INDUSTRIAL PRETREATMENT DESIGN PROPOSAL
Final Report

For: Joy Cone Co. Flagstaff

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List of Abbreviations

ABET: Accreditation Board for Engineering and Technology

ADOT: Arizona Department of Transportation

ASTM: American Society of Testing and Materials

BOD: Biological oxygen demand

EIT: Engineer in Training

ENG: Engineer

Lab Tech: Lab Technician

NAU: Northern Arizona University

NOAA: National Oceanic and Atmospheric Administration

POTW: Publicly owned treatment works

SENG: Senior Engineer

S Tech: Survey Technician

TKN: Total Kjeldahl nitrogen

TSS: Total suspended solids

USGS: United States Geological Survey

1.0 Project Understanding

1.1 Project Purpose

The main objective of this project is to improve or redesign the industrial wastewater pretreatment system currently in place at the Joy Cone Co. factory in Flagstaff, Arizona. The Factory produces 585,000,000 cones per year on site. As of recently the factory has been exceeding the concentration limits of several industrial pollutants regulated by their pretreatment permit with the City of Flagstaff. The pretreatment permit regulates the concentration of pollutants that can be discharged to the publicly owned treatment works (POTWs) of Flagstaff and is in place to ensure that influent can be treated efficiently and thoroughly by existing processes. Joy Cone Co. discharges roughly 500,000 gallons of water per year to the City of Flagstaff public wastewater system. Biological oxygen demand (BOD), total Kjeldahl nitrogen (TKN), and total suspended solids (TSS) are the primary pollutants of concern in the discharge, with TKN exceeding regulatory limits. These pollutants derive from the various ingredients used in the production process of ice cream cones and are found in the discharge stream of the water used to clean their batter transportation lines.

1.2 Project Background

1.2.1 Site Location

The Joy Cone Co. factory is located in southern Flagstaff, Arizona. Figure 1-1 below shows the location of the factory in relation to the rest of the city of Flagstaff. [1]

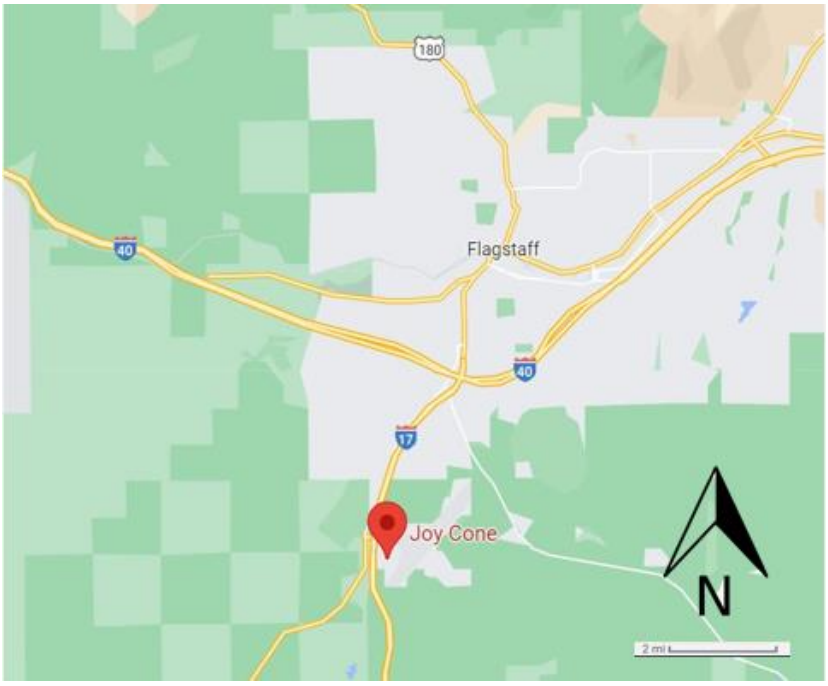


Figure 1: Joy Cone Co. Factory Location in Flagstaff [1]

The address of the Joy Cone Co. factory is 2843 W Shamrell Blvd #9414, Flagstaff, Arizona 86005. The factory owns 30 acres of land bordered by the Flagstaff Pulliam Regional Airport to the east and public Forest Service land to the south. Figure 1-2 shows the aerial view of the factory and the adjacent land. Interstate 17 can be seen west of the building and runways at the Flagstaff Pulliam Airport are to the east. [1]

