Proposal for the City of Phoenix 91st Avenue Advanced Water Purification Facility

Clearwater Jacks Engineering

Draft: 6

Client: WEF Competition and Dr. Jeffrey Heiderscheidt

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CENE 476C

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Table of Contents

Figures

Tables

Equations

No table of figures entries found.

Abbreviations

ABET- Accreditation Board for Engineering and Technology Inc.

ADEQ- Arizona Department of Environmental Quality

AWPF- Advanced Water Purification Facility

AZ Water- Arizona Water

AWP- Advanced Water Purification

BOD- Biochemical Oxygen Demand

CINT- Civil Engineering Intern

CJE- Clearwater Jacks Engineering

DENG- Design Engineer

EAS- Extended Aeration System

EINT- Environmental Engineering Intern

ENT- Engineering in Training

EOPC- Engineers Opinion of Probable Cost

EPA- Environmental Protection Agency

FRW- Tres Rios Flow Regulating Wetlands

GAC- Granulated Activated Carbon

MCESD- Maricopa County Environmental Services Department

MGD- Millon Gallons of Water per Day

NPDWR- U.S. Environmental Protection Agency National Primary Drinking Water Regulations

NPSH- Net Positive Section Head

PE- Professional Engineering License

SDC- Student Design Competition

SENG- Senior Engineer

WEF- Water Environment Federation

WTP- Water Treatment Plant

WWTP- Wastewater Treatment Plant

91st Ave WWTP- 91st Avenue Wastewater Treatment Plant

1.0 Project Understanding

Clearwater Jacks Engineering (CJE) provides this proposal for a comprehensive understanding of a new Advanced Water Purification Facility (AWPF). This section outlines the team's ability to address water scarcity and need for long-term sustainable drinking water supply located in Phoenix, Arizona. The proposed AWPF will treat effluent from the existing Wastewater Treatment Plant (WWTP) after the effluent has traveled through the Tres Rios Flow Regulating Wetlands (FRW). The treatment process for the AWPF will follow the standards set by the Safe Drinking Water Act (SDWA) and Advanced Water Purification regulations set by the Arizona Department of Environmental Quality (ADEQ). The team's technical approach will have a focus on designing a treatment train to remove significant pathogens, Total Dissolved Solids reduction, sustainability, brine management, and sustainable water supply for the future of Phoenix.

1.1 Project Purpose

Due to the water scarcity that Arizona is experiencing, it is critical to develop additional sources that meet municipal and agricultural water demands. Therefore, the first objective of this project is to design the City of Phoenix 91st Avenue Advanced Water Purification Facility (AWPF). The second objective is to compete in the annual Water Environment Federation Student Design Competition. CJE will present the design in the AZ Water Conference in Downtown Phoenix, AZ held from April 28th, 2026, to April 30^{th,} 2026.

1.2 Project Background

The project site is in Phoenix, Arizona as shown in Figure 1-1 [1]. The 91st Avenue Wastewater Treatment Plant (91st Ave WWTP) is constructing an AWPF.

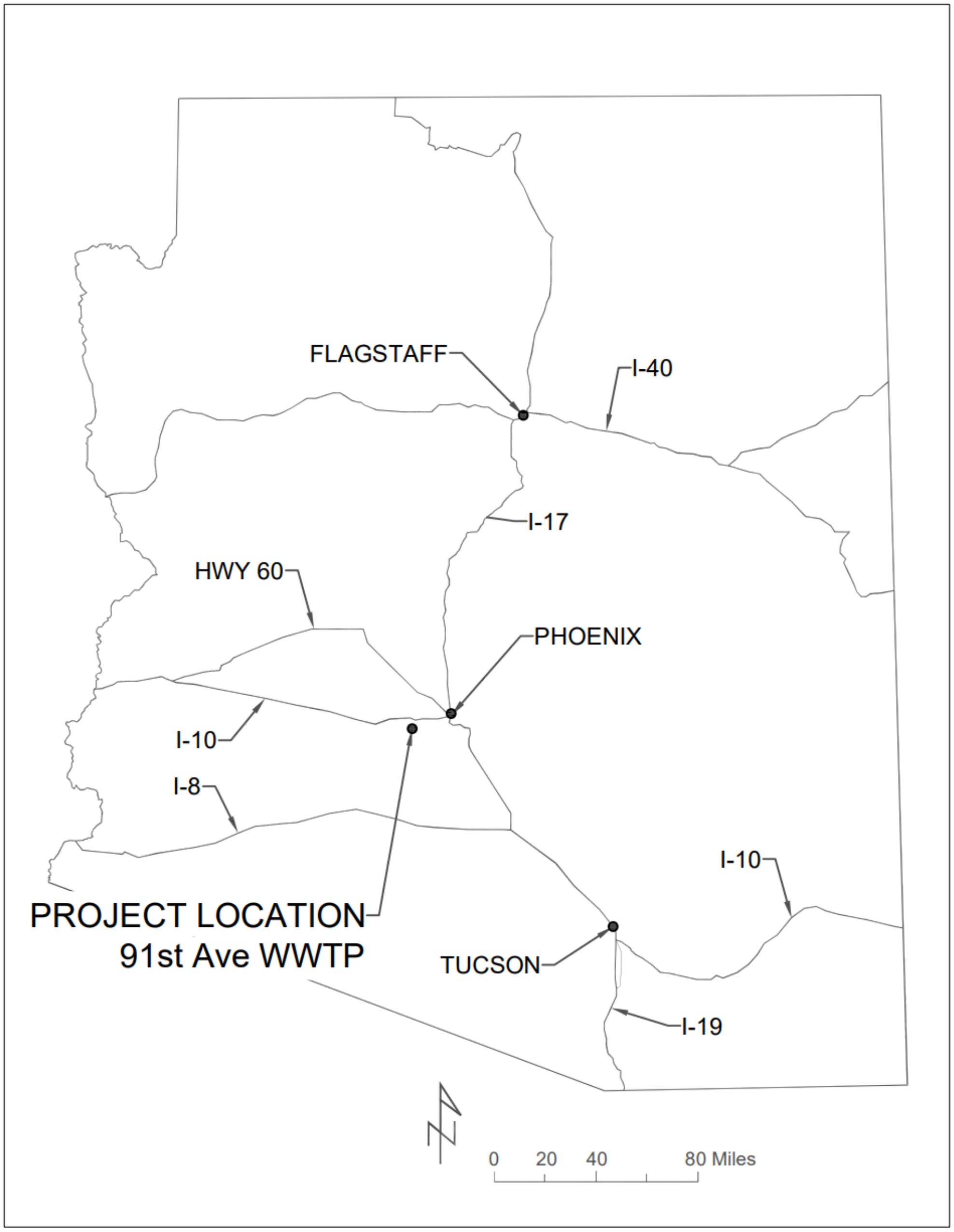

Figure 1-1: Location Map [1]

Specifically, the project's address is 91^{st} Ave, Pheonix, AZ. *Figure 1-2* shows the vicinity surrounding the project location.

