DMJ Engineering

Stormwater Utilization on NAU Campus

CENE 486C-Final Presentation: 7th December, 2018

Engineering Team: DMJ Engineering

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Client : Jon Heitzinger, NAU Facility Services

Project Information

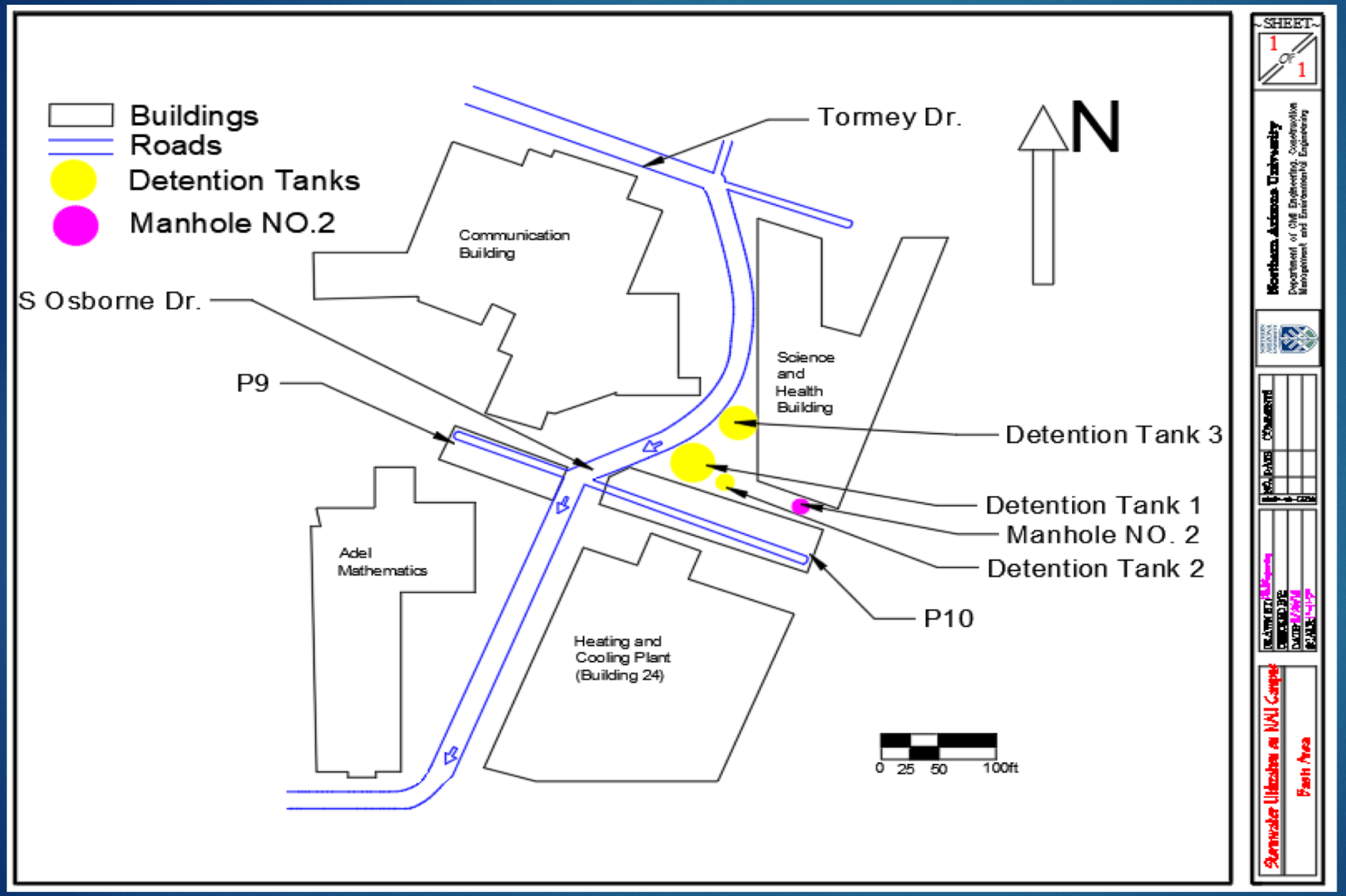


Figure 1. Location of the Underground Detention Tanks

Purpose: Utilize harvested stormwater from the three detention tanks to be used in the cooling process of the Heating and Cooling plant.

