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February 27, 2023

Subject: ***City Creek Daylighting Project Hydrology Summary***
City Creek Daylighting Project
Salt Lake City, Utah 84114

Background Information

City Creek is a small mountainous stream that flows from City Creek Canyon across part of Salt Lake City, Utah, and into the Jordan River, which empties into the Great Salt Lake. The creek is characterized by confined and partially confined valley settings with a steep gradient within the canyon. The upper parts demonstrate natural step-pool morphology with gravel-cobble and occasional boulder stream bed. The creek transitions to steep pool-riffle form in the lower parts. In the canyon, the banks of City Creek support a riparian zone of mature trees and shrubs. The City Creek Trail runs along the stream and in higher elevations of the canyon, and it is a popular recreational area.

To help prevent continued flood damages and to facilitate irrigation, the two branches of City Creek were combined into a 12-foot-wide cribbed ditch down the middle of North Temple Street in 1856. In 1902, Memory Grove is set aside as a City park. Through a series of projects, City Creek below Memory Grove Park is enclosed in underground pipes and becomes the North Temple Conduit (BIO-WEST 2010). In 1995, a portion of the creek was daylighted below Memory Grove through City Creek Park. In 2000, another portion of City Creek was daylighted along North Temple by the LDS Church Conference Center.

The City Creek watershed is snowmelt-dominated, with peak discharges through the months of May and June. The daily flows were measured at the USGS gage #10172500 from 1963 to 1980, and peak flow measurements from 1899 to 1983, with the highest recorded flow of 322 cfs in 1983. Salt Lake County currently measures flow at Memory Grove Park (period of record 1961-1963, and 1969 to present). City Creek drains approximately 19.20 square miles of land to this point. The mean elevation of the watershed is about 6,830 feet, with about 46% of the area covered by forest (StreamStats, 2019, Attachment A).

The historical flow records were previously analyzed, and return period peak flows for City Creek were calculated (Hansen, Allen & Luce, 2020). The return period, or recurrence interval, is based on the probability that the given event will be equaled or exceeded in any given year. For example, a 100-year interval has a 1% chance of being met or exceeded in any given year. Table 1 provides a summary of the calculated return period peak flows for City Creek.

Table 1. Return period peak flows for City Creek at Memory Grove

Return Interval	2-year	5-year	10-year	25-year	50-year	100-year
Flow (cfs)	65	100	122	147	165	181

Downstream of the LDS Church Conference Center area, the stream continues underground, running west beneath the North Temple, eventually flowing into the Jordan River. This stretch of City Creek conduit is a part of the North Temple Street Storm Sewer with a diversion (North Temple Diversion) located at approximately 600 West Street. The diversion has the ability to split the flow, with a portion continuing down the North Temple into the Jordan River and a portion diverted into the Folsom Drain Line (LimnoTech, 2019). Currently, the Folsom Drain Line runs from the Folsom Drain Line Junction Box (Basin Area) west and is located beneath the newly constructed Folsom Trail connecting the Jordan River Parkway Trail with downtown. The City Creek Daylighting Project aims to daylight a portion of the City Creek's flow within the Folsom Corridor, starting from the Folsom Drain Line Junction Box, following the Folsom Trail to the west, and eventually all the way to the Jordan River.

Previous evaluations of existing conditions compiled information from various reports, maps, spatial data, and research available up to date (LimnoTech, 2019, Hansen, Allen & Luce (HAL), 2019) and identified the gaps in existing data and the constraints for the conceptual design of the proposed daylighted stream. The data and information regarding site hydrology and water quality are provided in the following sections.

Existing Flow Conditions at the Project Site

The closest continuous flow data available are measured at Memory Grove, which does not reflect the conditions and additional flows that may occur through the city (Figure 1). The data for flows diverted into Folsom Drain needs to be quantified and are necessary to establish the baseflow for the daylighted portion of the City Creek within the project area. The City measured the flow at the North Temple diversion during the spring and summer of 2019. The year 2019 had a relatively high peak, wet spring, and summer, and conditions were above average.