Most of the land owned by Joy Cone Co. is undeveloped, with the exception of the parking lot and physical building; the rest of the land is a natural forest area. The protection of this natural area has been noted as extremely important to the owners of the land. Figure 1-2 shows the property boundaries of the land parcel where the factory is located outlined in red [1]. A City of Flagstaff sanitary sewer is located on the north side of the factory building along Shamrell Blvd. A retention basin is located on the west side of the factory, as seen in Figure 1-2.

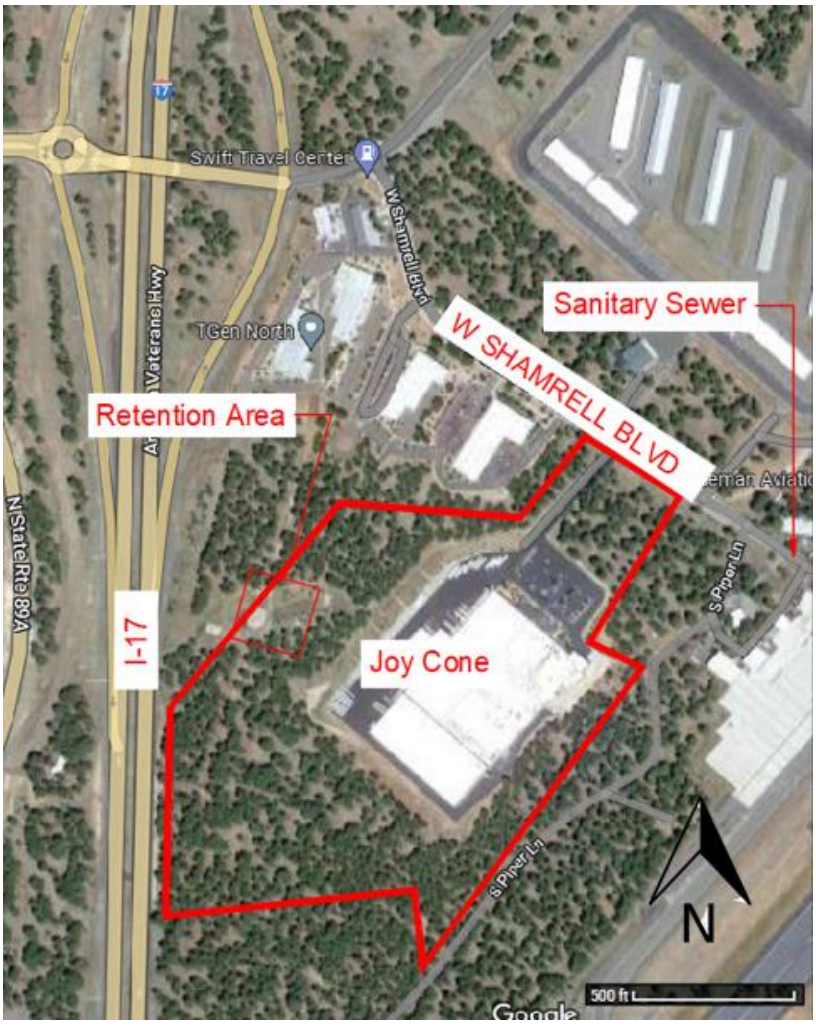


Figure 1- 1: Joy Cone Co. Factory Boundary

Since the surrounding area is public land, the integrity of the land and its aesthetic value shall be considered in the design.

1.2.2 Current Treatment System

The industrial effluent produced by Joy Cone Co. consists of leftover batter that is cleaned from their batter lines. Their batter lines mainly consist of flour, sugar, and water, along with the water and chemicals used in the washing process. This wastewater stream is roughly 500,000 gallons per year. Their wastewater treatment system features the use of a rotary drum vacuum filter using an earth media filter to remove suspended solids. There are two 8,000-gallon underground holding tanks located on the north-east side of the building that retain wastewater before pretreatment.

