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# Optimizing Pre-Treatment Design of Surface Drinking Water

## Project Definition

- The project deals with a conventional East Coast Drinking Water Treatment Plant that exceeds NS Drinking Water Guidelines. The source water parameters are:
  - Moderate to low turbidity, pH, and alkalinity.
  - Variation in NOM content due to seasonal and diurnal temperature changes.

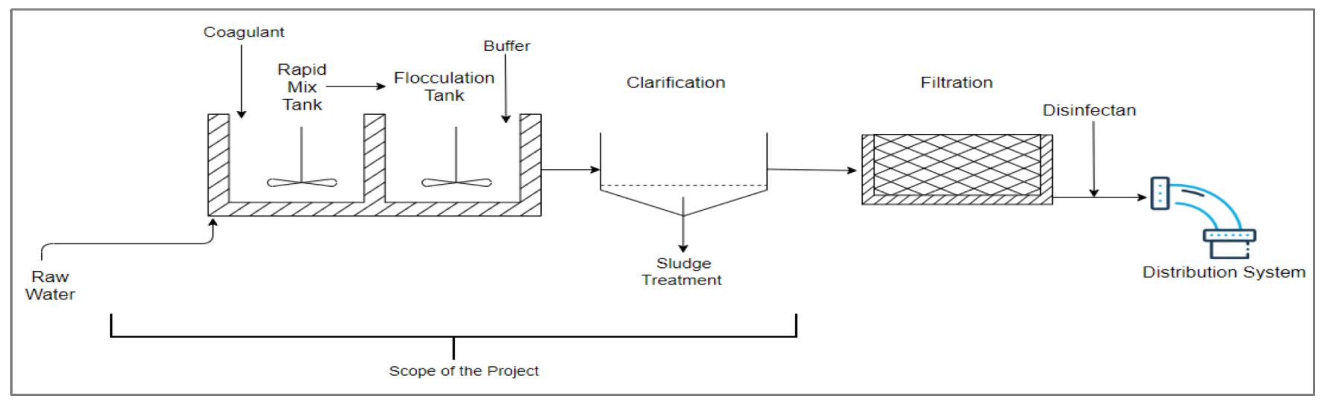


Figure 1: Current Treatment Process

## Objectives

- Audit the current plant design.
- Evaluate and assess potential design alternatives.
- Design an efficient treatment process train with an optimal service life.

