ALLAN LAKE RESTORATION

CENE 486

Capstone Presentation

4/28/17

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Background

- 40 miles SE of NAU
- About 10 miles south of Mormon Lake on Lake Mary Road.
- Improve waterfowl habitat
- Arizona Game and Fish
  - Disturbed the clay layer
  - Used explosives (dynamite)

Figure 1: Allan Lake Location [1]

Project Understanding

- Disturbed/penetrated clay layer
- Less native wetland plants
- Area within trenches is 17 acres
- The trenches are about 5-6’ deep

Figure 2: Allan Lake aerial picture [1]

The Problem in the Trenches

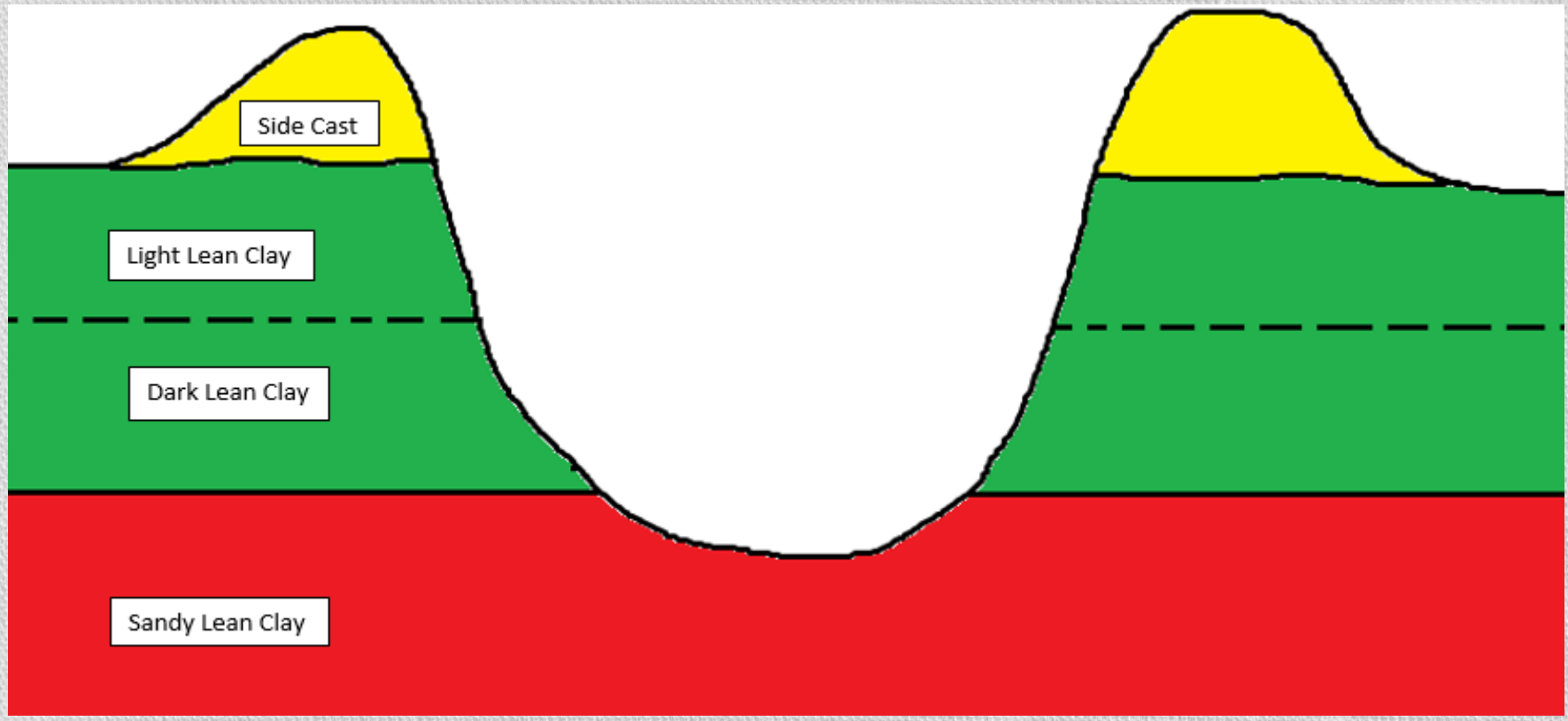


Figure 3: Basic overview of the soil profile

Project Purpose

Goal: To improve the site's water retention rate

We will provide the Forest Service with:

- Characterize the existing soil at Allan Lake
- Analyze the existing soil
- Develop an AutoCAD file of Allan Lake
- Develop a Cut and Fill analysis
- Provide cost estimations based on our alternatives

Exclusions

- **The Forest Service will conduct the following:**
- Permits for environmental protection
  - National Environmental Policy Act (NEPA)
- Permits for low impact on ecology & wildlife
  - Arizona Department of Environmental Quality (ADEQ)
  - Environmental Protection Agency (EPA)
- Construction management and construction
- Hydraulic model and analysis

Stakeholders & Client

Stakeholders:

- Arizona Game & Fish
- Ecology (natural inhabitants)
- National Forest Service
- People (recreation)

Figure 4: Smokey Bear [2]

Figure 5: Dr. Odem [3]

Client: Tom Runyon, Coordinator Hydrologist for the Coconino National Forest

Technical Advisors:

- Dr. Odem (grader)
- Gary Slim
- Kit McDonald

Acknowledgements:

- Mark Lamer
- Lar Reiboldt
- Pete Page

Survey work and Initial Sampling

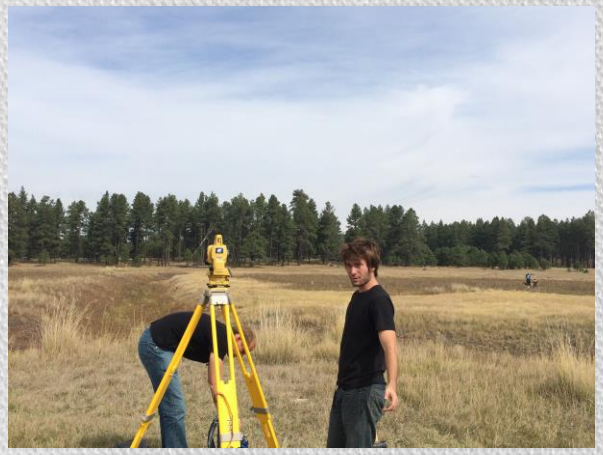


Figure 6: Surveying at Allan Lake [5]

Survey Work:

- Collected 2881 points
- Over 4 site visits

Sampling:

- Collected over 14 samples using a Soil Auger
- Developed Soil Profile

Figure 7: Soil Sample Locations [1]

Soil Profile Results

Table 1: Undisturbed soil profile data

Undisturbed Soil Profile		
Layer Description	**Thickness (inch)**	**Average Depth (feet)**
Top Soil	0”-6”	0’-0.5’
Top Clay Layer	11’’-30’’	0.5’-2.5’
Bottom Clay Layer	26’’-36’’	2.5’-5’
Sandy Bottom Layer	N/A	5’ and below

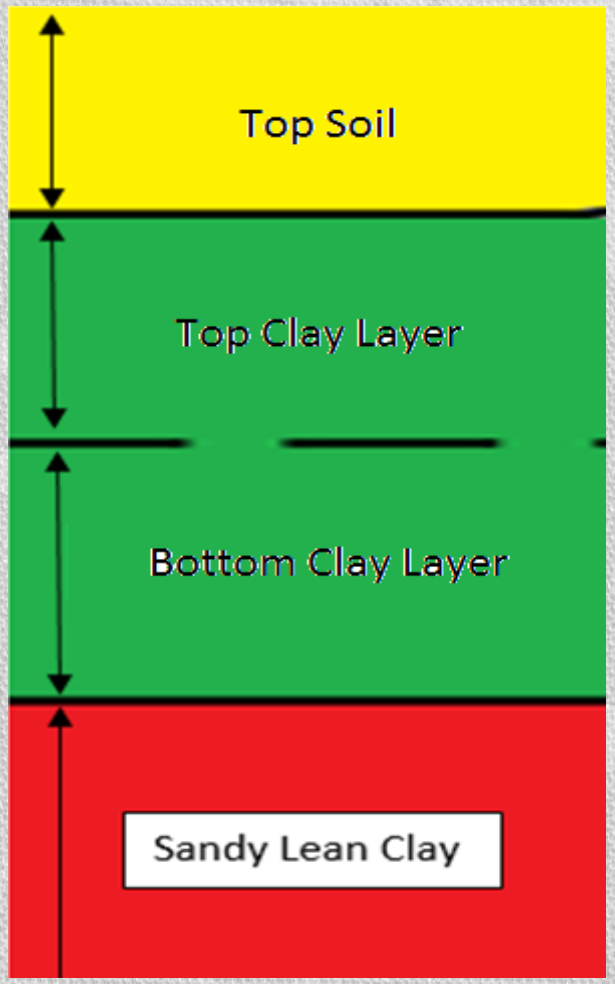


Figure 8: Undisturbed soil profile

Soil Profile Results

Table 2: Disturbed soil profile data

Disturbed Soil Profile		
Layer Description	**Thickness (inch)**	**Average Depth (feet)**
Side Cast	0”-18”	0’-1’
Top Clay Layer	11”-30”	1’-3’
Bottom Clay Layer	26”-26”	3’-5.5’
Sandy Bottom Layer	N/A	5.5’ and below

