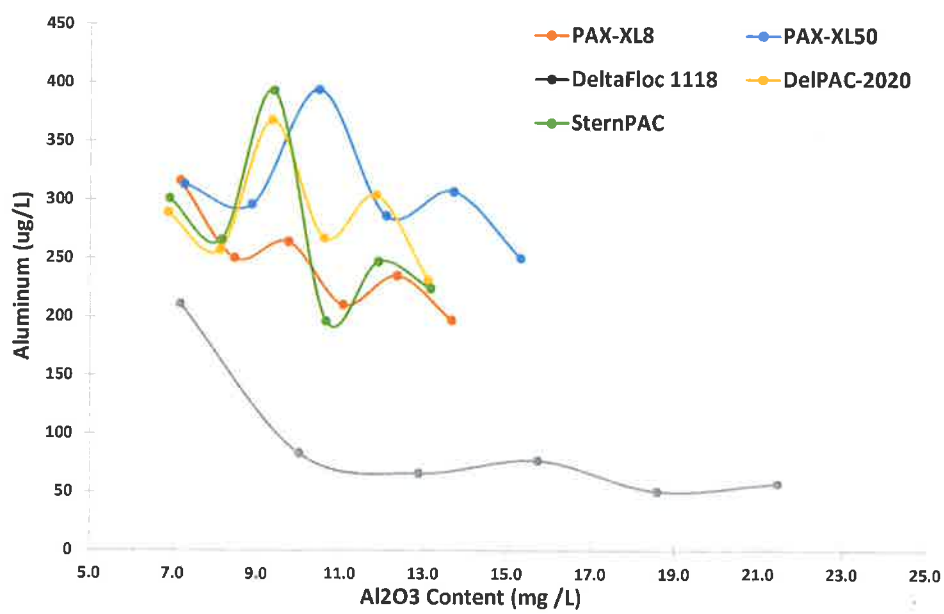
PAX-XL8
PAX-XL50
DeltaFloc 1118
DelPAC-2020
SternPAC
UVA
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
5.0
7.0
9.0
11.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0
Al2O3 Content (mg /L)


PAX-XL8
PAX-XL50
DeltaFloc 1118
DelPAC-2020
SternPAC
Dissolved Organic Carbon (mg/L)
Al2O3 Content (mg /L)
7
6.5
6
5.5
5
4.5
4
3.5
3
5.0
7.0
9.0
11.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0


PAX-XL8
PAX-XL50
DeltaFloc 1118
DelPAC-2020
SternPAC
Total Organic Carbon (mg/L)
Al2O3 Content (mg /L)
7
6.5
6
5.5
5
4.5
4
3.5
3
5.0
7.0
9.0
11.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0



PAX-XL8
PAX-XL50
DeltaFloc 1118
DelPAC-2020
SternPAC
Turbidity (NTU)
Al2O3 Content (mg /L)

PAX-XL8
PAX-XL50
DeltaFloc 1118
DelPAC-2020
SternPAC
Aluminum (ug/L)
Al2O3 Content (mg /L)