WEBER STORAGE SHEDS
1957 NORTH RULON WHITE BLVD.
WEBER COUNTY, UTAH 84404
STORM WATER STUDY
Project No. 21N713
11-15-2021

General Site Information:

The proposed Weber Storage Sheds site is located at 1957 North Rulon White Blvd along the west side of Rulon White Boulevard, in Weber County, Utah. Construction will consist of a new commercial storage complex consisting of buildings, parking lots, sidewalks, curb and gutter, underground utilities, and landscaped areas when completed.

Storm water from the site will be collected in inlet boxes and catch basins and will continue via storm drain to the southeast corner of the site. Storm water will be detained in a detention pond located at that corner of the site. The site is allowed a unit-release of 0.1 cfs per acre for the 100-yr storm into an existing storm drainage system in Rulon White Blvd. and will continue southeasterly along Rulon White Blvd in a historical fashion. The attached figure shows the project site and location of the storm water outfall. Detention calculations have been provided for the site. (See attached figure and calculations).

The study area is treated as a single drainage area for modeling purposes; labeled A-1. A runoff coefficient of 0.15 is used for natural ground and landscaped areas. A runoff coefficient of 0.90 is used for asphalt, concrete, buildings, and other hard surfaced areas. An average runoff coefficient of 0.79 was calculated for the overall study area.

Times of concentration are calculated using the FAA method assuming flow resistance coefficients of K=0.35 for landscape and K=0.91 for hardscape for each of the areas. The time of concentration is about 5.89 minutes for the study area. This time is based on the hydraulically longest drainage path inside each respective drainage area over grass or other vegetation, asphalt, concrete, and/or through a pipeline as applicable. Times calculated to be less than 5 minutes are rounded to 5 minutes (as applicable) when using this method. Rainfall Intensities were taken from NOAA Atlas 14 for pipe sizing and detention requirements. The values obtained were interpolated as necessary. A copy of these data is attached.

Data showing area information, runoff coefficient, time of concentration, peak flows, and detention storage requirements for the site are also provided and can be found in the attached calculations.

TEL (801) 394-4515 • FAX (801) 392-7544 • 5746 South 1475 East • Ogden, Utah 84403 • www.greatbasinengineering.com

Design Requirements:

The design storms and allowable stormwater release rate were found on 11/15/2021 at https://www.webercountyutah.gov/Engineering/documents/PublicWorksStandardsandSpecifications.pdf. For storm drain piping, the requirement is listed as the "…10-year storm…". For detention pond sizing, the requirement listed is "…0.1 cubic feet per second per acre…100-year storm".

Pipe Sizes:

Storm water pipes in the project are proposed to be polyvinylchloride pipes (PVC), concrete pipe (CP), and/or reinforced concrete pipe (RCP). All pipes in the project are sloped to provide the design capacity while maintaining a minimum scour speed of at least 2 feet per second when the pipes are flowing at least half full. The pipes and inlet boxes have enough capacity to convey the 10-year storm without surcharging.

Orifice Plate:

An orifice plate will be used to control the rate that storm water flows from the project. It will be located at the inlet box at node 13(See attached figure). The orifice opening is given a designation of Node 101 for convenience in modeling the reduced flow through the restriction. The orifice plate opening will be sized to allow the detention facility to utilize its capacity during a 100-yr storm with a release rate of 0.1 cfs/ac and the diameter of the orifice is found to be 2.31 inches. The orifice plate will allow small flows to pass through without detention. As the rate of storm water into the pipes and detention facility increases, the orifice plate will restrict the flow. The maximum flow through the plate will occur when the detention basin reaches the maximum design depth. A detail of the orifice plate can be found in the construction documents for this project.

