FINAL DESIGN REPORT

CENE 486C

Coppermine Road Water & Sewer Line Extension

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Table of Contents

List of Figures

List of Tables

List of Equations

Abbreviations

SWPPP:	Stormwater Pollution Prevention Plan
GIS:	Geographic Information System
HEC-HMS:	Hydrologic Engineering Center's Hydraulic Modeling System
ADOT:	Arizona Department of Transportation
fps:	Feet per second
cfs:	cubic feet per second
psi:	pounds per square inch
gpcd:	gallons per capita per day
gpm:	gallons per minute
TWD:	Total Water Demand
MHD:	Max Hourly Demand
MDD:	Max Daily Demand
NFF:	Needed Fire Flow
ESCP:	Erosion and Sediment Control Plan
ADEQ:	Arizona Department of Environmental Quality
NOI:	Notice of Intent
BMP:	Best Management Practices

Acknowledgements

Special thanks go to our client, Mark Lamer, for providing the site survey data since the site investigation was not conducted due to unexpected events. He also provided the GIS topographic map of all the contours in Page.

Special thanks go to Stephen Irwin for providing the GIS CAD file for the parcels in Page and for getting us in contact with the City of Page to request for as-builts.

Special thanks go to Shepard Wesnitzer Inc. for providing geographical resources and important references

Special thanks go to Maryam Moeinian for providing GIS data and As-Builts for the property neighborhood.

1.0 Project Introduction

The client in Page, AZ requested a water and sewer line extension across his property at 947 N. Coppermine Road. The city of Page required that he extend each pipe roughly 500 feet SE if he is to use the property for commercial purposes. The client plans to develop a commercial storage warehouse on the property.

1.1 Project Location

Figure 1-1, below, is the project site location, circled in red, in relation to the entire state of Arizona. The property location is within the City of Page limits.

Figure 1-1: Site Location in Arizona [1]

The property lies on Coppermine Road, just north of AZ-98, as shown in Figure 1-2. The project location based on the United States Public Land Survey System is in the southwest quarter of section five, township forty north, range nine east, in Coconino County.

Figure 1-2: Aerial View of Property Location [2]

The property is currently undeveloped and sits adjacent to two businesses on the northwest side. These businesses are labeled in red on Figure 1-3 below. The water and sewer lines are currently capped off at the bordering business, Bruce's Sales and Leasing. Figure 1-3, below, also outlines the borders of the property and their relation to Coppermine Rd.

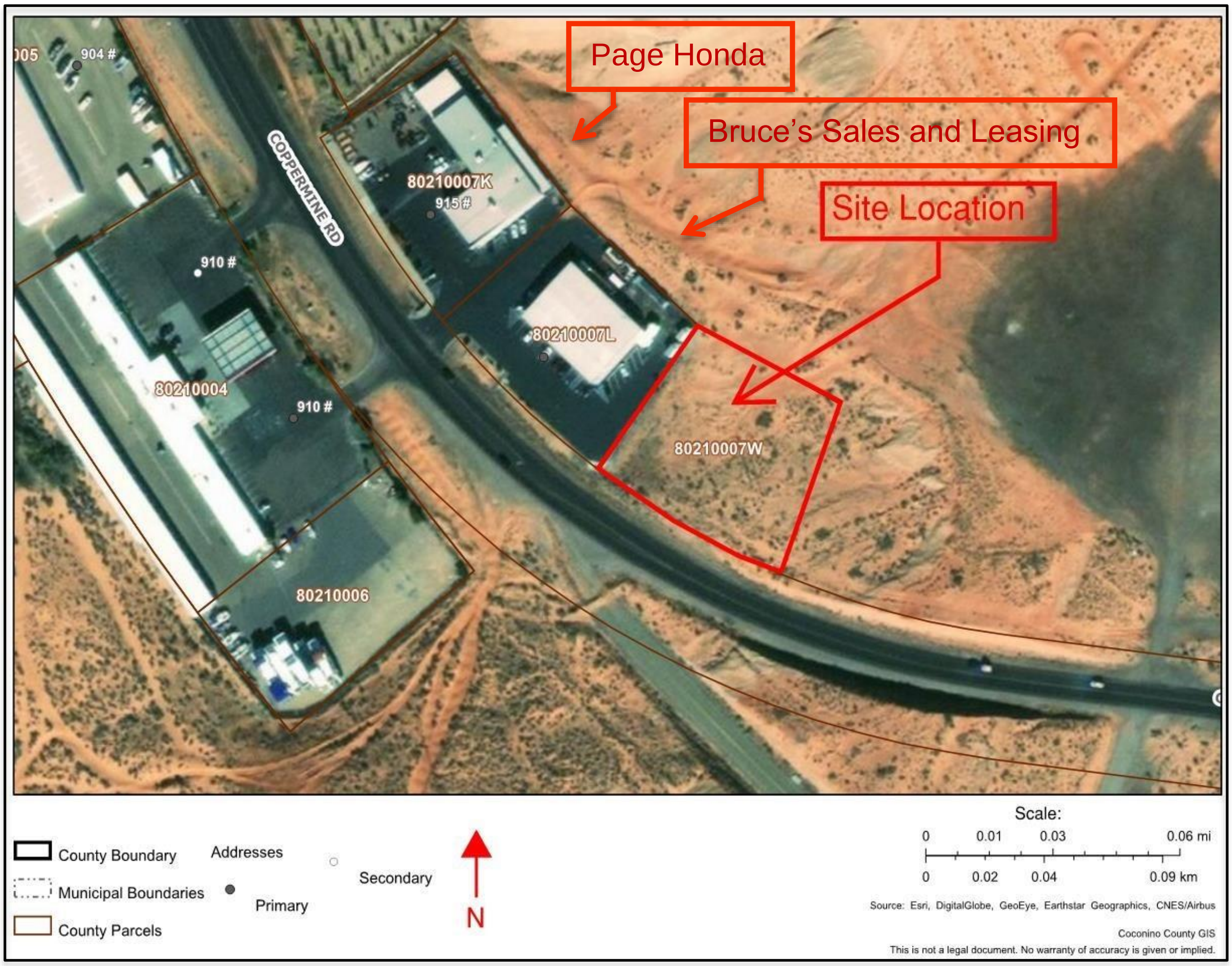

Figure 1-3: Project Vicinity Map (Zoomed In) [2]

1.2 Project Objective

The main project objective is to design sewer and water main extensions and develop a set of construction plans for the pipe extension. Additionally, there are several other analyses required by the client, such as a hydrologic and hydraulic analysis, and an erosion control report. The plans will include completing the "Construction Plan Requirements Checklist" found in the *Land Development Manual* required by the City of Page Planning and Zoning Department [3]. The checklist includes a geotechnical report, provided by Rosenberg Associates [4], and a drainage report for all projects adding impervious surface. This project does not add any additional impervious surfaces, so a drainage report is not necessary for this project. A Storm Water Pollution Protection Plan (SWPPP) is required to reduce erosion along with a Traffic Impact Analysis to reduce traffic disturbance.

1.3 Constraints/Limitations

Project constraints begin with the Covid-19 worldwide pandemic. Accessibility to the property along with any necessary permits or applications will be limited and/or inaccessible due to virus restrictions. The client is an individual with the intent to develop on his property. Thus, there will be budget constraints to accommodate the client's needs while also making it affordable. Time will also be a constraint because the deadline is the end of November, and this cannot be adjusted.

1.4 Major Deliverables

The objectives and deliverables of this project consist of:

- Developing a Civil3D topographic map that identifys the existing elevations, structures, and utilities for the project.
- Analyzing the hydrologic impacts, which will be applied in the SWPPP for redirecting stormwater flow to prevent erosion.
- A hydraulic analysis for the design of the sewer and water line.
- A traffic impact analysis to reduce traffic disturbance from construction.
- Developing a set of construction plans that encompass every standard and regulation set by the City of Page.

2.0 Existing Conditions

Due to unexpected events, the existing conditions were evaluated through technology means rather than walking the site in-person. The general conditions of the site were analyzed from the geotechnical report, GIS contour data, a preliminary survey of the site, and Google Earth. The site currently does not have any structures on the property.

2.1 Existing Utilities

There is an existing sewer manhole located in the easement between Page Honda and Bruce's Sales and Leasing, as shown in Figure 2-1. An easement and a drainage channel extend along the north edge pavement of Coppermine Road. There are two existing water valves between the two properties west of the project site. The closest valve is currently capped at the edge of Page Honda's property, but will be removed for the extension of the waterline. The easement located along the front of the property is used for underground utilities and the electric easement extends 20 feet across the east side of the site. The electric easement is above ground and will need to be considered as an overhead hazard when using equipment during the construction phase. These above ground power lines are shown in red in Figure 2-1 below.

