University of Alaska Anchorage

College of Engineering

Anchorage Regional Landfill Leachate Minimization Project

Senior Design Project Spring 2019

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Contact Information

This document has been prepared by students from the University of Alaska Anchorage College of Engineering as an in-house senior design project. Questions related to this document should be addressed to Emily Haas, student project manager. 907.891.0786 (email: erhaas@alaska.edu)

Acknowledgements and Disclaimer

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The work detailed in this report has been carried out by:

Ginger Cordero, Steve Erdman & Emily Haas

However, this report is not intended as a substitute for any engineering, geotechnical engineering or municipal engineering research with respect to this projects objectives.

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List of Acronyms and Abbreviations

ACAP Alternative Cover Assessment Program	LCRS leachate collection and removal system
AWWU Anchorage Water and Wastewater Utility	LEL lower explosive limit
BAT best available technology	LFG landfill gas
BOD biochemical oxygen demand	LMS leachate management system
BCT best conventional technology	LRS leachate recirculation system
BMP best management practice	MBR membrane bioreactor
BPT best practical technology	MOA Municipality of Anchorage
CAA Clean Air Act	MSW municipal solid waste
CCL compacted clay liner	NSPS New Source Performance Standards
CQA construction quality assurance	NSWMA National Solid Waste Management Association
CWA Clean Water Act	PCC post-closure care
EMP environmental monitoring program	POTW publicly owned treatment works
ET evapotranspirative	PVC polyvinyl chloride
FML flexible membrane liner	SDWA Safe Drinking Water Act
GCCS gas collection and control system	SEM surface emissions monitoring
GCL geosynthetic clay liner	SOP standard operating procedure
GEC geosynthetic erosion control	SWANA Solid Waste Association of North America
GHG greenhouse gas	SWM stormwater management
GM geomembrane	SWMS stormwater management system
GMS gas management system	SWMP surface water monitoring program
GT geotextile	SWS Solid Waste Services
GWMS groundwater monitoring system	RCRA Resource Conservation and Recovery Act
HDPE high density polyethylene	UAA University of Alaska Anchorage
HHE human health and the environment	USEPA United States Environmental Protection Agency

|Abstract|

The purpose of this report is to detail the senior design project conducted by the students of the University Of Alaska College Of Engineering. The project was focused on developing and designing alternative actions for the Anchorage Regional Landfill with the aim to minimize leachate generation within the landfill cells. Facility information and data were used in combination with literature research and an experiment conducted by the students to develop and design alternatives looking at minimizing leachate generation. These alternative actions were evaluated based on their overall cost and leachate reduction estimates; criteria delineated in the clients request for proposal.

The results show that the application of recycled latex paint and street sweepings would be sufficient to reduce leachate generated via precipitation infiltration by 30% annually, pay for itself in savings in 3 years out of its ten year project life. When combined with the public campaign focused on education and awareness about source reduction actions, leachate reduction estimates total to 32.6%. Implementing both actions ARL would divert up to 60 million gallons of leachate from entering the landfill and save $2.8 million in leachate transport and treatment costs in the first 10 year.

|Background|

Municipal Solid Waste (MSW) is the waste collected by sanitation or waste management services from residential and business institutions. Landfilling is the most common disposal method for municipal solid waste, and is the final link in the solid waste disposal chain. Landfills are carefully engineered structures where waste is deposited, compacted and covered on top of designed collection and management systems for both leachate and natural gas in order to protect the environment from containments in the waste. Leachate is generated as excess precipitation and surface run-off percolates through the layers of a landfill. This percolating process adds waste pollutants into the leachate through physical and chemical processes requiring it to be treated before being discharged into the environment or transported to a municipal wastewater treatment plant for additional treatment.

The Anchorage Regional Landfill began this project to examine alternatives in an effort to reduce leachate production in the future.

|Organization of this Report|

This paper will present our approach to the development of design alternatives, and recommended facility actions for ARL to take in order to reduce leachate generation. The report is dissected into sections: each of the sections is discussed below.

Section 1 provides the description, purpose and objectives of the project. Section 2 presents facility information on the Anchorage Regional Landfill. Section 3 describes the current leachate management and treatment processes at ARL. Section 4 denotes project requirements. Section 5 details the methodology and approach. Section 6 presents the developed alternative actions and the analysis of those alternatives. Section 7 provides suggested forward actions necessary for ARL to take in order to implement the proposed recommended actions. Section 8 concludes the report with our groups recommended facility actions for the optimal reduction of leachate generation at ARL.

1. Introduction

a. Project Description

The Anchorage Regional Landfill (ARL) has been in operation since 1987. ARL is owned by the Municipality of Anchorage (MOA) and operates as the Department of Solid Waste Services (SWS). Currently ARL is operating at 137 acres and is the only deposition point for collected municipal solid waste from the greater Anchorage area. Leachate generated at ARL is collected, loaded into trucks and transported to a dump station owned and operated by Anchorage Water and Wastewater Utility (AWWU) to be treated at their municipal wastewater treatment plant. The remaining lifespan of the landfill is estimated at 25 years; however, in recent years leachate generation has reached operational capacity at around 70,000 gallons per day. For this reason, ARL is currently looking into alternatives to minimize leachate production.