Additional measurements and more detailed flow information at different locations are needed and were recommended to better understand the project site's hydrology (LimnoTech, 2019). BIO-WEST, Inc. (BIO-WEST) conducted flow measurements at three of the recommended Folsom Drain locations on three different occasions in 2022, which was considered a dry year with a short peak flow season with flows reaching only 16 cfs. Flows were measured at the North Temple diversion, Folsom Drain junction box (Basin Area), and at the Folsom Drain at 1000 West Street (Figure 2). The low-flow diversion baffles were installed at North Temple in October 2022, enabling continuous flow to the Folsom Drain when flows are low. The last measurement of 2022 reflects this change.

Preliminary results show an increase in the downstream flow between Memory Grove and the North Temple Diversion (Figure 2). The flows at the North Temple Diversion include base flows measured at Memory Grove and groundwater inflows pumped from the underground parking lots between Memory Grove and the Folsom Drain Line. These groundwater inputs were not previously quantified, and even though more measurements are needed to capture the variability of the inputs throughout the year, preliminary results suggest significant groundwater contribution. Based on the measurements taken during spring, summer and early fall season, the flow at least doubles at North Temple. At one instance, the flow was 14 times bigger at North Temple when compared to flow at Memory Grove. Base flow at Memory Grove can reach values below 2 cfs (for example, in 2022, summer and fall flow reached 0.88 cfs for extended periods), thus these groundwater inputs are essential in providing a continuous flow to the Folsom Drain Line. However, two measurements at the Detention Basin Area suggest no flow or only a small portion of the flow from North Temple was diverted in to the line. After the low-flow diversion baffles were installed at North Temple in October 2022 more flow seems to be delivered to the Detention Basin. This conclusion is based on one discharge measurement (10/28/2022) so more measurements are required to test the baffles and quantify flows downstream from North Temple. The same

measurement suggest that the groundwater inputs may decrease later in the season (late fall), still providing little over 2 cfs at Detention Basin Area. Currently, there are flap gates at the end of the Folsom Drain Line at the Jordan River outlet, and they only open when there is sufficient head pressure difference between the Folsom Drain Line and Jordan River. This results in backing up the water upstream of the Jordan River with water in the pipe but no measurable downstream flow (Figure 2, Table 2, email communication with Michael Guymon).