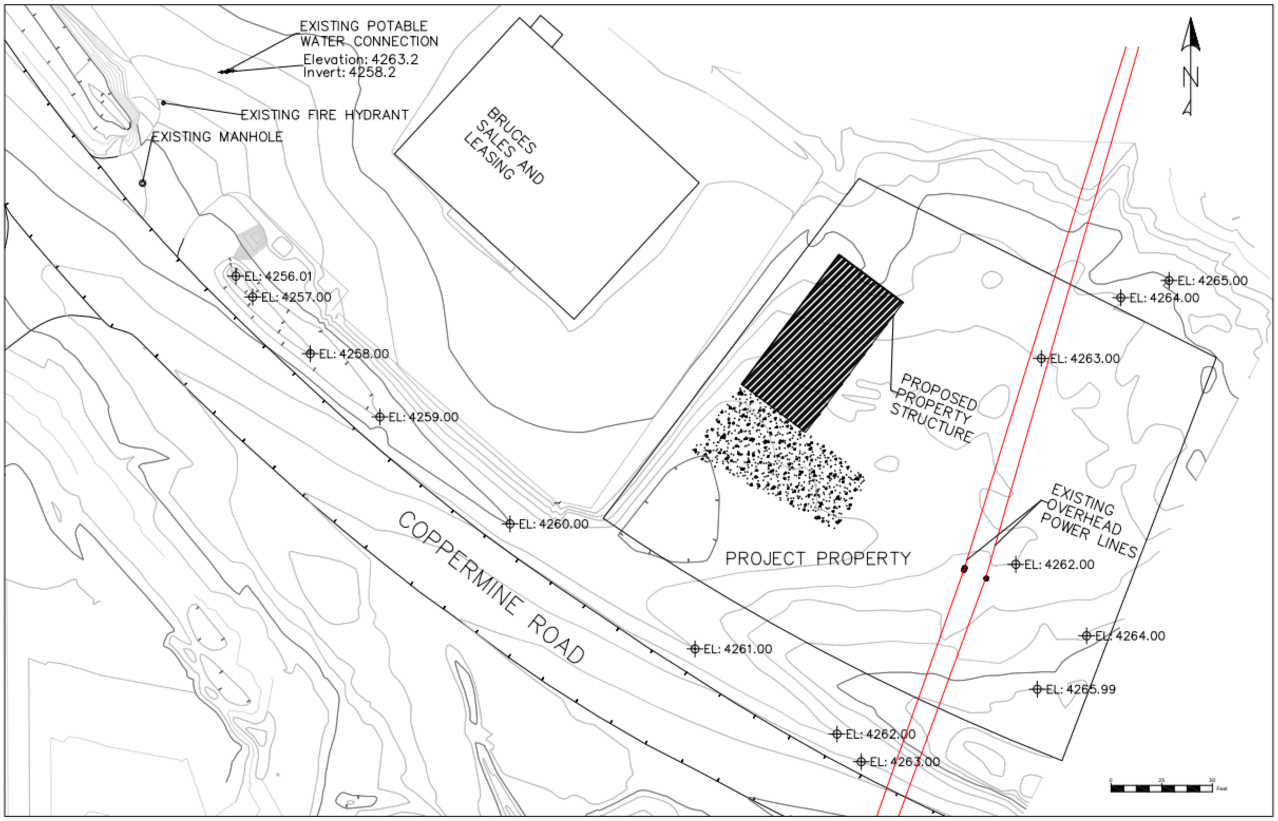

Figure 2-1: Existing Utilities

2.2 Site Topography

In Figure 2-2 below, the topographic map was created from hand drawn survey data that was provided from the client, Mark Lamer. The 1' and 5' contours came from GIS data of Page, AZ. This was provided from our technical advisor, Stephen Irwin. With these elevations the team was able to create a surface in Civil 3D. The topography of the client's property is generally flat, with an elevation change of approximately five feet gradually over the entire site.

The Geotech report for this project states that the current site drainage is predominately sheet flow towards the southwest edge of the property until it changes to open channel flow when it enters the drainage channel [4]. During the geotechnical analysis, groundwater was not encountered when max depths were explored. The soils found on the property were loose native sands as the subsurface, and sandstone bedrock when depths reached 0.75 and 1.25 below the surface [4]. The low-density sands will need to be reworked to achieve correct moisture content for recompacting where utilities will be placed.

Bruce's Sales and Leasing property has a higher elevation, but a retaining wall was constructed on the east side of their property to direct the stormwater to the drainage channel and away from the neighboring property. Due to the slight slope of the property directing the stormwater to the drainage channel, the existing ground elevation will remain the same and should be replaced back to original conditions after construction. It will not be necessary to create grading and drainage construction plans since there will be no changes in elevation from the existing.

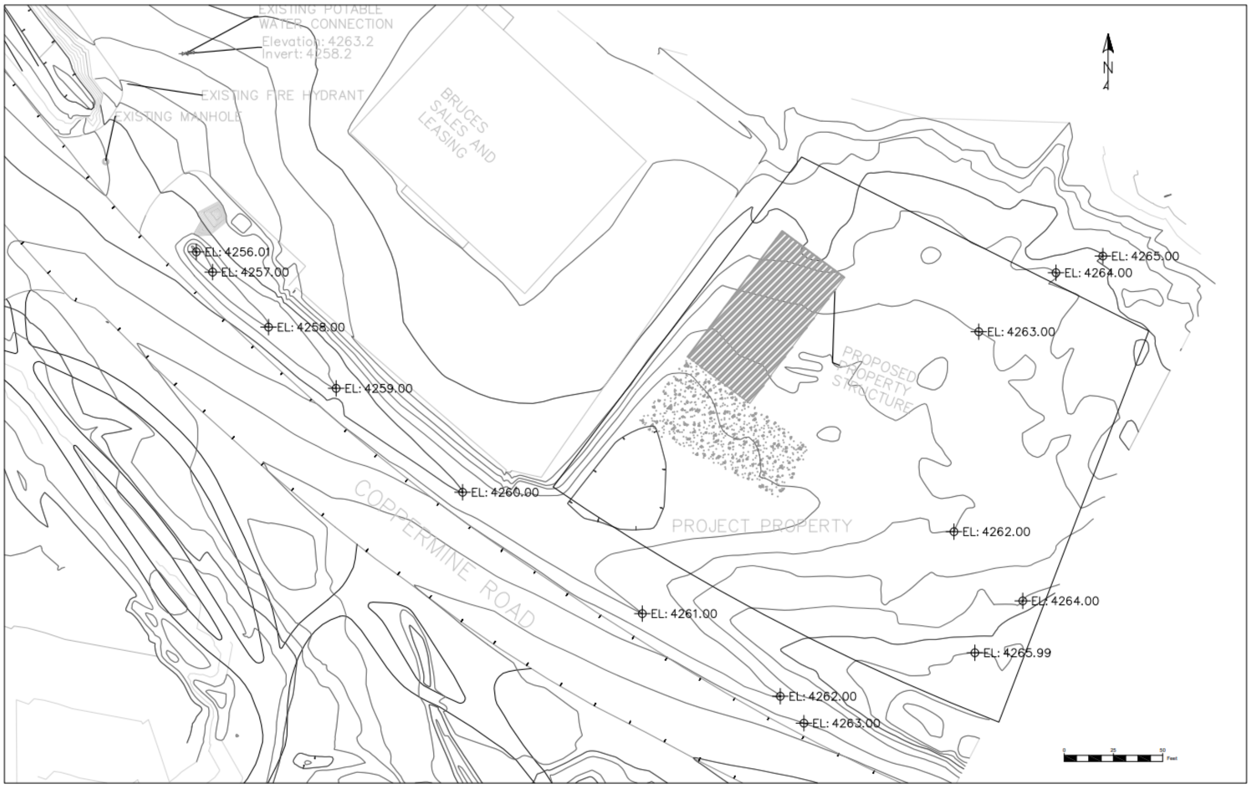

Figure 2-2: Topo Map

3.0 Hydrologic Analysis

A hydrologic analysis was performed using the given GIS data and NOAA Atlas 14 rainfall intensity to use in the program HEC-HMS. The results from HEC-HMS confirms that the water from a storm event runs across the project property into the open-channel that runs along Coppermine Road.

3.1 Delineation of Runoff Contribution Area

A hydrology study was performed to determine the flood flow paths for storm events that are associated with the project site. The purpose of the study was to determine the flow path of storm water that may occur directly on top of the designed water and sewer line extension placement. The hydrology study was completed using AutoCAD Civil 3D with provided GIS data from the client and City of Page. A watershed delineation showed that flows transfer into the upper sub-basin located on the project site. The stormwater from the upper sub-basin then flows into the open channel drainage located along Coppermine Road. The open channel runs alongside

Coppermine Road and supports the other businesses connected to Coppermine Road. The property northwest of the project site, Bruce's Sales and Leasing, has a retaining wall on the back side that rediverts stormwater flow onto the project property. Additionally, the existing open channel for stormwater drainage elevation must remain the same to allow proper stormwater drainage after completion of the project.