Process Schematic

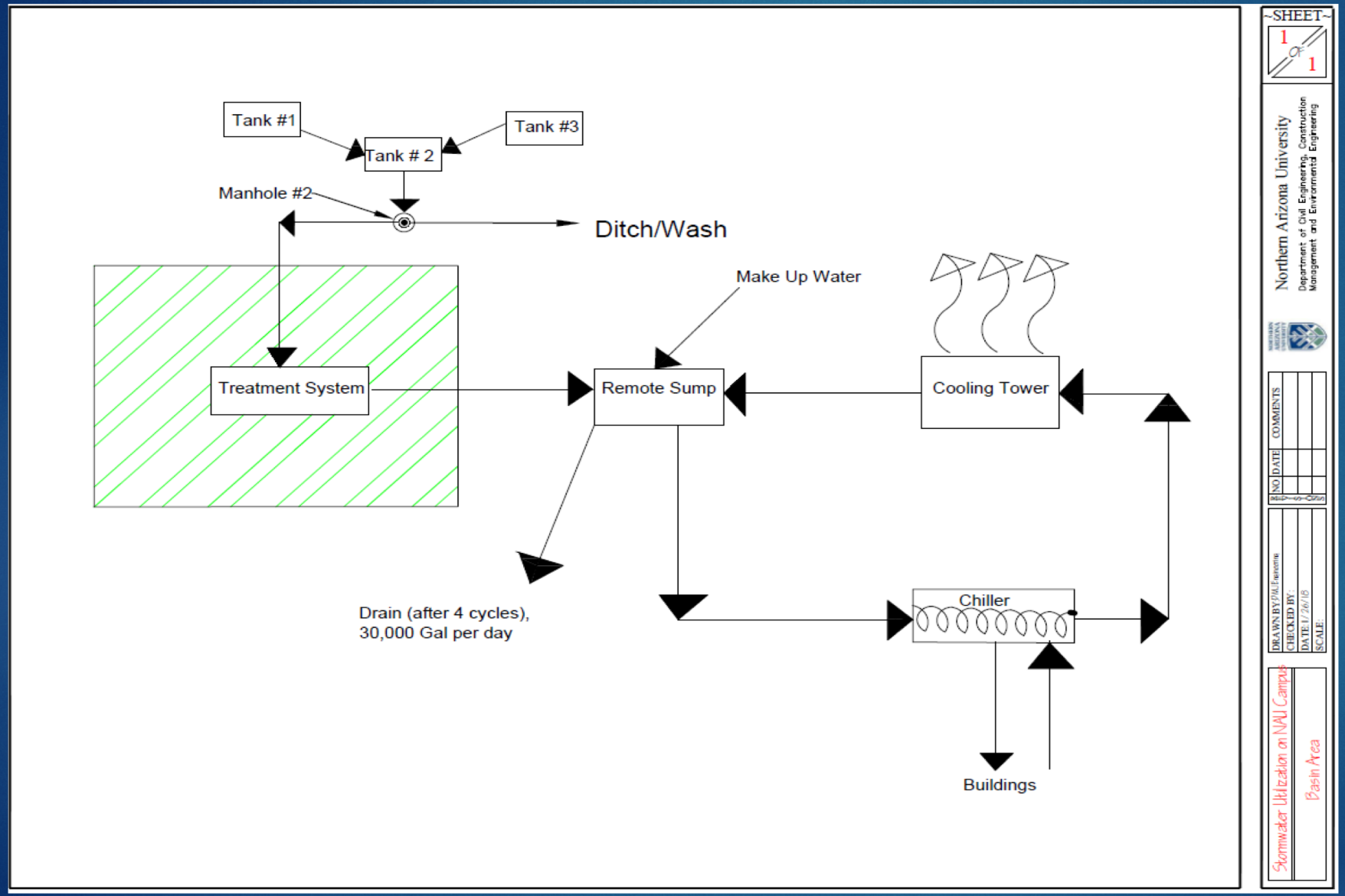


Figure 2. Block Diagram of Cooling System

Site Visit



Figure 3. Inside Tank 2
Taken by Dorshanna Coolie



Figure 4. Manhole 2
Taken by Dorshanna Coolie



Figure 5. Remote Sump in Heating and Cooling Plant
Taken by Dorshanna Coolie

Drainage Basin

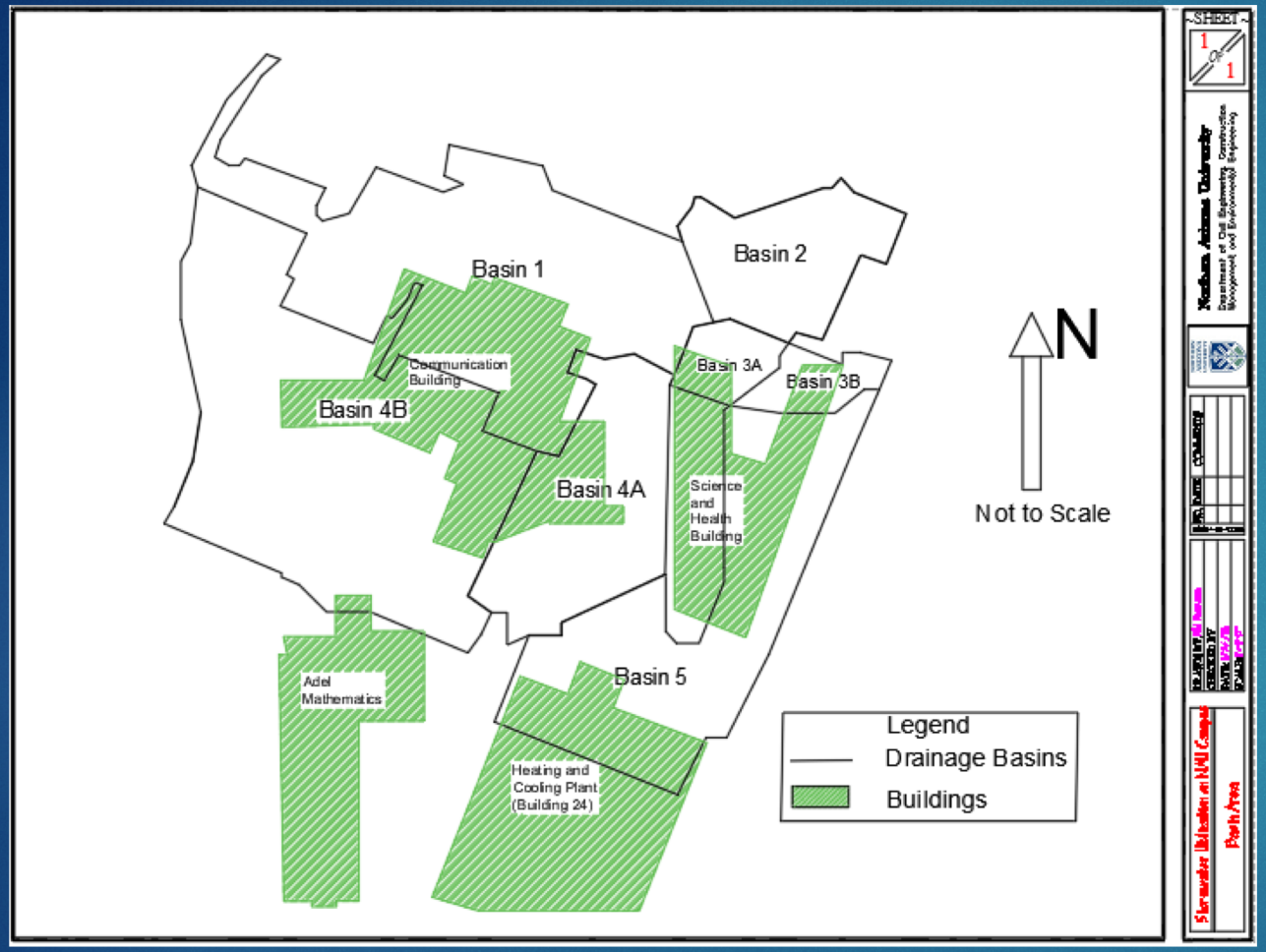


Figure 6. Drainage Basins for the Water Being Collected in the Detention Tanks [1]

Table 1. Area of Drainage Basins

Basin Number	Drainage Area (acres)
1	2.15
2	0.64
3A	0.20
3B	0.18
4A	1.22
4B	2.40
5	1.40
Total	**8.19**

Hydrologic Analysis

Table 2. Precipitation and Snowmelt Results [2]

Month/Year	Water Equivalent* (ft)	Average Daily Volume (gal/day)
Jan-16	0.47	41,807
Feb-16	0.11	9,859
Mar-16	0.04	3,262
Apr-16	0.11	10,007
May-16	0.18	16,159
Jun-16	0.08	7,264
Jul-16	0.43	38,027
Aug-16	0.25	22,608
Sep-16	0.18	16,382
Oct-16	0.07	6,597
Nov-16	0.31	27,204
Dec-16	0.40	35,951
Jan-17	0.39	34,320
