NAU Flooding Mitigation, Garden Design, and Storm Water Utilization

CENE 486C Presentation

Figure 1: Rolle Activity Center [1]

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Figure 2: Butterfly garden [2]

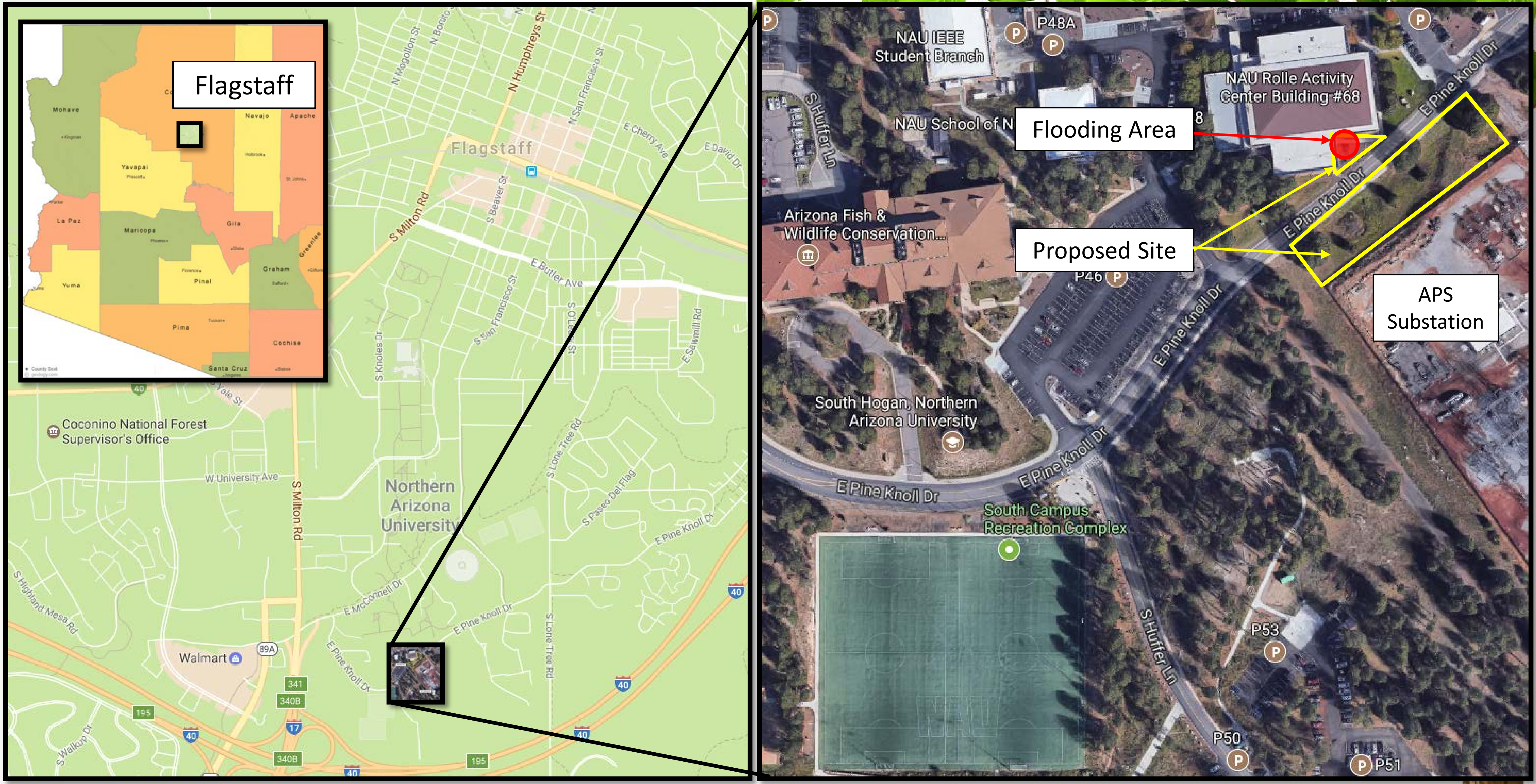


Figure 3 Vicinity and site [3]

Problem Statement

- Facility Services wants to mitigate flooding at Rolle Activity Center
- Office of Sustainability wants a garden between APS Substation and Pine Knoll Dr.

Figure 4: Flooding area behind Rolle Activity Center [4]

Figure 5: Proposed area for garden next to APS Substation [4]

Surveying

- Shot NAU's parking lot 46 and the east side of Pine Knoll Drive in front of APS Substation
- Accumulated ~1,600 points