3.2 HEC-HMS Results

A hydrologic analysis was performed using HEC-HMS to determine the stormwater flow depths for a 100-year storm event at 5-minute intervals for the open-channel east of Coppermine Road. A surface profile was produced in AutoCAD Civil 3D and imported into the HEC-HMS program for analysis. This storm event was chosen to simulate an extreme but rare event that may contribute to the open channel where the sewer line extension is being placed. The precipitation intensity was obtained from NOAA Atlas 14 and determined to be 2.45 in/hr. This data is applied to the storm event analysis in HEC-HMS. The results of the basin model simulation show that a level of 21.69 inches of stormwater accumulates above the open channel elevation. This analysis can be used aid in determining what Best Management Practices to implement for the SWPPP. The basin model simulation was conducted for the project site, shown in Figure 3-1.

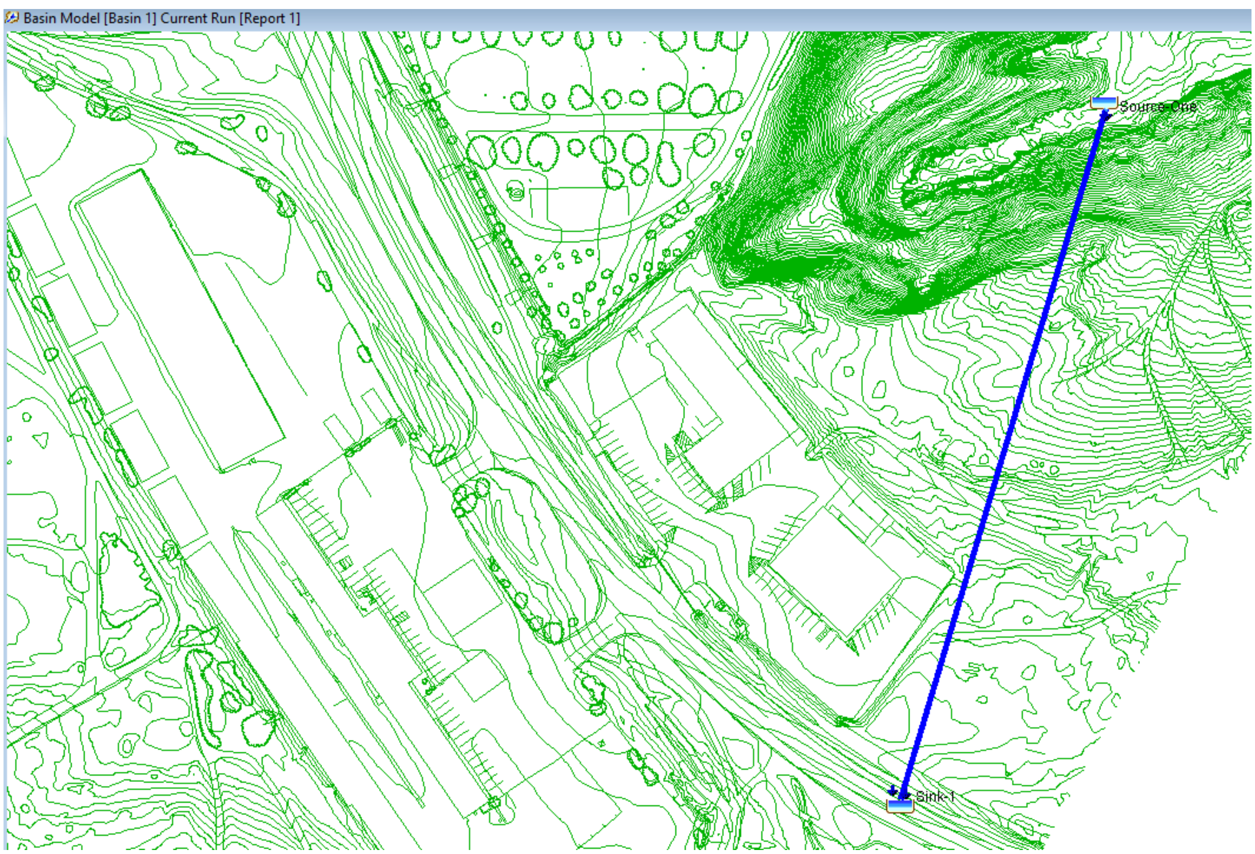

Figure 3-1: HEC-HMS Basin Model

The completion of the HEC-HMS basin model tells us that the water depth in the open channel is more than 21-inches in height. This information will be used for best management practices in the SWPPP. The results also show that straw hay bales would be required for this height of water for this storm event to prevent sediment and debris from flowing downstream.

4.0 Sewer Line Design

To successfully design a sewer line extension, there are factors that need to be calculated following design standards set by the City of Page and Arizona Administrative Code under Title 18 [5]. This includes the sanitary sewer flow for future development. A design of the main sewer line and service lateral is produced following CADD standards.

4.1 Design Flow

The design flow in gallons per day were calculated for the sewer design capacities, taking into consideration the existing and future structures that will contribute to the sewer flow. The existing and proposed structures are doubled for a 25-year future development following Page's Sewer Design requirements. The existing industrial structures in Page, AZ are shown in Table 4-1 below.

Table 4-1: Page Industrial Existing Structures

PAGE INDUSTRIAL EXISTING STRUCTURES	
Types of Buildings	**# of Buildings**
Trading Posts	2
Office Building	14
Utility Offices	2
Industrial Building	4
Automotice Services	3
Storage Building	2

There is one proposed structure for the projects site that was categorized as a storage building. With all the building types taken into consideration, the number of employees, employee quantity, building space, building space quantity, number of bays, and bay quantity were determined for the specific building to find the flow required for the sewer design. These standards for industrial/commercial designs are highlighted Appendix A and were found in the Arizona Administrative Code for Sewage Design Capacities [5]. Table 4-2 below shows the total design flow found from each type of structure that will be contributing to the same sewer line. The town of LeChee, the community southeast of the project, was not included for the sewer design demand because it has its own wastewater treatment facility.

Table 4-2: Sewer Design Flow for Existing & Future Structures

SEWER DESIGN FOR EXISTING & FUTURE STRUCTURES								
Types of Buildings	# of Buildings	# of Employees	Employee Qty	Bldg Space (ft^2)	Bldg Space Qty	# of Bays	Bay Qty	DEMAND (gal/day)
Trading Posts	4	12	20	18960	0.1	-	-	2136
Office Building	28	84	20	-	-	-	-	1680
Utility Offices	4	112	20	-	-	-	-	2240
Industrial Building	8	56	35	-	-	-	-	1960
Automotive Services	6	18	20	-	-	-	-	360
Storage Building	6	-	-	-	-	6	1000	6000
					TOTAL (gal/day)			14376
					TOTAL (gal/min)			9.98

4.2 Sewer Main Extension

The sewer line was designed using Civil 3D and Excel. The sewer line was designed to go through the easement. The upstream and downstream elevations were found from the contours on the topographic map minus the buried depth. The sewer invert at the existing manhole was provided in the as-builts from the previous sewer extension project. The existing sanitary sewer pipe is capped at an elevation of 4244.12 feet. The pipe depth for the extension relied on meeting the requirements for the velocity requirement set by the City of Page. The sewer line was designed for flowing full based off the City of Page's sewer system design requirements. These requirements also state that the minimum pipe size for a public sewer shall not be smaller than 8 inches in diameter [6]. The design velocities were determined using Manning's formula, where Manning's coefficient n=0.009 is for the selected 12-inch SDR-35 PVC pipe, as shown in Equation 4-1 below. According to Chin, *Water Resources Engineering*, the hydraulic radius (R) is calculated by dividing the pipe diameter by four. The hydraulic radius for the 12-inch sewer line was determined to be 0.245 feet.

Equation 4-1: Manning's Velocity Equation

$$V = \frac{1.49 \times R^{2/3} \times S^{1/2}}{n}$$

V = Velocity
R = Hydraulic radius
S = Slope
n = Manning friction coefficient

The "Page General Development and Subdivision Regulations" state that the velocity for a pipe between 6 and 18 inches must be within the range of 2 fps to 11 fps [6]. As shown in Table 4-3 below, the velocities are within range for all the sewer pipe designs.

