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#### 9.1.1 Air Release Valves

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1 Introduction

Choctaw Lake is an exclusive 285-acre private lake community located in Madison County, Ohio. Sewer service is provided by Madison County and water service is provided by Choctaw Utilities Inc., which operates a 400,000 gpd ground water drinking water treatment plant. The source water is supplied by three 200 gpm wells located on the treatment plant site located at the north-east end of Choctaw Lake. Each well is 250 feet deep and has a 300’ radius protection area. There are 875 water accounts and approximately 2,000 residents on the system.

The distribution system consists of 12 miles of asbestos concrete pipe ranging from 3” to 8” with most of the piping being in the 4” to 6” range. Pressure is controlled by the high service pumps and the 340,000 gallons of elevated storage associated with the system. There are a limited number of hydrants and air release vales which are also used for system flushing.

The treatment facility is aged but extremely well maintained consisting of an elevated induced draft aerator followed by a 52,000 gallon steel reaction tank. Chlorine is injected in the suction manifold of the three high-service pumps which are connected to four vertical mono-media pressure filters. Orthophosphate is added for corrosion control on the downstream side of the filters and the water enters the distribution system.

The Choctaw Utilities Water Treatment Facility has had a long record of excellent operation but in recent months, the system has experienced an inordinate number of red water and brown water issues in its distribution system. In addition, there was a minor episode in the orthophosphate feed level which caused an excursion in the maintenance of the EPA-required concentration range of 0.8 to 3.0 mg/l. While several factors likely contributed to this anomaly, the Utility is in the process of revamping the orthophosphate delivery system, entry point, and sampling protocol.

In addition to the orthophosphate excursion, there have been ongoing issues with copper in the distribution system. It has been determined that the source of copper is due to corrosion from over-softened water from residential water softeners (see attached “Copper Study” report).

To address the current issues, the Utility has decided to perform a comprehensive performance evaluation of its treatment processes to measure the effectiveness and efficiency of each treatment unit. In addition, the Utility will be developing a dynamic computerized hydraulic model for its distribution system which will provide a basis for an enhanced hydrant flushing program.

IBI Group was selected to provide engineering design services to evaluate and address red water issues in the treatment, storage, and distribution systems of Choctaw Utilities drinking water system. Said services include:

1) Facilitate a project meeting and wrap-up meeting
2) Construct a water model of the existing distribution system using WaterCAD
3) Prepare a distribution system analysis
4) Prepare a Comprehensive performance evaluation
5) Prepare an aeration tower evaluation
6) Prepare a pressure filter evaluation

The following report satisfies items 4-6 listed above. The Comprehensive performance evaluation
2 Comprehensive Performance Evaluation

IBI Group was commissioned to evaluate the efficacy of Choctaw Utilities water treatment process units to accurately identify any deficiencies and recommend any corrective needed action to maintain the high level of water quality that its customers have historically enjoyed. To that end, a comprehensive performance evaluation was conducted on October 25, 2016 to quantitatively evaluate the performance of each component of the treatment system. The comprehensive performance evaluation is the basis for recommendations for optimization and improvements in the treatment system. IBI Group has also performed a condition assessment of the aeration system, the reaction tank, filters, and chemical addition systems including chlorine and orthophosphate unit processes. Elements of the performance evaluation are provided below.

2.1 Sampling Protocol.

A key attribute of the performance evaluation was to evaluate the unit treatment processes across a range of flow rates. Because of limited capacity flexibility there is only two possible flow rates at which the plant can currently operate. For the purposes of this report, we will term these flow rates as “low flow” and high flow.” To capture the low flow and high flow characteristics, two sets of samples were taken; the initial set began at 10:14 am and the second batch was taken at 2:25 pm.

The plant is typically operated with one well in service during low flow and two wells in operation during high flow operations. On the day of sampling, well #1 and well #3 were in service. There are three high service pumps that draw from the reaction tank. During low flow operation one high service pump is in service while during high flow operation two high service pumps are used.

For the first set of samples the plant operation included well #1 and well #3, plus only one high service pump. The first sample taken at the aerator inflow was for wells #1 and #3 combined. Then well #3 was then turned off so only well #1 was flowing through the aerator. Then well #1 was turned off and well #2 was turned on; well #2 had not been run in two weeks. Then well #2 was shut off and well #3 was turned on. Finally, well #1 was turned on to get back to normal flow for this time with wells #1 and #3 turned on. There was approximately 2 minutes in-between when each sample was taken as the alternate well pumps were run. Once the aerator samples were taken, the plant was left to run for 30 minutes then samples from the filters were taken.

When the second set of samples was taken, well #1 was in service as well as two high service pumps. A sample from the aerator out location with one well pump running was taken at 2:25 pm. Then a sample was taken from filters 1, 2, and 3 once the plant had run for 30 minutes in this mode.

Three samples were taken for each measurement point and averaged to obtain the most reliable data. Sampling and testing methods were in accordance with generally accepted sampling methodology and tests were performed according to manufactures specification. The sampling points are shown schematically in the figure below.
2.2 Sampling Results

The result of the sampling and testing procedures were recorded and are presented in the table at the end of the report.

3 Aeration Tower and Contact Tank
3.1 Aeration Tower and Contact Tank Description

The aeration tower is part of the original construction of the water plant in 1969 and a baffled cascading flow aerator. The aerator is elevated and shows signs of structural failure. The aerator is an open air aerator with a screen providing debris protection. The screen is in poor condition and rusting and is in need of replacement.

The tank is a 52,000 steel tank installed after the initial plant was constructed. The tank is a steel walled tank that is 8’ high with a 35’-4” diameter. The tank paint is peeling and signs of wear are shown near pipe connections. The tank is connected by an open hole to the aerator and a collared connection which can easily be removed.

