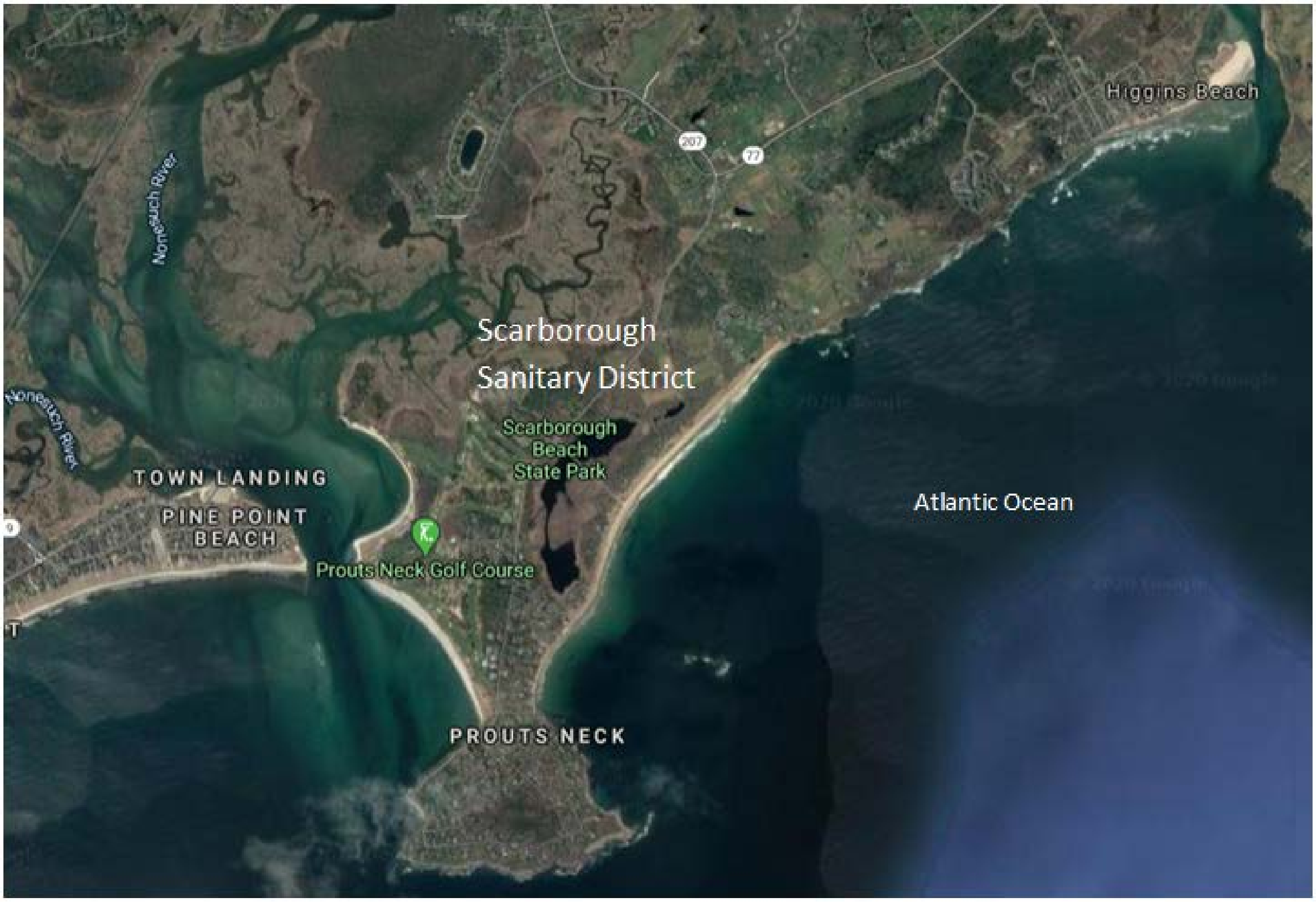
Westfalia Separator

# PILOT TEST REPORT




## The Scarborough Sanitary District Wastewater Facility
## 415 Black Point Road, Scarborough, Maine

**Test Dates: July 20 - 23, 2020**
**Tested by: James Hanson, PE, Decanter Specialist**
**Robert Trionfetti, Process Engineer**

