Elevated Solutions Engineering

2024 Concrete Canoe

Project Scope Draft 7

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Team Member Names:
Dylan Condra, Jon Duran, Kevin Tautimer, Derek Vecchia, Declan Geltmacher

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1 Project Understanding

1.1 Project Purpose

The National Concrete Canoe Competition (NCCC) is a yearly event that challenges engineering students affiliated with the American Society of Civil Engineers (ASCE) to conceive and construct a functional canoe using concrete as the primary material. The competition's objective is to acquire firsthand expertise and develop leadership skills through engagement in tasks related to concrete mix designs and project management. This competition facilitates the establishment of a robust student-faculty relationship while also providing students with the opportunity to seek clarification on concrete mix design concepts, thereby enhancing their knowledge and comprehension. The scoring in the 2023 Rules and Regulations is divided into four distinct categories, namely: Technical Proposal, Technical Presentation, Final Product Prototype, and Race Demonstration. The National Collegiate Conference Committee (NCCC) has nineteen distinct regional conferences.

1.2 Project Background

Most of the work will be done at the CECMEE Field Station, Figure 1 Utah State, Site Map, and the building that houses the College of Engineering, Informatics, and Applied Science. Utah State University's Logan, UT, campus will host the C4 Intermountain Southwest Conference (ISWS) competition in mid-April 2024, as seen in Figure 2: Utah State, Site Map. The competition in affiliation with the ASCE Intermountain Conference in Utah Figure 3. This will include teams from Utah State, Arizona State, University of Arizona, and Northern Arizona University.