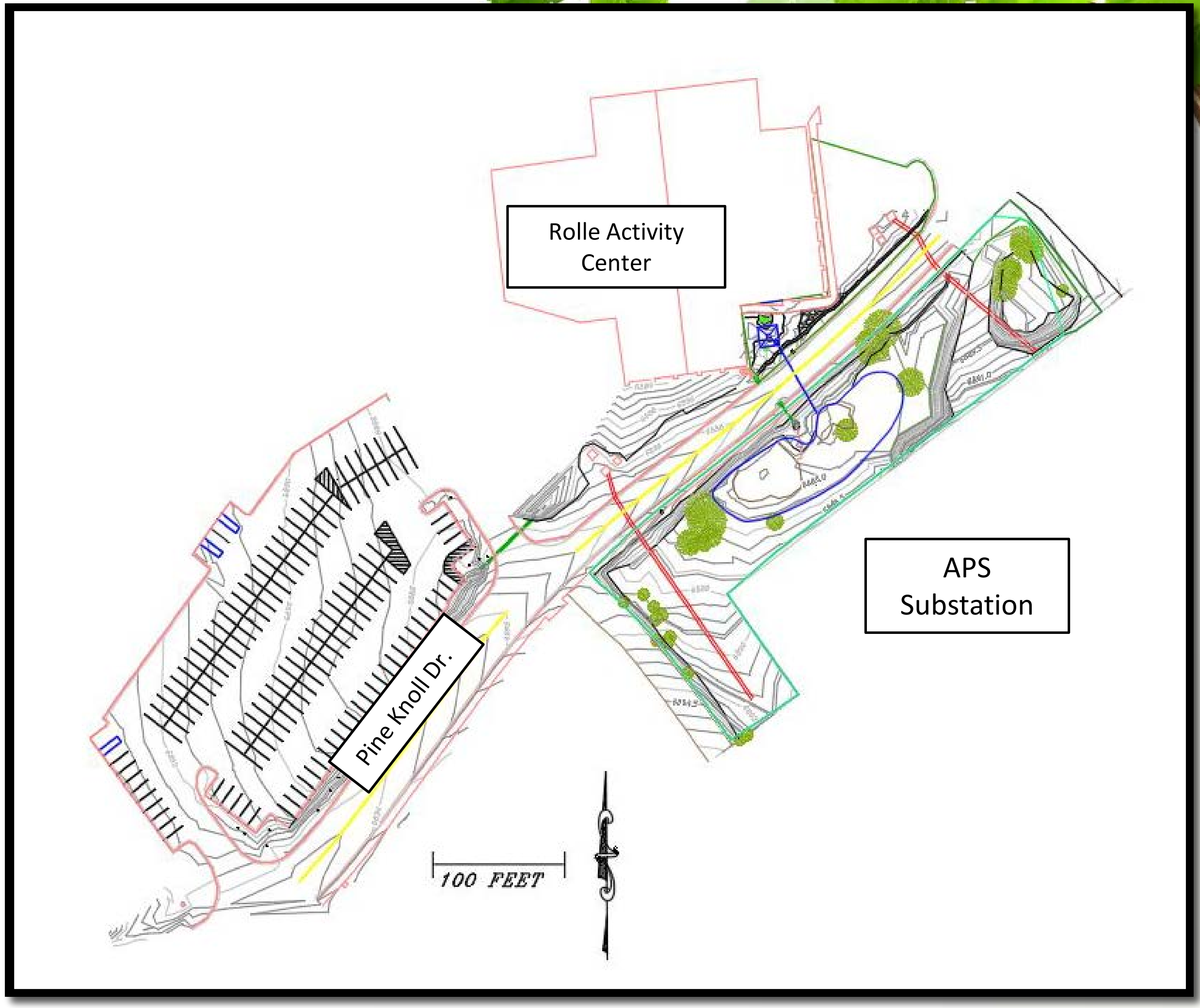


Figure 6: Area surveyed using both the Trimble R8 GPS Unit and the Trimble S6 Robotic Total Station [6]

Figure 7: Topographic site layout in the CAD created using survey data and AutoCAD Civil 3D

Hydrology – Rational Method

Rational Equation: $Q = C \cdot i \cdot A \cdot C_f$

Table 1 Rational Method results for area at Rolle Activity Center [7]

Rational Method	
Basin Area, A (ft^2)	26,638
Impervious Surface (ft^2)	11,375
Pervious Surface (ft^2)	15,263
Runoff Coefficient (Lawn Sandy Soils)[1]	0.10
Runoff Coefficient (Roofs/Concrete)[1]	0.95
Flooding Area (ft^2)	3021
Composite Coefficient, C	0.59
[1]City of Flagstaff Stormwater Management Design Manual - Rational Runoff Coefficients	

Table 2 Results based on type of storm and duration [7,8]

Rolle Activity Flooding Area					
Average Recurrence Interval (yrs)	**Duration of Storm (hrs)**	**Precipitation Frequency, *i* (in)[1]**	**Precipitation Factor, C_f[2]**	**Flow Rate, *Q* (ft^3/s)**	**Flooding Depth (ft)**
25	1	1.65	1.1	0.66	0.78
50	1	1.93	1.2	0.84	1.00
100	1	2.23	1.25	1.01	1.20
25	2	1.82	1.1	0.36	0.86
50	2	2.12	1.2	0.46	1.10
100	2	2.44	1.25	0.55	1.32
[1]NOAA Atlas 14 PDS - based point precipitation frequency estimates with 90% confidence intervals					
[2]City of Flagstaff Stormwater Management Design Manual - Antecedent Precipitation Factors based on storm frequency					

Figure 8: Rational Method area of focus [6]

Hydrology – SCS TR-55 CN Method

SCS Equation: $Q = (P-0.2S)^2/(P+0.8S)$

Table 3,4. SCS TR-55 CN Method results for volume of retention basin [6]

SCS TR-55 CN	
Total Basin Area (acres)	31
Basin Area, 15A (acres)	27
Basin Area, 17 (acres)	4
Hydrologic Soil group, 15A[1]	C
Hydrologic Soil group, 17[1]	D
CN, 15A[2]	77
CN, 17[2]	70
Composite CN	76.02
S	3.15
[1]Web Soil Survey - Hydrological Properties	
[2]City of Flagstaff Stormwater Management Design Manual Curve numbers for hydrologic soil group	

Retention Basin			
Average Recurrence Interval (yrs)	**Rainfall, *P* (in)**	**Flow Rate, *Q* (ft^3/s)**	**Volume of Water (ft^3)**
25	1.65	0.249	28,011
50	1.93	0.379	42,656
100	2.23	0.538	60,553

Figure 9: SCS TR-55 CN area of focus [5]

Alternative Design #1

Culvert Design

- Reduce flooding at Rolle Activity Center by gravity
- Design culvert to cross under roadway
    - Fill retention pond