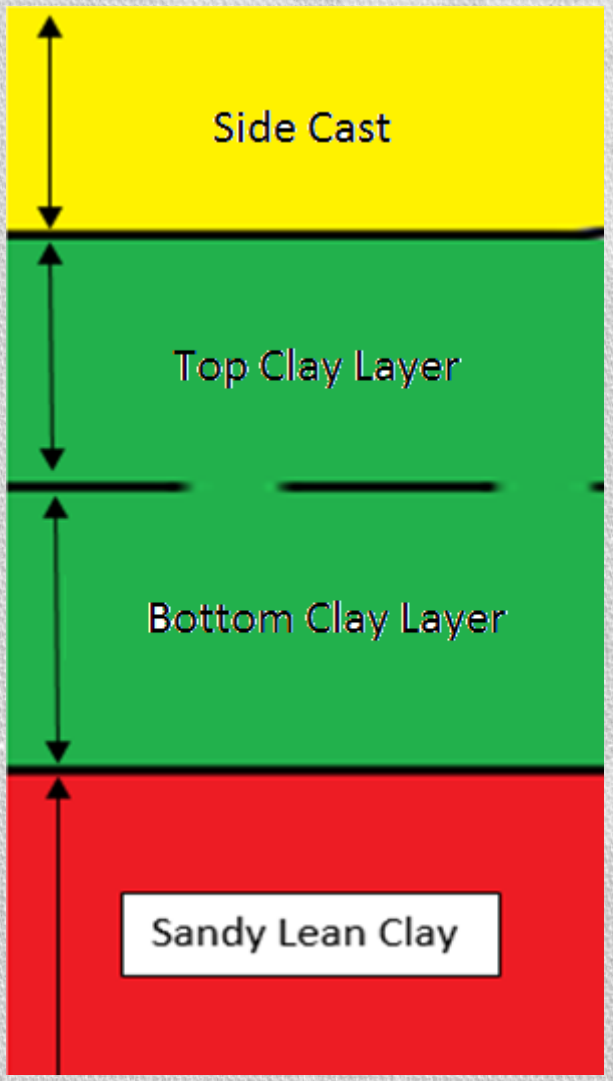


Figure 9: Disturbed soil profile

Tests Conducted for Soil Analysis

Table 3: Soil tests conducted

Test	Samples Tested	Number of Trials (per sample)	Total Tests Conducted
Liquid Limit	4	8	36
Plastic Limit	4	8	36
Hydraulic Conductivity	4	1-5	12
Organic Content	28	1	28
Proctor Compaction	3	5	15
Wet Sieve Analysis	4	3	12

Soil Testing

- ASTM D2974-Moisture Content
- ASTM D2974-Organic Content
- ASTM D4318-Atterberg Limits
- ASTM C325-Wet Sieve Analysis
- ASTM D5084-Hydraulic Conductivity
- ASTM D-698-Proctor Compaction

Soil Analysis Results

Table 4: Soil results

Soil	Liquid Limit (%)	Plastic Limit (%)	% Fines	USCS Soil Classification	Hydraulic Conductivity (cm/s)	Organic Content	Proctor Compaction Results-Ideal Moisture Content (%)
Side Casted Soil	59.8	49	75	Lean Clay with Sand	2.3 x 10^-5	12%	59.8
Top Clay Layer	71	40.6	93	Lean Clay	>1.0 x 10^-7*	8%	71
Bottom Clay Layer	63.4	38.6	95	Lean Clay	>1.0 x 10^-7*	6%	63.4
Sandy Bottom Layer	49	21	70	Sandy Lean Clay	4.8 x 10^-2	3%	49

Topographic Map

- Existing outlet: 7461.30 ft.
- Surveyed with ArcGIS
- Verified survey by site visit

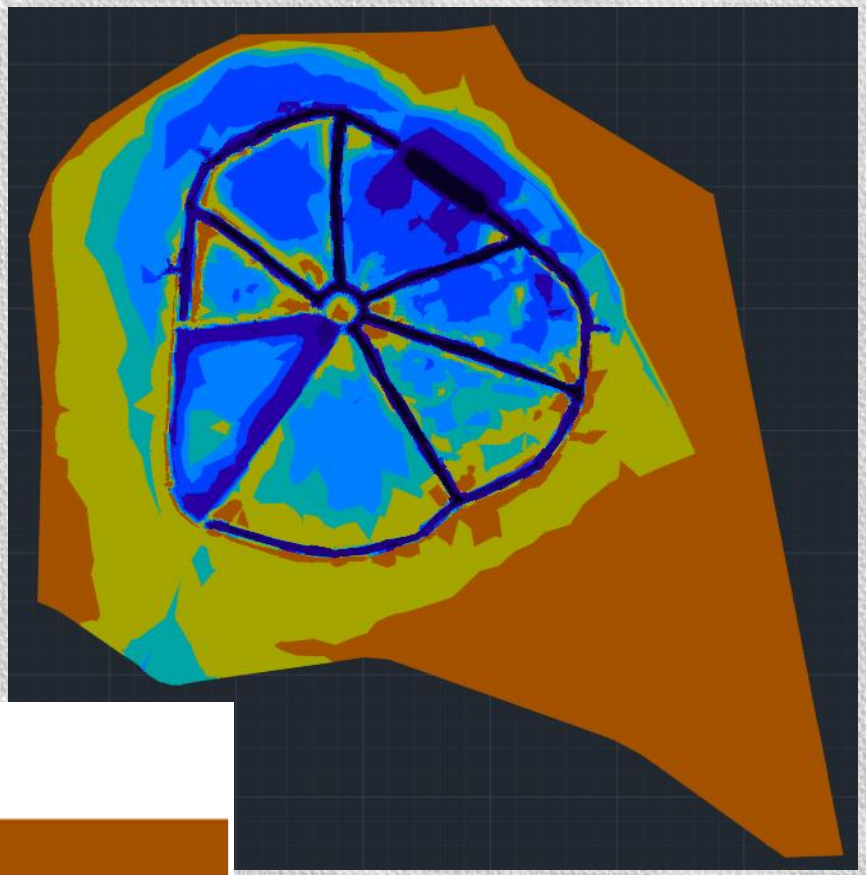


Figure 10: Current site conditions

Table 5: Key for topographic map

Maximum Elevation (feet)	Minimum Elevation (feet)
7473.04	7461.99
7461.99	7461.30
7461.30	7460.98
7460.98	7460.54
7460.54	7459.89
7459.89	7458.64
7458.64	7457.06
7457.06	7453.90

