Prospect Lake Feedstock Water Temperature Analysis

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Revision - 02

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Revision Notes

Revision History

Rev.	Date	Name	Description
P0	February 2026	Alon Leibu	Chemical Consumption
	February 2026	Iliya Haimov	Energy Consumption
	February 2026	Nadav Shai	Equipment and Materials of construction (MOC) changes

Revision Approval

	Name	Signature	Date
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1. Introduction

1.1. Background Information

The Prospect Lake Clean Water Center (PLCWC) design was based on a water analysis outlined in Annex G of the Comprehensive Agreement, specifying feedstock water characteristics. This analysis indicated a temperature range of 18.5°C to 25°C (65.3°F to 77.0°F). However, the City of Fort Lauderdale recently informed IDE that the actual temperature range is higher, approximately 23°C to 28°C (73.4°F to 82.4°F). Consequently, the city has requested IDE to assess the potential operational impacts of this revised temperature range on the facility.

1.2. Report Objective

Chemical processes are sensitive to temperature changes. The Prospect Lake Clean Water Facility consists of diverse process equipment such as Pressurized Media Filters (PMFs), stripping towers, Nanofiltration (NF) system and ion exchange which requires a detailed examination of their performance. The goal of this report is to conduct a preliminary assessment of the potential adjustments necessary for each process unit within the facility, considering the following factors:

- **Performance:** Evaluation of system performance under the revised temperature range.
- **Materials of Construction:** Evaluation of the durability of construction materials within the revised temperature range.
- **Energy Demand:** Evaluation of potential impacts on energy consumption.
- **Chemical Consumption:** Assessment of potential changes in chemical consumption rates.

1.3. Activities Performed

The following activities were performed by IDE to assess the temperature change consequences:

- **Chemical Reaction Modeling:** IDE's Process Engineers utilized chemical reaction modeling software to estimate the variations in chemical consumption across the old and new temperature ranges.
- **Membrane Separation Projection:** A detailed evaluation of NF system rejection changes was conducted using membrane separation process modeling software, considering both the new and old temperature ranges.
- **Vendor Consultation:** All main equipment vendors, including PMFs, stripping towers, and the IX system, were extensively consulted. This included questions regarding the durability of each system within the new temperature range and potential performance impacts due to the temperature variation.
- **Energy Consumption Analysis:** The IDE team conducted several calculations to estimate energy consumption changes resulting from the temperature changes. These calculations primarily focused on the energy consumption of the main pumps. In an initial independent evaluation was made by IDE without the participation of the supplier.

2. Main Impacts by Area

2.1. NF-PMF

2.1.1 Performance and Availability

The temperature change can affect the performance and availability of the pressurized media filters by the following aspects:

- **Viscosity:** Warmer water is less viscous meaning that bed expansion during backwash flushing is expected to be lower at the same flow rate. Therefore, it might be necessary to increase the backwash flow rate for achieving the same bed expansion.
- **Biological Activity:** Higher temperatures can accelerate the growth of microorganisms and the formation of biofilms on the filtration bed surface, which can slightly reduce PMF performance and increase the frequency of backwash cycles.

2.1.2 Equipment & Materials of Construction

There is no effect on the materials of construction on the equipment in this area.

2.1.3 Energy Demand

It is crucial to maintain a consistent bed expansion height for the PMF vessel's media during backwash, regardless of water temperature. Operating at higher temperatures reduces water viscosity, therefore, to maintain the same suspension height, a 3.5% increase in BW flowrate is required. According to the findings, operating at a higher temperature slightly increases the efficiency of the Back Wash (BW) pump but does not significantly change energy consumption. Specific energy consumption compared to the estimate is negligible.

2.1.4 Chemicals Consumption

- **Sodium hypochlorite (NaOCl):** Theoretically, higher temperature improves the effectiveness of NaOCl as a disinfectant. On the other hand, at higher temperature the NaOCl is consumed more rapidly due to higher biological activity. Therefore, the effect of increased water temperature on NaOCl consumption is expected to be negligible NF System.