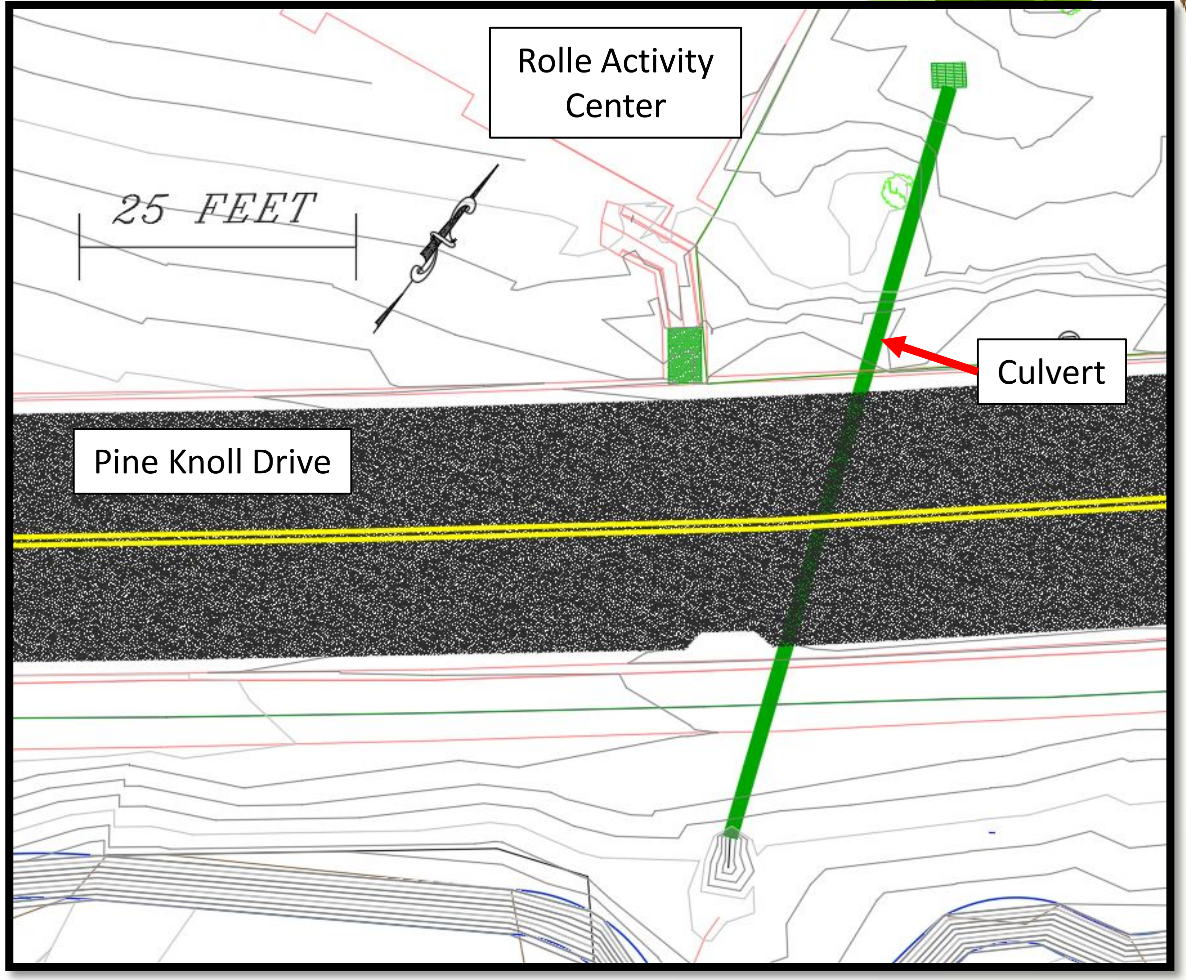


Figure 10: Culvert Design using AutoCAD

Alternative Design #2

Sump Pump

- Reduce flooding at Rolle Activity Center and convey water to retention basin on south side of Pine Knoll Drive
- Water will be used to irrigate the community garden

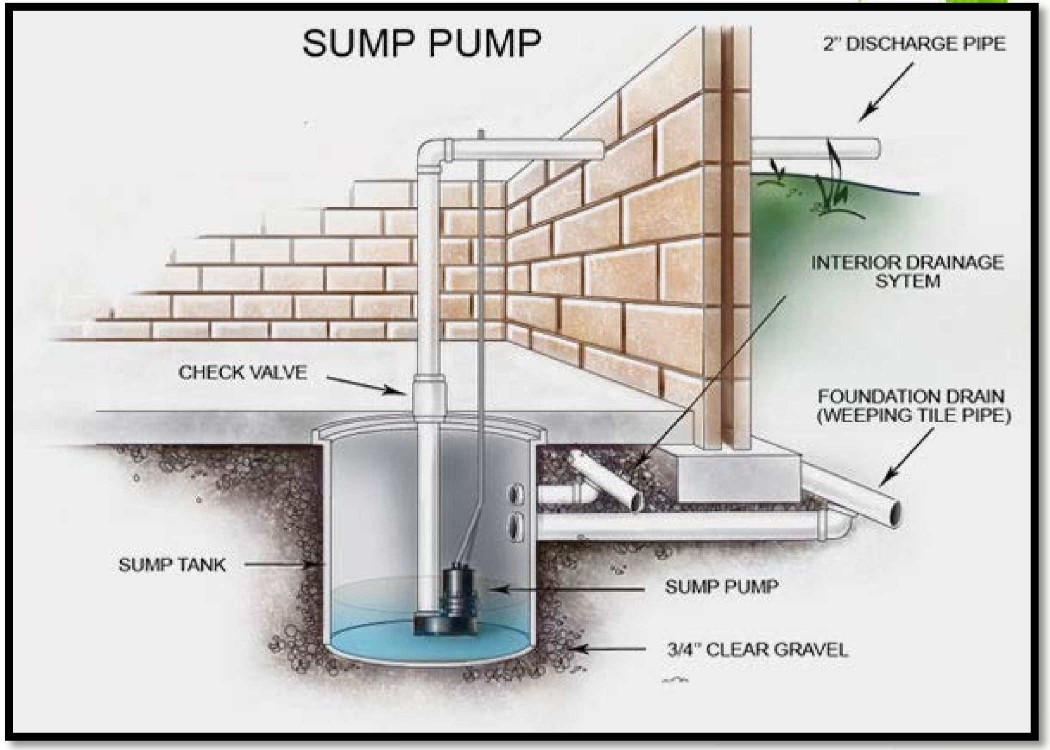


Figure 11: Sump pump system schematic [9]

Alternative Design #3

Grading Change Design

- Regrading landscape to naturally mitigate flooding
- Sheet flow is directed towards Sinclair Wash