Comparison of design cross sections

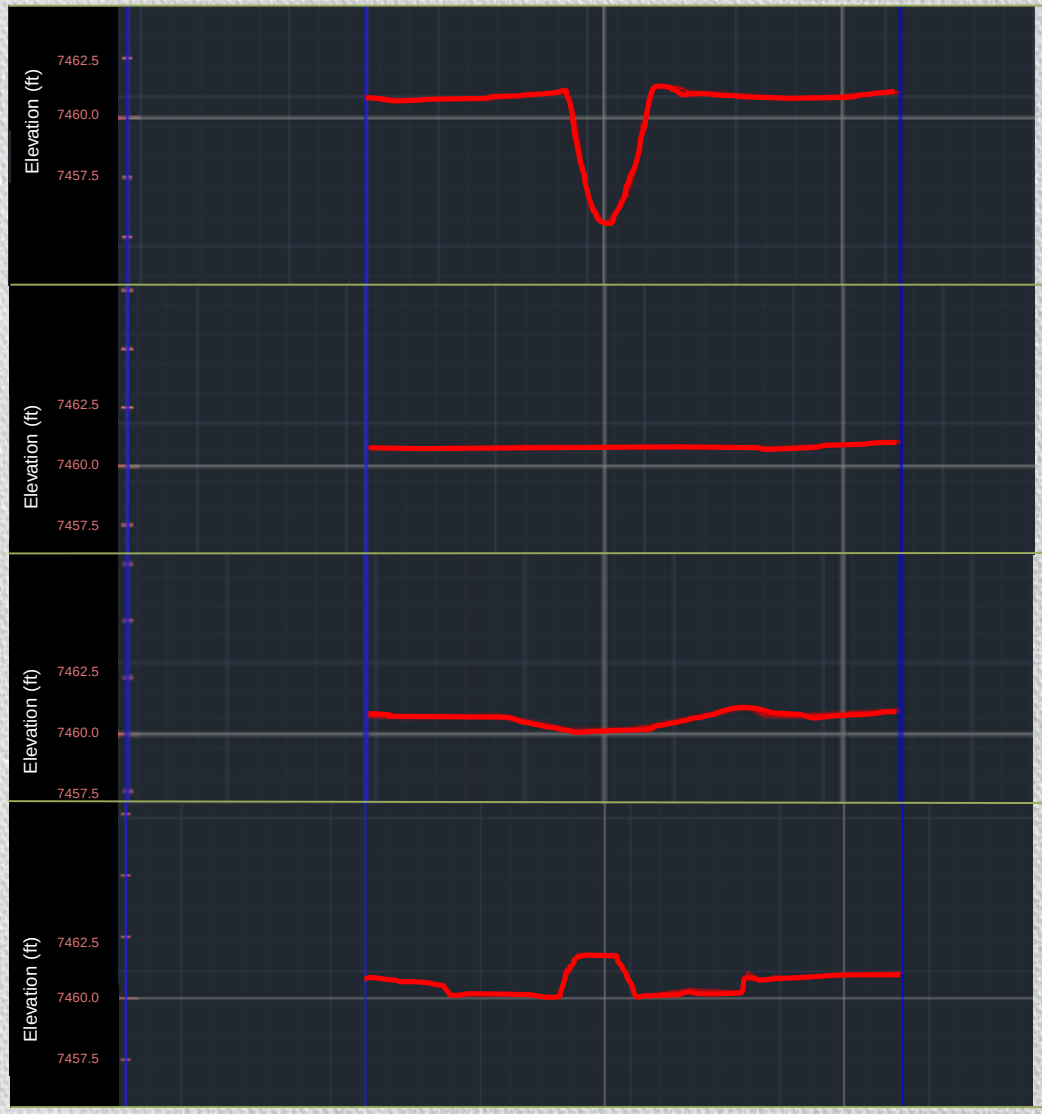


Figure 11: Current trenches

Figure 12: Pre-existing grade (estimated)

Figure 13: Alternative 1

Figure 14: Alternative 2

Construction Method

- Top 6” of topsoil must be removed due to organic matter
- Will be stockpiled for redistribution following construction
- Side cast will be backfilled into trench