Feb-17	0.00	-
Mar-17	0.31	27,204
Apr-17	0.02	1,483
May-17	0.02	2,076
Jun-17	0.00	-
Jul-17	0.66	58,411
Aug-17	0.36	31,652
Sep-17	0.07	6,078
Oct-17	0.00	-
Nov-17	0.00	371
Dec-17	0.00	-

Average Daily Volume Sample for January 2016(gal)=
8.19 acres*43,560 sf =
356,756 sf x 0.47 ft=
167,676 cf *7.48 gal/cf =
125,4211 gal/month *1 month /30 days=
41,807 gal/day

* 10" snow = 1" rain [3]

Stormwater Testing Analysis

Stormwater Quality Testing

Table 3. Test Parameters and Methods [3,4]

Test Parameter	Test Method
1. pH	HACH Method #8156: pH
2. Nitrate	HACH Method #8171: Nitrate
3. Ammonia	HACH Method #10031: Ammonia
4. Nitrogen	HACH Method #10071: Total Nitrogen
5. Coliform	HACH Method #8074: Coliform
6. Total Hardness	HACH Method #8266: Total Hardness
7. Turbidity	AWWA Standard Method #2130B: Nephelometric Method
8. Total Suspended Solids	AWWA Standard Method #2540 C: Suspended Solids
9. Total Dissolved Solids	AWWA Standard Method #2540: Total Solids