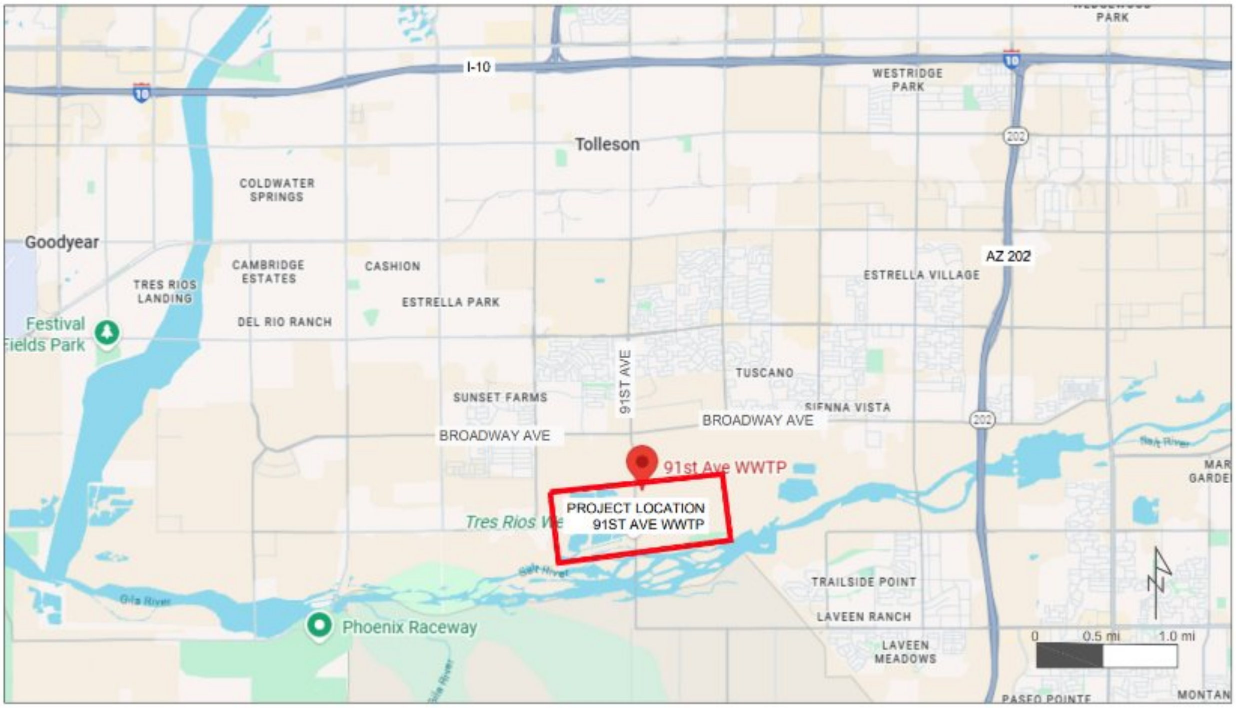

Figure 2-2: Vicinity Map [2]

Figure 1-3 shows the layout of the projected project site, 91st Ave WWTP, and FRW. The WWTP and FRW area is the larger area outlined in red and potential city-owned parcels for the AWPF projected project parcel is the smaller areas shown in red. The project site is surrounded by agricultural, industrial, and residential developments in the area. The parcels range from 0.5 to 5.0 acres and range from 800 feet to 3500 meters away from the FRW outfall.

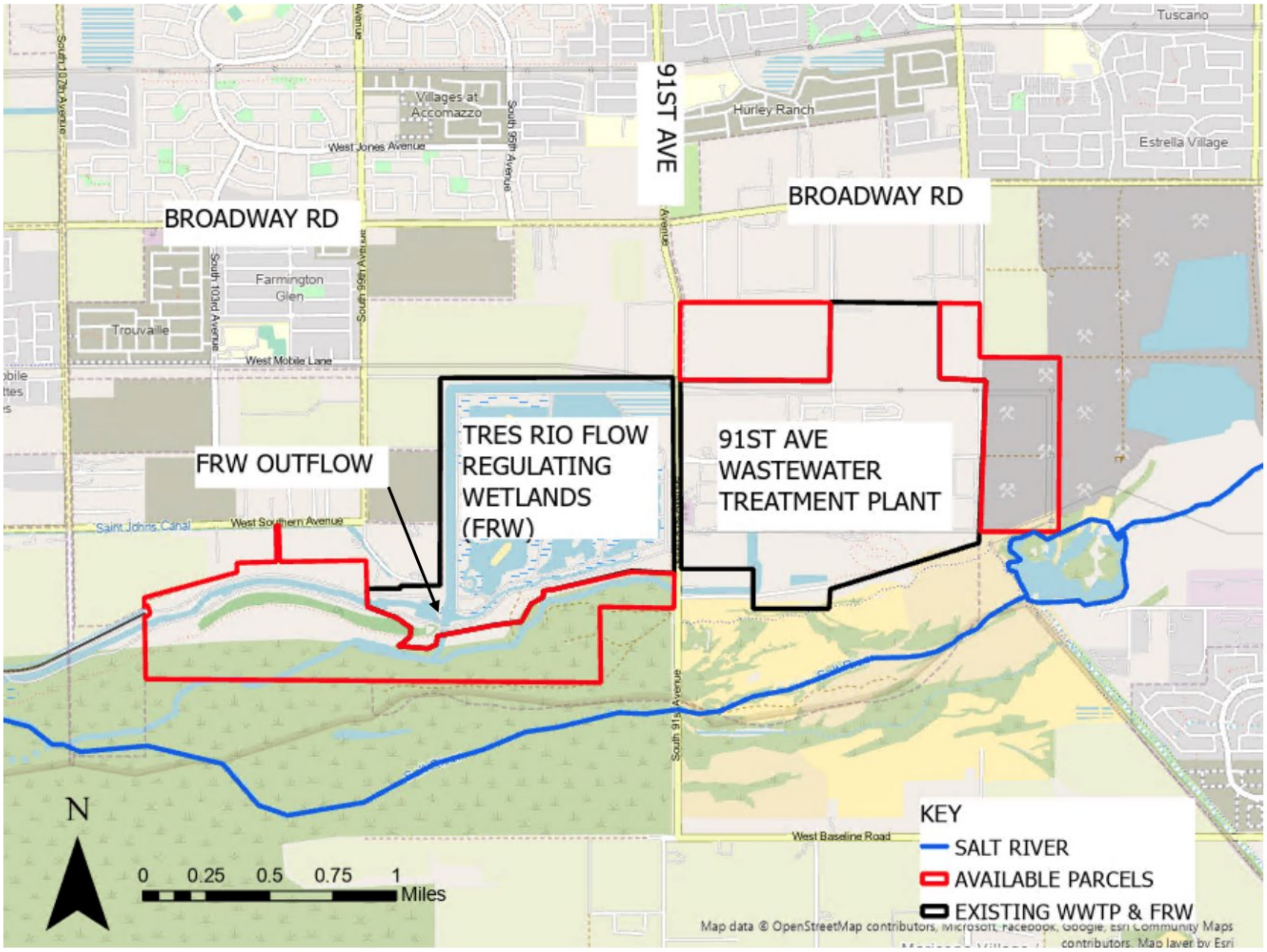

Figure 3-3: Site Map [3]

The WWTP was originally constructed in 1958; the facility has undergone expansion over the years to get present-day conditions [3]. The facility wants to expand by having an AWPF, so the facility can produce drinking water. 91st Ave WWTP consists of the main treatment facility and the FRW.

The focus of this project is to construct an AWPF that will meet current and future water demands along with treating 30 million gallons of water per day (MGD) from the FRW. This AWPF must comply to the maximum contaminate levels (MCL) set by the United States Environmental Protection Agency National Primary Drinking Water Regulations (NPDWR), the SWDA, and adhere to the AWP rules set forth by the ADEQ. The specific objectives provided by the Water Environmental Federation (WEF) Student Design Competition (SDC) are to design a treatment train and lift station to treat and convey the water within the regulations of Safe Drinking Water Act (SDWA) and ADEQ Advanced Water Purification (AWP). Lastly, the project must include a plan to engage and educate the public on the topic of AWP.