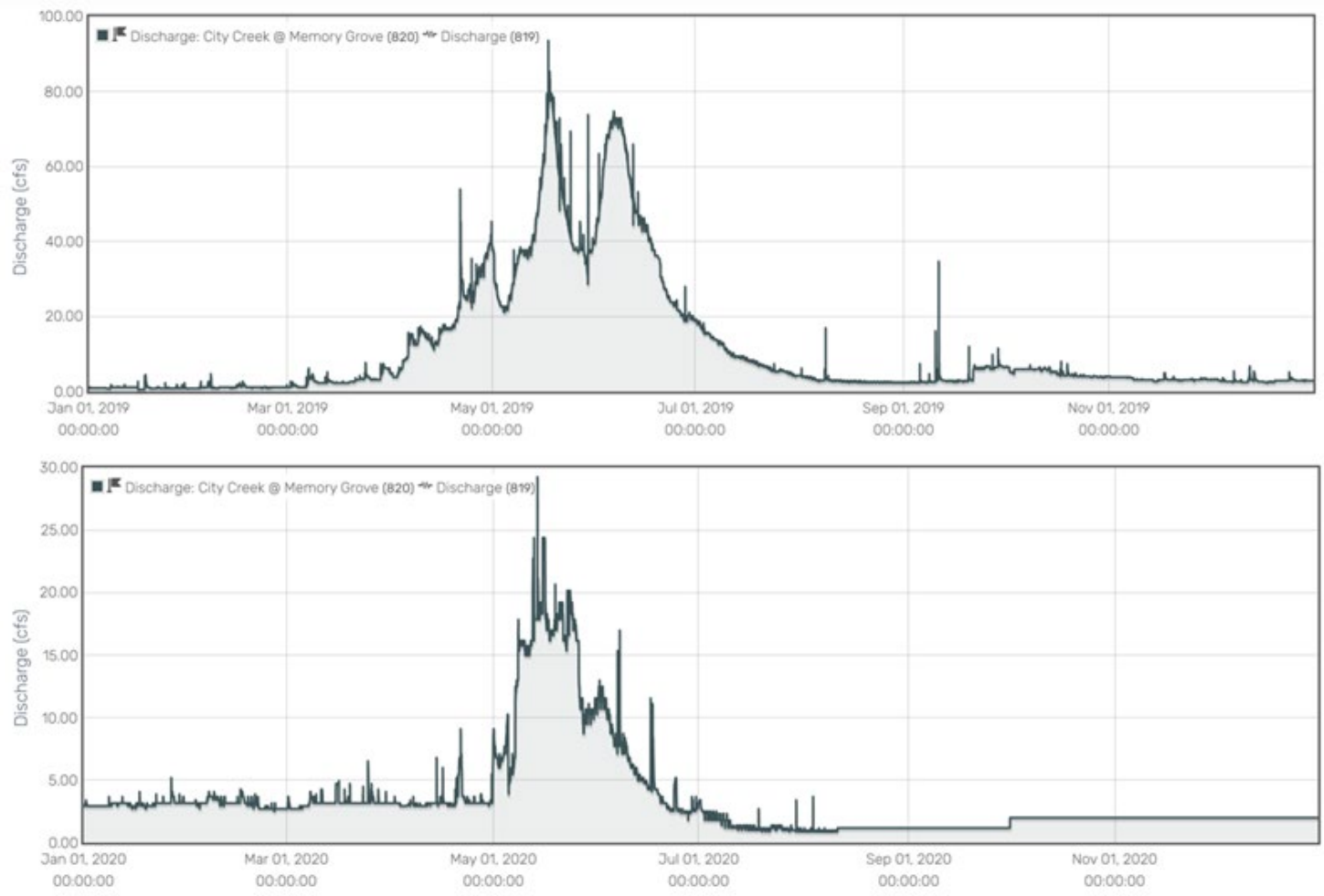

Figure 1. Continuous flow for City Creek at Memory Grove for 2019 and 2020 showing peak flows driven by snowmelt (Salt Lake County records).