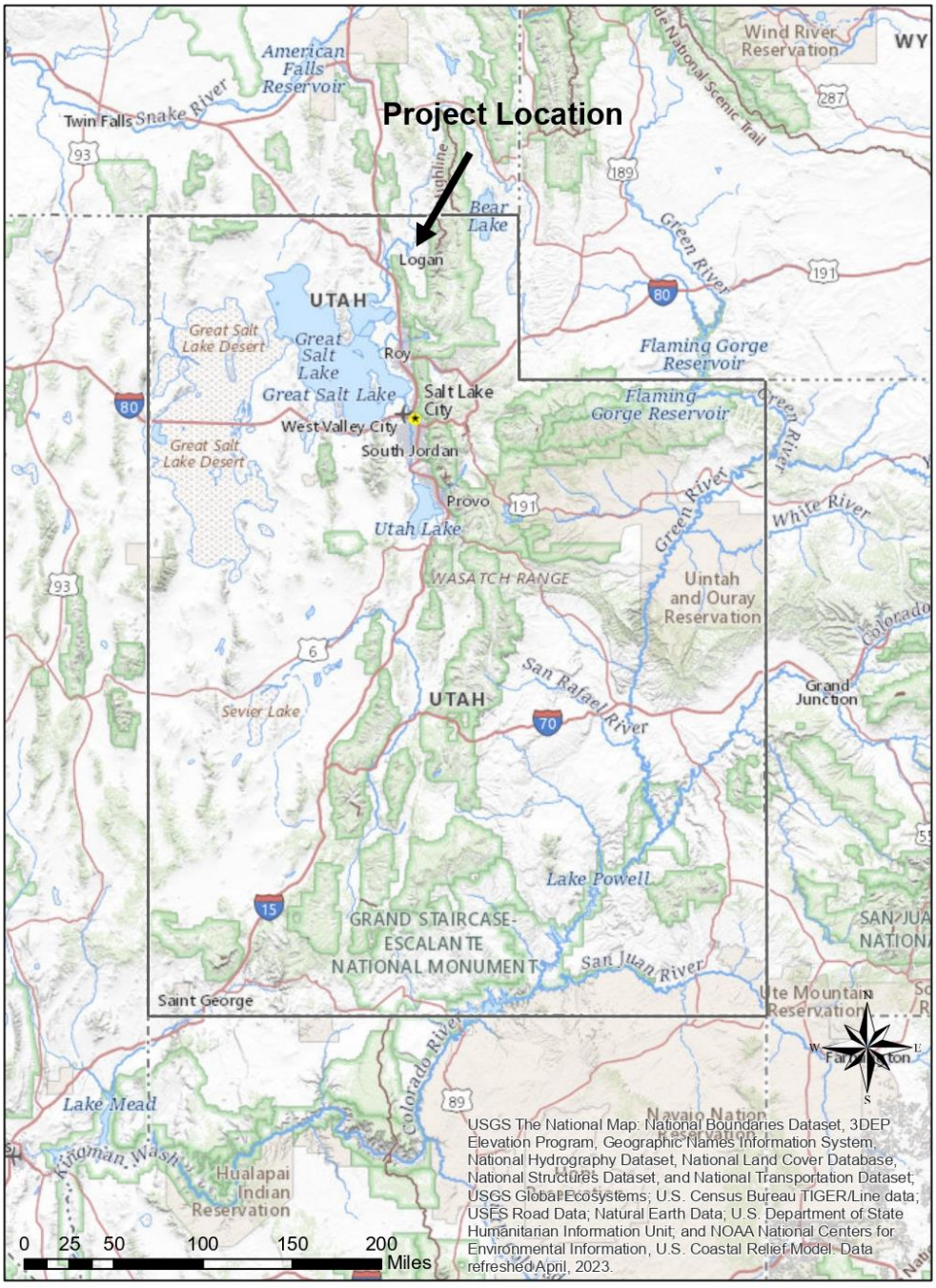


Figure 1: Utah State University, Location Map

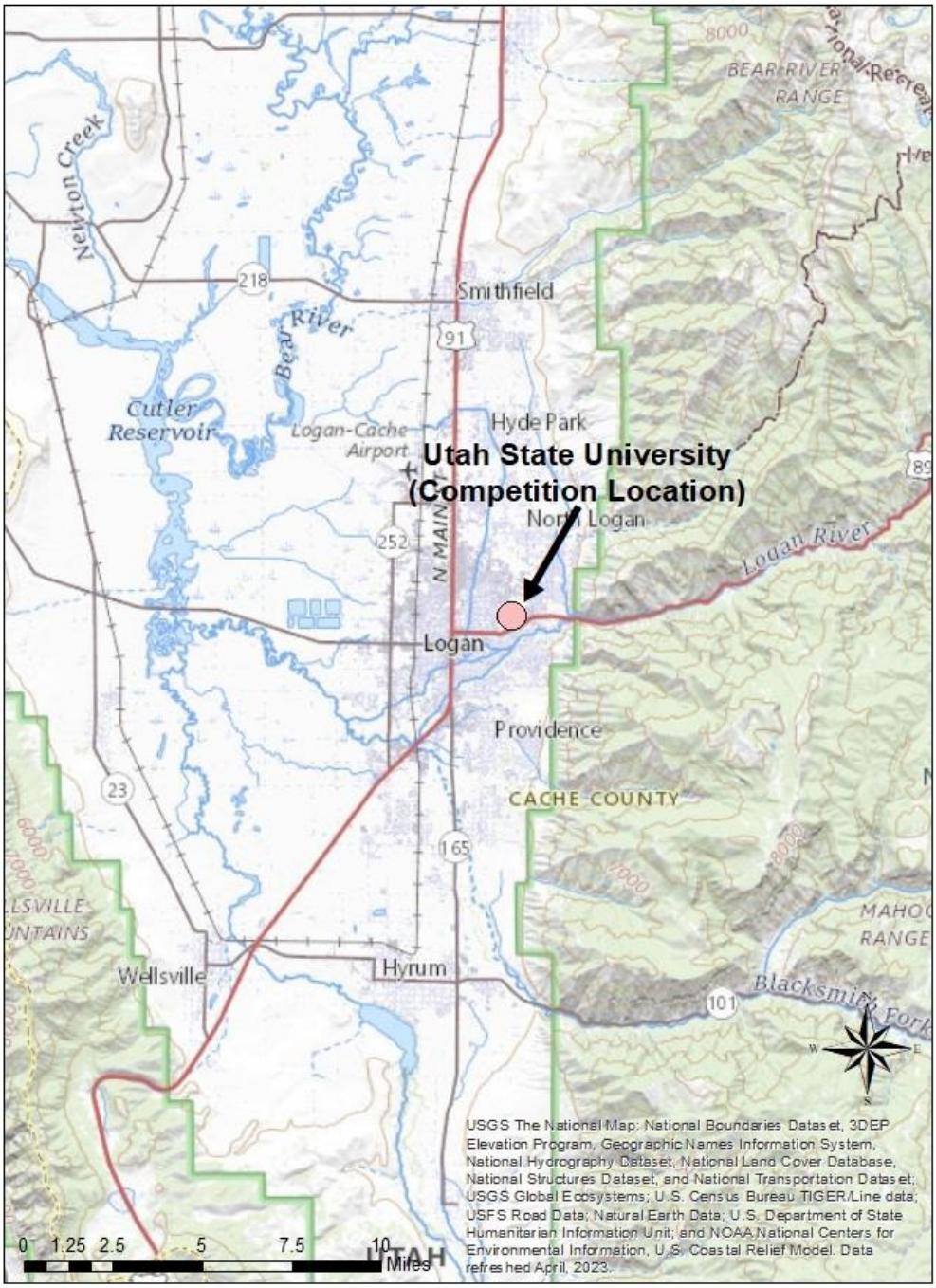


Figure 2: Utah State, Site Map

Figure 3: Northern Arizona University, Site Map

1.3 Technical Considerations

1.3.1 Hull Design

ASCE competition rules for 2024 have no regulations for length, width, or depth of the canoe. The materials available for the canoe will be presented in the RFPs for this year's competition. All materials and reinforcement of the canoe must also follow the guidelines listed in the RFP. Several different hull designs will be presented along with a decision matrix of related performance objectives to determine the final hull design. These designs will reference previous canoe designs from prior teams or existing canoe designs to help with the concrete canoe's performance. Research will be done to provide an understanding of why previous designs worked and others did not. When designing the canoe, a structural analysis is required according to the rules of the competition. The team will have to review previous course material to perform longitudinal analysis, punch shear, and a failure envelope analysis of the canoe properly and correctly. Hand calculations and software will be used to properly calculate such properties. The final hull design will then be created in a 3D software modeling program.

1.3.2 Concrete Mixture Design

There are many guidelines and regulations pertaining to the concrete mixture for the canoe because it is the project's foundation. Two important guidelines are that aggregate should make up at least 30% of the total mix design, and cement should make up no more than 50% of the total mix design. Ground pumice, hydrated lime, fly ash, silica fume, slag cement, metakaolin or calcined clay, and ground glass pozzolan are among the specific binders that must adhere to their respective ASTM regulations. If fibers adhere to ASTM C1116 [1], they are acceptable. As per their respective ASTM numbers, the following admixtures are permitted: admixtures (type S), air entraining, water reducing and set control, coloring admixtures, pigments, and agents. Clear silicone or siloxane-based concrete sealers are acceptable if all liquid compounds used in the curing and sealing process adhere to ASTM C1315 [2]. Materials such as quick lime, bonding adhesives, waste latex paints, asphalt emulsions, latex emulsions, epoxy resins, and other comparable products are prohibited. All components of the mix design used, as well as their specific qualities, will be recorded in a notebook.