The design and implementation of a new plan to reduce leachate production and generation is pertinent to ensuring that ARL will continue to be able to serve the MOA and its stakeholders effectively.

b. Project Objective

The objective of this senior design project was to develop, design and present a plan to minimize leachate generation at the Anchorage Regional Landfill. This projects specific objectives as laid out by the client in the request for proposal were to:

- review all existing reports, records, construction methods and material requirements;
- identify any constraints for construction methods and materials
- present construction methods and material options not previously considered.
- assess alternatives to minimize onsite production of landfill leachate.
- select an alternative based on preliminary design using a quantified scoring rubric that address client needs and preferences and external drivers.
- provide project cost estimates

- develop work plans and schedules for the landfill operations to achieve to minimize impacts to operations during implementation and/or construction of the project and maintaining function as the landfill is operated.
- conduct site investigations beyond what is provided by CED or found during research to ensure a complete and thorough bid set.
- identify and apply for all required permits, agreements, and approvals necessary for the implementation and/or construction of the project

c. Client Information

The owner and client that this project was prepared was the Municipality of Anchorage division of Solid Waste Services at the Anchorage Regional Landfill. The primary contact for the client was Mark Spafford, general manager of Solid Waste Services (SWS) with the Municipality of Anchorage.

2. Existing Facility Conditions

a. Facility Description

The Anchorage Regional Landfill (ARL) has been operating since 1987 following the closure of the Merrill Field landfill. ARL has a total land area of 275 acres and develops cells to accommodate the landfills refuse. The landfill is located north of Anchorage at the intersection of Hiland road and the Glenn Highway accessible via the Highland road exit. Currently the landfill operates at 137 acres, consisting of 12 active cells. ARL is permitted as a Class I landfill under Title 18 of the Alaska Administrative Code. ARL also meets both the operational and design criteria of a RCRA Subtitle D landfill. This landfill serves as the deposition point for Municipal Solid Waste (MSW) for all of the Anchorage Municipality. ARL accepts approximately 300,000 tons of waste per year. The waste disposed at ARL includes residential solid waste, commercial solid waste and hazardous waste. ARL has a permitted maximum capacity 45.2 million cubic yards and an estimated remaining airspace of 30.3 million cubic yards, as of 2017.Under the current integrated solid waste master plan (ISWMP) the remaining life span of ARL is estimated at 25 years. An aerial view of ARL is presented in Figure 1 below.

Figure 1: Anchorage Regional Landfill Aerial View

b. Land Ownership

This project is to be implemented within the boundaries of ARL on land owned by the Municipality. The land is currently zoned for industrial use and will require no zoning modifications. No land issues are expected for the scope of this project.

c. Geotechnical Summary

ARL is constructed on a large glacial moraine with soils that are well graded sand and gravel with numerous boulders and cobbles in excess of 36 inches in diameter. Groundwater is approximately 140 feet below the original surface. ARL has active landfill gas collection and control systems in place as well a leachate collection and recovery system embedded within the landfill liner layers. The liner system of the landfill includes a 2 foot drainage layer, a geotextile cushion, 80 mil of high density polyethylene geomembrane, geosynthetic clay liner, 6-inch foundation followed by a prepared subgrade.

d. Environmental Summary

This project will be implemented within the boundaries of the Anchorage Regional Landfill (ARL) on land owned by the Municipality of Anchorage (MOA). An initial environmental impact assessment was completed in 1986 for development of the landfill. Per this environmental impact assessment, no issues with threatened or endangered species, habitat, wetlands, or archeological or historical significance were identified. ARL is a fully developed industrial site, visually screened, with no adjacent development. From this assessment there are no projected adverse environmental impacts or other barriers to development.

3. Leachate at ARL

a. Leachate Data

In the 32 years of operation ARL has generated a total of 368 million gallons of leachate, an average of 11.4 million gallons of leachate yearly. ARL currently hauls on average 70,000 Gal/day of leachate to a dump station 10 miles away owned by Anchorage Wastewater & Water Utility (AWWU). On average SWS transports 25 million gallons annually to this facility for treatment. Leachate will continue to be generated even once the landfill has reached maximum capacity. Figure 2 below shows the annual gallons of leachate hauled per year, from 1990 – 2017, Table 1 shows the leachate haul data numerically.

