SK Geotechnical Company

Landfill Liner

Team Members: Ali Alrashed, Nayf Alotaibi, Joe Atkinson, Xiaoyi Tan
Date: 9 December 2016

Acknowledgments

Dr. Wilbert Odem
The grading instructor

Mr. Matthew Morales
client

Cinder Lake Landfill
materials provider

Mr. Gerjen Slim.
The technical advisor

Introduction

- Project Purpose: Create a liner for Cinder Lake Landfill, utilizing waste materials entering the waste stream, and meets the 40 CFR criteria
- Project Location: Approximately 12 miles Northeast of Flagstaff on Highway 89
- Landfill liner: Municipal landfill liner. 40 CFR, 258 [2]

Figure 1: Cinder Lake Landfill Site Location [3]

Introduction

- Criteria:

1. Referring to 40 CFR, section 258, the permeability of the liner should be less than or equal 1×10^{-7}cm/s
2. Cost effective
3. Withstand shear strength

Project Schedule

Table 1: Project Schedule

Task 1: Health and Safety Protocols	Begin data	End data
1.1 Safety protocol for Fly Ash	1/21/16	3/1/16
1.2 Safety protocol for PPS	1/21/16	3/1/16
1.3 Safety protocol for Polymers	1/21/16	3/1/16
1.4 Personal Safety	1/21/16	3/1/16
Task 2: Material Preparation	**Begin data**	**End data**
2.1 PPS Preparation	3/2/16	11/7/16
2.2 Fly Ash Preparation	3/2/16	11/7/16
2.3 Bentonite Preparation	3/2/16	11/7/16
2.4 Lime Preparation	3/2/16	11/7/16
Task 3: Material Testing	**Begin data**	**End data**
3.1 Sieve Analysis	3/2/16	3/10/16
3.2 Compaction Tests	3/11/16	10/31/16
3.3 Permeability Tests	3/20/16	10/31/16

Project Schedule

Table 1: Project Schedule

Task 4: Data Analysis	Begin data	End data
4.1 Sieve Analysis Results	3/11/16	3/15/16
4.2 Compaction Tests Results	3/16/16	11/30/16
4.3 Permeability Tests Results	3/26/16	11/30/16
Task 5: Project Management	**Begin data**	**End data**
5.1 Team Meetings	9/1/16	12/4/16
5.2 TA Meetings	9/1/16	12/4/16
5.3 Website	4/1/16	12/6/16
5.4 50% Report	9/1/16	10/15/16
5.5 Final Report	10/17/16	12/6/16
5.6 Final Presentation	10/17/16	12/6/16

Previously Used Materials

- Lime: Not cost effective.
- Soil: Increases hydraulic conductivity.
- Polymers: Increases hydraulic conductivity.
- Paper Millings (PPS) #4: Non-uniform compaction results.

Table 2: Best results obtained from mixing old materials.

Mixture (Percentage by Weight)	Hydraulic Conductivity (cm/s)
50% PPS, 50% Fly ash (Class F)	4.59×10^{-5}
47% PPS, 47% Soil, and 4.8% Fly ash (class F), 1.2% Lime.	1.2×10^{-4}
50% PPS, 49% Fly ash (Class F), and 1% Polymers.	4.59×10^{-5}
95% PPS, 5% Polymers.	5.71×10^{-6}

Previously Used Materials

- Burnt PPS: Takes long time for preparation, and classified as silty sand.
- Fly Ash (Class F): Classified as poorly graded sand with silt.

