NORTHERN ARIZONA UNIVERSITY

Project Proposal

AZ Water Student Design Competition:

Water or Wastewater Treatment Plant Design

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Abbreviations

WEF – Water Environment Federation

AWWA – American Water Works Association

GWRF - Greenfield Water Reclamation Facility

NWTP – North Gilbert Water Treatment Plant

MFC – Microbial Fuel Cells

ADEQ – Arizona Department of Environmental Quality

EPA – Environmental Protection Agency

AAC – Arizona Administrative Code

BOD – Biological Oxygen Demand

TSS – Total Suspended Solids

TA – Technical Advisor

G.I. - Grading Instructor

SENG – Senior Engineer

ENG – Engineer

TECH – Lab Technician

INT – Intern

CCCDEQ - Coconino County Community Development Environmental Quality Division

1.0 Project Understanding

The project understanding section expresses the project purpose, background, technical considerations, potential challenges, and stakeholders. The overall purpose of the project understanding is to layout the preliminary project information to ensure that all project goals are met and that all necessary information is obtained.

1.1 Project Purpose

The project requires the analysis and design of a drinking water or wastewater treatment facility for a community in Arizona. The AZ Water Student Design Competition is an annual competition organized by the AZ Water Association and Water Environment Federation. The competition includes students from different institutions in Arizona competing to design either a water or wastewater treatment plant. This project includes analysis on the overall treatment process in addition to pump selection, concentration calculations, analyzing flow requirements and more. In addition, it also includes life cycle cost analysis, as well as future population demands.

1.2 Project Background

During the first semester of the project there is limited information regarding the location and specific design criteria; during the second semester the team will obtain this information from WEF. Therefore, in order to prepare for any circumstances, it is necessary to review past highly accomplished team's designs. The following section will discuss past projects and what is known of the project.

1.2.1 Project Description

The Water Environment Federation (WEF) and American Water Works Association (AWWA) organize an annual competition with the Arizona Waters Association. The competition consists of universities throughout Arizona redesigning and updating an existing wastewater or water treatment plant. This competition occurs annually in April with the project being introduced to the competitors in January. For the duration of the proposal, there is no dedicated site but there are some assumptions and understandings from past competition entries that will allow our team to prepare for the competition.

Although there is an uncertainty on the specific location and what type of treatment plant, it can be assumed that the facility will be within the State of Arizona and will most likely have a traditional treatment plant layout.
The winners of the 2018 WEF competition were Northern Arizona University's student design team. The team was given a wastewater treatment plant known as the Greenfield Water Reclamation Facility (GWRF) which can be seen in

Figure 1.1 [1]. GWRF operates for the towns of Queen Creek and Gilbert along with the city of Mesa. The before and after layout photos are shown below in Figure 1.1 and Figure 1.2, respectively.

Figure 1.1: Aerial View of the 2018 project at GWRF Before Design [2]

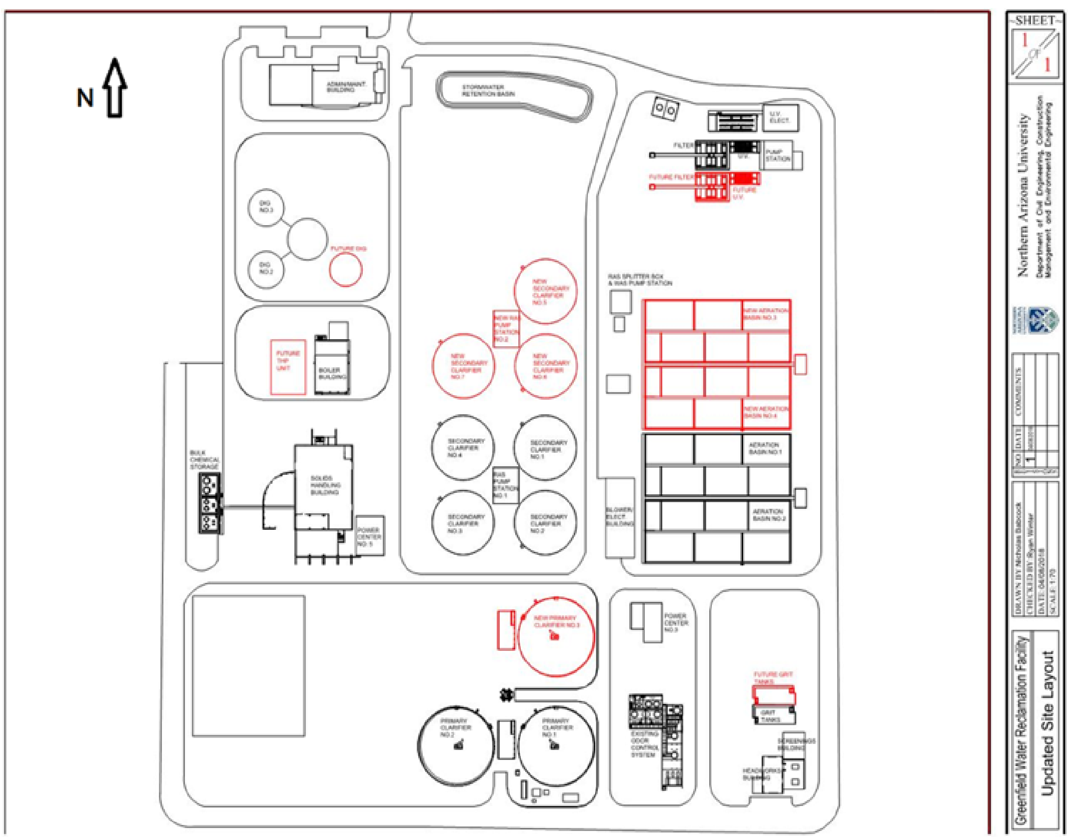


Figure 1.2: Aerial View of the 2018 project at GWRF After Design [2]

Another example from the WEF competition is the 2021 team from Northern Arizona University. Their project differed from the 2018 project due to their facility being a water treatment facility. Their project was located in Gilbert, Arizona and is known as the North Gilbert Water Treatment Plant (NWTP). The team used given data and resources to renovate the treatment plant and achieved second place in the competition. The before and after layout photos are shown below in Figure 1.3 and Figure 1.4, respectively.