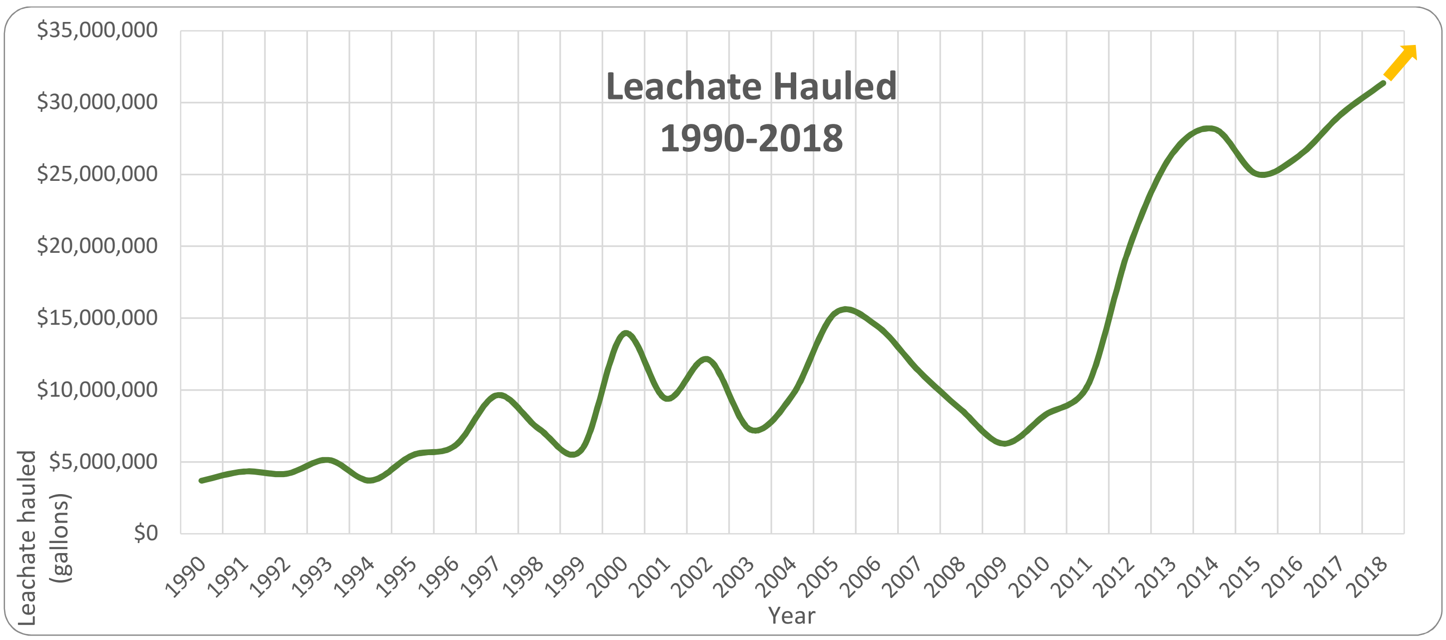

Figure 2: illustrates annual gallons hauled of leachate from 1990-2018

Table 1: Gallons of Leachate hauled per year from 1990-2018

Leachate Transported Annually							
Year	**(gallons)**	**Year**	**(gallons)**	**Year**	**(gallons)**	**Year**	**(gallons)**
1990	3693209	1998	7,282,479	2006	14,471,324	2014	28,158,063
1991	4,327,119	1999	5,831,921	2007	11,300,960	2015	25,032,778
1992	4,171,970	2000	13,913,179	2008	8,627,549	2016	26,289,569
1993	5,132,751	2001	9,398,869	2009	6,268,185	2017	29,183,318
1994	3,695,801	2002	12,135,028	2010	8,283,504	2018	31,349,001
1995	5,468,025	2003	7,247,359	2011	10,327,773		
1996	6,117,354	2004	9,643,577	2012	20,066,478	**Total**	**368,796,175**
1997	9,635,552	2005	15,318,044	2013	26,425,436		

b. Leachate Cost

Currently AWWU charges ARL 0.044 dollars per gallon for leachate treatment. Since operation ARL has spent a total of $16.2 million on the treatment of leachate. Since 2014 leachate costs to ARL have reached over one million annually, and are projected to continue accumulating after the landfill has reached maximum capacity. Figure 3 below shows the annual cost of leachate hauled per year, from 1990 – 2018. Table 2 shows this data numerically.