1.3.3 Post Tension

Canoe post tensioning is notoriously challenging, but the crew is determined to succeed this season. To ensure that the post tensioning equipment achieves the required tension, the team aims to construct a table/form that the post tensioning equipment may brace to. In addition, the team intends to conduct post tensioning using a half-scale mold to refine the necessary procedures.

1.4 Testing

The testing of the concrete will be done using the following tests. Table 1, Concrete Testing.

Table 1: Concrete Testing

Concrete Tests	
Compressive Strength	ASTM C39 [1]
Flexural Strength	ASTM C78 [2]
Density Testing	ASSHTO T 121 [3]
Air Percentage	ASTM C231 [4]
Specific weight	ASTM C127 [5]
Slump Test	ASSHTO T 119 [6]

1.5 Fabrication

The Styrofoam mold required for pouring the concrete will be acquired from which company we choose the team is currently in the process of deliberating about the selection of a suitable mold technology, namely between the options of male or female molds. Prior to pouring, it will be necessary to sand the mold to get the proper level of smoothness. The canoe mold will be coated with an authorized liner to facilitate the removal process. During the concrete pouring process, the canoe will adhere to quality assurance and quality control (QA/QC) protocols. Simultaneously, tests will be done to verify that the concrete meets the requirements set by the American Society for Testing and Materials (ASTM). The decision to employ post-tensioning or pre-tensioning techniques for the canoe will be contingent upon the potential compromise to the structural integrity of the canoe should the execution of these operations become excessively challenging. During the pouring process, it is essential to ensure that the mesh used does not exceed 50% of the thickness of the walls of the canoe. Samples will be collected from the pour to conduct tests according to the requirements set by ASTM. During the 28-day curing process, the team will diligently monitor the canoe to identify and address any potential cracks that may develop. The reason the canoe needs to be cured is because the concrete needs to be set to reach optimum strength.

1.6 Potential Challenges

Due to the scale of the project, getting outside help from sponsorships will be a vital part in securing materials and funding for the construction. The team will mitigate the cost of materials by contacting companies willing to sponsor us through cash donations or providing materials. Communication with the college is difficult and this will be dealt with by sending out emails 24 to 48 hours (about 2 days) in advance to be able to effectively communicate. Time constraints are another problem that our team must deal with, and we plan to set goals to complete the subject days in advance to prevent problems from arising at the last minute.

1.7 Stakeholders

This project has several key stakeholders, most notably the client Mark Lamer, our sponsors who have provided materials and funding, and Northern Arizona University. Our project team bears the responsibility of not only representing these stakeholders effectively but must also demonstrate a high-quality product. This project's success is crucial and demonstrates the dedication of the institution and the team's effectiveness.

2 Scope of Services

2.1 Task 1: Background Research

2.1.1 Task 1.1: Material Research

The purpose of this task is to research allowable materials such as cement, admixtures, aggregates, primary, and secondary reinforcements. This research will focus on how different compositions of mixtures will affect the desired qualities of the concrete.

2.1.2 Task 1.2: Competition Rules

The purpose of this task is to look over the 2024's ASCE rules for the materials to make sure the successful mix design. Will periodically check the rules sets if ASCE changes any rules regarding to mix design or other categories of the competition.

2.1.3 Task 1.3: NAU CE Lab. Access

The purpose of this task is to gain access to both Lab and Farm. The team will create a safety binder listing all materials and equipment that the team plans to use.

2.1.4 Task 1.4: Software Training

The purpose of this task is to ensure team members will know how to use the necessary computer software including but not limited to SolidWorks and AutoCAD.

2.2 Task 2: Concrete Mixture Design

2.2.1 Task 2.1: Concrete Design Criteria

The purpose of this task is to create a final design for the Concrete Mixture. The mix shall be determined by a decision matrix of several desirable factors such as, Compressive Strength, Relative Density, Concrete Shrinkage, the workability of the concrete, and if the concrete meets the projects criteria. The Concrete mixture that meets the most standards shall be selected.

2.2.2 Task 2.2: Aggregate Testing

The purpose of this task is to perform a sieve analysis that will be taken for the aggregate used for the concrete to be logged and stored in the mixture notebook for tracking data. The mix requires the use of ASTM C127, Standard Test Methods for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate. The test values are used to calculate the solid volume of aggregates, which is crucial information for creating a functional mixture.

2.2.3 Task 2.3: Concrete Testing

Table 2: Concrete Table Testing

Concrete Testing

Test	ASTM Number/ AASHTO	Number of Samples
Flexural Strength	ASTM C78 [4]	4 per design
Tensile Strength	ASTM C486	4 per design
Air Content	ASTM C231 [5]	1 per design
Density	ASSHTO T 121 [7]	1 per design
Compression Test	ASTM C39 [3]	4 per design
Slump Test	AASHTO T119 [8]	1 per design

2.3 Task 3: Hull Design

2.3.1 Task 3.1: Hull Design Modeling and Analysis

The purpose of this task is to research different canoe designs and the criteria for the canoe given by 2024 ASCE RFP. With the information obtained, the team will discuss the different advantages each design has and what the pros & cons are. Following all guidelines for the canoe, the team will then narrow down their designs to build a decision matrix for each design.

2.4 Task 4: Decision Matrix

2.4.1 Task 4.1: Hull Decision Matrix

The hull decision matrix will have the criteria of speed/aerodynamic, maneuverability, stability, buoyancy, and freeboard to judge each of the designs of the hull.