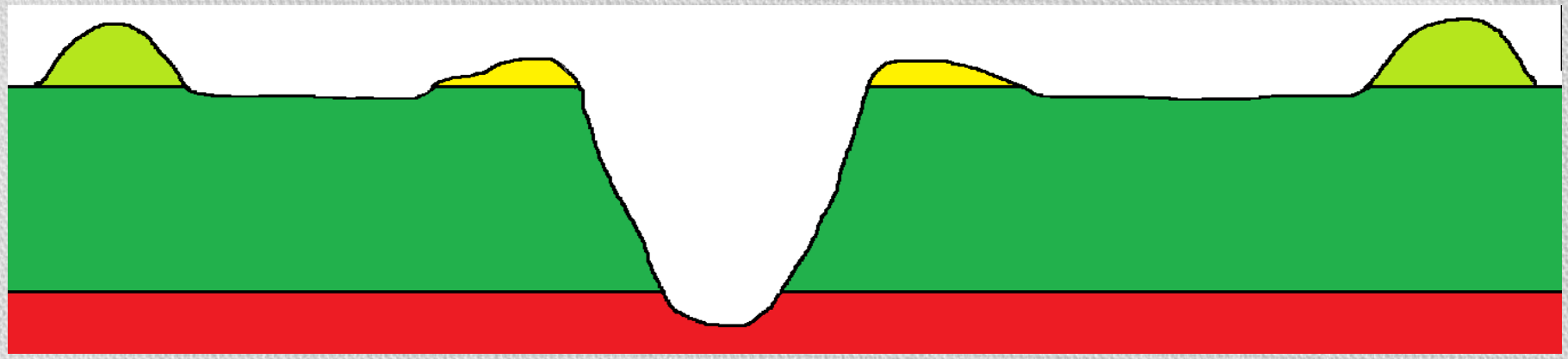


Figure 15: Top 6” of soil removed

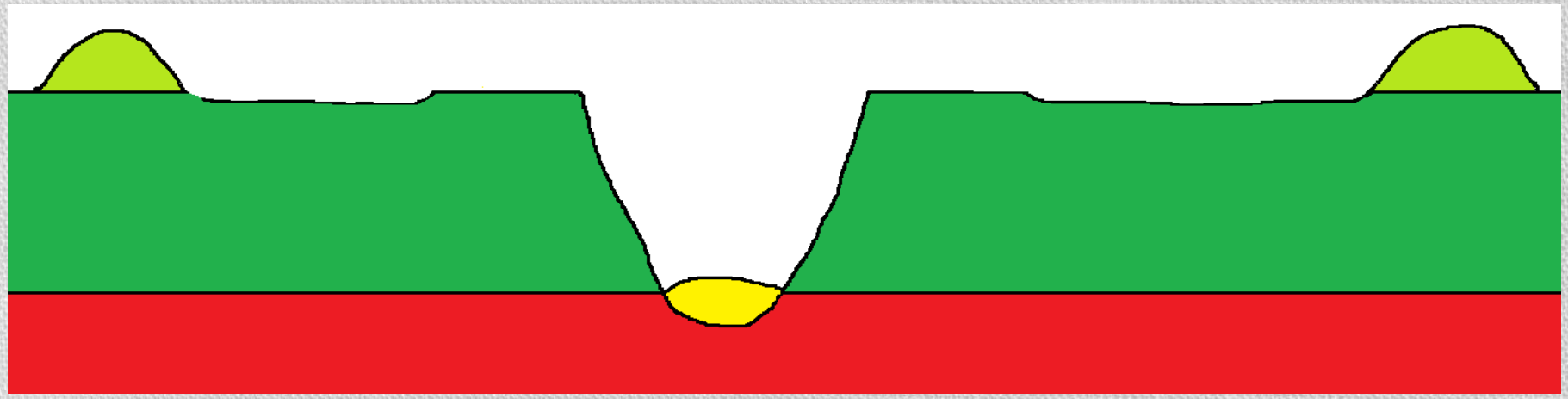


Figure 16: Side cast backfilled into trench

Design Alternatives

Alternative 1: Raise trenches to 1’ below pre-existing grade

Pros: Lower cost, lower evaporation rate, quicker construction

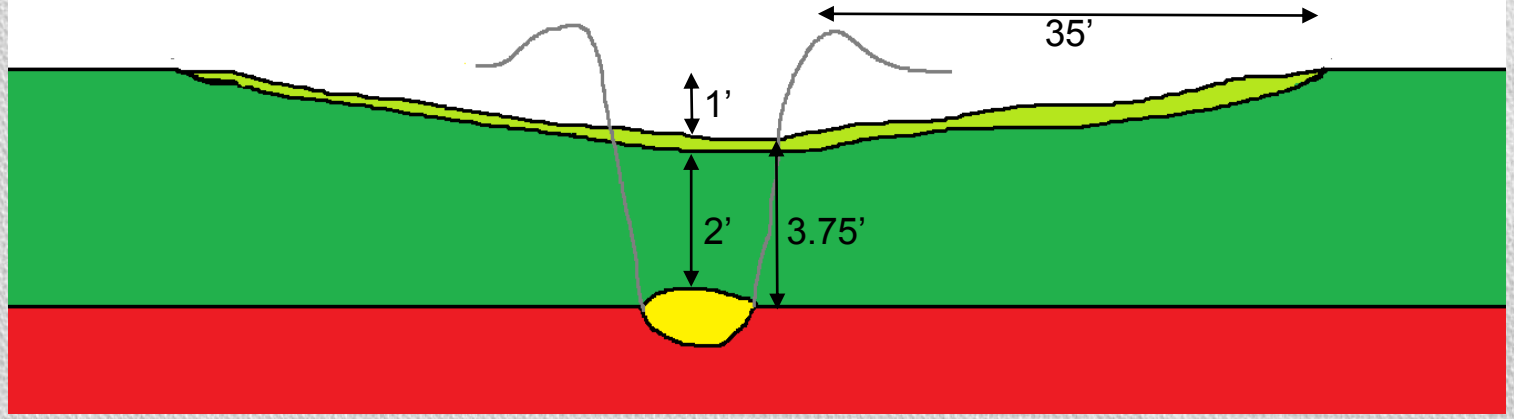


Figure 17: Design Alternative 1

Alternative 2: Raise trenches to .75’ above preexisting grade

Pros: Lower infiltration rate, less damage from large animals, less prone to freeze/thaw cycles

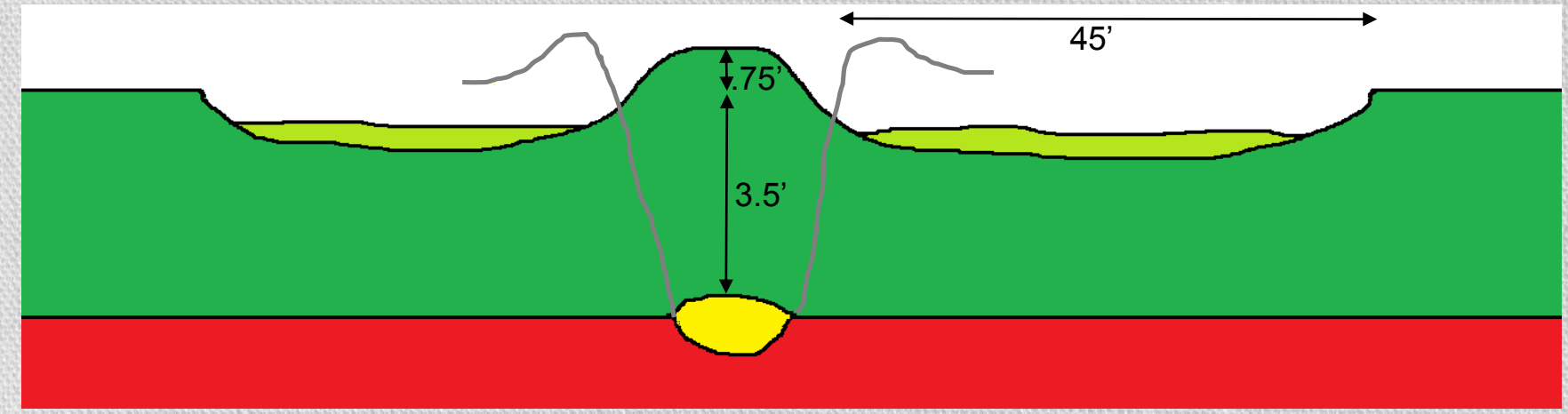


Figure 18: Design Alternative 2

Alternative 1: 1’ below pre-existing grade

Total Earthwork:

- 21,000 yd^3 clay cut
- 21,000 yd^3 clay fill
- 12,800 yd^3 topsoil cut
- 12,800 yd^3 topsoil fill

Swell factor: 1.40
Shrink Factor: 1.33

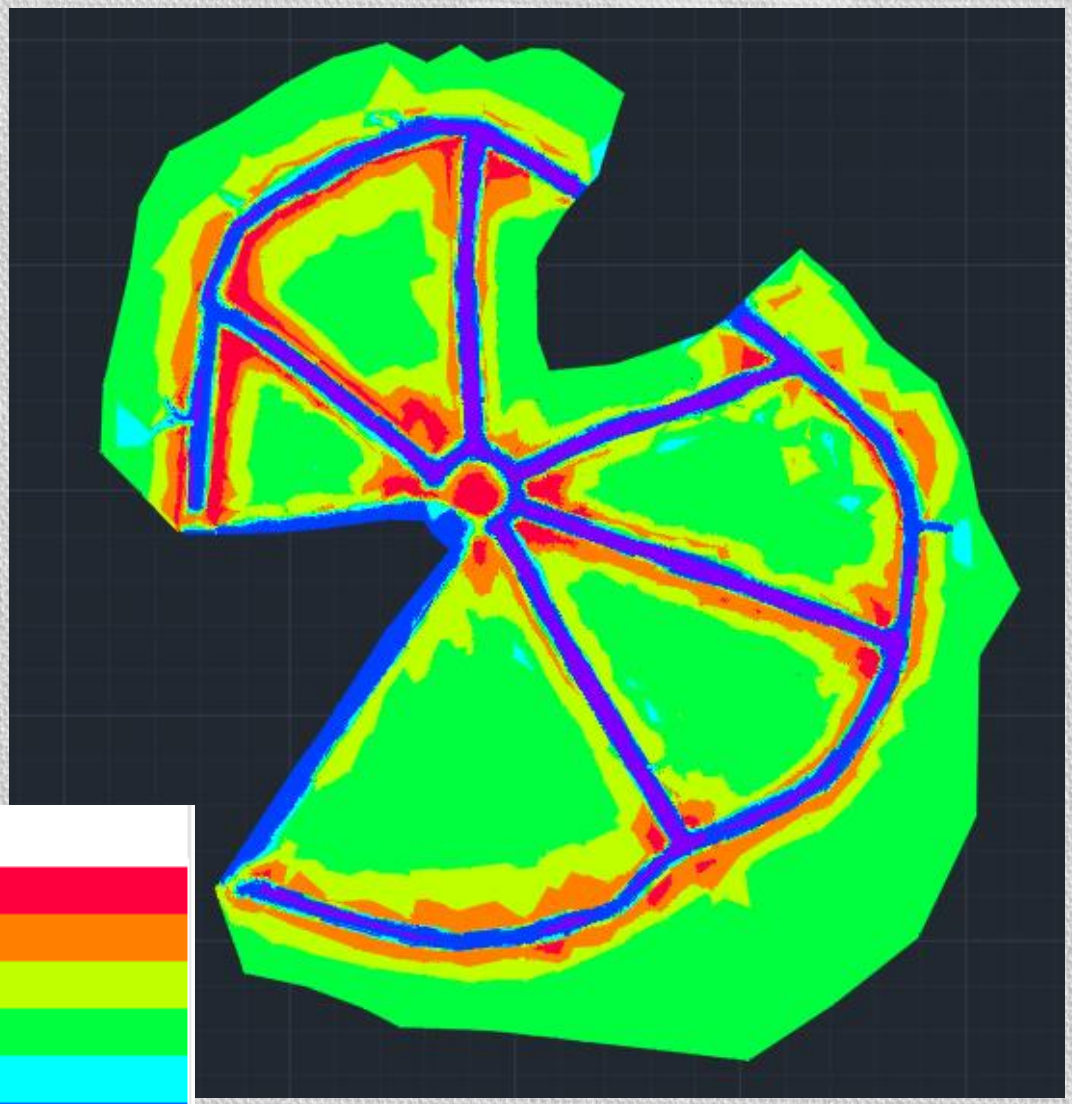


Figure 19: Proposed cut and fill

Table 6: Key for alternative 1

Minimum Elevation	Maximum Elevation	Color Scheme
-10.00'	-1.75'	
-1.75'	-1.00'	
-1.00'	-0.25'	
-0.25'	0.25'	
0.25'	1.00'	
1.00'	3.00'	
3.00'	10.00'	

Alternative 2: .75’ above pre-existing grade

Total Earthwork:

- 29,960 yd^3 clay cut
- 29,960 yd^3 clay fill
- 18,000 yd^3 topsoil cut
- 18,000 yd^3 topsoil fill