1.3 Technical Considerations

The following section will discuss the technical considerations that will be used to create a functioning AWPF.

1.3.1 Preliminary Analysis

A preliminary analysis is needed to gather information before creating a new design for the AWPF. This includes the understanding of the codes and regulations that will be applied to the facility along with a site assessment.

1.3.1.1 Codes and Regulations

Following codes and regulations is critical to designing an AWPF to guarantee that the facility adheres to the regulations placed. The Environmental Protection Agency (EPA) sets a drinking water standard for the country, and each state can create additional regulations if preferred.

Since the City of Phoenix 91st Ave AWPF that CJE is focused on is located in Arizona, CJE will closely be following the Arizona Department of Environmental Quality (ADEQ) codes and regulations along with the proposal provided by Arizona WEF.

1.3.1.2 Site Assessment

The site assessment is critical when designing the AWPF because it is important to gather data from the current facility. This data includes but is not limited to the operation costs, tank sizes, and type of water quality and contaminants. Some other factors to consider are climate, population/population growth, geography, topography, and space in the current plant.

1.3.2 Physical Separation: Screening, Coagulation, Flocculation & Sedimentation

The objective of the physical treatment is to remove physical pollutants that are in the surface water. The removal of the large physical pollutants is completed through screening by bar screen technologies. This technology varies in screen size and will remove twigs, leaves, trash and other possible pollutants that could clog or potentially break equipment in the facility. Coagulation is the process of combining small particles into the formation of flocs using various salts and chemical compounds [4].Flocs are clusters of a combination of sands, gravel, and other small pollutants from the surface water [5]. By creating flocs, these smaller pollutants are easier to settle out as they become denser. Flocs are formed using coagulants such as aluminum sulfate, ferric chloride and other chemicals, and these chemicals are stirred at a rapid pace to ensure particles collide with each other. Flocculation is the process of creating flocs by gently stirring the water for a specific amount of time that will continue to ensure the collision of particles to form macro flocs which ultimately increases sedimentation rates [5].

CJE will evaluate the possible physical separation technologies to ensure the system can properly handle inflow coming from the FRW and remove any pollutants.

1.3.3 Physical Treatment: Filtration

The process of filtration continues the removal of suspended particles and microorganisms in the water by various filtration technologies [5]. Common filtration technologies include rapid gravity filtration, slow sand filtration, and membrane filtration. Each of the technologies varies by price and effectiveness, and all have different procedures to remove particles.

The project will evaluate and research various filtration technologies that will best fit the City of Phoenix AWPF which will be chosen based on a decision matrix with a variation of criteria provided by AZ WEF Student Competition and created by CJE.

1.3.4 Disinfection

Disinfection is a critical process in the AWPF as it ensures that all pathogens, viruses, or bacteria that could harm the population drinking water are eliminated [6]. The process of disinfection uses various technologies such as UV radiation, chlorination, and ozone to remove pathogens. This step in the facility is important since the laws and regulations require specific pathogens, bacteria, and viruses to be removed.

Based on the AZ WEF Competition Proposal, the disinfection treatment in the project at hand must include UV radiation along with other disinfection options that will be determined through research completed by CJE. This decision will be measured through a decision matrix based on criteria provided by AZ WEF along with CJE.

1.3.5 Chemical Treatment: Adsorption, Precipitation, Softening, & pH Adjustment

The chemical treatment process varies depending on the water that is being treated. There are certain standards that drinking water facilities must uphold such as pH. The groundwater and surface water in Arizona tends to have hard or very hard water due to the mineral-rich content [7]. This means the treated water must undergo a softening process to remove minerals like calcium and magnesium using technology like split treatment and precipitation. Adsorption is a process used in water treatment where a substance will accumulate on the surface of another material and is often used in water purification facilities to remove dissolved pollutants, smell, color, and improve taste. Adsorption is commonly used with granulated activated carbon (GAC) or powdered activated carbon (PAC) due to its high surface area [8].

CJE will be closely analyzing the water quality in the Tres Rios FRW to determine any chemical treatment that needs to be set in place to comply with laws and regulations. If CJE establishes a necessity to adjust the water, CJE will research and create a decision matrix to decide on the best alternative.

1.3.6 Advanced Treatment

Advanced treatment is an additional form of treatment that is specific to the water quality in an area. Advanced treatment can include various technologies such as membrane filtration, reverse osmosis, and water oxidation [9]. These processes are capable of removing pharmaceuticals, microplastics, and PFAS in the water that other traditional treatment methods might not remove [8].

CJE is required to include an advanced treatment option in the project design which will be completed using a decision matrix with the criteria provided by the AZ WEF Student Competition Proposal and criteria created by CJE.

1.3.7 Hydraulic Design

The hydraulic design focuses on the transportation of the secondary treatment effluent from 91st Avenue Wastewater Treatment Plant that is released into the Tres Rios Flow Regulating Wetlands and that will to be transported via pipes, pumps, and a lift station.

1.3.7.3 Lift Station

A lift station design will be required to transport the water from the Tres Rios FRW water to reach the water purification facility. By installing a lift station, it ensures that consistent flow and pressure will be provided throughout the facility.

1.3.7.2 Pump Selection

A proper pump selection must be considered to pump the water flow. This selection is dependent on the pump performance curve and the system curve to find the best efficiency point. Additionally, the net positive section head (NPSH) curve is also valuable to the pump selection as it ensures that the pump will not cavitate.

1.3.7.1 Pipes

The purpose of having a well-designed pipe system is to ensure that the water is flowing without excessive head loss, pressure loss, and minimizing energy used. This is achieved by using the slope to create a gravity-driven flow. Using proper material for pipes will prevent corrosion along with biological growth.

1.3.8 Brine Handling and Sustainability Practices

Brine is the rejected water and solids from various steps of the treatment process. There are many ways to manage brine with options like retreating the brine by sending it back into the wastewater treatment plant, evaporation ponds, mechanical crystallization/evaporation and, through resource recovery. These options can promote sustainable practices to reduce the waste being produced along with finding alternatives to form resource recovery.

1.3.9 Economic Analysis

CJE places a high value on adhering to budgetary constraints. Operation costs (number of operators and the operator's wages), product costs (materials, chemicals and equipment needed), and maintenance costs will all be taken into consideration in the Engineers' Opinion of Probable Cost (EOPC).

1.4 Potential Challenges

Potential challenges for this project would be weather restrictions, such as weather that would prevent the team from visiting the site. Design restraints may also be a potential challenge for this project. Some design restraints include budget, land area limits, and being able to keep the existing plant operational at current capacity with the new remediations and installations. Anticipating the weather by using a weather app or keeping up with forecasts could help prevent this challenge. Given the restraints from the competition guidelines, those challenges will not be an impact on the project.

1.5 Stakeholders

The stakeholders that are involved in this project are the communities in the Metro-Phoenix area of Arizona, as well as the wastewater facility plant and partners.

The main stakeholders for the WWTP are the communities and businesses that the plant deals with. They are the main concern as the water is treated for public use and to prevent any sort of contamination. They also pay for the wastewater to be treated as well as the drinking water they gain after the treatment. This project is to help better an existing plant for a better environmental and economic solution for the Metro-Phoenix area in Arizona.