Joy Cone Co. currently discharges their pretreated industrial effluent to the City of Flagstaff sewer system regulated by the City of Flagstaff. The treated discharge is currently being pumped to the sanitary sewer located west of the factory as shown in Figure 1-2. This system has been capable of meeting regulatory requirements in the past, but a change in the regulation of TKN has caused exceedances in the factory's effluent. The rotary drum system is effective in removing suspended solids but does not treat nitrogen effectively enough to meet the updated TKN and BOD standards.

The surrounding area also includes a 1.46-acre retention basin (Figure 1-2) currently used for stormwater runoff that is not connected to the sewer or involved in the current pretreatment process. The basin is located on the west side of the facility and includes a ditch used to transport runoff from the parking lot and surrounding natural areas to the retention basin. There is no outlet in the basin, and water levels are reduced by infiltration to the soil.

Joy Cone Co. does not plan to increase production at this facility. Since there is no prediction of further growth, the factory does not want a design capable of treating more wastewater than they currently produce in order to reduce costs, maintenance, and land usage.

1.3 Technical Considerations

Wastewater pretreatment design options will need to be created using a combination of existing infrastructure and landscape as well as implementation of new treatment processes. Technical aspects of this project include hydrological analysis, surveying, hydraulic analysis, and wastewater contaminant characteristics and treatment options, including biological, chemical, and physical treatments.

1.4 Potential Challenges

There are two major constraints that must be considered in the design of the new pretreatment system. The first is the transportation of water from the factory to the sewer system. The facility is located at a lower elevation than the surrounding area; it is preferred to minimize the use of pumps to transport wastewater due to cost and maintenance. The location of the current retention basin is also lower than that of the sewer inlets.

Because the factory currently owns 30 acres of surrounding land, there is ample area to implement a new treatment system. Although the area is available, the factory is surrounded by trees and Forest Service land. Joy Cone Co. has stressed that removing trees is not ideal due to their aesthetic value, sound reduction qualities, and creation of a natural privacy barrier. The new design should reduce disturbance to natural areas as much as possible in order to retain these valuable qualities of the land.

Finally, Joy Cone Co. transports batter using a pipe network throughout the facility. These pipes are cleaned at a minimum of every six weeks, but as often as once per week. The pipes are cleaned to maintain the integrity of the batter and to prevent contamination between batter types. The cleaning process includes the use of a chlorinated detergent, Principal, and a liquid acid sanitizer, Mandate Plus, that are flushed through the system to eliminate buildup on the inside of the pipes. The use of these chemicals has made biological wastewater treatment difficult and could affect the health of microorganisms used in the treatment process. Since the cleaning does not occur daily, the concentration of these chemicals in the effluent is highly variable. The variability of the concentrations creates a challenge because treatment regimens may need to be adjusted or changed depending on the concentration of the chemicals and the pH of the water.

1.5 Stakeholders

1.5.1 Joy Cone Co. Flagstaff

The owners and operators of Joy Cone Co. are looking for a safe, low maintenance, and cost-effective way to treat their effluent to legal limits. They also want to maintain the natural areas around the factory and possibly create a natural system that increases the aesthetic value of the site.

1.5.2 US Forest Service and General Public

Because the Joy Cone Co. Factory is boarded by Forest Service public land, the Forest Service and the general public are also stakeholders in the project. A design including the retention basin on-site or an outdoor treatment process could change the aesthetics of the site or affect runoff and flooding zones. Additionally, an open system could create a drowning hazard to the public, therefore, the design should be safe for public access and create minimal odor. Removing trees, disrupting utilities, and altering

the landscape should be minimized to protect the land. If outdoor treatment basins are used, natural or otherwise, they should not affect the drainage regimen of the area and allow safe access by the public. Although the treatment area will be on private land owned by Joy Cone Co., easy access to the land through the adjoining public area makes safety a top concern for the public and the Joy Cone Co. owners.

1.5.3 The City of Flagstaff and its Citizens

The City of Flagstaff is the main entity responsible for regulating the concentrations of contaminants in effluent produced by the Joy Cone Co. factory. The City of Flagstaff has recently started fining the factory due to the exceedance of TKN in the effluent. Discharging high concentrations of contaminants to the sewer can overburden wastewater treatment processes which creates the need for additional treatment by the City of Flagstaff. These limits are put in place to reduce the treatment required at the publicly owned wastewater treatment facility, and it would be beneficial to all parties to reduce TKN levels to regulatory limits.