3.2 Aeration Tower and Contact Tank Condition Assessment

Figure 3: Aeration Tower Showing Signs of Wear
Figure 4: Connection Pipe from Aeration Tower to Contact Tank

Figure 5: Contact Tank with Signs of Rusting and Wear
It is the professional opinion of IBI Group’s water treatment operations and design engineering team that the condition of the aeration and contact chamber is categorized as “poor.” While currently functional, the 45 year-old aeration tower structure is well beyond its useful life and several components of the tower are rusted and compromised. The 52,000 gallon contact tank is also well beyond its useful life and exhibiting signs of structural failure.

3.3 Aeration Tower and Contact Tank Performance

3.3.1 Aeration Tower and Contact Tank Evaluation Methodology

The IBI Group operations team conducted a sampling protocol designed to measure the effectiveness of the aeration unit. Influent and effluent grab samples were taken at two different flow rates corresponding with low flow and high flow. Low flow raw influent samples were taken for each well and compared with high flow samples which were measured using the combined flow of wells #1 and #3. Representative samples of the influent were taken as noted at the aerator influent pipe. Intermediate samples were also taken at the aerator outflow prior to entering the reaction tank. Finally, samples were collected at the high service pump sampling port which were compared against the influent samples to evaluate the efficacy of the unit process.

The samples were analyzed in the field by our technicians to determine carbon dioxide removal, dissolved oxygen creation, and oxidation of soluble iron and manganese. Analysis methods and results for each parameter are described below:

3.3.2 CO2

Dissolved carbon dioxide (CO₂) is naturally present in ground waters and should be removed from drinking water to lower hardness. A common method of removing CO₂ is through an air stripping process in which raw water containing dissolved CO₂ is caused to pass through a series of baffles which increases the surface area of the water exposed to the atmosphere and also creates turbulence thereby removing the CO₂ from solution.

IBI Group employed the “Caustic Titrant with pH Indicator Method” be used to measure carbon dioxide in solution in accordance with APHA Standard Methods, 22nd ed., Method 4500-CO₂-C -1997. ASTM D 513-82, Total and Dissolved Carbon Dioxide in Water, Test Method E.

The results of the CO2 analysis associated with the aerator at low and high flow rates are depicted in Figure 1 below.
The dissolved CO2 concentration was reduced by means of air stripping from an influent concentration of over 13 mg/L to a non-detectable effluent concentration corresponding to <10 mg/l. This is an expected level of performance for the air stripping process. There is significant variability with such a sampling process and the precision of the testing method is non-detectable at concentration below 10 mg/l. After the aeration tower, the dissolved CO2 levels were not detectable in the downstream processes.

3.3.3 Dissolved Oxygen

Dissolved oxygen (DO) concentrations are increased when water is passed through an aerator. The increased DO oxidizes reduced soluble forms of iron and manganese such that these species can be precipitated and filtered out of the drinking water. IBI Group utilized the Indigo Carmine Method as specified by ASTM D 888-87, Dissolved Oxygen in Water, Test Method A. Gilbert, T. W., Behymer, T. D., Castañeda, H. B., "Determination of Dissolved Oxygen in Natural and Wastewaters," American Laboratory, March 1982, pp. 119-134.

The increase in dissolved oxygen concentration across the aerator process is shown in figure 2 below:
Dissolved oxygen levels at the outlet of the aeration process were of 6.0 mg/l for low flow and 8.33 mg/l for high flow. Through the contact tank the dissolved oxygen levels dropped from 6.0 mg/l to 5.0 mg/l for high flow and from 8.33 mg/l to 5.0 mg/l for low flow as shown in Figure 3 below.

**Figure 7 – Aerator DO increase**

**Figure 8 – DO concentrations through the contact tank**

3.3.4 Iron

Iron in the drinking water system can cause “red water” aesthetic problems in which dissolved ferrous is converted to a ferric precipitate when oxidized in the system. Iron is removed by intentionally oxidizing the reduced soluble divalent ferrous iron (Fe^{2+}) into insoluble trivalent ferric iron (Fe^{3+}) and subsequently removed.
To measure soluble and total iron across the unit treatment processes, IBI Group used the Phenanthroline Method (total & soluble; total & ferrous) as described in APHA Standard Methods, 22nd ed., Method 3500-Fe B - 1997. ASTM D 1068-77, Iron in Water, Test Method A. J.A. Tetlow and A.L. Wilson, “The Absorptiometric Determination of Iron in Boiler Feed-water”, Analyst. Vol. 89, p. 442 (1964). With the Phenanthroline Method, ferrous iron reacts with 1,10-phenanthroline to form an orange-colored chelate. To determine total iron, thioglycolic acid solution is added to reduce ferric iron to the ferrous state. The reagent formulation minimizes interferences from various metals. Results are expressed as (mg/L) Fe.

The iron concentration measured across the entire aeration and contact process is depicted in Figure 9:

![Iron concentration across the aeration and contact units](image)

**Figure 9 – Iron concentration across the aeration and contact units**

The dissolved iron concentration was measured at 2.09 mg/l at well #3 in previous studies and decreased to a level of .57 mg/l and .37 mg/l through the aeration process.

### 3.3.5 Manganese

Manganese in drinking water can cause aesthetic “brown water” problems in which the manganese in the +2 oxidation state, Mn(II), exists as an ion in solution. Like dissolved ferrous, when oxidized in water systems, it is converted to a precipitate, manganic dioxide, which is responsible for the poor aesthetic quality of water giving it the brown or blackish color. To address this, Mn (II) can be oxidized to insoluble manganic dioxide (MnO2) and removed subsequently by a clarification or filtration process. To measure the manganese in across the treatment process, IGI Group employed the Periodate Method referenced in APHA Standard Methods, 14th ed. Method 314 C (1975) to measure soluble manganese compounds. Results are expressed as (mg/L) Mn.