2.4.2 Task 4.2: Concrete Decision Matrix

The concrete mixture will be graded on the compressive strength, tensile strength, density, local sourcing/ environmental impact, and the workability of the concrete. Each of mix designs will be graded through a decision matrix.

2.5 Task 5: Analysis of Final Decision

2.5.1 Task 5.1: Structural Design Criteria and Analysis

The purpose of this task is to analyze the criteria of the RFP for structural design. The team will research how to do each required test in the RFP and build a 3D model to analyze the canoe in SolidWorks.

2.5.2 Task 5.2: 3D Analysis

2.5.2.1 Principal Stress State Analysis

The purpose of this task is to create a Mohr's circle representing the failure envelope analysis needed for the final proposal. Taking the maximum compressive and tensile strengths found with the above analysis, Mohr's stress circle shall be created, showing the tangent line, and defining it as well. A separate Mohr's circle will be done for both compressive (f_c') and tensile (f_t) to find the weak points of the canoe.

2.5.2.2 Task 5.3.2: Buoyancy Analysis

The purpose of this task is to test the buoyancy of the canoe. It shall be done by hand to test whether we are able to float in the water. The team will research multiple different buoyancy calculations for their final design.

2.5.3 Task 5.3: 2D Analysis

2.5.3.1 Task 5.3.1: Longitudinal Analysis

The purpose of this task is to create a shear and moment diagram will be done using the critical load case with the location and magnitude of both the shear and moment maximums. Defining critical section properties as moments of inertia and extreme fiber distances.

2.5.3.2 Task 5.3.3: Punch Shear Analysis

The purpose of this task is to do a 2D analysis on a software program that allows them to see the critical area for punching shear using a critical load case. This case will be the same for both longitudinal and punch shear analyses. It will also show the punch sheer stress for the critical load.

2.6 Task 6: Canoe Fabrication

2.6.1 Task 6.1: Lab Approval and Compliance

The purpose of this task is to gain access to both Lab and Farm. The team will create a safety binder listing all materials and equipment that the team plans to use. In accordance with utilizing the CECMEE Field Station (The Farm), a binder addressing the specific hazards including, but not limited to chemical hazards, power tool usage, emergency contact information, and how to address safety.

2.6.2 Task 6.2: Mold Acquisition

The purpose of this task is to acquire the mold from the company that the team chooses for the canoe mold.

2.6.3 Task 6.3: Establish Fabrication Procedures

The purpose of this task is to set up procedures on how to construct the concrete canoe. Since the people participating in construction will be ASCE members, mentees, and the capstone members guidelines will be set to prevent mishaps. The team will spend about two months preparing and creating the canoe from scratch. Once the mold has been acquired alongside all the materials, construction will begin and move rapidly from there.

2.6.4 Task 6.4: Concrete Placement, Curing, and Finishing

2.6.4.1 Task 6.4.1: Sand Form to Fit

The purpose of this task is to sand all the needed parts of the mold. The team will sand all exterior and interior areas of the canoe down to a smooth surface. Using different grit sandpaper and files. The purpose of this task is to create a slick inside in the mold for easier removal. The inside of the foam mold will be coated with a non-stick material prior to pouring into the concrete mixture.

2.6.4.2 Task 6.4.2: Concrete Quality Control

The purpose of this task will be to conduct quality control over the concrete mix that will be poured. This is to ensure that the concrete is correctly made and can be than be used to collect samples for further testing.

2.6.4.3 Task 6.4.3: Canoe Curing

The purpose of this task is to allow the canoe time to cure to bring the canoe up to strength. During this time the team will check for cracks in the mold.

2.6.4.4 Task 6.4.4: Finishing

The purpose of this task is to sand the concrete canoe to a smooth finish to allow the canoe to perform better in water.

2.6.5 Task 6.5: Lab Clean up

The purpose of this task is to clean up the farm after the concrete canoe has been constructed and is cured.

2.7 Task 7: Pre-Competition Preparation

2.7.1 Task 7.1: Transportation Preparation

The purpose of this task is to prepare the trailer for transportation for the ASCE competition.

2.7.2 Task 7.2: Race Practice

The purpose of this task is to practice for the concrete canoe. This will be done in either the NAU pool or at Lake Mary. During this time, we will invite mentees out and find the rowers for the race at the conference.

2.8 Task 8: Deliverables

2.8.1 Task 8.1: Capstone Deliverables

2.8.1.1 Task 8.1.1: 30% submittal

The purpose of this task is to submit a 30 percent finished submittal to the Grading Instructor by the specified deadline. The report will act as a first draft of the final draft, allowing the Grading Instructor to give feedback and ensure the team is heading in the right direction. For this deliverable, the team will have completed tasks 1 through 3 completed, with task 9 being collected throughout the course of the project.

2.8.1.2 Task 8.1.2: 60% submittal

The purpose of this task is to submit a 60 percent finished submittal to the Grading Instructor by the specified deadline. The report will act as a second draft of the final draft, allowing the Grading Instructor to give feedback and ensure the team is heading in the right direction. At this time the concrete canoe shall be poured into the mold and set to cure. For this deliverable, the team shall have completed task 4 through 6 and have started the canoe to cure.

2.8.1.3 Task 8.1.3: 90% submittal

The purpose of this task is to submit a 90 percent finished submittal to the Grading Instructor by the specified deadline. The report will act as a third draft of the final draft, allowing the Grading Instructor to give feedback and ensure the team is heading in the right direction. By this time, the ASCE deliverables will be all complete with the concrete canoe in the curing process. For this deliverable, all tasks shall be completed by the team including all ASCE deadlines.