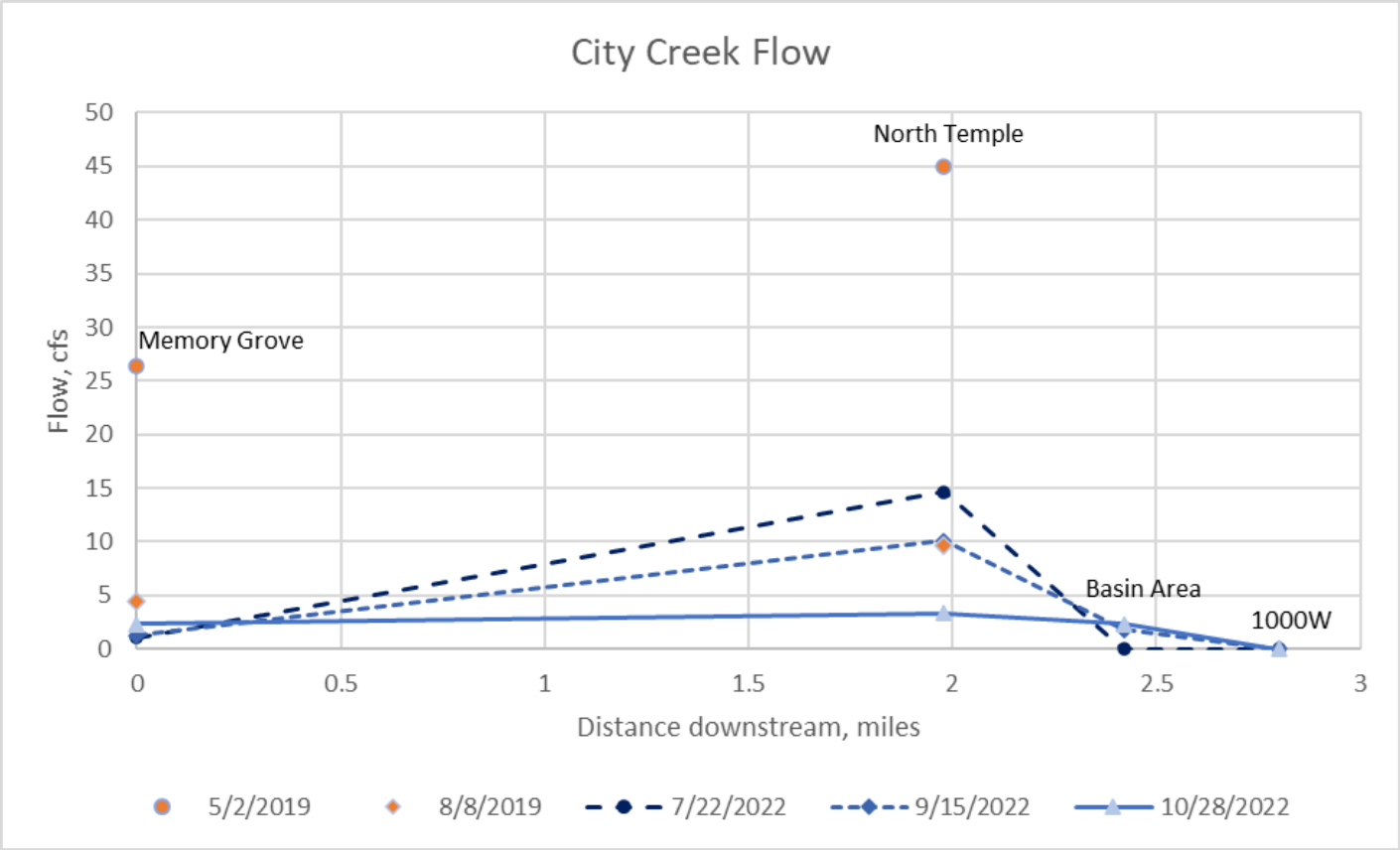

Figure 2. Discharge measurements at four different locations, starting at Memory Grove, continuing downstream to North Temple, Detention Basin Area and 1000 West. The measurements in orange represent the City or Salt Lake County (City Creek at Memory Grove) measurements, while blue are measurements collected by BIO-WEST, Inc.

Existing Water Quality at the Project Site

Similar to existing flow information data, there are gaps in water quality data, and more monitoring is needed to support and guide the stream design. Good water quality allows for more flexibility in design options, while poor water quality may require the addition of site access barriers if the quality does not support human contact. The following is a summary of current water quality beneficial use designations for City Creek and the Jordan River (Landmark Design, LimnoTech, Hansen, Allen & Luce, 2020):

- About one and a half miles upstream from the Folsom Corridor, City Creek (from the City drinking water plant to Memory Grove) currently has two designated uses (Utah Administrative Code, 2018):
  Class 2B - Protected for infrequent primary contact recreation. Also protected for secondary contact recreation where there is a low likelihood of water ingestion or a low degree of bodily contact with the water. Examples include, but are not limited to, wading, hunting, and fishing.
  Class 3A - Protected for cold-water species of game fish and other cold-water aquatic life, including the necessary aquatic organisms in their food chain.

- Downstream of the Folsom Corridor at the confluence with City Creek, the Jordan River has three designated uses (Utah Administrative Code, 2018):
  Class 2B (same as above)
  Class 3B - Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain.
  Class 4 - Protected for agricultural uses, including crop irrigation and stock watering.

The city measured water quality parameters on two occasions in 2019. One measurement occurred during high flows as a result of snowmelt (5/2/2019), and the second measurement took place during low summer flows (8/8/2019). Since then, BIO-WEST conducted additional water quality measurements at three locations on three different occasions (Table 2). This water quality information showed promise that the water could meet the designated use for contact recreation (Utah Administrative Code, 2018). It is recommended that more water quality samples are collected regularly from the North Temple diversion box and Folsom Drain Line to evaluate if water quality meets the designated use for contact recreation under all conditions. The most critical period for data collection is during the recreation season (late spring to early fall) and non-spring runoff wet weather. Due to the current lack of water quality data, it cannot be concluded that daylighting would improve water quality within the Folsom Drain (Landmark Design, LimnoTech, Hansen, Allen & Luce, 2020).

