Basketball Court Design

CENE 486C

Adel Alnasser, Hamad Alqalaf and Daij Alfahad
BASKETBALL COURT DESIGN TEAM

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1.0 Introduction

The main objective of this project is to develop a piece of land by designing a full basketball court with adjusting some of the existing conditions of the project. Moreover, the land is located within the Ponderosa Trail Unit Eight in the City of Flagstaff, Arizona. The purpose of this development project is to design a basketball court and a drainage system for the retreat Homeowner Association. Also, the project includes regulations of research, surveying, hydraulic analysis, hydrology analysis and traffic analysis.

2.0 Acknowledgments

The team acknowledges Dr. Edward Smaglik and The retreat HOA for giving the team the opportunity to work on this project. The team also acknowledges Mr. Mark Lamer for his guidance through the project. The team would also like to thank Mr. Gary Miller and the City of Flagstaff for providing all the needed documents that are related to the location of the proposed project.

3.0 Previous Work

The team has collected information about previous work from several institutions that have policies, regulations and research information, which are related to the project. The institutions include: Woodson Engineering and Surveying Incorporation and Western Technologies.

Woodson Engineering and Surveying Inc. did the construction plans (3) and the drainage report for the area (5). The team had to get those two documents to find out more information about the existing storm infrastructures.

4.0 Project Description

The project description of the Basketball court design project is based on three main parts, such as the project understanding, current condition, and constraints and limitation. Those three main parts provide details and information about different aspects of the project.

4.1 Project Understanding

The land of study is about 0.57 acres and is located at 590 W Cinnabar Trail, Flagstaff AZ, 86005 [Appendix A]. This piece of land is not occupied in the neighborhood. It would be a convenience for the residents to have a basketball court on this land since the standards of ponderosa trails do not allow residents to park or use it for any other activities (6). Also, the standards state that "Permanent basketball stands, backboards, hoops, and other associated fixtures are not permitted and Portable basketball stands, with attached backboard and hoop, are allowed only during time of game play. At all other times, portable basketball and associated equipment must be stored so that they are not visible from the street" (6). Therefore, the HOA decided to explore utilizing the empty land for a basketball court.

4.2 Current Conditions

The land is located by I-17 interstate and has a sub-basin that is approximately 1/3 of the total area. Also, a part of I-17 drainage discharge flows into the existing sub-basin. There are two circular culverts to convey this water out of the land and into the ponderosa trail drainage system. Moreover, there are some trees on the land that might be in the way of the proposed location of the basketball court. There are no parking spots by the land. The land is between two houses and it faces the street.

4.3 Constraints and Limitations

This design will adhere to the policies and regulations that are required by the City of Flagstaff. Also, the team's main constraint is to design a full basketball court, which will change the surface of the land as well as the location's demand. The limitations are the size of the land, trees and sub-basin area. The high school court dimensions are too big for the space available on the land. Therefore, a smaller court dimensions is needed to avoid cutting trees, to minimize post-development runoff area. The area is not a part of Federal Emergency Management Agency (FEMA). Also, the location does not include parking spots.

5.0 Literature Review

This project requires a full understanding of The City of Flagstaff codes, policies, regulations and requirements. The project requires the team to be familiar with drainage, traffic, and natural resources codes. The team had to do some research to find out how to deal with natural resources, such as trees on the construction site. The team reviewed Title 10, Flagstaff Zoning Code (4) and the City of Flagstaff Stormwater Design Manual Chapter Eight was reviewed in order to help the team design the detention basin based on the city requirements (2). Moreover, City of Flagstaff Transportation Engineering webpage was a helpful tool to make sure that the team follows and uses the correct approach in order to increase the safety and efficiency of the location. Title 10 was helpful for resources protection, which helped with trees protection. On the other hand, storm water design manual was used to design the detention basin based on the city requirements.

The Ponderosa trails standards document is used to ensure that the team is following the standards of the subdivision. Also, Flood Emergency Management Agency (FEMA) floodplain was reviewed to ensure that the location of the project is not part of FEMA designated floodplain area (1).

Low Impact Development (LID) Manual guidance was used to find out whether or not the project requires an LID design.

The court will not have an official basketball court size, which will require the team to design or scale down the official high school court size to fit within the area of project. The team will make sure that the three point curve line from the official sized court is maintained for the proposed design.

6.0 Data Collection

This part of the report includes details of all site work that was done for the design project, such as, the site elevation and surveying.

6.1 Site Evaluation

The team had to go out in the field to evaluate the site in terms of any elements that might affect the design process of the project. There are no underground utility lines buried within the land.

There are 22 trees in the whole area. And the existed sidewalk slop is 1.5%. Also, there are some rocks that can be removed. In addition, the land is between two houses and there are two fences, one on each side that separates each house from the land.

6.2 Surveying

Surveying will help in creating a topographic map of the needed site area. The topographic map, helps in designing the drainage system and establishing the ground surface elevation for the basketball court. Also, it will be required to get some accurate dimensions of the culverts. Surveying was done using an auto level in order to obtain accurate dimensions of the barrels circular culverts inlet and outlet. Total station was used to shoot around 300 points of gridlines, sidewalks, trees and culverts. This helped the team determining the locations of the trees which helped knowing whether the tree should be removed or kept. [Appendix, B]

Table 1: Culverts Dimensions

Parameters	Culvert 1	Culvert 2
Diameter (ft)	3	3
Length (ft)	80.65	80.65
Slope (ft/ft)	0.0005	0.0006

The AutoCAD drawing of the circular culverts is located on [Appendix, C]

7.0 Drainage Design

This section of the report includes details of all hydrology and hydraulic analyses that were done for the design project. Some of the data used for this section were obtained from the data collection while others were based on the site work analysis section. City of flagstaff requires a detention basin design to avoid any changing to the existing drainage system downstream. However, according to the guidance manual for site design and implementation, the site does not require a low impact development since the total developed area is less than 0.25 acre.

7.1 Hydrology analysis

This analysis is very important in the process of designing the detention basin for the site. The NOAA Atlas 14 data were used for the pre and post development runoff analysis [Appendix, D]. Also, the rational equation and sheet flow equation were used to determine runoff rates and time of concentration.

Rational Equation:

$$Q = C\ I\ A$$

Q is Discharge (cfs), C is Runoff Coefficient, I is Intensity (in/hr), A is Area (Acres)

C-bar = $\frac{\sum C\ A}{A_{total}}$

Sheet Flow Equation:

$$T = \frac{0.007\ (nl)^{0.8}}{P^{0.5}\ (s)^{0.4}}$$

T: Sheet Flow Travel Time (hr), n: Manning's Roughness Coefficient, L: Flow Length (ft),

P: Year 24 hours Precipitation (in), S: Slope (ft/ft)

- Pre-Development runoff rates for 2, 10 and 100 years storm events.

Table 2: Pre-Development Runoff Rates

Storm Event (Years)	***Q Runoff Rate (cfs)***
2	1.0089
10	1.6473
100	2.78445

The results are based on 5 min time of concentration, 0.5 runoff coefficient for pervious surface and 0.95 runoff coefficient for impervious surface. Impervious area is zero for this analysis.

- Post-Development runoff rates for 2, 10 and 100 years storm events.

  Increasing the impervious ratio of the total land will increase the runoff, which would increase the 10, 20 and 100 years flow peak.

Table 3: Post-Development Runoff Rates

Storm Event (Years)	***Q Runoff Rate (cfs)***
2	1.13634
10	1.85538
100	3.13617

The results are based on 5 min time of concentration, 0.5 runoff coefficient for pervious surface and 0.95 runoff coefficient for impervious surface. Impervious developed area is about 14% of the total area for this analysis.

The 100 year pre and post development has the highest change in runoff rates of **0.35 cfs**. [Appendix, D] Therefore, this result was used to estimate the storage volume for the detention basin.