Required Retention/Detention:

The required LID retention volume for the 80th percentile storm is calculated for each hybrid facility. These are calculated using the Reese Method (See https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf for the methodology). The 80th %-ile depth was taken from a spreadsheet titled "80th Percentile Storm Depths" under the "Resources" heading at https://deq.utah.gov/water-quality/low-impact-development and is d = 0.5 inches for the Weber County (East) area. The retention/detention serves as detention storage once the LID retention requirements are met which is a volume of 4452 cubic feet. This volume is met in the first 5 minutes of the design storm.

The required detention for the 100-year storm with a release rate of 0.1 cfs/acre is 15,826 cubic feet for the entire study area. The available volume in the detention facility is 19,754 cubic feet which is provided by two hybrid retention/detention facilities which share the same top of water. From Bernoulli's equation we know that this case can be considered one giant facility as they share the same top of water and are sloped downwards toward the orifice. There is an excess capacity of 4,026 cubic feet which could be very helpful as an existing 8-inch pipe from a neighboring system discharges into the south hybrid facility. The facilities are sized appropriately to meet the design storm and serves as an improvement in the event of a major storm. In the event the detention facility experiences a storm larger than the design storm water will then spill out onto Rulon White Boulevard and continue southwesterly in a historical fashion.

Great Basin Engineering, Inc.

Prepared by Abhishek Amalaraj, E.I.T

Abhishek Amalaraj

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STORM WATER STUDY EXHIBIT

Scale: 1" = 30'

Graphic Scale

Storm Water Calculations
Weber Storage Sheds
1957 N Rulon White Blvd. Ogden City Utah
20N713 - SWS- 1.dwg

11/15/2021

1 Detained Area

Hardscape C =	0.90
Landscape C =	0.15

Drainage Areas	Total Area (ft^2)	Total Area (acres)	Hardscape Area (ft^2)	Hardscape Area (ft^2)	Landscape (ft^2)	Landscape Area (acres)	C
Σ Det. Areas	141923	3.258	120593	2.768	21330	0.490	0.787
Σ All Areas	141923	3.258	120593	2.768	21330	0.490	0.787
A-1	141923	3.258	120593	2.768	21330	0.490	0.787

Time of Concentration--use FAA Method

For FAA Method, use K's of..

K =	0.35	for landscape
K =	0.91	for hardscape

$$t_c = \frac{1.8(1.1 - K)\sqrt{L}}{\sqrt[3]{S}}$$

Assume Pipe Flow is at 2 ft/s Scour Speed

**Note: S is in percent, 5 min is smallest allowed Tc

Area	Length on Landscape (ft)	Slope of Landscape (%)	Time on Landscape (min.)	Length on Hardscape (ft)	Slope of Hardscape (%)	Time on Hardscape (min.)	Length in Pipe (ft)	Time in Pipe (min.)
A-1	0.00	2.00	0.00	65.00	2.00	2.19	444.00	3.70

TC for entire Area (min.)
5.89

Rainfall Intensities
Data From NOAA

10-Year and 100-Year Intensities

The equations used for the 10-Year and 100-Year Intensities were found using the attached Rainfall data as well as Interpolated data where applicable.

		Storm Intensities	
AREA	Tc (minutes)	I (10-yr.) (in./hr.)	I (100-yr.) (in./hr.)
A-1	5.9	3.26	6.48

Peak Flow Information
Use Rational Method
10-Year and 100-Year Intensities

Q=CIA

					Peak Flows	
				Σ detained =	8.35	16.63
AREA	C	I10 (in./hr.)	I100 (in./hr.)	A (acres)	Q (10-yr.) (cfs)	Q (100-yr.) (cfs)
A-1	0.787	3.256	6.482	3.26	8.35	16.63

Node Inlet Requirements

Size pipes for 10 year storm

Area	Node #	% of Total	Q (cfs)
A-1	1	9.0%	0.75
A-1	2	9.0%	0.75
A-1	3	9.0%	0.75
A-1	4	9.0%	0.75
A-1	5	9.0%	0.75
A-1	6	9.0%	0.75
A-1	7	9.0%	0.75
A-1	8	9.0%	0.75
A-1	9	9.0%	0.75
A-1	10	0.0%	0.00
A-1	11	9.0%	0.75
A-1	12	10.0%	0.84
A-1	13	0.0%	0.00
A-1	101	-96.1%	(8.03)