Swell factor: 1.40
Shrink Factor: 1.33

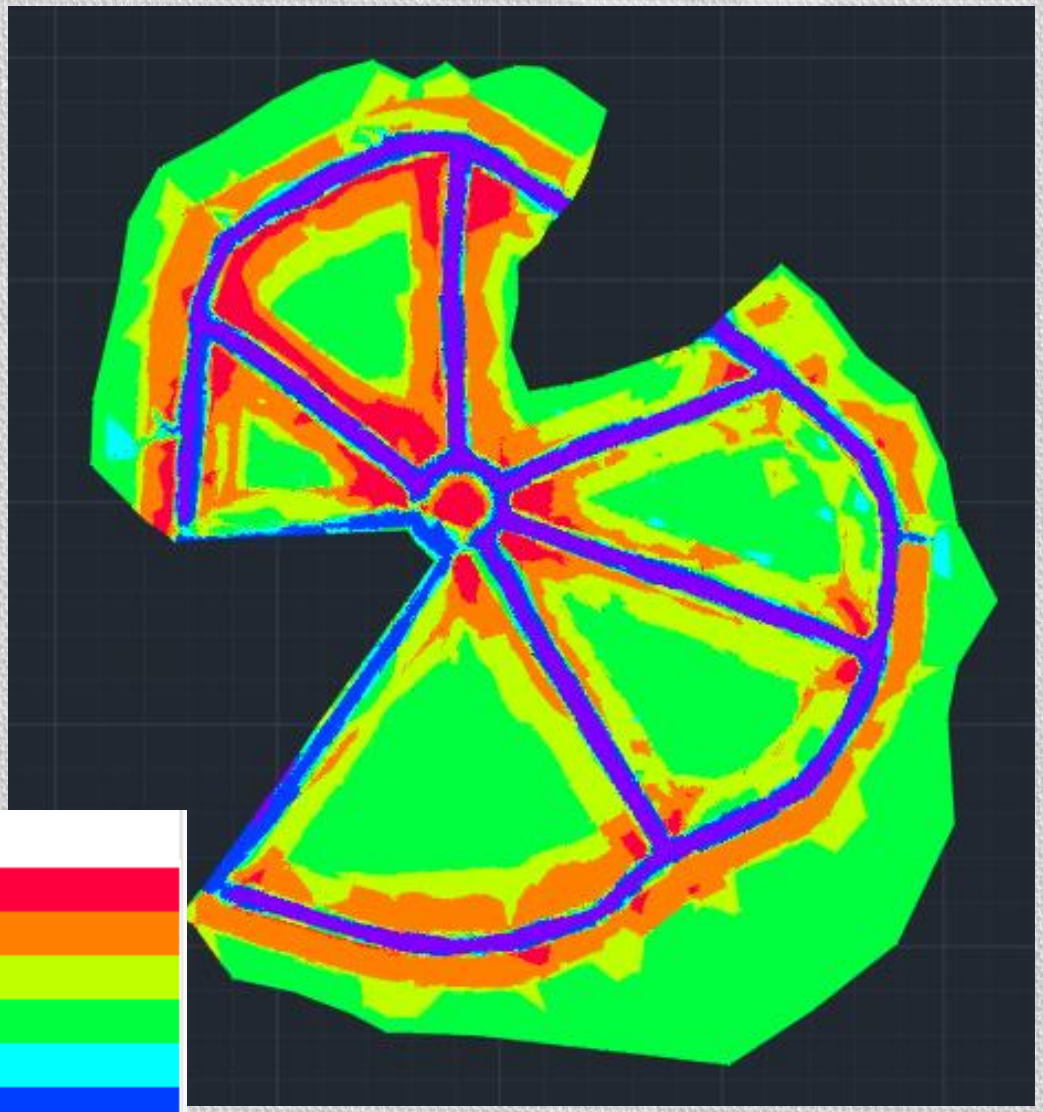


Figure 20: Proposed cut and fill

Table 7: Key for alternative 2

Minimum Elevation	Maximum Elevation	Color Scheme
-10.00'	-1.75'	
-1.75'	-1.00'	
-1.00'	-0.25'	
-0.25'	0.25'	
0.25'	1.00'	
1.00'	3.00'	
3.00'	10.00'	

Cost of Alternatives

Table 8: Cost Analysis of Alternative 1

Alternative 1	Quantity (ft^3)	Unit Cost ($)	Item Cost ($)
Cut & Fill of On-Site Clay:	21,000	$8.5 per cubic ft.	$178,500
Top Soil Removal and Redistribution:	12,800	$11.5 per cubic ft.	$147,200
Total Cost			**$325,700**

Table 9: Cost Analysis of Alternative 2

Alternative 2	Quantity (ft^3)	Unit Cost ($/ft^3)	Item Cost ($)
Cut & Fill of On-Site Clay:	29,960	$8.5 per cubic ft.	$254,660
Top Soil Removal and Redistribution:	18,000	$11.5 per cubic ft.	$207,000
Total Cost			**$461,660**

Project Management

Table 10 : Project Schedule

	Work	Projected Date	Actual Date
Task 1.0	**Research**	**10/13/2016**	**10/13/2016**
Task 2.0	**Field Work**	**11/18/2016**	**11/18/2016**
Task 3.0	**Geotechnical Lab Analysis**	**3/15/2017**	**3/23/2017**
3.1	**ASTM D2974 Moisture Content**	**2/3/2017**	**2/3/2017**
3.2	**ASTM D2974 Organic Content**	**2/3/2017**	**2/3/2017**
3.3	**ASTM D5054 Hydraulic Conductivity**	**2/14/2017**	**3/12/2017**
3.4	**ASTM D4318 Atterberg Limits**	**2/26/2017**	**3/12/2017**
3.5	**ASTM C325 Wet Sieve Analysis**	**3/14/2017**	**3/14/2017**
3.6	**ASTM D-698 Proctor Compaction**	**3/15/2017**	**3/15/2017**
Task 4.0	**Develop Design**	**4/20/2017**	**4/20/2017**
Task 5.0	**Project Management**	**5/3/2017**	**5/3/2017**

Conditions at Allan Lake

Figure 21 : Allan Lake March 10th [5]

Figure 22: Allan Lake February 17th [6]

Project Management Continue

Key:

Went over

Went under

Table 11: Staffing Cost.

1.0 Personnel	Staff	Projected Hours	Actual Hours	Rate, $/hr	Projected Cost	Actual Cost
	Project Engineer	40	45	163	$ 6,520.00	$ 7,335.00
	Engineer	45	65	88	$ 3,960.00	$ 5,720.00
	Geotechnical Technician	220	160	45	$ 9,900.00	$ 7,200.00
	Surveyor	120	100	65	$ 7,800.00	$ 6,500.00
	Administrative Assistant	35	45	45	$ 1,575.00	$ 2,025.00
	Intern	25	35	30	$ 750.00	$ 1,050.00
Total Personnel =		485	450	436	$30,505.00	$29,830.00
2.0 Travel	5 Meetings @ 55 mi/meeting	$2.00/mi			$ 100.00	$ 100.00
3.0 Total					$30,605.00	$29,930.00

Future Considerations

- Survey of the proposed road route
- Acquire permits for earthwork
- Building a dam
- Build a fence to keep elk and bovine out of wetland