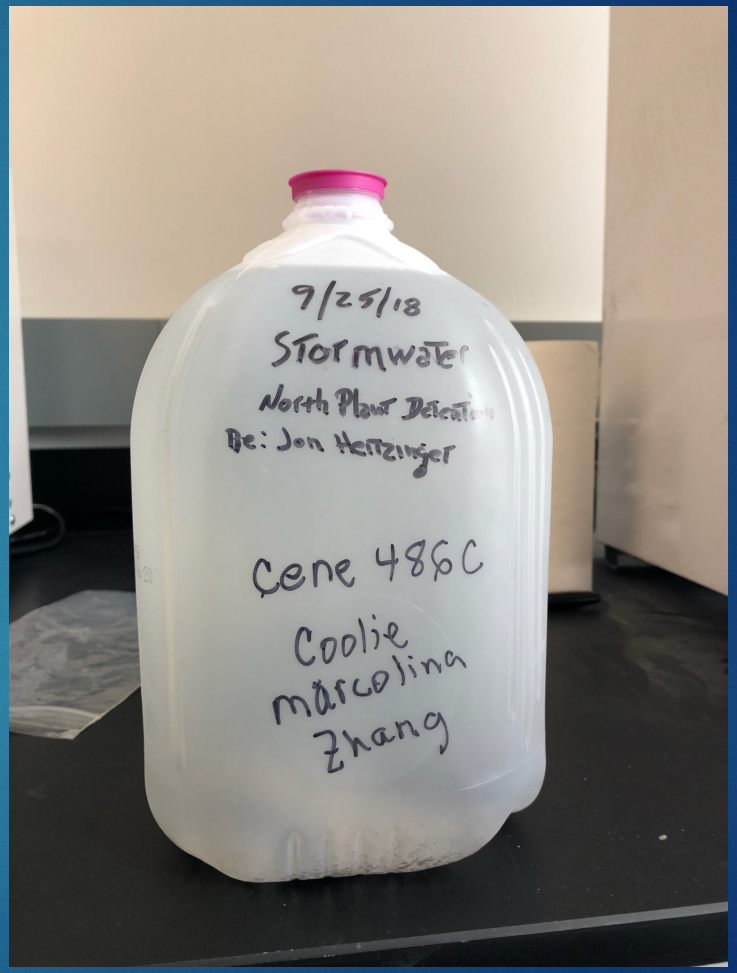


Figure 7. Stormwater from Detention Tanks

Water Testing



Figure 8. pH Testing of the Stormwater

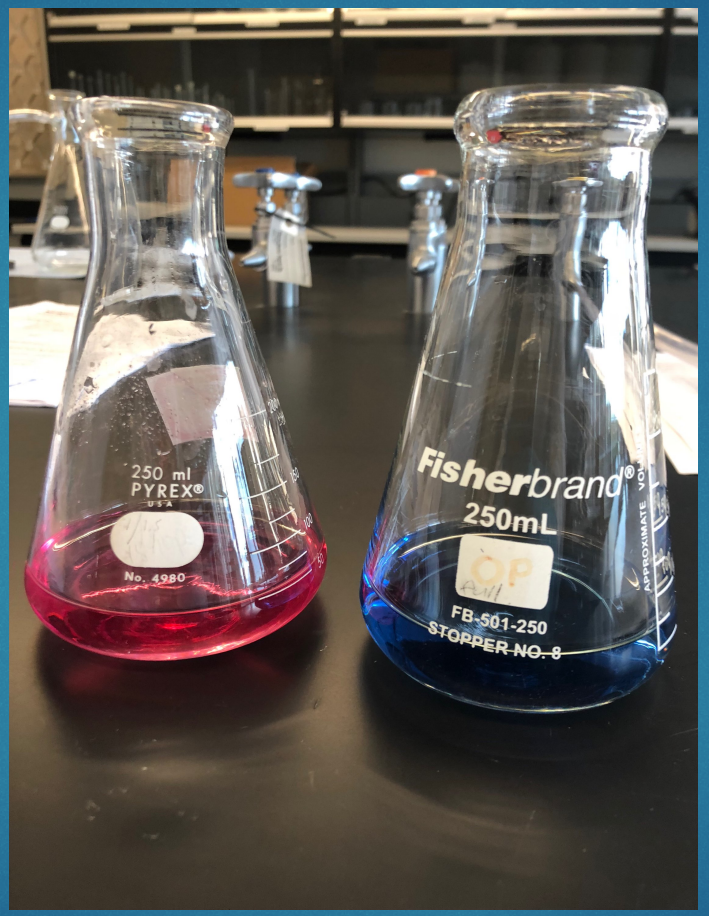


Figure 9. Before and After Hardness Testing



Figure 10. Gathering Results From the Turbidimeter

Water Testing Results

Table 4. Testing Results Summary

Test	Average	Domestic Water Standard	
		EPA [5]	ADEQ [6]
pH	5.03 +/- 0.11	6.5-8.5	6.5-8.5
Ammonia (mg/L as N)	0.27 +/- 0.21	N/A	<1.5
Total Nitrogen (mg/L)	0.5 +/- 0.26	N/A	<10
Total Hardness (mg/L as CaCO3)	18.53 +/- 2.2	<200	<200
Turbidity (NTU)	*5.84 +/- 0.35	<5	<5
TSS (mg/L)	88 +/- 23.07	N/A	<25
TDS (mg/L)	264 +/- 43.71	<500	<500
Total Coliform (CFU)	3.67+/-1.15	<5%	<23CFU/100mL
Nitrate (mg/L)	0.83+/-0.15	<1	N/A

Meets EPA and ADEQ Standards: Ammonia, Total Nitrogen, Total Hardness, Total Suspended Solids (TDS), Total Coliform, Nitrate

*Typical acceptable range for cooling water systems <20 NTU [7]

Total Suspended Solids (TSS) is too high

pH level is low

NTU: Nephelometric Turbidity Unit

CFU: Colony-Forming Unit

Stormwater Treatment Alternatives

To increase pH adjusted

- Sodium Hydroxide
  - Easily raises pH, while not influencing the hardness
- Calcite and Calcite-Corosex Blend Neutralizers
  - Easily accessed, low cost, and minimal maintenance

Remove TSS

- Reverse Osmosis
  - Highly effective, easy to maintain
- Activated Carbon Filter
  - Small size; can be built inline
- Pressurized Sand Filter
  - Low cost and easy to maintain

Stormwater Treatment Alternatives- Decision Matrix

Table 5. TSS Decision Matrix

Scale Parameter	Weight	Reverse Osmosis		Activated Carbon Filters		Pressurized Sand Filtration	
		Point	Total	Point	Total	Point	Total
Effectiveness	40%	3	1.2	3	1.2	3	1.2
Cost	20%	1	0.2	2	0.4	3	0.6
Size	20%	1	0.2	1	0.2	2	0.4
Maintenance Occurrence	20%	3	0.6	1	0.2	3	0.6
Total			2.2		2		2.8

Table 6. pH Decision Matrix

Scale Parameter	Weight	Sodium Hydroxide		Calcite & Calcite-Corosex Blend Neutralizers	
		Point	Total	Point	Total
Effectiveness	40%	3	1.2	3	1.2
Chemical Cost	30%	1	0.3	3	0.9
Maintenance Occurrence	30%	3	0.9	3	0.9
Total			2.4		3

Final Stormwater Treatment

TSS: Pressurized Sand Filtration – filter rate is 7.5 m/h

pH: Calcite & Calcite-Corosex Blend Neutralizers – 1cf can treat 1,278,730 gal of stormwater