There was no manganese detected in the raw water for the Choctaw Utilities water systems. Subsequent downstream tests verified the conclusion non-detect levels of manganese.
3.3.6 Turbidity

One of the most important parameters in drinking water treatment is turbidity measured by a turbidity meter and expressed in terms of nephelometric turbidity units (NTU). Turbidity is the measure of the cloudiness or light-scattering characteristic of water typically caused by suspended or colloidal particles in the water. Such particles can be the carrier for pathogens such as viruses, bacterial, and protozoa.

IBI Group used a PCE-TUM 20 turbidity meter with a range of 1 to 1,000 NTU to analyze the samples taken as part of the Choctaw Comprehensive Performance Evaluation. The results of the turbidity analysis are depicted below in Figure 5.

As indicated above, the turbidity increased through the aeration process from 5.61 NTU to 37.2 NTU for high flow and 13.11 NTU to 37.91 NTU for low flow.

3.4 Analysis of Results

From the results of these tests of the aeration unit process, IBI Group’s operations experts have determined that the process appears to be operating properly and adequately sized to meet the needs of Choctaw Utility in accordance with 10 State Standards sections 4.7.2 and 4.8. The induced draft aerator must be sized to meet the design criteria of 1-5 gpm/ft2 tray area and the contact tank must provide for at least 30 minute of detention time.

The aeration tower and reaction tank have lasted well beyond their useful life. The condition of the aeration process equipment is extremely poor and components of the process are currently failing. Therefore, it is recommended that the current system be decommissioned as soon as practical and be replaced. Consideration should be given to an integrated system that best achieves the goals of the Utility.
4 Pressure Filters

The filter influent was taken at the discharge of the high service pumps. Then a sample was taken from each of filters #1, #2 and #3. Filter #4 was out of service.

IBI Group proposes to evaluate the performance of the Utilities four pressure filter units by measuring particulate removal efficiency as well as iron and manganese removal efficiency. Particular attention will be focused on particulate removal efficiency. As with the aeration tower, filter influent and effluent samples will be taken at three flow rates corresponding with low, average and peak daily demand. With the pressure filters head loss will also be considered. IBI Group will also make a visual inspection of the current filtration media.

Iron and manganese removal efficiencies across the pressure filters will be measured using the test procedures outlined above, particulate removal efficiency will be determined by measuring the turbidity of the influent and effluent of the filters using nephelometry according to Standard Methods 2130B, established by the American Public Health Association (APHA) in Standard Methods for the Examination of Water and Wastewater, 19th edition. These data will be analyzed by IBI Group to determine whether any corrective action must be taken such as media replacement a change of media type.

IBI Group will also verify that the pressure filters are appropriately sized to meet the needs of Choctaw Utility in accordance with 10 State Standards. If replacement or enhancement of the pressure filtration unit process is indicated, IBI will provide performance specifications and an engineer's cost estimate for new equipment.

4.1 Pressure Filtration

![Figure 11: High Service Pumps for Pressure Filtration](image-url)
Two pressure filters were installed in 1969 with the original construction of the water plant in 1969. Approximately 10 years later, two additional filters were installed. The filters are 5'-6" in diameter, 5' tall on the straight wall of the cell, and have a total surface area of 96 SF between four filter cells.

The filters are fed by three high service pumps that draw from the contact basin and convey high pressure flow to the inlet of each filter. The pumps are two vertical High service pumps which are alternated between flows and one horizontal high service pump used as a redundant safety factor.

4.2 Pressure Filter Condition Assessment
It is the professional opinion of IBI Group’s water treatment operations and design engineering team that the condition of the pressure filters is categorized as “poor.” While currently functional and very well maintained, the 45 year-old filters are well beyond their useful life. The filters unit housings are heavily pitted from excessive wear and also encrusted with decades of scaling. The internal components are extremely old and subject to failure.

4.3 Pressure Filter Performance

4.3.1 Pressure Filter Evaluation Methodology

The IBI Group operations team conducted a sampling protocol designed to measure the effectiveness of the pressure filtration process. Influent and effluent grab samples were taken at two different flow rates corresponding with low flow and high flow. Low flow raw influent samples were taken with one high service pump in service and compared with high flow samples which were measured using two high service pumps. Representative samples of the influent were taken as noted at the high service pump sampling port. Effluent, samples were taken at the drain locations on each filter. Analytical results of the effluent samples were compared against the influent samples to evaluate the efficacy of the unit process.

The samples were analyzed in the field by our technicians to determine iron removal and turbidity reduction. Analysis methods and results for these parameters are described below.

4.3.2 Iron

As mentioned above, iron in the drinking water system can cause “red water” aesthetic problems in which dissolved ferrous is converted to a ferric precipitate when oxidized in the system. Iron is removed by intentionally oxidizing the reduced soluble divalent ferrous iron ($\text{Fe}^{2+}$) into insoluble trivalent ferric iron ($\text{Fe}^{3+}$) and subsequently removed. In the case of the Choctaw Utilities Water Plant, the removal is achieved through the pressure filtration system.
To measure soluble and total iron across the unit treatment processes, IBI Group used the Phenanthroline Method (total & soluble; total & ferrous) as described in APHA Standard Methods, 22nd ed., Method 3500-Fe B - 1997. ASTM D 1068-77, Iron in Water, Test Method A. J.A. Tetlow and A.L. Wilson, “The Absorptiometric Determination of Iron in Boiler Feed-water”, Analyst. Vol. 89, p. 442 (1964). With the Phenanthroline Method, ferrous iron reacts with 1,10-phenanthroline to form an orange-colored chelate. To determine total iron, thioglycolic acid solution is added to reduce ferric iron to the ferrous state. The reagent formulation minimizes interferences from various metals. Results are expressed as (mg/L) Fe.

The iron concentration measured across filters #1 through #3 is shown below. At the time of the evaluation, filter #4 was out of service. Figure #6 shows iron reduction across filter #1. Figure #7 show iron reduction across filter #2.

![Iron Removal Across Filter #1](image-url)
As indicated in the data above, the incoming iron was reduced to extremely low levels beyond the measurement precision of our field apparatus.