References

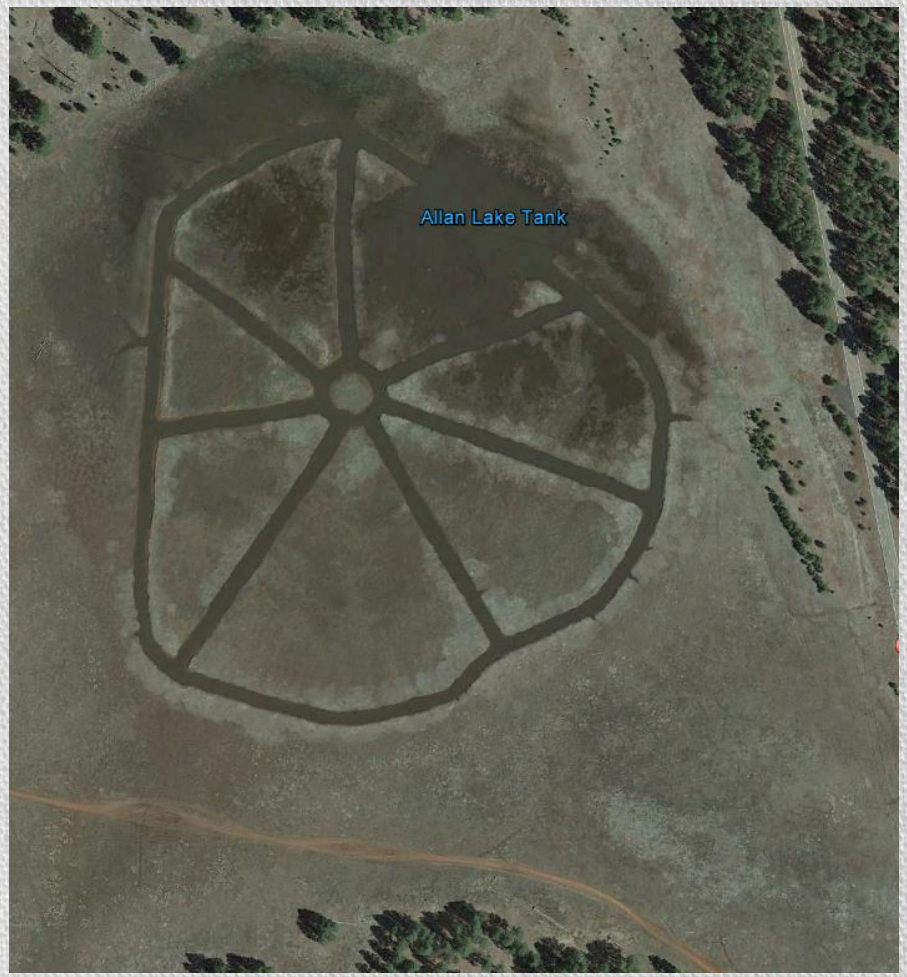
[1] Google Earth. “Allan Lake aerial picture” [Online]. Available: www.google.com/earth
[2] Google Images. “Smokey the Bear” [Online]. Available: www.google.com/Images
[3] Northern Arizona University Civil and Environmental Engineering. Faculty [Online]. Available: http://nau.edu/cefns/engineering/civil-environmental/ faculty/
[4] Photo taken by Brando Gutierrez
[5] Photo taken by Skylar Clemons
[6] Photo taken by Gabe Green

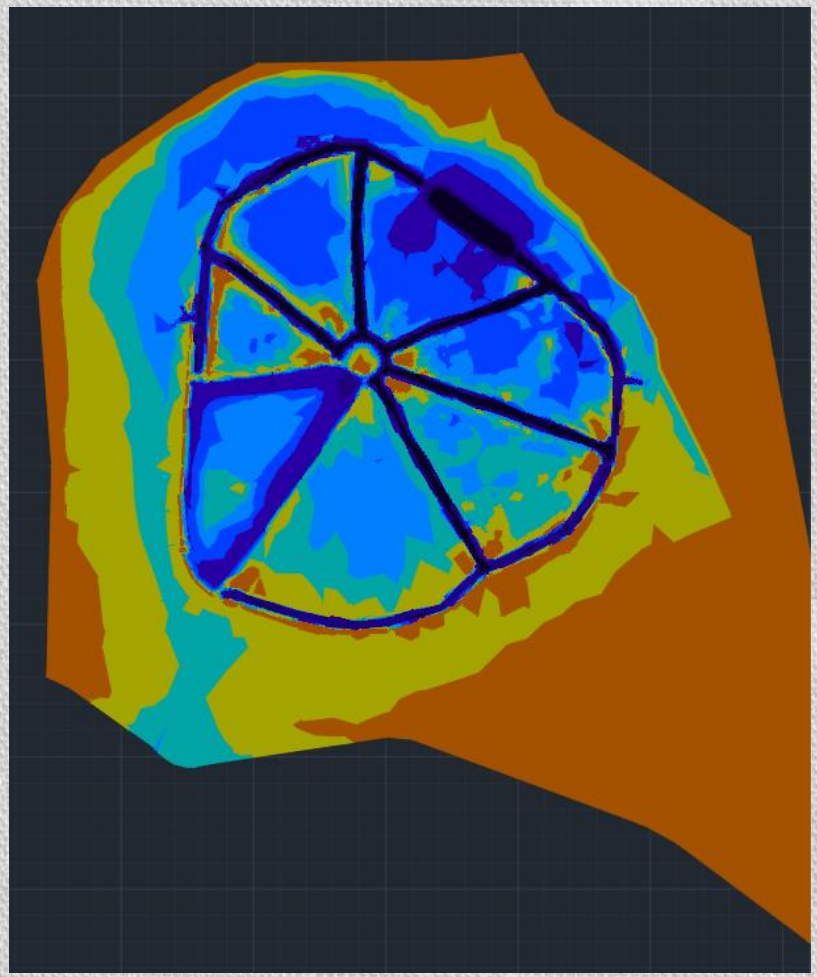
Questions?

Proposed rerouting of road

Image 2: Proposed route [11]

Supplemental





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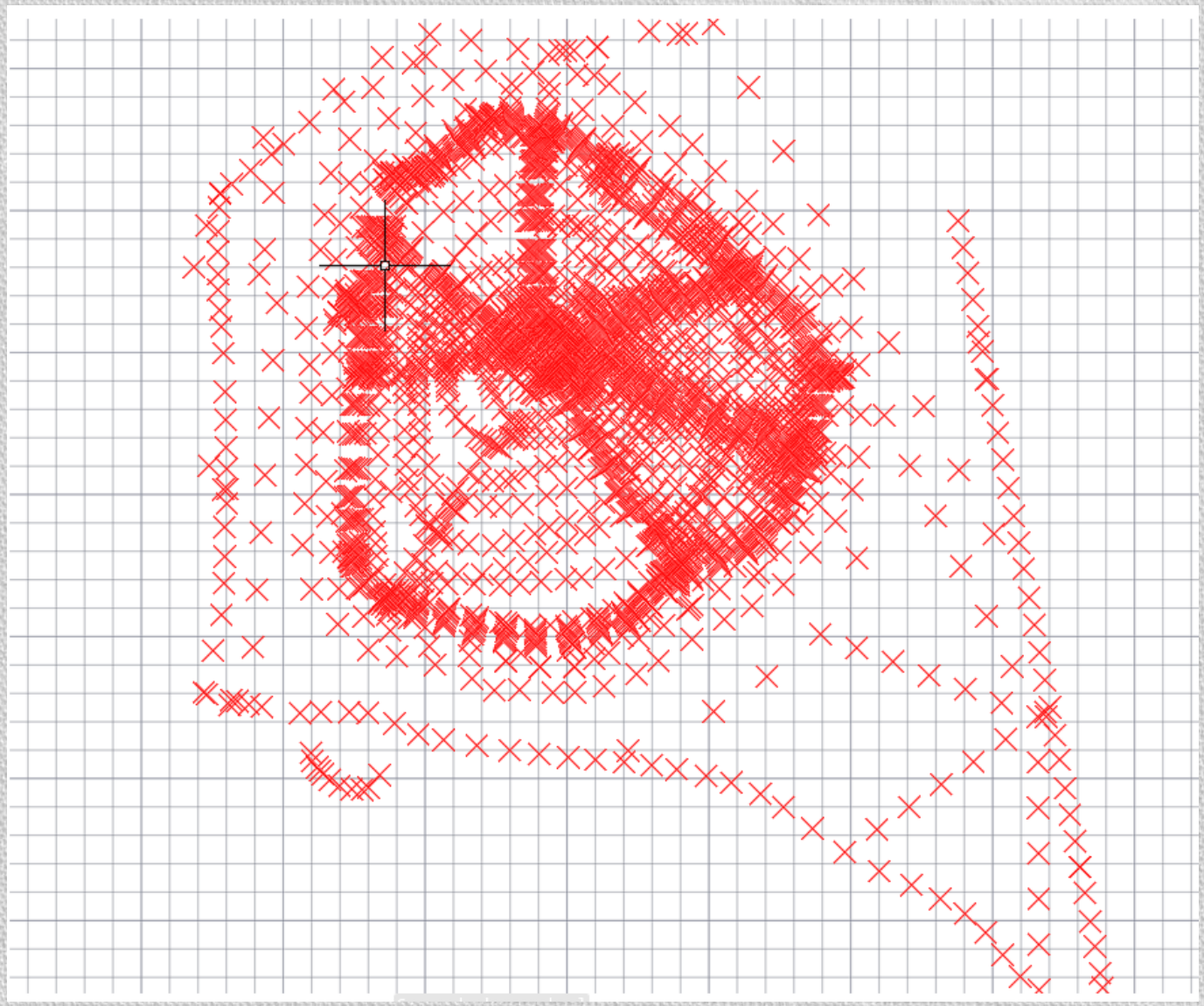