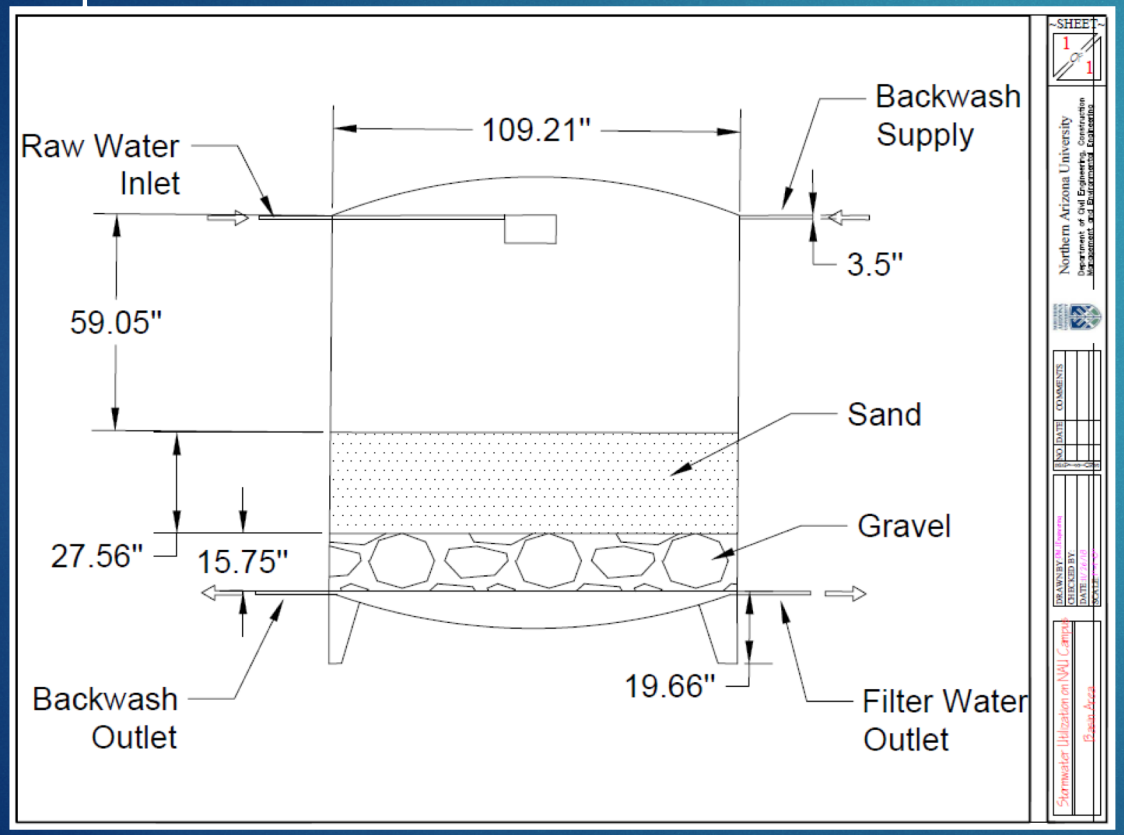


Figure 11. TSS Removal, Pressurized Sand Filter

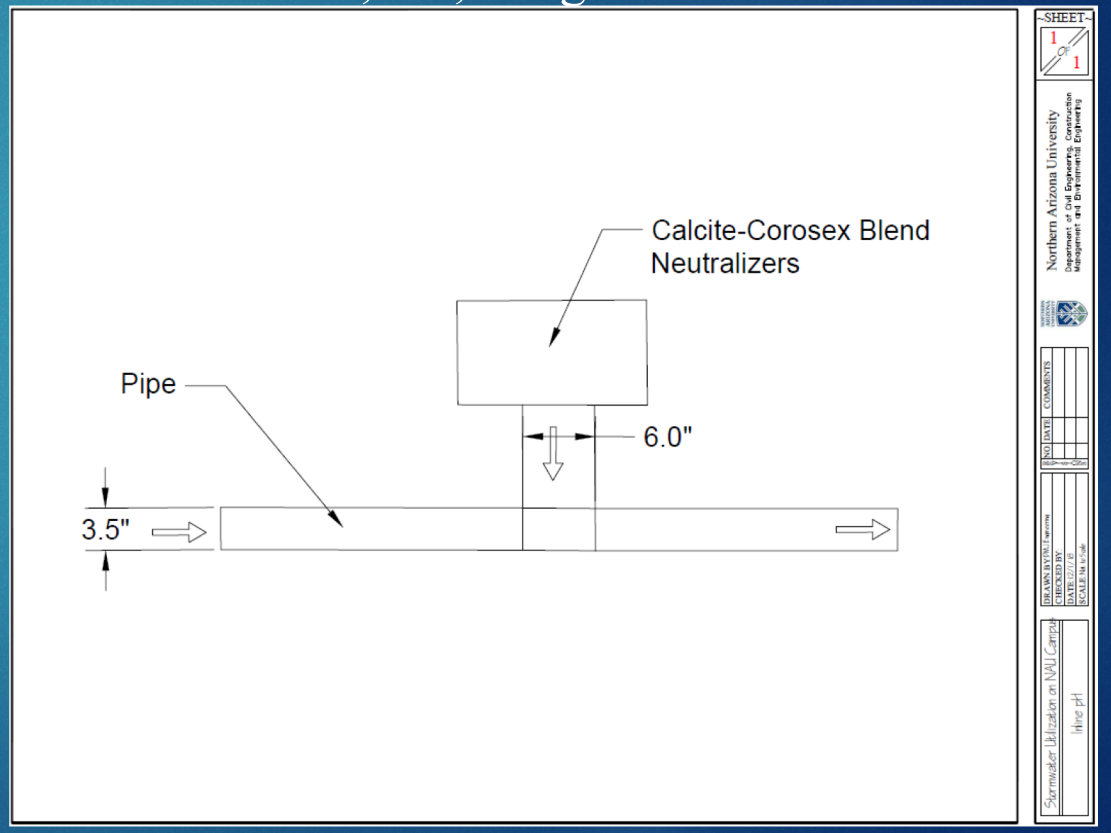