### 4.3.3 Turbidity

As mentioned above, turbidity is one of the most important parameters in drinking water treatment. Turbidity measured by a turbidity meter and expressed in terms of nephelometric turbidity units (NTU). Turbidity is the measure of the cloudiness or light-scattering characteristic of water typically caused by suspended or colloidal particles in the water. Such particles can be the carrier for pathogens such as viruses, bacterial and protozoa.
IBI Group used a PCE-TUM 20 turbidity meter with a range of 1 to 1,000 NTU to analyze the samples taken as part of the Choctaw Comprehensive Performance Evaluation. The results of the turbidity analysis are depicted below. Figure #9 indicates the turbidity reduction across filter #1. Figure #10 shows the turbidity removal for filter #2. Finally figure #11 indicates the removal of turbidity by filter #3. Filter #4 was out of service at the time of the evaluation.
4.4 Analysis of Results

From the results of these tests of the filtration, IBI Group’s operations experts have determined that the process appears to be operating properly and adequately sized to meet the needs of Choctaw Utility in accordance with 10 State Standards sections 4.3.2.2 and 4.3.2.3. Pressure filters must provide for a loading of no more than 4gpm/ft² of filter surface area and a backwash rate of 15gpm/ft² of filter surface area. Pressure filters are also required to have headloss gauges according to section 4.2.3.2 paragraph “f” of 10-State Standards.

Like the aeration tower and reaction tank, the pressure filters have lasted well beyond their useful lives. The condition of the equipment is poor and filter #4 recently failed. Therefore, it is recommended that the current system be decommissioned as soon as practical and be replaced. Consideration should be given to an integrated system that best achieves the goals of the Utility.

5 Water Sampling Data

Water samples were taken at each of the following locations

- Well #1 (i.e. aerator inflow with only Well #1 running)
- Well #2 (i.e. aerator inflow with only Well #2 running)
- Well #3 (i.e. aerator inflow with only Well #3 running)
- Aerator inflow (Well #1 and Well #3 running)
- Aerator outflow

As indicated above, the turbidity decreased through the filtration process 37.2 NTU for high flow and 37.91 NTU for low flow to virtually zero after filtration.
Each of the samples was tested for the following parameters:
- Dissolved oxygen
- Carbon dioxide
- Iron
- Manganese
- Turbidity

Three data points are provided for each sample location for each parameter. The following tables summarize the data collected.

<table>
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<th>Sample Set 1</th>
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<td><strong>Sample Name</strong></td>
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<td>Filter 3</td>
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A facilitated workshop was conducted on November 16, 2016 in which the findings of the comprehensive performance evaluation and distribution modeling were presented to the Board of Directors of Choctaw Utilities as well as concerned residents in the community. The presentation slides are included in the Appendix to this report.

As the owners of the Choctaw water system, the residents of Choctaw Lake represented by the Board of Director of Choctaw Utilities Inc. is responsible for deciding what action to take to address the needs of the utility based on the technical findings of the comprehensive performance evaluation and water distribution system modeling. After the technical findings were presented, at the workshop, the Board was asked to provide the project drivers to be used by IBI Group to develop a set of technical alternatives to address the needs of the community. The Board and community members listed eighteen items that represent the project drivers or criteria by which project alternatives can be developed. The items with explanations are provided below:

Cost – Initial capital costs as well as operating and maintenance and repair costs
Time – Time to completion for reliable water system
Safe Supply – Water to be safe and healthy and of sufficient quantify
Sustainable – Water system solution should be sustainable
Phased Install – Explore cost benefits of phased approach
Multiple Options - Explore full range of viable alternatives
Temporary Fixes – Look at possibility of temporary fixes verses permanent solution
New Equipment vs. Replaced Equipment – Explore benefits of new technology
Value-Cost – Focus on value and ROI

6 Decision Analysis Evaluation

<table>
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<th>Sample Name</th>
<th>Location</th>
<th>Dissolved Oxygen, mg/L</th>
<th>Carbon dioxide, mg/L</th>
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<th>Manganese, mg/L</th>
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</tr>
<tr>
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<td>0.23</td>
</tr>
<tr>
<td></td>
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<td>13</td>
<td>0.1</td>
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<td></td>
<td></td>
<td>5</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Filter 2</td>
<td>Filter 2 effluent</td>
<td>5</td>
<td>less than 10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>less than 10</td>
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<td>0</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>less than 10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Filter 3</td>
<td>Filter 3 effluent</td>
<td>6</td>
<td>less than 10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>less than 10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>less than 10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Cost Phase – Phasing of cost
Phased Hydrants -Phased approach to distribution system improvements
Timing – Make sure improvements occur at the right time
Quality Assurance – Ensure that at QA/QC plan is in place
Make Sure This Doesn’t Happen Again!
Range of Options – Explore all the options
Financing and Funding – Look at funding alternatives
Distribution System – Make sure distribution system issues are addressed

The above issues that were identified by the Choctaw residents were further discussed and distilled into five criteria. In addition, the items were assigned an initial “weighting factor” to reflect the relative importance of the criteria as assessed by the members of the community:

- Cost (40%)
- Reliability (20%)
- Quality (15%)
- Operability (15%)
- Sustainability (10%)

6.1 Development of Alternatives

Given the results of the comprehensive performance evaluation and the distribution systems modeling, IBI Group, has developed a set of four alternatives for evaluation. The result of the evaluation process will yield the preferred alternative. Technical information as well as community considerations will be addressed in a facilitated evaluation workshop to select the preferred alternative. Once the preferred alternative is selected, IBI Group will prepared a final recommendation which will include a detailed description of the preferred alternative and budget estimate.

The four alternatives are as follows:

Alternative 1 - Run to Failure. This alternative essentially involves doing nothing but making repairs and replacements as equipment fails.