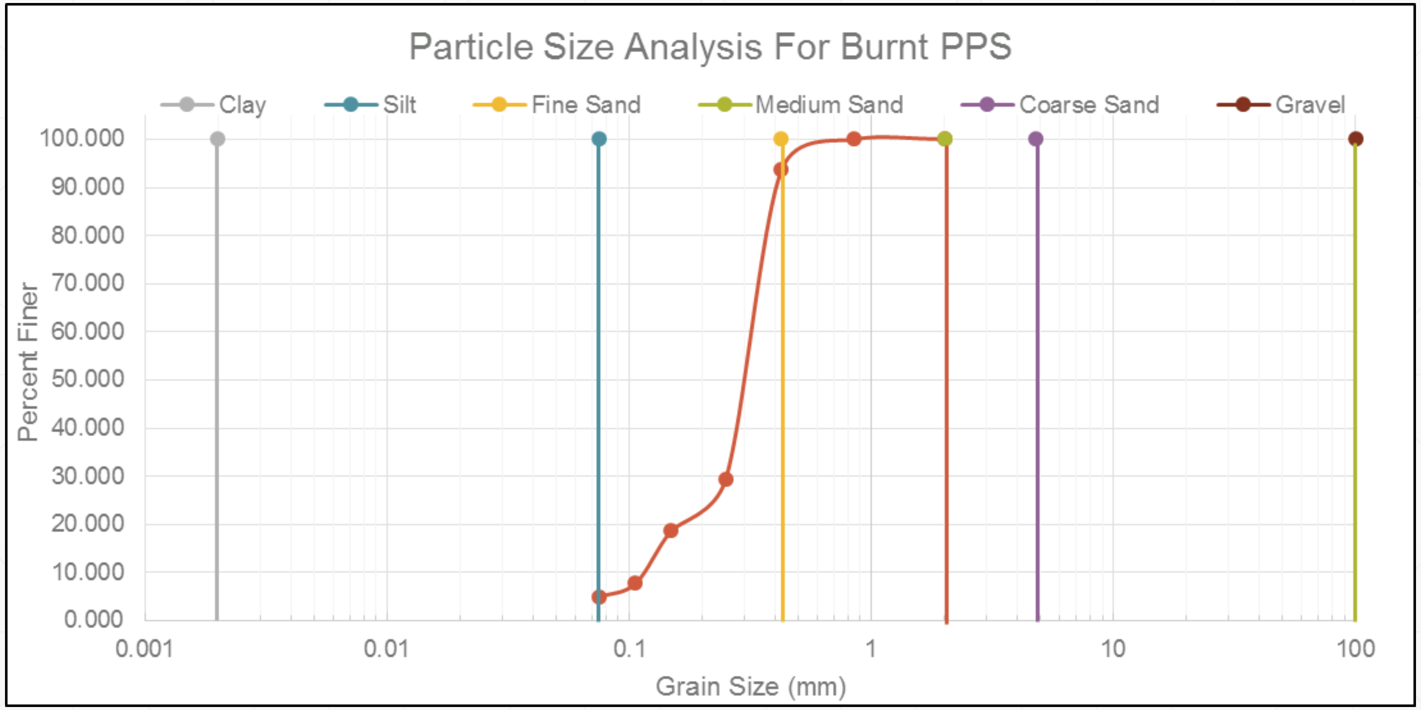

Figure 2: Particle Size Distribution for Burnt PPS

Comparison Between Bentonite and Kaolinite Compaction Results

- Kaolinite: Uses more water than Bentonite

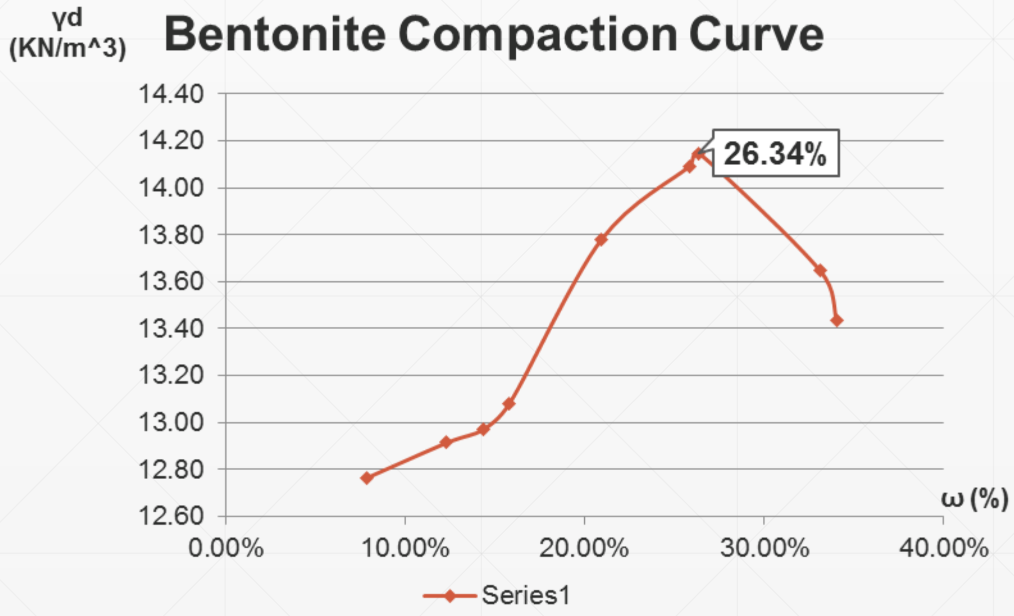