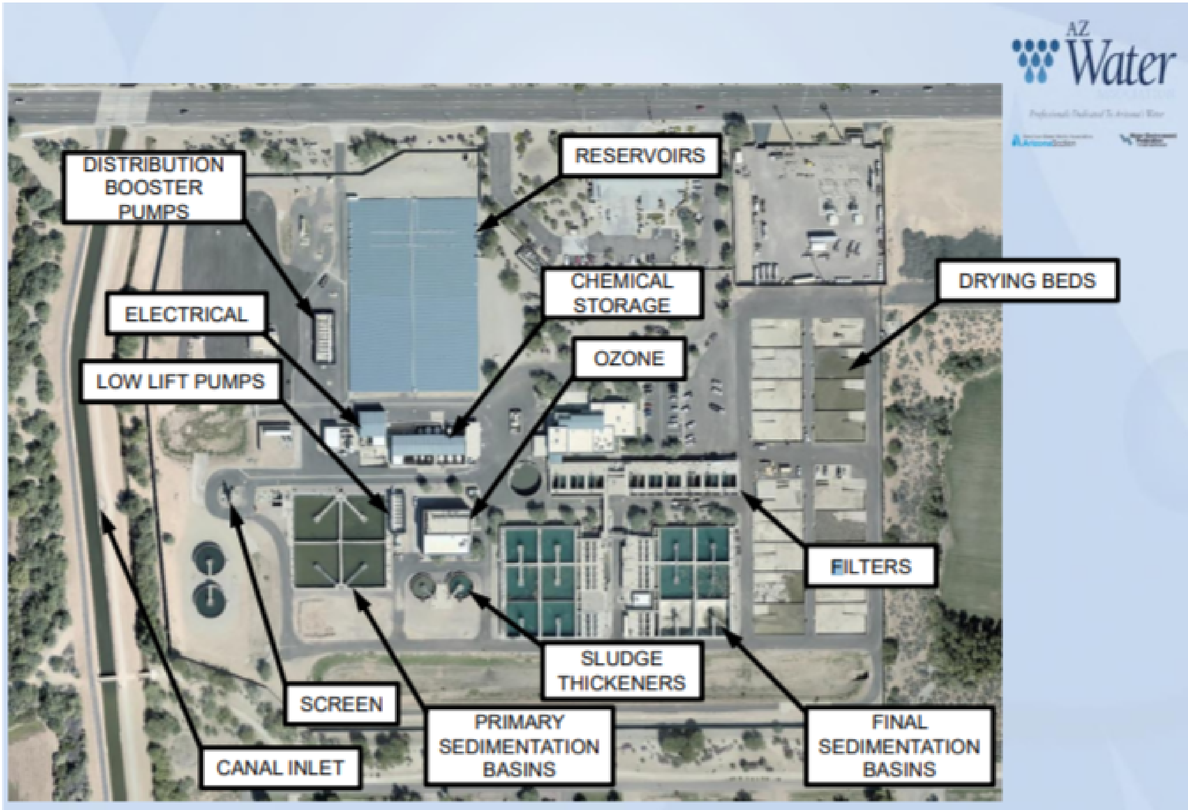


Figure 1.3: Aerial View of the 2021 project at NWTP Before Design [2]

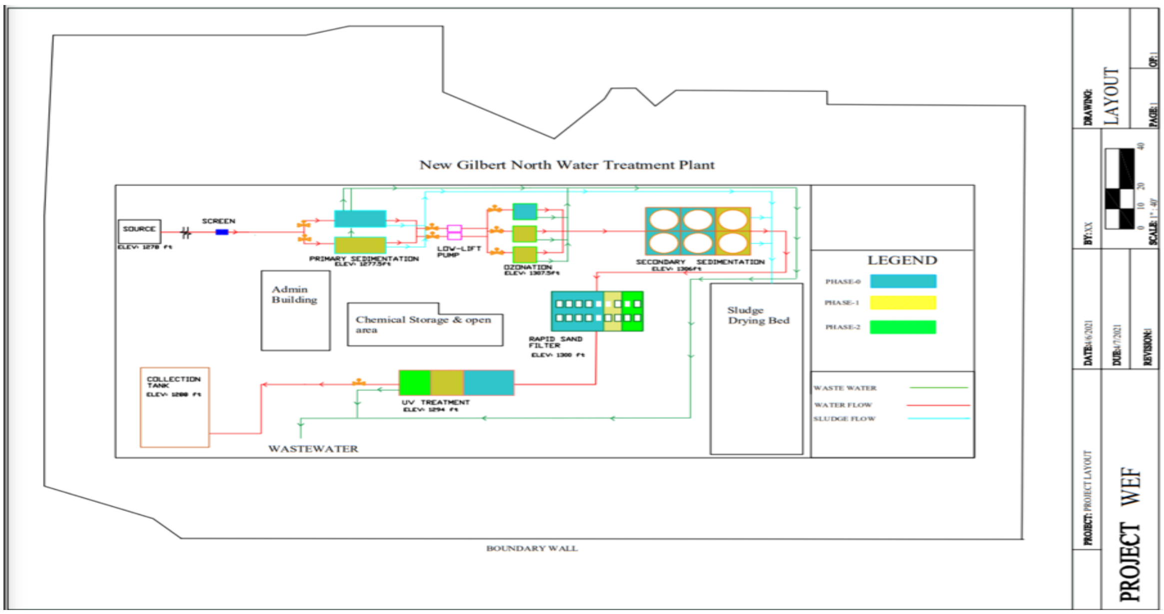


Figure 1.4: Aerial View of the 2021 project at NWTP Before Design [2]

1.3 Technical Considerations

The technical considerations section describes the necessary engineering analysis and potential technologies that will be used to complete the design.

1.3.1 Future Population Estimates

For wastewater treatment plants, future population estimation is crucial in determining the amount of water that the plant will need to treat per day based on the influent wastewater from the community. For water treatment plants, future population estimation is crucial in determining the community water demand to ensure that as the population changes the plant produces enough effluent per day. Future population estimation is done through calculations using the current population and the rate of increase based on previous population census trends along that period including an increase in people moving to Arizona, in addition to birth and death rates and the lifetime year of the plant given by WEF. Equations for this analysis will be introduced later. Overall, the population estimation is used to determine the water demand and affects how the plant is built to sustain the community for a long period of time.

1.3.2 Codes and Regulations

The water or wastewater treatment plant will meet all federal, state, and local codes and regulations. The regulations will be used to determine the required properties of the effluent in order to meet safe drinking water standards and safe wastewater discharge levels. This information will come from a variety of sources including the Environmental Protection Agency (EPA), Arizona Department of Environmental Quality (ADEQ), and local regulations from the city.