Table 2. City Creek water quality measurements

	City Creek Water Quality Samples, 2022 (BIO-WEST, Inc.)										City Measurements	
Parameter, Units	**Class 2B Standard ***	**7/22/2022**			**9/15/2022**			**10/28/2022**			**5/2/2019**	**8/8/2019**
Site		N.Temple	Basin	1000 W	N.Temple	Basin	1000 W	N.Temple	Basin	1000 W	N.Temple	N.Temple
Time		9:40	11:46	11:00	11:00	9:50	9:15	10:30	9:15	8:49		
Temp (°C)		22.6	24.6	24.3	17.7	17.8	16.5	6.8	7.5	9.9		
Discharge (cfs)		14.64	0	0	10.12	1.81	0	3.32	2.32	0	45	9.65
SpCond (mS/cm)		1.21	1.10	1.10	0.42	1.22	1.19	0.60	0.56	0.58		
DO (mg/L)		10.19	6.79	6.79	8.89	8.66	8.77	9.29	9.04	8.52		
pH	6.5-9.0	8.71	8.77	8.70	8.49	8.50	8.49	8.51	8.52	8.39	8.1	not meas.
Turbidity (NTU)	10.0	11.5	8.1	10.0	9.5	6.6	9.8	2.1	3.3	1.7	200.0	0.5
TDS		NA	NA	NA	0.10	0.80	0.80	0.38	0.37	0.37		
Ammonia as N (mg/kg)		0.08	0.07	0.08	ND**	ND**	ND**	ND**	ND**	ND**	not meas.	ND**
BOD (mg/L)	5	9	9	7	ND**	ND**	ND**	ND**	ND**	ND**	ND**	ND**
Nitrate as N (mg/L)		2.2	1.5	0.6	2.6	2.6	2.5	ND**	ND**	ND**	ND**	2.3
TSS (mg/L)		8	255	18	4	ND**	6	5	6	ND**	261	ND**
TP (mg/L)		0.07	0.20	0.06	0.05	0.02	0.03	0.03	0.02	0.02	0.1	0.03
Coliform (Org/ mL)		present	present	present	>2,400	>2,400	>2,400	>2,400	>2,400	>2,400	not meas.	>2,400
E. Coli (Org/ mL)	206/668***	present	present	present	340	440	1,300	490	650	1,300	10	101

**Class 2B Standard only listed if applicable; **ND means "not detected". Meaning parameters were either not present, or the concentration were too low to detect; ***30-day Geometric mean/maximum.*

Detention Basin

On the east side of 800 West at approximately 29 South, an open area is planned for a detention basin to reduce peak storm runoff by storing flow during peak periods. In addition, the detention basin would act as a water quality basin for downstream water quality enhancement. The water from the detention basin would be delivered to the daylighted stream channel downstream. However, the current elevation head difference between the detention basin and the channel is insufficient to use gravity for downstream water delivery. Thus, two alternatives were proposed in the feasibility study report:

1. providing a pump vault after the trash racks in the forebay of the proposed detention/water quality basin, and
2. installing grates on the floor of the existing box culvert with a pipe leading to a pump vault.

Both alternatives would require submersible pumps, which are controlled based on the water level in the pump vault.

Preliminary Hydrological Analyses

The hydrological analyses were included in the initial feasibility study and carried out by Hansen, Allen & Luce (2019, 2020). Three concepts were initially considered for daylighting options but were later eliminated due to multiple constraints and varying conditions along the Folsom corridor. Concepts 1 with daylighting a continuous baseflow of 2-4 cfs will be implemented for the Folsom Corridor and is described below (Landmark Design, LimnoTech, Hansen, Allen & Luce, 2020).

Concept 1 – Daylighting Continuous Baseflow (2-4 cfs)

Three variations were explored for Concept 1. The cross-section shape proposed by the US Army Corps of Engineers (Section 206 Preliminary Restoration Plan, 1999) was used. Manning's flow equation with the flow as a function of velocity, flow area, channel roughness (Manning's n), and slope was used to define a conceptual channel cross-section. The proposed cross-section shape is trapezoidal with a 2-foot bottom width and 2.67-ft Horizontal:1-ft Vertical side slopes. Assuming the same slope as the existing culvert of 0.00058 ft/ft and a Manning's n of 0.05, the computed depth in the channel is 1.27 feet with a top width of 8.8 feet and a flow rate of 4 cfs. The roughness coefficient would vary depending on the composition of the channel bed, but Manning's *n* value assumed is sufficient for conceptual feasibility purposes. The coefficient assumes coarse gravel and small cobbles in the bottom of the channel with vegetation growing on the side slopes. The channel would need to cross several existing roadways. Crossing options may include traditional culverts, inverted siphons, or other options that offer flow but are cost-effective considerations for the site. More flow measurements are needed to determine a more precise baseflow and channel dimensions to explore this concept further.