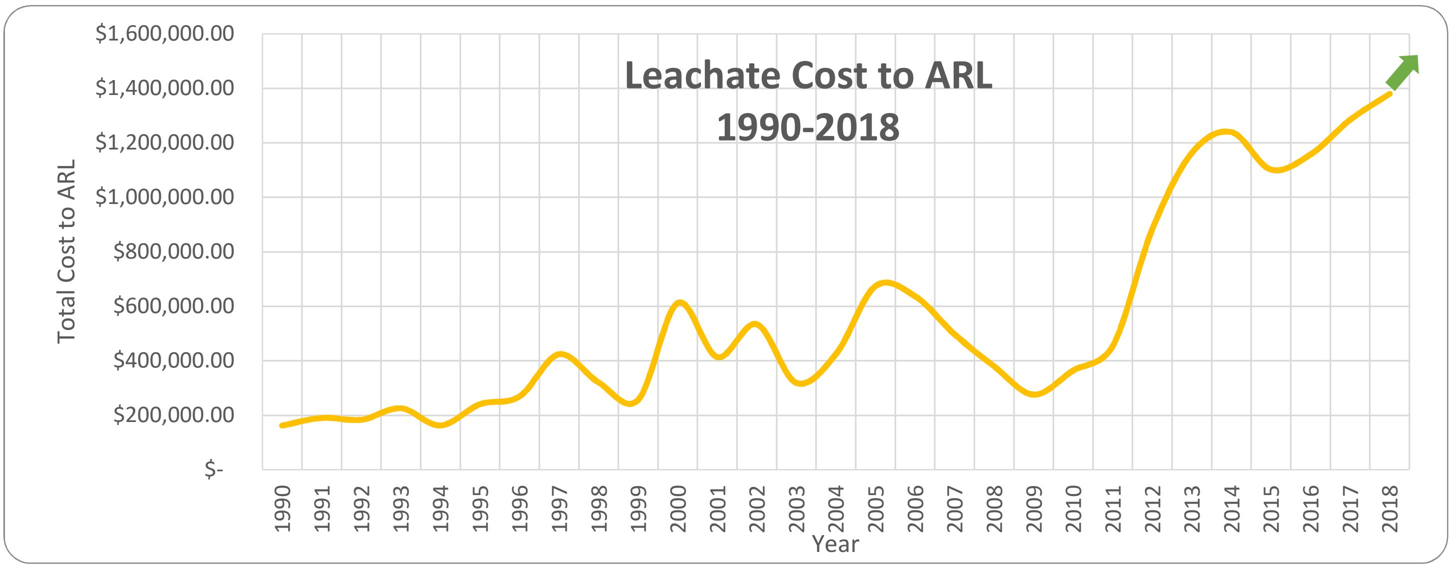

Figure 3: illustrates the annual cost of leachate transport & treatment from 1990-2018

Table 2: ARL annual leachate transport and treatment cost from 1990-2018

Leachate Transport & Treatment Cost Annually							
Year	**Cost**	**Year**	**Cost**	**Year**	**Cost**	**Year**	**Cost**
1990	$162,501	1998	$320,429	2006	$636,738	2014	$1,238,955
1991	$190,393	1999	$256,605	2007	$497,242	2015	$1,101,442
1992	$183,567	2000	$612,180	2008	$379,612	2016	$1,156,741
1993	$225,840	2001	$413,550	2009	$275,800	2017	$1,284,066
1994	$162,615	2002	$533,941	2010	$364,474	2018	$1,379,356
1995	$240,593	2003	$318,884	2011	$454,422	**Total**	**$16,227,032**
1996	$269,164	2004	$424,317	2012	$882,925		
1997	$423,964	2005	$673,994	2013	$1,162,719		

c. Management & Treatment Process

Leachate is currently collected and transported via pipelines placed at the bottom of active refuse cells to collection lagoons for pretreatment before it is pumped into trucks and transported to the Turpin dump station owned by AWWU for treatment. The amount of truck loads has increased substantially since ARL began operation. . Current hauling practices have reached capacity at 20-30 truckloads per week

d. Leachate Alternatives Considered

Previous studies on minimizing leachate generation have been conducted at the request of ARL illustrating their need for leachate minimization.

ARL has detailed that some cells recirculate a portion of leachate back into the landfill to increase the amount of moisture within the waste mass in order to speed up decomposition and reduce the amount of leachate transported to AWWU for treatment. This process of leachate recirculation results in a faster anaerobic biodegradation process and increases the rate of Landfill Gas (LFG) generation. However it does not serve as a long-term solution for minimizing the generation of leachate.

From their 2018 business plan ARL has proposed a pipeline to allow direct discharge to the AWWU system to reduce leachate transportation costs but this project is still in the conceptual phase with no set start date mentioned or funds appropriated.

e. Leachate Projections

Future leachate flow estimation was determined under the condition that no final cover systems have been installed for the refuse cells at ARL. This estimation was included in a Leachate Flow Analysis performed by BHC Consultants and was based on the current and recent conditions as well as including a contributing area of 166 acres. The predicted average annual leachate flow from this analysis was 95,284 gallons per day or 34.8 million gallons per year. However future precipitation amounts, population increases or the effects of global warming were not considered and are anticipated to increase leachate production. GES has estimated that leachate generation is to reach upwards of 41 million gallons per year if prevention practices are not implemented.

f. Leachate Cost Projections

Given the future leachate projection estimates and the projected population of anywhere from 318,000 to 323,517 by 2045. The Anchorage Regional Landfill is looking at anywhere from $35 to $40 million dollars in leachate treatment and transportation costs for the remaining landfill lifetime of 25 years. However, leachate will continue to require management and treatment even after the landfill reaches maximum capacity. The projected additional cost for post-life leachate management and treatment is estimated at $20 to $40 million dollars. GES estimates that for the next 50 years ARL is looking at a total projected cost of leachate management and treatment to $100 million dollars.

