Pre-Design Memorandum

Water Plant – Install Reverse Osmosis System

University of Iowa

UI Project No. 0544401
HDR Project No. 276214

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1 Project Description

The University of Iowa Water Plant is a lime softening surface water treatment facility of 6 million gallons per day (MGD) design capacity. The main source of raw water supply is the Iowa River, which has experienced increasing nitrate contaminant levels through the years. The lime softening water plant does not have the ability to remove nitrate in the existing treatment processes, and the existing Jordan Well can no longer be relied upon to blend down high nitrate levels to maintain compliance with federal and state drinking water standards.

This project includes the installation of a reverse osmosis (RO) water treatment system in the existing Water Plant building. The RO units will remove nitrate from a portion of the finished water from the conventional treatment process. The system is proposed to be operated with a 50% blend of RO-treated water full time, year-round to provide for continuously consistent water quality and plant operations.

Project elements were identified in a Preliminary Engineering Report by HR Green dated July 14, 2015. Three RO skids are proposed: Two at 1 MGD each and one at 0.5 MGD for a total capacity of 2.5 MGD. Design considerations include:

- Filter effluent from the under-filter clearwell is transferred to the above-grade 1 MG chlorine contact tank by three transfer pumps through 24” diameter piping. RO influent piping will be connected to the 24” transfer piping at an appropriate location and run to the second floor to a RO feed water tank to serve the three RO skids.

- RO effluent piping will be run back down to the transfer piping and connected at an appropriate location to blend RO effluent with the filter effluent ahead of the chlorine contact tank.

- The RO skids, RO feed water tank and pumps, and clean-in-place system are proposed to be located in the north room of the second floor. Demolition of the existing laboratory room and potentially restroom, and removal of existing shelving and materials stored thereon, will be necessary to clear space for the equipment. New larger doors must be added on the north wall to get the RO skids into the building.

- The RO system will require chemical feed systems including pH control, anti-scalant and dechlorination for membrane protection, and a clean-in-place system for membrane cleaning. The RO feed water tank will be utilized for carbon dioxide contact time for pH stabilization ahead of the membranes. These chemical storage/feed systems are proposed to be located in the south room of the second floor. Demolition and removal of the existing steel alum bins, soda ash feeder, and shelving and materials stored thereon, will be necessary to clear space for the chemical storage/feed systems. The existing potassium permanganate feed system will be moved to a new location by plant staff.

- The new RO system will be integrated into the existing GE Simplicity plant SCADA system for monitoring and control of the new process equipment.
This Pre-Design Phase of the project reviews the existing conditions, reviews and confirms/updates design conditions and criteria, and determines what modifications to the existing facilities will be required to integrate the proposed equipment installation. This pre-design review includes the following:

- **Architectural Analysis** – Perform analysis for code review, safety, and ingress/egress for new equipment and room areas.

- **Structural Analysis** – Perform analysis of existing floor and framing systems for support of new equipment and accessories, and any necessary modifications to facilitate support.

- **Process Analysis** – Perform analysis to confirm sizing, configuration, and layout of RO equipment, accessories, piping, and chemical storage/feed. Determine connection points to the existing filter effluent transfer piping for new RO influent and effluent piping, and the routing from the second floor to the lower level filter gallery for these new piping systems. Consult RO equipment manufacturers to determine equipment procurement schedule and overall project schedule for either Contractor-procurement or Owner-procurement of RO equipment.

2 **Architectural Analysis**

The architectural analysis consists of a code review of the areas of the University of Iowa’s existing Water Plant building affected by this project.

2.1 **Code Review**

The project involves introducing equipment for a reverse osmosis system into the existing Water Plant building.

Because the project is not adding space/area to the existing building, a full code analysis for the building should not be required. The building has been used for this purpose for many years, and this project does not change the use or occupancy group, and does not increase the building area, so a complete building code analysis is not applicable.

The assumptions are that the building is non-combustible Type IIB (unprotected) construction, and any new construction will be non-combustible. The building does not have a fire sprinkler system. The 2015 International Building Code is referenced, as the State is close to adopting this edition.