**Introduction**

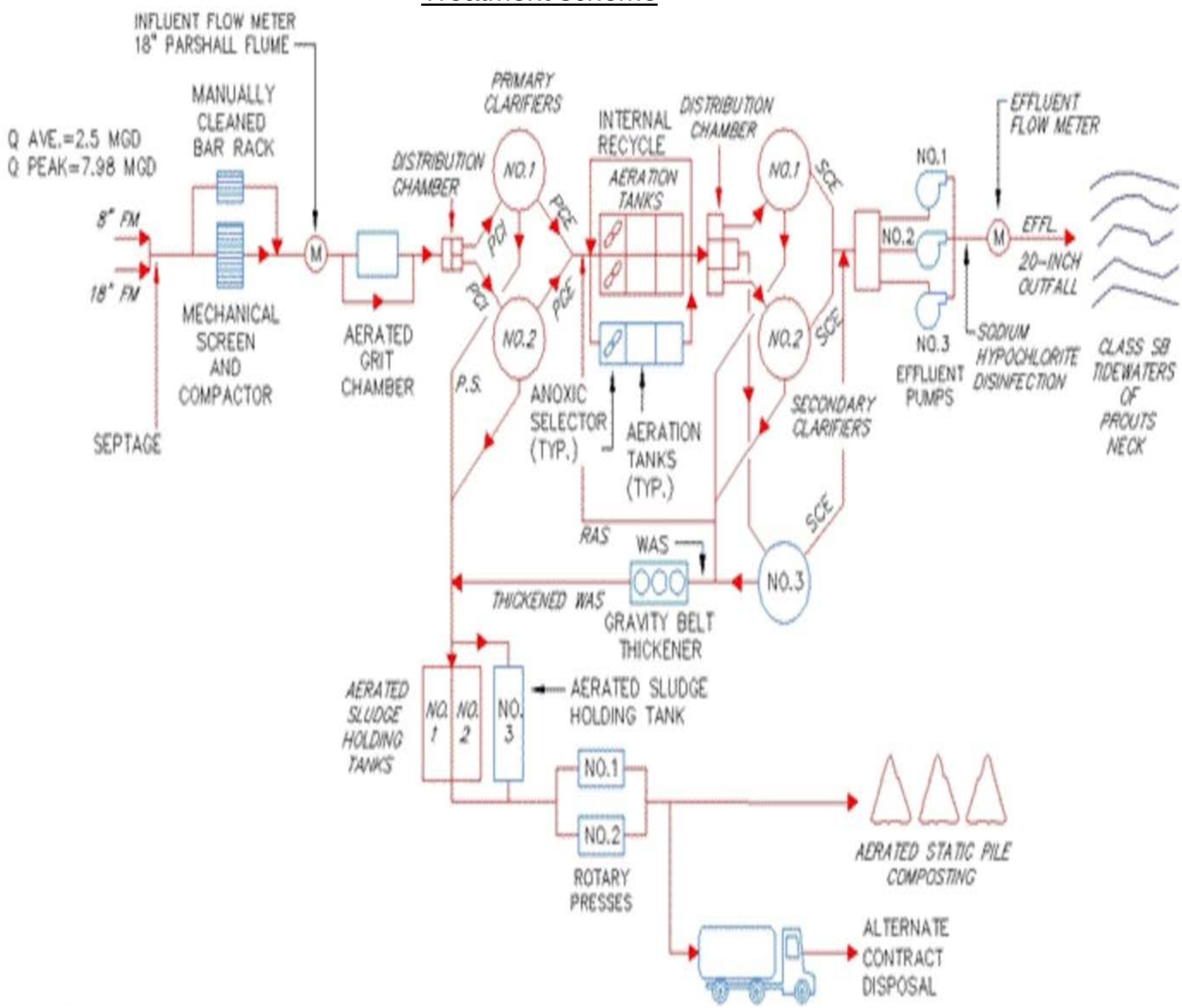
The Scarborough Sanitary District Wastewater Treatment Plant is a 2.5MGD activated sludge facility. Wastewater collected from the District is given secondary treatment then discharged at a deep location in the Atlantic Ocean.

Sludge from primary clarifiers is mixed with thickened waste activated sludge to yield a blend that is 70/30: primary/TWAS by weight. The blended sludge is dewatered using a Fournier press and sent to landfill.