Table 4-3: Sewer Pipe Design for Coppermine Road

Sewer Pipe Design for Coppermine Road									
Pipe Segment	Pipe Diameter (ft)	Invert Upstream Elev. (ft)	Invert Downstream Elev. (ft)	Buried Depth (ft)	Length (ft)	Slope	R (Full)	V (ft/s)	Vel. OK?
1	1	4245	4244.12	15.0	280	0.31%	0.245	3.64	YES
2	1	4246.5	4245.1	15.7	280	0.50%	0.245	4.59	YES
3	0.33	4247	4246.4	14.3	123.5	0.47%	0.083	2.16	YES

Two 48-inch pre-casted concrete manholes were implemented into the design where the sewer line changed direction and at the end of the project, as shown in Figure 4-1.

Figure 4-1: Sewer Design Profile

The proposed manholes were designed to be approximately 280 feet away from one another. These are within the standards set by Page, which state that manholes shall be placed at distances not greater than 300 feet for sewers that are 15-inches in diameter or less and is connected with 12-inch SDR-35 PVC pipe as shown in Figure 4-2 [6]. The black line shows the existing and proposed ground elevation, and the green line is the proposed sewer line.

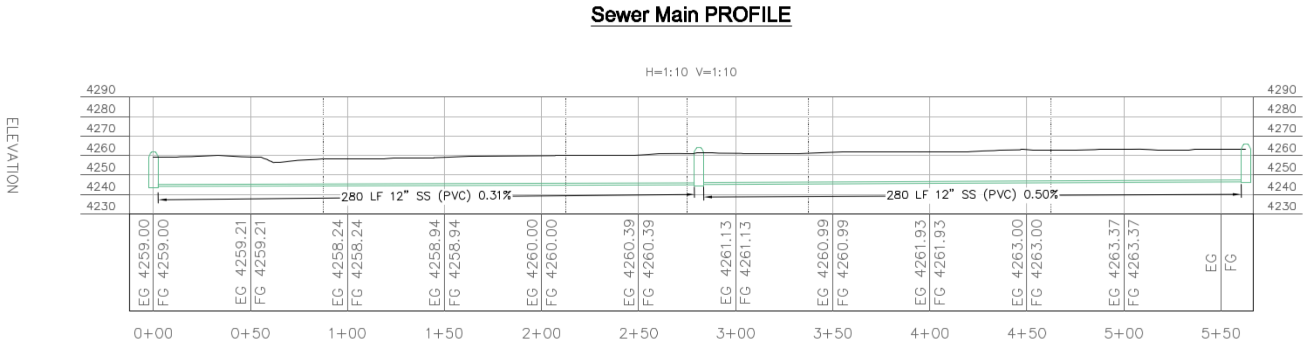

Figure 4-2: Sewer Main Profile

4.3 Sewer Service Lateral

A sewer service lateral is implemented into the design to connect to the proposed building on the project property to the main sewer line. The velocity and pipe placement follow Page's design Standards using Equation 4-1 to produce results in Table 4-3. The data for this pipe is shown in Table 4-3 and Figure 4-1 as Pipe Segment 3. Figure 4-3 shows the profile view of the service lateral connecting the main sewer line and the proposed structure.

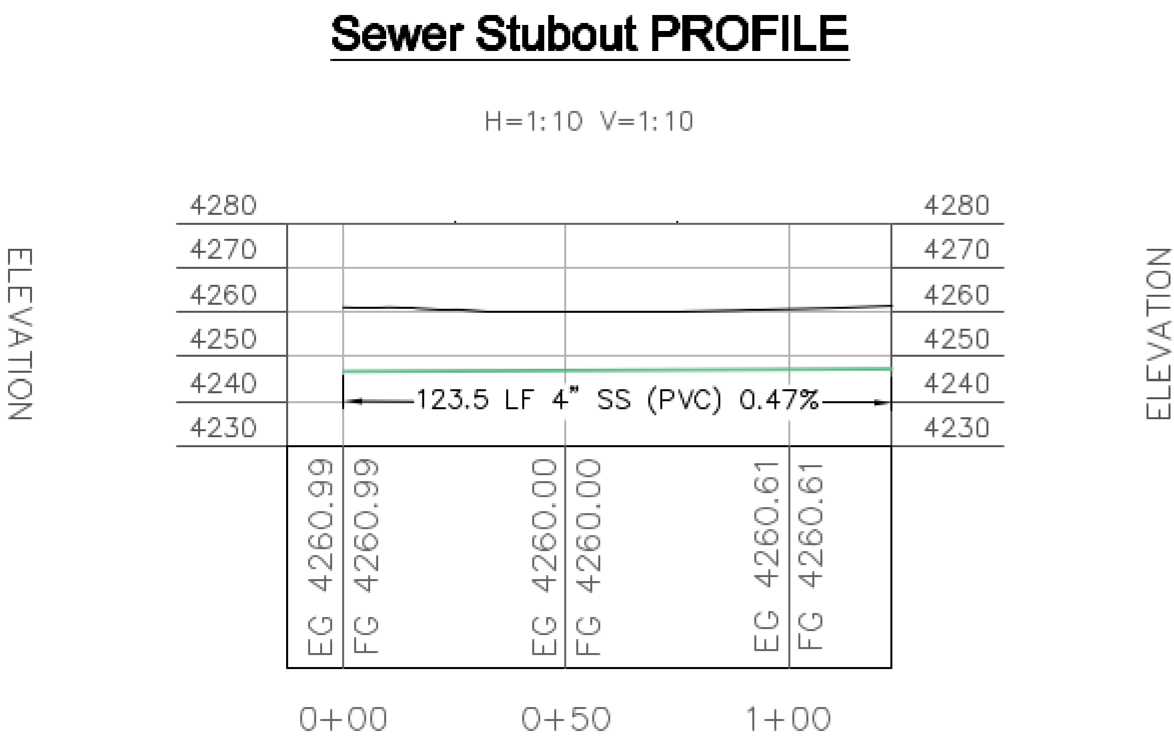

Figure 4-3: Sewer Service Profile

5.0 Potable Waterline Design

A potable water main is designed following the City of Page design standards for the minimum demand and fire flow requirements. This water flow is designed for a future 25-year population. The pressure requirements are checked using Bentley FlowMaster program.

5.1 Water Demand

The design of the potable waterline extension involves taking future water demands and fire flow demands into consideration. The City of Page have set a minimum residual water pressure of 20 psi, minimum demand of 495 gpcd, and a minimum fire flow of 1,000 gpm [6]. When determining the future water demand for the waterline extension, Page industrial area and the town of Lechee population is taken into consideration.

5.1.1 Estimate Future Population

The future population is calculated using the Population Growth Formula for both Page and LeChee. This equation will use the current population, rate of growth (r), and desired timeframe (t) to determine the population growth. A time length of 25-years will be used following Page utility extension requirements [6]. The census data is provided by Data USA [7].

Equation 5-1: Population Growth Formula

$$P = P_0 \times 2.72^{rt}$$

P = Population

P_0 = Starting population

r = Rate of growth

t = Time

Table 5-1 below tabulates the future population for both towns determined by Data USA [7].

Table 5-1: Future Population Calculation

Population			
	Page, AZ	LeChee, AZ	Total
Existing	7547	1589	9136
Future	8396	4387	12783
Population Growth (%) Per Year			
Page	LeChee	Future Design (yrs)	
0.426%	4.06%	25	

5.1.2 Calculate Future Water Demand

To determine the controlling demand, both the Total Water Demand (TWD) and Max Hourly Demand (MHD) will need to be calculated. The larger of these two demands will control the water demand of the waterline extension [8]. The total water demand is calculated by summing the Max Daily Demand (MDD) and Needed Fire Flow (NFF). Equations 5-2 to 5-6 are used to find the TWD and MHD. Table 5-2 provides the factors used in for calculations.

Table 5-2: Demand Factors and Variables [8]

WATER RESOURCES ENGINEERING BOOK VALUES	
Distribution Per Capita Demand	
Average Use	
Category	(gal/day)/Capita
Residential	100
Commercial	30
Industrial	22
Public	17
Loss	11
TOTAL	180
List of Factors	
MDD	1.8
MHD	3.25
Ci	0
Oi	0.75
Xi + Pi	1.4

Equation 5-2: Total Water Demand [8]

$$TWD = MDD + NFF$$

Equation 5-3: Average Daily Demand [8]

$$ADD = q \times P$$

Equation 5-4: Max Daily Demand [8]

$$MDD = ADD \times 1.80$$

Equation 5-5: Needed Fire Flow [8]

$$NFF = C_i \times O_i \times (X_i + P_i)$$

Equation 5-6: Max Hourly Demand [8]

$$MHD = ADD \times 3.25$$

<u>Where:</u>

TWD = Total Water Demand
MDD = Max Daily Demand
NFF = Needed Fire Flow
MHD = Max Hourly Demand
q = Demand per capita per day
P = Population

C_i = Construction factor
O_i = Occupancy factor
X_i = Exposure factor
P_i = Communication factor

Table 5-3 shows the water demand calculations for the future LeChee and Page industrial area. The max hourly demand is the controlling demand at 5,193 gpm.