The primary concern is that new installations in this project must not impede egress. Based on the layout in the preliminary engineering report, this will not be an issue.

In addition, chemicals indicated in the preliminary engineering report are not flammable. Sodium hydroxide and sodium bisulfite are corrosive chemicals that require care in storage and handling, but are not flammable. It is assumed that the University would have operational procedures in place to accommodate this.

Normally, buildings of this type are considered to be an F-1 occupancy group (Moderate-Hazard Factory Industrial). Storage of corrosives is limited to 500 gallons per Control Area on First Floor (375 gallons on Second Floor), and will need a 1-hour separation
from the remainder of the building (IBC 2015 Table 414.2.2). Also, Table 414.2.2 limits the number of Control Areas per floor: 4 on First Floor, 3 on Second Floor. Footnote ‘e’ on Table 307.1(2) allows the quantities to be doubled if the corrosives are stored in ‘storage cabinets, gas cabinets or exhausted enclosures’. So if exhaust is provided in these rooms, or if the corrosives will be stored in special cabinets, allowable quantities would be 1,000 gallons per control area on First Floor and 750 gallons per control area on Second Floor. This would allow for storage of 2,250 gallons on Second Floor in 3 control areas.

If the preference is to have one room for storing chemicals and these quantities are exceeded, then a 2-hour enclosure would be required as a separation between an F-1 occupancy and an H-4 occupancy per Table 508.4. An 8” concrete block wall would provide a 2-hour enclosure and a 90-minute door would be needed at the opening. This is not a major cost difference to provide a 2-hour enclosure because an 8” concrete block wall is proposed anyway, and the cost difference between a 60-minute and 90-minute door is negligible. In either case, a 4” poured concrete lid would be provided on the rooms which provides a 2-hour rating. The enclosure needs to include the floor and ceiling/roof of the control areas, so this is where it may get more involved. Though we know the floor is a 7” concrete slab, we may be required to isolate the structure under these control areas to provide the 2-hour rating.

In addition to ventilation of the chemical storage room, which will require uninterrupted power, we see no other impacts on the operation of this building except for paragraph 5004.2.2.5 of the Fire Code which requires monitoring of the containment area. This can be accomplished by visual inspection if approved by the AHJ.

All of these elements will need to be confirmed by the AHJ prior to completing bid/construction documents. The intent is to set up an informal review prior to officially sending project documents which are sent just prior to the bid phase, so that we are proceeding on an approved path to completion.

3 Structural Analysis

The structural analysis includes an evaluation of the existing floor and framing systems for support of new equipment and accessories.

3.1 Second Floor Slab

The existing Water Plant record drawings were reviewed, including the 1962 original construction, 1987 expansion, and 1996 addition. The reinforced concrete second floor slab in both the 1962 original building and the 1987 expansion is 7” thickness. The roof slab of the 1996 addition at the same elevation as the second floor slab is 9” thickness. The design live load capacity is 500 pounds per square foot (psf) for all of these slab areas. Review of the slab reinforcing steel sizes and spacing, the beam and column spacing, and the slab thicknesses confirms the 500 psf design live load capacities.

An RO equipment manufacturer was consulted to determine operating weights of the RO skids. The 1 MGD RO skids will weigh approximately 35,000 pounds in an approximate footprint area of 12’ x 23’. This results in a distributed load of approximately 127 psf,
which is substantially less than the 500 psf floor slab capacity. The skids would likely be supported by frames with nine points of contact with the floor, resulting in average point loads of approximately 3,900 pounds each. The floor supports would typically bear on 16" x 16" baseplates. The existing slab thickness and reinforcing steel should be adequate for punching shear for these point loads.

The RO skids will be delivered to the plant site fully assembled. This will require that they be lifted by crane from ground level, temporarily set on the roof of the 1996 addition, and rolled into the second floor area through a new larger door opening. This roof slab structure with live load capacity of 500 psf has adequate capacity to support these activities. Temporary plates or other means of protection of the roofing system must be provided for these activities.

The floor loads for the chemical storage and feed systems will be much less than the RO skids, with the exception of bulk sodium hydroxide storage. The height of the bulk storage tank(s) will be designed to limit the maximum liquid level to be safely within the 500 psf design live load capacity of the floor structure. This will also be the case for the height and configuration of the RO feed water tank.