Figure 3: Bentonite Compaction Curve

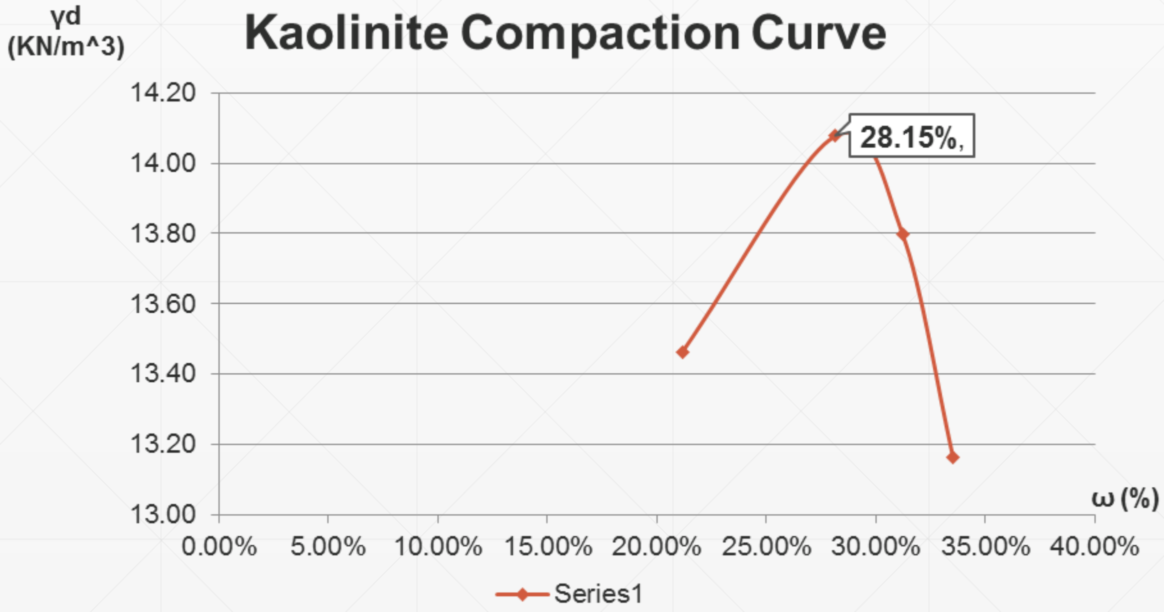

Figure 4: Kaolinite Compaction Curve.

Final Selected Materials

Figure 5: PPS # 3/8"

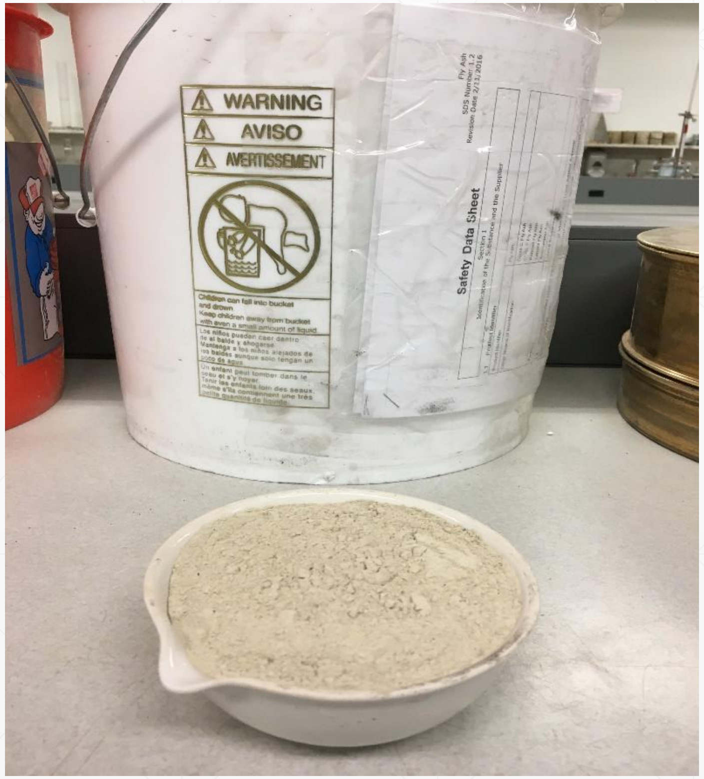

Figure 6: Fly Ash (Class C)

