LID Approach Effectiveness & Functionality Study 50% Report

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by

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A Capstone project submitted to

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Introduction

Recently, the EPA has required each state in the United States to develop stormwater systems that meet certain retention specifications. Municipalities in Utah are required to develop Low Impact Development (hereafter LID) stormwater systems that are able to retain the 90th percentile storm on site, as opposed to piping it to the river as has been common practice in the past. Spanish Fork has developed a LID system and has asked Team LID to analyze their system and compare its performance with the EPA standards, while giving any suggestions for possible system improvements. Furthermore, Team LID has been asked to investigate the system for silt build-up in order to suggest a proper cleaning and maintenance schedule of the system.

System Overview

The current LID system in use consists of rows of R-Tank structures (Figure 1) that are stacked two deep and lined in shallow trenches (about 4 feet deep), covered with geotextile fabric, and then backfilled, with about a foot of cover on top. The R-tanks are backfilled along the sides with a layer of sand to improve permeability. Storm drains along the street provide inlets to the system, allowing runoff to enter these R-Tank structures and then percolate into the soil, replenishing the aquifer. See Figure 2 for the standard drawing of the system.

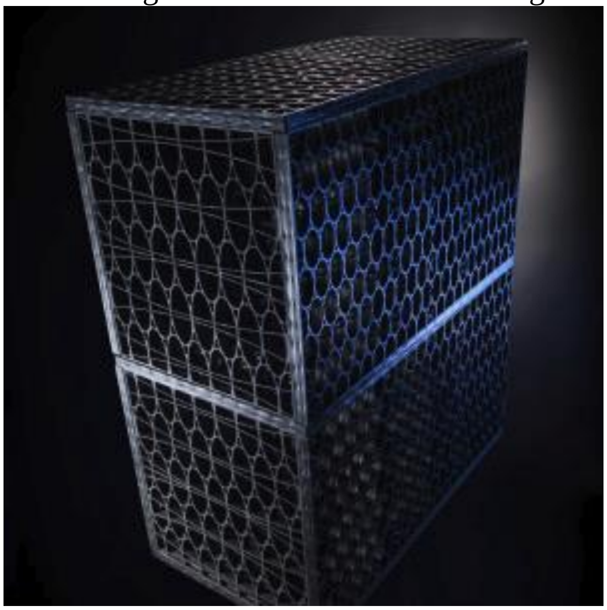

Figure 1: R-Tank image from ACF Environmental's website.