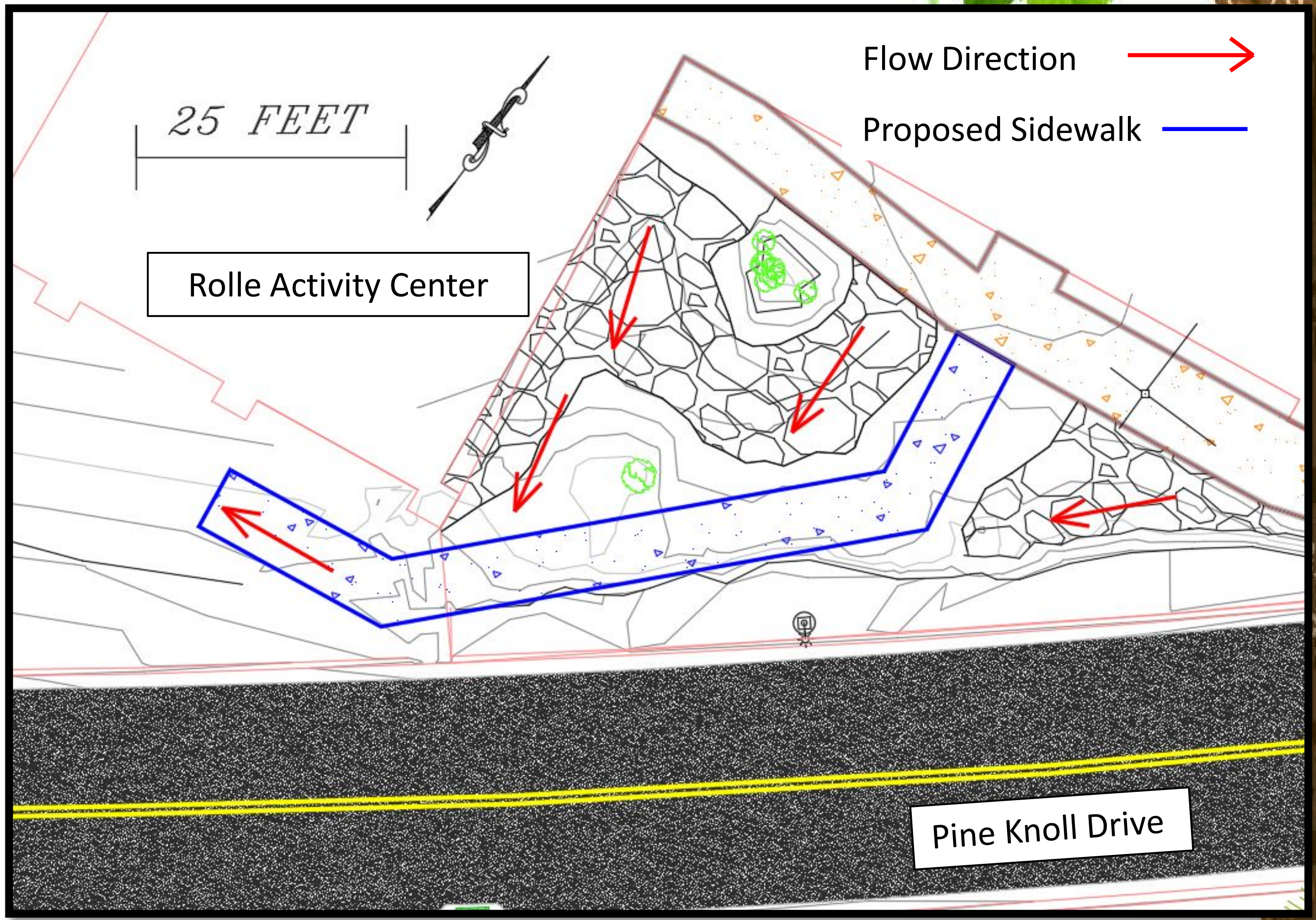


Figure 12: Grading change design using AutoCAD

Meeting Constraints

Mitigate flooding from Rolle Activity Center

- X Culvert Design – Possibility of flooding due to back flow
- ✓Sump Pump Design – Mitigates flooding without concerns
- ✓Grade Change – Effectively mitigate flooding

Irrigate a proposed butterfly garden near APS Substation

- ✓Culvert Design – Transport water across street near garden
- ✓Sump Pump Design – Transport water across street near garden
- X Grade Change – Water is transported to Sinclair Wash

System Profile

System Properties

- Well dimensions: 15’ x 5’ x 15’
- Pipe lengths:
  - 4” pipe = 1.5’
  - 6” pipe = 56.5’
- Pipe fittings:
  - 4” to 6” expansion
  - 6” 90 degree elbow
  - Pipe outlet cover

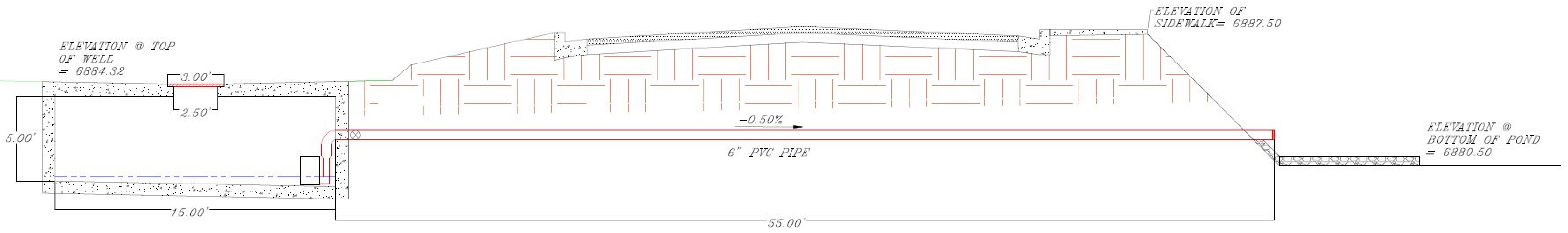


Figure 13: Overall system profile of design using AutoCAD Civil 3D

Selecting a Pump

Energy Equation: $Q = P_1/\gamma_w + V_1^2/2g + z_1 + h_p = P_2/\gamma_w + V_2^2/2g + z_2 + h_l$

Table 5 Well design and drainage results [10]

System Properties	
Δpressure, $P_2 - P_1$ (psi)	0
Unit Weight of Water, γ_w (lb/ft^3)	62.4
Gravity, g (ft/s^2)	32.2
Elevation of Water Surface, z_1 (ft)	6,879.15
Elevation of Pipe Outlet, z_2 (ft)	6,882.37
Diameter of Pipe A (in)	4
Diameter of Pipe B (in)	6
Length of Pipe A (ft)	1.5
Length of Pipe B (ft)	56.5
$K_{gradual\ expansion}$ [1]	0.72
$K_{90° \ elbow\ flanged}$ [1]	0.3
$K_{swing\ check\ valve}$ [1]	2
$K_{outlet\ grate}$ [1]	0.05
[1]Analysis of Flow in Pipes - minor loss coefficients	