2.8.1.4 Task 8.1.4: Final Submittal

The purpose of this task is to submit all final submissions including the final report, the final website, and the final presentation. The final report will be a revision of all three drafts done beforehand. The final website will be submitted through completed and submitted with the final report. The final presentation will be given at the end of the Spring semester to all

capstone teachers and departments heads. This deliverable will include all task completed with full revisions accessed.

2.8.2 Task 8.2: ASCE Competition Deliverables

2.8.2.1 Task 8.2.1: Submission of Letter of Intent, Pre-Qualification Form, and Project Preliminary Schedule

The purpose of this task is to send a Letter of Intent, Pre-qualification form, and a Preliminary schedule to ASCE by November 5th, at 5 pm, through the online submission portal. The letter of Intent will cover the team's understanding of the project and will be signed by all members of the team. The pre-qualification will be signed off by every member of the team and the ASCE student chapter faculty advisor. The schedule will show critical milestones achieved throughout the project.

2.8.2.2 Task 8.2.2: Project Proposal

The purpose of this task is to create a final proposal for the canoe design. The team will create a project display that showcases the concrete canoe. The canoe must be present on stands, an exhibit that shows the construction process and all materials used in the canoe. Material samples are required and include aggregate, reinforcement, and cylinders of each mixture used in the project. The mold used and a cross section are also needed to show the canoe in more detail.

2.8.2.3 Task 8.2.3: Mix Design Sheets

The purpose of this task is to cover all the mixed designs the team has created and the final design we choose. All the properties and calculations will be done on a spreadsheet as per the ASCE rulebook by May 15th.

2.8.2.4 Task 8.2.4: Materials Notebook

The purpose of this task is to note down all the materials used in the mix designs and their properties for the ASCE competition.

2.8.2.5 Task 8.2.5: Canoe Cost Assessment

The purpose of this task is to make a table to show the hourly rates, material costs, and time and materials with competition travel. The cost for the canoe will have to been to show the overall cost of constructing 100 canoes using the same materials.

2.8.2.6 Task 8.2.6: Project Display

The purpose of this task is to create a project display that showcases the concrete canoe. The canoe must be present on stands, an exhibit that shows the construction process and all materials used in the canoe. Samples of materials are required and include, but are not limited to, aggregate, reinforcement, and cylinders of each mixture used in the project. The mold used, as well as a cross section, are also needed to show the canoe in more detail.

2.8.2.7 Task 8.2.7: Project Presentation

The purpose of this task is to give a presentation about the concrete canoe at the conference. This will be limited to 5 minutes to present with 7 minutes of questions from the judges. This will focus on the primary aspects of the design, construction, and technical capabilities while briefly going over the major aspects.

2.8.2.8 Task 8.2.8: Canoe Race

The purpose of this task will be to compete with the canoe at the ASCE competition in five races. The five races are slalom and sprint broken up between women's and men's races and one co-ed sprint.

2.9 Task 9: Project Impact Analysis

2.9.1 Task 9.1: Social

The purpose of this task is to assess the social impacts of this project and their advantages and disadvantages.

2.9.2 Task 9.2: Economical

The purpose of this task is to assess the economic impacts of this project and their advantages and disadvantages.

2.9.3 Task 9.3: Environmental

The purpose of this task is to assess the environmental impacts of this project and their advantages and disadvantages.

2.10 Task 10: Project Management

2.10.1 Task 10.1: Meetings

2.10.1.1 Task 10.1.1: Client

The purpose of this task is to create meetings with the client periodically to ensure expectations. In accordance with CENE 476 and CENE 486C, the team will meet with the client periodically throughout the semester to ensure proper

communication and client expectations are met. This will also serve as a time for clarification or discussions.

2.10.1.2 Task 10.1.2: Grading Instructor (GI)

The purpose of this task is to be able to communicate with our Grading Instructor for our revisions. The team will meet with the grading instructor over the two semesters to ensure the submittals are following the guidelines and requirements of the grading structure, and general questions surrounding concrete properties.

2.10.1.3 Task 10.1.3: Technical Advisor (TA)

The purpose of this task is to create meetings with our Technical Advisor to ensure the correct expectations are met. For any questions regarding the structural aspects of the canoe including, but not limited to structural loadings and analysis, Mohr's Circle, or any aggregates that could enhance the structural integrity of the canoe.

2.10.2 Task 10.2: Resource Management

The purpose of this task is to go over our objectives that we will use to simulate a real company. This will be done to show how much time we put into the project.

Table 3: Resource Management

Resource Management
Staffing
Budget
Sponsorships
Meeting Minutes
Safety Binder

2.11 Exclusions

Training of mentees for paddling a canoe will be provided by others and is not part of this project. Lake Mary will be a possible location for this activity. The team members will each learn how to properly pour concrete into the mold. The team will fill out the proper driver and van training to head to competition properly. The team will only create 1 prototype canoe instead of the 100 canoes that ASCE proposed.

3 Scheduling

For the duration of the project, there will be 249 days (about 8 months) from start to finish. The start date will be September 4th, 2023, and the end date on May 10th, 2024. Due to the competition being fast paced, many tasks are critical for the success of the project. Some tasks include the decisions for hull design and mix design, obtaining the mold, and concrete curing. During that time, some of the important deadlines will be marked with milestones on the Gantt chart (Appendix A). These will be the submittals for CENE 486C and the ASCE Concrete Canoe proposal.

3.1 Critical Path

The critical path is meant to highlight the important steps in the schedule to successfully stay on track with the project and ensure that no delays in further tasks are created from potential delays caused by another task. The team will plan on maintaining the schedule with new updates so the software can update as necessary. The critical path will also be treated above the normal path to remain on track with the project's deadlines and milestones. If an issue arises, the team will take the best steps to mitigate it while continuing to progress.