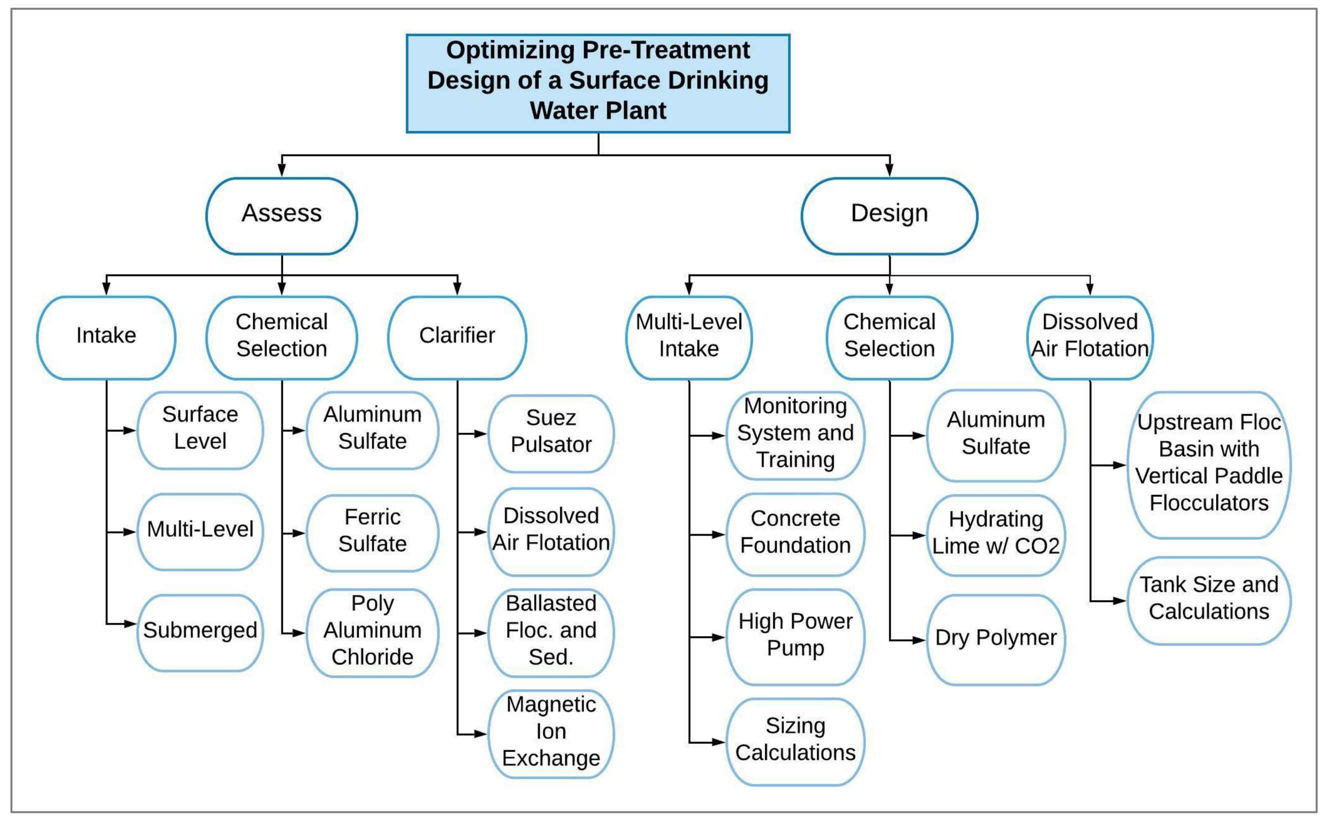


Figure 2: Work Breakdown Structure

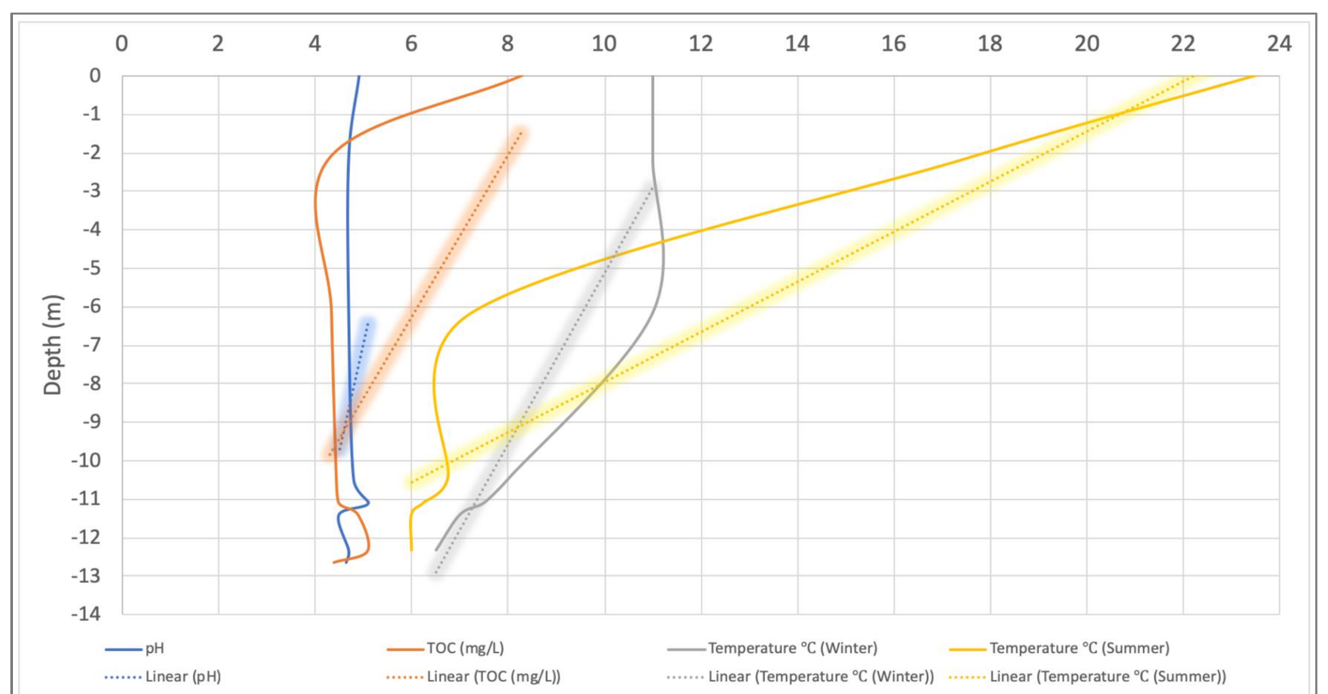


Figure 3: Changes in different water parameters with depth

## Final Details of Design

The final design consists of a Multi-Level Intake, rapid mixing with an Aluminum Sulfate coagulant, followed by a High Rate Dissolved Air Flotation clarification system.

