Alternatives Designs

Three storm drain design alternatives were analyzed and considered in a decision matrix based on client preference. The three alternatives consist of two parallel pipe designs and one single series pipe as described below. The plan view for each alternative design is shown in appendix-H.

Double 18" smooth wall HDPE pipes

The selection of pipe diameter was based on the 50 years storm. The FlowMaster results for the smooth wall pipe (see appendix F-7) required a diameter of at least 33.7" to handle the 50-year storm event therefore, discharge is divided by two parallel 18" pipes with n value of 0.011 for whole drainage. The two parallel pipes are connected along the existing channel through the CMP culverts.

The current average channel depth is about 3 feet which leaves us with 1.5 feet for the allowable cover. The minimum allowable cover based on the city of flagstaff storm design manual for the HDPE should be one pipe diameter which is 18" and satisfies the requirement. Joints for the HDPE will be spigot type and elastomeric gaskets that will provide a watertight connection between the joints.[4] An excel spreadsheet was used to select the design diameter of the pipe based on the 50 years storm event, the detailed calculation can be shown in appendix-G.

Double 18" reinforced Concrete pipes

The second alternative was similar to the previous one but with two parallel 18" reinforced concrete pipes with an n value of 0.013. The FlowMaster results for the concrete pipe (see appendix F-8) based on the 50 year storm event required a 35.9 inches of diameter therefore, the double concrete pipes is able to handle the peak discharge of 28.4 cfs.
The minimum allowable cover for the concrete pipe is 1 foot and the existing channel has more than enough depth to satisfy the requirement. Bell and spigot ends with O-ring rubber gaskets joints is used to connect the concrete pipes. An excel spreadsheet was used to select the design diameter of the pipe based on the 50 years storm event, the detailed calculation can be shown in appendix-G.

Single 48" Corrugated metal pipes

The third alternative is a single series 48" corrugated metal pipe with n value of 0.024 storm drain. The FlowMaster results for the CMP required a diameter of 58.9 inches and the next available pipe diameter to handle the 50 years storm peak discharge is 48". Since the average existing channel depth is at 3 feet, digging is required to install the 48" corrugated metal pipes. In addition, the current culverts that is within the channel must be replaced to connect the culverts to the storm drain which is very expensive compared to the other alternatives since it requires a lot of work. An excel spreadsheet was used to select the design diameter of the pipe based on the 50 years storm event, the detailed calculation can be shown in appendix- G.

Decision Matrix

A decision matrix was created to select the best design based on four different criteria's those were, cost of design, efficiency of design, maintenance, and client preference. A score from 1-5

was given for each criteria with 1 being poor and 5 being best as displayed in table 4.1. The cheapest material of pipe is the HDPE pipes at $16.5 per ft hence they were given a 5 in the decision matrix. The concrete pipes are the second cheapest material but almost double the price of the HDPE pipes at $30.5 per ft. The most expensive pipe material is the CMP at $50 per ft. The HDPE pipe is the most efficient material to handle the peak discharge due to the significantly low roughness coefficient value of 0.011. The concrete pipe has a roughness coefficient of 0.013. Even though the CMP has a very high roughness coefficient of 0.024, it was given a rating of 4 similar to the concrete pipes due to the large diameter which can handle up to the 100 year storm event discharge. According to the flagstaff storm design manual, the HDPE has a service life of 75 years highest than the other alternatives at 50 years.[4]

Table 4. 1 Summary of Decision Matrix

Criteria	Double 18" smooth wall HDPE pipes	Double 18" reinforced Concrete pipes	Single 48" Corrugated metal pipes
Material cost per ft	$16.5	$30.5	$50
Construction cost	4	3	1
Material cost	5	3	2
Efficiency of design	5	4	4
Maintenance cost	4	3	3
Client preference	5	4	3
Total	23	17	13

Final Design

Based on the decision matrix and client preference, the team selected the final design to be a double 18" smooth wall HDPE parallel pipes storm drain. The storm drain is designed based on the 50-year storm event and checked for the 100-year storm event. The cross section of the final storm drain design is shown in Appendix H-4.

Connecting design through existing CMP

Spigot type and elastomeric gaskets joints is used to connect the existing CMP with the storm drain design.[4]

Final Design Recommendation

The smooth wall HDPE parallel pipes were chosen as the final design. This design consists of two parallel HDPE pipes with a diameter of 18” in which the flow is split along those two pipes. To benefit from the very low n value of 0.011, the HDPE pipe was selected as the material since it can handle the flow more efficiently compared to the other alternatives. This is why it was given a rating of 5 in the decision matrix for the efficiency of design. The HDPE pipes has a service life span of 75 years thus it was given a score of 4 for maintenance cost. The FlowMaster results suggests that the double HDPE pipes can handle up to a maximum discharge of 40 cfs which is above the 50 years storm event peak discharge and is the best alternative to handle the 100 years storm. HDPE pipes are the cheapest to get compared to the other alternatives therefore, it was given a 5 for material cost in the decision matrix.