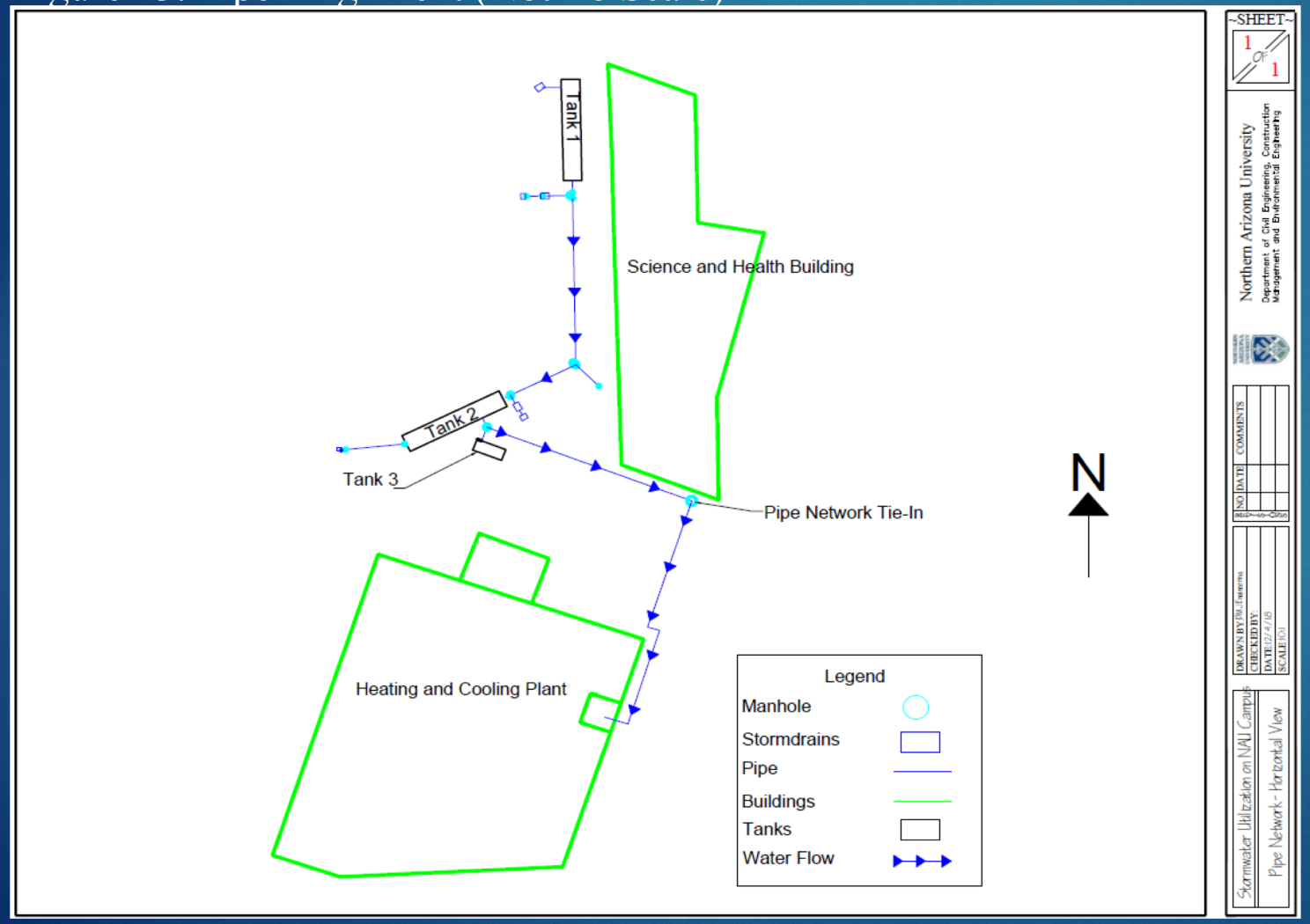


Figure 12. In Line pH Adjustor

Hydraulic Design

Hydraulic Design- Pipe Network

Figure 13. Pipe Alignment (Not To Scale)