4 Staffing

Below is the staffing table that will cover all the tasks and subtasks included in section 2 of the proposal.

Table 5, Staffing Hours Table will show the hours that each member of the team will work and how much time they propose they will need to do each.

Table 4, Staffing Position Table

Position	Qualifications	Responsibilities
Principal Design Engineer (PDE)	Professional Engineer license (PE), 10+ years of experience, bachelor's/master's degree in engineering.	Communicates with the client based on needs, edits, etc. Organizes meetings and other events. Maintains the schedule for deadlines, approves designs for implementation.
Technician/Drafter (TD)	Associate degree in math, or sciences. Experience in related fields.	Creating blueprints for the project. Performing analyses to ensure the design is functional. Reviews data and documents to create designs.
Project Construction Manager (PM)	Bachelor's degree in construction management/engineering, 5+ years of Construction experience.	Manages the construction and process of Cementous material of the project.
Graduate Field Engineer (EIT)	Bachelor's degree in engineering, FE license, 1-3 years' experience.	Creates and design canoes using programs. Conducts research on topics and relays the project status.
Quality Manager (QM)	Bachelor's degree in a field related to business and quality control.	Overviews the production of the concrete and determines the quality of it. Understands material and their properties

Table 5, Staffing Hours Table

Task Name	PDE Hours	PM Hours	TD Hours	EIT Hours	QM Hours
Task 1: Background Research	**20**	**58**	**49**	**24**	**46**
Task 2: Concrete Mixture Design	**0**	**36**	**16**	**2**	**27**
Task 3: Hull Design	**26**	**7**	**17**	**9**	**42**
Task 4: Decision Matrix	**13**	**9**	**11**	**11**	**16**
Task 5: Analysis of Final Decision	**4**	**9**	**15**	**22**	**30**
Task 6: Canoe Fabrication	**12**	**12**	**12**	**24**	**24**
Task 7: Pre-Competition Preparation	**8**	**4**	**4**	**4**	**4**
Task 8: Deliverables	**40**	**40**	**40**	**40**	**40**
Task 9: Project Impact Analysis	**6**	**6**	**6**	**6**	**6**
Task 10: Project Management	**40**	**30**	**20**	**20**	**20**
Subtotal:	169	211	190	162	255
Total:					987

5 Cost of Engineering Services

Our billing rates come from the ASCE Concrete Canoe Rules [9] for each team member. The overhead costs, benefits, and profit are all included in those hourly rates. The billing rate for travel will be over our rental of the vans to conference, our total miles, and hotel services with include allowance for meals for the team members. The use of the lab will be billed at $200 a day as per the ASCE Rules [9]. The facilities we will be using are the farm, geotechnic lab, and the waters lab. This section of the cost of service will go over the subcontracting we will have to do at the beginning to get properties to develop the mix design. This section will go over the materials that we will order for our canoe. This will include aggregates, sand, admixtures, fibers, and the reinforcement of the canoe.

Table 6, Cost of Estimate of Engineering Services

Engineering Services Cost Estimate

Description	Quantity	Unit of Measure	Rate (USD)	Cost
Personnel				
PDE	149	Hr.	$120	$17,880
PM	153	Hr.	$88	$13,464
TD	141	Hr.	$62	$8,742
EIT	138	Hr.	$87	$12,006
QM	209	Hr.	$38	$7,942
Total Personnel				**$60,034**
Travel for Competition				
Transportation	1,206	Miles	$0.40	$482
Van Rental	1	Van/Week	$340	$340
Hotel Rooms (2 rooms)	3	Nights	$400	$1,200
Meals (5 People, 4 Days)	3	Meals/Day/ Person	$20.00	$1,200
Total Travel				**$3,222**
Lab Use				
Farm	10	Days	$200	$2,000
Geotech Lab	10	Days	$200	$2,000
Water/Concrete Lab	10	Days	$200	$2,000
Total Lab Use				**$6,000**
Subcontract				
Mold Manufacturer				$1,000
Western Tech	5	Days	$200	$1,000
Total Subcontract				**$2,000**
Materials				
Cementous Materials	10	Cubic Feet	$8	$80
Aggregate	12	Cubic Feet	$22	$264
Sand	5	Cubic Feet	$10 per ton	$1
Admixtures	1	GAL	$20	$20
Reinforcement	20	Square Yard	$15	$300
Total Materials				**$665**
Project Total				**$71,921**

6 References

[1] ASTM, *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens,* West Conshohocken: ASTM International, 2021.

[2] ASTM, *Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading),* West Conshohocken: ASTM International, 2022.

[3] ASTM, *DENSITY (UNIT WEIGHT), YIELD, AND AIR CONTENT (GRAVIMETRIC) OF CONCRETE FOP FOR AASHTO T 121,* WSDOT Materials Manual, 2023.

