SHEET INDEX

S101 - GENERAL NOTES
S102 - WEST FORK SITE PLAN
S103 - CLEAR FORK SITE PLAN
S104 - WEST FORK / CLEAR FORK PROFILES
S105 - STRUCTURAL & FOUNDATION DETAILS

VICINITY MAP

GENERAL STRUCTURAL NOTES

1. FIELD SURVEY WAS NOT PERFORMED FOR THIS PROJECT. PLACEMENT OF PILES AND TETHER FOUNDATION BLOCKS ARE BASED ON THE DOWNSTREAM PILE CONTROL COORDINATES PROVIDED ON THE SITE PLANS.
2. ALL WORK IS ASSUMED TO BE NEW UNLESS OTHERWISE NOTED.
3. ALL MATERIALS AND WORKMANSHIP SHALL CONFORM TO THE MINIMUM STANDARDS OF THE 2015 INTERNATION BUILDING CODE (IBC).
4. THE CONTRACTOR SHALL EXAMINE THE CONSTRUCTION DOCUMENTS AND NOTIFY THE ENGINEER OF RECORD OF ANY DISCREPANCIES PRIOR TO PROCEEDING WITH THE WORK.
5. THESE CONSTRUCTION DOCUMENTS REPRESENT THE FINISHED STRUCTURE AND DO NOT INDICATE THE METHOD OF CONSTRUCTION. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES AND PROCEDURES.
6. THESE CONSTRUCTION DOCUMENTS DO NOT INCLUDE NECESSARY PROVISIONS FOR CONSTRUCTION SAFETY. THESE DOCUMENTS AND ALL PHASES OF CONSTRUCTION ARE TO BE GOVERNED BY APPLICABLE PROVISIONS OF THE CURRENT OCCUPATIONAL SAFETY AND HEALTH ACT.
7. IN THE EVENT THAT CERTAIN FEATURES OF THE CONSTRUCTION FOR THE FOUNDATIONS ARE NOT FULLY SHOWN ON THE DRAWINGS OR CALLED FOR IN THE GENERAL NOTES, THEIR CONSTRUCTION SHALL BE OF THE SAME CHARACTER AS SHOWN FOR SIMILAR CONDITIONS.
8. THE CONTRACTOR SHALL HAVE A COPY OF THE PROJECT GEOTECHNICAL INVESTIGATION ON THE JOB SITE.
9. THESE CONSTRUCTION DOCUMENTS SHALL NOT BE MODIFIED WITHOUT PRIOR WRITTEN APPROVAL OF THE ENGINEER OF RECORD.
10. CONSTRUCTION DOCUMENTS ARE NOT TO BE SCALED FOR DIMENSIONS. CONTRACTOR SHALL VERIFY ALL DIMENSIONS WITH THE TRASH WHEEL SUPPLIER PRIOR TO START OF CONSTRUCTION FOR THE MOORING PILES.
11. INSTALL TURBIDITY CURTAIN AS DIRCTED BY THE OWNER TO PROVIDE SEDIMENT CONTAINMENT WHILE CONSTRUCTION ACTIVITIES ARE OCCURRING. ALL APPLICABLE ORDINANCES AND CODES REGARDING EROSION AND SEDIMENT CONTROL SHOULD BE FOLLOWED.

STEEL PILES IN CONCRETE FILLED DRILLED SHAFTS

1. SHAFTS TO BE CONSTRUCTED IN ACCORDANCE WITH TXDOT ITEM 416.
2. AUGER CAST CONCRETE SHALL BE IN ACCORDANCE WITH TXDOT ITEM 421. CONCRETE SHALL HAVE A MINIMUM ULTIMATE COMPRESSIVE STRENGTH OF f'c = 4,000 PSI AT 28 DAYS WITH A MAXIMUM WATER/CEMENT RATIO OF 0.45.
3. THE CONTRACTOR SHALL CAST TEST CYLINDERS TO CHECK THE COMPRESSIVE STRENGTH.
4. THE CONTRACTOR IS RESPONSIBLE FOR ALL TESTING AND DISPOSING OF USED, BROKEN TEST SPECIMENS, UNLESS SPECIFIED OTHERWISE. ALL REPORTS SHALL BE TURNED IN TO THE INSPECTOR WITHIN 48 HOURS.
5. CONCRETE COMPRESSIVE AND FLEXURAL STRENGTH TEST SAMPLES SHALL BE RANDOMLY TAKEN AT EVERY 1/3RD THE INTERVAL/VOLUME OF THE TOTAL POUR.
6. SHAFTS AND PILES SHALL BE PLACED WITH A MAXIMUM VERTICAL PLUMBNESS TOLERANCE OF 1 INCH PER 10 FEET OF LENGTH/DEPTH.
7. REFERENCE THE PROJECT GEOTECHNICAL REPORT BY CMJ ENGINEERING, INC. DATED 07/16/2021 FOR EXPECTED SOIL CONDITIONS AND TESTING REQUIREMENTS.
8. THE PROJECT GEOTECHNICAL ENGINEER IS TO BE ON SITE DURING DRILLING OF PILE SHAFTS TO VERIFY REQUIRED RESISTANCE IS ACHIEVED.
9. PILES ARE TO BE ASTM A252, GRADE 3 (MOD) ROUND PIPE, IN ACCORDANCE WITH TXDOT ITEM 407. PILES ARE TO BE COATED WITH AN IMMERSION COATING SYSTEM MEETING THE REQUIREMENTS OF NORSOK STANDARD M-501, TO BE APPROVED BY THE ENGINEER OF RECORD. APPLY TO FULL LENGTH OF PILE.
10. PILE LENGTHS SHOWN ON PLANS ARE ESTIMATED BASED ON GEOTECHNICAL EXPLORATION FOR ROCK DEPTH LOCATION. PILES ARE REQUIRED TO BE INSTALLED A MINIMUM 10' INTO ROCK. ADDITIONAL LENGTH MAY BE REQUIRED IF VARIATIONS FROM TEST BORING LOCATIONS ARE FOUND.

GENERAL STRUCTURAL NOTES (CONT.)

CONCRETE FOUNDATIONS (TETHER BLOCKS)

1. CONCRETE FOUNDATIONS ARE TO BE CONSTRUCTED IN ACCORDANCE WITH TXDOT ITEM 420 AND 421.
2. CONCRETE FOR FOUNDATIONS SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 5,000 PSI AT 28 DAYS AND SHALL MEET THE REQUIREMENTS OF TYPE C CONCRETE AS STATED IN TXDOT ITEM 421.
3. ALL CONCRETE WORK SHALL COMPLY WITH IBC CHAPTER 19, ACI 318-14 AND THE LATEST EDITION OF THE ACI MANUAL OF CONCRETE PRACTICE.
4. ALL REINFORCING TO ASTM A615, GRADE 60.
5. REINFORCING IS TO BE LOCATED AS SHOWN ON THE PLANS AND HELD FIRMLY IN PLACE BEFORE AND DURING CONCRETE PLACEMENT USING BAR SUPPORTS THAT ARE ADEQUATE TO PREVENT DISPLACEMENT. BAR SUPPORTS IN CONTACT WITH SOIL OR SUBGRADE MUST BE APPROVED BY THE ENGINEER OF RECORD PRIOR TO USE.
6. REINFORCING BARS TO BE CLEAN OF RUST, GREASE OR OTHER MATERIAL LIKELY TO IMPAIR BOND.
7. VIBRATE ALL CONCRETE AS IT IS PLACED WITH A MECHANICAL VIBRATOR OPERATED BY EXPERIENCED PERSONNEL.
8. ALL CONCRETE SHALL BE WELL CONSOLIDATED AND THE MORTAR FLUSHED TO THE FORM SURFACES WITH IMMERSION TYPE VIBRATORS. VIBRATORS WHICH OPERATE BY ATTACHMENT TO FORMS OR REINFORCEMENT WILL NOT BE PERMITTED, EXCEPT ON STEEL FORMS. AT LEAST ONE (1) STAND-BY VIBRATOR SHALL BE PROVIDED FOR EMERGENCY USE IN ADDITION TO THOSE REQUIRED FOR PLACEMENT.
9. CONCRETE SHALL BE MAINTAINED IN A MOIST CONDITION FOR A MINIMUM OR 7 DAYS AFTER PLACEMENT OR CONCRETE SURFACES SHALL BE CURED WITH LIQUID MEMBRANE-FORMING CURING COMPOUND CONFORMING TO ASTM C309, TYPE 1, CLASS 1.
10. CONCRETE MIX DESIGN SHALL BE PREPARED BY THE CONCRETE SUPPLY PLANT. MIX DESIGN, INCLUDING CURRENT SUPPORTING DOCUMENTATION, SHALL BE SUBMITTED TO THE ENGINEER OF RECORD FOR REVIEW AND APPROVAL.
11. CONCRETE STRENGTH SHALL BE VERIFIED BY STANDARD CYLINDER TESTS (IN ACCORDANCE WITH IBC SECTION 1705.3) MADE BY AN APPROVED TESTING LABORATORY.

GRADING

1. RESTORE SOIL PROFILE TO THE ORIGINAL CONDITION FOLLOWING COMPLETION OF TETHER BLOCK CONSTRUCTION.

DESIGN CRITERIA

GOVERNING CODES:
- AMERICAN SOCIETY OF CIVIL ENGINEERS, MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES (ASCE/SEI 7–10)

FOR MOORING PILE DESIGN:
- AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS, 6 TH EDITION

SITE CONDITIONS:
- DESIGN WIND SPEED: 100 mph
- MAXIMUM FLOW VELOCITY BASED ON 100 YEAR FLOOD FOR REVISED HEC–RAS MODEL (UPPER TRINITY RIVER CDC MODEL_TRASHWHEEL):
  WEST FORK = 4.10 FT/S CLEAR FORK = 8.16 FT/S

FOR TETHER FOUNDATION DESIGN:
- 2015 INTERNATIONAL BUILDING CODE (IBC)
- ACI 318–14 BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE
- AISC 14TH EDITION – STEEL CONSTRUCTION MANUAL; SPECIFICATION FOR STRUCTURAL STEEL BUILDINGS (ANSI/AISC 360–10)

PRELIMINARY

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ENERCON

Engineer SANDEEP MENON
P.E. No. 106172 Date 9/9/2022

REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
0	FOR FINAL REVIEW	TF	SM	BP		9/9/22

ENERCON
FORT WORTH, TX

CITY OF FORT WORTH
FORT WORTH, TEXAS

TRINITY RIVER TRASH WHEEL
GENERAL NOTES

SIZE D | DWG NO. FWTHS–00259–DWG–S101 | REV 0

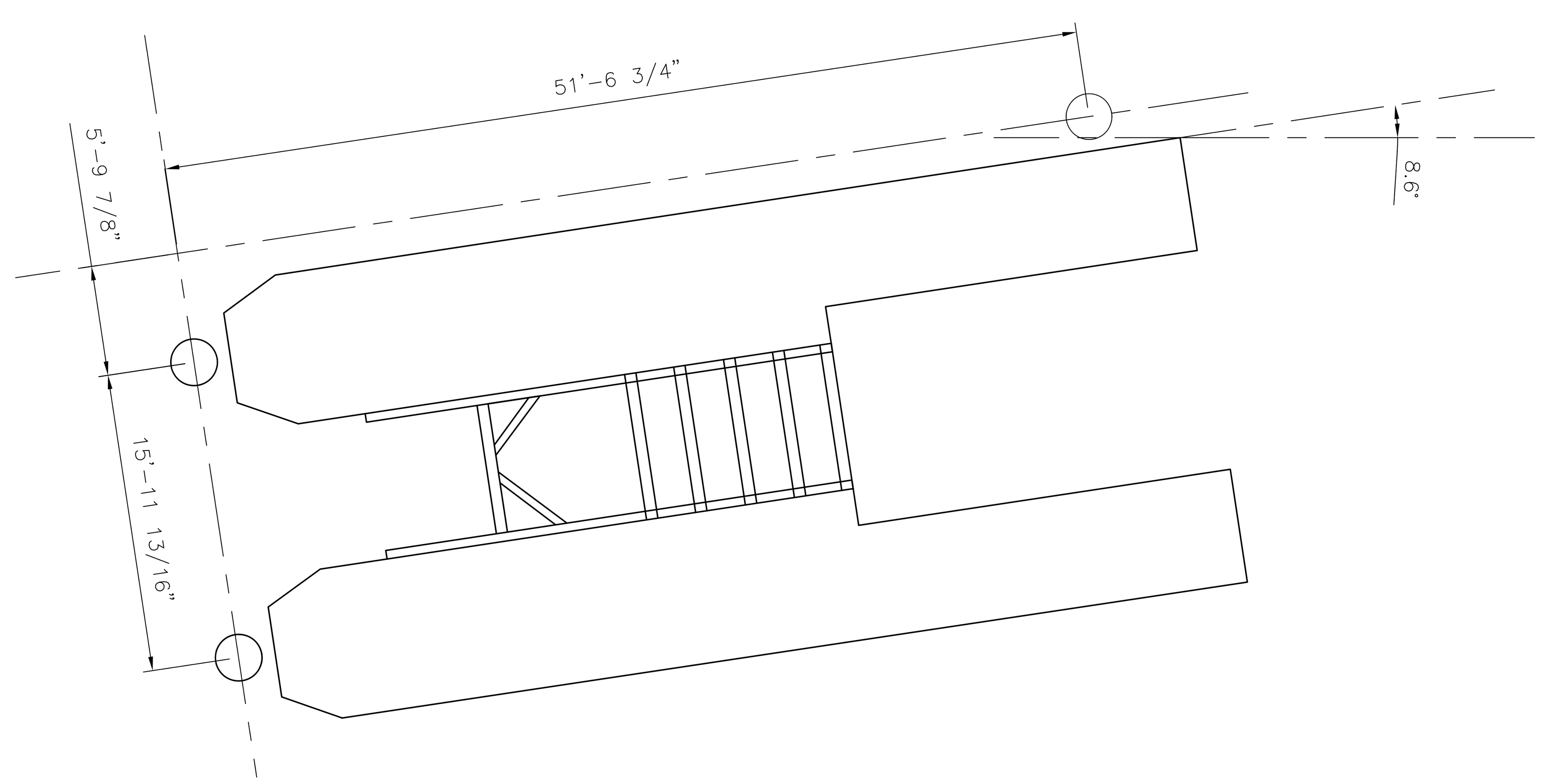
SCALE NONE | SHEET 1 of 1

SHEET NOTES

1. INSTALL PER GENERAL NOTES DRAWING FWTHS-00259-DWG-S101 AND TRASH WHEEL SUPPLIER SPECIFICATIONS.

KEY NOTES

1. MOORING PILES - SEE TABLE BELOW
2. HELICAL - SEE SUPPLIER SPECIFICATIONS AND MUST BE RATED FOR 30 KIP (SAFE BREAK POINT LOAD FOR THE ATTACHED BOOMS)
3. TRASH WHEEL FLOATING PLATFORM BY SUPPLIER

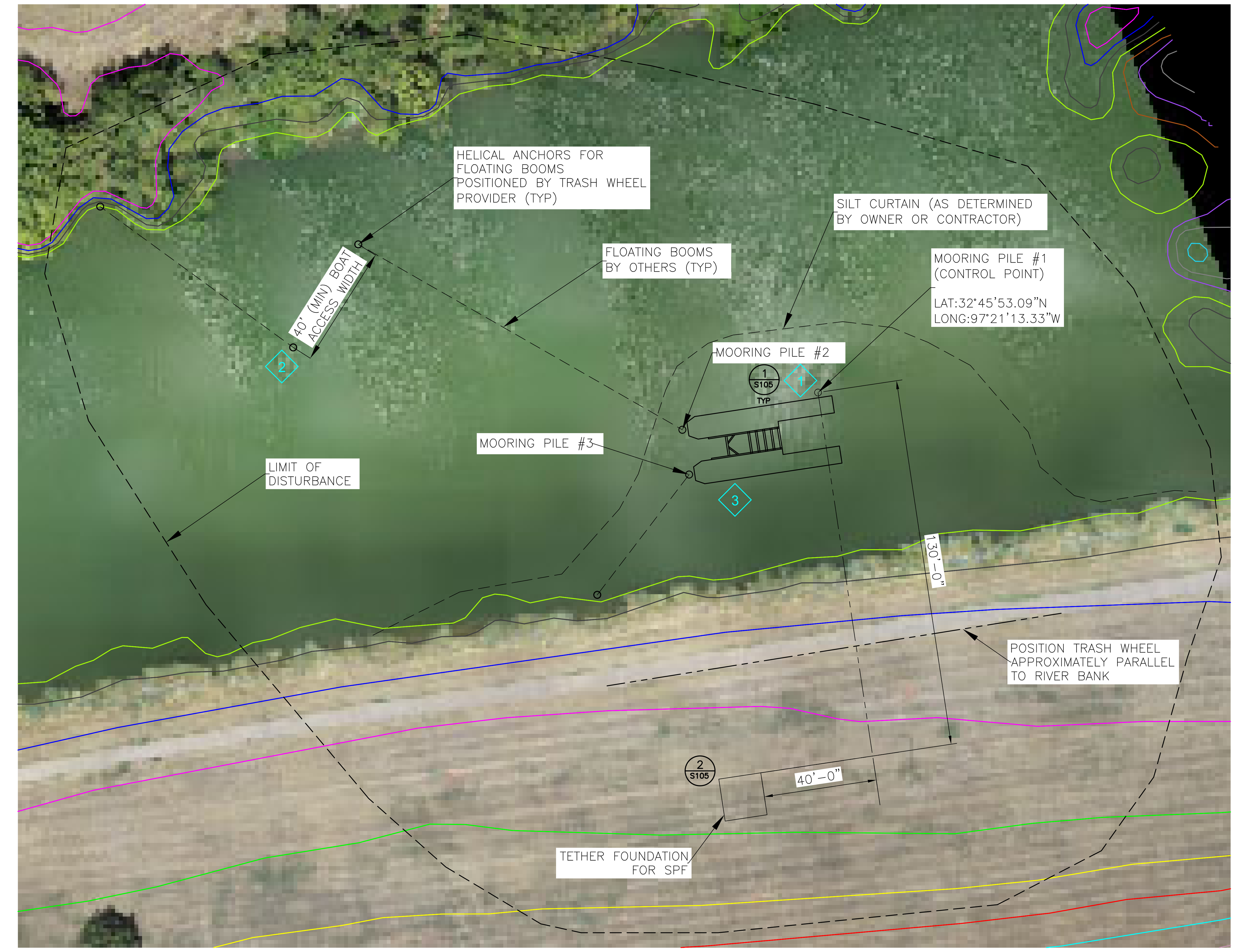


MOORING PILES

SCALE: 1/8" = 1'-0"

PILE #	DIAMETER inches	THICKNESS inches	ELEVATIONS (1) feet TOP	MUDLINE	BOTTOM	TOTAL LENGTH (1) feet
WEST FORK #1	30	3/4	541	514.21	474	67
WEST FORK #2				514.38		
WEST FORK #3				514.26		
(1) elevations/lengths may vary based on field conditions						

THE MUDLINE ELEVATION IS BASED ON THE PILE LOCATIONS POSITIONED IN THE PROJECT HEC-RAS UPPER TRINITY RIVER CDC MODEL. THE BOTTOM ELEVATION IS BASED ON THE LOCATION OF ROCK PROVIDED IN THE PROJECT GEOTECHNICAL REPORT. BOTTOM ELEVATION IS BASED ON A MINIMUM 10' EMBEDMENT INTO ROCK. THE TOTAL LENGTH WITH VARY BASED ON ACTUAL FIELD CONDITIONS AT THE LOCATIONS. PILES MUST BE EMBEDED 10' (MIN) INTO ROCK. THESE ESTIMATES ARE PROVIDED FOR BIDDING PURPOSES.



PLAN

WEST FORK TRINITY RIVER

SCALE: 1/32" = 1'-0"

NO SURVEY WAS PERFORMED IN THE DEVELOPMENT OF THESE CONSTRUCTION DOCUMENTS. PLACEMENT OF THE TRASH WHEEL AND PILES IN THE PLAN ABOVE IS BASED ON AERIAL IMAGING FROM DRONE FOOTAGE TAKEN BY ENERCON. PILE #1 IS THE CONTROL POINT AND SHOULD BE PLACED AT THE COORDINATES SPECIFIED ABOVE. THE REMAINING TWO PILES SHALL BE INSTALLED BASED ON THE ANGLE AND DIMENSIONS PROVIDED IN THE MOORING PILE DETAIL. THE DIMENSIONS BETWEEN PILES MUST BE CONFIRMED WITH CLEARWATER MILLS MANUFACTURE DRAWINGS PRIOR TO INSTALLATION.

PRELIMINARY

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ENERCON

Engineer SANDEEP MENON
P.E. No. 106172 Date 9/9/2022

REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
0	FOR FINAL REVIEW	TF	SM	BP		9/9/22

ENERCON
FORT WORTH, TX

CITY OF FORT WORTH
FORT WORTH, TEXAS

TRINITY RIVER TRASH WHEEL
WEST FORK SITE PLAN

SIZE D | DWG NO. FWTHS-00259-DWG-S102 | REV 0

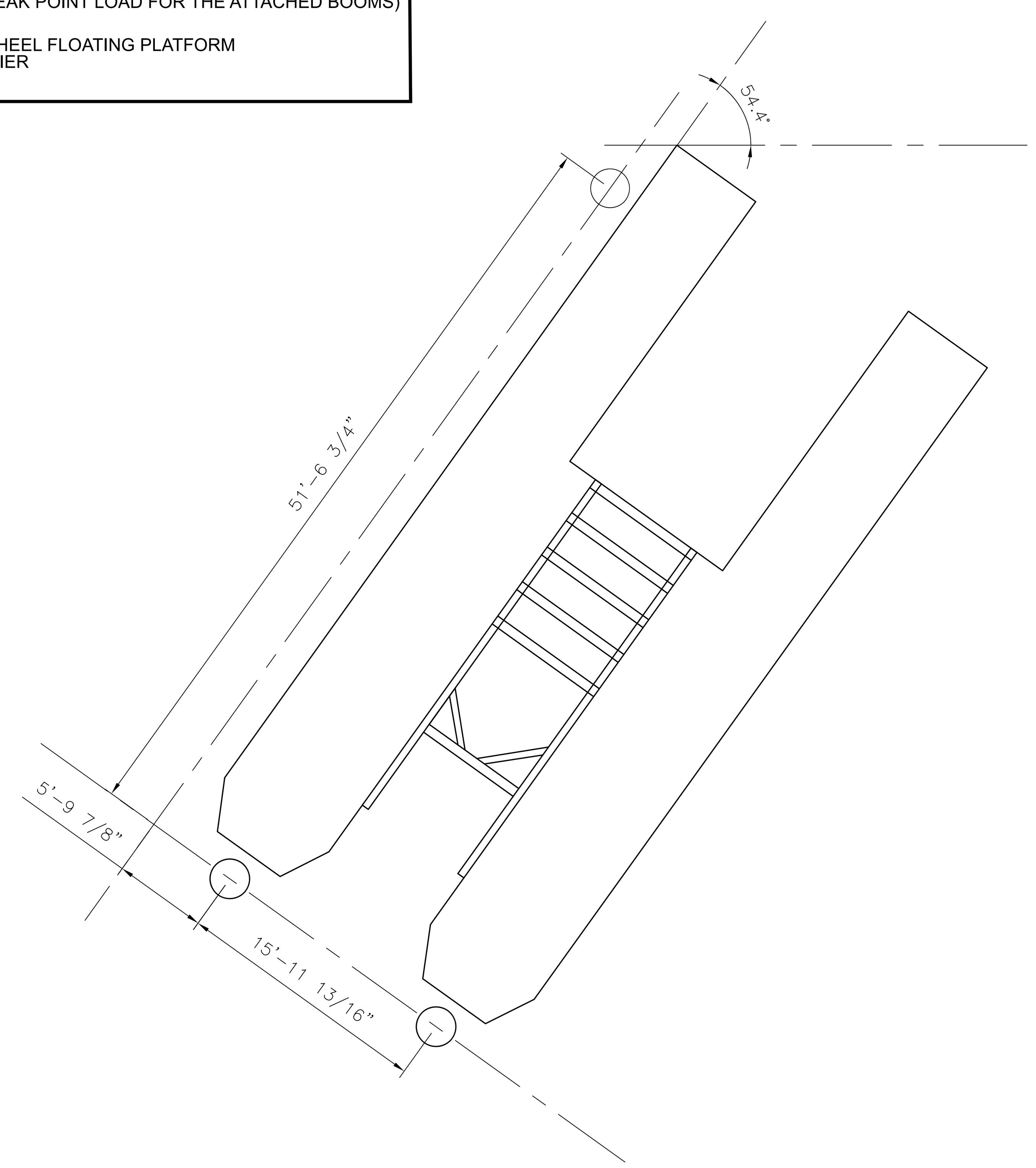
SCALE AS SHOWN | SHEET 1 of 1

SHEET NOTES

1. INSTALL PER GENERAL NOTES DRAWING FWTHS-00259-DWG-S101 AND TRASH WHEEL SUPPLIER SPECIFICATIONS.

KEY NOTES

1. MOORING PILES - SEE TABLE BELOW
2. HELICAL - SEE SUPPLIER SPECIFICATIONS AND MUST BE RATED FOR 30 KIP (SAFE BREAK POINT LOAD FOR THE ATTACHED BOOMS)
3. TRASH WHEEL FLOATING PLATFORM BY SUPPLIER

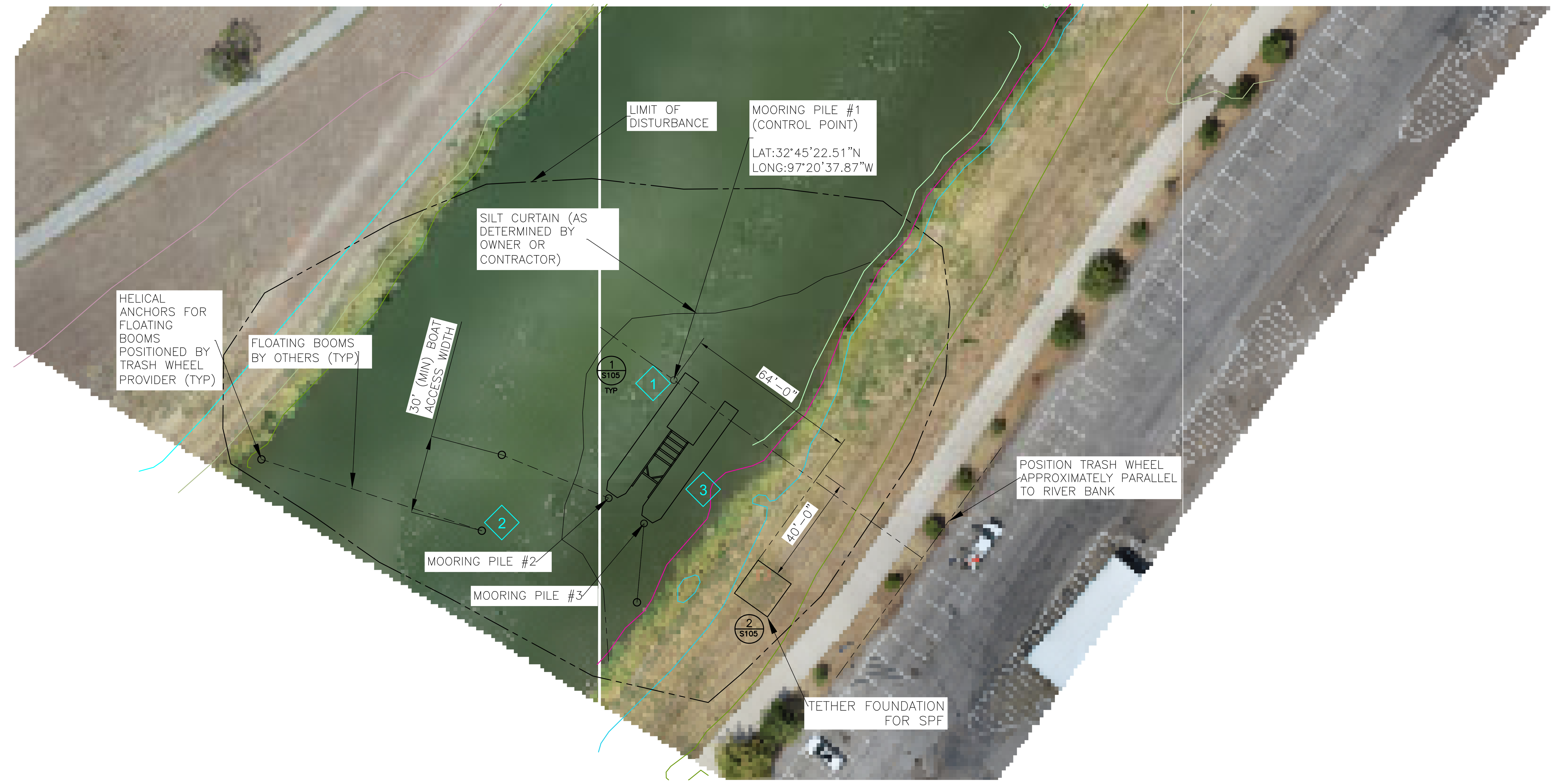


MOORING PILES

SCALE: 1/8" = 1'-0"

PILE #	DIAMETER inches	THICKNESS inches	ELEVATIONS (1) feet TOP	MUDLINE	BOTTOM	TOTAL LENGTH (1) feet
CLEAR FORK #1	30	3/4	541	514.15	480	61
CLEAR FORK #2				514.37		
CLEAR FORK #3				515.48		
(1) elevations/lengths may vary based on field conditions						

THE MUDLINE ELEVATION IS BASED ON THE PILE LOCATIONS POSITIONED IN THE PROJECT HEC-RAS UPPER TRINITY RIVER CDC MODEL. THE BOTTOM ELEVATION IS BASED ON THE LOCATION OF ROCK PROVIDED IN THE PROJECT GEOTECHNICAL REPORT. BOTTOM ELEVATION IS BASED ON A MINIMUM 10' EMBEDMENT INTO ROCK. THE TOTAL LENGTH WITH VARY BASED ON ACTUAL FIELD CONDITIONS AT THE LOCATIONS. PILES MUST BE EMBEDED 10' (MIN) INTO ROCK. THESE ESTIMATES ARE PROVIDED FOR BIDDING PURPOSES.



PLAN

CLEAR FORK TRINITY RIVER

SCALE: 1/32" = 1'-0"

NO SURVEY WAS PERFORMED IN THE DEVELOPMENT OF THESE CONSTRUCTION DOCUMENTS. PLACEMENT OF THE TRASH WHEEL AND PILES IN THE PLAN ABOVE IS BASED ON AERIAL IMAGING FROM DRONE FOOTAGE TAKEN BY ENERCON. PILE #1 IS THE CONTROL POINT AND SHOULD BE PLACED AT THE COORDINATES SPECIFIED ABOVE. THE REMAINING TWO PILES SHALL BE INSTALLED BASED ON THE ANGLE AND DIMENSIONS PROVIDED IN THE MOORING PILE DETAIL. THE DIMENSIONS BETWEEN PILES MUST BE CONFIRMED WITH CLEARWATER MILLS MANUFACTURE DRAWINGS PRIOR TO INSTALLATION.

PRELIMINARY

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ENERCON

Engineer SANDEEP MENON
P.E. No. 106172 Date 9/9/2022

REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
0	FOR FINAL REVIEW	TF	SM	BP		9/9/22

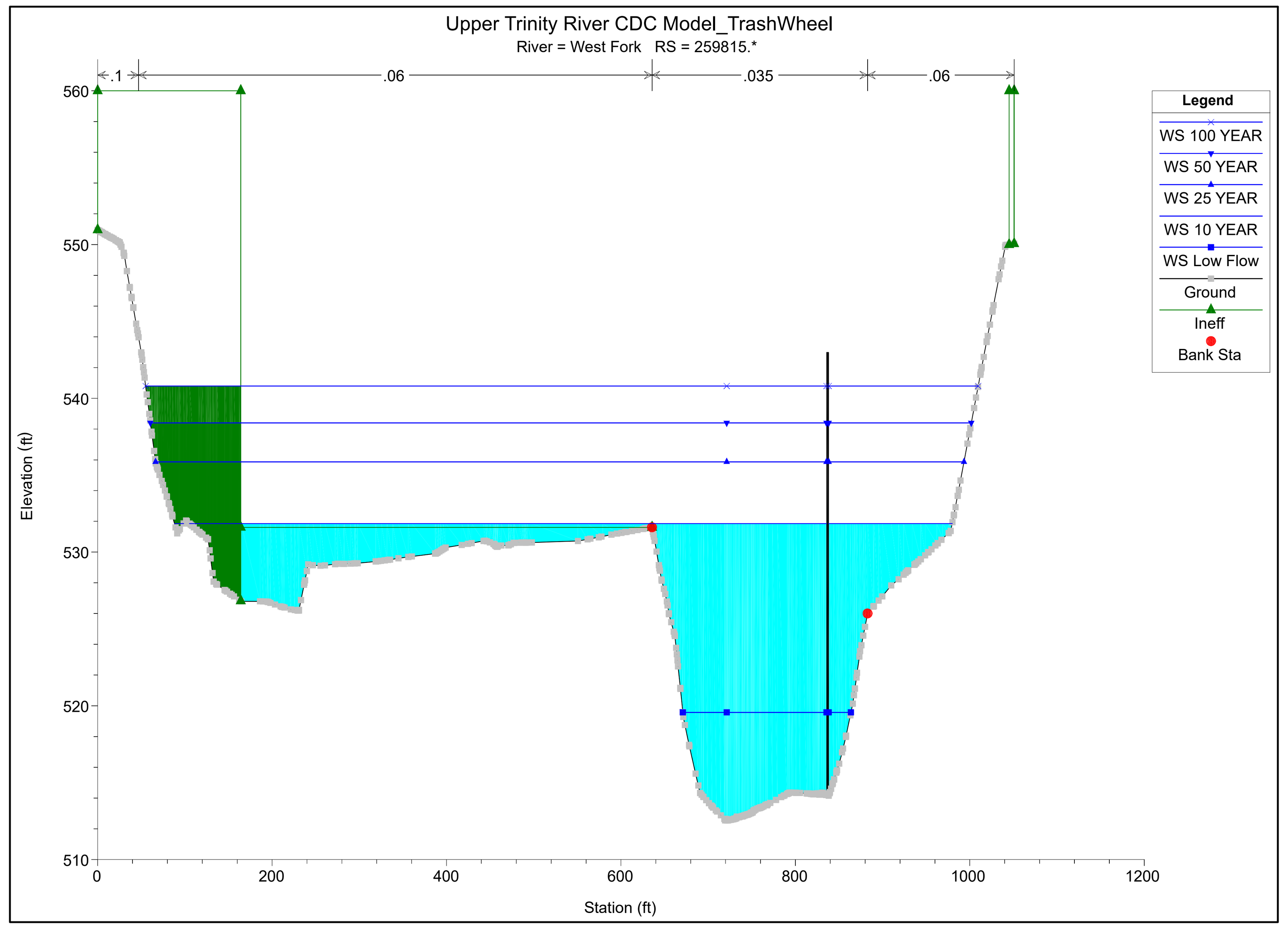
ENERCON
FORT WORTH, TX

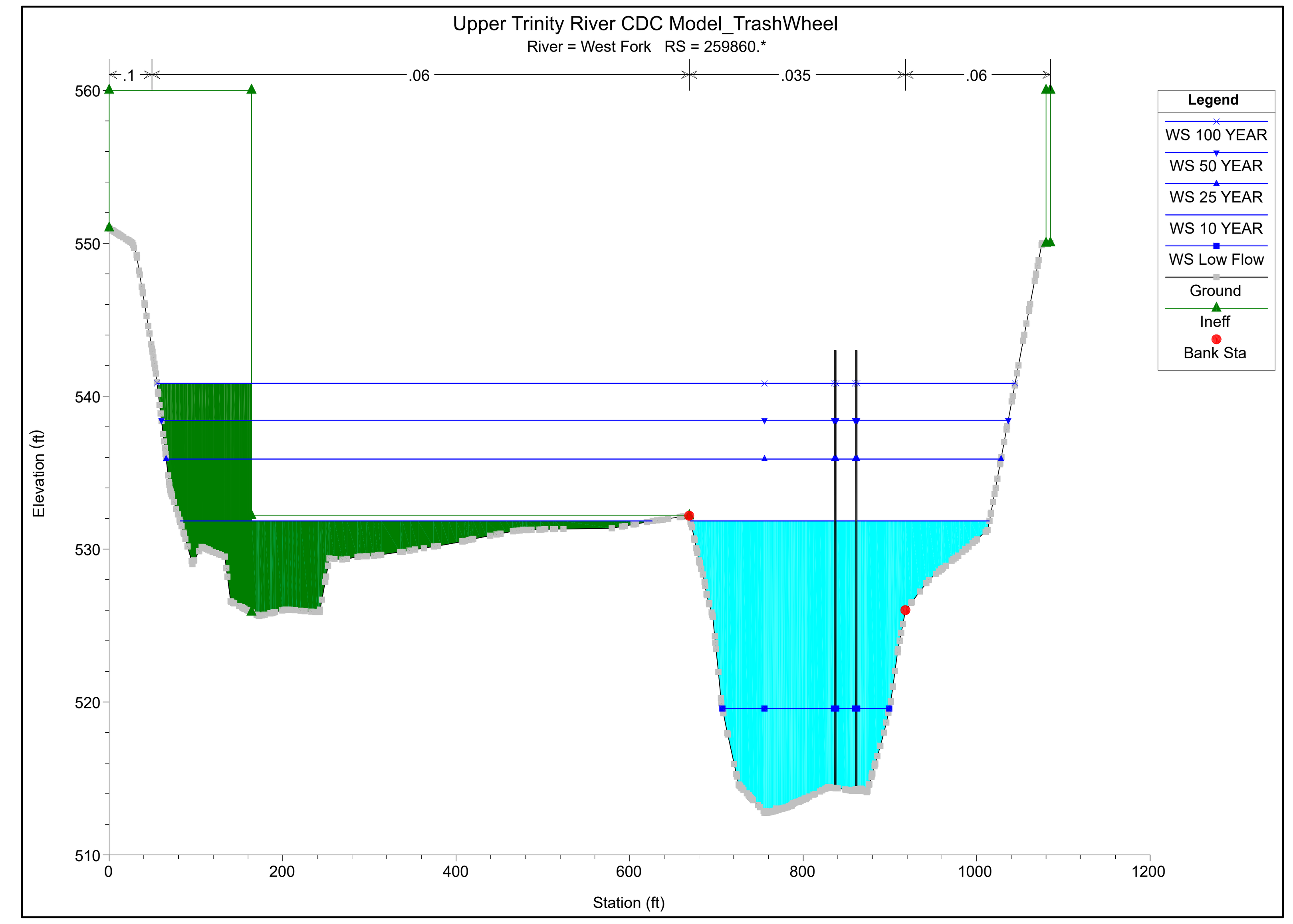
CITY OF FORT WORTH
FORT WORTH, TEXAS

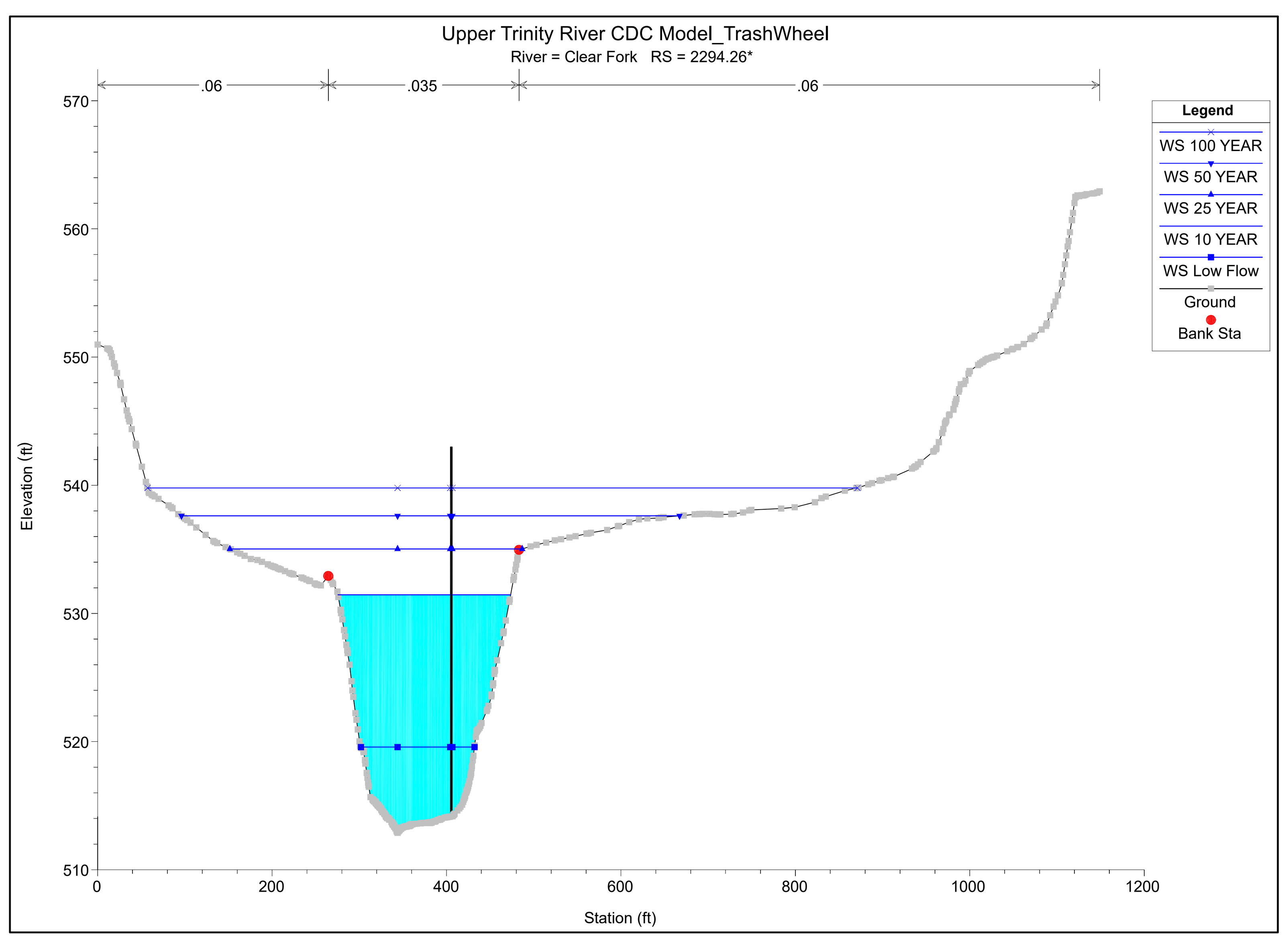
TRINITY RIVER TRASH WHEEL
CLEAR FORK SITE PLAN

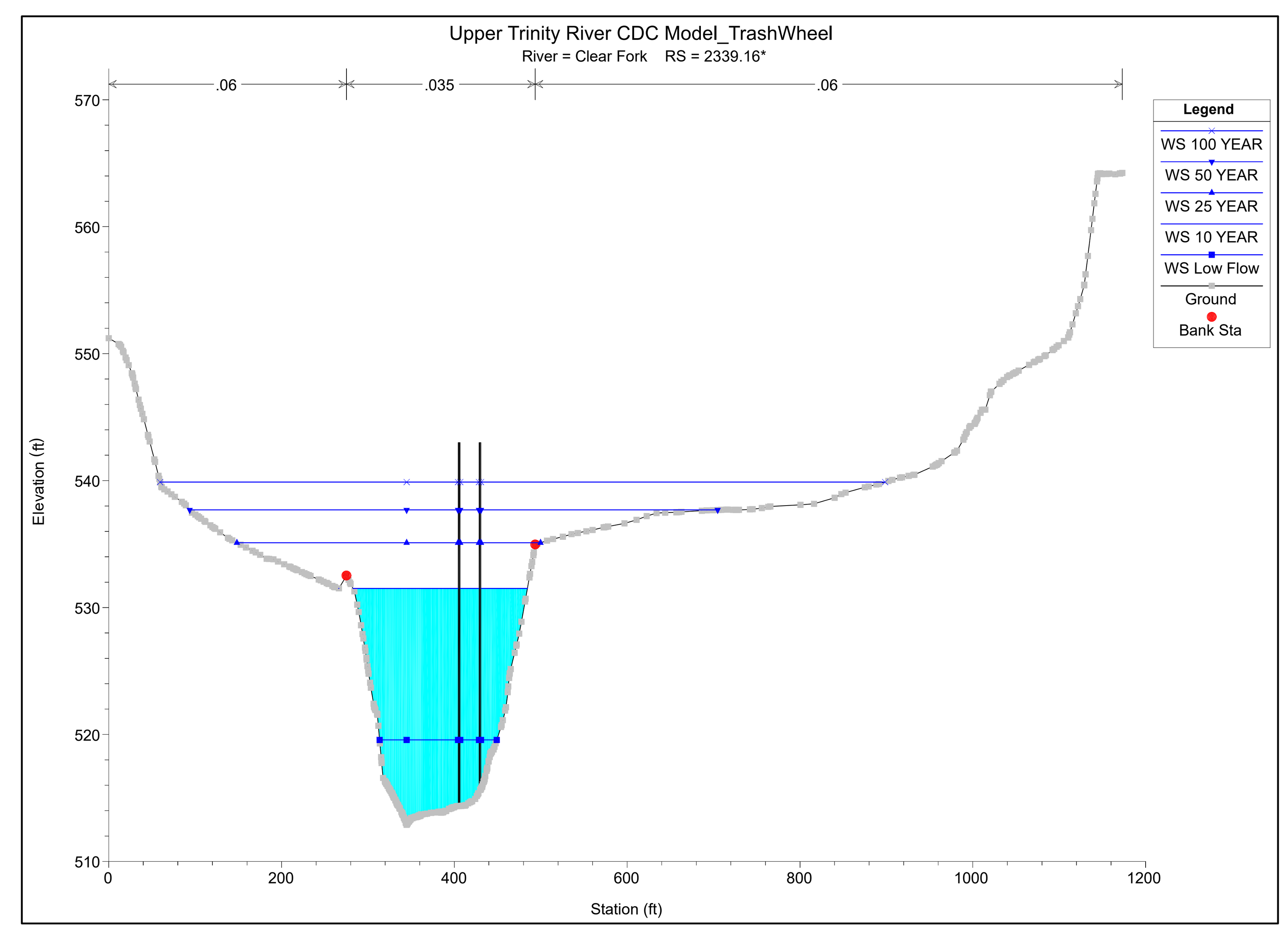
SIZE D | DWG NO. FWTHS-00259-DWG-S103 | REV 0

SCALE AS SHOWN | SHEET 1 of 1









RIVER PROFILES

SCALE: NTS

PRELIMINARY

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ENERCON

Engineer SANDEEP MENON
P.E. No. 106172 Date 9/9/2022

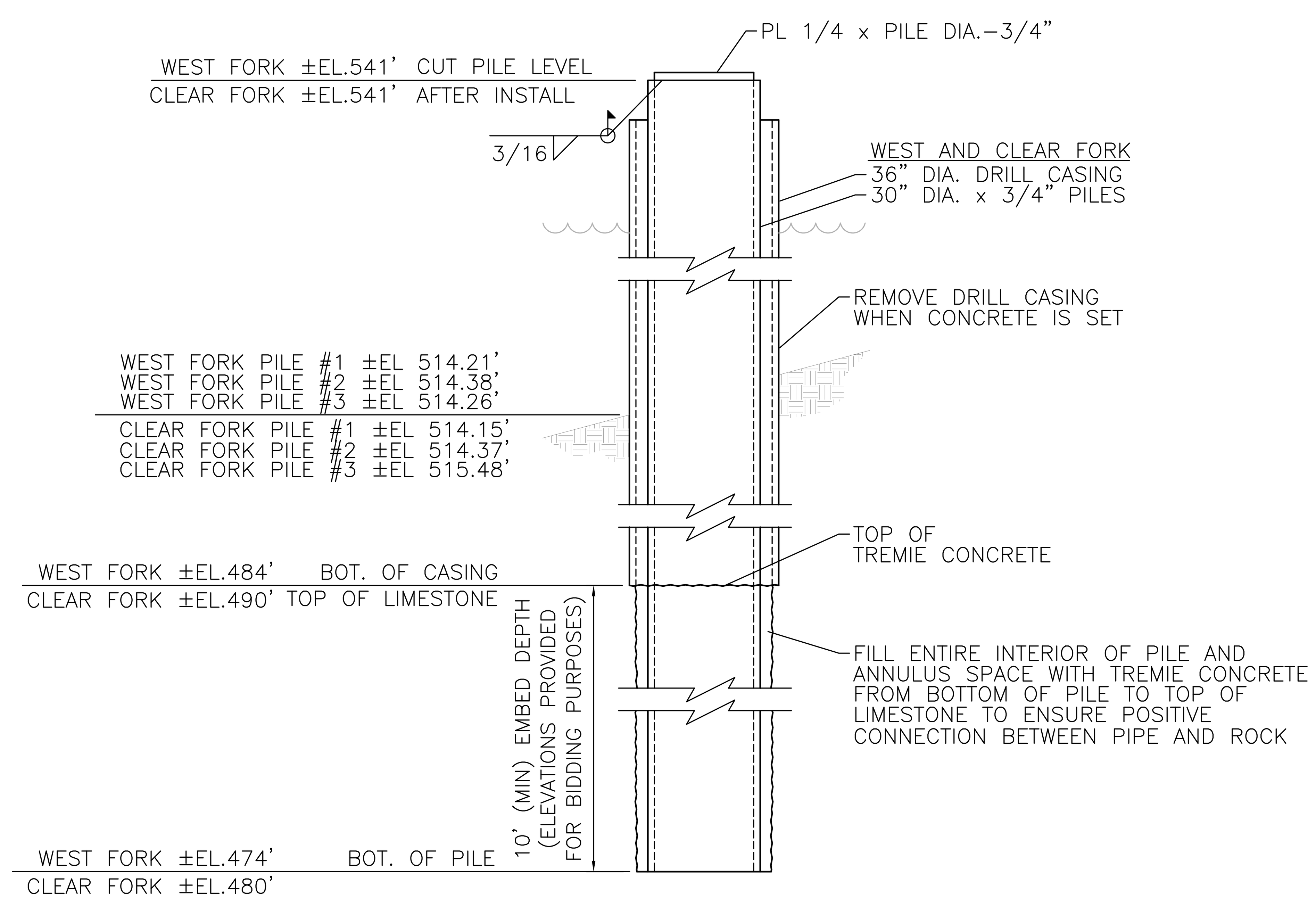
REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
0	FOR FINAL REVIEW	TF	SM	BP		9/9/22

ENERCON
FORT WORTH, TX

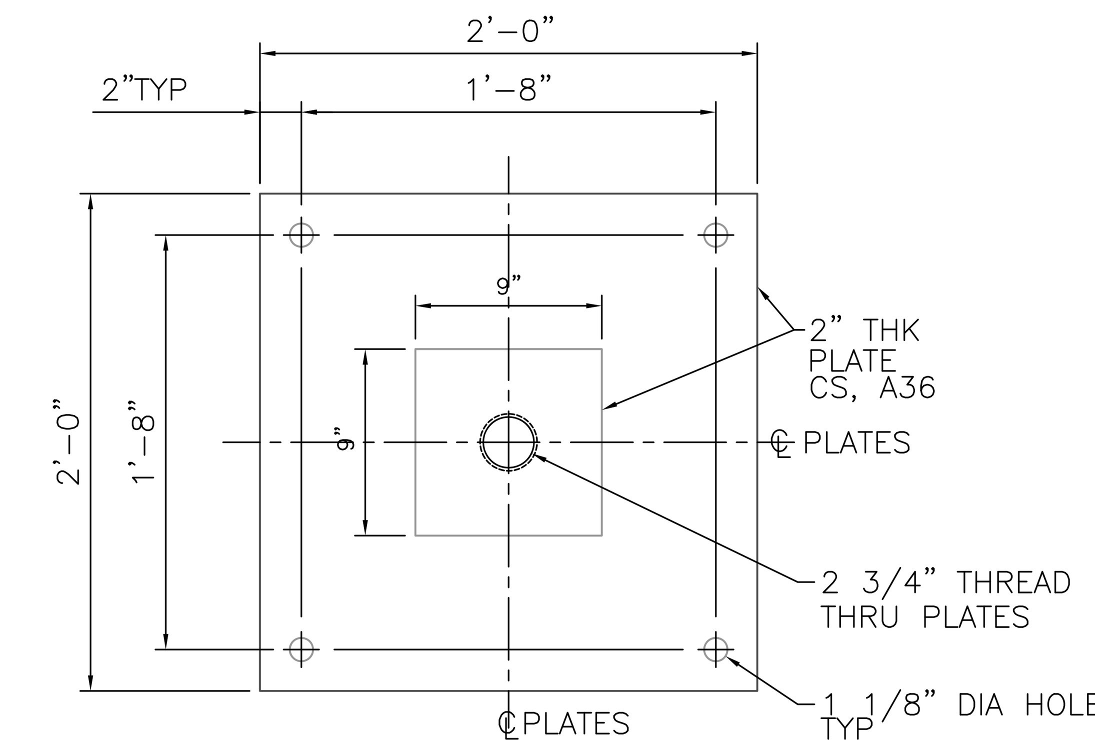
CITY OF FORT WORTH
FORT WORTH, TEXAS

TRINITY RIVER TRASH WHEEL
WEST FORK / CLEAR FORK PROFILES

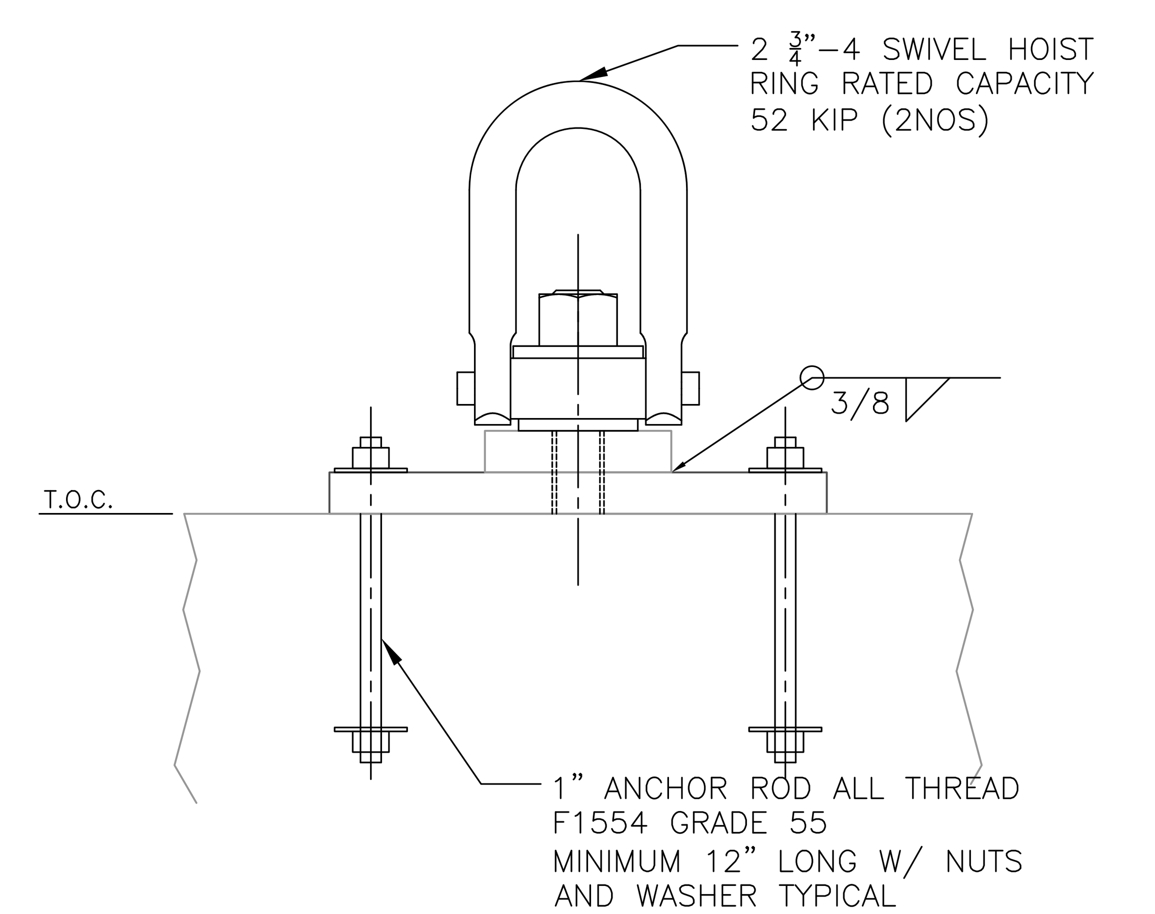
SIZE D DWG NO. FWTHS-00259-DWG-S104 REV 0
SCALE AS SHOWN SHEET 1 of 1



1 / S105 PILE CAP
SCALE: N.T.S.



PLAN
(HOIST RING NOT SHOWN FOR CLARITY)



ELEVATION

3 / S105 ANCHOR DETAIL
SCALE: N.T.S.

NOTE: MAX 1" THICK GROUT SHALL BE USED TO ASSURE THE PLATE HAS AT LEAST 80% BEARING ON CONCRETE

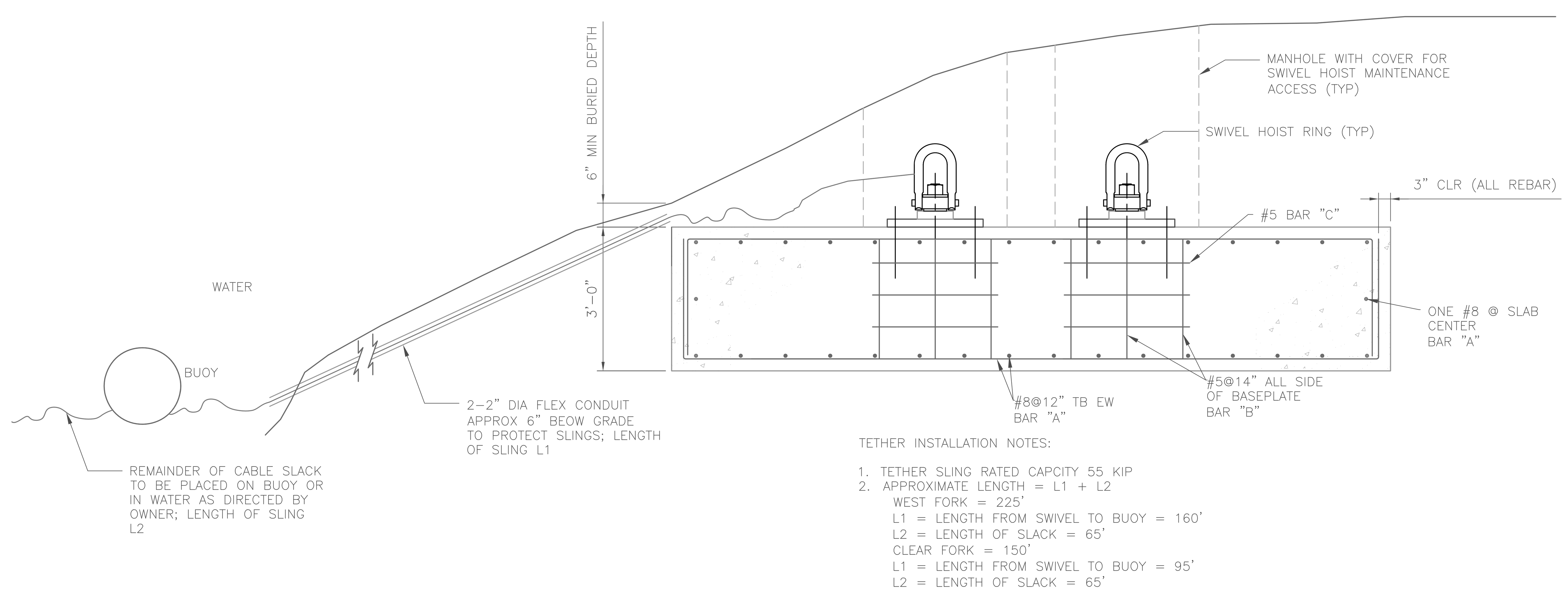
2'−6"
14'−6"
BAR "A"

2'−2"
2'−6"
BAR "B"

1'−2"
BAR "C"

BAR ID	BAR QTY PER FDN	TOTAL QTY
BAR A	75	150
BAR B	12	24
BAR C	10	20

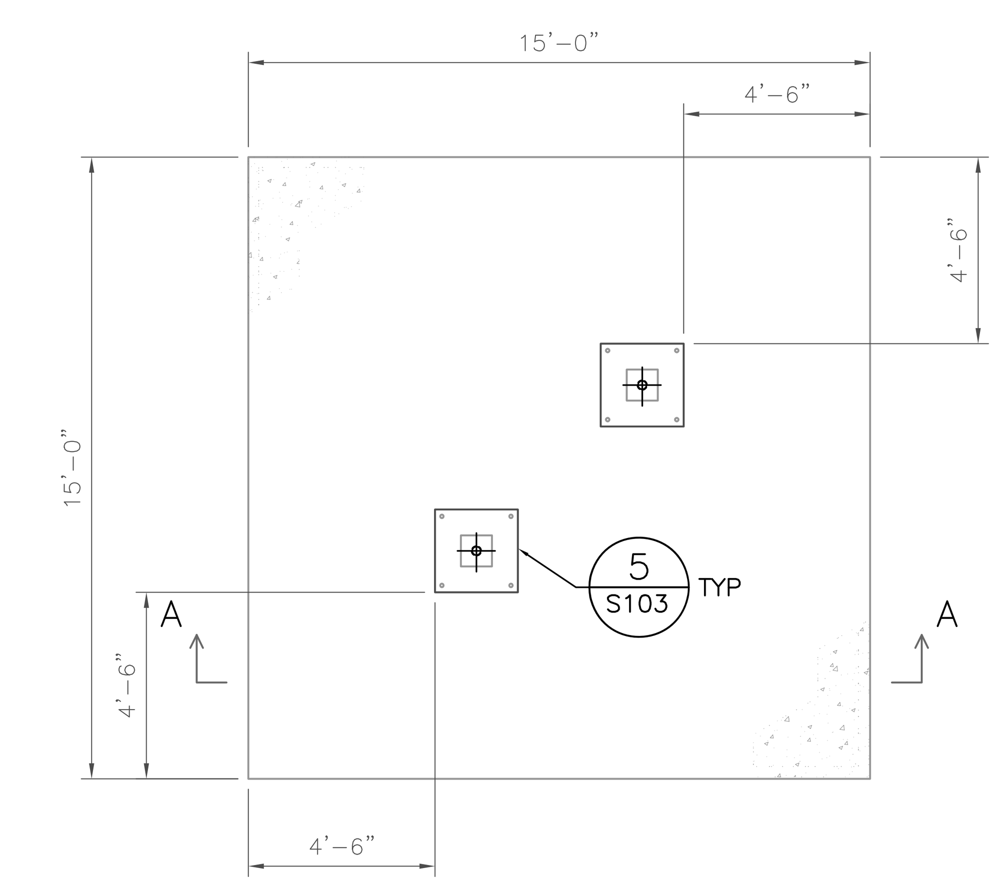
REBAR SCHEDULE
SCALE: 1/2" = 1'−0"



TETHER INSTALLATION NOTES:

1. TETHER SLING RATED CAPCITY 55 KIP
2. APPROXIMATE LENGTH = L1 + L2
   WEST FORK = 225'
   L1 = LENGTH FROM SWIVEL TO BUOY = 160'
   L2 = LENGTH OF SLACK = 65'
   CLEAR FORK = 150'
   L1 = LENGTH FROM SWIVEL TO BUOY = 95'
   L2 = LENGTH OF SLACK = 65'

TETHER FOUNDATION SECTION A−A
SCALE: 1/2" = 1'−0"



2 / S105 TETHER FOUNDATION PLAN
SCALE: 1/4" = 1'−0"

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ENERCON
Engineer SANDEEP MENON
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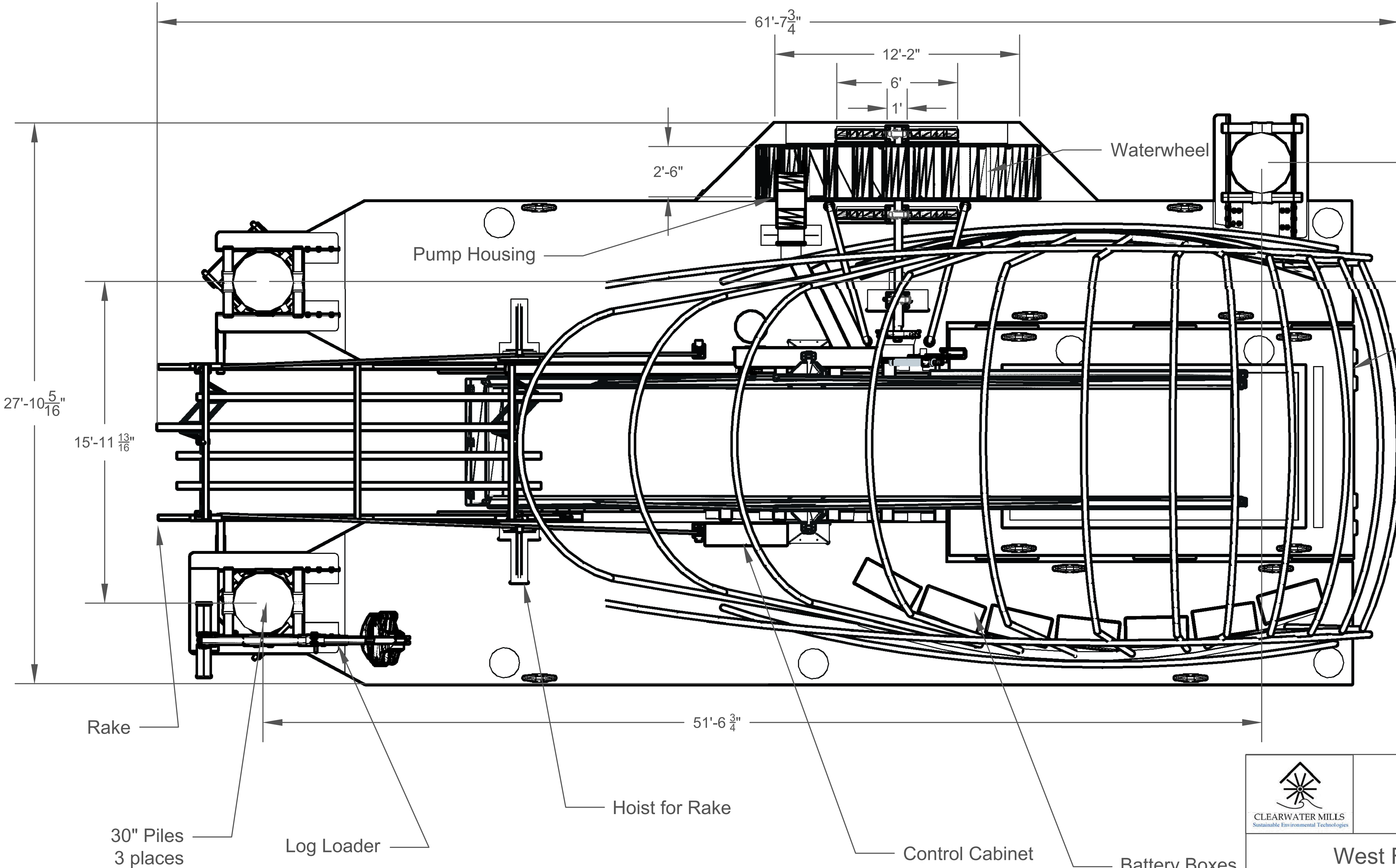
ENERCON
FORT WORTH, TX

CITY OF FORT WORTH
FORT WORTH, TEXAS

TRINITY RIVER TRASH WHEEL
STRUCTURAL & FOUNDATION DETAILS

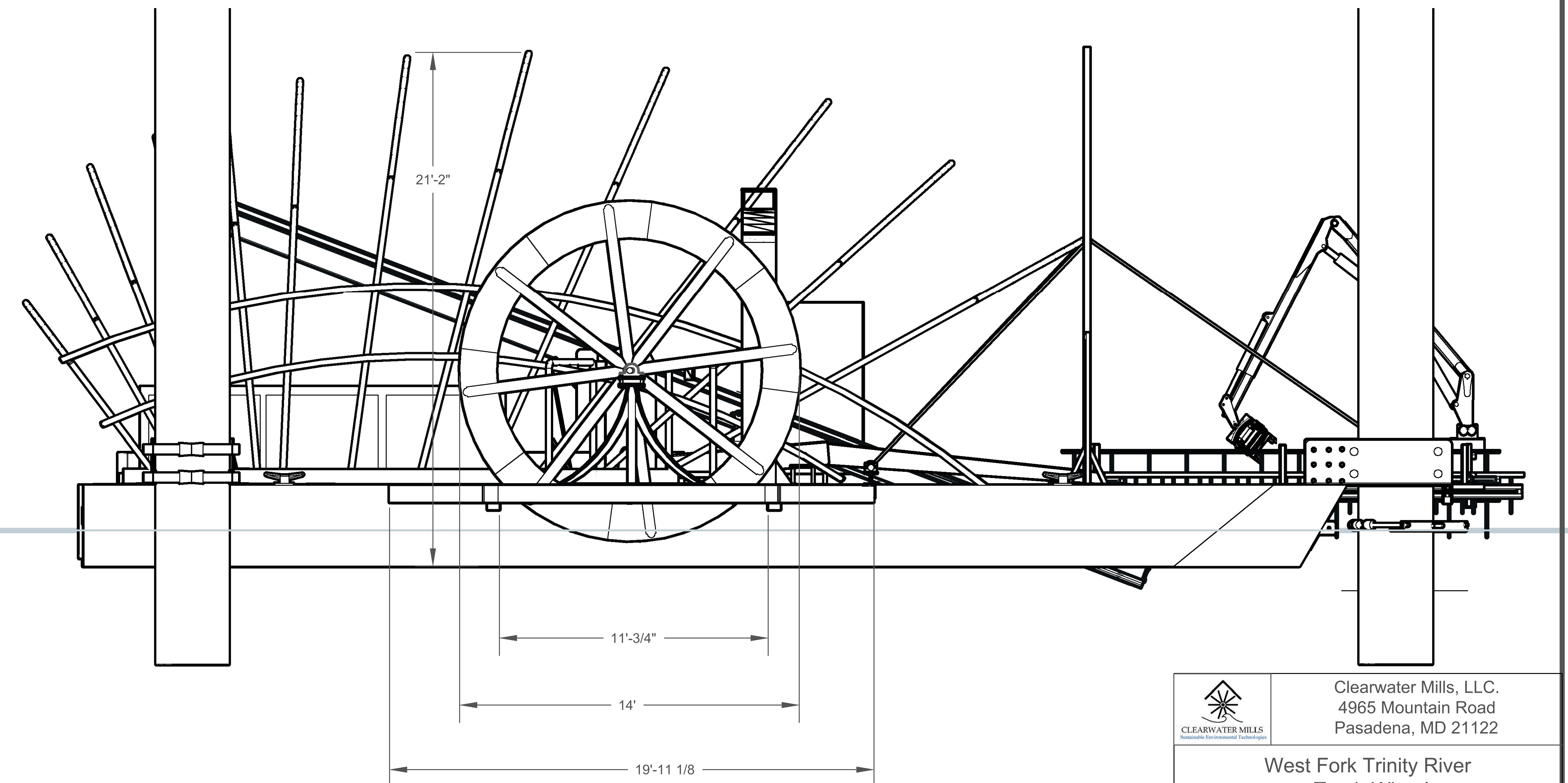
SIZE D DWG NO. FWTHS−00259−DWF−S105 REV 0
SCALE AS SHOWN SHEET 1 of 1



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Plan View

Date 6/30/2022 3/16" = 1'

