Young Environmental Consulting Group, LLC

Technical Memorandum

To: Linda Loomis, Administrator
Lower Minnesota River Watershed District

From: Kaci Fisher, Environmental Specialist
Katy Thompson, PE, CFM
Della Schall Young, PMP, CPESC

Date: January 15, 2022

Re: Spring Creek Hydrology Review

The Spring Creek Project (Project) consists of two properties (Site 1: 112 5th Street West and Site 2: 404 Broadway Street) in the city of Carver in Carver County, as shown in Figure 1. The owners raised concerns about erosion issues on their properties caused by Spring Creek, and Carver Soil and Water Conservation District (SWCD) designed a concept plan to stabilize both sites. Young Environmental Consulting Group (Young Environmental) visited the site along with Barr Engineering Co. (Barr Engineering) on June 21, 2019 (Attachment 1). From this site visit, Barr Engineering provided the following recommendations:

1) Per the Carver SWCD, remove fallen trees, armor eroded banks with riprap, and revegetate with deep-rooted species.
2) Complete an assessment of the hydrology to better understand historic changes and look to future conditions to help design stabilization measures.
3) Consider cross-vanes and additional grading to stabilize the channel profile and reconnect the channel to the former floodplain.
4) Consider restoring the channel to its previous alignments at Sites 1 and 2.

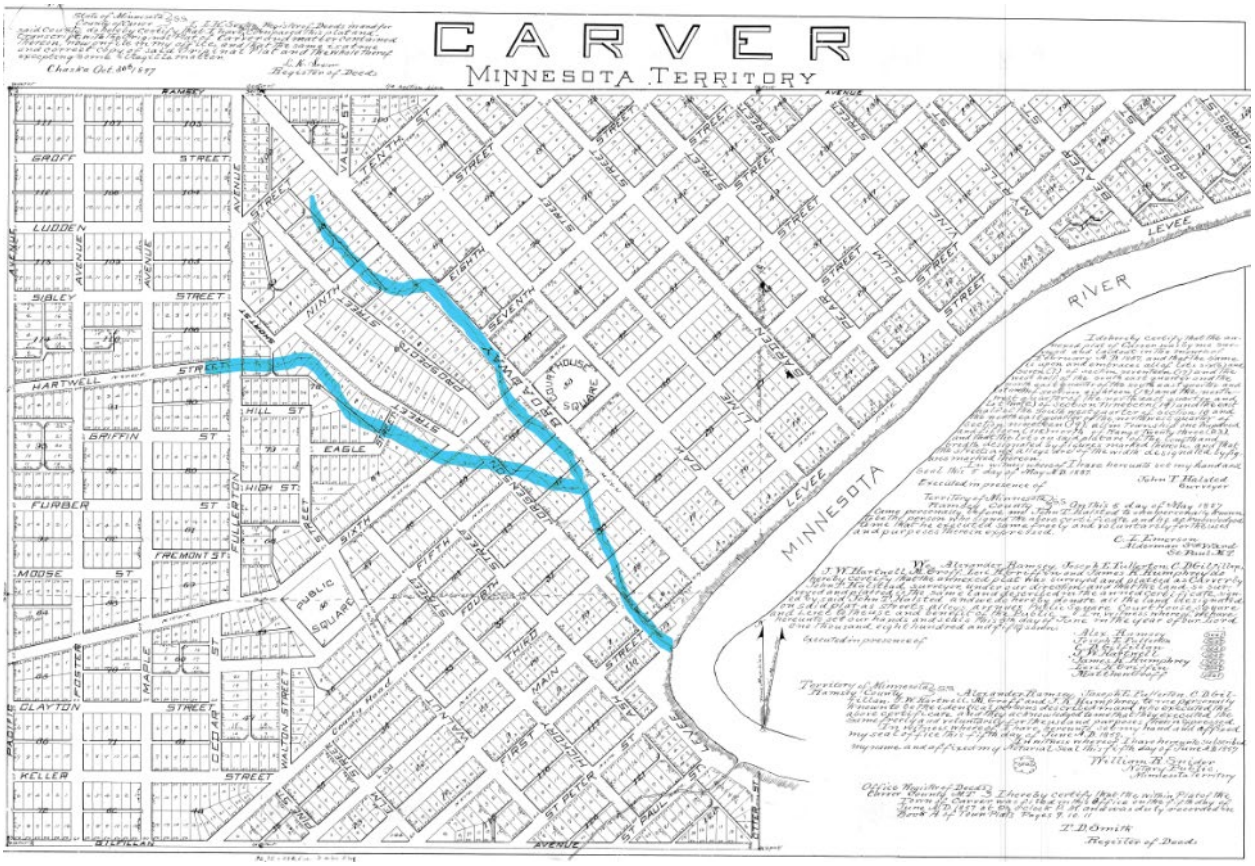
As recommended by Barr, Lower Minnesota River Watershed District (LMRWD) managers authorized Young Environmental to complete an assessment of the hydrology to better understand historic changes and look to future conditions to help design stabilization measures. Young Environmental has completed the assessment, which is documented in the following sections.

Figure 1. Spring Creek Project Location Map

Spring Creek History

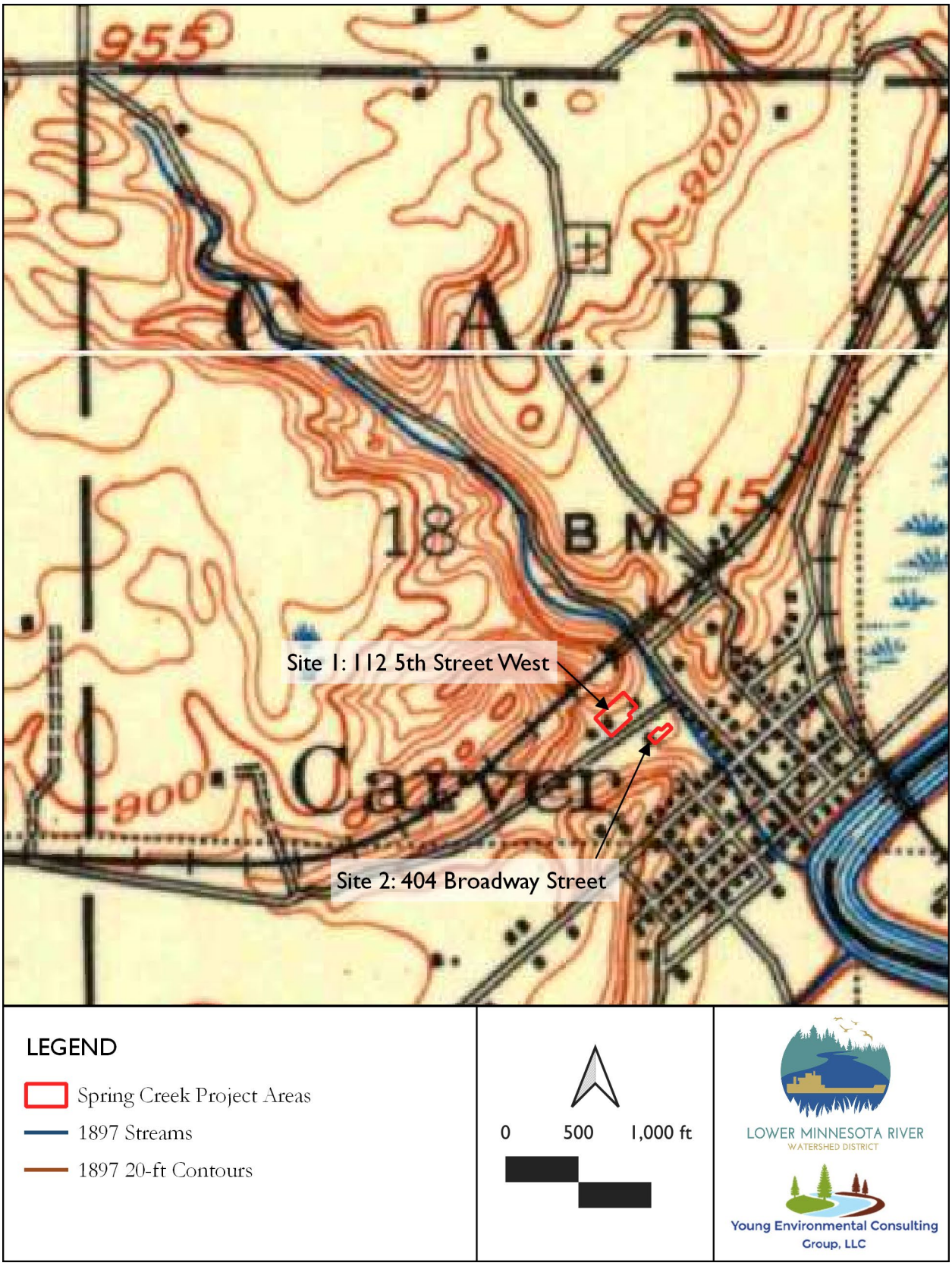
In 1854, the Carver Land Company founded the Village of Carver, which experienced exponential growth as an essential trade town along the Minnesota River. Because of its proximity to the river, the Village of Carver experienced widespread flooding which repeatedly damaged the river town. Today, the former Village of Carver now makes up the historic downtown district of the city of Carver and is listed on the National Register of Historic Places. Because of its private development, the village was platted before settlement and its early growth as a successful river town created near full development by the 1880s (City of Carver 2020). The 1857 land plat available from Carver County shows the former Village of Carver in great detail, including the alignment of Spring Creek (Figure 2). The numerous lots platted show no regard for the existing steep topography or natural features, and by 1897 Spring Creek was confined by multiple crossings and the downtown development, and was deeply incised into the river bluffs (Figure 3).

Figure 2. Spring Creek, highlighted in blue, as shown on Carver land plat[1]



[1] Carver County, *Carver, Minnesota Territory Plat* (Chaska, 1857).

Figure 3. City of Carver 1897 Topography



Aerial photos from the University of Minnesota's Minnesota Historic Aerial Photographs Online (MHAPO) website show that in 1937 the downtown area was much the same as in 1897, with agriculture lands dominating the landscape outside of the historic district. New and sizable gullies are shown creeping into agricultural lands upstream from the downtown district and are easily identifiable by the lack of vegetation within the channel (Figure 4).

By 1945, it appeared that these gullies had begun to stabilize. There were signs of vegetation establishment at the head cuts and within the gullies themselves. Between 1945 and 1964, the agricultural fields became more contoured, with elaborate drain tile systems and the gullies became more forested, however, the general top of the ravine boundary does not appear to have changed significantly, indicating that the system had reached a new equilibrium after the initial development in the 1850s (Figure 5).

The landscape remained somewhat stabilized until the 1997 aerial (Figure 6) which captured the 1997 flood on the Minnesota River and the conversion of agricultural lands to residential subdivisions. The gullies were still heavily vegetated and, excepting the western branches of Spring Creek, appeared to have stabilized. The western branches appeared to have widened between 1964 and 1997, but the upstream migration had halted because of barriers such as road crossings. One major change in the 1997 photograph is the absence of the Carver High Trestle bridge, which was constructed by the Chicago, Milwaukee & St. Paul Railway in 1899. The railway abandoned the track in 1978, and the bridge was removed in 1981.[2] By 2020, Spring Creek was almost entirely bounded by residential subdivisions and roads (Figure 7).

With the development of the agricultural landscape into a suburban residential landscape, it would be expected that the stormwater runoff from the watershed entering Spring Creek would increase, which in turn would also increase bank erosion and gully formation as the creek attempts to reach a new equilibrium, similar to what occurred after the initial development of the watershed at the beginning of the 20th century. The 2020 Gully Inventory and Condition Assessment noted ninety-one individual gullies forming within the Spring Creek watershed, of which forty were deemed high priority to correct.

Throughout all this development, while the watershed changed, the Spring Creek alignment generally remained the same, but on a local level, there were significant changes. At the two sites, the confluence with the Spring Creek west branch migrated upstream approximately 360 feet from its location in 1857 at 4th Street to upstream of 5th Street in 2011 (Figure 8). Additionally, the two sites are located in an area where the naturally steep topography begins to flatten and meet the Minnesota River floodplain,

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[2] Vern, Wigfield, John Hill, and Carver on the Minnesota, *Carver High Trestle* (2021).

creating a relatively dynamic system where channels may migrate over time. However, the creek is fixed upstream and downstream by culvert crossings at 6th and 4th Streets, which have been in place since the 1880s.[3]

[3] John von Walter, *Carver Historic* District (2016).

Figure 4. Spring Creek in 1937 (MHAPO)

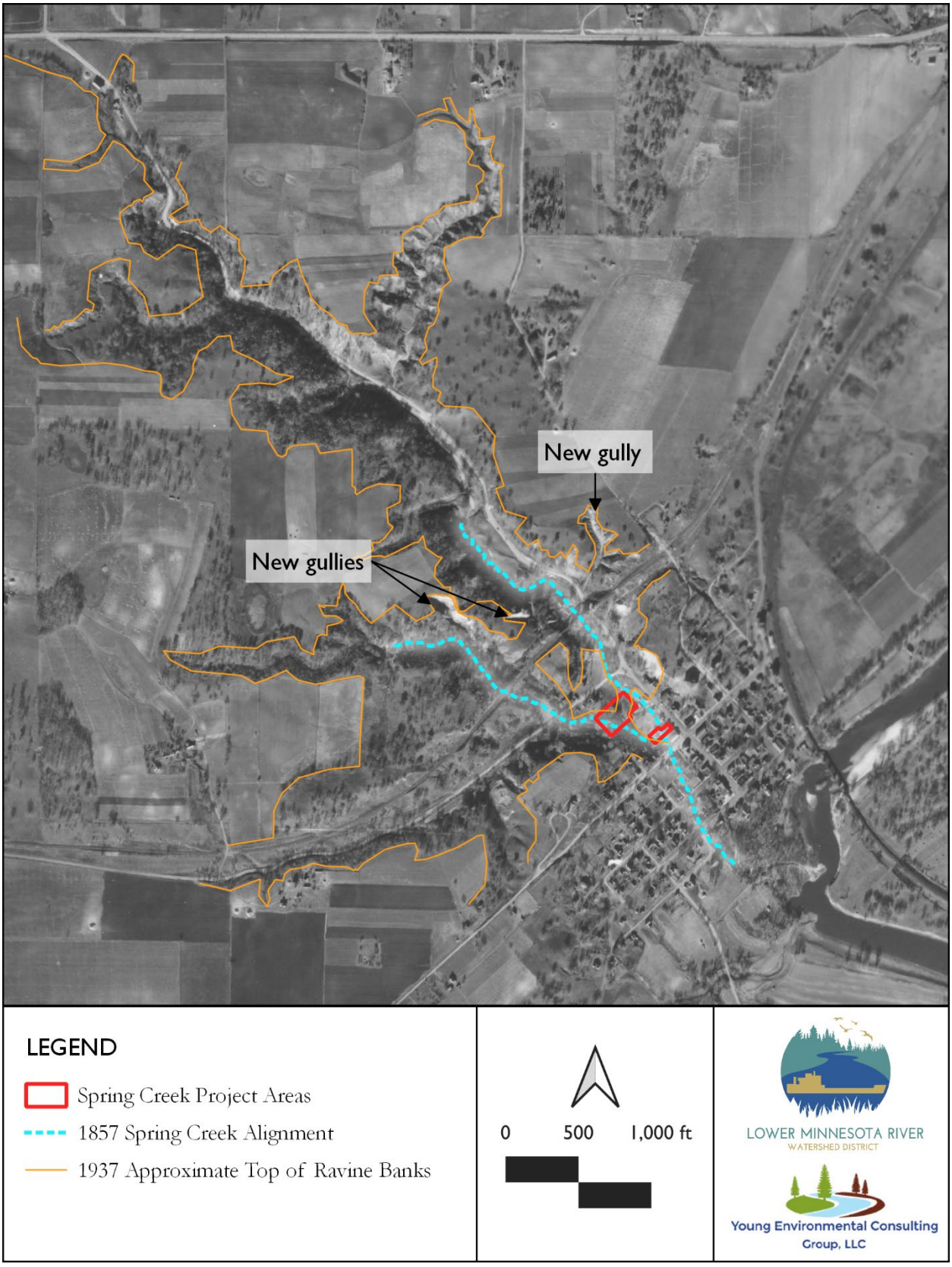


Figure 5. Spring Creek in 1964 (MHAPO)

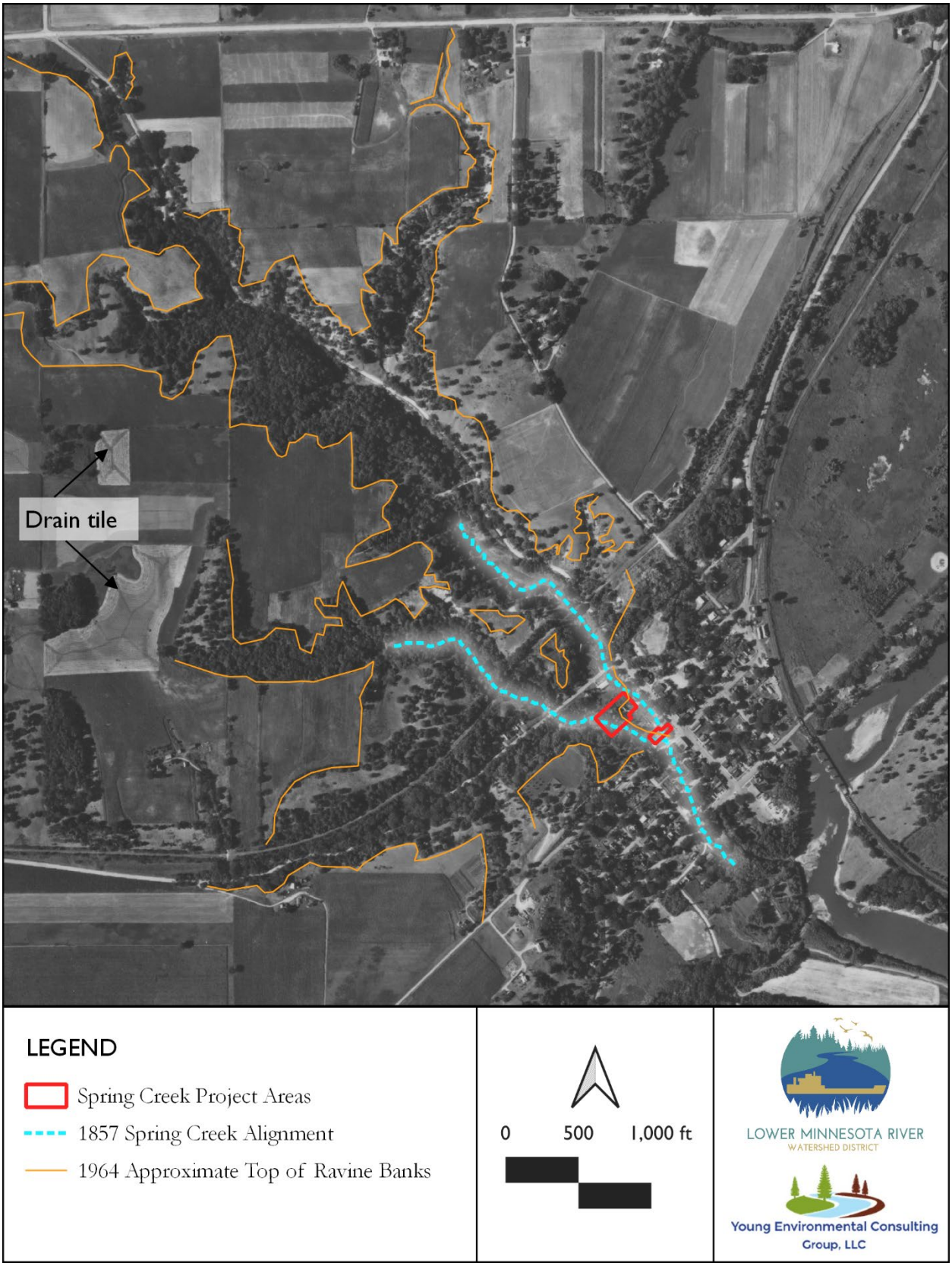


Figure 6. Spring Creek in 1997 (Minnesota Geospatial Commons)

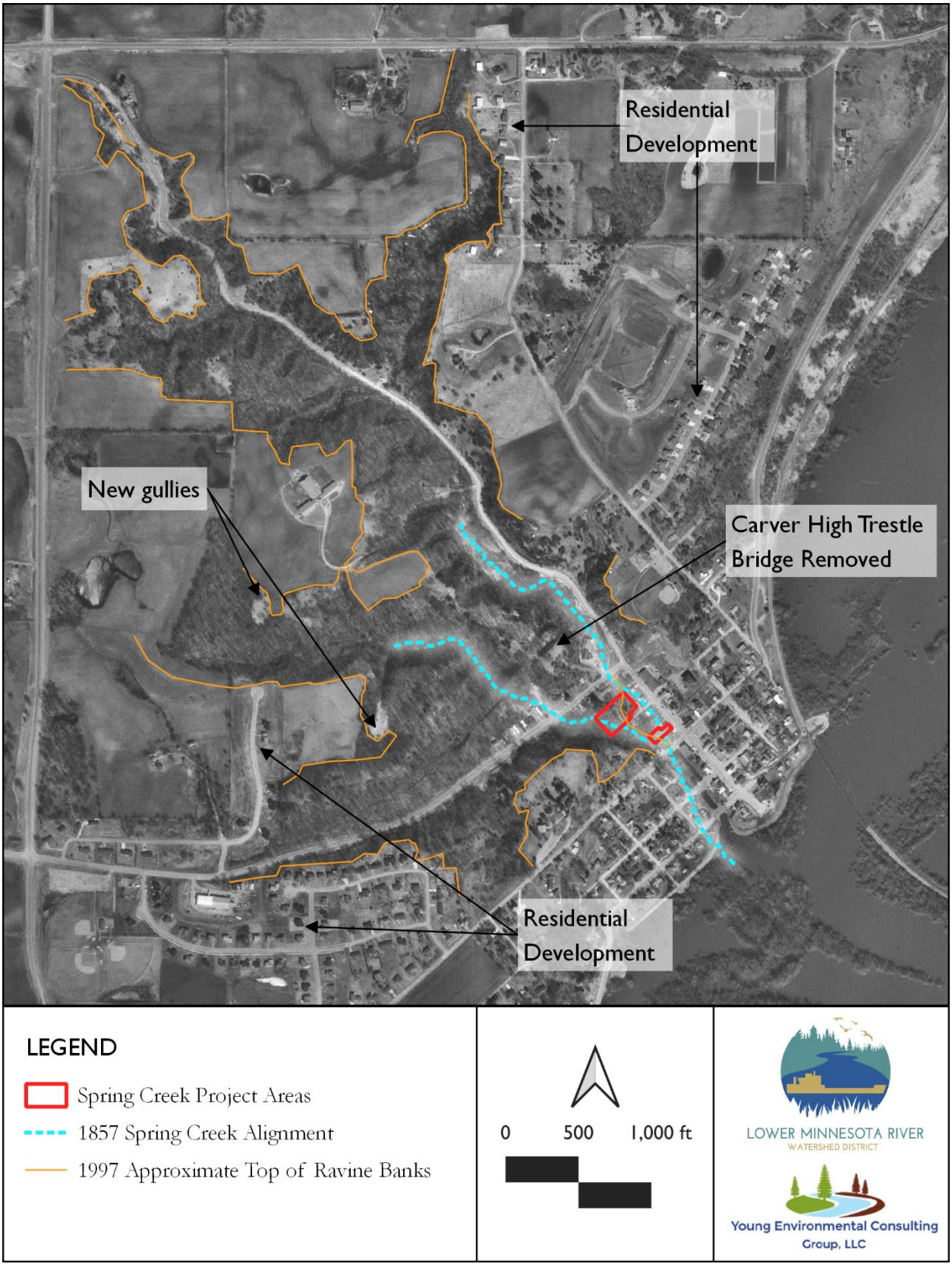


Figure 7. Spring Creek in 2020 (Minnesota Geospatial Commons)

Figure 8. Change in Spring Creek Alignment

2021 Field Visit

Young Environmental staff visited the two sites on May 28, 2021, walking along the left bank of Spring Creek from 520 Broadway to 404 Broadway, stopping at several locations (shown in Figure 9), and noting erosion concerns and previous restoration attempts.

At Site 1 (112 5th Street), we observed the left bank (when looking downstream) to be near vertical with some evidence of slope movement shown by trees leaning into the channel (Figure 10) and pistol-butted (or curved) tree trunks on the left bank itself (Figure 11). The right bank also showed some signs of slope sliding and erosion (Figure 11). In 2019, the resident was concerned because they observed the creek had moved approximately 30 feet from its previous alignment in the 1990s and is now closer to their residence. The historic imagery and the sediment deposits along the left bank near the confluence with the west branch seem to support the resident's claims; however, while both banks show signs of moderate to severe erosion, the creek does not appear to be threatening infrastructure currently, and downstream the channel appears to be stable (Figure 12).

Gregg Witt, the property owner of 104 6th Street and 420 Broadway, approached staff and discussed the Spring Creek erosion issues. Mr. Witt talked about landowners dumping debris within the channel to prevent the creek from meandering. At the time of the site visit, we observed riprap at the end of 5th Street (Figure 13), as well as construction debris, an old mattress and box spring, and a large recycling trash bin in the channel near 420 Broadway (Figure 14). He also pointed out an old wooden fence that used to be at the channel bank and had now fallen into the channel. Then he noted that the bluff across the bank (at 400 4th Street West) was eroding to such a degree that the driveway at the top of the bluff appeared to show signs of undercutting (Figures 15 and 16).

Walking further south to 404 Broadway, it is evident that the stream has caused significant erosion at Site 2, nearly undercutting an accessory structure in the property's backyard. The creek has several sharp meanders in this short stretch starting immediately upstream from 404 Broadway (Figure 17). The resident has placed logs and pallets along the left bank in an attempt to protect the structure (Figure 18). The creek makes two nearly 90-degree bends before entering the 4th Street culvert and appears to have caused failure of a retaining wall at 402 Broadway.

We should also note that there did not appear to be an appreciable difference in erosion appearances in 2021 compared to the photos taken in 2019 and 2018 (Attachment 1). In fact, many of the same leaning and fallen trees in the 2019 photos were observed in the field at the same locations, indicating that the rate of erosion may have slowed.

While the creek is extremely close to the accessory structure at Site 2, without survey

information, it is difficult to determine the rate of bank erosion. However, many of the same trees and banks appear to be in the same locations. Given the amount of vegetation present in this reach, it may be that the stream seems to have found an equilibrium with the remaining in-water structures. The driveway at 200 4th Street West (Site 3 and Figures 15 and 16) appears to be of greater concern because the creek has undercut the toe of the bank, creating a near vertical bank that is more than twenty feet tall.