- Detention Basin Volume Estimation "The Generalized Method".

$$V_s = Q_a\left(\frac{\gamma + \alpha + \gamma\alpha(\gamma + \alpha - 4)}{\gamma - \alpha}\right)\ for\ \alpha < 2 - \gamma$$

$$V_s = Q_a\left(\frac{\gamma - \alpha}{\gamma + \alpha}\right)\ for\ \alpha \geq 2 - \gamma$$

$$\alpha = \frac{q_{pb}}{q_{pa}}$$

$$\gamma = \frac{t_{cb}}{t_{ca}}$$

$$Q_a = \left(\frac{120}{121}\right)\left(q_p\frac{t_c}{A}\right)$$

A: watershed Area = 0.57 Acres

q_{pb}: Peak runoff rate before development = 2.78 cfs

q_{pa}: Peak runoff rate after development = 3.14 cfs

t_{cb}: Time of concentration (before) = 0.25 hr

t_{ca}: Time of concentration (after) = 0.08 hr

Q_a: Runoff Depth (after), Inches

α: Peak runoff ratio

γ: Time ratio

V_s: Storage Volume

Table 4: The Basin Calculated Volume

Storage Volume "Acre-ft"	*Storage Volume "ft^3"*
0.012	506

This is the volume used to calculate the final basin dimensions.

7.2 Hydraulic Analysis

This analysis was done to test the performance of the existing infrastructures, which is the culvert. The analysis also was used to design the detention basin based on hydrology analysis.

- Culvert Performance Analysis

Figure 1: Culverts Inlet

Two different softwares were used to determine the capacity of culverts based on the surveying data the team collected in Table 1. AutoCAD Civil 3D Hydraflow was used to analyze the culverts behavior at 10, 25 and 100 years flow. On the other hand, Bentley FlowMaster was used to determine the maximum capacity of each culvert. The data below are obtained from the drainage report of ponderosa trail unit eight done by Woodson Inc.

Table 5: Pre-Development Discharge Peak from I-17

The Peak Discharge Year	Hydrologic Element	Discharge Peak (Cfs)	Volume (ac-ft)	Area (mi^2)
10-Year	Sub-Basin 15a	9.5895	2.2996	0.180
	Junction 8	13.337	3.1667	0.192
25-Year	Sub-Basin 15a	29.857	4.7718	0.180
	Junction 8	32.908	5.9594	0.192
100-Year	Sub-Basin 15a	67.468	8.7316	0.180
	Junction 8	72.052	10.355	0.192

The maximum capacity of the culvert was estimated using AutoCAD Civil3D Q= 73.6 cfs [Appendix, E]. This means that the culvert is preforming well under pre-development conditions and has a higher capacity than the 100 years peak discharge coming from the Interstate I-17 culvert.

- Detention Basin Design

  The City of Flagstaff Stormwater Design Manual has all the requirements needed for our detention basin design (2). The team decided to design a flat top cone upside down for the shape of the basin. In order to find the dimensions that satisfy the requirements, the team had to come up with a relationship between the diameter of the bottom/top of the cone and the required height and slope. Then the team designed the basin based on the estimated volume for 2, 10 and 100 years calculated on the hydrology analysis part. Also, the team chose a depth of 2 ft to be the maximum water level in the basin.

Table 6: Basin Water Levels for Storm Events

Storm Event (years)	Volume ft^3	Water Level ft
2	183.28	1.05
10	296.20	1.45
100	506.00	2.00

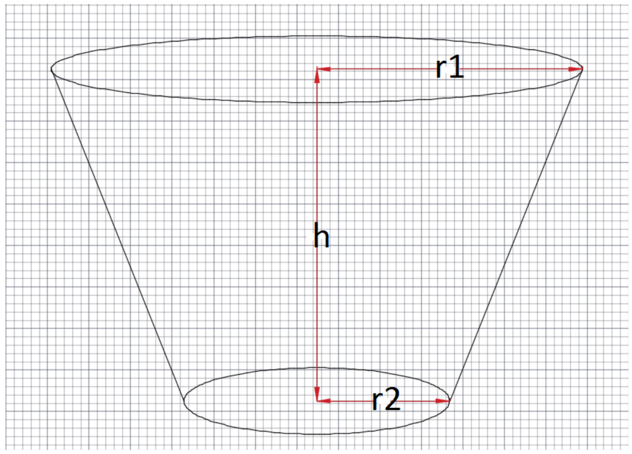

Figure 2: Flat Cone Volume

$$Volume = \frac{1}{3}\pi(r_1^2 + r_1 r_2 + r_2^2)h$$

Table 7: Detention Basin Final Design Dimension

r_1 (ft)	13.31
r_2 (ft)	5.81
H (ft)	2.5
V (ft^3)	754.62

These results include the required freeboard of 0.5, which result in a depth of 2.5 ft and volume of 254.62 ft^3. Cross Section View of the basin is located in construction plan. [Appendix, F]

- Basin Outlet Structure Design.

  Based on the water levels in the designed basin, the team could design an outlet structure to control the release rate for 2, 10 and 100 years storm events. The orifice area equation was used to determine the area of each opening through the wall based on the pre-development runoff and water level of each storm event.

  Orifice Equation:

$$A_0 = \frac{(0.2283\ q_{pb})}{(E_s - E_0)^{0.5}}$$

A_o: Orifice area, ft2

q_{pb}: Pre-development peak runoff, cfs

E_s: water elevation in basin, ft

E_o: Elevation of bottom of orifice opening, ft

Table 8: Orifice Area for 2,10 and 100 Years Storm Events

Storm Event (Years)	A_o (ft^2)
2	0.25
10	0.35
100	0.26

The drawing of the design is located in the construction plan [Appendix, F]

9.0 Basketball Court Design

The team tried to use a high school basketball court dimension, but the area of the land is very limited. Therefore, the team scaled down the high school dimensions and did several adjustments to it, such as the length and the width of the court. Although some dimensions were adjusted, the three point's area was kept with the same dimensions because it is very important for the players. Also, corner-to-corner slope of the court is 0.08 percent. Moreover, there is an additional 2 ft on each side of the court for safety. The concrete design, which will be used for the surface of the court, is class A Portland cement concrete with 5 to 7 percent air entrainment because it is an outdoor facility that is exposed to cold weather. The drawing of the court dimensions is located in construction plan [Appendix, F].

10.0 Site Design

This section of the report includes the design of sidewalk, benches, Low Impact Development (LID), American Disabilities Association requirement, traffic adjustment, and resource protection. The sidewalk will have the same type of concrete that will be used for the court surface. The sidewalk will have a 5ft width, 4in thickness and edge radiuses of 0.25in. According to Maricopa Association of Government (MAG) detail 230, the construction joints score mark is ½ in minimum depth every 5ft, and according to section 340 the expansion joints extent through the concrete and 1 inch through the subgrade. Sidewalk plan view and cross section view drawings are located in construction plans [Appendix, F]. Moreover, there will be two benches on one side of the court. Each bench is 8 ft long, and the benches pavement area is 20ft*3ft= 60ft^2. Since the slope of sidewalk is 1.5%, which is less than the maximum 2% slope that the ADA requires. Therefore, the design meets the ADA requirement. Since, the cite development area of the project is less than 0.25acres, there will be no LID design needed according to the City of Flagstaff. Also, there will be no major traffic changes to the street location of the project and there will be no parking spots available on the sides of the street, the “no parking” signage is the only thing that is necessary to be installed. The resource protection of our project is based on limiting the damages that could happen to the environment by limiting the tree cutting. The team did calculate the depth at breast height (DBH) to get the average canopy diameter, because the overhang canopy diameter over the development should not exceed the 20% area based on the City of Flagstaff requirements. Based on the team calculations, the team decision was to cut four trees from the nine trees close to the courts location.

11.0 Final Design

The team ended up developing the site with a 60 ft x 42 ft basketball court. The team also designed an entrance sidewalk as well as a bench area for people to sit and enjoy the site. A total area of 0.08 acre was developed. Therefore, a detention basin was designed to control the extra-generated runoff rate of 0.35 cfs. Construction plan located in [Appendix, F] shows the details of each element designed for the project. The team followed the city of flagstaff codes and regulations and made sure the final design meet the requirements.

12.0 Cost of Implementing the Design

The cost of the project implementation excluding the engineering services is **$15,113.6**. The table below shows detailed breakdown of the cost.

Table 9: Project Breakdown Cost

Material/ Equipment or work	*Price $*	*Quantity*	*Cost ($)*
Concrete mix	3.6/ft^3	974.4 ft^3	3507.6
Bench	303.0	2	606.0
Hoops	2500	2	5000
*Tree cutting**	(1000-2000)	4	6000
		Total Cost =	15113.6

Note*: Tree cutting may not be part of the cost. City of flagstaff has to approve cutting the trees; otherwise, a fine must be paid for every removed tree based on the diameter size at breast height (4).