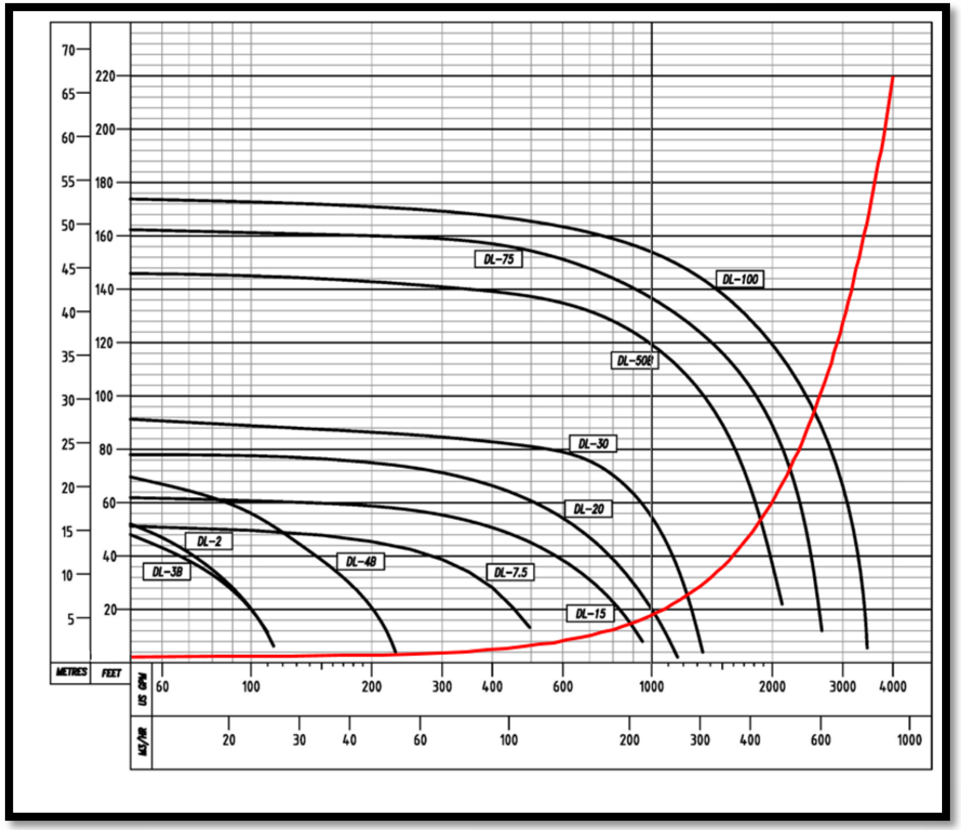


Figure 14: System curve aligned with DL TOYO Pump curves [11]

Table 6. DL-15 TOYO Pump [11]

Selected Pump	
Capacity (gpm)	890
Head of Pump (ft)	15

Sump Pump – Well Design

Table 7 Well Design and drainage results

Well and Sump Pump Characteristics	
Area of Well (gallons)	8415.6
Pump Capacity (gpm)	890
100 Year Storm Flow Rate (gpm)	453.3
Initial Time of Detention (min.)	13.9
Well Drainage Rate (gpm)	436.7
Time to Drain Well Entirely (min.)	14.5