2.1.5 Performance and Availability

The NF system performance and availability might be affected by the temperature change in the following aspects:

- **Reduced Rejection:** Membrane productivity is very sensitive to changes in feedwater temperature. As water temperature increases, water flux increases almost linearly, due primarily to the higher diffusion rate of water through the membrane. Increased feed water temperature also results in lower salt rejection or higher salt passage. This is due to a higher diffusion rate for salt through the membranes.
  Potential for Fouling: Higher temperatures can accelerate the growth of microorganisms and the

formation of biofilms on the membrane surface, which can slightly reduce membrane performance and increase the frequency of Cleaning In Place (CIP) cycles.

2.1.6 Equipment & Materials of Construction

There is no effect on the materials of construction on the equipment in this area.

2.1.7 Energy Demand

Due to the increased temperature, the NF Feed Pump pressure decreased by between 0.4 and 0.5 bar (5.8-7.2 psi). Despite temperature change we observed that efficiency slightly improved. According to the findings, working at a higher temperature does not cause significant changes in the Specific Energy (SE).

Higher temperature reduces pump efficiency, along with lower feed pressure requirements, has negligible effect on the specific energy.

2.1.8 Chemicals Consumption

- **Sulfuric Acid (H_2SO_4):** The dosage of sulfuric acid needed to achieve the necessary pH level in the NF membrane feed line is directly influenced by the operating temperature. Based on projections by IDE, an increase in the average temperature from 22°C to 26°C is expected to lead to a slightly lower consumption of H_2SO_4. However, this change would not have a significant impact on the dosing pumps and the storge tank.
- **Sodium bisulfite (SBS):** Sodium bisulfite is utilized for chlorine neutralization. Consequently, its dosage is directly dependent on the amount of sodium hypochlorite applied during NF-PMF backwash rinses. The temperature does not significantly influence the required sodium bisulfite dosage in this process.
- **Antiscalant (AS):** The change of max. temp. from 25°C to 28°C has a negligible impact on the Antiscalant dosage.

2.2. NF Stripping + Product Tank

2.2.1 Performance and Availability

The primary objective of the NF Stripping Tower is H_2S removal. The efficiency of this process is expected to increase at higher water temperature, as warmer water promotes the transferring of H_2S, from its liquid phase, to gas. The expected $H_2S(g)$ concentration is still within the limits defined for this project.

There is no effect on the materials of construction on the equipment in this area.

2.2.2 Energy Demand

Due to the absence of pumps in this area and the continuous operation of the stripping tower's air blowers on permanent power, the anticipated effect on energy demand is negligible.

2.2.3 Chemicals Consumption

- **Caustic Soda (NaOH):** Caustic soda is added before the NF stripping towers only during 100% NF operation. This is to elevate the pH to the recommended level for Alkalinity control. Consequently, the variation in caustic soda consumption at this stage is highly specific and minimal when compared to the overall caustic soda consumption within the product line
- **Sodium hypochlorite (NaOCl) – Product tank:** Theoretically, since the Contact Time (CT) value decreased from 3.4 to 2.4 and the retention time remained unchanged, the required NaOCl dosage should have decreased. However, according to the contractual requirements, the dosing system was designed so that the free chlorine concentration at the product transfer pump suction is sufficient to react with ammonia and achieve an average residual monochloramine concentration of 3.6 ppm. In addition, the free chlorine concentration required for oxidizing natural organic matter (NOM) was not affected by the temperature change. Therefore, the required NaOCl consumption is not influenced by the temperature variation.
- **Hydrochloric Acid (**HCl**) – NF Stripping CIP:** Since Hydrochloric Acid is used for cleaning the Degasifier during the CIP flushing. The dosing rate is fixed and does not depend on the temperature.

2.3. Product Line

2.3.1 Performance and Availability

The product line area, which houses the post-treatment chemicals but no process equipment, is unaffected by the feedwater temperature change. Therefore, area performance remains consistent. Chemical consumption variations resulting from the temperature difference are detailed in Section 2.3.4.

2.3.2 Equipment & Materials of Construction

There is no effect on the materials of construction on the equipment in this area.

2.3.3 Energy Demand

Higher temperature reduces Product Pumps efficiency, along with lower feed pressure requirements, has negligible effect on the specific energy.