13.0 Summery of Project Costs

This Section is a comparison between the proposed cost and effort and the actual cost and effort to complete the project. During the progress of the project, the team had to change some of the main tasks based on availability of data. The proposal's staffing plan has different hours and costs than the new staffing plan based on the old list of tasks and sub-tasks. The team needed slightly less hours and charged slightly lower cost for the actual engineering services provided to complete the project [Appendix, G]. The final engineering services came up to a total of **$28,680** for **411 hours**. The adjusted Gantt chart is located in [Appendix, H]. It shows all the actual preformed tasks and time taken to finish each task as well as the dependency of tasks on one another.

14.0 References

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(4) "Division 10 - 50.90 Resource Protection Standards." *FLAGSTAFF CITY CODE TITLE 10, FLAGSTAFF ZONING CODE* 10 - 50.90. Print.

(5) "Final Drainage Report." *PONDEROSA TRAIL UNIT 8* (2004): 1-103. Print.

(6) PONDEROSA TRAILS. "Residential Development Standards." Residential Development Standards (2013): 1-14. Web. 1 Sept. 2013. <http://www.ponderosatrailshoa.com/uploaded_files/224/files/RDS%20Final%2005-15-13.pdf>.

(7) "Transportation Engineering." *City of Flagstaff Service at Higher Elevation*. Web. 22 Aug. 2014. <http://www.flagstaff.az.gov/index.aspx?NID=29>.

15.0 Appendices

15.1 Appendix A

Figure 3: Site Plan

Figure 4: Project Location (Closer Look)

15.2 Appendix B

Surveying data collection points: 1

Station	Northing	Easting	Elevation	Description
	5000	5000	1000	nail
culvert	4943.811	5044.883	993.8183	culvert
culvert2	4949.103	5045.782	998.7315	culvert
culvert3	4935.384	5046.222	999.1067	culvert
culvert4	4935.164	5038.882	998.8055	culvert
culvert5	4937.847	5044.4	994.1981	culvert
f	5036.557	5056.594	1000.252	fince
f2	5042.738	5046.535	1000.092	fince
f3	5050.262	5035.477	1000.491	fince
f4	5056.391	5025.281	1000.944	fince
f5	5062.55	5014.836	1001.218	fince
f6	5068.264	5006.412	1001.794	fince
f7	5071.839	5000.758	1001.986	fince
gr	5008.415	5101.794	999.927	g
gr2	5012.984	5094.297	1000.787	g
gr3	5020.013	5083.758	1001.115	g
gr4	5026.845	5073.019	1000.456	g
gr5	5029.885	5067.112	1000.212	fince
gr6	5064.417	4994.486	1001.543	g
gr7	5057.095	5003.579	1000.883	g
gr8	5049.811	5013.064	1000.537	g
gr9	5041.824	5023.107	1000.178	g
gr10	5031.746	5033.209	999.9347	g
gr11	5021.205	5043.562	999.4965	g
gr12	5012.458	5056.133	999.5685	g
gr13	5005.773	5071.893	1000.046	g
gr14	4997.625	5087.1	1000.353	g
gr15	4984.479	5083.435	1000.068	g
gr16	4991.324	5071.937	999.8694	g
gr17	4999.988	5058.6	999.6668	g
gr18	5009.359	5044.38	999.4124	g
gr19	5016.382	5032.094	999.8937	g
gr20	5025.681	5020.644	1000.043	g
gr21	5032.978	5008.258	1000.36	g
gr22	5040.87	4988.507	1001.137	g
gr23	5034.588	4977.118	1001.364	g
gr24	5026.509	4988.834	1000.901	g
gr25	5019.35	5000.471	1000.496	g
gr26	5009.099	5011.936	1000.352	g
gr27	4999.681	5024.29	999.8783	g
gr28	4988.079	5035.412	999.4361	g
gr29	4976.632	5045.669	998.9198	g
gr30	4968.73	5059.583	999.3232	g
gr31	4962.52	5069.324	1000.32	g
gr32	4951.938	5062.38	1000.43	g
gr33	4959.02	5051.021	998.7364	g
gr34	4964.473	5039.264	998.2798	g
gr35	4968.796	5028.515	998.8067	g
gr36	4975.501	5015.578	999.1334	g
gr37	4980.468	5005.393	999.4732	g
gr38	4987.247	4995.303	1000.066	g
gr39	4995.991	4986.553	1000.073	g
gr40	5003.196	4974.536	1000.259	g
gr41	5009.198	4965.676	1000.525	g
gr42	5006.109	4959.316	1000.249	g
gr43	4999.743	4968.794	1000.154	g
gr44	4989.598	4981.71	1000.055	g
gr45	4983.048	4991.74	1000.034	g

gr46	4976.917	5002.795	999.2953	g
gr47	4970.526	5011.023	999.1687	g
gr48	4967.007	5020.133	998.7357	g
gr49	4962.889	5028.661	998.2775	g
gr50	4960.805	5036.727	997.6549	g
gr51	4958.781	5043.772	997.3972	g
gr52	4952.723	5052.901	999.2722	g
gr53	4946.91	5061.228	1000.39	g
gr54	4942.719	5054.595	1000.426	g
gr55	4946.056	5050.447	999.5189	g
gr56	4948.557	5047.471	997.6605	g
gr57	4950.706	5045.057	996.2007	g
gr58	4952.41	5042.311	995.4143	g
gr59	4953.981	5040.07	995.9799	g
gr60	4954.77	5038.173	996.5915	g
gr61	4957.499	5033.298	997.1727	g
gr62	4961.057	5029.091	998.0771	g
gr63	4966.068	5022.458	998.6611	g
gr64	4969.897	5012.877	999.1237	g
gr65	4973.166	5000.968	999.2608	g
gr66	4978.73	4991.905	999.8252	g
gr67	4984.967	4980.393	1000.115	g
gr68	4990.522	4966.646	1000.049	g
gr69	4996.727	4955.338	1000.248	g
gr70	4991.673	4953.899	1000.378	g
gr71	4984.529	4965.612	1000.036	g
gr72	4976.252	4979.384	1000.206	g
gr73	4972.726	4987.45	999.5138	g
gr74	4967.493	4997.886	999.1345	g
gr75	4961.822	5006.781	998.7472	g
gr76	4958.247	5017.145	997.9616	g
gr77	4954.432	5024.676	997.1242	g
gr78	4952.257	5030.131	995.8156	g
gr79	4952.18	5033.151	995.6026	g

gr80	4951.422	5037.194	995.1917	g
gr81	4950.282	5041.018	994.9299	g
gr82	4948.249	5044.902	995.2976	g
gr83	4942.42	5040.01	994.0205	g
gr84	4942.814	5034.462	993.9826	g
gr85	4944.845	5028.885	994.3847	g
gr86	4946.284	5025.389	994.7449	g
gr87	4947.496	5022.462	995.1495	g
gr88	4948.679	5020.243	995.9278	g
gr89	4949.299	5017.807	996.3672	g
gr90	4951.266	5014.372	997.1033	g
gr91	4954.795	5009.253	997.7233	g
gr92	4958.795	5003.979	998.5732	g
gr93	4961.162	4998.733	999.0427	g
gr94	4964.569	4991.184	999.2198	g
gr95	4969.891	4982.303	999.7984	g
gr96	4978.599	4968.762	1000.129	g
gr97	4985.234	4957.651	1000.102	g
gr98	4990.27	4950.014	1000.14	g
gr99	4983.992	4946.146	999.5668	g
gr100	4979.295	4954.516	999.8464	g
gr101	4974.488	4961.424	1000.069	g
gr102	4967.784	4969.898	1000.061	g
gr103	4962.664	4979.469	999.9884	g
gr104	4959.238	4986.552	998.9259	g
gr105	4956.54	4991.823	998.0696	g
gr106	4954.755	4996.071	997.0822	g
gr107	4950.528	5003.491	996.8951	g
gr108	4947.663	5006.602	996.6364	g
gr109	4943.178	5008.921	995.3724	g
gr110	4940.246	5014.506	994.8592	g
gr111	4939.764	5019.431	994.1364	g
gr112	4938.851	5022.601	993.8629	g
gr113	4938.139	5027.71	994.1234	g