Figure 9. Locations of 2021 Site Photos and Areas of Erosion

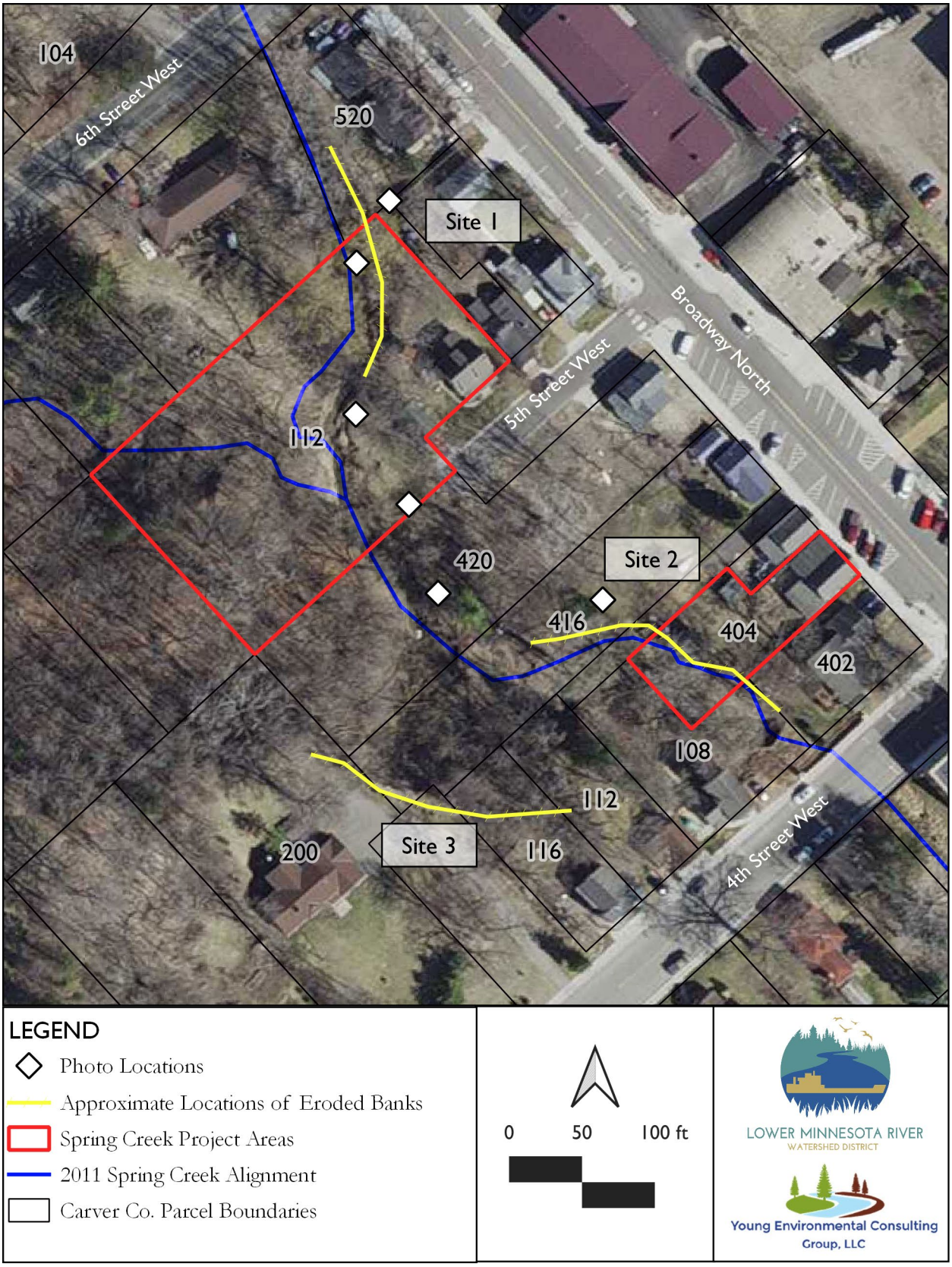


Figure 10. Spring Creek looking upstream from 520 Broadway at the 6th Street culvert crossing; note leaning trees on the left bank.

Figure 11.Spring Creek looking downstream from 112 5th Street (Site 1); note the near-vertical left bank and pistol-butted trees, indicating slow slope movement; erosion and slope instability are also present on the opposite right bank.

Figure 12. Spring Creek looking downstream from 112 5th Street (Site 1).

Figure 13. Looking upstream at riprap bank protection and stormwater outfall at the end of 5th Street West.

Figure 14. Riprap and debris placed on left bank at 420 and 416 Broadway.

Figure 15. Spring Creek looking downstream and up at right bank bluff erosion at 200 4th Street West (Site 3) from 416 Broadway. The approximate edge of the driveway and top of bluff is highlighted in orange below.

Figure 16. Spring Creek right bank and undercut bluff near 116 and 112 4th Street West (Site 3) from 416 Broadway; the approximate top of the bluff is highlighted in orange.

Figure 17. Looking upstream at Spring Creek from 416 Broadway (Site 2).

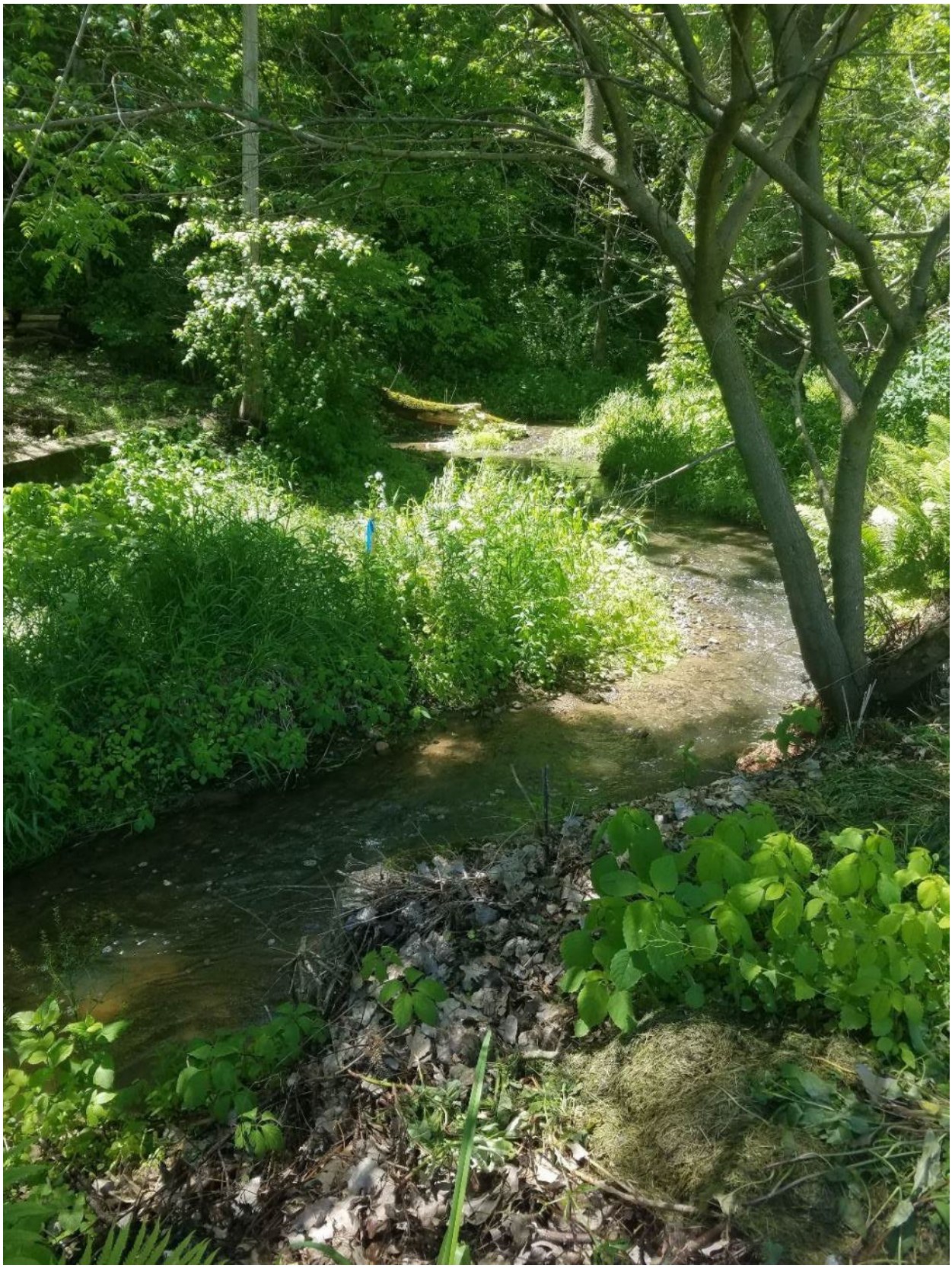


Figure 18. Spring Creek looking downstream at 404 Broadway accessory structure and debris pile on the left bank.

Figure 19. Spring Creek looking downstream at a failed retaining wall in the channel.

Hydrology Updates

We developed a HydroCAD model to ascertain the impacts of development on the flows in the creek. We collected soils data from the Natural Resources Conservation Service and obtained land use data from the Metropolitan Council for current (2016) and future conditions, while presettlement conditions were obtained from the Minnesota Department of Natural Resources Marschner Presettlement Vegetation GIS coverage. We ran the HydroCAD model using rainfall estimates from the National Oceanic and Atmospheric Administration (NOAA) from Technical Paper 40 (TP-40), developed in 1961, which provides an estimate of rainfall depths based on monitoring data. We used the TP-40 rainfall data to approximate the presettlement rainfall depths. The more current NOAA Atlas 14 rainfall depths provide a better estimate of rainfall depths today and we used them in the current (2016) condition analysis (Table 1). The flow results from the HydroCAD modeling are presented in Tables 2 and 3 below, and in Attachment 2.

Table 1. Precipitation Depths in Inches Used in Spring Creek Analysis

	Presettlement (NOAA TP-40)	Current (NOAA Atlas 14)
1-year	2.3	2.49
2-year	2.8	2.85
10-year	4.2	4.23
100-year	6.0	7.30

Table 2. Presettlement Conditions—Peak Flow Rates in Cubic Feet Per Second (cfs)

	Drainage Area (acres)	1-Year (cfs)	2-Year (cfs)	10-Year (cfs)	100-Year (cfs)
Main Branch North at Confluence	291.8	24	54	185	405
West Branch at Confluence	256.5	39	95	342	768
Main Branch South to Minnesota River	573.3	40	97	351	792

Table 3. Current Conditions—Peak Flow Rates

	Drainage Area (acres)	1-Year (cfs)	2-Year (cfs)	10-Year (cfs)	100-Year (cfs)
Main Branch North at Confluence	291.8	113	160	369	917
West Branch at Confluence	256.5	128	179	403	978
Main Branch South to Minnesota River	573.3	239	335	771	1,904

Looking at the presettlement discharge rates (Table 2) compared to the 2016 current conditions (Table 3), there has been a 154% increase in the 100-year 24-hour discharge rates, but a 461% increase in the 1-year 24-hour discharge rate. This indicates that while stormwater runoff to the creek has increased, it has done so the most during the most frequent events. The 10-year presettlement event may now be today's 2-year event. Channel sizes are often defined by these high-frequency, but low-flow events, so with the significant increase in the 1-year event, it is not surprising that there has also been significant erosion within the channel as the channel adjusts to these larger storms.

Finally, we based our evaluation of future conditions on the *Third National Climate Assessment*, which states that the upper Midwest experienced a 37% increase in heavy downpours between 1958 and 2012.[4] If climate change continues at that same pace, by 2050 it is possible that the Midwest could experience a 26% increase in rainfall. To estimate these flows in the HydroCAD model, we multiplied the NOAA Atlas 14 data by 26% and the results are shown in Table 4.

[4] John Walsh and Donald Wuebbles, *Fourth National Climate Assessment* (U.S. Global Change Research Program, 2014).

Table 4. Estimated Future Condition Peak Flow Rates

	Drainage Area (acres)	1-Year (cfs)	2-Year (cfs)	10-Year (cfs)	100-Year (cfs)
Main Branch North at Confluence	291.8	288	379	714	1,528
West Branch at Confluence	256.5	339	439	797	1,655
Main Branch South to Minnesota River	573.3	624	816	1,511	3,187

Hydraulics

The City of Carver is currently developing designs to improve the levee system around Spring Creek and the Minnesota River. The city developed a HEC-RAS model to evaluate their designs and has shared this model with Young Environmental for use in this study. The HEC-RAS model extends from the confluence with the Minnesota River upstream to the 6th Street crossing. It includes only the main branch of Spring Creek and all the constructed crossings that have been in place since the early 1900s. The City's HEC-RAS model was used to evaluate the proposed SWCD stabilization designs for Sites 1 and 2.

The SWCD has proposed vegetated riprap and Bio-D block walls with native plantings along the left bank at Site 1 to prevent Spring Creek from further eastward migration (Figure 20), at a cost of approximately $75,000. For Site 2, the SWCD recommended a more robust combination of riprap, Bio-D block, native plantings, and removal of the failing concrete walls (Figure 21), at a cost of approximately $88,000.

Figure 20. Carver SWCD 2019 proposed design for Site 1 (112 5th Street West)

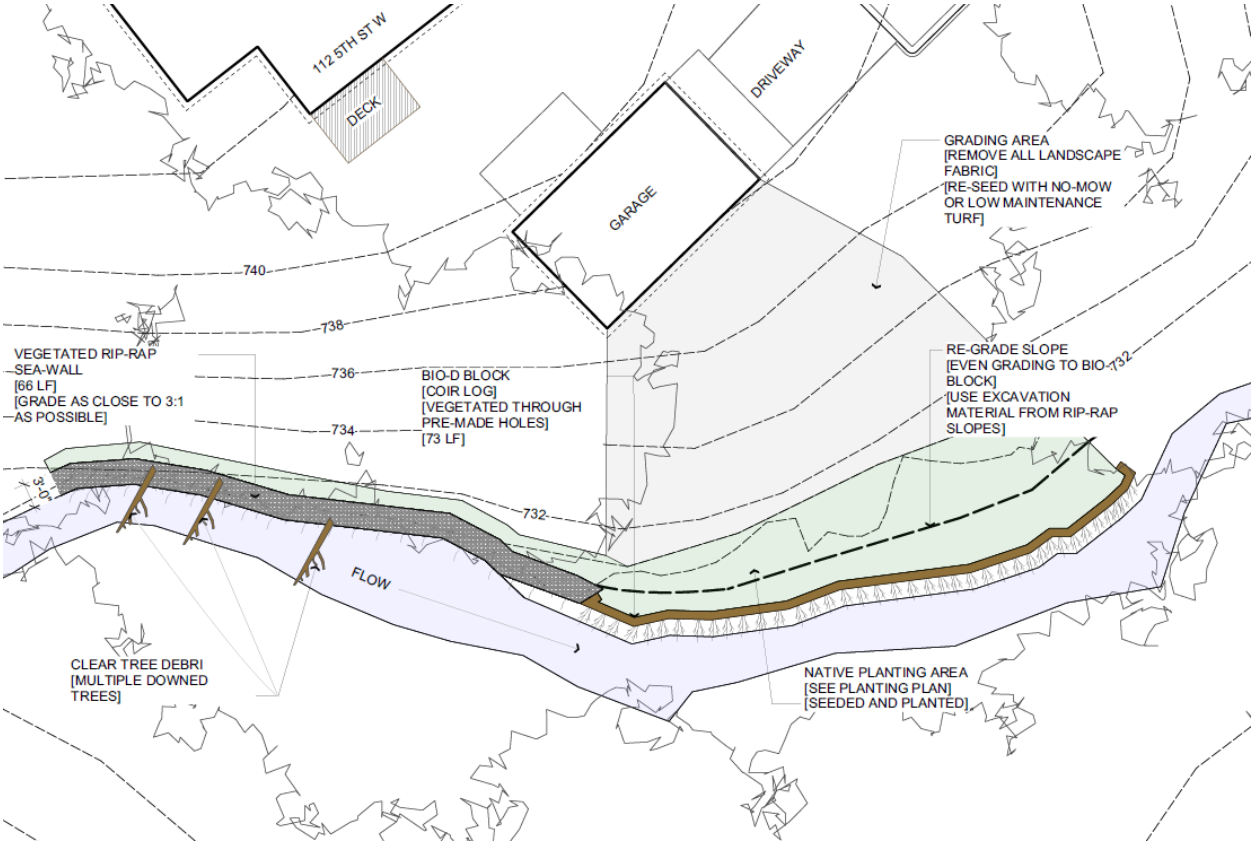
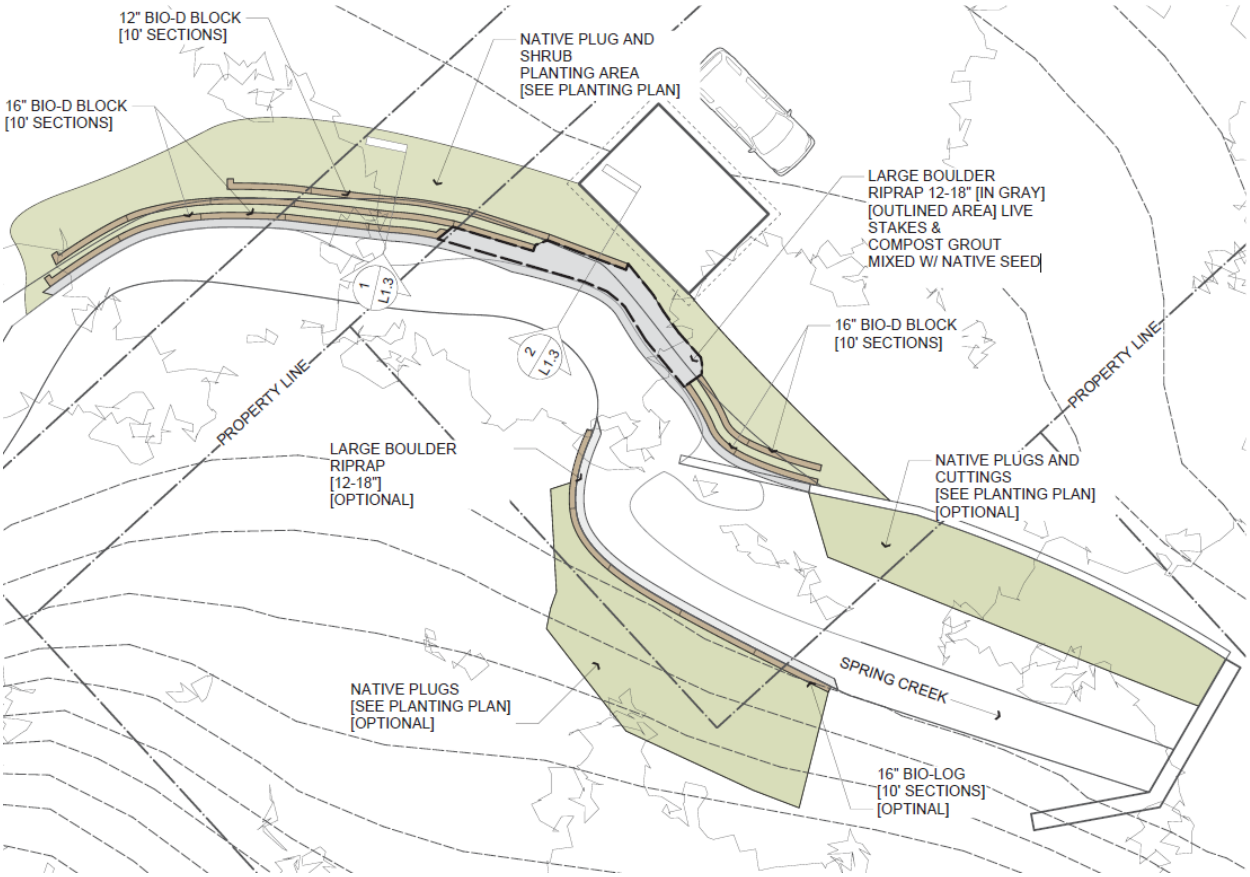


Figure 21. Carver SWCD 2019 proposed design for Site 2 (404 Broadway)



Bio-D block walls, similar to coir logs and mats, have an assumed permissible shear strength of four to eight pounds per square foot (lbs/sf), while riprap has a permissible shear strength of five to eight lbs/sf.[5] The maximum permissible shear stress and velocities assumed for the Carver SWCD design are provided in Table 5.

Table 5. Assumed Shear Stress and Velocities for Spring Creek Designs (adopted from Fischenich 2001)

	Permissible Velocities (feet per second [fps])	Permissible Shear Stress (lbs/sf)
Sandy Loam Soil	1.75	0.03
Long Native Grasses	5.0	1.5
Short Native and Bunch Grass	3.0	0.8
Bio-D Block Wall	9.5	5.0
Riprap	12.0	6.0

Barr Engineering reviewed the SWCD designs in 2019 and made additional

[5] Craig Fischenich, *Stability Thresholds for Stream Restoration Materials*, (Ecosystem Management and Restoration Research Program, May 2001).

recommendations which included evaluating past, present, and future hydrology and hydraulics to aid in the channel stabilization design; reconnecting the channel to its floodplain through grade control measures; and realigning the stream to its former alignment (Attachment 1).

To determine if the 2019 SWCD will be suitable for the site, we ran the HEC-RAS model with the presettlement, existing conditions, and 2050 estimated flows to determine the high-water elevations, velocities, and potential shear stress at each site (Tables 6 through 14, and Attachment 3). For reference, the garage at Site 1 is at elevation 737 and the garage at Site 2 is at elevation 725.45 per Carver SWCD.

Table 6. High Water Elevations (HWL) (NAVD88) at Spring Creek Project Sites—Presettlement Conditions

	Site 1 HWL (RS 1834.33)	Site 1 Garage Inundated	Site 2 HWL (RS 1389)	Site 2 Garage Inundated
1-Year	729.3	No	721.4	No
2-Year	729.5	No	722.1	No
10-Year	730.4	No	725.3	No
100-Year	731.2	No	730.6	Yes

Table 7. Total Velocity (fps) at Spring Creek Project Sites—Presettlement Conditions (assumes that long native grasses comprise the creek banks)

	Site 1 Total Velocity (RS 1834.33)	Site 1 Stable	Site 2 Total Velocity (RS 1389)	Site 2 Stable
1-Year	3.6	Yes	1.17	Yes
2-Year	5.5	No	1.76	Yes
10-Year	7.9	No	1.97	Yes
100-Year	10.1	No	1.21	Yes

Table 8. Total Shear Stress (lbs/sq ft) at Spring Creek Project Sites—Presettlement Conditions (assumes that long native grasses comprise the creek banks)

	Site 1 Total Shear (RS 1834.33)	Site 1 Stable	Site 2 Total Shear (RS 1389)	Site 2 Stable
1-Year	0.7	Yes	0.06	Yes
2-Year	1.6	No	0.12	Yes
10-Year	2.7	No	0.10	Yes
100-Year	3.6	No	0.04	Yes

Under presettlement conditions, assuming that Spring Creek comprised the underlying sandy loam and was vegetated with long native grasses, both sites would have been relatively stable in terms of velocities and total shear stresses during small, channel-forming events. Additionally, for Site 1, floodwaters would not have encroached upon the elevation of the garage. For Site 2, the garage is still below the 100-year flood elevation and would have been inundated even if the watershed was returned to its presettlement conditions. This indicates the location of the garage at 404 Broadway was potentially always within the floodplain.

Table 9. High Water Elevations (HWL) (NAVD88) at Spring Creek Project Sites—Existing Conditions

	Site 1 HWL (RS 1834.33)	Site 1 Garage Inundated	Site 2 HWL (RS 1389)	Site 2 Garage Inundated
1-Year	730.0	No	722.8	No
2-Year	730.2	No	723.4	No
10-Year	731.1	No	726.0	Yes
100-Year	732.4	No	733.2	Yes

Table 10. Total Velocity (fps) at Spring Creek Project Sites—Existing Conditions (assumes that short native and bunch grasses comprise the creek banks)

	Site 1 Total Velocity (RS 1834.33)	Site 1 Stable	Site 2 Total Velocity (RS 1389)	Site 2 Stable
1-Year	6.9	No	1.67	Yes
2-Year	7.6	No	1.80	Yes
10-Year	9.8	No	1.96	Yes
100-Year	12.5	No	0.93	Yes

Table 11. Total Shear Stress (lbs/sq ft) at Spring Creek Project Sites—Existing Conditions (assumes that short native and bunch grasses comprise the creek banks)

	Site 1 Total Shear Stress (RS 1834.33)	Site 1 Stable	Site 2 Total Shear Stress (RS 1389)	Site 2 Stable
1-Year	2.2	No	0.09	Yes
2-Year	2.5	No	0.10	Yes
10-Year	3.5	No	0.08	Yes
100-Year	4.3	No	0.02	Yes

Similar to the presettlement conditions, floodwaters at Site 1 are not expected to encroach upon the garage under the current Spring Creek hydrology; but at Site 2 the garage can expected to be flooded from the 10- and 100-year events.

Still assuming the same underlying sandy loam soils comprise the creek banks but are vegetated with short native and bunch grasses as was observed in the field, Site 2 is stable, however Site 1 would be expected to show signs of erosion (as it does currently). The proposed SWCD designs of Bio-D block walls and riprap should be sufficient to withstand the expected velocities and stresses under the current conditions. We recommend evaluating the size of the riprap to ensure it can withstand the expected velocities at Site 1.

Table 12. High Water Elevations (HWL) (NAVD88) at Spring Creek Project Sites—2050 Conditions

	Site 1 HWL (RS 1834.33)	Site 1 Garage Inundated	Site 2 HWL (RS 1389)	Site 2 Garage Inundated
1-Year	730.8	No	725.3	No
2-Year	731.1	No	726.4	Yes
10-Year	731.9	No	731.1	Yes
100-Year	733.5	No	734.9	Yes

Table 13. Total Velocity (fps) at Spring Creek Project Sites—2050 Conditions (assumes that short native and bunch grasses comprise the creek banks)

	Site 1 Total Velocity (RS 1834.33)	Site 1 Stable	Site 2 Total Velocity (RS 1389)	Site 2 Stable
1-Year	9.0	No	1.97	Yes
2-Year	9.9	No	1.93	Yes
10-Year	12.0	No	1.13	Yes
100-Year	13.2	No	1.21	Yes

Table 14. Total Shear Stress (lbs/sq ft) at Spring Creek Erosion Sites—2050 Conditions (assumes short native and bunch grasses comprise the creek banks)

	Site 1 Total Shear Stress (RS 1834.33)	Site 1 Stable	Site 2 Total Shear Stress (RS 1389)	Site 2 Stable
1-Year	3.2	No	0.10	Yes
2-Year	3.6	No	0.08	Yes
10-Year	4.1	No	0.03	Yes
100-Year	4.7	No	0.04	Yes

Similar to the other hydrology scenarios we evaluated, floodwaters at Site 1 are not expected to encroach upon the garage under the projected 2050 Spring Creek hydrology; but at Site 2 the garage will likely be flooded from regular rainfall events (2.89 inches of rainfall).

In terms of velocities and shear stresses, the existing short native and bunch grasses would not be expected to withstand future hydrologic conditions at Site 1, but Site 2 could remain relatively stable if the vegetation remains healthy and in place. The proposed SWCD designs for both sites would appear to be adequate, but the placement, gradation, and size of the riprap should be refined based on the hydraulic modeling to ensure that it can withstand the expected velocities and shear stresses of large events in the future.