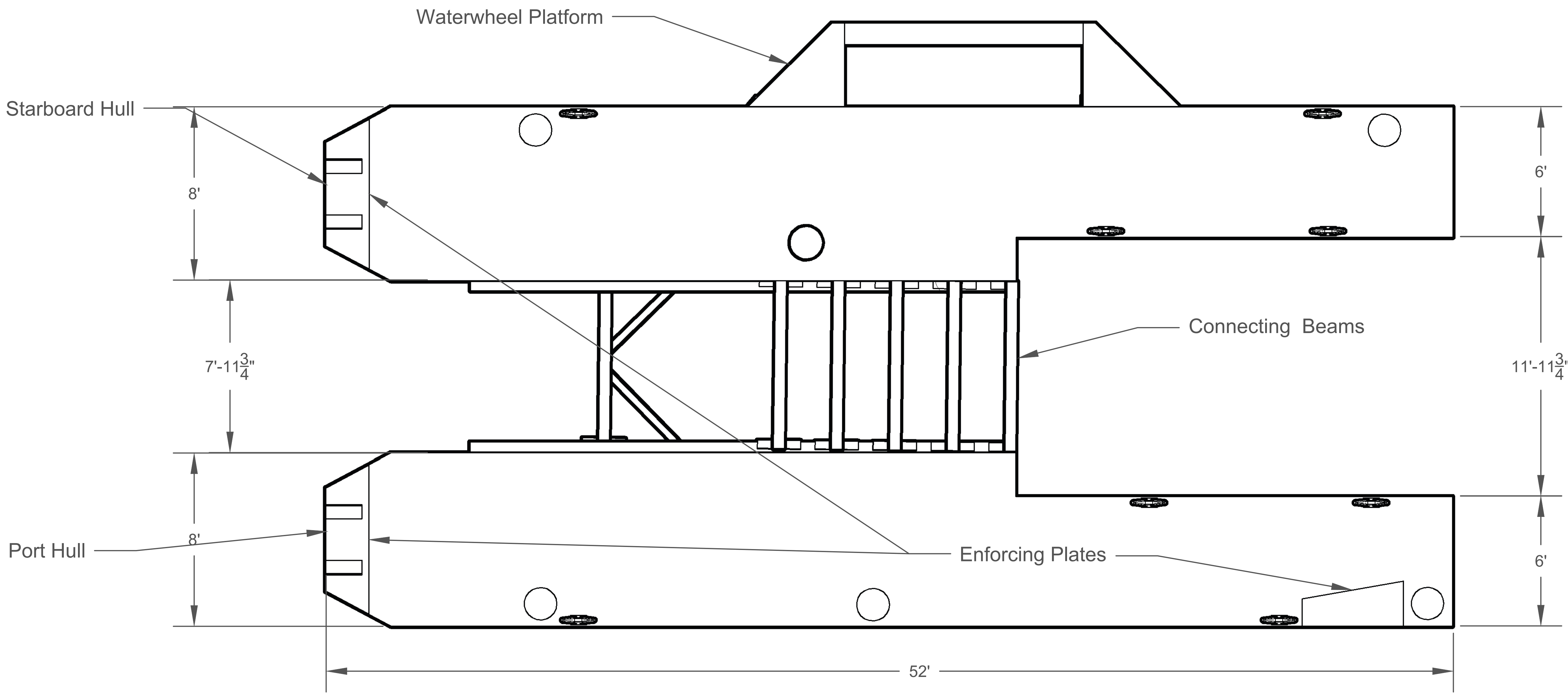


CLEARWATER MILLS
Sustainable Environmental Technologies

Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Elevation

Date 9/9/2022 | 1/4" = 1' | Page 2 of 20

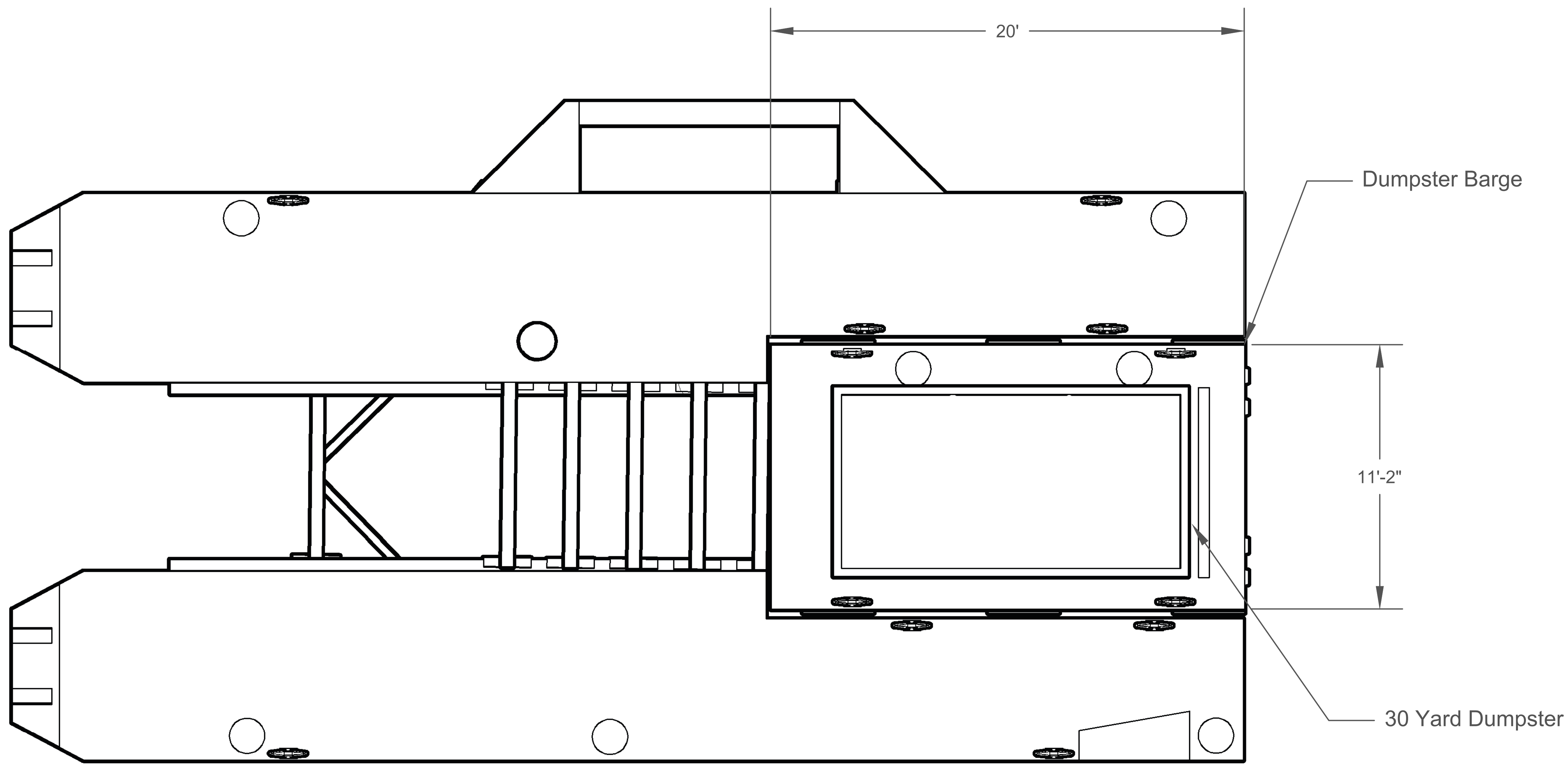


CLEARWATER MILLS
Sustainable Environmental Technologies

Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Hull Layout

Date 6/30/2022	3/16" = 1'	Page 3 of 20

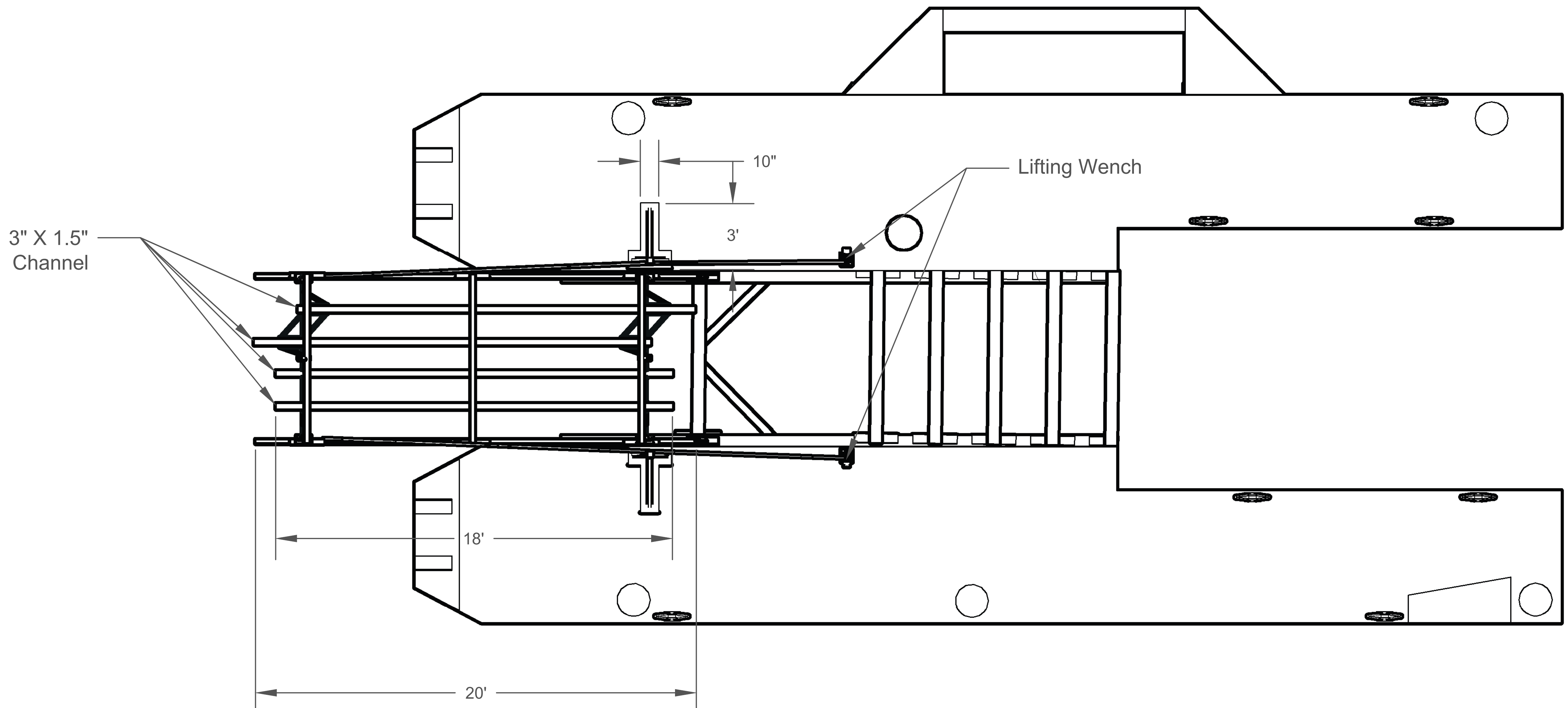


CLEARWATER MILLS
Sustainable Environmental Technologies

Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Dumpster Barge

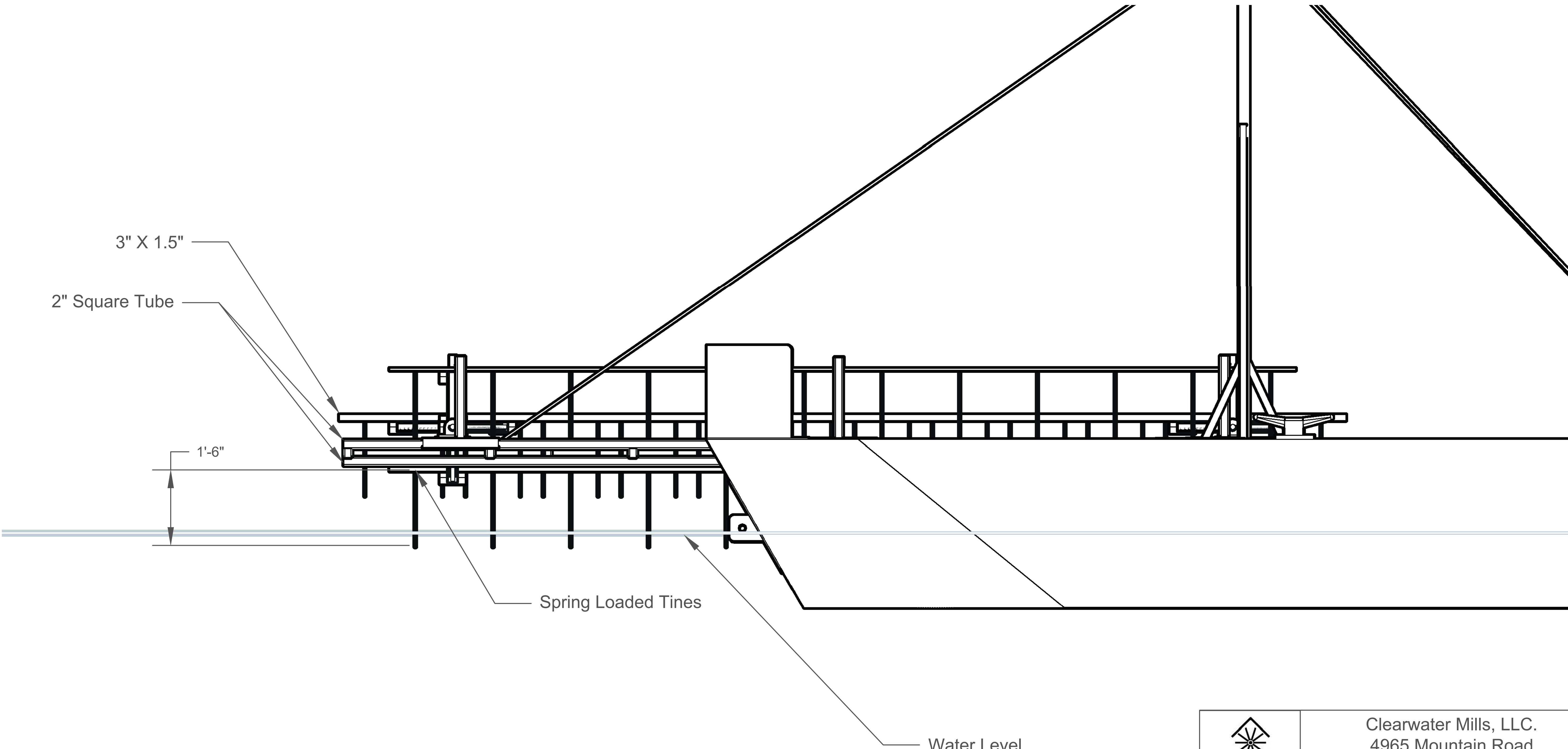
Date 6/30/2022 3/16" = 1'



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Rake

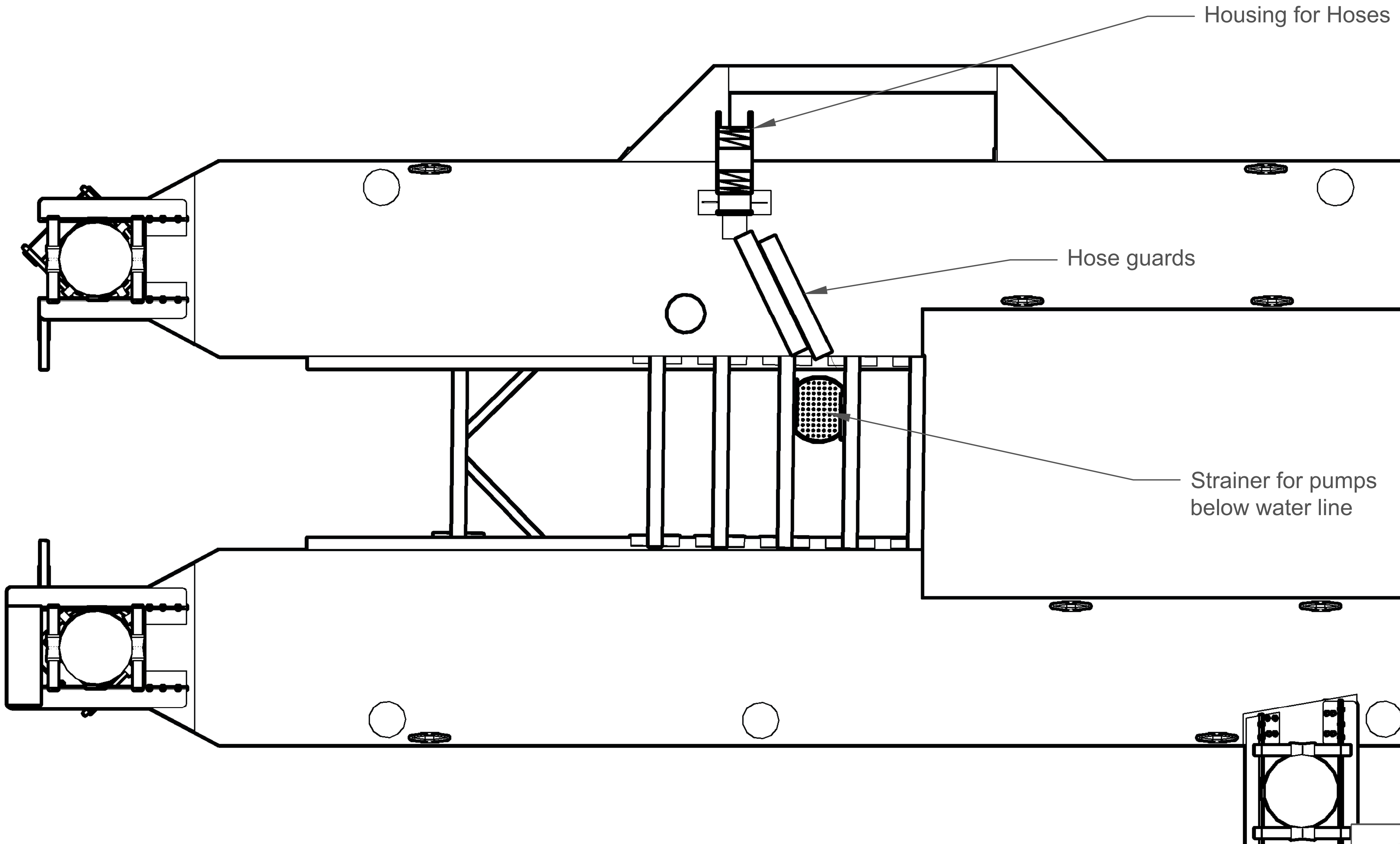
Date 6/30/2022 3/16" = 1'



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Rake

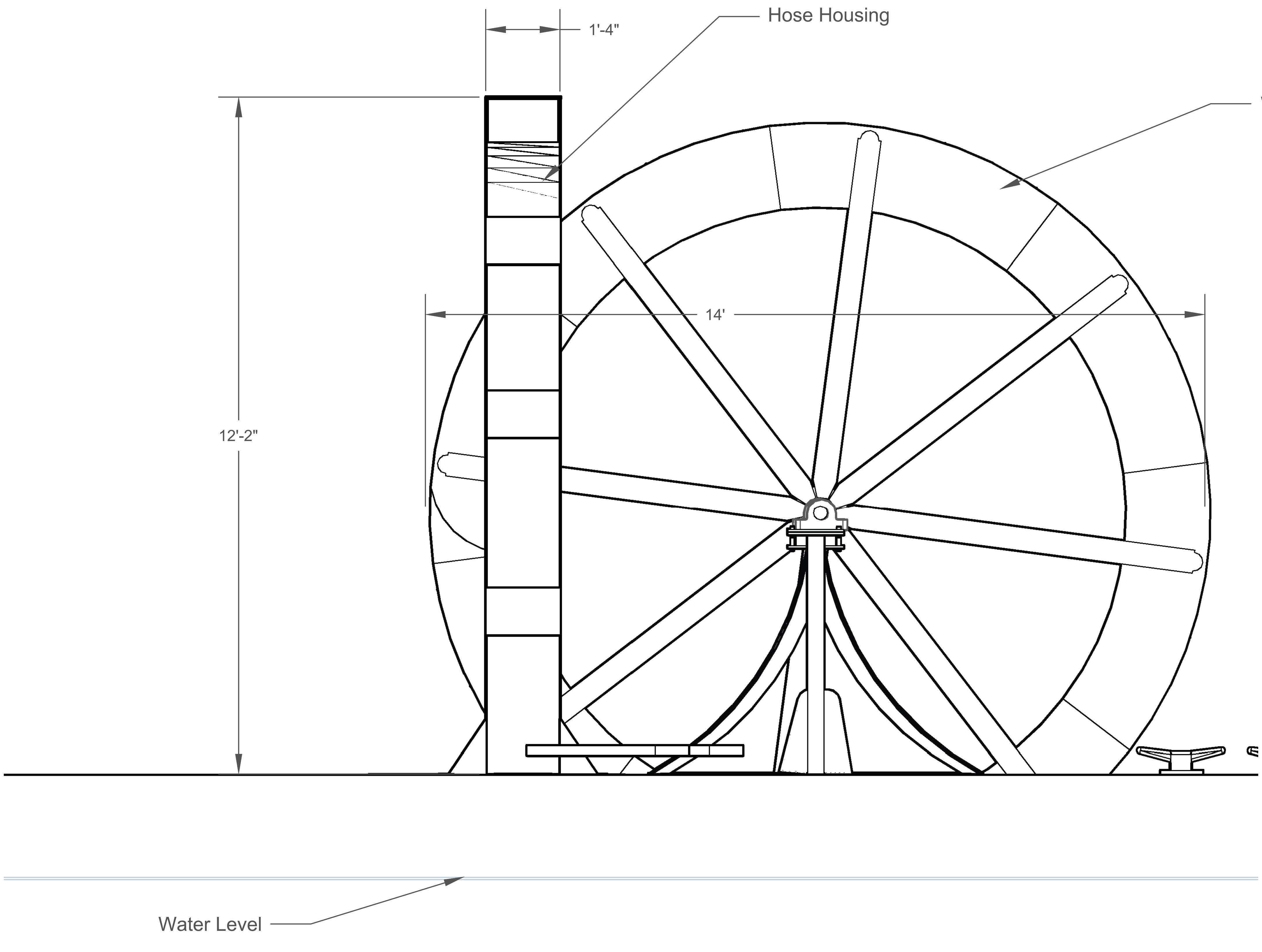
Date 6/30/2022	1/2" = 1'	Page 6 of 20



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Pump System

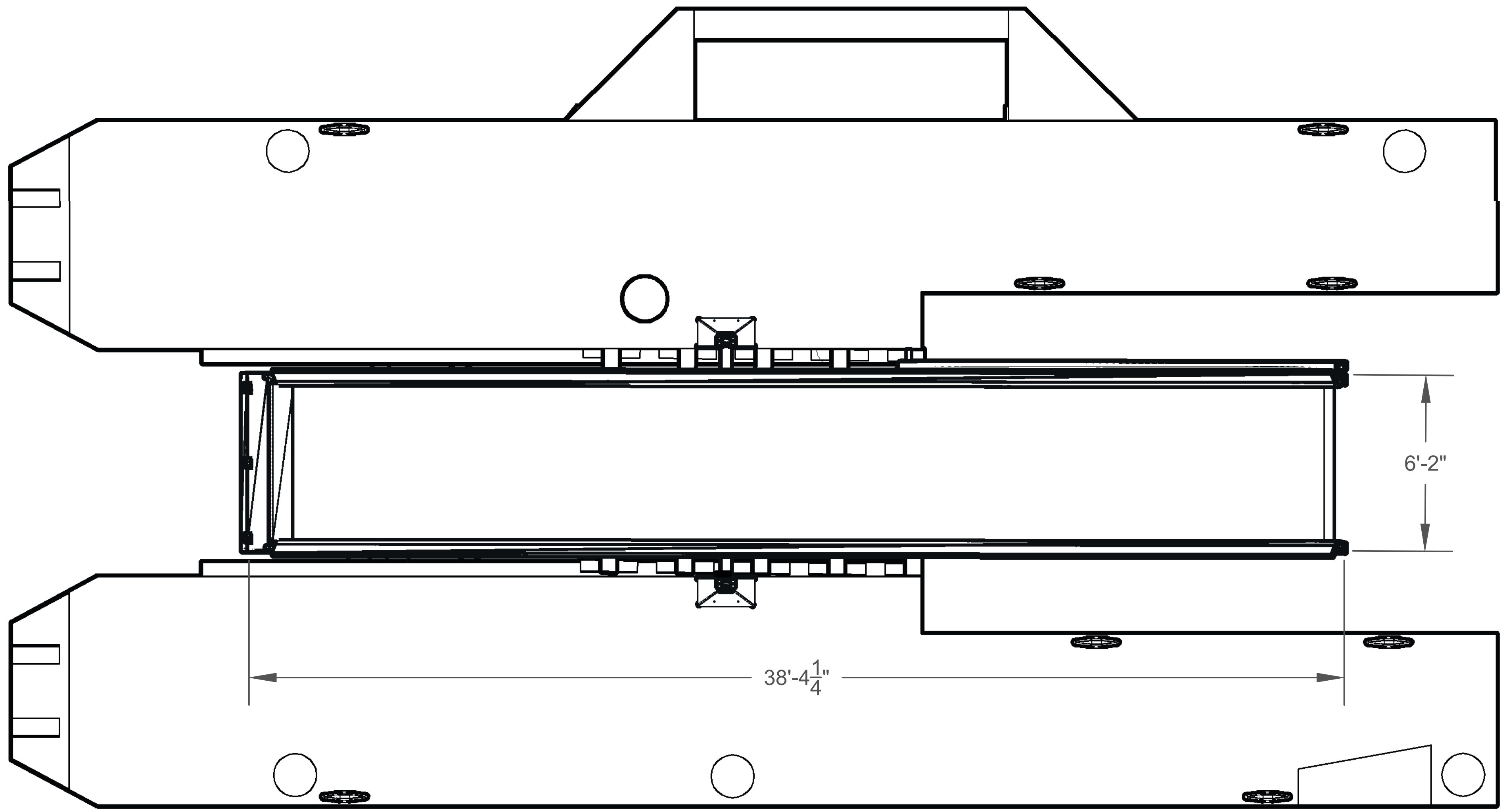
Date 6/30/2022 3/16" = 1'



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Pump System

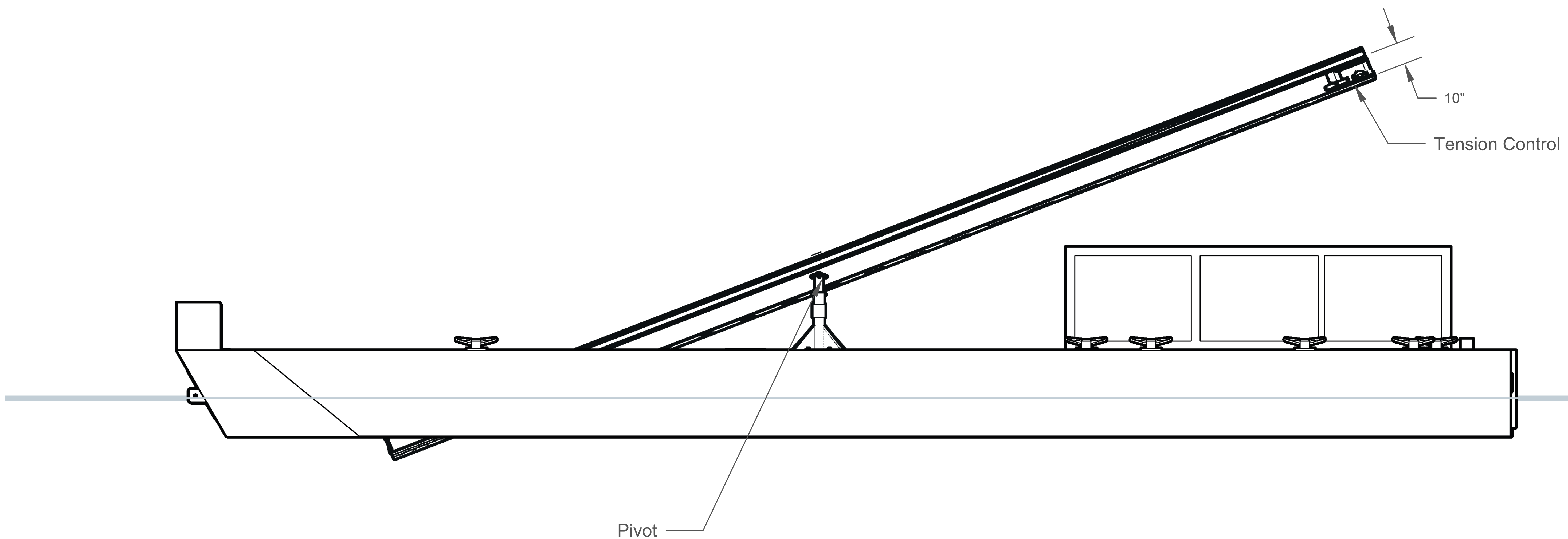
Date 6/30/2022 | 1/2" = 1' |



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Conveyor

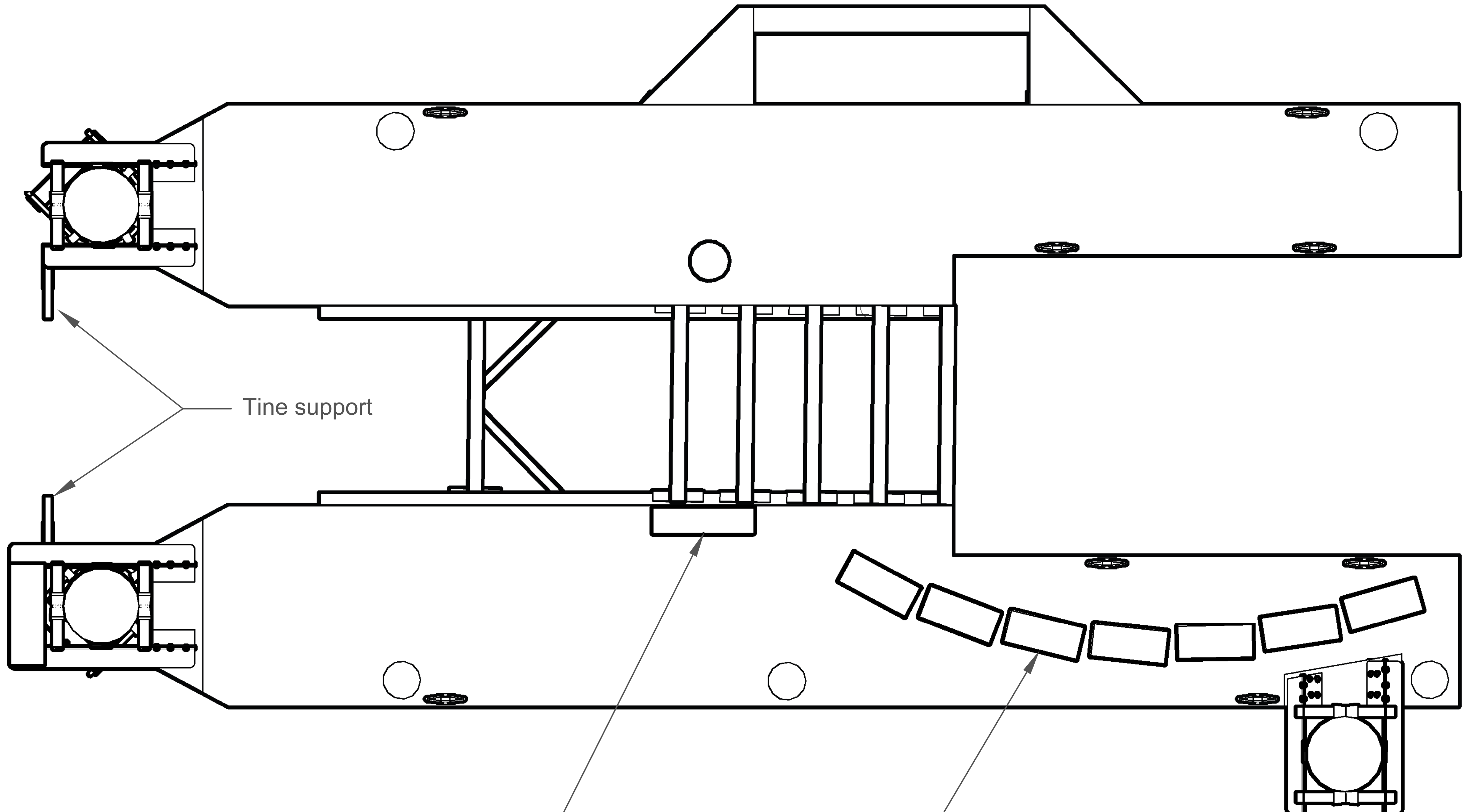
Date 6/30/2022 | 3/16" = 1' |



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Conveyor

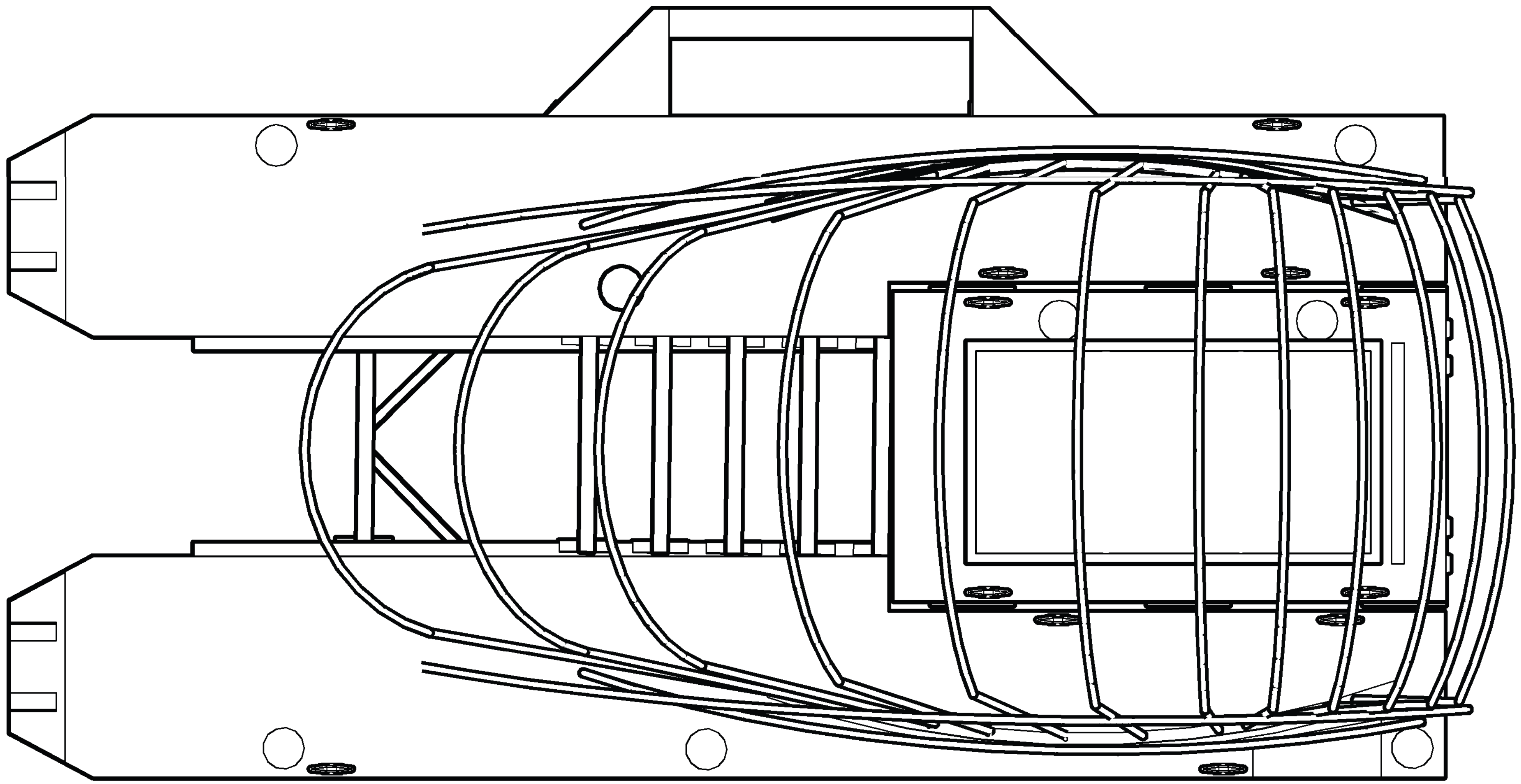
Date 6/30/2022 | 1/4" = 1' | Page 10 of 20



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Electronics

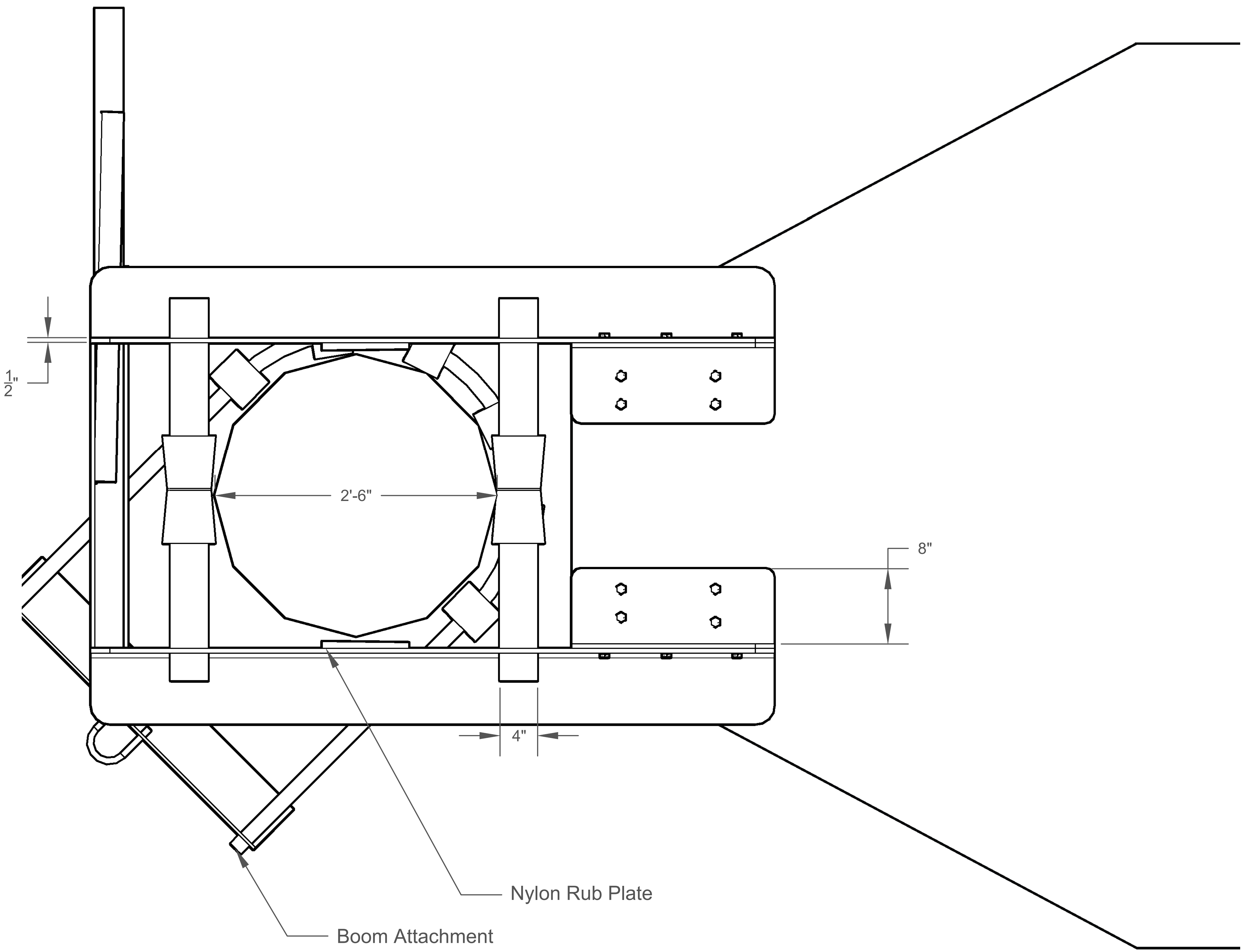
Date 6/30/2022 | 3/16" = 1' | Page 11 of 20



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Cover Frame

Date 6/30/2022	3/16" = 1'	Page 12 of 20



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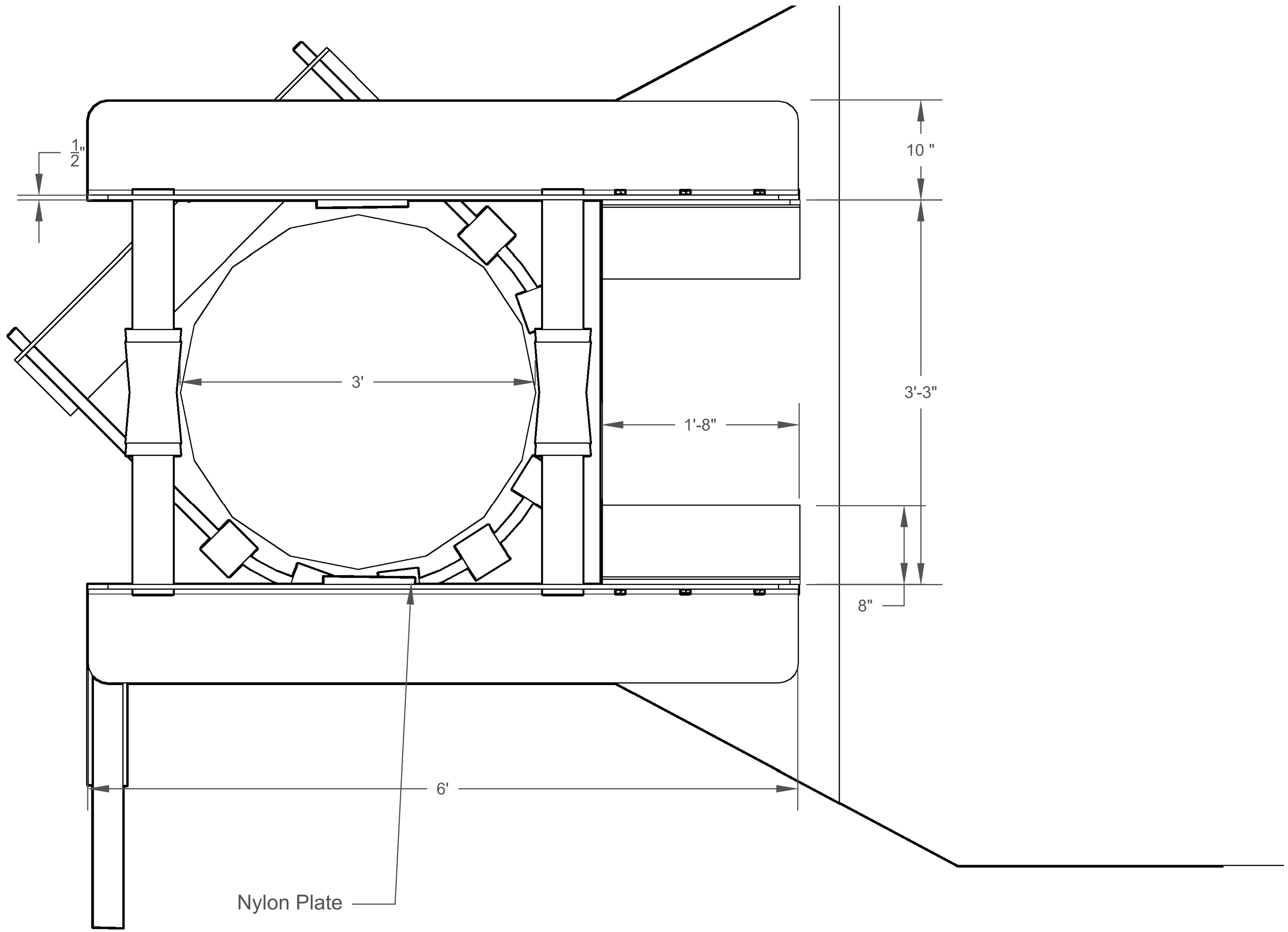
Clear Fork Trinity River
Trash Wheel
Piling Connection

Date 9/23/2021 | 1" = 1' | Page 13 of 20



Clearwater Mills, LLC.
4965 Mountain Road
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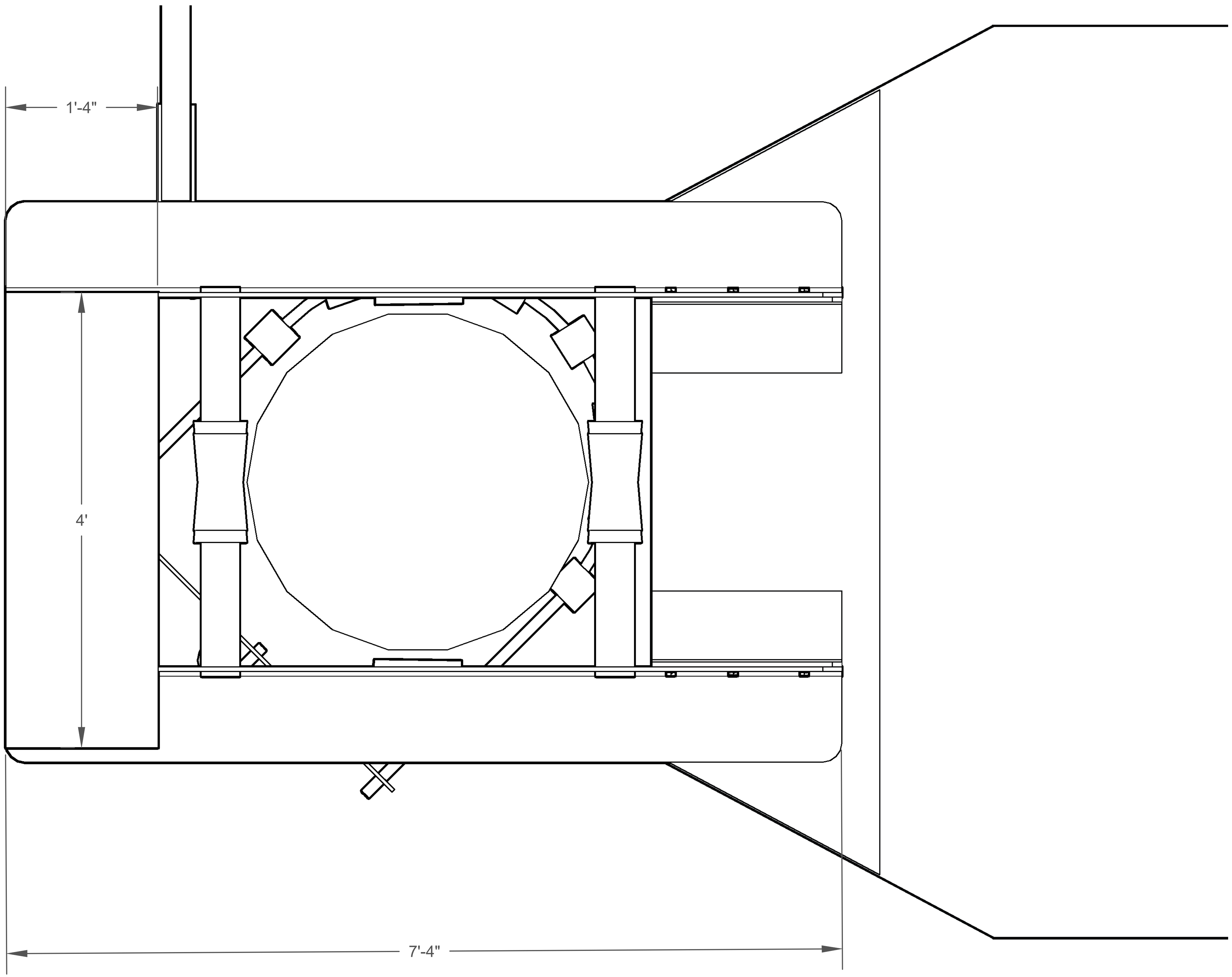
West Fork Trinity River
Trash Wheel
Starboard Piling Connection

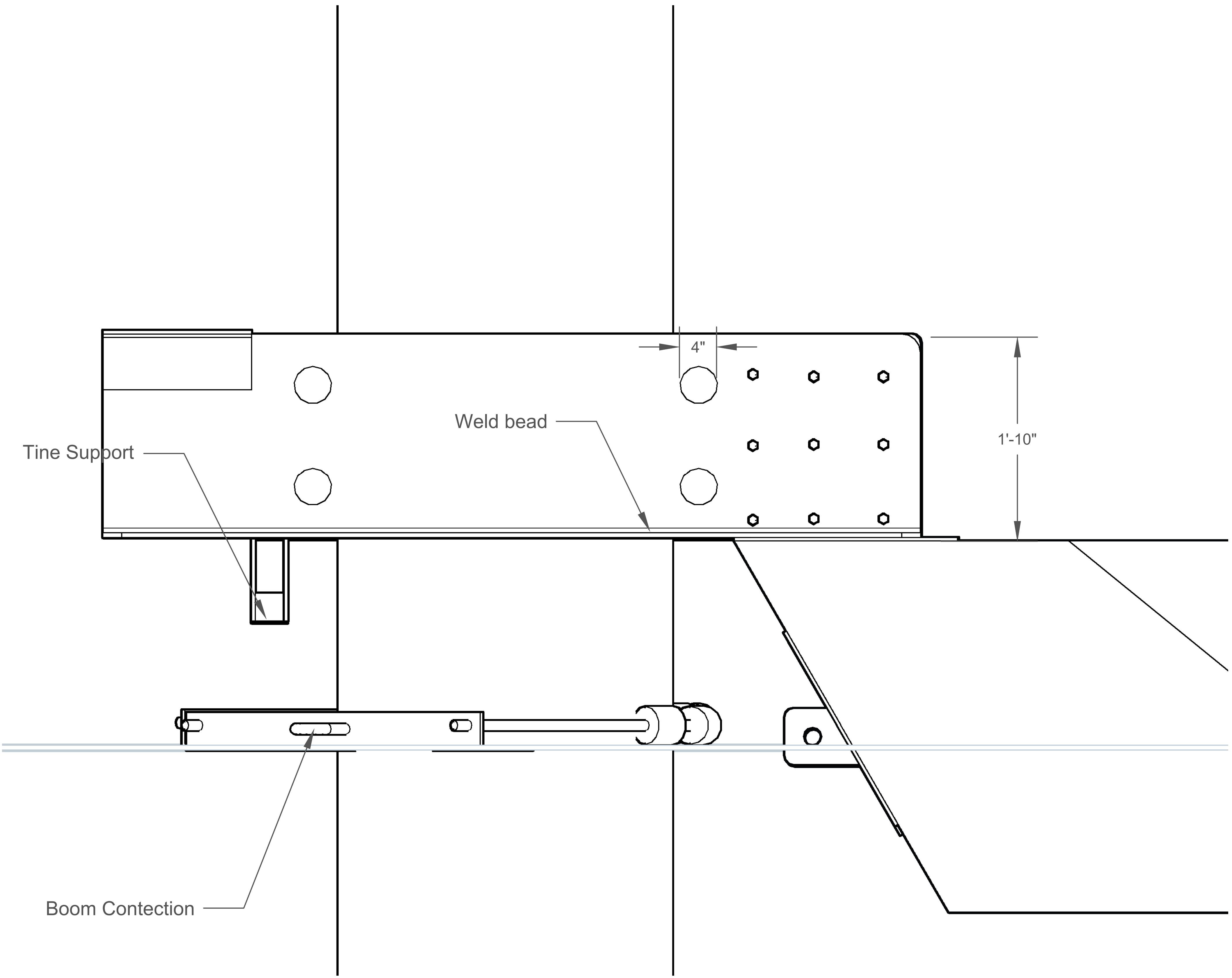
Date 6/30/2022 | 1" = 1' | Page 14 of 20



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Port Piling Connection

Date 6/30/2022 | 1" = 1' | Page 15 of 20



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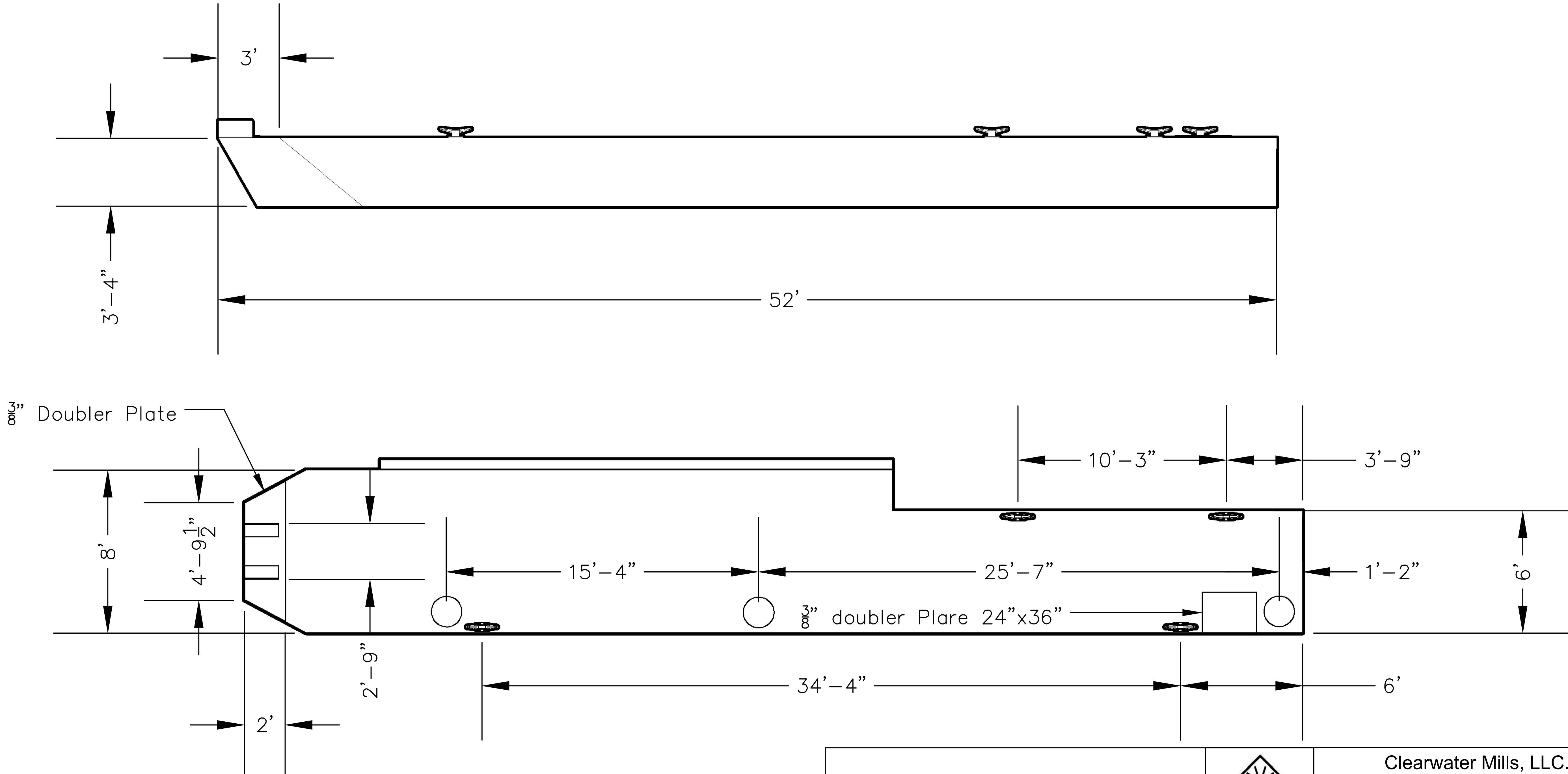
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Piling Connection

Date 6/30/2022 | 1" = 1' |



Clearwater Mills, LLC.
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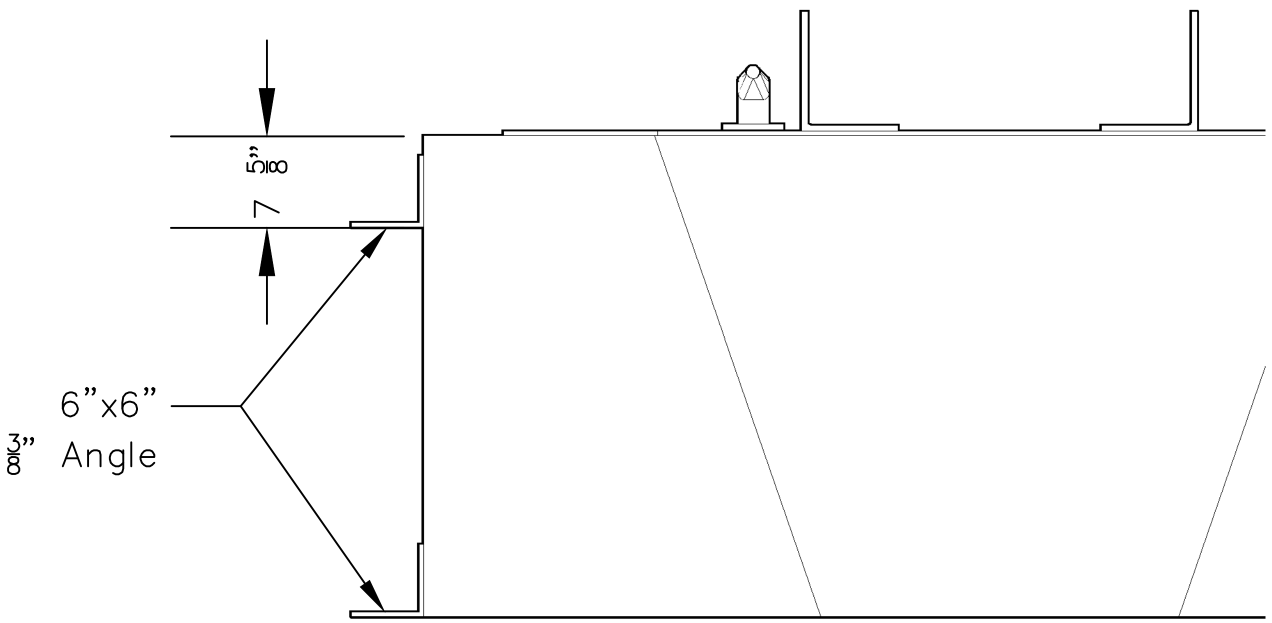
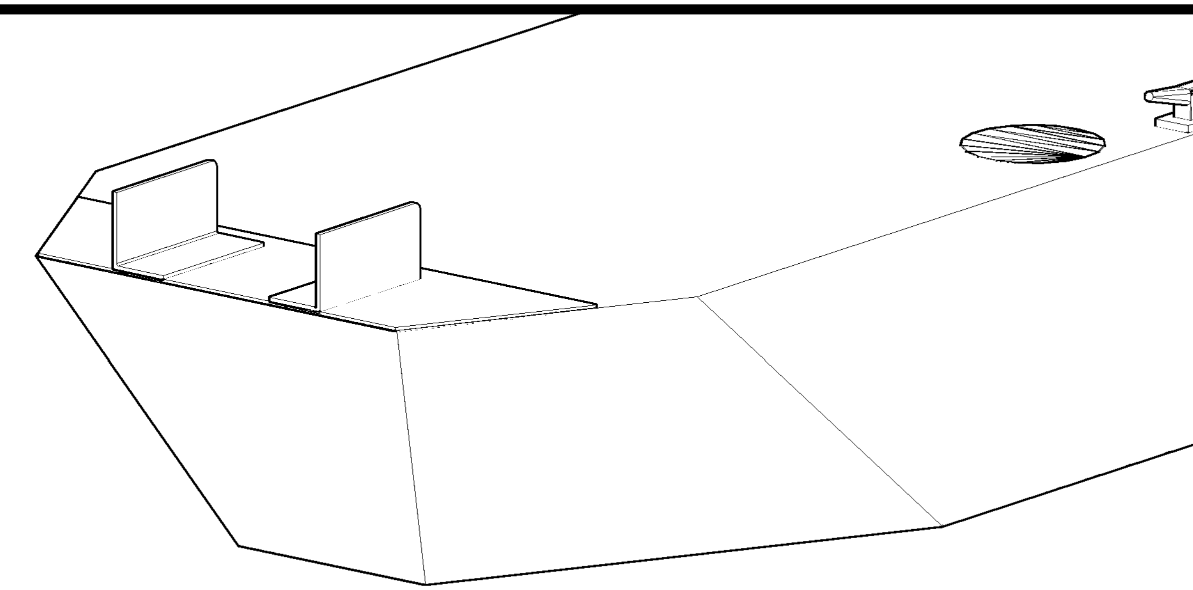
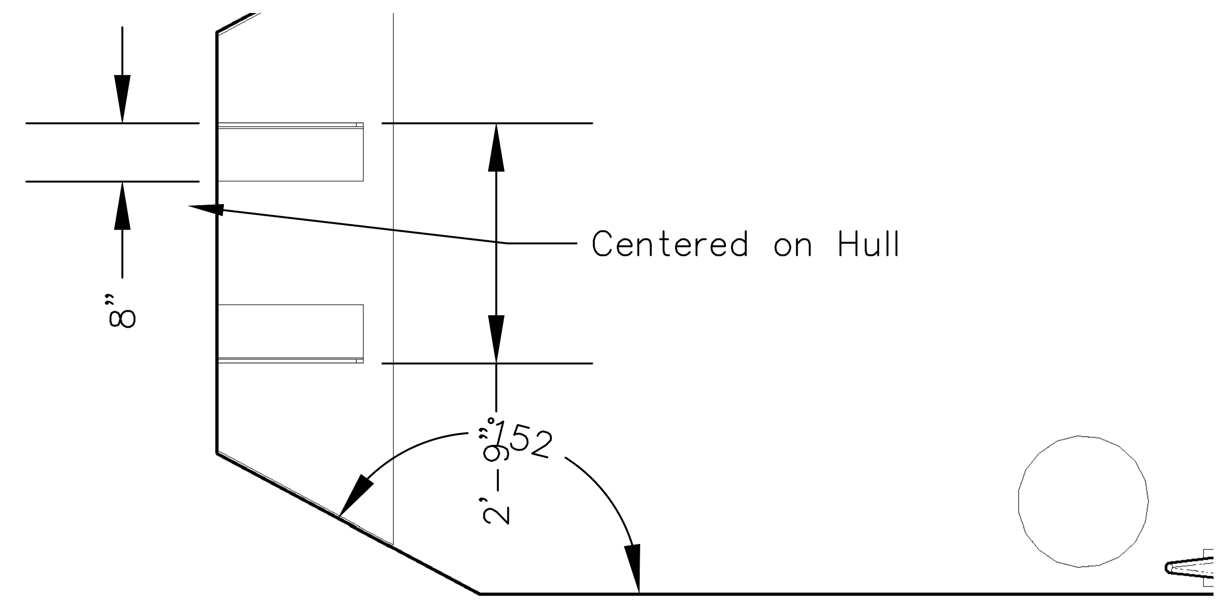
Pasadena, MD 21122

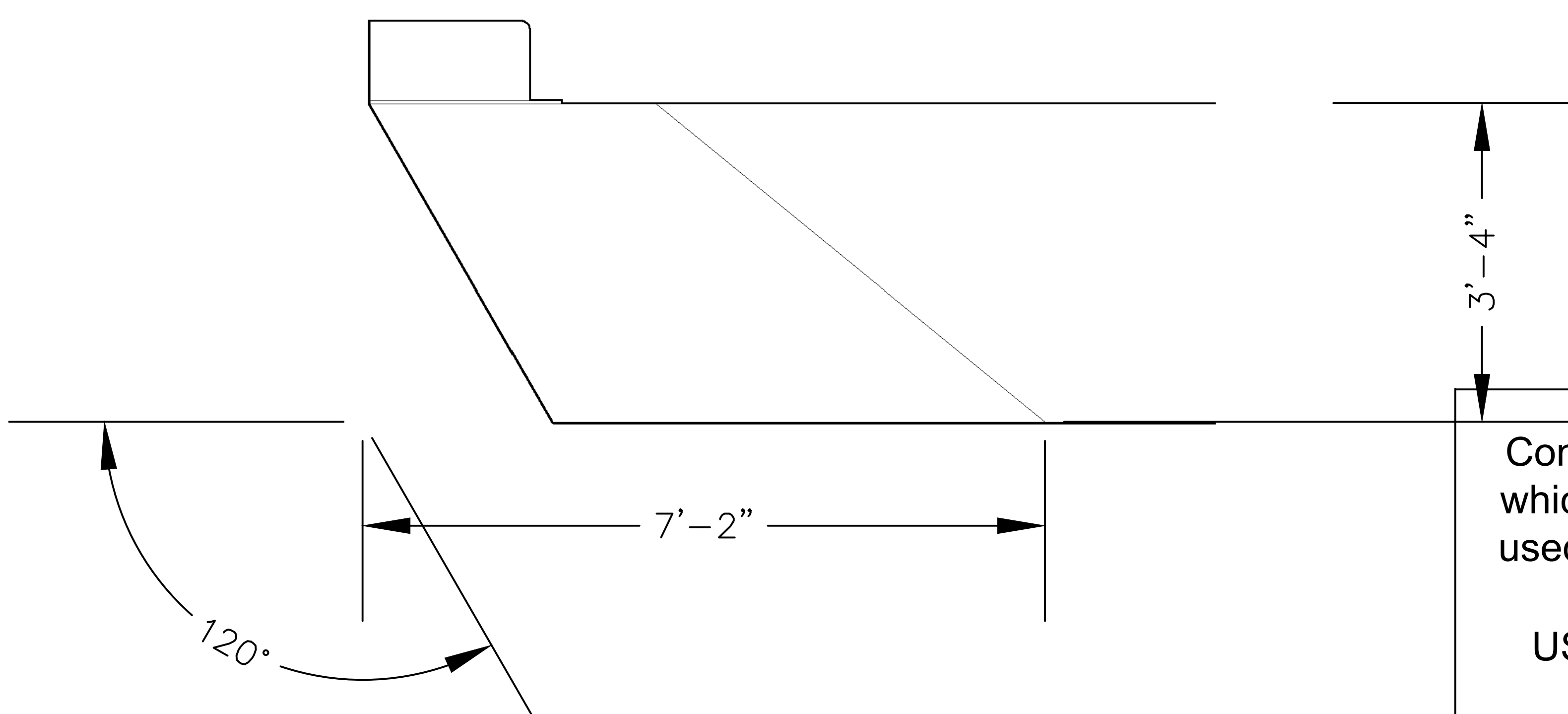
Fort Worth
Hull Design

12/1/2021 3/16" = 1'









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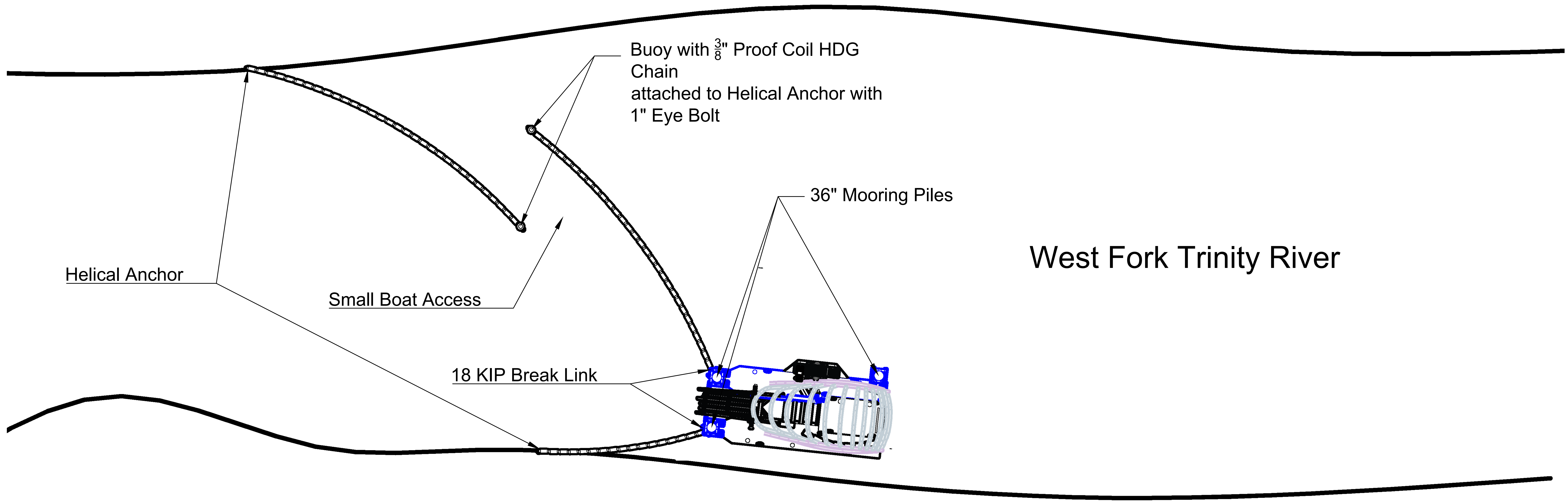
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



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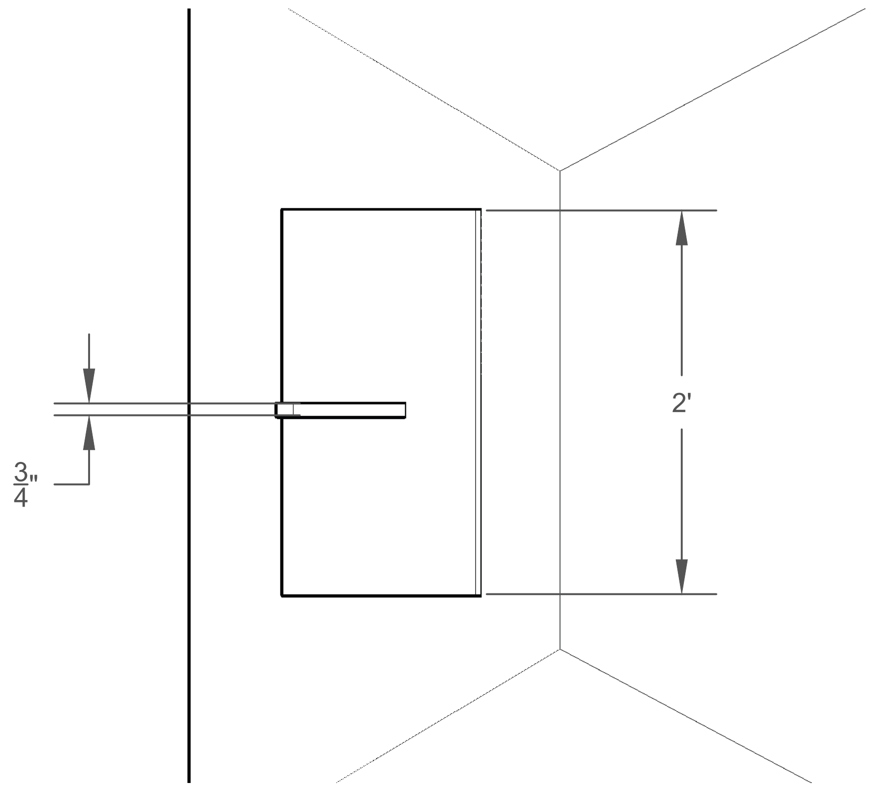
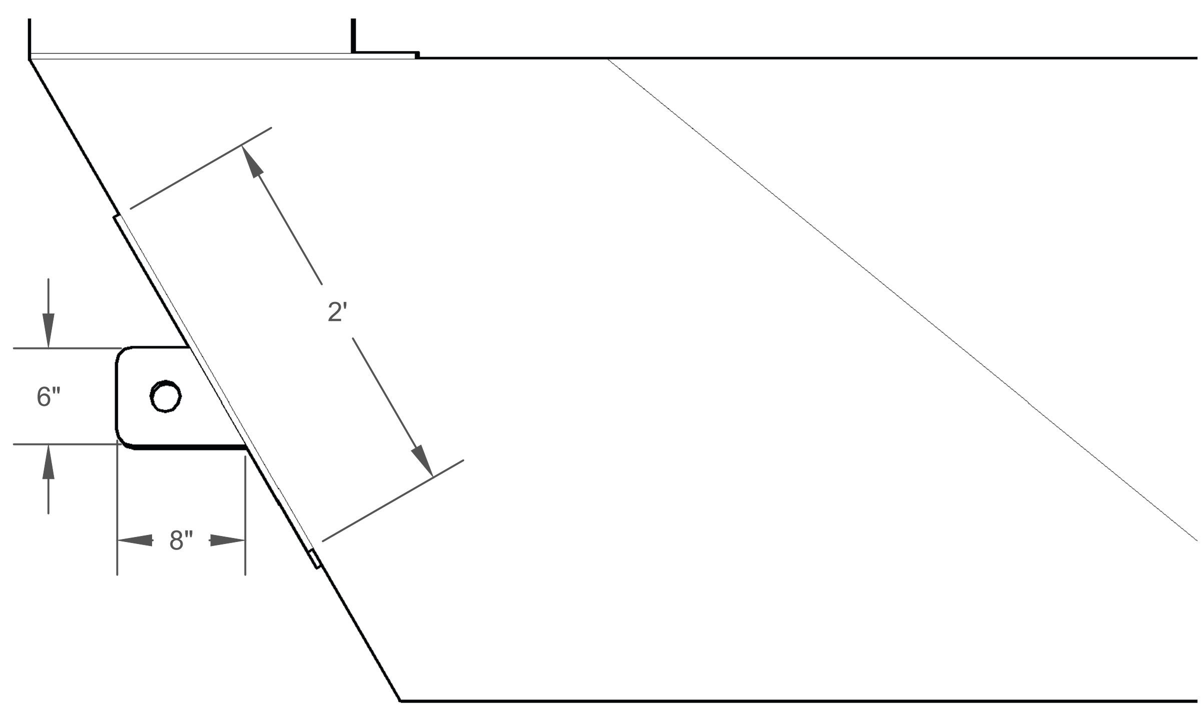
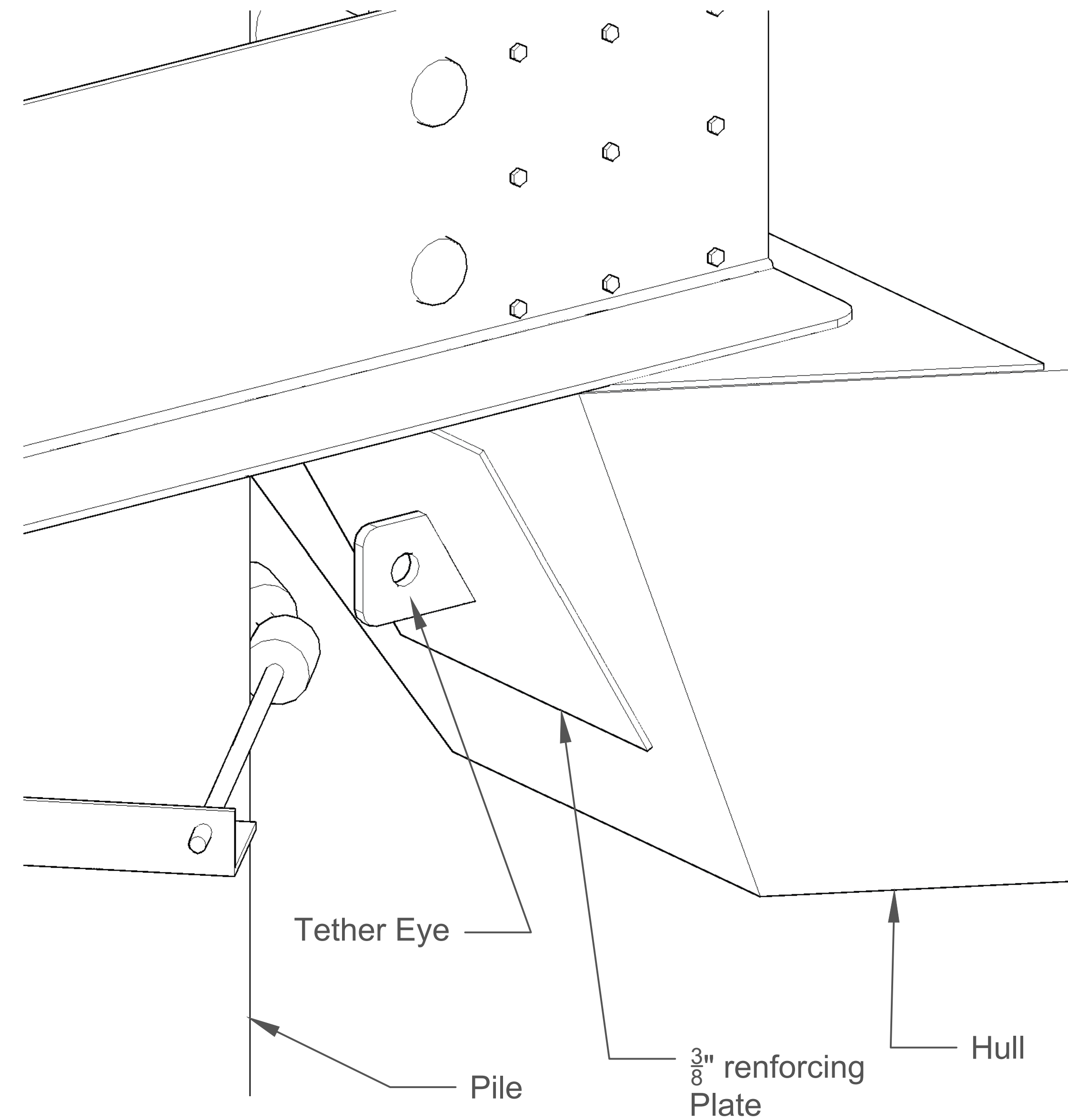
West Fork Trinity River Trash Wheel Site Plan

SIZE	DWG NO.	REV
	Page 19 of 20	
SCALE	SHEET	







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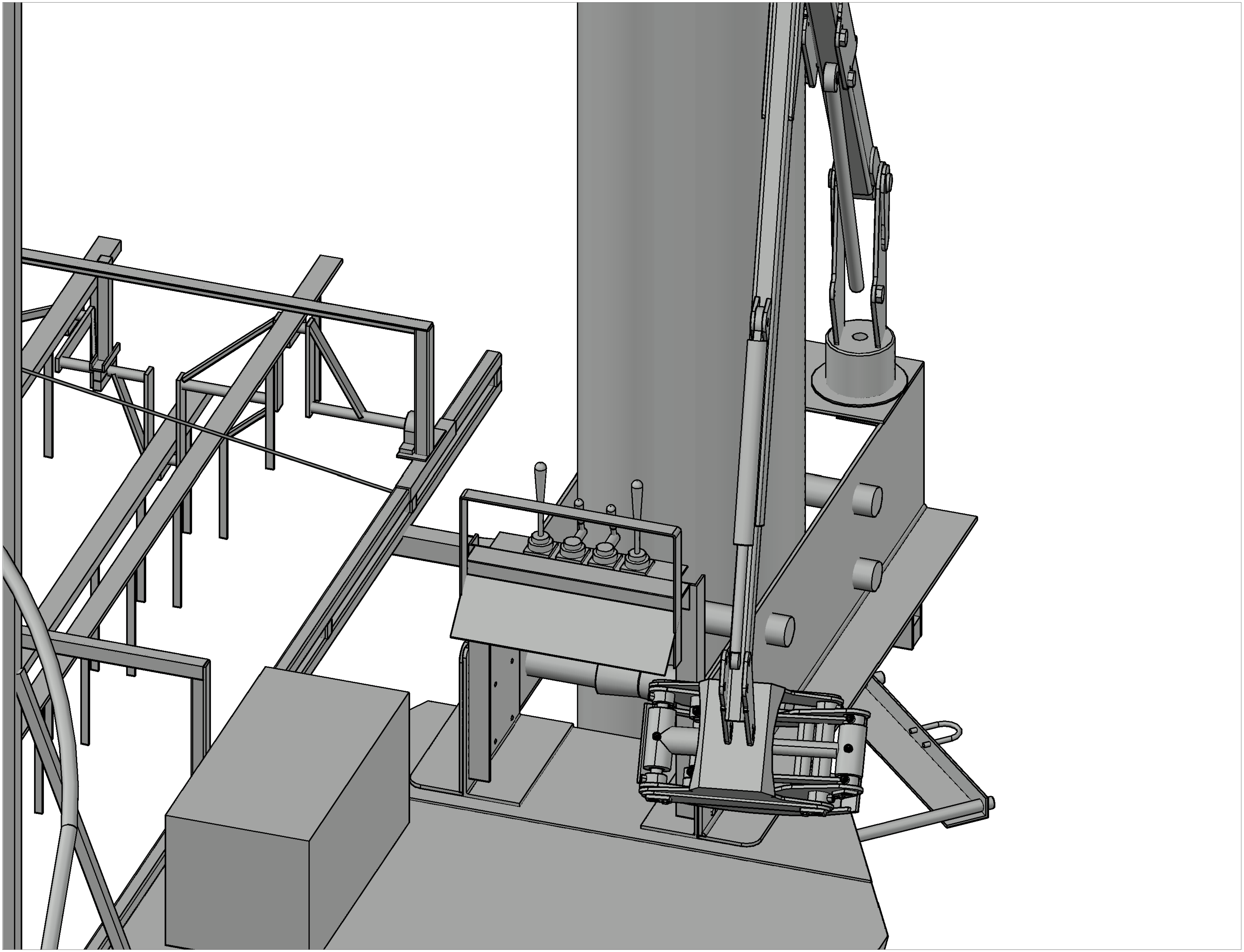
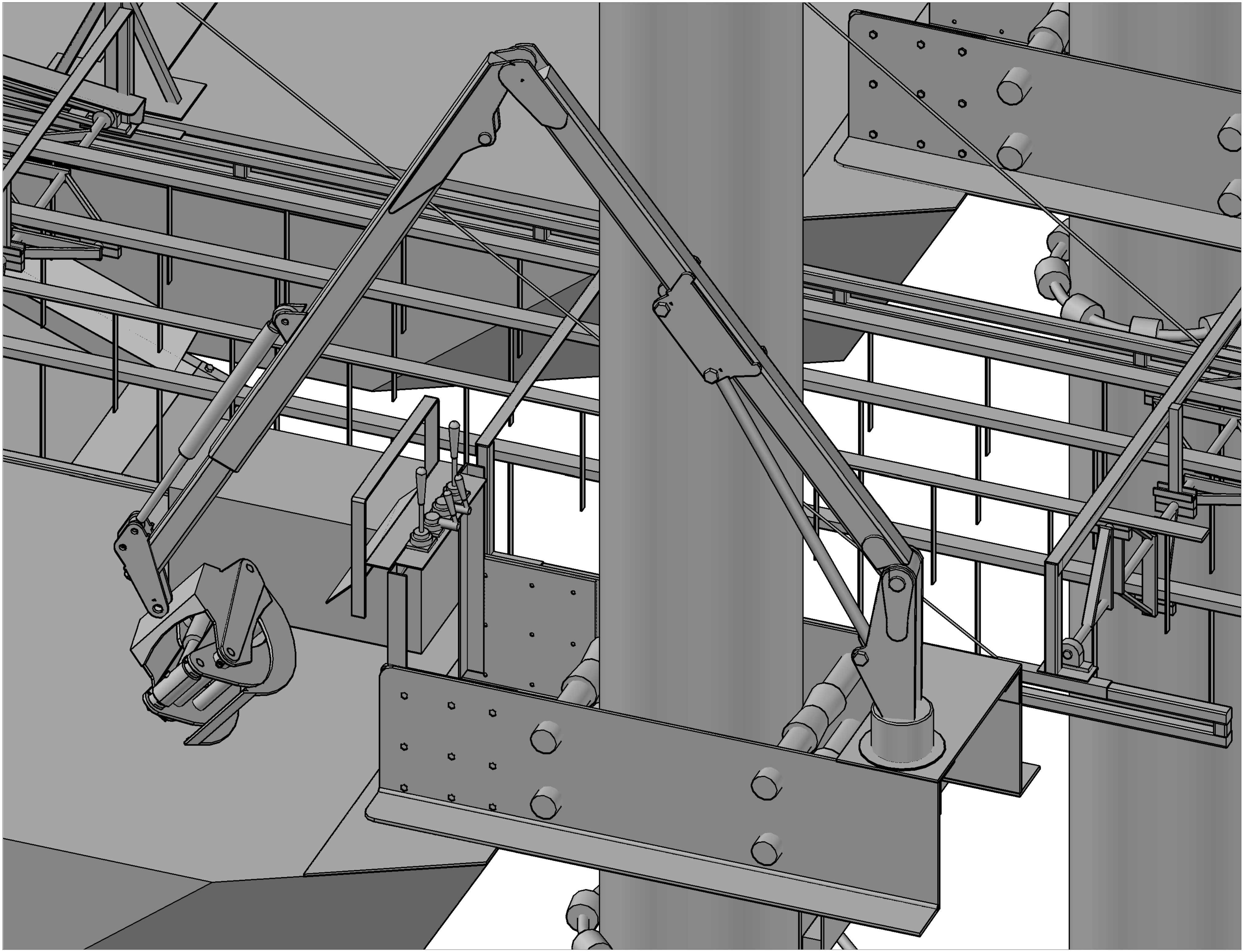
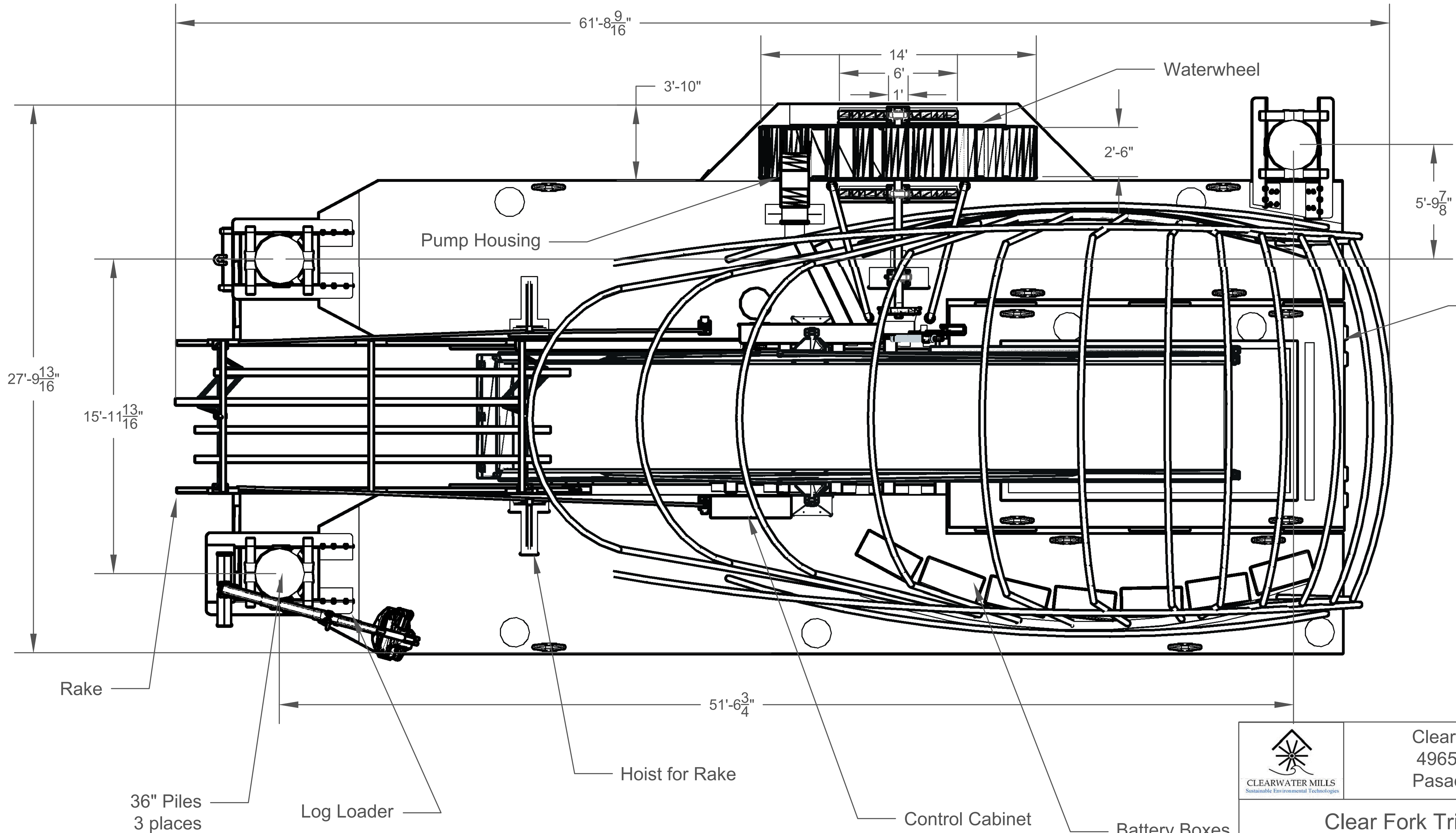
4965 Mountain Road
Pasadena, MD 21122