1.3.3 Hydraulic Analysis

To determine which technologies will be used in the plant in addition to design specifications such as pump type, pump configuration, and flow rate, calculations will be performed. For pipes, this includes analyzing pump characteristic curves which express flow rate, head, power input and pump efficiency for centrifugal pumps. Additionally, decisions on pumps in parallel or series will be made based on the needs of the project; pumps in series adds head to the system while pumps in parallel increases the flow rate of the system [3]. Pump analysis also includes accounting for head loss in the pipes, this can be analyzed using the Hazen-Williams equation. Additionally, online drafting through AutoCAD and Civil 3D will be used to create plant drafts. Water/wastewater testing will be done during site investigations in addition to gathering site data from the plant operators to understand the current conditions.

1.3.4 Treatment Process Design

An overall treatment design plan will be needed for the final plant design. This will include choosing the overall treatment for either a water or wastewater treatment plant. Additional considerations will be treatment sizing, chemical dosages and cost analysis. In order to determine the sizing of basins and clarifiers, calculations will be conducted such as determining the flow rate and required treatment per day based on the calculated population. Additionally, settling velocities and detention times will be calculated to determine the necessary tank dimensions. To conduct this analysis, the Froude number and Reynolds numbers will be utilized based on the type and shape of tank. To determine the chemical dosage, the daily flow rate will be utilized to determine the amount of chemical needed to treat the water or wastewater. These calculations will be done to ensure the water meets all regulations for proper water and wastewater effluent.

1.3.5 Life Cycle Cost Analysis

Once the plant is designed, there will be an analysis on the overall life cycle cost for the plant based on the construction cost, operation and maintenance costs, in addition to accounting for inflation, loans, interest and overall how much it will cost to keep the plant running for the entire design length.

1.3.6 Demand Flow Calculations

For a wastewater treatment plant, it is most important to consider the influent flow into the plant because there is a maximum capacity that the plant can treat per day, while for a drinking water treatment plant it is important to consider the amount of effluent flow required to adequately serve the community. In order to determine the inlet and outlet flow, calculations are performed based on the current and future population data in addition to the minimum, maximum, and average flow rates coming from and going into the surrounding community. The plant will be designed to withstand the maximum needed influent/effluent to ensure that the plant properly meets the needs of the community. Additionally, for wastewater treatment plants in particular, an equalization basin will be required to equalize flow as the influent flow rate throughout the day changes based on the time of day.

1.3.7 Design Size Calculations

To design the plant sizes of basins, tanks, and other units, calculations will be performed to express the needed size for each technology to treat the maximum requirement of wastewater or drinking water per day. Calculations for this include but are not limited to rectangular settling basin design, filtration design and chlorine contact basin design. These designs will be done using excel to perform each step of the calculation in addition to ensuring that the designs meet all required regulations and standards.

1.3.8 Concentration Calculations

In order to properly treat the wastewater or drinking water, there are required concentrations for BOD levels, chemical levels, and more. These calculations will be performed based on the size of technology, contaminant level, and flow rate. These calculations include but are not limited to lime soda treatment, stabilization, disinfection, and dechlorination.

1.4 Potential Challenges

The potential challenges that may be encountered during this project are outlined in this section.

1.4.1 Weather

The site investigation is scheduled in January or February 2022. Cold weather and snowy roads may present challenges to the project's site investigation.

1.4.2 Delay in Receiving Problem Statement

The project can only start when the location and rules are given. Therefore, time management is a challenge due to the team waiting for additional information.

1.4.3 COVID-19

The pandemic obstructs the in-person events such as the ability to conduct a site visit tour and field investigation.

1.5 Stakeholders

Stakeholders in the production and usage of this treatment plant mostly include the ADEQ, regulators, neighbors, the county of the city that the proposed plant will be built in, customers that will either receive or supply water to the plant, and the city that owns the plant for this proposed project. The ADEQ is one of the main stakeholders because it is the organization that will work closely with the plant. For example, per the EPA regulations the ADEQ aids in enforcing and potentially giving more stringent regulations. Therefore, the regulators are also a stakeholder because regulators will be responsible for ensuring the plant complies with the regulations. The county of the city for the proposed plant and the city that owns this plant will have interest in the success of this site because it will directly affect the health and safety of the residents if the water or wastewater is not properly treated. The customers and the neighbors of this proposed site are one of the most important stakeholders because if risks are taken at the plant, it will directly affect their lives. A big concern for living near or working at a wastewater treatment plant can be the health risk of being exposed to bioaerosols and other chemicals, because microorganisms from wastewater travel through the air. They can travel through air into nearby neighborhoods where they multiply. This makes the neighbors of the plant stakeholders because it affects the residents that are breathing them in by causing infection and disease. The neighbors are also stakeholders due to the potential noise and odor that can be produced from the construction and operation of a plant near them. The customers also play a role as they are the ones receiving the water, therefore, if the plant is not operating correctly, the customers will be directly affected. The customers are mostly invested as they will be paying for the services of this plant.

2.0 Scope of Services

The scope of services provides tasks that must be completed as preparation for the AZ water competition. These tasks include initial project preparation, site investigation, population research, analyzing applicable regulations, treatment design, life cycle cost analysis, impact of analysis, deliverables, project management, and exclusions.

2.1 Task 1.0 Initial Project Preparation

The team will prepare for the project by registering for the WEF competition and looking through rules, criteria, and treatment processes needed.

2.1.1 Task 1.1 Application for WEF

The team must apply for the WEF competition, this requires the team to sign up for the competition by the set due date.

2.1.2 Task 1.2 Review WEF Rules and Criteria

Team will be required to fully analyze, design, and create design documents for entry into the AZ Water Spring 2022 student design competition which consist of completing the plant design, attending the conference and submitting all competition required items.

2.1.3 Task 1.3 Additional Treatment Research

It is not clear whether the design will be for water treatment or wastewater treatment, so team will study and collect relevant information on both topics at the same time. During this project, site investigation, population estimation, analyze applicable regulations, treatment design, and impacts analysis will be carried out. The team will need to know the specific field and population data served by the site to ensure that the subsequent processing plan is complete. The team will make sure to comply with relevant regulations to avoid risk and uncertainties that would cause the project to fail and not be implemented. Finally, the team will evaluate the social, economic, and environmental impacts of the plan, and avoid adverse effects as early as possible. The following will describe in detail how to conduct research on the above topics.

2.2 Task 2.0 Site Investigation

The team will conduct a site investigation in order to obtain information about the existing site infrastructure, technology, and overall data such as the influent and effluent flows, concentrations of contaminants, concentrations of chemicals, maximum daily flow, technology, and overall plant size and minimum daily effluent for a water treatment plant.