CJE considers ADEQ an important stakeholder as well. The stakeholder's regulations and demands needed to be considered because any failure of operations would fall under their jurisdiction. The stakeholders oversee the laws and guidelines for the plants in the area; therefore, the stakeholders must have a major hand in the project.

Another stakeholder that was considered for this project was the communities that would be using the effluent from the treated water for drinking water, in which they pay for the wastewater that goes to the facility as well as the drinking water that is treated with the facility.

The last stakeholders considered were the wastewater facility's team and partners. How the project works and results will fall onto the facility's team and directly affect the partners of the site. These two groups are either a part of operations or help fund/monitor where these operations affect communities around it, which makes both crucial stakeholders the result.

2.0 Scope of Services Plan

The following shows the scopes outline for work and what will be done to complete the project.

2.1 Task 1.0: Research and Preparation

CJE will research the codes and regulations for an AWPF. This will prepare CJE for the site visit that will be conducted.

2.1.1 Task 1.1: Codes and Regulation Research

Codes and regulations from local, state, and federal agencies are targeted towards wastewater and water treatment. These codes may vary from county to county. CJE will research and evaluate regulations that are set by Maricopa County Environmental Services Department (MCESD), ADEQ, and the EPA. This will help ensure that CJE's design follows all codes and regulations that are set.

2.1.2 Task 1.2: Water Treatment Research

AWPF uses different types of advanced treatment to produce drinking water. These different treatments must be researched before creating an effective treatment train.

2.1.3 Task 1.3: WEF Application

CJE's will fill out an entry form and submit the form to Arizona Water (AZ Water). The form will show primary contacts on the CJE team for the competition coordinator. This form will also have contact information for the whole CJE team and CJE's faculty advisor.

2.2 Task 2.0: Site Investigation

CJE will research the background of the project to help understand the scope of the project and competition.

2.2.1 Task 2.1: Site Visit

CJE will visit the site to understand how the site is laid out and what the existing conditions are, and to ask questions of plant personnel about operations and issues the WWTP faces.

2.2.2 Task 2.2: Site Data Analysis

After the site visit, data collected from the site will be analyzed and used to make decisions on the treatment selection for the final design.

2.3 Task 3.0: Treatment Selection

In this task, CJE will be researching and creating decision matrices for each treatment process needed in the water purification facility. The decision matrices will be based on criteria provided by AZ WEF and will contain criteria CJE deemed necessary. Three treatment trains will be formed using this method and will be selected based on a decision matrix.

2.3.1 Task 3.1: Physical Separation

Physical separation is the first process in a water purification facility that removes large pollutants along with suspended solids using forms of screening, coagulation, flocculation, and sedimentation. In coagulation, chemicals such as aluminum sulfate or ferric chloride are added to form small clusters (flocs) from fine particles. Flocculation then gently stirs the water to grow flocs into larger ones to settle out easier.

2.3.1.1 Task 3.1.1: Determine Criteria

The AZ Water SDC prompt provided competition teams with three criteria that must be included in the decision matrix process for the water treatment facility at hand. However, a minimum of four criteria must be included to weigh possible alternatives. Therefore, CJE has a responsibility of determining one to two additional criteria CJE deems valuable for the project. The criteria provided by AZ Water are footprint, operational flexibility, and costs.

2.3.1.2 Task 3.1.2: Develop Alternatives

CJE will complete research on various primary separation technologies which include but is not limited to the following processes: screening, coagulation, and flocculation to identify and develop viable alternatives given the criteria and conditions. Once alternatives are found, CJE will narrow options to the best alternatives that will then become part of treatment trains that will be evaluated in Task 3.7. The final treatment train will be designed in Task 4.0: Final Design.

2.3.1.3 Task 3.1.3: Eliminate Less Suitable Alternatives

A weighted decision matrix will be created that will use the criteria that CJE and AZ WEF deemed valuable along with alternatives chosen. Each criterion will be weighed based on how important it is to the competition, design and overall, success of the wastewater treatment plant. Once alternatives are found, CJE will narrow options to the best alternatives that will then become part of treatment trains that will be evaluated in Task 3.7. The final treatment train will be designed in Task 4.0: Final Design.

2.3.2 Task 3.2: Physical Treatment

The physical treatment step includes filtration which removes additional suspended solids that were not removed through sedimentation along with smaller contaminants such as pathogens and microorganisms through various technologic forms. Filtration removes remaining suspended particles using methods such as rapid gravity, slow sand, or membrane filtration. There are more technology options that CJE will do research on.

2.3.2.1 Task 3.2.1: Determine Criteria

The AZ Water SDC prompt provided competition teams with three criteria that must be included in the decision matrix process for the water treatment facility at hand. However, a minimum of four criteria must be included to weigh possible alternatives. Therefore, CJE has a responsibility of determining one to two additional criteria CJE deems valuable for the project. The criteria provided by AZ Water are footprint, operational flexibility, and costs.

2.3.2.2 Task 3.2.2: Develop Alternatives

CJE will complete research on various physical treatment technologies which include filtration to identify and develop viable alternatives given the criteria and conditions.

2.3.2.3 Task 3.2.3: Eliminate Less Suitable Alternatives

A weighted decision matrix will be created that will use the criteria that CJE and AZ WEF deemed valuable along with alternatives chosen. Each criterion will be weighed based on how important it is to the competition, design, and overall, success of the wastewater treatment plant. Once alternatives are found, CJE will narrow options to the best alternatives that will then become part of treatment trains that will be evaluated in Task 3.7. The final treatment train will be designed in Task 4.0: Final Design.

2.3.3 Task 3.3: Chemical Treatment

The chemical process involves processes of adsorption, precipitation, softening, and pH adjustment. These processes vary on the water quality that is being treated and can remove dissolved pollutants along with removing color and odor. Precipitation and softening remove hard minerals like calcium and magnesium. Granulated or powdered activated carbon are common equipment used to eliminate dissolved pollutants, odors, colors and can often improve taste.

2.3.3.1 Task 3.3.1: Determine Criteria

The AZ Water SDC prompt provided competition teams with three criteria that must be included in the decision matrix process for the water treatment facility at hand. However, a minimum of four criteria must be included to weigh possible alternatives. Therefore, CJE has a responsibility of determining one to two additional criteria CJE deems valuable for the project. The criteria provided by AZ Water are footprint, operational flexibility, and costs.

2.3.3.2 Task 3.3.2: Develop Alternatives

CJE will research various chemical treatment technologies which include but are not limited to the following processes: adsorption, precipitation, and softening to identify and develop viable alternatives given the criteria and conditions.

2.3.3.3 Task 3.3.3: Eliminate Less Suitable Alternatives

A weighted decision matrix will be created that will use the criteria that CJE and AZ WEF deemed valuable along with alternatives chosen. Each criterion will be weighed based on how important it is to the competition, design and overall, success to the wastewater treatment plant. Once alternatives are found, CJE will narrow options to the best alternatives that will then become part of treatment trains that will be evaluated in Task 3.7. The final treatment train will be designed in Task 4.0: Final Design.

2.3.4 Task 3.4: Advanced Treatment

Advanced treatment is the further removal of pollutants such as pharmaceuticals, microplastics, and PFAS. Types of technologies include membrane filtration, reverse osmosis, and oxidation.