Discussion

Unsurprisingly, the increase in rainfall runoff directly increases the water surface elevations in the above scenarios. Interestingly, there is not as clear a correlation between flow rates and the total channel shear stress. Given the sandy nature of the watershed's soils, the creek will be prone to channel incision and bank erosion without the added protection of adequate vegetation. Site 1 experiences the highest shear stresses and the greatest velocities of five to fifteen fps in this reach, making it more active than Site 2. Site 2 has average velocities between one and six fps and very low shear stresses, indicating that while the creek has experienced significant erosion, it may have reached an equilibrium. Both sites would benefit from the proposed SWCD designs; however, based on this analysis, Site 1 appears to be the more active reach at this time.

Complicating this project is the fact that the entire channel is privately owned by multiple

landowners. While individual landowners can and should work to prevent erosion of their streambanks, in a case like this, the causes of erosion are being driven by the larger landscape changes and are somewhat out of the individual's control. It also makes it unlikely that spot repairs like those proposed by the SWCD would be successful in the long-term without addressing the underlying causes of erosion.

During the annual LMRWD coordination meeting with the city of Carver on May 11, 2021, the city indicated that it would be interested in a large-scale project but cannot get involved on an individual scale because it only benefits two landowners. A successful restoration would review the project wholistically and work with all affected landowners so that a restoration on one property does not cause issues for a neighbor and benefits the entire neighborhood. The hydraulic analysis indicates that portions of the entire reach between 4th and 6th Streets would benefit from stabilization measures to prevent the channel from further migrating and causing damage to property, as well as causing increased sediment to enter the Minnesota River. The existing vegetation and native soils are unlikely to withstand the current and future velocities and shear stresses.

Recommendations

Spring Creek is a dynamic system which has been experiencing and adapting to a changing environment since the 1800s and will continue to do so, as evidenced by the number of gullies still forming within the watershed. Based on the data we reviewed, we recommend the following management strategies for Spring Creek (these are summarized in Table 15):

- While the Carver SWCD designs appear to be appropriate with slight modifications to the riprap sizes, rather than embark upon single restorations for these individual landowners, we recommend that the District reach out to all Spring Creek landowners in this reach to determine if there is interest for a larger project and how long and where this erosion has been occurring.
- With landowner interest, we recommend conducting routine monitoring of this reach to establish erosion rates and quantify the amount of sediment that is entering the Minnesota River annually from Spring Creek. This would include establishing monitoring cross-sections to be surveyed annually and conducting a biannual channel profile or thalweg survey to objectively measure changes in the creek.
- Vegetation management, particularly in the floodplain and channel banks, should be explored with the property owners. Removing invasive species and establishing native plantings would improve the riparian corridor's resilience to erosion.
- Site 2 and 116 4th Street West (Site 3) are the most at risk in terms of erosion from Spring Creek. These two locations should be prioritized for stabilization measures to prevent further erosion and potential property damage:
    - The SWCD design for Site 2 is appropriate with an increase in riprap size

combined with a standard gradation.
    - Stabilization designs for 112, 116, and 200 4th Street West (Site 3) have not yet been developed. We recommend reaching out to the property owner and Carver SWCD to conduct a site survey and determine the level of interest for a valley stabilization effort first, then complete a feasibility study to determine the best approach.
- The structures at Site 1 do not appear to be under immediate threat from Spring Creek. We recommend reevaluating the need for stabilization pending the results of the monitoring and vegetation management study.
- This is a complicated reach, further complicated by the city of Carver's proposal to construct a new levee downstream which would further alter the hydrology and hydraulics of Spring Creek. We recommend continued coordination with the city to evaluate the proposed designs and the potential impacts to the erosion of Spring Creek.

Table 15. Spring Creek Recommendations

No.	Recommendation	Type	Year	Estimated Cost
1	Landowner Outreach	Data Collection	2022	$3,000
2	Spring Creek Monitoring and Surveys	Data Collection	2022–2025	$5,000–$10,000 annually
3	Site 3 (116 4th Street West) Feasibility Study	Study	2022–2023	$30,000
4	Site 2 (404 Broadway Street) Stabilization	Construction	2022–2023	$100,000–$150,000
5	Vegetation Management	Study	2024	$40,000
6	Reevaluate Site 1 (112 5th Street) Stabilization Needs	Potential Construction	2026	$75,000–$120,000
7	Coordination with City	Data Collection	Ongoing	$2,000 annually

Attachments

- Barr Engineering Co. Spring Creek Assessment Summary, September 6, 2019
- Spring Creek HydroCAD Models
- Spring Creek HEC-RAS Model Result Tables

Attachment 1—Barr Engineering Co. Spring Creek Assessment Summary, September 6, 2019

resourceful. naturally.
engineering and environmental consultants

BARR

Technical Memorandum

To: Della Schall Young, Young Environmental Consulting Group
From: Jeff Weiss and Kallie Doeden, Barr Engineering
Subject: Spring Creek Assessment Summary
Date: September 6, 2019
Project: 23101028.05

Introduction

Young Environmental Consulting Group contracted with Barr Engineering (Barr) to conduct a site assessment of the stream bank stabilization and erosion at two properties along Spring Creek in Carver, MN. Residents at the two properties (112 5th Street West and 404 Broadway Street; Figure 1) have raised awareness about erosion issues on their properties, and the Carver Soil and Water Conservation District (SWCD) has developed concept plans to stabilize each site. The purpose of this assessment was to develop an additional understanding of the erosion issues; estimate erosion extents and causes; and comment on the Carver SWCD concept plans.

Site Assessment

The two residential properties impacted by the stream bank erosion are located along Spring Creek in Carver, MN in Carver County and within the boundaries of the Lower Minnesota River Watershed District. Staff from Young Environmental Consulting Group and Barr visited the two properties located at 112 5th Street West and 404 Broadway Street on June 21, 2019. The concept plans completed by Carver SWCD are attached to this memorandum.

112 5th Street West

Site Visit

Barr and Young Environmental Consulting Group staff met with the homeowners from the 112 5th Street West property, who showed staff around and explained the stream changes they have seen over the years. Barr and Young Environmental Consulting Group staff inspected the upstream and downstream portions of the main stem of the creek that flows along the property. The homeowners report that the stream path of Spring Creek has moved approximately 25 feet closer to their home in recent years and that the channel is a few feet lower than it used to be. An abandoned stream bed was apparent where the residents said the stream was previously located. It has filled in significantly with sediment and the vegetation does not contain any woody species in the old channel. Homeowners are especially concerned with the rate of erosion and the proximity to the back of their garage. Photos 1 through 6 show several areas along this creek section.

Photo 1: Upstream section unaffected by significant stream bank instability. Structure is approximately 50-feet from the channel.

Photo 2: Stream section facing upstream directly behind garage (sudden drop-off on the right caused by recent erosion, new plant growth on the left, and a previously fallen tree caused by stream bank instability)

Photo 3: Downstream section of creek (new growth is on the right, eroded bank is on the left, and the stream path is relatively new). Barr staff in photo.

Photo 4: Area of stream path changes (from the left flows the incoming fork, to the right is the main stem of the creek, and in the center is the new growth and old stream path). Young Environmental Consulting Group staff, Barr staff, and residents in photo.

Photo 5: Small headcuts causing the stream to become incised.

Photo 6: Bank erosion looking towards the residence at 112 5th Street West. Bank is approximately 40 feet from the structure.

The active bank erosion area is approximately 50-60 feet long, with bank heights between 3-4 feet. The stream gradient in this area is rather steep; however, a survey was not completed to quantify the gradient. The homeowners have stated that flows have increased to the site in recent years, and attribute the increase to development within the watershed. Additional future development within the watershed has been proposed, so they are concerned that the flows will continue to increase.

Evidence observed in the field supports the residents' claim that the stream has moved and become lower. As noted above, an old channel is located nearby, and the channel within the erosion area has tall banks and lacks a sufficient connection to the floodplain. This is evidence that that stream has downcut. Barr and Young Environmental Consulting Group staff did not observe a "smoking gun" of a headcut in the area, but there were several small drops in the stream both within the area in question and in the steep channel upstream of the site.

The erosion observed is likely to continue if stabilization measures are not installed. The erosion does not appear to pose an immediate threat to any structures; however, given the changes the residents have reported in recent years, the system has been changing relatively quickly. Given the recent changes to the system, this site has a moderate level of urgency, meaning that the site should be examined at least once per year and, if possible, visit the site shortly after significant rainfall events to develop a better understanding of the magnitude of flows and velocities at this location. Additional stabilization measures should be installed within five years to minimize the risk of additional erosion; however, installing stabilization measures sooner than five years would be preferable.

Carver SWCD Concept Plan Assessment

The Carver SWCD concept plan includes removing fallen trees, using riprap to armor the channel were banks are eroding, and revegetating with deep rooted species. Barr concurs with the general concept with the following considerations:

1) Additional assessment of the hydrology should be completed to better understand potential changes that have already occurred and may occur into the future, and to help design stabilization measures.
2) Cross vanes should also be installed to provide additional grade control. They may also be used to elevate the stream bed to reconnect the stream to the former floodplain.
3) If the cross vanes cannot completely restore a floodplain connection, then additional grading should be considered to create a floodplain.

A rough estimate for this concept is $75,000, including construction costs, a 30% contingency on construction costs, engineering and design, and the considerations listed above. It would be reasonable to expect the cost to range between -25% and +40% of the estimate above, resulting in an approximate range of $55,000 to $105,000.

Alternative consideration

In a situation like this where the channel has moved, restoring the channel to the previous alignment is often a potential solution. It may be possible in this location; however, it is likely to cost more than the concept developed by Carver SWCD or otherwise stabilizing the channel in place. To restore the channel to the previous alignment, a relatively sharp meander would need to be restored in the midst of the steep channel slope. Flow energy in the channel is likely high due to the steep slope, so the banks would need to be armored in the meander. Furthermore, a significant amount of sediment has already been eroded from the new channel alignment. It is unlikely that accumulated sediment in the old channel would be sufficient to fill the new channel, therefore, additional fill may be necessary to fill the relatively new channel. If the new channel is not completely filled, then it may remain a preferential flow path during high flow events.

A rough estimate for this concept is $114,000, including construction costs, a 30% contingency on construction costs, engineering and design, and the considerations listed above. The main difference between the two estimates is the additional excavation needed to move the channel, plus the additional clearing and restoration that would be required. It would be reasonable to expect the cost to range between -25% and +40% of the estimate above, resulting in an approximate range of $86,000 to $160,000.

404 Broadway Street

Site Visit

The residents from the 404 Broadway Street property were not available, so Barr and Young Environmental Consulting Group staff inspected the portion of Spring Creek that flows along the property. The stream path of Spring Creek has made significant changes, as is evident by the damage to the existing retaining wall and erosion along the stream banks. It is unknown when the retaining wall was breeched and erosion began to pose an immediate threat to the garage; however Google Earth imagery suggests the stream has been moving closer to the garage since 2012. Photos 7 through 10 show several areas of along this creek section.

Photo 7: Upstream section with noticeable change in stream path

Photo 8: Downstream section of stream with significant erosion encroaching on the garage and damaged retaining wall

Photo 9: Close-up of recent erosion that is within a foot or two of the homeowner's garage

Photo 10: Close-up of damaged retaining wall most likely caused by stream path change

The upstream resident at 112 5th Street noted increased flows in recent years. If true, then the increased flows could be contributing to the increased erosion rate at this property as well. Stream also appears to

have been straightened at some point in the past, likely when the retaining wall was installed. Some of the cause of erosion may be attributed to the stream attempting to recreate a meander pattern. Fresh sand bars were also observed in this area, which could be eroded material from upstream. The stream gradient is noticeably less steep in this area, so it would be a location for sediment to deposit. The sediment deposition may be exacerbating the channel movement.

The erosion has already encroached to within a few feet of the garage, so the garage is under an immediate threat of damage if erosion continues. Stabilization work at this site should be implemented as soon as possible.

Carver SWCD Concept Plan Assessment

The Carver SWCD concept plan includes using riprap to armor the channel were banks are eroding, installing coir blocks in other areas with less stress, and revegetating with deep rooted species. Barr concurs with the general concept with the following considerations:

1) Additional assessment of the hydrology should be completed to better understand potential changes that have already occurred and may occur into the future.

A rough estimate for this concept is $88,000, including construction costs, a 30% contingency on construction costs, engineering and design, and the considerations listed above. It would be reasonable to expect the cost to range between -25% and +40% of the estimate above, resulting in an approximate range of $66,000 to $124,000.

Alternative consideration

In a situation like this where the channel has moved, restoring the channel to the previous alignment is often a potential solution. It may be possible in this location; and even though it would likely restore an artificially straightened channel, it would also reduce the risk of additional erosion in the newly created meander on the bank opposite of the garage.. Similar to the upstream property, additional fill would be necessary to restore all banks, so the cost would likely be more than the Carver SWCD concept.

A rough estimate for this concept is $99,000, including construction costs, a 30% contingency on construction costs, engineering and design, and the considerations listed above. It would be reasonable to expect the cost to range between -25% and +40% of the estimate above, resulting in an approximate range of $75,000 to $139,000.

Conclusions and Recommendations

Per the site assessment and review of the proposed plans, Barr has the following recommendations:

- Complete an assessment of the hydrology, including potential future changes. This information will be important for the design of stabilization measures at both locations. Given the urgency of implementing stabilization at the 404 Broadway site, the design and hydrologic analysis could be done concurrently.

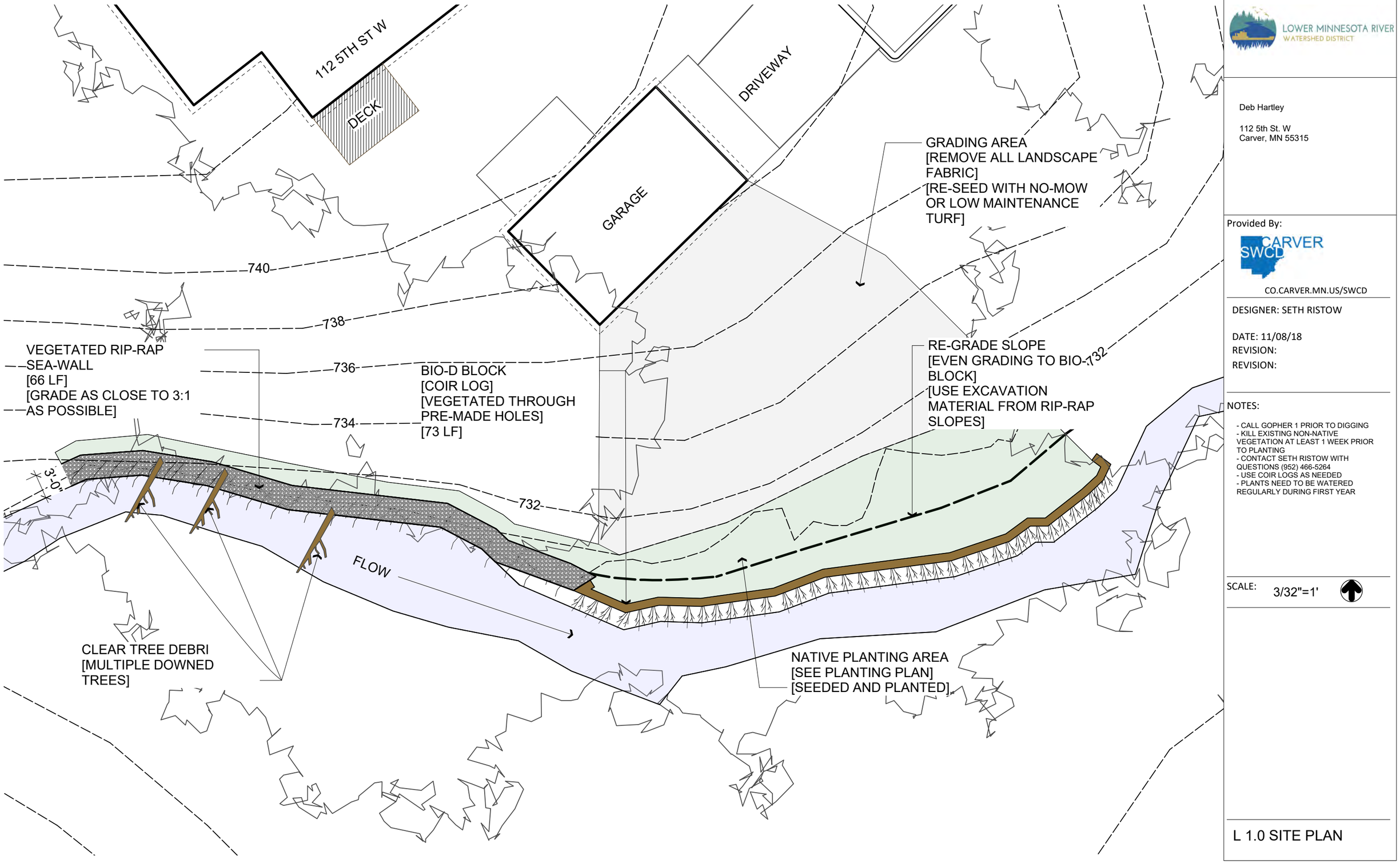
- At 404 Broadway, restore the channel to the previous alignment, which will provide additional space between the garage and the creek.
- Restore the previous channel alignment at 112 5th Street, with consideration of the modified hydrology draining to this location.

Barr Footer: ArcGIS 10.6, 2019-09-06 12:46 File: I:\Client\LowerMinnesotaWD\Work_Orders\2019_Spring_Creek\Maps\Spring Creek base.mxd User: jdw

BARR

SPRING CREEK
EROSION SITES
Carver, MN
Lower Minnesota River
Watershed District

FIGURE 1



LOWER MINNESOTA RIVER WATERSHED DISTRICT

Deb Hartley

112 5th St. W
Carver, MN 55315

Provided By:

CARVER SWCD

CO.CARVER.MN.US/SWCD

DESIGNER: SETH RISTOW

DATE: 11/08/18
REVISION:
REVISION:

NOTES:

- CALL GOPHER 1 PRIOR TO DIGGING
- KILL EXISTING NON-NATIVE VEGETATION AT LEAST 1 WEEK PRIOR TO PLANTING
- CONTACT SETH RISTOW WITH QUESTIONS (952) 466-5264
- USE COIR LOGS AS NEEDED
- PLANTS NEED TO BE WATERED REGULARLY DURING FIRST YEAR

SCALE: 3/32"=1'

L 1.0 SITE PLAN

Quantity	Common Name	Latin Name
10	Bush Honeysuckle	Diervilla lonicera
3	Nannyberry	Viburnum lentago
11	Pussy Willow	Salix discolor
1	Chokecherry	Prunus virginiana
45	Tufted Hair Grass	Deschampsia caespitosa
43	Ostrich Fern	Matteuccia struthiopteris
5	Buttonbush	Cephalanthus occidentalis
3	Blackhaw Viburnum	Viburnum prunifolium
3	Ninebark	Physocarpus opulifolius
7	Prairie Cordgrass	Spartina pectinata
7	Culver's Root	Veronicastrum
5	Queen of the Prairie	Filipendula rubra
6	Joe-Pye Weed	Eupatorium purpureum
6	Marsh Blazing Star	Liatris spicata
7	Switchgrass	Panicum virgatum
6	Canadian Anemone	Anemone canadensis

15-Tufted Hair Grass
43-Ostrich Fern
3-Marsh Blazing Star
3-Marsh Blazing Star
1-Chokecherry
3-Nannyberry
eysuckle
3-Canadian Anemone
7-Switchgrass
3-Canadian Anemone
5-Queen of the Prairie
16-Tufted Hair Grass
14-Tufted Hair Grass
5-Pussy Willow
3-Blackhaw Viburnum
5-Buttonbush
7-Culver's Root
7-Bush Honeysuckle
5-Pussy Willow
6-Joe-Pye Weed
3-Ninebark
7-Prairie Cordgrass

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L 1.0 PLANTING PLAN

CARVER SWCD
MATERIAL & COST ESTIMATE

Hartley

Streambank Stabilization

LF: 140
SF: NA
Date: 21-Nov-18

Materials: Streambank Stabilization

Item	Qty	Unit	Unit Cost	Amount	Potential Source
Twice-Shredded Hardwood Mulch (3" depth)	8.0	cu-yd	$ 30.00	$ 240.00	Hedberg, Frador, Local Supplier
Non-Woven Geotextile (Geotex 401, Mirfani 140N, or equal)	200	sq-ft	$ 0.07	$ 14.00	Brock White, (651) 647-0950
C125BN (6.5' x 108.5')	1,390	sq-ft	$ 0.22	$ 305.80	Brock White, (651) 647-0950
Bio D Block 12 (10')	8	each	$ 126.00	$ 1,008.00	Rolanka
Wood Stakes (2" x 4" x 48" - hardwood)	40	each	$ 1.00	$ 40.00	Brock White, (651) 647-0950
Aggregate: Buff Limestone (18"-24")	15.0	Tons	$ 30.00	$ 450.00	Hedberg, Frador, Local Supplier
			Materials Subtotal	$ 2,057.80	

Plants: Streambank Stabilization

Item	Qty	Unit	Unit Cost	Amount	Potential Source
Native Plant: Plug	132	each	$ 2.00	$ 264.00	Native Plant Supplier
Native Shrub: 1 Gallon	36	each	$ 15.00	$ 540.00	Native Plant Supplier
Native Seed (Moist Meadow) 1/4LB	1.00	each	$ 125.00	$ 125.00	Native Plant Supplier
No Mow Seed	2.00	lb	$ 7.00	$ 14.00	Native Plant Supplier
			Plants Subtotal	$ 943.00	

Labor: Streambank Stabiliza

Mobilization	1.00	job	$ 250.00	$ 250.00	Landscape/Excavation Contractor
Deliveries (Mulch, Plants, Rock, Soil, etc)	2	job	$ 150.00	$ 300.00	Suppliers/Contractors
Disposal	1.00	job	$ 500.00	$ 500.00	Landscape/Excavation Contractor
Grading (Tracked Equipment Only - no wheeled vehicles in excavation area)	5	hrs	$ 85.00	$ 425.00	Landscape/Excavation Contractor
Material Installation (4 person crew/ 10hr day)	4.50	job	$ 2,500.00	$ 11,250.00	Landscape/Excavation Contractor
			Subtotal	$ 12,725.00	

Project Total: Raingarden #4

Materials Estimate:	$	2,057.80
Plants Estimate:	$	943.00
Labor Estimate:	$	12,725.00
Project Estimate:	$	15,725.80
:-10%	$	14,153.22
:+10%	$	17,298.38

AREA OF EROSION

X[725.7]

EXISTING CONCRETE
DEBRI
[REMOVE]

PROPERTY LINE

GARAGE

X[723.03]

X[722.13]

X[722.06]

SPRING CREEK

X[725.45]

X[721.71]

PROPERTY LINE

X[722.85]

TOP OF BANK

X[724.3]

EXISTING CONCRETE
WALL
[REMOVE AT JOINT]

PROPERTY LINE

EXISTING CONCRETE
WALL
[KEEP]

EXISTING CONCRETE
WALL
[REMOVE]

FLOW

AREA OF EROSION

BRIDGE

4TH ST. E

LOWER MINNESOTA RIVER
WATERSHED DISTRICT

SPRING CREEK [CITY OF CARVER]

404 BROADWAY ST.
CARVER, MN 55315

Provided By:

CARVER SWCD

CO.CARVER.MN.US/SWCD

DESIGNER: SETH RISTOW

DATE: 02/12/19
REVISION:
REVISION:

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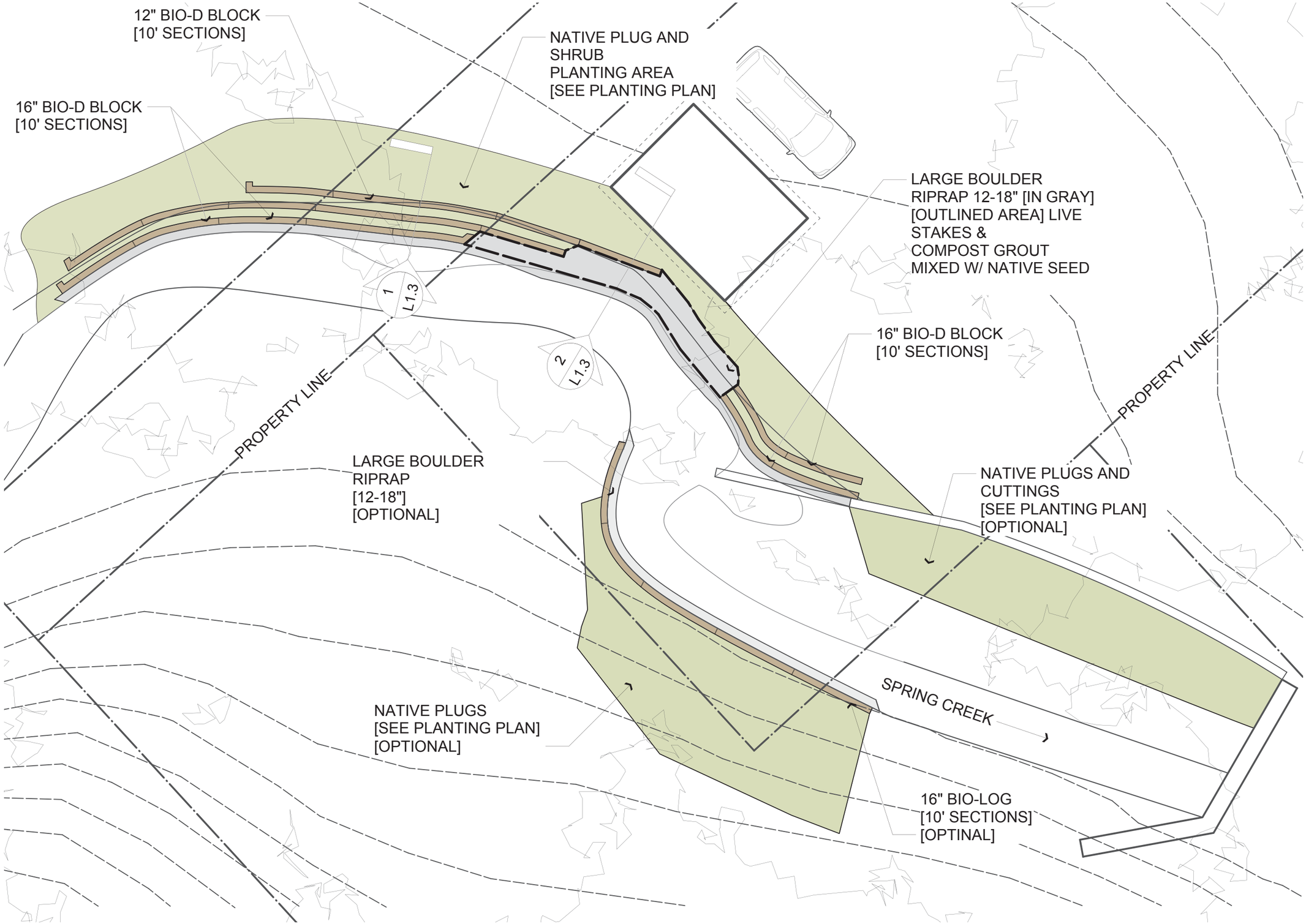
L 1.0 EXISTING SITE