gr114	4937.333	5034.249	994.1547	g
gr115	4937.821	5039.099	993.6913	g
gr116	4937.574	5044.222	994.124	g
gr117	4925.955	5042.093	1000.397	g
gr118	4926.9	5038.258	999.2681	g
gr119	4928.326	5035.356	997.6682	g
gr120	4929.114	5032.762	996.0517	g
gr121	4930.789	5030.445	995.266	g
gr122	4934.188	5025.262	994.137	g
gr123	4937.895	5019.73	994.0981	g
gr124	4940.948	5013.545	994.9474	g
gr125	4942.665	5007.566	995.1194	g
gr126	4945.589	5002.436	995.4613	g
gr127	4948.89	4996.924	995.954	g
gr128	4952.722	4991.612	996.7473	g
gr129	4957.347	4986.225	998.2674	g
gr130	4960.339	4982.532	999.2239	g
gr131	4963.181	4977.853	999.9688	g
gr132	4969.372	4970.272	1000.065	g
gr133	4977.397	4961.456	1000.002	g
gr134	4983.897	4949.584	1000.036	g
gr135	4976.125	4945.384	999.4036	g
gr136	4971.186	4952.358	999.0375	g
gr137	4964.614	4960.775	998.6295	g
gr138	4959.122	4969.67	997.8044	g
gr139	4953.846	4981.528	997.0561	g
gr140	4950.421	4989.231	996.1886	g
gr141	4946.234	4999.801	995.5084	g
gr142	4939.917	5009.504	995.0805	g
gr143	4933.798	5018.7	994.2884	g
gr144	4930.114	5026.457	994.8777	g
gr145	4927.832	5030.385	996.1441	g
gr146	4923.58	5034.315	998.9607	g
gr147	4920.824	5038.4	1000.586	g

gr148	4914.264	5036.962	1001.294	g
gr149	4916.503	5030.587	999.3199	g
gr150	4918.724	5026.242	997.7649	g
gr151	4918.335	5020.318	996.846	g
gr152	4922.302	5014.481	996.4646	g
gr153	4928.53	5007.373	995.5902	g
gr154	4931.311	4999.65	994.918	g
gr155	4938.005	4989.96	994.8737	g
gr156	4942.262	4981.01	995.0903	g
gr157	4949.091	4969.276	995.5559	g
gr158	4956.041	4958.007	996.6921	g
gr159	4963.909	4947.275	997.1737	g
gr160	4970.526	4941.184	998.2056	g
gr161	4965.842	4937.366	998.3643	g
gr162	4960.606	4945.487	997.2239	g
gr163	4955.359	4952.269	996.2853	g
gr164	4950.351	4959.908	995.5804	g
gr165	4944.709	4969.369	995.3793	g
gr166	4938.278	4982.025	994.9161	g
gr167	4933.351	4990.477	994.8961	g
gr168	4929.599	5001.957	995.0556	g
gr169	4926.217	5008.981	996.2005	g
gr170	4923.618	5014.24	996.2086	g
gr171	4919.428	5021.22	997.0356	g
gr172	4914.677	5028.997	999.4723	g
gr173	4911.415	5034.102	1001.27	g
gr174	4909.335	5037.155	1001.684	g
gr175	4898.326	5026.146	1001.815	g
gr176	4903.084	5016.664	998.9896	g
gr177	4906.721	5011.23	997.7887	g
gr178	4910.57	5005.175	997.2676	g
gr179	4916.539	4997.64	997.0418	g
gr180	4922.062	4988.415	996.4769	g
gr181	4924.677	4983.678	995.2488	g

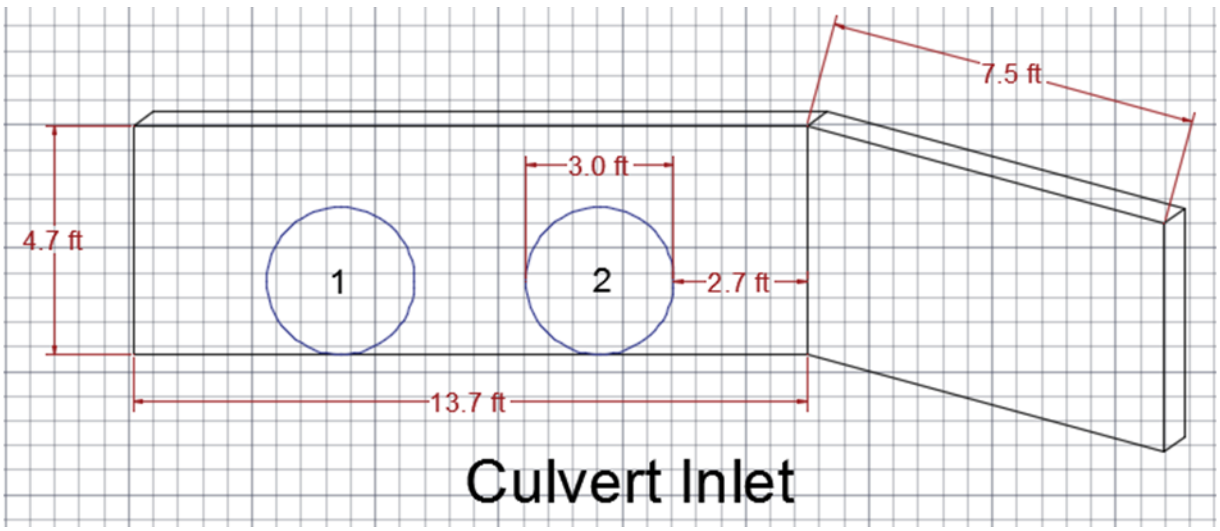
gr182	4930.577	4977.771	995.0865	g
gr183	4936.99	4969.977	995.7611	g
gr184	4945.563	4960.531	995.5854	g
gr185	4951.205	4949.239	996.1344	g
gr186	4957.473	4937.705	998.0031	g
gr187	4955.851	4932.212	998.0673	g
gr188	4951.679	4938.2	997.0021	g
gr189	4945.72	4947.326	996.1876	g
gr190	4940.357	4956.1	996.4872	g
gr191	4935.428	4963.534	996.67	g
gr192	4929.437	4974.053	994.9517	g
gr193	4925.34	4982.121	994.9902	g
gr194	4921.704	4986.965	996.5735	g
gr195	4916.882	4992.859	997.2021	g
gr196	4910.309	5003.898	997.4383	g
gr197	4904.535	5013.211	998.5839	g
gr198	4897.286	5025.947	1001.779	g
gr199	4891.303	5024.811	1002.188	g
gr200	4897.592	5011.255	999.4606	g
gr201	4901.198	5005.545	998.0053	g
gr202	4905.257	4998.263	997.7021	g
gr203	4913.088	4984.372	997.3193	g
gr204	4917.207	4975.604	996.3437	g
gr205	4920.759	4969.264	995.1128	g
gr206	4927.569	4958.973	995.9791	g
gr207	4932.959	4950.275	997.5794	g
gr208	4940.985	4939	995.8991	g
gr209	4946.368	4926.821	996.4506	g
gr210	4935.088	4930.79	997.4852	g
gr211	4932.743	4939.567	997.1776	g
gr212	4927.355	4947.605	997.8154	g
gr213	4921.329	4956.256	995.393	g
gr214	4914.059	4965.941	995.9667	g
gr215	4906.398	4975.785	997.6632	g

gr216	4896.017	4985.837	998.0439	g
gr217	4881.927	5007.034	1001.359	g
gr218	4869.477	5001.606	1001.971	g
gr219	4873.005	4996.972	1000.614	g
gr220	4877.718	4989.987	999.425	g
gr221	4888.138	4973.965	998.6475	g
gr222	4891.987	4966.526	998.2959	g
gr223	4895.989	4958.377	998.2397	g
gr224	4902.87	4948.827	997.5958	g
gr225	4908.207	4940.071	996.5089	g
gr226	4914.532	4927.516	995.945	g
gr227	4922.01	4912.541	996.9637	g
gr228	4912.859	4906.674	996.6214	g
gr229	4903.21	4923.707	996.7217	g
gr230	4896.182	4935.154	997.7167	g
gr231	4888.464	4946.503	998.6058	g
gr232	4878.816	4960.854	999.6342	g
gr233	4871.226	4970.581	1000.055	g
sw1	5010.504	5102.773	999.9379	sw
sw2	5007.561	5107.426	999.9468	sw
sw3	4996.56	5100.499	999.938	sw
sw4	4999.273	5096.047	1000.043	sw
sw5	4987.404	5088.5	999.9585	sw
sw6	4984.617	5092.733	999.816	sw
sw7	4972.012	5084.853	999.9758	sw
sw8	4974.778	5080.534	1000.049	sw
sw9	4961.963	5072.389	1000.213	sw
sw10	4959.262	5076.731	1000.002	sw
sw11	4932.336	5059.603	1000.681	sw
sw12	4935.179	5055.402	1000.716	sw
sw13	4919.796	5045.661	1001.143	sw
sw14	4917.194	5050.071	1001.07	sw
sw15	4903.595	5041.492	1001.425	sw
sw16	4906.323	5037.159	1001.521	sw