PIPE FLOWS

Upstream Node	Downstream node	Pipe Flow (cfs)
1	2	0.75
2	3	1.50
3	4	2.26
4	11	3.01
5	6	0.75
6	7	1.50
7	8	2.26
8	10	3.01
9	10	0.75
10	11	3.76
11	12	7.52
12	13	8.35
13	101	8.35
101	Outfall 1	0.33

Options for Pipe Sizes Between the Specified Nodes

Up Stream Node	Dn Stream Node	Q (cfs)	Pipe Size (in)	Design Min Slope (%)	Area (ft^2)	Rh (ft)	Manning's n	Scour Min. Slope (%)	First Trial Pipe Size
1	2	0.75	6	1.285%	0.196	0.125	0.011	1.000%	8
		0.75	8	0.277%	0.349	0.167	0.011	0.400%	
		0.75	10	0.084%	0.545	0.208	0.011	0.280%	
2	3	1.50	6	5.139%	0.196	0.125	0.011	1.000%	10
		1.50	8	1.108%	0.349	0.167	0.011	0.400%	
		1.50	10	0.337%	0.545	0.208	0.011	0.280%	
3	4	2.26	8	2.493%	0.349	0.167	0.011	0.400%	12
		2.26	10	0.758%	0.545	0.208	0.011	0.280%	
		2.26	12	0.401%	0.785	0.250	0.013	0.200%	
4	11	3.01	10	1.348%	0.545	0.208	0.011	0.280%	15
		3.01	12	0.712%	0.785	0.250	0.013	0.200%	
		3.01	15	0.217%	1.227	0.313	0.013	0.145%	
5	6	0.75	6	1.285%	0.196	0.125	0.011	1.000%	8
		0.75	8	0.277%	0.349	0.167	0.011	0.400%	
		0.75	10	0.084%	0.545	0.208	0.011	0.280%	
6	7	1.50	6	5.139%	0.196	0.125	0.011	1.000%	10
		1.50	8	1.108%	0.349	0.167	0.011	0.400%	
		1.50	10	0.337%	0.545	0.208	0.011	0.280%	
7	8	2.26	8	2.493%	0.349	0.167	0.011	0.400%	12
		2.26	10	0.758%	0.545	0.208	0.011	0.280%	
		2.26	12	0.401%	0.785	0.250	0.013	0.200%	
8	10	3.01	10	1.348%	0.545	0.208	0.011	0.280%	15
		3.01	12	0.712%	0.785	0.250	0.013	0.200%	
		3.01	15	0.217%	1.227	0.313	0.013	0.145%	
9	10	0.75	18	0.005%	1.767	0.375	0.013	0.114%	18
		0.75	24	0.001%	3.142	0.500	0.013	0.078%	
		0.75	30	0.000%	4.909	0.625	0.013	0.058%	
10	11	3.76	18	0.128%	1.767	0.375	0.013	0.114%	18
		3.76	24	0.028%	3.142	0.500	0.013	0.078%	
		3.76	30	0.008%	4.909	0.625	0.013	0.058%	
11	12	7.52	18	0.512%	1.767	0.375	0.013	0.114%	24
		7.52	24	0.110%	3.142	0.500	0.013	0.078%	
		7.52	30	0.034%	4.909	0.625	0.013	0.058%	

12	13	8.35	15	1.671%	1.227	0.313	0.013	0.145%	**24**
		8.35	18	0.632%	1.767	0.375	0.013	0.114%	
		8.35	24	0.136%	3.142	0.500	0.013	0.078%	

13	101	8.35	15	1.671%	1.227	0.313	0.013	0.145%	**24**
		8.35	18	0.632%	1.767	0.375	0.013	0.114%	
		8.35	24	0.136%	3.142	0.500	0.013	0.078%	