Flow and Water Quality Conclusion

In conclusion, additional flow and water quality measurements are necessary to better understand site hydrology and establish the available base flow rate daylighting City Creek within the Folsom Corridor. The preliminary results suggest significant groundwater inputs between Memory Grove and North Temple diversion. These groundwater inputs would support a continuous flow delivery into the Folsom Corridor even during drier low flow months as base flow at Memory Grove could reach values below 2 cfs. New low-flow diversion baffles installed at North Temple in October 2022 may facilitate a minimum delivery of flow to the site. More discharge measurements are needed to test the baffles and quantify flows downstream from North Temple. The measurement conducted after the low-flow baffles were installed shows delivery of 2.32 cfs to the Detention Basin Area which was the base flow at Memory Grove at the time. The current water quality information suggests that the water could meet the designated beneficial use for contact recreation (Utah Administrative Code, 2018). It is recommended that additional flow and water quality measurements are collected regularly from the North Temple diversion box and Folsom Drain Line to further define existing conditions and to better understand the hydrology of the project area to guide the design for daylighting of City Creek along the Folsom Corridor.

Stormwater Runoff Estimates

BIO-WEST performed stormwater runoff calculations to estimate runoff from different surfaces within the project area. The Folsom Corridor project area is segmented by streets, which results in creating four distinct areas for the calculations. The list of individual segments in the east-to-west direction include:

- Detention Basin Area
- 800 West to Jeremy Street
- Jeremy Street to 900 West
- 900 West to 1000 West.

These segments were further divided into distinct units for the purpose of stormwater runoff analyses (Attachment B). The existing Folsom Trail and its sloping surfaces were used to divide each segment into north and south units, or in the case of the Detention Basin Area, into the west and east unit. The trail sloped to the west in the Detention Basin Area, to the south in the 800 West to Jeremy Street segment, and to the north, in both Jeremy Street to 900 West and 900 West to 1000 West segments. Different types of surfaces or land uses were digitized in each unit (Attachment C) and later used to determine peak flows for various rain events and stormwater runoff calculations (Attachment D). The precipitation data from Salt Lake City International Airport, UT (427598) were used to specify the annual average precipitation in the analyses.

References

1. BIO-WEST, Inc. 2010. Salt Lake City Riparian Corridor Study. Final City Creek Management Plan. October 2010.
2. Hansen, Allen & Luce. 2019, Existing Conditions Preliminary Report City Creek Daylighting Feasibility Study.
3. Landmark Design, LimnoTech, Hansen, Allen & Luce. 2020, City Creek Daylighting Feasibility Study, June 18, 2020, Final Draft.
4. LimnoTech.2019, Existing Conditions of the Folsom Corridor for Feasibility Analysis for Daylighting a Portion of City Creek: Preliminary Findings.
5. NOAA Precipitation Frequency Data Server; https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ut
6. U.S. Geological Survey. 2019, The StreamStats program, https://streamstats.usgs.gov/ss/ Accessed 2/16/2023
7. Utah Administrative Code. November 1, 2018, Utah Administrative Code Rule R317-2. Standards of Quality for Waters of the State. Retrieved from Utah Office of Administrative Rules: https://rules.utah.gov/publicat/code/ r317/r317-002.htm#T8
8. Western Regional Climate Center, https://wrcc.dri.edu/summary/Climsmut.html