2.0 Scope of Services

The Scope of Services section provides a list of tasks that will be completed by the Honeycomb Engineering, Inc. team in the process of researching, creating, and presenting the final design to treat the contaminants discussed in Section 1.0 of this proposal for the Joy Cone Co. factory in Flagstaff, Arizona.

2.1 Task 1.0 Preliminary Project Setup

This portion of the project will include background research and preparatory work pertaining to the project.

2.1.1 Task 1.1 Regulations Research

In order to fully develop and design a new treatment plan for Joy Cone Co., all applicable regulations for industrial discharge on the federal, state, and city level must be researched and understood. This includes the current permits held by Joy Cone Co. as well as new standards that may pertain to a new water treatment system.

2.1.2 Task 1.2 Treatment Process Research

Research will be conducted to determine common treatment methods for TKN, BOD, and TSS in industrial wastewater streams common to the food processing industry. This research will aid in the production of design alternatives in later tasks. In order to fully evaluate all treatment alternatives, physical, chemical, and biological treatment methods will be investigated.

2.1.3 Task 1.3 Laboratory Preparation

To gain access to the laboratory at NAU, a lab binder must be prepared outlining the lab procedures and safety techniques that will be used. A sampling plan will also be created, which will allow the team to collect samples of the wastewater efficiently and accurately during the site investigation.

2.2 Task 2.0: Site Investigation:

The project site consists of 30-acres of land which includes a parking lot, the Joy Cone Co. factory building, and the surrounding forest. The topography of the land is vital to designing a treatment system capable of retaining and transporting water to the desired locations.

2.2.1 Task 2.1 Facility Investigation

A field visit will be conducted to examine the treatment equipment on-site. This process will help the team determine if the wastewater treatment system or equipment can be incorporated into a new design. Data will be collected regarding the production process and wastewater treatment process at the Joy Cone Co. factory. Data will include equipment size and type, flow rates, physical spacing, manufacturer information, and exterior connections to city facilities. A complete process block diagram will be created to document the information collected during the facility investigation.

2.2.2 Task 2.2: Surveying

Surveying with NAU instruments will be necessary during the field visit. Land surrounding the Joy Cone Co. factory will be surveyed with specific focus on the retention basin on site used for stormwater runoff. The purpose of this survey is to determine the elevations and land area that will aid in creating a design that may include the retention basin and ditch. Information gathered during the site visit will also be used for later hydraulic and hydrologic analysis.

2.2.3 Task 2.3: Sampling

Samples of the wastewater produced by Joy Cone Co. will be collected in accordance with the sampling plan prepared in task 1.3.

2.3 Task 3.0: Analytical Testing

There are a variety of pollutants in the industrial discharge that will need to be tested throughout the design process to determine the concentrations of BOD, TSS, and TKN in the wastewater. The concentrations of these pollutants will be tested based on the standards created by the ASTM and HACH methods, including ASTM D2329 Method of Test for Biochemical Oxygen Demand of Industrial Water and Industrial Wastewater, ASTM D5907-18 Standard Test Methods for Filterable Matter (Total Dissolved Solids) and Nonfilterable Matter (Total Suspended Solids) in Water, and HACH 10242 Simplified

Spectrophotometric Measurement of Total Kjeldahl Nitrogen in Water and Wastewater.

2.4 Task 4.0 Hydrological Analysis

In order to fully investigate all possible design alternatives, a hydrological analysis of the watershed on which the project site is located will need to be performed to estimate the amount of precipitation and stormwater runoff entering the site. The design may include use of the retention basin and adjoining ditch, so hydrological analysis will provide information on area and depth requirements of the basin. The goal of the hydrological analysis is to ensure that it will be large enough to treat and retain runoff and wastewater without flooding or damaging the surrounding area.

2.4.1 Task 4.1: Creation of Topographic Map

Using survey data collected in Task 2.2, Honeycomb Engineering will create a surface using Autodesk Civil3D in order to analyze the topographic data of the site.