4. Project Requirements

This projects specific design criteria as denoted by the client in the request for proposal were that the leachate reduction alternative must strive to:

- minimize changes in operational practice at the landfill
- utilize existing construction equipment at the landfill
- be easily adaptable and adjusted as solid waste is placed within the landfill
- provide effective operational in all seasonal conditions
- be cognizant of all environmental regulations that may pertain to capture and discharge of storm water on or adjacent to the landfill.

5. Project Approach & Methodology

a. Project Approach

The technical challenge that this senior design project looked to addressing was the urgent need for the minimization of leachate generation at the Anchorage Regional Landfill through the design and implementation of recommended facility actions. The approach that GES took to combat this challenge is detailed below.

First GES analyzed and assessed the data given by the client. This included leachate cost and haul amount data as well as an engineering report into ARL's past leachate minimization alternatives considered.

Second GES went into a 'project development' stage which consisted of preliminary engineering designs and establishing a project budget and schedule. In this stage the project scope was reviewed, a strategy for attacking the project problem was formalized and project criteria and requirements were assessed before moving forward.

Third GES entered a 'detailed design' phase wherein GES' Engineers produced alternatives, adhering to the project criteria then analyzed the alternatives on basis of cost and leachate reduction estimates before exploring how ARL would implement those alternatives.

The final phase of this project was the 'closing and commencement" phase which overviews the entirety of the projects data highlighting actions ARL should consider for forward action as well as GES' recommended facility actions to optimize the minimization of leachate generation.

6. Facility Action Analysis

a. Alternative Cover

This alternative looks at reducing the amount of precipitation entering the landfill via infiltration by applying a layer of latex paint on top of street sweepings to the top interior side slopes. By utilizing on-site materials and applying a 50 mil thickness of latex paint on the side slopes we estimate that this alternative could divert 30% of precipitation into infiltration basins and pay for itself in the amount saved in 3 years.

i. Laboratory Experiment for Alternative Cover Analysis

A laboratory experiment was conducted to determine the effectiveness that a coating containing street sweepings and latex paint would have on reducing precipitation infiltration on landfill side slopes by changing the permeability of landfill surface. The tests were aimed at determining the most effective and efficient amount of a latex paint and street sweeping cover needed for yielding the maximum leachate generation reduction. The information was then used to evaluate the required amount of materials necessary for the facility to implement this design alternative action.

All materials used as cover for this laboratory experiment were disposed of as waste at ARL, recycled and provided by to us by SWS. All tests were performed at the University of Alaska Anchorage in the Engineering Industry Building Lab space using student made containers simulating landfill precipitation infiltration on a sloped side wall at ARL.

The sloped surfaces were covered in aggregate, gravel or a mixture of gravel and street sweepings, then coated with a specified thickness of the recycled latex paint before a specified volume of water was applied using a watering can. These tests were performed to measure the amount of precipitation that would infiltrate the aggregate and latex paint coating and that amount was compared to the total amount of precipitation applied.

The raw data from the experiment conducted was compiled for evaluation and analysis. A detailed lab report for the experiment conducted containing the procedure, materials and data is attached in Appendix A. The experimental results and analysis are shown in Table 3.

Box No.	Coating Thickness	Water Applied	Run-Off Collected	Leachate Generated	% of Water applied turned into Leachate	% of Precipitation Diverted
	(mill)	(L)	(L)	(L)	(%)	%
1	N/A	5.507	0.132	4.539	82.42%	2.40%
2	10	5.682	0.014	5.547	97.62%	0.25%
3	**50**	**5.96**	**1.906**	**2.87**	**48.15%**	**31.98%**
4	75	5.759	0.21	3.54	61.47%	3.65%

Table 3: Experimental Data & Analysis

ii. Cost Estimates

The cost of implementing this action are generated by the labor required and the initial cost of specialized machinery used to apply the recycled latex paint coating. Table 4 breaks down the cost of the action.

	Cost	Total
Machine to apply paint	$70,000 per each	$70,000
Labor	$1,600 per year x 10 years	$16,000
Total Cost to Completion		$86,000

Table 4: Calculated Cost of implementing Action A

iii. Leachate Reduction Estimates

GES estimates that in the first 10 years of implementation ARL would divert a total of 31 million gallons of leachate and save $1.37 million. Using the estimate that 25% leachate is generated is from precipitation infiltrating through the side slopes, it is calculated that 32% of that precipitation can be diverted by applying latex paint and street sweepings to those side slopes. Table 3 details the estimated gallons of leachate reduced as well as the annual and total cost to ARL in the first 10 years of the projects implementation.