The District plans to replace the press and is now evaluating different dewatering technologies. In July of 2020 a GEA CF4000 centrifuge was tested on-site for its ability to dewater the plant's mixed raw sludge.

We thank the staff at the facility for their generous cooperation over the course of this dewatering test.

Treatment scheme



**Test Procedure**
The GEA pilot test trailer, equipped with a CF-4000 centrifuge, a variable-speed sludge feed pump, and a polymer blending unit, was stationed at the Scarborough WWTP.
The suction line of the sludge feed pump was dropped into an aerated storage tank containing the sludge blends to be dewatered.
While the centrifuge was in operation, the dewatered cake it produced was conveyed from the test trailer and dropped into a dumpster for disposal at landfill.

Centrate was routed to a sump then returned to the plant headworks.

The range of sludge feed rates processed was from 35 to 100 gpm, with solids loadings from 550 to 1080 dry lbs/hour.

For flocculation of the sludge solids we used the same emulsion polymer that is currently employed on the plant's dewatering press.

During each test run, in order to hold a constant dewatering pressure on the solids inside the centrifuge a consistent level of scroll torque was maintained. The constant torque was held for 30 to 45 minutes before samples were collected to assure that the sample results would represent a steady-state operation.

For successive test runs the operating conditions were varied so as to optimize the three performance parameters: cake dryness, throughput capacity, and polymer dosage.

At the end of each run, samples of the feed sludge, the centrate and the dewatered cake were collected; also the operating data was recorded.

The centrate samples were given to the plant laboratory for analyses. The samples of feed sludge and cake were tested by the GEA representative for their total solids concentrations.

A spreadsheet listing all the collected data as well as the analytical results is shown on page 9.

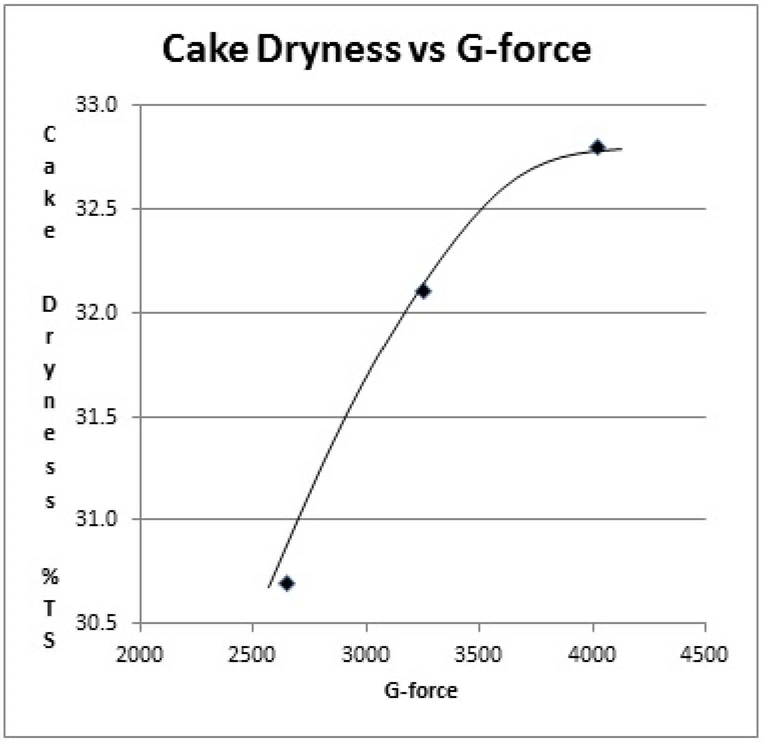
**RESULTS**

On each of the four test days a different blend of primary-TWAS or primary-WAS was tested. Before blending the concentration of the primary sludge was 2.2% and the TWAS concentration was about 3 to 4%.

| Test Day | | Blend by Volume | Concentration |
|---|---|---|---|
| Day1 | Monday: | primary only | 2.2%TS |
| Day2 | Tuesday: | 40 primary: 60TWAS | 3.1%TS to 3.2%TS |
| Day3 | Wednesday: | 40 primary: 60TWAS | 3.3%TS to 3.6%TS |
| Day4 | Thursday: | 25 primary: 50 WAS: 25 TWAS blend | 1.9%TS |