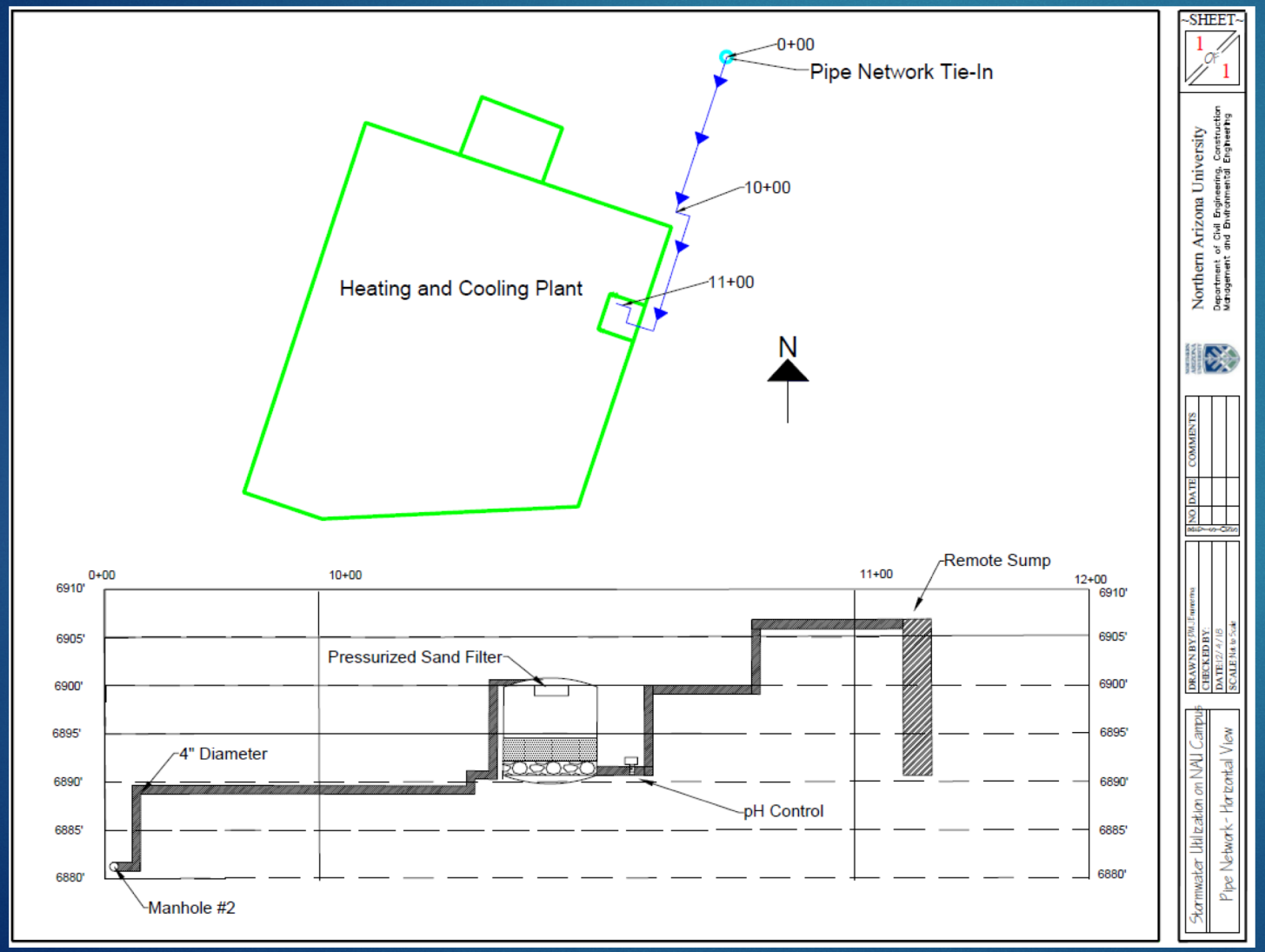


Pipe alignment goes from the bottom of manhole 2 to Rm. 114 in the Heating and Cooling Plant

- Pipe buried 3 feet below surface
- Design Flowrate: match tank 2 pump flowrate
- Determined Design Volume: 30,000 gpd (per client's request)

Pipe Network

Figure 14. Pipe Network Schematic



Profile view of the pipe alignment starting from manhole 2 to the remote sump.

- Underground until the Heating and Cooling Plant.
- Pipe Material: C-900 PVC
- Pressurized piping

Design Pipe Network System Curve

Diameter: 4 in.

Total Length: ~288 ft.

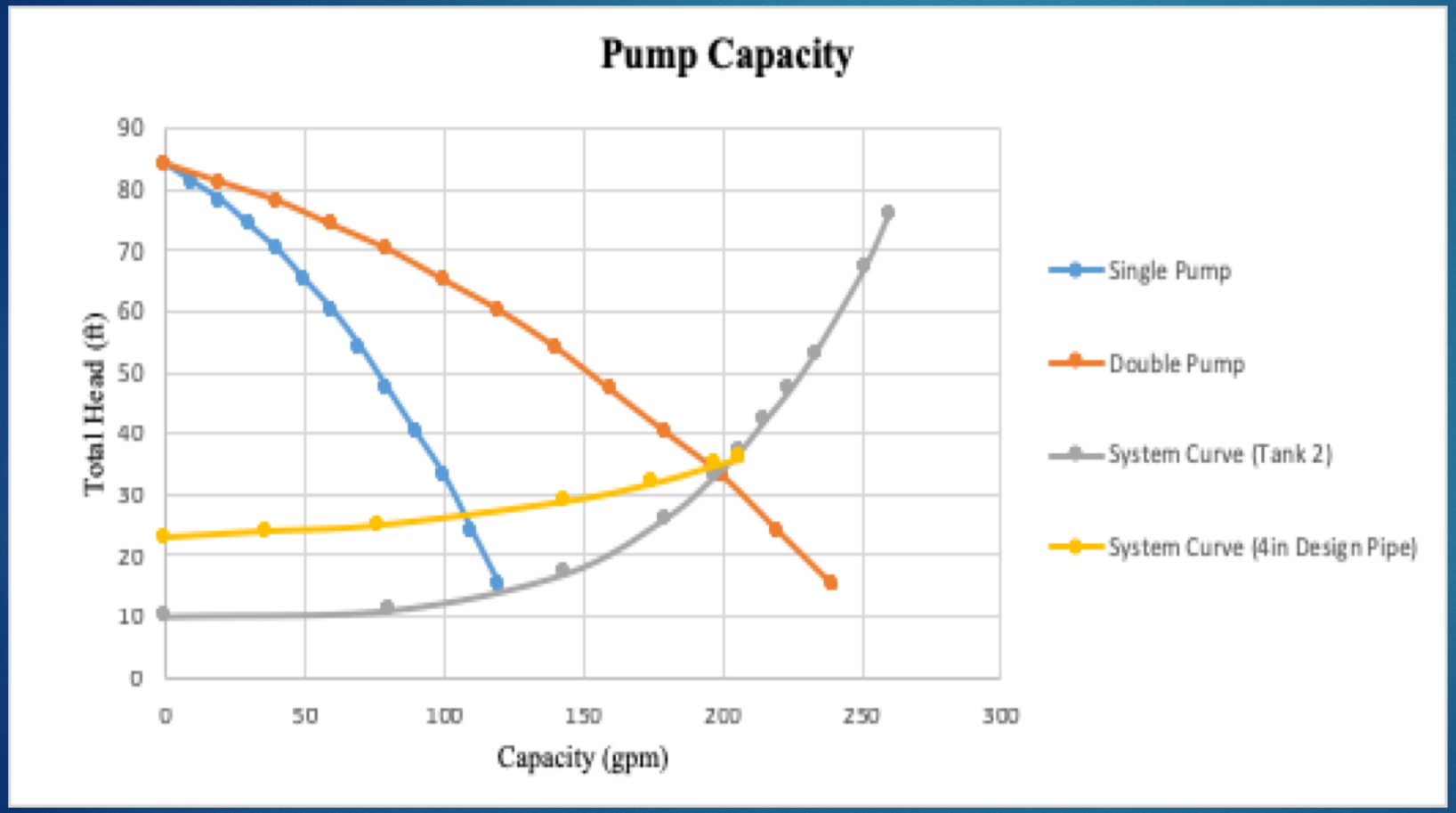
Overall Flow-Rate: 0.45 cfs (200 gpm)