Year	Painted Area	Estimated Leachate Diverted	Annual Savings to ARL	Cumulative Savings to ARL
	(Acre)	(gallons)	(USD)	(USD)
1	4	573,617	$25,239	$25,239
2	8	1,147,222	$50,478	$75,717
3	12	1,720,826	$75,716	$151,433
4	16	2,294,431	$100,955	$252,388
5	20	2,868,035	$126,194	$378,582
6	24	3,441,639	$151,432	$530,014
7	28	4,015,244	$176,671	$706,685
8	32	4,588,848	$201,909	$908,594
9	36	5,162,453	$227,148	$1,135,742
10	40	5,270,003	$231,880	$1,367,622

Table 4: Leachate Reduction Estimates & Estimated Savings to ARL for 10 years

GES estimates that with a coating of street sweepings and latex paint as much as 5.2 million gallons of leachate per year can be diverted, and that the cost of implementation would be mitigated within three years of leachate cost savings.

iv. Required Materials

It is estimated that 200,000 gallons of paint is required to coat the 37 acres of side slopes. At the current yearly intake rate ARL receives enough waste latex paint to supply the coating of 4 acres per year and they currently have enough ready on-site material to complete 4 acres of coating.

It is estimated that 1,000-2,000 of street sweepings is received by ARL each year. The bulk of the street sweepings brought to ARL happen in the springtime when snow has melted. At the current yearly intake rate ARL receives enough street sweepings to complete 4 acres per year.

v. Process of Facility Implementation

GES recommends that the painting occur in the spring time to coincide with the delivery of street sweepings as well as to take advantage of dry weather. From the laboratory experiment GES recommends that in order to prevent sloughing on the side slopes that paint should be applied in double layers to a thickness of at least 50 mil. With this process of allocating and coordinating on-site recycled materials and the proposed schedule of application this action would coat the 37 acres of side slopes at ARL in 10 years.

b. Public Education/Outreach

This recommended facility action looks at reducing the amount of liquid entering the from a source reduction approach to preemptively reduce leachate generation within the landfill. Through a public campaign focused on educating the SWS customers on the leachate problem at ARL and promoting awareness on how those customers can help reduce leachate generation by source reduction GES estimates that 1.2 million gallons of leachate could be prevented from entering the landfill annually. If this action is implemented over 10 years, ARL would save a total of $282,000 in leachate treatment cost and the cost of the campaign would be mitigated by the amount of cost saved after the first year.

i. Leachate Reduction Estimates

Leachate reduction calculations for this proposed facility action are difficult due to the estimation of factors such as the level of public involvement as well as the amount that liquids in municipal solid waste contributes to overall leachate production.

GES has opted to estimate that through the public campaign 2% of the total leachate haul could be diverted from being generated which would result in a leachate reduction estimate of 641,600 gallons annually. Using this estimated annual gallon amount of potential leachate mitigated GES proposes that this alternative could divert a total of 31 million gallons of leachate, saving ARL a cumulative $1.4 million dollars.

ii. Cost Estimates

The cost of implementing this public campaign action are broken down in Table 5 below.

Action	Cost
Graphic Insert included in SWS Bill	**$800**
Design	($300)
Implementation	($500)
Radio Public Service Announcement	**$1000**
Total cost for 1 year of campaign	**$7,200-$9,200**

Table 5: Cost breakdown for Public Campaign

Campaign cost vs. Resulting Savings			
Year	**Cumulative Campaign cost**	**Cumulative Savings from Leachate Diverted**	**Cumulative Cost Savings to ARL($)**
1	$9,200	$28,230	$25,239
2	$18,400	$56,461	$50,478
3	$27,600	$84,691	$75,716
4	$36,800	$112,922	$100,955
5	$46,000	$141,152	$126,194
6	$55,200	$169,382	$151,432
7	$64,400	$197,613	$176,671
8	$73,600	$225,843	$201,909
9	$82,800	$254,074	$227,148
10	$92,000	$282,304	$231,880

Table 6: Campaign cost to ARL vs. ARL's Savings from the Campaign

The total cost of implementing a public awareness campaign updated on a quarterly basis including a $2000 contingency would cost ARL $7,200 to $9,200. However, the estimated savings from the leachate diverted would offset the cost of the campaign and save ARL a total of $282,304 dollars in leachate treatment costs.

iii. Required Materials

There are no distinct materials required for this recommendation, as flyers only require the same equipment normally used to produce paper correspondence to SWS customers.

iv. Process of Facility Implementation

The public campaign has no limitations on the start and end date. The communication plan can begin with any one of the promotional strategies, whether it be the graphic flyer insert, social media engagement, or a public service announcement. The primary goal of this campaign is to reach as many customers with the message, in order to see results as soon as possible. A group of staff at SWS should be appointed roles in managing and maintaining the public campaign to ensure that the ongoing communication plan is continuously updated and is in action for at least 10 years. It is recommended that the recycling coordinator at SWS is involved in the planning of the public campaign strategies.