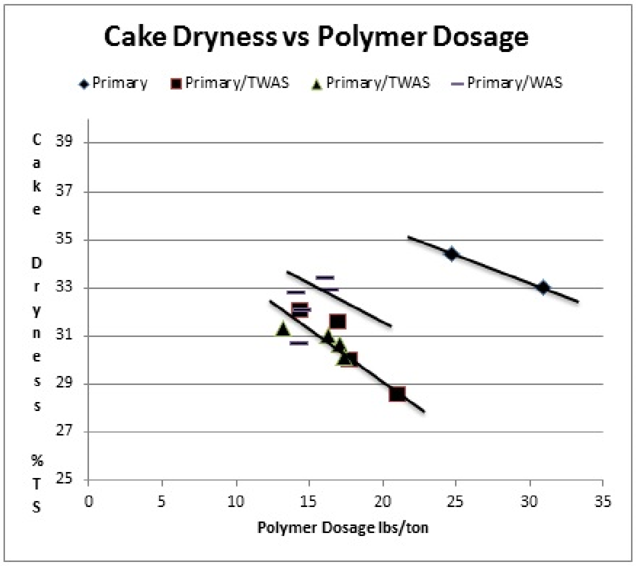
The range of cake dryness obtained was 29 to 34%TS with all cake discharges appearing dry and crumbly. The polymer dosages used ranged from 13 to 31 active-lbs/ton.

**Effect of G-force**
In order to see whether the cake dryness would be sensitive to changes in the G-force of the centrifuge the bowl speed was varied to yield: 2650, 3250, and 4020 G's (test runs 11, 12, 13). The graph below "Cake Dryness vs G-force" shows that the cake dryness increased by 2%, from 30.7% to 32.7% as the G-force was increased from 2650XG to the highest level, 4020XG.

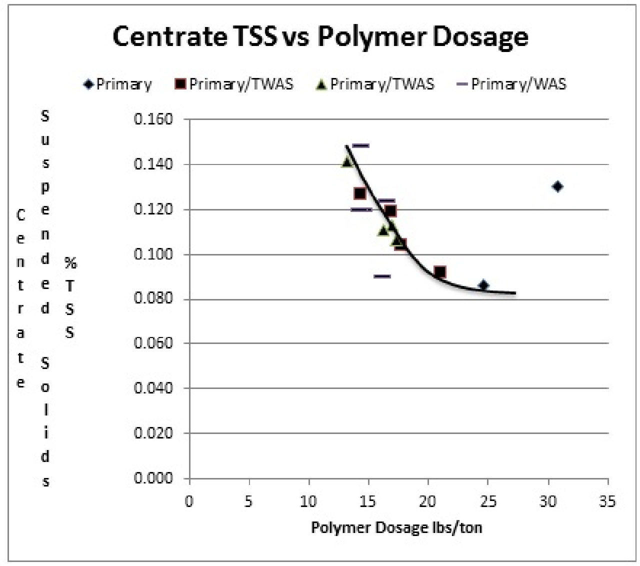



**Unusual Trends Observed**
Cake dryness behavior
An unusual relationship was seen between the polymer dose and the cake dryness.
Increasing the polymer dose caused the cake to become wetter; normally the cake would become drier. A theory to explain that observation is offered later in this report.
Limitation encountered on TSS removal
Increasing the polymer dose increased the removal of centrate suspended solids however the TSS concentration which remained in the centrate reached a lower limit near 800 ppm. Normally centrate TSS can be reduced to the range 50 - 200 ppm.

Graph1




Graph2




Graph1,"Cake Dryness vs Polymer Dosage", shows that for all sludge blends tested, increasing the polymer dosage decreased the cake dryness. In general an increase of 5-lbs/ton caused the cake dryness to decrease about 1%TS. It appears that the increased dosage reacts very inefficiently with a class of suspended solids discussed below, and those solids are recovered as a 5 to 10% probably gelatinous cake.

Graph2, "Centrate TSS vs Polymer Dosage", shows that increasing the polymer dose within the dosage range 15 to 20 lbs/ton caused a linear decrease in the centrate TSS concentration. But as the dosage was further increased from 20 to 31lbs/ton little further reduction in suspended solids occurred. About 800 ppm of centrate TSS remained resistant to removal by additional polymer dosage.