2.4.2 Task 4.2: Watershed Delineation

The watershed upon which the site is located will be delineated using USGS (United States Geological Survey) StreamStats so that the watershed area may be determined.

2.4.3 Task 4.3: Collection of Rainfall Data

Rainfall depth and intensity data will be collected for the watershed using the NOAA Atlas 14 database.

2.4.4 Task 4.4 Determination of Time of Concentration (TOC)

Time of concentration for the watershed will be determined using the rainfall data and the time of concentration equation.

2.4.5 Task 4.5: Determination of Peak Flow and Retention Volume

The ADOT Rational Method tool will be used to determine the peak discharge of the watershed for the design storms required by the Coconino County Drainage Design Criteria Manual, which are the 2-year, 10-year, 25-year, and 100-year storms [2]. The peak flow rates will be applied to determine the volume of stormwater runoff required to be retained by the current basin. This will aid in determining the total required volume of the basin if used in the final design.

2.5 Task 5.0: Selection of Preferred Alternative

Alternative designs will be created and evaluated to determine the best treatment option for Joy Cone Co. The alternatives will fully address the pollutants of concern and all other project requirements. The engineering team will evaluate biological, physical, and chemical treatment options for the project. Several

alternatives will be designed using a combination of these methods, and a decision matrix will be used to select the best treatment solutions.

2.5.1 Task 5.1: Creation of Decision Matrix

All criteria for the final design will be investigated and summarized. This includes a synthesis of information provided by the client, relevant regulation and legislation, and information collected in Tasks 1-5. This portion of the design process serves to ensure that no criteria are missed during the final design.

2.5.2 Task 5.2: Creation of Design Alternatives

The team will investigate the possible biological, physical, and chemical treatment design methods. Several preliminary designs using these technologies will be created to meet the requests of the client and the criteria discussed in Task 5.1. The purpose of examining all types of treatment is to select the best possible treatment design to meet regulatory standards. It is important to note that biological, physical, and chemical treatments are often used in combination with one another to target specific contaminants best removed by each technology. Since there is already an existing pre-treatment process on site, this infrastructure will be analyzed to determine if the existing equipment will be useful in the final design. This analysis is done to determine if incorporating aspects of the existing treatment process will reduce costs or maintenance of the final design. This task will only create preliminary designs sufficient to be evaluated in the following task. A detailed design will not be completed during this step of the design process.

2.5.3 Task 5.3: Evaluation of Alternatives

After the list of potential treatment design alternatives is created, the decision matrix will be used to evaluate each against the criteria established in Task 6.1, and the preferred alternative will be selected.

2.6 Task 6.0: Final Design

The final design task will include the included final design with new equipment, piping, hydraulic analysis, and permitting requirements as needed.

2.6.1 Task 6.1: Completed Final Design

The selected preliminary design will be completed in this task. This includes sizing calculations, detailed drawings and analysis, construction plans, maintenance plans, and any other relevant documentation.

2.6.2 Task 6.2: Cost Analysis

A cost analysis will be performed for the final design to determine the construction, operation, and maintenance costs of the treatment method chosen. The possibility of variation in costs due to the financial state will be considered in analysis to ensure the plausibility of the design.

2.6.3 Task 6.3: Evaluation of Impacts

In creating a new wastewater pretreatment system for Joy Cone Co., the environmental, societal, and economic impacts must be considered. These impacts will be fully discussed for the selected alternative.

2.7 Task 7.0: Deliverables

The deliverables for this project focus on regularly updating the client on the progress of the project to ensure that the project is on schedule and meets the expectations of the client.

2.7.1 Task 7.1: 30% Submittal

The 30% milestone will include Task 1.0: Preliminary Project Setup, Task 2.0: Site investigation, and Task 3.0: Analytical Testing. This deliverable consists of a 30% report and presentation and will be completed by February 10th, 2023.

2.7.2 Task 7.2: 60% Submittal

The 60% submittal will include the tasks related to the design process. Task 4.0: Hydrological Analysis, and Task 5.0 Selection of Preferred Alternative. This deliverable consists of a 60% report and presentation and will be completed by March 10th, 2023.