2.2.1 Task 2.1 Field Visit

The team will go to the given site water/wastewater treatment plant and collect data on the current site's technology such as types of tanks and size of tanks being used in the treatment process in addition to the overall treatment process from start to finish.

2.2.2 Task 2.2 Collect Current Data from Operators

This data will be obtained from operators regarding the current site and will include information such as the current inlet and outlet flows, the types of treatment currently in use, and water quality data.

2.3 Task 3.0 Evaluation of Site Investigation Data

The information obtained in the field investigation will be evaluated to aid in the future plant design.

2.3.1 Task 3.1 Analyze Data of Current Plant

Once the data is obtained, the team will analyze it to determine information for the new design such as if additional treatment must be added, if so, how much influent and effluent flow will change, examine the current data and how well the plant is operating under current conditions. This will also include ensuring the current and future plant is in regulation for codes from the EPA and ADEQ.

2.3.2 Task 3.2 Review Existing Site Design and Technology

The team will analyze what technologies currently exist at the water/wastewater treatment plant to aid in determining what additional technologies must be added and which current technologies can be used again in the new design.

2.4 Task 4.0 Population Estimation

The current and future population will be analyzed and calculated in order to determine the design criteria to meet the needs of the community for a water or wastewater treatment plant.

2.4.1 Task 4.1 Current Population Research

The current population data will be used in relation to plan for the future population as explained below. This data will be obtained from the current site and the census for the given city.

2.4.2 Task 4.2 Future Population Calculation

The future population will be calculated using a standard population estimation equation. This will require information on the current population, death and birth rates, and the population rate of increase, in addition to the required design years for the lifetime of the plant.

2.5 Task 5.0 Analyze Applicable Regulations

The constraints and criteria of the project will be separated into the three main policy regulations such as federal, state, and county. In analyzing the regulations, the team will look through all regulations of water from federal, state, and county levels to ensure that the contaminant levels and treatment plant guidelines are met in design.

2.5.1 Task 5.1 Federal Regulations

The team will do research on the regulations and policies that must be implemented on a federal level. The federal regulations will help the team establish the design criteria. Some criteria that must be reviewed include contaminant level reductions and what level of certain compounds are allowed to enter publics' use. Some research will involve reviewing federal regulation resources from federal departments such as the EPA.

2.5.2 Task 5.2 State Regulations

The team will do research on the regulations and policies that must be implemented on a state level as state regulations can be stricter than the federal regulations and must be met as well. Some research will involve review of regulations with the ADEQ along with some specified criteria found with the EPA. Another area that must be reviewed on a state aspect is the Arizona Administrative Code (AAC).

2.5.3 Task 5.3 County Regulations

The team will do research on the regulations and policies that must be implemented on a county level as counties can identify stricter regulations than the state and federal levels and must be met by the plant as they will be the one working closest with the plant and checking that the regulations are met. There will also be research for the county but due to the specified location being unknown, there is no known area to research at the moment. An example of what might need to be reviewed for further details in regulation for the City of Flagstaff would be the Coconino County Community Development Environmental Quality Division (CCCDEQ).

2.6 Task 6.0 Treatment Design

The treatment design process will first determine the criteria for each treatment design. The team will design for either a water or wastewater treatment plant. The determination will be made after the initial project preparations. Several treatment methods will be analyzed for initial, essential, advanced, disinfection and solids handling treatment. The team will pick one or two methods from each treatment stage and combine them together as an alternative. Several alternatives will be made and ready to be rated for the next step. After that, a final decision will be made that includes the processes used, piping system, and pump selection.

2.6.1 Task 6.1 Determine Criteria

After reviewing the constraints and regulations, the team will determine the criteria through the design process. The water source conditions, and the effluent requirements will be based on the instructions of the WEF competition.

2.6.2 Task 6.2 Determine Water Demand

The team will determine the water demand based on the population and stakeholders in the area given by the competition rules. The team will conduct research on the area and the average daily flow to calculate the total water demand.

2.6.3 Task 6.3 Initial Treatment

Initial treatment is to remove large, suspended solids in the influent water. The team will research on different technologies and analyze their efficiency, cost, and maintenance.

2.6.3.1 Task 6.3.1 Preliminary Design of Alternatives

The team will design the initial screen system and gravity treatment in this part. Proper technologies will be developed, and several potential solutions will be made as alternatives.

2.6.3.2 Task 6.3.2 Decision Matrix and Choose Alternatives

A decision matrix will be made based on the criteria to evaluate the alternatives for initial treatment. The team will pick two or more alternatives as part of the final potential solutions.

2.6.4 Task 6.4 Essential Treatment

The essential treatment includes physical, chemical, and/or biological treatment. The team will design based on appropriate treatment methods after more information becomes available.

2.6.4.1 Task 6.4.1 Preliminary Design of Alternatives

Alternatives will be made after the team is notified to design a water or wastewater treatment plant. The team will research on proper technologies based on the influent water condition and the requirements of the effluent. This will include a filtration tank and choosing the proper tank size and type. Factors such as the flow rate, flow velocity, and settling time will be considered. Additionally, coagulation and flocculation will be considered if necessary. The team will select several coagulate chemicals and determine the chemical dosage and the mixing time. Lastly, potential technologies for biological treatment includes oxidation pond, activated sludge, and membrane bioreactors. The team will design in detail for each technology such as the volume of pond or tank, detention time, and air supply.

2.6.4.2 Task 6.4.2 Decision Matrix and Choose Alternatives

A decision matrix will be made based on the criteria to evaluate the alternatives for essential treatment. The team will pick two or more alternatives as part of the final potential solutions.

2.6.5 Task 6.5 Advanced Treatment

In this stage, the team will review the effluent requirements and check if any additional treatment will be needed for water or wastewater. The team will also consider the design for water reuse.

2.6.5.1 Task 6.5.1 Preliminary Design of Alternatives

Different technologies will be considered to decrease loads of organic matter, remove nutrients, or constituents that inhibit water reclamation if necessary. Potential technologies include air stripping, ion exchange, or a reverse-osmosis.

2.6.6.2 Task 6.6.2 Decision Matrix and Choose Alternatives

A decision matrix will be made based on the criteria to evaluate the alternatives for advanced treatment. The team will pick two or more alternatives as part of the final potential solutions.

2.6.6 Task 6.6 Disinfection

The team will first determine the potential disinfection technologies. After that, the team will design in detail for each technology. For example, the team will determine the presence of UV duration if UV radiation is used.