West Fork Trinity River
Trash Wheel
Tether Connection

Date 6/30/2022	1" = 1'	Page 20 of 20







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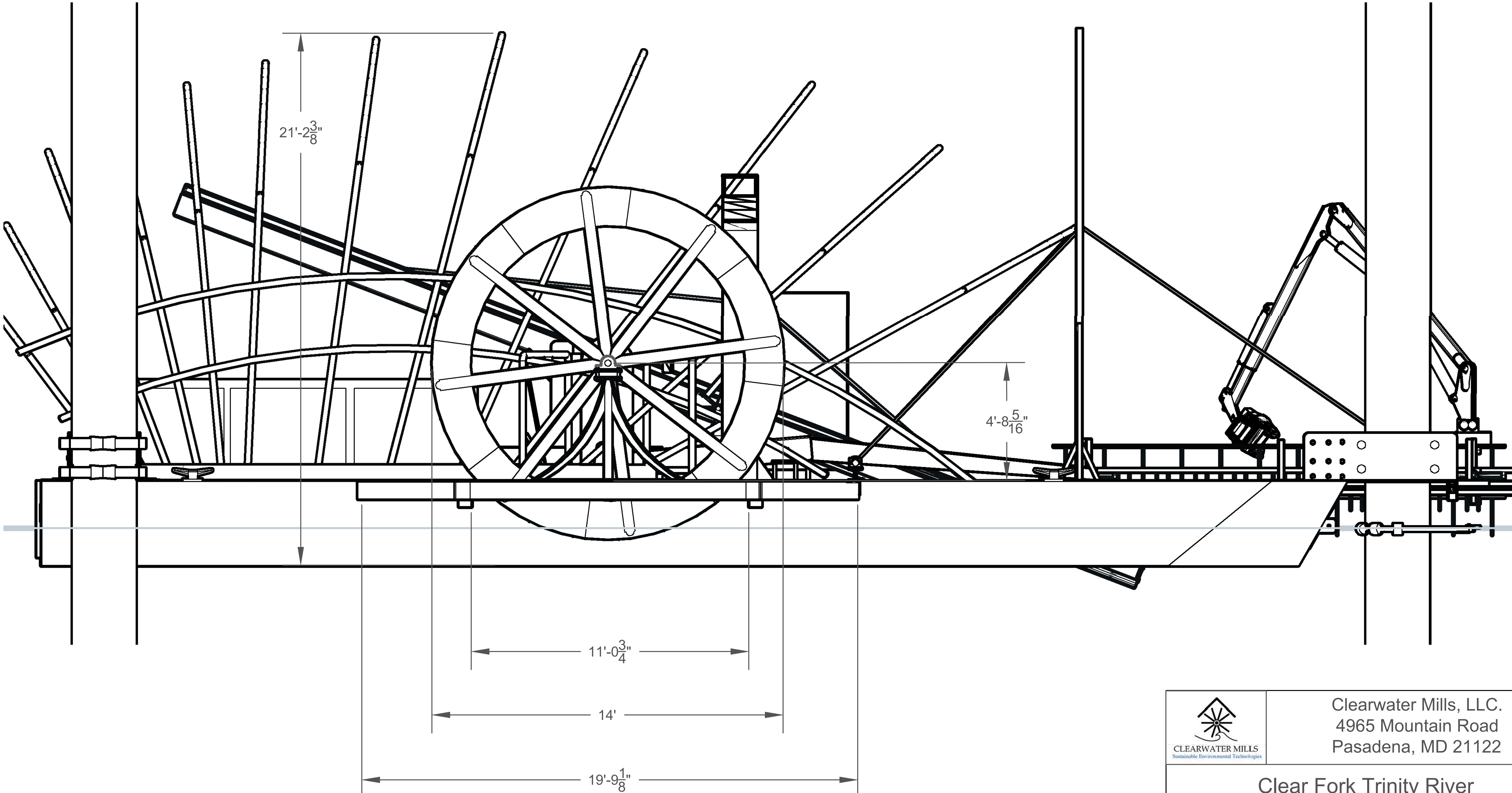
CLEARWATER MILLS
Sustainable Environmental Technologies

Clear Fork Trinity River
Trash Wheel
Plan View

Date 9/9/2022 3/16" = 1'



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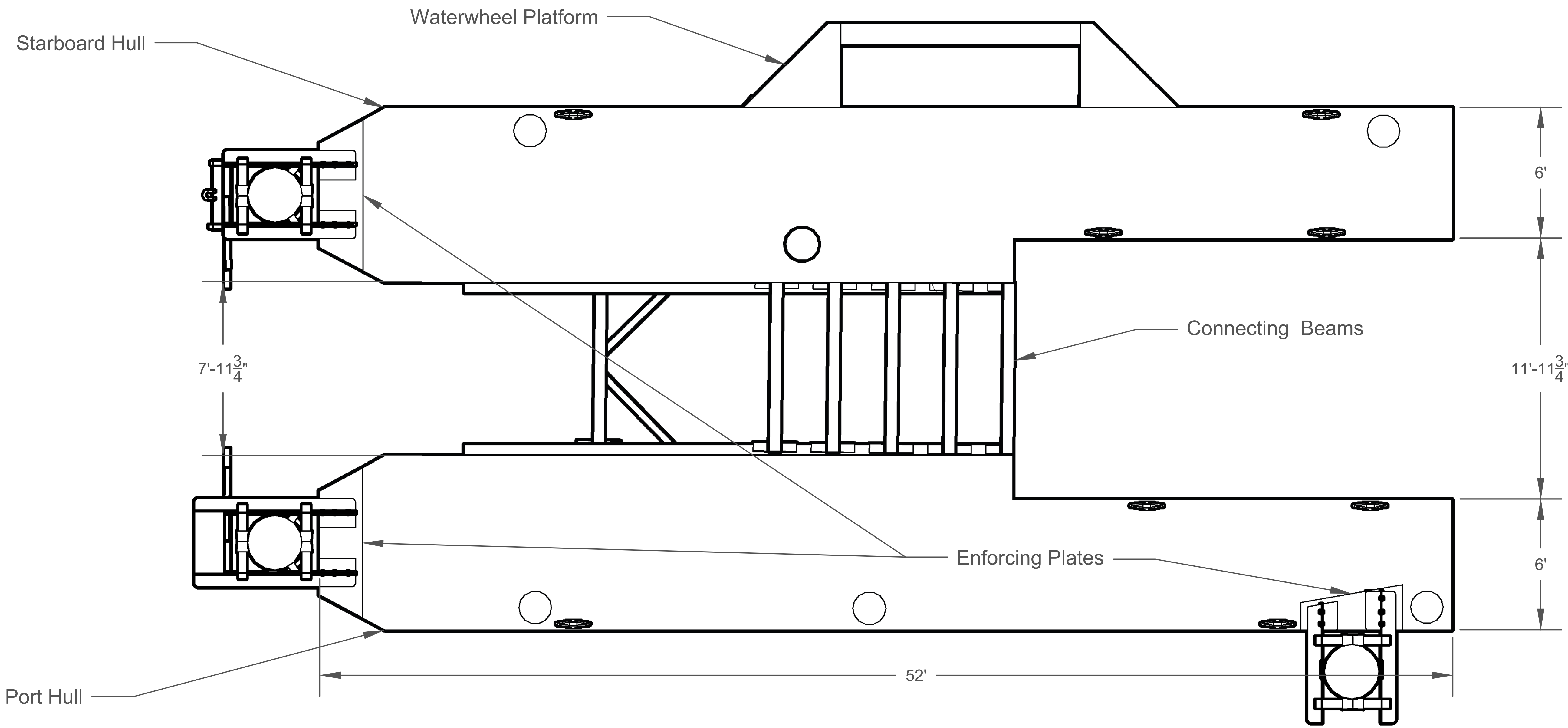
Sustainable Environmental Technologies

Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Elevation

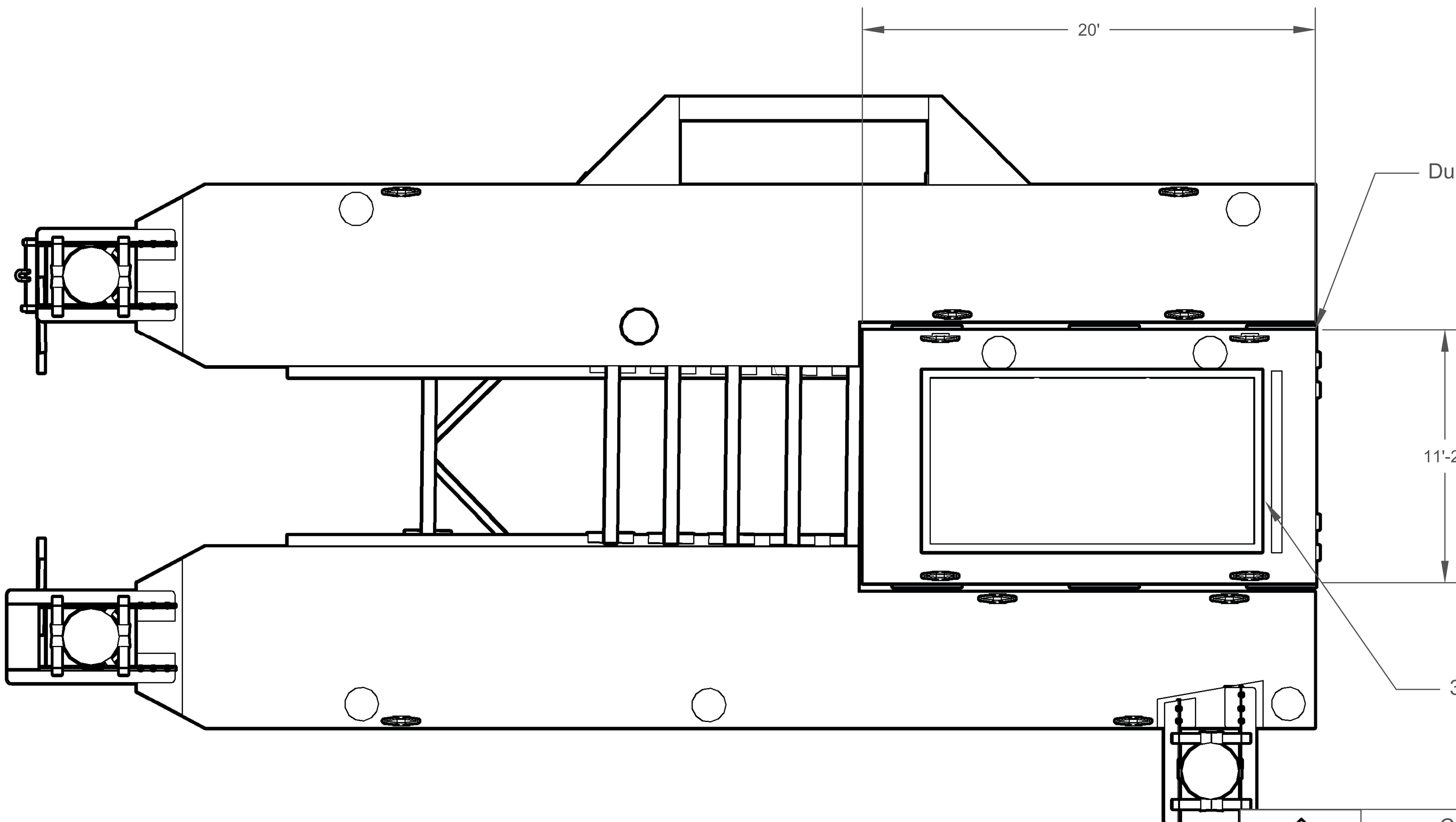
Date 9/9/2022 | 1/4" = 1' | Page 2 of 17



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Hull Layout

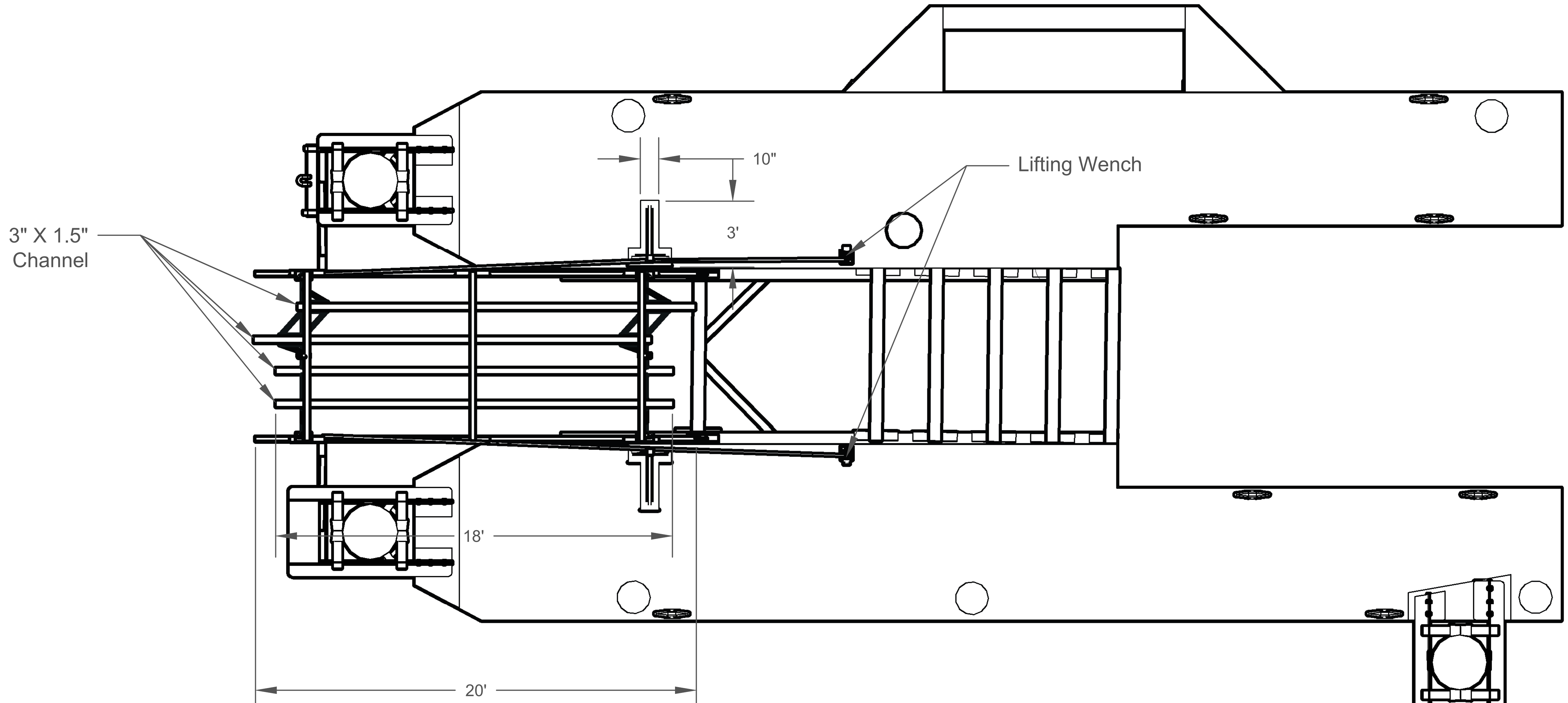
Date 6/30/2022 | 3/16" = 1'



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Dumpster Barge

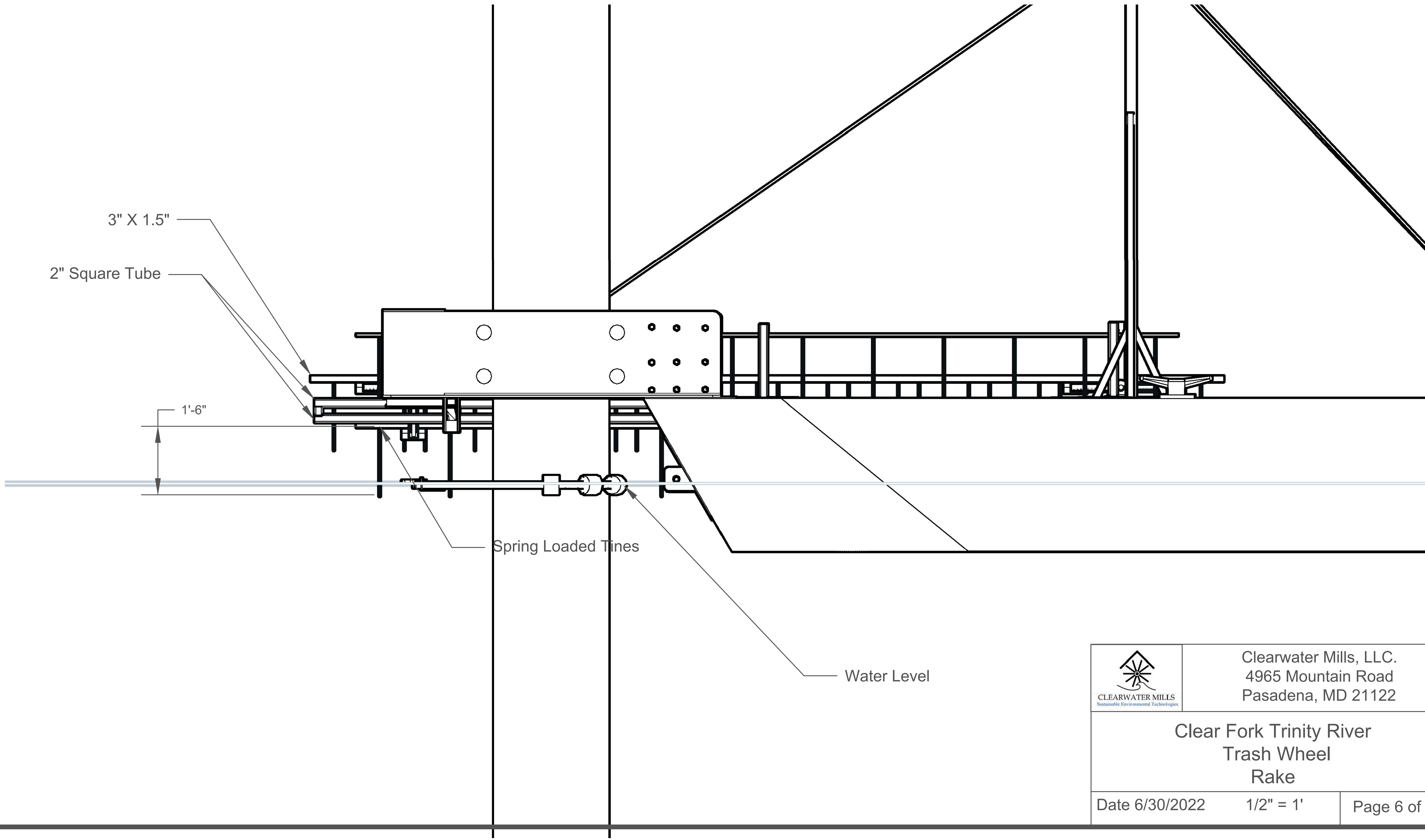
Date 6/30/2022 3/16" = 1'



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Rake

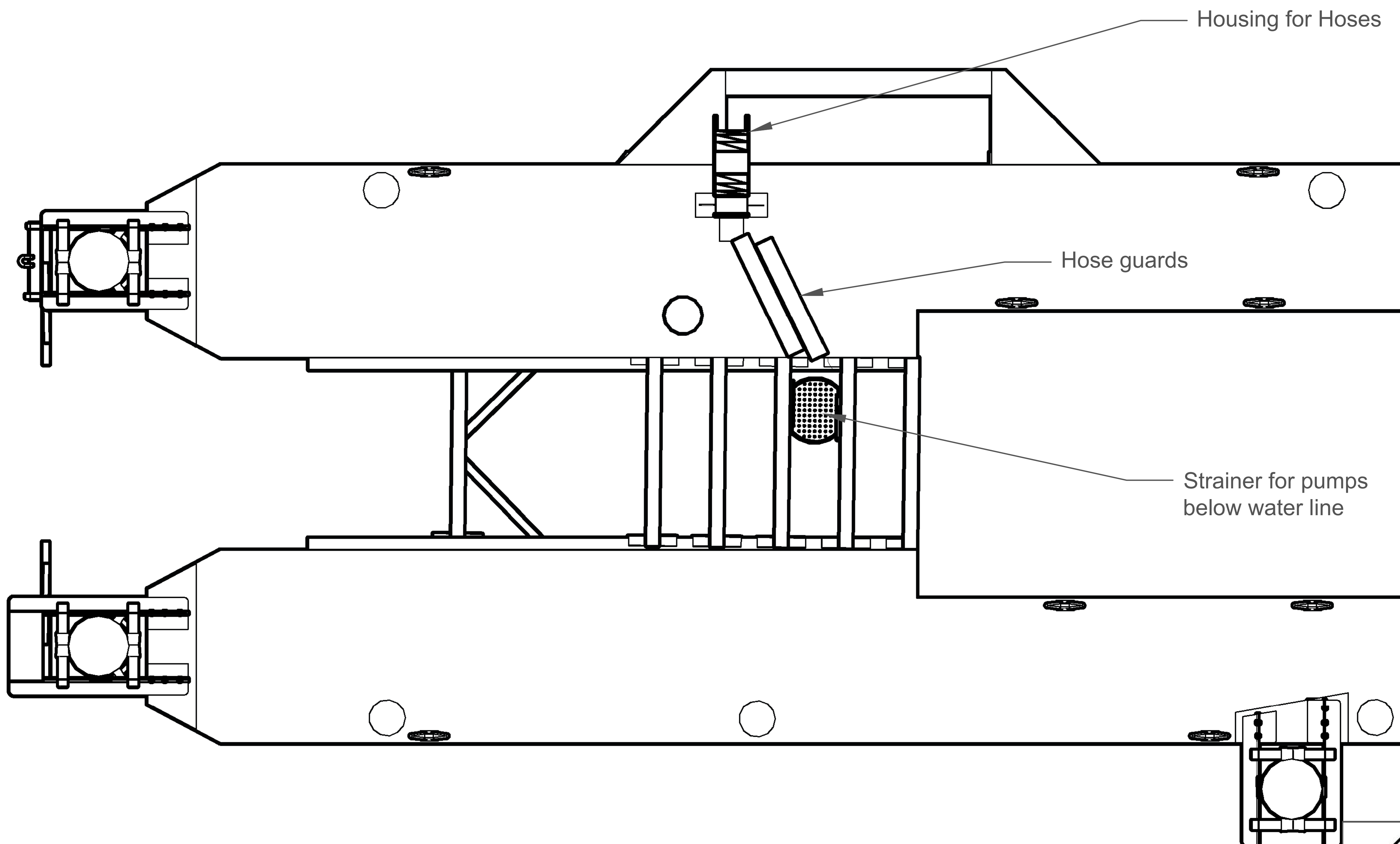
Date 6/30/2022 3/16" = 1'



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Rake

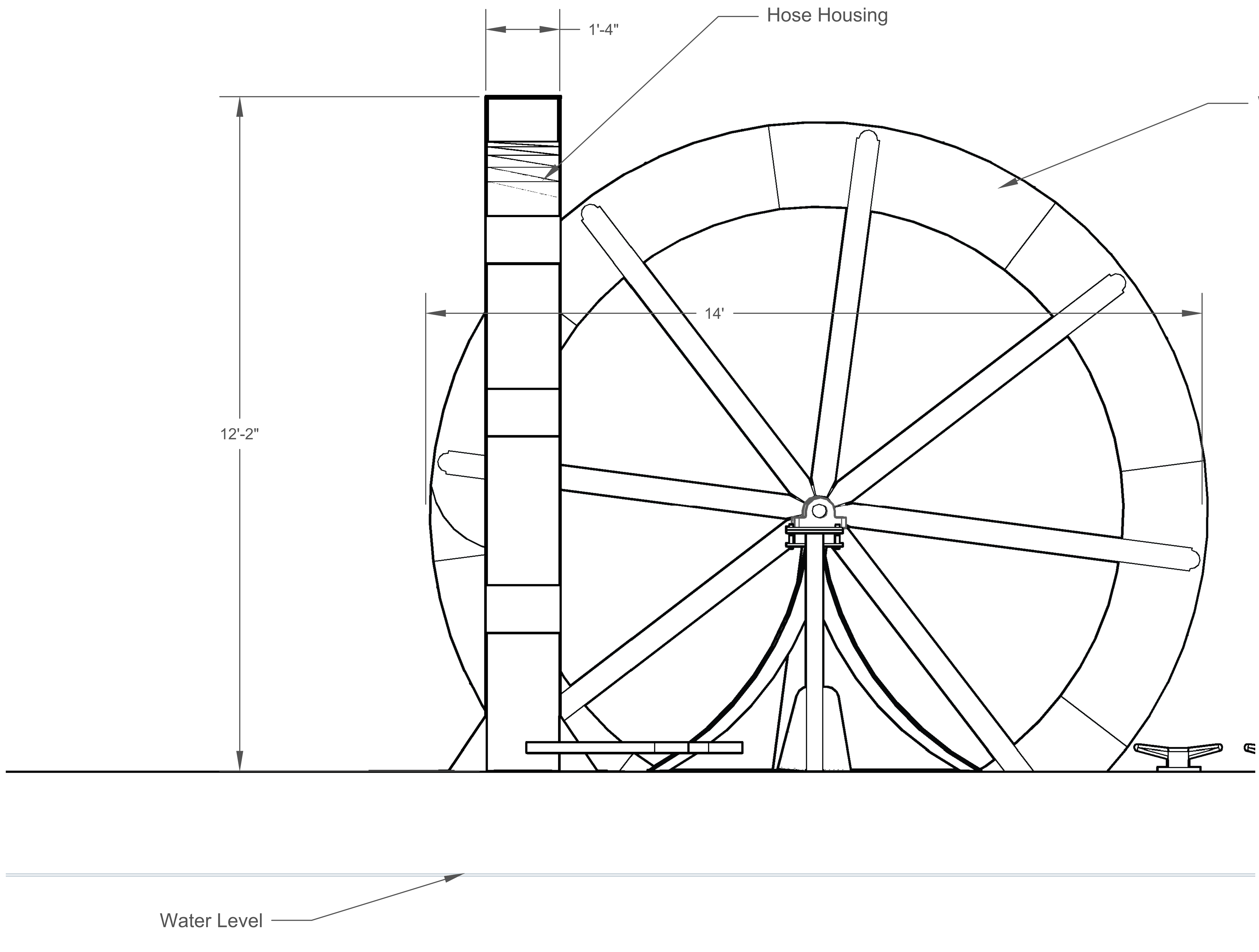
Date 6/30/2022 | 1/2" = 1' | Page 6 of 17



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Pump System

Date 6/30/2022 3/16" = 1'



CLEARWATER MILLS
Sustainable Environmental Technologies

Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Pump System

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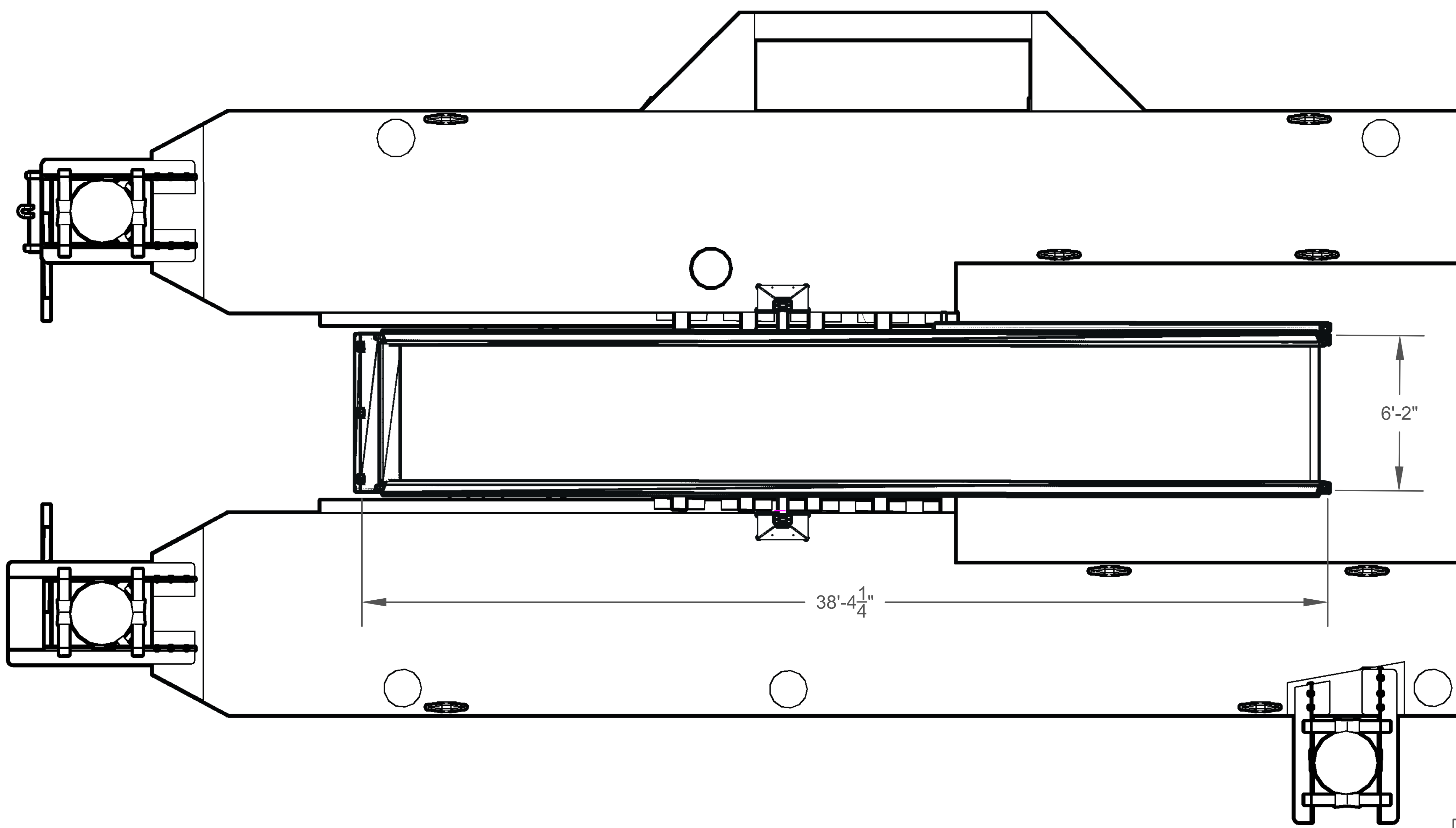
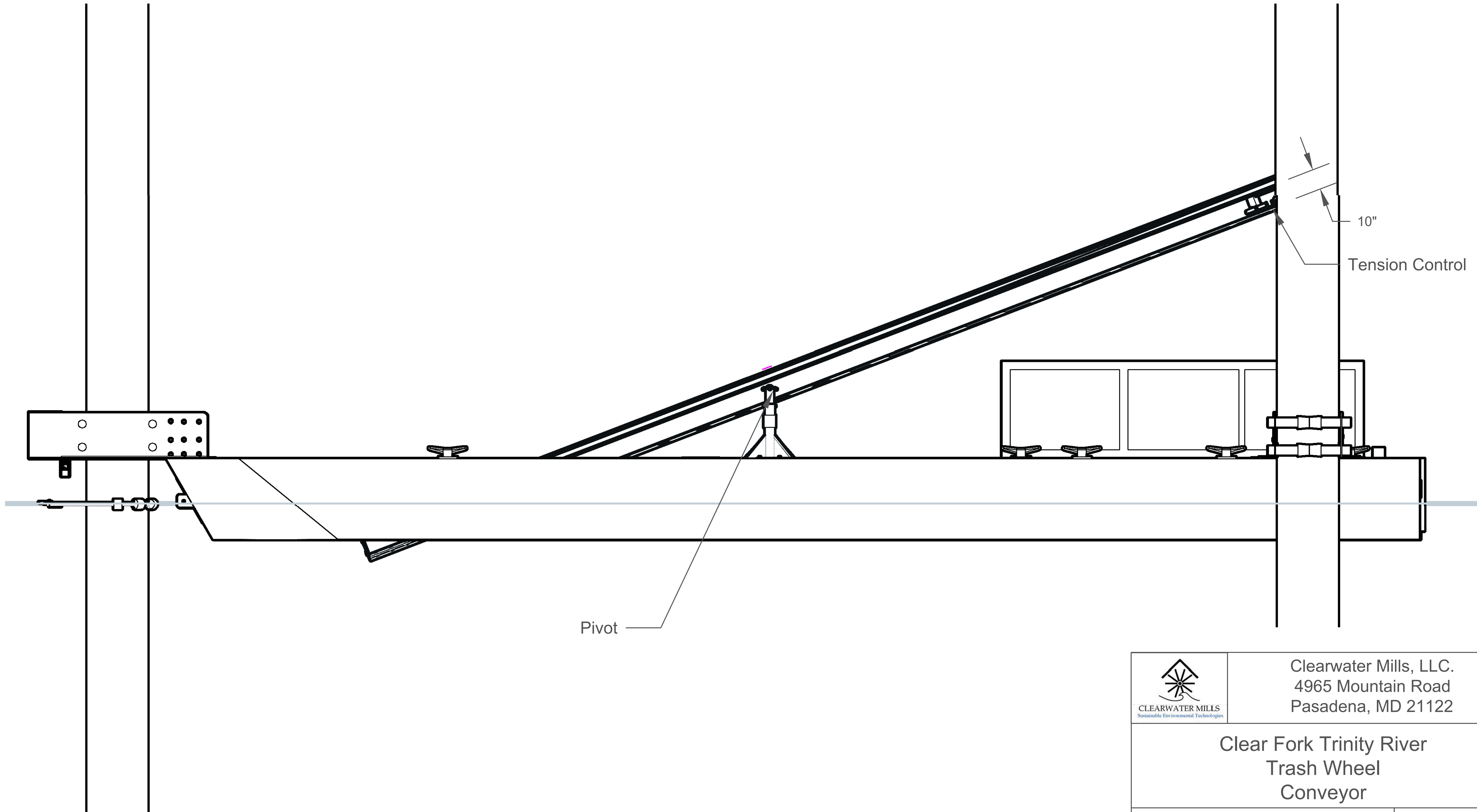


Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Conveyor

Date 6/30/2022	3/16" = 1'	Page 9 of 17



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Conveyor

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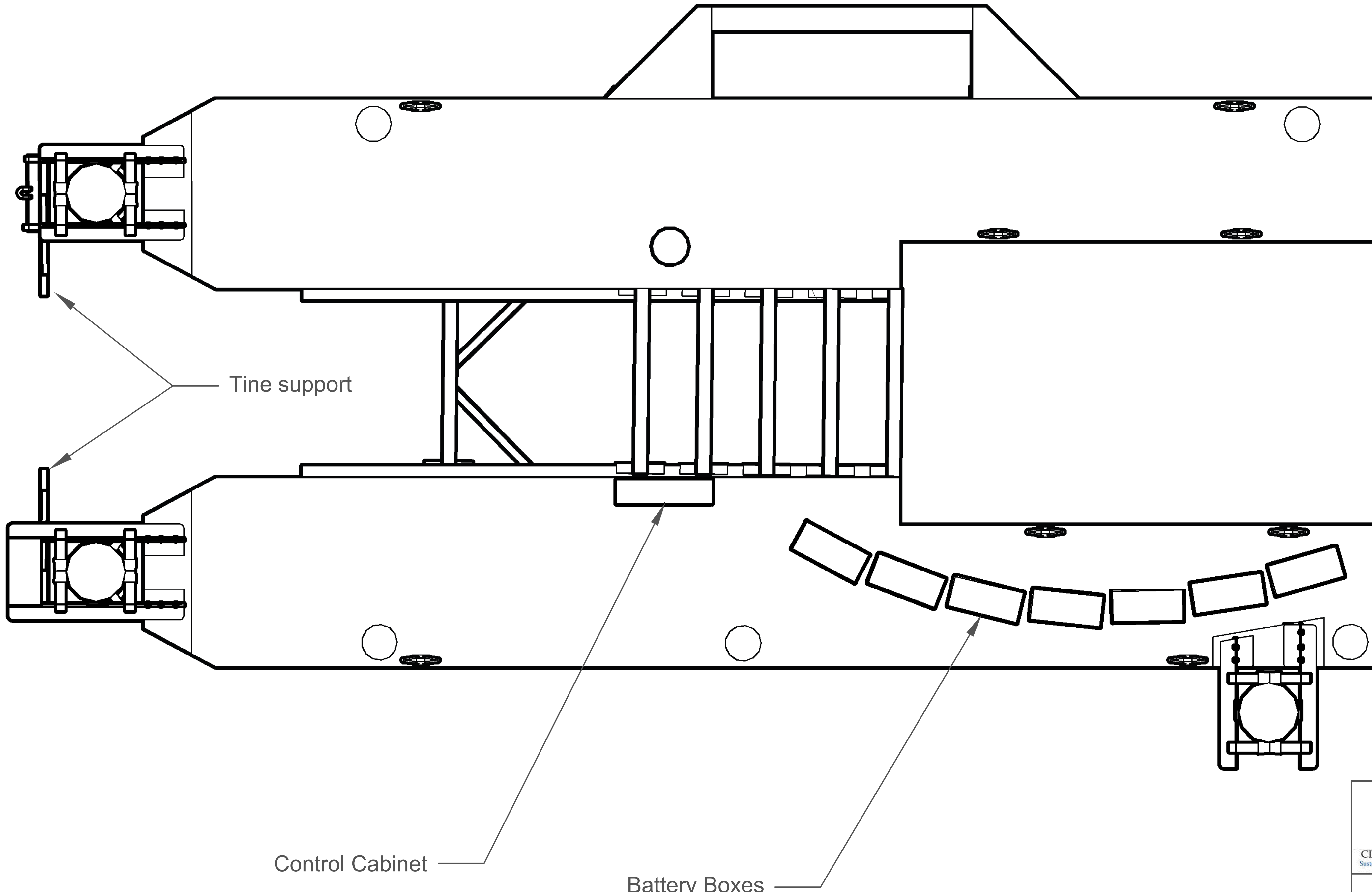

CLEARWATER MILLS
Sustainable Environmental Technologies
Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Electronics

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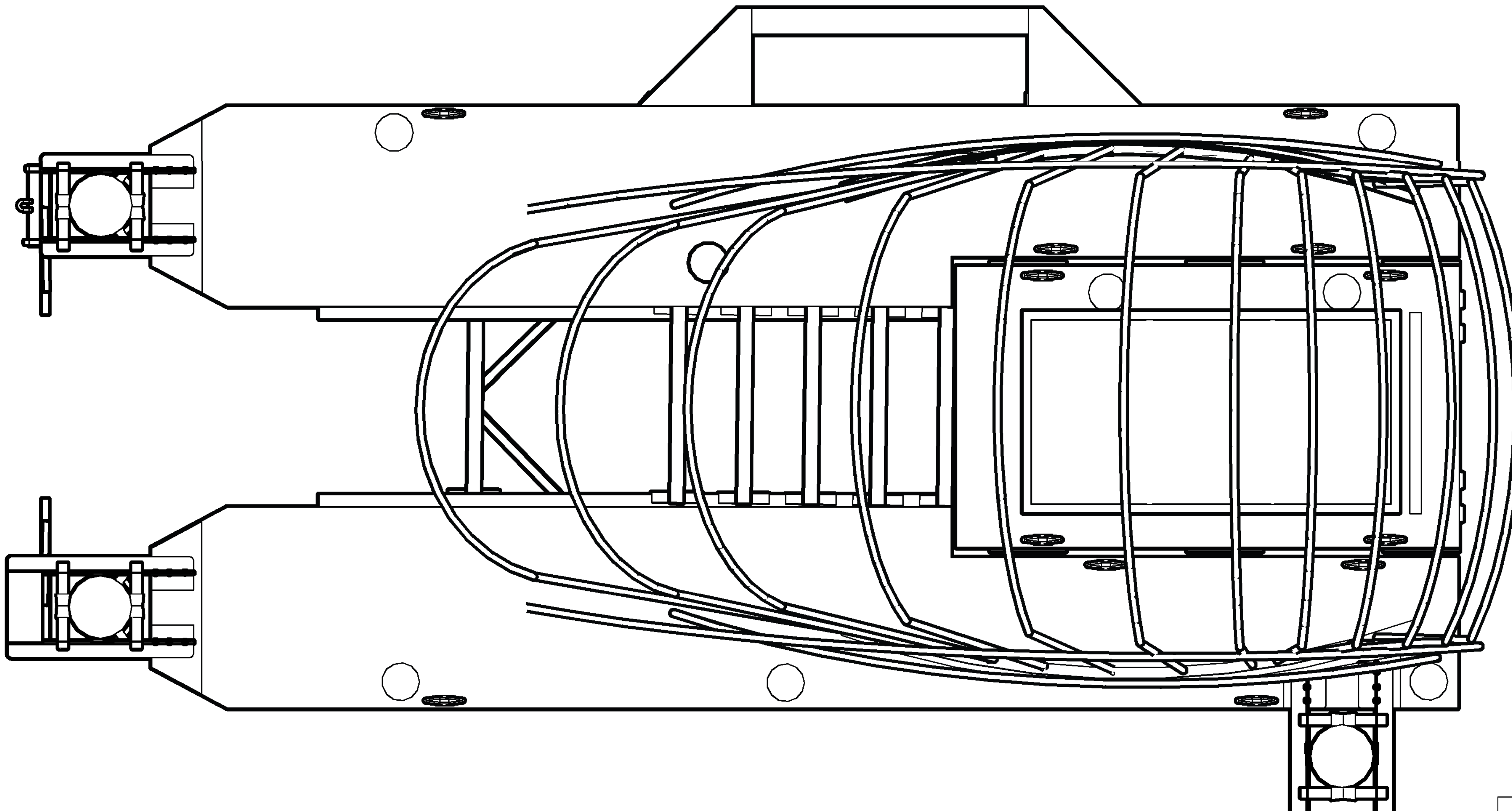
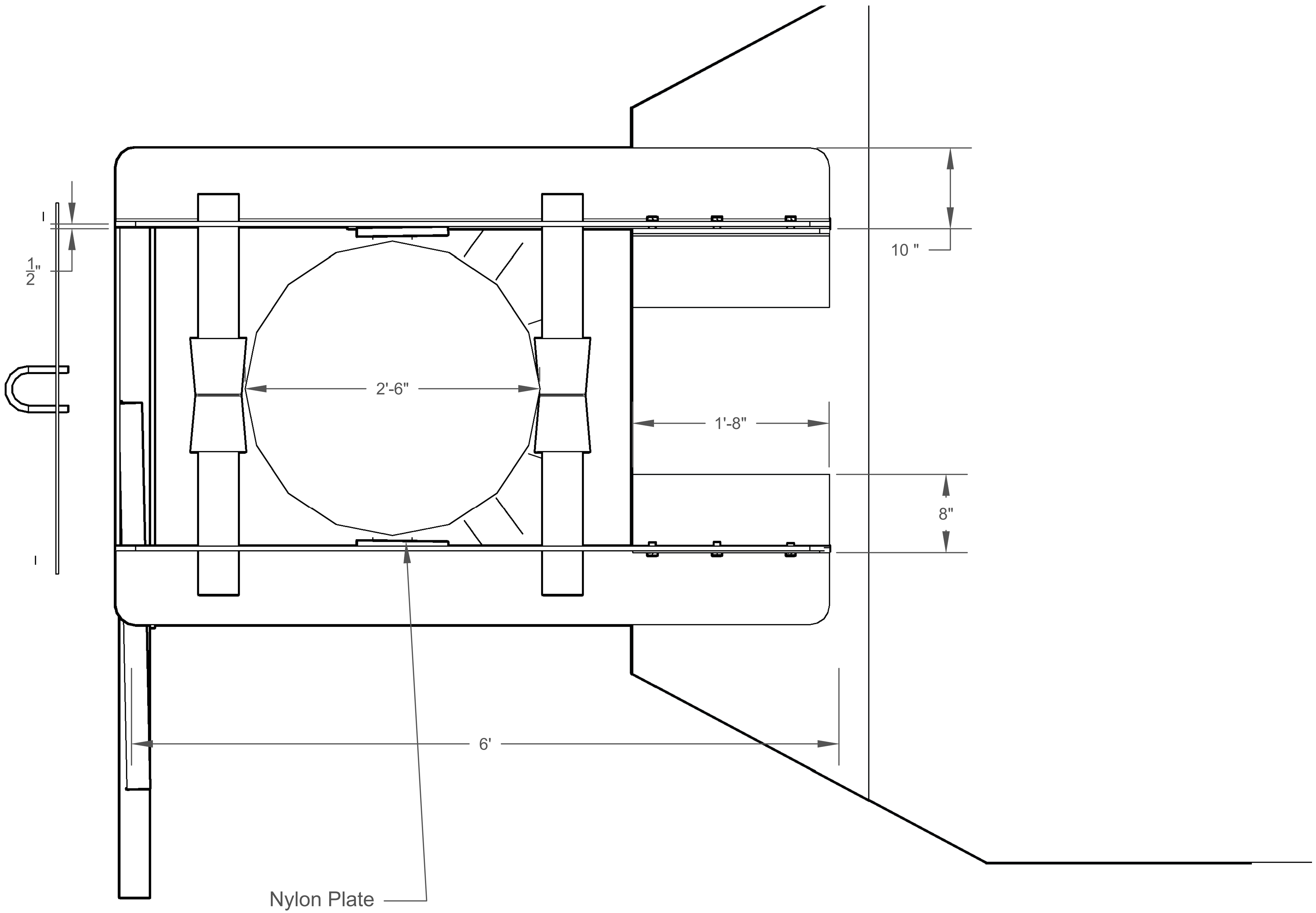


CLEARWATER MILLS
Sustainable Environmental Technologies

Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Cover Frame

Date 6/30/2022	3/16" = 1'	Page 12 of 17

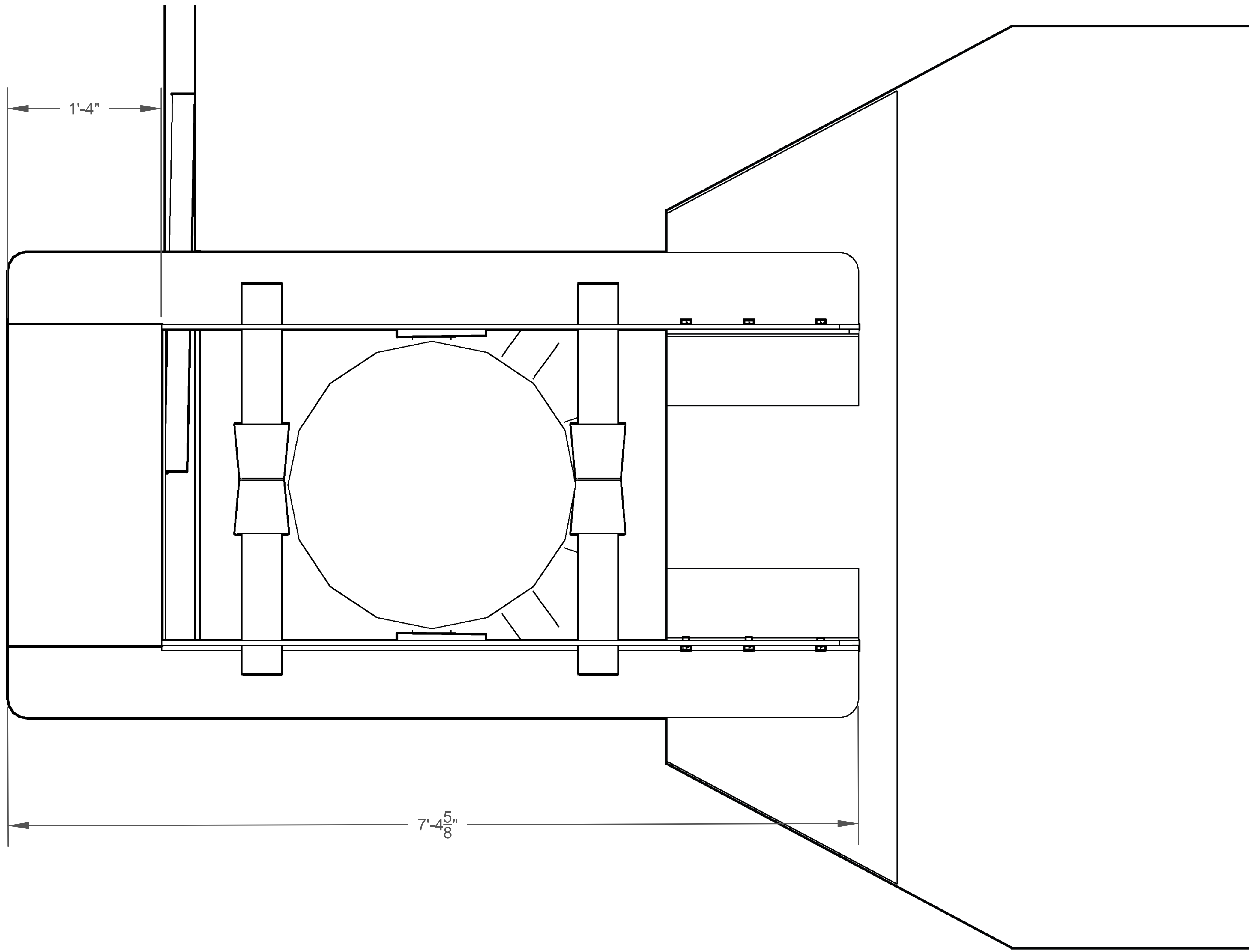


CLEARWATER MILLS
Sustainable Environmental Technologies

Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Starboard Piling Connection

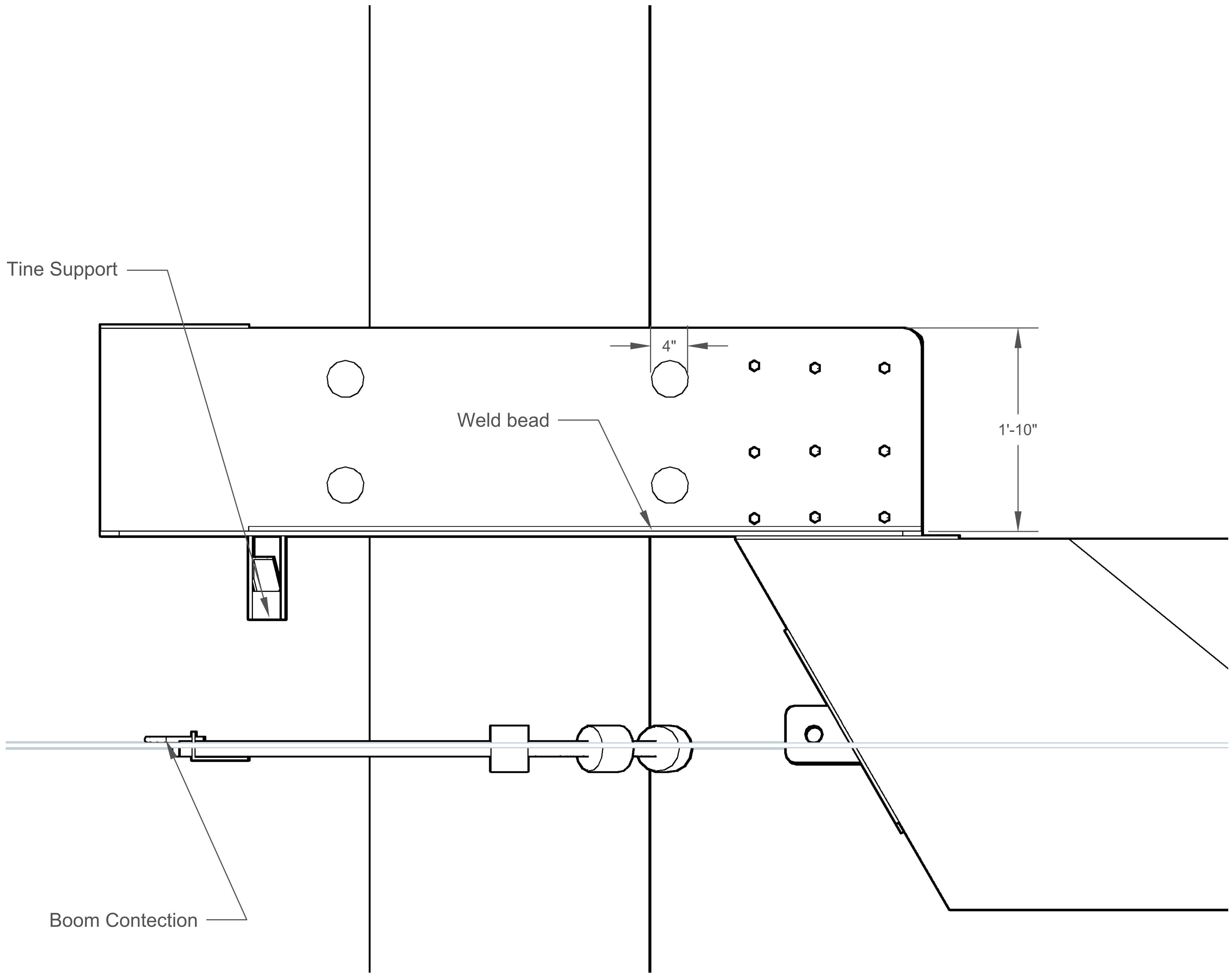
Date 6/30/2022	1" = 1'	Page 13 of 17



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Port Piling Connection

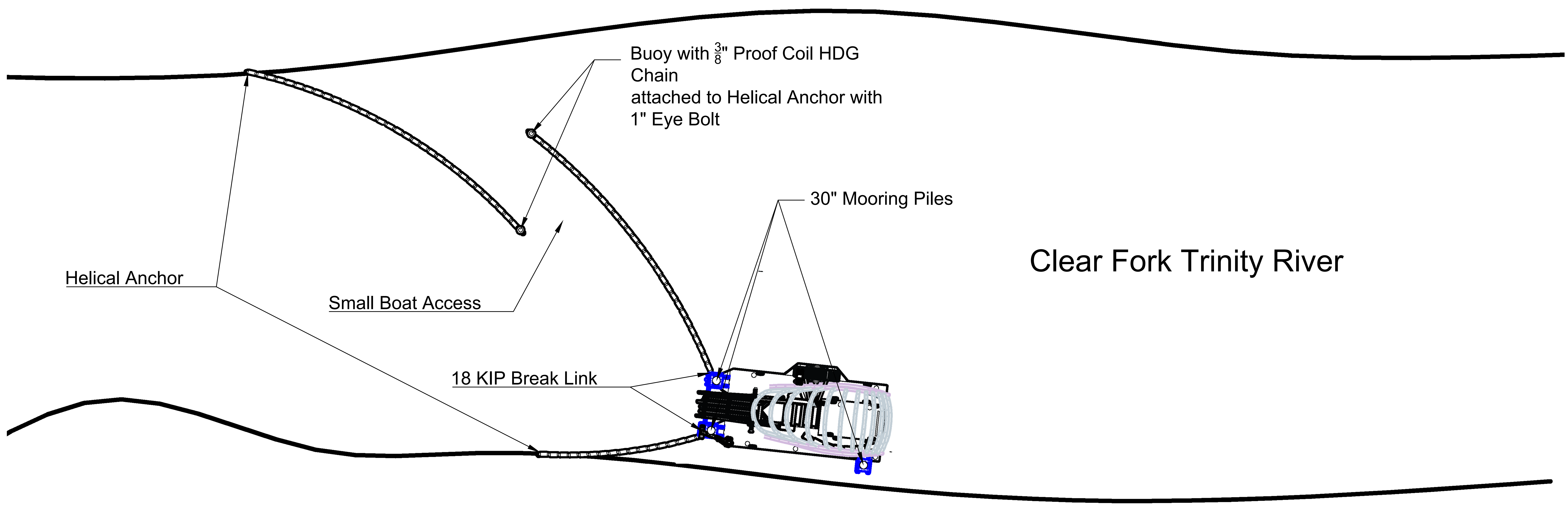
Date 6/30/2022 1" = 1'



Clearwater Mills, LLC.
4965 Mountain Road
Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Piling Connection

Date 6/30/2022 1" = 1'

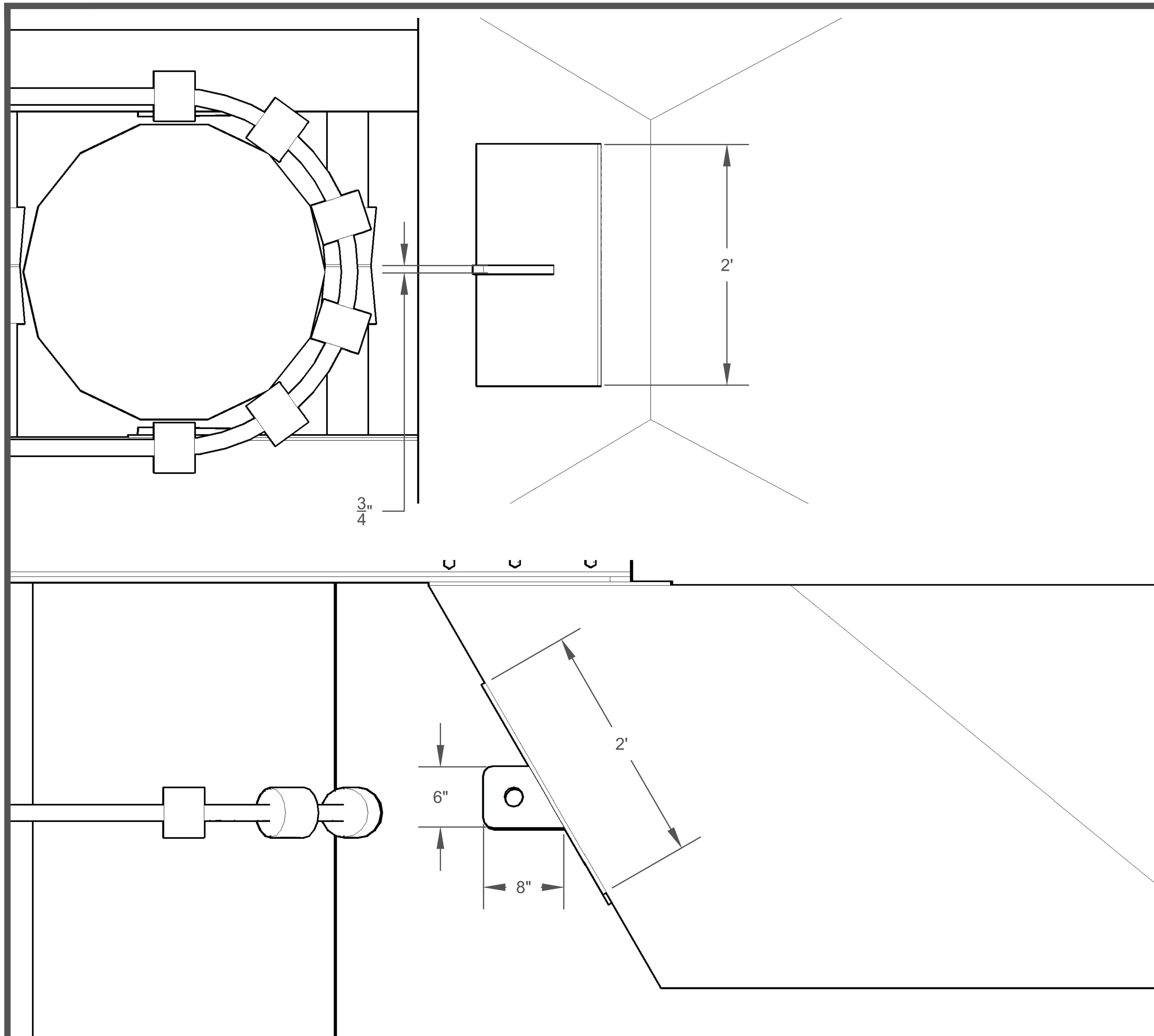


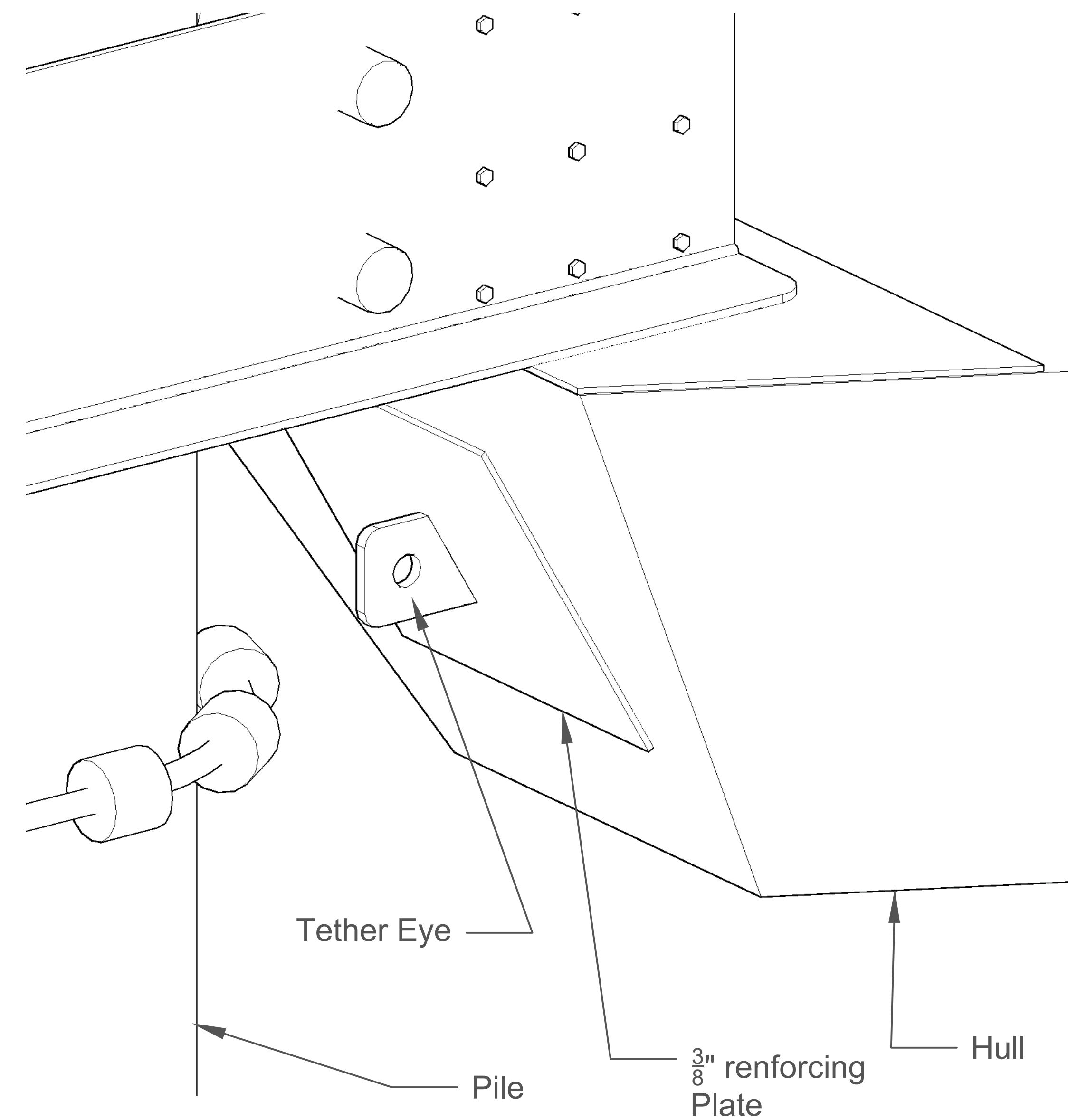
CLEARWATER MILLS
Sustainable Environmental Technologies
4965 Mountian Road
Pasadena, MD 21122

Clear Fork Trinity River Trash Wheel Site Plan

SIZE	DWG NO.	REV
	Page 16 of 17	

SCALE	SHEET





CLEARWATER MILLS Sustainable Environmental Technologies	Clearwater Mills, LLC. 4965 Mountain Road Pasadena, MD 21122

Clear Fork Trinity River
Trash Wheel
Tether Connection

Date 6/30/2022 1" = 1'

Title:	ANCHOR PILE ANALYSIS AND DESIGN		**CALC NO.**	**FWTHFS00259-CALC-001**	
			REV.	**000**	
Client:	City of Fort Worth	**Project Identifier:**	FWTHFS00259		

Item	Cover Sheet Items	Yes	No
1	Does this calculation contain any open assumptions, including preliminary information, that require confirmation? (If **YES**, identify the assumptions.)	☐	☒
2	Does this calculation serve as an "Alternate Calculation"? (If **YES**, identify the approved calculation.) **Original Calculation No.** N/A.	☐	☒
3	Does this calculation supersede an existing Calculation? (If **YES**, identify the approved calculation.) **Superseded Calculation No.** N/A.	☐	☐

Scope of Revision:
Initial Submittal

Revision Impact on Results:
N/A.

☐ **Study Calculation** ☒ **Final Calculation**

☐ **Safety-Related** ☐ **Augmented Quality** ☒ **Non-safety Related**
☐ **Safety Class** ☐ **Safety Significant** ☐ **General Services** ☐ **Production Support**

(Print Name and Sign)

Preparer: **Sandeep Menon**	**Date:**
Design Verifier (Design Reviewer[1]): **Brian Pace**	**Date:**
Approver:	**Date:**

Note 1: For Nonsafety Related, DOE General Services, or DOE Production Support calculations, design verification can be substituted by review.

Title:	ANCHOR PILE ANALYSIS AND DESIGN	CALC NO.	FWTHFS00259-CALC-001
		REV.	000

CALCULATION REVISION STATUS

REVISION	DATE	DESCRIPTION
0	See Cover Page	Initial Submittal

PAGE REVISION STATUS

PAGE NO.	REVISION	PAGE NO.	REVISION
-	-	-	-

APPENDIX/ATTACHMENT REVISION STATUS

APPENDIX NO.	NO. OF PAGES	REVISION NO.	ATTACHMENT NO.	NO. OF PAGES	REVISION NO.
1	10	0	1	1	0
			2	1	0

Title:	ANCHOR PILE ANALYSIS AND DESIGN	CALC NO.	FWTHFS00259-CALC-001
		REV.	000

1.0 **Purpose and Scope** 4

2.0 **Summary of Results and Conclusions** 4

3.0 **References** 4

4.0 **Assumption** 5

5.0 **Design Inputs** 5

6.0 **Methodology** 6

7.0 **Calculations** 7

8.0 **Computer Software** 110

Appendices 111

Attachments 120

Calculation Preparation Checklist 122

Title:	ANCHOR PILE ANALYSIS AND DESIGN	CALC NO.	FWTHFS00259-CALC-001
		REV.	000

1.0 Purpose and Scope

The purpose of this calculation is to provide mooring piles to support the waterwheel platform powered trash interceptor including the log loader to be installed on the Clear Fork and West Fork area of the Trinity River in Fort Worth, Texas. This calculation also documents the adequacy of the tethering system to anchor the trash wheel equipment during a standard project flood (SPF) condition.

2.0 Summary of Results and Conclusions

The West Fork trash interceptor mooring platform is to be supported by three – 30 inch diameter piles ¾" thick. The Clear Fork interceptor mooring platform is to be supported by three – 30 inch diameter piles ¾" thick. See Section **Error! Reference source not found.** for pile calculations. See Project Plans in Appendix 1.

The trash interceptor supplier provides calculations and specifications for design of the waterwheel, mooring platform, anchorage of the mooring platform to the mooring piles, log loader and associated support and anchorage of the floating booms procured and installed by an approved vendor. The pile locations are determined by the trash interceptor supplier and the City of Fort Worth.

3.0 References

3.1 Texas Department of Transportation (TXDOT) Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges, 2014.
3.2 AASHTO LRFD Bridge Design Specification – Publication Code LRFDUS-6
3.3 International Building Code (IBC), 2015
3.4 ACI CODE-318-14: Building Code Requirements for Structural Concrete and Commentary
3.5 Steel Construction Manual, AISC 14th Edition
3.6 Minimum Design Loads for Buildings and Other Structures, ASCE/SEI 7-10.
3.7 CMJ PROJECT NO. 2878-21-01 - Geotechnical Engineering Study Proposed Trash Wheels West Fork And Clear Fork Trinity River Fort Worth, Texas - July 2021
3.8 Drawing FWTHS-00259-DWG-S101, Rev. 0
3.9 Drawing FWTHS-00259-DWG-S102, Sheet 1, Rev. 0
3.10 Drawing FWTHS-00259-DWG-S102, Sheet 2, Rev. 0
3.11 Drawing FWTHS-00259-DWG-S103, Rev. 0

Title:	ANCHOR PILE ANALYSIS AND DESIGN	CALC NO.	FWTHFS00259-CALC-001
		REV.	000

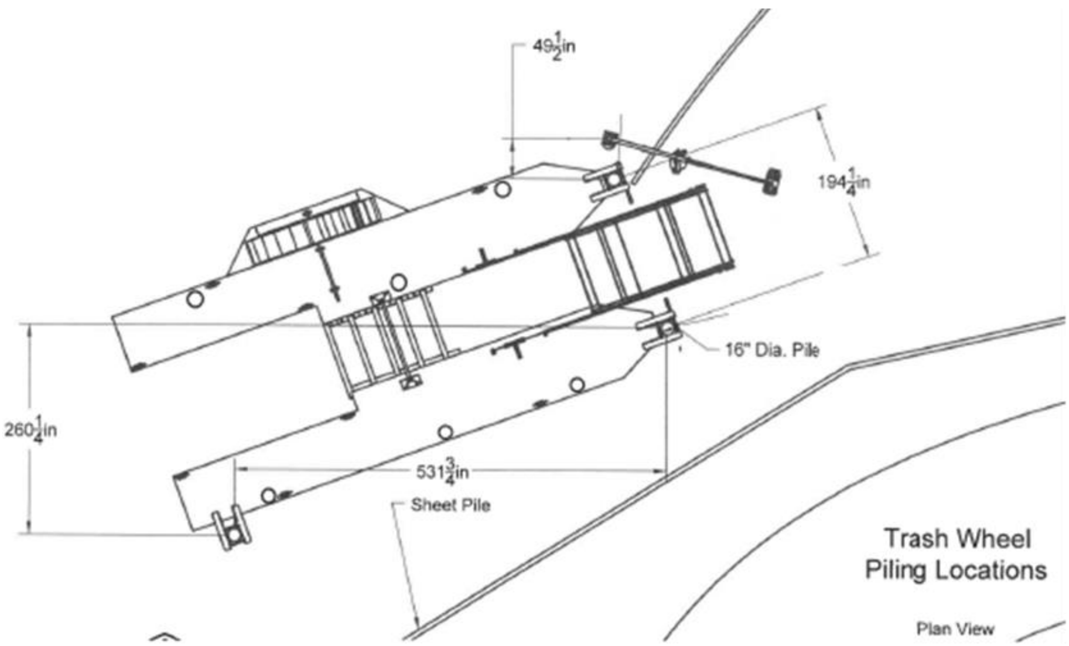
4.0 Assumption

There are no assumptions that require later justification in this calculation

5.0 Design Inputs

5.1 Mooring platform parameters

Ref. Layout for a previous project provided by Clearwater Mills, LLC for developing the design inputs –



Pontoon Hull Sections 8’ W x 52' L x 40’" D

5.2 Hydrology parameters

West Fork (Location is between RS 259346.8, for 100 year storm conservatively using inputs from 260154.) See Attachment 1

Average Water Velocity = 4.49 ft/s

Water Surface elevation (WS) = 540.82 ft.

Minimum Channel elevation = 510.80 ft.

Clear Fork (Location is between RS 1980, for 100 year storm conservatively using inputs from 260154.) See Attachment **Error! Reference source not found.**

Average Water Velocity = 8.42 ft/s

Water Surface elevation (WS) = 540.36 ft.

Minimum Channel elevation = 512.88 ft.

6.0 Methodology

This calculation analyzes the mooring platform piles for the loading conditions specified in

AASHTO. Following loads were considered for the design of the mooring piles:

- Stream Current – AASHTO LRFD Section 3.7.3
- Ice Loads – AASHTO Section 3.9.2
- Wind loads – AASHTO LRFD 3.8

The critical load combinations considered in this calculation are from the AASHTO Load Combinations.

- Strength III: 1.0 (current on pile & hull + wave + boom) + 1.0 wind on platform resisted by 1 of 3 piles
- Extreme II - Primarily for ice impact loading
- Service I - Will be considered to limit deflections

Approximate layout of the pile for the trash wheel support structure and the soil profile based on the geotechnical report are drawn to help design the pile foundation. As per the recommendation in the geotechnical report (section 4.2.1) the piles have to be embedded 5.00' deeper in to unweathered rock.