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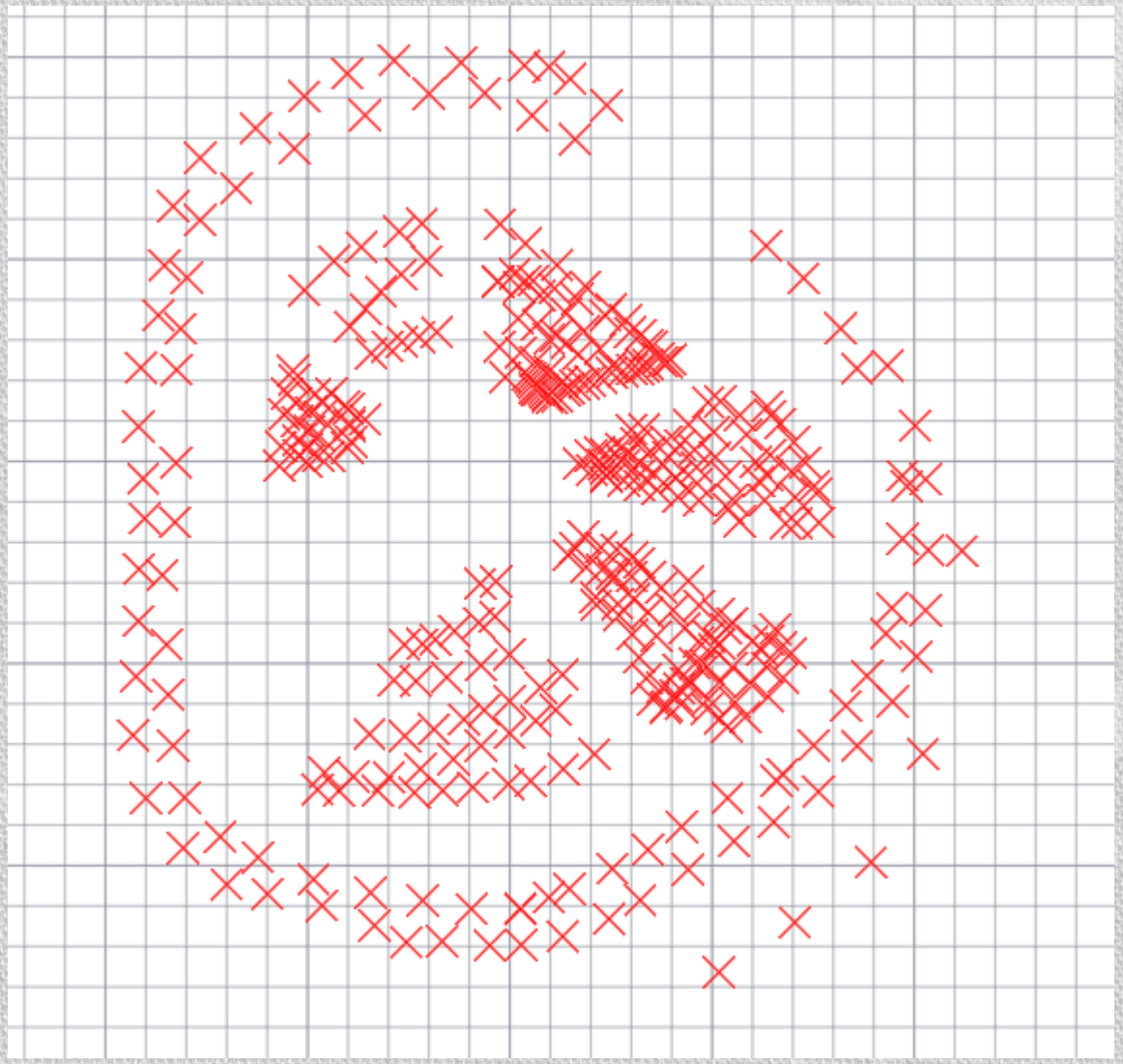


Additional Considerations

- By adding a dam, water retention can greatly improved
- Difficult to analyze impacts of designs without changing soil analysis
- Using current site conditions the following table was generated (average end area method)

Water Elevation (ft)	Volume (ft^3)	Percent Full (%)
7455.00	2,400	1
7457.00	69,000	39
7459.00	119,300	68
7460.00	163,400	93
7461.29	176,200	100
7462.00	428,000	243
7463.00	1,046,800	594

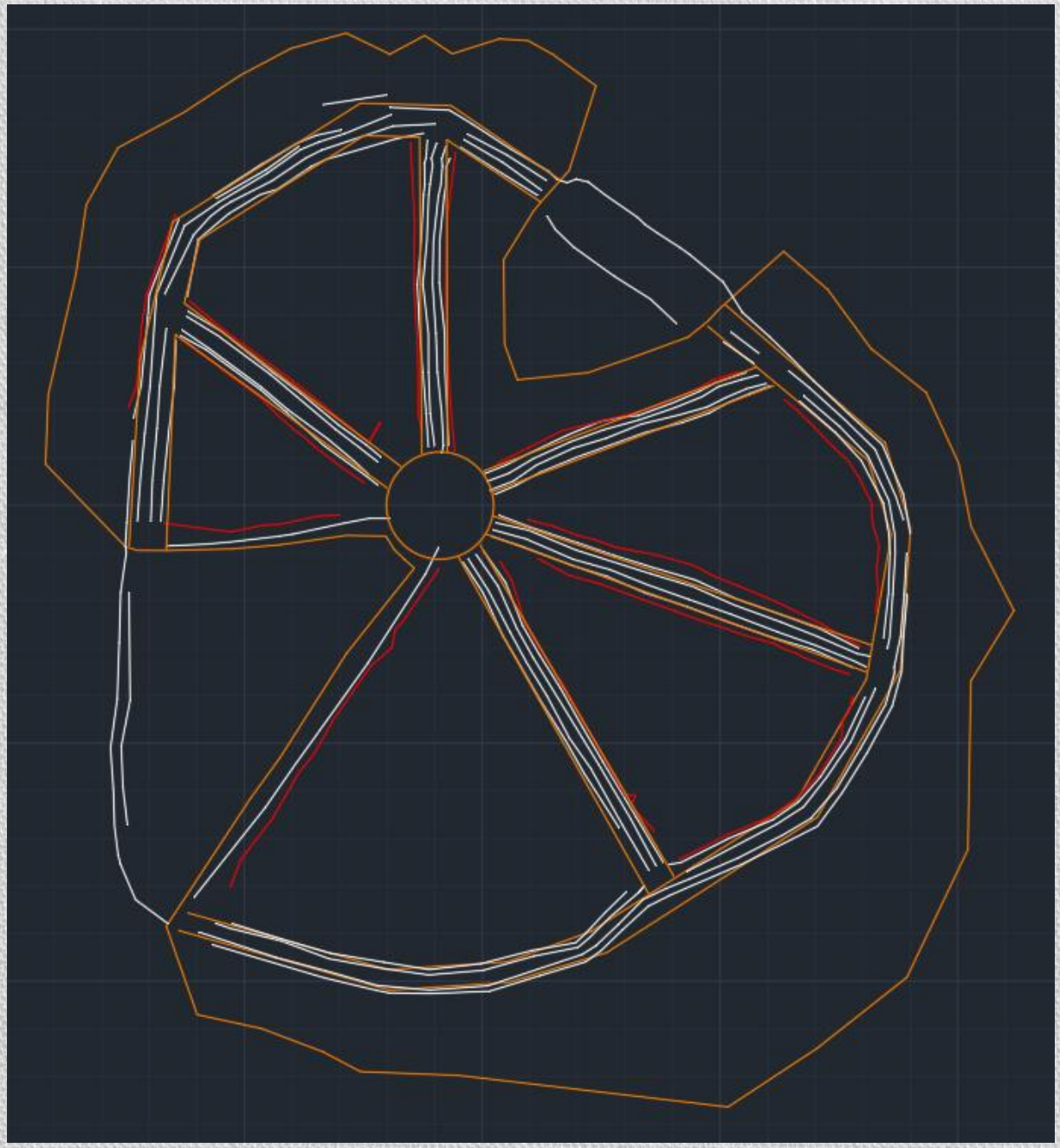
Table 1: Water elevation comparisons [10]