2.6.7 Task 6.7 Solids Handling

The team will decide on the handling method based on the mass and composition of sludge and the disposal requirements. Potential methods include land application, incineration, surface disposal, and landfilling. Priorities of concern includes the cost, efficient technology, and whether the technology is environmentally sustainable.

2.6.8 Task 6.8 Final Design Matrix

A decision matrix will be made for the alternatives for each treatment. The team will consider the criteria identified and efficiency for the potential solutions of each task. A percentage weight will be determined for each of these factors and the potential solutions will be analyzed and scored based on these factors. Then, the total score will be the sum of each score times it's percentage weight. The team will compare the total scores and select the most efficient one as the final solution.

2.6.9 Task 6.9 Final Decision and Design

The final decision will be made after the design matrix. After determining the final solution, the team will then design for the piping system and do the pump selection. This part includes a layout of the piping system with the location of the pumps and pump types identified.

2.7 Task 7.0 Life Cycle Cost Analysis

This task will include determining the cost of the project and plant during it life cycle in operation. The total cost is currently unknown, however, it is an important factor regarding the selection of the processes and technologies.

2.7.1 Task 7.1 Construction Cost

The construction cost task will be to determine cost for all equipment, materials, transports, and other elements that go into constructing a treatment plant. The construction cost will be modified depending on the processes and number of systems chosen for the plant but can be found by researching previous construction cost of treatment plants in the State of Arizona and calculating the average cost. When the location is identified, an average for that specific city and type of treatment will be researched and used to be accurate.

2.7.2 Task 7.2 Operation and Maintenance Cost

Operation and Maintenance cost will determine all expenses that go into running the plant on a daily basis and the maintenance cost that are spent to fix systems that may go down or need to be replaced within the lifespan of the treatment plant. This can be done by researching upgrades and operating cost that have been documented at treatment plants in Arizona and calculating the average cost spent on operation and maintenance per year for a treatment plant.

2.7.3 Task 7.3 Life Cycle Cost

A cost needs to be calculated for the expected life cycle which is the expenses that will be needed to run this plant for the lifespan it is predicted to work efficiently for. This cost will be an addition of the construction cost and the operation and maintenance cost over the years that the plant will run and multiplied by a factor to account for inflation.

2.8 Task 8.0 Impacts Analysis

This section focuses on the positive and negative impacts that the project might have with the following topics: social, economic, and environmental impacts.

2.9 Task 9.0 Deliverables

The completion of this project is based on meeting milestones and showing the progress made on the project throughout the time spent working on it and sending proof to the client and grading instructor.

2.9.1 Task 9.1 30% Submission

This submission will include the 30% design report and presentation. The following tasks will be completed; Task 1: Initial Project Preparation, Task 2: Site Investigation, Task 3: Evaluation of Site Investigation Data, Task 4: Population Estimation and Task 5: Analyze Applicable Regulations.

2.9.2 Task 9.2 60% Submission

The submission will include the 60% design report and presentation when the following tasks have been completed; Task 6: Treatment Design, Task 7: Life Cycle Cost Analysis and Task 8: Impacts Analysis.

2.9.3 Task 9.3 90% Submission

This submission will include the 90% design report, website, and final draft presentation. In order to do this, all technical tasks will be completed.

2.9.4 Task 9.4 100% Submission

All work, reports and findings will be completed. This submission will include the 100% design report, final presentation and completed website.

2.9.5 Task 9.5 Competition Deliverables

The competition deliverables include completing an entry form, project description, supporting documents and references and acknowledgments. The supporting documents needed include drawings, calculations, tables, cost estimates and other documents. These documents establish design criteria, research treatment process, selection of processes, and design of the new plant.

2.10 Task 10.0 Project Management

2.10.1 Task 10.1 Meetings

We will have regular meetings with our team, client, TA, and G.I.

2.10.2 Task 10.2 Schedule Management

Review and update to ensure that milestones, deliverables, and final completion are on time.

2.10.3 Task 10.3 Resource Management

Team will track hours spent and resources used to ensure project will be completed on time within budget.

2.11 Exclusions

The team will not be responsible for any designs for the site construction. The team will design a layout of the plant and the treatment process and decide on the technologies that will be used but will not focus on how to construct the plant.

The design process will also not include any lab work. The design will indicate the steps at which water quality needs to be studied in the laboratory, but it will not actually be studied. The team will follow the constraints and criteria from the regulations listed in Task 5: Analyze Applicable Regulations but permits required for the construction or development of land will not be sought out nor acquired by this team.

The team will not do the land surveying or field sampling. The hydrogeology analysis will not be included in the design process.

3.0 Schedule

The schedule in the Appendix demonstrates the tasks that the team will complete in order to achieve a successful project on time. A critical path is identified to show which tasks must be done to stay on track for completion.

3.1 Schedule Overview

Regarding the timetable of this project, the total design period is 82 days, from January 10th, 2022 to May 3rd, 2022. All of the design processes will be completed before April 25th. The main task is Task 6: Treatment Design, which is expected to take 60 days. The team is ultimately expected to be able to deliver a complete and mature water/wastewater treatment plant design plan.

3.2 Major Tasks and Deliverables

In this project, there are three main tasks and their related deliverables, which are Task 2, Task 4, and Task 6. For Task 2, it is a site investigation around the processing plant to obtain the data necessary for future design. The related deliverables are field visiting and collecting current data from operators. Then, Task 4 is an estimation of the population served at the treatment plant site. This is significant for estimating the daily water treatment, cost estimation, and impacts on the surrounding environment and society. There are deliverables about current population and future population calculations where the different populations need to be calculated. The top priority is Task 6, which is about wastewater/water treatment design. The team will design for either a water treatment plant or wastewater treatment plant. Several treatment methods for initial, essential, advanced, disinfection and solids handling treatment will be analyzed and the team will select at least 2 approaches from each treatment stage and combine the secondary approaches as alternatives. With all alternatives considered, a design matrix will calculate the most efficient treatment plant which will be chosen for final design.