A fraction of

Graph2 indicates that the concentration of problem solids in the sludge is about 0.15% (1500 ppm), with .08% (800 ppm) being virtually unreactive with the polymer. These solids will need some different treatment, perhaps an anionic, non-ionic, or inorganic coagulant to bring them out of suspension.

For those solids on Graph2 in the concentration range: 800 to 1500 ppm it appears that there capture includes a large amount of moisture bound to them. Once they are incorporated into the cake, that mix that is noticeably wetter than the normal cake solids.

## Centrate sample results from the Scarborough laboratory

**GEA Centrifuge Pilot Test**
**Scarborough Sanitary District**

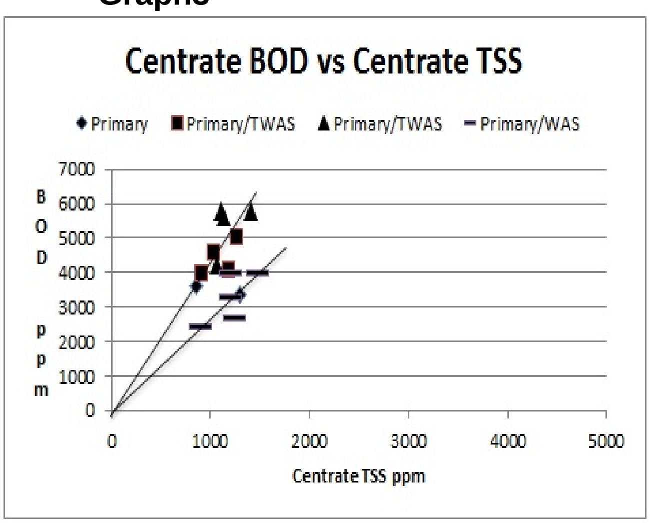
| Filtrate Sample | | TSS, mg/L | TS mg/L | BOD, mg/L | BOD Load, lbs/day |
|---|---|---|---|---|---|
| *Tuesday, July 21, 2020* | | | | | |
| 100% Primary Sludge | | | | | |
| Averge Feed Rate @ 60 gpm | | | | | |
| | Sample 1 | 1300 | 2976 | 3360 | 2,423 |
| | Sample 2 | 860 | 2812 | 3600 | 2,596 |
| | Sample 3 | 1190 | 3556 | 4080 | 2,942 |
| | Sample 4 | 920 | 3328 | 3960 | 2,855 |
| | Sample 5 | 1270 | 4068 | 5040 | 3,634 |
| | Sample 6 | 1040 | 3504 | 4560 | 3,288 |
| *Wednesday, July 22, 2020* | | | | | |
| 40 Primay Sludge/60% TWAS | | | | | |
| Averge Feed Rate @ 60 gpm | | | | | |
| | Sample 7 | 1130 | 3636 | 5640 | 4,067 |
| | Sample 8 | 1110 | 3824 | 5760 | 4,153 |
| | Sample 9 | 1410 | 4212 | 5760 | 4,153 |
| | Sample 10 | 1060 | 3492 | 4200 | 3,028 |
| *Thursday, July 23, 2020* | | | | | |
| 50% WAS, 25% Primary Sludge, 25% Wed Blend | | | | | |
| Averge Feed Rate @ 100 gpm | | | | | |
| | Sample 11 | 1480 | 3100 | 3960 | 4,759 |
| | Sample 12 | 1200 | 2780 | 3240 | 3,894 |
| | Sample 13 | 1200 | 3036 | 3960 | 4,759 |
| | Sample 14 | 1240 | 2776 | 2640 | 3,173 |
| | Sample 15 | 900 | 2608 | 2400 | 2,884 |