Table 5-3: TWD & MHD Calculations

Total Water Demand		
Demands		Flows Rounded Up
ADD (gpd)	2,300,962	
ADD (gpm)	1,598	
MDD (gpm)	2,876	
NFF (gpm)	1,050	1,250
TWD (gpm)		4,126
Max Hourly Demand		
MHD (gpm)		5,193

The Page minimum requirements are calculated following the Page General Development and Subdivision Regulations for the waterline extensions [6]. The calculated Max Hourly Demand exceeds the minimum demand requirement of 4,394 gpm shown in Table 5-4. Confirming that the design based on an MHD = 5,193 gpm is acceptable.

Table 5-4: Page Minimum Demand Requirements

Page Minimum Demand Requirements		
Water Demand (gpcd)	Peak Factor	Req'd Demand (gpcd)
165	3	495
Minimum Required Demand (gpm)		
4394		
Fire Flow Minimum Delivery (gpm)		
1000		

5.2 Potable Water Main Extension

To determine the pressure in the designed potable waterline extension network, the Bentley program, FlowMaster is utilized. The potable waterline network is broken into three segments for analysis. Figure 5-1 shows the locations of the segments to be analyzed.

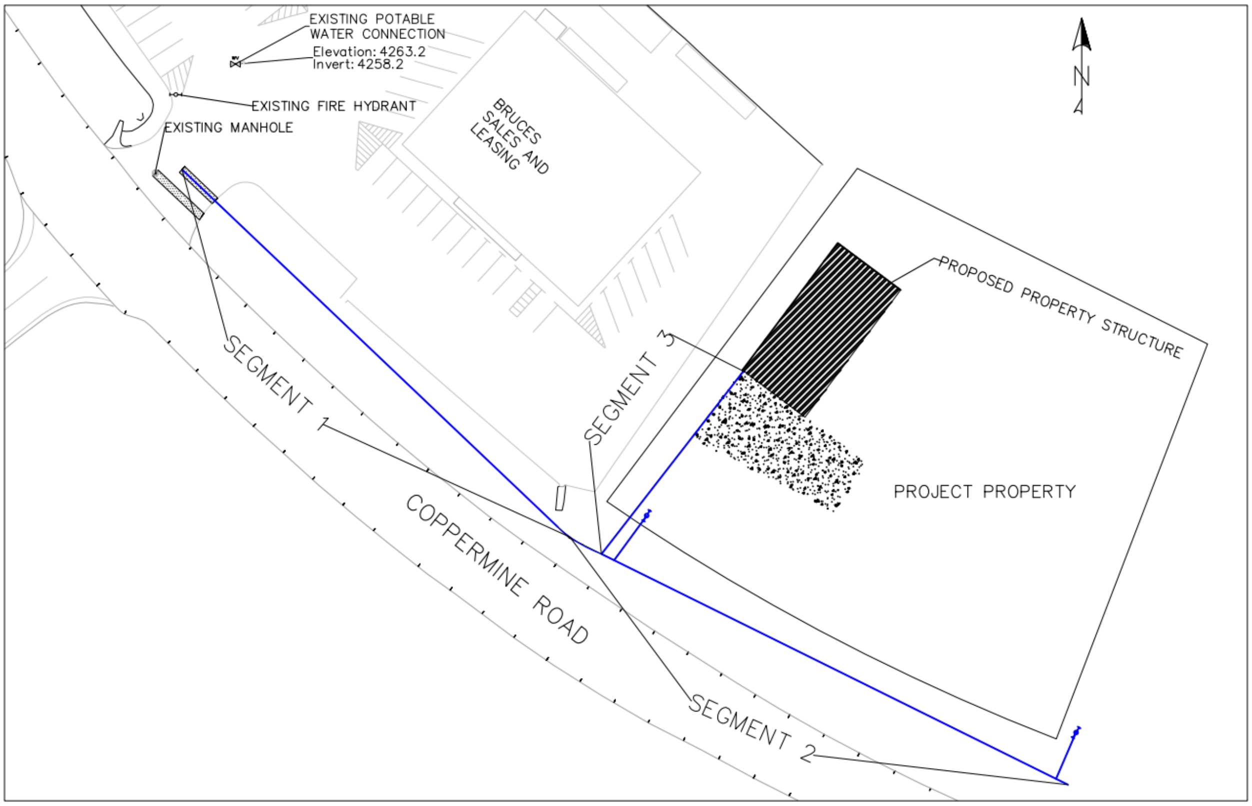

Figure 5-1:Potable Water Segments for FlowMaster Analysis

Table 5-5 shows the FlowMaster simulation results for each segment using Manning's method. The FlowMaster analysis accounts for when water demand is at its peak flow from the calculated max hourly demand of 5,193 gpm (11.57 cfs). The water pressure in each potable waterline is above the 20-psi minimum requirement. Therefore, the 8-inch water main and 2-inch service lateral pipe using C-900 PVC material are adequate for potable water delivery for future water usage. The completed FlowMaster analysis results can be found in Appendix B.

Table 5-5: FlowMaster Analysis

FlowMaster Analysis for Potable Water Pipe Segments							
Pipe Segment	Pipe Size (in)	Upstream Elev. (ft)	Downstream Elev. (ft)	Length(ft)	US Pressure (psi)	DS Pressure (psi)	Velocity (fps)
1	8	4253	4253	268	80	57	33.15
2	8	4253	4253	280	57	33	33.15
3	2	4253	4253	116	57	57	1.62

C-900 PVC Potable Water Pipe Info					
Size (in)	O.D. (in)	I.D. (in)	Length (ft)	Rating (psi)	Manning Coeff.
8	9.05	7.68	20	305	0.009
2	2.375	2	20	240	0.009

The potable waterline and sewer line minimum required separation distances of 6-feet horizontally and 2-feet vertically follows Page's pipe placement regulations [6]. Figure 5-2 shows the horizontal distances between the potable water and sewer pipelines. The horizontal distances are greater than 6-feet for all sections. The vertical separation of the potable water and sewer mains can be seen in the buried pipe depths in Table 4-3. The top of all sewer pipes are more than 2-feet below the bottom of the potable water pipes. This includes where the potable water main crosses above the sewer main indicated by a green circle of Figure 5-2.

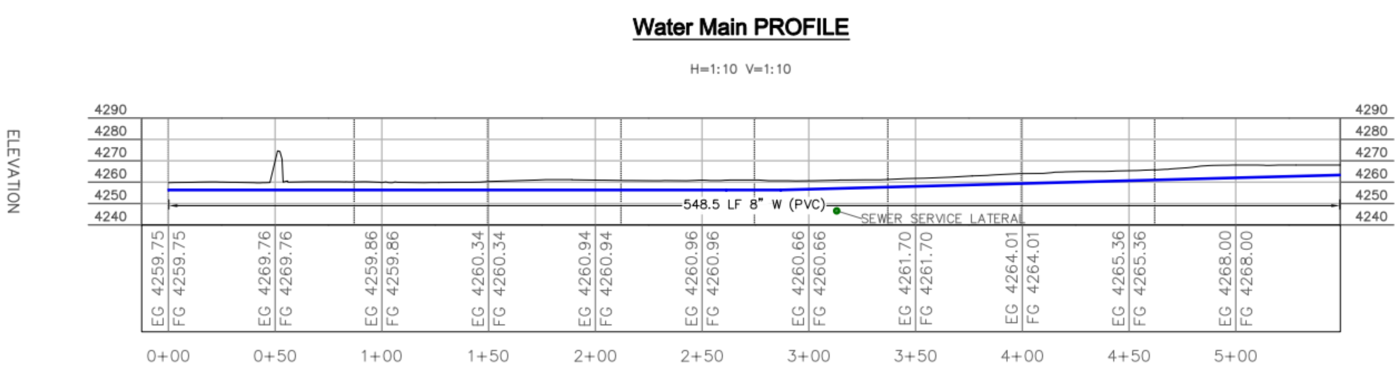

Figure 5-2: Water Main Profile

5.3 Water Service Lateral

A 2-inch service lateral taps into the 8-inch water main to supply water to the proposed structure. A 2-inch pipe size is used to provide adequate water pressure for a potential power wash station. Figure 5-3 shows the profile view of service lateral.