101	Outfall 1	0.33	10	0.016%	0.545	0.208	0.011	0.280%	**10**
		0.33	12	0.008%	0.785	0.250	0.013	0.200%	
		0.33	15	0.003%	1.227	0.313	0.013	0.145%	

Weber Storage Sheds

Combined Detention/LID Retention Facility

C = 0.79

Area = 3.26 acres

Remaining Unit Discharge = 0.100 cfs/acre

Release through Restriction = 0.326 cfs

Detention Pond Sized For The 100 Year Storm

Time min	Rainfall Intensity in./hr.	Accumulated Volume (CF)	Allowable Release (CF)	Needed Storage (CF)	
5	6.77	5210	0	5210	
10	5.15	7926	98	7828	
15	4.26	9834	195	9639	
20	3.63	11162	293	10868	
25	3.19	12271	391	11880	
30	2.86	13205	489	12716	
35	2.62	14118	586	13532	
40	2.38	14680	684	13996	
45	2.19	15160	782	14378	
50	2.02	15555	880	14675	
55	1.88	15928	977	14950	
60	1.77	16344	1075	15269	
90	1.26	17487	1662	15826	<- Det.
120	0.98	18062	2248	15814	
180	0.67	18478	3421	15057	
360	0.37	20555	6940	13615	
720	0.23	25154	13977	11177	
1440	0.13	27702	28052	-350	

Required Storage Volume = **15826** ft^3

LID Retention Calculation:

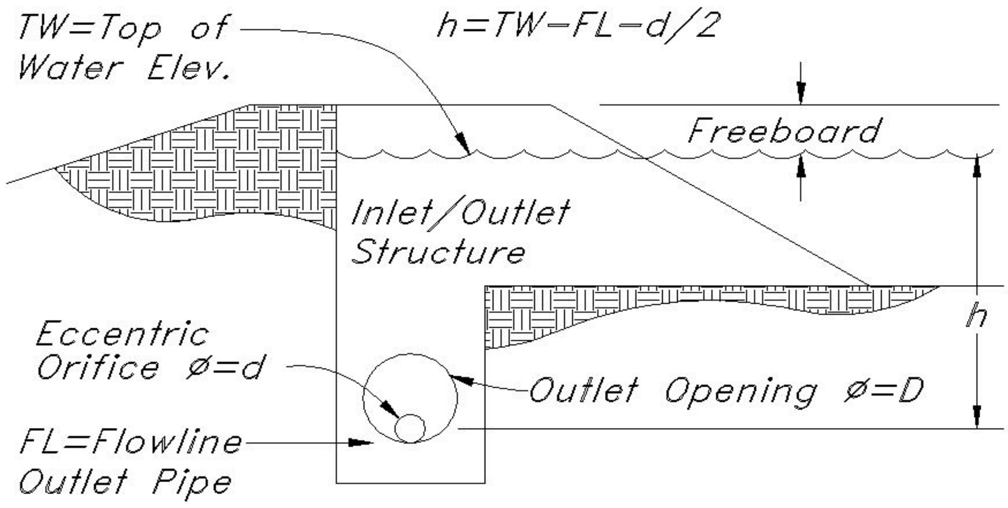
Hardscape Area =	120593	sf
A = Total Area =	141923	sf
i =	0.850	unitless
d =	0.5	in
Rv =	0.753	cf
V =	**4452**	cf

Reese method:

$$R_V = 0.91i - 0.0204$$

$$V_{goal} = R_V d A$$

ORIFICE PLATE CALCULATIONS



$$Q_{orif} = 0.62 \cdot A_o \cdot \sqrt{64.4 \cdot h}$$

$$A_o = \frac{\pi \cdot d^2}{4}$$

$$h = TW - FL - {}^{d}/_{2}$$

$$Q_{req} = Q_{orif}$$

Let $\Delta = Q_{req} - Q_{orif}$, and Goal Seek Δ to zero by changing "trial d".