Centrate BOD

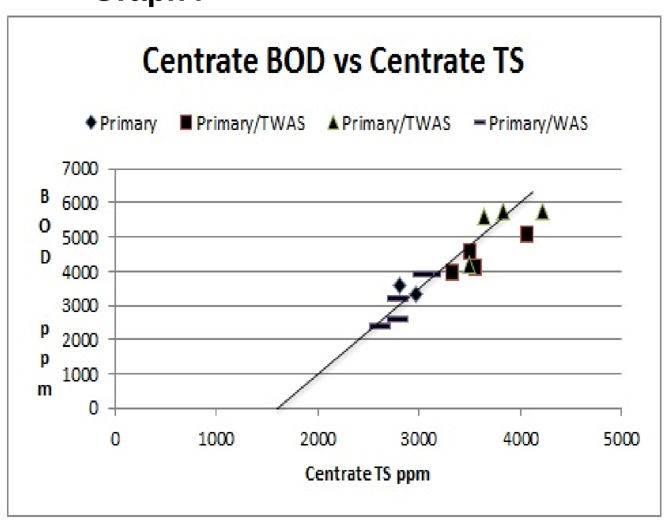
Although the solids recovery level achieved dewatering the primary-TWAS blend was 97% of the TSS nevertheless the remaining 3% of TSS that escapes in the centrate is important to the customer because of the BOD load it imposes on his treatment process.

The graphs below show how the concentrations of centrate suspended solids and centrate total solids relate to the concentration of centrate BOD.

**Graph3**




**Graph4**



On Graph3, “Centrate BOD vs Centrate TSS”, two trendlines are scribed. The left-side line traces the BOD/TSS relationship observed in the centrate from the primary sludge and the centrate from the primary-TWAS blends. The right-side line shows the relationship seen in the centrate from the primary-WAS blend. The slope of right-side line shows that the suspended solids associated with the primary-WAS blend carried less BOD per ppm of TSS compared to the other blends. The source of that difference is a subject to investigate later.
Both trendlines extrapolate to a zero-BOD intercept when the TSS value is also zero. That suggests that all of the centrate BOD is contained in the suspended solids and little or none is in the dissolved solids.
On Graph4, “Centrate BOD vs Centrate TS”, extrapolating the trendline, shows that a condition of zero-BOD is encountered when the TS concentration reaches 1700 ppm.
That suggests that the dissolved solids (TDS) concentration of the sludge is about 1700 ppm and that those solids are comprised of non-biodegradable salts.

## Conclusion

The CF-4000 readily dewatered the raw sludge blends at the Scarborough Sanitary District producing 96% average solids recovery and crumbly dry cake. The sludge contains a unique fraction of suspended solids which is resistant to recovery by use of the current polymer. Further study is needed in order to determine a strategy for their removal.
The results obtained dewatering the various blends are tabulated below:

Primary sludge

| Feed Rate Gpm | Feed Conc %TS | Solids Load dry lbs/hr | Cake Dryness %TS | Solids Recovery % of TSS | Polymer Dose active lbs/hr |
|---|---|---|---|---|---|
| 50 | 1.3 | 550 | 33 | 95 | 25 |

Primary-TWAS blends

| Feed Rate Gpm | Feed Conc %TS | Solids Load dry lbs/hr | Cake Dryness %TS | Solids Recovery % of TSS | Polymer Dose active lbs/hr |
|---|---|---|---|---|---|
| 35 -60 | 3.2 | 560 – 960 | 31 | 97 | 16 |

Primary-WAS blend

| Feed Rate Gpm | Feed Conc %TS | Solids Load dry lbs/hr | Cake Dryness %TS | Solids Recovery % of TSS | Polymer Dose active lbs/hr |
|---|---|---|---|---|---|
| 90 | 1.9 | 850 | 33 | 95 | 16 |
| 100 | 1.9 | 950 | 32 | 94 | 15 |