7. Environmental Permitting & Regulations

As denoted in the request for proposal (RFP) the project is to be cognizant of all environmental regulations that may relate to the capture and discharge of storm water on or adjacent to the landfill. Below describes all accordance that ARL has with environmental regulations both Federal and State. Section. ARL is designed and constructed to be a Subtitle D Resource Conservation and Recovery Act (RCRA) facility. The site meets all the requirements of sections of Title 40 in the Code of Federal Regulations (CFR) and operates under an Alaska Solid Waste Permit issued by the State of Alaska, Department of Environmental Conservation, Division of Environmental Health, and Solid Waste Program. This permit is in accordance with Alaska Statute (AS) 46.03; Title 18, Chapter 15 of the Alaska Administrative Code (18 AAC 15) as well as Solid Waste Regulations (18 AAC 60). ARL also receives annual inspections from the State of Alaska, Department of Environmental Conservation (ADEC), and Solid Waste Management Program.

On top of the above-mentioned environmental regulations and permitting ARL must also comply with other mandated regulations. These regulations include, but are not limited to: The Clean Water Act, The Federal Clean Air Act and the Occupational Safety and Health Administration.

8. Required Data for Forward Action

This senior design report has been conducted based off information provided by the client for 2018, 2017 & 2016. In order to fully examine and evaluate all the leachate minimization alternatives ARL should record and compute the total cost of leachate transportation and treatment, as well as perform a follow up study to estimate precipitation for the remaining lifespan of ARL.

Since the total cost to SWS for leachate disposal is difficult to calculate with labor, fuel and vehicle O&M costs and AWWU's disposal fee to consider. GES recommends that SWS record all the costs associated with the transportation and treatment of leachate such that a detailed analysis can be done to assess the total leachate cost to ARL.

9. Facility Recommended Actions

With precipitation being the primary source of leachate generation the effects of the public campaign action would be minimal if implemented alone but combined with the latex and street sweeping cover ARL would be effectively looking at reducing leachate from all sources. GES believes that the combination of the two recommended facility actions would effectively reduce leachate generation at ARL from both primary sources of leachate generation while providing the stakeholders with education on how to make a difference. The combination of the two actions is estimated to divert as much as 60 million gallons of leachate from entering the landfill and save the Anchorage Regional Landfill $2.8 million in leachate treatment costs.

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Appendix

A. Experimental Lab Report
B. Leachate Data & Analysis

Appendix A:

Laboratory Experiment: Analysis of the Permeability of Painted Slopes

Conducted by : Stephen Erdman, Ginger Cordero, Emily Haas   Data collected: 3/3/19 and 3/17/19

Introduction:

This experiment was conducted to determine the effect of using latex paint on slopes to reduce permeability and turn more precipitation into runoff.

Description of Work:

Special boxes were constructed with interior screens at a slope of 1 to 3 which corresponds with their open surface slopes. One box was filled with plain gravel and the other was filled with a mixture of gravel and street sweepings. The box with plain gravel was painted at an approximate thickness of 10 mil using a paint brush and allowed to dry. An initial test was conducted by pouring water from a watering can over the slopes and recording runoff and seepage at 30 minutes. The box with street sweepings and gravel was painted at a thickness of approximately 50 mil using a paint sprayer. The box with painted regular gravel had an additional 65 mil of paint sprayed onto it. Another test was conducted by pouring water onto the slopes and recording the runoff and seepage at 30 minutes.

Test Results:

3/3/19

For the box of gravel mixed with street sweepings:

5.507L of water was poured over the slope. The amount of runoff generated was 0.132L. The amount of seepage generated at 30 minutes was 4.539L.

For the box of plain gravel with 10 mil of brushed paint:

5.682L of water was poured over the slope. The amount of runoff generated was 0.014L. The amount of seepage generated at 30 minutes was 5.547L.

3/17/19

For the box of street sweepings and gravel with 50 mil of sprayed paint:

5.96L of water was poured over the slope. The amount of runoff generated was 1.906L. The amount of seepage generated at 30 minutes was 2.87L

For the box of plain gravel with 75 mil of sprayed paint:

5.759L of water was poured over the slope. The amount of runoff generated was 0.21L. The amount of seepage generated was 3.54L

Conclusions:

On the preparation of the slope:

When the first test on 3/3/19 yielded a smaller than expected amount of runoff for painted gravel, we believed the thickness of the paint to be cause. After the second test on 3/17/19 with thicker paint on plain gravel still gave a smaller than expected amount of runoff, we realized that the surface of the slope was not very flat which created a porous surface. The box with the gravel street sweepings mixture had a smoother slope and gave better amounts of runoff. We believe that the application of a layer of street sweepings on top of the gravel to help smooth out the slope would provide the best results.

On the application of paint:

After spraying 50 mil of paint onto the street sweeping gravel mixture, a small amount of sluffing was observed. On the box with 10 mil of paint from a previous test, 65 mil of paint was sprayed, and no sluffing was observed. For best results, we believe that the paint should be applied in at least 2 layers.

Overall conclusions:

In the box of street sweepings and gravel painted with 50 mil of paint, we observed that approximately 32% of the water we poured became runoff. We believe that slopes of gravel with a layer of street sweepings applied for smoothness that has been painted with at least 2 layers to a total thickness of at least 50 mil should see a similar percentage of precipitation prevented from becoming leachate.