Sincerely,

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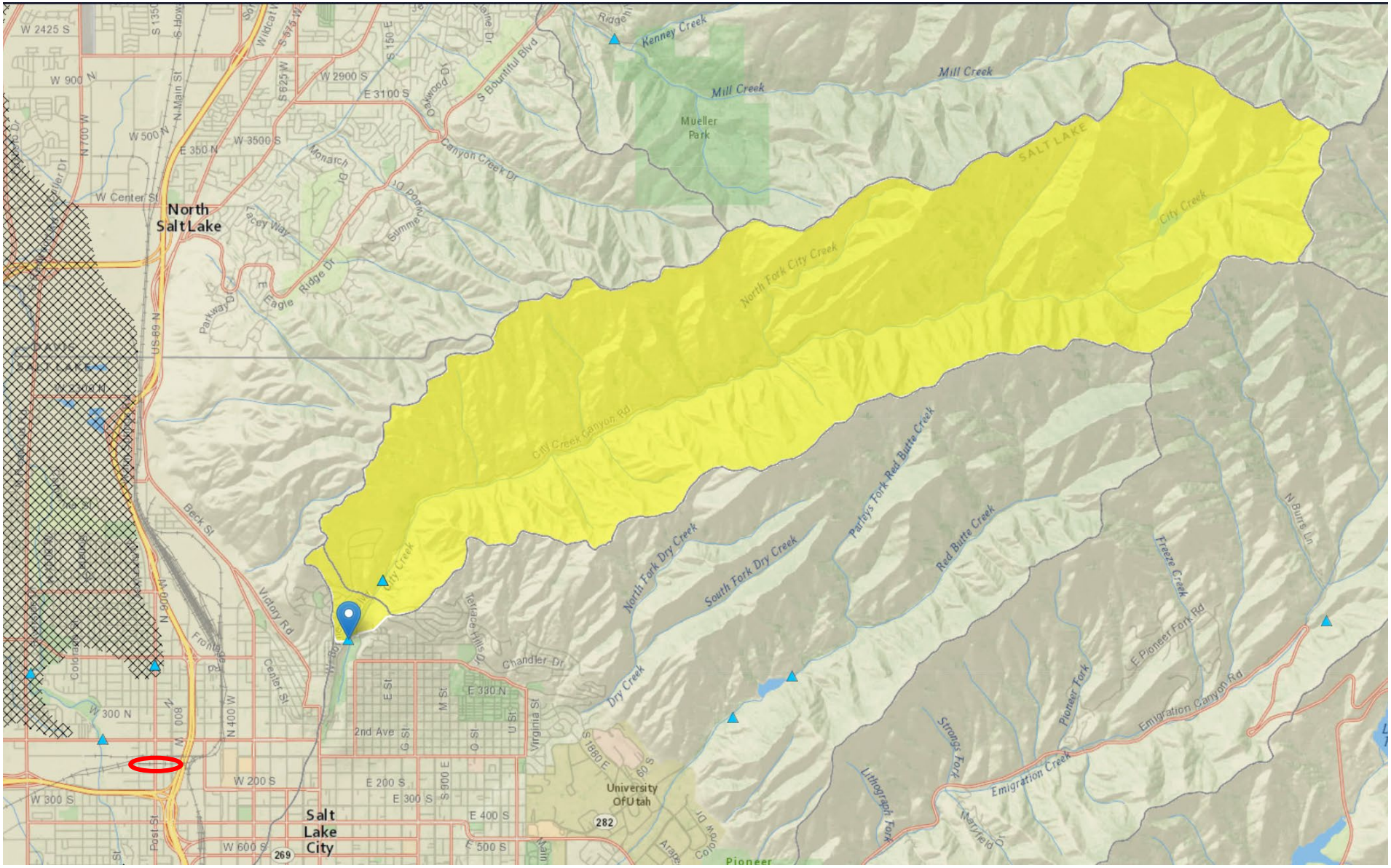
Water Resources Scientist/Hydrologist, BIO-WEST, Inc.

Attachments:
1. City Creek Upper Watershed and Project Area (red ellipse)
2. Project Area with Individual Areas and Units Used for the Stormwater Runoff Calculations
3. Project Area Surfaces
4. Stormwater Runoff for City Creek Daylighting Project Area

Attachment A


Kenney Creek
Mill Creek
Mill Creek
Mueller Park
SALT LAKE
City Creek
North Fork City Creek
Canyon Creek Dr
Monarch Dr
Summerwood Dr
Oakwood Dr
S Bountiful Blvd
E 3100 S
W 2900 S
W 3500 S
E 350 N
W 500 N
W Center St
North Salt Lake
Facey Way
Ridge Dr
Eagle
Parkway Dr
US-89 N
Cliff Creek Canyon Rd
Beck St
Victory Rd
Frontage Rd
Center St
N 900 W
N 400 W
W 300 N
W 200 S
W 300 S
W 600 S
Post St
Salt Lake City
269
Dry Creek
Terrace Hills Dr
Chandler Dr
E 300 N
E St
M St
G St
Q St
U St
Virginia St
2nd Ave
E 200 S
E 300 S
E 400 S
E 500 S
S 900 E
S 1880 E
University Of Utah
282
North Fork Dry Creek
South Fork Dry Creek
Parleys Fork Red Butte Creek
Red Butte Creek
Freeze Creek
N Burns Ln
E Pioneer Fork Rd
Emigration Canyon Rd
Pioneer Fork
Strongs Fork
Lithograph Fork
Emigration Creek
Marryfield Dr
Pioneer