3.3 Critical Path

The critical path made up from the critical tasks can be seen in the Appendix with the red representing of critical tasks. By determining the critical path, the team can clearly understand the order of progress for the project. Also, the team can reserve extra time on important tasks to prevent delays caused by uncertainties. The critical path is made up of multiple critical tasks, these tasks represent tasks that must be completed on time. If these are not completed on time, the entire timeline of the project will shift due to the dependency of following tasks on the critical path. For example, the field visit and collection of current data must happen before any data can be analyzed, before the population research, and before beginning the treatment design. Therefore, this task must be completed on time, or it will push back the rest of the project. Task 6 is one of the critical tasks since it includes the final design of the project which represents the main goal of whole project. Additionally, on the schedule these tasks are staggered due the effluent from the previous treatment affecting the influent of the following treatment. The last part that contains the key tasks is in Task 9: Deliverables. Each subtask needs to be completed on time to achieve 100% completion of the project by the due date. Consequently, it is essential to complete these deliverables on time. Lastly, the most important way for the team to stay on track is to let critical tasks have a strict position in the overall plan. Therefore, if the schedule is followed this will aid in avoiding exceeding the plan deadline because of the unfinished or late completion of the critical tasks.

4.0 Staffing Plan

The staffing plan was created for a team that consist of one senior engineer, one engineer, one engineer in training, one technician, and one intern. Table 4.1 below shows the staffing plan which shows how many hours each team member will fulfill for each of the task and subtask.

The senior engineer (SENG) is required to have a bachelor's degree in engineering, as well as at least four years of relevant work experience and their Professional Engineering License (PE). The senior engineer will be focusing on the final presentation along with communication between the team and the clients. The senior engineer is also responsible for overseeing and reviewing the work of the engineer.

The engineer (ENG) is required to have a bachelor's degree in engineering and their Fundamental Engineering License (FE). The engineer will be working on the technical aspects of the project while also spending some of the time guiding the intern and engineer in training in their specified assignments.

The engineer in training (EIT) is required to have a bachelor's degree in engineering and their FE. The engineer in training will be focusing on learning from the engineer, doing research for the engineer's future calculations, and contributing to the project while being supervised by professional engineers and/or engineers in a higher position.

The intern (INT) needs to be a recent graduate or soon to be graduate with a degree in environmental engineering. The intern will be working on the work assigned by the engineer. It is important that the engineers dedicate some time for scheduled meetings with the intern in order to answer any concerns or issues they have within the project.

The technician (TECH) is required to have a license or certification to use the relevant drafting and modeling software. The technician will be focusing on the design aspect of the project with most of their hours being used for drafting, using water design programs, and analyzing the water plant's data. The following staffing table was used to divide the working hours respectfully.

The hours of each role can be seen in Table 4.1 Staffing below which breaks down the hours for the project into each of the five roles discussed previously based on their job descriptions.

Table 4.1: Staffing

Task	SENG (hr)	ENG (hr)	EIT (hr)	TECH (hr)	INT (hr)
Task 1: Initial Project Preparation	1	7	9	10	12
Task 1.1 Application for WEF	0	1	2	2	2
Task 1.2: Review WEF Rules and Criteria	1	2	3	3	3
Task 1.3: Additional Treatment Research	0	4	4	5	7
Task 2: Site Investigation	0	8	9	9	8
Task 2.1: Field Visit	0	7	7	7	7
Task 2.2: Collect Current Data from Operators	0	1	2	2	1
Task 3: Evaluation of Site Investigation Data	2	6	12	8	8
Task 3.1: Analyze Data of Current Plant	2	3	6	4	4
Task 3.2: Review Existing Site Design and Technology	0	3	6	4	4
Task 4: Population Estimation	2	9	13	4	11
Task 4.1: Current Population of City	0	3	5	2	5
Task 4.2: Future Population Calculation	2	6	8	2	6
Task 5: Analyze Applicable Regulations	0	12	18	0	12
Task 5.1: Federal Regulations	0	4	6	0	4
Task 5.2: State Regulations	0	4	6	0	4
Task 5.3: County Regulation	0	4	6	0	4
Task 6: Treatment Design	19	103	80	47	78
Task 6.1 Determine Criteria	1	6	4	0	3
Task 6.2 Determine Water Demand	2	3	4	3	7
Task 6.3 Initial Treatment	2	16	12	6	9
Task 6.3.1 Preliminary Design of Alternatives	1	13	7	4	6
Task 6.3.2 Decision Matrix and Choose Alternative(s)	1	3	5	2	3
Task 6.4 Essential Treatment	2	17	14	8	13
Task 6.4.1 Preliminary Design of Alternatives	1	14	8	5	10
Task 6.4.2 Decision Matrix and Choose Alternative(s)	1	3	6	3	3
Task 6.5 Advanced Treatment	2	15	12	6	13
Task 6.5.1 Preliminary Design of Alternatives	1	12	8	4	9
Task 6.5.2 Decision Matrix and Choose Alternative(s)	1	3	4	2	4
Task 6.6 Disinfection	2	11	10	5	10
Task 6.6.1 Preliminary Design of Alternatives	1	8	6	3	6
Task 6.6.2 Decision Matrix and Choose Alternative(s)	1	3	4	2	4
Task 6.7 Solids Handling	2	10	7	4	9
Task 6.7.1 Preliminary Design of Alternatives	1	8	5	3	6
Task 6.7.2 Decision Matrix and Choose Alternative(s)	1	2	2	1	3
Task 6.8 Final Design Matrix	3	9	7	3	6
Task 6.9 Final Decision and Design	3	16	10	12	8
Task 7: Lifecycle Cost Analysis	6	9	16	6	20
Task 7.1 Construction Cost	2	3	5	3	8
Task 7.2 Operation and Maintenance Cost	2	3	5	3	8
Task 7.3 Expected Lifecycle Cost	2	3	6	0	4
Task 8: Impacts of Analysis	2	2	12	0	6
Task 9: Deliverables	10	36	52	30	60
Task 9.1 30% Submission	2	8	12	9	12
Task 9.2 60% Submission	2	8	12	5	12
Task 9.3 90% Submission	2	8	12	8	12
Task 9.4 100% Submission	2	8	12	4	12
Task 9.5 Competition Deliverables	2	4	4	4	12
Task 10: Project Management	24	32	32	28	32
Task 10.1: Meetings	18	18	18	18	18
Task 10.2: Schedule	4	8	8	8	8
Task 10.3: Resources	2	6	6	2	6
Subtotal	66	224	253	142	247
Total	932				

Table 4.2 shows a summarization of the total hours needed for each major task based on Table 4.1.