Alternative 2 – Repair Existing Process. This two-phased repair alternative would include immediate replacement of the aerator and contact tank as well as installation of process control equipment on the pressure filtration and pumping systems. In addition, make minimum building code improvements and regulatory required improvements in the ancillary systems. A second capital project would occur in five years (or upon system failure) to replace the pressure filtration system and make additional improvements to the others systems. Electrical upgrades and building improvements would also be deferred.

Alternative 3 – Replace Process. This alternative would reuse as much of the existing building and equipment as possible but replace the existing main treatment process equipment with newer, cost-effective technology. One example of such technology would be an integrated system of gravity filters incorporating aeration, detention and filtration in a single unit. Another example would be an iron removal ion exchange system. This
alternative could relegate ancillary systems, building improvements, and electrical upgrades to a future project.

Alternative 4 – New Plant. This alternative would involve construction of a new state-of-the-art membrane treatment facility on the existing site. All systems and equipment would be replaced including buildings, electrical and ancillary systems.

The criteria by which these three alternatives must be evaluated are as follows:

Cost – Present and future capital costs as well as future and annualized and repair costs are all brought back to net present worth (NPW) to compare alternatives on an “apples-to-apples” basis. Using engineering economics, the time value of money is considered to convert future costs to equivalent present value.

Reliability – This criterion assesses the alternative in terms of the durability and functionality. A lower score would indicated increased susceptibility to failure.

Quality – This criterion is associated with the quality of the water delivered from the treatment plant in terms of health safety and aesthetic considerations.

O&M – Frequency, relative cost, and complexity of maintenance will be assessed as well as the relative complexity and intensity of operations.

Sustainability - Each alternative will be evaluated in terms of long-term sustainability as well as environmental impact.

For complex analyses such as Choctaw Water System project, IBI Group often employs a decision matrix approach in which reasonable alternatives are developed and appropriate criteria are identified. Subsequently, a systematic process is employed to analyze each alternative with respect to each criterion. The decision matrix illustrated below provides a tool to evaluate each alternative in terms of the evaluation criteria mentioned above.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Weight</th>
<th>Run to Failure</th>
<th>Repair Process</th>
<th>Replace Process</th>
<th>New Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>40%</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
</tr>
<tr>
<td>Reliability</td>
<td>20%</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
</tr>
<tr>
<td>Quality</td>
<td>15%</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>15%</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
</tr>
<tr>
<td>Sustainability</td>
<td>10%</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
</tr>
</tbody>
</table>

Weighted Score

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>unacceptable</td>
</tr>
<tr>
<td>2</td>
<td>poor</td>
</tr>
<tr>
<td>3</td>
<td>average</td>
</tr>
<tr>
<td>4</td>
<td>good</td>
</tr>
<tr>
<td>5</td>
<td>excellent</td>
</tr>
</tbody>
</table>

For each alternative, the total weighted score is calculated by taking the sum of the scores associated with each criterion multiplied by the corresponding weighting factor. While
some of the criteria of the evaluation are objective such as cost, many criteria are more subjective and even speculative.

The decision matrix is not intended to produce an objective “answer” but instead, it is a process to systematically think through a decision. The main elements are developing a full range of alternatives and a relevant set of evaluation criteria. Weighting factors are adjusted based on the decision-maker’s priorities and project drivers.

One productive way to work through such an analysis is in a workshop environment where key stakeholders along with subject-matter experts can develop consensus regarding evaluation criteria and weighting factors. Subsequently, each alternative can be evaluated with respect to each criterion to produce a final score. Often during this process weighting factors are modified, criteria are changed and even new alternatives are developed. Again, the goal of a decision matrix is not to produce an answer per se but to efficiently and effectively involve key stakeholders and subject experts in a thorough analysis to yield a fully informed decision.

Based on community input from the previous workshop, IBI Group is presenting a decision matrix with the initial weighting factors given to each criterion as follows: Cost 40%, Reliability 20%, Quality 15%, Operability 10%, and Sustainability 10%.

Initial scores were developed for each criteria based on the following rationale:

Cost
Cost is a driver on any project and for Choctaw Utilities, care must be taken to craft a solution that will represent good stewardship of funds and not unduly burden the user of the system. Cost was given an initial weighting factor of 40% to begin the discussion.

For the purposes of this evaluation, engineering economics analysis techniques were used to determine the relative costs of the alternatives. Projected annual costs and future costs were converted to equivalent present values and combined with initial capital costs to determine net present value (NPV).

Once the NPV costs were determined for each alternative a formula was used to normalize the costs as follows: cost = (cost - mincost)/(maxcost – mincost)

Reliability
Reliability was given a weighting factor of 20%. Next to cost this criterion is extremely important for the residents of Choctaw Lake. The goal is to have a reliable water supply system into the future. Reliability is assessed by analyzing condition assessment data and projecting the likelihood of failure. Generally, newer equipment is less prone to failure than aged equipment

Quality
Quality is also an important criterion and was weighted at 15%. Quality refers to the health and safety of the water as well as aesthetic considerations such as taste, odor, and color. Different technologies will produce differing results in terms of quality. All alternatives should produce safe water. Therefore, the main focus of this criterion is aesthetics.

Operability
Operability is also weighted at 15%. This criterion incorporates the assessment of several factors including:

The technological complexity of the alternative and the subsequent ease or difficulty of operating and maintaining the equipment

Training level needed for operations and maintenance personnel
The level of effort in terms of man-hours required to operate and maintain the process

**Sustainability**

Sustainability is an important factor as well and is weighted at 10%. This criterion includes the assessment of durability or longevity of the process. In addition, the idea of environmental sustainability is included.

### 6.2 Evaluation

The evaluation process was conducted in a workshop format on December 1, 2016. The criteria were presented and described and each alternative was presented described and discussed. The Choctaw residents and Utilities Board along with IBI Group operations experts and design engineers worked together to evaluate each alternative with respect to the evaluation criteria. The results of the workshop are presented below in the form of a completed evaluation matrix along with an explanation of each score. It should again be noted that this exercise is qualitative in nature and intended to promote a thorough discussion of the alternatives. The weighted score is not intended to be taken as a quantitative result or final answer.