2.3.4 Chemicals Consumption

- **Calcium Chloride (CaCl2):** According to IDE Projections, since the calcium rejection is getting lower as the temperature is getting higher, less calcium chloride is needed to be added at higher temperature during operating the system at 100% NF.
- **Caustic Soda (NaOH):** Due to lower membrane rejection rates at higher temperatures, increased alkalinity will pass through the membranes and thus should increase the NaOH consumption, however, the NF permeate pH is also expected to be increased, hence overall caustic soda consumption should not be affected by feedstock water temperature increase.
- **Sodium hypochlorite (NaOCl):** This dosing location will serve as an alternative to the dosing location within the product tank. As detailed in Section 2.2.3, the Sodium hypochlorite dosage at this location remains unaffected by temperature changes.

- **Ammonium sulfate:** The Ammonium sulfate dosing goal is the formation of residual monochloramine by reaction with the free chlorine. Therefore, its dosage depends directly on the Sodium hypochlorite (NaOCl) dosage to the product tank which will not be changed (explained in Section 2.2.3) hence the ammonium sulfate dosage will also not be changed.
- **Corrosion inhibitor:** The corrosion inhibitor dosage is fixed and was contractually defined. Thus, it's dosage does not varies along with the temperature.
- **Fluorosilicic acid:** The Fluorosilicic acid dosage is determined by the local State regulation, so it does not depend on the temperature.

2.4. IX Stripping

2.4.1 Performance and Availability

Higher temperatures generally accelerate chemical reaction so the oxidation of Fe^{+2} to Fe^{+3} should be faster, which may improve the iron removal efficiency.
The IX stripping tower removes only a small amount of H_2S because the inlet water pH is relatively high; therefore, significant H_2S degassing to the air is not expected.

2.4.2 Equipment & Materials of Construction

There is no effect on the materials of construction on the equipment in this area.

2.4.3 Energy Demand

According to the findings, the changes in IX PMF Feed pumps efficiency and energy consumption due to operation at high temperature is negligible.

2.4.4 Chemicals Consumption

- **Hydrochloric Acid (HCl) – IX Stripping CIP:** Since Hydrochloric Acid is used for cleaning the degasifiers during the CIP flushing, the dosing rate is fixed and does not depend on the temperature.

2.5. IX PMF

2.5.1 Performance and Availability

Same as described in section 2.1.1.

2.5.2 Equipment & Materials of Construction

There is no effect on the materials of construction on the equipment in this area.

2.5.3 Energy Demand

It is crucial to maintain a consistent bed expansion height for the PMF vessel's media during backwash, regardless of water temperature. Operating at higher temperatures reduces water viscosity, therefore, to maintain the same suspension height, a 3.5% increase in BW flowrate is required. According to the findings, operating at a higher temperature slightly increases efficiency of the Back BW pump but does not significantly change energy consumption. Specific energy consumption compared to the estimate is negligible.

2.5.4 Chemicals Consumption

- **Ferric chloride ($FeCl_3$):** dosage calculation is affected mainly by the Total Suspended Solids (TSS) concentration and does not depend on the temperature.
- **Sodium hypochlorite (NaOCl):** Same explanation as in the NF – PMF area, see section 2.1.4.
- **Sodium bisulfite (SBS):** Same explanation as in the NF – PMF area, see section 2.1.8.

2.6. IX System

2.6.1 Performance and Availability

Generally, higher temperature may improve the color adsorption and thus might impact regeneration requirements. IDE designed the system with N+2 IX vessels and a robust regeneration system to cope with a reasonable increase in the regeneration requirements. Also, chemicals consumption wise, there is enough margin to accommodate the increase in the regeneration frequency.

2.6.2 Equipment & Materials of Construction

There is no effect on the materials of construction on the equipment in this area.

2.6.3 Energy Demand

It is crucial to maintain a consistent suspension height for the IX and regeneration resin during backwash, regardless of water temperature. Operating at higher temperatures reduces water viscosity, therefore, to maintain the same suspension height, hence higher BW flowrate is required.

IX BW pumps:

According to the findings, operating at a higher flowrate, about 3-5%, slightly increases efficiency but does not significantly change energy consumption. Specific energy consumption compared to the estimate is negligible.

Softener BW pumps:

According to the findings, operating at a higher flowrate, about 3-5%, slightly increases efficiency but does not significantly change energy consumption. Specific energy consumption compared to the estimate is negligible.