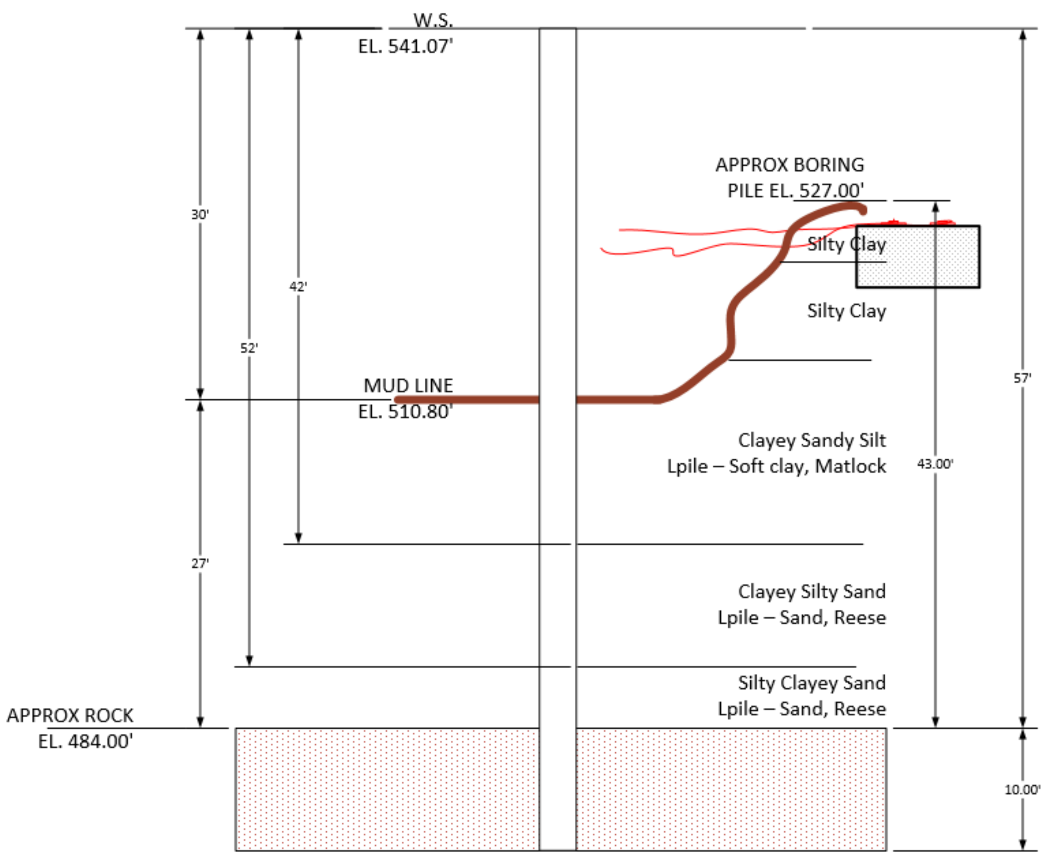
Loads are calculated for each trash interceptor location using the Excel spreadsheet. The pile is then designed using L-Pile software. The pile is evaluated for strength using the maximum Strength or Extreme Event level load combination and for deflection using the maximum Service level load combination.

Title:	ANCHOR PILE ANALYSIS AND DESIGN	CALC NO.	FWTHFS00259-CALC-001
		REV.	000

The soil profile at both the locations are based on one soil boring data at each location and since it was taken away from the actual location a conservative approach was used to size the pile structure. Two runs were made to determine the adequacy of the pile foundation –

1. Only rock at the depth per the Geotech report.
2. Only rock and the layer of soil above the rock per the depths shown in the Geotech report.

7.0 Calculations



SOIL PROFILE FOR PILE DESIGN
AT WEST FORK LOCATION

Note – Geotech report section 4.2.1 recommends that the piers should penetrate into the bearing stratum a minimum of 5.00'. Conservatively used 10.00' as the depth in unweathered rock

7.0 Mooring Pile Design Calculations

A) Loading on Mooring Pile at West Fork Trinity River Fort Worth, Texas

1. Stream Current Calculations

$V := 4.49$ — Design velocity of water for the 100-year design flood in strength and service limit states and for the check flood in the extreme event limit state (ft/sec). Attachment 1

$C_D := 1.4$ — Drag coefficient for piers considering debris lodged against the pier. AASHTO Table 3.7.3.1-1

$p := \frac{C_D \cdot V^2}{1000} \cdot ksf = 0.028 \cdot ksf$ — Pressure of flowing water. AASHTO Eq. 3.7.3.1-1

$H_p := 30ft$ — Height above mud line to flood elevation. Attachment 1

$d_{pile} := 30in$ — Diameter of pile. (Rolled and welded pipe Yield strength of 60 ksi) Ref. 3.9

$F_{current} := d_{pile} \cdot H_p \cdot p = 2.117\,kip$ — Force due to current pressure considered to be acting at the top of the pile.

2. Current Pressure on Booms

$L := 50ft$ — Transverse distance between two piles (conservative). Appendix 1

$S := 10ft$ — Assume between straight line and boom. Appendix 1

$X := \frac{L}{2} = 25\,ft$ — Distance to max sag location

$t_{boom} := 1.33ft$ — Boom thickness. Appendix 1

$q_{boom} := p \cdot t_{boom} = 0.038 \cdot \frac{kip}{ft}$ — Distributed load along boom

$L_{beam} := 8ft$ — Length of beams between hulls. Appendix 1

$F_{beam} := \frac{q_{boom} \cdot L_{beam}}{2} = 0.15\,kip$ — Longitudinal reaction on piles

$F_{boom.trans} := \frac{0.75 \cdot q_{boom} \cdot X^2}{2 \cdot S} = 0.88\,kip$ — Transverse component of tension

$F_{boom.long} := 0.75 \cdot q_{boom} \cdot X = 0.704\,kip$ — Longitudinal component of tension

$F_{boom} := \sqrt{F_{boom.trans}^2 + F_{boom.long}^2} + F_{beam} = 1.277\,kip$ — Force on piles due to booms

3. Ice Load Calculations

$p_{ice} := 8.0ksf$

Effective Ice Strength, where breakup occurs at melting temperatures and the ice structure is substantially disintegrated. AASHTON 3.9.2.1

$\alpha := 0.8$

Coefficient for local conditions, normally less than 1.0 considering "windy lake without snow". AASHTO C3.9.2.2

Date	T (degrees)	Σ(32-T)
2/9/2021	30.72	1.28
2/10/2021	28.11	3.89
2/11/2021	24.91	7.09
2/12/2021	22.85	9.15
2/13/2021	22.31	9.69
2/14/2021	13.47	18.53
2/15/2021	6.27	25.73
2/16/2021	11	21
2/17/2021	20.83	11.17
2/18/2021	23.83	8.17
2/19/2021	26.92	5.08
SUM		120.78

Freezing index calculation, considering February 2021 Winter Storm - Data used from this website - https://www.wunderground.com/history/monthly/us/tx/fort-worth/KFTW/date/2021-2

$S_f := 120.78$

Freezing index, summed from the date of freeze-up to the date of interest, in degree days. AASHTO C3.9.2.2

$t := 0.083\alpha\cdot\sqrt{S_f}\cdot ft = 8.757\cdot in$

Thickness of ice. AASHTO C3.9.2.2-1

$C_a := \sqrt{5\cdot\frac{t}{d_{pile}} + 1} = 1.568$

Coefficient accounting for the effect of the pier width/ice thickness ratio where the flow fails by crushing AASHTO Equation 3.9.2.2-3

AASHTO considers a "small stream" to be a stream which has a width of less than 300 ft at the mean water levee. The width is approximately 200 ft at mean water level.

Assuming that an ice flow would be smaller than most winter areas and the number of bridge piers upstream of the location, an Area of 400 ft2 is considered for the largest ice floe.

$A := 400ft^2$

Plan area of the largest ice floe

$r := \frac{d_{pile}}{2} = 1.25\,ft$

Radius of pier nose

$K_{1.table} := \frac{A}{r^2} = 256$

Reduction Factor K1 for small streams criteria AASHTO Table C3.9.2.3-1

$K_1 := 0.70$

Conservative, Reduction Factor K1 for small streams. AASHTO Table C3.9.2.3-1

$F_{ice} := K_1 \cdot C_a \cdot p_{ice} \cdot t \cdot d_{pile} = 16.022\,kip$

Horizontal ice force caused by ice floes that fail by crushing over the full width of the pier. AASHTO Eq. 3.9.2.2-1. This load is conservative as Fort Worth do not see extreme cold weather conditions. This load also accounts for any impact loads from the debris during a flood condition

4. Wind Load on Trash Collector

$A_w := 275ft^2$

Estimated area of covered wheel. Appendix 1

$V_{DZ} := 100$

Design wind velocity (mph) (below 30ft). AASHTO 3.8.1.1

$P_B := 0.04$

Base pressures corresponding to V.B=100 mph for large flat surfaces. (ksf) AASHTO Table 3.8.1.2.1-1

$P_D := P_B \cdot \frac{V_{DZ}^2}{10000} \cdot ksf = 0.04\,ksf$

Design wind pressure. AASHTO Eq 3.8.1.2.1-1

$F_{wind} := A_w \cdot P_D = 11\,kip$

Force due to wind pressure

Wind on the pile is ignored. It is assumed that the maximum wind load occurs during the design basis flood event, where the wind load is due to the wind on the trash wheel itself.

Pile Resistance Calculations

1. Flexural Resistance (AASHTO Section 6.12.2.2.3)

$\phi_f := 1.00$

Resistance factor for flexure. AASHTO 6.5.4.2

$t_{pile} := 0.75in$

Thickness of pile

$\frac{d_{pile}}{t_{pile}} = 40$

Width to thickness ratio

$E_{pile} := 29000ksi$

Modulus of Elasticity of steel. AASHTO 6.4.1

$F_{y.pile} := 60ksi$

Specified minimum yield strength of steel. Attachment 2

$0.11 \cdot \frac{E_{pile}}{F_{y.pile}} = 53.167$ $\quad 0.11 \cdot \frac{E_{pile}}{F_{y.pile}} > \frac{d_{pile}}{t_{pile}} = 1$

Requirement for depth to thickness of circular tubes. AASHTO 6.9.4.2.1-5

$$localbuckling := \begin{cases} \text{"OKAY"} & \text{if } \frac{d_{pile}}{t_{pile}} > 0.07 \cdot \frac{E_{pile}}{F_{y.pile}} \\ \text{"Check"} & \text{otherwise} \end{cases}$$

Check for local buckling applicability. If not true, check local buckling per 6.12.2.2.3

$$localbuckling = \text{"OKAY"}$$

$$S_{pile} := \frac{\pi\left[d_{pile}^{\,4} - \left(d_{pile} - 2 \cdot t_{pile}\right)^4\right]}{32 \cdot d_{pile}} = 491.692 \cdot in^3$$

Elastic section modulus

$$F_{cr.local} := \frac{0.33 \cdot E_{pile}}{\left(\frac{d_{pile}}{t_{pile}}\right)} = 239.25 \cdot ksi$$

Elastic local buckling stress,
(AASHTO Section 6.12.2.2.3-4)

$$\frac{0.31 \cdot E_{pile}}{F_{y.pile}} = 149.833$$

$$M_{n.local} := \begin{cases} \left(\frac{0.021 \cdot E_{pile}}{\frac{d_{pile}}{t_{pile}}} + F_{y.pile}\right) \cdot S_{pile} & \text{if } \frac{d_{pile}}{t_{pile}} < 0.31 \cdot \frac{E_{pile}}{F_{y.pile}} \\ F_{cr.local} \cdot S_{pile} & \text{otherwise} \end{cases} = 36987.513 \cdot kip \cdot in$$

(AASHTO Section 6.12.2.2.3-2, -3)

$$Z := \frac{\left(d_{pile}^{\,3}\right)}{6} - \frac{\left(d_{pile} - 2 \cdot t_{pile}\right)^3}{6} = 641.813 \cdot in^3$$

Plastic section modulus of round pile

$$M_p := F_{y.pile} \cdot Z = 38508.75 \cdot kip \cdot in$$

Plastic moment for Circular Tubes
AASHTO Equation 6.12.2.2.3-1

$$M_n := \min\left(M_p, M_{n.local}\right) = 36987.513 \cdot kip \cdot in$$

Nominal flexural resistance specified in Articles 6.12.2.2 for non composite members

$$M_r := \phi_f \cdot M_n = 36987.513 \cdot kip \cdot in$$

Factored flexural resistance
AASHTO Equation 6.12.1.2.1-1

2. Shear resistance. (AASHTO Section 6.12.1.2.3c)

$\phi_v := 1.00$ — Resistance factor for shear. AASHTO 6.5.4.2

$L_v := 8.84ft = 106.08 \cdot in$ — Distance between points of maximum and zero shear

$$F_{cr1} := \frac{1.60E_{pile}}{\sqrt{\frac{L_v}{d_{pile}} \cdot \left(\frac{d_{pile}}{t_{pile}}\right)^{\frac{5}{4}}}} = 35322.331\,ksf$$

Shear buckling resistance - first criteria
AASHTO Equation 6.12.1.2.3c-2

$$F_{cr2} := \frac{0.78 \cdot E_{pile}}{\left(\frac{d_{pile}}{t_{pile}}\right)^{\frac{3}{2}}} = 12875.53\,ksf$$

Shear buckling resistance - second criteria
AASHTO Eq 6.12.1.2.3c-3

$F_{cr.max} := 0.58 \cdot F_{y.pile} = 5011.2\,ksf$ — Maximum allowable shear buckling resistance. AASHTO Eq. 6.12.1.2.3c-2&3

$F_{cr} := \min(F_{cr1}, F_{cr2}, F_{cr.max}) = 5011.2\,ksf$ — Shear buckling resistance

$A_{g.pile} := 68.92in^2$ — Gross area of the section. Attachment 2

$V_n := 0.5 \cdot F_{cr} \cdot A_{g.pile} = 1199.208\,kip$ — Nominal shear resistance. AASHTO 6.12.1.2.3c-1

$V_r := \phi_v \cdot V_n = 1199.208\,kip$ — Factored shear resistance. AASHTO 6.12.1.2.3a-1

These calculations capture the reasonably expected loads to occur on the trash wheel, booms, and mooring piles. Due to the varying nature of rivers, the pile design itself will be limited to utilization ratios of 0.6 to be conservative enough to account for potential unknowns (i.e. higher impact loads, flood loads, ice loads, etc.).

There are three applicable loading combinations:

Strength III - General strength. AASHTO code for bridge design considers this using 55 mph winds, but for this design, the full 100 mph wind load will be considered.

Extreme II - Primarily for ice impact loading

Service I - Will be considered to limit deflections

$F_{current} = 2.117\ kip$ $F_{boom} = 1.277 \cdot kip$

$F_{wind} = 11\ kip$ Wind is applied to 2 piles.

$F_{ice} = 16.022\ kip$

$$Strength_{III} := 1.00 \cdot F_{current} + 1.00 \cdot F_{boom} + \frac{1.4 \cdot F_{wind}}{2} = 11.094 \cdot kip$$

$$Extreme_{II} := 1.00 \cdot F_{current} + 1.00 \cdot F_{boom} + 1.00 \cdot F_{ice} = 19.416\ kip$$

$$Service_{I} := 1.00 \cdot F_{current} + 1.00 \cdot F_{boom} + \frac{0.3 \cdot F_{wind}}{2} = 5.044\ kip$$

$P_{top} := \max\left(Strength_{III}, Extreme_{II}, Service_{I}\right) = 19.416\ kip$ (Conservatively used 25.0 kip as Lpile input)

Additional Moment on the pile due to Log Loader - (Not functional during any flood condition.)

$P_{logloader} := 1500lbf$

$L_{logloader} := 12ft$

$M_{pile} := 1.25P_{logloader} \cdot L_{logloader} = 270000 \cdot lbf \cdot in$ This log loader is used to clear logs during normal operation condition

$L_{pile} := 60ft$ Length of pile. From Appendix 1

$M_{max} := 1.74 \times 10^{7} lbf \cdot in$ Maximum Moment from LPILE Output pg. 23

$$M := \begin{cases} \text{"good"} & \text{if } M_r \geq M_{max} \\ \text{"redesign"} & \text{otherwise} \end{cases}$$ $M = \text{"good"}$

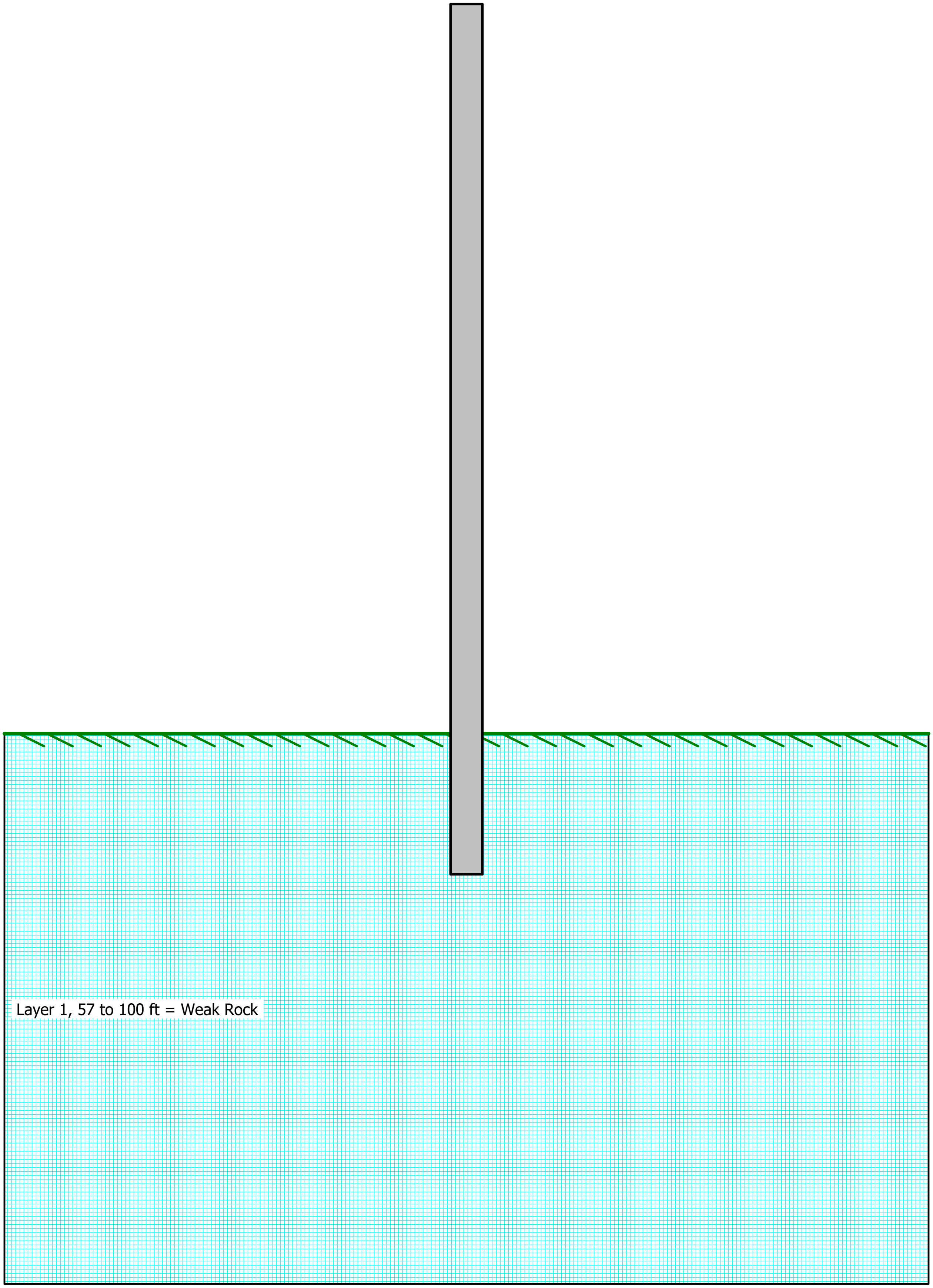
$V_{max} := 396132lbf$ Maximum Shear Load. LPILE Output pg. 23

$$V := \begin{cases} \text{"good"} & \text{if } V_r \geq V_{max} \\ \text{"redesign"} & \text{otherwise} \end{cases}$$ $V = \text{"good"}$

$UT_b := \frac{M_{max}}{M_r} = 0.47$ $UT_b < 0.6 = 1$ Utilization for bending. Limited to 0.6 for project specific conditions

$UT_v := \frac{V_{max}}{V_r} = 0.33$ $UT_v < 0.6 = 1$ Utilization for shear. Limited to 0.6 for project specific conditions

CASE 1 - ANCHOR PILE ONLY ON ROCK



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```
===============================================================================

                    LPile for Windows, Version 2022-12.003

                Analysis of Individual Piles and Drilled Shafts
               Subjected to Lateral Loading Using the p-y Method
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-------------------------------------------------------------------------------
                             Files Used for Analysis
-------------------------------------------------------------------------------

Path to file locations:
\\enercon.sharepoint.com@SSL\DavWWWRoot\sites\NSG_NC\Clients\FWTH\FWTHFS\FWTHFS-00254\FWTHFS-002
42 (Original Project Docs)\Deliverables_SP\Calculations\Trash Wheel\Final\westfork\08_09_2022\

Name of input data file:
West Fork30dia 0.75wall.lp12d

Name of output report file:
West Fork30dia 0.75wall.lp12o

Name of plot output file:
West Fork30dia 0.75wall.lp12p

Name of runtime message file:
West Fork30dia 0.75wall.lp12r


-------------------------------------------------------------------------------
                            Date and Time of Analysis
-------------------------------------------------------------------------------

               Date:  August 9, 2022            Time:  13:37:54


-------------------------------------------------------------------------------
                                  Problem Title
-------------------------------------------------------------------------------

Project Name: Fort Worth Trash Wheel


Job Number: FWTHFS-00242


Client: City of Fort Worth


Engineer: Sandeep Menon
```

Description: Clear Fork LPILE

Program Options and Settings

Computational Options:
- Conventional Analysis

Engineering Units Used for Data Input and Computations:
- US Customary System Units (pounds, feet, inches)

Analysis Control Options:
- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 300.0000 in
- Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:
- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 1
Total length of pile = 68.000 ft
Depth of ground surface below top of pile = 57.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	30.0000
2	68.000	30.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a steel pipe pile
Length of section = 68.000000 ft

Pile diameter = 30.000000 in

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	57.000000 ft
Distance from top of pile to bottom of layer	=	100.000000 ft
Effective unit weight at top of layer	=	140.000000 pcf
Effective unit weight at bottom of layer	=	140.000000 pcf
Uniaxial compressive strength at top of layer	=	275.000000 psi
Uniaxial compressive strength at bottom of layer	=	275.000000 psi
Initial modulus of rock at top of layer	=	100000. psi
Initial modulus of rock at bottom of layer	=	100000. psi
RQD of rock at top of layer	=	30.000000 %
RQD of rock at bottom of layer	=	30.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 32.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Weak	57.0000	140.0000	275.0000	30.0000	1.00E-04	100000.
	Rock	100.0000	140.0000	275.0000	30.0000	1.00E-04	100000.

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 25000. lbs	M = 270000. in-lbs	0.0000000	No	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head

y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel Pipe Pile:

Length of Section	=	68.000000 ft
Outer Diameter of Pipe	=	30.000000 in
Pipe Wall Thickness	=	0.750000 in
Yield Stress of Pipe	=	60.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	68.918689 sq. in.
Moment of Inertia	=	7375. in^4
Elastic Bending Stiffness	=	213885920. kip-in^2
Plastic Modulus, Z	=	641.812500in^3
Plastic Moment Capacity = Fy Z	=	38509.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	4135.121 kips
Nominal Axial Tensile Capacity	=	-4135.121 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000293	626.8754973	213875170.	15.0000000	1.2622500	
0.00000586	1254.	213875170.	15.0000000	2.5245000	
0.00000879	1881.	213875170.	15.0000000	3.7867500	
0.00001172	2508.	213875170.	15.0000000	5.0490000	
0.00001466	3134.	213875170.	15.0000000	6.3112500	
0.00001759	3761.	213875170.	15.0000000	7.5735001	
0.00002052	4388.	213875170.	15.0000000	8.8357501	
0.00002345	5015.	213875170.	15.0000000	10.0980001	
0.00002638	5642.	213875170.	15.0000000	11.3602501	
0.00002931	6269.	213875170.	15.0000000	12.6225001	
0.00003224	6896.	213875170.	15.0000000	13.8847501	
0.00003517	7523.	213875170.	15.0000000	15.1470001	

0.00003810	8149.	213875170.	15.0000000	16.4092501	
0.00004103	8776.	213875170.	15.0000000	17.6715001	
0.00004397	9403.	213875170.	15.0000000	18.9337501	
0.00004690	10030.	213875170.	15.0000000	20.1960001	
0.00004983	10657.	213875170.	15.0000000	21.4582501	
0.00005276	11284.	213875170.	15.0000000	22.7205002	
0.00005569	11911.	213875170.	15.0000000	23.9827502	
0.00005862	12538.	213875170.	15.0000000	25.2450002	
0.00006155	13164.	213875170.	15.0000000	26.5072502	
0.00006448	13791.	213875170.	15.0000000	27.7695002	
0.00006741	14418.	213875170.	15.0000000	29.0317502	
0.00007034	15045.	213875170.	15.0000000	30.2940002	
0.00007328	15672.	213875170.	15.0000000	31.5562502	
0.00007621	16299.	213875170.	15.0000000	32.8185002	
0.00007914	16926.	213875170.	15.0000000	34.0807502	
0.00008207	17553.	213875170.	15.0000000	35.3430002	
0.00008500	18179.	213875170.	15.0000000	36.6052502	
0.00008793	18806.	213875170.	15.0000000	37.8675003	
0.00009086	19433.	213875170.	15.0000000	39.1297503	
0.00009379	20060.	213875170.	15.0000000	40.3920003	
0.00009672	20687.	213875170.	15.0000000	41.6542503	
0.00009966	21314.	213875170.	15.0000000	42.9165003	
0.0001026	21941.	213875170.	15.0000000	44.1787503	
0.0001055	22568.	213875170.	15.0000000	45.4410003	
0.0001084	23194.	213875170.	15.0000000	46.7032503	
0.0001114	23821.	213875170.	15.0000000	47.9655003	
0.0001143	24448.	213875170.	15.0000000	49.2277503	
0.0001202	25702.	213875170.	15.0000000	51.7522503	
0.0001260	26956.	213875170.	15.0000000	54.2767504	
0.0001319	28209.	213875170.	15.0000000	56.8012504	
0.0001378	29463.	213875170.	15.0000000	59.3257504	
0.0001436	30613.	213152380.	15.0000000	60.0000000	Y
0.0001495	31479.	210583666.	15.0000000	60.0000000	Y
0.0001553	32160.	207022224.	15.0000000	60.0000000	Y
0.0001612	32722.	202983179.	15.0000000	60.0000000	Y
0.0001671	33204.	198746654.	15.0000000	60.0000000	Y
0.0001729	33620.	194414878.	15.0000000	60.0000000	Y
0.0001788	33988.	190095167.	15.0000000	60.0000000	Y
0.0001847	34309.	185802169.	15.0000000	60.0000000	Y
0.0001905	34595.	181585311.	15.0000000	60.0000000	Y
0.0001964	34852.	177470462.	15.0000000	60.0000000	Y
0.0002022	35082.	173468097.	15.0000000	60.0000000	Y
0.0002081	35291.	169585196.	15.0000000	60.0000000	Y
0.0002140	35481.	165826064.	15.0000000	60.0000000	Y
0.0002198	35654.	162192964.	15.0000000	60.0000000	Y
0.0002257	35813.	158681275.	15.0000000	60.0000000	Y
0.0002316	35956.	155281614.	15.0000000	60.0000000	Y
0.0002374	36088.	152005500.	15.0000000	60.0000000	Y
0.0002433	36212.	148851238.	15.0000000	60.0000000	Y
0.0002491	36325.	145802256.	15.0000000	60.0000000	Y
0.0002550	36429.	142857873.	15.0000000	60.0000000	Y
0.0002609	36528.	140027612.	15.0000000	60.0000000	Y
0.0002667	36617.	137283086.	15.0000000	60.0000000	Y
0.0002726	36702.	134642575.	15.0000000	60.0000000	Y
0.0002784	36780.	132089238.	15.0000000	60.0000000	Y
0.0002843	36854.	129625023.	15.0000000	60.0000000	Y
0.0002902	36922.	127243261.	15.0000000	60.0000000	Y
0.0002960	36987.	124943000.	15.0000000	60.0000000	Y
0.0003019	37048.	122715893.	15.0000000	60.0000000	Y
0.0003078	37106.	120568203.	15.0000000	60.0000000	Y
0.0003136	37158.	118481064.	15.0000000	60.0000000	Y
0.0003195	37210.	116470517.	15.0000000	60.0000000	Y
0.0003253	37257.	114515408.	15.0000000	60.0000000	Y
0.0003312	37302.	112624803.	15.0000000	60.0000000	Y
0.0003371	37347.	110797855.	15.0000000	60.0000000	Y
0.0003429	37385.	109016833.	15.0000000	60.0000000	Y
0.0003488	37424.	107295678.	15.0000000	60.0000000	Y
0.0003722	37561.	100904523.	15.0000000	60.0000000	Y
0.0003957	37672.	95205408.	15.0000000	60.0000000	Y
0.0004191	37765.	90100759.	15.0000000	60.0000000	Y
0.0004426	37842.	85502779.	15.0000000	60.0000000	Y
0.0004660	37907.	81340543.	15.0000000	60.0000000	Y
0.0004895	37964.	77559576.	15.0000000	60.0000000	Y

0.0005129	38015.	74112823.	15.0000000	60.0000000	Y
0.0005364	38056.	70949672.	15.0000000	60.0000000	Y
0.0005598	38094.	68046000.	15.0000000	60.0000000	Y
0.0005833	38126.	65365798.	15.0000000	60.0000000	Y
0.0006067	38156.	62889062.	15.0000000	60.0000000	Y
0.0006302	38181.	60588308.	15.0000000	60.0000000	Y
0.0006536	38206.	58452630.	15.0000000	60.0000000	Y
0.0006771	38225.	56456945.	15.0000000	60.0000000	Y
0.0007005	38244.	54593653.	15.0000000	60.0000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	38244.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 25000.0 lbs
Applied moment at pile head = 270000.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	15.1613	270000.	25000.	-0.03160	549.1245	2.14E+11	0.00	0.00	0.00
0.6800	14.9035	474000.	25000.	-0.03159	964.0186	2.14E+11	0.00	0.00	0.00
1.3600	14.6458	678000.	25000.	-0.03156	1379.	2.14E+11	0.00	0.00	0.00
2.0400	14.3884	882000.	25000.	-0.03153	1794.	2.14E+11	0.00	0.00	0.00
2.7200	14.1312	1086000.	25000.	-0.03150	2209.	2.14E+11	0.00	0.00	0.00
3.4000	13.8744	1290000.	25000.	-0.03145	2624.	2.14E+11	0.00	0.00	0.00
4.0800	13.6179	1494000.	25000.	-0.03140	3038.	2.14E+11	0.00	0.00	0.00
4.7600	13.3619	1698000.	25000.	-0.03134	3453.	2.14E+11	0.00	0.00	0.00
5.4400	13.1065	1902000.	25000.	-0.03127	3868.	2.14E+11	0.00		

								0.00	0.00
6.1200	12.8517	2106000.	25000.	-0.03119	4283.	2.14E+11	0.00	0.00	0.00
6.8000	12.5975	2310000.	25000.	-0.03111	4698.	2.14E+11	0.00	0.00	0.00
7.4800	12.3440	2514000.	25000.	-0.03102	5113.	2.14E+11	0.00	0.00	0.00
8.1600	12.0913	2718000.	25000.	-0.03092	5528.	2.14E+11	0.00	0.00	0.00
8.8400	11.8394	2922000.	25000.	-0.03081	5943.	2.14E+11	0.00	0.00	0.00
9.5200	11.5885	3126000.	25000.	-0.03069	6358.	2.14E+11	0.00	0.00	0.00
10.2000	11.3385	3330000.	25000.	-0.03057	6773.	2.14E+11	0.00	0.00	0.00
10.8800	11.0896	3534000.	25000.	-0.03044	7187.	2.14E+11	0.00	0.00	0.00
11.5600	10.8418	3738000.	25000.	-0.03030	7602.	2.14E+11	0.00	0.00	0.00
12.2400	10.5951	3942000.	25000.	-0.03015	8017.	2.14E+11	0.00	0.00	0.00
12.9200	10.3497	4146000.	25000.	-0.03000	8432.	2.14E+11	0.00	0.00	0.00
13.6000	10.1055	4350000.	25000.	-0.02984	8847.	2.14E+11	0.00	0.00	0.00
14.2800	9.8627	4554000.	25000.	-0.02967	9262.	2.14E+11	0.00	0.00	0.00
14.9600	9.6214	4758000.	25000.	-0.02949	9677.	2.14E+11	0.00	0.00	0.00
15.6400	9.3815	4962000.	25000.	-0.02930	10092.	2.14E+11	0.00	0.00	0.00
16.3200	9.1431	5166000.	25000.	-0.02911	10507.	2.14E+11	0.00	0.00	0.00
17.0000	8.9064	5370000.	25000.	-0.02891	10921.	2.14E+11	0.00	0.00	0.00
17.6800	8.6713	5574000.	25000.	-0.02870	11336.	2.14E+11	0.00	0.00	0.00
18.3600	8.4380	5778000.	25000.	-0.02848	11751.	2.14E+11	0.00	0.00	0.00
19.0400	8.2065	5982000.	25000.	-0.02826	12166.	2.14E+11	0.00	0.00	0.00
19.7200	7.9768	6186000.	25000.	-0.02803	12581.	2.14E+11	0.00	0.00	0.00
20.4000	7.7490	6390000.	25000.	-0.02779	12996.	2.14E+11	0.00	0.00	0.00
21.0800	7.5233	6594000.	25000.	-0.02754	13411.	2.14E+11	0.00	0.00	0.00
21.7600	7.2996	6798000.	25000.	-0.02728	13826.	2.14E+11	0.00	0.00	0.00
22.4400	7.0780	7002000.	25000.	-0.02702	14241.	2.14E+11	0.00	0.00	0.00
23.1200	6.8586	7206000.	25000.	-0.02675	14656.	2.14E+11	0.00	0.00	0.00
23.8000	6.6414	7410000.	25000.	-0.02647	15070.	2.14E+11	0.00	0.00	0.00
24.4800	6.4266	7614000.	25000.	-0.02619	15485.	2.14E+11	0.00	0.00	0.00
25.1600	6.2141	7818000.	25000.	-0.02589	15900.	2.14E+11	0.00	0.00	0.00
25.8400	6.0040	8022000.	25000.	-0.02559	16315.	2.14E+11	0.00	0.00	0.00
26.5200	5.7965	8226000.	25000.	-0.02528	16730.	2.14E+11	0.00	0.00	0.00
27.2000	5.5915	8430000.	25000.	-0.02496	17145.	2.14E+11	0.00	0.00	0.00
27.8800	5.3891	8634000.	25000.	-0.02464	17560.	2.14E+11	0.00	0.00	0.00
28.5600	5.1895	8838000.	25000.	-0.02430	17975.	2.14E+11	0.00	0.00	0.00
29.2400	4.9925	9042000.	25000.	-0.02396	18390.	2.14E+11	0.00	0.00	0.00
29.9200	4.7984	9246000.	25000.	-0.02361	18804.	2.14E+11	0.00	0.00	0.00

30.6000	4.6072	9450000.	25000.	-0.02326	19219.	2.14E+11	0.00	0.00	0.00
31.2800	4.4189	9654000.	25000.	-0.02289	19634.	2.14E+11	0.00	0.00	0.00
31.9600	4.2336	9858000.	25000.	-0.02252	20049.	2.14E+11	0.00	0.00	0.00
32.6400	4.0514	1.01E+07	25000.	-0.02214	20464.	2.14E+11	0.00	0.00	0.00
33.3200	3.8723	1.03E+07	25000.	-0.02175	20879.	2.14E+11	0.00	0.00	0.00
34.0000	3.6964	1.05E+07	25000.	-0.02136	21294.	2.14E+11	0.00	0.00	0.00
34.6800	3.5238	1.07E+07	25000.	-0.02095	21709.	2.14E+11	0.00	0.00	0.00
35.3600	3.3545	1.09E+07	25000.	-0.02054	22124.	2.14E+11	0.00	0.00	0.00
36.0400	3.1885	1.11E+07	25000.	-0.02012	22539.	2.14E+11	0.00	0.00	0.00
36.7200	3.0261	1.13E+07	25000.	-0.01970	22953.	2.14E+11	0.00	0.00	0.00
37.4000	2.8671	1.15E+07	25000.	-0.01926	23368.	2.14E+11	0.00	0.00	0.00
38.0800	2.7117	1.17E+07	25000.	-0.01882	23783.	2.14E+11	0.00	0.00	0.00
38.7600	2.5600	1.19E+07	25000.	-0.01837	24198.	2.14E+11	0.00	0.00	0.00
39.4400	2.4120	1.21E+07	25000.	-0.01791	24613.	2.14E+11	0.00	0.00	0.00
40.1200	2.2677	1.23E+07	25000.	-0.01744	25028.	2.14E+11	0.00	0.00	0.00
40.8000	2.1273	1.25E+07	25000.	-0.01697	25443.	2.14E+11	0.00	0.00	0.00
41.4800	1.9907	1.27E+07	25000.	-0.01649	25858.	2.14E+11	0.00	0.00	0.00
42.1600	1.8581	1.29E+07	25000.	-0.01600	26273.	2.14E+11	0.00	0.00	0.00
42.8400	1.7296	1.31E+07	25000.	-0.01550	26687.	2.14E+11	0.00	0.00	0.00
43.5200	1.6051	1.33E+07	25000.	-0.01500	27102.	2.14E+11	0.00	0.00	0.00
44.2000	1.4848	1.35E+07	25000.	-0.01449	27517.	2.14E+11	0.00	0.00	0.00
44.8800	1.3687	1.37E+07	25000.	-0.01397	27932.	2.14E+11	0.00	0.00	0.00
45.5600	1.2568	1.39E+07	25000.	-0.01344	28347.	2.14E+11	0.00	0.00	0.00
46.2400	1.1493	1.41E+07	25000.	-0.01290	28762.	2.14E+11	0.00	0.00	0.00
46.9200	1.0462	1.43E+07	25000.	-0.01236	29177.	2.14E+11	0.00	0.00	0.00
47.6000	0.9476	1.45E+07	25000.	-0.01181	29592.	2.14E+11	0.00	0.00	0.00
48.2800	0.8535	1.48E+07	25000.	-0.01125	30007.	2.14E+11	0.00	0.00	0.00
48.9600	0.7640	1.50E+07	25000.	-0.01068	30421.	2.14E+11	0.00	0.00	0.00
49.6400	0.6791	1.52E+07	25000.	-0.01011	30836.	2.14E+11	0.00	0.00	0.00
50.3200	0.5990	1.54E+07	25000.	-0.00953	31251.	2.14E+11	0.00	0.00	0.00
51.0000	0.5237	1.56E+07	25000.	-0.00894	31666.	2.14E+11	0.00	0.00	0.00
51.6800	0.4532	1.58E+07	25000.	-0.00834	32081.	2.14E+11	0.00	0.00	0.00
52.3600	0.3876	1.60E+07	25000.	-0.00773	32496.	2.14E+11	0.00	0.00	0.00
53.0400	0.3270	1.62E+07	25000.	-0.00712	32911.	2.14E+11	0.00	0.00	0.00
53.7200	0.2714	1.64E+07	25000.	-0.00650	33326.	2.14E+11	0.00	0.00	0.00
54.4000	0.2209	1.66E+07	25000.	-0.00587	33741.	2.14E+11	0.00	0.00	0.00
55.0800	0.1756	1.68E+07	25000.	-0.00523	34156.	2.14E+11	0.00		

								0.00	0.00
55.7600	0.1355	1.70E+07	25000.	-0.00459	34570.	2.14E+11	0.00	0.00	0.00
56.4400	0.1007	1.72E+07	25000.	-0.00394	34985.	2.14E+11	0.00	0.00	0.00
57.1200	0.07130	1.74E+07	-3738.	-0.00327	35400.	2.14E+11	-7044.	806083.	0.00
57.8000	0.04729	1.71E+07	-71323.	-0.00262	34861.	2.14E+11	-9521.	1642970.	0.00
58.4800	0.02861	1.62E+07	-153441.	-0.00198	33033.	2.14E+11	-10606.	3024787.	0.00
59.1600	0.01499	1.46E+07	-241194.	-0.00139	29768.	2.14E+11	-10902.	5934560.	0.00
59.8400	0.00593	1.23E+07	-327027.	-8.76E-04	25027.	2.14E+11	-10135.	1.40E+07	0.00
60.5200	6.94E-04	9299759.	-396132.	-4.64E-04	18914.	2.14E+11	-6803.	8.00E+07	0.00
61.2000	-0.00164	5840845.	-385063.	-1.75E-04	11879.	2.14E+11	9515.	4.72E+07	0.00
61.8800	-0.00216	3015524.	-299933.	-6.09E-06	6133.	2.14E+11	11350.	4.28E+07	0.00
62.5600	-0.00174	945934.	-205274.	6.95E-05	1924.	2.14E+11	11851.	5.55E+07	0.00
63.2400	-0.00103	-334548.	-110617.	8.11E-05	680.4025	2.14E+11	11349.	9.00E+07	0.00
63.9200	-4.19E-04	-859339.	-24193.	5.84E-05	1748.	2.14E+11	9833.	1.92E+08	0.00
64.6000	-7.63E-05	-729386.	31484.	2.81E-05	1483.	2.14E+11	3813.	4.08E+08	0.00
65.2800	3.92E-05	-345524.	39047.	7.56E-06	702.7245	2.14E+11	-1960.	4.08E+08	0.00
65.9600	4.71E-05	-92137.	21449.	-7.91E-07	187.3885	2.14E+11	-2354.	4.08E+08	0.00
66.6400	2.63E-05	4526.	6486.	-2.46E-06	9.2039	2.14E+11	-1314.	4.08E+08	0.00
67.3200	6.88E-06	13717.	-277.298	-2.11E-06	27.8982	2.14E+11	-344.056	4.08E+08	0.00
68.0000	-8.24E-06	0.00	0.00	-1.85E-06	0.00	2.14E+11	412.0210	2.04E+08	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

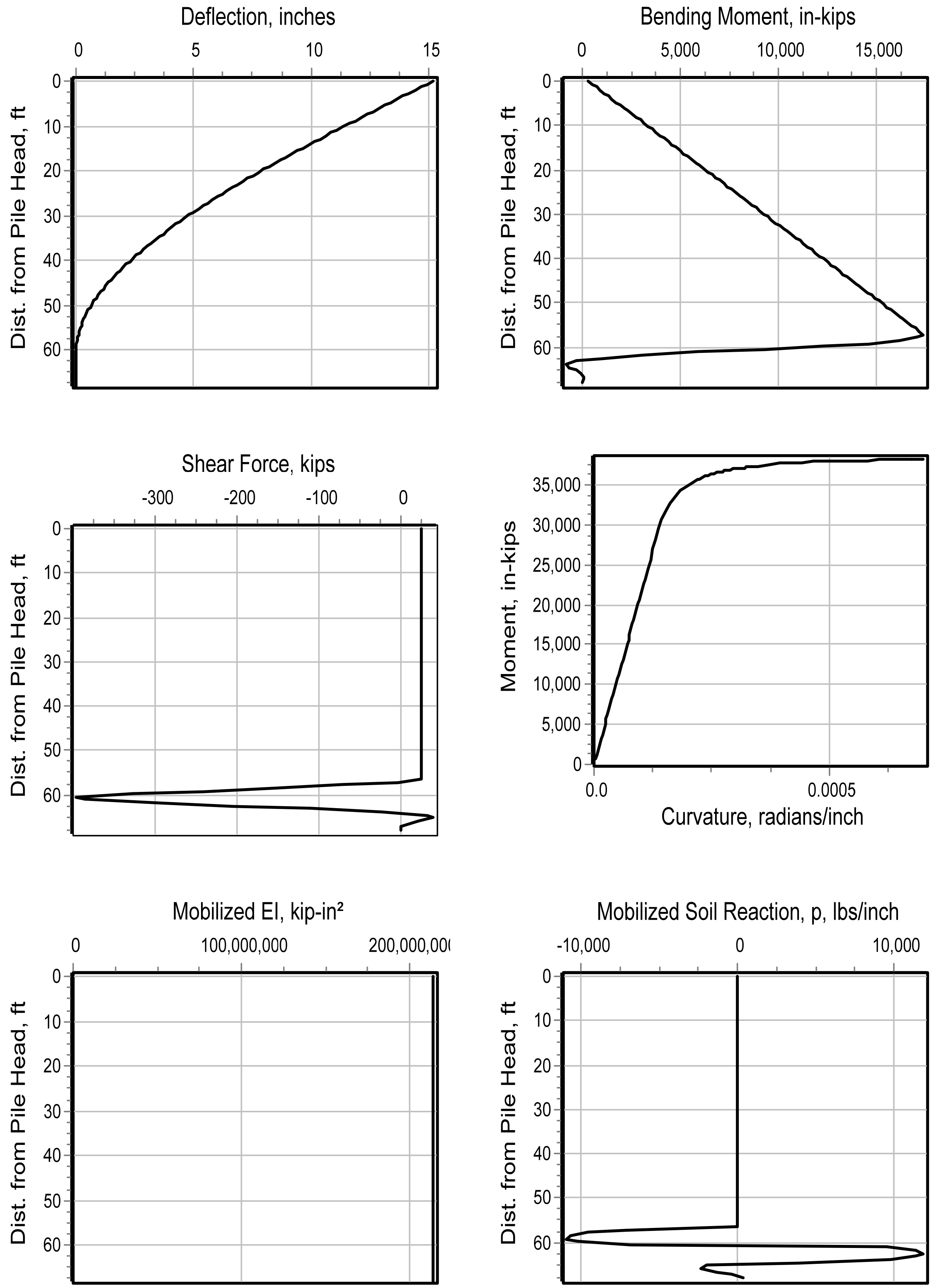
Pile-head deflection = 15.16129351 inches
Computed slope at pile head = -0.0315995 radians
Maximum bending moment = 17406000. inch-lbs
Maximum shear force = -396132. lbs
Depth of maximum bending moment = 57.12000000 feet below pile head
Depth of maximum shear force = 60.52000000 feet below pile head
Number of iterations = 28
Number of zero deflection points = 3
Pile deflection at ground = 0.07649671 inches

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

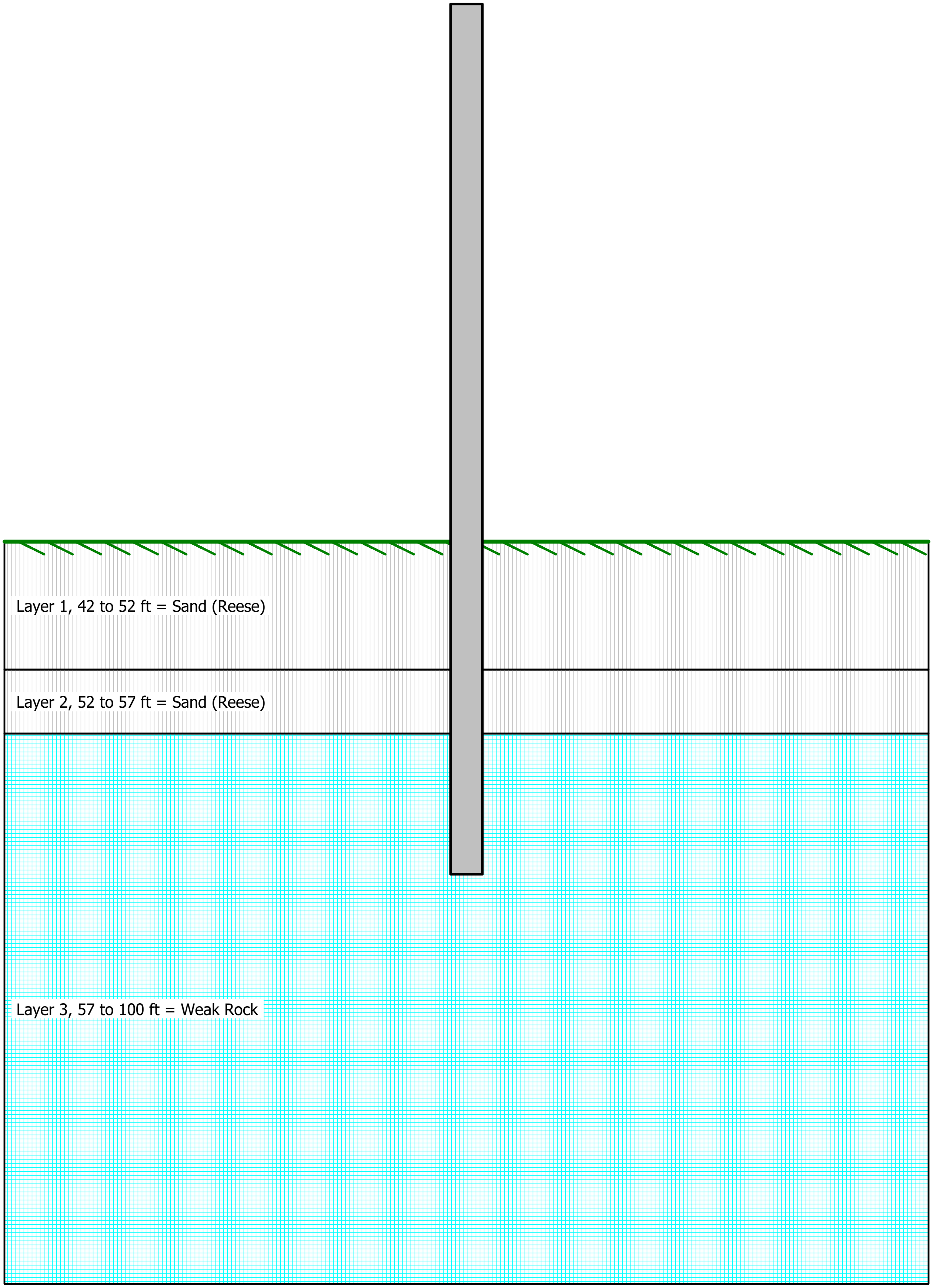
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

```
Load Load                Load                 Axial    Pile-head  Pile-head  Max Shear Max
Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in Pile    in
Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs      in-lbs

---- ----- ---------- ---------- ---------- ---------- ---------- ---------- ----------
----------
  1  V, lb     25000.  M, in-lb     270000.       0.00    15.1613   -0.03160   -396132.
1.74E+07


Maximum pile-head deflection = 15.1612935073 inches
Maximum pile-head rotation   = -0.0315994820 radians = -1.810517 deg.

The analysis ended normally.
```



CASE 1 - RESULTS SUMMARY ANCHOR PILE ONLY ON ROCK

CASE 2 - ANCHOR PILE WITH 2 SOIL LAYERS AND ROCK



```
===============================================================================

                    LPile for Windows, Version 2022-12.003

                Analysis of Individual Piles and Drilled Shafts
               Subjected to Lateral Loading Using the p-y Method
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-------------------------------------------------------------------------------
                             Files Used for Analysis
-------------------------------------------------------------------------------

Path to file locations:
\\enercon.sharepoint.com@SSL\DavWWWRoot\sites\NSG_NC\Clients\FWTH\FWTHFS\FWTHFS-00254\FWTHFS-002
42 (Original Project Docs)\Deliverables_SP\Calculations\Trash Wheel\Final\westfork\08_09_2022\

Name of input data file:
West Forkwith2soillayer.lp12d

Name of output report file:
West Forkwith2soillayer.lp12o

Name of plot output file:
West Forkwith2soillayer.lp12p

Name of runtime message file:
West Forkwith2soillayer.lp12r


-------------------------------------------------------------------------------
                            Date and Time of Analysis
-------------------------------------------------------------------------------

               Date:  August 9, 2022             Time:  14:36:37


-------------------------------------------------------------------------------
                                  Problem Title
-------------------------------------------------------------------------------

Project Name: Fort Worth Trash Wheel


Job Number: FWTHFS-00242


Client: City of Fort Worth


Engineer: Sandeep Menon
```

Description: Clear Fork LPILE

Program Options and Settings

Computational Options:
- Conventional Analysis

Engineering Units Used for Data Input and Computations:
- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	300.0000 in
- Number of pile increments	=	100

Loading Type and Number of Cycles of Loading:
- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:
- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined	=	1
Total length of pile	=	68.000 ft
Depth of ground surface below top of pile	=	42.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	30.0000
2	68.000	30.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a steel pipe pile

Length of section	=	68.000000 ft

Pile diameter = 30.000000 in

Soil and Rock Layering Information

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	42.000000 ft
Distance from top of pile to bottom of layer	=	52.000000 ft
Effective unit weight at top of layer	=	110.000000 pcf
Effective unit weight at bottom of layer	=	110.000000 pcf
Friction angle at top of layer	=	24.000000 deg.
Friction angle at bottom of layer	=	24.000000 deg.
Subgrade k at top of layer	=	20.000000 pci
Subgrade k at bottom of layer	=	20.000000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	52.000000 ft
Distance from top of pile to bottom of layer	=	57.000000 ft
Effective unit weight at top of layer	=	120.000000 pcf
Effective unit weight at bottom of layer	=	120.000000 pcf
Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	60.000000 pci
Subgrade k at bottom of layer	=	60.000000 pci

Layer 3 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	57.000000 ft
Distance from top of pile to bottom of layer	=	100.000000 ft
Effective unit weight at top of layer	=	140.000000 pcf
Effective unit weight at bottom of layer	=	140.000000 pcf
Uniaxial compressive strength at top of layer	=	275.000000 psi
Uniaxial compressive strength at bottom of layer	=	275.000000 psi
Initial modulus of rock at top of layer	=	100000. psi
Initial modulus of rock at bottom of layer	=	100000. psi
RQD of rock at top of layer	=	30.000000 %
RQD of rock at bottom of layer	=	30.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 32.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	42.0000	110.0000	24.0000	--	--	--	20.0000	--
	(Reese, et al.)	52.0000	110.0000	24.0000	--	--	--	20.0000	--
2	Sand	52.0000	120.0000	32.0000	--	--	--	60.0000	--
	(Reese, et al.)	57.0000	120.0000	32.0000	--	--			

```
  --          60.0000       --
  3            Weak              57.0000     140.0000       --         275.0000      30.0000
1.00E-04       --           100000.
               Rock             100.0000     140.0000       --         275.0000      30.0000
1.00E-04       --           100000.
```

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition               Condition            Axial Thrust      Compute Top
y     Run Analysis
 No.    Type            1                        2                 Force, lbs      vs. Pile
Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       25000. lbs   M =      270000. in-lbs        0.0000000           No
         Yes
```

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

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Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel Pipe Pile:

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Length of Section                                      =    68.000000 ft
Outer Diameter of Pipe                                 =    30.000000 in
Pipe Wall Thickness                                    =     0.750000 in
Yield Stress of Pipe                                   =    50.000000 ksi
Elastic Modulus                                        =       29000. ksi
Cross-sectional Area                                   =    68.918689 sq. in.
Moment of Inertia                                      =        7375. in^4
Elastic Bending Stiffness                              =   213885920. kip-in^2
Plastic Modulus, Z                                     =   641.812500in^3
Plastic Moment Capacity = Fy Z                         =       32091.in-kip
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Axial Structural Capacities:

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Nom. Axial Structural Capacity = Fy As                 =     3445.934 kips
Nominal Axial Tensile Capacity                         =    -3445.934 kips
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Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000244	522.3962477	213875170.	15.0000000	1.0518750	
0.00000489	1045.	213875170.	15.0000000	2.1037500	
0.00000733	1567.	213875170.	15.0000000	3.1556250	
0.00000977	2090.	213875170.	15.0000000	4.2075000	
0.00001221	2612.	213875170.	15.0000000	5.2593750	
0.00001466	3134.	213875170.	15.0000000	6.3112500	
0.00001710	3657.	213875170.	15.0000000	7.3631250	
0.00001954	4179.	213875170.	15.0000000	8.4150001	
0.00002198	4702.	213875170.	15.0000000	9.4668751	
0.00002443	5224.	213875170.	15.0000000	10.5187501	
0.00002687	5746.	213875170.	15.0000000	11.5706251	
0.00002931	6269.	213875170.	15.0000000	12.6225001	
0.00003175	6791.	213875170.	15.0000000	13.6743751	
0.00003420	7314.	213875170.	15.0000000	14.7262501	
0.00003664	7836.	213875170.	15.0000000	15.7781251	
0.00003908	8358.	213875170.	15.0000000	16.8300001	
0.00004152	8881.	213875170.	15.0000000	17.8818751	
0.00004397	9403.	213875170.	15.0000000	18.9337501	
0.00004641	9926.	213875170.	15.0000000	19.9856251	
0.00004885	10448.	213875170.	15.0000000	21.0375001	
0.00005129	10970.	213875170.	15.0000000	22.0893751	
0.00005374	11493.	213875170.	15.0000000	23.1412502	
0.00005618	12015.	213875170.	15.0000000	24.1931252	
0.00005862	12538.	213875170.	15.0000000	25.2450002	
0.00006106	13060.	213875170.	15.0000000	26.2968752	
0.00006351	13582.	213875170.	15.0000000	27.3487502	
0.00006595	14105.	213875170.	15.0000000	28.4006252	
0.00006839	14627.	213875170.	15.0000000	29.4525002	
0.00007083	15149.	213875170.	15.0000000	30.5043752	
0.00007328	15672.	213875170.	15.0000000	31.5562502	
0.00007572	16194.	213875170.	15.0000000	32.6081252	
0.00007816	16717.	213875170.	15.0000000	33.6600002	
0.00008060	17239.	213875170.	15.0000000	34.7118752	
0.00008305	17761.	213875170.	15.0000000	35.7637502	
0.00008549	18284.	213875170.	15.0000000	36.8156252	
0.00008793	18806.	213875170.	15.0000000	37.8675003	
0.00009037	19329.	213875170.	15.0000000	38.9193753	
0.00009282	19851.	213875170.	15.0000000	39.9712503	
0.00009526	20373.	213875170.	15.0000000	41.0231253	
0.0001001	21418.	213875170.	15.0000000	43.1268753	
0.0001050	22463.	213875170.	15.0000000	45.2306253	
0.0001099	23508.	213875170.	15.0000000	47.3343753	
0.0001148	24553.	213875170.	15.0000000	49.4381253	
0.0001197	25511.	213152380.	15.0000000	50.0000000	Y
0.0001246	26232.	210583666.	15.0000000	50.0000000	Y
0.0001295	26800.	207022224.	15.0000000	50.0000000	Y
0.0001343	27269.	202983179.	15.0000000	50.0000000	Y
0.0001392	27670.	198746654.	15.0000000	50.0000000	Y
0.0001441	28017.	194414878.	15.0000000	50.0000000	Y
0.0001490	28323.	190095167.	15.0000000	50.0000000	Y
0.0001539	28591.	185802169.	15.0000000	50.0000000	Y
0.0001588	28829.	181585311.	15.0000000	50.0000000	Y
0.0001636	29043.	177470462.	15.0000000	50.0000000	Y

0.0001685	29235.	173468097.	15.0000000	50.0000000	Y
0.0001734	29409.	169585196.	15.0000000	50.0000000	Y
0.0001783	29568.	165826064.	15.0000000	50.0000000	Y
0.0001832	29712.	162192964.	15.0000000	50.0000000	Y
0.0001881	29844.	158681275.	15.0000000	50.0000000	Y
0.0001930	29963.	155281614.	15.0000000	50.0000000	Y
0.0001978	30074.	152005500.	15.0000000	50.0000000	Y
0.0002027	30177.	148851238.	15.0000000	50.0000000	Y
0.0002076	30271.	145802256.	15.0000000	50.0000000	Y
0.0002125	30357.	142857873.	15.0000000	50.0000000	Y
0.0002174	30440.	140027612.	15.0000000	50.0000000	Y
0.0002223	30514.	137283086.	15.0000000	50.0000000	Y
0.0002272	30585.	134642575.	15.0000000	50.0000000	Y
0.0002320	30650.	132089238.	15.0000000	50.0000000	Y
0.0002369	30711.	129625023.	15.0000000	50.0000000	Y
0.0002418	30769.	127243261.	15.0000000	50.0000000	Y
0.0002467	30823.	124943000.	15.0000000	50.0000000	Y
0.0002516	30873.	122715893.	15.0000000	50.0000000	Y
0.0002565	30922.	120568203.	15.0000000	50.0000000	Y
0.0002614	30965.	118481064.	15.0000000	50.0000000	Y
0.0002662	31009.	116470517.	15.0000000	50.0000000	Y
0.0002711	31047.	114515408.	15.0000000	50.0000000	Y
0.0002760	31085.	112624803.	15.0000000	50.0000000	Y
0.0002809	31122.	110797855.	15.0000000	50.0000000	Y
0.0002858	31154.	109016833.	15.0000000	50.0000000	Y
0.0002907	31187.	107295678.	15.0000000	50.0000000	Y
0.0003102	31301.	100904523.	15.0000000	50.0000000	Y
0.0003297	31393.	95205408.	15.0000000	50.0000000	Y
0.0003493	31471.	90100759.	15.0000000	50.0000000	Y
0.0003688	31535.	85502779.	15.0000000	50.0000000	Y
0.0003884	31590.	81340543.	15.0000000	50.0000000	Y
0.0004079	31637.	77559576.	15.0000000	50.0000000	Y
0.0004274	31679.	74112823.	15.0000000	50.0000000	Y
0.0004470	31713.	70949672.	15.0000000	50.0000000	Y
0.0004665	31745.	68046000.	15.0000000	50.0000000	Y
0.0004861	31772.	65365798.	15.0000000	50.0000000	Y
0.0005056	31797.	62889062.	15.0000000	50.0000000	Y
0.0005251	31818.	60588308.	15.0000000	50.0000000	Y
0.0005447	31838.	58452630.	15.0000000	50.0000000	Y
0.0005642	31854.	56456945.	15.0000000	50.0000000	Y
0.0005838	31870.	54593653.	15.0000000	50.0000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	31870.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Top of   Equivalent

Layer No.	Layer Below Pile Head ft	Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	42.0000	0.00	N.A.	No	0.00	79557.
2	52.0000	7.3425	Yes	No	79557.	151079.
3	57.0000	15.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 25000.0 lbs
Applied moment at pile head = 270000.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	12.6836	270000.	25000.	-0.02796	549.1245	2.14E+11	0.00	0.00	0.00
0.6800	12.4555	474000.	25000.	-0.02795	964.0186	2.14E+11	0.00	0.00	0.00
1.3600	12.2275	678000.	25000.	-0.02792	1379.	2.14E+11	0.00	0.00	0.00
2.0400	11.9998	882000.	25000.	-0.02789	1794.	2.14E+11	0.00	0.00	0.00
2.7200	11.7723	1086000.	25000.	-0.02786	2209.	2.14E+11	0.00	0.00	0.00
3.4000	11.5452	1290000.	25000.	-0.02781	2624.	2.14E+11	0.00	0.00	0.00
4.0800	11.3184	1494000.	25000.	-0.02776	3038.	2.14E+11	0.00	0.00	0.00
4.7600	11.0922	1698000.	25000.	-0.02770	3453.	2.14E+11	0.00	0.00	0.00
5.4400	10.8664	1902000.	25000.	-0.02763	3868.	2.14E+11	0.00	0.00	0.00
6.1200	10.6413	2106000.	25000.	-0.02755	4283.	2.14E+11	0.00	0.00	0.00
6.8000	10.4168	2310000.	25000.	-0.02747	4698.	2.14E+11	0.00	0.00	0.00
7.4800	10.1930	2514000.	25000.	-0.02738	5113.	2.14E+11	0.00	0.00	0.00
8.1600	9.9700	2718000.	25000.	-0.02728	5528.	2.14E+11	0.00	0.00	0.00
8.8400	9.7479	2922000.	25000.	-0.02717	5943.	2.14E+11	0.00	0.00	0.00
9.5200	9.5267	3126000.	25000.	-0.02705	6358.	2.14E+11	0.00	0.00	0.00
10.2000	9.3064	3330000.	25000.	-0.02693	6773.	2.14E+11	0.00	0.00	0.00
10.8800	9.0872	3534000.	25000.	-0.02680	7187.	2.14E+11	0.00	0.00	0.00
11.5600	8.8690	3738000.	25000.	-0.02666	7602.	2.14E+11	0.00	0.00	0.00

12.2400	8.6521	3942000.	25000.	-0.02651	8017.	2.14E+11	0.00	0.00	0.00
12.9200	8.4364	4146000.	25000.	-0.02636	8432.	2.14E+11	0.00	0.00	0.00
13.6000	8.2219	4350000.	25000.	-0.02620	8847.	2.14E+11	0.00	0.00	0.00
14.2800	8.0088	4554000.	25000.	-0.02603	9262.	2.14E+11	0.00	0.00	0.00
14.9600	7.7972	4758000.	25000.	-0.02585	9677.	2.14E+11	0.00	0.00	0.00
15.6400	7.5870	4962000.	25000.	-0.02566	10092.	2.14E+11	0.00	0.00	0.00
16.3200	7.3783	5166000.	25000.	-0.02547	10507.	2.14E+11	0.00	0.00	0.00
17.0000	7.1713	5370000.	25000.	-0.02527	10921.	2.14E+11	0.00	0.00	0.00
17.6800	6.9659	5574000.	25000.	-0.02506	11336.	2.14E+11	0.00	0.00	0.00
18.3600	6.7623	5778000.	25000.	-0.02484	11751.	2.14E+11	0.00	0.00	0.00
19.0400	6.5605	5982000.	25000.	-0.02462	12166.	2.14E+11	0.00	0.00	0.00
19.7200	6.3605	6186000.	25000.	-0.02439	12581.	2.14E+11	0.00	0.00	0.00
20.4000	6.1625	6390000.	25000.	-0.02415	12996.	2.14E+11	0.00	0.00	0.00
21.0800	5.9664	6594000.	25000.	-0.02390	13411.	2.14E+11	0.00	0.00	0.00
21.7600	5.7724	6798000.	25000.	-0.02364	13826.	2.14E+11	0.00	0.00	0.00
22.4400	5.5805	7002000.	25000.	-0.02338	14241.	2.14E+11	0.00	0.00	0.00
23.1200	5.3908	7206000.	25000.	-0.02311	14656.	2.14E+11	0.00	0.00	0.00
23.8000	5.2034	7410000.	25000.	-0.02283	15070.	2.14E+11	0.00	0.00	0.00
24.4800	5.0182	7614000.	25000.	-0.02254	15485.	2.14E+11	0.00	0.00	0.00
25.1600	4.8354	7818000.	25000.	-0.02225	15900.	2.14E+11	0.00	0.00	0.00
25.8400	4.6551	8022000.	25000.	-0.02195	16315.	2.14E+11	0.00	0.00	0.00
26.5200	4.4772	8226000.	25000.	-0.02164	16730.	2.14E+11	0.00	0.00	0.00
27.2000	4.3019	8430000.	25000.	-0.02132	17145.	2.14E+11	0.00	0.00	0.00
27.8800	4.1293	8634000.	25000.	-0.02100	17560.	2.14E+11	0.00	0.00	0.00
28.5600	3.9593	8838000.	25000.	-0.02066	17975.	2.14E+11	0.00	0.00	0.00
29.2400	3.7921	9042000.	25000.	-0.02032	18390.	2.14E+11	0.00	0.00	0.00
29.9200	3.6277	9246000.	25000.	-0.01997	18804.	2.14E+11	0.00	0.00	0.00
30.6000	3.4661	9450000.	25000.	-0.01962	19219.	2.14E+11	0.00	0.00	0.00
31.2800	3.3075	9654000.	25000.	-0.01925	19634.	2.14E+11	0.00	0.00	0.00
31.9600	3.1520	9858000.	25000.	-0.01888	20049.	2.14E+11	0.00	0.00	0.00
32.6400	2.9994	1.01E+07	25000.	-0.01850	20464.	2.14E+11	0.00	0.00	0.00
33.3200	2.8501	1.03E+07	25000.	-0.01811	20879.	2.14E+11	0.00	0.00	0.00
34.0000	2.7039	1.05E+07	25000.	-0.01772	21294.	2.14E+11	0.00	0.00	0.00
34.6800	2.5610	1.07E+07	25000.	-0.01731	21709.	2.14E+11	0.00	0.00	0.00
35.3600	2.4213	1.09E+07	25000.	-0.01690	22124.	2.14E+11	0.00	0.00	0.00
36.0400	2.2851	1.11E+07	25000.	-0.01648	22539.	2.14E+11	0.00	0.00	0.00
36.7200	2.1524	1.13E+07	25000.	-0.01606	22953.	2.14E+11	0.00		

								0.00	0.00
37.4000	2.0231	1.15E+07	25000.	-0.01562	23368.	2.14E+11	0.00	0.00	0.00
38.0800	1.8974	1.17E+07	25000.	-0.01518	23783.	2.14E+11	0.00	0.00	0.00
38.7600	1.7754	1.19E+07	25000.	-0.01473	24198.	2.14E+11	0.00	0.00	0.00
39.4400	1.6571	1.21E+07	25000.	-0.01427	24613.	2.14E+11	0.00	0.00	0.00
40.1200	1.5425	1.23E+07	25000.	-0.01380	25028.	2.14E+11	0.00	0.00	0.00
40.8000	1.4318	1.25E+07	25000.	-0.01333	25443.	2.14E+11	0.00	0.00	0.00
41.4800	1.3249	1.27E+07	25000.	-0.01285	25858.	2.14E+11	0.00	0.00	0.00
42.1600	1.2221	1.29E+07	24916.	-0.01236	26273.	2.14E+11	-20.634	137.7810	0.00
42.8400	1.1232	1.31E+07	24359.	-0.01186	26685.	2.14E+11	-115.924	842.1854	0.00
43.5200	1.0284	1.33E+07	23027.	-0.01136	27081.	2.14E+11	-210.480	1670.	0.00
44.2000	0.9378	1.35E+07	20951.	-0.01085	27449.	2.14E+11	-298.386	2596.	0.00
44.8800	0.8514	1.37E+07	18199.	-0.01033	27776.	2.14E+11	-376.029	3604.	0.00
45.5600	0.7692	1.38E+07	14870.	-0.00981	28053.	2.14E+11	-439.923	4667.	0.00
46.2400	0.6913	1.39E+07	11060.	-0.00928	28270.	2.14E+11	-494.005	5831.	0.00
46.9200	0.6178	1.40E+07	6865.	-0.00875	28420.	2.14E+11	-534.154	7055.	0.00
47.6000	0.5486	1.40E+07	2386.	-0.00821	28498.	2.14E+11	-563.654	8384.	0.00
48.2800	0.4837	1.40E+07	-2270.	-0.00768	28499.	2.14E+11	-577.401	9740.	0.00
48.9600	0.4233	1.40E+07	-7015.	-0.00714	28423.	2.14E+11	-585.644	11291.	0.00
49.6400	0.3671	1.39E+07	-11764.	-0.00661	28266.	2.14E+11	-578.373	12855.	0.00
50.3200	0.3153	1.38E+07	-16460.	-0.00608	28032.	2.14E+11	-572.448	14813.	0.00
51.0000	0.2678	1.36E+07	-21026.	-0.00556	27720.	2.14E+11	-546.810	16660.	0.00
51.6800	0.2246	1.34E+07	-25301.	-0.00505	27334.	2.14E+11	-500.951	18203.	0.00
52.3600	0.1855	1.32E+07	-30701.	-0.00454	26880.	2.14E+11	-822.553	36186.	0.00
53.0400	0.1505	1.29E+07	-37243.	-0.00404	26315.	2.14E+11	-780.847	42331.	0.00
53.7200	0.1196	1.26E+07	-43303.	-0.00355	25644.	2.14E+11	-704.421	48067.	0.00
54.4000	0.09257	1.22E+07	-48612.	-0.00308	24878.	2.14E+11	-596.790	52604.	0.00
55.0800	0.06937	1.18E+07	-53173.	-0.00262	24031.	2.14E+11	-521.173	61304.	0.00
55.7600	0.04985	1.14E+07	-57189.	-0.00218	23113.	2.14E+11	-463.144	75815.	0.00
56.4400	0.03386	1.09E+07	-60515.	-0.00175	22133.	2.14E+11	-352.063	84838.	0.00
57.1200	0.02126	1.04E+07	-85398.	-0.00135	21104.	2.14E+11	-5747.	2205142.	0.00
57.8000	0.01190	9488689.	-136358.	-9.67E-04	19298.	2.14E+11	-6744.	4625028.	0.00
58.4800	0.00548	8151495.	-192507.	-6.30E-04	16578.	2.14E+11	-7018.	1.04E+07	0.00
59.1600	0.00161	6346975.	-246612.	-3.54E-04	12908.	2.14E+11	-6243.	3.16E+07	0.00
59.8400	-2.89E-04	4126781.	-252673.	-1.54E-04	8393.	2.14E+11	4757.	1.34E+08	0.00
60.5200	-9.04E-04	2223351.	-203636.	-3.29E-05	4522.	2.14E+11	7262.	6.56E+07	0.00
61.2000	-8.26E-04	803435.	-141327.	2.49E-05	1634.	2.14E+11	8010.	7.91E+07	0.00