LOWER MINNESOTA RIVER WATERSHED DISTRICT

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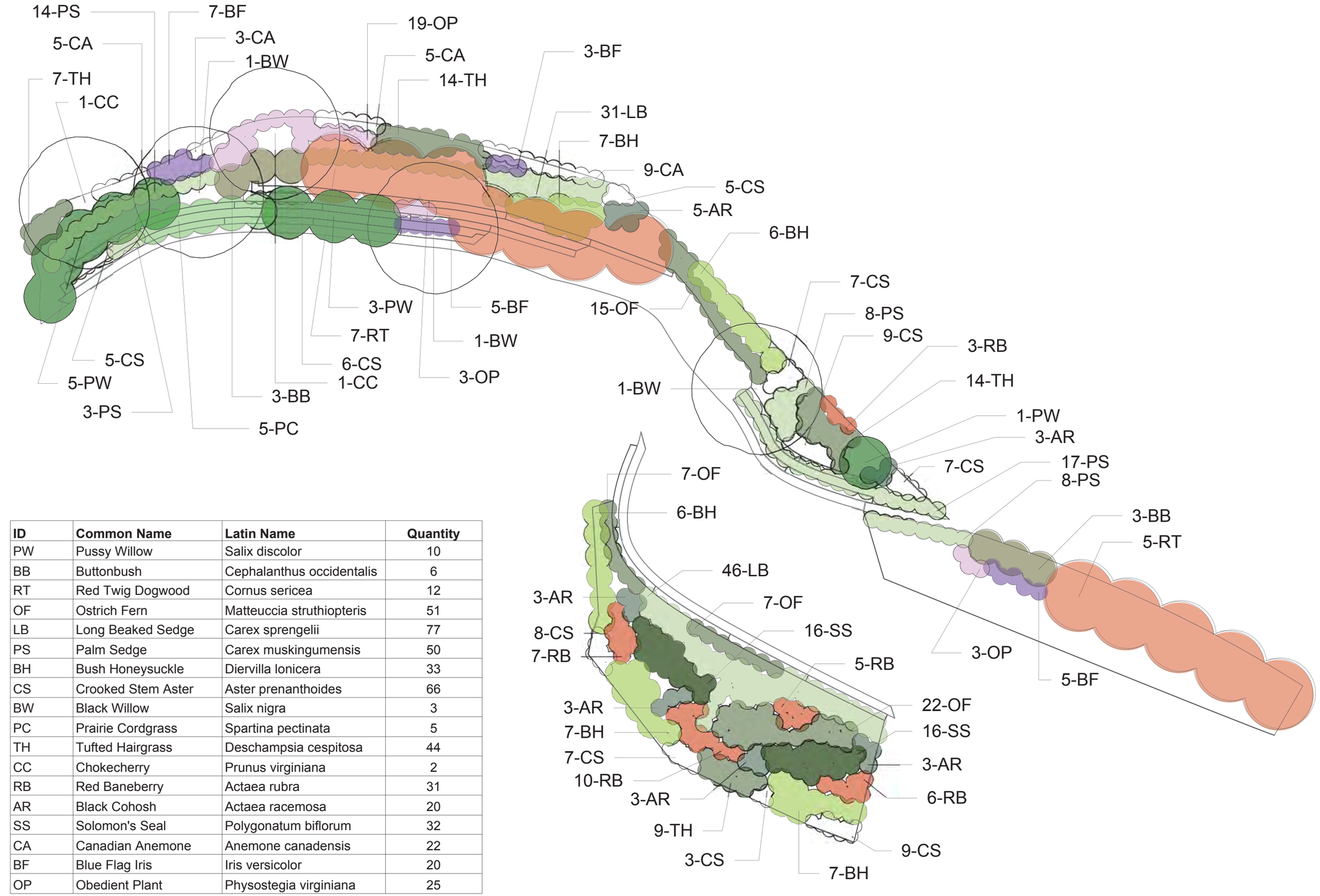
L 1.1 SITE PLAN



ID	Common Name	Latin Name	Quantity
PW	Pussy Willow	Salix discolor	10
BB	Buttonbush	Cephalanthus occidentalis	6
RT	Red Twig Dogwood	Cornus sericea	12
OF	Ostrich Fern	Matteuccia struthiopteris	51
LB	Long Beaked Sedge	Carex sprengelii	77
PS	Palm Sedge	Carex muskingumensis	50
BH	Bush Honeysuckle	Diervilla lonicera	33
CS	Crooked Stem Aster	Aster prenanthoides	66
BW	Black Willow	Salix nigra	3
PC	Prairie Cordgrass	Spartina pectinata	5
TH	Tufted Hairgrass	Deschampsia cespitosa	44
CC	Chokecherry	Prunus virginiana	2
RB	Red Baneberry	Actaea rubra	31
AR	Black Cohosh	Actaea racemosa	20
SS	Solomon's Seal	Polygonatum biflorum	32
CA	Canadian Anemone	Anemone canadensis	22
BF	Blue Flag Iris	Iris versicolor	20
OP	Obedient Plant	Physostegia virginiana	25

LOWER MINNESOTA RIVER WATERSHED DISTRICT

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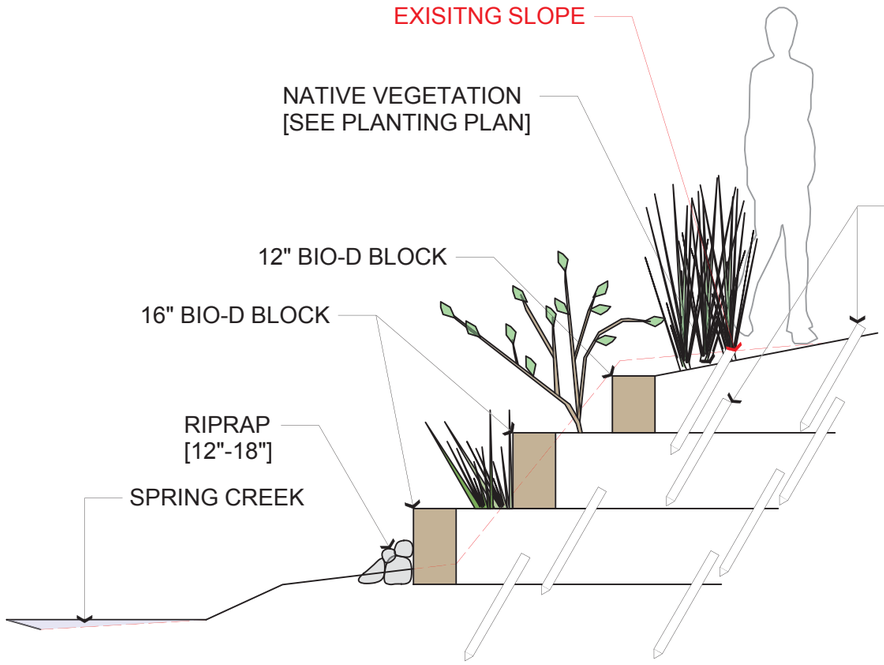
SCALE: 3/32"=1'

L 1.2 PLANTING PLAN

1 SECTION 1
Scale: 3/8" = 1'-0"



2 SECTION 2
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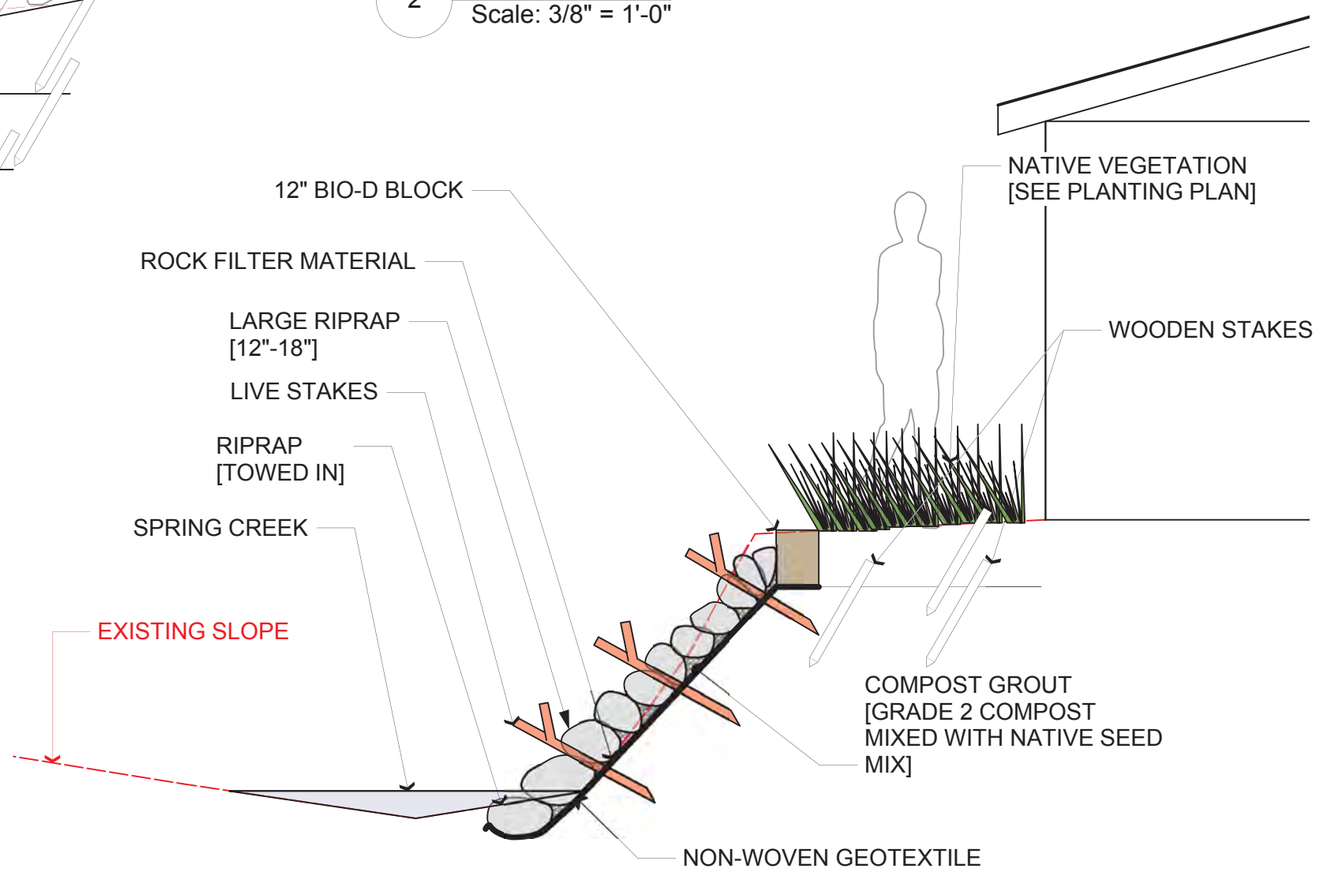

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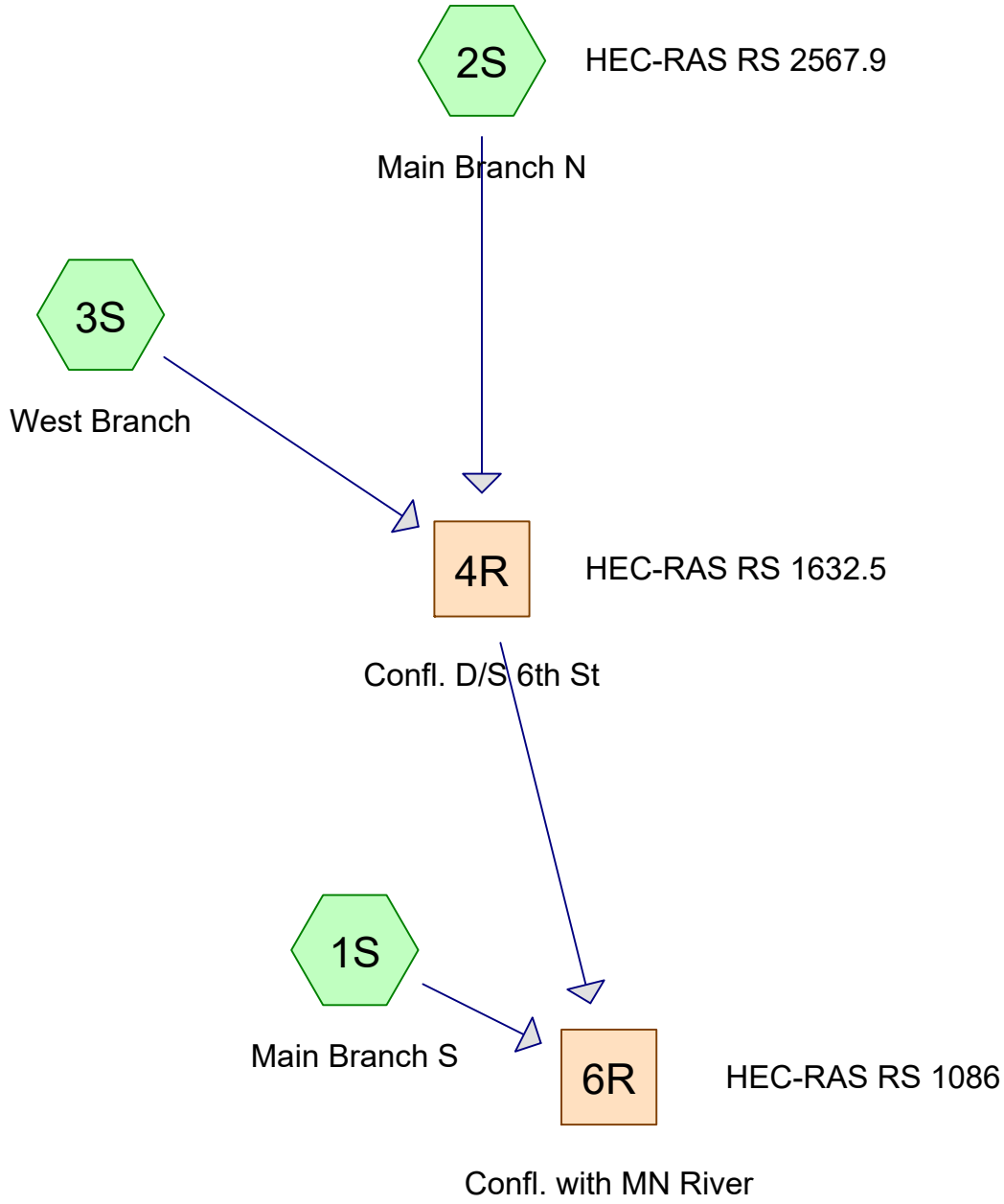
L 1.3 SECTIONS

Attachment 2—Spring Creek HydroCAD Models

Pre-Settlement Conditions



Subcat Reach Pond Link

Routing Diagram for SpringCk_PreSettlement_v1
Prepared by {enter your company name here}, Printed 12/15/2021

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	1-YR	Type II 24-hr		Default	24.00	1	2.30	2
2	2-YR	Type II 24-hr		Default	24.00	1	2.80	2
3	10-YR	Type II 24-hr		Default	24.00	1	4.20	2
4	100-YR	Type II 24-hr		Default	24.00	1	6.00	2

Summary for Subcatchment 1S: Main Branch S

Runoff = 0.88 cfs @ 12.45 hrs, Volume= 0.293 af, Depth= 0.14"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 1-YR Rainfall=2.30"

	Area (ac)	CN	Description
*	24.956	61	
	24.956		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
29.0	2,593	0.1571	1.49		**Lag/CN Method,**

Summary for Subcatchment 2S: Main Branch N

Runoff = 23.64 cfs @ 12.71 hrs, Volume= 6.106 af, Depth= 0.25"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 1-YR Rainfall=2.30"

	Area (ac)	CN	Description
*	291.836	66	
	291.836		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.2	7,373	0.1994	2.35		**Lag/CN Method,**

Summary for Subcatchment 3S: West Branch

Runoff = 16.07 cfs @ 12.60 hrs, Volume= 4.340 af, Depth= 0.20"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 1-YR Rainfall=2.30"

	Area (ac)	CN	Description
*	256.495	64	
	256.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
42.8	4,622	0.1556	1.80		**Lag/CN Method,**

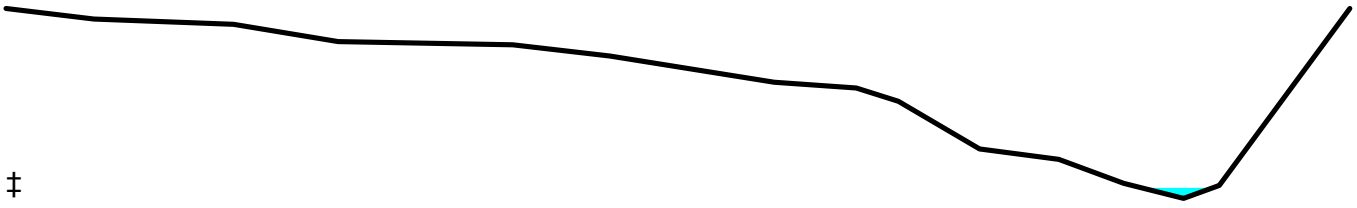
Summary for Reach 4R: Confl. D/S 6th St

Inflow Area = 548.331 ac, 0.00% Impervious, Inflow Depth = 0.23" for 1-YR event
Inflow = 39.30 cfs @ 12.66 hrs, Volume= 10.446 af
Outflow = 39.27 cfs @ 12.69 hrs, Volume= 10.446 af, Atten= 0%, Lag= 1.8 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Reference Flow= 29.47 cfs Estimated Depth= 1.26' Velocity= 2.67 fps
m= 1.333, c= 3.56 fps, dt= 3.0 min, dx= 412.0' / 1 = 412.0', K= 1.9 min, X= 0.382
Max. Velocity= 4.10 fps, Min. Travel Time= 1.7 min
Avg. Velocity = 3.56 fps, Avg. Travel Time= 1.9 min

Peak Storage= 4,543 cf @ 12.68 hrs
Average Depth at Peak Storage= 1.27' , Surface Width= 17.25'
Bank-Full Depth= 22.91' Flow Area= 2,801.7 sf, Capacity= 42,244.13 cfs

Custom cross-section, Length= 412.0' Slope= 0.0097 '/' (112 Elevation Intervals)
Constant n= 0.040
Inlet Invert= 726.00', Outlet Invert= 722.00'



‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	746.53	0.00
21.36	745.26	1.27
55.32	744.62	1.91
80.79	742.54	3.99
123.24	742.14	4.39
146.82	740.79	5.74
186.80	737.63	8.90
206.79	736.93	9.60
217.02	735.34	11.19
236.78	729.59	16.94
256.03	728.33	18.20
271.84	725.43	21.10
286.39	723.62	22.91
295.06	725.18	21.35
326.81	746.53	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Width (feet)	Storage (cubic-feet)	Discharge (cfs)	m
0.00	0.0	0.0	0.0	0	0.00	1.333
1.56	16.5	21.4	21.2	6,816	50.94	1.333
1.81	22.1	23.9	23.6	9,123	77.00	1.362
4.71	119.7	45.2	43.7	49,332	839.27	1.394
5.97	188.1	66.7	64.8	77,508	1,374.15	1.280
11.72	642.3	97.6	93.1	264,644	8,256.18	1.419
13.31	800.5	110.8	105.7	329,789	10,948.28	1.386
14.01	881.8	132.1	126.8	363,319	11,445.31	1.346
17.17	1,353.0	177.8	171.5	557,453	19,158.29	1.290
18.52	1,601.8	203.9	197.0	659,932	23,171.24	1.262
18.92	1,689.2	247.1	240.1	695,951	22,274.71	1.345
21.00	2,218.3	276.3	268.6	913,935	32,554.33	1.360
21.64	2,401.4	311.5	303.6	989,375	34,307.23	1.324
22.91	2,801.7	335.1	326.8	1,154,293	42,244.13	1.329

Summary for Reach 6R: Confl. with MN River

Cross-section from HEC-RAS RS 1086; outflow from this node used to set D/S boundary conditions in HEC-RAS model

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[61] Hint: Exceeded Reach 4R outlet invert by 0.78' @ 12.70 hrs

Inflow Area = 573.287 ac, 0.00% Impervious, Inflow Depth = 0.22" for 1-YR event
Inflow = 40.06 cfs @ 12.69 hrs, Volume= 10.738 af
Outflow = 40.05 cfs @ 12.73 hrs, Volume= 10.738 af, Atten= 0%, Lag= 2.5 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 30.04 cfs Estimated Depth= 0.86' Velocity= 5.48 fps
m= 1.507, c= 8.26 fps, dt= 1.5 min, dx= 1,240.0' / 2 = 620.0', K= 1.3 min, X= 0.478
Max. Velocity= 10.11 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 8.27 fps, Avg. Travel Time= 2.5 min

Peak Storage= 6,008 cf @ 12.71 hrs
Average Depth at Peak Storage= 0.78' , Surface Width= 7.35'
Bank-Full Depth= 20.00' Flow Area= 700.0 sf, Capacity= 21,848.71 cfs

5.00' x 20.00' deep channel, n= 0.030
Side Slope Z-value= 1.5 '/' Top Width= 65.00'
Length= 1,240.0' Slope= 0.0210 '/'
Inlet Invert= 722.00', Outlet Invert= 696.00'

Summary for Subcatchment 1S: Main Branch S

Runoff = 3.29 cfs @ 12.34 hrs, Volume= 0.608 af, Depth= 0.29"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-YR Rainfall=2.80"

	Area (ac)	CN	Description
*	24.956	61	
	24.956		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
29.0	2,593	0.1571	1.49		**Lag/CN Method,**

Summary for Subcatchment 2S: Main Branch N

Runoff = 54.02 cfs @ 12.64 hrs, Volume= 11.005 af, Depth= 0.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-YR Rainfall=2.80"

	Area (ac)	CN	Description
*	291.836	66	
	291.836		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.2	7,373	0.1994	2.35		**Lag/CN Method,**

Summary for Subcatchment 3S: West Branch

Runoff = 42.26 cfs @ 12.52 hrs, Volume= 8.215 af, Depth= 0.38"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-YR Rainfall=2.80"

	Area (ac)	CN	Description
*	256.495	64	
	256.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
42.8	4,622	0.1556	1.80		**Lag/CN Method,**

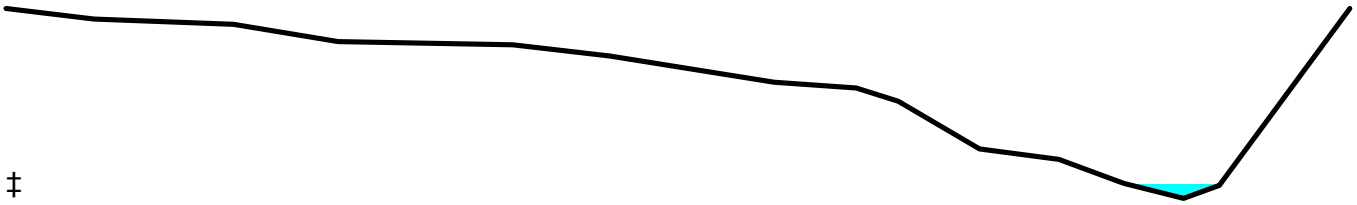
Summary for Reach 4R: Confl. D/S 6th St

Inflow Area = 548.331 ac, 0.00% Impervious, Inflow Depth = 0.42" for 2-YR event
Inflow = 95.04 cfs @ 12.59 hrs, Volume= 19.220 af
Outflow = 94.92 cfs @ 12.61 hrs, Volume= 19.220 af, Atten= 0%, Lag= 1.5 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Reference Flow= 71.28 cfs Estimated Depth= 1.76' Velocity= 3.39 fps
m= 1.356, c= 4.60 fps, dt= 3.0 min, dx= 412.0' / 1 = 412.0', K= 1.5 min, X= 0.338
Max. Velocity= 5.10 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 4.60 fps, Avg. Travel Time= 1.5 min

Peak Storage= 8,500 cf @ 12.60 hrs
Average Depth at Peak Storage= 1.74' , Surface Width= 22.95'
Bank-Full Depth= 22.91' Flow Area= 2,801.7 sf, Capacity= 42,244.13 cfs

Custom cross-section, Length= 412.0' Slope= 0.0097 '/' (112 Elevation Intervals)
Constant n= 0.040
Inlet Invert= 726.00', Outlet Invert= 722.00'



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Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	746.53	0.00
21.36	745.26	1.27
55.32	744.62	1.91
80.79	742.54	3.99
123.24	742.14	4.39
146.82	740.79	5.74
186.80	737.63	8.90
206.79	736.93	9.60
217.02	735.34	11.19
236.78	729.59	16.94
256.03	728.33	18.20
271.84	725.43	21.10
286.39	723.62	22.91
295.06	725.18	21.35
326.81	746.53	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Width (feet)	Storage (cubic-feet)	Discharge (cfs)	m
0.00	0.0	0.0	0.0	0	0.00	1.333
1.56	16.5	21.4	21.2	6,816	50.94	1.333
1.81	22.1	23.9	23.6	9,123	77.00	1.362
4.71	119.7	45.2	43.7	49,332	839.27	1.394
5.97	188.1	66.7	64.8	77,508	1,374.15	1.280
11.72	642.3	97.6	93.1	264,644	8,256.18	1.419
13.31	800.5	110.8	105.7	329,789	10,948.28	1.386
14.01	881.8	132.1	126.8	363,319	11,445.31	1.346
17.17	1,353.0	177.8	171.5	557,453	19,158.29	1.290
18.52	1,601.8	203.9	197.0	659,932	23,171.24	1.262
18.92	1,689.2	247.1	240.1	695,951	22,274.71	1.345
21.00	2,218.3	276.3	268.6	913,935	32,554.33	1.360
21.64	2,401.4	311.5	303.6	989,375	34,307.23	1.324
22.91	2,801.7	335.1	326.8	1,154,293	42,244.13	1.329

Summary for Reach 6R: Confl. with MN River

Cross-section from HEC-RAS RS 1086; outflow from this node used to set D/S boundary conditions in HEC-RAS model

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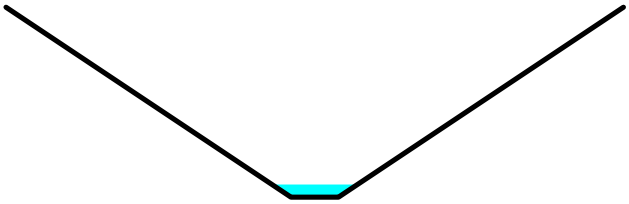
[61] Hint: Exceeded Reach 4R outlet invert by 1.32' @ 12.60 hrs

Inflow Area = 573.287 ac, 0.00% Impervious, Inflow Depth = 0.42" for 2-YR event
Inflow = 97.22 cfs @ 12.61 hrs, Volume= 19.828 af
Outflow = 96.98 cfs @ 12.64 hrs, Volume= 19.828 af, Atten= 0%, Lag= 2.0 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 72.92 cfs Estimated Depth= 1.42' Velocity= 7.18 fps
m= 1.460, c= 10.48 fps, dt= 1.5 min, dx= 1,240.0' / 1 = 1,240.0', K= 2.0 min, X= 0.481
Max. Velocity= 18.29 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 10.52 fps, Avg. Travel Time= 2.0 min

Peak Storage= 11,482 cf @ 12.62 hrs
Average Depth at Peak Storage= 1.32' , Surface Width= 8.97'
Bank-Full Depth= 20.00' Flow Area= 700.0 sf, Capacity= 21,848.71 cfs