Appendix B

Leachate Data & Analysis

Year	Area Contributing	Annual Precipitation	Annual Leachate Haul Volume	Annual Leachate haul per inch of precipitation	Annual Leachate haul per inch of percipitation per Acre
	(Acres)	(inches)	(gallons)	(gallons)	(gallons)
2012	113	15.82	19,945,691	1,260,790	11,157
2013	113	24.4	25,916,016	1,062,132	9,399
2014	113	12.72	28,158,062	2,213,684	19,590
2015	125	15.58	24,914,184		
2016	137	13.83	27,105,182	1,959,883	14,306
2017	137	14.1	26,391,897	1,871,766	13,663

Appendix – Table 1: Provided client data on annual precipitation and leachate haul from 2012-2017

Year	Area Contributing	Annual Precipitation	Average Day Haul	Average Day Haul per Acre
	(Acres)	(inches)	(gallons)	(gallons)
2012	113	15.82	54,496	482
2013	113	24.4	71,003	628
2014	113	12.72	77,145	683
2015.1	113	1.77	70,186	621
2015.2	137	13.81	67,314	491
2015	125	15.58		
2016	137	13.83	74,058	541
2017	137	14.1	78,782	575

Appendix – Table 2: Consolidated client data on annual precipitation and leachate haul from 2012-2017

Leachate Transported Annually					
Year	(Truck Loads)	(gallons)	gallons/truck	Leachate Cost to ARL	Leachate cost per truck load
1990	660	3693209	5,596	$ 162,501.20	$ 246.21
1991	738	4,327,119	5,863	$ 190,393.24	$ 257.99
1992	714	4,171,970	5,843	$ 183,566.68	$ 257.10
1993	878	5,132,751	5,846	$ 225,841.04	$ 257.22
1994	622	3,695,801	5,942	$ 162,615.24	$ 261.44
1995	949	5,468,025	5,762	$ 240,593.10	$ 253.52
1996	1,055	6,117,354	5,798	$ 269,163.58	$ 255.13
1997	1,637	9,635,552	5,886	$ 423,964.29	$ 258.99
1998	1,255	7,282,479	5,803	$ 320,429.08	$ 255.32
1999	1,063	5,831,921	5,486	$ 256,604.52	$ 241.40
2000	2,430	13,913,179	5,726	$ 612,179.88	$ 251.93
2001	1,649	9,398,869	5,700	$ 413,550.24	$ 250.79
2002	2,142	12,135,028	5,665	$ 533,941.23	$ 249.27
2003	1,369	7,247,359	5,294	$ 318,883.80	$ 232.93
2004	1,761	9,643,577	5,476	$ 424,317.39	$ 240.95
2005	2,785	15,318,044	5,500	$ 673,993.94	$ 242.01
2006	2,630	14,471,324	5,502	$ 636,738.26	$ 242.11
2007	2,064	11,300,960	5,475	$ 497,242.24	$ 240.91
2008	1,622	8,627,549	5,319	$ 379,612.16	$ 234.04
2009	1,134	6,268,185	5,528	$ 275,800.14	$ 243.21
2010	1,686	8,283,504	4,913	$ 364,474.18	$ 216.18
2011	1,834	10,327,773	5,631	$ 454,422.01	$ 247.78
2012	3,785	20,066,478	5,302	$ 882,925.03	$ 233.27
2013	4,620	26,425,436	5,720	$ 1,162,719.18	$ 251.67
2014	5,116	28,158,063	5,504	$ 1,238,954.77	$ 242.17
2015	4,502	25,032,778	5,560	$ 1,101,442.23	$ 244.66
2016	4,808	26,289,569	5,468	$ 1,156,741.04	$ 240.59
2017	5,268	29,183,318	5,540	$ 1,284,065.99	$ 243.75
2018	5,257	31,349,001	5,963	$ 1,379,356.04	$ 262.38

Appendix – Table 3: Provided client data on annual leachate transport volumes, truck loads per year and cost to ARL for leachate treatment from 1990-2018

	Monthly Average Day Peak Flow	Monthly Average Day Peak Flow per Acre	Peak Day Flow	Peak Day Flow per Acre
	(gallons)	(gallons)	(gallons)	(gallons)
Average	87,704	713	139,588	1138
Mediam	87,771	712	139,660	1163
SD	10,473	92	6,372	120
Max	11,080	879	154,747	1369
Min	72,603	560	125,922	966

Appendix – Table 4: Provided leachate flow analysis conducted by BHC Consultants

Acres	Average Annual Daily Flow per Acre	Average Day Peak Month flow per Acre	Peak Day Flow Per Acre	Average Annual Flow	Average Day Peak Month Flow	Peak Day Flow
	(gallon)	(gallon)	(gallon)	(gpd)	(gallons)	(gallons)
166	574	857	1,303	95,284	142,262	216,298

Appendix – Table 5: future leachate flow estimates conducted by BHC Consultants