61.8800	-4.98E-04	-83100.	-76573.	3.86E-05	169.0082	2.14E+11	7861.	1.29E+08	0.00
62.5600	-1.96E-04	-446236.	-16513.	2.85E-05	907.5515	2.14E+11	6860.	2.86E+08	0.00
63.2400	-3.28E-05	-352598.	17262.	1.33E-05	717.1126	2.14E+11	1418.	3.53E+08	0.00
63.9200	2.06E-05	-164514.	19106.	3.40E-06	334.5876	2.14E+11	-966.510	3.83E+08	0.00
64.6000	2.28E-05	-40785.	10519.	-5.13E-07	82.9488	2.14E+11	-1138.	4.08E+08	0.00
65.2800	1.22E-05	7151.	3380.	-1.15E-06	14.5445	2.14E+11	-611.400	4.08E+08	0.00
65.9600	3.92E-06	14378.	86.4639	-7.44E-07	29.2412	2.14E+11	-195.858	4.08E+08	0.00
66.6400	8.25E-08	8563.	-729.465	-3.07E-07	17.4144	2.14E+11	-4.125	4.08E+08	0.00
67.3200	-1.09E-06	2473.	-524.664	-9.61E-08	5.0291	2.14E+11	54.3207	4.08E+08	0.00
68.0000	-1.49E-06	0.00	0.00	-4.89E-08	0.00	2.14E+11	74.2735	2.04E+08	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =    12.68359380 inches
Computed slope at pile head      =     -0.0279593 radians
Maximum bending moment           =      14012863. inch-lbs
Maximum shear force              =       -252673. lbs
Depth of maximum bending moment  =    48.28000000 feet below pile head
Depth of maximum shear force     =    59.84000000 feet below pile head
Number of iterations             =             25
Number of zero deflection points =              3
Pile deflection at ground        =     1.24626437 inches
```

Summary of Pile-head Responses for Conventional Analyses

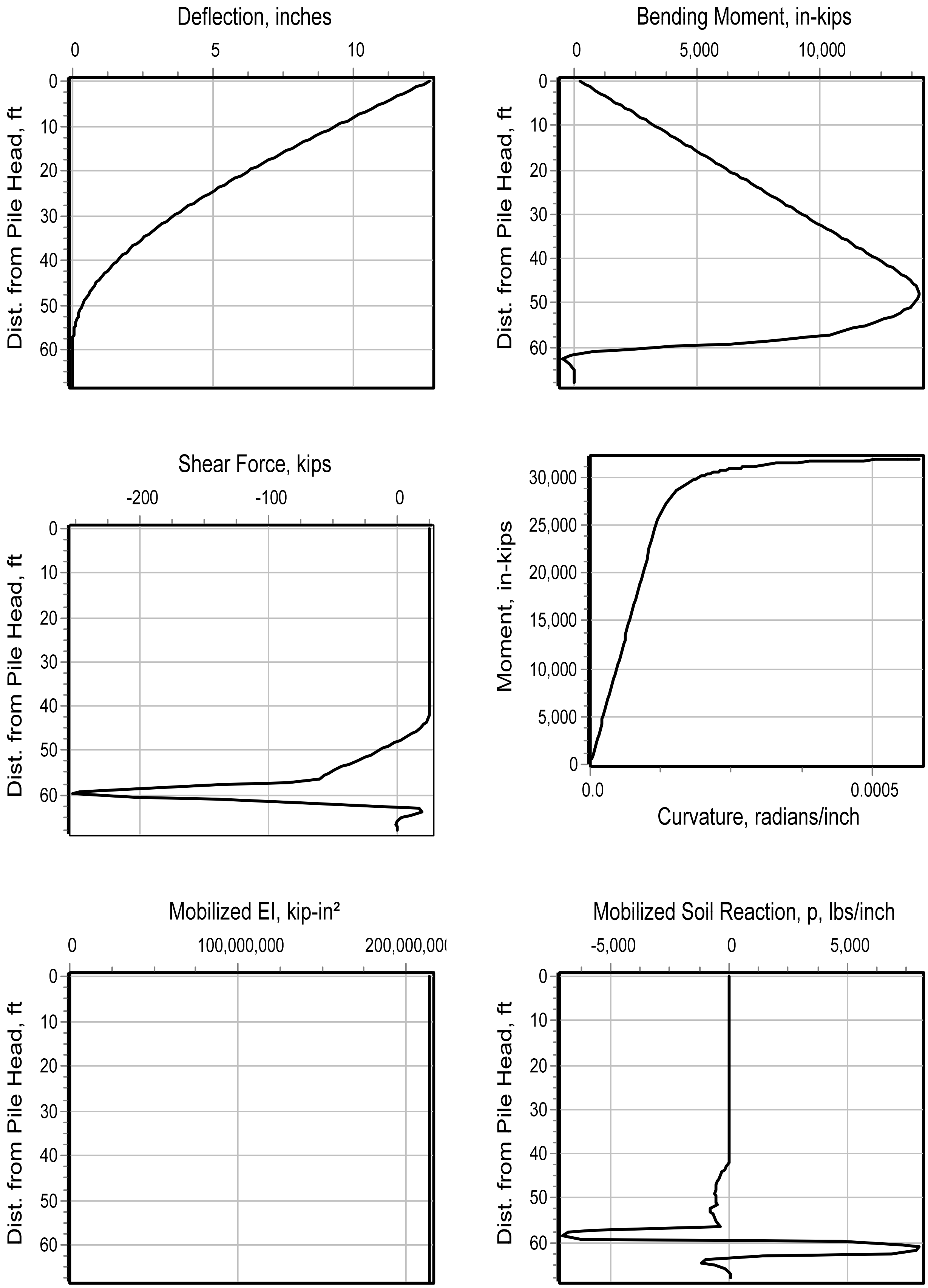
Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	25000.	M, in-lb	270000.	0.00	12.6836	-0.02796	-252673.	1.40E+07

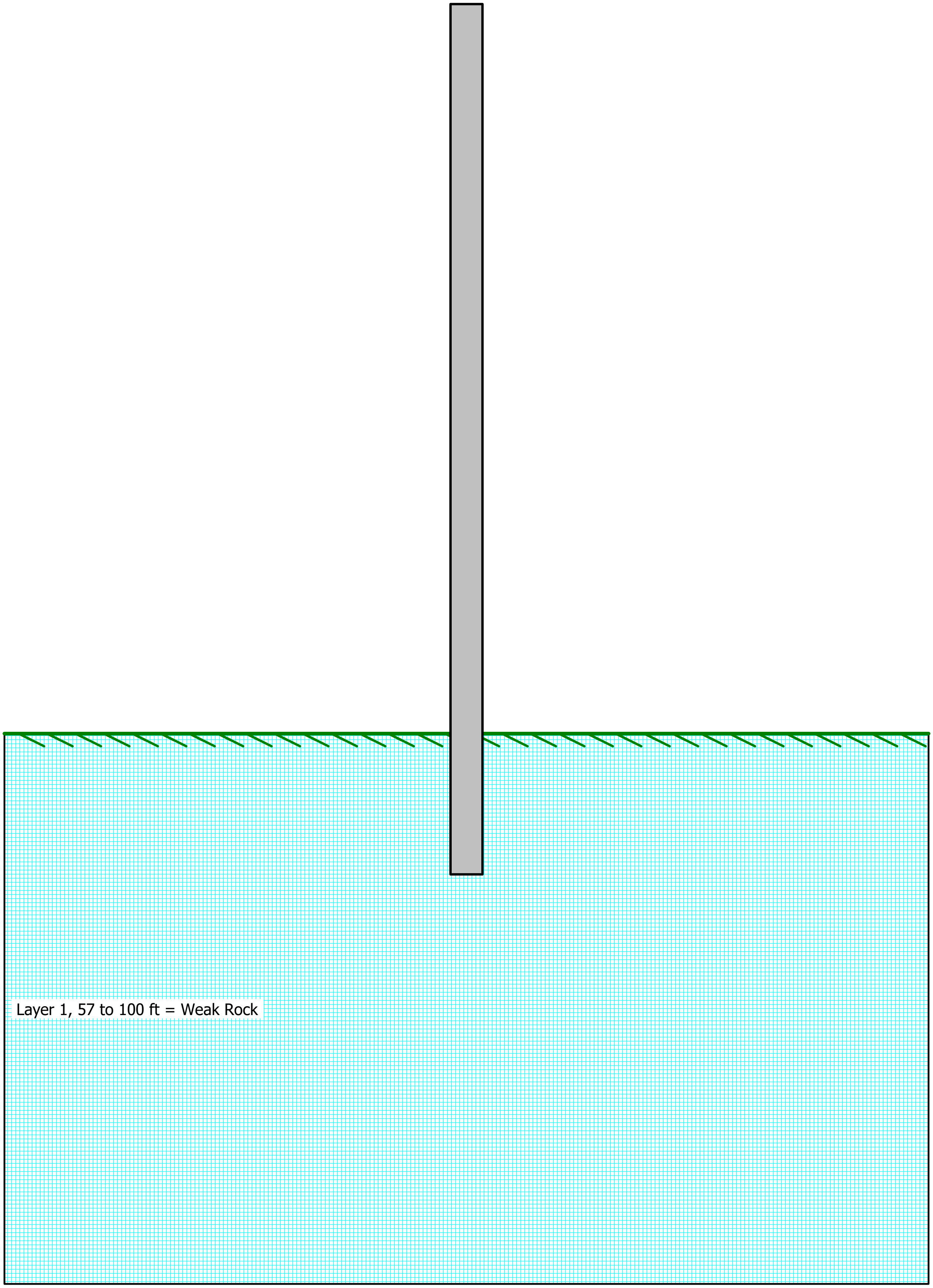
Maximum pile-head deflection = 12.6835937979 inches
Maximum pile-head rotation   = -0.0279593405 radians = -1.601952 deg.

The analysis ended normally.



CASE 2 - RESULTS SUMMARY ANCHOR PILE WITH 2 SOIL LAYERS AND ROCK

CASE 3 - ANCHOR PILE ONLY ON ROCK SERVICE LOAD CONDITION



LPile 2022.12.03, © 2022 by Ensoft, Inc.

==

LPile for Windows, Version 2022-12.003

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

==

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Files Used for Analysis

Path to file locations:
\\enercon.sharepoint.com@SSL\DavWWWRoot\sites\NSG_NC\Clients\FWTH\FWTHFS\FWTHFS-00254\FWTHFS-00242 (Original Project Docs)\Deliverables_SP\Calculations\Trash Wheel\Final\westfork\08_09_2022\

Name of input data file:
West Fork30dia 0.75wall_service.lp12d

Name of output report file:
West Fork30dia 0.75wall_service.lp12o

Name of plot output file:
West Fork30dia 0.75wall_service.lp12p

Name of runtime message file:
West Fork30dia 0.75wall_service.lp12r

Date and Time of Analysis

Date: August 13, 2022 Time: 18:37:05

Problem Title

Project Name: Fort Worth Trash Wheel

Job Number: FWTHFS-00242

Client: City of Fort Worth

Engineer: Sandeep Menon

Description: Clear Fork LPILE

```
--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     300.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                        =            1
Total length of pile                                   =       68.000 ft
Depth of ground surface below top of pile              =      57.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000          30.0000
  2           68.000          30.0000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a steel pipe pile
   Length of section                                   =    68.000000 ft
```

Pile diameter = 30.000000 in

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	57.000000 ft
Distance from top of pile to bottom of layer	=	100.000000 ft
Effective unit weight at top of layer	=	140.000000 pcf
Effective unit weight at bottom of layer	=	140.000000 pcf
Uniaxial compressive strength at top of layer	=	275.000000 psi
Uniaxial compressive strength at bottom of layer	=	275.000000 psi
Initial modulus of rock at top of layer	=	100000. psi
Initial modulus of rock at bottom of layer	=	100000. psi
RQD of rock at top of layer	=	30.000000 %
RQD of rock at bottom of layer	=	30.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 32.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Weak	57.0000	140.0000	275.0000	30.0000	1.00E-04	100000.
	Rock	100.0000	140.0000	275.0000	30.0000	1.00E-04	100000.

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 5500. lbs	M = 270000. in-lbs	0.0000000	No	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head

y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel Pipe Pile:

Length of Section	=	68.000000 ft
Outer Diameter of Pipe	=	30.000000 in
Pipe Wall Thickness	=	0.750000 in
Yield Stress of Pipe	=	60.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	68.918689 sq. in.
Moment of Inertia	=	7375. in^4
Elastic Bending Stiffness	=	213885920. kip-in^2
Plastic Modulus, Z	=	641.812500in^3
Plastic Moment Capacity = Fy Z	=	38509.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	4135.121 kips
Nominal Axial Tensile Capacity	=	-4135.121 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000293	626.8754973	213875170.	15.0000000	1.2622500	
0.00000586	1254.	213875170.	15.0000000	2.5245000	
0.00000879	1881.	213875170.	15.0000000	3.7867500	
0.00001172	2508.	213875170.	15.0000000	5.0490000	
0.00001466	3134.	213875170.	15.0000000	6.3112500	
0.00001759	3761.	213875170.	15.0000000	7.5735001	
0.00002052	4388.	213875170.	15.0000000	8.8357501	
0.00002345	5015.	213875170.	15.0000000	10.0980001	
0.00002638	5642.	213875170.	15.0000000	11.3602501	
0.00002931	6269.	213875170.	15.0000000	12.6225001	
0.00003224	6896.	213875170.	15.0000000	13.8847501	
0.00003517	7523.	213875170.	15.0000000	15.1470001	

0.00003810	8149.	213875170.	15.0000000	16.4092501	
0.00004103	8776.	213875170.	15.0000000	17.6715001	
0.00004397	9403.	213875170.	15.0000000	18.9337501	
0.00004690	10030.	213875170.	15.0000000	20.1960001	
0.00004983	10657.	213875170.	15.0000000	21.4582501	
0.00005276	11284.	213875170.	15.0000000	22.7205002	
0.00005569	11911.	213875170.	15.0000000	23.9827502	
0.00005862	12538.	213875170.	15.0000000	25.2450002	
0.00006155	13164.	213875170.	15.0000000	26.5072502	
0.00006448	13791.	213875170.	15.0000000	27.7695002	
0.00006741	14418.	213875170.	15.0000000	29.0317502	
0.00007034	15045.	213875170.	15.0000000	30.2940002	
0.00007328	15672.	213875170.	15.0000000	31.5562502	
0.00007621	16299.	213875170.	15.0000000	32.8185002	
0.00007914	16926.	213875170.	15.0000000	34.0807502	
0.00008207	17553.	213875170.	15.0000000	35.3430002	
0.00008500	18179.	213875170.	15.0000000	36.6052502	
0.00008793	18806.	213875170.	15.0000000	37.8675003	
0.00009086	19433.	213875170.	15.0000000	39.1297503	
0.00009379	20060.	213875170.	15.0000000	40.3920003	
0.00009672	20687.	213875170.	15.0000000	41.6542503	
0.00009966	21314.	213875170.	15.0000000	42.9165003	
0.0001026	21941.	213875170.	15.0000000	44.1787503	
0.0001055	22568.	213875170.	15.0000000	45.4410003	
0.0001084	23194.	213875170.	15.0000000	46.7032503	
0.0001114	23821.	213875170.	15.0000000	47.9655003	
0.0001143	24448.	213875170.	15.0000000	49.2277503	
0.0001202	25702.	213875170.	15.0000000	51.7522503	
0.0001260	26956.	213875170.	15.0000000	54.2767504	
0.0001319	28209.	213875170.	15.0000000	56.8012504	
0.0001378	29463.	213875170.	15.0000000	59.3257504	
0.0001436	30613.	213152380.	15.0000000	60.0000000	Y
0.0001495	31479.	210583666.	15.0000000	60.0000000	Y
0.0001553	32160.	207022224.	15.0000000	60.0000000	Y
0.0001612	32722.	202983179.	15.0000000	60.0000000	Y
0.0001671	33204.	198746654.	15.0000000	60.0000000	Y
0.0001729	33620.	194414878.	15.0000000	60.0000000	Y
0.0001788	33988.	190095167.	15.0000000	60.0000000	Y
0.0001847	34309.	185802169.	15.0000000	60.0000000	Y
0.0001905	34595.	181585311.	15.0000000	60.0000000	Y
0.0001964	34852.	177470462.	15.0000000	60.0000000	Y
0.0002022	35082.	173468097.	15.0000000	60.0000000	Y
0.0002081	35291.	169585196.	15.0000000	60.0000000	Y
0.0002140	35481.	165826064.	15.0000000	60.0000000	Y
0.0002198	35654.	162192964.	15.0000000	60.0000000	Y
0.0002257	35813.	158681275.	15.0000000	60.0000000	Y
0.0002316	35956.	155281614.	15.0000000	60.0000000	Y
0.0002374	36088.	152005500.	15.0000000	60.0000000	Y
0.0002433	36212.	148851238.	15.0000000	60.0000000	Y
0.0002491	36325.	145802256.	15.0000000	60.0000000	Y
0.0002550	36429.	142857873.	15.0000000	60.0000000	Y
0.0002609	36528.	140027612.	15.0000000	60.0000000	Y
0.0002667	36617.	137283086.	15.0000000	60.0000000	Y
0.0002726	36702.	134642575.	15.0000000	60.0000000	Y
0.0002784	36780.	132089238.	15.0000000	60.0000000	Y
0.0002843	36854.	129625023.	15.0000000	60.0000000	Y
0.0002902	36922.	127243261.	15.0000000	60.0000000	Y
0.0002960	36987.	124943000.	15.0000000	60.0000000	Y
0.0003019	37048.	122715893.	15.0000000	60.0000000	Y
0.0003078	37106.	120568203.	15.0000000	60.0000000	Y
0.0003136	37158.	118481064.	15.0000000	60.0000000	Y
0.0003195	37210.	116470517.	15.0000000	60.0000000	Y
0.0003253	37257.	114515408.	15.0000000	60.0000000	Y
0.0003312	37302.	112624803.	15.0000000	60.0000000	Y
0.0003371	37347.	110797855.	15.0000000	60.0000000	Y
0.0003429	37385.	109016833.	15.0000000	60.0000000	Y
0.0003488	37424.	107295678.	15.0000000	60.0000000	Y
0.0003722	37561.	100904523.	15.0000000	60.0000000	Y
0.0003957	37672.	95205408.	15.0000000	60.0000000	Y
0.0004191	37765.	90100759.	15.0000000	60.0000000	Y
0.0004426	37842.	85502779.	15.0000000	60.0000000	Y
0.0004660	37907.	81340543.	15.0000000	60.0000000	Y
0.0004895	37964.	77559576.	15.0000000	60.0000000	Y

0.0005129	38015.	74112823.	15.0000000	60.0000000	Y
0.0005364	38056.	70949672.	15.0000000	60.0000000	Y
0.0005598	38094.	68046000.	15.0000000	60.0000000	Y
0.0005833	38126.	65365798.	15.0000000	60.0000000	Y
0.0006067	38156.	62889062.	15.0000000	60.0000000	Y
0.0006302	38181.	60588308.	15.0000000	60.0000000	Y
0.0006536	38206.	58452630.	15.0000000	60.0000000	Y
0.0006771	38225.	56456945.	15.0000000	60.0000000	Y
0.0007005	38244.	54593653.	15.0000000	60.0000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	38244.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head	=	5500.0 lbs
Applied moment at pile head	=	270000.0 in-lbs
Axial thrust load on pile head	=	0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	3.3951	270000.	5500.	-0.00739	549.1245	2.14E+11	0.00	0.00	0.00
0.6800	3.3348	314880.	5500.	-0.00738	640.4012	2.14E+11	0.00	0.00	0.00
1.3600	3.2747	359760.	5500.	-0.00737	731.6779	2.14E+11	0.00	0.00	0.00
2.0400	3.2146	404640.	5500.	-0.00735	822.9546	2.14E+11	0.00	0.00	0.00
2.7200	3.1547	449520.	5500.	-0.00733	914.2313	2.14E+11	0.00	0.00	0.00
3.4000	3.0949	494400.	5500.	-0.00732	1006.	2.14E+11	0.00	0.00	0.00
4.0800	3.0353	539280.	5500.	-0.00730	1097.	2.14E+11	0.00	0.00	0.00
4.7600	2.9758	584160.	5500.	-0.00728	1188.	2.14E+11	0.00	0.00	0.00
5.4400	2.9166	629040.	5500.	-0.00725	1279.	2.14E+11	0.00		

								0.00	0.00
6.1200	2.8575	673920.	5500.	-0.00723	1371.	2.14E+11	0.00	0.00	0.00
6.8000	2.7986	718800.	5500.	-0.00720	1462.	2.14E+11	0.00	0.00	0.00
7.4800	2.7400	763680.	5500.	-0.00717	1553.	2.14E+11	0.00	0.00	0.00
8.1600	2.6815	808560.	5500.	-0.00714	1644.	2.14E+11	0.00	0.00	0.00
8.8400	2.6234	853440.	5500.	-0.00711	1736.	2.14E+11	0.00	0.00	0.00
9.5200	2.5655	898320.	5500.	-0.00708	1827.	2.14E+11	0.00	0.00	0.00
10.2000	2.5079	943200.	5500.	-0.00704	1918.	2.14E+11	0.00	0.00	0.00
10.8800	2.4506	988080.	5500.	-0.00701	2010.	2.14E+11	0.00	0.00	0.00
11.5600	2.3936	1032960.	5500.	-0.00697	2101.	2.14E+11	0.00	0.00	0.00
12.2400	2.3369	1077840.	5500.	-0.00693	2192.	2.14E+11	0.00	0.00	0.00
12.9200	2.2805	1122720.	5500.	-0.00688	2283.	2.14E+11	0.00	0.00	0.00
13.6000	2.2245	1167600.	5500.	-0.00684	2375.	2.14E+11	0.00	0.00	0.00
14.2800	2.1689	1212480.	5500.	-0.00680	2466.	2.14E+11	0.00	0.00	0.00
14.9600	2.1136	1257360.	5500.	-0.00675	2557.	2.14E+11	0.00	0.00	0.00
15.6400	2.0587	1302240.	5500.	-0.00670	2648.	2.14E+11	0.00	0.00	0.00
16.3200	2.0043	1347120.	5500.	-0.00665	2740.	2.14E+11	0.00	0.00	0.00
17.0000	1.9502	1392000.	5500.	-0.00660	2831.	2.14E+11	0.00	0.00	0.00
17.6800	1.8966	1436880.	5500.	-0.00654	2922.	2.14E+11	0.00	0.00	0.00
18.3600	1.8435	1481760.	5500.	-0.00649	3014.	2.14E+11	0.00	0.00	0.00
19.0400	1.7908	1526640.	5500.	-0.00643	3105.	2.14E+11	0.00	0.00	0.00
19.7200	1.7385	1571520.	5500.	-0.00637	3196.	2.14E+11	0.00	0.00	0.00
20.4000	1.6868	1616400.	5500.	-0.00631	3287.	2.14E+11	0.00	0.00	0.00
21.0800	1.6355	1661280.	5500.	-0.00625	3379.	2.14E+11	0.00	0.00	0.00
21.7600	1.5848	1706160.	5500.	-0.00618	3470.	2.14E+11	0.00	0.00	0.00
22.4400	1.5346	1751040.	5500.	-0.00612	3561.	2.14E+11	0.00	0.00	0.00
23.1200	1.4850	1795920.	5500.	-0.00605	3653.	2.14E+11	0.00	0.00	0.00
23.8000	1.4359	1840800.	5500.	-0.00598	3744.	2.14E+11	0.00	0.00	0.00
24.4800	1.3874	1885680.	5500.	-0.00591	3835.	2.14E+11	0.00	0.00	0.00
25.1600	1.3395	1930560.	5500.	-0.00584	3926.	2.14E+11	0.00	0.00	0.00
25.8400	1.2922	1975440.	5500.	-0.00576	4018.	2.14E+11	0.00	0.00	0.00
26.5200	1.2455	2020320.	5500.	-0.00569	4109.	2.14E+11	0.00	0.00	0.00
27.2000	1.1994	2065200.	5500.	-0.00561	4200.	2.14E+11	0.00	0.00	0.00
27.8800	1.1539	2110080.	5500.	-0.00553	4291.	2.14E+11	0.00	0.00	0.00
28.5600	1.1092	2154960.	5500.	-0.00545	4383.	2.14E+11	0.00	0.00	0.00
29.2400	1.0651	2199840.	5500.	-0.00536	4474.	2.14E+11	0.00	0.00	0.00
29.9200	1.0216	2244720.	5500.	-0.00528	4565.	2.14E+11	0.00	0.00	0.00

30.6000	0.9789	2289600.	5500.	-0.00519	4657.	2.14E+11	0.00	0.00	0.00
31.2800	0.9369	2334480.	5500.	-0.00510	4748.	2.14E+11	0.00	0.00	0.00
31.9600	0.8956	2379360.	5500.	-0.00501	4839.	2.14E+11	0.00	0.00	0.00
32.6400	0.8551	2424240.	5500.	-0.00492	4930.	2.14E+11	0.00	0.00	0.00
33.3200	0.8153	2469120.	5500.	-0.00483	5022.	2.14E+11	0.00	0.00	0.00
34.0000	0.7763	2514000.	5500.	-0.00473	5113.	2.14E+11	0.00	0.00	0.00
34.6800	0.7380	2558880.	5500.	-0.00464	5204.	2.14E+11	0.00	0.00	0.00
35.3600	0.7006	2603760.	5500.	-0.00454	5296.	2.14E+11	0.00	0.00	0.00
36.0400	0.6639	2648640.	5500.	-0.00444	5387.	2.14E+11	0.00	0.00	0.00
36.7200	0.6281	2693520.	5500.	-0.00434	5478.	2.14E+11	0.00	0.00	0.00
37.4000	0.5932	2738400.	5500.	-0.00423	5569.	2.14E+11	0.00	0.00	0.00
38.0800	0.5591	2783280.	5500.	-0.00413	5661.	2.14E+11	0.00	0.00	0.00
38.7600	0.5258	2828160.	5500.	-0.00402	5752.	2.14E+11	0.00	0.00	0.00
39.4400	0.4934	2873040.	5500.	-0.00391	5843.	2.14E+11	0.00	0.00	0.00
40.1200	0.4620	2917920.	5500.	-0.00380	5934.	2.14E+11	0.00	0.00	0.00
40.8000	0.4314	2962800.	5500.	-0.00369	6026.	2.14E+11	0.00	0.00	0.00
41.4800	0.4018	3007680.	5500.	-0.00358	6117.	2.14E+11	0.00	0.00	0.00
42.1600	0.3731	3052560.	5500.	-0.00346	6208.	2.14E+11	0.00	0.00	0.00
42.8400	0.3453	3097440.	5500.	-0.00334	6300.	2.14E+11	0.00	0.00	0.00
43.5200	0.3185	3142320.	5500.	-0.00322	6391.	2.14E+11	0.00	0.00	0.00
44.2000	0.2927	3187200.	5500.	-0.00310	6482.	2.14E+11	0.00	0.00	0.00
44.8800	0.2679	3232080.	5500.	-0.00298	6573.	2.14E+11	0.00	0.00	0.00
45.5600	0.2441	3276960.	5500.	-0.00286	6665.	2.14E+11	0.00	0.00	0.00
46.2400	0.2213	3321840.	5500.	-0.00273	6756.	2.14E+11	0.00	0.00	0.00
46.9200	0.1995	3366720.	5500.	-0.00260	6847.	2.14E+11	0.00	0.00	0.00
47.6000	0.1788	3411600.	5500.	-0.00247	6938.	2.14E+11	0.00	0.00	0.00
48.2800	0.1592	3456480.	5500.	-0.00234	7030.	2.14E+11	0.00	0.00	0.00
48.9600	0.1406	3501360.	5500.	-0.00221	7121.	2.14E+11	0.00	0.00	0.00
49.6400	0.1231	3546240.	5500.	-0.00207	7212.	2.14E+11	0.00	0.00	0.00
50.3200	0.1067	3591120.	5500.	-0.00194	7304.	2.14E+11	0.00	0.00	0.00
51.0000	0.09145	3636000.	5500.	-0.00180	7395.	2.14E+11	0.00	0.00	0.00
51.6800	0.07733	3680880.	5500.	-0.00166	7486.	2.14E+11	0.00	0.00	0.00
52.3600	0.06434	3725760.	5500.	-0.00152	7577.	2.14E+11	0.00	0.00	0.00
53.0400	0.05252	3770640.	5500.	-0.00138	7669.	2.14E+11	0.00	0.00	0.00
53.7200	0.04187	3815520.	5500.	-0.00123	7760.	2.14E+11	0.00	0.00	0.00
54.4000	0.03241	3860400.	5500.	-0.00109	7851.	2.14E+11	0.00	0.00	0.00
55.0800	0.02415	3905280.	5500.	-9.38E-04	7943.	2.14E+11	0.00		

```
0.00       0.00
   55.7600    0.01710   3950160.      5500.  -7.88E-04      8034.   2.14E+11       0.00
0.00       0.00
   56.4400    0.01129   3995040.      5500.  -6.36E-04      8125.   2.14E+11       0.00
0.00       0.00
   57.1200    0.00672   4039920.    -12079.  -4.83E-04      8216.   2.14E+11     -4309.
5231998.       0.00
   57.8000    0.00341   3797914.    -49785.  -3.34E-04      7724.   2.14E+11     -4933.
1.18E+07       0.00
   58.4800    0.00128   3227436.    -89802.  -1.99E-04      6564.   2.14E+11     -4875.
3.12E+07       0.00
   59.1600   1.52E-04   2332353.   -123001.  -9.34E-05      4744.   2.14E+11     -3262.
1.76E+08       0.00
   59.8400  -2.48E-04   1220052.   -117618.  -2.57E-05      2481.   2.14E+11      4582.
1.51E+08       0.00
   60.5200  -2.67E-04    412821.    -77075.   5.50E-06   839.5932   2.14E+11      5356.
1.64E+08       0.00
   61.2000  -1.58E-04    -37806.    -34341.   1.26E-05    76.8898   2.14E+11      5118.
2.64E+08       0.00
   61.8800  -6.06E-05   -147628.     -4546.   9.11E-06   300.2440   2.14E+11      2184.
2.94E+08       0.00
   62.5600  -9.26E-06   -111993.      5865.   4.16E-06   227.7703   2.14E+11   367.1688
3.24E+08       0.00
   63.2400   7.25E-06    -51910.      6083.   1.03E-06   105.5740   2.14E+11   -313.782
3.53E+08       0.00
   63.9200   7.60E-06    -12720.      3348.  -2.00E-07    25.8705   2.14E+11   -356.421
3.83E+08       0.00
   64.6000   3.99E-06      2737.      1081.  -3.90E-07     5.5659   2.14E+11   -199.338
4.08E+08       0.00
   65.2800   1.23E-06      4921.   17.3261  -2.44E-07    10.0077   2.14E+11    -61.352
4.08E+08       0.00
   65.9600  -7.15E-10      3019.  -232.846  -9.29E-08     6.1410   2.14E+11    0.03574
4.08E+08       0.00
   66.6400  -2.88E-07      1121.  -173.862  -1.39E-08     2.2792   2.14E+11    14.4211
4.08E+08       0.00
   67.3200  -2.27E-07   182.0612   -68.668   1.10E-08     0.3703   2.14E+11    11.3618
4.08E+08       0.00
   68.0000  -1.09E-07      0.00       0.00   1.44E-08       0.00   2.14E+11     5.4685
2.04E+08       0.00

* This analysis computed pile response using nonlinear moment-curvature rela-
  tionships. Values of total stress due to combined axial and bending stresses
  are computed only for elastic sections only and do not equal the actual
  stresses in concrete and steel. Stresses in concrete and steel may be inter-
  polated from the output for nonlinear bending properties relative to the
  magnitude of bending moment developed in the pile.


Output Summary for Load Case No. 1:

Pile-head deflection              =     3.39506772 inches
Computed slope at pile head       =     -0.0073894 radians
Maximum bending moment            =       4039920. inch-lbs
Maximum shear force               =       -123001. lbs
Depth of maximum bending moment   =    57.12000000 feet below pile head
Depth of maximum shear force      =    59.16000000 feet below pile head
Number of iterations              =             14
Number of zero deflection points =              4
Pile deflection at ground         =     0.00752626 inches


--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians
```

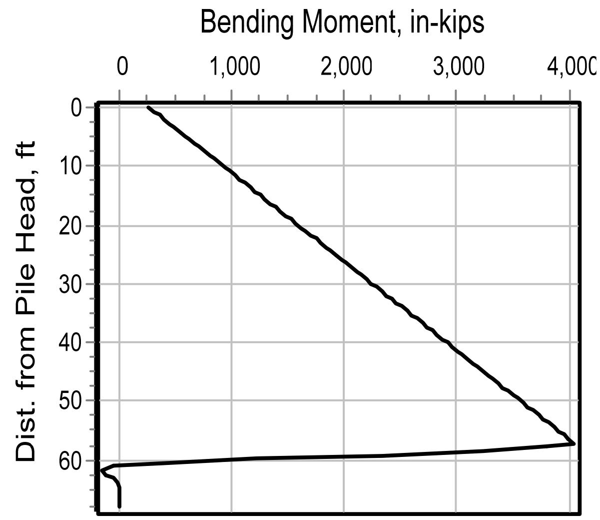
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	5500.	M, in-lb	270000.	0.00	3.3951	-0.00739	-123001.	4039920.

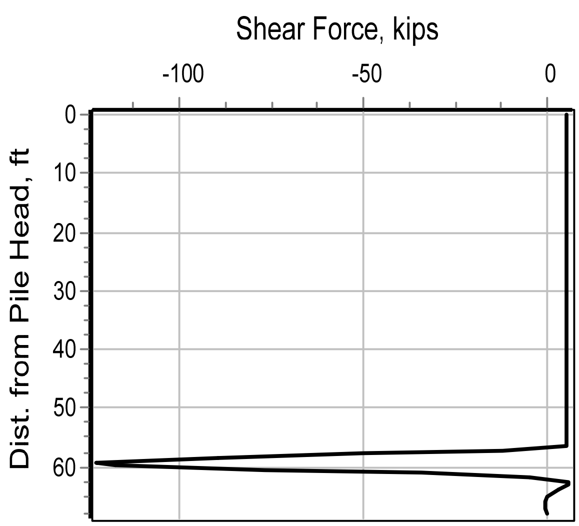
Maximum pile-head deflection = 3.3950677193 inches
Maximum pile-head rotation = -0.0073893666 radians = -0.423380 deg.

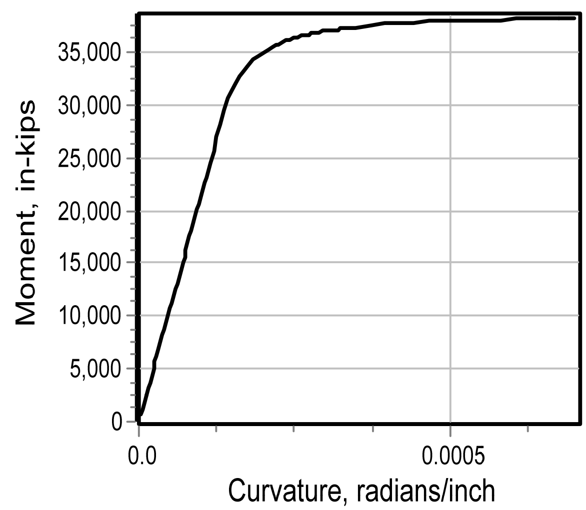
The analysis ended normally.

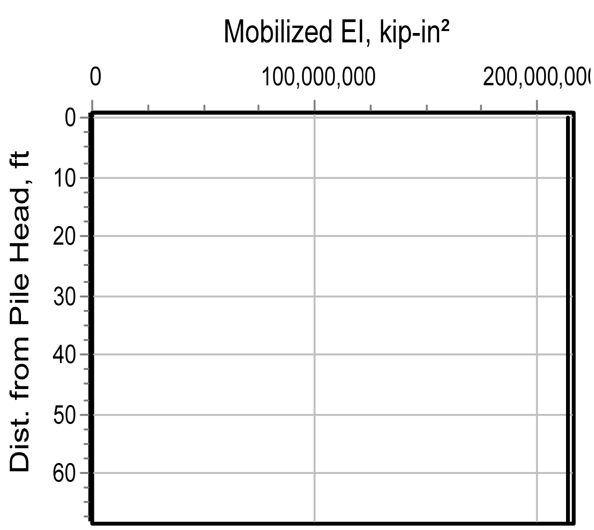
The lateral deflection of the pile is 3.39 in which is span/240 and is with in the AISC code requirements hence acceptable. This was a conservative run only considering the rock layer and ignoring the soil layers above.

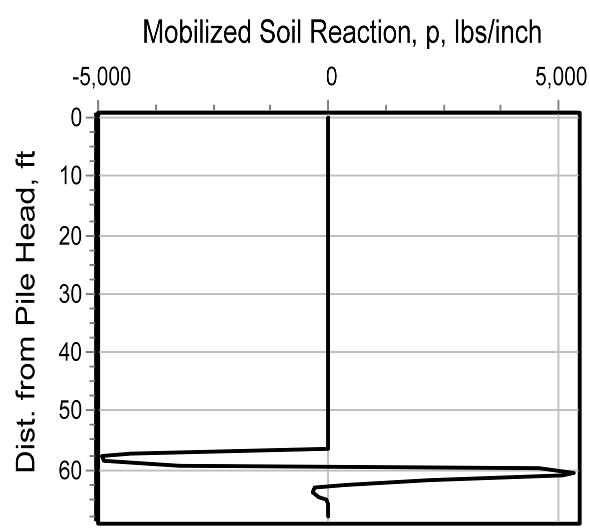

Deflection, inches
0
1
2
3
Dist. from Pile Head, ft
0
10
20
30
40
50
60

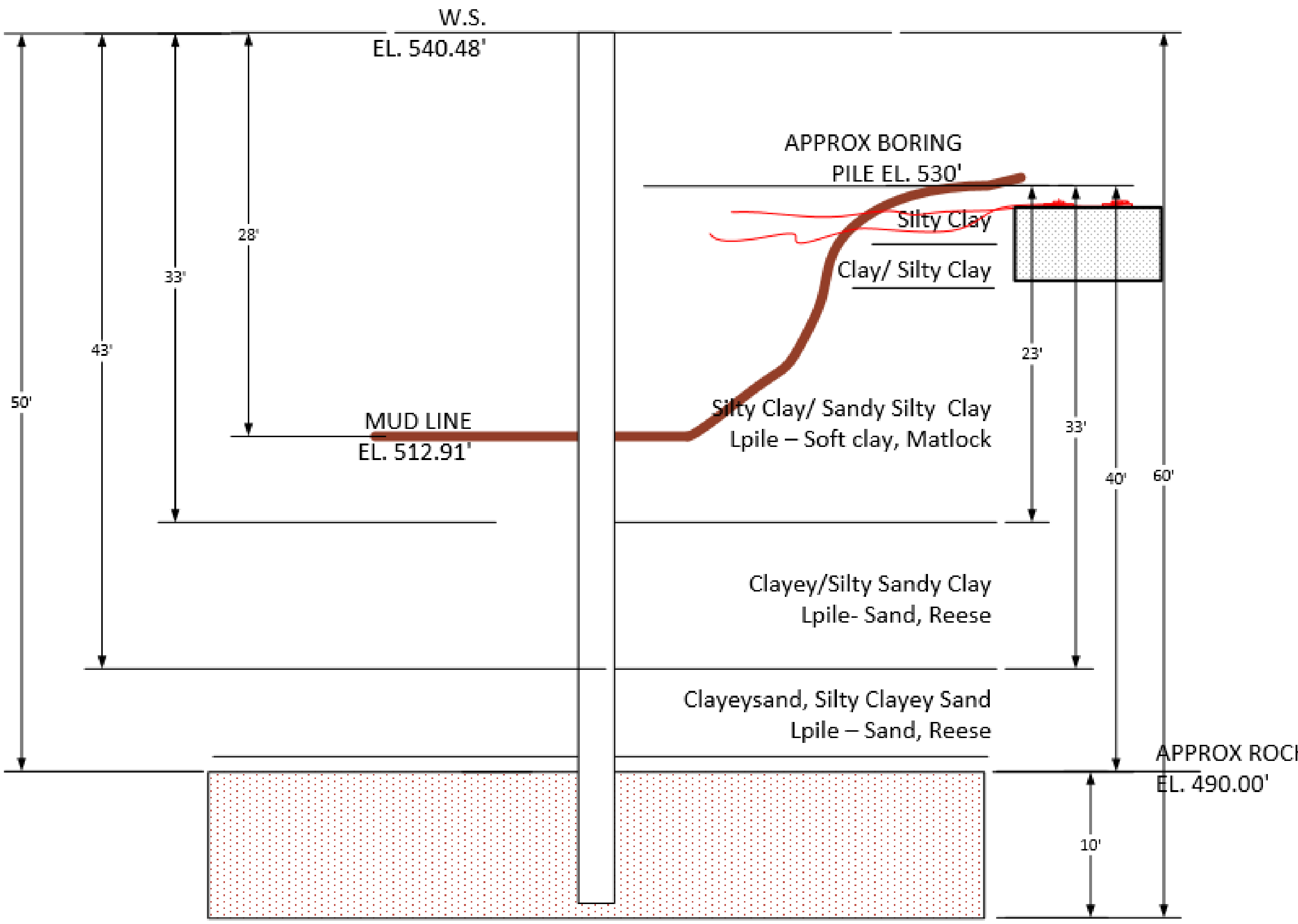

Bending Moment, in-kips
0
1,000
2,000
3,000
4,000
Dist. from Pile Head, ft
0
10
20
30
40
50
60


Shear Force, kips
-100
-50
0
Dist. from Pile Head, ft
0
10
20
30
40
50
60


Moment, in-kips
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0.0
0.0005
Curvature, radians/inch


Mobilized EI, kip-in²
0
100,000,000
Dist. from Pile Head, ft
0
10
20
30
40
50
60


Mobilized Soil Reaction, p, lbs/inch
-5,000
0
5,000
Dist. from Pile Head, ft
0
10
20
30
40
50
60



SOIL PROFILE FOR PILE DESIGN AT CLEAR FORK LOCATION

Note – Geotech report section 4.2.1 recommends that the piers should penetrate into the bearing stratum a minimum of 5.00'. Conservatively used 10.00' as the depth in unweathered rock

7.0 Mooring Pile Design Calculations

B) Loading on Mooring Pile at Clear Fork Trinity River Fort Worth, Texas

1. Stream Current Calculations

$V := 8.42$ — Design velocity of water for the 100-year design flood in strength and service limit states and for the check flood in the extreme event limit state (ft/sec). Attachment 1

$C_D := 1.4$ — Drag coefficient for piers considering debris lodged against the pier. AASHTO Table 3.7.3.1-1

$p := \frac{C_D \cdot V^2}{1000} \cdot ksf = 0.099 \cdot ksf$ — Pressure of flowing water. AASHTO Eq. 3.7.3.1-1

$H_p := 27.57ft$ — Height above mud line to flood elevation. Attachment 1

$d_{pile} := 30in$ — Diameter of pile (Spiralweld pipe Yield strength of 60 ksi)

$F_{current} := d_{pile} \cdot H_p \cdot p = 6.841\ kip$ — Force due to current pressure considered to be acting at the top of the pile.

2. Current Pressure on Booms

$L := 50ft$ — Transverse distance between two piles (conservative). Appendix 1

$S := 10ft$ — Assume between straight line and boom. Appendix 1

$X := \frac{L}{2} = 25\ ft$ — Distance to max sag location

$t_{boom} := 1.33ft$ — Boom thickness. Appendix 1

$q_{boom} := p \cdot t_{boom} = 0.132 \cdot \frac{kip}{ft}$ — Distributed load along boom

$L_{beam} := 8ft$ — Length of beams between hulls. Appendix 1

$F_{beam} := \frac{q_{boom} \cdot L_{beam}}{2} = 0.528\ kip$ — Longitudinal reaction on piles

$F_{boom.trans} := \frac{0.75 \cdot q_{boom} \cdot X^2}{2 \cdot S} = 3.094\ kip$ — Transverse component of tension

$F_{boom.long} := 0.75 \cdot q_{boom} \cdot X = 2.475\ kip$ — Longitudinal component of tension

$F_{boom} := \sqrt{F_{boom.trans}^2 + F_{boom.long}^2} + F_{beam} = 4.49\ kip$ — Force on piles due to booms

3. Ice Load Calculations

$p_{ice} := 8.0ksf$

Effective Ice Strength, where breakup occurs at melting temperatures and the ice structure is substantially disintegrated. AASHTO 3.9.2.1

$\alpha := 0.8$

Coefficient for local conditions, normally less than 1.0 considering "windy lake without snow". AASHTO C3.9.2.2

Date	T (degrees)	Σ(32-T)
2/9/2021	30.72	1.28
2/10/2021	28.11	3.89
2/11/2021	24.91	7.09
2/12/2021	22.85	9.15
2/13/2021	22.31	9.69
2/14/2021	13.47	18.53
2/15/2021	6.27	25.73
2/16/2021	11	21
2/17/2021	20.83	11.17
2/18/2021	23.83	8.17
2/19/2021	26.92	5.08
SUM		120.78

Freezing index calculation, considering February 2021 Winter Storm - Data used from this website - https://www.wunderground.com/history/monthly/us/tx/fort-worth/KFTW/date/2021-2

$S_f := 120.78$

Freezing index, summed from the date of freeze-up to the date of interest, in degree days. AASHTO C3.9.2.2

$t := 0.083\alpha \cdot \sqrt{S_f} \cdot ft = 8.757 \cdot in$

Thickness of ice. AASHTO C3.9.2.2-1

$C_a := \sqrt{5 \cdot \frac{t}{d_{pile}} + 1} = 1.568$

Coefficient accounting for the effect of the pier width/ice thickness ratio where the flow fails by crushing AASHTO Equation 3.9.2.2-3

AASHTO considers a "small stream" to be a stream which has a width of less than 300 ft at the mean water levee. The width is approximately 200 ft at mean water level.

Assuming that an ice flow would be smaller than most winter areas and the number of bridge piers upstream of the location, an Area of 400 ft2 is considered for the largest ice floe.

$A := 400ft^2$

Plan area of the largest ice floe

$r := \frac{d_{pile}}{2} = 1.25\, ft$

Radius of pier nose

$K_{1.table} := \frac{A}{r^2} = 256$ — Reduction Factor K1 for small streams criteria AASHTO Table C3.9.2.3-1

$K_1 := 0.737$ — Reduction Factor K1 for small streams. AASHTO Table C3.9.2.3-1

$F_{ice} := K_1 \cdot C_a \cdot p_{ice} \cdot t \cdot d_{pile} = 16.869\,kip$ — Horizontal ice force caused by ice floes that fail by crushing over the full width of the pier. AASHTO Eq. 3.9.2.2-1. This load is conservative as Fort Worth do not see extreme cold weather conditions. This load also accounts for any impact loads from the debris during a flood condition

4. Wind Load on Trash Collector

$A_w := 275ft^2$ — Estimated area of covered wheel. Appendix 1

$V_{DZ} := 100$ — Design wind velocity (mph) (below 30ft). AASHTO 3.8.1.1

$P_B := 0.04$ — Base pressures corresponding to V.B=100 mph for large flat surfaces. (ksf) AASHTO Table 3.8.1.2.1-1

$P_D := P_B \cdot \frac{V_{DZ}^2}{10000} \cdot ksf = 0.04\,ksf$ — Design wind pressure. AASHTO Eq 3.8.1.2.1-1

$F_{wind} := A_w \cdot P_D = 11\,kip$ — Force due to wind pressure

Wind on the pile is ignored. It is assumed that the maximum wind load occurs during the design basis flood event, where the wind load is due to the wind on the trash wheel itself.

Pile Resistance Calculations

1. Flexural Resistance (AASHTO Section 6.12.2.2.3)

$\phi_f := 1.00$ — Resistance factor for flexure. AASHTO 6.5.4.2

$t_{pile} := 0.75in$ — Thickness of pile

$\frac{d_{pile}}{t_{pile}} = \frac{30 \cdot in}{0.75 \cdot in} = 40$ — Width to thickness ratio

$E_{pile} := 29000ksi$ — Modulus of Elasticity of steel. AASHTO 6.4.1

$F_{y.pile} := 60ksi$ — Specified minimum yield strength of steel. Attachment 2

$0.11 \cdot \frac{E_{pile}}{F_{y.pile}} = 53.167$ $\quad 0.11 \cdot \frac{E_{pile}}{F_{y.pile}} > \frac{d_{pile}}{t_{pile}} = 1$ — Requirement for depth to thickness of circular tubes. AASHTO 6.9.4.2.1-5

$$localbuckling := \begin{cases} \text{"OKAY"} & \text{if } \frac{d_{pile}}{t_{pile}} > 0.07 \cdot \frac{E_{pile}}{F_{y.pile}} \\ \text{"Check"} & \text{otherwise} \end{cases}$$

Check for local buckling applicability. If not true, check local buckling per 6.12.2.2.3

$localbuckling = \text{"OKAY"}$

$$S_{pile} := \frac{\pi \left[d_{pile}^{\ 4} - \left(d_{pile} - 2 \cdot t_{pile}\right)^4 \right]}{32 \cdot d_{pile}} = 491.692 \cdot in^3$$

Elastic section modulus

$$F_{cr.local} := \frac{0.33 \cdot E_{pile}}{\left(\frac{d_{pile}}{t_{pile}}\right)} = 239.25 \cdot ksi$$

Elastic local buckling stress,
(AASHTO Section 6.12.2.2.3-4)

$$\frac{0.31 \cdot E_{pile}}{F_{y.pile}} = 149.833$$

$$M_{n.local} := \begin{cases} \left(\frac{0.021 \cdot E_{pile}}{\frac{d_{pile}}{t_{pile}}} + F_{y.pile} \right) \cdot S_{pile} & \text{if } \frac{d_{pile}}{t_{pile}} < 0.31 \cdot \frac{E_{pile}}{F_{y.pile}} \\ F_{cr.local} \cdot S_{pile} & \text{otherwise} \end{cases} = 36987.513 \cdot kip \cdot in$$

(AASHTO Section 6.12.2.2.3-2, -3)

$$Z := \frac{\left(d_{pile}^{\ 3}\right)}{6} - \frac{\left(d_{pile} - 2 \cdot t_{pile}\right)^3}{6} = 641.813 \cdot in^3$$

Plastic section modulus of round pile

$$M_p := F_{y.pile} \cdot Z = 38508.75 \cdot kip \cdot in$$

Plastic moment for Circular Tubes
AASHTO Equation 6.12.2.2.3-1

$$M_n := \min\left(M_p, M_{n.local}\right) = 36987.513 \cdot kip \cdot in$$

Nominal flexural resistance specified in Articles 6.12.2.2 for non composite members

$$M_r := \phi_f \cdot M_n = 36987.513 \cdot kip \cdot in$$

Factored flexural resistance
AASHTO Equation 6.12.1.2.1-1

2. Shear resistance. (AASHTO Section 6.12.1.2.3c)

$\phi_v := 1.00$ — Resistance factor for shear. AASHTO 6.5.4.2

$L_v := 48in$ — Distance between points of maximum and zero shear

$$F_{cr1} := \frac{1.60E_{pile}}{\sqrt{\frac{L_v}{d_{pile}}} \cdot \left(\frac{d_{pile}}{t_{pile}}\right)^{\frac{5}{4}}} = 52510.42\,ksf$$

Shear buckling resistance - first criteria
AASHTO Equation 6.12.1.2.3c-2

$$F_{cr2} := \frac{0.78 \cdot E_{pile}}{\left(\frac{d_{pile}}{t_{pile}}\right)^{\frac{3}{2}}} = 12875.53\,ksf$$

Shear buckling resistance - second criteria
AASHTO Eq 6.12.1.2.3c-3

$F_{cr.max} := 0.58 \cdot F_{y.pile} = 5011.2\,ksf$ — Maximum allowable shear buckling resistance. AASHTO Eq. 6.12.1.2.3c-2&3

$F_{cr} := \min\left(F_{cr1}, F_{cr2}, F_{cr.max}\right) = 5011.2\,ksf$ — Shear buckling resistance

$A_{g.pile} := 68.92in^2$ — Gross area of the pile section. Attachment 2

$V_n := 0.5 \cdot F_{cr} \cdot A_{g.pile} = 1199.208\,kip$ — Nominal shear resistance. AASHTO 6.12.1.2.3c-1

$V_r := \phi_v \cdot V_n = 1199.208\,kip$ — Factored shear resistance. AASHTO 6.12.1.2.3a-1

These calculations capture the reasonably expected loads to occur on the trash wheel, booms, and mooring piles. Due to the varying nature of rivers, the pile design itself will be limited to utilization ratios of 0.6 to be conservative enough to account for potential unknowns (i.e. higher impact loads, flood loads, ice loads, etc.).

There are three applicable loading combinations:

1. Strength III - General strength. AASHTO code for bridge design considers this using 55 mph winds, but for this design, the full 100 mph wind load will be considered.
2. Extreme II - Primarily for ice impact loading
3. Service I - Will be considered to limit deflections

$F_{current} = 6.841 \text{ kip}$ $F_{boom} = 4.49 \cdot \text{kip}$

$F_{wind} = 11 \text{ kip}$ Wind is applied to 2 piles.

$F_{ice} = 16.869 \text{ kip}$

$$Strength_{III} := 1.00 \cdot F_{current} + 1.00 \cdot F_{boom} + \frac{1.4 \cdot F_{wind}}{2} = 19.031 \cdot \text{kip}$$

$$Extreme_{II} := 1.00 \cdot F_{current} + 1.00 \cdot F_{boom} + 1.00 \cdot F_{ice} = 28.2 \text{ kip}$$

$$Service_{I} := 1.00 \cdot F_{current} + 1.00 \cdot F_{boom} + \frac{0.3 \cdot F_{wind}}{2} = 12.981 \text{ kip}$$

$$P_{top} := \max\left(Strength_{III}, Extreme_{II}, Service_{I}\right) = 28.2 \text{ kip}$$

Additional Moment on the pile due to Log Loader - (Not functional during any flood condition.)

$P_{logloader} := 1500 \text{lbf}$

$L_{logloader} := 12 \text{ft}$

$M_{pile} := 1.25 P_{logloader} \cdot L_{logloader} = 270000 \cdot \text{lbf} \cdot \text{in}$ This log loader is used to clear logs during normal operation condition and only used after a flood condition.

$L_{pile} := 60 \text{ft}$ Length of pile. From Appendix 1

$M_{max} := P_{top} \cdot L_{pile} = 20304.131 \text{kip} \cdot \text{in}$ Maximum Moment from LPILE Output pg. 66, (18277200. inch-lbs)

$$M := \begin{cases} \text{"good"} & \text{if } M_r \geq M_{max} \\ \text{"redesign"} & \text{otherwise} \end{cases}$$

$M = \text{"good"}$

$V_{max} := 42 \text{kip}$ Maximum Shear Load. LPILE Output pg. 66

$$V := \begin{cases} \text{"good"} & \text{if } V_r \geq V_{max} \\ \text{"redesign"} & \text{otherwise} \end{cases}$$

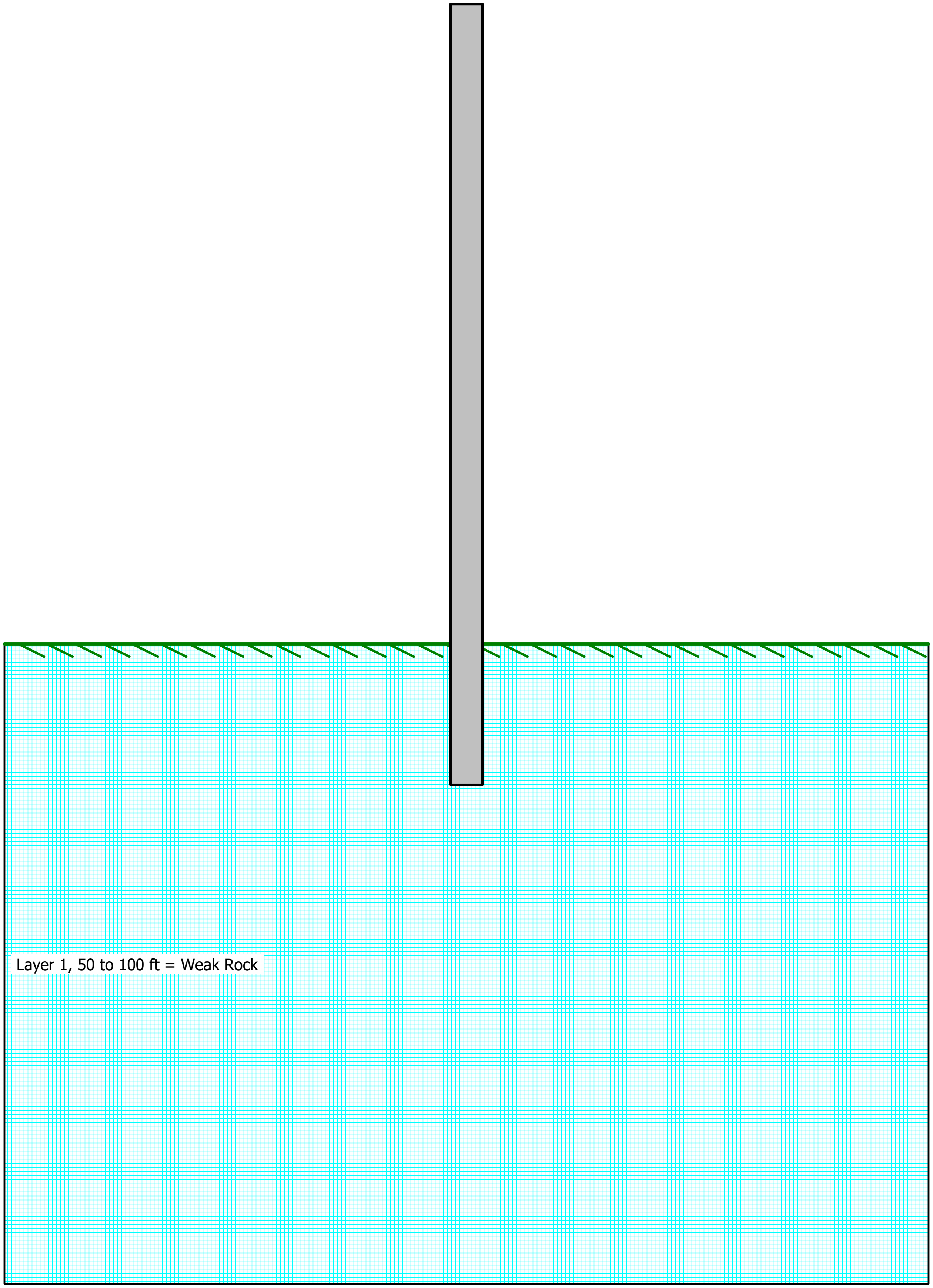
$V = \text{"good"}$

$UT_b := \frac{M_{max}}{M_r} = 0.549$ $UT_b < 0.6 = 1$ Utilization for bending. Limited to 0.6 for project specific conditions

$UT_v := \frac{V_{max}}{V_r} = 0.035$ $UT_v < 0.6 = 1$ Utilization for shear. Limited to 0.6 for project specific conditions

The Pile section selected is adequate to support the Trash wheel equipment.

CASE 1 - ANCHOR PILE ONLY ON ROCK



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LPile for Windows, Version 2022-12.003

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

==

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Files Used for Analysis

Path to file locations:
\\enercon.sharepoint.com@SSL\DavWWWRoot\sites\NSG_NC\Clients\FWTH\FWTHFS\FWTHFS-00254\FWTHFS-00242 (Original Project Docs)\Deliverables_SP\Calculations\Trash Wheel\Final\clearfork\08092022\

Name of input data file:
Clear Fork rock.lp12d

Name of output report file:
Clear Fork rock.lp12o

Name of plot output file:
Clear Fork rock.lp12p

Name of runtime message file:
Clear Fork rock.lp12r

Date and Time of Analysis

Date: August 9, 2022 Time: 15:16:47

Problem Title

Project Name: Fort Worth Trash Wheel

Job Number: FWTHFS-00242

Client: City of Fort Worth

Engineer: Sandeep Menon

```
Description: Clear Fork LPILE



--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     300.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                        =            1
Total length of pile                                   =       61.000 ft
Depth of ground surface below top of pile              =      50.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000          30.0000
  2           61.000          30.0000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a steel pipe pile
   Length of section                                   =    61.000000 ft
```

Pile diameter = 30.000000 in

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	50.000000 ft
Distance from top of pile to bottom of layer	=	100.000000 ft
Effective unit weight at top of layer	=	140.000000 pcf
Effective unit weight at bottom of layer	=	140.000000 pcf
Uniaxial compressive strength at top of layer	=	275.000000 psi
Uniaxial compressive strength at bottom of layer	=	275.000000 psi
Initial modulus of rock at top of layer	=	100000. psi
Initial modulus of rock at bottom of layer	=	100000. psi
RQD of rock at top of layer	=	30.000000 %
RQD of rock at bottom of layer	=	30.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 39.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Weak	50.0000	140.0000	275.0000	30.0000	1.00E-04	100000.
	Rock	100.0000	140.0000	275.0000	30.0000	1.00E-04	100000.

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 30000. lbs	M = 270000. in-lbs	0.0000000	Yes	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head

y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel Pipe Pile:

Length of Section	=	61.000000 ft
Outer Diameter of Pipe	=	30.000000 in
Pipe Wall Thickness	=	0.750000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	68.918689 sq. in.
Moment of Inertia	=	7375. in^4
Elastic Bending Stiffness	=	213885920. kip-in^2
Plastic Modulus, Z	=	641.812500in^3
Plastic Moment Capacity = Fy Z	=	32091.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	3445.934 kips
Nominal Axial Tensile Capacity	=	-3445.934 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000244	522.3962477	213875170.	15.0000000	1.0518750	
0.00000489	1045.	213875170.	15.0000000	2.1037500	
0.00000733	1567.	213875170.	15.0000000	3.1556250	
0.00000977	2090.	213875170.	15.0000000	4.2075000	
0.00001221	2612.	213875170.	15.0000000	5.2593750	
0.00001466	3134.	213875170.	15.0000000	6.3112500	
0.00001710	3657.	213875170.	15.0000000	7.3631250	
0.00001954	4179.	213875170.	15.0000000	8.4150001	
0.00002198	4702.	213875170.	15.0000000	9.4668751	
0.00002443	5224.	213875170.	15.0000000	10.5187501	
0.00002687	5746.	213875170.	15.0000000	11.5706251	
0.00002931	6269.	213875170.	15.0000000	12.6225001	

0.00003175	6791.	213875170.	15.0000000	13.6743751	
0.00003420	7314.	213875170.	15.0000000	14.7262501	
0.00003664	7836.	213875170.	15.0000000	15.7781251	
0.00003908	8358.	213875170.	15.0000000	16.8300001	
0.00004152	8881.	213875170.	15.0000000	17.8818751	
0.00004397	9403.	213875170.	15.0000000	18.9337501	
0.00004641	9926.	213875170.	15.0000000	19.9856251	
0.00004885	10448.	213875170.	15.0000000	21.0375001	
0.00005129	10970.	213875170.	15.0000000	22.0893751	
0.00005374	11493.	213875170.	15.0000000	23.1412502	
0.00005618	12015.	213875170.	15.0000000	24.1931252	
0.00005862	12538.	213875170.	15.0000000	25.2450002	
0.00006106	13060.	213875170.	15.0000000	26.2968752	
0.00006351	13582.	213875170.	15.0000000	27.3487502	
0.00006595	14105.	213875170.	15.0000000	28.4006252	
0.00006839	14627.	213875170.	15.0000000	29.4525002	
0.00007083	15149.	213875170.	15.0000000	30.5043752	
0.00007328	15672.	213875170.	15.0000000	31.5562502	
0.00007572	16194.	213875170.	15.0000000	32.6081252	
0.00007816	16717.	213875170.	15.0000000	33.6600002	
0.00008060	17239.	213875170.	15.0000000	34.7118752	
0.00008305	17761.	213875170.	15.0000000	35.7637502	
0.00008549	18284.	213875170.	15.0000000	36.8156252	
0.00008793	18806.	213875170.	15.0000000	37.8675003	
0.00009037	19329.	213875170.	15.0000000	38.9193753	
0.00009282	19851.	213875170.	15.0000000	39.9712503	
0.00009526	20373.	213875170.	15.0000000	41.0231253	
0.0001001	21418.	213875170.	15.0000000	43.1268753	
0.0001050	22463.	213875170.	15.0000000	45.2306253	
0.0001099	23508.	213875170.	15.0000000	47.3343753	
0.0001148	24553.	213875170.	15.0000000	49.4381253	
0.0001197	25511.	213152380.	15.0000000	50.0000000	Y
0.0001246	26232.	210583666.	15.0000000	50.0000000	Y
0.0001295	26800.	207022224.	15.0000000	50.0000000	Y
0.0001343	27269.	202983179.	15.0000000	50.0000000	Y
0.0001392	27670.	198746654.	15.0000000	50.0000000	Y
0.0001441	28017.	194414878.	15.0000000	50.0000000	Y
0.0001490	28323.	190095167.	15.0000000	50.0000000	Y
0.0001539	28591.	185802169.	15.0000000	50.0000000	Y
0.0001588	28829.	181585311.	15.0000000	50.0000000	Y
0.0001636	29043.	177470462.	15.0000000	50.0000000	Y
0.0001685	29235.	173468097.	15.0000000	50.0000000	Y
0.0001734	29409.	169585196.	15.0000000	50.0000000	Y
0.0001783	29568.	165826064.	15.0000000	50.0000000	Y
0.0001832	29712.	162192964.	15.0000000	50.0000000	Y
0.0001881	29844.	158681275.	15.0000000	50.0000000	Y
0.0001930	29963.	155281614.	15.0000000	50.0000000	Y
0.0001978	30074.	152005500.	15.0000000	50.0000000	Y
0.0002027	30177.	148851238.	15.0000000	50.0000000	Y
0.0002076	30271.	145802256.	15.0000000	50.0000000	Y
0.0002125	30357.	142857873.	15.0000000	50.0000000	Y
0.0002174	30440.	140027612.	15.0000000	50.0000000	Y
0.0002223	30514.	137283086.	15.0000000	50.0000000	Y
0.0002272	30585.	134642575.	15.0000000	50.0000000	Y
0.0002320	30650.	132089238.	15.0000000	50.0000000	Y
0.0002369	30711.	129625023.	15.0000000	50.0000000	Y
0.0002418	30769.	127243261.	15.0000000	50.0000000	Y
0.0002467	30823.	124943000.	15.0000000	50.0000000	Y
0.0002516	30873.	122715893.	15.0000000	50.0000000	Y
0.0002565	30922.	120568203.	15.0000000	50.0000000	Y
0.0002614	30965.	118481064.	15.0000000	50.0000000	Y
0.0002662	31009.	116470517.	15.0000000	50.0000000	Y
0.0002711	31047.	114515408.	15.0000000	50.0000000	Y
0.0002760	31085.	112624803.	15.0000000	50.0000000	Y
0.0002809	31122.	110797855.	15.0000000	50.0000000	Y
0.0002858	31154.	109016833.	15.0000000	50.0000000	Y
0.0002907	31187.	107295678.	15.0000000	50.0000000	Y
0.0003102	31301.	100904523.	15.0000000	50.0000000	Y
0.0003297	31393.	95205408.	15.0000000	50.0000000	Y
0.0003493	31471.	90100759.	15.0000000	50.0000000	Y
0.0003688	31535.	85502779.	15.0000000	50.0000000	Y
0.0003884	31590.	81340543.	15.0000000	50.0000000	Y
0.0004079	31637.	77559576.	15.0000000	50.0000000	Y

0.0004274	31679.	74112823.	15.0000000	50.0000000	Y
0.0004470	31713.	70949672.	15.0000000	50.0000000	Y
0.0004665	31745.	68046000.	15.0000000	50.0000000	Y
0.0004861	31772.	65365798.	15.0000000	50.0000000	Y
0.0005056	31797.	62889062.	15.0000000	50.0000000	Y
0.0005251	31818.	60588308.	15.0000000	50.0000000	Y
0.0005447	31838.	58452630.	15.0000000	50.0000000	Y
0.0005642	31854.	56456945.	15.0000000	50.0000000	Y
0.0005838	31870.	54593653.	15.0000000	50.0000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	31870.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 30000.0 lbs
Applied moment at pile head = 270000.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	12.5853	270000.	30000.	-0.02963	549.1245	2.14E+11	0.00	0.00	0.00
0.6100	12.3684	489600.	30000.	-0.02962	995.7458	2.14E+11	0.00	0.00	0.00
1.2200	12.1517	709200.	30000.	-0.02960	1442.	2.14E+11	0.00	0.00	0.00
1.8300	11.9351	928800.	30000.	-0.02957	1889.	2.14E+11	0.00	0.00	0.00
2.4400	11.7188	1148400.	30000.	-0.02953	2336.	2.14E+11	0.00	0.00	0.00
3.0500	11.5027	1368000.	30000.	-0.02949	2782.	2.14E+11	0.00	0.00	0.00
3.6600	11.2870	1587600.	30000.	-0.02944	3229.	2.14E+11	0.00	0.00	0.00
4.2700	11.0717	1807200.	30000.	-0.02938	3675.	2.14E+11	0.00	0.00	0.00
4.8800	10.8569	2026800.	30000.	-0.02932	4122.	2.14E+11	0.00		

								0.00	0.00
5.4900	10.6425	2246400.	30000.	-0.02924	4569.	2.14E+11	0.00	0.00	0.00
6.1000	10.4288	2466000.	30000.	-0.02916	5015.	2.14E+11	0.00	0.00	0.00
6.7100	10.2156	2685600.	30000.	-0.02907	5462.	2.14E+11	0.00	0.00	0.00
7.3200	10.0031	2905200.	30000.	-0.02898	5909.	2.14E+11	0.00	0.00	0.00
7.9300	9.7913	3124800.	30000.	-0.02888	6355.	2.14E+11	0.00	0.00	0.00
8.5400	9.5804	3344400.	30000.	-0.02877	6802.	2.14E+11	0.00	0.00	0.00
9.1500	9.3702	3564000.	30000.	-0.02865	7248.	2.14E+11	0.00	0.00	0.00
9.7600	9.1610	3783600.	30000.	-0.02852	7695.	2.14E+11	0.00	0.00	0.00
10.3700	8.9527	4003200.	30000.	-0.02839	8142.	2.14E+11	0.00	0.00	0.00
10.9800	8.7454	4222800.	30000.	-0.02825	8588.	2.14E+11	0.00	0.00	0.00
11.5900	8.5391	4442400.	30000.	-0.02810	9035.	2.14E+11	0.00	0.00	0.00
12.2000	8.3340	4662000.	30000.	-0.02794	9482.	2.14E+11	0.00	0.00	0.00
12.8100	8.1300	4881600.	30000.	-0.02778	9928.	2.14E+11	0.00	0.00	0.00
13.4200	7.9273	5101200.	30000.	-0.02761	10375.	2.14E+11	0.00	0.00	0.00
14.0300	7.7258	5320800.	30000.	-0.02743	10821.	2.14E+11	0.00	0.00	0.00
14.6400	7.5257	5540400.	30000.	-0.02724	11268.	2.14E+11	0.00	0.00	0.00
15.2500	7.3270	5760000.	30000.	-0.02705	11715.	2.14E+11	0.00	0.00	0.00
15.8600	7.1297	5979600.	30000.	-0.02685	12161.	2.14E+11	0.00	0.00	0.00
16.4700	6.9339	6199200.	30000.	-0.02664	12608.	2.14E+11	0.00	0.00	0.00
17.0800	6.7396	6418800.	30000.	-0.02643	13055.	2.14E+11	0.00	0.00	0.00
17.6900	6.5470	6638400.	30000.	-0.02620	13501.	2.14E+11	0.00	0.00	0.00
18.3000	6.3560	6858000.	30000.	-0.02597	13948.	2.14E+11	0.00	0.00	0.00
18.9100	6.1668	7077600.	30000.	-0.02573	14394.	2.14E+11	0.00	0.00	0.00
19.5200	5.9793	7297200.	30000.	-0.02549	14841.	2.14E+11	0.00	0.00	0.00
20.1300	5.7936	7516800.	30000.	-0.02523	15288.	2.14E+11	0.00	0.00	0.00
20.7400	5.6099	7736400.	30000.	-0.02497	15734.	2.14E+11	0.00	0.00	0.00
21.3500	5.4280	7956000.	30000.	-0.02470	16181.	2.14E+11	0.00	0.00	0.00
21.9600	5.2482	8175600.	30000.	-0.02443	16627.	2.14E+11	0.00	0.00	0.00
22.5700	5.0704	8395200.	30000.	-0.02414	17074.	2.14E+11	0.00	0.00	0.00
23.1800	4.8947	8614800.	30000.	-0.02385	17521.	2.14E+11	0.00	0.00	0.00
23.7900	4.7212	8834400.	30000.	-0.02355	17967.	2.14E+11	0.00	0.00	0.00
24.4000	4.5499	9054000.	30000.	-0.02325	18414.	2.14E+11	0.00	0.00	0.00
25.0100	4.3808	9273600.	30000.	-0.02294	18861.	2.14E+11	0.00	0.00	0.00
25.6200	4.2141	9493200.	30000.	-0.02261	19307.	2.14E+11	0.00	0.00	0.00
26.2300	4.0498	9712800.	30000.	-0.02229	19754.	2.14E+11	0.00	0.00	0.00
26.8400	3.8879	9932400.	30000.	-0.02195	20200.	2.14E+11	0.00	0.00	0.00

27.4500	3.7284	1.02E+07	30000.	-0.02161	20647.	2.14E+11	0.00	0.00	0.00
28.0600	3.5716	1.04E+07	30000.	-0.02125	21094.	2.14E+11	0.00	0.00	0.00
28.6700	3.4173	1.06E+07	30000.	-0.02090	21540.	2.14E+11	0.00	0.00	0.00
29.2800	3.2657	1.08E+07	30000.	-0.02053	21987.	2.14E+11	0.00	0.00	0.00
29.8900	3.1167	1.10E+07	30000.	-0.02016	22434.	2.14E+11	0.00	0.00	0.00
30.5000	2.9706	1.12E+07	30000.	-0.01977	22880.	2.14E+11	0.00	0.00	0.00
31.1100	2.8272	1.15E+07	30000.	-0.01939	23327.	2.14E+11	0.00	0.00	0.00
31.7200	2.6868	1.17E+07	30000.	-0.01899	23773.	2.14E+11	0.00	0.00	0.00
32.3300	2.5492	1.19E+07	30000.	-0.01859	24220.	2.14E+11	0.00	0.00	0.00
32.9400	2.4147	1.21E+07	30000.	-0.01817	24667.	2.14E+11	0.00	0.00	0.00
33.5500	2.2832	1.23E+07	30000.	-0.01776	25113.	2.14E+11	0.00	0.00	0.00
34.1600	2.1548	1.26E+07	30000.	-0.01733	25560.	2.14E+11	0.00	0.00	0.00
34.7700	2.0295	1.28E+07	30000.	-0.01689	26007.	2.14E+11	0.00	0.00	0.00
35.3800	1.9074	1.30E+07	30000.	-0.01645	26453.	2.14E+11	0.00	0.00	0.00
35.9900	1.7886	1.32E+07	30000.	-0.01600	26900.	2.14E+11	0.00	0.00	0.00
36.6000	1.6731	1.34E+07	30000.	-0.01555	27346.	2.14E+11	0.00	0.00	0.00
37.2100	1.5610	1.37E+07	30000.	-0.01508	27793.	2.14E+11	0.00	0.00	0.00
37.8200	1.4523	1.39E+07	30000.	-0.01461	28240.	2.14E+11	0.00	0.00	0.00
38.4300	1.3471	1.41E+07	30000.	-0.01413	28686.	2.14E+11	0.00	0.00	0.00
39.0400	1.2454	1.43E+07	30000.	-0.01365	29133.	2.14E+11	0.00	0.00	0.00
39.6500	1.1473	1.45E+07	30000.	-0.01315	29580.	2.14E+11	0.00	0.00	0.00
40.2600	1.0528	1.48E+07	30000.	-0.01265	30026.	2.14E+11	0.00	0.00	0.00
40.8700	0.9620	1.50E+07	30000.	-0.01214	30473.	2.14E+11	0.00	0.00	0.00
41.4800	0.8750	1.52E+07	30000.	-0.01163	30919.	2.14E+11	0.00	0.00	0.00
42.0900	0.7918	1.54E+07	30000.	-0.01110	31366.	2.14E+11	0.00	0.00	0.00
42.7000	0.7125	1.56E+07	30000.	-0.01057	31813.	2.14E+11	0.00	0.00	0.00
43.3100	0.6371	1.59E+07	30000.	-0.01003	32259.	2.14E+11	0.00	0.00	0.00
43.9200	0.5657	1.61E+07	30000.	-0.00948	32706.	2.14E+11	0.00	0.00	0.00
44.5300	0.4982	1.63E+07	30000.	-0.00893	33152.	2.14E+11	0.00	0.00	0.00
45.1400	0.4349	1.65E+07	30000.	-0.00837	33599.	2.14E+11	0.00	0.00	0.00
45.7500	0.3757	1.67E+07	30000.	-0.00780	34046.	2.14E+11	0.00	0.00	0.00
46.3600	0.3207	1.70E+07	30000.	-0.00722	34492.	2.14E+11	0.00	0.00	0.00
46.9700	0.2700	1.72E+07	30000.	-0.00664	34939.	2.14E+11	0.00	0.00	0.00
47.5800	0.2235	1.74E+07	30000.	-0.00605	35386.	2.14E+11	0.00	0.00	0.00
48.1900	0.1815	1.76E+07	30000.	-0.00545	35832.	2.14E+11	0.00	0.00	0.00
48.8000	0.1438	1.78E+07	30000.	-0.00484	36279.	2.14E+11	0.00	0.00	0.00
49.4100	0.1106	1.81E+07	30000.	-0.00423	36725.	2.14E+11	0.00		

								0.00	0.00
50.0200	0.08191	1.83E+07	5573.	-0.00360	37172.	2.14E+11	-6674.	596443.	0.00
50.6300	0.05781	1.81E+07	-51532.	-0.00298	36891.	2.14E+11	-8929.	1130541.	0.00
51.2400	0.03826	1.75E+07	-122885.	-0.00237	35638.	2.14E+11	-10567.	2021755.	0.00
51.8500	0.02309	1.63E+07	-202520.	-0.00179	33233.	2.14E+11	-11192.	3547321.	0.00
52.4600	0.01202	1.46E+07	-284115.	-0.00126	29608.	2.14E+11	-11102.	6758234.	0.00
53.0700	0.00460	1.22E+07	-361304.	-8.06E-04	24773.	2.14E+11	-9988.	1.59E+07	0.00
53.6800	2.32E-04	9268390.	-417378.	-4.38E-04	18850.	2.14E+11	-5333.	1.68E+08	0.00
54.2900	-0.00182	6070301.	-400652.	-1.76E-04	12346.	2.14E+11	9903.	3.99E+07	0.00
54.9000	-0.00234	3402847.	-321894.	-1.39E-05	6921.	2.14E+11	11615.	3.63E+07	0.00
55.5100	-0.00202	1357778.	-234687.	6.76E-05	2761.	2.14E+11	12212.	4.43E+07	0.00
56.1200	-0.00135	-32968.	-146164.	9.03E-05	67.0507	2.14E+11	11975.	6.47E+07	0.00
56.7300	-6.98E-04	-782061.	-62339.	7.63E-05	1591.	2.14E+11	10928.	1.15E+08	0.00
57.3400	-2.37E-04	-945608.	10377.	4.68E-05	1923.	2.14E+11	8940.	2.76E+08	0.00
57.9500	-1.31E-05	-630145.	45491.	1.98E-05	1282.	2.14E+11	654.3483	3.66E+08	0.00
58.5600	5.29E-05	-279620.	38207.	4.23E-06	568.6906	2.14E+11	-2644.	3.66E+08	0.00
59.1700	4.88E-05	-70788.	19597.	-1.77E-06	143.9690	2.14E+11	-2440.	3.66E+08	0.00
59.7800	2.70E-05	7279.	5725.	-2.86E-06	14.8042	2.14E+11	-1350.	3.66E+08	0.00
60.3900	7.01E-06	13023.	-497.206	-2.51E-06	26.4868	2.14E+11	-350.257	3.66E+08	0.00
61.0000	-9.72E-06	0.00	0.00	-2.29E-06	0.00	2.14E+11	486.1056	1.83E+08	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection              =    12.58529038 inches
Computed slope at pile head       =     -0.0296311 radians
Maximum bending moment            =      18277200. inch-lbs
Maximum shear force               =       -417378. lbs
Depth of maximum bending moment   =    50.02000000 feet below pile head
Depth of maximum shear force      =    53.68000000 feet below pile head
Number of iterations              =             25
Number of zero deflection points  =              3
Pile deflection at ground         =     0.08284846 inches
```

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

```
Shear      =          30000. lbs
Moment     =         270000. in-lbs
Axial Load =              0. lbs
```

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
61.00000	12.58529038	18277200.	-417378.
57.95000	12.74897307	18419940.	-422467.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

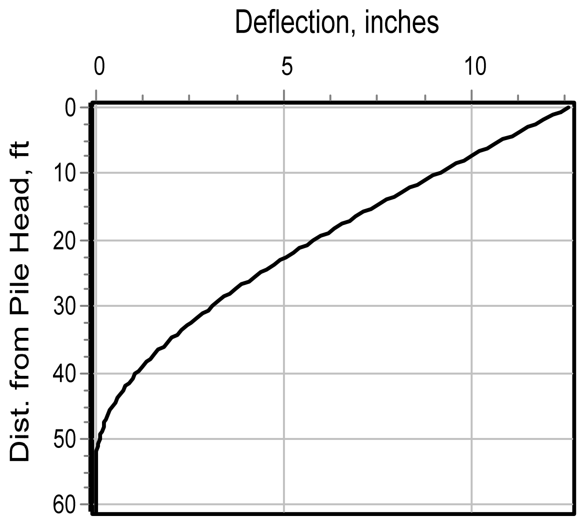
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

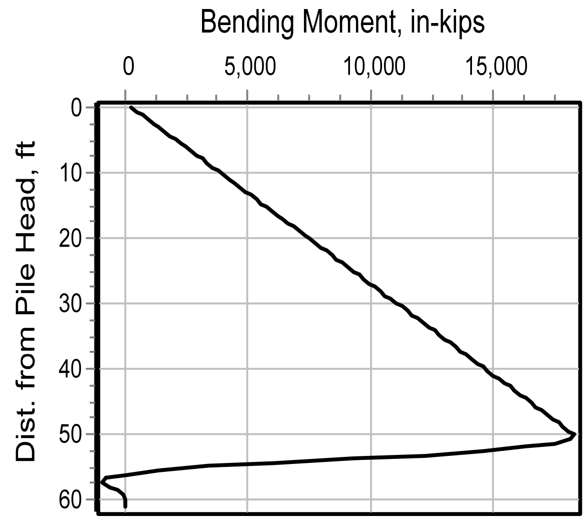
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	30000.	M, in-lb	270000.	0.00	12.5853	-0.02963	-417378.	1.83E+07

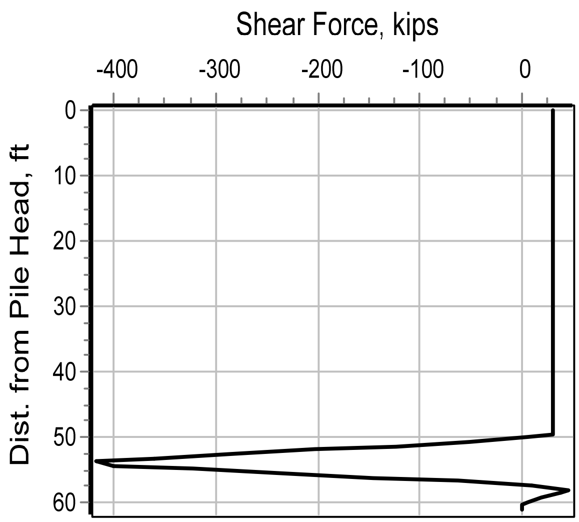
Maximum pile-head deflection = 12.5852903829 inches
Maximum pile-head rotation = -0.0296311209 radians = -1.697738 deg.