5.00' x 20.00' deep channel, n= 0.030
Side Slope Z-value= 1.5 '/' Top Width= 65.00'
Length= 1,240.0' Slope= 0.0210 '/'
Inlet Invert= 722.00', Outlet Invert= 696.00'



Summary for Subcatchment 1S: Main Branch S

Runoff = 16.57 cfs @ 12.27 hrs, Volume= 1.905 af, Depth= 0.92"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=4.20"

	Area (ac)	CN	Description
*	24.956	61	
	24.956		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
29.0	2,593	0.1571	1.49		**Lag/CN Method,**

Summary for Subcatchment 2S: Main Branch N

Runoff = 184.65 cfs @ 12.58 hrs, Volume= 29.363 af, Depth= 1.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=4.20"

	Area (ac)	CN	Description
*	291.836	66	
	291.836		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.2	7,373	0.1994	2.35		**Lag/CN Method,**

Summary for Subcatchment 3S: West Branch

Runoff = 163.01 cfs @ 12.45 hrs, Volume= 23.231 af, Depth= 1.09"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=4.20"

	Area (ac)	CN	Description
*	256.495	64	
	256.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
42.8	4,622	0.1556	1.80		**Lag/CN Method,**

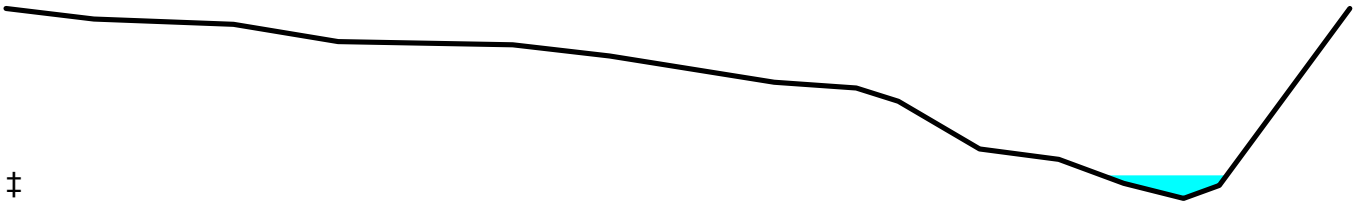
Summary for Reach 4R: Confl. D/S 6th St

Inflow Area = 548.331 ac, 0.00% Impervious, Inflow Depth = 1.15" for 10-YR event
Inflow = 342.01 cfs @ 12.51 hrs, Volume= 52.594 af
Outflow = 341.66 cfs @ 12.53 hrs, Volume= 52.594 af, Atten= 0%, Lag= 1.0 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Reference Flow= 256.51 cfs Estimated Depth= 2.87' Velocity= 5.02 fps
m= 1.414, c= 7.10 fps, dt= 3.0 min, dx= 412.0' / 1 = 412.0', K= 1.0 min, X= 0.247
Max. Velocity= 7.49 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 7.10 fps, Avg. Travel Time= 1.0 min

Peak Storage= 19,831 cf @ 12.52 hrs
Average Depth at Peak Storage= 2.77' , Surface Width= 30.28'
Bank-Full Depth= 22.91' Flow Area= 2,801.7 sf, Capacity= 42,244.13 cfs

Custom cross-section, Length= 412.0' Slope= 0.0097 '/' (112 Elevation Intervals)
Constant n= 0.040
Inlet Invert= 726.00', Outlet Invert= 722.00'



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Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	746.53	0.00
21.36	745.26	1.27
55.32	744.62	1.91
80.79	742.54	3.99
123.24	742.14	4.39
146.82	740.79	5.74
186.80	737.63	8.90
206.79	736.93	9.60
217.02	735.34	11.19
236.78	729.59	16.94
256.03	728.33	18.20
271.84	725.43	21.10
286.39	723.62	22.91
295.06	725.18	21.35
326.81	746.53	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Width (feet)	Storage (cubic-feet)	Discharge (cfs)	m
0.00	0.0	0.0	0.0	0	0.00	1.333
1.56	16.5	21.4	21.2	6,816	50.94	1.333
1.81	22.1	23.9	23.6	9,123	77.00	1.362
4.71	119.7	45.2	43.7	49,332	839.27	1.394
5.97	188.1	66.7	64.8	77,508	1,374.15	1.280
11.72	642.3	97.6	93.1	264,644	8,256.18	1.419
13.31	800.5	110.8	105.7	329,789	10,948.28	1.386
14.01	881.8	132.1	126.8	363,319	11,445.31	1.346
17.17	1,353.0	177.8	171.5	557,453	19,158.29	1.290
18.52	1,601.8	203.9	197.0	659,932	23,171.24	1.262
18.92	1,689.2	247.1	240.1	695,951	22,274.71	1.345
21.00	2,218.3	276.3	268.6	913,935	32,554.33	1.360
21.64	2,401.4	311.5	303.6	989,375	34,307.23	1.324
22.91	2,801.7	335.1	326.8	1,154,293	42,244.13	1.329

Summary for Reach 6R: Confl. with MN River

Cross-section from HEC-RAS RS 1086; outflow from this node used to set D/S boundary conditions in HEC-RAS model

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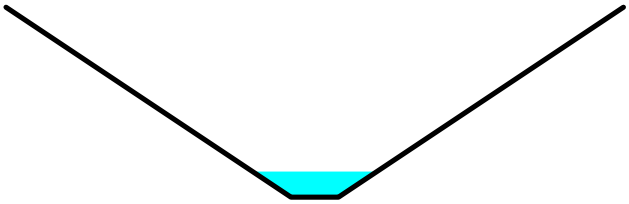
[61] Hint: Exceeded Reach 4R outlet invert by 2.70' @ 12.55 hrs

Inflow Area = 573.287 ac, 0.00% Impervious, Inflow Depth = 1.14" for 10-YR event
Inflow = 352.17 cfs @ 12.52 hrs, Volume= 54.500 af
Outflow = 351.17 cfs @ 12.54 hrs, Volume= 54.500 af, Atten= 0%, Lag= 1.5 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 264.13 cfs Estimated Depth= 2.80' Velocity= 10.25 fps
m= 1.399, c= 14.34 fps, dt= 1.5 min, dx= 1,240.0' / 1 = 1,240.0', K= 1.4 min, X= 0.462
Max. Velocity= 16.12 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 14.32 fps, Avg. Travel Time= 1.4 min

Peak Storage= 30,385 cf @ 12.53 hrs
Average Depth at Peak Storage= 2.70' , Surface Width= 13.11'
Bank-Full Depth= 20.00' Flow Area= 700.0 sf, Capacity= 21,848.71 cfs

5.00' x 20.00' deep channel, n= 0.030
Side Slope Z-value= 1.5 '/' Top Width= 65.00'
Length= 1,240.0' Slope= 0.0210 '/'
Inlet Invert= 722.00', Outlet Invert= 696.00'



Summary for Subcatchment 1S: Main Branch S

Runoff = 41.57 cfs @ 12.25 hrs, Volume= 4.171 af, Depth= 2.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=6.00"

	Area (ac)	CN	Description
*	24.956	61	
	24.956		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
29.0	2,593	0.1571	1.49		**Lag/CN Method,**

Summary for Subcatchment 2S: Main Branch N

Runoff = 404.74 cfs @ 12.55 hrs, Volume= 59.345 af, Depth= 2.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=6.00"

	Area (ac)	CN	Description
*	291.836	66	
	291.836		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.2	7,373	0.1994	2.35		**Lag/CN Method,**

Summary for Subcatchment 3S: West Branch

Runoff = 376.81 cfs @ 12.42 hrs, Volume= 48.379 af, Depth= 2.26"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=6.00"

	Area (ac)	CN	Description
*	256.495	64	
	256.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
42.8	4,622	0.1556	1.80		**Lag/CN Method,**

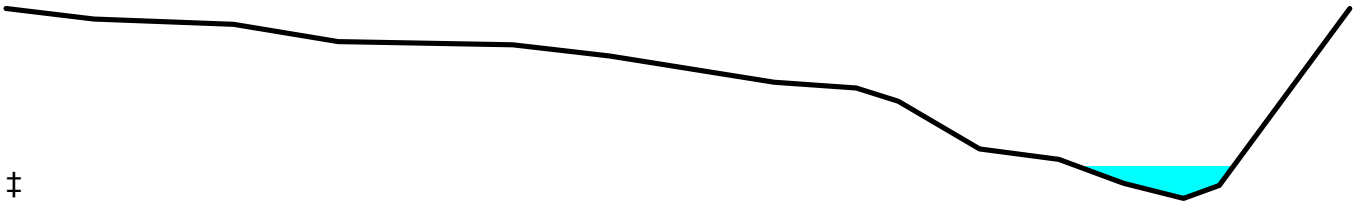
Summary for Reach 4R: Confl. D/S 6th St

Inflow Area = 548.331 ac, 0.00% Impervious, Inflow Depth = 2.36" for 100-YR event
Inflow = 768.42 cfs @ 12.48 hrs, Volume= 107.724 af
Outflow = 768.07 cfs @ 12.49 hrs, Volume= 107.724 af, Atten= 0%, Lag= 0.8 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Reference Flow= 576.31 cfs Estimated Depth= 4.01' Velocity= 6.32 fps
m= 1.403, c= 8.87 fps, dt= 3.0 min, dx= 412.0' / 1 = 412.0', K= 0.8 min, X= 0.142
Max. Velocity= 9.10 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 8.87 fps, Avg. Travel Time= 0.8 min

Peak Storage= 35,678 cf @ 12.49 hrs
Average Depth at Peak Storage= 3.90' , Surface Width= 38.09'
Bank-Full Depth= 22.91' Flow Area= 2,801.7 sf, Capacity= 42,244.13 cfs

Custom cross-section, Length= 412.0' Slope= 0.0097 '/' (112 Elevation Intervals)
Constant n= 0.040
Inlet Invert= 726.00', Outlet Invert= 722.00'



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Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	746.53	0.00
21.36	745.26	1.27
55.32	744.62	1.91
80.79	742.54	3.99
123.24	742.14	4.39
146.82	740.79	5.74
186.80	737.63	8.90
206.79	736.93	9.60
217.02	735.34	11.19
236.78	729.59	16.94
256.03	728.33	18.20
271.84	725.43	21.10
286.39	723.62	22.91
295.06	725.18	21.35
326.81	746.53	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Width (feet)	Storage (cubic-feet)	Discharge (cfs)	m
0.00	0.0	0.0	0.0	0	0.00	1.333
1.56	16.5	21.4	21.2	6,816	50.94	1.333
1.81	22.1	23.9	23.6	9,123	77.00	1.362
4.71	119.7	45.2	43.7	49,332	839.27	1.394
5.97	188.1	66.7	64.8	77,508	1,374.15	1.280
11.72	642.3	97.6	93.1	264,644	8,256.18	1.419
13.31	800.5	110.8	105.7	329,789	10,948.28	1.386
14.01	881.8	132.1	126.8	363,319	11,445.31	1.346
17.17	1,353.0	177.8	171.5	557,453	19,158.29	1.290
18.52	1,601.8	203.9	197.0	659,932	23,171.24	1.262
18.92	1,689.2	247.1	240.1	695,951	22,274.71	1.345
21.00	2,218.3	276.3	268.6	913,935	32,554.33	1.360
21.64	2,401.4	311.5	303.6	989,375	34,307.23	1.324
22.91	2,801.7	335.1	326.8	1,154,293	42,244.13	1.329

Summary for Reach 6R: Confl. with MN River

Cross-section from HEC-RAS RS 1086; outflow from this node used to set D/S boundary conditions in HEC-RAS model

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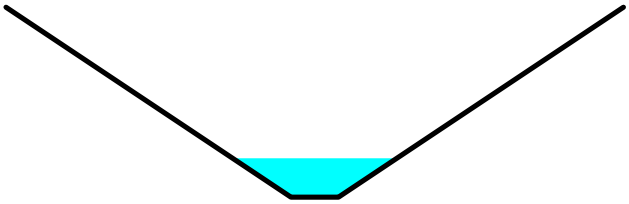
[62] Hint: Exceeded Reach 4R OUTLET depth by 0.19' @ 12.50 hrs

Inflow Area = 573.287 ac, 0.00% Impervious, Inflow Depth = 2.34" for 100-YR event
Inflow = 794.06 cfs @ 12.48 hrs, Volume= 111.895 af
Outflow = 792.15 cfs @ 12.50 hrs, Volume= 111.895 af, Atten= 0%, Lag= 1.3 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 595.54 cfs Estimated Depth= 4.18' Velocity= 12.66 fps
m= 1.373, c= 17.38 fps, dt= 1.5 min, dx= 1,240.0' / 1 = 1,240.0', K= 1.2 min, X= 0.441
Max. Velocity= 19.61 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 17.36 fps, Avg. Travel Time= 1.2 min

Peak Storage= 56,564 cf @ 12.49 hrs
Average Depth at Peak Storage= 4.09' , Surface Width= 17.28'
Bank-Full Depth= 20.00' Flow Area= 700.0 sf, Capacity= 21,848.71 cfs

5.00' x 20.00' deep channel, n= 0.030
Side Slope Z-value= 1.5 '/' Top Width= 65.00'
Length= 1,240.0' Slope= 0.0210 '/'
Inlet Invert= 722.00', Outlet Invert= 696.00'



Events for Subcatchment 1S: Main Branch S

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
1-YR	2.30	0.88	0.293	0.14
2-YR	2.80	3.29	0.608	0.29
10-YR	4.20	16.57	1.905	0.92
100-YR	**6.00**	**41.57**	**4.171**	**2.01**

Events for Subcatchment 2S: Main Branch N

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
1-YR	2.30	23.64	6.106	0.25
2-YR	2.80	54.02	11.005	0.45
10-YR	4.20	184.65	29.363	1.21
100-YR	**6.00**	**404.74**	**59.345**	**2.44**

Events for Subcatchment 3S: West Branch

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
1-YR	2.30	16.07	4.340	0.20
2-YR	2.80	42.26	8.215	0.38
10-YR	4.20	163.01	23.231	1.09
100-YR	**6.00**	**376.81**	**48.379**	**2.26**

Events for Reach 4R: Confl. D/S 6th St

Event	Inflow (cfs)	Outflow (cfs)	Elevation (feet)	Storage (cubic-feet)
1-YR	39.30	39.27	727.27	4,543
2-YR	95.04	94.92	727.74	8,500
10-YR	342.01	341.66	728.77	19,831
100-YR	**768.42**	**768.07**	**729.90**	**35,678**

Events for Reach 6R: Confl. with MN River

Event	Inflow (cfs)	Outflow (cfs)	Elevation (feet)	Storage (cubic-feet)
1-YR	40.06	40.05	722.78	6,008
2-YR	97.22	96.98	723.32	11,482
10-YR	352.17	351.17	724.70	30,385
100-YR	**794.06**	**792.15**	**726.09**	**56,564**

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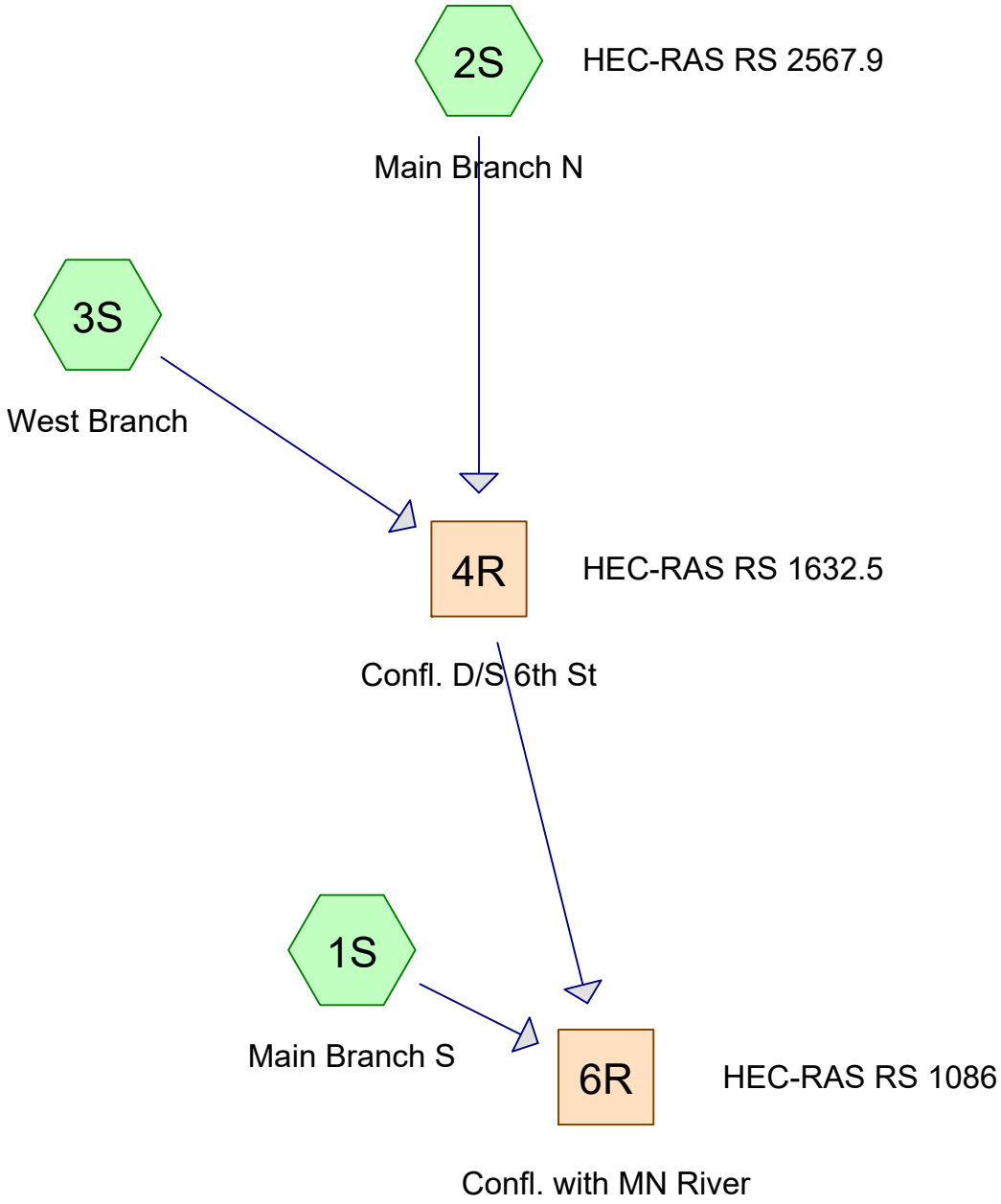
Existing Conditions



Subcat Reach Pond Link

Routing Diagram for SpringCk_2016_v1
Prepared by {enter your company name here}, Printed 12/15/2021

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	1-YR	MSE 24-hr	3	Default	24.00	1	2.49	2
2	2-YR	MSE 24-hr	3	Default	24.00	1	2.85	2
3	10-YR	MSE 24-hr	3	Default	24.00	1	4.23	2
4	100-YR	MSE 24-hr	3	Default	24.00	1	7.30	2

Summary for Subcatchment 1S: Main Branch S

Runoff = 9.32 cfs @ 12.40 hrs, Volume= 0.937 af, Depth= 0.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 1-YR Rainfall=2.49"

	Area (ac)	CN	Description
*	24.956	70	
	24.956		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.9	2,593	0.1571	1.88		**Lag/CN Method,**

Summary for Subcatchment 2S: Main Branch N

Runoff = 113.11 cfs @ 12.66 hrs, Volume= 14.656 af, Depth= 0.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 1-YR Rainfall=2.49"

	Area (ac)	CN	Description
*	291.836	74	
	291.836		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
42.0	7,373	0.1994	2.92		**Lag/CN Method,**

Summary for Subcatchment 3S: West Branch

Runoff = 128.38 cfs @ 12.50 hrs, Volume= 13.780 af, Depth= 0.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 1-YR Rainfall=2.49"

	Area (ac)	CN	Description
*	256.495	75	
	256.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.8	4,622	0.1556	2.42		**Lag/CN Method,**

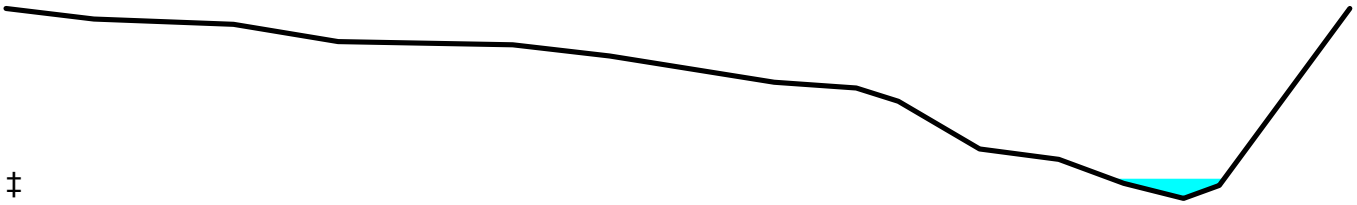
Summary for Reach 4R: Confl. D/S 6th St

Inflow Area = 548.331 ac, 0.00% Impervious, Inflow Depth = 0.62" for 1-YR event
Inflow = 232.69 cfs @ 12.56 hrs, Volume= 28.436 af
Outflow = 232.35 cfs @ 12.58 hrs, Volume= 28.436 af, Atten= 0%, Lag= 1.2 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Reference Flow= 174.52 cfs Estimated Depth= 2.46' Velocity= 4.48 fps
m= 1.410, c= 6.32 fps, dt= 3.0 min, dx= 412.0' / 1 = 412.0', K= 1.1 min, X= 0.282
Max. Velocity= 6.64 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 6.32 fps, Avg. Travel Time= 1.1 min

Peak Storage= 15,147 cf @ 12.58 hrs
Average Depth at Peak Storage= 2.38' , Surface Width= 27.55'
Bank-Full Depth= 22.91' Flow Area= 2,801.7 sf, Capacity= 42,244.13 cfs

Custom cross-section, Length= 412.0' Slope= 0.0097 '/' (112 Elevation Intervals)
Constant n= 0.040
Inlet Invert= 726.00', Outlet Invert= 722.00'



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Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	746.53	0.00
21.36	745.26	1.27
55.32	744.62	1.91
80.79	742.54	3.99
123.24	742.14	4.39
146.82	740.79	5.74
186.80	737.63	8.90
206.79	736.93	9.60
217.02	735.34	11.19
236.78	729.59	16.94
256.03	728.33	18.20
271.84	725.43	21.10
286.39	723.62	22.91
295.06	725.18	21.35
326.81	746.53	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Width (feet)	Storage (cubic-feet)	Discharge (cfs)	m
0.00	0.0	0.0	0.0	0	0.00	1.333
1.56	16.5	21.4	21.2	6,816	50.94	1.333
1.81	22.1	23.9	23.6	9,123	77.00	1.362
4.71	119.7	45.2	43.7	49,332	839.27	1.394
5.97	188.1	66.7	64.8	77,508	1,374.15	1.280
11.72	642.3	97.6	93.1	264,644	8,256.18	1.419
13.31	800.5	110.8	105.7	329,789	10,948.28	1.386
14.01	881.8	132.1	126.8	363,319	11,445.31	1.346
17.17	1,353.0	177.8	171.5	557,453	19,158.29	1.290
18.52	1,601.8	203.9	197.0	659,932	23,171.24	1.262
18.92	1,689.2	247.1	240.1	695,951	22,274.71	1.345
21.00	2,218.3	276.3	268.6	913,935	32,554.33	1.360
21.64	2,401.4	311.5	303.6	989,375	34,307.23	1.324
22.91	2,801.7	335.1	326.8	1,154,293	42,244.13	1.329

Summary for Reach 6R: Confl. with MN River

Cross-section from HEC-RAS RS 1086; outflow from this node used to set D/S boundary conditions in HEC-RAS model

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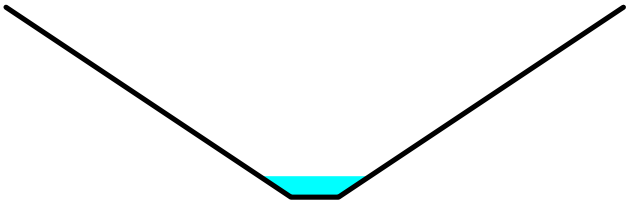
[61] Hint: Exceeded Reach 4R outlet invert by 2.20' @ 12.60 hrs

Inflow Area = 573.287 ac, 0.00% Impervious, Inflow Depth = 0.61" for 1-YR event
Inflow = 239.35 cfs @ 12.58 hrs, Volume= 29.373 af
Outflow = 238.55 cfs @ 12.61 hrs, Volume= 29.373 af, Atten= 0%, Lag= 1.7 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 179.52 cfs Estimated Depth= 2.30' Velocity= 9.23 fps
m= 1.416, c= 13.07 fps, dt= 1.5 min, dx= 1,240.0' / 1 = 1,240.0', K= 1.6 min, X= 0.469
Max. Velocity= 14.15 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 13.06 fps, Avg. Travel Time= 1.6 min

Peak Storage= 22,645 cf @ 12.59 hrs
Average Depth at Peak Storage= 2.20' , Surface Width= 11.60'
Bank-Full Depth= 20.00' Flow Area= 700.0 sf, Capacity= 21,848.71 cfs

5.00' x 20.00' deep channel, n= 0.030
Side Slope Z-value= 1.5 '/' Top Width= 65.00'
Length= 1,240.0' Slope= 0.0210 '/'
Inlet Invert= 722.00', Outlet Invert= 696.00'



Summary for Subcatchment 1S: Main Branch S

Runoff = 14.15 cfs @ 12.38 hrs, Volume= 1.315 af, Depth= 0.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-YR Rainfall=2.85"

	Area (ac)	CN	Description
*	24.956	70	
	24.956		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.9	2,593	0.1571	1.88		**Lag/CN Method,**

Summary for Subcatchment 2S: Main Branch N

Runoff = 159.53 cfs @ 12.64 hrs, Volume= 19.809 af, Depth= 0.81"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-YR Rainfall=2.85"

	Area (ac)	CN	Description
*	291.836	74	
	291.836		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
42.0	7,373	0.1994	2.92		**Lag/CN Method,**

Summary for Subcatchment 3S: West Branch

Runoff = 178.66 cfs @ 12.49 hrs, Volume= 18.470 af, Depth= 0.86"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-YR Rainfall=2.85"

	Area (ac)	CN	Description
*	256.495	75	
	256.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.8	4,622	0.1556	2.42		**Lag/CN Method,**