sw17	4895.091	5036.065	1001.692	sw
tree	4874.964	4952.467	999.6753	tree
tree2	4901.17	4921.1	996.7413	tree
tree3	4931.762	4926.979	998.0742	tree
tree4	5029.062	4990.423	1000.61	tree
tree5	5039.653	5006.676	1000.532	tree
tree6	5045.244	4991.897	1001.683	tree
tree7	5020.508	5037.053	999.7546	tree

tree8	5005.953	5035.107	999.0817	tree
tree9	4979.937	5044.525	999.1243	tree
tree10	4982.76	5051.555	999.0765	tree
tree11	4957.756	5044.136	997.4423	tree
tree12	4942.034	5014.029	995.0399	tree
tree13	4932.697	5006.973	994.9307	tree
tree14	4930.77	4994.706	994.7818	tree

15.3 Appendix C



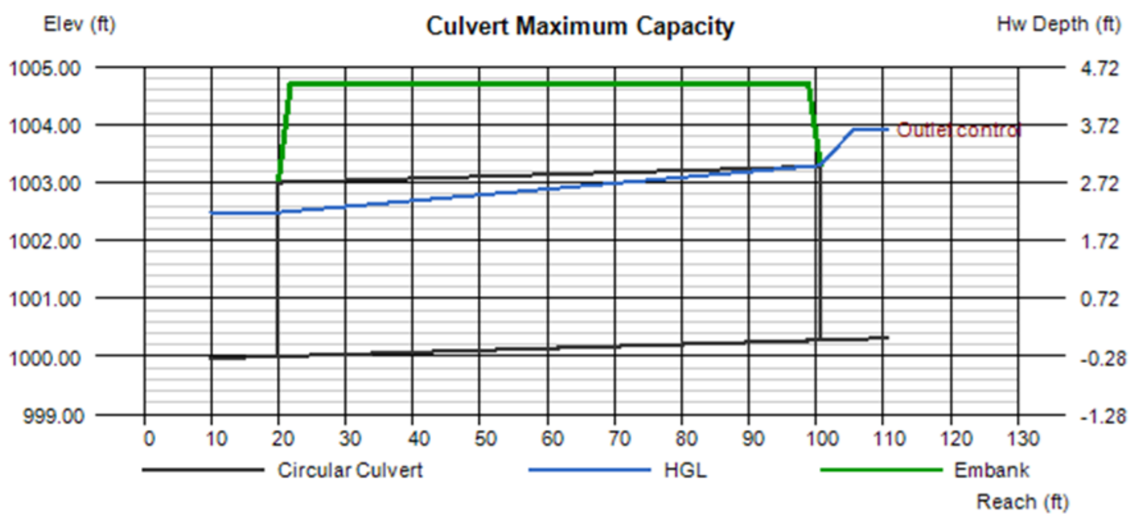
15.4 Appendix D

Precipitation Frequency (in/hr)			
by duration	2 years	10 years	100 years
5-min:	3.54	5.78	9.77
10-min:	2.69	4.4	7.44
15-min:	2.23	3.64	6.15
30-min:	1.5	2.45	4.14
60-min:	0.93	1.51	2.56
2-hr:	0.53	0.83	1.39
3-hr:	0.38	0.58	0.95
6-hr:	0.23	0.33	0.51
12-hr:	0.14	0.2	0.29
24-hr:	0.1	0.14	0.21

Pre-Development					
	Pervious	Impervious			
Area (Acre)	0.570	0.000		Total Area =	0.570
C	0.5	0.95		C-bar =	0.500
Tc (min)	5	5			
2 years	Area (Acre)	Tc (min)	Intensity in/hr	C	Q (Cfs)
Total A	0.570	5	3.540	0.500	1.0089
10 years	Area (Acre)	Tc (min)	Intensity in/hr	C	Q (Cfs)
Total A	0.570	5	5.78	0.500	1.6473
100 years	Area (Acre)	Tc (min)	Intensity in/hr	C	Q (Cfs)
Total A	0.570	5	9.77	0.500	2.78445

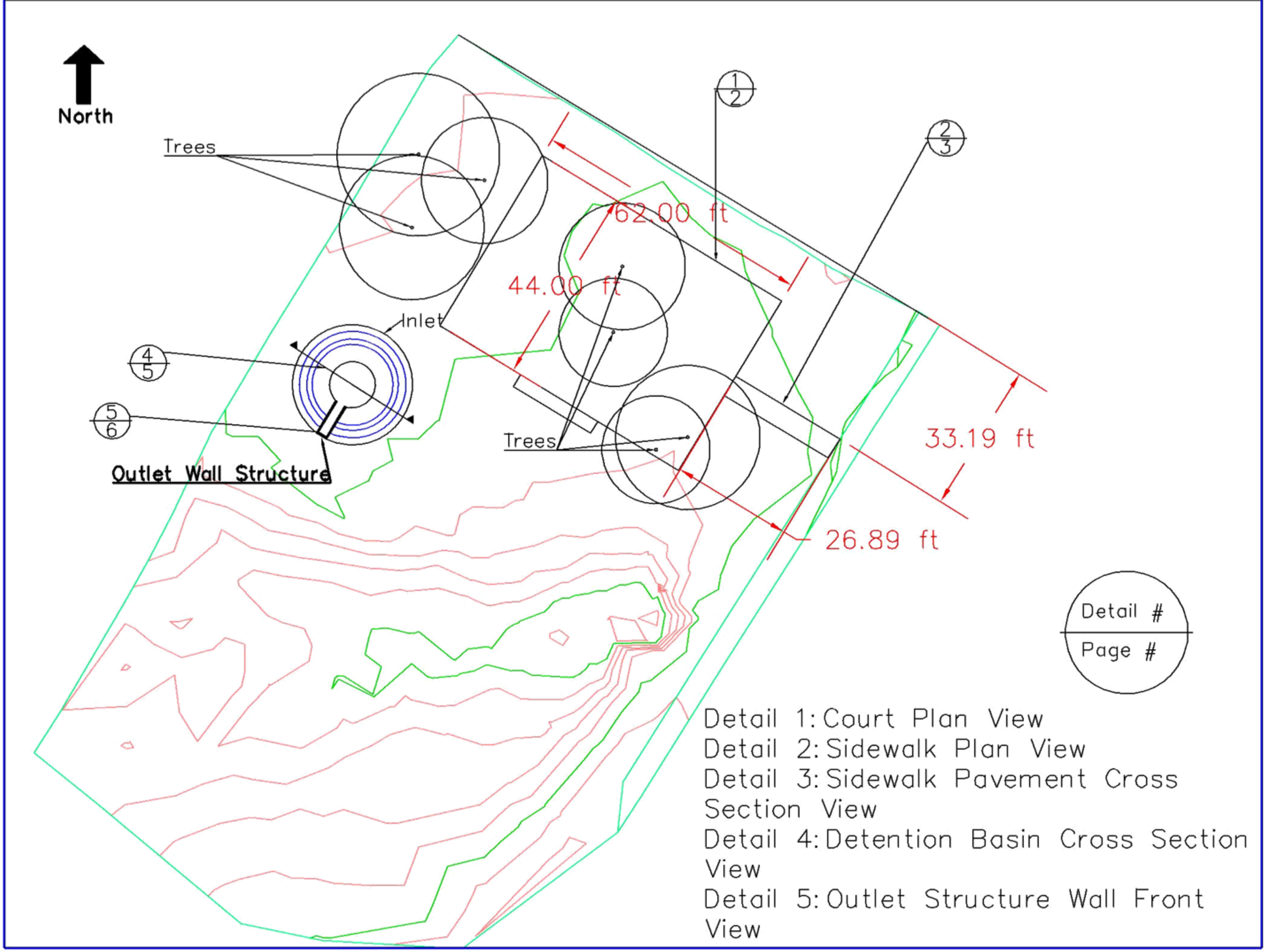
Post-Development					
	Pervious	Impervious			
Area (Acre)	0.490	0.080		Total Area =	0.570
C	0.5	0.95		C-bar =	0.563
Tc (min)	5	5			
2 years	Area (Acre)	Tc (min)	Intensity in/hr	C	Q (Cfs)
Total A	0.570	5	3.540	0.563	1.13634
10 years	Area (Acre)	Tc (min)	Intensity in/hr	C	Q (Cfs)
Total A	0.570	5	5.78	0.563	1.85538
100 years	Area (Acre)	Tc (min)	Intensity in/hr	C	Q (Cfs)
Total A	0.570	5	9.77	0.563	3.13617