Therefore, the existing floor and framing systems have adequate capacity to support the new equipment and accessories. Appropriate concrete or grout base pads and anchorage to the existing floor slabs will be designed for the various new equipment items.

## 4 Process Analysis

### 4.1 Equipment

Three RO skids are proposed to be located in the north room of the second floor. Demolition of the existing laboratory room and potentially restroom, and removal of existing shelving and materials stored thereon, will be necessary to clear space for the RO skids.

#### 4.1.1 RO Equipment

The RO equipment design parameters are as follows:

- Number and size of units:
  - Two RO systems capable of producing 1.0 MGD permeate, each
  - One RO system capable of producing 0.5 MGD permeate
- Recovery: 75%
- Expected nitrate rejection: 92%
- Design Flux:
  - Average flux = 13 gfd
  - Maximum allowable flux = 15 gfd
- Stages: 2 stage systems

In addition to the RO skids, an RO feed water tank, RO feed pumps, and a CIP (Clean In Place) tank and skid will be located near the ROs in the north room on the second floor. The RO feed water tank will be utilized for carbon dioxide contact time for pH...
stabilization ahead of the membranes. The CIP tank and skid will be used to make up solutions of cleaning chemicals that will remove fouling from the membranes.

The new RO system will be integrated into the existing GE Simplicity plant SCADA system for monitoring and control of the new process equipment.

The expected sizes of the RO skids are approximately 12 feet wide x 23 feet long x 15 feet high. An initial equipment plan layout is shown on Figure 1. The sizes of the RO feed tank and CIP tank and skid must be confirmed. The final locations of these systems may be different than that shown.

The project as described with a total of 2.5 MGD of RO permeate capacity should provide for 15-20 years of plant capacity, based on recent water demand and nitrate projections. Additional capacity beyond that could be provided by placing more RO skids on the roof area of the sludge dewatering expansion to the north and enclosing this building area in the future.

In order to accommodate this future capacity expansion capability, the RO influent piping, permeate piping, and concentrate waste piping from the second floor to the basement level will be hydraulically designed for a size to carry a total of 5 MGD of RO permeate. This will allow for an additional 2.5 MGD of RO permeate capacity to be fed to the north expansion area in the future.
Figure 1 – Preliminary RO Equipment Layout
4.1.2 Chemical Feed Systems

The RO treatment process will require new chemical feed systems to be added to the water treatment plant. The chemical feed systems will include pH control before and after RO treatment, anti-scalant and dechlorination for membrane protection, and clean-in-place chemicals for membrane cleaning. Additional chemicals may be required for corrosion control in finished water and neutralization of the CIP chemical solutions.

The new chemical storage and feed systems are proposed to be located in the south room of the second floor. Demolition and removal of the existing steel alum bins, soda ash feeder, and shelving and materials stored thereon, will be necessary to clear space for the chemical storage/feed systems. The existing potassium permanganate feed system will be moved to a new location by plant staff.