<table>
<thead>
<tr>
<th>Decision Model</th>
<th>Run to Failure</th>
<th>Repair Process</th>
<th>Replace Process</th>
<th>New Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criterion</td>
<td>Weight</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
</tr>
<tr>
<td>Cost</td>
<td>40%</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Reliability</td>
<td>20%</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Quality</td>
<td>15%</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>15%</td>
<td>2</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Sustainability</td>
<td>10%</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td><strong>Weighted Score</strong></td>
<td></td>
<td><strong>3.2</strong></td>
<td><strong>4.4</strong></td>
<td><strong>4.2</strong></td>
</tr>
</tbody>
</table>

After extensive discussion the board requested that IBI Group to provide additional detailed information related to the costs of alternative 2 “repair process” and alternative 3 “replace process”. It was further requested that alternative 2 be analyzed without the phasing component and that just capital costs be included for each alternative. The complete results of the additional analyses can be found in the appendix of this report. A summary of the costs is provided in the table below.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 2</td>
<td>$2.65M</td>
</tr>
<tr>
<td>Alternative 3</td>
<td>$2.91M</td>
</tr>
</tbody>
</table>
7 Conclusion and Recommendations

7.1 Conclusion

The Choctaw Utilities Water Treatment Facility has had a long record of excellent operation but in the past year, the system has experienced an inordinate number of red water and brown water issues in its distribution system. In addition, there was a minor episode in the orthophosphate feed level which caused an excursion in the maintenance of the EPA-required concentration range of 0.8 to 3.0 mg/l. While several factors likely contributed to this anomaly, the Utility is in the process of revamping the orthophosphate delivery system, entry point, and sampling protocol. IBI Group conducted a comprehensive performance evaluation and the results indicate the following:

- Based the result of the aeration tower and reaction tank evaluation, these unit processes appear to be operating properly and are adequately sized to meet the needs of Choctaw Utility in accordance with 10 State Standards sections 4.7.2 and 4.8. The induced draft aerator must be sized to meet the design criteria of 1-5 gpm/ft² tray area and the contact tank must provide for at least 30 minute of detention time.

- The aeration tower and reaction tank have lasted well beyond their useful life. The condition of the aeration process equipment is extremely poor and components of the process are currently failing. Therefore, it is recommended that the current system be decommissioned as soon as practical and be replaced. Consideration should be given to an integrated system that best achieves the goals of the Utility.

- From the results of the pressure filter evaluation, the process appears to be operating properly and adequately sized to meet the needs of Choctaw Utility in accordance with 10 State Standards sections 4.3.2.2 and 4.3.2.3. Pressure filters must provide for a loading of no more than 4gpm/ft² of filter surface area and a backwash rate of 15gpm/ft² of filter surface area. Pressure filters are also required to have headloss gauges according to section 4.2.3.2 paragraph “f” of 10-State Standards.

- The pressure filters have lasted well beyond their useful lives. The condition of the equipment is poor and filter #4 recently failed. Therefore, it is recommended that the current system be decommissioned as soon as practical and be replaced. Consideration should be given to an integrated system that best achieves the goals of the Utility.

A facilitated workshop was conducted on November 16, 2016 in which the above findings were presented to the Board of Directors of Choctaw Utilities as well as concerned residents in the community. There was a significant question and answer period during which the findings were discussed in detail.

At the conclusion of workshop, the Board was asked to provide the project drivers to be used by IBI Group to develop a set of technical alternatives to address the needs of the community. The Board and community members listed eighteen items that represent the project drivers or criteria by which treatment alternatives were developed by IBI Group.
In an additional workshop format on December 1, 2016, four treatment alternatives were developed and presented to the Board as follows:

- Alternative 1 - Run to Failure.
- Alternative 4 – New Plant.

The criteria by which these three alternatives were to be evaluated were presented as follows:

- Cost
- Reliability
- Quality
- O&M
- Sustainability

The Choctaw residents and Utilities Board along with IBI Group operations experts and design engineers worked together to evaluate each alternative with respect to the evaluation criteria. There was again significant discussion on the pros and cons of each alternative during the question and answer period associated with the workshop.

At the conclusion of the workshop, the Board directed IBI Group to focus on Alternative 2 and Alternative 3 and requested that additional detailed cost information be prepared for each. IBI Group prepared detailed budget estimates for a non-phased alternative two and alternative three. The budget estimates are $2.65M for Alternative 2 and $2.91M for Alternative 3.

Based on our analyses and profession judgement, it is the conclusion of IBI Group that an investment in either Alternative 2 or Alternative 3 would provide for reliable, safe and healthy water supply at affordable cost for the Choctaw community.

7.2 Recommendations

It is the recommendation of IBI Group that Choctaw Utilities take action in the form of Alternative 2 or Alternative 3 to improve its water treatment facilities.

8 Water Model

Watercad uses detailed plans to run simulations of a water distribution system. The system requires accurate information of pipe sizes, types, lengths, connections, water storage, and water production. From this information, a system can be mapped and ensemble simulations ran to analyze water age and water velocity through pipes in the system. The model was ran on best and worst case scenarios for the community based on historical flow from the previous years and projections for maximum flow. The lowest flow rate from the plant in analysis was 100,000 Gallons Per Day (GPD) with the highest flow rate from the plant being 400,000 GPD. The model assumes constant production through the plant to meet the GPD requirement, and constant pipe flow. The model also assumes there is no water loss through leaks in the system. Changes in both of these will decrease water age.
and could change the water velocity and direction based on the location and severity of the water loss.

8.1 Velocity

The velocities in the pipes are very much determinant of the velocity of the plant or how full the tower is. At the time of the analysis, the simulations were ran with the understanding that no valves were closed during operation or flushing to increase water velocity by isolating lines. As such, the fastest water velocity would always be present immediately outside the plant or immediately beyond the tower. In future sections, the importance of velocities in line flushing will be discussed.