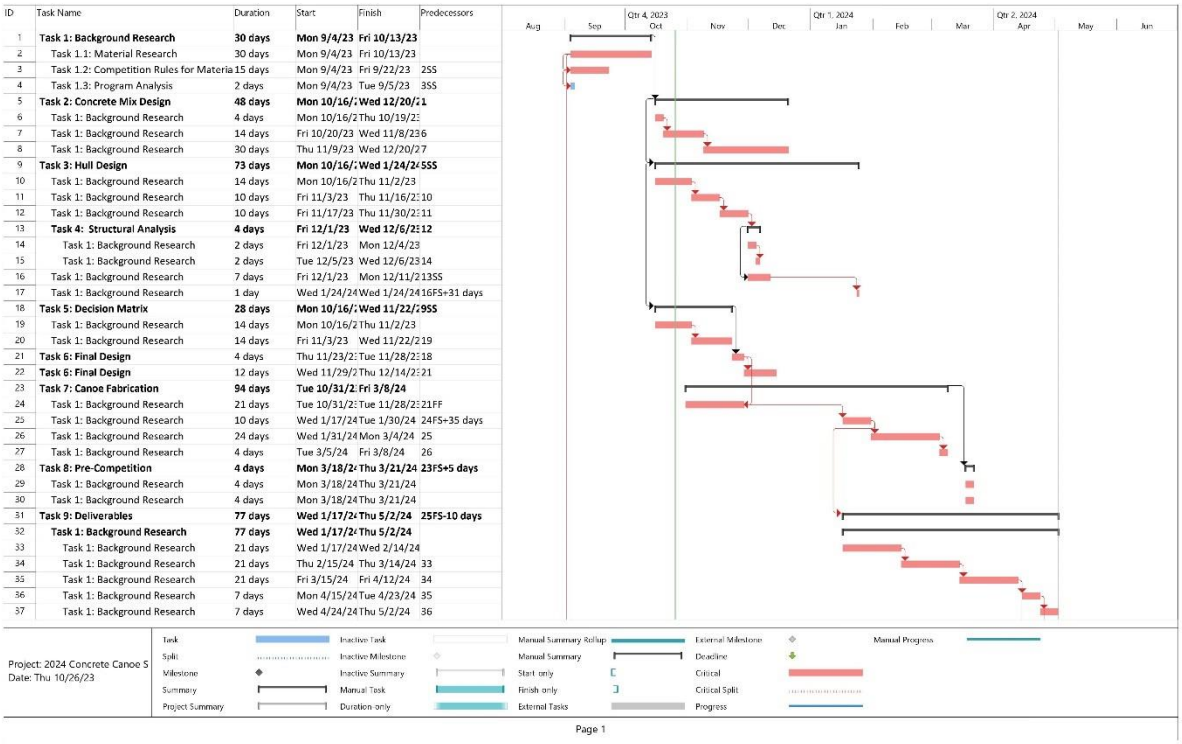
[4] ASTM, *Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method,* West Conshohocken: ASTM International, 2022.

[5] ASTM, *Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate,* West Conshohocken: ASTM International, 2016.

[6] ASSHTO, *SLUMP OF HYDRAULIC CEMENT CONCRETE FOP FOR AASHTO T 119,* WSDOT Materials Manual, 2023.

[7] A. C. o. C. C. Competition, "2024 ASCE Request For Proposals," September 2023. [Online]. Available: https://www.asce.org/-/media/asce-images-and-files/communities/students-and-younger-members/documents/2024-asce-concrete-canoe-competition-request-for-proposals-rules.pdf. [Accessed September 2023].

Appendix A



ID	Task Name	Duration	Start	Finish	Predecessors
1	**Task 1: Background Research**	**30 days**	**Mon 9/4/23**	**Fri 10/13/23**	
2	Task 1.1: Material Research	30 days	Mon 9/4/23	Fri 10/13/23	
3	Task 1.2: Competition Rules for Materia	15 days	Mon 9/4/23	Fri 9/22/23	2SS
4	Task 1.3: Program Analysis	2 days	Mon 9/4/23	Tue 9/5/23	3SS
5	**Task 2: Concrete Mix Design**	**48 days**	**Mon 10/16/2**	**Wed 12/20/2**	**1**
6	Task 1: Background Research	4 days	Mon 10/16/2	Thu 10/19/2	
7	Task 1: Background Research	14 days	Fri 10/20/23	Wed 11/8/23	6
8	Task 1: Background Research	30 days	Thu 11/9/23	Wed 12/20/2	7
9	**Task 3: Hull Design**	**73 days**	**Mon 10/16/2**	**Wed 1/24/24**	**5SS**
10	Task 1: Background Research	14 days	Mon 10/16/2	Thu 11/2/23	
11	Task 1: Background Research	10 days	Fri 11/3/23	Thu 11/16/2	10
12	Task 1: Background Research	10 days	Fri 11/17/23	Thu 11/30/2	11
13	**Task 4: Structural Analysis**	**4 days**	**Fri 12/1/23**	**Wed 12/6/2**	**12**
14	Task 1: Background Research	2 days	Fri 12/1/23	Mon 12/4/23	
15	Task 1: Background Research	2 days	Tue 12/5/23	Wed 12/6/23	14
16	Task 1: Background Research	7 days	Fri 12/1/23	Mon 12/11/2	13SS
17	Task 1: Background Research	1 day	Wed 1/24/24	Wed 1/24/24	16FS+31 days
18	**Task 5: Decision Matrix**	**28 days**	**Mon 10/16/2**	**Wed 11/22/2**	**9SS**
19	Task 1: Background Research	14 days	Mon 10/16/2	Thu 11/2/23	
20	Task 1: Background Research	14 days	Fri 11/3/23	Wed 11/22/2	19
21	**Task 6: Final Design**	4 days	Thu 11/23/2	Tue 11/28/2	18
22	**Task 6: Final Design**	12 days	Wed 11/29/2	Thu 12/14/2	21
23	**Task 7: Canoe Fabrication**	**94 days**	**Tue 10/31/2**	**Fri 3/8/24**	
24	Task 1: Background Research	21 days	Tue 10/31/2	Tue 11/28/2	21FF
25	Task 1: Background Research	10 days	Wed 1/17/24	Tue 1/30/24	24FS+35 days
26	Task 1: Background Research	24 days	Wed 1/31/24	Mon 3/4/24	25
27	Task 1: Background Research	4 days	Tue 3/5/24	Fri 3/8/24	26
28	**Task 8: Pre-Competition**	**4 days**	**Mon 3/18/2**	**Thu 3/21/24**	**23FS+5 days**
29	Task 1: Background Research	4 days	Mon 3/18/24	Thu 3/21/24	
30	Task 1: Background Research	4 days	Mon 3/18/24	Thu 3/21/24	
31	**Task 9: Deliverables**	**77 days**	**Wed 1/17/2**	**Thu 5/2/24**	**25FS-10 days**
32	**Task 1: Background Research**	**77 days**	**Wed 1/17/2**	**Thu 5/2/24**	
33	Task 1: Background Research	21 days	Wed 1/17/24	Wed 2/14/24	
34	Task 1: Background Research	21 days	Thu 2/15/24	Thu 3/14/24	33
35	Task 1: Background Research	21 days	Fri 3/15/24	Fri 4/12/24	34
36	Task 1: Background Research	7 days	Mon 4/15/24	Tue 4/23/24	35
37	Task 1: Background Research	7 days	Wed 4/24/24	Thu 5/2/24	36