The chemical systems that will be added in this project are listed in Table 1 along with their purpose, usage rates, and storage requirements.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Purpose</th>
<th>Max Day Use</th>
<th>Average Day Use</th>
<th>Required 30 Days Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>Lower pH ahead of RO</td>
<td>- 769 lb/d ahead of RO</td>
<td>- 614 lb/d after softening</td>
<td>12.2 tons</td>
</tr>
<tr>
<td>Sodium Bisulfite, 38%</td>
<td>Neutralize chlorine residual ahead of RO</td>
<td>15 gal/day</td>
<td>12 gal/day</td>
<td>360 gallons</td>
</tr>
<tr>
<td>Antiscalant</td>
<td>Condition water ahead of RO</td>
<td>6 gal/day</td>
<td>5 gal/day</td>
<td>150 gallons</td>
</tr>
<tr>
<td>Caustic Soda (Sodium Hydroxide), 25%</td>
<td>Raise pH of treated water and neutralize low pH CIP solution</td>
<td>- 109 gal/day to raise pH of treated water - Additional volume to neutralize CIP solution 4-6 times per year, if needed.</td>
<td>- 55 gal/day to raise pH of treated water - Additional volume to neutralize CIP solution 4-6 times per year, if needed.</td>
<td>- 1650 gal to raise pH of treated water - Additional volume to neutralize CIP solution 4-6 times per year, if needed.</td>
</tr>
<tr>
<td>Low pH CIP</td>
<td>Remove inorganic fouling from membranes</td>
<td>1000 lb (powder form) - 400 lb Train 1 - 400 lb Train 2 - 200 lb Train 3 - 4-6 times per year</td>
<td>1000 lb (powder form) - 400 lb Train 1 - 400 lb Train 2 - 200 lb Train 3 - 4-6 times per year</td>
<td>Need 2500 gallon CIP tank to mix 2% solution by weight.</td>
</tr>
<tr>
<td>Ortho- or Poly-Phosphate, if needed</td>
<td>Corrosion control in finished water, if needed</td>
<td>10.2 gal/day</td>
<td>5.2 gal/day</td>
<td>155 gallons</td>
</tr>
</tbody>
</table>

An initial chemical equipment plan layout is shown on Figure 2. The sizes of the storage tanks and final locations of these systems may be different than that shown. Additional space will be selected for storage of the low pH CIP chemical in dry form (drums or carboys) and for a corrosion control chemical if it is needed.
Figure 2 – Preliminary Chemical Equipment Layout
4.2 Piping

4.2.1 RO Feed Water Piping Connection

Filter effluent from the under-filter clearwell is currently transferred to the above-grade 1 million gallon chlorine contact tank by three transfer pumps through 24-inch diameter piping. New piping will be connected to the 24-inch transfer piping at an appropriate location and run to the second floor to a RO feed water tank to serve the three RO skids. The connection point and routing of this new piping will be determined after the initial plant site visit during the Schematic Design Phase of the project.

4.2.2 RO Permeate Piping Connection

RO permeate piping will be run back down to the transfer piping and connected at an appropriate location to blend RO effluent with the filter effluent ahead of the existing chlorine contact tank. The connection point and routing of this new piping will be determined after the initial plant site visit during the Schematic Design Phase of the project.

4.3 Schedule

4.3.1 Equipment Procurement Schedule

The proposed RO procurement schedule is summarized in Table 2 below.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Start</th>
<th>Completion</th>
<th>Approximate Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop RO Procurement Documents</td>
<td>April 4, 2016</td>
<td>May 5, 2016</td>
<td>3 weeks</td>
</tr>
<tr>
<td>UI Review and Finalize RO Procurement Documents</td>
<td>May 6, 2016</td>
<td>May 27, 2016</td>
<td>5 weeks</td>
</tr>
<tr>
<td>Purchasing Issue RFP for RO Equipment</td>
<td>May 30, 2016</td>
<td>June 6, 2016</td>
<td>1 week</td>
</tr>
<tr>
<td>Vendor Proposal Development</td>
<td>June 7, 2016</td>
<td>June 29, 2016</td>
<td>3 weeks</td>
</tr>
<tr>
<td>RO Equipment Proposal Evaluation</td>
<td>June 30, 2016</td>
<td>July 21, 2016</td>
<td>3 weeks</td>
</tr>
<tr>
<td>Select RO Equipment Vendor and Issue Purchase Order</td>
<td>July 22, 2016</td>
<td>August 4, 2016</td>
<td>2 weeks</td>
</tr>
<tr>
<td>RO Equipment Shop Drawing Development</td>
<td>August 5, 2016</td>
<td>September 15, 2016</td>
<td>6 weeks</td>
</tr>
<tr>
<td>RO Shop Drawing Review and Final Shop Drawing Revisions</td>
<td>September 16, 2016</td>
<td>October 13, 2016</td>
<td>4 weeks</td>
</tr>
</tbody>
</table>
RO vendors, including Wigen, Harn, H2O Innovation, and U.S. Water, have confirmed that the proposed schedule is realistic.

4.3.2 Overall Project Schedule

The proposed overall project schedule is shown in Figure 3.
Figure 3 – Proposed Overall Project Schedule