As it stands the plant provides the highest velocity for flushing: 385 GPM. Using this, the best locations for flushing without a protocol to isolate lines in place from the plant are at the 2” hydrant on the North side of the lake, the drainage valve on the Northwest side by the bridge, and the Hydrant at the corner of Choctaw Drive and Sanchez Trail. The best locations to flush from the tower are the drainage valves on North Columbus road and just north of the tower.

8.2 Water Age

Water age is important to note based on deterioration of additives to preserve the water. The longer water is aged, the less effective disinfecting chemicals are to maintaining pure, clean water. Aged water also accumulates more suspended particles in the pipe which forces pipes to be flushed more frequently to maintain the distribution system.

During this analysis, water age was determined for three runs: 100,000 GPD; 200,000 GPD; and 400,000 GPD. The results are shown in the figures below. The oldest water in all iterations of the analysis was located in the Southwest corner and West side of the lake, close to the tower and North along the same road as the tower. There is a location along the North-most loop on the West side of the lake which has water age higher than expected in the system.
Figure 21: Water age at 100,000 GPD. Blue is less than 10 hours; Green is between 10 and 20 hours; Yellow is Between 20 and 30 hours; Red is over 30 Hours.

Figure 22: Water age at 200,000 GPD. Blue is less than 10 hours; Green is between 10 and 20 hours; Yellow is Between 20 and 30 hours; Red is over 30 Hours.
Figure 23: Water age at 400,000 GPD. Blue is less than 10 hours; Green is between 10 and 20 hours; Yellow is between 20 and 30 hours; Red is over 30 Hours.

9 Location of Utilities

9.1 Existing Utilities

9.1.1 Air Release Valves

Currently, 14 air releases are in service in the distribution system. These are located in high spots in the line to remove air pockets as well as protect the pipeline from pressure transients and collapses. Air bubbles float to high spots in pipes and, if not released, accumulate there creating pockets of trapped air. Trapped air in pipes creates a narrower channel for water to travel through which creates friction headloss and flow reduction in the pipe. These pockets can be flushed out with enough water velocity, but also can be removed through the use of air release valves. For best results, every high spot in the distribution line would have an air release valve which would protect the system and distribution piping. Currently, half of the presumed high spots in the system have air release valves.

9.1.2 Hydrants and Water Drainage Valves

There are currently four hydrants and seven drainage valves in the system. One hydrant is immediately adjacent to the water tower, with two in close proximity on the North West side of the lake. The last one is at the intersection of Choctaw Drive and Sanchez Trail. These are the only locations capable of flushing the system with sediment removal as the drainage
valve only allow the system to drain from that location. The two hydrants on the North West Side are undersized (2") and cannot allow enough flow through them to adequately remove sediment. After interviewing the operator, the drainage valves were determined to only allow water to seep out of them. It is determined these will not allow sediment removal because they do not generate enough velocity through the pipe to allow flushing. The current service location is shown below.

Figure 24: Location of Existing Utilities. Blue utilities are air release valves. Yellow are existing drainage valves and hydrants.

9.2 Proposed Upgrades

9.2.1 Phase I

Phase I of proposed service work would involve installing new flushing hydrants to all locations which currently (a) have a hydrant, or (b) have a blow-off assembly; and the addition of flushing hydrants on both sides of distribution lines crossing the lake. These would be upsized hydrants capable of allowing a large volume of water through them which aids in proper flushing of the service lines. Currently, the hydrants are too small to adequately flush lines, and the drainage valves do not adequately remove sediment or flush water. This stage would involve the installation of 14 new hydrants.

Phase I would also include the inspection of all air release valves currently in the system. If the valve is in need of repair or replacement, these can be performed in this phase. There are 14 air release valves currently in the system. The phase I map is shown below. The estimate for hydrant installation is $112,000. Air release valve inspection and repair for every valve is estimated at $42,000. The total estimate construction costs for Phase I is $211,200, including contingency and mobilization.
Note: this estimate is with the replacement of all air release valves. If inspection shows that air release valves are in good condition, air releases costs will decrease.

Figure 25: Phase I upgrades. Yellow are existing services in need of a new hydrant. Red are new hydrant locations. Blue dots are existing air release valves that need inspected and replaced if needed.

9.2.2 Phase II

Phase II of proposed utilities includes the installation of more hydrants and flushing valves to better serve the community. 9 additional air release valves are expected to be installed in high spots in the line that are not addressed in the current distribution system. 13 new hydrants in low locations of the line. These will be used to aid in flushing, create a better dispersal of hydrants allowing for better line isolation. The proposed final system from Phase II is shown in the image below.

The estimation for phase II hydrant installation is $104,000. Installation of air release valves is $45,000. Total cost for phase II: $174,900 including contingency and mobilization.
9.3 Flushing Protocol

9.3.1 Frequency

The entire system should have their lines flushed on a regular basis. This allows for adequate removal of sediment and helps to prevent buildup which decreases system efficiency. Because the community has high and low flow months, sediment buildup can happen more frequently in areas of the line where residents are gone for extended periods of time – for example, winter months. Total sediment buildup would have to be monitored to identify when a line flush would be required, but it is recommended to flush at minimum once a year.

9.3.2 Line Isolation

Line isolation is very important for distribution system flushing. The EPA requires unidirectional flow during line flushing, meaning the flow through the flushing hydrant must be isolated to ensure it is coming from one direction. If unidirectional flow is not achieved, flushing will not be able to effectively remove sediment buildup. The Lake Choctaw
distribution system is designed in a manner that the system can remain in operation while isolation of lines is used to flush with high speed. This is done by closing off connecting sections of lines while maintaining distribution functionality through a full elevated storage tower and running the plant to provide feed line pressure. This would allow up to 385 gpm to be flushed through individual lines, increasing the velocity from current practices. Flushes with high flow have the ability to remove more sediment in the lines and scour the lines to displace buildup. This maintenance will help to elongate pipe useful life while helping to clean out the distribution system of sediment, allowing clean water to be distributed free of particulates trapped in the lines.