TW =	4290.00	
FL =	4284.78	
Q_{req} =	0.326	cfs
trial d=	0.1922	ft
Δ =	-0.001	ft

d =	2.31	inches

NOAA Atlas 14, Volume 1, Version 5
Location name: Brigham City, Utah, USA*
Latitude: 41.5011°, Longitude: -112.0408°
Elevation: 4257.11 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**1.51** (1.32-1.74)	**1.92** (1.69-2.21)	**2.63** (2.28-3.02)	**3.28** (2.83-3.78)	**4.31** (3.65-5.00)	**5.27** (4.33-6.17)	**6.40** (5.11-7.56)	**7.73** (5.96-9.30)	**9.86** (7.22-12.2)	**11.8** (8.27-14.9)
10-min	**1.15** (1.01-1.33)	**1.46** (1.28-1.69)	**1.99** (1.74-2.30)	**2.49** (2.15-2.87)	**3.28** (2.78-3.81)	**4.01** (3.30-4.69)	**4.87** (3.89-5.75)	**5.88** (4.54-7.07)	**7.51** (5.50-9.27)	**9.00** (6.29-11.4)
15-min	**0.948** (0.832-1.09)	**1.20** (1.06-1.39)	**1.65** (1.44-1.90)	**2.06** (1.78-2.38)	**2.71** (2.30-3.15)	**3.31** (2.73-3.88)	**4.02** (3.22-4.76)	**4.86** (3.75-5.85)	**6.20** (4.54-7.66)	**7.44** (5.20-9.40)
30-min	**0.640** (0.560-0.736)	**0.810** (0.714-0.938)	**1.11** (0.966-1.28)	**1.39** (1.20-1.60)	**1.82** (1.55-2.12)	**2.23** (1.84-2.61)	**2.71** (2.17-3.20)	**3.27** (2.52-3.94)	**4.18** (3.06-5.16)	**5.01** (3.50-6.33)
60-min	**0.396** (0.346-0.456)	**0.501** (0.442-0.580)	**0.687** (0.598-0.793)	**0.857** (0.741-0.990)	**1.13** (0.956-1.31)	**1.38** (1.14-1.62)	**1.68** (1.34-1.98)	**2.02** (1.56-2.44)	**2.58** (1.89-3.19)	**3.10** (2.17-3.92)
2-hr	**0.256** (0.229-0.290)	**0.321** (0.286-0.364)	**0.419** (0.370-0.473)	**0.510** (0.446-0.577)	**0.657** (0.562-0.748)	**0.792** (0.663-0.910)	**0.950** (0.772-1.11)	**1.14** (0.892-1.35)	**1.44** (1.07-1.75)	**1.71** (1.22-2.13)
3-hr	**0.198** (0.179-0.223)	**0.246** (0.223-0.276)	**0.310** (0.279-0.348)	**0.370** (0.331-0.417)	**0.466** (0.408-0.527)	**0.552** (0.474-0.631)	**0.656** (0.549-0.760)	**0.778** (0.630-0.917)	**0.975** (0.754-1.18)	**1.16** (0.858-1.43)
6-hr	**0.134** (0.123-0.147)	**0.165** (0.151-0.182)	**0.202** (0.184-0.223)	**0.236** (0.213-0.261)	**0.285** (0.254-0.318)	**0.327** (0.287-0.366)	**0.374** (0.323-0.424)	**0.428** (0.362-0.491)	**0.528** (0.432-0.620)	**0.618** (0.491-0.740)
12-hr	**0.086** (0.079-0.094)	**0.105** (0.097-0.116)	**0.128** (0.117-0.141)	**0.148** (0.135-0.164)	**0.178** (0.160-0.197)	**0.202** (0.179-0.226)	**0.228** (0.199-0.257)	**0.256** (0.218-0.292)	**0.299** (0.248-0.349)	**0.334** (0.270-0.397)