System curve, which analyzes the following:

- Varying Flow
- Velocity
- Reynolds number
- Head loss due to friction and minor losses

Hydraulic Design- Pump Selection

Figure 15. System Curve for Pump Selection



Design Flowrate: match tank 2 pump flowrate

Two pumps in parallel (double capacity)

EBARA Pump Model- 50DSH61.5 (2HP)

Max capacity of Tank 2:

~200 gpm

Final Design

Water Treatment

TSS: Pressurized Sand Filtration

pH: In Line Calcite & Calcite-Corosex Blend Neutralizers Injectior

Pipe

Length:~288 ft.

Material: PVC C-900

Diameter: 4 in.

Pump

EBARA Pump Model- 50DSH61.5 (2HP)

Two Pumps in Parallel

200 gpm

Cost of Implementation

Table 7. Capital Cost of Implementation

Water Treatment	Quantity	Cost Per Unit	Unit	Total Cost
Pressurized Sand Filtration	1	1500	LS	1500
Calcite-Corosex Blend Neuralizer	1	600	LS	600
Pipe Network				
4" PVC C-900	288	2.67	LF	768.96
Fittings	9	2.42	LS	21.78
Valve	2	46	LS	92
Pump				
EBARA Pump Model- 50DSH61.5 (2HP)	2	2000	LS	4000
Construction/Labor				
Pipe Segment	288	5.642	LF	1624.896
			Total Cost	**8607.64**

Engineering Work

Table 8. Projected Engineering Work

Task	Staff			Task Total (hr)
	Senior Engineer	EIT	Lab Technician	
1.0 Hydrologic Analysis	15	45	0	60
2.0 Water Testing	10	10	40	60
3.0 Water Treatment Process Design	10	40	0	50
4.0 System Design	45	90	0	135
5.0 Cost Analysis	15	50	0	65
6.0 Project Management	40	130	0	170
Staff Total (hr)	135	365	40	540

Table 9. Actual Engineering Work

Task	STAFF			Task Total (hr)
	Senior Engineer	EIT	Lab Technician	
1.0 Hydrologic Analysis	5	14	0	19
2.0 Water Testing	7	15	68.25	90.25
3.0 Water Treatment Process Design	6	30	0	36
4.0 System Design	11	24	0	35
5.0 Cost Analysis	4	12	0	16
6.0 Project Management	45	151	0	196
Staff Total (hr)	78	246	68.25	392.25

Project Schedule

Table 10. Project Schedule

Task Name	Projected Finish Date	Actual Finish Date
Task 1: Hydrologic Analysis	Sep.10	Sep.10
Task 2 : Water Testing		
Task 2.1: Stormwater Quality	Oct.20	Nov.9
Task 2.2: Detention Tank Water Quality	Nov.20	Nov.9
Task 3: Water Treatment System Design	Oct. 29	Nov.30
Task 4: Hydraulic System Design		
Task 4.1: Pipe Network	Oct.11	Nov.20
Task 4.2: Pump Selection	Nov.5	Nov.30
Task 4.3: Tank/Storage	Nov.20	Nov.20
Task 5: Cost Analysis	Dec.3	Dec.3
Task 6: Project Management	Dec. 6	Dec. 6

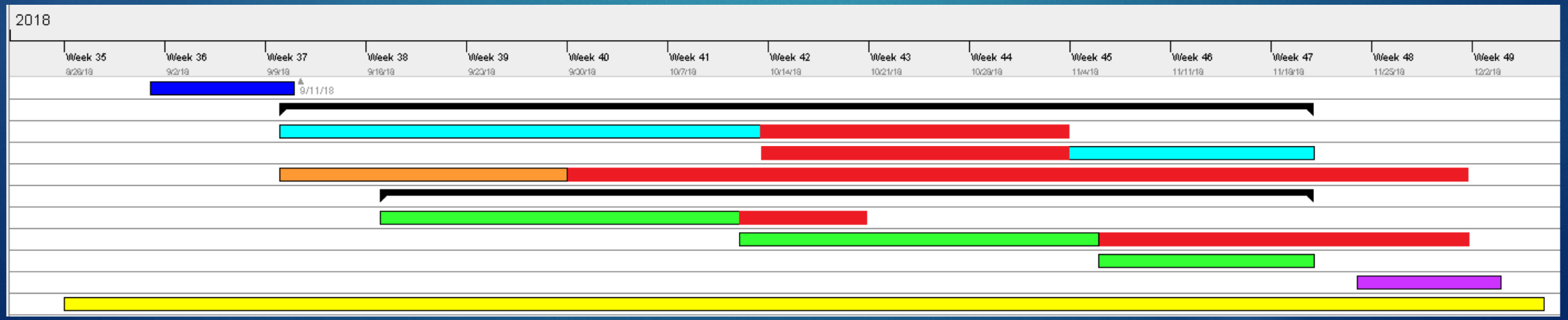


Figure 16. Project Schedule Gantt Chart

Design Conclusion

Meets client requirements

- PVC C-900
- Water Treatment located in Rm. 144

After treating the stormwater it will meet cooling water standards (domestic water standards)

Impacts

- Social
- Environmental
- Economic

Reference Page

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Questions?