KEY

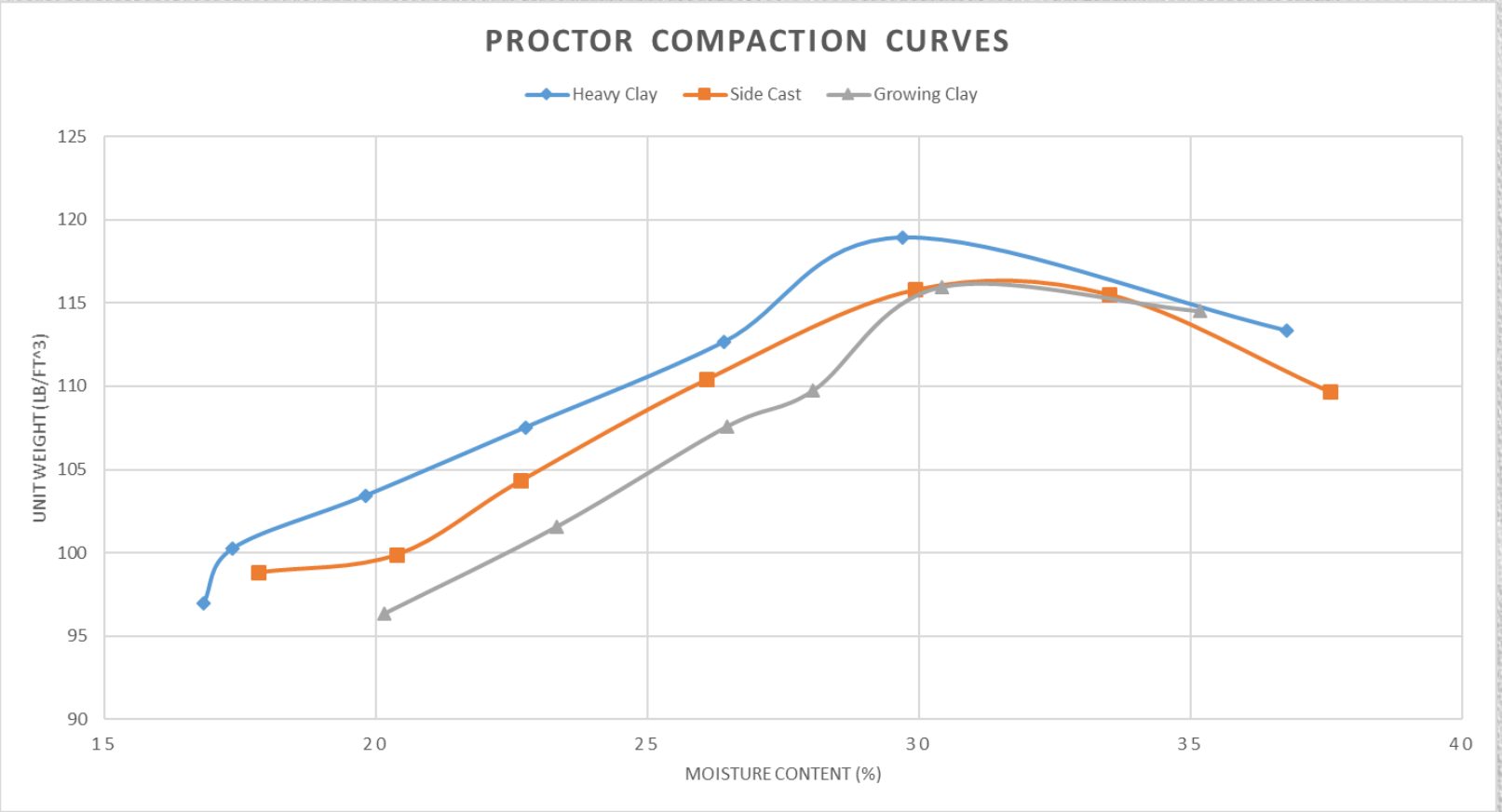
Adding a dam

Supplemental

Supplemental



Proctor Compaction Results



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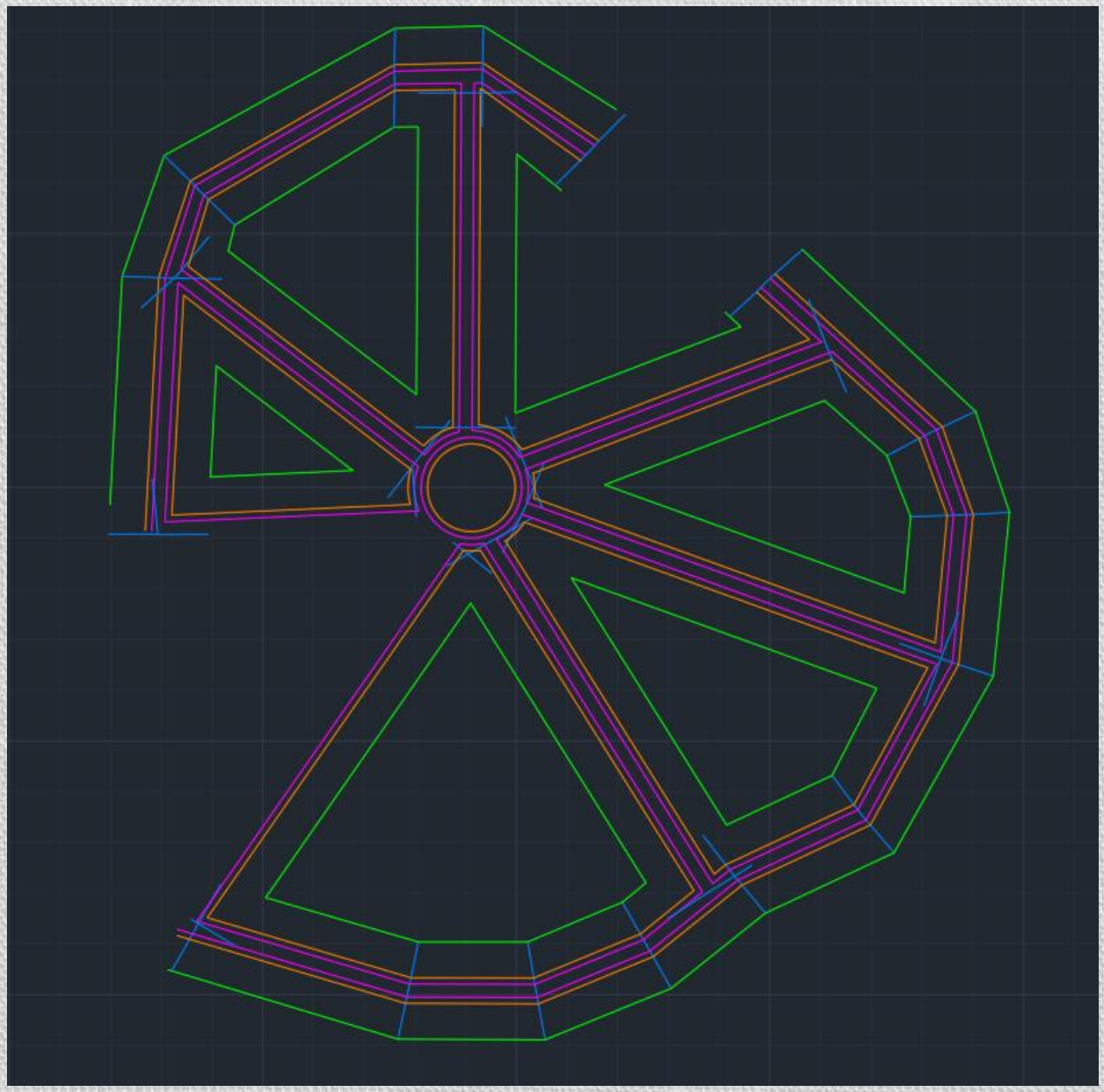

Difficulties with the Soil

Image 4: The start of Digging [5]

Image 5: 30 minutes into digging [6]

Image 6: 1 hour into digging [7]

Image 7: 2 hours into digging [8]

Image 8: Clay Brownies [9]

Image 9: Clay stuck to the extractor head [10]