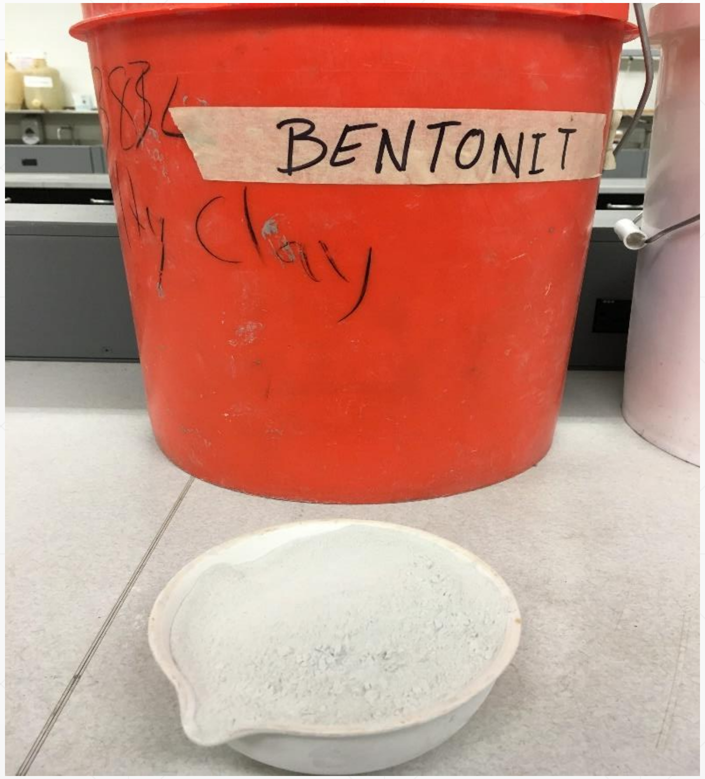

Figure 7: Bentonite

Task 2: Materials Preparation

- 2.1 PPS Preparation
- 2.2 Bentonite Preparation
- 2.3 Fly Ash (Class C) Preparation
- Preparation is done by drying the PPS in the oven, pass the PPS through 3/8” sieve, and mixing all materials using the prepared mixing plan

Task 3: Materials Testing, and Task 4: Data Analysis

- Compaction Tests: to find the optimum moisture content for the following materials: ASTM, D-698

  3.2.1 PPS, # 3/8”

  3.2.2 Bentonite

  3.2.3 Fly Ash (Class C)

- Compaction Tests Results

  PPS, # 3/8”: 44.96% (results provided by previous team)

  Bentonite: 26.34%

  Fly Ash (Class C): 20% [1]

Task 3: Materials Testing, and Task 4: Data Analysis

- Permeability Tests

3.3.1 Consolidation Tests

3.3.2 Permeability Tests

- Purpose

Consolidation Test: To prepare samples for the Permeability Tests

Permeability Test: To measure the hydraulic conductivity of the mixtures

- Equation used to calculate permeability:

$K = \frac{a .* L}{A * t} * \ln(\frac{h_1}{h_2})$, where:

K: Hydraulic Conductivity (cm/s)

a: Area of drainage hole (cm^2)

L: Length of sample (cm)

A: Area of sample (cm^2)

t: Time (s)

h_1: Start height (cm)

h_2: End height (cm)