Figure 4-Gantt Chart for Concrete Canoe Project

Appendix B

Task Name	PDE Hours	PM Hours	TD Hours	EIT Hours	QM Hours
Task 1: Background Research	**20**	**58**	**49**	**24**	**46**
Task 1.1: Material Research	2	40	10	7	15
Task 1.2: Competition Rules	6	6	6	6	6
Task 1.3: NAU CE Lab Access	2	2	18	4	10
Task 1.4: Software Training	10	10	15	7	15
Task 2: Concrete Mixture Design	**0**	**36**	**16**	**2**	**27**
Task 2.1: Concrete Design Criteria	0	30	5	0	10
Task 2.2: Aggregate Testing	0	6	6	0	12
Task 2.3: Concrete Testing	0	0	5	2	5
Task 3: Hull Design	**26**	**7**	**17**	**9**	**42**
Task 3.1: Hull Design Criteria	2	2	2	2	2
Task 3.2: Hull Modeling and analysis	10	0	5	0	20
Task 3.3: Analysis Alternatives	14	5	10	7	20
Task 4: Decision Matrix	**13**	**9**	**11**	**11**	**16**
Task 4.1: Final Hull Design Selection	1	1	1	1	1
Task 4.2: Punch Shear Analysis	10	4	5	5	10
Task 4.3: Principal Stress State Analysis	2	4	5	5	5
Task 5: Analysis of Final Decision	**4**	**9**	**15**	**22**	**30**
Task 5.1: Structural Design Criteria and Analysis	2	5	5	10	10
Task 5.2: 3D Analysis	2	4	5	10	10
Task 5.3: 2D Analysis	0	0	5	2	10
Task 6: Canoe Fabrication	**12**	**12**	**12**	**24**	**24**
Task 6.1: Lab Approval and Compliance	8	8	8	8	8
Task 6.2: Mold Acquisition	0	0	0	16	16
Task 6.3: Establish Fabrication Procedures	4	4	4	0	0
Task 7: Pre-Competition Preparation	**8**	**4**	**4**	**4**	**4**
Task 7.1: Transportation Preparation	4	0	0	0	0
Task 7.2: Race Practice	4	4	4	4	4
Task 8: Deliverables	**40**	**40**	**40**	**40**	**40**
Task 8.1: Capstone Deliverables	20	20	20	20	20
Task 8.2: ASCE Competition Deliverables	20	20	20	20	20
Task 9: Project Impact Analysis	**6**	**6**	**6**	**6**	**6**
Task 9.1: Social	2	2	2	2	2

Task 9.2: Economical	2	2	2	2	2
Task 9.3: Environmental	2	2	2	2	2
Task 10: Project Management	**40**	**30**	**20**	**20**	**20**
Task 10.1: Meetings	20	20	20	20	20
Task 10.2: Resource Management	20	10	0	0	0
Subtotal:	**169**	**211**	**190**	**162**	**255**
Total:					987

Figure 5-Project staffing hours based on position.

Appendix C

To: Mark Lamer, PE
From: Dylan Condra, Jon Duran, Declan Geltmacher, Kevin Tautimer, Derek Vecchia
CC: Dr. Robin Tuchscherer, Dr. Ben Dymond
Re: 2024 ASCE Concrete Canoe Letter of Transmittal
Date: 12/12/2023

Dear Mr. Lamer,

Outlined in the letter of transmittal are the contents of the final proposal of the ASCE Concrete Canoe project. With the project, we demonstrate a project understanding/background, scope of services, schedule for the project, staffing hours, and cost of services. The project understanding aims to demonstrate the location of the project, the constraints, and criteria per the Concrete Canoe Competition Committee (C4), and the considerations for technical work such as concrete mix design and hull design. The scope of services will be provided for each task in the project. Each task will provide information on the task specifically and how the process will be completed. The schedule is a Gantt chart that demonstrates the major milestones and bars associated with time and the length of the task. The start date is September 4th, 2023, and the end date is May 10th, 2024. Staffing represents the number of hours associated with the task per five different positions. The cost of services is broken down the cost in three categories: personnel, travel, and manufacturing processes/materials. Each section has allotted estimated costs based on the needs of the project. In total, the project is projected to cost a total of $72,791.

Please reach out if you have any questions or concerns and we hope you will consider our proposal. Thank you for your time.

Dylan Condra

Project Manager

(480)684-4719

dmc578@nau.edu

Figure 6-Letter of transmittal for concrete canoe