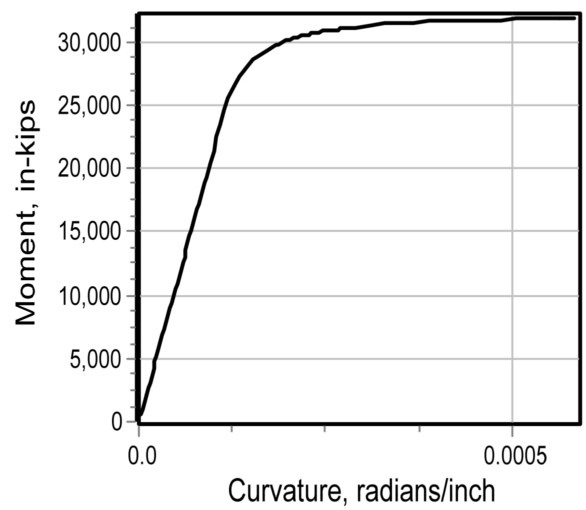
The analysis ended normally.

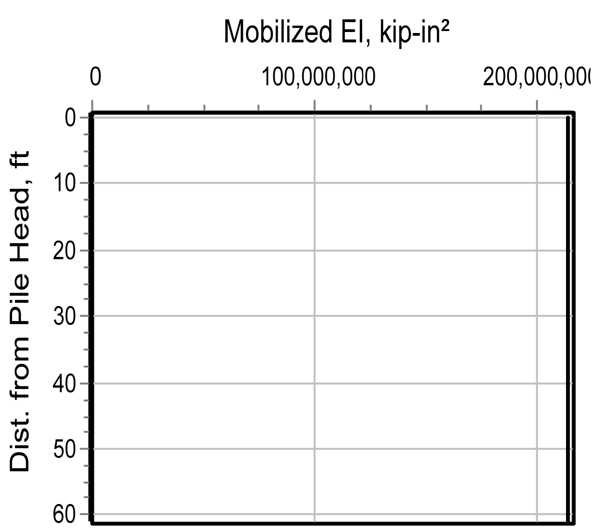
CASE 1 - RESULTS SUMMARY ANCHOR PILE ONLY ON ROCK

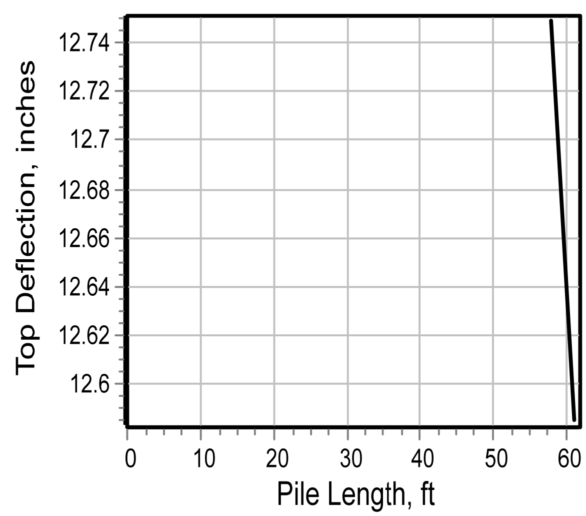




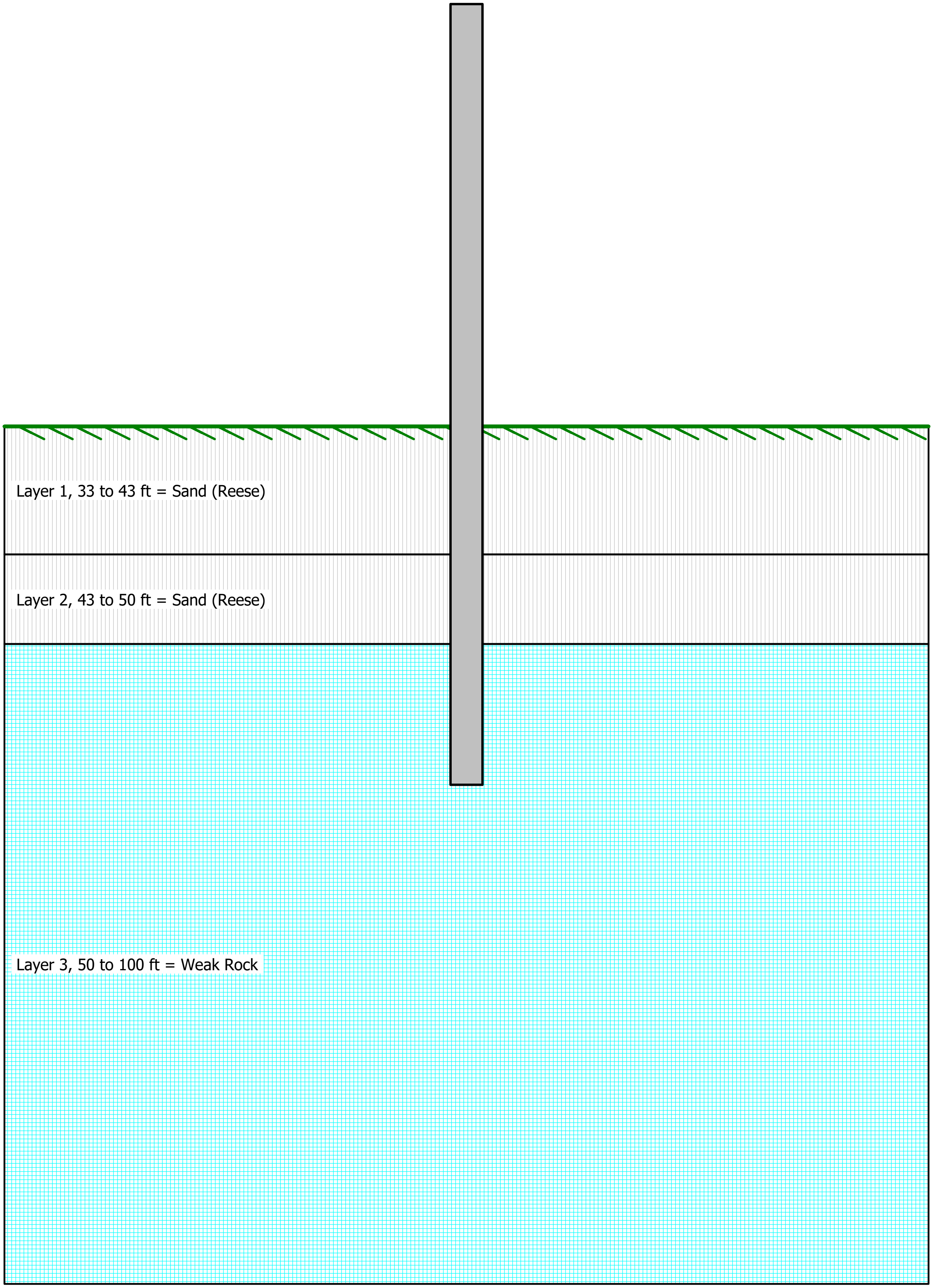








CASE 2 - ANCHOR PILE WITH 2 SOIL LAYERS AND ROCK



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==

LPile for Windows, Version 2022-12.003

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

==

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Files Used for Analysis

Path to file locations:
\\enercon.sharepoint.com@SSL\DavWWWRoot\sites\NSG_NC\Clients\FWTH\FWTHFS\FWTHFS-00254\FWTHFS-00242 (Original Project Docs)\Deliverables_SP\Calculations\Trash Wheel\Final\clearfork\08092022\

Name of input data file:
Clear Fork all ayer.lp12d

Name of output report file:
Clear Fork all ayer.lp12o

Name of plot output file:
Clear Fork all ayer.lp12p

Name of runtime message file:
Clear Fork all ayer.lp12r

Date and Time of Analysis

Date: August 9, 2022 Time: 15:27:05

Problem Title

Project Name: Fort Worth Trash Wheel

Job Number: FWTHFS-00242

Client: City of Fort Worth

Engineer: Sandeep Menon

Description: Clear Fork LPILE

```
--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                 =          500
 - Deflection tolerance for convergence                 =   1.0000E-05 in
 - Maximum allowable deflection                         =     300.0000 in
 - Number of pile increments                            =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats




--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                         =            1
Total length of pile                                    =       61.000 ft
Depth of ground surface below top of pile               =      33.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000           30.0000
  2           61.000           30.0000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a steel pipe pile
   Length of section                                    =    61.000000 ft
```

Pile diameter = 30.000000 in

Soil and Rock Layering Information

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	33.000000 ft
Distance from top of pile to bottom of layer	=	43.000000 ft
Effective unit weight at top of layer	=	125.000000 pcf
Effective unit weight at bottom of layer	=	125.000000 pcf
Friction angle at top of layer	=	36.000000 deg.
Friction angle at bottom of layer	=	36.000000 deg.
Subgrade k at top of layer	=	120.000000 pci
Subgrade k at bottom of layer	=	120.000000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	43.000000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	125.000000 pcf
Effective unit weight at bottom of layer	=	125.000000 pcf
Friction angle at top of layer	=	36.000000 deg.
Friction angle at bottom of layer	=	36.000000 deg.
Subgrade k at top of layer	=	120.000000 pci
Subgrade k at bottom of layer	=	120.000000 pci

Layer 3 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	50.000000 ft
Distance from top of pile to bottom of layer	=	100.000000 ft
Effective unit weight at top of layer	=	140.000000 pcf
Effective unit weight at bottom of layer	=	140.000000 pcf
Uniaxial compressive strength at top of layer	=	275.000000 psi
Uniaxial compressive strength at bottom of layer	=	275.000000 psi
Initial modulus of rock at top of layer	=	100000. psi
Initial modulus of rock at bottom of layer	=	100000. psi
RQD of rock at top of layer	=	30.000000 %
RQD of rock at bottom of layer	=	30.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 39.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	33.0000	125.0000	36.0000	--	--	--	120.0000	--
	(Reese, et al.)	43.0000	125.0000	36.0000	--	--	--	120.0000	--
2	Sand	43.0000	125.0000	36.0000	--	--	--	120.0000	--
	(Reese, et al.)	50.0000	125.0000	36.0000	--	--			

```
  --        120.0000       --
  3           Weak              50.0000     140.0000       --         275.0000      30.0000
1.00E-04       --          100000.
              Rock             100.0000     140.0000       --         275.0000      30.0000
1.00E-04       --          100000.
```

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 30000. lbs	M = 270000. in-lbs	0.0000000	Yes	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
----

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel Pipe Pile:

```
Length of Section                                   =    61.000000 ft
Outer Diameter of Pipe                              =    30.000000 in
Pipe Wall Thickness                                 =     0.750000 in
Yield Stress of Pipe                                =    50.000000 ksi
Elastic Modulus                                     =       29000. ksi
Cross-sectional Area                                =    68.918689 sq. in.
Moment of Inertia                                   =        7375. in^4
Elastic Bending Stiffness                           =   213885920. kip-in^2
Plastic Modulus, Z                                  =   641.812500in^3
Plastic Moment Capacity = Fy Z                      =       32091.in-kip
```

Axial Structural Capacities:

```
Nom. Axial Structural Capacity = Fy As              =     3445.934 kips
Nominal Axial Tensile Capacity                      =    -3445.934 kips
```

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000244	522.3962477	213875170.	15.0000000	1.0518750	
0.00000489	1045.	213875170.	15.0000000	2.1037500	
0.00000733	1567.	213875170.	15.0000000	3.1556250	
0.00000977	2090.	213875170.	15.0000000	4.2075000	
0.00001221	2612.	213875170.	15.0000000	5.2593750	
0.00001466	3134.	213875170.	15.0000000	6.3112500	
0.00001710	3657.	213875170.	15.0000000	7.3631250	
0.00001954	4179.	213875170.	15.0000000	8.4150001	
0.00002198	4702.	213875170.	15.0000000	9.4668751	
0.00002443	5224.	213875170.	15.0000000	10.5187501	
0.00002687	5746.	213875170.	15.0000000	11.5706251	
0.00002931	6269.	213875170.	15.0000000	12.6225001	
0.00003175	6791.	213875170.	15.0000000	13.6743751	
0.00003420	7314.	213875170.	15.0000000	14.7262501	
0.00003664	7836.	213875170.	15.0000000	15.7781251	
0.00003908	8358.	213875170.	15.0000000	16.8300001	
0.00004152	8881.	213875170.	15.0000000	17.8818751	
0.00004397	9403.	213875170.	15.0000000	18.9337501	
0.00004641	9926.	213875170.	15.0000000	19.9856251	
0.00004885	10448.	213875170.	15.0000000	21.0375001	
0.00005129	10970.	213875170.	15.0000000	22.0893751	
0.00005374	11493.	213875170.	15.0000000	23.1412502	
0.00005618	12015.	213875170.	15.0000000	24.1931252	
0.00005862	12538.	213875170.	15.0000000	25.2450002	
0.00006106	13060.	213875170.	15.0000000	26.2968752	
0.00006351	13582.	213875170.	15.0000000	27.3487502	
0.00006595	14105.	213875170.	15.0000000	28.4006252	
0.00006839	14627.	213875170.	15.0000000	29.4525002	
0.00007083	15149.	213875170.	15.0000000	30.5043752	
0.00007328	15672.	213875170.	15.0000000	31.5562502	
0.00007572	16194.	213875170.	15.0000000	32.6081252	
0.00007816	16717.	213875170.	15.0000000	33.6600002	
0.00008060	17239.	213875170.	15.0000000	34.7118752	
0.00008305	17761.	213875170.	15.0000000	35.7637502	
0.00008549	18284.	213875170.	15.0000000	36.8156252	
0.00008793	18806.	213875170.	15.0000000	37.8675003	
0.00009037	19329.	213875170.	15.0000000	38.9193753	
0.00009282	19851.	213875170.	15.0000000	39.9712503	
0.00009526	20373.	213875170.	15.0000000	41.0231253	
0.0001001	21418.	213875170.	15.0000000	43.1268753	
0.0001050	22463.	213875170.	15.0000000	45.2306253	
0.0001099	23508.	213875170.	15.0000000	47.3343753	
0.0001148	24553.	213875170.	15.0000000	49.4381253	
0.0001197	25511.	213152380.	15.0000000	50.0000000	Y
0.0001246	26232.	210583666.	15.0000000	50.0000000	Y
0.0001295	26800.	207022224.	15.0000000	50.0000000	Y
0.0001343	27269.	202983179.	15.0000000	50.0000000	Y
0.0001392	27670.	198746654.	15.0000000	50.0000000	Y
0.0001441	28017.	194414878.	15.0000000	50.0000000	Y
0.0001490	28323.	190095167.	15.0000000	50.0000000	Y
0.0001539	28591.	185802169.	15.0000000	50.0000000	Y
0.0001588	28829.	181585311.	15.0000000	50.0000000	Y
0.0001636	29043.	177470462.	15.0000000	50.0000000	Y

0.0001685	29235.	173468097.	15.0000000	50.0000000	Y
0.0001734	29409.	169585196.	15.0000000	50.0000000	Y
0.0001783	29568.	165826064.	15.0000000	50.0000000	Y
0.0001832	29712.	162192964.	15.0000000	50.0000000	Y
0.0001881	29844.	158681275.	15.0000000	50.0000000	Y
0.0001930	29963.	155281614.	15.0000000	50.0000000	Y
0.0001978	30074.	152005500.	15.0000000	50.0000000	Y
0.0002027	30177.	148851238.	15.0000000	50.0000000	Y
0.0002076	30271.	145802256.	15.0000000	50.0000000	Y
0.0002125	30357.	142857873.	15.0000000	50.0000000	Y
0.0002174	30440.	140027612.	15.0000000	50.0000000	Y
0.0002223	30514.	137283086.	15.0000000	50.0000000	Y
0.0002272	30585.	134642575.	15.0000000	50.0000000	Y
0.0002320	30650.	132089238.	15.0000000	50.0000000	Y
0.0002369	30711.	129625023.	15.0000000	50.0000000	Y
0.0002418	30769.	127243261.	15.0000000	50.0000000	Y
0.0002467	30823.	124943000.	15.0000000	50.0000000	Y
0.0002516	30873.	122715893.	15.0000000	50.0000000	Y
0.0002565	30922.	120568203.	15.0000000	50.0000000	Y
0.0002614	30965.	118481064.	15.0000000	50.0000000	Y
0.0002662	31009.	116470517.	15.0000000	50.0000000	Y
0.0002711	31047.	114515408.	15.0000000	50.0000000	Y
0.0002760	31085.	112624803.	15.0000000	50.0000000	Y
0.0002809	31122.	110797855.	15.0000000	50.0000000	Y
0.0002858	31154.	109016833.	15.0000000	50.0000000	Y
0.0002907	31187.	107295678.	15.0000000	50.0000000	Y
0.0003102	31301.	100904523.	15.0000000	50.0000000	Y
0.0003297	31393.	95205408.	15.0000000	50.0000000	Y
0.0003493	31471.	90100759.	15.0000000	50.0000000	Y
0.0003688	31535.	85502779.	15.0000000	50.0000000	Y
0.0003884	31590.	81340543.	15.0000000	50.0000000	Y
0.0004079	31637.	77559576.	15.0000000	50.0000000	Y
0.0004274	31679.	74112823.	15.0000000	50.0000000	Y
0.0004470	31713.	70949672.	15.0000000	50.0000000	Y
0.0004665	31745.	68046000.	15.0000000	50.0000000	Y
0.0004861	31772.	65365798.	15.0000000	50.0000000	Y
0.0005056	31797.	62889062.	15.0000000	50.0000000	Y
0.0005251	31818.	60588308.	15.0000000	50.0000000	Y
0.0005447	31838.	58452630.	15.0000000	50.0000000	Y
0.0005642	31854.	56456945.	15.0000000	50.0000000	Y
0.0005838	31870.	54593653.	15.0000000	50.0000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	31870.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Top of   Equivalent

Layer No.	Layer Below Pile Head ft	Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	33.0000	0.00	N.A.	No	0.00	222057.
2	43.0000	10.0000	Yes	No	222057.	558325.
3	50.0000	17.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 30000.0 lbs
Applied moment at pile head = 270000.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	7.5569	270000.	30000.	-0.02099	549.1245	2.14E+11	0.00	0.00	0.00
0.6100	7.4033	489600.	30000.	-0.02098	995.7458	2.14E+11	0.00	0.00	0.00
1.2200	7.2497	709200.	30000.	-0.02096	1442.	2.14E+11	0.00	0.00	0.00
1.8300	7.0964	928800.	30000.	-0.02093	1889.	2.14E+11	0.00	0.00	0.00
2.4400	6.9433	1148400.	30000.	-0.02090	2336.	2.14E+11	0.00	0.00	0.00
3.0500	6.7905	1368000.	30000.	-0.02085	2782.	2.14E+11	0.00	0.00	0.00
3.6600	6.6380	1587600.	30000.	-0.02080	3229.	2.14E+11	0.00	0.00	0.00
4.2700	6.4859	1807200.	30000.	-0.02075	3675.	2.14E+11	0.00	0.00	0.00
4.8800	6.3343	2026800.	30000.	-0.02068	4122.	2.14E+11	0.00	0.00	0.00
5.4900	6.1832	2246400.	30000.	-0.02061	4569.	2.14E+11	0.00	0.00	0.00
6.1000	6.0326	2466000.	30000.	-0.02053	5015.	2.14E+11	0.00	0.00	0.00
6.7100	5.8827	2685600.	30000.	-0.02044	5462.	2.14E+11	0.00	0.00	0.00
7.3200	5.7334	2905200.	30000.	-0.02034	5909.	2.14E+11	0.00	0.00	0.00
7.9300	5.5849	3124800.	30000.	-0.02024	6355.	2.14E+11	0.00	0.00	0.00
8.5400	5.4371	3344400.	30000.	-0.02013	6802.	2.14E+11	0.00	0.00	0.00
9.1500	5.2902	3564000.	30000.	-0.02001	7248.	2.14E+11	0.00	0.00	0.00
9.7600	5.1442	3783600.	30000.	-0.01988	7695.	2.14E+11	0.00	0.00	0.00
10.3700	4.9991	4003200.	30000.	-0.01975	8142.	2.14E+11	0.00	0.00	0.00

10.9800	4.8550	4222800.	30000.	-0.01961	8588.	2.14E+11	0.00	0.00	0.00
11.5900	4.7120	4442400.	30000.	-0.01946	9035.	2.14E+11	0.00	0.00	0.00
12.2000	4.5701	4662000.	30000.	-0.01931	9482.	2.14E+11	0.00	0.00	0.00
12.8100	4.4294	4881600.	30000.	-0.01914	9928.	2.14E+11	0.00	0.00	0.00
13.4200	4.2899	5101200.	30000.	-0.01897	10375.	2.14E+11	0.00	0.00	0.00
14.0300	4.1516	5320800.	30000.	-0.01879	10821.	2.14E+11	0.00	0.00	0.00
14.6400	4.0147	5540400.	30000.	-0.01861	11268.	2.14E+11	0.00	0.00	0.00
15.2500	3.8792	5760000.	30000.	-0.01841	11715.	2.14E+11	0.00	0.00	0.00
15.8600	3.7451	5979600.	30000.	-0.01821	12161.	2.14E+11	0.00	0.00	0.00
16.4700	3.6126	6199200.	30000.	-0.01800	12608.	2.14E+11	0.00	0.00	0.00
17.0800	3.4815	6418800.	30000.	-0.01779	13055.	2.14E+11	0.00	0.00	0.00
17.6900	3.3521	6638400.	30000.	-0.01757	13501.	2.14E+11	0.00	0.00	0.00
18.3000	3.2244	6858000.	30000.	-0.01733	13948.	2.14E+11	0.00	0.00	0.00
18.9100	3.0984	7077600.	30000.	-0.01710	14394.	2.14E+11	0.00	0.00	0.00
19.5200	2.9741	7297200.	30000.	-0.01685	14841.	2.14E+11	0.00	0.00	0.00
20.1300	2.8517	7516800.	30000.	-0.01660	15288.	2.14E+11	0.00	0.00	0.00
20.7400	2.7311	7736400.	30000.	-0.01634	15734.	2.14E+11	0.00	0.00	0.00
21.3500	2.6125	7956000.	30000.	-0.01607	16181.	2.14E+11	0.00	0.00	0.00
21.9600	2.4959	8175600.	30000.	-0.01579	16627.	2.14E+11	0.00	0.00	0.00
22.5700	2.3813	8395200.	30000.	-0.01551	17074.	2.14E+11	0.00	0.00	0.00
23.1800	2.2689	8614800.	30000.	-0.01522	17521.	2.14E+11	0.00	0.00	0.00
23.7900	2.1586	8834400.	30000.	-0.01492	17967.	2.14E+11	0.00	0.00	0.00
24.4000	2.0505	9054000.	30000.	-0.01461	18414.	2.14E+11	0.00	0.00	0.00
25.0100	1.9447	9273600.	30000.	-0.01430	18861.	2.14E+11	0.00	0.00	0.00
25.6200	1.8412	9493200.	30000.	-0.01398	19307.	2.14E+11	0.00	0.00	0.00
26.2300	1.7401	9712800.	30000.	-0.01365	19754.	2.14E+11	0.00	0.00	0.00
26.8400	1.6414	9932400.	30000.	-0.01331	20200.	2.14E+11	0.00	0.00	0.00
27.4500	1.5452	1.02E+07	30000.	-0.01297	20647.	2.14E+11	0.00	0.00	0.00
28.0600	1.4515	1.04E+07	30000.	-0.01262	21094.	2.14E+11	0.00	0.00	0.00
28.6700	1.3605	1.06E+07	30000.	-0.01226	21540.	2.14E+11	0.00	0.00	0.00
29.2800	1.2721	1.08E+07	30000.	-0.01189	21987.	2.14E+11	0.00	0.00	0.00
29.8900	1.1864	1.10E+07	30000.	-0.01152	22434.	2.14E+11	0.00	0.00	0.00
30.5000	1.1034	1.12E+07	30000.	-0.01114	22880.	2.14E+11	0.00	0.00	0.00
31.1100	1.0233	1.15E+07	30000.	-0.01075	23327.	2.14E+11	0.00	0.00	0.00
31.7200	0.9461	1.17E+07	30000.	-0.01035	23773.	2.14E+11	0.00	0.00	0.00
32.3300	0.8718	1.19E+07	30000.	-0.00995	24220.	2.14E+11	0.00	0.00	0.00
32.9400	0.8004	1.21E+07	30000.	-0.00954	24667.	2.14E+11	0.00		

								0.00	0.00
33.5500	0.7321	1.23E+07	29491.	-0.00912	25113.	2.14E+11	-138.970	1389.	0.00
34.1600	0.6670	1.26E+07	27841.	-0.00869	25545.	2.14E+11	-312.079	3425.	0.00
34.7700	0.6049	1.28E+07	24897.	-0.00826	25942.	2.14E+11	-492.084	5955.	0.00
35.3800	0.5461	1.29E+07	20656.	-0.00782	26286.	2.14E+11	-666.773	8938.	0.00
35.9900	0.4904	1.31E+07	15179.	-0.00737	26557.	2.14E+11	-829.551	12381.	0.00
36.6000	0.4381	1.31E+07	8597.	-0.00693	26738.	2.14E+11	-968.841	16188.	0.00
37.2100	0.3890	1.32E+07	1059.	-0.00648	26813.	2.14E+11	-1091.	20522.	0.00
37.8200	0.3433	1.32E+07	-7264.	-0.00602	26770.	2.14E+11	-1183.	25232.	0.00
38.4300	0.3009	1.31E+07	-16173.	-0.00558	26597.	2.14E+11	-1251.	30435.	0.00
39.0400	0.2617	1.29E+07	-25458.	-0.00513	26288.	2.14E+11	-1286.	35969.	0.00
39.6500	0.2257	1.27E+07	-34894.	-0.00469	25839.	2.14E+11	-1292.	41911.	0.00
40.2600	0.1930	1.24E+07	-44244.	-0.00426	25249.	2.14E+11	-1262.	47868.	0.00
40.8700	0.1634	1.21E+07	-53320.	-0.00384	24522.	2.14E+11	-1218.	54566.	0.00
41.4800	0.1367	1.16E+07	-61998.	-0.00344	23661.	2.14E+11	-1153.	61748.	0.00
42.0900	0.1130	1.11E+07	-70066.	-0.00305	22676.	2.14E+11	-1051.	68067.	0.00
42.7000	0.09211	1.06E+07	-77261.	-0.00268	21575.	2.14E+11	-914.793	72697.	0.00
43.3100	0.07386	1.00E+07	-83591.	-0.00232	20375.	2.14E+11	-814.902	80764.	0.00
43.9200	0.05811	9384613.	-89351.	-0.00199	19086.	2.14E+11	-758.701	95567.	0.00
44.5300	0.04472	8710239.	-94650.	-0.00168	17715.	2.14E+11	-689.068	112791.	0.00
45.1400	0.03351	7998943.	-99315.	-0.00139	16268.	2.14E+11	-585.777	127965.	0.00
45.7500	0.02430	7256260.	-103092.	-0.00113	14758.	2.14E+11	-446.161	134395.	0.00
46.3600	0.01691	6489670.	-105916.	-8.98E-04	13199.	2.14E+11	-325.344	140825.	0.00
46.9700	0.01115	5705648.	-107928.	-6.90E-04	11604.	2.14E+11	-224.251	147255.	0.00
47.5800	0.00681	4909610.	-109272.	-5.08E-04	9985.	2.14E+11	-143.045	153685.	0.00
48.1900	0.00371	4105907.	-110092.	-3.54E-04	8351.	2.14E+11	-81.129	160115.	0.00
48.8000	0.00163	3297857.	-110525.	-2.27E-04	6707.	2.14E+11	-37.163	166545.	0.00
49.4100	3.84E-04	2487816.	-110695.	-1.28E-04	5060.	2.14E+11	-9.075	172975.	0.00
50.0200	-2.42E-04	1677289.	-104231.	-5.68E-05	3411.	2.14E+11	1775.	5.37E+07	0.00
50.6300	-4.48E-04	961869.	-87587.	-1.17E-05	1956.	2.14E+11	2773.	4.53E+07	0.00
51.2400	-4.13E-04	395018.	-64982.	1.16E-05	803.3864	2.14E+11	3403.	6.03E+07	0.00
51.8500	-2.79E-04	10530.	-38957.	1.85E-05	21.4164	2.14E+11	3707.	9.73E+07	0.00
52.4600	-1.42E-04	-175306.	-13366.	1.57E-05	356.5359	2.14E+11	3285.	1.69E+08	0.00
53.0700	-4.93E-05	-185143.	3413.	9.51E-06	376.5437	2.14E+11	1300.	1.93E+08	0.00
53.6800	-2.89E-06	-125333.	8484.	4.19E-06	254.9024	2.14E+11	85.5149	2.17E+08	0.00
54.2900	1.21E-05	-60941.	7339.	1.01E-06	123.9422	2.14E+11	-398.267	2.41E+08	0.00
54.9000	1.18E-05	-17889.	4315.	-3.43E-07	36.3833	2.14E+11	-427.970	2.64E+08	0.00

55.5100	7.09E-06	2231.	1726.	-6.11E-07	4.5373	2.14E+11	-279.400	2.88E+08	0.00
56.1200	2.90E-06	7380.	250.5285	-4.46E-07	15.0102	2.14E+11	-123.754	3.12E+08	0.00
56.7300	5.60E-07	5899.	-296.450	-2.19E-07	11.9968	2.14E+11	-25.693	3.36E+08	0.00
57.3400	-3.05E-07	3040.	-335.661	-6.61E-08	6.1834	2.14E+11	14.9800	3.60E+08	0.00
57.9500	-4.08E-07	984.6349	-206.216	2.79E-09	2.0025	2.14E+11	20.3875	3.66E+08	0.00
58.5600	-2.64E-07	21.3427	-83.282	2.00E-08	0.04341	2.14E+11	13.2009	3.66E+08	0.00
59.1700	-1.15E-07	-234.613	-13.933	1.64E-08	0.4772	2.14E+11	5.7469	3.66E+08	0.00
59.7800	-2.46E-08	-182.633	11.6097	9.21E-09	0.3714	2.14E+11	1.2319	3.66E+08	0.00
60.3900	1.99E-08	-64.647	12.4749	4.98E-09	0.1315	2.14E+11	-0.995	3.66E+08	0.00
61.0000	4.83E-08	0.00	0.00	3.87E-09	0.00	2.14E+11	-2.413	1.83E+08	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

Pile-head deflection = 7.55689501 inches
Computed slope at pile head = -0.0209938 radians
Maximum bending moment = 13183851. inch-lbs
Maximum shear force = -110695. lbs
Depth of maximum bending moment = 37.21000000 feet below pile head
Depth of maximum shear force = 49.41000000 feet below pile head
Number of iterations = 17
Number of zero deflection points = 4
Pile deflection at ground = 0.79372108 inches

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

Shear = 30000. lbs
Moment = 270000. in-lbs
Axial Load = 0. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
61.00000	7.55689501	13183851.	-110695.
57.95000	7.55623391	13181216.	-109906.
54.90000	7.55462878	13183217.	-109633.
51.85000	7.58138763	13177349.	-113319.
48.80000	12.59019274	13055534.	-152992.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.

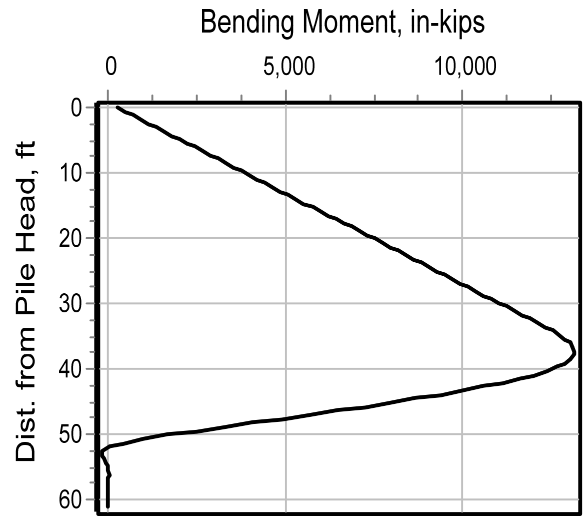
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

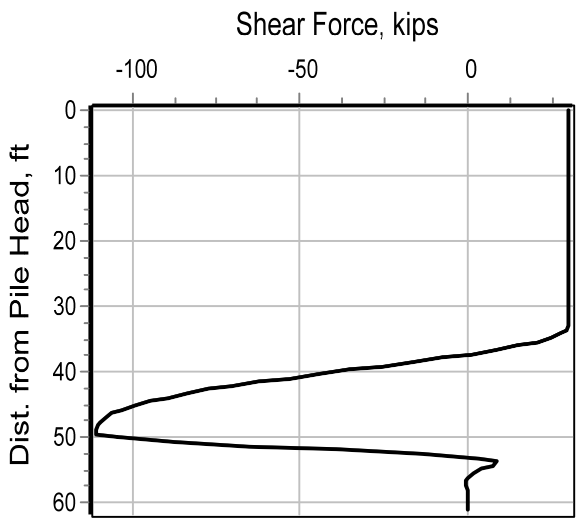
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	30000.	M, in-lb	270000.	0.00	7.5569	-0.02099	-110695.	1.32E+07

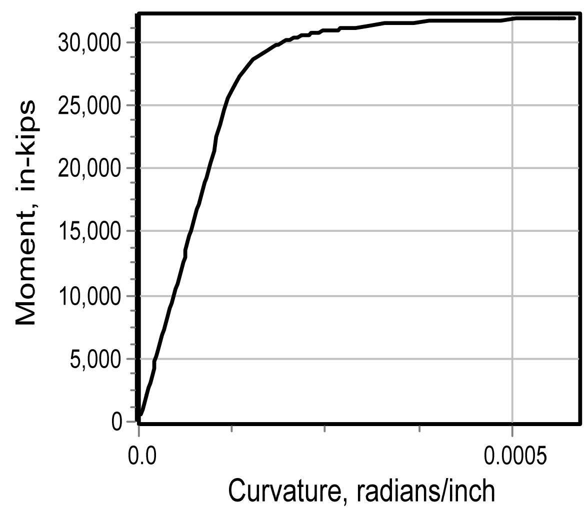
Maximum pile-head deflection = 7.5568950056 inches
Maximum pile-head rotation   = -0.0209938345 radians = -1.202858 deg.

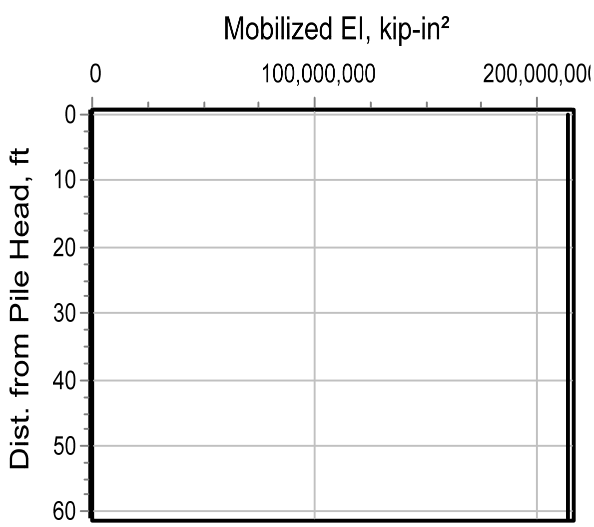
The analysis ended normally.

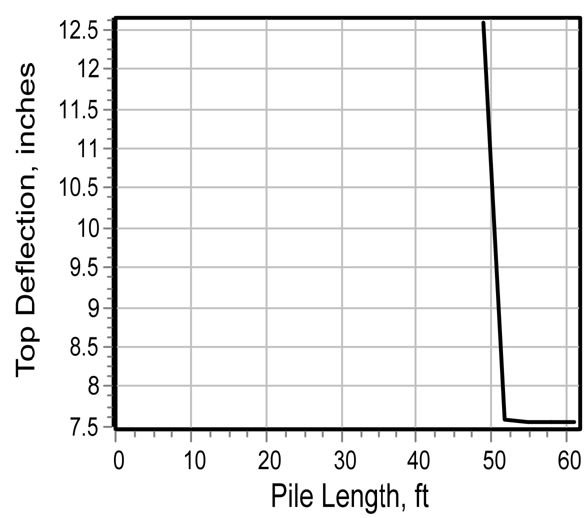
CASE 2 - RESULTS SUMMARY ANCHOR PILE WITH 2 SOIL LAYERS AND ROCK



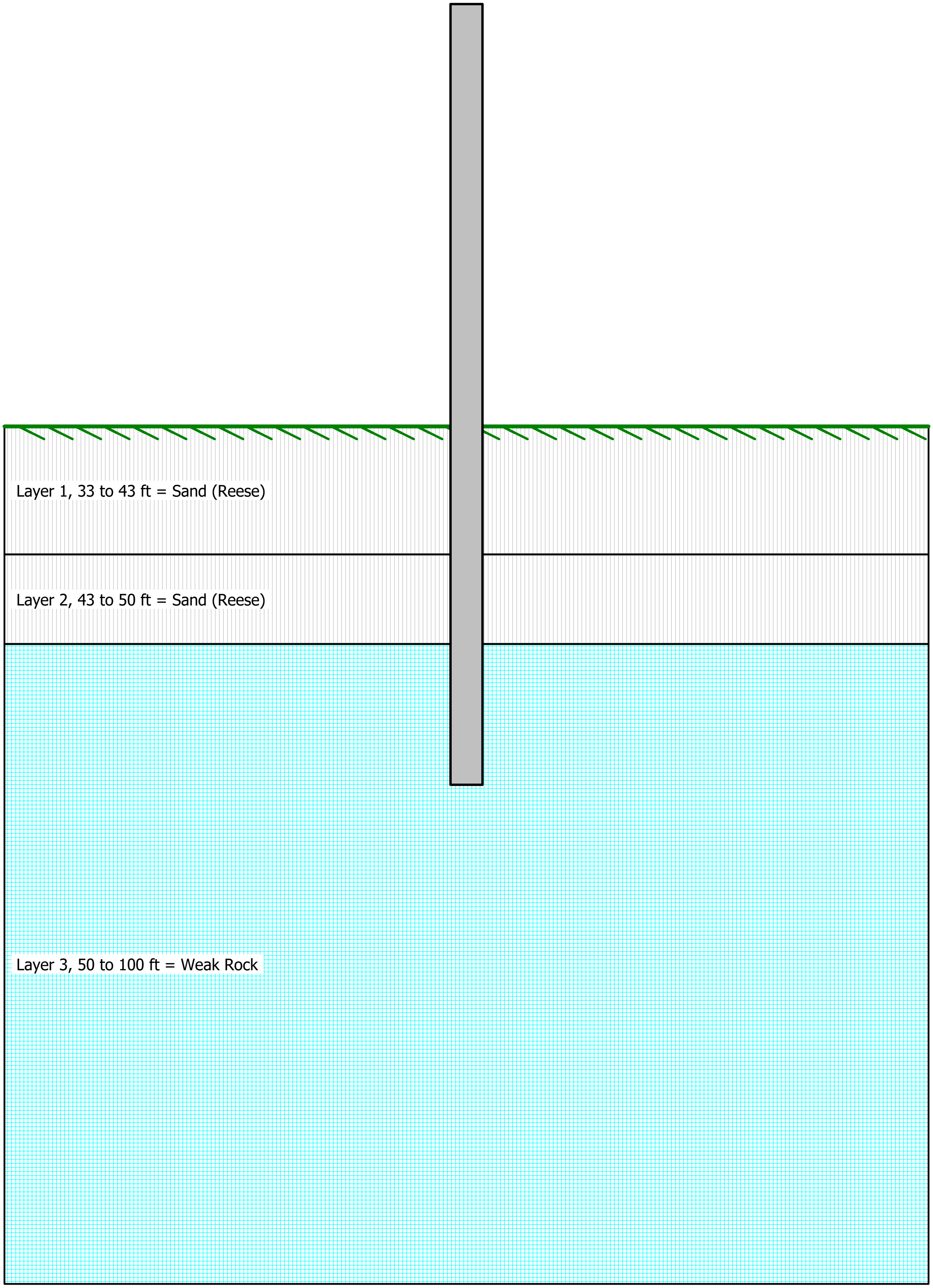








CASE 3 - ANCHOR PILE - SERVICE LOAD



LPile 2022.12.03, © 2022 by Ensoft, Inc.

```
================================================================================

                    LPile for Windows, Version 2022-12.003

                Analysis of Individual Piles and Drilled Shafts
               Subjected to Lateral Loading Using the p-y Method
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================================================================================

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--------------------------------------------------------------------------------
                             Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\\enercon.sharepoint.com@SSL\DavWWWRoot\sites\NSG_NC\Clients\FWTH\FWTHFS\FWTHFS-00254\FWTHFS-002
42 (Original Project Docs)\Deliverables_SP\Calculations\Trash Wheel\Final\clearfork\08092022\

Name of input data file:
Clear Fork all ayer - Copy.lp12d

Name of output report file:
Clear Fork all ayer - Copy.lp12o

Name of plot output file:
Clear Fork all ayer - Copy.lp12p

Name of runtime message file:
Clear Fork all ayer - Copy.lp12r


--------------------------------------------------------------------------------
                            Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  August 13, 2022            Time:  20:04:06


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: Fort Worth Trash Wheel


Job Number: FWTHFS-00242


Client: City of Fort Worth


Engineer: Sandeep Menon
```

Description: Clear Fork LPILE

Program Options and Settings

Computational Options:
 - Conventional Analysis

Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed = 500
 - Deflection tolerance for convergence = 1.0000E-05 in
 - Maximum allowable deflection = 300.0000 in
 - Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 1
Total length of pile = 61.000 ft
Depth of ground surface below top of pile = 33.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	30.0000
2	61.000	30.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a steel pipe pile
Length of section = 61.000000 ft

Pile diameter = 30.000000 in

Soil and Rock Layering Information

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	33.000000 ft
Distance from top of pile to bottom of layer	=	43.000000 ft
Effective unit weight at top of layer	=	125.000000 pcf
Effective unit weight at bottom of layer	=	125.000000 pcf
Friction angle at top of layer	=	36.000000 deg.
Friction angle at bottom of layer	=	36.000000 deg.
Subgrade k at top of layer	=	120.000000 pci
Subgrade k at bottom of layer	=	120.000000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	43.000000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	125.000000 pcf
Effective unit weight at bottom of layer	=	125.000000 pcf
Friction angle at top of layer	=	36.000000 deg.
Friction angle at bottom of layer	=	36.000000 deg.
Subgrade k at top of layer	=	120.000000 pci
Subgrade k at bottom of layer	=	120.000000 pci

Layer 3 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	50.000000 ft
Distance from top of pile to bottom of layer	=	100.000000 ft
Effective unit weight at top of layer	=	140.000000 pcf
Effective unit weight at bottom of layer	=	140.000000 pcf
Uniaxial compressive strength at top of layer	=	275.000000 psi
Uniaxial compressive strength at bottom of layer	=	275.000000 psi
Initial modulus of rock at top of layer	=	100000. psi
Initial modulus of rock at bottom of layer	=	100000. psi
RQD of rock at top of layer	=	30.000000 %
RQD of rock at bottom of layer	=	30.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 39.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	33.0000	125.0000	36.0000	--	--	--	120.0000	--
	(Reese, et al.)	43.0000	125.0000	36.0000	--	--	--	120.0000	--
2	Sand	43.0000	125.0000	36.0000	--	--	--	120.0000	--
	(Reese, et al.)	50.0000	125.0000	36.0000	--	--			

```
  --          120.0000        --
  3             Weak              50.0000     140.0000       --         275.0000      30.0000
1.00E-04       --           100000.
                Rock             100.0000     140.0000       --         275.0000      30.0000
1.00E-04       --           100000.
```

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 12981. lbs	M = 270000. in-lbs	0.0000000	Yes	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

----

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel Pipe Pile:

```
Length of Section                                       =    61.000000 ft
Outer Diameter of Pipe                                  =    30.000000 in
Pipe Wall Thickness                                     =     0.750000 in
Yield Stress of Pipe                                    =    50.000000 ksi
Elastic Modulus                                         =       29000. ksi
Cross-sectional Area                                    =    68.918689 sq. in.
Moment of Inertia                                       =        7375. in^4
Elastic Bending Stiffness                               =   213885920. kip-in^2
Plastic Modulus, Z                                      =   641.812500in^3
Plastic Moment Capacity = Fy Z                          =       32091.in-kip
```

Axial Structural Capacities:

```
Nom. Axial Structural Capacity = Fy As                  =     3445.934 kips
Nominal Axial Tensile Capacity                          =    -3445.934 kips
```

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000244	522.3962477	213875170.	15.0000000	1.0518750	
0.00000489	1045.	213875170.	15.0000000	2.1037500	
0.00000733	1567.	213875170.	15.0000000	3.1556250	
0.00000977	2090.	213875170.	15.0000000	4.2075000	
0.00001221	2612.	213875170.	15.0000000	5.2593750	
0.00001466	3134.	213875170.	15.0000000	6.3112500	
0.00001710	3657.	213875170.	15.0000000	7.3631250	
0.00001954	4179.	213875170.	15.0000000	8.4150001	
0.00002198	4702.	213875170.	15.0000000	9.4668751	
0.00002443	5224.	213875170.	15.0000000	10.5187501	
0.00002687	5746.	213875170.	15.0000000	11.5706251	
0.00002931	6269.	213875170.	15.0000000	12.6225001	
0.00003175	6791.	213875170.	15.0000000	13.6743751	
0.00003420	7314.	213875170.	15.0000000	14.7262501	
0.00003664	7836.	213875170.	15.0000000	15.7781251	
0.00003908	8358.	213875170.	15.0000000	16.8300001	
0.00004152	8881.	213875170.	15.0000000	17.8818751	
0.00004397	9403.	213875170.	15.0000000	18.9337501	
0.00004641	9926.	213875170.	15.0000000	19.9856251	
0.00004885	10448.	213875170.	15.0000000	21.0375001	
0.00005129	10970.	213875170.	15.0000000	22.0893751	
0.00005374	11493.	213875170.	15.0000000	23.1412502	
0.00005618	12015.	213875170.	15.0000000	24.1931252	
0.00005862	12538.	213875170.	15.0000000	25.2450002	
0.00006106	13060.	213875170.	15.0000000	26.2968752	
0.00006351	13582.	213875170.	15.0000000	27.3487502	
0.00006595	14105.	213875170.	15.0000000	28.4006252	
0.00006839	14627.	213875170.	15.0000000	29.4525002	
0.00007083	15149.	213875170.	15.0000000	30.5043752	
0.00007328	15672.	213875170.	15.0000000	31.5562502	
0.00007572	16194.	213875170.	15.0000000	32.6081252	
0.00007816	16717.	213875170.	15.0000000	33.6600002	
0.00008060	17239.	213875170.	15.0000000	34.7118752	
0.00008305	17761.	213875170.	15.0000000	35.7637502	
0.00008549	18284.	213875170.	15.0000000	36.8156252	
0.00008793	18806.	213875170.	15.0000000	37.8675003	
0.00009037	19329.	213875170.	15.0000000	38.9193753	
0.00009282	19851.	213875170.	15.0000000	39.9712503	
0.00009526	20373.	213875170.	15.0000000	41.0231253	
0.0001001	21418.	213875170.	15.0000000	43.1268753	
0.0001050	22463.	213875170.	15.0000000	45.2306253	
0.0001099	23508.	213875170.	15.0000000	47.3343753	
0.0001148	24553.	213875170.	15.0000000	49.4381253	
0.0001197	25511.	213152380.	15.0000000	50.0000000	Y
0.0001246	26232.	210583666.	15.0000000	50.0000000	Y
0.0001295	26800.	207022224.	15.0000000	50.0000000	Y
0.0001343	27269.	202983179.	15.0000000	50.0000000	Y
0.0001392	27670.	198746654.	15.0000000	50.0000000	Y
0.0001441	28017.	194414878.	15.0000000	50.0000000	Y
0.0001490	28323.	190095167.	15.0000000	50.0000000	Y
0.0001539	28591.	185802169.	15.0000000	50.0000000	Y
0.0001588	28829.	181585311.	15.0000000	50.0000000	Y
0.0001636	29043.	177470462.	15.0000000	50.0000000	Y

0.0001685	29235.	173468097.	15.0000000	50.0000000	Y
0.0001734	29409.	169585196.	15.0000000	50.0000000	Y
0.0001783	29568.	165826064.	15.0000000	50.0000000	Y
0.0001832	29712.	162192964.	15.0000000	50.0000000	Y
0.0001881	29844.	158681275.	15.0000000	50.0000000	Y
0.0001930	29963.	155281614.	15.0000000	50.0000000	Y
0.0001978	30074.	152005500.	15.0000000	50.0000000	Y
0.0002027	30177.	148851238.	15.0000000	50.0000000	Y
0.0002076	30271.	145802256.	15.0000000	50.0000000	Y
0.0002125	30357.	142857873.	15.0000000	50.0000000	Y
0.0002174	30440.	140027612.	15.0000000	50.0000000	Y
0.0002223	30514.	137283086.	15.0000000	50.0000000	Y
0.0002272	30585.	134642575.	15.0000000	50.0000000	Y
0.0002320	30650.	132089238.	15.0000000	50.0000000	Y
0.0002369	30711.	129625023.	15.0000000	50.0000000	Y
0.0002418	30769.	127243261.	15.0000000	50.0000000	Y
0.0002467	30823.	124943000.	15.0000000	50.0000000	Y
0.0002516	30873.	122715893.	15.0000000	50.0000000	Y
0.0002565	30922.	120568203.	15.0000000	50.0000000	Y
0.0002614	30965.	118481064.	15.0000000	50.0000000	Y
0.0002662	31009.	116470517.	15.0000000	50.0000000	Y
0.0002711	31047.	114515408.	15.0000000	50.0000000	Y
0.0002760	31085.	112624803.	15.0000000	50.0000000	Y
0.0002809	31122.	110797855.	15.0000000	50.0000000	Y
0.0002858	31154.	109016833.	15.0000000	50.0000000	Y
0.0002907	31187.	107295678.	15.0000000	50.0000000	Y
0.0003102	31301.	100904523.	15.0000000	50.0000000	Y
0.0003297	31393.	95205408.	15.0000000	50.0000000	Y
0.0003493	31471.	90100759.	15.0000000	50.0000000	Y
0.0003688	31535.	85502779.	15.0000000	50.0000000	Y
0.0003884	31590.	81340543.	15.0000000	50.0000000	Y
0.0004079	31637.	77559576.	15.0000000	50.0000000	Y
0.0004274	31679.	74112823.	15.0000000	50.0000000	Y
0.0004470	31713.	70949672.	15.0000000	50.0000000	Y
0.0004665	31745.	68046000.	15.0000000	50.0000000	Y
0.0004861	31772.	65365798.	15.0000000	50.0000000	Y
0.0005056	31797.	62889062.	15.0000000	50.0000000	Y
0.0005251	31818.	60588308.	15.0000000	50.0000000	Y
0.0005447	31838.	58452630.	15.0000000	50.0000000	Y
0.0005642	31854.	56456945.	15.0000000	50.0000000	Y
0.0005838	31870.	54593653.	15.0000000	50.0000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	31870.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Top of   Equivalent

Layer No.	Layer Below Pile Head ft	Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	33.0000	0.00	N.A.	No	0.00	222057.
2	43.0000	10.0000	Yes	No	222057.	558325.
3	50.0000	17.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 12981.0 lbs
Applied moment at pile head = 270000.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	3.0625	270000.	12981.	-0.00890	549.1245	2.14E+11	0.00	0.00	0.00
0.6100	2.9974	365021.	12981.	-0.00889	742.3775	2.14E+11	0.00	0.00	0.00
1.2200	2.9324	460042.	12981.	-0.00887	935.6305	2.14E+11	0.00	0.00	0.00
1.8300	2.8675	555063.	12981.	-0.00885	1129.	2.14E+11	0.00	0.00	0.00
2.4400	2.8028	650084.	12981.	-0.00883	1322.	2.14E+11	0.00	0.00	0.00
3.0500	2.7382	745105.	12981.	-0.00881	1515.	2.14E+11	0.00	0.00	0.00
3.6600	2.6738	840126.	12981.	-0.00878	1709.	2.14E+11	0.00	0.00	0.00
4.2700	2.6096	935146.	12981.	-0.00875	1902.	2.14E+11	0.00	0.00	0.00
4.8800	2.5457	1030167.	12981.	-0.00872	2095.	2.14E+11	0.00	0.00	0.00
5.4900	2.4820	1125188.	12981.	-0.00868	2288.	2.14E+11	0.00	0.00	0.00
6.1000	2.4186	1220209.	12981.	-0.00864	2482.	2.14E+11	0.00	0.00	0.00
6.7100	2.3555	1315230.	12981.	-0.00860	2675.	2.14E+11	0.00	0.00	0.00
7.3200	2.2927	1410251.	12981.	-0.00855	2868.	2.14E+11	0.00	0.00	0.00
7.9300	2.2303	1505272.	12981.	-0.00850	3061.	2.14E+11	0.00	0.00	0.00
8.5400	2.1682	1600293.	12981.	-0.00845	3255.	2.14E+11	0.00	0.00	0.00
9.1500	2.1066	1695314.	12981.	-0.00839	3448.	2.14E+11	0.00	0.00	0.00
9.7600	2.0454	1790335.	12981.	-0.00833	3641.	2.14E+11	0.00	0.00	0.00
10.3700	1.9846	1885356.	12981.	-0.00827	3834.	2.14E+11	0.00	0.00	0.00

10.9800	1.9243	1980377.	12981.	-0.00820	4028.	2.14E+11	0.00	0.00	0.00
11.5900	1.8645	2075397.	12981.	-0.00813	4221.	2.14E+11	0.00	0.00	0.00
12.2000	1.8052	2170418.	12981.	-0.00806	4414.	2.14E+11	0.00	0.00	0.00
12.8100	1.7465	2265439.	12981.	-0.00799	4607.	2.14E+11	0.00	0.00	0.00
13.4200	1.6883	2360460.	12981.	-0.00791	4801.	2.14E+11	0.00	0.00	0.00
14.0300	1.6308	2455481.	12981.	-0.00782	4994.	2.14E+11	0.00	0.00	0.00
14.6400	1.5738	2550502.	12981.	-0.00774	5187.	2.14E+11	0.00	0.00	0.00
15.2500	1.5175	2645523.	12981.	-0.00765	5380.	2.14E+11	0.00	0.00	0.00
15.8600	1.4618	2740544.	12981.	-0.00756	5574.	2.14E+11	0.00	0.00	0.00
16.4700	1.4069	2835565.	12981.	-0.00746	5767.	2.14E+11	0.00	0.00	0.00
17.0800	1.3526	2930586.	12981.	-0.00736	5960.	2.14E+11	0.00	0.00	0.00
17.6900	1.2991	3025607.	12981.	-0.00726	6153.	2.14E+11	0.00	0.00	0.00
18.3000	1.2463	3120628.	12981.	-0.00716	6347.	2.14E+11	0.00	0.00	0.00
18.9100	1.1943	3215649.	12981.	-0.00705	6540.	2.14E+11	0.00	0.00	0.00
19.5200	1.1431	3310669.	12981.	-0.00694	6733.	2.14E+11	0.00	0.00	0.00
20.1300	1.0928	3405690.	12981.	-0.00682	6926.	2.14E+11	0.00	0.00	0.00
20.7400	1.0433	3500711.	12981.	-0.00670	7120.	2.14E+11	0.00	0.00	0.00
21.3500	0.9946	3595732.	12981.	-0.00658	7313.	2.14E+11	0.00	0.00	0.00
21.9600	0.9469	3690753.	12981.	-0.00646	7506.	2.14E+11	0.00	0.00	0.00
22.5700	0.9001	3785774.	12981.	-0.00633	7699.	2.14E+11	0.00	0.00	0.00
23.1800	0.8543	3880795.	12981.	-0.00620	7893.	2.14E+11	0.00	0.00	0.00
23.7900	0.8094	3975816.	12981.	-0.00606	8086.	2.14E+11	0.00	0.00	0.00
24.4000	0.7655	4070837.	12981.	-0.00592	8279.	2.14E+11	0.00	0.00	0.00
25.0100	0.7227	4165858.	12981.	-0.00578	8472.	2.14E+11	0.00	0.00	0.00
25.6200	0.6808	4260879.	12981.	-0.00564	8666.	2.14E+11	0.00	0.00	0.00
26.2300	0.6401	4355900.	12981.	-0.00549	8859.	2.14E+11	0.00	0.00	0.00
26.8400	0.6004	4450920.	12981.	-0.00534	9052.	2.14E+11	0.00	0.00	0.00
27.4500	0.5619	4545941.	12981.	-0.00519	9246.	2.14E+11	0.00	0.00	0.00
28.0600	0.5245	4640962.	12981.	-0.00503	9439.	2.14E+11	0.00	0.00	0.00
28.6700	0.4882	4735983.	12981.	-0.00487	9632.	2.14E+11	0.00	0.00	0.00
29.2800	0.4532	4831004.	12981.	-0.00471	9825.	2.14E+11	0.00	0.00	0.00
29.8900	0.4193	4926025.	12981.	-0.00454	10019.	2.14E+11	0.00	0.00	0.00
30.5000	0.3867	5021046.	12981.	-0.00437	10212.	2.14E+11	0.00	0.00	0.00
31.1100	0.3554	5116067.	12981.	-0.00420	10405.	2.14E+11	0.00	0.00	0.00
31.7200	0.3253	5211088.	12981.	-0.00402	10598.	2.14E+11	0.00	0.00	0.00
32.3300	0.2965	5306109.	12981.	-0.00384	10792.	2.14E+11	0.00	0.00	0.00
32.9400	0.2691	5401130.	12981.	-0.00366	10985.	2.14E+11	0.00		

0.00	0.00						
33.5500	0.2430	5496151.	12608.	-0.00347	11178.	2.14E+11	-101.807
3067.	0.00						
34.1600	0.2183	5585716.	11409.	-0.00328	11360.	2.14E+11	-225.790
7571.	0.00						
34.7700	0.1950	5663184.	9289.	-0.00309	11518.	2.14E+11	-353.568
13272.	0.00						
35.3800	0.1731	5721706.	6257.	-0.00289	11637.	2.14E+11	-474.858
20079.	0.00						
35.9900	0.1527	5754785.	2381.	-0.00270	11704.	2.14E+11	-584.183
28011.	0.00						
36.6000	0.1337	5756561.	-2221.	-0.00250	11708.	2.14E+11	-673.009
36861.	0.00						
37.2100	0.1161	5722276.	-7259.	-0.00230	11638.	2.14E+11	-703.720
44377.	0.00						
37.8200	0.09994	5650284.	-12374.	-0.00211	11492.	2.14E+11	-693.681
50807.	0.00						
38.4300	0.08522	5541123.	-17352.	-0.00192	11270.	2.14E+11	-666.361
57237.	0.00						
39.0400	0.07189	5396257.	-22079.	-0.00173	10975.	2.14E+11	-625.252
63666.	0.00						
39.6500	0.05991	5217888.	-26467.	-0.00155	10612.	2.14E+11	-573.666
70096.	0.00						
40.2600	0.04923	5008781.	-30450.	-0.00137	10187.	2.14E+11	-514.698
76526.	0.00						
40.8700	0.03981	4772095.	-33986.	-0.00121	9705.	2.14E+11	-451.199
82956.	0.00						
41.4800	0.03159	4511232.	-37049.	-0.00105	9175.	2.14E+11	-385.751
89386.	0.00						
42.0900	0.02450	4229701.	-39634.	-8.97E-04	8602.	2.14E+11	-320.650
95816.	0.00						
42.7000	0.01846	3930988.	-41752.	-7.57E-04	7995.	2.14E+11	-257.889
102246.	0.00						
43.3100	0.01341	3618456.	-43424.	-6.28E-04	7359.	2.14E+11	-199.149
108676.	0.00						
43.9200	0.00927	3295254.	-44687.	-5.10E-04	6702.	2.14E+11	-145.794
115106.	0.00						
44.5300	0.00595	2964240.	-45582.	-4.02E-04	6029.	2.14E+11	-98.869
121535.	0.00						
45.1400	0.00338	2627929.	-46161.	-3.07E-04	5345.	2.14E+11	-59.100
127965.	0.00						
45.7500	0.00146	2288450.	-46475.	-2.23E-04	4654.	2.14E+11	-26.896
134395.	0.00						
46.3600	1.22E-04	1947530.	-46582.	-1.50E-04	3961.	2.14E+11	-2.357
140825.	0.00						
46.9700	-7.32E-04	1606485.	-46537.	-8.92E-05	3267.	2.14E+11	14.7260
147255.	0.00						
47.5800	-0.00118	1266228.	-46392.	-4.01E-05	2575.	2.14E+11	24.8598
153685.	0.00						
48.1900	-0.00132	927303.	-46196.	-2.55E-06	1886.	2.14E+11	28.8488
160115.	0.00						
48.8000	-0.00122	589924.	-45988.	2.34E-05	1200.	2.14E+11	27.7889
166545.	0.00						
49.4100	-9.76E-04	254034.	-45802.	3.79E-05	516.6527	2.14E+11	23.0652
172975.	0.00						
50.0200	-6.67E-04	-80620.	-37315.	4.08E-05	163.9650	2.14E+11	2296.
2.52E+07	0.00						
50.6300	-3.78E-04	-292251.	-19151.	3.44E-05	594.3790	2.14E+11	2667.
5.16E+07	0.00						
51.2400	-1.63E-04	-360987.	513.2609	2.33E-05	734.1729	2.14E+11	2706.
1.22E+08	0.00						
51.8500	-3.78E-05	-284737.	13164.	1.22E-05	579.0968	2.14E+11	750.6421
1.45E+08	0.00						
52.4600	1.60E-05	-168266.	14560.	4.46E-06	342.2190	2.14E+11	-369.175
1.69E+08	0.00						
53.0700	2.76E-05	-71577.	10548.	3.59E-07	145.5723	2.14E+11	-726.944
1.93E+08	0.00						
53.6800	2.12E-05	-13839.	5586.	-1.10E-06	28.1447	2.14E+11	-628.891
2.17E+08	0.00						
54.2900	1.14E-05	10202.	1909.	-1.16E-06	20.7491	2.14E+11	-375.616
2.41E+08	0.00						
54.9000	4.18E-06	14116.	-17.589	-7.49E-07	28.7099	2.14E+11	-150.909
2.64E+08	0.00						

55.5100	4.66E-07	9945.	-637.038	-3.37E-07	20.2254	2.14E+11	-18.340	2.88E+08	0.00
56.1200	-7.54E-07	4790.	-586.533	-8.46E-08	9.7422	2.14E+11	32.1389	3.12E+08	0.00
56.7300	-7.73E-07	1358.	-339.064	2.06E-08	2.7615	2.14E+11	35.4754	3.36E+08	0.00
57.3400	-4.52E-07	-173.717	-127.903	4.09E-08	0.3533	2.14E+11	22.2190	3.60E+08	0.00
57.9500	-1.75E-07	-514.691	-14.608	2.91E-08	1.0468	2.14E+11	8.7358	3.66E+08	0.00
58.5600	-2.63E-08	-387.580	22.1742	1.36E-08	0.7883	2.14E+11	1.3141	3.66E+08	0.00
59.1700	2.51E-08	-190.060	22.3991	3.76E-09	0.3865	2.14E+11	-1.253	3.66E+08	0.00
59.7800	2.88E-08	-59.657	12.5498	-5.13E-10	0.1213	2.14E+11	-1.438	3.66E+08	0.00
60.3900	1.75E-08	-6.331	4.0749	-1.64E-09	0.01288	2.14E+11	-0.877	3.66E+08	0.00
61.0000	4.73E-09	0.00	0.00	-1.75E-09	0.00	2.14E+11	-0.236	1.83E+08	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     3.06247915 inches
Computed slope at pile head      =     -0.0088963 radians
Maximum bending moment           =       5756561. inch-lbs
Maximum shear force              =        -46582. lbs
Depth of maximum bending moment  =    36.60000000 feet below pile head
Depth of maximum shear force     =    46.36000000 feet below pile head
Number of iterations             =              7
Number of zero deflection points =              5
Pile deflection at ground        =     0.26653594 inches
```

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