2.3.4.1 Task 3.4.1: Determine Criteria

The AZ Water SDC prompt provided competition teams with three criteria that must be included in the decision matrix process for the water treatment facility at hand. However, a minimum of four criteria must be included to weigh possible alternatives. Therefore, CJE has a responsibility of determining one to two additional criteria CJE deems valuable for the project. The criteria provided by AZ Water are footprint, operational flexibility, and costs.

2.3.4.2 Task 3.4.2: Develop Alternatives

CJE will research various advanced treatment technologies to identify and develop viable alternatives given the criteria and conditions.

2.3.4.3 Task 3.4.3: Eliminate Less Suitable Alternatives

A weighted decision matrix will be created that will use the criteria that CJE and AZ WEF deemed valuable along with alternatives chosen. Each criterion will be weighed based on how important it is to the competition, design and overall, success to the wastewater treatment plant. Once alternatives are found, CJE will narrow options to the best alternatives that will then become part of treatment trains that will be evaluated in Task 3.7. The final treatment train will be designed in Task 4.0: Final Design.

2.3.5 Task 3.5: Disinfection

The disinfection process eliminates pathogens, viruses, and bacteria that could harm the population by drinking water. There are many effective forms of treatment such as UV radiation, ozone, and chlorination. Regulations require the removal of specific microorganisms to ensure water safety. UV radiation along with a form of chlorine residual must be included as part of the alternative treatment trains according to AZ Water.

2.3.5.1 Task 3.5.1: Determine Criteria

The AZ Water SDC prompt provided competition teams with three criteria that must be included in the decision matrix process for the water treatment facility at hand. However, a minimum of four criteria must be included to weigh possible alternatives. Therefore, CJE has a responsibility of determining one to two additional criteria CJE deems valuable for the project. The criteria provided by AZ Water are footprint, operational flexibility, and costs.

2.3.5.2 Task 3.5.2: Develop Alternatives

CJE will complete research on various disinfection treatment technologies to identify and develop viable alternatives given the criteria and conditions.

2.3.5.3 Task 3.5.3: Eliminate Less Suitable Alternatives

A weighted decision matrix will be created that will use the criteria that CJE and AZ WEF deemed valuable along with alternatives chosen. Each criterion will be weighed based on how important it is to the competition, design and overall, success to the wastewater treatment plant. Once alternatives are found, CJE will narrow options to the best alternatives that will then become part of treatment trains that will be evaluated in Task 3.7. The final treatment train will be designed in Task 4.0: Final Design.

2.3.6 Task 3.6: Brine Handling

Brine handling is how the rejected water that contains pollutants will be managed to reduce waste and prevent contamination. There are many ways to manage brine with options like evaporation ponds, sending back through the wastewater treatment plant and mechanical evaporation. These options promote sustainable practices to reduce waste along with finding alternatives for resource recovery.

2.3.6.1 Task 3.6.1: Determine Criteria

The AZ Water SDC prompt provided competition teams with three criteria that must be included in the decision matrix process for the water treatment facility at hand. However, a minimum of four criteria must be included to weigh possible alternatives. Therefore, CJE has a responsibility of determining one to two additional criteria CJE deems valuable for the project. The criteria provided by AZ Water are footprint, operational flexibility, and costs.

2.3.6.2 Task 3.6.2: Develop Alternatives

CJE will research various brine handling processes to identify and develop viable alternatives given the criteria and conditions.

2.3.6.3 Task 3.6.3: Eliminate Less Suitable Alternatives

A weighted decision matrix will be created that will use the criteria that CJE and AZ WEF deemed valuable along with alternatives chosen. Each criterion will be weighed based on how important it is to the competition, design and overall, success to the wastewater treatment plant. Once alternatives are found, CJE will narrow options to the best alternatives that will then become part of treatment trains that will be evaluated in Task 3.7. The final treatment train will be designed in Task 4.0: Final Design.

2.3.7 Task 3.7: Creating Treatment Train Alternatives

This task will be the creation of the three treatment train alternatives where all three will be weighed against each other based on the determined criteria.

2.3.7.1 Task 3.7.1: Determine Criteria

The AZ Water SDC prompt provided competition teams with three criteria that must be included in the decision matrix process for the water treatment facility at hand. However, a minimum of four criteria must be included to weigh possible alternatives. Therefore, CJE has a responsibility of determining one to two additional criteria CJE deems valuable for the project. The criteria provided by AZ Water are footprint, operational flexibility, and costs.

2.3.7.2 Task 3.7.2: Develop Alternatives

CJE will develop three alternative trains to weigh them in a decision matrix based on the treatment alternatives chosen in the tasks above.

2.3.7.3 Task 3.7.3: Select Best Alternative

A weighted decision matrix will be created that will use the criteria that CJE and AZ WEF deemed valuable and will identify the best alternative for the final design. Each criterion will be weighed based on how important it is to the competition, design and overall, success of the wastewater treatment plant.

2.4 Task 4.0: Final Design

The final design goes over the treatment train process design, hydraulic design, construction phasing, site layout, and project impact analysis.

2.4.1 Task 4.1: Treatment Processes

The final design will determine the tank sizes, flow rates, site civil, and other characteristics of each process for the treatment train chosen from task 3.7.

2.4.2 Task 4.2: Site Layout

This subtask involves the development of the detailed site layout for the AWPF. The work will be conducted in Civil3D for a logical and efficient layout of the given area. Optimized safety, efficient operation, and hydraulic performance are the goals to have an efficient system.

2.4.3 Task 4.3: Hydraulic Design

This task entails all the work required to analyze and design the hydraulic systems for the proposed AWPF. The goal is to guarantee an efficient, reliable, and feasible conveyance of the 30 MGD effluent from Tres Rios Flow Regulating Wetland through the AWPF's treatment train. The final deliverable of this task shall be a complete hydraulic profile view of the plant's system.

2.4.3.1 Task 4.3.1 Lift Station Design

This subtask involves the complete preliminary design of the new lift station required to convey 30 MGD of effluent from Tres Rios Flow Regulating Wetland to the proposed AWPF.

2.4.3.2 Task 4.3.2 Pump Selection

Detailed analysis of new pumps for the facility lift station. The engineering team will develop system curves based on the calculated Total Dynamic Head and compare them against the pump manufacturer's performance graph to select the best configuration for optimal efficiency and prevent cavitation.

2.4.3.3 Task 4.3.3 Pipe Design

This subtask will determine the necessary pipe diameter and material for the new pressurized pipe system for the proposed AWPF. With the use of the Darcy-Weisbach equation to model friction losses, pipe sizes will be defined to ensure sustainability throughout the facility.

2.4.3 Task 4.3.4 Hydraulic Profile Design

The development of the Hydraulic Grade Line for the facility's treatment train. The work will include the calculation of head losses and final design elevations to verify the influent will be conveyed through the whole system.

2.4.4 Task 4.4: Construction Phasing

This subtask focuses on creating a construction sequencing plan for the new AWPF. The goal is to keep an existing plant working at full capacity while new systems are built, installed into an operable state, and while minimizing site conflicts for a high-quality project delivery.

2.4.5 Task 4.5: Public Outreach Plan

This subtask involves the development of a plan to educate and engage with the public on the topic of AWP. The goal is to demystify and gain the trust of the public for acceptance of the new water supply.

2.5 Task 5.0: Cost Analysis

The cost analysis describes the probable cost of construction, operation, and maintenance along with the life cycle costs.

2.5.1 Task 5.1: Opinion of Probable Construction Cost

This section goes over the team's estimation of construction cost for the AWTP. This will include the cost of site work, foundation and structure, and any interior/exterior furnishing of the site. The cost of all construction is discussed in this section.