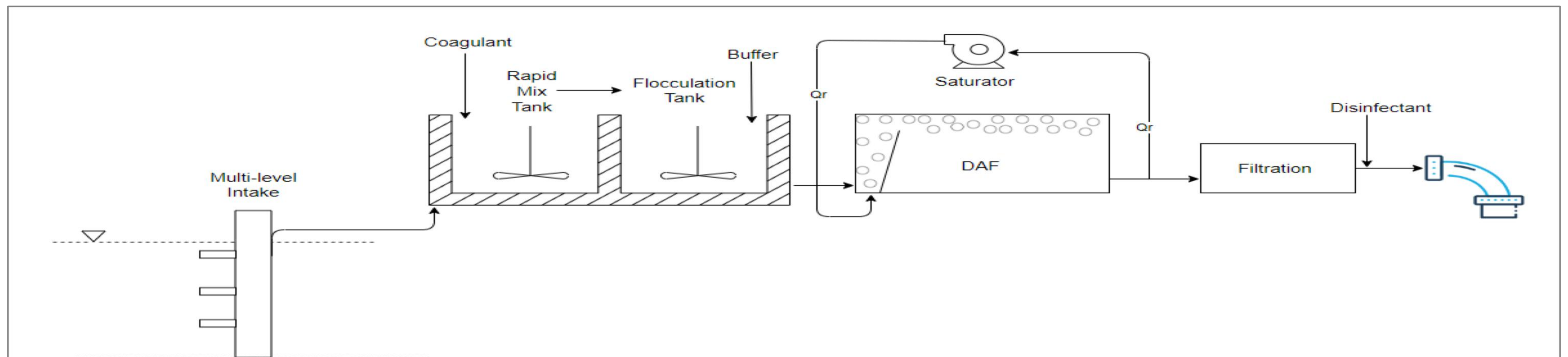


Figure 4: Final Design Treatment Process

## Multi-Level Intake

- Cylindrical shaped tower 15.86m tall by 4.62m wide by 0.4m thick.
- Situated in the center of the source water to achieve greatest depth and water quality.
- Three variable valves at 3.85m intervals with 4.64m ice clearance and 1.52m debris clearance. Achieving optimal and consistent water quality.
- 105m hydraulic head pump, in order to maintain flow rate of roughly 1.296m³/s.
- 4030m of 340mm diameter piping traveling from the center of the source water to the WTP intake.
- Five electronically controlled gate valves.
- Three real time UV 254 monitors, pH monitors, TDS monitors, and temperature monitors.