Permeability Test Process

1 2 3 4 5

Figure 8: Material Preparation

Figure 9: Material Compaction

Figure 10: Samples Preparation

Figure 11: Samples Saturation

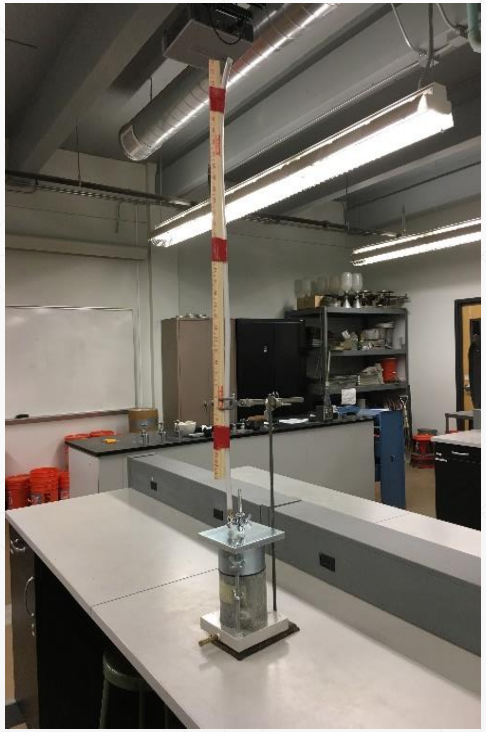

Figure 12: Permeability Testing

Permeability Test Results

Table 3: Permeability test results

Mixture (Percentage by Weight)	Hydraulic Conductivity (cm/s)
80% PPS, 20% Bentonite	3.27×10^{-8}
90% PPS, 10% Bentonite	5.9×10^{-8}
85% PPS, 15% Bentonite	2.59×10^{-8}
80% PPS, 15% Bentonite, 5% Fly Ash (Class C)	4.77×10^{-8}

- Total sample weight is 4.5 kg
- Desired hydraulic conductivity is less than or equal to 1×10^{-7} cm/s