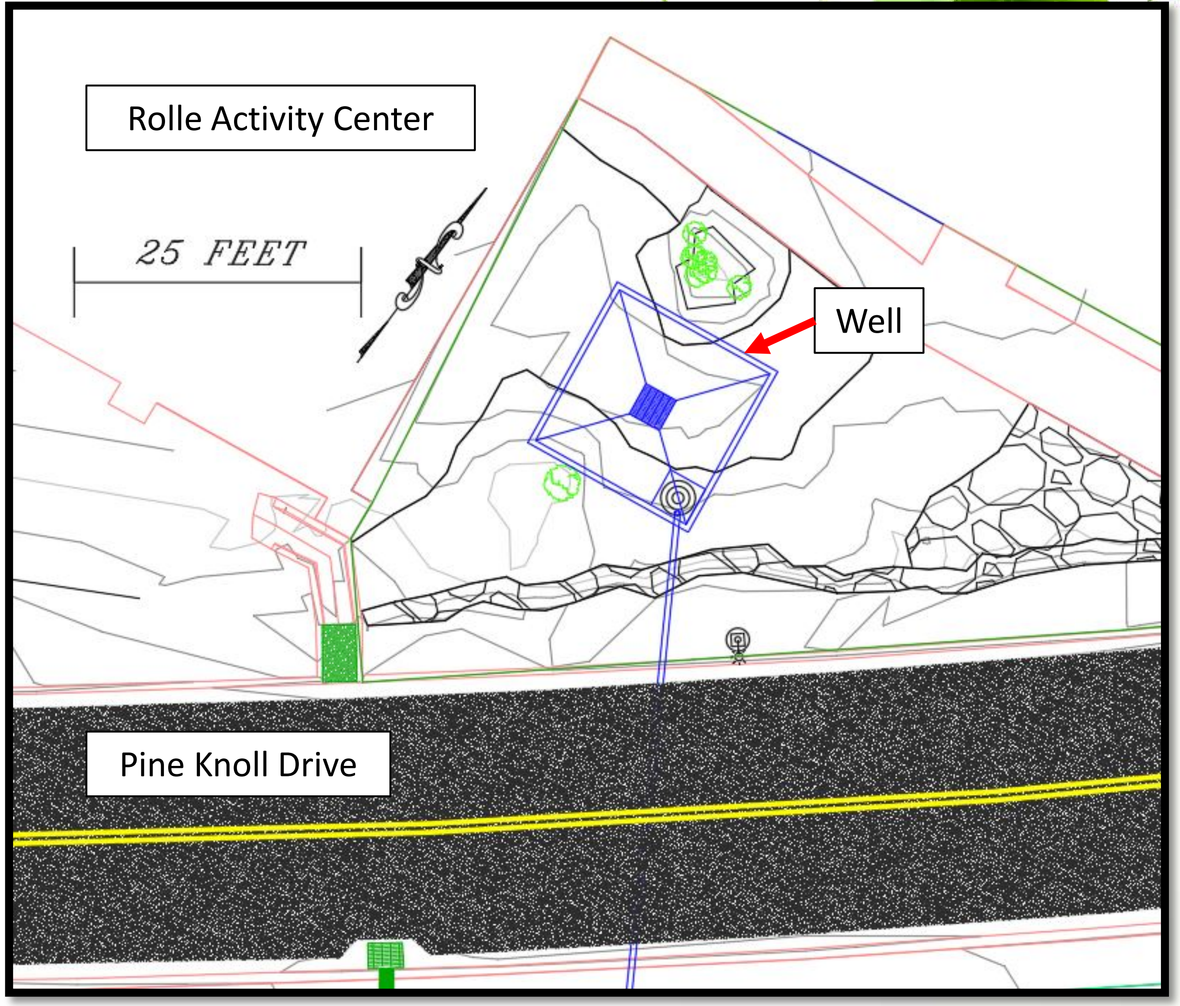


Figure 15: Plan view of sump pump well using AutoCAD Civil 3D

Retention Pond

- Volume: 67,200 ft^3
- Exterior slope 1:1
- Island preserving existing tree

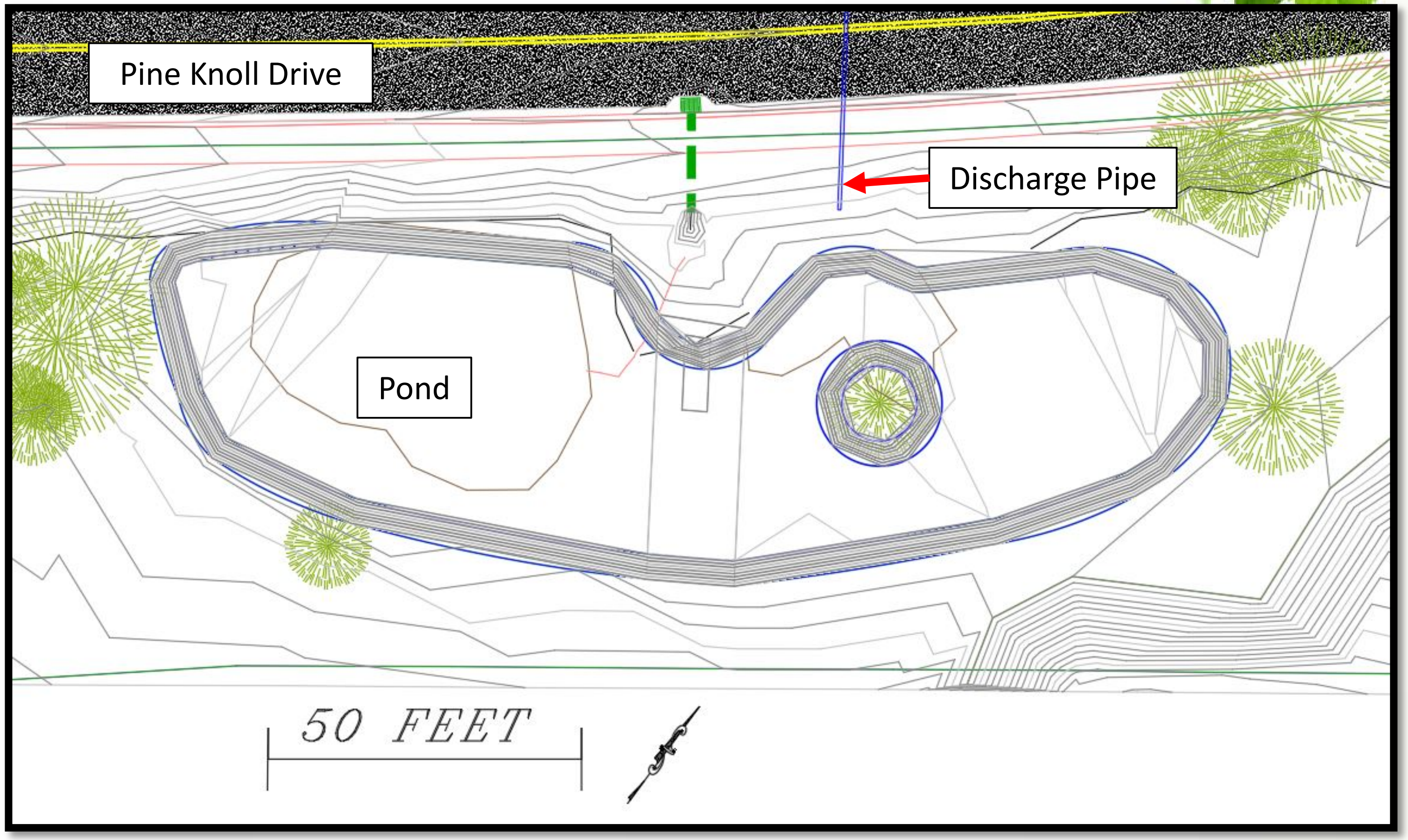