24-hr	**0.054** (0.049-0.059)	**0.066** (0.061-0.072)	**0.080** (0.073-0.088)	**0.092** (0.084-0.101)	**0.108** (0.099-0.119)	**0.121** (0.110-0.133)	**0.135** (0.122-0.148)	**0.149** (0.134-0.163)	**0.168** (0.149-0.185)	**0.183** (0.161-0.202)
2-day	**0.031** (0.028-0.034)	**0.038** (0.035-0.042)	**0.046** (0.042-0.050)	**0.053** (0.048-0.058)	**0.062** (0.056-0.068)	**0.069** (0.062-0.076)	**0.076** (0.069-0.084)	**0.084** (0.075-0.092)	**0.094** (0.084-0.104)	**0.103** (0.090-0.113)
3-day	**0.023** (0.021-0.025)	**0.028** (0.025-0.031)	**0.034** (0.031-0.037)	**0.038** (0.035-0.042)	**0.045** (0.041-0.050)	**0.050** (0.046-0.055)	**0.056** (0.050-0.061)	**0.061** (0.055-0.068)	**0.069** (0.061-0.076)	**0.075** (0.066-0.083)
4-day	**0.018** (0.017-0.020)	**0.023** (0.021-0.025)	**0.027** (0.025-0.030)	**0.031** (0.029-0.035)	**0.037** (0.033-0.041)	**0.041** (0.037-0.045)	**0.046** (0.041-0.050)	**0.050** (0.045-0.055)	**0.057** (0.050-0.063)	**0.061** (0.054-0.068)
7-day	**0.013** (0.012-0.014)	**0.016** (0.014-0.017)	**0.019** (0.017-0.021)	**0.022** (0.020-0.024)	**0.025** (0.023-0.028)	**0.028** (0.025-0.031)	**0.031** (0.028-0.035)	**0.034** (0.031-0.038)	**0.038** (0.034-0.043)	**0.042** (0.037-0.046)
10-day	**0.010** (0.009-0.011)	**0.012** (0.011-0.014)	**0.015** (0.014-0.016)	**0.017** (0.015-0.019)	**0.020** (0.018-0.022)	**0.022** (0.020-0.024)	**0.024** (0.022-0.026)	**0.026** (0.024-0.029)	**0.029** (0.026-0.032)	**0.031** (0.028-0.035)
20-day	**0.006** (0.006-0.007)	**0.008** (0.007-0.009)	**0.009** (0.009-0.010)	**0.011** (0.010-0.012)	**0.012** (0.011-0.013)	**0.013** (0.012-0.015)	**0.015** (0.013-0.016)	**0.016** (0.014-0.017)	**0.017** (0.016-0.019)	**0.018** (0.016-0.020)
30-day	**0.005** (0.005-0.006)	**0.006** (0.006-0.007)	**0.008** (0.007-0.008)	**0.009** (0.008-0.009)	**0.010** (0.009-0.011)	**0.011** (0.010-0.012)	**0.012** (0.011-0.013)	**0.013** (0.012-0.014)	**0.014** (0.013-0.015)	**0.015** (0.013-0.016)
45-day	**0.004** (0.004-0.005)	**0.005** (0.005-0.006)	**0.006** (0.006-0.007)	**0.007** (0.007-0.008)	**0.008** (0.007-0.009)	**0.009** (0.008-0.009)	**0.009** (0.009-0.010)	**0.010** (0.009-0.011)	**0.011** (0.010-0.011)	**0.011** (0.010-0.012)
60-day	**0.004** (0.004-0.004)	**0.005** (0.004-0.005)	**0.005** (0.005-0.006)	**0.006** (0.006-0.007)	**0.007** (0.006-0.007)	**0.007** (0.007-0.008)	**0.008** (0.007-0.009)	**0.008** (0.008-0.009)	**0.009** (0.008-0.010)	**0.009** (0.009-0.010)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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PF graphical