2.7.3 Task 7.3: 90% Submittal

The 90% progress submittal will include a final draft presentation and project website. All technical tasks will be completed. This deliverable consists of a 90% report and presentation and will be completed by April 14th, 2023.

2.7.4 Task 7.4: Final Submittal

The final submittal will include the completed design report, website, and presentation of the project. The final submittal will be completed by May 5, 2023.

2.8 Task 8.0: Project Management

Project management is essential to keeping the design within budget and on schedule. Regular meetings will ensure that the project is completed to the highest possible degree of quality while staying within the proposed budget and schedule.

2.8.1 Task 8.1: Schedule and Resource Management

The schedule and team working hours will be tracked on a regular basis to assure the project stays on schedule and within budget.

2.8.2 Task 8.2: Meetings

A binder will be kept containing the agendas and meeting minutes of team, technical advisor, grading instructor and client meetings. Each meeting will be scheduled in advance, and action items for the next meeting will be discussed and documented at the end of each meeting.

2.9 Project Exclusions

The final design will not include any analysis or design of infrastructure pertaining to the potable water entering the facility. Honeycomb Engineering, Inc. will not change the location of any sanitary sewer discharge sites. Contaminants not regulated under the City of Flagstaff Industrial Pretreatment permit currently held by Joy Cone Co. will not be considered in the creation of the treatment design.

3.0 Schedule

The total duration of the project is 25 weeks, starting on November 6, 2022 and ending on May 4, 2023. Task 1.0 Preliminary Project Setup has a start date of January 17th and a duration of 5 days, Task 2.0 Site Investigation has a start date of January 20th and a duration of 10 days, Task 3.0 Analytical Testing has a start date of February 3rd and a duration of 15 days, Task 4.0 Hydrological Analysis has a start date of February 3rd and a duration of 8 days, Task 5.0 Selection of Preferred Alternative has a start date of February 24th and a duration of 10 days. Task 6.0 Final Design has a start date of March 10th and a duration of 20 days.

The Gantt Chart showing the project schedule can be found in the Appendix.

The critical path is the shortest time required to complete the project. Any task on the critical path that is completed late will affect the completion of the project. Tasks that are on the critical path include Task 1, Task 2.1, Task 2.3, Task 3.0, Task 5.0, Task 6.0, Task 7.3 and Task 7.4. The critical path is displayed in red on the Gantt Chart.

4.0 Staffing Plan

4.1 Honeycomb Engineering Staff

The staff from Honeycomb Engineering, Inc. that will be working on this project are as follows: Senior Engineer (SENG), Engineer (ENG), Survey Technician (S Tech), Lab Technician (Lab Tech), and Engineer in Training (EIT). The SENG must have a bachelor's degree in either Civil or Environmental Engineering from a university/program accredited by the Accreditation Board for Engineering and Technology (ABET) and must have obtained a Professional Engineer's (PE) license. The SENG should have at least 5 years of practice as a PE in a water/wastewater division. The ENG must also have a bachelor's degree in either Civil or Environmental Engineering from an ABET accredited university/program, they must have obtained a PE license, and should have practiced for at least 2-3 years as a PE in a water/wastewater division. The Lab Tech must have a bachelor's degree in either Civil or Environmental Engineering from an ABET accredited university/program and should have experience with laboratory testing methods associated with water/wastewater treatment. The EIT must have successfully passed the Fundamentals of Engineering exam (FE) and obtained Engineer in Training status. They must either be in progress of receiving

or have already received a bachelor's degree in either Civil or Environmental Engineering from an ABET accredited university/program.

4.2 Project Staffing

This project will require 625 hours of staff time. The expected hours of each staff member are shown in Table 4-1 below. The total number of hours for the Senior Engineer is estimated to be 108 hours. The total number of hours for the Engineer is estimated to be 199 hours. The total number of hours for the Survey Technician is estimated to be 30 hours. The total number of hours for the Lab Technician is estimated to be 92 hours. The total number of hours for the Engineer in Training is estimated to be 196 hours.