Table 4.2: Staffing Summary

Task	SENG (hr)	ENG (hr)	EIT (hr)	TECH (hr)	INT (hr)	Total (hr)
Task 1: Initial Project Preparation	1	7	9	10	12	39
Task 2: Site Investigation	0	8	9	9	8	34
Task 3: Evaluation of Site Investigation Data	2	6	12	8	8	36
Task 4: Population Estimation	2	9	13	4	11	39
Task 5: Analyze Applicable Regulations	0	12	18	0	12	42
Task 6: Treatment Design	19	103	80	47	78	327
Task 7: Lifecycle Cost Analysis	6	9	16	6	20	57
Task 8: Impacts Analysis	2	2	12	0	6	22
Task 9: Deliverables	10	36	52	30	60	188
Task 10: Project Management	24	32	32	28	32	148
Total Hours	66	224	253	142	247	932

5.0 Cost of Engineering Services

For the different positions discussed previously, the total cost of staff members is $68,505. The personnel cost includes salaries, overhead, and benefits in the estimated rate. The second part is about the travel expenses during the site investigation and competition, which has a total cost $1,010.50. It includes $371.50 for car rental and fuel, $639 for two nights at the hotel and $675 for two days of food. The last is the 10-day supplies for the computer lab, which costs $1,000, the computer lab hours include time spent using software for CAD to draft our design. These last two parts are expected to cost a total of $2,010.50. Thus, the overall cost of the project is $70,515.50 as shown in Table 5.1.

Table 5.1: Cost Estimate

1.0 Personnel	Classification	Hours	Rate, $/hr	Cost
	SENG	66	180	$11,880
	ENG	224	100	$22,400
	EIT	253	80	$20,240
	TECH	142	55	$7,810
	INT	247	25	$6,175
Personnel Cost				$68,505
2.0 Travel			**Cost Per, $**	**Cost**
Site Visit Rental Van	1 Van 2-Day Trip		44/day	$88
Competition Rental Van	1 Van 2-Day Trip		44/day	$88
Site Visit Mileage	550 mi Roundtrip		0.23/mi	$126.5
Competition Mileage	300 mi Roundtrip		0.23/mi	$69
Site Visit Hotel	3 Rooms 1 Night		119/night	$357
Competition Hotel	3 Rooms 1 Night		94/night	$282
Site Visit Per Diem	5 People 2-Day		33.75/day	$337.5
Competition Per Diem	5 People 2-Day		33.75/day	$337.5
Total Travel Cost				$1,010.50
3.0 Supplies			**Cost Per, $**	**Cost**
	Computer Lab, 10 days		100/day	$1,000
4.0 Total Project Cost				$70,515.50

6.0 References

[1] AZ Water Association, "AZ Water Association," AZ Water Association, ND ND ND. [Online]. Available: https://www.azwater.org/default.aspx. [Accessed 18 September 2021].

[2] Town of Gilbert Public Work Departments, "WW075 / WW114: Greenfield Water Reclamation Plant Phase III Expansion," Town of Gilbert Public Work Department, ND ND ND. [Online]. Available: https://www.gilbertaz.gov/departments/public-works/engineering-services/capital-improvement-projects/ww075-ww114-greenfield-water-reclamation-plant-phase-iii-expansion. [Accessed 18 September 2021].

[3] Engineering Toolbox, "Pumps in Parallel or Serial," Engineering Toolbox, ND ND 2004. [Online]. Available: https://www.engineeringtoolbox.com/pumps-parallel-serial-d_636.html. [Accessed 18 September 2021].

[5] City of Oconomowoc Government, "Oconomowoc Wisconsin: Treatment Steps," City of Oconomowoc Government, ND ND ND. [Online]. Available: https://www.oconomowoc-wi.gov/270/Treatment-Steps. [Accessed 18 September 2021].

[6] Sydney Water, "Wastewater Treatment Plant: Stage 3- Tertiary Treatment," Sydney Water, ND ND 2010. [Online]. Available: https://www.sydneywater.com.au/Education/Tours/virtualtour/html/tertiary-treatment.html. [Accessed 18 September 2021].

[7] City of San Angelo, "Water Reclamation," City of San Angelo, ND ND 2021. [Online]. Available: https://www.cosatx.us/departments-services/water-reclamation. [Accessed 18 September 2021].

[8] AOS Treatment Solutions, LLC, "Treatment Solution: 4 Example of New Wastewater Treatment Technology," AOS Treatment Solutions, LLC, 28 December 2016. [Online]. Available: https://aosts.com/4-exciting-new-technologies-associated-wastewater-treatment/. [Accessed 18 September 2021].

[9] National Small Flows Clearinghouse, "Constructed Wetlands Factsheet," National Small Flows Clearinghouse, ND ND ND. [Online]. Available: https://engineering.purdue.edu/~frankenb/NU-prowd/cwetfact.htm. [Accessed 18 September 2021].

[10] City of Scottsdale, "Recycled Water," City of Scottdale, ND ND 2021. [Online]. Available: https://www.scottsdaleaz.gov/water/recycled-water. [Accessed 18 September 2021].

[11] R. R. Trussell and I. Najm, "New and Emerging Drinking Water Treatment Technologies," in *Identifying Future Water Contaminants*, Washington, National Academy of Sciences, 1999, pp. 220-241.

[12] N. Abdel-Raouf, A. Al-Homaidan and I. Ibraheem, "Microalgae and Wastewater Treatment," *Saudi Journel of Biological Sciences,* vol. 19, no. 3, pp. 257-275, 2012.

[13] Nature Education, "Biofiltration as a treatment technology in water and wastewater purification," Nature Education, ND ND 2014. [Online]. Available: https://www.nature.com/scitable/content/biofiltration-as-a-treatment-technology-in-water-100451278/. [Accessed 18 September 2021].

[14] S. R. Chowdhury, F. Alhelal, M. Alahmadi, N. Alqahtani, A. Alkhaldi and A. Asiz, "An Overview on Major Design Constraints, Impact and Challenges for a Conventional Wastewater Treatment Design," *Journal of Environmental Treatment Techniques,* vol. 9, no. 1, pp. 7-16, 2021.