Final Test Cell Design

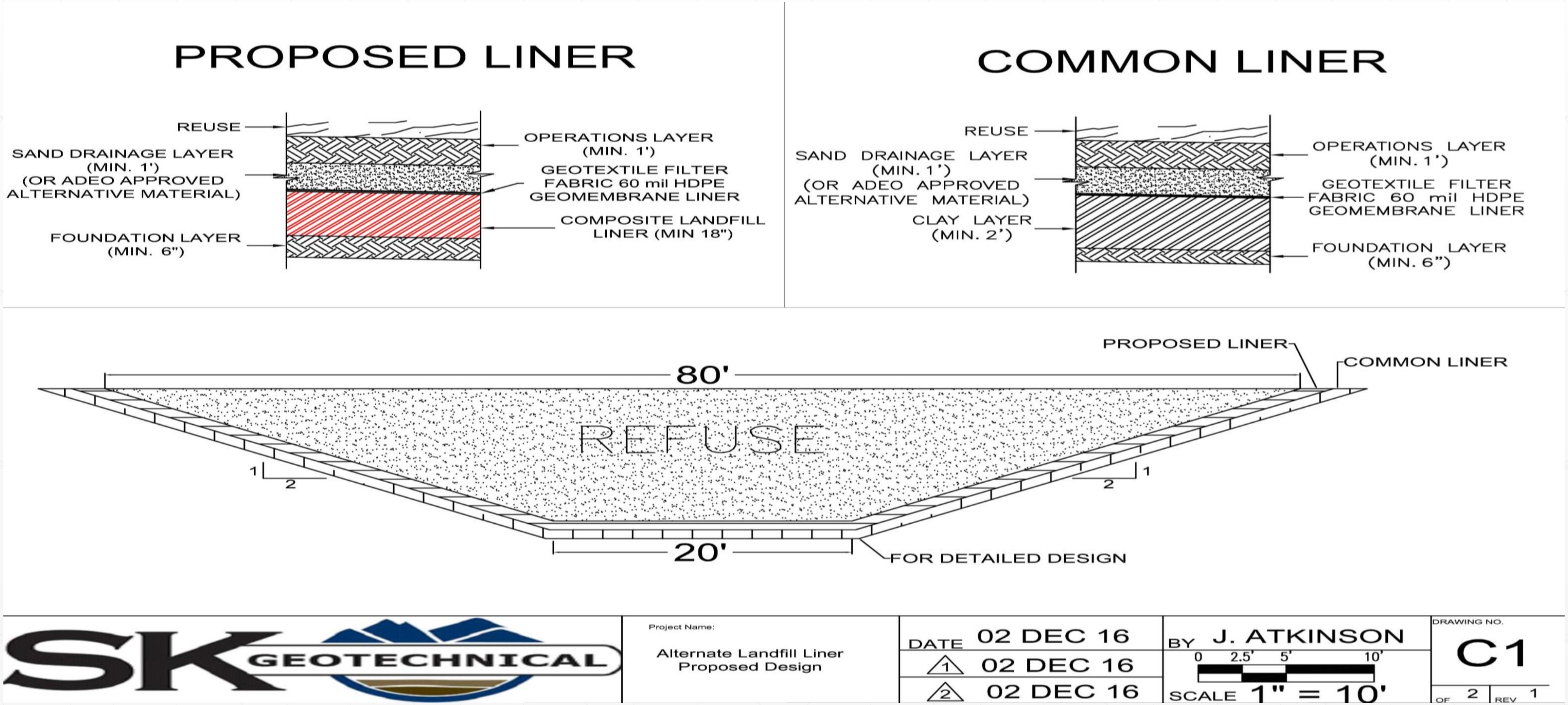

Figure 13: Final Test Cell Design

Final Test Cell Design

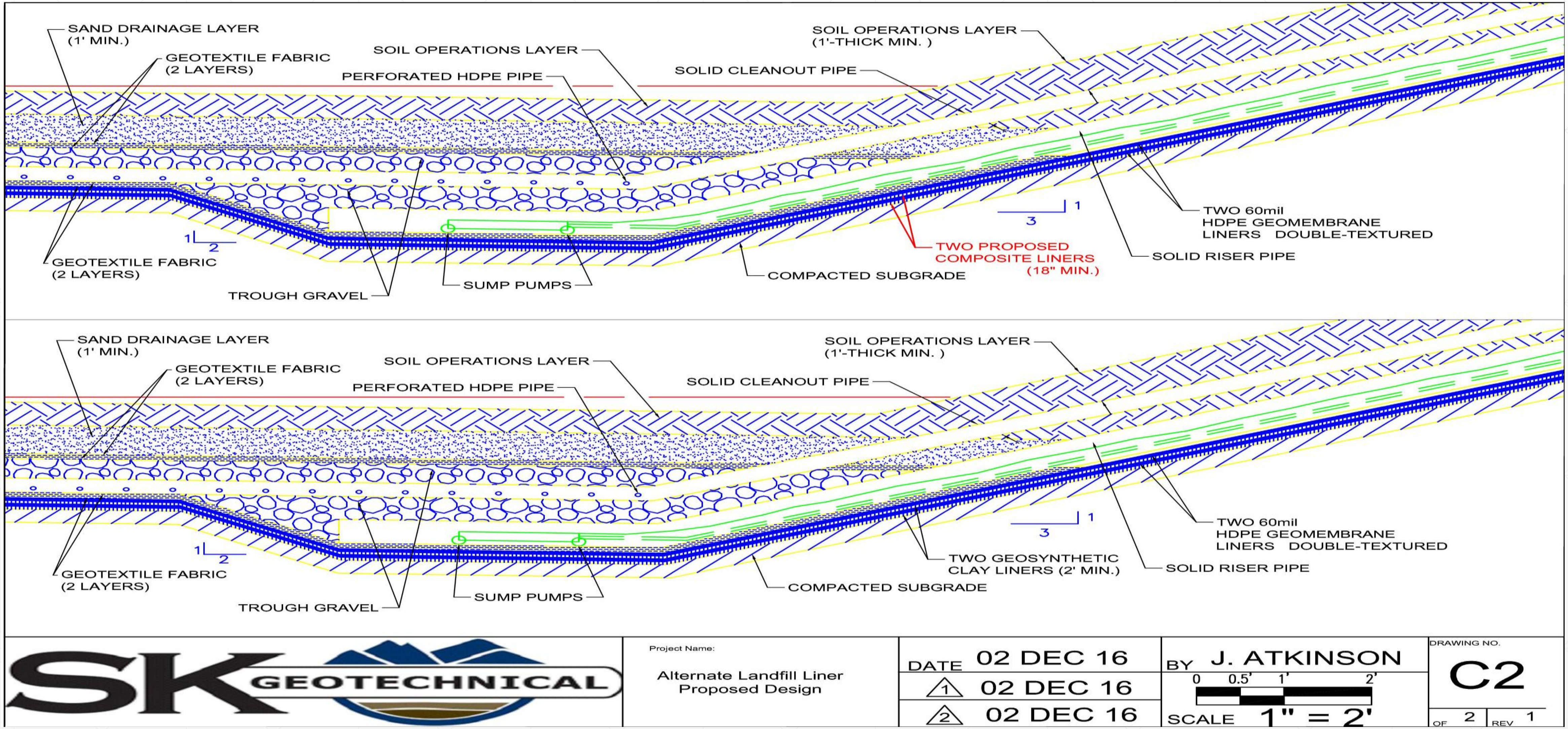

Figure 14: Final Test Cell Design

Total Required Hours

Table 4: Proposed Hours

Task	DENG	RENG	LAB	INT
1.0 Health and Safety Protocols.	-	-	12	-
2.0 Material Preparation.	-	2	40	-
3.0 Material Testing.	-	3	300	-
4.0 Data Analysis.	30	-	60	-
5.0 Project Management	10	60	30	40
Subtotal	40	77	430	40
Total Hours + 80 hours researching = 667 hours				

Table 5: Actual Hours

Task	DENG	RENG	LAB	INT
1.0 Health and Safety Protocols.	-	-	12	-
2.0 Material Preparation.	-	2	100	-
3.0 Material Testing.	-	2	400	-
4.0 Data Analysis.	15	-	35	-
5.0 Project Management	5	35	-	50
Subtotal	20	39	547	50
Total Hours = 646 + 10 hours researching = 656 hours				

Engineering Services Cost

Table 6: Engineering Services Cost

Position	Classification	Hours	Rate, $/hr	Cost
Development Engineer	DENG	20	165	$ 3300.00
Research Engineer	RENG	39	90	$ 3500.00
Lab Assistant	LAB	547	60	$ 32,900.00
Engineering Intern	INT	50	30	$ 1500.00
Total personnel expenses				$ 41,200.00
Lab rental		240 days	$30/day	$ 7,200.00
Total Staffing Cost	$ 48,400.00			

Project Implementation Cost

Table 7: Material Costs

Required Materials	Material Cost per 2 Tons + Shipping
Bentonite	$2,240.00
Fly Ash (Class C)	$1,320.00
Paper Pulp Sludge (PPS)	Free

Table 8: Total Liner Cost per Test Cell

Material	Required Quantity	Total Cost
80%PPS, 20%Bentonite	65.4 tons	$14,650.00
90%PPS, 10%Bentonite		$7,330.00
85%PPS, 15%Bentonite		$10,990.00
80%PPS, 15% Bentonite, 5% Fly Ash (Class C)		$13,150.00