2.6.4 Chemicals Consumption

- **Sodium chloride (NaCl):** This chemical is used for IX resin regeneration. The temperature change for this application has minor impact which is difficult to predict. Theoretically, higher temperature may improve the color absorbent but from the other side cause shorter regeneration interval, hence the consumption should not be affected by temperature change.
- **Caustic Soda (NaOH):** The goal of this caustic soda is IX resin cleaning, so the concentration is set by the required concentration defined by the vendors for cleaning solution and hence does not depend on the temperature.

2.7. Waste & Neutralization Area

2.7.1 Performance and Availability

Similarly to the product line area, there is no main process equipment in this area. The target of this area is to neutralize the facility's wastewater before disposing it to the injection wells. Therefore, the function of this will not be affected by the temperature change.

2.7.2 Equipment & Materials of Construction

There is no effect on the materials of construction on the equipment in this area.

2.7.3 Energy Demand

According to the findings, the change in Neutralization and Process Wastewater pumps efficiency and energy consumption due to operation at high temperature is negligible.

2.7.4 Chemicals Consumption

- **Caustic Soda (NaOH):** This Chemical dosage Is not steady and changes with the change of the water quality flowing to the neutralization tank. Therefore, it does not depend on the temperature.
- **Sulfuric Acid (H_2SO_4):** Same as Caustic soda above.

3. Summary and Conclusions

This report has analyzed the anticipated impacts of a change in feedwater temperature on the performance and operation of the Prospect Lake Clean Water Center. The analysis focused on four key areas: Performance impacts, Equipment and materials of construction changes, energy demand and chemical consumption. The shift in feedwater temperature, from the old range of 18.5°C to 25°C (65.3°F to 77.0°F) to the new range of 23°C to 28°C (73.4°F to 82.4°F) was found to have some impact on the facility which are summarized in the subsections below.

3.1. Performance and Availability

The facility's performance is expected to be impacted by several temperature-related factors:

- **Fouling -** Increased temperatures can accelerate microbial growth and biofilm formation on the media in the PMF and stripping towers, as well as on the NF membranes. This could lead to more frequent cleaning (NF CIPs, PMF backwash rinsings, and stripping tower CIPs), increasing both chemical consumption and energy demand. In general, CIP process takes place a few times per year, so still the impact is very negligible.
- **Viscosity –** Higher temperatures decrease water viscosity, affecting the facility's energy demand. While lower viscosity generally reduces pumping energy, it may also increase backwash flow rate requirements to achieve the same bed expansion during PMF backwash risings.
- **NF reduced rejection –** Higher temperatures reduce the NF membrane rejection rate, leading to higher ions concentration in the permeate. In our case, the only parameter that will have an impact on the product quality is Iron (the limitation on Ca / Mg is high).
- **Equipment & Materials of Construction -** Following consultation with all equipment vendors, it has been determined that the anticipated temperature change will not significantly affect any equipment. Hence no design changes are needed.

3.2. Energy Demand

Examining the operation at a higher temperature, the following conclusions have been reached:

- From an initial test, we see a minor increase in the efficiency of the NF Feed pump.
- From an initial test, we see a minor increase in the efficiency of all the BW pumps.
- There is a minimal change in the efficiency of all pumps. Those changes are negligible.
- It was found that the pumps can meet project requirements in the proposed temperature range, thus no changes are required in Annex L-1 of the CA.

3.3. Chemicals Consumption

The difference in the chemicals consumption due to the update of the feedstock water temperature is negligible.

3.4. Conclusions & Recommendations

Increased water temperature will lower the membranes' rejection, which will lower the Iron rejection.

DuPont projections (membranes supplier for this project) do not include the iron as an input or output. Hence, Dupont considers similar ions (in terms of size & electrical load) such as Magnesium (Mg) as an indicator to membrane's iron rejection efficiency.

Projections made by DuPont showed increase of 10% to 20% in the Magnesium concentration in the permeate water (depending on the operating scenario). Adding safety factor (as required by the membranes vendor) will show even higher values.

Based on the information provided above, it is requested to increase the iron maximum concentration, specified in Annex H-2 of the Comprehensive Agreement, from 0.15 to 0.20 ppm.

The proposed value is lower than the Secondary Drinking Water standard for this parameter (0.3 ppm) as shown in Annex H-1.