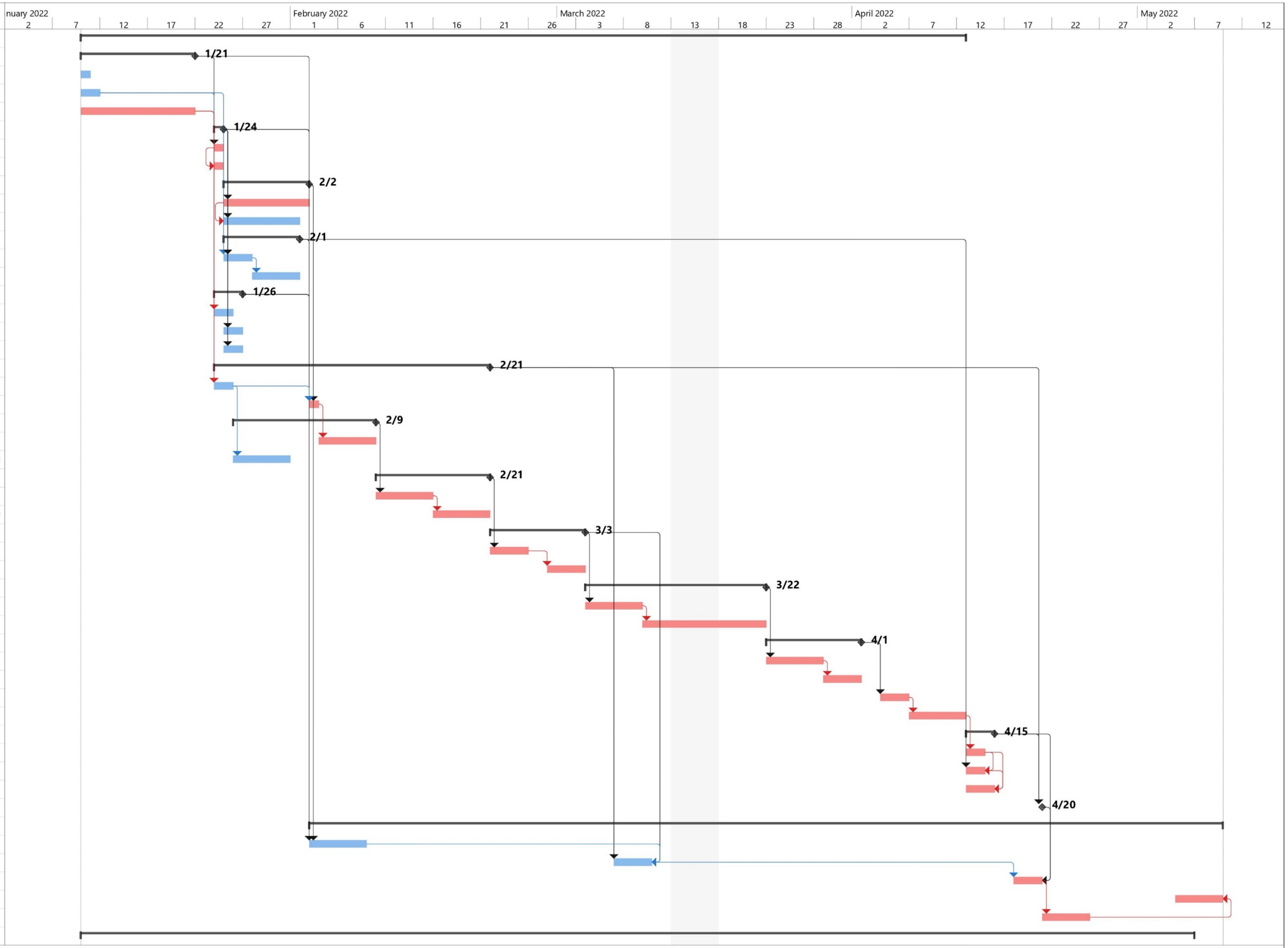
[15] A. Ambulkar, "Top 10 Challenges In Water And Wastewater Construction Projects," 05 September 2019. [Online]. Available: https://www.wateronline.com/doc/top-ten-challenges-in-water-and-wastewater-construction-projects-0001. [Accessed 18 September 2021].

[16] H. S. Alyasi and R. Isaifan, "A Review on Pollution Emissions and Impact from Waste Treatment and," *Journal of Environmental and Toxicological Studies,* vol. 2, no. 1, pp. 1-9, 2018.

Appendix A WEF Schedule

Next Page

ID	Task Name
1	**Project Summary**
2	**Task 1 Initial Project Preparations**
3	Task 1.1 Application for WEF
4	Task 1.2 Review WEF Rules and Criteria
5	Task 1.3 Additional Treatment Research
6	**Task 2 Site Investigation**
7	Task 2.1 Field Visit
8	Task 2.2 Collect Current Data from Operators
9	**Task 3 Evaluation of Site Investigation Data**
10	Task 3.1 Analyze Data of Current Plant
11	Task 3.2 Review Exisiting Site Design and Technology
12	**Task 4 Population Estimation**
13	Task 4.1 Current Population Research
14	Task 4.2 Future Population Calculation
15	**Task 5 Analyze Applicable Regulations**
16	Task 5.1 Federal Regulations
17	Task 5.2 State Regulations
18	Task 5.3 County Regulations
19	**Task 6 Treatment Design**
20	Task 6.1 Determine Criteria
21	Task 6.2 Determine Water Demand
22	**Task 6.3 Initial Treatment**
23	Task 6.3.1 Preliminary Design of Alternatives
24	Task 6.3.2 Decision Matrix and Choose Alternative(s)
25	**Task 6.4 Essential Treatment**
26	Task 6.4.1 Preliminary Design of Alternatives
27	Task 6.4.2 Decision Matrix and Choose Alternative(s)
28	**Task 6.5 Advanced Treatment**
29	Task 6.5.1 Preliminary Design of Alternatives
30	Task 6.5.2 Decision Matrix and Choose Alternative(s)
31	**Task 6.6 Disinfection**
32	Task 6.6.1 Preliminary Design of Alternatives
33	Task 6.6.2 Decision Matrix and Choose Alternative(s)
34	**Task 6.7 Solids Handling**
35	Task 6.7.1 Preliminary Design of Alternatives
36	Task 6.7.2 Decision Matrix and Choose Alternative(s)
37	Task 6.8 Final Design Matrix
38	Task 6.9 Final Decision and Design
39	**Task 7 Lifecycle Cost Analysis**
40	Task 7.1 Construction Cost
41	Task 7.2 Operation and Maintenance Cost
42	Task 7.3 Expected Lifecycle Cost
43	**Task 8 Impacts Analysis**
44	**Task 9 Deliverables**
45	Task 9.1 30% Submission
46	Task 9.2 60% Submission
47	Task 9.3 90% Submission
48	Task 9.4 100% Submission
49	Task 9.5 Competition Deliverables
50	**Task 10 Project Management**



Project: WEF Schedule Projects
Date: Wed 12/1/21

Task, Split, Milestone, Summary, Project Summary, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, External Tasks, External Milestone, Deadline, Critical, Critical Split, Progress, Manual Progress