Table 4- 1: Staffing Hours by Task

Task	Hours					
	SENG	ENG	S TECH	LAB TECH	EIT	Total Hours
Task 1.0 Preliminary Project Setup						
Task 1.1 Regulations Research	2	5	0	0	5	12
Task 1.2 Treatment Process Research	2	5	0	0	5	12
Task 1.3 Laboratory Preparation	0	8	0	40	16	64
Task 2.0: Site Investigation:						
Task 2.1 Facility Investigation	8	8	8	0	8	32
Task 2.2: Surveying	0	2	16	0	2	20
Task 2.3: Sampling	0	4	0	8	4	16
Task 3.0: Analytical Testing	0	16	0	40	20	76
Task 4.0 Hydrological Analysis						
Task 4.1: Creation of Topographic Map	0	5	2	0	5	12
Task 4.2: Watershed Delineation	0	1	0	0	5	6
Task 4.3: Collection of Rainfall Data	0	1	0	0	2	3
Task 4.4 Determination of Time of Concentration (TOC)	0	4	0	0	4	8
Task 4.5: Determination of Peak Flow and Retention Volume	2	4	0	0	4	10
Task 5.0: Selection of Preferred Alternative						
Task 5.1: Creation of Decision Matrix	4	4	0	0	4	12
Task 5.2: Creation of Design Alternatives	10	20	0	0	20	50
Task 5.3: Evaluation of Alternatives	1	2	0	0	2	5
Task 6.0: Final Design						
Task 6.1: Completed Final Design	20	60	0	0	40	120
Task 6.2: Cost Analysis	4	2	0	0	2	8
Task 6.3: Evaluation of Impacts	1	2	0	0	2	5
Task 7.0: Deliverables						
Task 7.1: 30% Submittal	5	8	0	0	8	21
Task 7.2: 60% Submittal	5	8	0	0	8	21
Task 7.3: 90% Submittal	5	8	0	0	8	21
Task 7.4: Final Submittal	8	8	0	0	8	24
Task 8.0: Project Management						
Task 8.1: Schedule and Resource Management	16	4	2	2	4	28
Task 8.2: Meetings	15	10	2	2	10	39
Total Hours	108	199	30	92	196	625

5.0 Cost of Engineering Services

The cost of the project is $52,608.00. Table 5-1 details these costs. These estimates are based on the expected number of work hours and hourly rates for each employee as well as the laboratory and supplies costs of the project.

Table 5 - 1: Cost of Engineering Services

Cost of Engineering Services				
Item	Description	Quantity	Rate	Cost
1.0 Personnel Cost		hours	$/hr	$
Personnel	SENG	108	155	16,740.00
	ENG	199	120	23,880.00
	STECH	30	50	1,500.00
	LAB TECH	92	50	4,600.00
	EIT	196	25	4,900.00
			Total	$ 51,620.00
2.0 Laboratory Facilities		days	$/day	
Lab Rental	NAU ENE Laboratory	5	100	500.00
			Total	$ 500.00
3.0 Supplies		-	-	
Lab Supplies	See Table 5-2	-	-	488.00
			Total	$ 488.00
Total Cost of Engineering Services:				**$ 52,608.00**

Table 5-2 shows the expendable supplies required. Nonexpendable lab supplies such as glassware are included in the lab rental fee shown in Table 5-1.