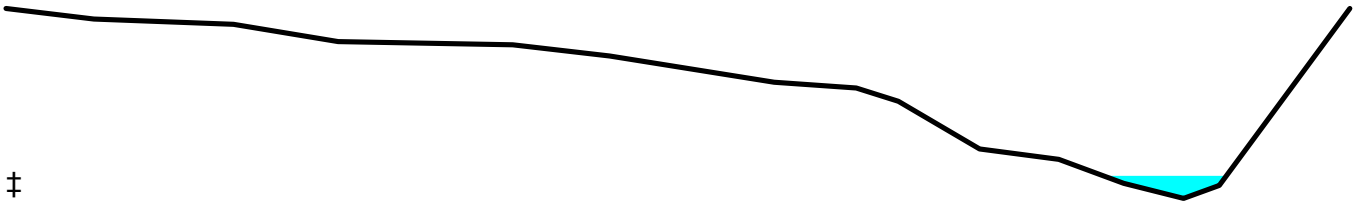
Summary for Reach 4R: Confl. D/S 6th St

Inflow Area = 548.331 ac, 0.00% Impervious, Inflow Depth = 0.84" for 2-YR event
Inflow = 326.53 cfs @ 12.55 hrs, Volume= 38.279 af
Outflow = 326.25 cfs @ 12.57 hrs, Volume= 38.279 af, Atten= 0%, Lag= 1.0 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Reference Flow= 244.90 cfs Estimated Depth= 2.81' Velocity= 4.96 fps
m= 1.414, c= 7.01 fps, dt= 3.0 min, dx= 412.0' / 1 = 412.0', K= 1.0 min, X= 0.251
Max. Velocity= 7.29 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 7.01 fps, Avg. Travel Time= 1.0 min

Peak Storage= 19,181 cf @ 12.56 hrs
Average Depth at Peak Storage= 2.72' , Surface Width= 29.92'
Bank-Full Depth= 22.91' Flow Area= 2,801.7 sf, Capacity= 42,244.13 cfs

Custom cross-section, Length= 412.0' Slope= 0.0097 '/' (112 Elevation Intervals)
Constant n= 0.040
Inlet Invert= 726.00', Outlet Invert= 722.00'



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Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	746.53	0.00
21.36	745.26	1.27
55.32	744.62	1.91
80.79	742.54	3.99
123.24	742.14	4.39
146.82	740.79	5.74
186.80	737.63	8.90
206.79	736.93	9.60
217.02	735.34	11.19
236.78	729.59	16.94
256.03	728.33	18.20
271.84	725.43	21.10
286.39	723.62	22.91
295.06	725.18	21.35
326.81	746.53	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Width (feet)	Storage (cubic-feet)	Discharge (cfs)	m
0.00	0.0	0.0	0.0	0	0.00	1.333
1.56	16.5	21.4	21.2	6,816	50.94	1.333
1.81	22.1	23.9	23.6	9,123	77.00	1.362
4.71	119.7	45.2	43.7	49,332	839.27	1.394
5.97	188.1	66.7	64.8	77,508	1,374.15	1.280
11.72	642.3	97.6	93.1	264,644	8,256.18	1.419
13.31	800.5	110.8	105.7	329,789	10,948.28	1.386
14.01	881.8	132.1	126.8	363,319	11,445.31	1.346
17.17	1,353.0	177.8	171.5	557,453	19,158.29	1.290
18.52	1,601.8	203.9	197.0	659,932	23,171.24	1.262
18.92	1,689.2	247.1	240.1	695,951	22,274.71	1.345
21.00	2,218.3	276.3	268.6	913,935	32,554.33	1.360
21.64	2,401.4	311.5	303.6	989,375	34,307.23	1.324
22.91	2,801.7	335.1	326.8	1,154,293	42,244.13	1.329

Summary for Reach 6R: Confl. with MN River

Cross-section from HEC-RAS RS 1086; outflow from this node used to set D/S boundary conditions in HEC-RAS model

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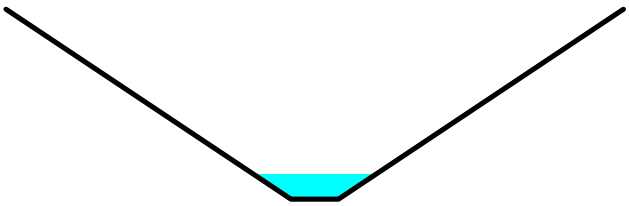
[61] Hint: Exceeded Reach 4R outlet invert by 2.63' @ 12.60 hrs

Inflow Area = 573.287 ac, 0.00% Impervious, Inflow Depth = 0.83" for 2-YR event
Inflow = 336.64 cfs @ 12.56 hrs, Volume= 39.594 af
Outflow = 335.28 cfs @ 12.59 hrs, Volume= 39.594 af, Atten= 0%, Lag= 1.5 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 252.48 cfs Estimated Depth= 2.74' Velocity= 10.12 fps
m= 1.401, c= 14.18 fps, dt= 1.5 min, dx= 1,240.0' / 1 = 1,240.0', K= 1.5 min, X= 0.462
Max. Velocity= 15.25 fps, Min. Travel Time= 1.4 min
Avg. Velocity = 14.16 fps, Avg. Travel Time= 1.5 min

Peak Storage= 29,340 cf @ 12.58 hrs
Average Depth at Peak Storage= 2.64' , Surface Width= 12.92'
Bank-Full Depth= 20.00' Flow Area= 700.0 sf, Capacity= 21,848.71 cfs

5.00' x 20.00' deep channel, n= 0.030
Side Slope Z-value= 1.5 '/' Top Width= 65.00'
Length= 1,240.0' Slope= 0.0210 '/'
Inlet Invert= 722.00', Outlet Invert= 696.00'



Summary for Subcatchment 1S: Main Branch S

Runoff = 37.19 cfs @ 12.35 hrs, Volume= 3.089 af, Depth= 1.49"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 10-YR Rainfall=4.23"

	Area (ac)	CN	Description
*	24.956	70	
	24.956		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.9	2,593	0.1571	1.88		**Lag/CN Method,**

Summary for Subcatchment 2S: Main Branch N

Runoff = 368.79 cfs @ 12.61 hrs, Volume= 42.975 af, Depth= 1.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 10-YR Rainfall=4.23"

	Area (ac)	CN	Description
*	291.836	74	
	291.836		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
42.0	7,373	0.1994	2.92		**Lag/CN Method,**

Summary for Subcatchment 3S: West Branch

Runoff = 402.51 cfs @ 12.47 hrs, Volume= 39.352 af, Depth= 1.84"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 10-YR Rainfall=4.23"

	Area (ac)	CN	Description
*	256.495	75	
	256.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.8	4,622	0.1556	2.42		**Lag/CN Method,**

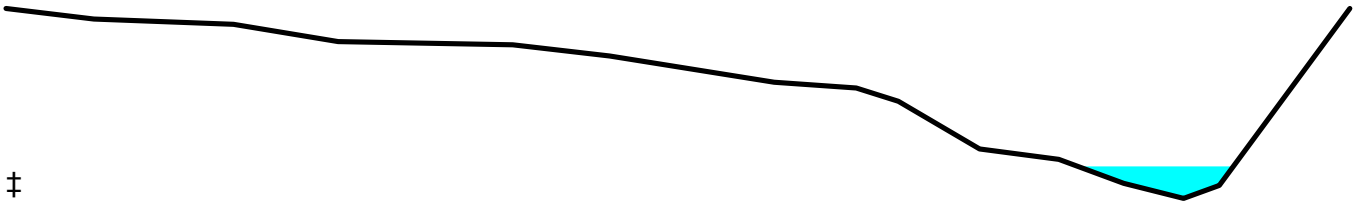
Summary for Reach 4R: Confl. D/S 6th St

Inflow Area = 548.331 ac, 0.00% Impervious, Inflow Depth = 1.80" for 10-YR event
Inflow = 747.17 cfs @ 12.53 hrs, Volume= 82.328 af
Outflow = 746.64 cfs @ 12.54 hrs, Volume= 82.328 af, Atten= 0%, Lag= 0.8 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Reference Flow= 560.37 cfs Estimated Depth= 3.97' Velocity= 6.27 fps
m= 1.403, c= 8.80 fps, dt= 3.0 min, dx= 412.0' / 1 = 412.0', K= 0.8 min, X= 0.147
Max. Velocity= 9.05 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 8.81 fps, Avg. Travel Time= 0.8 min

Peak Storage= 34,936 cf @ 12.54 hrs
Average Depth at Peak Storage= 3.85' , Surface Width= 37.76'
Bank-Full Depth= 22.91' Flow Area= 2,801.7 sf, Capacity= 42,244.13 cfs

Custom cross-section, Length= 412.0' Slope= 0.0097 '/' (112 Elevation Intervals)
Constant n= 0.040
Inlet Invert= 726.00', Outlet Invert= 722.00'



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Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	746.53	0.00
21.36	745.26	1.27
55.32	744.62	1.91
80.79	742.54	3.99
123.24	742.14	4.39
146.82	740.79	5.74
186.80	737.63	8.90
206.79	736.93	9.60
217.02	735.34	11.19
236.78	729.59	16.94
256.03	728.33	18.20
271.84	725.43	21.10
286.39	723.62	22.91
295.06	725.18	21.35
326.81	746.53	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Width (feet)	Storage (cubic-feet)	Discharge (cfs)	m
0.00	0.0	0.0	0.0	0	0.00	1.333
1.56	16.5	21.4	21.2	6,816	50.94	1.333
1.81	22.1	23.9	23.6	9,123	77.00	1.362
4.71	119.7	45.2	43.7	49,332	839.27	1.394
5.97	188.1	66.7	64.8	77,508	1,374.15	1.280
11.72	642.3	97.6	93.1	264,644	8,256.18	1.419
13.31	800.5	110.8	105.7	329,789	10,948.28	1.386
14.01	881.8	132.1	126.8	363,319	11,445.31	1.346
17.17	1,353.0	177.8	171.5	557,453	19,158.29	1.290
18.52	1,601.8	203.9	197.0	659,932	23,171.24	1.262
18.92	1,689.2	247.1	240.1	695,951	22,274.71	1.345
21.00	2,218.3	276.3	268.6	913,935	32,554.33	1.360
21.64	2,401.4	311.5	303.6	989,375	34,307.23	1.324
22.91	2,801.7	335.1	326.8	1,154,293	42,244.13	1.329

Summary for Reach 6R: Confl. with MN River

Cross-section from HEC-RAS RS 1086; outflow from this node used to set D/S boundary conditions in HEC-RAS model

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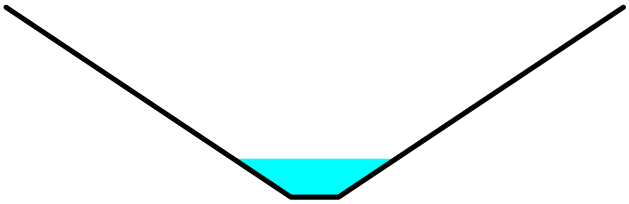
[62] Hint: Exceeded Reach 4R OUTLET depth by 0.19' @ 12.60 hrs

Inflow Area = 573.287 ac, 0.00% Impervious, Inflow Depth = 1.79" for 10-YR event
Inflow = 773.33 cfs @ 12.53 hrs, Volume= 85.417 af
Outflow = 770.76 cfs @ 12.55 hrs, Volume= 85.417 af, Atten= 0%, Lag= 1.3 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 580.00 cfs Estimated Depth= 4.12' Velocity= 12.57 fps
m= 1.373, c= 17.27 fps, dt= 1.5 min, dx= 1,240.0' / 1 = 1,240.0', K= 1.2 min, X= 0.442
Max. Velocity= 18.53 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 17.25 fps, Avg. Travel Time= 1.2 min

Peak Storage= 55,401 cf @ 12.54 hrs
Average Depth at Peak Storage= 4.04' , Surface Width= 17.12'
Bank-Full Depth= 20.00' Flow Area= 700.0 sf, Capacity= 21,848.71 cfs

5.00' x 20.00' deep channel, n= 0.030
Side Slope Z-value= 1.5 '/' Top Width= 65.00'
Length= 1,240.0' Slope= 0.0210 '/'
Inlet Invert= 722.00', Outlet Invert= 696.00'



Summary for Subcatchment 1S: Main Branch S

Runoff = 100.31 cfs @ 12.34 hrs, Volume= 8.047 af, Depth= 3.87"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-YR Rainfall=7.30"

	Area (ac)	CN	Description
*	24.956	70	
	24.956		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.9	2,593	0.1571	1.88		**Lag/CN Method,**

Summary for Subcatchment 2S: Main Branch N

Runoff = 916.62 cfs @ 12.58 hrs, Volume= 104.690 af, Depth= 4.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-YR Rainfall=7.30"

	Area (ac)	CN	Description
*	291.836	74	
	291.836		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
42.0	7,373	0.1994	2.92		**Lag/CN Method,**

Summary for Subcatchment 3S: West Branch

Runoff = 977.46 cfs @ 12.45 hrs, Volume= 94.365 af, Depth= 4.41"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-YR Rainfall=7.30"

	Area (ac)	CN	Description
*	256.495	75	
	256.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.8	4,622	0.1556	2.42		**Lag/CN Method,**

Summary for Reach 4R: Confl. D/S 6th St

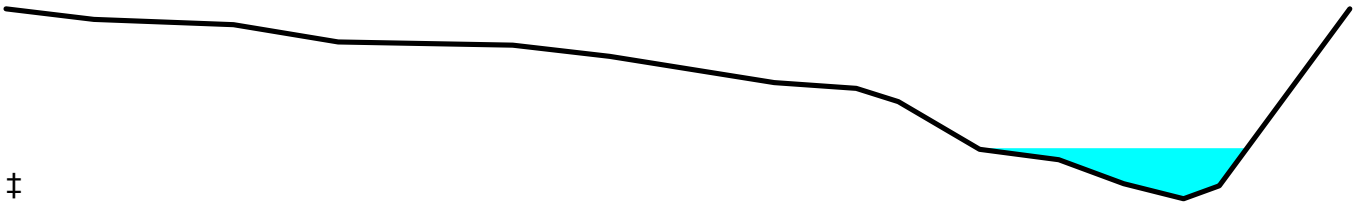
[97] Warning: Factor X out of range

Inflow Area = 548.331 ac, 0.00% Impervious, Inflow Depth = 4.36" for 100-YR event
Inflow = 1,839.47 cfs @ 12.51 hrs, Volume= 199.055 af
Outflow = 1,838.75 cfs @ 12.52 hrs, Volume= 199.055 af, Atten= 0%, Lag= 0.7 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Reference Flow= 1,379.60 cfs Estimated Depth= 5.98' Velocity= 7.31 fps
m= 1.281, c= 9.37 fps, dt= 3.0 min, dx= 412.0' / 1 = 412.0', K= 0.7 min, X= 0.000
Max. Velocity= 9.37 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 9.37 fps, Avg. Travel Time= 0.7 min

Peak Storage= 80,858 cf @ 12.52 hrs
Average Depth at Peak Storage= 6.09' , Surface Width= 65.45'
Bank-Full Depth= 22.91' Flow Area= 2,801.7 sf, Capacity= 42,244.13 cfs

Custom cross-section, Length= 412.0' Slope= 0.0097 '/' (112 Elevation Intervals)
Constant n= 0.040
Inlet Invert= 726.00', Outlet Invert= 722.00'



‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	746.53	0.00
21.36	745.26	1.27
55.32	744.62	1.91
80.79	742.54	3.99
123.24	742.14	4.39
146.82	740.79	5.74
186.80	737.63	8.90
206.79	736.93	9.60
217.02	735.34	11.19
236.78	729.59	16.94
256.03	728.33	18.20
271.84	725.43	21.10
286.39	723.62	22.91
295.06	725.18	21.35
326.81	746.53	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Width (feet)	Storage (cubic-feet)	Discharge (cfs)	m
0.00	0.0	0.0	0.0	0	0.00	1.333
1.56	16.5	21.4	21.2	6,816	50.94	1.333
1.81	22.1	23.9	23.6	9,123	77.00	1.362
4.71	119.7	45.2	43.7	49,332	839.27	1.394
5.97	188.1	66.7	64.8	77,508	1,374.15	1.280
11.72	642.3	97.6	93.1	264,644	8,256.18	1.419
13.31	800.5	110.8	105.7	329,789	10,948.28	1.386
14.01	881.8	132.1	126.8	363,319	11,445.31	1.346
17.17	1,353.0	177.8	171.5	557,453	19,158.29	1.290
18.52	1,601.8	203.9	197.0	659,932	23,171.24	1.262
18.92	1,689.2	247.1	240.1	695,951	22,274.71	1.345
21.00	2,218.3	276.3	268.6	913,935	32,554.33	1.360
21.64	2,401.4	311.5	303.6	989,375	34,307.23	1.324
22.91	2,801.7	335.1	326.8	1,154,293	42,244.13	1.329

Summary for Reach 6R: Confl. with MN River

Cross-section from HEC-RAS RS 1086; outflow from this node used to set D/S boundary conditions in HEC-RAS model

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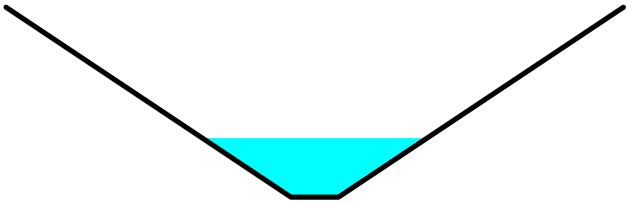
[62] Hint: Exceeded Reach 4R OUTLET depth by 0.12' @ 12.50 hrs

Inflow Area = 573.287 ac, 0.00% Impervious, Inflow Depth = 4.34" for 100-YR event
Inflow = 1,910.63 cfs @ 12.51 hrs, Volume= 207.101 af
Outflow = 1,904.21 cfs @ 12.52 hrs, Volume= 207.101 af, Atten= 0%, Lag= 1.0 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 1,432.97 cfs Estimated Depth= 6.28' Velocity= 15.82 fps
m= 1.353, c= 21.41 fps, dt= 1.5 min, dx= 1,240.0' / 1 = 1,240.0', K= 1.0 min, X= 0.411
Max. Velocity= 22.80 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 21.39 fps, Avg. Travel Time= 1.0 min

Peak Storage= 110,402 cf @ 12.52 hrs
Average Depth at Peak Storage= 6.22' , Surface Width= 23.65'
Bank-Full Depth= 20.00' Flow Area= 700.0 sf, Capacity= 21,848.71 cfs

5.00' x 20.00' deep channel, n= 0.030
Side Slope Z-value= 1.5 '/' Top Width= 65.00'
Length= 1,240.0' Slope= 0.0210 '/'
Inlet Invert= 722.00', Outlet Invert= 696.00'



Events for Subcatchment 1S: Main Branch S

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
1-YR	2.49	9.32	0.937	0.45
2-YR	2.85	14.15	1.315	0.63
10-YR	4.23	37.19	3.089	1.49
100-YR	**7.30**	**100.31**	**8.047**	**3.87**

Events for Subcatchment 2S: Main Branch N

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
1-YR	2.49	113.11	14.656	0.60
2-YR	2.85	159.53	19.809	0.81
10-YR	4.23	368.79	42.975	1.77
100-YR	**7.30**	**916.62**	**104.690**	**4.30**

Events for Subcatchment 3S: West Branch

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
1-YR	2.49	128.38	13.780	0.64
2-YR	2.85	178.66	18.470	0.86
10-YR	4.23	402.51	39.352	1.84
100-YR	**7.30**	**977.46**	**94.365**	**4.41**

Events for Reach 4R: Confl. D/S 6th St

Event	Inflow (cfs)	Outflow (cfs)	Elevation (feet)	Storage (cubic-feet)
1-YR	232.69	232.35	728.38	15,147
2-YR	326.53	326.25	728.72	19,181
10-YR	747.17	746.64	729.85	34,936
100-YR	**1,839.47**	**1,838.75**	**732.09**	**80,858**

Events for Reach 6R: Confl. with MN River

Event	Inflow (cfs)	Outflow (cfs)	Elevation (feet)	Storage (cubic-feet)
1-YR	239.35	238.55	724.20	22,645
2-YR	336.64	335.28	724.64	29,340
10-YR	773.33	770.76	726.04	55,401
100-YR	**1,910.63**	**1,904.21**	**728.22**	**110,402**

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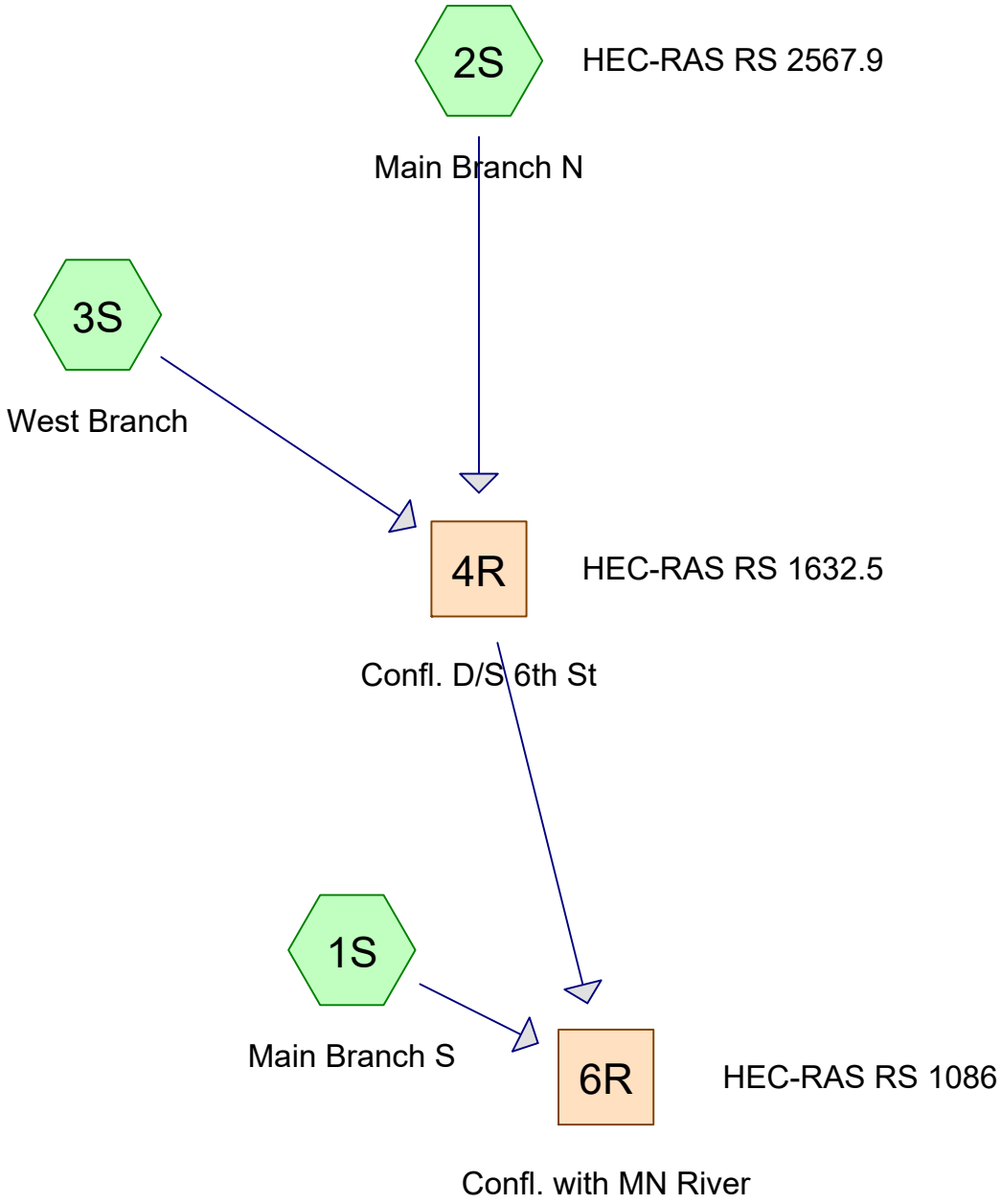
Future (2050)
Conditions



Subcat Reach Pond Link

Routing Diagram for SpringCk_2050_v1
Prepared by {enter your company name here}, Printed 12/15/2021

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	1-YR	MSE 24-hr	3	Default	24.00	1	3.10	2
2	2-YR	MSE 24-hr	3	Default	24.00	1	3.60	2
3	10-YR	MSE 24-hr	3	Default	24.00	1	5.30	2
4	100-YR	MSE 24-hr	3	Default	24.00	1	9.20	2

Summary for Subcatchment 1S: Main Branch S

Runoff = 39.53 cfs @ 12.27 hrs, Volume= 2.757 af, Depth= 1.33"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 1-YR Rainfall=3.10"

	Area (ac)	CN	Description
*	24.956	80	
	24.956		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.2	2,593	0.1571	2.52		**Lag/CN Method,**

Summary for Subcatchment 2S: Main Branch N

Runoff = 287.87 cfs @ 12.53 hrs, Volume= 30.694 af, Depth= 1.26"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 1-YR Rainfall=3.10"

	Area (ac)	CN	Description
*	291.836	79	
	291.836		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
36.3	7,373	0.1994	3.39		**Lag/CN Method,**

Summary for Subcatchment 3S: West Branch

Runoff = 338.60 cfs @ 12.40 hrs, Volume= 29.728 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 1-YR Rainfall=3.10"

	Area (ac)	CN	Description
*	256.495	81	
	256.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.6	4,622	0.1556	2.90		**Lag/CN Method,**

Summary for Reach 4R: Confl. D/S 6th St

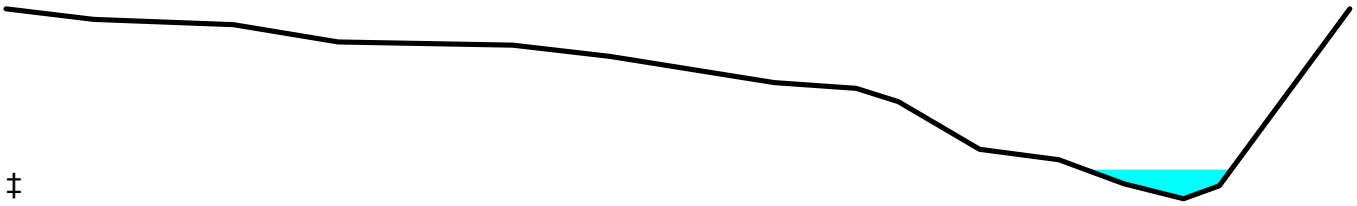
[97] Warning: Factor X out of range

Inflow Area = 548.331 ac, 0.00% Impervious, Inflow Depth = 1.32" for 1-YR event
Inflow = 604.54 cfs @ 12.45 hrs, Volume= 60.422 af
Outflow = 602.95 cfs @ 12.46 hrs, Volume= 60.422 af, Atten= 0%, Lag= 0.9 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 453.40 cfs Estimated Depth= 3.63' Velocity= 5.92 fps
m= 1.408, c= 8.33 fps, dt= 1.5 min, dx= 412.0' / 3 (preset) = 137.3', K= 0.3 min, X= 0.000
Max. Velocity= 8.83 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 8.33 fps, Avg. Travel Time= 0.8 min

Peak Storage= 29,825 cf @ 12.46 hrs
Average Depth at Peak Storage= 3.51' , Surface Width= 35.40'
Bank-Full Depth= 22.91' Flow Area= 2,801.7 sf, Capacity= 42,244.13 cfs

Custom cross-section, Length= 412.0' Slope= 0.0097 '/' (112 Elevation Intervals)
Constant n= 0.040
Inlet Invert= 726.00', Outlet Invert= 722.00'