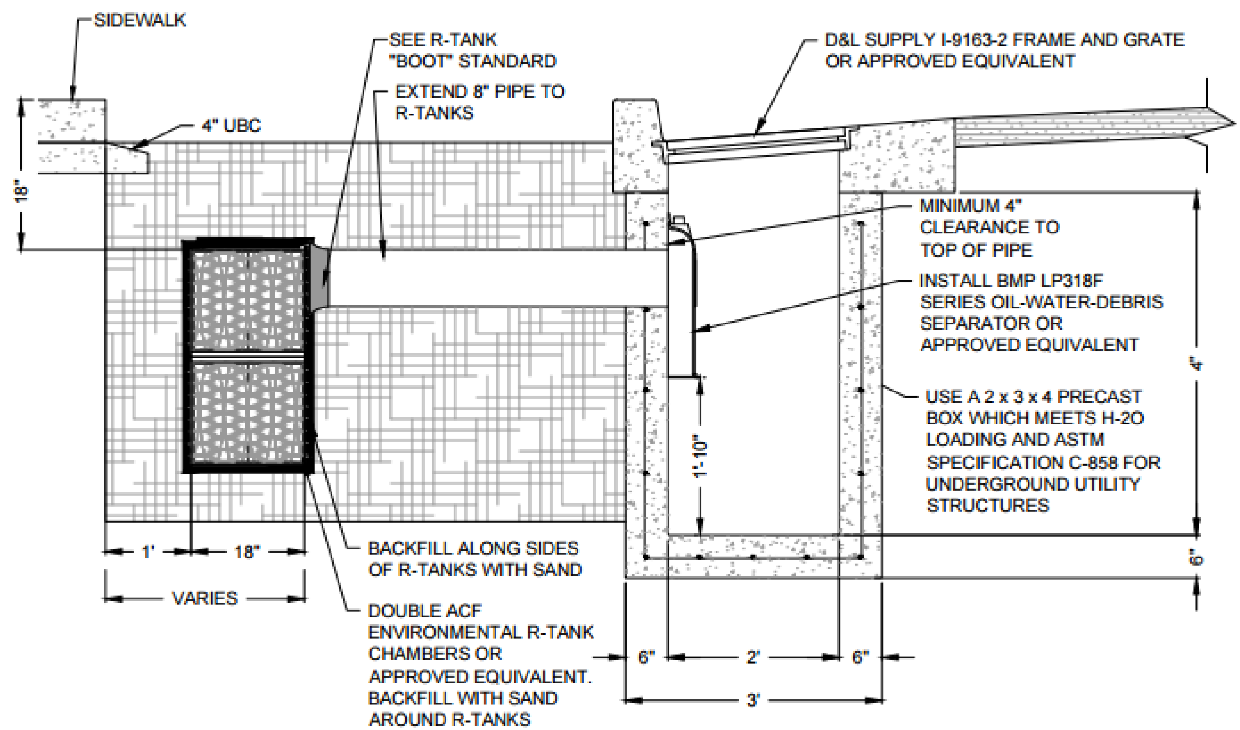

Figure 2: Standard design drawing from Spanish Fork's website.

Site Description

Site One

Located on N Chappel Dr, Spanish Fork, UT. Currently not much development has happened at the site. There is an asphalt path on the east side of Chappel Dr. that runs nearly parallel to Chappel Dr. and crosses a stream. The stream, on the East side of Chappel Dr., also runs south, parallel with Chappel Dr. for a section, but then goes southwest under the road. Due to the season being winter the location was covered partially by snow, with little vegetation. The testing was done behind a storm drain. The soil had very low permeability as seen in Table 1, being made up of mostly clay with a layer of gravel.

Site Two

Located on 1430 S Mill Rd, Spanish Fork, UT. Currently the development is nearly completed. The testing was done on a corner vacant lot at the intersection of 1430 S and Mill Rd behind a storm drain. Surrounding lots are completed and occupied. Due to the winter season, the location was covered partially by snow. The soil had high permeability as seen in Table 1, being made up of mostly clayey sand with a layer of gravel.

Site Three

Located on 1100 S 1500 E, Spanish Fork, UT. Currently the neighborhood is being developed with few occupied homes. The testing was done behind a storm drain. Due to the lack of development, the area lacked vegetation. Due to the winter season, the location was covered partially by snow. The soil had high permeability as seen in Table 1, being made up of mostly clayey sand with a layer of gravel.

Literature Review

Overall, this project involved a lot of testing with which we weren't very familiar, so we had to research various sources in order to ensure that our procedures were correct. Our first source of knowledge was our faculty advisor, Dr. Williams. Dr. Williams helped us to understand the EPA requirements for percolation testing, directing us to the EPA website where we could find the proper testing procedures. These proper procedures can be found on page 41 of the EPA instruction document. https://www.epa.gov/sites/production/files/2015-06/documents/septic_1980_osdm_all.pdf.

It was also important to research the precipitation frequencies for Spanish Fork so that we could properly calculate expected runoff during the 90th percentile storm. We found this data at NOAA's Hydrological Design Studies Center website. http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ut

Percolation Tests

Task

Our task is to perform percolation tests on the three sites that have been chosen by our sponsor. The second site is our target site; but the other two sites are also tested so that comparisons may be made.

Tools

Buckets, auger, stopwatch, measuring tape, pen, a piece of paper.

Actual Procedure

All procedures are in general accordance to the falling head percolation test on the EPA standards. These standards are provided in the Literature Review section. Steps and adjustments will be provided here. These adjustments are made based on the results and observations from an early site visit that we have done.

- According to the EPA standards, three holes 6 inches in diameters should be dug at each site. For our tests, three holes were dug at site 1. One hole was dug at the other two sites because high permeability. The weather also limited the length of time that we could work on the sites. The holes are also dug with 7 in diameter. This is done because the tool that we have access to can only allow us to have a 7 in diameter hole.

Figure 3: Hole dug for percolation tests

- All the holes are then filled with about 12 in of water. For the more clayey area, the holes have been soaked until water maintains its height. For the sites 2 and 3, which are mainly sand and gravel, holes were filled with water more than 4 times. After these preparations, the percolation tests are ready to proceed.

Figure 4: Filling up the test hole with water

Figure 5: Test hole filled with 12 in water

- For each site, the heights of the water and the elapsed times are recorded. The percolation rates are calculated using: percolation rate = time/height, which yields a result of min/in.

Table 1. Data and Results.