Attachment B

Folsom Corridor City Creek Daylighting Project

Project Area Map

0 200 400 800 Feet

N

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Project Area Units

Imagery Source: World Imagery (ESRI Online)
Coordinate System: NAD 1983 State Plane Utah Central
Datum: North American 1983

Attachment C

Folsom Corridor City Creek Daylighting Project

Project Area Surfaces

0 200 400 800 Feet

N

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Imagery Source: World Imagery (ESRI Online)
Coordinate System: NAD 1983 State Plane Utah Central
Datum: North American 1983

- Folsom Trail
- Other Impervious Surfaces
- Gravel/Dirt
- Grass
- Forest/Trees/Bushes

Attachment D

Project Area Individual Units and Their Surfaces

City Creek Daylighting Unit Location	Unit Name	Area (square feet)	Area (acres)	Trail (concrete)	Parking Lot (concrete)	Concrete Other	Gravel-Dirt	Grass	Wooded Areas	Other
Detention Basin	DB EAST	79820	1.832	0.0	0.0	568.8	22265.9	42183.1	8007.0	6795.2
	DB WEST	1920	0.044	1447.3	0.0	0.0	0.0	472.8	0.0	0.0
800 West to Jeremy Street	800W-JEREMY ST. NORTH	13310	0.306	6.8	0.0	10.5	0.0	13292.7	0.0	0.0
	800W-JEREMY ST. SOUTH	14440	0.331	3570.2	0.0	33.5	0.0	10836.3	0.0	0.0
Jeremy Street to 900 West	JEREMY ST.-900W NORTH	15670	0.360	3608.3	0.0	44.6	0.0	12017.1	0.0	0.0
	JEREMY ST.-900W SOUTH	11780	0.270	41.7	3511.9	7.8	2684.8	5533.8	0.0	0.0
900 Weste to 1000 West	900W-100W NORTH	42680	0.980	7847.3	0.0	16.1	0.0	34816.6	0.0	0.0
	900W-100W SOUTH	9524	0.219	29.8	0.0	9.6	0.0	9484.7	0.0	0.0

Peak Flows and Stormwater Runoff for Impervious Surfaces in Individual Units

City Creek Daylighting Unit Location	Unit Name	Area (square feet)	Area (acres)	Impervious Surface (square feet)	Impervious Surface (acres)	Peak Flow for Different Rain Events, Q (cfs)			Annual Stormwater Runoff (gal)	Annual Stormwater Runoff (acre-feet)
						100-year/60 min	100-year/12 hours	100-year/24 hours		
Detention Basin	DB EAST	79820	1.832	568.830	0.013	0.020	0.030	0.033	5526	0.017
	DB WEST	1920	0.044	1447.300	0.033	0.051	0.075	0.085	14061	0.043
800 West to Jeremy Street	800W-JEREMY ST. NORTH	13310	0.306	17.300	0.000	0.001	0.001	0.001	168	0.001
	800W-JEREMY ST. SOUTH	14440	0.331	3603.733	0.083	0.128	0.188	0.211	35012	0.107
Jeremy Street to 900 West	JEREMY ST.-900W NORTH	15670	0.360	3652.938	0.084	0.130	0.190	0.214	35490	0.109
	JEREMY ST.-900W SOUTH	11780	0.270	3561.389	0.082	0.127	0.186	0.208	34600	0.106
900 West to 1000 West	900W-100W NORTH	42680	0.980	7863.411	0.181	0.280	0.410	0.460	76396	0.234
	900W-100W SOUTH	9524	0.219	39.360	0.001	0.001	0.002	0.002	382	0.001
ALL		189144	4.342	20754	0.476	0.738	1.082	1.213	201636	0.619