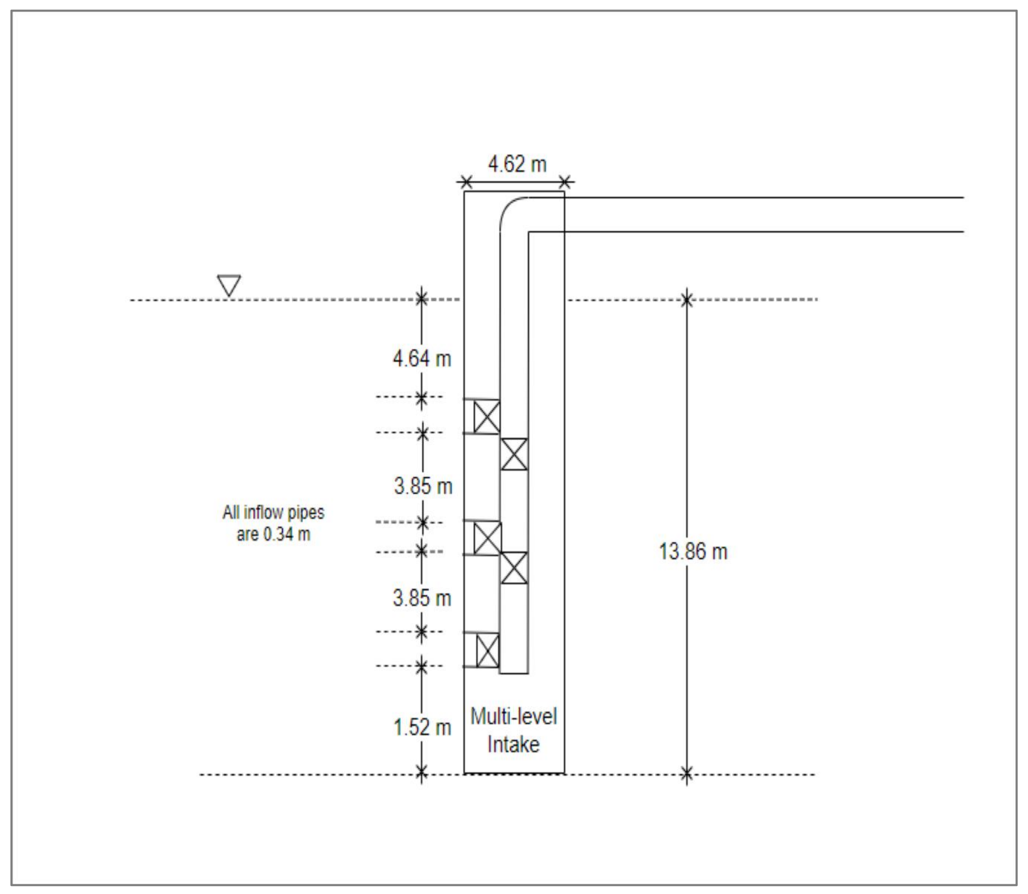


Figure 5: Detailed design for Multi-Level Intake

## Aluminum Sulfate Coagulant

- Cost effective, and readily available.
- Efficient in removing NOM , turbidity and color.
- Less lead being released into the water.

Table 1: Comparison of Alternative Coagulants

| Parameter | Raw Water | PACL | Alum | Ferric Sulfate |
|---|---|---|---|---|
| Coagulant Dosage(mg/L) | - | 1.5 | 8 | 5.4 |
| Coagulant pH | - | 6 | 5.5 | 5 |
| Alkalinity(mg/L as $CaCO_3$) | 0 | 16.3 ± 1.6 | 16.8 ± 2.8 | 32.6 ± 7.4 |
| TOC(mg/L) | 2.82 ± 0.13 | 1.86 ± 0.57 | 1.88 ± 0.10 | 2.50 ± 0.20 |

## Dissolved Air Flotation Clarification

- Upstream floc basin and vertical paddle flocculators can provide up to 70% footprint space gain.
- High rate clarification provides a much higher overflow rate, with the same removal efficiency.
- Very susceptible to cooler temperatures, as well as diurnal and seasonal temperature variances.
- More effective at achieving NOM removal in soft waters, that have a low pH and turbidity.