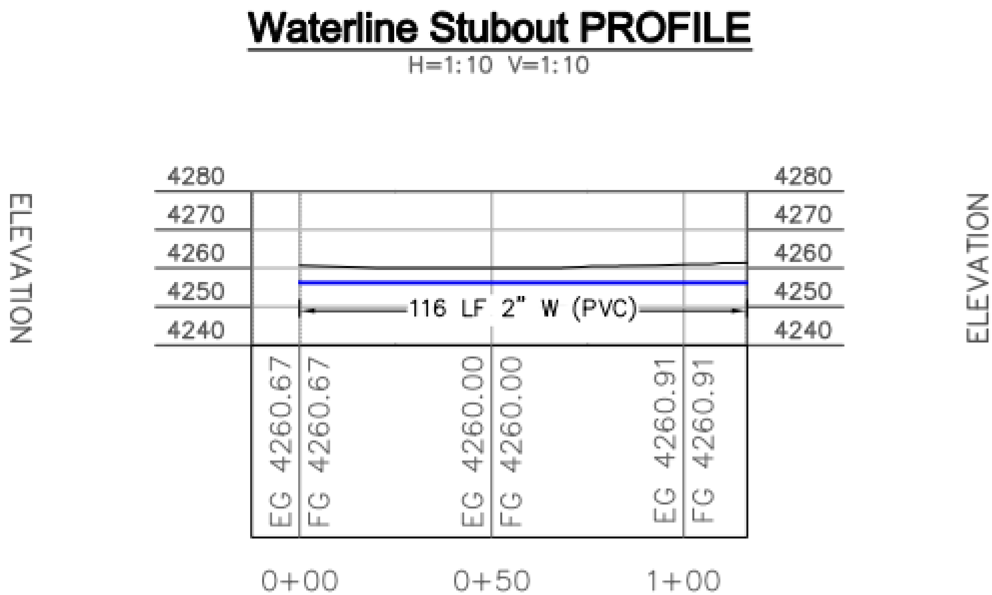

Figure 5-3:Waterline Service Lateral Profile

6.0 SWPPP

The city of Page requires a SWPPP/Erosion and Sediment Control Plan (ESCP) for a development causing more than 1-acre of disturbance [9]. The SWPPP guidelines are referenced from the "Coconino County Stormwater Quality And Runoff Control Ordinance" and the "ADEQ Stormwater Pollution Prevention Plan Template and must be reviewed and approved by the county prior to any site disturbance [10, 11].

6.1 Codes and Regulations

The SWPPP must be submitted to the county department and receive approval prior to submitting a Notice of Intent (NOI) [12]. Additionally, permit coverage must be obtained under the General Permit from ADEQ. The SWPPP contains the ESCP, which includes the Best Management Practices (BMPs) that will be used during construction. These practices and control designs are to ensure erosion will be minimized, sediment transport will be managed on site, and controls for other wastes are in place during construction [11]. Routine inspections must be done, and an inspection schedule must be completed. The BMPs used in this project include:

- Avoid winter construction from October 1 through April 1, and possibly the monsoon season during August.
- Grade checks will be done to ensure the slope of the property does not exceed 3%, which is the ideal slope to avoid erosion from flow.
- Seeding for native vegetation will be required for post-construction to ensure there is no drop in foliage.
- A temporary gravel entrance/exit will be constructed directly west of the project manhole.
- Dust control will be done by watering the soil during construction to reduce wind erosion.
- Waste management including storage, disposal, and well-maintained toiletries will be installed on the western side of the property.
- Storage must be available for all materials that can contribute pollutants to stormwater.
- Routine inspections must be completed by trained inspectors weekly. The inspection report used can be found in the EPA's guide to developing an SWPPP [12].
- Straw wattles will be put in place to direct sediment flow into the trench.
- Hay bales below the culvert outlet should be in place during construction.

These BMPs come from the EPA SWPPP Guide and the ADOT Erosion and Pollution Control Manual [13].

6.2 Erosion Control Plan

The erosion control plan for the construction phase of the project includes using an eight-inch diameter straw wattle along the easement. The straw wattles will be staked three feet north of the trench to mitigate any sediment transport produced from construction. These wattles will act as barriers for sediment to guide it along or into the trench where it will end up. Stakes will be driven into each wattle every three to four feet and there will be no more than two feet left on either end without a stake. Each stake must be driven into the ground at least eighteen inches below the ground surface to ensure the wattle is secure. Additionally, a straw barrier will be placed at the open channel located on the southern corner of Bruce's Sales and Leasing parking lot to ensure no sediment will leak into the lot. Figure 6-1 below shows a physical representation of the SWPPP plan that will be incorporated into the construction plan set. A straw wattle standard detail can be found in Appendix C.

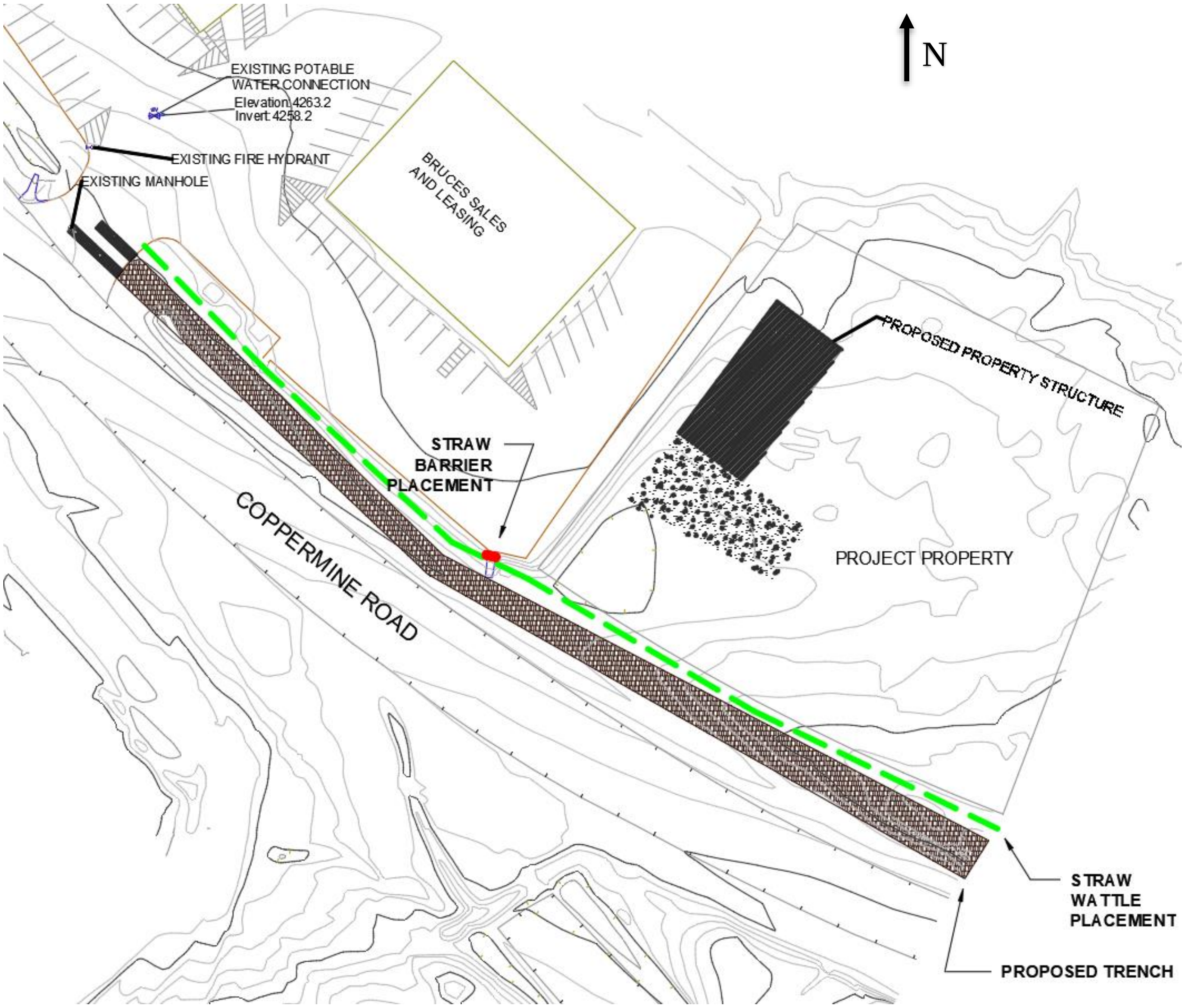

Figure 6- 1: Stormwater Pollution Prevention Plan

7.0 Construction Estimate

Table 7-1 below shows the engineers estimate for the construction of the project, which is 213,651 dollars. This estimate reflects a reasonable price for the job cost for each construction item and it includes a 35% gross contractor margin. The contractors margin considers the total overhead, such as administration, insurance, rent, utilities, and profit. The job cost for each construction item considers the labor, material, equipment, services, and utilities. The price of each item was developed from Courtney's experience working as an estimator for a construction company that specializes in utilities in Coconino County.