15.5 Appendix E



15.6 Appendix F

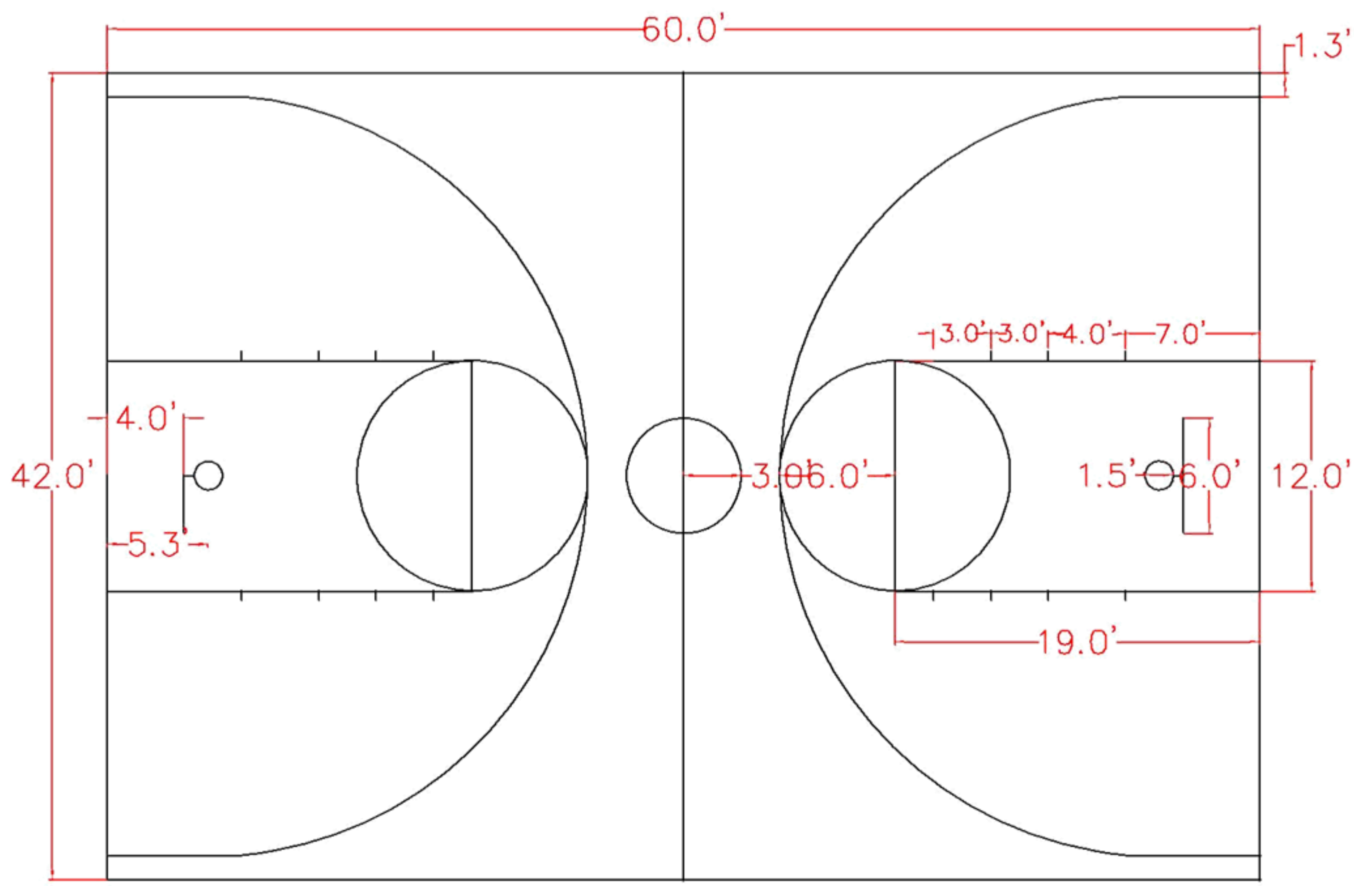
Construction Plan of The Basketball Court Design



Detail 1: Court Plan View
Detail 2: Sidewalk Plan View
Detail 3: Sidewalk Pavement Cross Section View
Detail 4: Detention Basin Cross Section View
Detail 5: Outlet Structure Wall Front View

Basketball Court Design	DRAWN BY:	REV	NO.	DATE	COMMENTS	Northern Arizona University	SHEET 1 of 6
Construction Plan	CHECKED BY:					Department of Civil Engineering, Construction Management and Environmental Engineering	
	DATE:						
	SCALE:						

Basketball Court

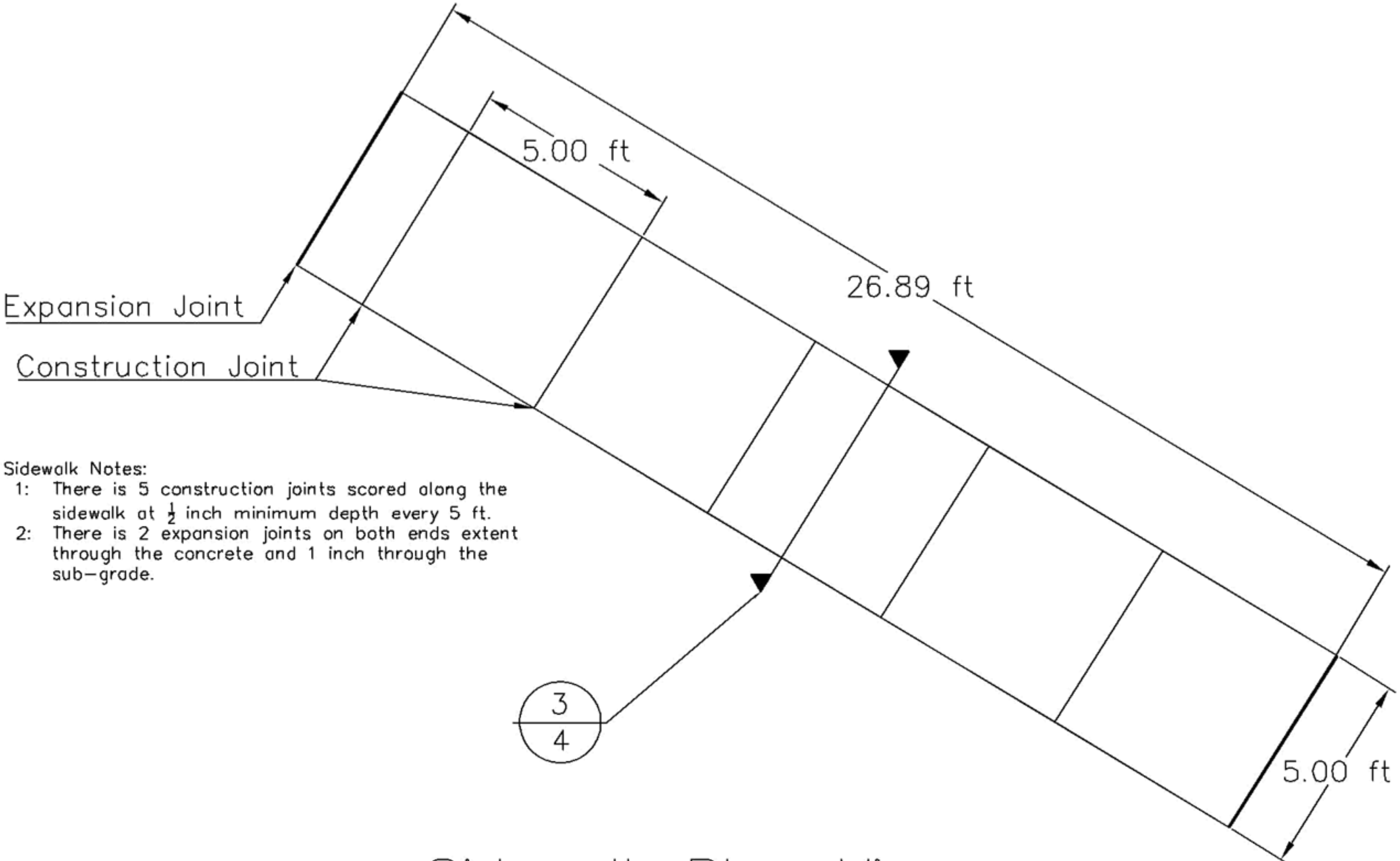


Note:
The pavement design of the court is the same as the sidewalk (See detail 3).