A full scale investigation into existing valve conditions in the system will allow for a detailed line isolation protocol to be written for every segment of pipe. A suggested Phase I Line Flushing Protocol can be found in the appendix. Phase II line flushing would allow even more isolation of lines allowing better operability.
Appendix A: Flushing Protocol
## FLUSHING PROTOCOL

| Valve | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 |
|-------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---
Appendix B: Cost Estimate
Choctaw Utilities Water System  
Madison County, Ohio  
Plant Upgrades Option 3: Dualator  
January 5, 2017

Cost Estimate

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT PRICE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Process Upgrades</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobilization/Demobilization</td>
<td>LS</td>
<td>1</td>
<td>$80,000</td>
<td>$80,000</td>
</tr>
<tr>
<td>Demolition of Existing Tank and Aerator Tower</td>
<td>LS</td>
<td>1</td>
<td>$40,000</td>
<td>$40,000</td>
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<tr>
<td>Demolition of Existing Equipment (Filters, Piping, and Appertences)</td>
<td>LS</td>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
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<tr>
<td>Temporary Piping and Controls</td>
<td>LS</td>
<td>1</td>
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<td>$50,000</td>
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<tr>
<td>17' x 42'H 69,000 Gallon Aquastore Tank</td>
<td>EA</td>
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<tr>
<td>Dualator</td>
<td>LS</td>
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<tr>
<td>Connection Piping and Metering Equipment</td>
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<tr>
<td>SCADA</td>
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Subtotal, Process Upgrades $1,725,000

<table>
<thead>
<tr>
<th>Possible Upgrade Alternatives</th>
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</thead>
<tbody>
<tr>
<td>Upgrades to the Backup Generator, Complete with Transfer Switch</td>
<td>EA</td>
<td>1</td>
<td>$150,000</td>
<td>$150,000</td>
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<tr>
<td>Estimated Electrical Upgrades and Appertences</td>
<td>LS</td>
<td>1</td>
<td>$150,000</td>
<td>$150,000</td>
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<tr>
<td>Red Water Filter With Geosynthetic Bag System for Backwash Wastes</td>
<td>LS</td>
<td>1</td>
<td>$200,000</td>
<td>$200,000</td>
</tr>
</tbody>
</table>

Subtotal, Possible Upgrade Alternatives $500,000

<table>
<thead>
<tr>
<th>SUBTOTAL, ALL CONSTRUCTION</th>
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<tbody>
<tr>
<td>10% CONTINGENCY</td>
<td></td>
<td></td>
<td></td>
<td>$222,500</td>
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<tr>
<td>TOTAL CONSTRUCTION COSTS</td>
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<td></td>
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<td>$2,447,500</td>
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</table>

<table>
<thead>
<tr>
<th>Non-Construction Costs</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Engineering</td>
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<td></td>
<td>$258,000</td>
</tr>
<tr>
<td>Construction Inspection and Administration</td>
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<td></td>
<td></td>
<td>$200,600</td>
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<tr>
<td>SUBTOTAL</td>
<td></td>
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<td></td>
<td>$458,600</td>
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</tbody>
</table>

TOTAL PROJECT COST $2,906,100
## Cost Estimate

**DESCRIPTION** | **UNIT** | **QUANTITY** | **UNIT PRICE** | **TOTAL**
---|---|---|---|---
**Process Upgrades** | | | | |
Mobilization/Demobilization | LS | 1 | $80,000 | $80,000
Demolition of Existing Tank and Aerator Tower | LS | 1 | $40,000 | $40,000
Demolition of Existing Equipment (Filters, Piping, and Appertenance) | LS | 1 | $50,000 | $50,000
Temporary Piping and Controls | LS | 1 | $50,000 | $50,000
Aerator Tower | EA | 1 | $100,000 | $100,000
17' x 42'H 69,000 Gallon Aquastore Tank | EA | 1 | $180,000 | $180,000
Pressure Filters (3 filters) | LS | 1 | $870,000 | $870,000
Connection Piping and Metering Equipment | LS | 1 | $50,000 | $50,000
SCADA | LS | 1 | $100,000 | $100,000

Subtotal, Process Upgrades | | | | $1,520,000

**Possible Upgrade Alternatives** | | | | |
Upgrades to the Backup Generator, Complete with Transfer Switch | EA | 1 | $150,000 | $150,000
Estimated Electrical Upgrades and Appertenance | LS | 1 | $150,000 | $150,000
Red Water Filter With Geosynthetic Bag System for Backwash Wastes | LS | 1 | $200,000 | $200,000

Subtotal, Possible Upgrade Alternatives | | | | $500,000

**SUBTOTAL, ALL CONSTRUCTION** | | | | $2,020,000
10% CONTINGENCY | | | | $202,000
**TOTAL CONSTRUCTION COSTS** | | | | $2,222,000

**Non-Construction Costs** | | | | |
Design | | | | $242,400
Construction Inspection and Administration | | | | $182,000
**SUBTOTAL** | | | | $424,400

**TOTAL PROJECT COST** | | | | $2,646,400
Cost Estimate

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT PRICE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobilization/Demobilization</td>
<td>LS</td>
<td>1</td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>Replace Existing Air Release Valves with New Air Release Assembly</td>
<td>EA</td>
<td>14</td>
<td>$5,000</td>
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<tr>
<td>Install New Fire Hydrants</td>
<td>EA</td>
<td>14</td>
<td>$8,000</td>
<td>$112,000</td>
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</tbody>
</table>

SUBTOTAL $192,000
10% CONTINGENCY $19,200
TOTAL CONSTRUCTION COSTS $211,200

Non-Construction Costs

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Engineering</td>
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<tr>
<td>Construction Inspection and Administration</td>
<td>$17,400</td>
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SUBTOTAL $40,400

TOTAL PROJECT COST $251,600