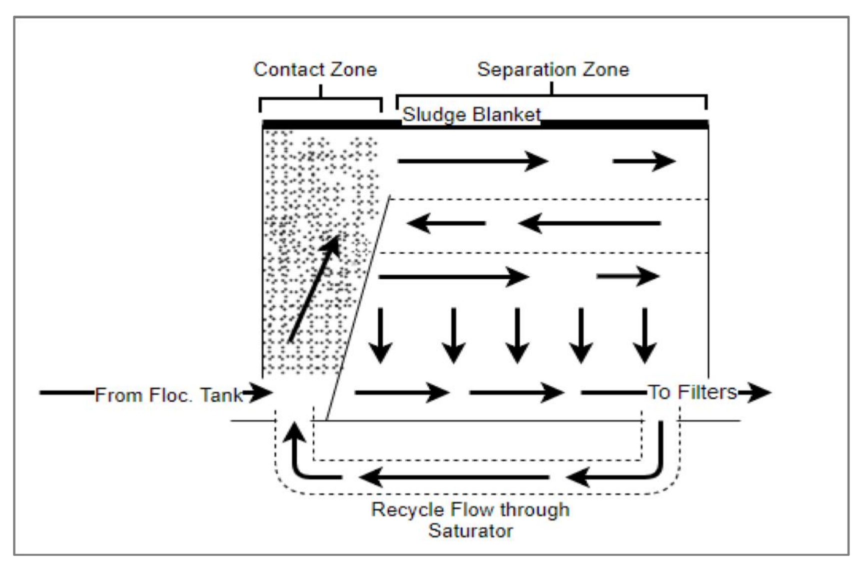


Figure 6: Detailed design for Dissolved Air Flotation

Table 2: Treatment Train Matrix

| Ranking Treatment Trains | Comparison | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Criteria | Weight Factor | Train #1 | Train #2 | Train #3 | Train #4 | Train #5 | Train #6 | Train #7 |
| NOM Removal | 10 | 10 | 9 | 9 | 8 | 9 | 9 | 9 |
| Environmental Impacts | 8 | 7 | 9 | 8 | 5 | 4 | 7 | 3 |
| Seasonal Resilience | 6 | 9 | 6 | 8 | 9 | 6 | 8 | 7 |
| Ease of Operations | 5 | 7 | 9 | 6 | 6 | 3 | 7 | 4 |
| Sustainable Design | 8 | 8 | 8 | 8 | 5 | 6 | 5 | 6 |
| Cost | 5 | 5 | 3 | 2 | 7 | 3 | 3 | 2 |
| Total Score | | 37.47 | 35.76 | 34.79 | 35.32 | 33.2 | 35 | 31.95 |

1) Multi-level intake - Alum - DAF Clarification
2) Surface intake - PACL coagulant - DAF Clarification
3) Surface intake - Alum coagulant - Ballasting Agent flocculation - DAF Clarification
4) Surface intake - Alum coagulant - DAF Clarification
5) Surface intake - MIEX coagulant - DAF Clarification
6) Submerged intake - Alum coagulant - DAF Clarification
7) Surface intake - Contractor - Resin Separation - Product water

| Legend: |
|---|
| 10 = design alternative meets and exceeds criterion in full |
| 8 = design alternative exceptionally meets criterion |
| 6 = design alternative meets criterion in part |
| 4 = design alternative narrowly meets criterion |
| 2 = design alternative does not meet criterion |
| ***Total Score is equal to weighted score |

## Economics

- Multi-Level Intake Structure
  - $8,000,000
- Dissolved Air Flotation Retrofit
  - $5,000,000
- Total Capital Cost
  - $12,000,000

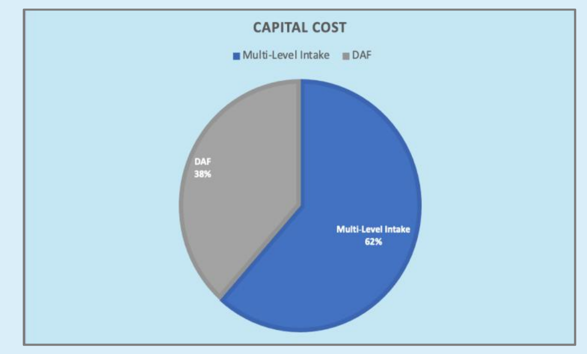


Figure 7: Breakdown of Cost

## Conclusion and Recommendations

- A Work Breakdown Structure was developed to outline all design alternatives that were considered.
- A treatment train matrix was developed utilizing an Analytical Hierarchy Approach to designate a best recommended train.(Train #1: Multi-Level Intake, Alum and DAF system).
- Throughout consideration it has been proven to show several viable treatment train options including the use of all intake, coagulant, and clarifier alternatives.

## References

Baruth, E. E. (2005). *Water Treatment Plant Design*. New York: McGraw-Hill.

Chaulk, M. (N.D.). *Water Supply Plant Process Optimization Study*(pp. 1-35, rep. No. 140825.01). CBCL.

Nova Scotia Treatment Standards for Municipal Drinking ... (N.D.). Retrieved from https://www.Novascotia.Ca/nse/water/docs/treatment_standards_for_municipal_drinking_water_systems.Pdf

Waddell, C. (2018, November 30). *Supervisor of Nova Scotia Water Treatment Plant*. Address presented at Nova Scotia Water Treatment Plant tour.

Walsh, m., Zhao, N., Gora, S., & Gagnon, G. (2009). Effect of Coagulation and Flocculation Conditions on Water Quality in an Immersed Ultrafiltration Process. *Environmental Technology,30*(9), 927-938. Doi:10.1080/09593330902971287