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Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	746.53	0.00
21.36	745.26	1.27
55.32	744.62	1.91
80.79	742.54	3.99
123.24	742.14	4.39
146.82	740.79	5.74
186.80	737.63	8.90
206.79	736.93	9.60
217.02	735.34	11.19
236.78	729.59	16.94
256.03	728.33	18.20
271.84	725.43	21.10
286.39	723.62	22.91
295.06	725.18	21.35
326.81	746.53	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Width (feet)	Storage (cubic-feet)	Discharge (cfs)	m
0.00	0.0	0.0	0.0	0	0.00	1.333
1.56	16.5	21.4	21.2	6,816	50.94	1.333
1.81	22.1	23.9	23.6	9,123	77.00	1.362
4.71	119.7	45.2	43.7	49,332	839.27	1.394
5.97	188.1	66.7	64.8	77,508	1,374.15	1.280
11.72	642.3	97.6	93.1	264,644	8,256.18	1.419
13.31	800.5	110.8	105.7	329,789	10,948.28	1.386
14.01	881.8	132.1	126.8	363,319	11,445.31	1.346
17.17	1,353.0	177.8	171.5	557,453	19,158.29	1.290
18.52	1,601.8	203.9	197.0	659,932	23,171.24	1.262
18.92	1,689.2	247.1	240.1	695,951	22,274.71	1.345
21.00	2,218.3	276.3	268.6	913,935	32,554.33	1.360
21.64	2,401.4	311.5	303.6	989,375	34,307.23	1.324
22.91	2,801.7	335.1	326.8	1,154,293	42,244.13	1.329

Summary for Reach 6R: Confl. with MN River

Cross-section from HEC-RAS RS 1086; outflow from this node used to set D/S boundary conditions in HEC-RAS model

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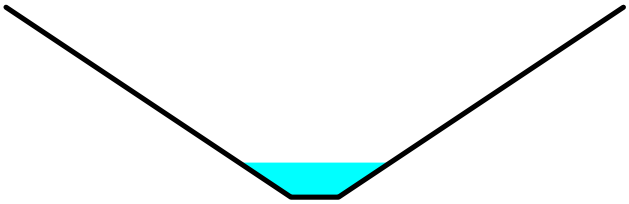
[62] Hint: Exceeded Reach 4R OUTLET depth by 0.13' @ 12.50 hrs

Inflow Area = 573.287 ac, 0.00% Impervious, Inflow Depth = 1.32" for 1-YR event
Inflow = 626.98 cfs @ 12.45 hrs, Volume= 63.178 af
Outflow = 624.11 cfs @ 12.47 hrs, Volume= 63.178 af, Atten= 0%, Lag= 1.3 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 470.24 cfs Estimated Depth= 3.73' Velocity= 11.91 fps
m= 1.379, c= 16.43 fps, dt= 1.5 min, dx= 1,240.0' / 1 = 1,240.0', K= 1.3 min, X= 0.448
Max. Velocity= 17.79 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 16.41 fps, Avg. Travel Time= 1.3 min

Peak Storage= 47,158 cf @ 12.46 hrs
Average Depth at Peak Storage= 3.64' , Surface Width= 15.91'
Bank-Full Depth= 20.00' Flow Area= 700.0 sf, Capacity= 21,848.71 cfs

5.00' x 20.00' deep channel, n= 0.030
Side Slope Z-value= 1.5 '/' Top Width= 65.00'
Length= 1,240.0' Slope= 0.0210 '/'
Inlet Invert= 722.00', Outlet Invert= 696.00'



Summary for Subcatchment 1S: Main Branch S

Runoff = 51.51 cfs @ 12.27 hrs, Volume= 3.569 af, Depth= 1.72"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-YR Rainfall=3.60"

	Area (ac)	CN	Description
*	24.956	80	
	24.956		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.2	2,593	0.1571	2.52		**Lag/CN Method,**

Summary for Subcatchment 2S: Main Branch N

Runoff = 379.33 cfs @ 12.52 hrs, Volume= 39.983 af, Depth= 1.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-YR Rainfall=3.60"

	Area (ac)	CN	Description
*	291.836	79	
	291.836		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
36.3	7,373	0.1994	3.39		**Lag/CN Method,**

Summary for Subcatchment 3S: West Branch

Runoff = 438.48 cfs @ 12.39 hrs, Volume= 38.258 af, Depth= 1.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-YR Rainfall=3.60"

	Area (ac)	CN	Description
*	256.495	81	
	256.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.6	4,622	0.1556	2.90		**Lag/CN Method,**

Summary for Reach 4R: Confl. D/S 6th St

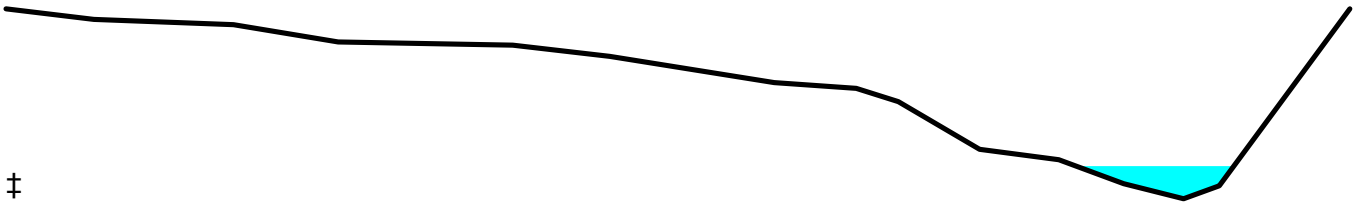
[97] Warning: Factor X out of range

Inflow Area = 548.331 ac, 0.00% Impervious, Inflow Depth = 1.71" for 2-YR event
Inflow = 790.30 cfs @ 12.44 hrs, Volume= 78.241 af
Outflow = 788.26 cfs @ 12.45 hrs, Volume= 78.241 af, Atten= 0%, Lag= 0.8 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 592.73 cfs Estimated Depth= 4.06' Velocity= 6.37 fps
m= 1.402, c= 8.94 fps, dt= 1.5 min, dx= 412.0' / 3 (preset) = 137.3', K= 0.3 min, X= 0.000
Max. Velocity= 9.44 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 8.94 fps, Avg. Travel Time= 0.8 min

Peak Storage= 36,334 cf @ 12.45 hrs
Average Depth at Peak Storage= 3.94' , Surface Width= 38.38'
Bank-Full Depth= 22.91' Flow Area= 2,801.7 sf, Capacity= 42,244.13 cfs

Custom cross-section, Length= 412.0' Slope= 0.0097 '/' (112 Elevation Intervals)
Constant n= 0.040
Inlet Invert= 726.00', Outlet Invert= 722.00'



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Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	746.53	0.00
21.36	745.26	1.27
55.32	744.62	1.91
80.79	742.54	3.99
123.24	742.14	4.39
146.82	740.79	5.74
186.80	737.63	8.90
206.79	736.93	9.60
217.02	735.34	11.19
236.78	729.59	16.94
256.03	728.33	18.20
271.84	725.43	21.10
286.39	723.62	22.91
295.06	725.18	21.35
326.81	746.53	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Width (feet)	Storage (cubic-feet)	Discharge (cfs)	m
0.00	0.0	0.0	0.0	0	0.00	1.333
1.56	16.5	21.4	21.2	6,816	50.94	1.333
1.81	22.1	23.9	23.6	9,123	77.00	1.362
4.71	119.7	45.2	43.7	49,332	839.27	1.394
5.97	188.1	66.7	64.8	77,508	1,374.15	1.280
11.72	642.3	97.6	93.1	264,644	8,256.18	1.419
13.31	800.5	110.8	105.7	329,789	10,948.28	1.386
14.01	881.8	132.1	126.8	363,319	11,445.31	1.346
17.17	1,353.0	177.8	171.5	557,453	19,158.29	1.290
18.52	1,601.8	203.9	197.0	659,932	23,171.24	1.262
18.92	1,689.2	247.1	240.1	695,951	22,274.71	1.345
21.00	2,218.3	276.3	268.6	913,935	32,554.33	1.360
21.64	2,401.4	311.5	303.6	989,375	34,307.23	1.324
22.91	2,801.7	335.1	326.8	1,154,293	42,244.13	1.329

Summary for Reach 6R: Confl. with MN River

Cross-section from HEC-RAS RS 1086; outflow from this node used to set D/S boundary conditions in HEC-RAS model

---

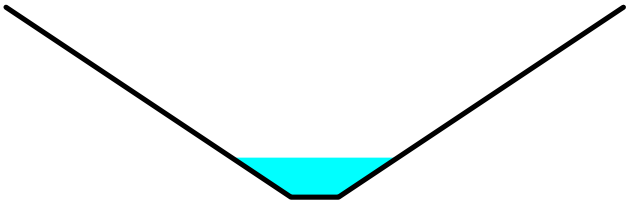
[62] Hint: Exceeded Reach 4R OUTLET depth by 0.22' @ 12.50 hrs

Inflow Area = 573.287 ac, 0.00% Impervious, Inflow Depth = 1.71" for 2-YR event
Inflow = 819.63 cfs @ 12.45 hrs, Volume= 81.809 af
Outflow = 815.96 cfs @ 12.47 hrs, Volume= 81.809 af, Atten= 0%, Lag= 1.2 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 614.72 cfs Estimated Depth= 4.24' Velocity= 12.76 fps
m= 1.372, c= 17.51 fps, dt= 1.5 min, dx= 1,240.0' / 1 = 1,240.0', K= 1.2 min, X= 0.441
Max. Velocity= 18.85 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 17.50 fps, Avg. Travel Time= 1.2 min

Peak Storage= 57,865 cf @ 12.46 hrs
Average Depth at Peak Storage= 4.15' , Surface Width= 17.46'
Bank-Full Depth= 20.00' Flow Area= 700.0 sf, Capacity= 21,848.71 cfs

5.00' x 20.00' deep channel, n= 0.030
Side Slope Z-value= 1.5 '/' Top Width= 65.00'
Length= 1,240.0' Slope= 0.0210 '/'
Inlet Invert= 722.00', Outlet Invert= 696.00'



Summary for Subcatchment 1S: Main Branch S

Runoff = 94.75 cfs @ 12.26 hrs, Volume= 6.564 af, Depth= 3.16"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 10-YR Rainfall=5.30"

	Area (ac)	CN	Description
*	24.956	80	
	24.956		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.2	2,593	0.1571	2.52		**Lag/CN Method,**

Summary for Subcatchment 2S: Main Branch N

Runoff = 713.99 cfs @ 12.51 hrs, Volume= 74.457 af, Depth= 3.06"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 10-YR Rainfall=5.30"

	Area (ac)	CN	Description
*	291.836	79	
	291.836		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
36.3	7,373	0.1994	3.39		**Lag/CN Method,**

Summary for Subcatchment 3S: West Branch

Runoff = 797.33 cfs @ 12.38 hrs, Volume= 69.508 af, Depth= 3.25"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 10-YR Rainfall=5.30"

	Area (ac)	CN	Description
*	256.495	81	
	256.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.6	4,622	0.1556	2.90		**Lag/CN Method,**

Summary for Reach 4R: Confl. D/S 6th St

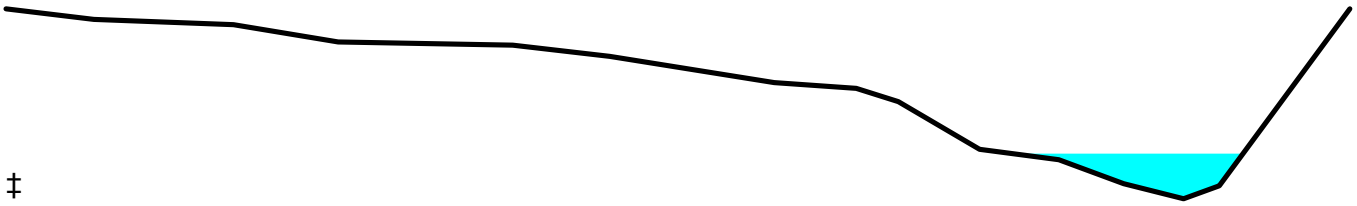
[97] Warning: Factor X out of range

Inflow Area = 548.331 ac, 0.00% Impervious, Inflow Depth = 3.15" for 10-YR event
Inflow = 1,463.97 cfs @ 12.43 hrs, Volume= 143.965 af
Outflow = 1,460.04 cfs @ 12.44 hrs, Volume= 143.965 af, Atten= 0%, Lag= 0.8 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 1,097.98 cfs Estimated Depth= 5.41' Velocity= 7.10 fps
m= 1.315, c= 9.34 fps, dt= 1.5 min, dx= 412.0' / 3 (preset) = 137.3', K= 0.2 min, X= 0.000
Max. Velocity= 9.84 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 9.34 fps, Avg. Travel Time= 0.7 min

Peak Storage= 64,377 cf @ 12.44 hrs
Average Depth at Peak Storage= 5.44' , Surface Width= 55.97'
Bank-Full Depth= 22.91' Flow Area= 2,801.7 sf, Capacity= 42,244.13 cfs

Custom cross-section, Length= 412.0' Slope= 0.0097 '/' (112 Elevation Intervals)
Constant n= 0.040
Inlet Invert= 726.00', Outlet Invert= 722.00'



‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	746.53	0.00
21.36	745.26	1.27
55.32	744.62	1.91
80.79	742.54	3.99
123.24	742.14	4.39
146.82	740.79	5.74
186.80	737.63	8.90
206.79	736.93	9.60
217.02	735.34	11.19
236.78	729.59	16.94
256.03	728.33	18.20
271.84	725.43	21.10
286.39	723.62	22.91
295.06	725.18	21.35
326.81	746.53	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Width (feet)	Storage (cubic-feet)	Discharge (cfs)	m
0.00	0.0	0.0	0.0	0	0.00	1.333
1.56	16.5	21.4	21.2	6,816	50.94	1.333
1.81	22.1	23.9	23.6	9,123	77.00	1.362
4.71	119.7	45.2	43.7	49,332	839.27	1.394
5.97	188.1	66.7	64.8	77,508	1,374.15	1.280
11.72	642.3	97.6	93.1	264,644	8,256.18	1.419
13.31	800.5	110.8	105.7	329,789	10,948.28	1.386
14.01	881.8	132.1	126.8	363,319	11,445.31	1.346
17.17	1,353.0	177.8	171.5	557,453	19,158.29	1.290
18.52	1,601.8	203.9	197.0	659,932	23,171.24	1.262
18.92	1,689.2	247.1	240.1	695,951	22,274.71	1.345
21.00	2,218.3	276.3	268.6	913,935	32,554.33	1.360
21.64	2,401.4	311.5	303.6	989,375	34,307.23	1.324
22.91	2,801.7	335.1	326.8	1,154,293	42,244.13	1.329

Summary for Reach 6R: Confl. with MN River

Cross-section from HEC-RAS RS 1086; outflow from this node used to set D/S boundary conditions in HEC-RAS model

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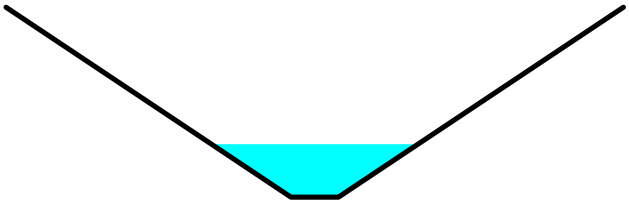
[62] Hint: Exceeded Reach 4R OUTLET depth by 0.14' @ 12.50 hrs

Inflow Area = 573.287 ac, 0.00% Impervious, Inflow Depth = 3.15" for 10-YR event
Inflow = 1,517.91 cfs @ 12.43 hrs, Volume= 150.528 af
Outflow = 1,511.23 cfs @ 12.45 hrs, Volume= 150.528 af, Atten= 0%, Lag= 1.1 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 1,138.43 cfs Estimated Depth= 5.65' Velocity= 14.93 fps
m= 1.357, c= 20.26 fps, dt= 1.5 min, dx= 1,240.0' / 1 = 1,240.0', K= 1.0 min, X= 0.420
Max. Velocity= 21.81 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 20.25 fps, Avg. Travel Time= 1.0 min

Peak Storage= 92,587 cf @ 12.45 hrs
Average Depth at Peak Storage= 5.58' , Surface Width= 21.75'
Bank-Full Depth= 20.00' Flow Area= 700.0 sf, Capacity= 21,848.71 cfs

5.00' x 20.00' deep channel, n= 0.030
Side Slope Z-value= 1.5 '/' Top Width= 65.00'
Length= 1,240.0' Slope= 0.0210 '/'
Inlet Invert= 722.00', Outlet Invert= 696.00'



Summary for Subcatchment 1S: Main Branch S

Runoff = 198.13 cfs @ 12.26 hrs, Volume= 14.054 af, Depth= 6.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-YR Rainfall=9.20"

	Area (ac)	CN	Description
*	24.956	80	
	24.956		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.2	2,593	0.1571	2.52		**Lag/CN Method,**

Summary for Subcatchment 2S: Main Branch N

Runoff = 1,528.00 cfs @ 12.49 hrs, Volume= 161.336 af, Depth= 6.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-YR Rainfall=9.20"

	Area (ac)	CN	Description
*	291.836	79	
	291.836		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
36.3	7,373	0.1994	3.39		**Lag/CN Method,**

Summary for Subcatchment 3S: West Branch

Runoff = 1,655.08 cfs @ 12.37 hrs, Volume= 147.098 af, Depth= 6.88"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-YR Rainfall=9.20"

	Area (ac)	CN	Description
*	256.495	81	
	256.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.6	4,622	0.1556	2.90		**Lag/CN Method,**

Summary for Reach 4R: Confl. D/S 6th St

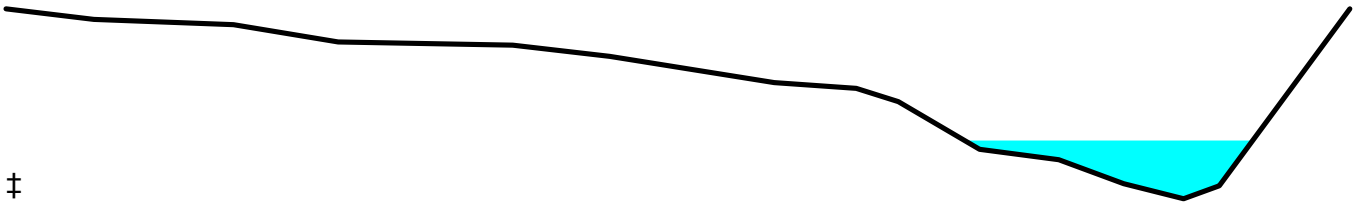
[97] Warning: Factor X out of range

Inflow Area = 548.331 ac, 0.00% Impervious, Inflow Depth = 6.75" for 100-YR event
Inflow = 3,090.67 cfs @ 12.42 hrs, Volume= 308.435 af
Outflow = 3,078.14 cfs @ 12.43 hrs, Volume= 308.435 af, Atten= 0%, Lag= 0.7 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 2,318.00 cfs Estimated Depth= 7.13' Velocity= 8.69 fps
m= 1.367, c= 11.88 fps, dt= 1.5 min, dx= 412.0' / 3 (preset) = 137.3', K= 0.2 min, X= 0.000
Max. Velocity= 12.61 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 11.88 fps, Avg. Travel Time= 0.6 min

Peak Storage= 106,749 cf @ 12.43 hrs
Average Depth at Peak Storage= 7.02' , Surface Width= 70.02'
Bank-Full Depth= 22.91' Flow Area= 2,801.7 sf, Capacity= 42,244.13 cfs

Custom cross-section, Length= 412.0' Slope= 0.0097 '/' (112 Elevation Intervals)
Constant n= 0.040
Inlet Invert= 726.00', Outlet Invert= 722.00'



‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	746.53	0.00
21.36	745.26	1.27
55.32	744.62	1.91
80.79	742.54	3.99
123.24	742.14	4.39
146.82	740.79	5.74
186.80	737.63	8.90
206.79	736.93	9.60
217.02	735.34	11.19
236.78	729.59	16.94
256.03	728.33	18.20
271.84	725.43	21.10
286.39	723.62	22.91
295.06	725.18	21.35
326.81	746.53	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Width (feet)	Storage (cubic-feet)	Discharge (cfs)	m
0.00	0.0	0.0	0.0	0	0.00	1.333
1.56	16.5	21.4	21.2	6,816	50.94	1.333
1.81	22.1	23.9	23.6	9,123	77.00	1.362
4.71	119.7	45.2	43.7	49,332	839.27	1.394
5.97	188.1	66.7	64.8	77,508	1,374.15	1.280
11.72	642.3	97.6	93.1	264,644	8,256.18	1.419
13.31	800.5	110.8	105.7	329,789	10,948.28	1.386
14.01	881.8	132.1	126.8	363,319	11,445.31	1.346
17.17	1,353.0	177.8	171.5	557,453	19,158.29	1.290
18.52	1,601.8	203.9	197.0	659,932	23,171.24	1.262
18.92	1,689.2	247.1	240.1	695,951	22,274.71	1.345
21.00	2,218.3	276.3	268.6	913,935	32,554.33	1.360
21.64	2,401.4	311.5	303.6	989,375	34,307.23	1.324
22.91	2,801.7	335.1	326.8	1,154,293	42,244.13	1.329

Summary for Reach 6R: Confl. with MN River

Cross-section from HEC-RAS RS 1086; outflow from this node used to set D/S boundary conditions in HEC-RAS model

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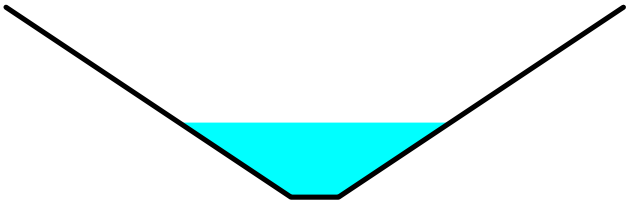
[62] Hint: Exceeded Reach 4R OUTLET depth by 0.83' @ 12.45 hrs

Inflow Area = 573.287 ac, 0.00% Impervious, Inflow Depth = 6.75" for 100-YR event
Inflow = 3,204.32 cfs @ 12.42 hrs, Volume= 322.489 af
Outflow = 3,187.04 cfs @ 12.44 hrs, Volume= 322.489 af, Atten= 1%, Lag= 0.9 min

Routing by Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs / 2
Reference Flow= 2,403.24 cfs Estimated Depth= 7.91' Velocity= 18.01 fps
m= 1.346, c= 24.24 fps, dt= 1.5 min, dx= 1,240.0' / 1 = 1,240.0', K= 0.9 min, X= 0.387
Max. Velocity= 25.65 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 24.23 fps, Avg. Travel Time= 0.9 min

Peak Storage= 163,232 cf @ 12.43 hrs
Average Depth at Peak Storage= 7.85' , Surface Width= 28.55'
Bank-Full Depth= 20.00' Flow Area= 700.0 sf, Capacity= 21,848.71 cfs

5.00' x 20.00' deep channel, n= 0.030
Side Slope Z-value= 1.5 '/' Top Width= 65.00'
Length= 1,240.0' Slope= 0.0210 '/'
Inlet Invert= 722.00', Outlet Invert= 696.00'



Events for Subcatchment 1S: Main Branch S

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
1-YR	3.10	39.53	2.757	1.33
2-YR	3.60	51.51	3.569	1.72
10-YR	5.30	94.75	6.564	3.16
100-YR	**9.20**	**198.13**	**14.054**	**6.76**

Events for Subcatchment 2S: Main Branch N

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
1-YR	3.10	287.87	30.694	1.26
2-YR	3.60	379.33	39.983	1.64
10-YR	5.30	713.99	74.457	3.06
100-YR	**9.20**	**1,528.00**	**161.336**	**6.63**

Events for Subcatchment 3S: West Branch

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
1-YR	3.10	338.60	29.728	1.39
2-YR	3.60	438.48	38.258	1.79
10-YR	5.30	797.33	69.508	3.25
100-YR	**9.20**	**1,655.08**	**147.098**	**6.88**

Events for Reach 4R: Confl. D/S 6th St

Event	Inflow (cfs)	Outflow (cfs)	Elevation (feet)	Storage (cubic-feet)
1-YR	604.54	602.95	729.51	29,825
2-YR	790.30	788.26	729.94	36,334
10-YR	1,463.97	1,460.04	731.44	64,377
100-YR	**3,090.67**	**3,078.14**	**733.02**	**106,749**

Events for Reach 6R: Confl. with MN River

Event	Inflow (cfs)	Outflow (cfs)	Elevation (feet)	Storage (cubic-feet)
1-YR	626.98	624.11	725.64	47,158
2-YR	819.63	815.96	726.15	57,865
10-YR	1,517.91	1,511.23	727.58	92,587
100-YR	**3,204.32**	**3,187.04**	**729.85**	**163,232**

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Attachment 3—Spring Creek HEC-RAS Model Result Tables