100% Bentonite		$72,240.00

Impacts

Table 8: Impacts of Project.

Impact Type	Positive	Negative
Environment	• Reduces the amount of clay required to construct the liner • Protect groundwater by decreasing the infiltration of leachate	• Influence the normal life of wildlife • More waste entering the landfill
Social	• Reusing waste materials will reduce the amount of waste in the landfill	• Produce foul odors and noise during construction
Economic	• Will save the landfill money over time. • Might decrease the waste disposal cost	• Need huge initial investment from the City of Flagstaff or the Federal Government

References

[1] City of Flagstaff. “Arizona Department of Air Quality,” April 13th, 2006. [Online]. Available: https://www.azdeq.gov/environ/air/permits/title_v/36194/deqfinal.pdf. [Accessed: 2 October, 2016]

[2] Cinder Lake Landfill. “Technical Review and Evaluation of Application,” [Online]. Available: https://www.azdeq.gov/environ/air/permits/title_v/MSWL/COFFPW/36194/deqsupport.pdf. [Accessed: 2 October 2016].

[3] Google Maps. “Cinder Lake Landfill”, [Online]. Available: https://www.google.com/maps?biw=808&bih=630&q=cinder+lake+landfill&bav=on.2,or.&bvm=bv.114195076,d.eWE&sns=1&um=1&ie=UTF-8&sa=X&sqi=2&ved=0ahUKEwi7rMyJm4DLAhXBLyYKHSlFDPQQ_AUIBigB. [Accessed: 2 October, 2016].

[4] “Closure Criteria,” U.S Government Publishing Office, 2016, [Online]. Available: http://www.ecfr.gov/cgi-bin/text-idx?SID=b67b217c1e8767c774a3aa0ff9bff80c&mc=true&node=se40.25.258_160&rgn=div8. [Accessed: 20 April 2016].

[5] *Modified Proctor Compaction Test*, ASTM D1557

[6] *Permiability Test*, ASTM D5084

Q & A