Table 7-1: Construction Estimate

Construction Estimate					
Item	**Description**	**Unit**	**Quantity**	**Unit Cost**	**Extended Cost**
	GENERAL CONDITIONS				
	MOBILIZATION	LS	1	$11,345.00	$ 11,345.00
	TRAFFIC CONTROL	LS	1	$ 3,781.00	$ 3,781.00
	SURVEY	LS	1	$ 3,781.00	$ 3,781.00
	QUALITY CONTROL	LS	1	$ 1,890.00	$ 1,890.00
	SWPPP	LS	1	$ 3,781.00	$ 3,781.00
	SEWER CONSTRUCTION				
1	INSTALL 4" SEWER SERVICE LINE INCLUDING ALL APPURTENANCES	LF	123	$ 34.00	$ 4,182.00
2	INSTALL 12" SEWER MAIN INCLUDING ALL APPURTENANCES	LF	560	$ 162.00	$ 90,720.00
3	INSTALL 48" DIA. SEWER MANHOLE	EA	2	$ 7,425.00	$ 14,850.00
4	INSTALL 4" SEWER SERVICE CONNECTION	EA	1	$ 675.00	$ 675.00
5	REMOVE AND REPLACE ASPHALT PAVEMENT	SF	127	$ 84.00	$ 10,668.00
	WATER CONSTRUCTION				
1	INSTALL 4" WATER SERVICE LINE INCLUDING ALL APPURTENANCES	LF	116	$ 29.00	$ 3,364.00
2	INSTALL 8" WATER MAIN INCLUDING ALL APPURTENANCES	LF	549	$ 75.00	$ 41,175.00
3	INSTALL FIRE HYDRANT ASSEMBLY	EA	2	$ 6,345.00	$ 12,690.00
4	INSTALL 4" WATER SERVICE CONNECTION	EA	1	$ 3,105.00	$ 3,105.00
5	REMOVE AND REPLACE ASPHALT PAVEMENT	SF	91	$ 84.00	$ 7,644.00
		ENGINEERS ESTIMATE			**$ 213,651.00**

8.0 Summary of Engineering Work

Table 8-1 shows the estimated staff hours for the proposed design project. Each staff member was required to keep track of their hours based off the specific task.

Table 8-1: Estimated Staff Hours

ESTIMATED STAFF HOURS					
Task	Staff (hr)				Total
	Senior Engineer	Professional Engineer	Design Engineer	Intern	Task
Task 1.0: Analyze Existing Conditions	**0**	**22**	**22**	**22**	**66**
Task 1.1: Site Visit Planning	0	6	6	6	18
Task 1.2: Site Investigation	0	8	8	8	24
Task 1.3: Land Survey	0	8	8	8	24
Task 2.0: Existing Conditions	**2**	**16**	**25**	**25**	**68**
Task 2.1: Create Topographic Map	1	6	15	15	37
Task 2.2: Hydrologic Analysis	1	10	10	10	31
Task 3.0: Hydraulic Analysis	**3**	**24**	**24**	**18**	**69**
Task 3.1: Determine Water Demand and Sewer Design Flow	1	8	8	6	23
Task 3.2: Municipal Potable Waterline	1	8	8	6	23
Task 3.3: Sanitary Sewer	1	8	8	6	23
Task 4.0: Construction Plans	**8**	**50**	**50**	**26**	**134**
Task 4.1: Potable Waterline Design	4	16	16	10	46
Task 4.2: Sanitary Sewer Line Design	4	16	16	10	46
Task 4.3: Cost Estimation	2	8	8	6	24
Task 5.0: Project Management	**58**	**70**	**114**	**114**	**356**
Task 5.1: Project Impacts					
Task 5.1.1: Regulatory	0	0	6	6	12
Task 5.1.2: Health/Environmental	0	0	6	6	12
Task 5.1.3: Economic	0	0	6	6	12
Task 5.1.4: Social	0	0	6	6	12
Task 5.2: Resource Management	4	4	0	0	8
Task 5.3: Schedule Management	0	8	0	0	8
Task 5.4: Meetings					
Task 5.4.1: Team Meetings	12	12	12	12	48
Task 5.4.2: Technical Advisor Meetings	4	4	4	4	16
Task 5.4.3: Grading Instructor Meetings	4	4	4	4	16
Task 5.4.4: Client Meetings	4	4	4	4	16
Task 5.5: Project Deliverables					
Task 5.5.1: 30% Report	4	5	8	8	25
Task 5.5.2: 60% Report	6	6	10	10	32
Task 5.5.3: 90% Report	8	8	12	12	40
Task 5.5.4: 90% Website	4	5	8	8	25
Task 5.5.5: Final Presentation	4	5	8	8	25
Task 5.5.6: Final Report & Website	4	5	20	20	49
Staff Total	**71**	**182**	**235**	**205**	**693**

The results of the total amount of hours each staff member worked for every task is listed in Table 8-2 below. The design engineer worked the greatest number of hours, followed by the professional engineer, intern, and then finally the senior engineer. The total staff hours sum to 528, which is less than the estimated hours.

Table 8-2: Actual Staff Hours

ACTUAL STAFF HOURS					
Task	Staff (hr)				Total Task
	Senior Engineer	Professional Engineer	Design Engineer	Intern	
Task 1.0: Analyze Existing Conditions	**0**	**2**	**8**	**2**	**12**
Task 1.1: Site Visit Planning	0	0	0	0	0
Task 1.2: Site Investigation	0	2	8	2	12
Task 1.3: Land Survey	0	0	0	0	0
Task 2.0: Existing Conditions	**10**	**11**	**16**	**7**	**44**
Task 2.1: Create Topographic Map	6	8	10	3	27
Task 2.2: Hydrologic Analysis	4	3	6	4	17
Task 3.0: Hydraulic Analysis	**6**	**11**	**26**	**12**	**55**
Task 3.1: Determine Water Demand and Sewer Design Flow	2	4	10	4	20
Task 3.2: Municipal Potable Waterline	2	3	8	4	17
Task 3.3: Sanitary Sewer	2	4	8	4	18
Task 4.0: Construction Plans	**8**	**36**	**56**	**14**	**114**
Task 4.1: Potable Waterline Design	0	12	24	4	40
Task 4.2: Sanitary Sewer Line Design	0	8	22	4	34
Task 4.3: Cost Estimation	8	16	10	6	40
Task 5.0: Project Management	**28**	**77**	**139**	**54**	**298**
Task 5.1: Project Impacts					
Task 5.1.1: Regulatory	0	0	6	4	10
Task 5.1.2: Health/Environmental	0	0	6	5	11
Task 5.1.3: Economic	0	0	6	5	11
Task 5.1.4: Social	0	0	5	4	9
Task 5.2: Resource Management	2	8	0	0	10
Task 5.3: Schedule Management	4	4	0	0	8
Task 5.4: Meetings					
Task 5.4.1: Team Meetings	4	8	12	4	28
Task 5.4.2: Technical Advisor Meetings	2	2	4	2	10
Task 5.4.3: Grading Instructor Meetings	2	7	11	7	27
Task 5.4.4: Client Meetings	2	3	4	3	12
Task 5.5: Project Deliverables					
Task 5.5.1: 30% Report	2	6	9	2	19
Task 5.5.2: 60% Report	2	6	24	4	36
Task 5.5.3: 90% Report	2	10	18	4	34
Task 5.5.4: 90% Website	2	16	20	4	42
Task 5.5.5: Final Presentation	2	4	6	2	14
Task 5.5.6: Final Report & Website	2	3	8	4	17
Staff Total	**52**	**137**	**245**	**89**	**523**

9.0 Summary of Engineering Costs

The estimated and actual cost of engineering services for this project is listed in Table 9-1 below.

Table 9-1: Cost of Engineering Services

Estimated Cost of Engineering Services				
1.0 Personnel	Classification	Rate ($/hr)	Hours	Cost
	SEGR	$ 190	71	$ 13,490
	PEGR	$ 130	182	$ 23,660
	DEGR	$ 100	235	$ 23,500
	INT	$ 25	205	$ 5,125
	Total Personnel			**$ 65,775**
2.0 Travel	**Classification**	**Item Total**	**Unit Cost**	**Cost**
	1 visit @ 260 mi/visit	260	$0.49	$127
	Vehicle Rental (per day/trip)	1	$125.00	$125
	Total Travel		**Per Diem**	**$252**
3.0 Supplies	**Classification**	**Days**	**($/day)**	**Cost**
	Surveying	1	$275	$275
	PPE	1	$80	$80
	Total Supplies			**$355**
4.0 Total				**$66,382**

Actual Cost of Engineering Services				
1.0 Personnel	Classification	Rate ($/hr)	Hours	Cost
	SEGR	$ 190	52	$ 9,880
	PEGR	$ 130	137	$ 17,810
	DEGR	$ 100	245	$ 24,500
	INT	$ 25	89	$ 2,225
	Total Personnel			**$ 54,415**
2.0 Travel	**Classification**	**Item Total**	**Unit Cost**	**Cost**
	1 visit @ 260 mi/visit	0	$0.49	$0
	Vehicle Rental (per day/trip)	0	$125	$0
	Total Travel		**Per Diem**	**$0**
3.0 Supplies	**Classification**	**Days**	**Unit Cost ($/day)**	**Cost**
	Surveying	0	$275	$0
	PPE	0	$80	$0
	Total Supplies			**$0**
4.0 Total				**$54,415**

10.0 Impacts Analysis

10.1 Regulatory

This project will have a positive impact if the hydraulic calculations and design follow the regulatory standards set by the city of Page. It is unethical for engineers to not comply with local, state and federal regulations. Regulations are set in place for the safety of the pubic and can mitigate design flaws if they are in compliance. A negative regulatory impact would be that standards and regulations could make the cost of the project more expensive for the client.