## Data Spreadsheet

| Scarborough SA Data | | | PROCESS READINGS | | | | POLY INFO | | LABORATORY | | | CALCULATIONS | | | | Motor Data | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Blend | Date | Run Number | Feed Rate gpm | Diffential (RPM) | Torque (%) | Bowl Speed (rpm) | Neat Poly % Active | Poly Flow gph | Feed % TS | Cake % TS | Centrate % TSS | Feed Solids Loading | Poly Dose Active lbs/ton | Solids Recovery % of TSS | G Force | Bowl Motor Kw | Scroll Motor Kw | Bowl Motor Amps |
| 100Pri | 7/20/20 | 1 | 50 | 5.0 | 40 | 3500 | 45 | 2.26 | 2.19 | 33.0 | 0.130 | 548 | 31 | 94 | 2740 | 5.4 | 1.9 | 16.1 |
| 100Pri | 7/20/20 | 2 | 50 | 5.2 | 39 | 3500 | 45 | 1.80 | 2.19 | 34.4 | 0.086 | 548 | 25 | 96 | 2740 | 5.4 | 2.1 | 16.3 |
| Pri-TWAS | 7/21/20 | 3 | 35 | 10.8 | 47 | 4200 | 45 | 1.24 | 3.15 | 31.6 | 0.119 | 552 | 17 | 97 | 3946 | 8.7 | 3.8 | 18.1 |
| Pri-TWAS | 7/21/20 | 4 | 52 | 10.8 | 46 | 4200 | 45 | 2.25 | 3.10 | 28.6 | 0.092 | 807 | 21 | 97 | 3946 | 10.1 | 3.7 | 20.0 |
| Pri-TWAS | 7/21/20 | 5 | 45 | 11.7 | 45 | 4200 | 45 | 1.35 | 3.15 | 32.1 | 0.127 | 709 | 14 | 96 | 3946 | 9.6 | 3.8 | 19.2 |
| Pri-TWAS | 7/21/20 | 6 | 45 | 12.2 | 43 | 4200 | 45 | 1.69 | 3.18 | 30.0 | 0.104 | 716 | 18 | 97 | 3946 | 9.7 | 3.6 | 19.2 |
| Pri-TWAS | 7/22/20 | 7 | 60 | 10.5 | 59 | 4200 | 45 | 2.25 | 3.30 | 30.6 | 0.113 | 991 | 17 | 97 | 3946 | 10.6 | 4.6 | 20.7 |
| Pri-TWAS | 7/22/20 | 8 | 60 | 11.2 | 53 | 4200 | 45 | 2.14 | 3.28 | 31.0 | 0.111 | 985 | 16 | 97 | 3946 | 10.7 | 4.2 | 20.9 |
| Pri-TWAS | 7/22/20 | 9 | 60 | 11.5 | 53 | 4200 | 45 | 1.91 | 3.62 | 31.3 | 0.141 | 1087 | 13 | 97 | 3946 | 10.8 | 4.7 | 20.9 |
| Pri-TWAS | 7/22/20 | 10 | 55 | 12.2 | 43 | 4200 | 45 | 2.14 | 3.36 | 30.1 | 0.106 | 925 | 17 | 97 | 3946 | 10.6 | 4.0 | 20.5 |
| Pri-WAS | 7/23/20 | 11 | 100 | 12.2 | 57 | 3440 | 45 | 1.80 | 1.89 | 30.7 | 0.148 | 946 | 14 | 93 | 2647 | 8.9 | 4.6 | 21.0 |
| Pri-WAS | 7/23/20 | 12 | 100 | 13.9 | 62 | 3814 | 45 | 1.80 | 1.86 | 32.1 | 0.120 | 931 | 15 | 94 | 3254 | 11.0 | 5.3 | 22.6 |
| Pri-WAS | 7/23/20 | 13 | 100 | 13.5 | 63 | 4240 | 45 | 1.80 | 1.92 | 32.8 | 0.120 | 961 | 14 | 94 | 4021 | 14.7 | 5.4 | 25.7 |
| Pri-WAS | 7/23/20 | 14 | 100 | 14.8 | 66 | 4240 | 45 | 2.03 | 1.85 | 32.9 | 0.124 | 926 | 16 | 94 | 4021 | 14.1 | 6.5 | 25.1 |
| Pri-WAS | 7/23/20 | 15 | 90 | 15.0 | 66 | 4240 | 45 | 1.82 | 1.89 | 33.4 | 0.090 | 851 | 16 | 95 | 4021 | 13.4 | 6.5 | 24.2 |

Polymer dilution rate = 10 gpm

## Formulae for Calculations

Feed Solids Loading = dry lbs/hour

(Feed %TS) X (Feed Rate gpm) X ((8.34 X 60) / 100)

Polymer Dosage = active lbs/ton

$$\frac{\text{Emulsion \%-activity X Emulsion flow gph X 2000}}{\text{Feed sludge \%TS X Feed sludge flow gpm X 60}}$$

%Recovery of TSS =

$$\frac{\text{Cake\%TS x (Feed\%TS - Centrate\%TSS) x 100}}{\text{Feed\%TS x (Cake\%TS - Centrate\%TSS)}}$$