```
Shear      =         12981. lbs
Moment     =        270000. in-lbs
Axial Load =             0. lbs
```

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
61.00000	3.06247915	5756561.	-46582.
57.95000	3.06361494	5758640.	-45962.
54.90000	3.06291959	5758737.	-45798.
51.85000	3.06423216	5757562.	-43977.
48.80000	3.59758433	5737994.	-60306.
45.75000	7.30661085	5687594.	-81667.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians

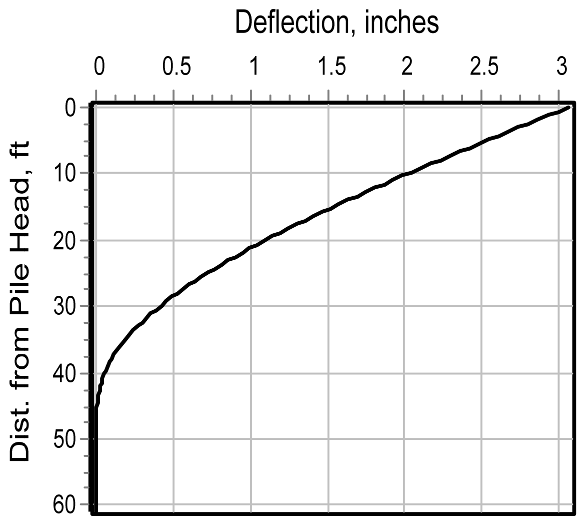
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

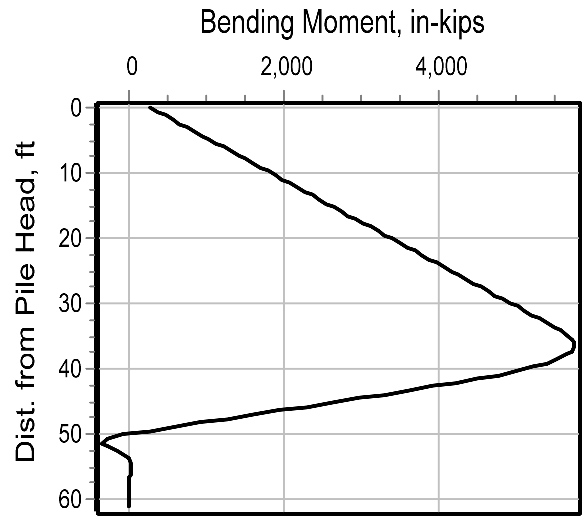
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	12981.	M, in-lb	270000.	0.00	3.0625	-0.00890	-46582.	5756561.

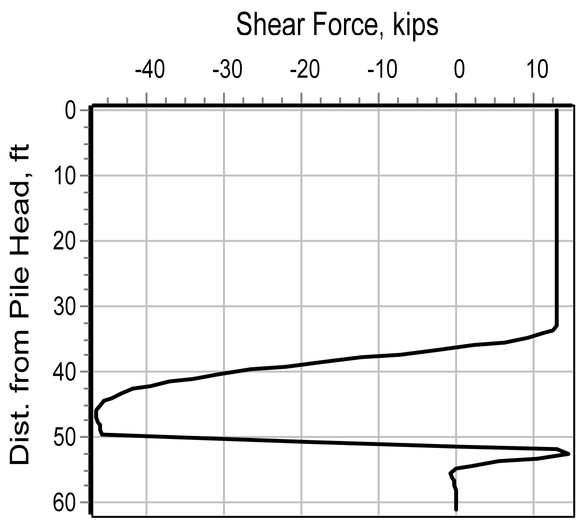
Maximum pile-head deflection = 3.0624791456 inches
Maximum pile-head rotation = -0.0088963378 radians = -0.509723 deg.

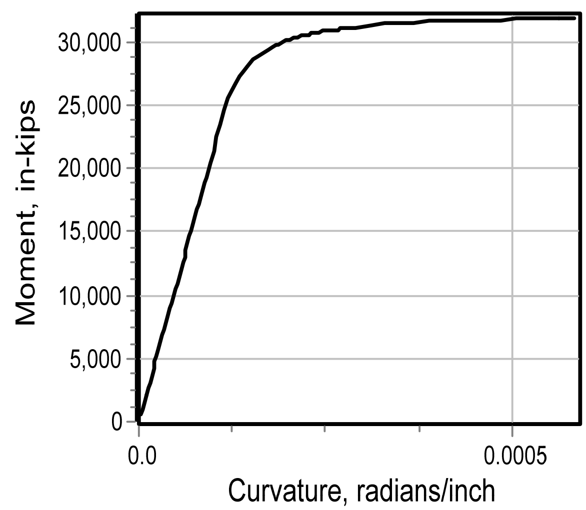
The analysis ended normally.

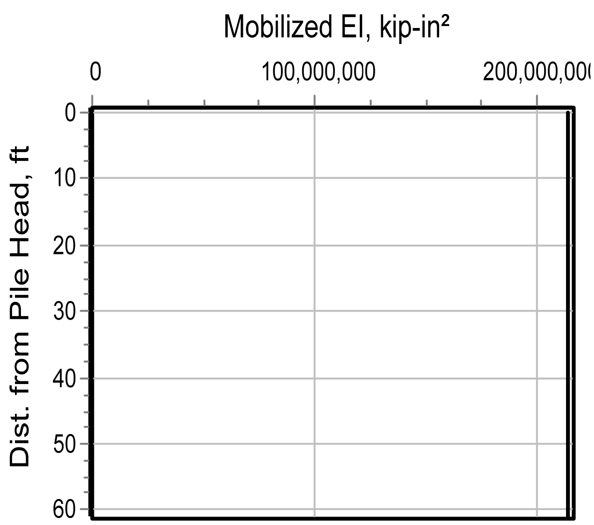
The lateral deflection of the pile is 3.06 in which is approximately span/240 and satisfies the AISC code deflection requirement and is acceptable.

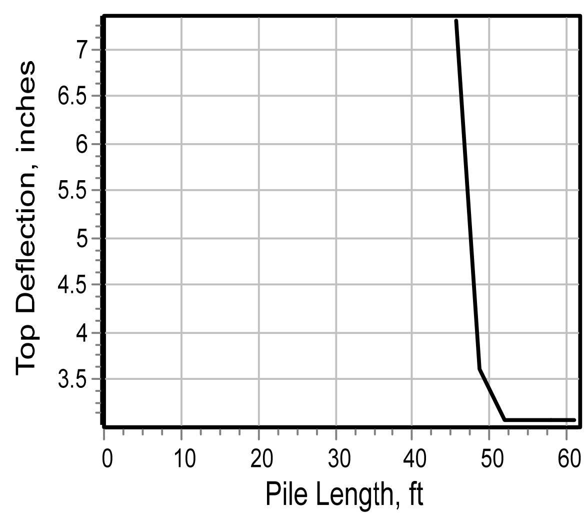

Deflection, inches
0 0.5 1 1.5 2 2.5 3
Dist. from Pile Head, ft
0 10 20 30 40 50 60


Bending Moment, in-kips
0 2,000 4,000
Dist. from Pile Head, ft
0 10 20 30 40 50 60


Shear Force, kips
-40 -30 -20 -10 0 10
Dist. from Pile Head, ft
0 10 20 30 40 50 60


Moment, in-kips
0 5,000 10,000 15,000 20,000 25,000 30,000
Curvature, radians/inch
0.0 0.0005


Mobilized EI, kip-in²
0 100,000,000 200,000,00
Dist. from Pile Head, ft
0 10 20 30 40 50 60

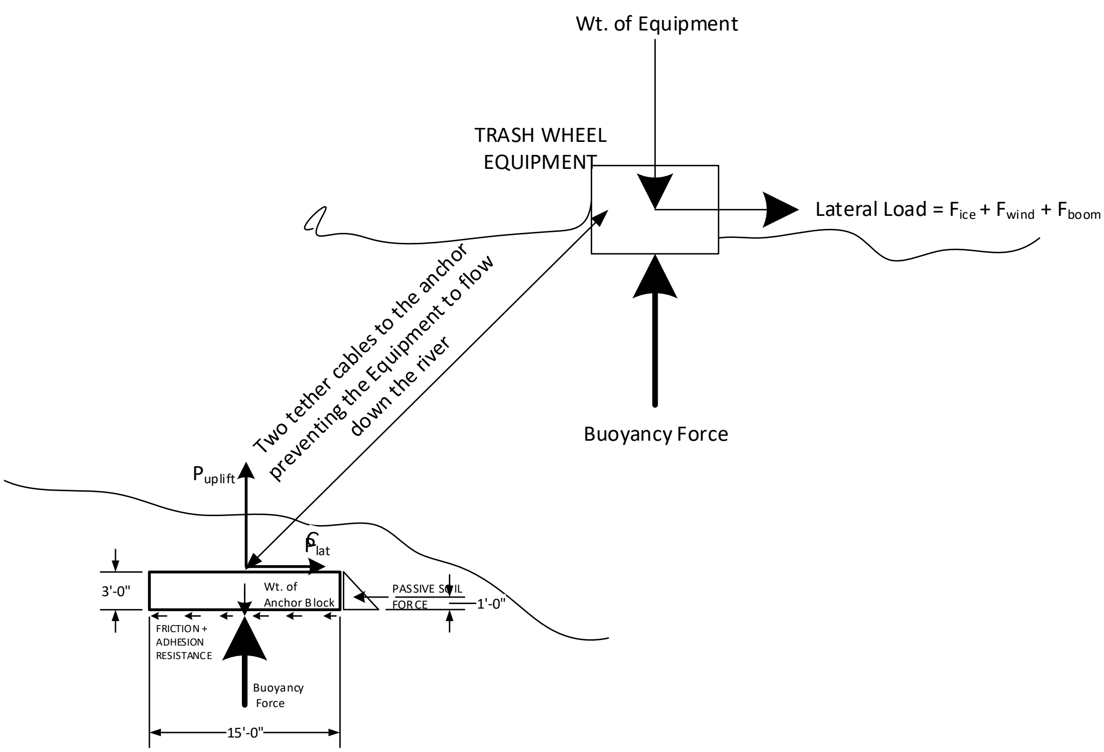

Top Deflection, inches
3.5 4 4.5 5 5.5 6 6.5 7
Pile Length, ft
0 10 20 30 40 50 60

This calculation provides a tether anchor design for the trash wheel equipment during a standard project flood (SFP) event such that the trash wheel does not come loose and collide with other building/bridge structure during this event.

As the trash wheel equipment is floating the vertical dead weight of the equipment is balanced by the buoyant force. The tethering system for the trash wheel will be conservatively designed to resist the lateral pull due to the lateral force acting on the trash wheel i.e. the wind force, the force due to the water current and the ice load as calculated for the pile design. After the tether reaches its maximum length the weight of the trash wheel equipment is assumed to be balanced by the buoyancy force of the river and the contribution of self weight will not be seen on the tether system.

To determine the maximum lateral force acting on the trash wheel during a SFP condition the maximum lateral forces for the Strength II loading condition used in the design for mooring piles is used. This is a conservative assumption as the channel flow velocity for the SFP condition is less than the average velocity considered for the 100 year flood condition and is based on the HEC RAS model input.

Based on the HEC-RAS data available it is assumed the water level will rise approximately 35'-0" above the normal water level and at that time the trash wheel equipment will float above the support structure and the tether system will be engaged. The anchor system is assumed to be installed such that the slings will have a 45 degree angle or less when the tether is active. It is conservative to consider a 45 degree angle for the design purposes as it will generate the worst tension in the cable. Swivel hoist rings will be used on both sides of the tether system for smooth load transfer and to avoid any additional stresses on the system.



$F_{ice} := 16.022kip$

Pg. 10, of this calculation documents the ice and wind load.

$F_{wind} := 11.0kip$

$F_{boom} := 4.49kip$ pg.51 of this calculation (maximum force at both location.)

$W_{lat} := F_{ice} + F_{wind} + F_{boom} = 31.512kip$, Say $W_{lat} := 32.0kip$

$W_{lat} := 32.0kip$ — Conservatively assuming that the tether system has to resist the forces as shown above.

$\theta := 45deg$ — (Based on the length of the tether cable and vertical rise of the river, θ will never exceed 45 degree)

$T_{ten} := 1.25 \cdot \frac{W_{lat}}{\cos(45deg)} = 56.569 \cdot kip$ — Conservatively using a 25% safety margin and the total force is resisted by 2 anchor points.

$Lat_{force} := T_{ten} \cdot \cos(\theta) = 40 \cdot kip$

Forces to be resisted by the Tether block

$Uplift_{force} := T_{ten} \cdot \sin(\theta) = 40 \cdot kip$

Design Inputs - Using a Concrete Block 15'-0" x 15'-0" x 3'-0" deep

$L_{pedestal} := 15ft$ $\quad w_{pedestal} := 15ft$ — Length and Width of Concrete block

$z := 3.0ft$ — Height of the concrete block.

$a_{soil} := 400psf$ $\quad p_{soil} := 900psf$ $\quad \mu_{soil} := 0.30$ — Adhesion, Passive resistance and coefficient of frictional resistance. Soil properties from Geotechnical report

$F_p := p_{soil} \cdot L_{pedestal} \cdot z \cdot 0.5 = 20.25 \cdot kip$ — Conservatively assuming 50% of the effective length of pedestal resisting the lateral pull.

$\gamma_{conc} := 150pcf$ $\quad \gamma_{water} := 62.4pcf$ — Density of concrete and water.

Check for Uplift -

$P_{uplift} := L_{pedestal} \cdot w_{pedestal} \cdot z \cdot (\gamma_{conc} - \gamma_{water}) = 59.13kip$ **>** $Uplift_{force} = 40 \cdot kip$,

∴ Adequate to resist the uplift

Check for Sliding -

$P_{lat} := L_{pedestal} \cdot w_{pedestal} \cdot a_{soil} + F_p + P_{uplift} \cdot \mu_{soil} = 127.989kip$ **>** $Lat_{force} = 40 \cdot kip$

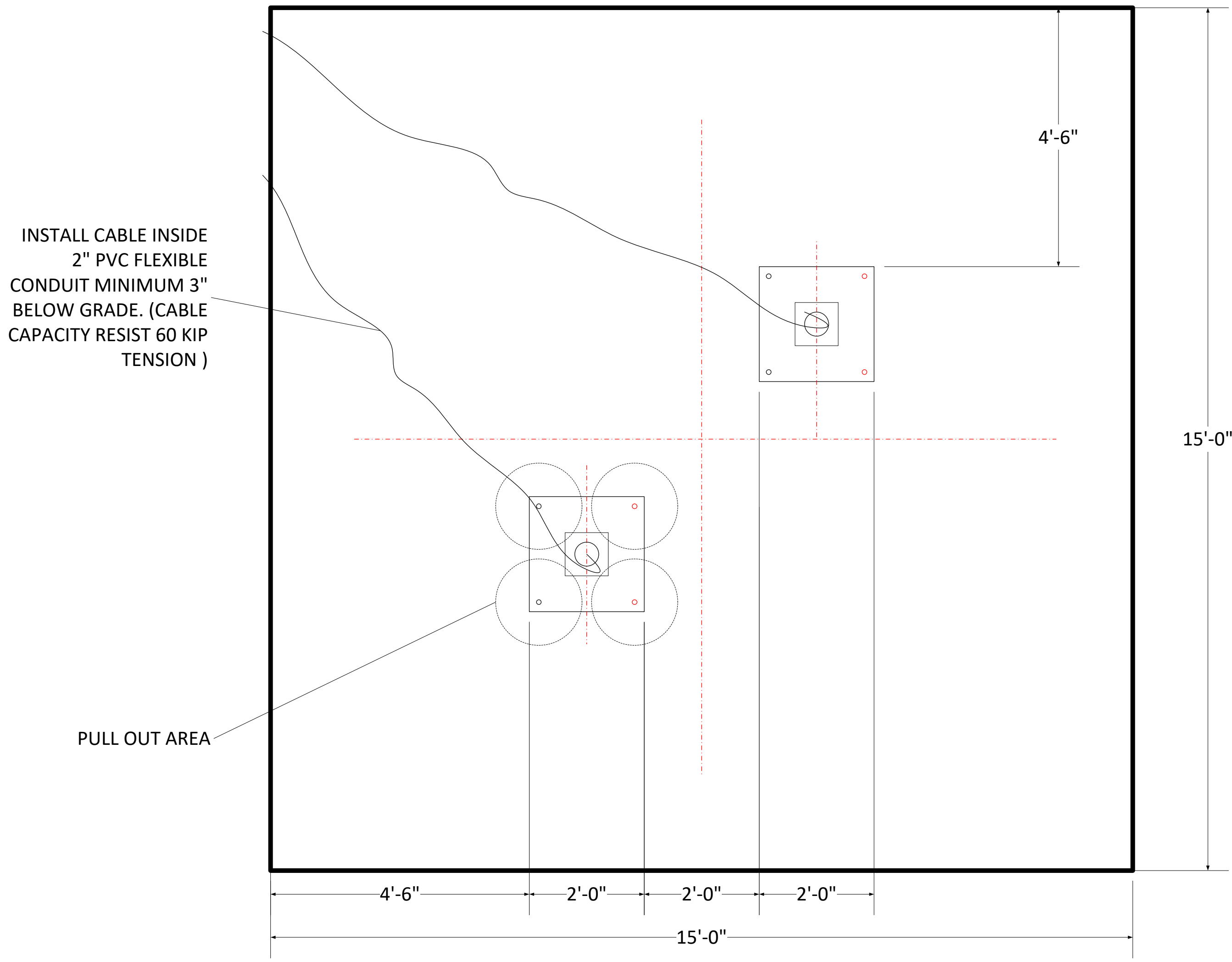
$FS_{sliding} := \frac{P_{lat}}{Lat_{force}} = 3.2$ — The concrete anchor block is safe and will not slide.

Check for Over turning/Rotation -

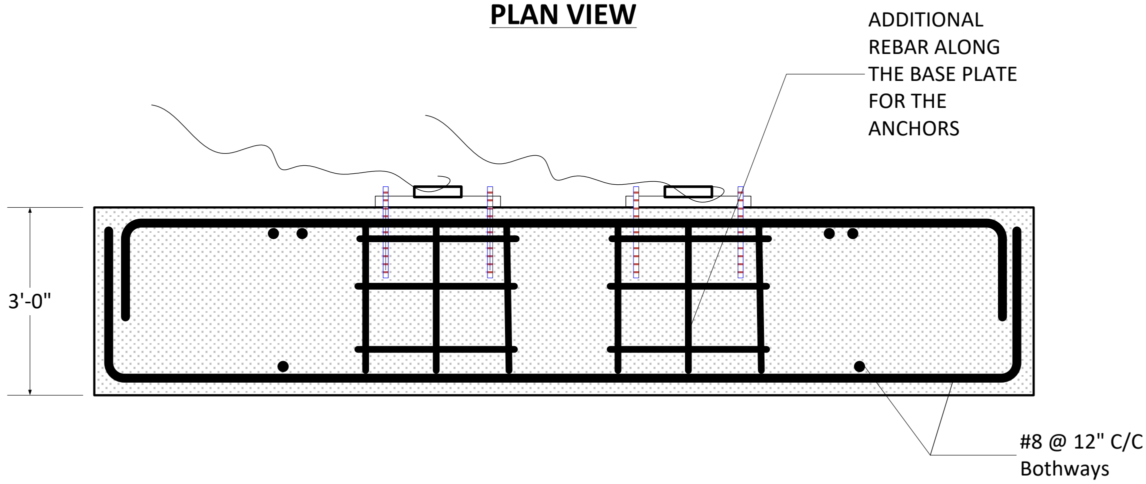
$OT_{mom} := Lat_{force} \cdot z + Uplift_{force} \cdot \frac{L_{pedestal}}{2} = 420 \cdot kip \cdot ft$ — Overturning Moment

$R_{mom} := \left[L_{pedestal} \cdot w_{pedestal} \cdot z \cdot (\gamma_{conc} - \gamma_{water})\right] \cdot \frac{L_{pedestal}}{2} + F_p \cdot \frac{z}{3} = 463.725\ ft \cdot kip$ — Resisting Moment

$FS_{rot} := \frac{R_{mom}}{OT_{mom}} = 1.104$ — The concrete anchor block is safe and will not rotate.



PLAN VIEW

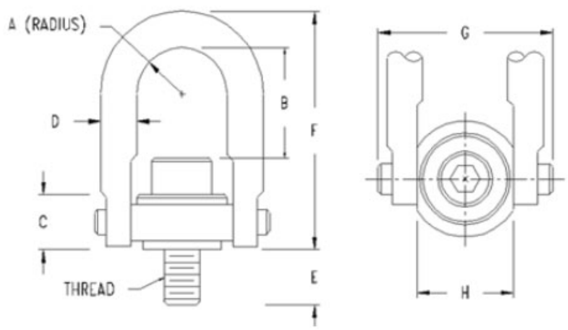


SECTION

Tether Cable length

1. West Fork Location - The block is approximately 130'-0" away from the pile and conservatively assuming additional 20'-0" for the ground profile and 30'-0" of travel on the pile from the mud line to the top of pile and a additional 30'-0" for the trash wheel to move out of the current location the total cable length = 130'-0" + 20'-0" + 30'-0" +30'-0" = 210'-0" say 225'-0" (approximately).
2. Clear Fork Location - The block is approximately 65'-0" away from the pile and conservatively assuming additional 15'-0" for the ground profile and 30'-0" of travel on the pile from the mud line to the top of pile and a additional 30'-0" for the trash wheel to move out of the current location the total cable length = 65'-0" + 15'-0" + 30'-0" +30'-0" = 140'-0" say 150'-0"

SWIVEL HOIST to be procured shall meet or exceed the minimum requirements tabulated below -



Rated Load (Lbs.)	55000
Size	2-3/4" - 4
Thread Protrusion	4"
Dim. B (mm)	6.16
Torque	2100ft/lb
Weight	1.0000

2 3/4" - 4 Swivel Hoist Ring

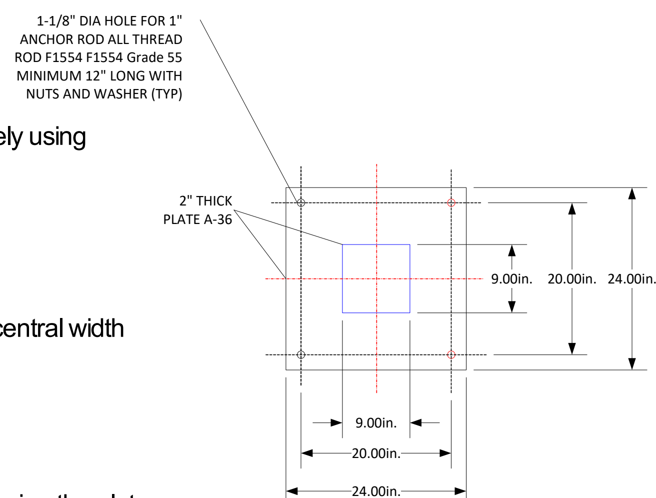
(with 5:1 design safety factor.)

$P_{swivel} := 55kip$

$P_{swivel} = 55 \cdot kip$ **>** $\frac{T_{ten}}{2} = 28.284 \cdot kip$, $\therefore$ Swivel is adequate for the load.

Slings 225'-0" (minimum) 2 no's. for both location to be procured and shall meet or exceed the 55.0 kip requirements calculated above .

Plate to anchor the Swivel hoist -



$T_{ten} = 56.569 \cdot kip$ Total tension, Conservatively using as the vertical uplift force

$F_{y\_plate} := 36ksi$

$L_{plate} := 2ft$

$w_{plate} := 6in$ Conservatively assuming only 6" central width of the plate will resist the bending

$t_{plate} := 4in$

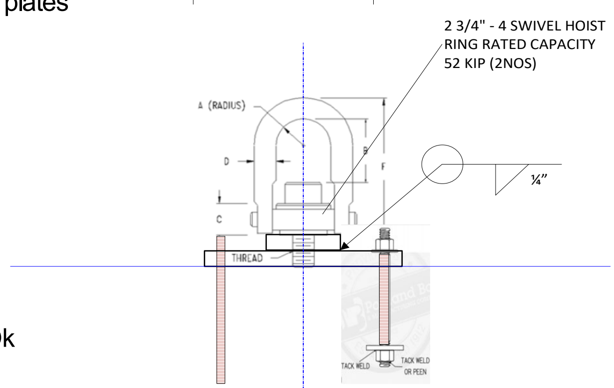
$$M_{plate} := \frac{\frac{T_{ten}}{2} \cdot L_{plate}}{4}$$

Conservative assuming the plates to be simply supported.

$$Z_x := \frac{w_{plate} \cdot t_{plate}^{2}}{4} = 24 \cdot in^3$$

$\Omega := 1.67$ Per AISC, the default omega factor (Ω) for Flexure is 1.67

$$f_{y\_act} := \frac{M_{plate}}{Z_x} = 7.071 \cdot ksi < \frac{F_{y\_plate}}{\Omega} = 21.557 \cdot ksi, \therefore \text{ Ok}$$



Concrete Anchor Bolt design -

1. References

1. Manual of Steel Construction 9th Edition (Allowable Stress Design) : AISC
2. Base Plate and Anchor Rod Design 2nd Edition : AISC Steel Design Guide
3. Building Code Requirements for Structural concrete : ACI 318-14

2. Design Basis

This calculation Based on ACI 328-02 Appendix D (CCD Method)

Tension and Shear are acting simultaneously on anchor bolt.

3. Input Units and Material Constants

3.1 Material Constants

Yield strength of F1554 Grade 55 Steel : $f_{ya} := 55 \cdot ksi$

Ultimate strength of F1554 Grade 55 Bolt : $f_{ua} := 75 \cdot ksi$

Compressive strength of Concrete : $f'_c := 5 \cdot ksi$

Strength reduction factor ϕ_t for Tension load: $\phi_t := 0.75$ ACI 318, Section 17.3.3

Strength reduction factor ϕ_v for shear load: $\phi_v := 0.65$

3.2 Factored Load on Anchor Bolt

Note - The actual forces are 20.0 kip uplift and 20.0 kip shear on each anchor plate . As the previous anchor bolt calculations used a conservative value no changes have been made for this section.

Shear and Tension Governing Case

Tension force $P_{pull} := Uplift_{force} = 30.052 \cdot kip$ Total pull to be resisted by the Anchor rods

Shear force $H := Lat_{force} = 30.052 \cdot kip$ Total Shear to be resisted by the Anchor rods

Assume a load factor of 1.4 to convert the loads to Ultimate load $L_f := 1.4$

Tension : $Tension1 := L_f \cdot P_{pull}$ $Tension1 = 42.07 \cdot kip$

Shear : $Shear1 := L_f \cdot H$ $Shear1 = 42.07 \cdot kip$

3.3 Section Property of Base Plate and Anchor Bolt

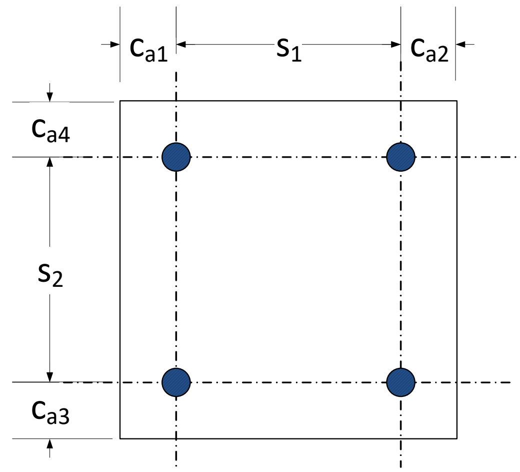
Base Plate Thk. : $t_b := 2.0 \cdot in$

Diameter of Anchor Bolt : $d_o := 1.00 \cdot in$

No. of Anchor bolts : $No_{bolt} := 4$

Distance between anchor bolt : $s_1 := 20 \cdot in$

$s_2 := 20 \cdot in$



3.5 Pedestal size

Length $P_l := 120 \cdot in$

Width $P_w := 120 \cdot in$

Edge Distance $c_{a1} := 26in$ $c_{a2} := 40in$ $c_{a3} := 40in$ $c_{a4} := 26in$

4. Anchor Bolt Design

Anchor bolt length will be calculated by trial and error method.
First, calculate anchor bolt in tension load case only and then calculate by trial & error for tension and shear load case.

4.1 Bolt length in tension force only Ref. - ACI 318-14, Section 17.4.1.2

Caused by tension

$f_{uta} := \min\left(f_{ua}, 1.9 \cdot f_{ya}, 125000 \cdot psi\right) = \min(75 \cdot ksi, 104.5 \cdot ksi, 125000 \cdot psi)$ $f_{uta} = 75 \cdot ksi$

$$A_{se\_calc} := \frac{Tension1}{\phi_t \cdot f_{uta} \cdot No_{bolt}} = \frac{42.073 \cdot kip}{0.75 \cdot 75 \cdot ksi \cdot 4}$$

$A_{se\_calc} = 0.187 \cdot in^2$

Use 1" anchor bolt - 12" long

$d_o = 1 \cdot in$ $n_t := \frac{10}{in}$ 10 UNC Threading

Effective cross section area of bolt $A_{se} := \frac{\pi}{4} \cdot \left(d_o - \frac{0.9743}{n_t}\right)^2$ $A_{se} = 0.64 in^2$ > $A_{se\_calc} = 0.187 in^2$

4.2 Calculate Tensile Design Strength

$h_{ef} := 12 \cdot in$ Considering the bolt to be minimum 12" long

4.2.1 Steel Tensile Strength (Ref. ACI 318-14, Section 17.4.1)

ϕ_t: strength reduction factor ductile steel tension : 0.75 $\phi_t = 0.75$

$\phi N_s := \phi_t \cdot No_{bolt} \cdot A_{se} \cdot f_{uta}$ ACI 318-14, Section 17.4.1.2

$\phi N_s = 143.957 kip$ > $Tension1 = 42.073 kip$ Steel Strengthin tension

4.2.2 Concrete breakout strength (Ref. ACI 318-14, Section 17.4.2)

c_{max} = the largest edge distance, in.

c_{min} = the smallest edge distance, in.

$c_{max} := max(c_{a1}, c_{a2}, c_{a3}, c_{a4})$ $c_{max} = 40 \cdot in$

$c_{min} := min(c_{a1}, c_{a2}, c_{a3}, c_{a4})$ $c_{min} = 26 \cdot in$

ϕ_c : strength reduction factor, see ACI 318-14 Section 17.3.3 $\phi_c := 0.70$

Check if one edge distance is at least 1.5hef, Ref. ACI 318-14, Section 17.4.2.1

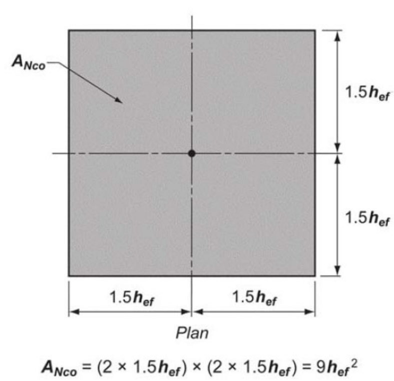
$c_{min} \ge 1.5 \cdot h_{ef}$ explicit, C_{min}, h_{ef} $= c_{min} \ge 1.5 \cdot 12 \cdot in = c_{min} \ge 18.0 \cdot in$

$Check :=$ | "OKAY"" if $c_{min} \ge 1.5 \cdot h_{ef}$
| "Section 17.4.2.1.2" otherwise

Check = "OKAY""

Projected concrete failure area for 1 bolt

$A_{Nco} := 9 \cdot h_{ef}^2$ $A_{Nco} = 9 \cdot ft^2$



ACI 318-14, Fig. R17.4.2.1

Projected concrete failure area for group bolt

Consider the assumed pedestal size and base plate

Define $c_{a1\_t} := \min\left(c_{a1}, 1.5 \cdot h_{ef}\right)$ $\quad c_{a1\_t} = 18 \cdot in$

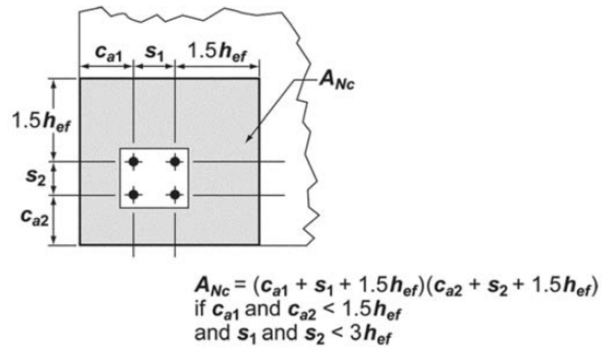
$c_{a2\_t} := \min\left(c_{a2}, 1.5 \cdot h_{ef}\right)$ $\quad c_{a2\_t} = 18 \cdot in$

$c_{a3\_t} := \min\left(c_{a3}, 1.5 \cdot h_{ef}\right)$ $\quad c_{a3\_t} = 18 \cdot in$

$c_{a4\_t} := \min\left(c_{a4}, 1.5 \cdot h_{ef}\right)$ $\quad c_{a4\_t} = 18 \cdot in$

$s_{1\_t} := \min\left(s_1, 3 \cdot h_{ef}\right)$ $\quad s_{1\_t} = 20 \cdot in$

$s_{2\_t} := \min\left(s_2, 3 \cdot h_{ef}\right)$ $\quad s_{2\_t} = 20 \cdot in$



ACI 318-14, Fig. R17.4.2.1

$A_{Nc} := \left(c_{a1\_t} + s_{1\_t} + c_{a2\_t}\right) \cdot \left(c_{a3\_t} + s_{2\_t} + c_{a4\_t}\right)$ $\quad A_{Nc} = 3136 \cdot in^2$

$$A_{Nc} := \begin{cases} A_{Nc} & \text{if } A_{Nc} \le No_{bolt} \cdot A_{Nco} \\ No_{bolt} \cdot A_{Nco} & \text{otherwise} \end{cases} \qquad A_{Nc} = 3136 \cdot in^2$$

For single anchor, consider upper corner anchor

$A_{Ns} := \left(c_{a1\_t} + 0.5 \cdot s_{1\_t}\right) \cdot \left(c_{a4\_t} + 0.5 \cdot s_{2\_t}\right)$ $\quad A_{Ns} = 784 \cdot in^2$

$k_c := 24$ for cast-in anchors; and ACI 318-14, Section 17.4.2.2a and Appendix B

$k_2 := 17$ for post-installed anchors.

$\lambda_a := 1.0$ ACI 318-14 Section 17.2.6 and Table 19.2.4.2 for normal weight concrete

$N_b := k_c \cdot \lambda_a \cdot \sqrt{f'_c \cdot lbf} \cdot h_{ef}^{1.5} \cdot in^{-.5}$ $\quad N_b = 70.545 \cdot kip$ ACI 318-14, Eq 17.4.2.2a, b

Modification factor for eccentricity

$e_{N1} := 0 \cdot in$

$\psi_{ecN} := 1$ ((ACI 318-14, Section 17.4.2.4) Factor equals 1, since there is no eccentric load.

Modification factor for edge effects

c_{min} : min edge distance $\quad c_{min} = 26 \cdot in$

$$\psi_{edN} := \begin{cases} 1 & \text{if } c_{min} \ge 1.5 \cdot h_{ef} \\ 0.7 + 0.3 \cdot \dfrac{c_{min}}{1.5 \cdot h_{ef}} & \text{otherwise} \end{cases} \qquad \psi_{edN} = 1$$

(ACI 318-14, Section 17.4.2.5a,b)

Modification factor for crack = 1 : cracked concrete
= 1.25 no cracked concrete(cast-in)
= 1.4 no cracked concrete(post-install)

$\psi_{cN} := 1$ ACI 318-14, Section 17.4.2.6, cracked concrete

Breakout splitting factor

$\psi_{cpN} := 1$ ACI 318-14, Section 17.4.2.7a,b, cast-in anchors

<u>Concrete breakout strength of anchor in tension:</u>

For a single anchor (does not apply for group of four anchors, calculated for completeness of code provisions):

$$N_{cb} := \frac{A_{Ns}}{A_{Nco}} \cdot \psi_{edN} \cdot \psi_{cN} \cdot \psi_{cpN} \cdot N_b \qquad N_{cb} = 42.68 \cdot kip$$ ACI 318-14, Eqn. 17.4.2.1a

For a group of anchors:

$$N_{cbg} := \frac{A_{Nc}}{A_{Nco}} \cdot \psi_{ecN} \cdot \psi_{edN} \cdot \psi_{cN} \cdot \psi_{cpN} \cdot N_b \qquad N_{cbg} = 170.702 \cdot kip$$ ACI 318-14, Eqn. 17.4.2.1b

$\phi N_{cbg} := \phi_c \cdot N_{cbg}$ $\phi N_{cbg} = 119.492 kip$ > $Tension1 = 42.073 kip$

Additional_bar := | "additional bar is necessary" if $\phi N_{cbg} \le Tension1$
| "additional bar is not necessary" otherwise

Additional_bar = "additional bar is not necessary"

The concrete tension breakout strength is adequate to resist the factored tension load.

4.2.3 Pullout Strength (ACI 318-14 Section 17.4.3)

Strength reduction factor for tension load
see ACI 318-14 Section 17.3.3 (C) ii $\phi_p := 0.70$

Modification factor for pullout strength for cracking ACI 318-14, Section 17.4.3.6
= 1.0 : concrete cracking at service load
= 1.4 : no concrete cracking at service load $\psi_{cP} := 1.0$

$Bolt_{type} := 1$ 1 : single headed or headed bolt (D.5.3.4)
2 : hooked type (D.5.3.5)

Bearing area of anchor head : $A_{brg} := 1.472 \cdot in^2$ Using area of hex nut

outside diameter of hook type : $d_o := Dia_{bolt}$ $d_o = 1 \cdot in$

distance between inner space of J type bolt $e_h := 0$

$$N_p := \begin{cases} 8A_{brg}\cdot f'_c & \text{if } Bolt_{type} = 1 \\ 0.9\cdot f'_c\cdot e_h\cdot d_o & \text{otherwise} \end{cases}$$

(ACI 318-14, Eqn. 17.4.3.4)

(ACI 318-14, Eqn. 17.4.3.5)

$N_p = 58.88\cdot kip$ We have four bolts $No_{bolt} = 4$

$\phi N_p := No_{bolt}\cdot\phi_p\cdot\psi_{cP}\cdot N_p$ $\phi N_p = 164.864kip > Tension1 = 42.073kip$ ACI 318-14, Table 17.3.1.1

4.2.4 Side face blowout strength (ACI 318-14, Section 17.4.4)

The side face distance : $c_{min} = 26\cdot in$ $h_{ef} = 12\cdot in$ < $2.5\cdot c_{min} = 65\cdot in$

$\phi_{sfb} := 0.7$

Strength reduction factor for tension load
see ACI 318-14 Section 17.3.3 (C) ii

$$fact := \begin{cases} \dfrac{\left(1 + \dfrac{c_{a2}}{c_{a1}}\right)}{4} & \text{if } 1.0 \le \dfrac{c_{a2}}{c_{a3}} \le 3.0 \\ 1 & \text{otherwise} \end{cases}$$

$fact = 0.635$

$$N_{sb} := fact\cdot 160\cdot c_{a1}\cdot\sqrt{A_{brg}\cdot in^2}\cdot\lambda_a\cdot\sqrt{f'_c\cdot psi}\,in^{-1} = 226.487\cdot kip$$

$$\phi N_{sbg} := \phi_{sfb}\cdot\left(1 + \frac{c_{min}}{6\cdot c_{a1}}\right)\cdot N_{sb} = 184.964\cdot kip$$

$\phi N_{sbg} = 184.964kip > Tension1 = 42.073kip$

4.2.5 Summary of Tensile Strength

Steel Tensile Strength $\phi N_s = 143.957\cdot kip$

Concrete breakout strength $\phi N_{cbg} = 119.492\cdot kip$ <------------Controls

Pullout strength $\phi N_p = 164.864\cdot kip$

Side face blowout strength $\phi N_{sbg} = 184.964\cdot kip$

Min. tensile strength : $\phi N := \min\left(\phi N_s, \phi N_{cbg}, \phi N_p, \phi N_{sbg}\right)$ $\phi N = 119.492\cdot kip$

$\phi N = 119.492kip > Tension1 = 42.073kip > P_{pull} = 30.052kip$

The anchor bolts will adequately transfer the load to the concrete block

4.3 Calculate Shear Design Strength of anchor

Ref. section 17.5 of ACI 318-14

4.3.1 Steel Shear Strength (ACI 318-14, Section 17.5.1)

ϕs : strength reduction factor see ACI 318-14 Section 17.3.3 $\phi_s := 0.65$

$Bolt_{type2} := 2$

3 : post-installed anchors
2 : cast in headed bolt and hooked bolt anchor
1 : cast in headed stud anchors

Anchor bolt sleeve not used

$A_{seV} := A_{se} = 0.64 \cdot in^2$ Effective cross sectional area of an anchor in shear

Consider all bolts effective in resisting shear $n := 4$

$$V_s := \begin{cases} n \cdot A_{se} \cdot f_{uta} & \text{if } Bolt_{type2} = 1 \\ 0.6 \cdot n \cdot A_{se} \cdot f_{uta} & \text{otherwise} \end{cases}$$

ACI 318-14, Eqn. 17.5.1.2a and 17.5.1.2b

$V_s = 115.166 \cdot kip$

$\phi sV_s := \phi_s \cdot V_s$ $\phi sV_s = 74.858 \cdot kip$

Apply a factor of 0.8 where anchors are used with built-up grout pads; see ACI 318-14 Section 17.5.1.3

With grout pad $\phi sV_s := 0.8\phi_s \cdot V_s$ $\phi sV_s = 59.886 kip$ > $Shear1 = 42.073 kip$, $\therefore$ Ok

4.3.2 Concrete Breakout Strength (ACI 318-14, Section 17.5.2)

ϕcb : strength reduction factor, see ACI 318-14 Section 17.3.3 $\phi_{cb} := 0.7$

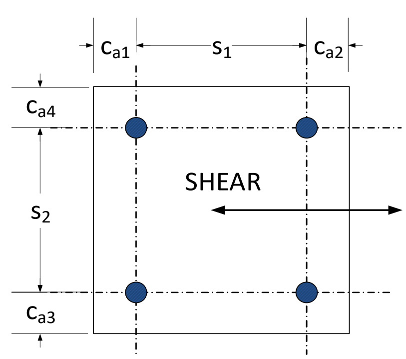
$Bolt_{type3} := 2$ 2 : group anchor
1 : single anchor

Projected concrete failure area for one bolt

$A_{Vco} := 4.5 \cdot c_{min}^2$ $A_{Vco} = 3042 \cdot in^2$ ACI 318-14, Eqn. 17.5.2.1c

Projected concrete failure area for group bolt

Consider the assumed pedestal size and base plate

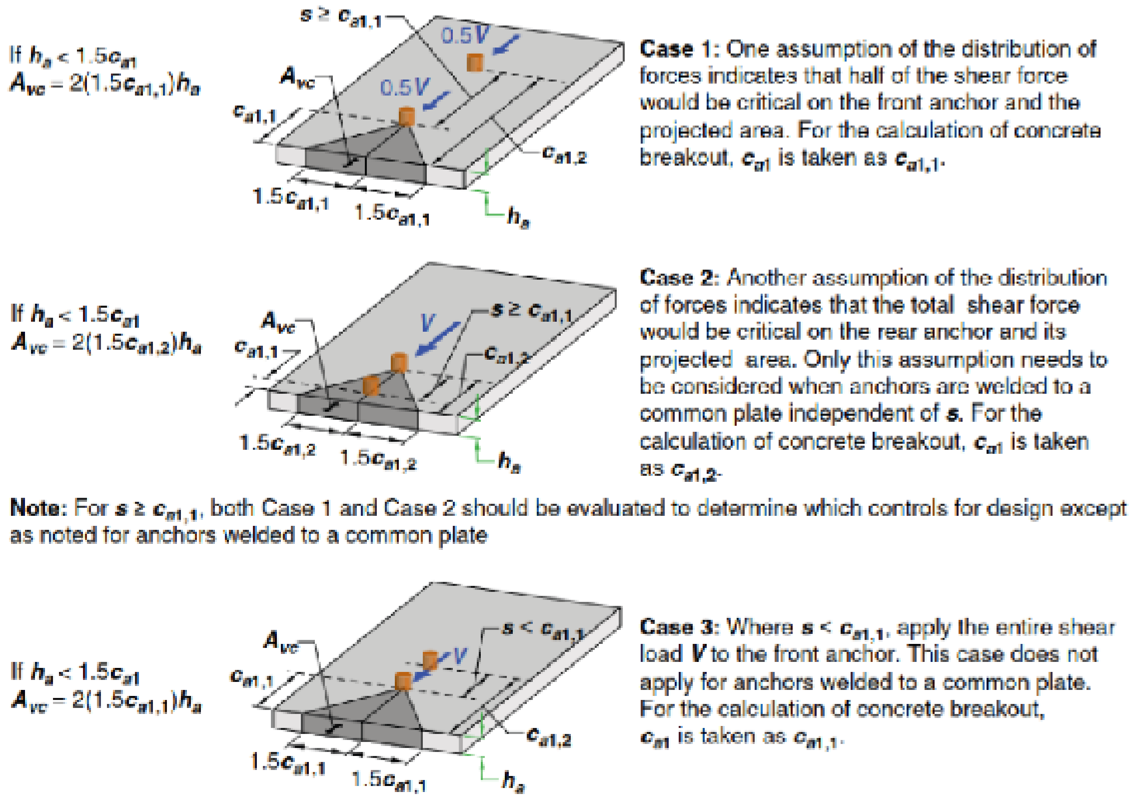


Define $c_{a4\_s} := \min(c_{a4}, 1.5 \cdot c_{min})$ $c_{a4\_s} = 26 \cdot in$

$c_{a3\_s} := \min(c_{a3}, 1.5 \cdot c_{min})$ $c_{a3\_s} = 39 \cdot in$

$s_{2\_s} := \min(s_2, 3 \cdot c_{min})$ $s_{2\_s} = 20 \cdot in$

Depth of pedestal is greater than $1.5 \cdot c_{a1} = 39 \cdot in$ $h_a := 60 \cdot in$



From ACI 318-14 - Fig. R17.5.2.1b

$$Check := \begin{cases} \text{"Evaluate Case 1 and Case 2"} & \text{if } s_1 \geq c_{a1} \\ \text{"Evaluate Case 3"} & \text{otherwise} \end{cases}$$ Check = "Evaluate Case 3"

For group of anchors, two bolts on leading edge per Case 3 of Fig. R17.5.2.1b

$A_{Vc} := (c_{a4\_s} + s_{2\_s} + c_{a3\_s}) \cdot 1.5 \cdot c_{a1}$ $A_{Vc} = 3315 \cdot in^2$

Number of anchors in the group $n := 4$

$$A_{Vc} := \begin{cases} A_{Vc} & \text{if } A_{Vc} \leq n \cdot A_{Vco} \\ n \cdot A_{Vco} & \text{otherwise} \end{cases}$$ $A_{Vc} = 3315 \cdot in^2$ ACI 318-14 Section 17.5.2.1

For single anchors, consider upper corner anchor

$A_{Vs} := (c_{a4\_s} + \min(0.5s_{2\_s}, 1.5c_{a1})) \cdot 1.5 \cdot c_{a1}$ $\qquad A_{Vs} = 1404 \cdot in^2$

Breakout eccentricity factor

$e'_V := 0 \cdot in$

$$\psi_{ecV} := \frac{1}{\left(1 + \frac{2 \cdot e'_V}{3 \cdot c_{a1}}\right)}$$

ACI 318-14, Eqn. 17.5.2.5

$\psi_{ecV} = 1$

Breakout edge effect factor

ca4 = orthogonal to ca1 $\qquad c_{a4} = 26 \cdot in \qquad 1.5 \cdot c_{a1} = 39 \cdot in$

$$\psi_{edV} := \begin{cases} 1.0 & \text{if } c_{a4} \geq 1.5 \cdot c_{a1} \\ 0.7 + 0.3 \cdot \frac{c_{a4}}{1.5 \cdot c_{a1}} \end{cases}$$

$\psi_{edV} = 0.9$ $\qquad$ ACI 318-14 Eqn. 17.5.2.6a, b

Breakout cracking Modification factor, ACI 318-14 Section - 17.5.2.7

$\psi_{c,V}$ **= 1.0** for anchors in cracked concrete without supplementary reinforcement or with edge reinforcement smaller than a No. 13 bar
$\psi_{c,V}$ **= 1.2** for anchors in cracked concrete with reinforcement of a No. 13 bar or greater between the anchor and the edge
$\psi_{c,V}$ **= 1.4** for anchors in cracked concrete with reinforcement of a No. 13 bar or greater between the anchor and the edge, and with the reinforcement enclosed within stirrups spaced at not more than 100 mm

$\psi_{cV} := 1.0$ $\qquad$ Without supplemental steel

Breakout thickness factor, ACI 318-14 Section - 17.5.2.8

$$\psi_{hV} := \begin{cases} \sqrt{\frac{1.5 \cdot c_{a1}}{h_a}} & \text{if } h_a \leq 1.5 \cdot c_{a1} \\ 1.0 & \text{if } \sqrt{\frac{1.5 \cdot c_{a1}}{h_a}} < 1.0 \end{cases}$$

$\psi_{hV} = 1$

$L_{breakout}$: load bearing length for shear, ACI 318-14, Section 17.5.2.2

= 8_{do} : generally used
= h_{eff} : anchor with head
= $2d_o$: torque control exp. anchor

$l_c := \min(8 \cdot d_o, h_{ef})$

$l_c = 8 \cdot in$

$V_{b1} := 7 \cdot \left(\frac{l_c}{d_o}\right)^{0.2} \cdot \sqrt{\frac{d_o}{in}} \cdot \lambda_a \cdot \sqrt{f'_c \cdot lbf} \cdot c_{a1}^{1.5} \cdot in^{-.5}$ $\quad V_{b1} = 99.463 \cdot kip$ ACI 318-14, Eqn. 17.5.2.2a & App. B

$V_{b2} := 9 \cdot \lambda_a \cdot \sqrt{f'_c \cdot lbf} \cdot \left(c_{a1}^{1.5} \cdot in^{-.5}\right)$ $\quad V_{b2} = 84.37 \cdot kip$ ACI 318-14, Eqn. 17.5.2.2b

$V_b := \min(V_{b1}, V_{b2})$ $\quad V_b = 84.37 \cdot kip$

Concrete breakout strength of single anchor in shear

$\phi cbV_{cb} := \phi_{cb} \cdot \frac{A_{Vs}}{A_{Vco}} \cdot \psi_{edV} \cdot \psi_{cV} \cdot \psi_{hV} \cdot V_b$ $\quad \phi cbV_{cb} = 24.532 \cdot kip$

Concrete breakout strength of group of anchors in shear

$\phi cbV_{cbg} := \phi_{cb} \cdot \frac{A_{Vc}}{A_{Vco}} \cdot \left(\psi_{ecV} \cdot \psi_{edV} \cdot \psi_{cV} \cdot \psi_{hV} \cdot V_b\right)$ $\quad \phi cbV_{cbg} = 57.923 kip >$ $Shear1 = 42.073 kip, \therefore$ Ok

4.2.3 Pryout Strength Ref. ACI 318-14 Section 17.5.3

ϕcb : strength reduction factor see ACI 318-14 Section 17.3.3 $\quad \phi_{cp} := 0.7$

k_{cp} = 1.0 $h_{ef} < 2.5$ in
= 2.0 $h_{ef} > 2.5$ in

$k_{cp} := 2$

$N_{cp} := N_{cb} = 42.676 \cdot kip$ For single anchor per ACI 318-14 Section 17.5.3

$N_{cpg} := N_{cbg} = 170.702 \cdot kip$ For group of anchors per ACI 318-14 Section 17.5.3

$\phi cpV_{cp} := \phi_{cp} \cdot k_{cp} \cdot N_{cp}$ $\quad \phi cpV_{cp} = 59.746 \cdot kip$ ACI 318-14, Eqn. 17.5.3.1a

$\phi cpV_{cpg} := \phi_{cp} \cdot k_{cp} \cdot N_{cpg}$ $\quad \phi cpV_{cpg} = 238.983 kip >$ $Shear1 = 42.073 kip, \therefore$ Ok

4.3.4 Summary of Shear Strength

Steel Shear Strength $(\phi sV_s) = 59.886 \cdot kip$

Concrete breakout strength $(\phi cbV_{cbg}) = 57.923 \cdot kip$ <------------Controls

Pryout strength $(\phi cpV_{cpg}) = 238.983 \cdot kip$

Min. shear strength : $(\phi V := \min(\phi sV_s, \phi cbV_{cbg}, \phi cpV_{cpg}))$

$(\phi V) = 57.923 \cdot kip$

4.4 Check Tension and Shear Interaction (Ref. ACI 318-14 Section 17.6)

If Vu < 0.2 ϕ Vn : then full strength in shear shall be permitted ϕ Nn > Nu

If Nu < 0.2 ϕ Nn : then full strength in tension shall be permitted ϕ Vn > Vu

If Vu > 0.2 ϕ Vn and Nu > 0.2 ϕ Nn, then $\frac{N_u}{\phi N_n} + \frac{V_u}{\phi V_n} \leq 1.2$

$V_u := Shear1$ $V_u = 42.073 \cdot kip$ $\phi V = 57.923 \cdot kip$

$N_u := Tension1$ $N_u = 42.073 \cdot kip$ $\phi N = 119.492 \cdot kip$

Shear_check := | "full tension Strength" if $V_u \leq 0.2 \cdot \phi V$
| "check interection" otherwise

Shear_check = "check interection"

Tensile_check := | "full shear Strength" if $N_u \leq 0.2 \cdot \phi N$
| "check interection" otherwise

Tensile_check = "check interection"

$Interaction := \frac{N_u}{\phi N} + \frac{V_u}{\phi V}$ $(Interaction) = 1.078$

Interaction_check := | "OKAY" if $Interaction \leq 1.2$
| "Check again" otherwise

(Interaction_check) = "OKAY"

8.0 Computer Software

L pile software was used to analyze the mooring piles at both West Fork and Clear Fork location subjected to the lateral loads.

Appendices

1. GFTW Design Report For Reference Only.

SUMMARY OF ANCHOR PILE ANALYSES & DESIGN
WATERWHEEL TRASH INTERCEPTOR DEEP FOUNDATION ANALYSES
GWYNNS FALLS: PROPOSED WATER WHEEL POWERED TRASH INTERCEPTOR SYSTEM
BALTIMORE, MARYLAND

SUMMARY OF CONTROLLING LATERAL PILE CAPACITY ANALYSIS OF STEEL PIPE PILE FOUNDATIONS
16" DIA & 5/8" @ 50-Foot Long (with reduced section allowance for corrosion effects)

Date: 11/4/2019
Rev: 6/30/2020

Critical Loading Conditions:	Service IV [5]	Service IV [5]	Strength III [6]	Strength III [6]	Extreme II [6]	Extreme II [6]
Design WS Elev. (ft) [1]	100-YR EL. 7.1	100-YR EL. 7.1	100-YR EL. 7.1	100-YR EL. 7.1	100-YR EL. 7.1	100-YR EL. 7.1
Connection Bracket Elev. (ft) [1]	EL. 9.4	EL. 9.4	EL. 9.4	EL. 9.4	EL. 9.4	EL. 9.4
Total Applied Lateral Load (kips) [1,2]	10.5	6.5	13.0	9.0	14.0	13.0
Assumed No. of Loaded Piles [3]	1 [4]	2	1 [4]	2	1 [4]	2
Max Top Deflection (in)	15	8	20	12.5	22	20
Deformation at Mud level (in)	4.5	2.0	-	-	-	-
Max Shear (kips)	30	15	40 (< 285, OK)	22 (< 285, OK)	42 (< 285 k, OK)	40 (< 285 k, OK)
Max Moment (ft-kips)	270	150	325	220	355	325
% Factored Moment Ovestress	< 416 ft-kips, OK	< 416 ft-kips, OK	< 416 ft-kips, OK	< 416 ft-kips, OK	< 416 ft-kips, OK	< 416 ft-kips, OK
% Nominal Moment Ovestress						

NOTES:

1. LATERAL LOADS APPLIED AT DESIGN STORM WSE (MHHW & 100-YR DESIGN FLOOD), AND HULL CONNECTION BRACKET LOCATIONS.
2. ESTIMATED LATERAL LOADING INCLUDES: STREAM CURRENT, WAVE, WIND, ICE, BOOM, AND HULL.
3. NOTE THAT THE TRASH WHEEL IS SUPPORTED BY THREE (3) PILES. HOWEVER, FOR CONSERVATIVE DESIGN PURPOSES, LATERAL LOADING IS APPLIED TO EITHER A TWO-PILE SYSTEM ((WITH THIRD PILE ASSUMED TO BE REDUNDANT), OR A ONE-PILE SYSTEM (WITH 2 REDUNDANT PILES).
4. WORST CASE LOADING (MOST CONSERVATIVE DESIGN) OCCURS WITH LATERAL LOADING IMPOSED ON ONLY ***ONE PILE*** (ASSUMING 2 PILES ARE REDUNDANT).
5. PILE LATERAL DEFLECTION CRITERIA IS BASED ON SERVICE LOADING CONDITIONS ONLY.
6. PILE STRUCTURAL CAPACITY CRITERIA: BASED ON STRENGTH AND EXTREME LOADING CONDITIONS AS FOLLOWS:

Nominal Shear Capacity = 317 kips
Design/Factored Shear Capacity = 285 kips
Nominal Moment Capacity = 462 ft-kips
Design/Factored Moment Capacity = 416 ft-kips

7. REFERENCE THE ATTACHED DOCS FOR DETAILS OF THE LOADINGS AND RESULTS OF PILE ANALYSES FOR DIFFERENT LOADING CONDITIONS.

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"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED AND APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND, PE LICENSE NO.:____54247_____EXPIRATION DATE:____12-18-2020_______"

GWYNN FALLS WATERWHEEL POWERED TRASH INTERCEPTOR WATER SURFACE CALCULATIONS

<u>Water Surface Elevations (WSE) Calculations at location of Trash Wheel Mooring Piles</u> Datum – NAV88	**Water Surface Levels Elev (ft)**				
	Station Datum Above MSL (ft)	Above MLLW (ft)	Elev. (ft) (NAVD88)	Say	
1. Top of Piling (includes say +1 to 2' above Connectors- Factor of Safety) □		11.45	11.42	11.5	Pile Top Elevation
2. Connection Bracket (12 to 16 inches above WSE) JK: Per CWM Design		9.45	9.42	2.33	ft Above 100-YR WSE
3. **Significant Wave Height** (@ 80 knots; Fetch of 0.71 km; Duration = 6 hr) = 0.94 m (3.08 ft) See Exhibit 3. It is assumed eye of hurricane drives water into bay and then wind shifts from the S to the N. *Since wheel is not in open waters, anticipate limited wave action. Thus, assume 1/3 of computed wave height for Middle Branch River.* ***Say 1-foot***	1.0	8.12	8.08	1.00	ft Above 100-YR WSE
4. **100-Yr extreme WSE** (depth above the MHHW) See Exhibit 2 (1.8 m = 6 ft) https://tidesandcurrents.noaa.gov/est/est_station.shtml?stnid=8574680	6.0	7.12	7.08		
5. **MHHW** (Mean High High Water) See Exhibit 1 (0.34 m above MSL)	1.12	1.67	1.08		
6. **MHW** (Mean High Water) See Exhibit 1 (0.25 m above MSL)	0.82	1.38	0.79		
7. **NAVD88** (North American Vertical Datum of 1988) See Exhibit 1 (0.01 above MSL)	0.03	0.59	0.00	Reference Datum for Analysis	
8. **MSL**□(Mean Sea Level) See Exhibit 1	0.00	0.56	-0.03		
8. **MLW**□(Mean Low Water Level) See Exhibit (-0.10 below MSL)	-0.33	0.23	-0.36		
10. **MLLW**□(Mean Low Low Water) See Exhibit 1 (-0.17 above MSL)	-0.56	0.00	-0.59		
11. STND (Station Dataum - and also assumed bottom elevation at location of pilings?) See Exhibit 1	0				
12. Piling driven depth to be calculated: (Say = 50 ft Minimum)	50				
13. Total Piling Length & Tip Elevations (ft): □	50	-38.55	-38.58	-38.50	TIP Elev.
To be more conservative, i.e., climate change factor, say (ft)	55	-43.55	-43.58	-43.50	TIP Elev.

REFERENCES:

NOAA TIDES & CURRENTS WEBSITE
https://tidesandcurrents.noaa.gov/map/index.shtml?region=Maryland
To refer water level heights to NAVD88 (North American Vertical Datum of 1988), apply the values located at National Geodetic Survey.

Station Datum: A fixed base elevation at a tide station to which all water level measurements are referred. The datum is unique to each station and is established at a lower elevation than the water is ever expected to reach. It is referenced to the primary bench mark at the station and is held constant regardless of changes to the water level gauge or tide staff. The datum of tabulation is most often at the zero of the first tide staff installed
https://tidesandcurrents.noaa.gov/waterlevels.html?id=8574680&units=standard&bdate=20180125&edate=20180130&timezone=GMT&datum=MLLW&interval=6&action=

Wave Generation Calculator at: https://swellbeat.com/wave-calculator/
https://swellbeat.com/wave-calculator/

https://tidesandcurrents.noaa.gov/waterlevels.html?id=8574680&units=standard&bdate=20180125&edate=20180130&timezone=GMT&datum=MLLW&interval=6&action=

GWYNS FALLS WATERWHEEL POWERED TRASH INTERCEPTOR MOORING DEEP FOUNDATION ANALYSES
BALTIMORE, MARYLAND

DESIGN BY:	KBA	8/19/2019	REVISED BY	KBA 8/20/19	11/4/2019	6/30/2020
CHECK BY:	CK		CHECK BY:	CK		6/30/2020

1. STREAM CURRENT CALCULATIONS

PER AASHTO LRFD Section 3.7.3 STREAM PRESSURE
PER AASHTO ASD Section 3.18.1.1 STREAM PRESSURE

A. REGULAR STREAM CURRENT (Strength & Service Limit States))

Design Water Flow Velocity, Vavg: 6.0 ft/sec — Vavg= Design velocity of water for the design flood in Strength and Service Limit States
Drag Coefficient, C_D or K: 0.7 circular piles — The stream flow data from 1998 to 2020 varies from 0.2 to max 6.2 ft/sec. So design for 6 ft/sec current or 3.6 knots
Avearge flow = 1.0 fps; Median flow = 0.8 fps (https://waterdata.usgs.gov/md/nwis/uv/?site_no=01589352&PARAmeter_cd=00065,00060,62615,62620)

Avg. Current Pressure: Pavg = 25 psf — (C_Dx V^2 or KxV^2avg) LRFD 3.7.3.1-1 / ASD 3.1.1.1
Max Current Pressure: Pmax = 50 psf

Pile Width or Diameter: d (ft): 1.33 — 16" Dia. X 5/8" Steel Pipe Pile
Exposed Pile Height above Mud Level, Hp (ft): 10.0 — Mud Level to Water Surface: MLLW/MLW Elev.: -10.0 — MLLW: EL. -0.59; MLW: EL-0.36
Exposed Pile Height above Mud Level, Hp (ft): 11.0 — Mud Level to Water Surface: MHW/MHHW Elev.: — MHW: EL. +0.79; MHHW: EL.+1.08

Compute Exposed Height				Hp (ft)
9.41	9.64	9.5		10
10.79	11.08	10.9		11

Current Flow Force F_current: Hp x d x Pavg

F_current (kips) =	0.34	Hp=10	MLLW	Triangular Pressure Load: P_max =	42 lb/in	@ MLLW	P_min = 0	@ Mud Level
F_current (kips) =	0.37	Hp=11'	MHHW	Triangular Pressure Load: P_max =	46 lb/in	@ MHHW	P_min = 0	@ Mud Level

B. STREAM CURRENT AT 100-YEAR DESIGN FLOOD (Strength & Service Limit States)

Extreme Current Flow, V_f: 6 ft/sec — V_f= Design velocity of Check Flood in the the Extreme Events 100-YEAR Flood
Extreme 100-YR Flood above Mud Level, Hp (ft): 17 — Mud Level to Water Surface: Mud Level at Elev. -10 100-yr WSE 7.08 17.08
Avg. Current Pressure: Pavg = 25.2 psf
Max Current Pressure: Pmax = 50.4 psf
100-YR Design Flood, F_current (kips): 0.57 Hp=17 per pile — Triangular Pressure Load: P_max = 71 lb/in @ 100-YR WSE P_min = 0 @ Mud Level

2. ICE LOAD/FORCE CALCULATIONS

(A) AASHTO 17TH Ed. ASD SECTION 3.18.2.2 DYNAMIC ICE FORCE

[Section 3.18.2.1 dynamic pressure due to moving ice sheets/ice-floes carried by stream flow, wind or currents]

Effective Ice Crushing Strength: p = 100 psi — AASHTO ASD 3.18.2 — 14.4 ksf — [400 psi=57.6 ksf Alaska]
Design Thickness of Ice in contact with Pier/Pile: t_ice = 6 in

Pile Diameter/Ice Thickness	w/t_ice =	2.7		w= width of pier or diameter of pile
Horizontal Crushing Ice Force on Pier	F_ice= Cn x Cr x p x t x w			ASD 3.18.2.2.1
Coefficient of Nose Inclination	Cn =	1.0	0 to 15 deg	
Force Reduction Coefficient	Cr =	0.93		[AASHTO ASD Table 3.18.2.2.4 with w/t_ice] 0.93
Longitudinal Force	F_ice,L =	9.0	kips	Force along Longitudinal Axis of Pier Parallel to the Principal Direction of Ice Flow 3.18.2.2.5
Transverse Force (acting simult. w/ long. force)	F_ice,T =	1.8	kips	Transverse Force acting on Pier due to Ice Shifts taken as no less than 20% of Longitudinal Force 3.18.2.2.5
Horizontal Ice Force applied at water surface	F_ice =	9.1	kips	Resultant of Longitudinal & Transverse Forces

(B) USACOE PUBLICATION EM 1110-2-1612 October 2002 (Chapter 6 - Ice Force on Structures) & AASHTO LRFD PROCEDURE (Section 3.9.2)

Total Ice Force on Structure, F = Pe Dh=Pex Width of Structure x t_ice (Eqn 6-10, EM 1110-2-1612)
Pe = Effective Pressure; Nominal Contact Area = Pile Width x t_ice

p = 14.4 ksf — AASHTO LRFD 100.0 psi
Ice Thickness: t_ice = 6 in — t=0.083*alpha*Sf^.5 (ft) — 0.49 ft — alpha= 0.5 — Average river with snow
Sf (deg F-days) 142 — 5.93 in — AASHTO LRFD C3.9.2.2-1
Width of Structure: w=d (in) 16 — Pile Diameter — 10-yr return Period
Aspect Ratio: t_ice/w = 0.375 — w/t= 2.67

Use Fc

Empirical Factor to account for Aspect Ratio	Ca=(5t/w+1)^0.5 =	1.7		Eqn. 3.9.2.2-3
Crushing Ice Failure Fc = Ca x p x t x w	F_ice,L =	16.3	kips	Eqn. 3.9.2.2-1
Transverse Force (acting simult. w/ long. force)	F_ice,T =	3.3	kips	Transverse Forces due to Ice Shifts taken as no less than 15% of Longitudinal Force 3.9.2.4.1 or 20% 3.9.4.2
Horizontal Ice Force applied at water surface	F_ice =	16.6	kips	Resultant of Longitudinal & Transverse Forces
Design Dynamic Ice Force	F_ice (per pile)=	8.3	kips	The codes recommend reducing the dynamic ice force by 50% for piers in streams to unlikely encounter large-size floes.

3. WAVE LOAD CALCULATIONS

(Based on ASCE/SEI 7-10 Minimum Design Loads for Buildings & Other Structures, Chapter 5 Flood Loads)

Computed Wave Height above 100-YR WSE (ft)	3.0		[https://woodshole.er.usgs.gov/project-pages/coastal_model/Tools/fetch_limited.html]
Base Flood Elevation (BFE) For MHHW =	1.08		
MHHW Depth above Mud Line, BFE-GS (ft) =	11.08		Mud Level at El. -10.0
Local Still water Depth, ds = 0.65*(BFE - GS) =	7.20	ft	Eq. 5.4-2 & 5.4-3
Breaking Wave Height, Hb = 0.78*ds	5.62	ft	[Hb = 0.78ds, where ds = local still water depth in ft, ASCE Eqn 5.4-2]
Design Breaking Wave Height, Hb =	5.60	ft	For Still Water at MHHW
Density of Brackish Water, γ_w =	63.2	pcf	[Fresh Water = 62.4 pcf; Saline water=62.9 pcf; Brackish Water=63.9 pcf; Salt Water = 64.0 pcf]
Coefficient of Drag for Breaking Waves, C_D =	1.75		[1.75 for round piles or columns; 2.25 for square piles or columns]
Pile Diameter, w =	1.33	ft	[pile or column dia for circular sections; or for a square pile use 1.4 times the width of the pile]

Based on ASCE 7-10, Section 5.4.4.1 Breaking Wave Loads on Vertical Pilings & Columns -

Net Horizontal Wave Force on Pile, F_wave= 0.5 x γ_w x C_D x w x Hb^2			ASCE 7-10, Eq. 5.4-4
MHHW Breaking Wave Height, Hb =	5.6	ft	Water Surface at MHHW
F_wave (per pile)=	2.3	kips	(applied at MHHW Surface)
100-YE WSE Breaking Wave Height, Hb =	3.0	ft	Water Surface at 100-YR WSE
F_wave (per pile)=	0.7	kips	(applied at 100-YR WSE)

4. WIND LOADING ON TRASH COLLECTOR (AASHTO LRFD Section 3.8)

Est. Area of Covered Wheel Aw =	275.0		sq. ft	Platform =24' x 52' Solar Panels=96"x33	Perp to Wind Pontoons 8'W x52'L x 40"D	22.2
Design Wind Velocity (Significant Wave) Vdz_extreme =	80		knots	92.1 mph	Extreme Wind Speed	
Normal Design Wind Velocity Vdz_normal =	23		mph	Assume Normal Wind	Max Winds 23 mph (April 3, 2016)	
Base Wind Velocity Vb =	100		mph		Typical Winds < 11 mph (Avg. 2.5 mph)	
Base Wind Pressure (Flat Surface) Pb =	0.04		ksf	[AASHTO LRFD Section 3.8.1.2.1]		
Wind Pressure on Wheel = Pd=Pb(Vdz/Vb)^2 = Pd =	0.034	0.002	ksf		AASHTO LRFD Eqn. 3.8.1.2.1-1	
EXTREME Design Wind Load = AwPd Wd_extreme =	9.3		kips	on Structure		
NORMAL Design Wind Load = AwPd Wd_normal =	0.6		kips	on Structure		

5. REACTION ON PILES DUE TO CURRENT PRESSURE ON BOOMS, CONVEYOR & HULL CONNECTORS

E/W Transverse Distance between 2 Piles, L=	50.0	ft	Horizontal distance Floating platform: 24' x 52'
Assume between straight line & Boom, S=	10.0	ft	Pontoon Hull Sections 8' W x 52' L x 40" D
E/W Distance to Maximum Sag Location, X = L/2	25.0	ft	
Boom Thickness (equal to beam thickness), t =	16.00	in	
Avg. Current Pressure Pavg =	25.2	psf	
Distributed Load along Boom, q = P_avg x t=	33.6	lb/lf	
Length of Beams between Hulls, L_beam =	8.0	ft	
N/S Longitudinal Reaction on Piles, Fbeam = q x L_beam/2 =	0.1	kip	
E/W Component of Tension, F_boom, trans = (0.75xq X^2/2)/S	0.8	kip	There is a 25% reduction of current pressure acting on the boom due to perforated nature of the boom
N/S Component of Tension, F_boom, long = 0.75*qX =	0.6	kip	
F_boom =	1.1	kips	Per Pile

6. HULL RESISTANCE COMPUTATIONS (PER US NAVAL ACADEMY, USNA)

REF: YARD PATROL CHAPTER 7 - RESISTANCE & POWERING OF SHIPS

I knot = 1.688 ft/sec

Avg. Current Flow Rate against Hull, Vs =	6.0	ft/sec	
Speed of Water Flowing against Hull, Vs =	3.6	knots	
Speed -to-Length Ratio, Vs/SQRT(L_hull) =	0.58	k/ft^0.5	Ls (ft) = 38 Hull Length
Froude Number, Fn = V/sqrt(g x Ls) =	0.17	Per USNA	At low speeds (Fn <0.12 or V/L^.5 < 0.4, water friction or R_current accounts for up to 85% of a Hull's Total Resistance

Total Hull Resistance Curve for a Navy Yard Patrol Craft:

PER USNA, The Total Hull Resistance, R_T = **R_current + R_wave +R_air**

where: R_curent= R_viscous= friction and viscous effects of water acting on the hull

R_wave = wave making resistance

R_air = Resistance that air provides to hull motion

* At low flow currents or speed (where, Fn <0.2 or V/L^.5 < 0.4), R_current dominates with up to 85% of a Hull's Total Resistance

				pcf	kg/m^3
Unit Weight of Water	63 lbm/ft3	1009.6 kg/m^3		62.4	1000
Unit Weight of Ice	57.2 lbm/ft3	916.7 kg/m^3			
Gravity, g	32.17 ft/s^2	9.807 m/s^2			
Density of Water	1.96 lb-s^2/ft^4	102.9 kg-s^2/m^4			
Density of Ice	1.78 lb-s^2/ft^4	93.5 kg-s^2/m^4			
Effective HPower at 6 fps=4 knots, EHP =	20.0 HP	EHP = $R_T V_S/550$ (ft-lb/sec/HP)	[See Attached Power Curve for Yard Patrol Craft]		
Total Hull Resistance, R_T =	1833 lbs	R_T = EHP*550/Vs is the Total Hull Resistance			
F_{HULL} =	1.8 kip	V_S is ship's speed in ft/sec			

7. ICE LOADING ON HULL (ICE FORCE ON STRUCTURES - Head-on Collison between a Ship and Ice Floe)

Ref: Ship Ice Interaction - Determination of Bow Forces and Hull Response Due to Head-On and Glancing Impact between a Ship and an Ice Floe by Claude Daley, Richard Hayward & Kej Riska for Ship Safety Northern Transport Canada Publication No. TP 121734E, November 1996. Ocean Engineering Research Centre, Memorial University of Newfoundland, Canada

Maximum Normal Ice Force on Hull: **$F_{n,max} = 0.766 \times K^{0.4} \sin^{0.2}\beta\, (M \rho g A_{wp})^{0.5}\, V = K^{0.4} \times$ Constant [N]** — Max Bow ice Force ina head-on Collision with a Large Ice Feature

Where: **Constant = $0.766 \sin^{0.2}\beta\, (M \rho g A_{wp})^{0.5}\, V$**

ICE Force is based on Assuming that Ice Contact Pressure Model of the form: **$Poc = C_1\, Ac^{-0.5}$** where, Ac = Ice Contact Area, and C_1 is an empirical constant

				SI UNITS		
Vessel Speed or Stream Flow	V =	1.00	ft/sec	0.30	m/s	Total Weight (kips) Wt per 3-pile (kips)
Total Weight of Structures & Equipment	W =	[illegible]	lbf	259763	N	58.4 19.5 per pile
Mass of Vessel or Floating Platform	M = W/g =	1815	$lbf\text{-}s^2/ft$	26488	$N\text{-}s^2/m$ = kg	
Water Plane Area for the Vessel	A_{wp} = L*W =	408	sq. ft	37.9	m^2	A = Loaded Area, Contact Area

Floating Platform Dimensions

	Length (ft)	Width (ft.)	Height (ft)	Volume (cu.ft.)	Awp=LxW (s.q ft.)
Stem Section:	16.0	4.5	2.33	168	72
Mid-Section:	19.3	6.0	2.33	270	116
Bow Section:	2.7	6.0	2.33	6	16
			Single Pontoon	444	204
			Total for 2 Pontoons =	888	408 sq. ft.

Hull Stem Angle to the Horizontal **20° <= β <= 40°** deg

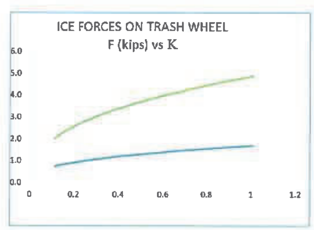
Assume, β (deg) = [illegible] — $\sin^{0.2}(\beta)$ = 0.92

Constant = $0.766 \sin^{0.2}\beta\, (M \rho g A_{wp})^{0.5}\, V$ = 21309 Newton

Constant = $0.766 \sin^{0.2}\beta\, (M \rho g A_{wp})^{0.5}\, V$ = 4.79 kips

Non-Dimensional Ice Strength **0.1 <= K <= 1.0** — **K = keq/(γ_wAc); tan(K) = t_ice/2R** (R= Radius of Loaded Area)

		F = $K^{0.4}$xConstant	F_Iceh per Pile	Reduction Factor
K	K^.4	4.79	kips	3
0.1	0.40	1.9	0.6	
0.15	0.47	2.2	0.7	
0.2	0.53	2.5	0.8	
0.25	0.57	2.8	0.9	
0.3	0.62	3.0	1.0	
0.35	0.66	3.1	1.0	
0.4	0.69	3.3	1.1	
0.5	0.76	3.6	1.2	
0.75	0.89	4.3	1.4	
1	1.00	4.8	1.6	



SUMMARY OF HORIZONTAL/LATERAL FORCES ON PILES

1. Water Current Force, Average	**Avg. F_current =**	0.3	kips	Hp=10'	MLLW	Service I-IV / Strength I-IV/ Extreme I & II	
Triangular Water Force Dist. Max at MLLW	**F_c max =**	0.7	kips				
Water Current Force, Average	**Avg. F_current =**	0.4	kips	Hp=11'	MHHW	Service I-IV / Strength I-IV/ Extreme I & II	
Triangular Water Force Dist. Max at MHHW	**F_c max =**	0.7	kips				
Current Force due to 100-YR WSE	**Avg. F_current =**	0.8	kips	Hp=17'	100-YR WSE	Service I - IV & Extreme Event II	
Triangular Water Force Dist. Max at 100-YR	**F_c max =**	1.1	kips				
2. Ice Force	F_ice =	8.3	kips	100 psi (14.4 ksf)	Extreme Event II		
3. Wave Force	F_wave =	2.3	kips	MHHW	Extreme Event II		
	F_wave =	0.7	kips	100-YR WSE			
4. Wind Loading	**Normal F_wind =**	0.6	kips	On Entire Trash Collector Structure			
Service I - Normal Wind Load	F_wind= Wd*0.3	0.2	kips	Service I Load Factor = 0.3 with 55 mph wind and normal load conditions			MHHW
Strength V - Normal Wind Forces	F_wind= Wd*0.4	0.2	kips	Strength V Load Factor = 0.4, load combination for normal use wind velocity of 55 mph			MHHW
80 Knots	**Extreme F_wind =**	9.3	kips	On Entire Trash Collector Structure			
Service IV - Extreme Wind Force	F_wind= Wd*0.7	6.5	kips	Service IV Load Factor=0.7 on high wind forces			100-YR
Strength III - Extreme Wind Forces	F_wind= Wd*1.4	13.1	kips	Strength III Load Factor = 1.4, structure exposed to wind velocity exceeding 55 mph			100-YR
5. Water Current Pressure on Boom & Hull	**F_boom =**	1.1	kips	Per Pile	Service I-IV / Strength I-IV		
6. Hull Resistance due to Current Force:	**F_hull =**	1.8	kips		Service I-IV / Strength I-IV		
7. Ice Loading on Hull	**F_ice_hull =**	1.6	kips	Per Pile	Extreme Event II	(Check Section 7.0)	

Service Load Combinations:

SERVICE Load Combinations= F_current+ F_wind + F_wave + F_boom+F_hull

Typical Service Load: Current Loading Only (Pile, Boom & Hull) =	3.3	kips	Max @ MHHW	Load on 1 Pile
Typical Service Load: Current Loading Only (Pile, Boom & Hull) =	2.4	kips	Min @ MHHW	Load on 2 Piles
Service I: F_current+ 0.3F_wind + F_wave + F_boom+F_hull =	5.8	kips	Max @ MHHW	1 Pile: Assume full wind load on One Pile
Service I: F_current+ 0.3F_wind/2 + F_wave + F_boom+F_hull =	4.8	kips	Min @ MHHW	2 Piles: Assume Wind load on Two Piles
Service IV: F_current+ 0.7F_wind + F_wave + F_boom+F_hull =	10.7	kips	Max @ 100-YR WSE	1 Pile: Assume full wind load on One Pile
Service IV: F_current+ 0.7F_wind/2 + F_wave + F_boom+F_hull =	6.5	kips	Min @ 100-YR WSE	2 Piles: Assume Wind load on Two Piles

Strength Load Combinations:

Strength III: F_current+ 1.0F_wind + F_wave + F_boom+F_hull =	12.8	kips	Max @ 100-YR WSE	1 Pile: Assume full wind load on One Pile
Strength III: F_current+ 1.4F_wind/2 + F_wave + F_boom+F_hull =	9.1	kips	Min @ 100-YR WSE	2 Piles: Assume Wind load on Two Piles
Strength V: F_current+ 0.4F_wind + F_wave + F_boom+F_hull =	5.8	kips	Max @ MHHW	1 Pile: Assume full wind load on One Pile
Strength V: F_current+ 0.4F_wind/2 + F_wave + F_boom+F_hull =	4.8	kips	Min @ MHHW	2 Piles: Assume Wind load on Two Piles

EXTREME EVENT II: F_ice + F_current + F_wave+ F_boom + F_hull +F_ice_hull

F_ice + F_current + F_wave+ F_boom + F_hull + F_ice_hull =	15.5	kips	Max @ MHHW	Ice-Loading on Boom Resisted by One Pile
F_ice + F_current + F_wave+ F_boom + F_hull/2 + F_ice_hull =	14.6	kips	Min @ MHHW	Ice-Loading on Boom Resisted by Two Piles
F_ice + F_current + F_wave+ F_boom + F_hull + F_ice_hull =	14.1	kips	Max @ 100-yr WSE	Ice-Loading on Boom Resisted by One Pile
F_ice + F_current + F_wave+ F_boom + F_hull/2 + F_ice_hull =	13.1	kips	Min @ 100-yr WSE	Ice-Loading on Boom Resisted by Two Piles

SUMMARY OF LATERAL PILE CAPACITY ANALYSIS (LPILE V5) OF 16" DIA STEEL PIPE PILE

(with reduced pile section of 1/16" due to Potential corrosion)

LOADING CONDITIONS	Service I	Service IV	Strength III	Strength V	Extreme II	Extreme II
TYPICAL LOADING WITH 2 PILES	Min (Load on 2 Piles) 5.0 kips @ MHHW	Min (Load on 2 Piles) 6.5 kips @ 100-yr	Min (Load on 2 Piles) 9.0 kips @ 100-yr	Min (Load on 2 Piles) 5.0 kips @ MHHW	Min (Load on 2 Piles) 14.5 kips @ MHHW	Min (Load on 2 Piles) 13 kips @ 100-yr
Max Top Deflection (in)	4.0	8.0	12.5	4.0	16	20
Deflection at Mud Level (in)	1.0	2.2	3.5	1.0	5	6
Max Induced Shear (kips)	7	15	22	10	33	40
Max Induced Moment (in-kips)	1000	1800	2600	1000	3300	3900
Max Induced Moment (ft-kips)	83	150	217	83	275	325
WORST LOADING CASE SCENARIO WITH ONE PILE	Max (Load on 1 Pile) 6.0 kips @ MHHW	Max (Load on 1 Pile) 10.5 kips @ 100-yr	Max (Load on 1 Pile) 13 kips @ 100-yr	Max (Load on 1 Pile) 6.0 kips @ MHHW	Max (Load on 1 Pile) 15.5 kips @ MHHW	Max (Load on 1 Pile) 14 kips @ 100-yr
Max Top Deflection (in)	5.0	15	20	5.0	18	22
Deflection at Mud Level (in)	1.5	4.5	6	1.5	6	7
Max Induced Shear (kips)	10	30	40	10	40	42
Max Induced Moment (in-kips)	1200	3200	3900	1200	3600	4250
Max Induced Moment (ft-kips)	100	267	325	100	300	354

STRUCTURAL CAPACITY OF STEEL HELICAL PILE FOUNDATIONS

16" Dia & 5/8" THICK STEEL PIPE PILE ANALYSIS

SHEAR CAPACITY

Nominal, Vn= 0.6xFyA/2 =

Steel Yield Stress	Fy =	42 ksi
Steel Tensile Stress	Fu =	58 ksi

Resistance Factors

Tensile Yielding	0.9	Compression	0.9
Tensile Rupture	0.75	Flexure	0.9
		Shear	0.9

	Original Pile Properties		*Modified Pile Properties Allowing for Corrosion* *Assume 1/16"Reduction in Pile thickness for Corrosion*	
Outside Diameter	OD=	16 in	OD_mod =	15.88 in
Wall Thickness	t_o =	0.625 in	t_mod = t_o-1/16"=	0.5625 in
Inside Diameter	ID	14.8 in	ID_mod =	14.8 in
Effective Steel Area	As=	30.2 in^2	As_mod =	27.1 in^2
	D/t = OD/(0.93*t)	27.5	D/t =	30.3
	A* = 0.93*As	28.1 in^2	A*_mod =	25.2 in^2
Elastic Flexural Section Modulus	S =	112 in^3	S_mod =	100 in^3
Plastic Section Modulus	Z = (OD^3-ID^3)/6	148 in^3	Z_mod =	132 in^3
Moment of Inertia	I =	893.5 in^4	I_mod =	794 in^4

Design Shear Capacity

Nominal, Vn= 0.6xFyA*_mod/2 =	317 kips	
Factored/Design Shear Strength Vr = ϕVn =	285 kips	(where ϕ = 0.9 for shear strength)
Max Induced Shear <Vr	40 kips	Shear Capacity OK FOR 2-PILE SYSTEM
Max Induced Shear <Vr	42 kips	Shear Capacity OK FOR 1-PILE SYSTEM

MOMENT CAPACITY

Fkexure Yielding Check

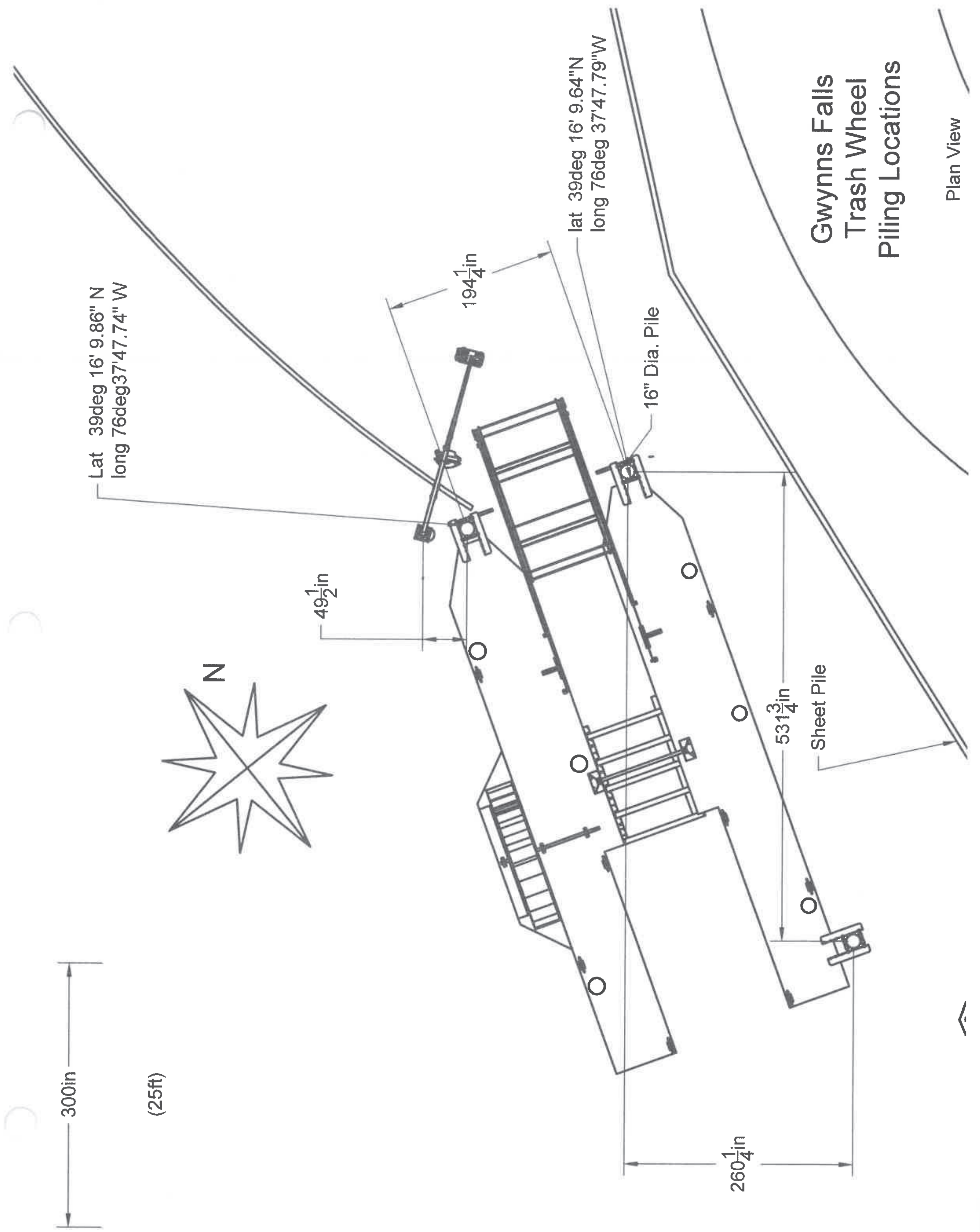
Nominal Flexural Strength for Yielding. Mp=FyZ	5 542 in-kips	
Mp =	462 ft-kips	
Plastic Modulus Z	132 in^3	
Factored/Design Flexural Strength Mc = ϕMn =	416 ft-kips	(where ϕ = 0.9 for flexure)

Max Induced Moments:

STRENGTH Loading: 2-PILE SYSTEM	217 ft-kips	Less than Factored Moment Capacity OK	-48% Understress
STRENGTH Loading: 1-PILE SYSTEM	325 ft-kips	Less than Factored Moment Capacity OK	-22% Understress
EXTREME II Loading: 2-PILE SYSTEM	325 ft-kips	Factored Moment Capacity OK	-22% Understress
EXTREME II Loading: 1-PILE SYSTEM	354 ft-kips	Factored Moment Capacity OK	-23% Understress
		Less than Factored Moment Capacity OK	-15% Understress

Local Buckling Check:

Mn = Fcr x S, where, Fcr = 0.021E/(D/t) + Fy	Fcr =	64.1 ksi	Fcr_mod =	62.1 ksi
Local Buckling Moment, Mn	Mn =	597 ft-kips	Mn_mod =	518 ft-kips


Gwynns Falls
Trash Wheel
Piling Locations
Plan View
lat 39deg 16' 9.64"N
long 76deg 37'47.79"W
Lat 39deg 16' 9.86" N
long 76deg37'47.74" W
194 1/4 in
16" Dia. Pile
49 1/2 in
N
531 3/4 in
Sheet Pile
300in
(25ft)
260 1/4 in

Attachments

1. HEC-RAS input (Upper Trinity River CDC Model).

Plan: Baseline West Fork wf4 RS: 259346.8 Profile: 100-year					
E.G. Elev (ft)	541.07	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.25	Wt. n-Val.	0.060	0.035	0.060
W.S. Elev (ft)	540.82	Reach Len. (ft)	320.01	409.36	515.53
Crit W.S. (ft)	523.50	Flow Area (sq ft)	3582.13	6005.42	1370.75
E.G. Slope (ft/ft)	0.000150	Area (sq ft)	3939.81	6005.42	1370.75
Q Total (cfs)	35400.00	Flow (cfs)	6451.91	26968.35	1979.74
Top Width (ft)	665.21	Top Width (ft)	303.43	230.93	130.85
Vel Total (ft/s)	3.23	Avg. Vel. (ft/s)	1.80	4.49	1.44
Max Chl Dpth (ft)	30.02	Hydr. Depth (ft)	14.54	26.01	10.48
Conv. Total (cfs)	2885678.0	Conv. (cfs)	525936.0	2198361.0	161380.9
Length Wtd. (ft)	407.28	Wetted Per. (ft)	248.15	237.19	132.25
Min Ch El (ft)	510.80	Shear (lb/sq ft)	0.14	0.24	0.10
Alpha	1.54	Stream Power (lb/ft s)	0.24	1.07	0.14
Frctn Loss (ft)	0.07	Cum Volume (acre-ft)	229.33	762.47	192.47
C & E Loss (ft)	0.01	Cum SA (acres)	22.65	24.79	18.79

Plan: 10y to 1%+ Clear Fork cf RS: 1980 Profile: 100 YEAR					
E.G. Elev (ft)	540.48	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.06	Wt. n-Val.	0.060	0.035	0.060
W.S. Elev (ft)	539.43	Reach Len. (ft)	217.00	217.00	205.00
Crit W.S. (ft)		Flow Area (sq ft)	319.14	4394.09	985.40
E.G. Slope (ft/ft)	0.000789	Area (sq ft)	319.14	4394.09	985.40
Q Total (cfs)	38676.00	Flow (cfs)	404.15	37003.89	1267.96
Top Width (ft)	744.37	Top Width (ft)	129.56	223.38	391.43
Vel Total (ft/s)	6.79	Avg. Vel. (ft/s)	1.27	8.42	1.29
Max Chl Dpth (ft)	26.52	Hydr. Depth (ft)	2.46	19.67	2.52
Conv. Total (cfs)	1377090.0	Conv. (cfs)	14390.0	1317553.0	45146.8
Length Wtd. (ft)	216.63	Wetted Per. (ft)	129.90	234.11	391.62
Min Ch El (ft)	512.91	Shear (lb/sq ft)	0.12	0.92	0.12
Alpha	1.47	Stream Power (lb/ft s)	0.15	7.78	0.16
Frctn Loss (ft)	0.16	Cum Volume (acre-ft)	21.74	239.13	73.49
C & E Loss (ft)	0.03	Cum SA (acres)	3.68	7.60	12.19

2. Vendor Information - Pile Section Properties

PIPE

Diameter in mm	Wall in mm	Weight lb/ft kg/m	Inside Diameter in mm	Cross Sectional Area in² cm²	Total Area of Pile in² cm²	Internal Area in² cm²	Internal Volume ft³/ft m³/m	External Coating Area ft²/ft m²/m	Moment of Inertia in⁴ cm⁴	Section Modulus in³ cm³	Radius of Gyration in cm	Maximum Available Yield Strength of A252 ERW ksi (MPa)	SW	R&W
20 **508**	0.312 7.925	65.67 97.72	19.38 492.2	19.30 124.5	314.2 2,027	294.9 1,902	2.048 0.190	5.24 1.60	935.3 38,930	93.5 1,533	6.96 17.68	60 414	60 414	Not Available
	0.375 9.525	78.67 117.1	19.25 489.0	23.12 149.2	314.2 2,027	291.0 1,878	2.021 0.188	5.24 1.60	1,113 46,350	111.3 1,825	6.94 17.63	60 414	60 414	
	0.500 12.700	104.2 155.1	19.00 482.6	30.63 197.6	314.2 2,027	283.5 1,829	1.969 0.183	5.24 1.60	1,457 60,640	145.7 2,387	6.90 17.52	60 414	60 414	
	0.625 15.875	129.5 192.6	18.75 476.3	38.04 245.4	314.2 2,027	276.1 1,781	1.917 0.178	5.24 1.60	1,787 74,380	178.7 2,928	6.85 17.41	60 414	60 414	
24 **610**	0.312 7.925	79.01 117.6	23.38 593.8	23.22 149.8	452.4 2,919	429.2 2,769	2.980 0.277	6.28 1.92	1,629 67,800	135.7 2,224	8.38 21.27	60 414	60 414	Not Available
	0.375 9.525	94.71 140.9	23.25 590.6	27.83 179.6	452.4 2,919	424.6 2,739	2.948 0.274	6.28 1.92	1,942 80,840	161.9 2,652	8.35 21.22	60 414	60 414	
	0.500 12.700	125.6 186.9	23.00 584.2	36.91 238.2	452.4 2,919	415.5 2,680	2.885 0.268	6.28 1.92	2,549 106,100	212.4 3,481	8.31 21.11	60 414	60 414	
	0.625 15.875	156.2 232.4	22.75 577.9	45.90 296.1	452.4 2,919	406.5 2,623	2.823 0.262	6.28 1.92	3,137 130,600	261.4 4,284	8.27 21.00	60 414	60 414	
	0.750 19.050	186.4 277.4	22.50 571.5	54.78 353.4	452.4 2,919	397.6 2,565	2.761 0.257	6.28 1.92	3,705 154,200	308.8 5,060	8.22 20.89	Not Available	50 345	
	0.875 22.225	216.3 321.9	22.25 565.2	63.57 410.1	452.4 2,919	388.8 2,509	2.700 0.251	6.28 1.92	4,255 177,100	354.6 5,811	8.18 20.78		50 345	
	1.000 25.400	245.9 365.9	22.00 558.8	72.26 466.2	452.4 2,919	380.1 2,452	2.640 0.245	6.28 1.92	4,787 199,300	398.9 6,537	8.14 20.67		50 345	
30 **762**	0.312 7.925	99.02 147.3	29.38 746.2	29.10 187.7	706.9 4,560	677.8 4,373	4.71 0.44	7.85 2.39	3,206 133,500	213.8 3,503	10.50 26.66	Not Available	60 414	Not Available
	0.375 9.525	118.8 176.7	29.25 743.0	34.90 225.2	706.9 4,560	672.0 4,335	4.67 0.43	7.85 2.39	3,829 159,400	255.3 4,184	10.47 26.61		60 414	