Width (in)	Height (in)	Start Height (in)	End Height (in)	Elapsed Time (min)	Change in Height (in)	Permeability height/time (min/in)
Site One						
7	12	10.5	9.00	20	1.5	13.33
7	12	11	8.50	121	2.5	48.4
7	11	10.75	8.00	112	2.75	40.7
Site Two						
8	12.5	14	0	1	14	0.07
Site Three						
7.5	12	6	2	3.68	4	0.92

Measurements

ArcGIS

ArcGIS is a geographic information system (GIS) for working with maps. It can be used for a variety of projects. For this LID project we used it to calculate surface area of each site as shown in Table 2. Areas were calculated by drawing polygon shapes. Each polygon was drawn according to the contour lines.

Table 2. Surface Areas of each site.

Site One	12471 m^2
Site Two	28157 m^2
Site Three	87613 m^2

R-tank

The lengths of the R-tanks were measured through Spanish Fork City's public map, which can be found at http://suvgis.spanishfork.org/appsSF/SFC-MapPublic/. The online measuring tool was used to measure the lengths of each of the R-tanks. The measured values were adjusted so that each length consists of equal R-tank length increments, as the measurement tool used wasn't precise.

Future work

Calculations will need to be performed for our next stage of work:

- Using the percolation rates and permeable areas to calculate runoff. (We are still in the process of learning how to use WMS. We may use this software to obtain our runoff values.)
- Decide the effectiveness of the R tanks based on the runoff values and the total volume of the R tanks.
- Perform next site visit to dig up some R tanks and exam the silt built-up in the R tanks.
- Evaluate the serviceability of the R tanks.
- Suggestions for further improvement.

Readjusted schedule

February

Su	M	Tu	W	Th	F	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28				

March

Su	M	Tu	W	Th	F	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

April

Su	M	Tu	W	Th	F	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

Milestones

Feb 3	Percolation test visit
Feb 13	Reconfirming percolation test visit
Mar 10	Compare EPA standards
Mar 10	Silt build up investigation
Mar 17	Determining required maintenance
Mar 24	Investigate design improvement
Apr 10	All Deliverables Complete

Appendices

Table 3. Typical percolation values for different soil

Description	USCS	min (m/s)	max (m/s)	Specific value (m/s)	Reference
Well graded gravel, sandy gravel, with little or no fines	GW	5.00E-04	5.00E-02		[1],
Poorly graded gravel, sandy gravel, with little or no fines	GP	5.00E-04	5.00E-02		[1],
Silty gravels, silty sandy gravels	GM	5.00E-08	5.00E-06		[1],
Alluvial sand and gravel	(GM)	4.00E-04	4.00E-03		[2&3 in 4]
Clayey gravels, clayey sandy gravels	GC	5.00E-09	5.00E-06		[1],
Well graded sands, gravelly sands, with little or no fines	SW	1.00E-08	1.00E-06		[1],
Very fine sand, very well sorted	(SW)			8.40E-05	[5] ,
Medium sand, very well sorted	(SW)			2.23E-03	[5] ,
Coarse sand, very well sorted	(SW)			3.69E-01	[5] ,
Poorly graded sands, gravelly sands, with little or no fines	SP	2.55E-05	5.35E-04		[1], [2&3 in 4]
Clean sands (good aquifers)	(SP-SW)	1.00E-05	1.00E-02		[5],
Uniform sand and gravel	(SP-GP)	4.00E-03	4.00E-01		[2&3 in 4]
Well graded sand and gravel without fines	(GW-SW)	4.00E-05	4.00E-03		[2&3 in 4]
Silty sands	SM	1.00E-08	5.00E-06		[1],
Clayey sands	SC	5.50E-09	5.50E-06		[1], [5]
Inorganic silts, silty or clayey fine sands, with slight plasticity	ML	5.00E-09	1.00E-06		[1],
Inorganic clays, silty clays, sandy clays of low plasticity	CL	5.00E-10	5.00E-08		[1],
Organic silts and organic silty clays of low plasticity	OL	5.00E-09	1.00E-07		[1],
Inorganic silts of high plasticity	MH	1.00E-10	5.00E-08		[1],
Inorganic clays of high plasticity	CH	1.00E-10	1.00E-07		[1],
Compacted silt	(ML-MH)	7.00E-10	7.00E-08		[2&3 in 4]
Compacted clay	(CL-CH)	-	1.00E-09		[2&3 in 4]
Organic clays of high plasticity	OH	5.00E-10	1.00E-07		[1],
Peat and other highly organic soils	Pt	-	-		

http://www.geotechdata.info/parameter/permeability.html