2.5.2 Task 5.2: Operations and Maintenance Cost

This section goes over the cost of the maintenance and cost of operations for the remediated site. It discusses the cost of the new systems implemented into remediation, the cost of touching up existing infrastructure, and the cost of the new treatment processes.

2.5.3 Task 5.3: Life Cycle Cost

This section goes over the cost of the system in its entirety of use. It discusses the cost of maintenance, continuous operation, replacements, and other costs that are influential for the new design.

2.6 Task 6.0: Project Impacts

This section will analyze the positive and negative global, social, environmental, and economic impact of the final design.

2.7 Task 7.0: Project Deliverables

The CJE team will complete the following deliverables set by WEF and Northern Arizona University's CENE 486 Capstone Course.

2.7.1 Task 7.1: 30% Deliverable

This submittal will entail the completion of the project's (Task's 1.0, 2.0, 3.0) preliminary analysis, such as site investigation and treatment selection. This work will be reflected in the 30% report and presentation.

2.7.2 Task 7.2: 60% Deliverable

This deliverable involves the completion of treatment process and hydraulic design (Task's 4.1 and 4.3). The objective of this sub-task is to provide detailed completion thus far in a 60% report and presentation.

2.7.3 Task 7.3: 90% Deliverable

This submittal will include the nearly complete report of all technical aspects in the treatment and hydraulic design process, additionally the construction phasing and public outreach (Task's 4.0 and 5.0). The objective is to reflect the 90% completion of our project in a report, presentation, website, and poster.

2.7.4 Task 7.4: Final Deliverable

This submittal is the complete final report of the project. The final report includes all technical and conceptual specifications and plans. All of the report will be reflected in a professional quality website, final report, poster, and final presentation.

2.7.5 Task 7.5: WEF Competition Final Report

This submittal is the final competition report for the project. The final competition report includes all specifications outlined in the AZ Water Student Design Competition prompt. From this report, a set of slides will be created for the competition.

2.7.6 Task 7.6: WEF Competition Final Slide Presentation

This submittal is the final competition slide presentation for the project. The final competition slide presentation includes specifications outlined in the AZ Water Student Design Competition prompt.

2.8 Task 8.0: Project Management

Project management will ensure the effectiveness of the team's communication, time, and resource management.

2.8.1 Task 8.1: Meetings

During this project, the CJE team will conduct regular meetings with the client, technical advisor, and grading instructor for feedback. All meetings will be documented with key notes and agendas.

2.8.2 Task 8.2: Schedule Management

The team will actively manage and update the schedule to stay on track and submit deliverables promptly and complete the project on schedule.

2.8.3 Task 8.3: Resource Management

The management of money, time, and personnel will be monitored for high quality deliverables and to ensure the project is completed on budget. Tracking hours of tasks will ensure proper resource management.

2.9 Exclusions

Several items are not included in the scope of the work and will not be completed. The water quality data will not be collected from the WWTP or the AWPF. There will be no field survey data that will be collected from the site visit, but the survey data will be provided by the client. Public outreach will be considered during the duration of the project; however, no public outreach meeting will be held.

3.0 Schedule

CJE will follow the schedule that is outlined in the sub-sections below.

3.1 Total Durations

The project schedule was created using the software Microsoft Project [10] and a Gantt chart is shown in Appendix A. The project will start on the 20th of November 2026 and will take 92 business days to complete. The design will be completed by the 1st of May 2026.

3.2 Major Tasks

The major tasks are the efforts that need to be completed in order for the project to progress as scheduled. These major tasks include the site visit, the treatment selection, the final design and the life cycle cost analysis. The site visit is a valuable step for CJE as it will provide a time to ask questions and gather information about the current facility and its processes. The site visit will also prepare CJE for the treatment selection after seeing the current facility and its process. The treatment selection can be determined after gathering information about the 91st Avenue Wastewater Treatment Plant and only then can alternatives for each treatment step be researched and chosen. Once the final treatment train alternative is selected a final design can be created in addition to the hydraulic design which includes the lift station, hydraulic profile design, pipes and pump selection. Once the final design is completed a life cycle cost analysis will need to be completed to provide an estimation on the costs throughout the life cycle of the AWPF. Lastly, there will be an impact analysis that will analyze the social, environmental, and economic impact of the final design.

3.3 Deliverables

Due to this project being a competition, there are set deliverables for both the AZ Water Student Design Competition and the CENE 486C class.

The first deliverable that will be completed is the 30% report for the CENE 486C class. The deliverable will be completed and submitted on the 10th of February 2026. This report will contain research preparation, site investigation findings, the plant's determination, and the alternative selection for the treatment train.

The second deliverable that will be completed is the 60% report for the CENE 486C class. The deliverable will be completed and submitted on the 24th of March 2026. This report will contain the corrections for the 30% deliverable and the final treatment train process design and pump design.

The third deliverable that will be completed is for the AZ Water Student Design Competition. The deliverable will be completed and submitted on the 23rd of April 2026. This report will contain all of Tasks 3, 4, and 5 which are the all the treatment train process designs and pump design, the site layout, and the cost analysis.

Fifth, the final presentation and report for the AZ Water Student Design Competition will be completed and submitted by 28th of April 2026.

The fourth deliverable that will be completed is the 90% deliverable for the CENE 486C class. This will be completed and submitted on 23rd of April 2026. This report will contain the project impacts and all additional capstone requirements.

The last report that will be completed and submitted is the final report which will be due on 5th of May 2026. This final report will contain all the corrections from the 90% which will show all the work that was performed by CJE.

3.4 Critical Path

A critical path is a chain of dependent tasks with no flexibility that identifies tasks that are essential for meeting a project's deadline, which are known as a critical task. The critical path of the project is displayed in red on the Gannt chart in Appendix A. The path will ensure that the team completes all the tasks that are required for the report to be completed in a timely manner following the deadlines given.

The first step for the report would be conducting research in preparation for the site visit mentioned in Task 1, which will kick start the entire design project. The site visit is a critical task because it needs to be completed on time to give the team the information needed to start deciding on the new design for AWTP. The treatment processes will be researched to determine three alternative treatment trains for the facility, which is explained in Task 3.7. The final design consists of a treatment process design that was explained earlier in the paragraph and a hydraulic design. The treatment train which includes the tanks and flows needs to be determined to keep the team on schedule. The hydraulic design, which includes the pipe design and pump selection, will also need to be determined to have the team complete Task 5. Task 5 will explain the cost analysis, which is needed to finalize the project for the construction phase. It is important for each of these tasks to be completed in a timely manner to prevent the team from falling behind. Deliverables must be made on time to be submitted to the stakeholders, which cannot be completed until all the other tasks have been completed.

To prevent the team from falling behind, work is not scheduled for the weekends or over spring break. However, tasks that are not completed within allotted time can be done on weekends or over spring break to get back on schedule.