10.2 Health & Environmental

The extension of a water and sewer line can have positive and negative impacts to the health of people and the environment in the surrounding area. A positive impact is that the project ensures the removal of waste from this property and future developments. It also provides safe drinking water to the client and his business. A negative impact that could occur from construction or post-construction would be any displacement of sediment, hazardous waste, or pipe leakage. This could cause serious damage to the environment and could potentially make its way to Lake Powell if there was a large enough storm event to transport the debris. The use of construction equipment will pollute the air and can elevate dust particles, which is harmful to human health if not controlled. If new drainage patterns arise from an increase in impervious surfaces or the grading does not follow the regulations, then during a storm event scouring could occur and harm ecosystems.

10.3 Economic

The project can positively impact the local economy and the client's economic interests. The city of Page would benefit from the project because it would add a tax-paying commercial property. New construction jobs also boost the local economy and provide jobs to people living in the community. A negative impact for the local economy is that taxpayer's money could go towards the future extension of the utilities. The extension of the water and sewer line will increase the property value for the client. However, it would be a costly investment initially for an independent client.

10.4 Social

One positive effect of this project is being able to provide water and sewer utilities for future expansion south of the project site. This includes the town of LeChee, Arizona that relies on the water supply from Page, Arizona. Additionally, the industrial area south of Page may be able to expand their operations with the utility extensions. The convenience of receiving clean water and a being connected to a sewage system will bring more people to the city of Page and can allow for the city's population to grow. The quality of life for the client will be improved because the other options for sewage disposal can be unpleasant and undesirable. Septic tanks often require routine maintenance, whereas if a property is connected to the city's sewage system than there is no maintenance required. Some negative social impacts from construction and the increase of future development would be noise pollution. The soil type in the area is typically bedrock, so excavating trenches is a loud and slow process, which can be disturbing to neighboring residential communities. Another negative impact from construction is traffic congestion along the high-density road.

11.0 Conclusion

The objective of this project was to design an extension of a water and sewer line across the client's property that adheres to the standards and regulations set by the City of Page. Prior to the design of the construction plans, a hydrologic and hydraulic analysis was required. The hydraulic analysis met all the codes and regulations to ensure the safety of the public and the longevity of the pipelines. The project was completed on time and met the objectives. In the future, it is recommended that a fire hydrant flow test be conducted on both new hydrants installed. The waterline should also be flushed to remove particulates that may be left over from construction debris and a pressure test should be conducted once the waterline is installed.

References

[1] "Arizona Map," Destination 360, 2020. [Online]. Available: http://www.destination360.com/north-america/us/arizona/map. [Accessed 22 February 2020].

[2] "Coconino County Parcel Viewer," Coconino County Arizona , Page, 2020.

[3] "Land Development Manual: Construction Plan Requirements Checklist," City of Page , Page, 2018.

[4] P. Custer, "Geotechnical Investigation: Proposed Custer Storage Warehouse," Rosenberg Associates, Page, 2020.

[5] Arizona Administrative Code Department of Environmental Protection, "TITLE 18. ENVIRONMENTAL QUALITY CHAPTER 9. DEPARTMENT OF ENVIRONMENTAL QUALITY," *Sewage Collection System,* 30 September 2005.

[6] City of Page, "Page General Development and Subdivision Regulations," Page, City of Page, 1983.

[7] Data USA, "Data USA Census," Data USA, [Online]. Available: https://datausa.io/profile/geo/lechee-az/. [Accessed 3 October 2020].

[8] D. Chin, Water Resource Engineering, Upper Saddle River: Pearson, 2014.

[9] "Construction Site Runoff," Coconino County, 2020. [Online]. Available: https://www.coconino.az.gov/1101/Construction-Site-Runoff. [Accessed 1 September 2020].

[10] "Stormwater Construction General Permit SWPPP Template," Arizona Department of Environmental Quality, Flagstaff, 2020.

[11] "Coconino County Stormwater Quality And Runoff Control Ordinance," Coconino County Community Development Stormwater Management Program , Flagstaff, 2017.

[12] "What is a SWPPP?," Arizona Department of Environmental Quality, 2020. [Online]. Available: https://azdeq.gov/AZPDES/SWPPP. [Accessed 1 September 2020].

[13] "Erosion and Pollution Control Manual," Arizona Department of Transportation, 2016.

Appendices

Appendix A: Industrial/Commercial Design Capacities [5]

Arizona Administrative Code
Department of Environmental Protection — Sewage Collection System Snippet

Dwelling For on-site wastewater treatment facilities per R18-9-E302 through R18-9-E323: Apartment Building 1 bedroom 2 bedroom 3 bedroom 4 bedroom	 Apartment Apartment Apartment Apartment	 200 300 400 500
Seasonal or Summer Dwelling (with recorded seasonal occupancy restriction)	Resident	100
Single Family Dwellings	see R18-9-A314(D)(1)	see R18-9-A314(D)(1)
Other than Single Family Dwelling, the greater flow value based on: Bedroom count 1-2 bedrooms Each bedroom over 2 Fixture count	 Bedroom Bedroom Fixture unit	 300 150 25
Fire Station	Employee	45
Hospital All flows Kitchen waste only Laundry waste only	 Bed Bed Bed	 250 25 40
Hotel/motel Without kitchen With kitchen	 Bed (2 person) Bed (2 person)	 50 60
Industrial facility Without showers With showers Cafeteria, add	 Employee Employee Employee	 25 35 5
Institutions Resident Nursing home Rest home	 Person Person Person	 75 125 125
Laundry Self service Commercial	 Wash cycle Washing machine	 50 Per manufacturer, if consistent with this Chapter
Office Building	Employee	20

Park (temporary use) Picnic, with showers, flush toilets Picnic, with flush toilets only Recreational vehicle, no water or sewer connections Recreational vehicle, with water and sewer connections Mobile home/Trailer	 Parking space Parking space Vehicle space Vehicle space Space	 40 20 75 100 250
Restaurant/Cafeteria With toilet, add Kitchen waste, add Garbage disposal, add Cocktail lounge, add Kitchen waste disposal service, add	Employee Customer Meal Meal Customer Meal	20 7 6 1 2 2
Restroom, public	Toilet	200
School Staff and office Elementary, add Middle and High, add with gym & showers, add with cafeteria, add Boarding, total flow	 Person Student Student Student Student Person	 20 15 20 5 3 100
Service Station with toilets	First bay Each additional bay	1000 500
Shopping Center, no food or laundry	Square foot of retail space	0.1
Store Public restroom, add	Employee Square foot of retail space	20 0.1
Swimming Pool, Public	Person	10
Theater Indoor Drive-in	 Seat Car space	 5 10

Appendix B: Bentley FlowMaster Analysis Segment

Coppermine_Rd_Report_Final

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Label	Solve For	Pressure at 2 (psi)	Pressure at 1 (psi)	Friction Method	Elevation at 1 (ft)
Water Segment 1	Pressure at 2	57	80	Manning Formula	4,253.00
Water Segment 2	Pressure at 2	33	57	Manning Formula	4,253.00
Water Stubout	Pressure at 2	52	57	Manning Formula	4,253.00

Elevation at 2 (ft)	Length (ft)	Roughness Coefficient	Diameter (in)	Discharge (cfs)	Energy Grade at 1 (ft)
4,253.00	268.0	0.006	8.0	11.57	4,454.60
4,253.00	280.0	0.006	8.0	11.57	4,401.55
4,253.00	116.0	0.006	2.0	0.20	4,385.78

Energy Grade at 2 (ft)	Hydraulic Grade at 1 (ft)	Hydraulic Grade at 2 (ft)	Flow Area (ft²)	Wetted Perimeter (ft)	Velocity (ft/s)
4,402.26	4,437.53	4,385.19	0.3	2.1	33.15
4,346.86	4,384.47	4,329.79	0.3	2.1	33.15
4,374.78	4,384.47	4,373.47	0.0	0.5	9.17

Velocity Head (ft)	Friction Slope (ft/ft)	Notes	Messages
17.07	0.195		
17.07	0.195		
1.31	0.095		

Appendix C: Straw Wattle Standard Detail [9]