Figure 16: Plan view of retention pond using AutoCAD Civil 3D

Conceptual Landscape Layout

Butterfly Garden

- Native nectar plants
- Added pond
- Boardwalk
- Seating Area

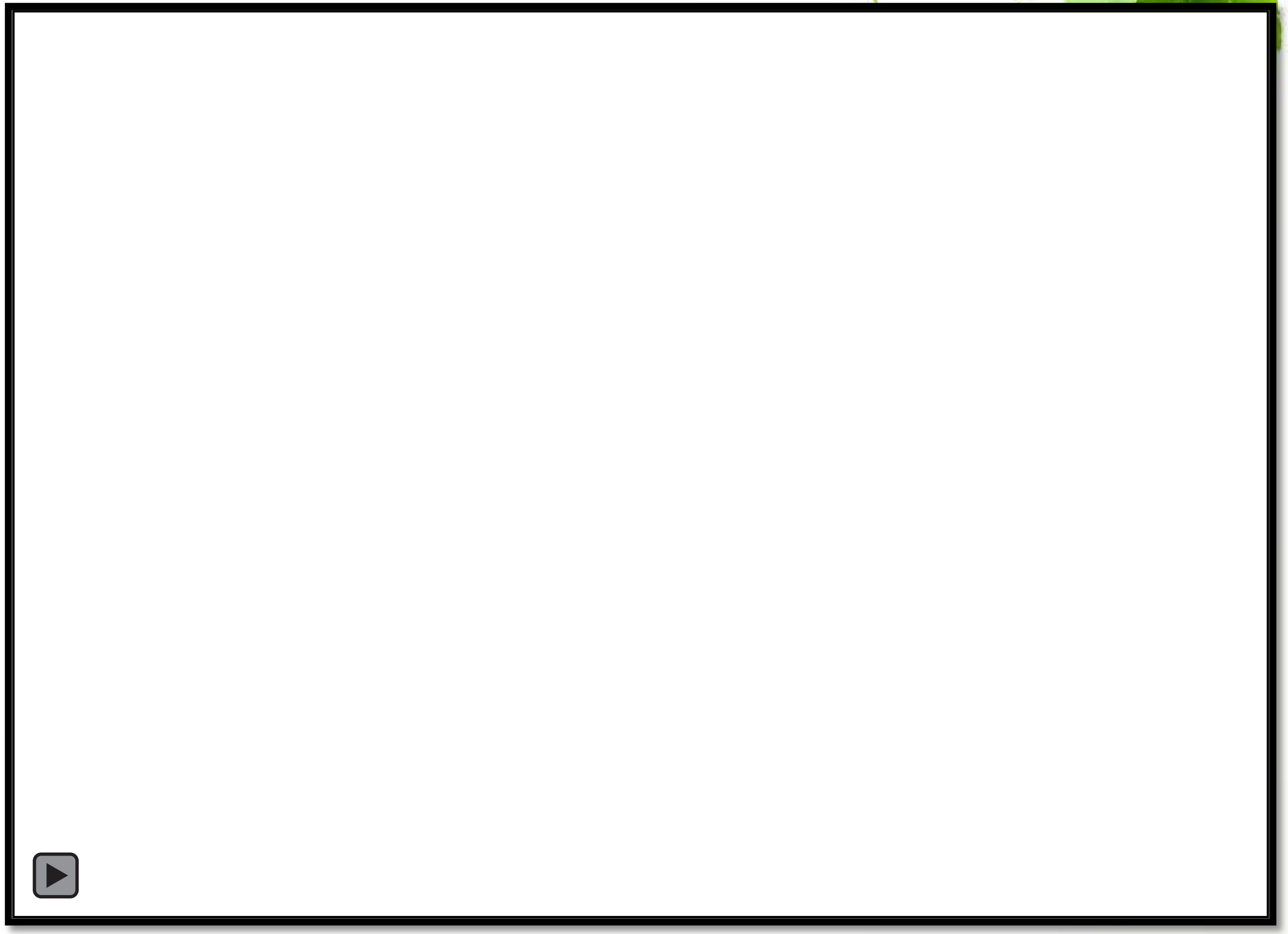
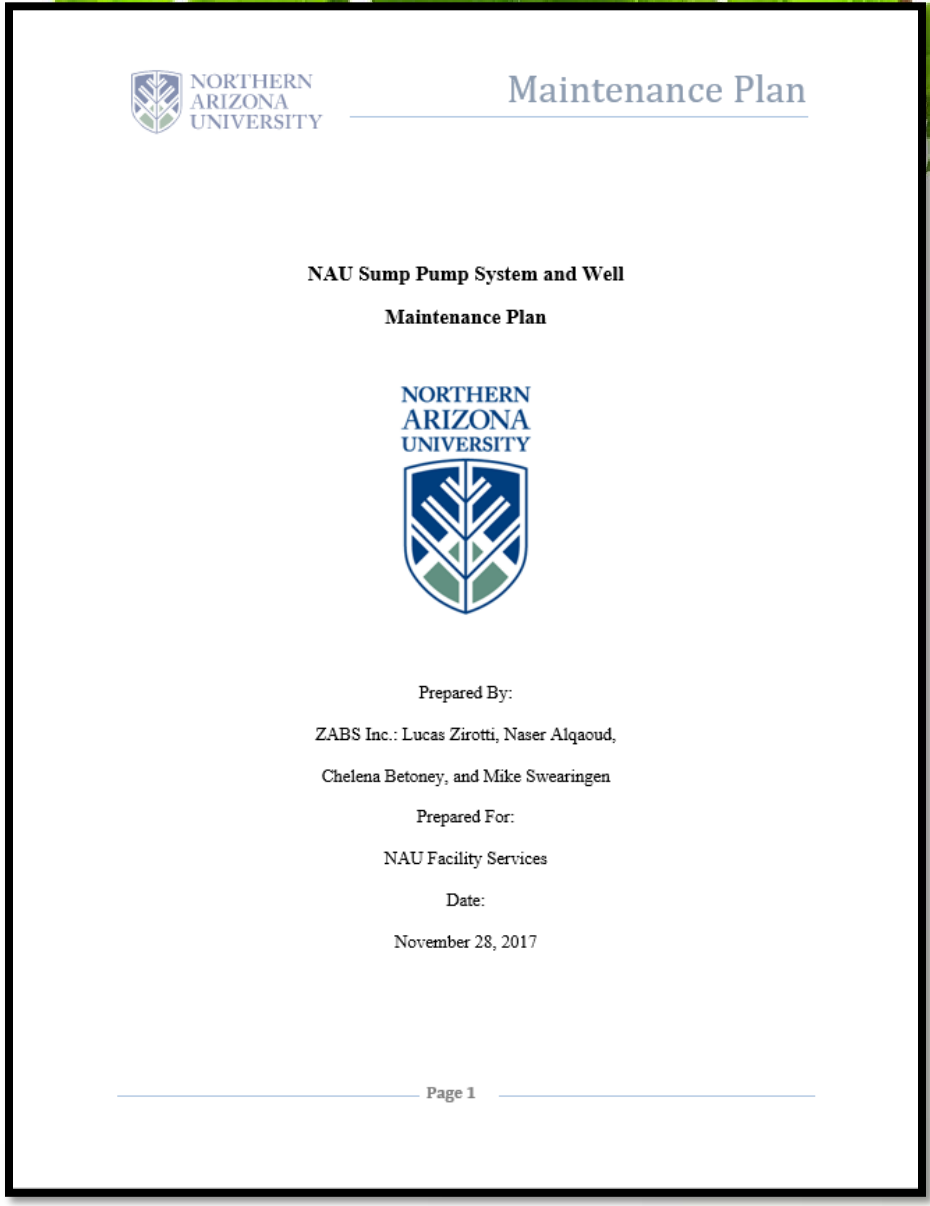