Basketball Court Design	DRAWN BY:	NO. DATE COMMENTS
Court plan view	CHECKED BY:	
	DATE:	
	SCALE:	

Northern Arizona University
Department of Civil Engineering, Construction Management and Environmental Engineering

~SHEET~ 2 of 6



Sidewalk Notes:

1: There is 5 construction joints scored along the sidewalk at $\frac{1}{2}$ inch minimum depth every 5 ft.
2: There is 2 expansion joints on both ends extent through the concrete and 1 inch through the sub-grade.

Sidewalk Plan View

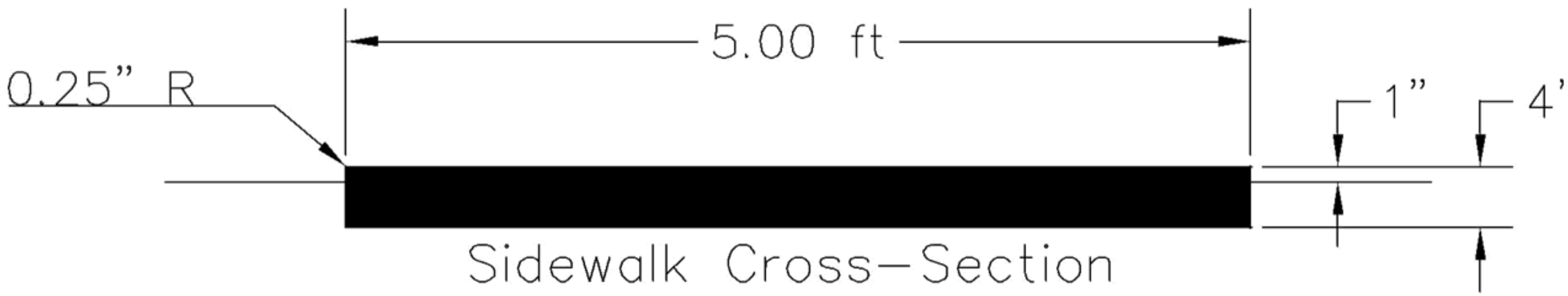
~SHEET~ 3 of 6

Northern Arizona University
Department of Civil Engineering, Construction Management and Environmental Engineering

NO.	DATE	COMMENTS

DRAWN BY:
CHECKED BY:
DATE:
SCALE:

Basketball Court Design
Sidewalk Plan View



Sidewalk Cross-Section

Notes:

1: Thickness of the pavement is 4".

2: Sidewalk is 1" above the finished grade.

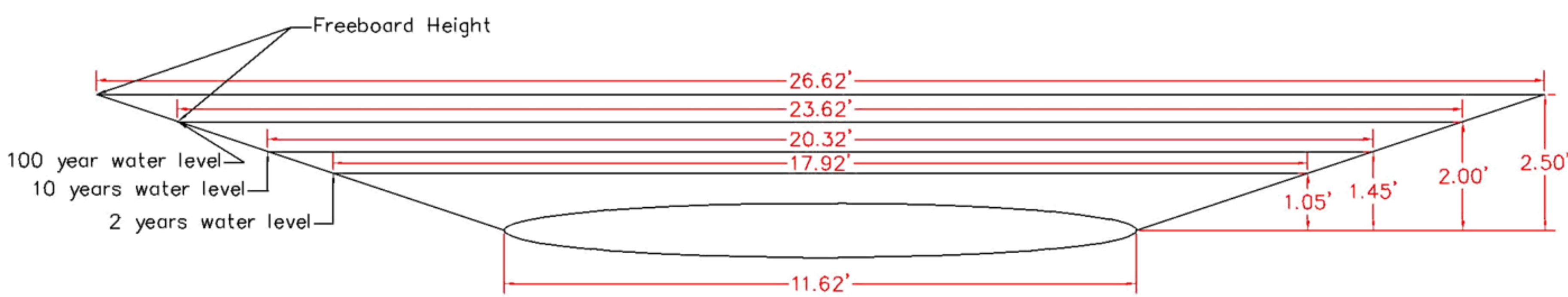
3: Radius is 0.25" at every edge between construction and expansion joints

Basketball Court Design	DRAWN BY:
Sidewalk Cross Section	CHECKED BY:
	DATE:
	SCALE:

REVISIONS NO.	DATE	COMMENTS

Northern Arizona University
Department of Civil Engineering, Construction Management and Environmental Engineering

~SHEET~ 4 of 6



Detention Basin Cross-Section View

Basketball Court Design

Detention Basin Cross Section

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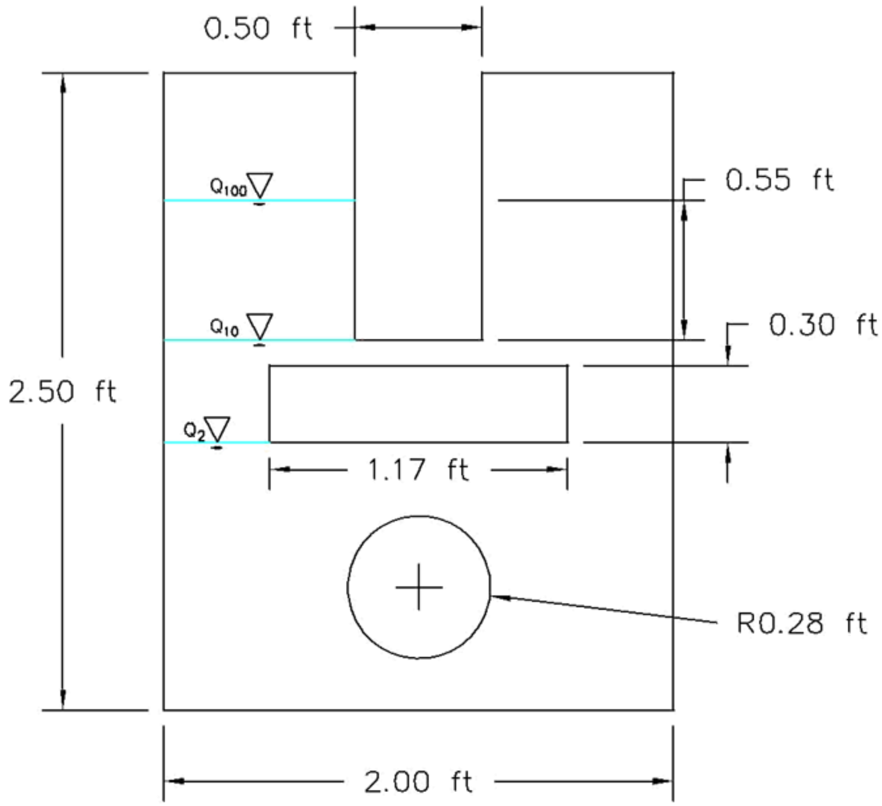
CHECKED BY:
DATE:
SCALE:

NO.	DATE	COMMENTS

Northern Arizona University

Department of Civil Engineering, Construction Management and Environmental Engineering

~SHEET~ 5 of 6



Outlet Wall Structure Front View

Basketball Court Design
Outlet Structure

DRAWN BY:
CHECKED BY:
DATE:
SCALE:

REVISIONS	NO.	DATE	COMMENTS

Northern Arizona University
Department of Civil Engineering, Construction Management and Environmental Engineering

~SHEET~ 6 of 6

15.7 Appendix G

Table 10: The Initial Staffing Plan

Tasks	Staff	Classification	Rate ($/hr)	Hours	Cost Estimate($)
1.1 Professional Meetings	Hamad Alqalaf Adel Alnasser Daij Alfahad	Engineering	80	30	2400
1.2 Team meetings	Hamad Alqalaf Adel Alnasser Daij Alfahad	Engineering	80	46	3680
2.1 meeting with Home Owner Association	Adel Alnasser Daij Alfahad	Engineering	80	12	960
2.2 Policies and Regulations Research	Hamad Alqalaf Adel Alnasser	Engineering	80	24	1920
3.1 Data Collection	Hamad Alqalaf Daij Alfahad	Technician	45	24	1080
3.2 Topographic Map	Hamad Alqalaf Adel Alnasser Daij Alfahad	Technician	45	15	675
4.1 Existing Infrastructures Analysis	Hamad Alqalaf Daij Alfahad	Engineering	80	16	1280
4.2 runoff analysis	Adel Alnasser Daij Alfahad	Engineering	80	16	1280
5.1 Soil Analysis	Hamad Alqalaf Adel Alnasser	Engineering	80	16	1280
5.2 Cut and Fill and Compaction.	Adel Alnasser Daij Alfahad	Engineering	80	16	1280
6.1 Open Channel Design	Hamad Alqalaf Daij Alfahad	Engineering	80	22	1760
7.1 court dimensions	Adel Alnasser	Technician	45	20	900
7.2 court surface material	Hamad Alqalaf Adel Alnasser Daij Alfahad	Technician	45	36	1620
7.3 Purchasing Equipment	Hamad Alqalaf Adel Alnasser Daij Alfahad	Engineering	80	18	1440
8.1 Sidewalk and benches	Adel Alnasser	Engineering	80	12	960
8.2 Fence	Daij Alfahad	Engineering	80	12	960

Tasks	Staff	Classification	Rate ($/hr)	Hours	Cost Estimate($)
9.1 Traffic Signage	Hamad Alqalaf	Technician	45	18	810
9.2 Traffic Striping	Daij Alfahad	Technician	45	18	810
10.1 Design Report	Hamad Alqalaf Adel Alnasser Daij Alfahad	Engineering	80	18	1440
10.2 Presentation	Hamad Alqalaf Adel Alnasser Daij Alfahad	Engineering	80	24	1920
10.3 Website	Daij Alfahad	Technician	45	16	720
Total				**429**	**$ 29175**

Table 11: The Final Staffing Plan

Tasks	**Staff**	**Classification**	**Rate ($/hr)**	**Hours**	**Cost Estimate($)**
1.1 Professional Meetings	Hamad Alqalaf Adel Alnasser Daij Alfahad	Engineering	80	30	2400
1.2 Team meetings	Hamad Alqalaf Adel Alnasser Daij Alfahad	Engineering	80	60	4800
2.1 meeting with Home Owner Association and the City of Flagstaff	Hamad Alqalaf Adel Alnasser Daij Alfahad	Engineering	80	25	2000
2.2 Policies and Regulations Research	Hamad Alqalaf Adel Alnasser	Engineering	80	40	3200
3.1 Data Collection	Hamad Alqalaf Daij Alfahad	Technician	45	35	1575
3.2 Topographic Map	Hamad Alqalaf Adel Alnasser Daij Alfahad	Technician	45	15	675
4.1 Hydrology Analysis	Hamad Alqalaf Daij Alfahad	Engineering	80	30	2400
4.2 Hydraulics Analysis	Adel Alnasser Daij Alfahad	Engineering	80	35	2800
5.1 Traffic	Hamad Alqalaf Adel Alnasser	Engineering	80	5	400
5.2 Court Dimensions and Surface Design	Adel Alnasser Hamad Alqalaf	Technician	45	50	2250
5.3 Sidewalk and Benches	Adel Alnasser	Engineering	80	12	960
6.1 Design Report	Hamad Alqalaf Adel Alnasser Daij Alfahad	Engineering	80	30	2400
6.2 Presentation	Hamad Alqalaf Adel Alnasser Daij Alfahad	Engineering	80	24	1920
6.3 Website	Daij Alfahad	Technician	45	20	900
Total				411	28680

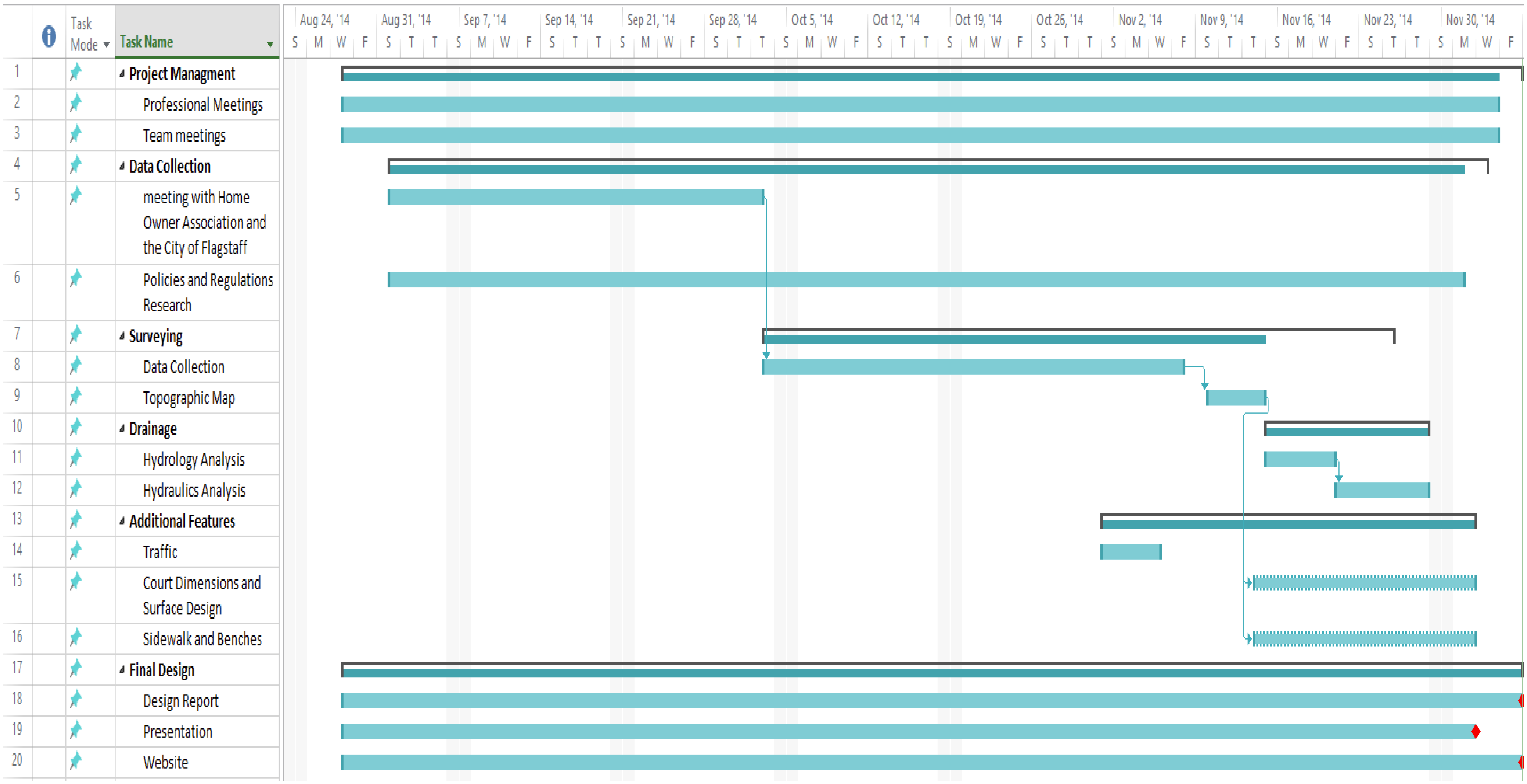


Figure 5: Final Gantt Chart