4.0 Staffing Plan

This section outlines the staffing plan for CJE to successfully complete the project. The plan identifies the staff positions needed and the estimated hours each will spend on the project tasks. CJE has defined four staff positions for this project. The roles and responsibilities for each position are as follows:

- Senior Engineer (SENG): A Senior Engineer must have a bachelor’s degree in civil engineering, environmental engineering or related fields. The engineer must have obtained their Professional Engineer (PE) License along with a minimum of ten years of experience in wastewater treatment design, drinking water regulations, and design. The senior engineer will provide final project oversight and quality assurance. This role guides the team's technical direction, reviews major deliverables before submission, and handles high-level client communication.
- Design Engineer (DENG): The Design Engineer must have a bachelor’s degree in civil engineering, environmental engineering or related fields. The engineer must have a minimum of five years of work experience. A PE is encouraged; however, the engineer must be licensed as an Engineer in Training (EIT). Acts as the technical lead for the project. This role manages the detailed design work, oversees the alternatives analysis, and checks that all engineering calculations are accurate.
- Civil Engineering Intern (CINT): The Civil Engineering Intern must be enrolled in an ABET accredited university studying civil engineering. The intern must be at least in their last year of the engineering program. It is preferred if the student has their EIT license, however it is not required. The intern will perform detailed design work, focusing on the physical and hydraulic components. This role is responsible for the hydraulic modeling, lift station and pipe design, site layout in Civil 3D, and cost estimation.
- Environmental Engineering Intern (EINT): The Environmental Engineering Intern must be enrolled in an ABET accredited university studying environmental engineering. The intern must be at least in their last year of the engineering program. It is preferred if the intern has their EIT license, however it is not required. The intern will focus on the water quality and treatment process. This role is responsible for researching advanced treatment technologies, performing process sizing calculations, and drafting the technical report.

The following Staffing Matrix Summary (*Table 4-1*) details the estimated hours for each position assigned to the tasks outlined in Section 2.0; the full staffing matrix including sub-tasks can be found in Appendix B

Table 4-1 Staffing Matrix Summary

Task	SENG (hrs)	DENG (hrs)	CINT (hrs)	EINT (hrs)	Totals
Task 1.0: Research and Preparation	2	5	16	16	39
Task 2.0: Site Investigation	8	8	22	22	60
Task 3.0: Treatment Selection	14	29	51	52	146
Task 4.0: Final Design	11	121	35	34	201
Task 5.0: Cost Analysis	3	10	13	15	41
Task 6.0: Project Impacts	2	4	7	8	21
Task 7.0: Project Deliverables	5	15	28	28	77
Task 8.0: Project Management	13	45	15	15	88
Summary	**59**	**237**	**187**	**190**	**673**

5.0 Cost of Engineering Services

In *Table 5-1*, is the project's cost for supplies, travel, and personnel. Supplies are identified as items and software's needed to complete the design for both the AWPF and lift station design. The software needed is AutoCAD, Civil 3D, and Revu Bluebeam. CJE needs a computer lab space to use this software for the design of the AWPF.

Travel is divided into two subsections; one subsection is for the Site Visit, and the other is for the AZ Water SDC. The travel costs for the team include per diem, car rental, milage, and hotels for the overnight trip which were obtained using NAU's comptroller website [11].

The last section is for the personnel that are needed to complete the design for the AWPF and pump system. The personnel that are needed are the Senior Engineer, Design Engineer, Civil Engineer Intern, and Environmental Engineer Intern. The personnel billing rates are based on the hourly pay rate, employee benefits, profit, and overhead costs. These rates were found by researching existing job listings in the City of Phoenix for positions needed for the project. In the searched job listings, the salary or wage was provided. In order to calculate the billing rate, the salaries were multiplied by a multiplier between 2-4% depending on the role, a higher multiplier was added to the role with more experience and was enough to be profitable but continue to offer competitive wages.

Table 5-1 Cost Breakdown of Engineering Services

Category	Sub-Category	Classification	Quantity	Unit	Rate	Unit	Cost ($)
1.0 Personnel		SENG	59	hours	315	$/hr	$18,585
		DENG	237	hours	225	$/hr	$53,325
		CINT	187	hours	40	$/hr	$7,480
		EINT	190	hours	40	$/hr	$7,600
						Subtotal:	**$86,990**
2.0 Supplies		WEF Membership	4	memberships	21	$/ membership	$84
		Computer Lab Rental	15	days	100	$/day	$1,500
						Subtotal:	**$1,584**
3.0 Travel	**3.1 Site Visit**	Mileage	302	miles	0.28	$/mile	$85
		Car Rental	1	day	50.75	$/day	$51
	3.2 Competition	Mileage	284	miles	0.28	$/mile	$80
		Car	2	days	50.75	$/day	$102
		Hotel (one night)	3	night-room	142	$/night-room	$426
		Per Diem (2 days)	10	Day-person	40	$/day-person	$400
						Subtotal:	**$1,144**
Total Cost of Engineering Services							**$89,718**

Table 5-1 shows the cost for personnel, supplies, and travel. The total cost for supplies is projected to be $1,534 which will encompass the cost for the Water Environment Federation (WEF) membership and computer lab space. Travel is projected to be $1,144 to include the cost for both the site visit and the AZ Water SDC. The most expensive estimated cost is for personnel at $86,990. With the personnel, supplies, and travel costs, the total cost of engineering services is projected to be $89,718.

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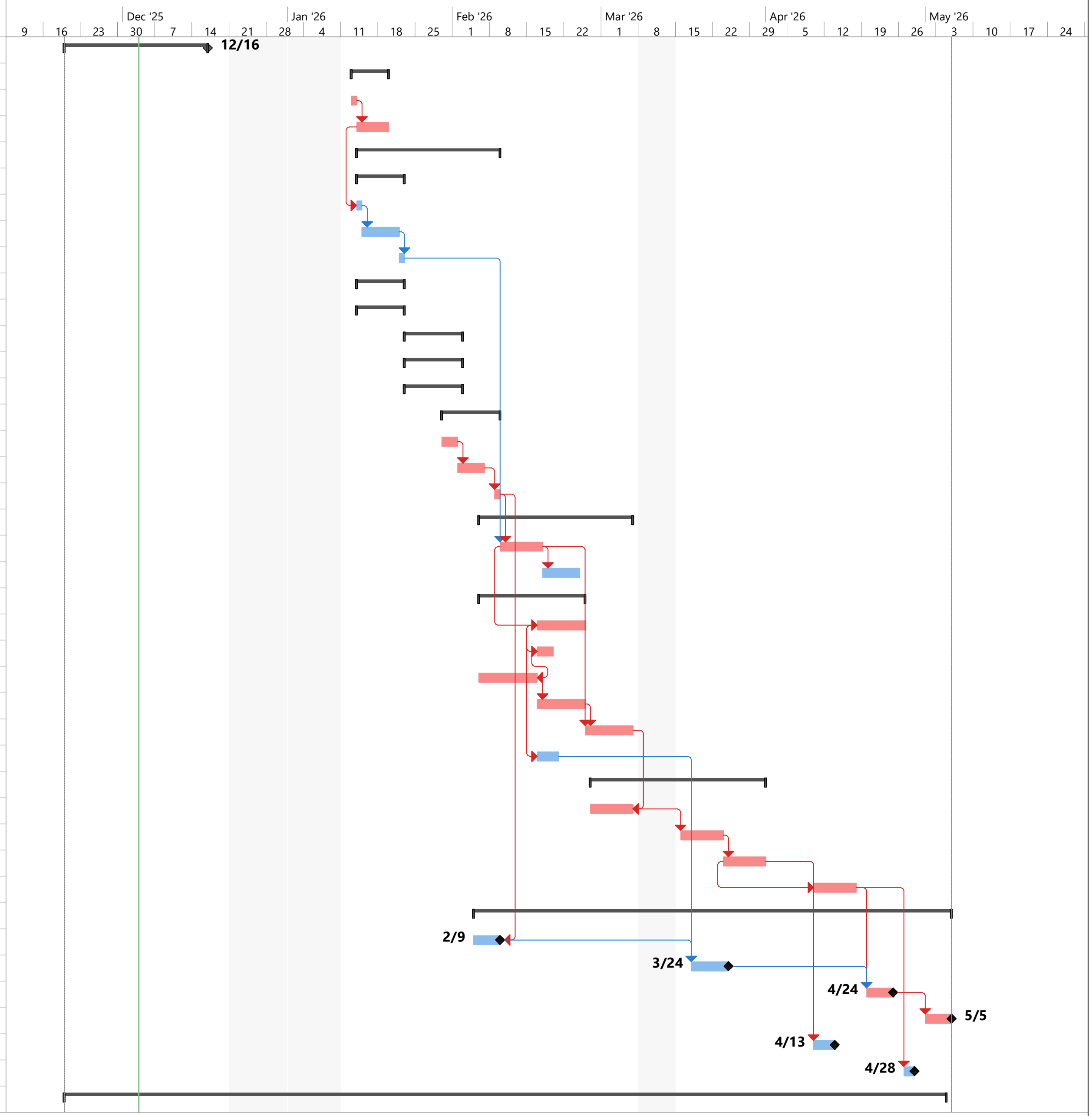
Appendices