	0.500 12.700	157.7 234.6	29.00 736.6	46.34 299.0	706.9 4,560	660.5 4,261	4.59 0.43	7.85 2.39	5,042 209,900	336.1 5,508	10.43 26.50		60 414	
	0.625 15.875	196.3 292.1	28.75 730.3	57.68 372.1	706.9 4,560	649.2 4,188	4.51 0.42	7.85 2.39	6,224 259,100	414.9 6,800	10.39 26.39		60 414	
	0.750 19.050	234.5 349.0	28.50 723.9	68.92 444.6	706.9 4,560	637.9 4,116	4.43 0.41	7.85 2.39	7,375 307,000	491.7 8,057	10.34 26.28		60 414	
	0.875 22.225	272.4 405.4	28.25 717.6	80.06 516.5	706.9 4,560	626.8 4,044	4.35 0.40	7.85 2.39	8,497 353,700	566.5 9,283	10.30 26.17		60 414	
	1.000 25.400	310.0 461.3	28.00 711.2	91.11 587.8	706.9 4,560	615.8 3,973	4.28 0.40	7.85 2.39	9,589 399,100	639.3 10,480	10.26 26.06		50 345	
36 **914**	0.375 9.525	142.8 212.5	35.25 895.4	41.97 270.8	1,018 6,567	975.9 6,296	6.78 0.63	9.43 2.87	6,659 277,200	369.9 6,062	12.60 31.99	Not Available	60 414	60 414
	0.500 12.700	189.8 282.4	35.00 889.0	55.76 359.8	1,018 6,567	962.1 6,207	6.68 0.62	9.43 2.87	8,786 365,700	488.1 7,999	12.55 31.88		60 414	60 414
	0.625 15.875	236.4 351.7	34.75 882.7	69.46 448.1	1,018 6,567	948.4 6,119	6.59 0.61	9.43 2.87	10,870 452,400	603.8 9,894	12.51 31.77		60 414	60 414
	0.750 19.050	282.6 420.6	34.50 876.3	83.06 535.8	1,018 6,567	934.8 6,031	6.49 0.60	9.43 2.87	12,910 537,200	717.0 11,750	12.47 31.66		60 414	60 414
	0.875 22.225	328.6 488.9	34.25 870.0	96.55 622.9	1,018 6,567	921.3 5,944	6.40 0.59	9.43 2.87	14,900 620,200	827.8 13,560	12.42 31.55		50 345	60 414
	1.000 25.400	374.2 556.8	34.00 863.6	110.0 709.4	1,018 6,567	907.9 5,858	6.31 0.59	9.43 2.87	16,850 701,400	936.2 15,340	12.38 31.44		50 345	60 414

Calculation Preparation Checklist	CALC NO.	FWTHFS00259-CALC-001
	REV.	000

CHECKLIST ITEMS[1]	YES	NO[2]	N/A
GENERAL REQUIREMENTS			
1. Are the latest procedure revisions being used?	☒	☐	☐
2. Are the proper forms being used and are they the latest revision?	☒	☐	☐
3. Have the appropriate client review forms/checklists been completed?	☐	☐	☒
4. Are all pages properly identified with a calculation number, calculation revision and page number consistent with the requirements of the client's procedure?	☒	☐	☐
5. Is all information legible and reproducible?	☒	☐	☐
6. Is the calculation presented in a logical and orderly manner?	☒	☐	☐
7. Have all other calculations impacted by this change been revised or voided as appropriate?	☐	☐	☒
8. If an existing calculation is being used for design inputs, are the key design inputs, assumptions and engineering judgments used in that calculation valid and do they apply to the calculation revision being performed.	☐	☐	☒
9. Is the format of the calculation consistent with applicable procedures and expectations?	☐	☐	☒
10. Were design input/output documents properly updated to reference this calculation?	☐	☐	☒
11. Can the calculation logic, methodology and presentation be properly understood without referring back to the originator for clarification?	☒	☐	☐
OBJECTIVE AND SCOPE			
12. Does the calculation provide a clear concise statement of the problem and objective of the calculation?	☒	☐	☐
13. Does the calculation provide a clear statement of quality classification?	☒	☐	☐
14. Is the reason for performing and the end use of the calculation understood?	☒	☐	☐
15. If the calculation provides the basis for information found in the plant's license basis, is it clearly documented in the calculation?	☐	☐	☒
16. If the calculation provides or supports the basis for information found in the plant's design basis documentation, is it clearly documented in the calculation?	☐	☐	☒
17. Has the appropriate design or license basis documentation been revised, or has the change notice or change request documents being prepared for submittal?	☐	☐	☒

Calculation Preparation Checklist	CALC NO.	FWTHFS00259-CALC-001
	REV.	000

CHECKLIST ITEMS[1]	YES	NO[2]	N/A
DESIGN INPUTS			
18. Are design inputs clearly identified?	☒	☐	☐
19. Are design inputs retrievable or have they been added as attachments?	☒	☐	☐
20. If Attachments are used as design inputs or assumptions are the Attachments traceable and verifiable?	☒	☐	☐
21. Are design inputs clearly distinguished from assumptions?	☒	☐	☐
22. If the calculation relies on Attachments for design inputs or assumptions, are the attachments properly referenced in the calculation?	☒	☐	☐
23. Are input sources (including industry codes and standards) appropriately selected and are they consistent with the quality classification and objective of the calculation?	☒	☐	☐
24. Are input sources (including industry codes and standards) consistent with the plant's design and license basis?	☐	☐	☒
25. If applicable, do design inputs adequately address actual plant conditions?	☐	☐	☒
26. Are input values reasonable and correctly applied?	☒	☐	☐
27. Are design input sources approved?	☒	☐	☐
28. Does the calculation reference the latest revision of the design input source?	☒	☐	☐
29. Were all applicable plant operating modes considered?	☐	☐	☒
ASSUMPTIONS			
30. Are assumptions reasonable/appropriate to the objective?	☐	☐	☒
31. Is adequate justification/basis for all assumptions provided?	☐	☐	☒
32. If engineering judgements are used, are they clearly identified as such?	☐	☐	☒
33. If engineering judgments are used as design inputs, are they reasonable and can they be quantified or substantiated by reference to site or industry standards, engineering principles, physical laws or other appropriate criteria?	☐	☐	☒
METHODOLOGY			
34. Is the methodology used in the calculation consistent with the methodology described or implied in the plant's licensing basis?	☐	☐	☒
35. If the methodology used differs from that described in the plant's licensing basis, has the appropriate license document change notice been initiated?	☐	☐	☒

Calculation Preparation Checklist	CALC NO. FWTHFS00259-CALC-001		
	REV. 000		

CHECKLIST ITEMS[1]	YES	NO[2]	N/A
36. Is the methodology used consistent with the stated objective?	☒	☐	☐
37. Is the methodology used appropriate when considering the quality classification of the calculation and intended use of the results?	☐	☐	☒
BODY OF CALCULATION			
38. Are equations used in the calculation consistent with recognized engineering practice and the plant's design and license basis?	☒	☐	☐
39. Is there reasonable justification provided for the use of equations not in common use?	☐	☐	☒
40. Are the mathematical operations performed properly and documented in a logical fashion?	☒	☐	☐
41. Is the math performed correctly?	☒	☐	☐
42. Have adjustment factors, uncertainties and empirical correlations used in the analysis been correctly applied?	☒	☐	☐
43. Has proper consideration been given to results that may be overly sensitive to very small changes in input?	☒	☐	☐
SOFTWARE/COMPUTER CODES			
44. If computer codes or software languages used in the preparation of the calculation, have the requirements of CSP 3.09, including verification of accuracy and applicability been met?	☐	☐	☒
45. If computer codes have been used, are they properly identified along with source vendor, organization, and revision level?	☒	☐	☐
46. If a computer code is being used, is it applicable for the analysis being performed?	☒	☐	☐
47. If applicable, does the computer model adequately consider actual plant conditions?	☒	☐	☐
48. If applicable, are the inputs to the computer code clearly identified and consistent with the inputs and assumptions documented in the calculation?	☒	☐	☐
49. If applicable, is the computer output clearly identified?	☒	☐	☐
50. If applicable, does the computer output clearly identify the appropriate units?	☒	☐	☐
51. If applicable, are the computer outputs reasonable when compared to the inputs and what was expected?	☒	☐	☐

Calculation Preparation Checklist	CALC NO.	FWTHFS00259-CALC-001
	REV.	000

CHECKLIST ITEMS[1]		YES	NO[2]	N/A
52.	If applicable, was the computer output reviewed for ERROR or WARNING messages that could invalidate the results?	☒	☐	☐
RESULTS AND CONCLUSIONS				
53.	Is adequate acceptance criteria specified?	☒	☐	☐
54.	Are the stated acceptance criteria consistent with the purpose of the calculation, and intended use?	☒	☐	☐
55.	Are the stated acceptance criteria consistent with the plant's design basis, applicable licensing commitments and industry codes, and standards?	☒	☐	☐
56.	Do the calculation results and conclusions meet the stated acceptance criteria?	☒	☐	☐
57.	Are the results represented in the proper units with an appropriate tolerance, if applicable?	☒	☐	☐
58.	Are the calculation results and conclusions reasonable when considered against the stated inputs and objectives?	☒	☐	☐
59.	Is sufficient conservatism applied to the outputs and conclusions?	☒	☐	☐
60.	If the calculation results and conclusions affect other calculations, have the affected calculations been revised and cross referenced?	☐	☐	☒
61.	Have any conceptual, unconfirmed or open assumptions requiring later confirmation been properly identified?	☐	☐	☒
DESIGN REVIEW				
62.	If alternate calculation methods were used to verify calculation results, are they properly documented and included?	☐	☐	☒

Note 1: Where required, provide clarification/justification for answers to the questions in the space provided below each question.

Note 2: An explanation is required for any questions answered as "No".

Preparer: Sandeep Menon

Print Name and Sign

Date

Fort Worth Trinity River
Waterwheel Powered Trash Interceptors
Fort Worth, Texas

Basis of Design, Technical Specifications, Operations, Service Manual, Design Calculations, and Construction Drawings

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4965 Mountain Road
Pasadena, MD 21122
www.clearwatermills.com

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Fort Worth, TX 76116
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September 9, 2022

Table of Contents

1. Introduction
1.1 Background
1.2 Principles of Operation
1.3 Benefits of the System
1.4 Locations
2. Basis of Design
2.1 Environmental
2.2 Geometric Constraints
2.3 Geotechnical
2.4 Structural Loading Criteria
2.5 Application of Loading
2.6 Anchor Pile Design Loads
2.7 Material Specifications
2.8 Operating Design Criteria
2.9 Service Life
3. Equipment and Systems Description/General Specifications
3.1 Floating Platform & Dumpster Barge
3.2 Mooring Pilings and Mooring Attachments
3.3 Dumpster
3.4 Waterwheel
3.5 Conveyor
3.6 Power Transmission
3.7 Solar Power System
2.7a Panels
2.7b Controls
2.7c Batteries
3.8 Pump System
3.9 Remote Monitoring and Control System
3.10 Power Rake System
3.11 Covering Structure
3.12 Trash & Debris Containment Boom System
3.13 Log loader system
3.14 Safety tethering system
4. Service Equipment and Facilities
4.1 Vessel
4.2 Monitoring Equipment
4.3 Dumpster Transfer Facility
5. Operation and Maintenance
5.1 Safety
5.2 Basic Operation Procedures
5.3 General Maintenance Requirements

List of Attachments:

Attachment 1 – Anchor Piling Analysis & Design
Attachment 2 – Equipment Plans & Drawings for Waterwheel Powered Trash Interceptor
Attachment 3 – Cost Estimate

Section 1 Introduction

1.1 Background

In 2008, Clearwater Mills, LLC installed the world's first Waterwheel Powered Trash Interceptor in the mouth of the Jones Fall River in Baltimore's Inner Harbor. The operation of this first installation demonstrated that this technology can effectively and economically collect and remove trash and debris from stormwater runoff before it moves downstream.

As with all new technologies, the first application afforded us the opportunity to identify areas where improvements could be made. The positive impact of the prototype led to a permanent installation in May of 2014. This unique, efficient, and attractive approach to controlling floating stormwater pollution has garnered numerous awards for design and innovation and generated worldwide attention. The technology has also proven adaptable for use in different sizes and types of waterways as was demonstrated by the installation of three more machines in Baltimore Harbor. The proposed Waterwheel interceptors for the Clear Fork and West Fork of the Trinity River operate on the same principles with site modifications made where necessary.

1.2 Principles of Operation

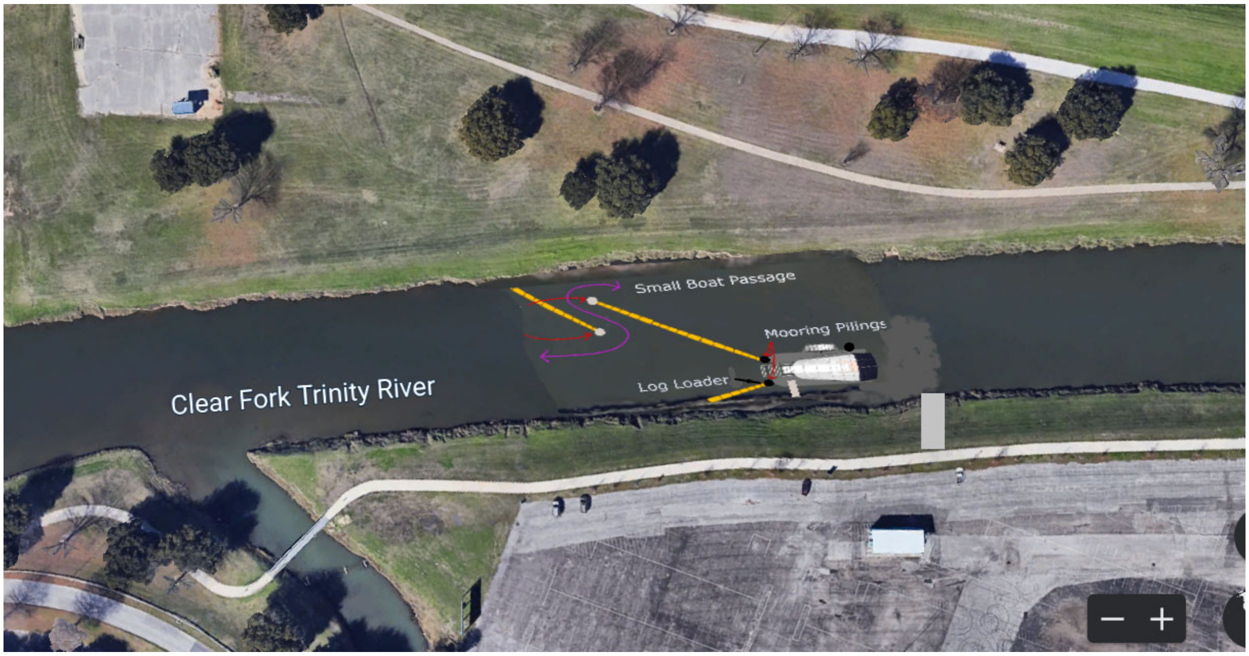
Storm sewers and feeder streams carry runoff to the waterway and on downstream. Floating trash booms are utilized to guide the trash to the machine. Here the Waterwheel Powered Trash Interceptor uses the river's current, supplemented by solar powered pumps to power a hybrid waterwheel. This wheel is then used to power a conveyor which lifts debris from the river and deposits it into a dumpster. The dumpster is located on a separate barge which can be pushed to a boat ramp or other transfer facility, where it is emptied or replaced by a standard trash hauling vehicle.

1.3 Benefits of the System

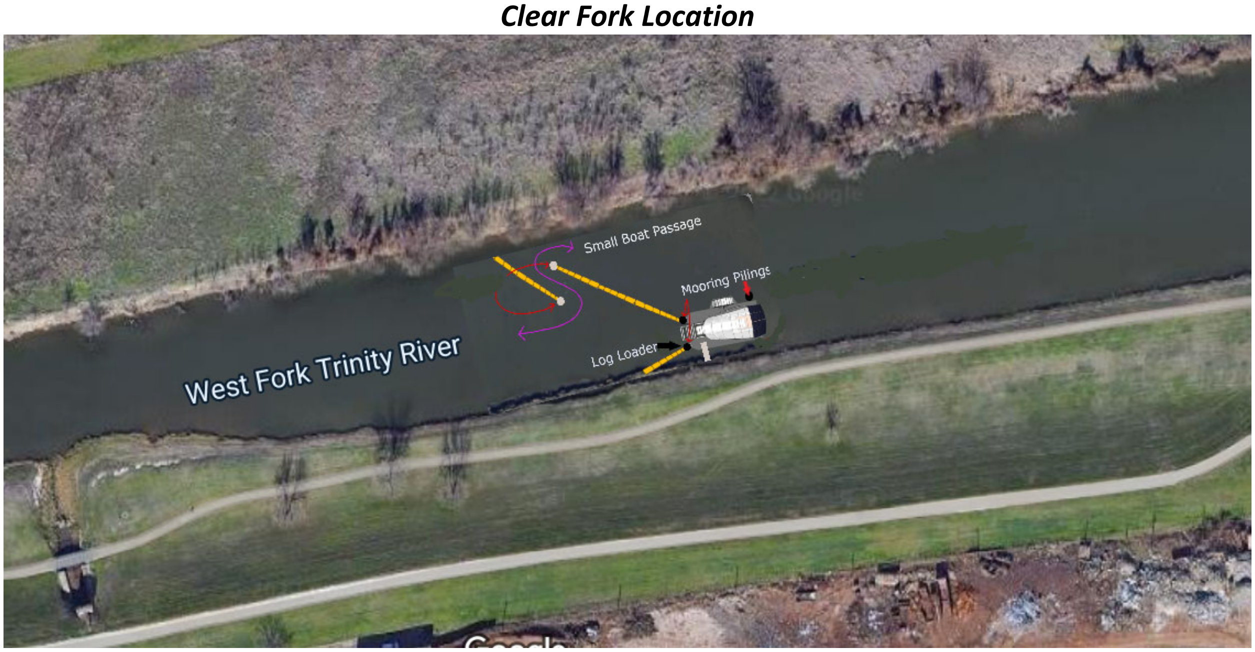
- On-demand collection of floating trash and debris
- Capable of continuous operation
- Low operating costs
- Uses renewable power sources
- Does not require specialty service equipment or disposable refuse containers
- Facilitates analysis of quantity and composition of floating pollution
- Attractive means for addressing an unsightly problem
- Provides an ongoing demonstration of the effort to achieve a healthy waterway
- Provides an educational point of interest

1.4 Locations

In late 2020, a team consisting of representatives from Clearwater Mills LLC, The City of Fort Worth, TRWD and Enercon conducted a survey of potential locations for utilizing Waterwheel Powered Trash Interceptors within the city of Fort Worth. Locations were examined on Trinity River including the Clear and West Forks. It was determined that the waterways were well suited for Waterwheel interceptors and two locations were selected for installation design. The design criteria for each of these locations are very similar and almost all of the equipment and installation specifications are the same for both.



Clear Fork Location



West Fork Location

Section 2 Design Criteria, Constraints and Loading

Overview

The Waterwheel Powered Trash Interceptor is an innovative technology and, in many ways, a unique piece of equipment that is successfully addressing a serious global problem in a manner that has not been attempted before. As such, the WPTI falls outside of most local design codes and specific categories, and yet incorporates elements of multiple engineering disciplines including water resources, marine, mechanical, environmental, structural, solar and electrical. In designing our systems, including for Fort Worth, Clearwater Mills LLC has relied on a variety of design standards as guides and utilized the recommendations of experts from diverse fields. Perhaps most importantly, Clearwater Mills has years of experience in designing, fabricating, installing, operating and maintaining marine equipment, including several Waterwheel interceptors. We are continuously using this experience to continue to develop designs for equipment that is durable, cost effective, user friendly and attractive. The Waterwheel interceptors we have constructed have proven to withstand extreme conditions including record flooding, high winds, heavy snow, and impact from large objects. They have proven effective at capturing and removing stormwater pollutants ranging from oil and cigarette butts to logs weighing in excess of 1000 pounds. The same award-winning design and construction standards will be used in Fort Worth only modified where necessary for the scale and conditions present at this location.

2.1 Environmental Criteria

Available data about the environmental conditions at the project location and within the watershed were used to inform the design of the Trash Wheel for each of the two Fort Worth locations. The environmental considerations include:

- Flow data for the river in storm events and dry periods, including velocity and flow rate
- Watershed area
- Watershed characteristics including topography and land use
- Water depths over the full river stage range
- Solar potential and orientation
- Prevalence of tree fall debris

Studies and reports provided by TRWD, the site assessment, reconnaissance done by Clearwater Mills and Enercon, as well as online resources were utilized in the design of the equipment and installation.

2.2 Geometric Constraints

The location, scale and specifications of the equipment were partially determined by the physical and topographical conditions at the site. Geometric constraints include:

- Width of channel
- Water depth
- Containment boom layout
- Accommodating an appropriate sized dumpster for the anticipated trash and debris load
- Underwater and shoreline features

2.3 Geotechnical Factors

After a geotechnical survey was conducted at each location, it was determined that the subsurface conditions will require drilling and casting of piles. This type of piling installation is significantly more complex than previous installations and will add substantially to the installation budget. The geotechnical report is included in the "Anchor Piling Analysis and Design Report" attached to this document.

2.4 Structural Loading Criteria

The Waterwheel Powered Trash Interceptor and its component parts are designed to provide longevity, stability, functionality and attractive aesthetics in a harsh marine environment subject to loading from a variety of sources. These loads include:

A. Weight of equipment and structures
    - Floating platform – 43,500 lbs.
    - Conveyor – 3,200 lbs.
    - Waterwheel – 1800 lbs.
    - Drive system – 700 lbs.
    - Batteries, boxes and wiring – 2,700 lbs.
    - Covering Structure and solar panels – 4,200 lbs.
    - Brackets, supports, rakes and winches – 2,500 lbs.
    - Pump system and controls – 800 lbs.

B. Current from streamflow- The current from streamflow loading is a function of current velocity, and is used in the analysis to produce the mooring piling specifications.

C. Wind- simplified wind load tests were performed on the covering structure. A standard of 80 knot wind load was used as a test basis. The assembled covering structure was test loaded to 15% more than the anticipated wind load with no yield. The covering structure will be essentially the same structure using the same build specifications. Wind loading on the Trash Wheel will have an effect on the structural loadings, e.g., piling design and connections bracket design.

D. Snow- Snow load was also simulated on the covering structure with no yield.

E. Ice-The machine will need to be monitored in sub-freezing temperatures to ensure ice buildup on moving parts and on deck is controlled. Ice loading will be considered in the structural analysis and piling design.
F. Debris impact- The potential for damage due to impact from floodwater-carried debris is nearly eliminated due to the shape of the bow front, the angle of the conveyor, the positioning of the mooring pilings and the construction of the exposed surfaces. Floating tree fall debris will be considered in the structural analysis and piling design.
G. Live Loads- The effects of vertical live loads on the design waterline and on the center of gravity for an operational Trash Wheel are negligible and transient, mostly as the result of people servicing or otherwise visiting the machine. Regular monitoring and servicing may be done by either one or two people. A practical maximum number of people to visit at once is probably on the order of 8-10. Live vertical loads from high winds or waves breaking over the machine may be experienced on a transient basis, and the machine is capable of brief submergence without harm. The other machines of this design in operation have experienced these loads to negligible effect on both the operation and on the stability.

2.5 Application of Loading

Despite the fact that the Trash Wheel is unique in its application, most of its component parts are commonly used in industrial and maritime applications where they are exposed to similar or greater loading. The specifications used for our components are in many cases based on these tried-and-true designs and developed in consultation with experts in their fabrication.

The waterwheel, for example, is based on designs that have been in use for centuries and the specifications were developed in consultation with The Waterwheel Factory which has designed, fabricated and installed hundreds of successful waterwheels.

The American Bureau of Shipping (ABS) rules for ship and barge construction were utilized in the design of the floating platform and dumpster barge. ASTM, manufacturers' specifications and industry standards as well as the experience of Clearwater Mills were used to determine component specifications and capacities. All of these specifications include a very conservative factor of safety.

2.6 Anchor Pile Design Loads

A complete analysis and design was conducted for the anchor piles and a complete report with the calculations is attached. This analysis revealed that the site conditions at both West Fork and Clear Fork are significantly different from previous trash wheel locations. Both the piling size and method of installation are substantially greater in scale and complexity for these locations.

2.7 Material Specifications

The materials for each component were selected based on their characteristics relevant to the suitability to their application. In most cases strength was a primary concern but corrosion resistance was also a priority particularly for materials in high exposure and in-water applications. The materials selected are included in the component descriptions. Their strength and other properties are readily available in engineering reference handbooks.

2.8 Operating Design Criteria

The Waterwheel Powered Trash Interceptor is designed to be capable of operating in almost all conditions expected to be present at this location, including low flow. Only when the stream is iced-over will the machine be inoperable, though it is designed to survive the ice.

The pump system includes multiple separate pumps in order to provide flexibility in power usage, redundancy for pump blockage or failure and ample power availability for removing heavy debris loads quickly. The solar panels and batteries were selected to provide 72 hours of continuous run time with no sun and a 16-hour full recharge recovery time in full sun. The remote monitoring and control system permits effective power management.

2.9 Service Life

The Trash Wheel is designed to provide many years (20+) of service with proper maintenance. Some relatively inexpensive parts will require replacement at the following intervals:

- Drive belts- 4000 hrs. or 2 years
- Pumps – rated for 2000 hrs. (In practice the service life has averaged almost twice the rating.)
- Containment booms 2-5 years
- Batteries – approximately 3 years
- Conveyor chain - approximately 5 years

Deck and hull coatings are industrial/marine grade epoxy *(Amercoat 235 or equivalent applied to a minimum16 mil thickness)* selected for maximum service life, and are generally expected to last 10 years or more. However, in the harsh conditions that the WPTI experiences, coatings may have to be renewed at more frequent intervals.

Section 3 Equipment and System Descriptions and General Specifications

3.0 General Description

The Trash Wheel uses all renewable energy to collect and remove trash and debris from stormwater runoff. The waterwheel powers a ladder type conveyor that is submerged on the upstream end. Containment booms guide the debris to the conveyor which lifts it from the water and deposits it into a dumpster. The equipment is mounted on a floating platform that is held in place by pilings. A covering structure is designed to support the solar array while allowing for adequate solar exposure, provides protection from the elements for equipment, and helps prevent trash from becoming wind-blown. The covering structure is designed to enhance the aesthetics as well as display the operation of the Trash Wheel. A standard sized dumpster is located on a separate small barge which can be pushed by a service vessel to a transfer point for disposal The power to turn the waterwheel is generated from the flow of the waterway and from solar panels mounted on the covering structure. The solar electricity generated is stored in batteries and is used to pump water to turn the waterwheel when the river flow does not provide sufficient power.

Figure 1 illustrates the primary components.

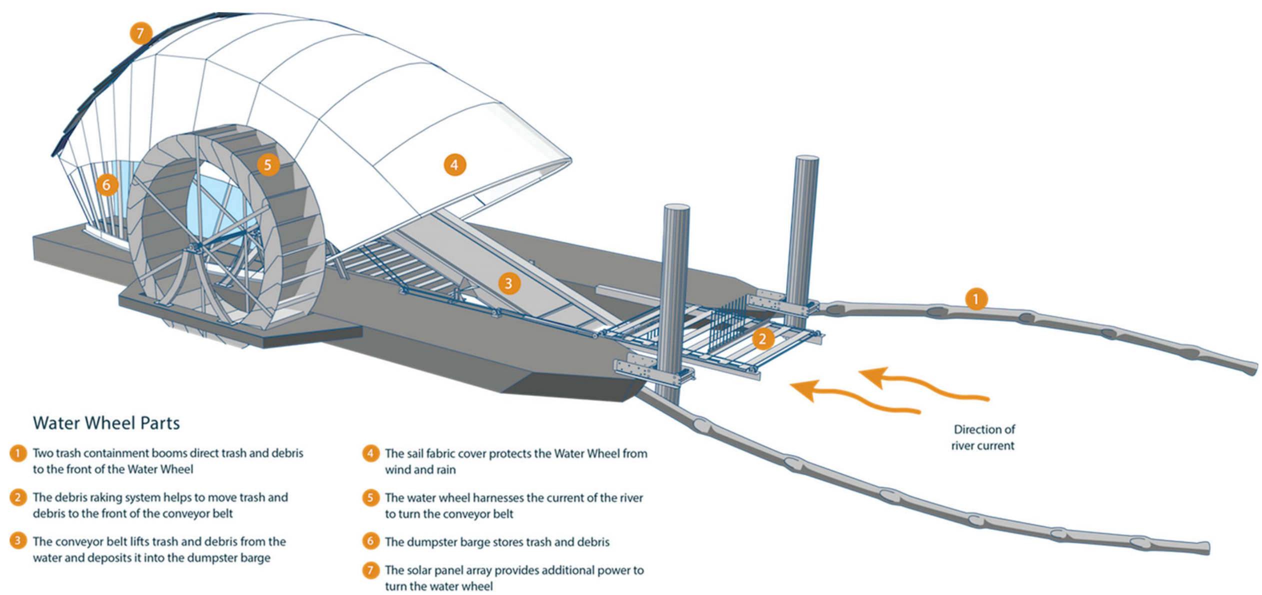


Figure 1

3.1 Floating Platform and Dumpster Barge

All of the equipment and covering structure of the Trash Wheel is mounted on and supported by a sectional steel barge floating platform with the exception of the dumpster which is on a separate barge for transport to a shore-side transfer facility. The dimensions and structural design of the floating platform have been selected for the location and its estimated debris load. The trash and debris load was estimated based on research conducted by Clearwater Mills for this location.

The amount of trash and debris carried by stormwater to an outfall is highly variable and dependent on a number of factors including:

- Size of the watershed

- Land use within the watershed
- Nature of streambanks and buffer zones
- Amount and intensity of precipitation
- Length of time between storm events
- Solid waste management within the watershed i.e., street sweeping, trash collection system, inlet screens etc.
- “Hotspots” such as illegal dumping areas

Figure 2 and plan drawings illustrate the dimensions, layout and design of the floating platform.

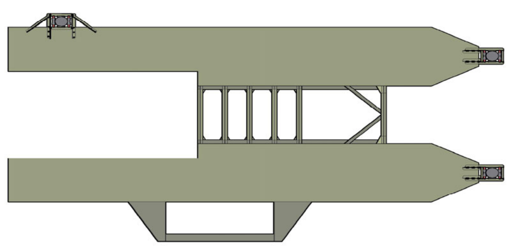


Figure 2

Floating platform: 24’ x 52’

The criteria dictating the design and specifications of the platform are:

- Provide sufficient buoyancy to support the equipment and structures at the proper elevation above the waterline.
- Provide lift under high flow conditions associated with storm events to counteract downward forces on the conveyor.
- Provide free flow of water past the conveyor and the waterwheel to ensure adequate trash loading and maximize hydro power.
- Provide the lateral and longitudinal strength necessary for a stable structural mounting surface under varying stress and load conditions.

In order to achieve these design criteria, epoxy coated steel hull pontoons with planing bow fronts are utilized. The pontoon hulls are compartmentalized with two watertight bulkheads per pontoon forming three watertight compartments. The starboard and port pontoons are linked by steel trusses providing an 8'wide conveyor flow channel.

In order to create a mooring bay that is 12' wide and 16' long for the dumpster barge, the pontoons are narrowed from 8' to 6' wide in the stern section.

Floating Platform Specifications:

- Pontoon Hull Sections 8' W x 52' L x 40'" D
- Two pontoons are raked one end
- Three (3) compartments each section with three (3) flush watertight hatches
- Two internal bulkheads welded in each pontoon.
- ASTM A36 1/4" low carbon steel plate throughout. All seams welded inside and out below the deck plate
- Transverse frames on 24" centers: 3" x 3" x 1/4" angle
- Longitudinal angles under deck on 18" centers: 3" x 3" x 1/4" angle
- Exterior angles, 6" x 6" x 3/8" angle, on one side, top and bottom
- Interior painted with one coat of gray epoxy
- Deck painted with two coats gray epoxy with a non-skid additive
- Barge coated with two coats black marine epoxy
- 4 20# zinc anodes stud mounted below waterline on each pontoon barge for cathodic protection

Waterwheel Support Bracket:

- 1/4" plate steel frame bolted to the starboard pontoon to support the waterwheel and main drive shaft

Dumpster Barge: 11'-6" x 20' x 36"

- Two (2) compartments each section with two (2) flush watertight hatches
- One bulkhead welded in each barge
- ASTM A36 1/4" plate throughout. All seams welded inside and out below the deck plate
- Transverse frames on 24" centers: 3" x 3" x 1/4" angle
- Longitudinal angles under deck on 18" centers: 3" x 3" x 1/4" angle

3.2 Mooring Pilings & Mooring Attachments

Mooring Pilings: The floating platform is held in place by three pilings.

Mooring Piling Specifications: Mooring piling specifications and calculations are included in Attachment #1.

Mooring Attachments: The floating platform is attached to the pilings utilizing custom fabricated attachment brackets. These attachments are designed to provide a secure mooring under all flow and wind conditions and permit the free vertical movement of the floating platform at all water levels.

Figure 3 illustrates the mooring attachments, dimensions for the attachments are shown are typical, final dimensions will be included with mooring specifications and calculations.

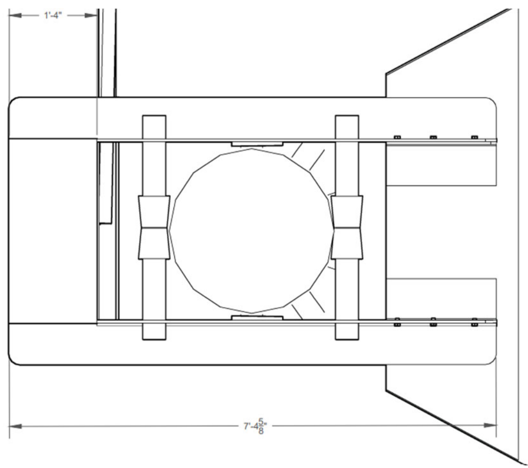


Figure 3

Attachment Specifications:

- Bracket Arms – 8"x22" hot dipped galvanized steel angle
- Mounting Bolts (12/bracket) – ¾" hot dipped galvanized hex bolts
- Roller Pins (4/bracket) – 4" hot dipped galvanized bar
- Rollers – 6" diameter polyethylene

3.3 Dumpster

The dumpster for the WPTI will be sized to fit the application.

One significant advantage that the Waterwheel Powered Trash Interceptor has over other trash interceptors is that it does not contain trash and debris in the water, it collects and removes the trash from the water. Removing trash as it comes reduces "damming," backups, system overloads, and facilitates the disposal process. The system deposits trash and debris in a refuse container (dumpster) out of the water where it is out of sight and allowed to drain through drain holes in the bottom. The dumpster is positioned on a dumpster barge which can be easily pushed to a transfer facility for removal and disposal.

Dumpster specifications

Construction – epoxy coated 3/16" steel
Dimensions – 16'x8'x4'10"
Capacity – 15 cubic yards
Configuration – cable hoist, roll-off transport

3.4 Waterwheel

The purpose of the waterwheel is to convert power from renewable sources into mechanical energy and transfer it to the conveyor and rake system to remove trash and debris. The waterwheel is designed as a "hybrid" wheel to effectively use two different sources of energy. First the wheel operates as an undershot or Poncelet wheel to produce mechanical power from the flow of the river. Secondly, the waterwheel is designed as a backshot wheel to effectively utilize the energy produced by the solar panels and the pump system . The waterwheel is mounted on the outboard side of the pontoon on the waterwheel support brackets and framework. This mounting position allows for the unobstructed flow of water to the wheel and enhances the equipment aesthetics.

Waterwheel Specifications:

- Construction – Precision-machined steel plate, welded into sections bolted together around a steel drive shaft.
- Dimensions:
  - Diameter – 14'
  - Width – 3'
  - Number of buckets – 21
  - Shaft Diameter – 3"

3.5 Conveyor

The conveyor is designed to be submerged to a depth of 24" on the upstream end. It is supported by a brace and pivot system to allow for easy service and maintenance. The conveyor drive system is composed of steel, corrosion resistant steel, and stainless steel components including upper drive shaft, chain sprockets, shaft collars, chain, and shaft bearings. The lower drive shaft is designed to allow the proper movement of the chain and paddles in a submerged environment. Proper chain tension is achieved through adjustment of the upper drive shaft bearing take up frames. When conveyor capacity is exceeded drive belt slippage occurs. Drive belt tension will be adjusted to achieve this limit. This will prevent damage to other components which are rated for higher loads.

Conveyor chain (Fig.4) is ANSI #60 corrosion resistant treated steel. Conveyor paddles are 3” stainless steel angle connected to the conveyor chain with K-1 type connecting links. (Fig.5)

Conveyor Chain (Fig.4)

Chain-Paddle connecting link (Fig.5)

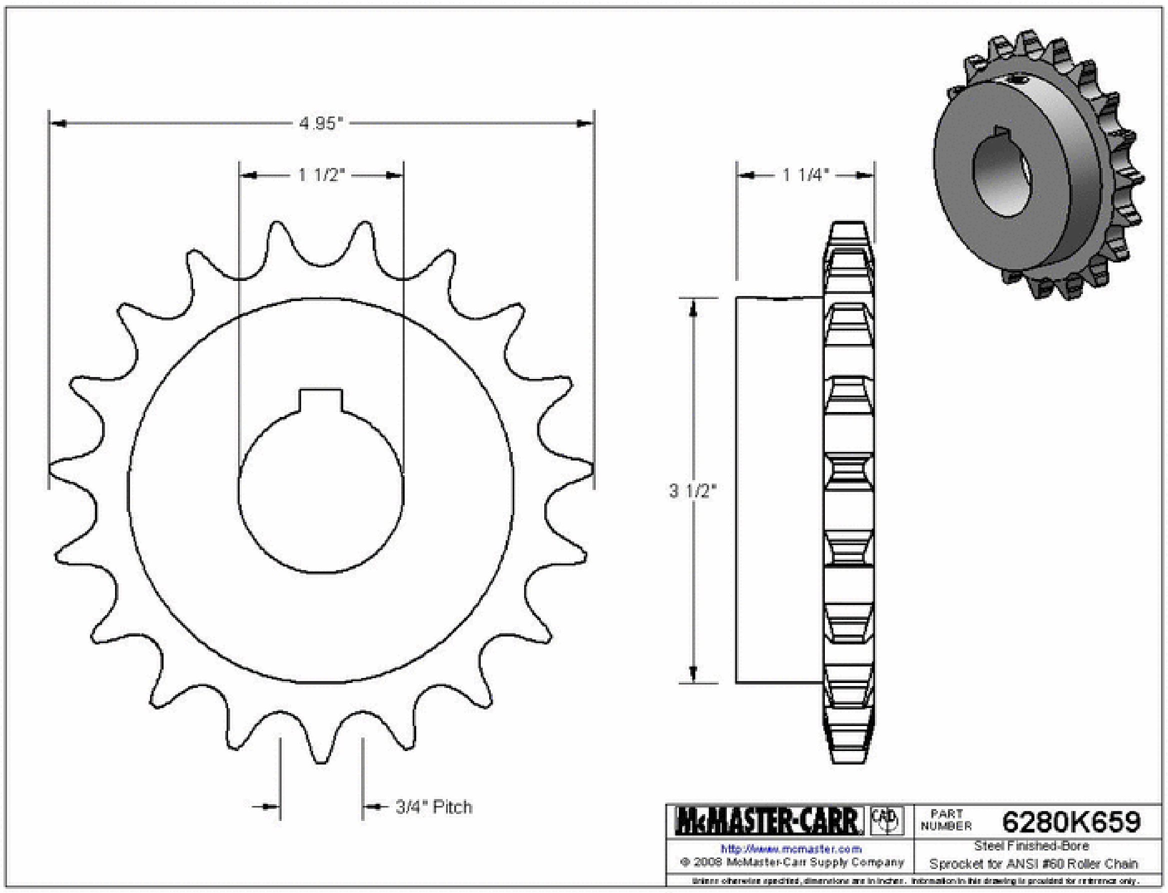


Fig.6

Conveyor Drive Sprockets (4) shown in (Fig.6) are used on the upper and lower shafts to drive the conveyor chain.

Conveyor bed is fiberglass coated plywood fastened to the steel conveyor frame with stainless steel screws.

Conveyor Frame – The conveyor frame is constructed of 2 sections of welded 3/16” galvanized steel.

Conveyor Lower End Debris Guard Systems – The guard system ensures proper loading of the conveyor and prevents debris from interfering with conveyor drive components.

Service of the lower conveyor end is accomplished by using the conveyor pivot system to position the conveyor in its service position removing hood nuts, removing hood, cleaning all components, lubricating lower bearings, replacing hood and re-securing hood nuts.

Conveyor Sides – The functions of the conveyor sides are to:

1. Contain debris on the conveyor
2. Protect the chain from debris

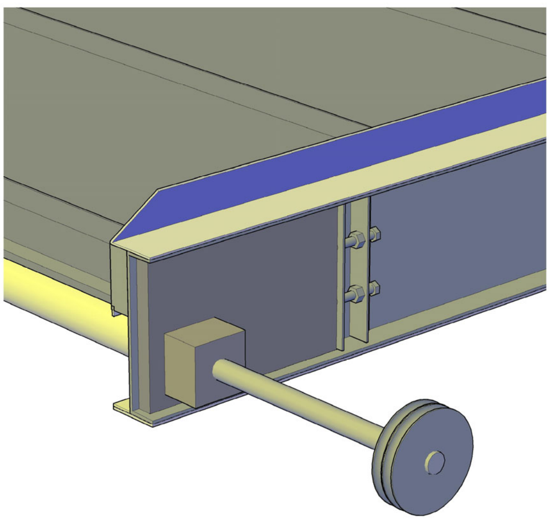


Fig.7

Conveyor Specifications

- Length – 38’
- Width (overall) – 6’
- Depth upstream end below Design Water Line – 24”
- Height downstream end above DWL – 9.5’
- Capacity – 1400 lbs.
- Chain – ANSI #60
- Constructed of 3/16” galvanized steel frame and fiberglass conveyor bed

3.6 Power Transmission

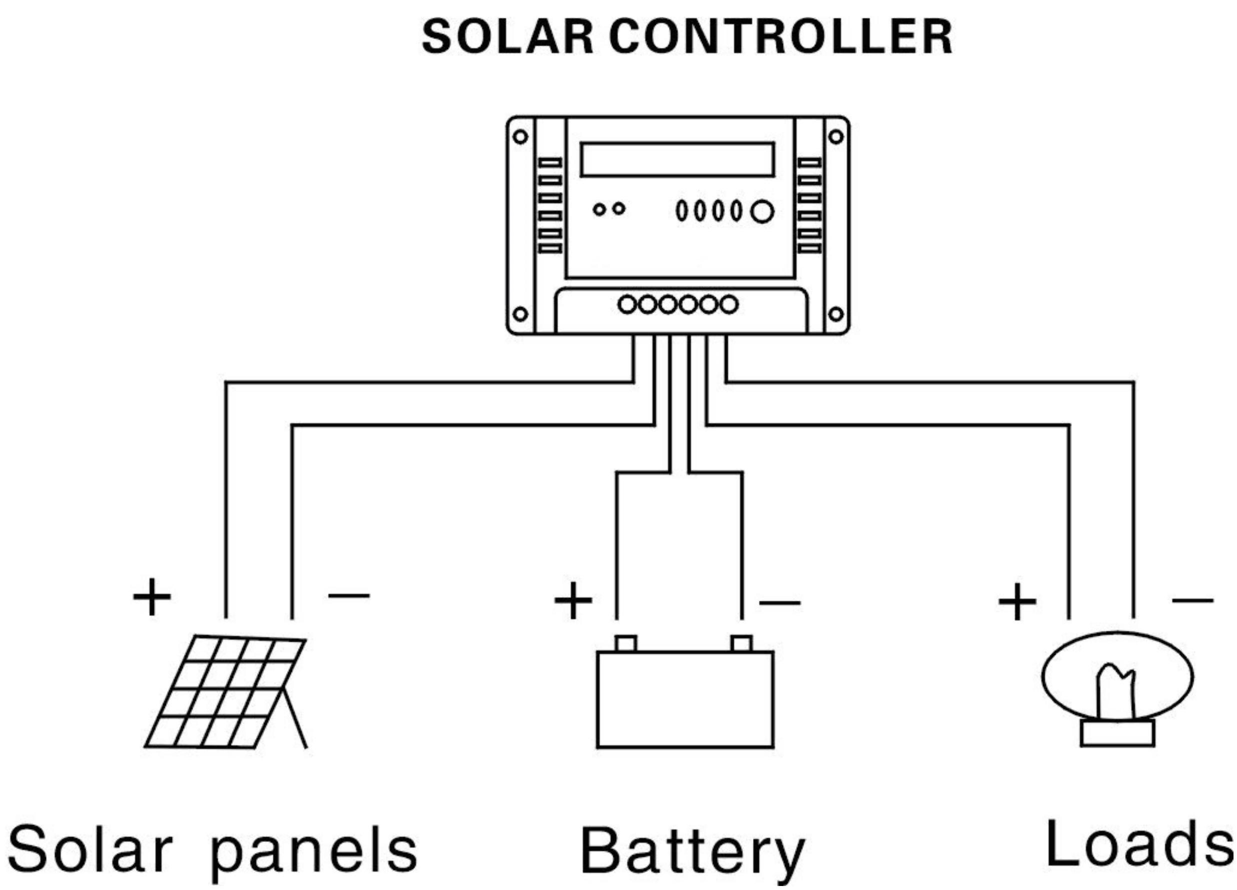
The power generated by the rotating waterwheel is transferred to the conveyor through a system of gears, pulleys, shafts, bearings, and belts. Periodic lubrication of moving parts is required to prevent premature wear and corrosion.

3.7 Solar Power System

The solar power system (Fig. 8) serves the following purposes:

- Provides electrical power to the pump system to pump water to the waterwheel to turn the wheel and produce mechanical power for the conveyor and rake system.
- Provides power for the remote control and monitoring system.
- Provides power for lighting and accessories.

Fig.8



3.7a Solar Panels - The solar power required for these purposes is generated through an array of solar panels mounted on the covering structure.

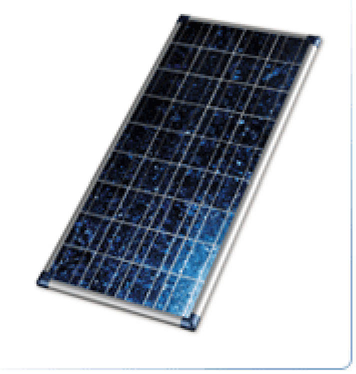


Fig.9 Solar Panel 21”w x 47”h

Solar Panel Specifications:

- Minimum rated array output – 7,000 W

3.7b Solar Powered Control Center - Provides automatic charge control, battery condition monitoring, charge level monitoring and voltage regulation. The charge controllers are housed in an electrical enclosure.

Specifications:

- Voltage –12/ 24 V dc
- Display – multi function digital/led.

3.7c Batteries – store solar electric power for use in all electrical systems including pumps, monitoring, lighting, controls and log lift. Batteries are housed in enclosures on deck.

Specification:

- Voltage – 6 V
- 70Ah @ 20 min
- Duty – deep cycle
- Type – lead acid
- Minimum number of batteries – 36

3.8 Pump System

This system pumps river water into the buckets of the waterwheel. The weight and the momentum of the water in the buckets causes the waterwheel to turn. In this manner, electrical energy generated by the solar voltaic panels and stored in the batteries is converted into mechanical power to power the equipment. The pump system consists of 10 -3600 gph submersible pumps connected to a discharge near the top of the waterwheel. Pumps are housed in a screened intake compartment below conveyor. The pumps are mounted below the waterline with sufficient clearance above the bottom of the floating platform to prevent material from the bottom from being taken in at low water conditions.

Specifications:

- Pump capacity @ 0' – 3,600 gph
- Pump capacity @ operational elevation – 2,500+ gph (field test)
- Discharge elevation - +8' DWL
- Operation Settings – remote & manual
- Intake – Dual filter submersible
- 10 Required

3.9 Remote Monitoring and Control System

A key benefit of the Trash Wheel is its ability to contain, collect and remove trash and debris from stormwater during and immediately following storm events. In order to maximize this benefit, the Trash Wheel is equipped with internet-based remote monitoring and control features. This system provides the following capabilities:

- Remote trash flow monitoring
- Remote system monitoring
- Remote system activation and control
- Many additional systems are compatible, including battery maintenance, power monitoring, sensors, alarms, and automation.

The system consists of:

- 1 on-site monitoring camera
- 1 onboard computer control center w/ relay control board
- Network interface
- Control software

Fig. 10 Cameras

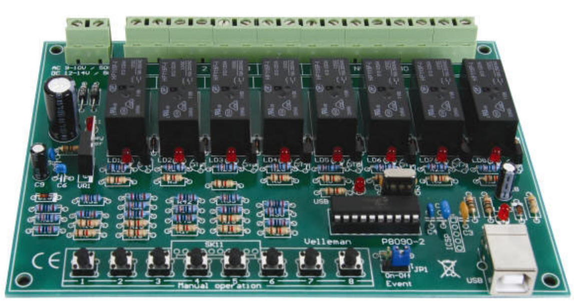


Fig. 11 Relay control board

3.10 Power Rake System

The purposes of the power rake system (Fig. 11) are to facilitate loading of the conveyor and to turn and guide larger objects as they approach the conveyor. The power for the system is transferred mechanically from the waterwheel through a system of belts, pulleys, shafts, bearings, sprockets, and chain.

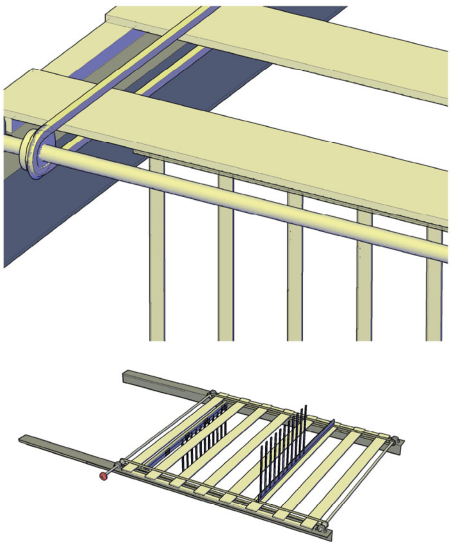


Fig. 12 Power Rake System

Description: The power rake system utilizes spring loaded, offset rakes, mounted on a framework directly above and in front of the loading area of the conveyor. In this area, the trash booms concentrate and contain the stormwater-carried debris. The rakes travel through this catchment area, break up the pile and push trash onto the conveyor. The spring hinges on the rakes prevent jamming and overloading.

Specifications:

- Rake width: 36”
- Rake length: 22”
- Tines/Rake: 64
- Spacing: 2’ on center
- Rake travel: 10’
- Approximate travel rate: 24 ft/min.
- Rake chain: ANSI #60 corrosion resistant steel
- Bearings: Polymer housed self-aligning
- Sprocket: 7” diameter
- Drive: single V belt

3.11 Covering Structure

The purposes of the covering structure are to protect the equipment, prevent wind from blowing trash off the conveyor, to house the dumpster and dumpster barge, provide support and orientation for the solar array, and to improve the aesthetics of the equipment. The award-winning design team of Ziger/Snead Architects has developed the character of the covering structure.

3.12 Trash and Debris Containment Boom System

The containment boom system is designed to effectively guide trash and debris to the catchment area. The booms run at an angle from the stream banks to the machine forming a funnel to the conveyor. The containment boom consists of encapsulated floatation units which form a barrier for floating debris and a ballasted curtain which is a barrier to submerged debris.

The longitudinal strength of the boom is enhanced by a hot dipped galvanized 5/16" chain at the top and a ballast chain at the bottom of the curtain. Reinforcing attachment plates are utilized at each end to attach the booms to the pilings at the interceptor and upstream anchor points. A boom section extends from the mooring piling to the conveyor side to guide debris onto the conveyor.

For both Fort Worth locations, installation of a 12 ft. "kayak gate" will be provided in the boom installation by providing 2 additional boom anchors with buoys on one side of the machine.
The containment booms can also be equipped with solar-powered LED marker lights to as an aid to navigation at night.

Solar Marker Light

3.13 Log Loader system

At both Fort Worth locations, large organic and manmade items are present in the stormwater runoff and some of these items are either too large to easily pass up the conveyor or too long to fit in the dumpster. In order to handle these items, the machines are equipped with a hydraulic log grapple that is mounted on the upstream end of the shoreside piling bracket. A gas-powered hydraulic power unit is mounted on the deck to power the grapple. Controls are pedestal mounted at the bow of the port pontoon where the operator can utilize the grapple to remove large items. The system is illustrated in the attached drawings.

3.14 Safety tethering system

The Fort Worth locations are susceptible to extremely large rises in water surface elevation in historic flood conditions. It is possible, that extreme flooding could cause the river level to rise above the top elevation of the mooring pilings allowing the Waterwheel Powered Trash Interceptor to float free of the pilings. In this rare circumstance, an emergency tether system has been designed to prevent the device from going downstream. Cables link the bow of each pontoon to a concrete mooring block on the bank of the river. In an extreme high-water condition, these cables would allow the machine to swing out of the main flow of the river and towards the riverbank where it would settle as the floodwaters recede. After the event, the machine could be reattached to the mooring pilings.

Section 4 - Service Equipment and Facilities

4.1 Monitoring Equipment

The following equipment will be provided to monitor the equipment and environmental conditions:

- Video monitoring cameras
- Monitoring and control software

4.2 Dumpster Transfer Facility

The simplest method for transferring dumpsters to land for disposal and replacement with empty containers is to utilize a boat ramp facility. At a boat ramp, a dumpster transport truck can remove the full container and replace it with an empty one without requiring any additional equipment.

Section 5 Operation & Maintenance

5.1 Safety and Security

The safe operation and use of the equipment is a top priority in the design of the Waterwheel Powered Trash Interceptor. However, all operations, repairs and visits to the equipment should be done in accordance with the following safety guidelines:

- All operators and service personnel should be qualified and trained in safety procedures before operating equipment.
- Stormwater may contain hazardous substances. No contact should be made with the equipment or collected debris without protective gloves.
- All persons should stay clear of moving parts while in use.
- All guards, supports, and fasteners should be in place while equipment is in use.
- All visitors must be accompanied by trained personnel.
- U.S. Coast Guard certified Personal Floatation Devices (PFDs) must be worn while on board the equipment or service vessel.
- Service and dumpster transport should not be attempted in extreme weather conditions.
- Precautions and mitigation measures should be taken to prevent spillage of lubricants and battery fluids. Batteries are stored in a spill containment area constructed of acid resistant material. When batteries are moved from this area precautions should be taken to prevent leakage.
- Lock out Tag out procedures are required when servicing moving parts or electrical equipment.
- Use of wheel brake bar is required when servicing moving parts
- Operation of the log loader system should only be done by trained equipment operators and all the safety precautions associated with the use of this type of equipment should be followed.

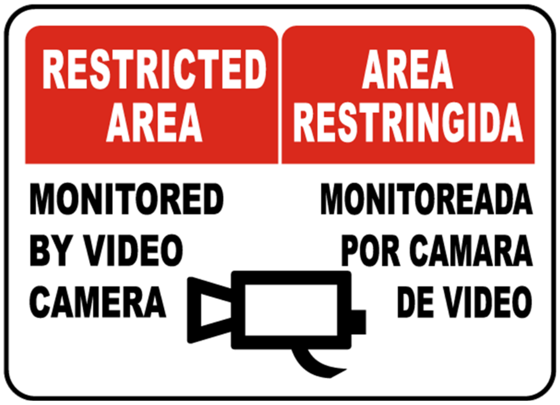
5.1.2 Safety and Security Signage and Barriers

The Waterwheel Powered Trash Interceptor is equipped with guards, barriers, and signage to protect operators, service personnel and visitors from hazards associated with moving parts, electrical components and collected material, as well as to provide warnings and protection against unauthorized entry or activities. It is important that these measures are in continuous use. It is also important to note that although these elements provide some protection, it is also necessary that all service personnel are trained and follow the safety guidelines and that all visitors are supervised and avoid the hazard areas.

Guards and Barriers- Guards and barriers will be provided where moving parts are present in access areas and could present mechanical entrapment hazards to service personnel or visitors. As is the case with many types of heavy machinery, it is not possible, however, to completely enclose all moving parts and safe operating and access procedures are required. The guards and barriers are shown on the plan sheets.

Signage

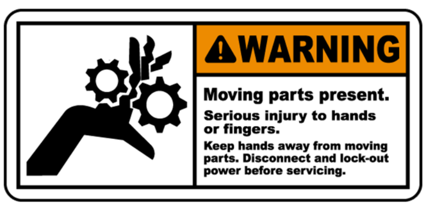
Signage warning of specific hazards and for access control is included as follows:



At access points (3)

At waterwheel and conveyor (2)

At electrical panel and battery box (2)



At power transmission area and conveyor sides (3)

5.2 Basic Operating Procedures

1. Complete System and Safety Check
2. Activate auxiliary power system using internet control or manual switch panel.
3. When dumpster is full, the dumpster should be removed.
4. To change dumpster, shut down auxiliary power and disengage conveyor clutch.
   a. Secure push boat to dumpster barge. Lines should be tight.
   b. Release dumpster float docking lines.
   c. Back dumpster float out of float bay and push to boat ramp.
   d. Push float until its bow is solidly contacting ramp – dumpster can now be emptied.
   e. When dumpster is repositioned on float, ensure that it contacts side and aft docks.
   f. Return to dumpster bay and re-secure dock lines.
5. Perform system safety check after dumpster is secured in position.

System Check

Before operating system ensure that:

1. Dumpster float is properly secured.
2. Dumpster is properly positioned and has sufficient reserve capacity.
3. Conveyor supports are secured.
4. All guards and safety barriers are in place.
5. All moving parts are free of obstructions, and all personnel are safely clear of machinery.

When these steps are taken the conveyor can be engaged, and auxiliary power can be utilized if required.

5.3 General Maintenance Requirements

The Trash Wheel is designed and constructed to withstand the rigors of a harsh environment and provide years of reliable service. As with any equipment, proper maintenance is required to ensure dependable performance and longevity. Maintenance should be performed by qualified trained personnel to ensure proper service and the safety of technicians.

The general maintenance requirements are broken down by prescribed frequency.

- Daily – Monitor weather and river conditions. Check dumpster level.
- Weekly and after storm events – Inspect equipment making sure that all moving parts are free of debris and obstructions. Check belt and chain tension and adjust if necessary. Inspect pump well and intake and clear obstructions if present. Check battery condition and charge status. Check solar panel output.
- Monthly : Clean trash boom curtain
  Conveyor Service – Pivot conveyor to service position by removing support bracket bolts and lowering chain hoists until conveyor is level. Remove conveyor lower end hood. Clean and inspect conveyor lower end drive assembly. Lubricate lower shaft bearings with marine grease. Replace hood ensuring that all retainer bolts are secured with lock washers in place. Return conveyor to the in-service position and secure support bracket bolts. Check drive belt tension and adjust if necessary. Lubricate upper drive bearings with marine grease. Lubricate conveyor drive chain with marine grease.
  Power Transmission Service – Lubricate all bearings with marine grease including:
    - Waterwheel main shaft bearings (2)
    - Reversing gear shaft bearings (2)
    - Belt tensioner shaft (2)

Lubricate main gears with marine grease.
Power Rake System –

- Lubricate rake drive bearings (4) with marine grease
- Apply grease to drive chain and sprockets
- Check belt and chain tension and adjust if necessary

Batteries – test battery condition and check cell levels.
Solar Panels – clean solar panels.

- Annually – Conduct a complete system survey and note any concerns or irregularities. System survey will include:
    - Solar array output analysis
    - Pump output test
    - Conveyor alignment check
    - Battery condition test
    - Solar controller test
    - Hull plate inspection
    - Chain condition inspection
    - Conveyor speed analysis in loaded and unloaded condition
    - Hoist system check, including complete cable inspection
    - Sacrificial anode inspection and replacement
    - Gear alignment
    - Bearing, keys and shaft inspection
    - Belt replacement

- Every 3 years:
    - Battery replacement
    - Renewal of above waterline coatings

- Every 5-7 years:
    - Haulout for hull inspection and coating renewal
    - Conveyor chain replacement

LITTER CONTROL & BEAUTIFICATION

Trinity River Waterwheels Initiative

Code Compliance – Environmental Quality Division

FORT WORTH®

KEEP FORT WORTH Beautiful
KEEP AMERICA BEAUTIFUL AFFILIATE

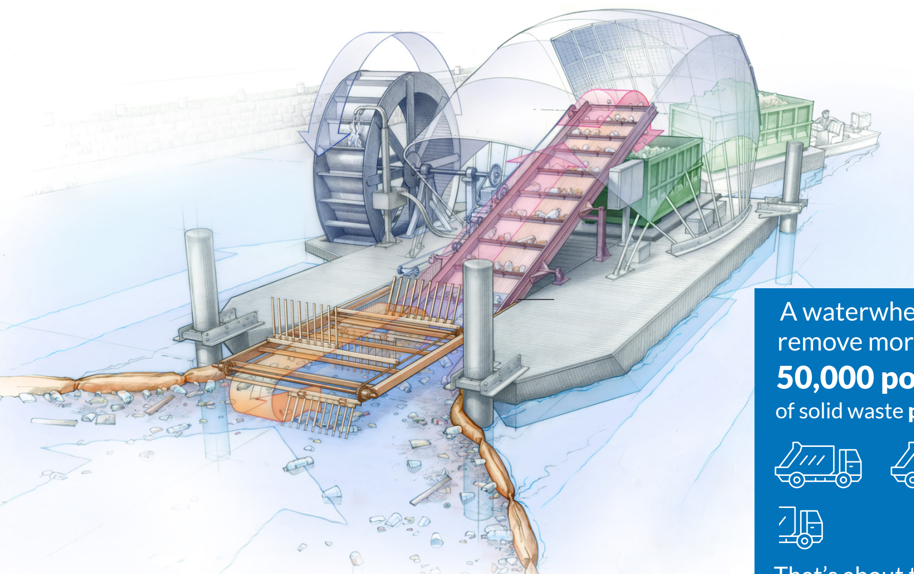
trwd Tarrant Regional Water District

Streams & Valleys

The City of Fort Worth is home to over 100 miles of trails along the beautiful Trinity River and its tributaries. We are all stewards of these natural resources in our community. To help protect these waterways, we have the opportunity to install two solar-powered litter control waterwheels to collect and remove trash and debris at a fraction of the per ton cost of other systems.

What is a Waterwheel?

A waterwheel is a pollution-control, wheel-based machine that is placed in flowing waterways to collect and remove floatable pollution.



The waterwheel measures 52' long, 24' wide with a wheel that is 14' in diameter and 3' wide.

A waterwheel can remove more than **50,000 pounds** of solid waste **per day**.

That's about the size of **2 ½** garbage trucks.

Important Waterwheel Highlights

The Waterwheel Powered Trash Interceptor collects and removes trash and debris at a fraction of the per ton cost of other systems:

- Uses all renewable energy, minimizing fuel costs
- Effectively contains and collects debris at a single point to prevent it from continuing downstream
- Uses reusable refuse containers (i.e., dumpsters instead of disposable nets)
- Incorporates high-quality construction for durability and low maintenance costs

Benefits of a Waterwheel

- Collects trash and litter from rivers and streams
- Improves the aesthetics and the usability of waterways
- Improves aquatic ecosystems for fish and wildlife
- Uses solar power – a sustainable energy source
- Provides an opportunity to educate the general public about the problem of pollution
- Inspires people to become a part of the solution to end litter

Importance of Protecting Our Water Quality

- Provides drinking water for Fort Worth and customers cities
- Supports efforts for economic development
- Contributes to positive community appeal, appearance and overall quality of life
- Provides habitat for aquatic life and recreation

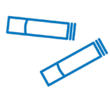
Projected Impact

Waterwheels are a proven, sustainable, lower-cost technology to clean our valuable Trinity River.

1,561 tons of trash and debris:

755,558
Plastic Bags

+



12,109,248
Cigarette Butts

+

1,278,972
Foam Containers

+

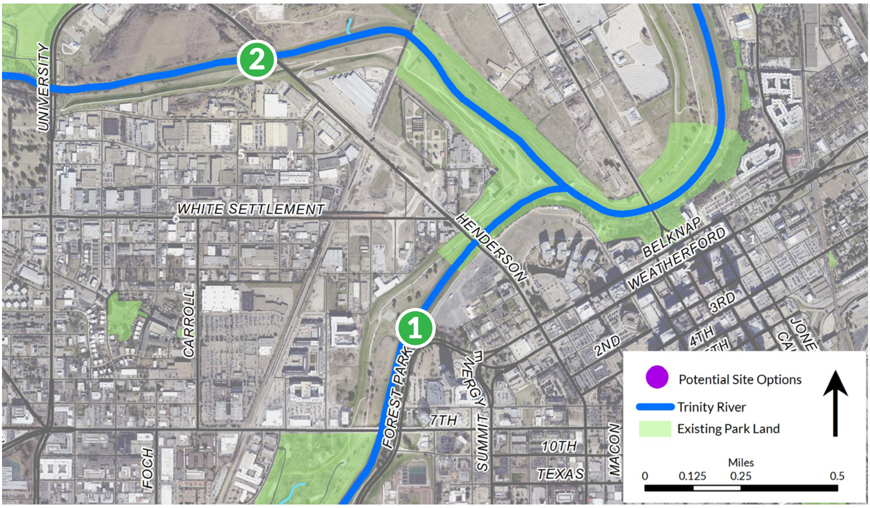
1,256,194
Plastic Bottles

*Approximated data excerpted from Baltimore, MD Healthy Harbor Initiative. For latest data, visit www.mrtrashwheel.com.

Waterwheel Locations

1 Purcey Street Outfall

2 Henderson Street Bridge



Installation & Maintenance Costs

- Cost per waterwheel: $597,000
  (2x) = $1.2 million
- Annual Operational Costs: Approximately $50,000
  Daily, weekly and monthly system checks with annual system audits.

How Can You Help?

There are many opportunities to support the waterwheels project. Thank you for your interest! Let's set a time to discuss ways you can get involved.

Contact Keep Fort Worth Beautiful: (817) 392-2046
KFWB@fortworthtexas.gov

Co-Sponsors

Keep Fort Worth Beautiful — Keep America Beautiful Affiliate
trwd Tarrant Regional Water District
Streams&Valleys

Waterwheel Sponsorship Levels

SIGNATURE DONOR (Donations up to $1,000)

- Thank you letter
- Invitation to the groundbreaking ceremony with name listed on printed event program
- Invitation to the opening ceremony with name listed on printed event program
- Name listed on the Keep Fort Worth Beautiful website

BRONZE ($1,000 - $4,999)

Signature Donor level plus:

- Logo on the KFWB website
- Logo on groundbreaking ceremony program
- Logo on opening ceremony program

SILVER ($5,000 - $9,999)

Bronze Donor level plus:

- Donor gift
- Logo on opening ceremony banner

GOLD ($10,000 - $49,999)

Silver Donor level plus:

- Booth at opening ceremony
- Quarterly metrics update

PLATINUM ($50,000 - $99,999)

Gold Donor level plus:

- Excerpt about company/organization on the KFWB website
- Photo opportunity with shovel at groundbreaking ceremony
- Logo on wheel signage
- Personal tour of waterwheel with KFWB board members

DIAMOND ($100,000 - $400,000)

Platinum Donor level plus:

- Branded quarterly metrics media pack for two years
- Branded placard on ground-level site marker
- Opportunity to speak at media events

TITLE SPONSOR (Donations over $400,000)

Diamond Donor level plus:

- Branding on the waterwheel

How to Donate

Become part of the litter solution with the Waterwheel Initiative for a cleaner Trinity River. Donating is simple and there are several options.

Keep Fort Worth Beautiful

501(c) Nonprofit organization

908 Monroe, 7th Floor
Fort Worth, Texas 76102

Email: kfwb@fortworthtexas.gov

Call: 817-392-2046

BY CHECK:
Make payable to Keep Fort Worth Beautiful.

ONLINE: www.fortworthtexas.gov/waterwheel

Streams and Valleys

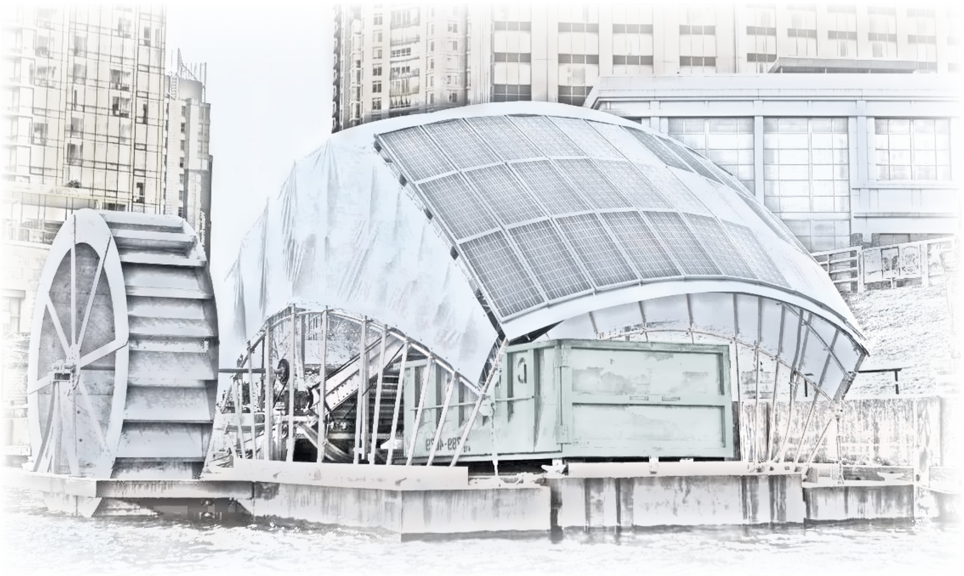
501(c)(3) Nonprofit organization

Email: info@streamsandvalleys.org

Call: 817-926-0006

Website: www.streamsandvalleys.org

100% of donations to Keep Fort Worth Beautiful go toward the Trinity River Waterwheel Initiative. All donations are tax-deductible.



Thank you for supporting Keep Fort Worth Beautiful and the Trinity River Waterwheels Initiative!

Photos and statistics courtesy of Clearwater Mills LLC. (2013) Clearwater Mills Sustainable Environmental Technologies.
www.clearwatermills.com

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