Figure 17: Visual representation of the conceptual landscape layout using 3D SketchUp

Maintenance Plan

- Pump components
- Cleaning the well to prevent clogging
- Cleaning out pipe of vegetation


Maintenance Plan

NAU Sump Pump System and Well

Maintenance Plan

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Chelena Betoney, and Mike Swearingen

Prepared For:

NAU Facility Services

Date:

November 28, 2017

Page 1

Figure 18: Maintenance plan cover page

Impacts – Triple Bottom Line

Social

- Aesthetically appealing to students and faculty

Environmental

- Butterfly garden increases pollination, promotes environmental awareness, and require fewer resources to maintain []
- Storm water utilization

Economic

- Protects Rolle Activity Center flooding damages
- Creates job opportunity

Project Hours and Consulting Cost

Table 8 Proposed vs. Actual project hours and consulting costs

Position	Hourly Rate ($)	Task Hours		Consulting Cost ($)	
		Projected	Actual	Projected	Actual
Project Manager	120	160	136	26,400	8,280
Sr. Engineer (P.E.)	105	272	224	18,960	18,960
Jr. Engineer (E.I.T.)	90	304	236	27,240	31,320
Licensed Surveyor	75	72	72	6,240	6,240
	Total	**808**	**668**	**$ 78,840.00**	**$ 64,800.00**

Total Project Cost

Table 9 Material and service costs [11, 12, 13]

Item	Material	Unit	Quantity	Unit Cost ($)	Total Cost ($)
1	4-inch Sch. 40 PVC	feet	1	8.62	8.62
2	6-inch Sch. 40 PVC	feet	7	39.60	277.20
3	6-inch PVC 90 degree elbow	Each	2	10.98	21.96
4	4 in. x 6in. PVC Reducer coupling	Each	1	7.02	7.02
5	6-inch drainage grate cap	Each	1	4.24	4.24
6	TOYO DL-15 Sump Pump	Each	1	8,445.00	8,445.00
				Total	**$8,764.04**
Item	**Services**	**Unit**	**Quantity**	**Unit Cost ($)**	**Total Cost ($)**
1	Horizontal boring	feet	61.5	400	24,600.00
2	Excavation of soil	cubic yard	953.5	30	28,605.00
3	Installation of TOYO DL-15	Each	1	1,022	1,022.00
				Total	**$ 54,227.00**

Table 10 Consulting Services Costs

Project Costs	Cost ($)
Consulting	64,800.00
Material	8,764.04
Service	54,227.00
Total	**$ 127,791.04**

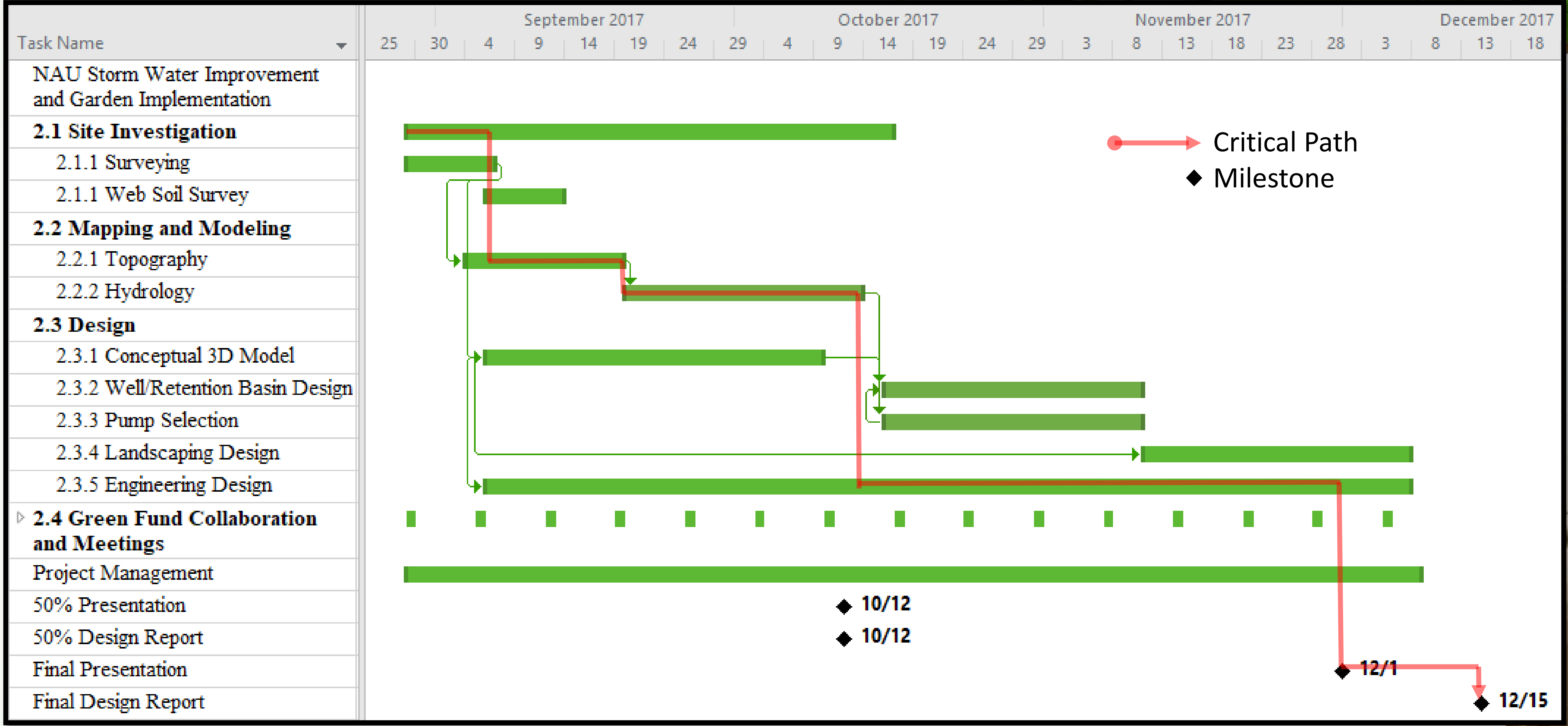

Figure 19: Proposed project gantt chart

Figure 20: Actual project gantt chart

References

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