Table 5 - 2: Itemized Laboratory Supplies Cost List

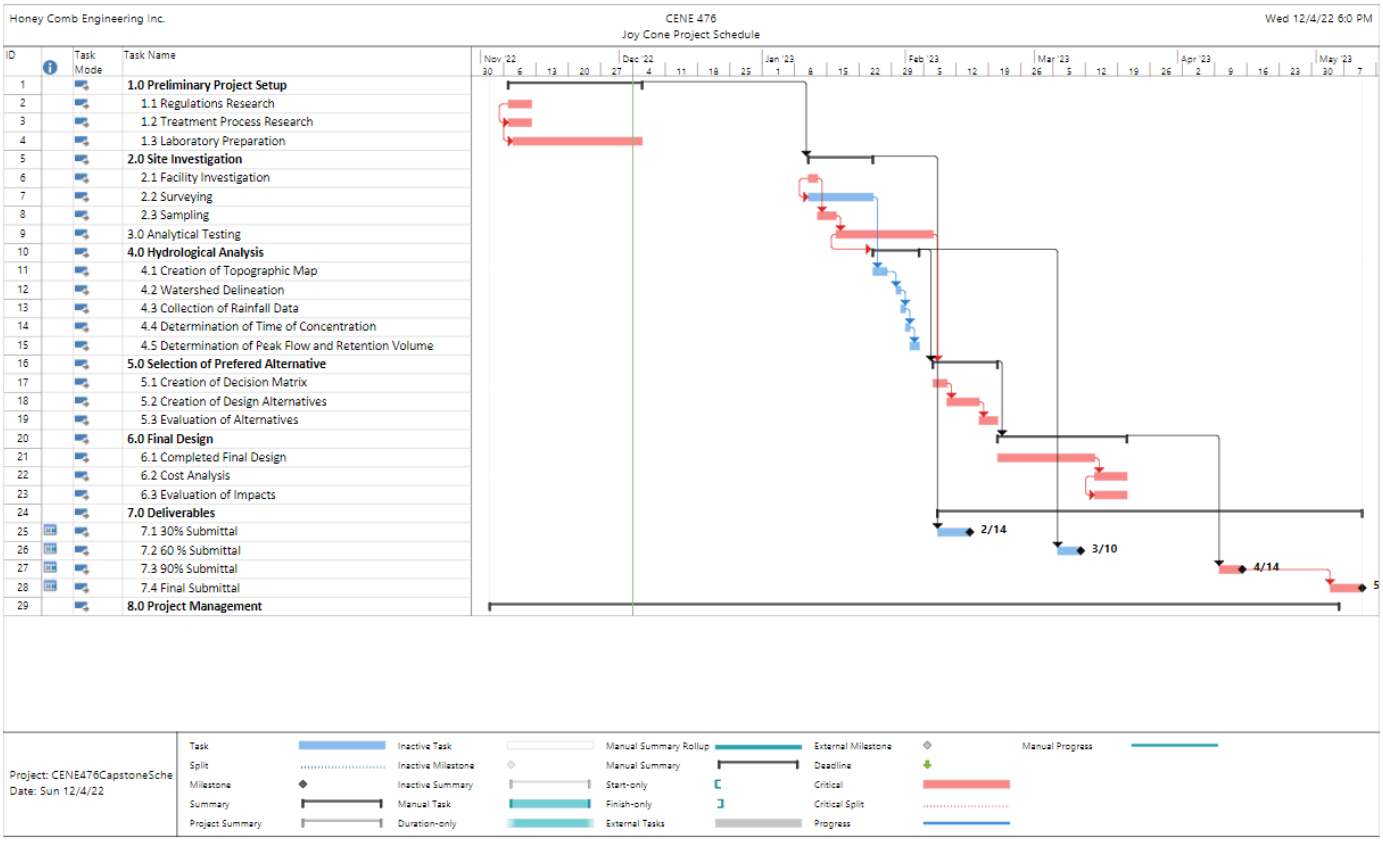
Item	Description	Quantity	Unit Cost ($/ea.)	Cost ($)
Glass Fiber Filters	100 per pack	1	57.00	57.00
Gloves	100 per box Disposable	1	12.00	12.00
Goggles	Laboratory goggles	4	1.50	6.00
ASTM D5907-18	TSS test document	1	57.00	57.00
ASTM D2329	BOD5 test document	1	69.00	69.00
HACH TKN Test Kit	25 samples per kit	1	220.00	220.00
Pipettes	Disposable 250 per pack	1	67.00	67.00
			Total:	$ 488.00

6.0 References

[1] Google, " Joy Cone Co. Factory Flagstaff," [Online]. Available: https://www.google.com/maps/place/Joy+Cone/@35.163294,-111.7042132,13z/data=!4m5!3m4!1s0x872d8545871493b1:0xc6542499f789062e!8m2!3d35.1350737!4d-111.6811641. [Accessed 24 Sept. 2022].

[2] C. County, "Drainage Design Criteria Manual," Coconino County, Arizona, Flagstaff, 2020.

7.0 Appendices



Appendix A: Gantt Chart showing Project Schedule and Critical Path in Red