Appendix A: Gnatt Chart

Chart on the next page.

ID	Task Name
1	**Task 1.0: Research and Preparation**
5	**Task 2.0: Site Investigation**
6	Task 2.1 Site Visit
7	Task 2.2: Site Data Analysis
8	**Task 3.0: Treatment Selection**
9	**Task 3.1: Physical Separation**
10	Task 3.1.1 Determine Criteria
11	Task 3.1.2 Develop Alternatives
12	Task 3.1.3 Eliminate Less Suitable Alternative
13	**Task 3.2: Physical Treatment**
17	**Task 3.3: Chemical Treatment**
21	**Task 3.4: Advanced Treatment**
25	**Task 3.5: Disinfection**
29	**Task 3.6: Brine Handling**
33	**Task 3.7 Create Treatment Train Alternatives**
34	Task 3.7.1 Develop Criteria
35	Task 3.7.2 Develop Alternatives
36	Task 3.7.3 Select Best Alternatives
37	**Task 4.0: Final Design**
38	Task 4.1: Treatment Processes
39	Task 4.2: Site Layout
40	**Task 4.3 Hydraulic Design**
41	Task 4.3.1: Lift Station Design
42	Task 4.3.2: Pump Selection
43	Task 4.3.3: Pipe Design
44	Task 4.3.4: Hydraulic Profile Design
45	Task 4.4 Construction Phasing
46	Task 4.6 Public Outreach Plan
47	**Task 5.0 Cost Analysis**
48	Task 5.1 Opinion of Probable Cost
49	Task 5.2 Operations and Maintenance Cost
50	Task 5.3 Life Cycle Cost
51	Task 6.0: Project Impacts
52	**Task 7.0 Project Deliverables**
53	Task 7.1 30% Deliverable
54	Task 7.2 60% Deliverable
55	Task 7.3 90% Deliverable
56	Task 7.4 Final Deliverable
57	Task 7.5 WEF Competition Final Report
58	Task 7.6 WEF Competiton Final Presentation
59	**Task 8.0 Project Management**



Appendix B: Staffing Matrix

Table on the next page.

Task Number	Task Description	SENG (hrs)	DENG (hrs)	CINT (hrs)	EINT (hrs)	Total (hrs)
Task 1.0	**Research and Preparation**	2	5	16	16	39
1.1	Codes and Regulation Research	1	2	7	6	16
1.2	Water Treatment Research	0	2	8	9	19
1.3	WEF Application	1	1	1	1	4
Task 2.0	**Site Investigation**	8	8	22	22	60
2.1	Site Visit	6	6	10	10	32
2.2	Site Data Analysis	2	2	12	12	28
Task 3.0	**Treatment Selection**	14	29	51	52	146
3.1	Physical Separation	2	3	6	6	17
3.1.1	*Determine Criteria*	0	1	1	1	
3.1.2	*Develop Alternatives*	1	1	4	4	
3.1.3	*Eliminate Less Suitable Alternative*	1	1	1	1	
3.2	Physical Treatment	2	3	6	6	17
3.2.1	*Determine Criteria*	0	1	1	1	
3.2.2	*Develop Alternatives*	1	1	4	4	
3.2.3	*Eliminate Less Suitable Alternative*	1	1	1	1	
3.3	Chemical Treatment	2	4	8	8	22
3.3.1	*Determine Criteria*	0	1	1	1	
3.3.2	*Develop Alternatives*	1	2	6	6	
3.3.3	*Eliminate Less Suitable Alternative*	1	1	1	1	
3.4	Advanced Treatment	2	5	8	8	23
3.4.1	*Determine Criteria*	0	1	1	1	
3.4.2	*Develop Alternatives*	1	3	6	6	
3.4.3	*Eliminate Less Suitable Alternative*	1	1	1	1	
3.5	Disinfection	2	4	8	8	22
3.5.1	*Determine Criteria*	0	1	1	1	
3.5.2	*Develop Alternatives*	1	2	6	6	
3.5.3	*Eliminate Less Suitable Alternative*	1	1	1	1	
3.6	Brine Handling	2	5	9	9	25
3.6.1	*Determine Criteria*	0	1	1	1	
3.6.2	*Develop Alternatives*	1	3	7	7	
3.6.3	*Eliminate Less Suitable Alternative*	1	1	1	1	
3.7	Creating Treatment Train Alternatives	2	5	6	7	20
3.7.1	*Determine Criteria*	0	1	1	1	
3.7.2	*Develop Alternatives*	1	3	4	5	
3.7.3	*Select Best Alternative*	1	1	1	1	
Task 4.0	**Final Design**	11	121	35	34	201
4.1	Treatment Processes	2	30	6	9	47
4.2	Site Layout	1	20	7	4	32
4.3	Hydraulic Design	6	56	16	13	91
4.3.1	*Lift Station Design*	2	23	6	4	
4.3.2	*Pump Selection*	1	12	4	3	
4.3.3	*Pipe Design*	2	11	4	4	
4.3.4	*Hydraulic Profile Design*	1	10	2	2	
4.4	Construction Phasing	1	8	4	4	17
4.5	Public Outreach Plan	1	7	2	4	14
Task 5.0	**Cost Analysis**	3	10	13	15	41
5.1	Opinion of Probable Construction Cost	1	5	8	2	16
5.2	Operations and Maintenance Cost	1	3	2	10	16
5.3	Life Cycle Cost	1	2	3	3	9
Task 6.0	**Project Impacts**	2	4	7	8	21
Task 7.0	**Project Deliverables**	6	15	28	28	77
7.1	30% Deliverable	1	2	5	5	13
7.2	60% Deliverable	1	3	5	5	14
7.3	90% Deliverable	1	4	6	6	17
7.4	Final Deliverable (CENE)	2	3	5	5	15
7.5	WEF Competition Final Report	1	2	5	5	13
7.6	WEF Competition Final Presentation	0	1	2	2	5
Task 8.0	**Project Management**	13	45	15	15	88
8.1	Meetings	8	15	15	15	53
8.2	Schedule Management	2	15	0	0	17
8.3	Resource Management	3	15	0	0	18
Summary	---	**59**	**237**	**187**	**190**	**673**