Spring Creek Pre-Settlement Conditions HEC-RAS Model Results

HEC-RAS Plan: 1800s River: Spring Creek Reach: Spring Creek

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Vel Left	Vel Right	Vel Total	Top Width	Shear Chan	Shear LOB	Shear ROB	Shear Total	
			(cfs)	(ft)	(ft)	(ft/s)	(ft/s)	(ft/s)	(ft/s)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	
Spring Creek	2567.9	1	24.00	745.20	745.93	4.18			4.18	10.72	0.98			0.98	
Spring Creek	2567.9	2	54.00	745.20	746.33	5.13			5.13	13.12	1.29			1.29	
Spring Creek	2567.9	10	185.00	745.20	747.28	7.18		0.70	7.13	20.67	2.11		0.15	1.89	
Spring Creek	2567.9	100	405.00	745.20	748.13	9.30		2.10	8.30	33.75	3.10		0.77	2.19	
Spring Creek	2137.7	1	24.00	734.49	736.21	1.48			1.48	17.11	0.10			0.10	
Spring Creek	2137.7	2	54.00	734.49	736.77	2.04	0.29	0.12	2.01	21.66	0.17	0.02	0.01	0.15	
Spring Creek	2137.7	10	185.00	734.49	738.13	3.38	1.01	0.85	2.95	30.41	0.37	0.14	0.11	0.28	
Spring Creek	2137.7	100	405.00	734.49	740.47	3.62	1.18	1.13	2.73	42.99	0.35	0.15	0.14	0.23	
Spring Creek	2120.5	1	24.00	734.67	735.84	4.40			4.40	9.20	1.05			1.05	
Spring Creek	2120.5	2	54.00	734.67	736.29	5.26			5.26	12.33	1.35			1.35	
Spring Creek	2120.5	10	185.00	734.67	737.34	7.23	0.72	1.26	7.11	18.02	2.04	0.15	0.35	1.80	
Spring Creek	2120.5	100	405.00	734.67	740.24	5.04	1.55	1.47	3.96	33.25	0.71	0.28	0.26	0.47	
Spring Creek	2087.7		Culvert												
Spring Creek	2011.1	1	24.00	732.64	733.60	6.70			6.70	6.70	2.55			2.55	
Spring Creek	2011.1	2	54.00	732.64	734.22	5.99			5.99	10.72	1.75			1.75	
Spring Creek	2011.1	10	185.00	732.64	734.74	12.12			12.12	13.12	6.44			6.44	
Spring Creek	2011.1	100	405.00	732.64	735.53	15.09			15.09	16.23	8.91			8.91	
Spring Creek	1948.00*	1	24.00	731.14	732.38	3.88			3.88	9.59	0.80			0.80	
Spring Creek	1948.00*	2	54.00	731.14	732.79	5.02			5.02	12.49	1.21			1.21	
Spring Creek	1948.00*	10	185.00	731.14	733.82	7.10			7.10	17.01	2.02			2.02	
Spring Creek	1948.00*	100	405.00	731.14	734.92	8.71	1.01	0.12	8.70	20.16	2.65	0.16		2.58	
Spring Creek	1884.90*	1	24.00	729.63	730.76	4.30			4.30	10.00	1.03			1.03	
Spring Creek	1884.90*	2	54.00	729.63	731.18	5.13			5.13	13.27	1.30			1.30	
Spring Creek	1884.90*	10	185.00	729.63	732.05	7.70			7.70	17.55	2.45			2.45	
Spring Creek	1884.90*	100	405.00	729.63	732.88	10.17	0.61		10.17	20.46	3.82	0.09		3.78	
Spring Creek	1834.33*	1	24.00	728.13	729.29	3.63			3.63	11.90	0.73			0.73	112 5th Street
Spring Creek	1834.33*	2	54.00	728.13	729.53	5.52			5.52	13.95	1.57			1.57	* Garage El. 73
Spring Creek	1834.33*	10	185.00	728.13	730.36	7.91			7.91	18.45	2.65			2.65	
Spring Creek	1834.33*	100	405.00	728.13	731.18	10.16	1.12	0.72	10.13	22.74	3.84	0.23	0.17	3.58	* Residence El. 74
Spring Creek	1758.70*	1	24.00	726.63	727.75	3.37			3.37	13.57	0.64			0.64	
Spring Creek	1758.70*	2	54.00	726.63	728.07	4.56			4.56	16.04	1.05			1.05	
Spring Creek	1758.70*	10	185.00	726.63	729.04	5.66		1.19	4.41	60.50	1.31		0.29	0.66	
Spring Creek	1758.70*	100	405.00	726.63	730.75	3.91	1.06	1.63	2.61	70.78	0.48	0.12	0.30	0.35	
Spring Creek	1695.60*	1	24.00	725.12	726.10	3.82			3.82	14.51	0.88			0.88	
Spring Creek	1695.60*	2	54.00	725.12	726.42	4.77			4.77	16.62	1.18			1.18	
Spring Creek	1695.60*	10	185.00	725.12	727.76	4.51	0.83	1.00	3.86	44.61	0.77	0.11	0.19	0.48	
Spring Creek	1695.60*	100	405.00	725.12	730.74	2.62	0.92	1.06	1.77	71.15	0.19	0.07	0.11	0.13	
Spring Creek	1632.5	1	39.00	723.62	724.87	3.12			3.12	17.97	0.50			0.50	
Spring Creek	1632.5	2	95.00	723.62	725.37	4.20		0.45	4.20	22.98	0.81		0.07	0.80	
Spring Creek	1632.5	10	342.00	723.62	726.29	7.68	1.82	1.74	7.39	28.39	2.18	0.46	0.54	1.85	
Spring Creek	1632.5	100	768.00	723.62	730.52	4.24	1.46	1.27	2.97	73.41	0.45	0.17	0.17	0.25	
Spring Creek	1509	1	39.00	722.24	723.17	3.41			3.41	17.73	0.61			0.61	
Spring Creek	1509	2	95.00	722.24	723.71	3.84			3.84	30.14	0.72			0.72	
Spring Creek	1509	10	342.00	722.24	725.43	3.74	1.65	0.69	3.13	55.06	0.47	0.25	0.09	0.36	
Spring Creek	1509	100	768.00	722.24	730.61	1.76	0.76	0.48	1.08	151.00	0.07	0.04	0.02	0.04	
Spring Creek	1455.5	1	39.00	720.68	721.91	4.59			4.59	13.27	1.12			1.12	
Spring Creek	1455.5	2	95.00	720.68	722.46	5.48			5.48	18.93	1.41			1.41	
Spring Creek	1455.5	10	342.00	720.68	725.18	4.42	0.83	1.54	3.84	35.22	0.59	0.09	0.28	0.40	
Spring Creek	1455.5	100	768.00	720.68	730.58	2.32	0.84	0.68	1.24	146.90	0.12	0.05	0.04	0.06	
Spring Creek	1389	1	39.00	719.94	721.42	1.17			1.17	30.20	0.06			0.06	404 Broadway
Spring Creek	1389	2	95.00	719.94	722.10	1.76	0.07	0.06	1.76	31.26	0.12			0.12	* Garage El. 725.4
Spring Creek	1389	10	342.00	719.94	725.29	2.15	0.43	0.66	1.97	41.88	0.13	0.02	0.05	0.10	
Spring Creek	1389	100	768.00	719.94	730.58	1.85	0.61	0.42	1.21	129.26	0.07	0.03	0.02	0.04	
Spring Creek	1319	1	39.00	719.82	721.26	2.11			2.11	17.72	0.20			0.20	
Spring Creek	1319	2	95.00	719.82	721.82	3.30			3.30	18.75	0.44			0.44	
Spring Creek	1319	10	342.00	719.82	725.08	3.69	0.63	0.48	3.63	21.28	0.38	0.04	0.03	0.32	
Spring Creek	1319	100	768.00	719.82	730.39	3.67	1.52	0.61	3.33	52.84	0.30	0.11	0.04	0.21	
Spring Creek	1282.2		Culvert												
Spring Creek	1243.2	1	39.00	719.14	719.71	6.92			6.92	12.28	3.58			3.58	
Spring Creek	1243.2	2	95.00	719.14	720.69	4.91			4.91	15.90	1.31			1.31	
Spring Creek	1243.2	10	342.00	719.14	722.72	6.14	3.30	1.76	5.89	23.82	1.50	0.69	0.35	1.29	
Spring Creek	1243.2	100	768.00	719.14	724.72	7.99	5.34	3.26	7.36	31.80	2.16	1.38	0.87	1.81	
Spring Creek	1206	1	39.00	717.25	718.62	5.29			5.29	8.41	1.71			1.71	
Spring Creek	1206	2	95.00	717.25	719.36	6.60			6.60	10.56	2.32			2.32	
Spring Creek	1206	10	342.00	717.25	721.19	8.86			8.86	15.89	3.49			3.49	
Spring Creek	1206	100	768.00	717.25	723.05	10.50			10.50	21.32	4.39			4.39	
Spring Creek	1177	1	39.00	716.11	717.83	4.13			4.13	9.12	0.99			0.99	
Spring Creek	1177	2	95.00	716.11	718.68	5.15			5.15	11.96	1.36			1.36	
Spring Creek	1177	10	342.00	716.11	720.71	6.90			6.90	18.74	2.05			2.05	
Spring Creek	1177	100	768.00	716.11	723.01	7.55			7.55	26.40	2.18			2.18	

HEC-RAS Plan: 1800s River: Spring Creek Reach: Spring Creek (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Vel Left	Vel Right	Vel Total	Top Width	Shear Chan	Shear LOB	Shear ROB	Shear Total
			(cfs)	(ft)	(ft)	(ft/s)	(ft/s)	(ft/s)	(ft/s)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
Spring Creek	1149	1	39.00	715.72	717.41	3.98			3.98	8.94	0.90			0.90
Spring Creek	1149	2	95.00	715.72	718.26	5.13			5.13	11.59	1.34			1.34
Spring Creek	1149	10	342.00	715.72	720.20	7.31			7.31	17.66	2.30			2.30
Spring Creek	1149	100	768.00	715.72	722.73	7.56			7.56	25.58	2.17			2.17
Spring Creek	1131	1	39.00	715.61	717.05	4.38			4.38	9.05	1.13			1.13
Spring Creek	1131	2	95.00	715.61	717.64	6.40			6.40	10.85	2.18			2.18
Spring Creek	1131	10	342.00	715.61	719.42	8.78			8.78	16.22	3.43			3.43
Spring Creek	1131	100	768.00	715.61	722.60	7.25			7.25	25.86	1.98			1.98
Spring Creek	1120	1	39.00	715.11	716.38	4.82			4.82	11.14	1.53			1.53
Spring Creek	1120	2	95.00	715.11	716.98	6.21			6.21	13.08	2.19			2.19
Spring Creek	1120	10	342.00	715.11	718.28	10.08			10.08	15.55	4.76			4.76
Spring Creek	1120	100	768.00	715.11	722.57	6.32			6.32	26.89	1.49			1.49
Spring Creek	1110	1	39.00	713.68	714.26	10.78			10.78	9.67	9.30			9.30
Spring Creek	1110	2	95.00	713.68	714.66	12.23			12.23	10.90	9.74			9.74
Spring Creek	1110	10	342.00	713.68	718.33	5.45			5.45	18.63	1.21			1.21
Spring Creek	1110	100	768.00	713.68	722.76	4.48			4.48	31.38	0.70			0.70
Spring Creek	1086	1	40.00	713.00	714.56	5.55			5.55	7.55	1.85			1.85
Spring Creek	1086	2	97.00	713.00	715.37	6.76			6.76	10.08	2.42			2.42
Spring Creek	1086	10	351.00	713.00	717.29	8.88			8.88	16.08	3.50			3.50
Spring Creek	1086	100	792.00	713.00	722.70	4.62			4.62	32.71	0.74			0.74
Spring Creek	1038	1	40.00	712.14	713.82	3.06			3.06	10.49	0.51			0.51
Spring Creek	1038	2	97.00	712.14	714.65	4.27			4.27	12.83	0.89			0.89
Spring Creek	1038	10	351.00	712.14	716.73	6.33			6.33	18.67	1.67			1.67
Spring Creek	1038	100	792.00	712.14	722.69	3.66			3.66	35.36	0.44			0.44
Spring Creek	990.8	1	40.00	711.97	712.92	4.97			4.97	10.50	1.57			1.57
Spring Creek	990.8	2	97.00	711.97	713.55	6.41			6.41	11.74	2.23			2.23
Spring Creek	990.8	10	351.00	711.97	716.16	6.59			6.59	17.90	1.82			1.82
Spring Creek	990.8	100	792.00	711.97	722.64	3.60	0.85	0.56	3.54	34.60	0.41	0.06	0.04	0.36
Spring Creek	945		Culvert											
Spring Creek	911.5	1	40.00	711.50	712.79	2.61			2.61	15.48	0.40			0.40
Spring Creek	911.5	2	97.00	711.50	713.56	3.50			3.50	16.64	0.61			0.61
Spring Creek	911.5	10	351.00	711.50	715.28	6.00			6.00	19.25	1.50			1.50
Spring Creek	911.5	100	792.00	711.50	718.46	6.22			6.22	24.06	1.38			1.38
Spring Creek	877	1	40.00	711.07	712.28	3.69			3.69	12.11	0.82			0.82
Spring Creek	877	2	97.00	711.07	713.01	4.65			4.65	15.45	1.14			1.14
Spring Creek	877	10	351.00	711.07	714.87	6.15			6.15	23.33	1.64			1.64
Spring Creek	877	100	792.00	711.07	718.36	4.83			4.83	38.07	0.84			0.84
Spring Creek	842.6	1	40.00	710.61	711.85	3.40			3.40	12.01	0.68			0.68
Spring Creek	842.6	2	97.00	710.61	712.55	4.62			4.62	14.39	1.10			1.10
Spring Creek	842.6	10	351.00	710.61	714.20	7.10			7.10	19.98	2.20			2.20
Spring Creek	842.6	100	792.00	710.61	718.20	5.06			5.06	33.88	0.91			0.91
Spring Creek	795	1	40.00	709.80	710.84	4.87			4.87	11.08	1.52			1.52
Spring Creek	795	2	97.00	709.80	711.46	6.18			6.18	13.17	2.10			2.10
Spring Creek	795	10	351.00	709.80	713.24	7.88			7.88	19.20	2.77			2.77
Spring Creek	795	100	792.00	709.80	718.15	4.42			4.42	35.76	0.68			0.68
Spring Creek	753.9	1	40.00	709.09	710.38	2.21			2.21	18.18	0.28			0.28
Spring Creek	753.9	2	97.00	709.09	711.33	2.59			2.59	22.37	0.33			0.33
Spring Creek	753.9	10	351.00	709.09	713.52	3.61			3.61	32.14	0.53			0.53
Spring Creek	753.9	100	792.00	709.09	718.22	2.96			2.96	52.41	0.26			0.26
Spring Creek	731.9		Culvert											
Spring Creek	684.9	1	40.00	708.10	708.86	6.03			6.03	12.70	2.64			2.64
Spring Creek	684.9	2	97.00	708.10	709.31	7.43			7.43	15.47	3.43			3.43
Spring Creek	684.9	10	351.00	708.10	710.93	8.12	1.28	1.30	8.04	22.50	3.02	0.29	0.37	2.77
Spring Creek	684.9	100	792.00	708.10	712.27	10.91	3.28	2.86	10.17	28.58	4.63	1.17	1.20	3.63
Spring Creek	613	1	40.00	705.55	706.47	4.19			4.19	18.49	1.25			1.25
Spring Creek	613	2	97.00	705.55	706.91	5.33			5.33	20.45	1.71			1.71
Spring Creek	613	10	351.00	705.55	707.67	10.13	0.72	1.60	10.04	23.42	5.09	0.23	0.76	4.80
Spring Creek	613	100	792.00	705.55	708.78	13.20	2.51	3.22	12.49	27.78	7.25	1.43	2.07	6.03
Spring Creek	585	1	40.00	704.61	705.44	3.72			3.72	18.78	0.96			0.96
Spring Creek	585	2	97.00	704.61	705.97	4.55			4.55	20.82	1.19			1.19
Spring Creek	585	10	351.00	704.61	707.30	6.85	1.00	1.24	6.73	25.86	2.09	0.28	0.38	1.87
Spring Creek	585	100	792.00	704.61	707.82	12.42	2.34	2.66	11.94	27.89	6.38	1.24	1.50	5.44
Spring Creek	545	1	40.00	703.45	704.96	2.62			2.62	18.87	0.42			0.42
Spring Creek	545	2	97.00	703.45	705.58	3.36			3.36	25.12	0.62			0.62
Spring Creek	545	10	351.00	703.45	707.26	4.45	1.36	1.66	4.24	38.30	0.82	0.16	0.22	0.67
Spring Creek	545	100	792.00	703.45	709.03	5.50	2.28	2.29	4.75	56.71	1.06	0.33	0.33	0.70
Spring Creek	533		Bridge											
Spring Creek	521	1	40.00	703.22	704.30	4.57			4.57	13.23	1.38			1.38
Spring Creek	521	2	97.00	703.22	704.86	5.64	0.65		5.64	17.20	1.82	0.08		1.79
Spring Creek	521	10	351.00	703.22	706.23	8.07	3.32	2.74	7.47	26.20	2.83	0.87	0.65	2.16

HEC-RAS Plan: 1800s River: Spring Creek Reach: Spring Creek (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Vel Left	Vel Right	Vel Total	Top Width	Shear Chan	Shear LOB	Shear ROB	Shear Total
			(cfs)	(ft)	(ft)	(ft/s)	(ft/s)	(ft/s)	(ft/s)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
Spring Creek	521	100	792.00	703.22	707.81	9.64	4.14	4.16	7.99	40.52	3.40	1.12	1.13	2.11
Spring Creek	423	1	40.00	699.94	701.28	2.84			2.84	14.25	0.47			0.47
Spring Creek	423	2	97.00	699.94	701.94	3.98			3.98	16.92	0.82			0.82
Spring Creek	423	10	351.00	699.94	702.49	10.21			10.21	19.23	5.02			5.02
Spring Creek	423	100	792.00	699.94	703.77	13.17	1.45	2.28	12.73	24.72	7.02	0.75	1.48	5.83
Spring Creek	297	1	40.00	699.41	700.24	2.52			2.52	21.73	0.41			0.41
Spring Creek	297	2	97.00	699.41	700.76	3.48			3.48	25.19	0.68			0.68
Spring Creek	297	10	351.00	699.41	702.07	5.34			5.34	32.43	1.30			1.30
Spring Creek	297	100	792.00	699.41	703.44	6.98	0.79	0.89	6.88	39.62	1.91	0.21	0.26	1.73
Spring Creek	232.6	1	40.00	698.67	699.30	3.25			3.25	22.86	0.75			0.75
Spring Creek	232.6	2	97.00	698.67	699.69	4.48			4.48	24.63	1.21			1.21
Spring Creek	232.6	10	351.00	698.67	700.76	6.95			6.95	29.44	2.33			2.33
Spring Creek	232.6	100	792.00	698.67	701.88	9.29	1.36	0.91	9.16	34.48	3.57	0.59	0.32	3.26

Spring Creek Current Conditions HEC-RAS Model Results

HEC-RAS Plan: Existing River: Spring Creek Reach: Spring Creek

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Vel Left	Vel Right	Vel Total	Top Width	Shear Chan	Shear LOB	Shear ROB	Shear Total	
			(cfs)	(ft)	(ft)	(ft/s)	(ft/s)	(ft/s)	(ft/s)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	
Spring Creek	2567.9	1	113.00	745.20	746.86	6.16			6.16	16.42	1.68			1.68	
Spring Creek	2567.9	2	160.00	745.20	747.15	6.82		0.34	6.82	18.81	1.95		0.05	1.87	
Spring Creek	2567.9	10	369.00	745.20	748.01	9.03		1.95	8.20	31.75	2.97		0.69	2.14	
Spring Creek	2567.9	100	917.00	745.20	749.33	11.95		4.25	9.81	39.72	4.52		2.22	3.52	
Spring Creek	2137.7	1	113.00	734.49	737.49	2.78	0.71	0.54	2.56	26.87	0.27	0.08	0.06	0.21	
Spring Creek	2137.7	2	160.00	734.49	737.92	3.20	0.91	0.76	2.83	29.41	0.34	0.12	0.09	0.26	
Spring Creek	2137.7	10	369.00	734.49	740.06	3.64	1.17	1.12	2.81	41.01	0.36	0.15	0.14	0.24	
Spring Creek	2137.7	100	917.00	734.49	747.61	2.62	0.91	0.89	1.58	78.76	0.14	0.07	0.06	0.08	
Spring Creek	2120.5	1	113.00	734.67	736.85	6.28		0.40	6.28	15.28	1.71		0.06	1.69	
Spring Creek	2120.5	2	160.00	734.67	737.19	6.91	0.35	1.05	6.86	16.91	1.93	0.05	0.26	1.79	
Spring Creek	2120.5	10	369.00	734.67	739.82	5.18	1.54	1.48	4.17	31.30	0.77	0.29	0.27	0.52	
Spring Creek	2120.5	100	917.00	734.67	747.57	3.23	1.08	0.95	1.85	78.23	0.21	0.09	0.08	0.11	
Spring Creek	2087.7		Culvert												
Spring Creek	2011.1	1	113.00	732.64	734.33	11.12			11.12	11.38	5.91			5.91	
Spring Creek	2011.1	2	160.00	732.64	734.62	11.69			11.69	12.64	6.13			6.13	
Spring Creek	2011.1	10	369.00	732.64	735.43	14.67			14.67	15.81	8.52			8.52	
Spring Creek	2011.1	100	917.00	732.64	738.41	11.32	3.17	2.04	10.84	24.29	3.71	0.77	0.66	3.01	
Spring Creek	1948.00*	1	113.00	731.14	733.32	6.30			6.30	14.92	1.72			1.72	
Spring Creek	1948.00*	2	160.00	731.14	733.66	6.85			6.85	16.45	1.92			1.92	
Spring Creek	1948.00*	10	369.00	731.14	734.76	8.53	0.63		8.53	19.78	2.59	0.08		2.56	
Spring Creek	1948.00*	100	917.00	731.14	735.97	13.54	3.31	2.14	13.19	23.46	5.66	1.01	0.83	4.84	
Spring Creek	1884.90*	1	113.00	729.63	731.66	6.45			6.45	15.93	1.84			1.84	
Spring Creek	1884.90*	2	160.00	729.63	731.92	7.32			7.32	17.09	2.26			2.26	
Spring Creek	1884.90*	10	369.00	729.63	732.78	9.75			9.75	20.22	3.56			3.56	
Spring Creek	1884.90*	100	917.00	729.63	734.03	13.80	3.36	2.59	11.53	49.41	6.03	1.11	1.14	3.21	
Spring Creek	1834.33*	1	113.00	728.13	729.97	6.89			6.89	16.63	2.18			2.18	112 5th Street
Spring Creek	1834.33*	2	160.00	728.13	730.24	7.58			7.58	17.89	2.49			2.49	* Garage El. 73
Spring Creek	1834.33*	10	369.00	728.13	731.08	9.79	0.77	0.37	9.79	21.78	3.64	0.13	0.06	3.52	* Residence El. 74
Spring Creek	1834.33*	100	917.00	728.13	732.36	13.75	3.57	2.93	12.49	33.84	5.98	1.28	1.36	4.25	
Spring Creek	1758.70*	1	113.00	726.63	728.51	5.79		0.38	5.76	22.09	1.51		0.06	1.28	
Spring Creek	1758.70*	2	160.00	726.63	728.92	5.55		0.98	4.60	53.75	1.28		0.22	0.64	
Spring Creek	1758.70*	10	369.00	726.63	729.39	8.10	1.06	2.40	5.77	64.07	2.50	0.20	0.93	1.47	
Spring Creek	1758.70*	100	917.00	726.63	733.23	4.10	1.35	1.92	2.65	83.55	0.43	0.14	0.32	0.33	
Spring Creek	1695.60*	1	113.00	725.12	726.84	6.00			6.00	19.57	1.66			1.66	
Spring Creek	1695.60*	2	160.00	725.12	726.97	7.41			7.41	20.55	2.47			2.47	
Spring Creek	1695.60*	10	369.00	725.12	727.94	7.97	1.69	1.93	6.55	48.86	2.33	0.40	0.64	1.42	
Spring Creek	1695.60*	100	917.00	725.12	733.21	3.35	1.13	1.46	2.12	92.69	0.27	0.09	0.18	0.17	
Spring Creek	1632.5	1	128.00	723.62	725.53	4.84	0.41	0.72	4.82	24.15	1.02	0.05	0.14	0.98	
Spring Creek	1632.5	2	179.00	723.62	725.82	5.39	0.95	1.02	5.31	25.67	1.18	0.16	0.23	1.08	
Spring Creek	1632.5	10	403.00	723.62	726.39	8.59	2.09	1.99	8.21	29.07	2.67	0.59	0.69	2.24	
Spring Creek	1632.5	100	978.00	723.62	733.19	3.15	1.33	0.96	2.08	84.42	0.22	0.11	0.08	0.14	
Spring Creek	1509	1	128.00	722.24	723.90	4.16	0.64	0.17	4.00	44.56	0.79	0.09		0.57	
Spring Creek	1509	2	179.00	722.24	724.03	5.08	1.14	0.39	4.72	46.59	1.13	0.22	0.06	0.82	
Spring Creek	1509	10	403.00	722.24	726.11	3.32	1.42	0.70	2.63	80.70	0.34	0.12	0.08	0.20	
Spring Creek	1509	100	978.00	722.24	733.23	1.43	0.66	0.42	0.86	171.87	0.04	0.02	0.02	0.03	
Spring Creek	1455.5	1	128.00	720.68	722.67	5.94	0.68	0.35	5.92	21.16	1.58	0.11	0.05	1.51	
Spring Creek	1455.5	2	179.00	720.68	723.20	5.51	1.12	1.20	5.31	24.53	1.19	0.20	0.28	1.02	
Spring Creek	1455.5	10	403.00	720.68	725.90	4.19	0.76	1.37	3.25	62.56	0.49	0.07	0.22	0.23	
Spring Creek	1455.5	100	978.00	720.68	733.22	1.80	0.72	0.60	0.94	174.48	0.07	0.03	0.03	0.03	
Spring Creek	1389	1	128.00	719.94	722.79	1.69	0.24	0.28	1.67	34.80	0.10	0.01	0.02	0.09	404 Broadway
Spring Creek	1389	2	179.00	719.94	723.40	1.87	0.33	0.42	1.80	37.41	0.11	0.02	0.03	0.10	* Garage El. 725.4
Spring Creek	1389	10	403.00	719.94	725.99	2.20	0.33	0.70	1.96	52.89	0.13	0.01	0.05	0.08	
Spring Creek	1389	100	978.00	719.94	733.21	1.61	0.56	0.41	0.93	178.70	0.05	0.02	0.01	0.02	
Spring Creek	1319	1	128.00	719.82	722.61	2.92	0.23		2.91	19.53	0.30	0.01		0.30	
Spring Creek	1319	2	179.00	719.82	723.21	3.21	0.39		3.21	19.89	0.34	0.02		0.33	
Spring Creek	1319	10	403.00	719.82	725.78	3.77	0.71	0.52	3.68	21.91	0.38	0.04	0.04	0.31	
Spring Creek	1319	100	978.00	719.82	733.02	3.66	0.88	0.77	2.98	91.43	0.27	0.04	0.05	0.12	
Spring Creek	1282.2		Culvert												
Spring Creek	1243.2	1	128.00	719.14	720.27	9.83			9.83	14.26	5.76			5.76	
Spring Creek	1243.2	2	179.00	719.14	721.52	5.33	1.50	0.77	5.28	19.17	1.33	0.23	0.11	1.23	
Spring Creek	1243.2	10	403.00	719.14	723.07	6.44	3.69	1.98	6.12	25.14	1.59	0.81	0.42	1.34	
Spring Creek	1243.2	100	978.00	719.14	725.93	8.02	5.66	3.81	7.35	36.34	2.02	1.40	1.02	1.75	
Spring Creek	1206	1	128.00	717.25	719.69	7.08			7.08	11.53	2.56			2.56	
Spring Creek	1206	2	179.00	717.25	720.13	7.66			7.66	12.80	2.85			2.85	
Spring Creek	1206	10	403.00	717.25	722.80	5.92			5.92	20.60	1.42			1.42	
Spring Creek	1206	100	978.00	717.25	725.75	6.89			6.89	29.68	1.70			1.70	
Spring Creek	1177	1	128.00	716.11	719.06	5.52			5.52	13.22	1.50			1.50	
Spring Creek	1177	2	179.00	716.11	719.54	5.97			5.97	14.84	1.67			1.67	
Spring Creek	1177	10	403.00	716.11	722.86	4.13			4.13	25.89	0.65			0.65	
Spring Creek	1177	100	978.00	716.11	725.85	5.16			5.16	35.65	0.91			0.91	

HEC-RAS Plan: Existing River: Spring Creek Reach: Spring Creek (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Vel Left	Vel Right	Vel Total	Top Width	Shear Chan	Shear LOB	Shear ROB	Shear Total
			(cfs)	(ft)	(ft)	(ft/s)	(ft/s)	(ft/s)	(ft/s)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
Spring Creek	1149	1	128.00	715.72	718.63	5.57			5.57	12.74	1.51			1.51
Spring Creek	1149	2	179.00	715.72	719.09	6.13			6.13	14.19	1.76			1.76
Spring Creek	1149	10	403.00	715.72	722.80	3.90			3.90	25.79	0.57			0.57
Spring Creek	1149	100	978.00	715.72	725.78	5.04			5.04	35.12	0.86			0.86
Spring Creek	1131	1	128.00	715.61	717.94	7.03			7.03	11.75	2.52			2.52
Spring Creek	1131	2	179.00	715.61	718.37	7.60			7.60	13.05	2.81			2.81
Spring Creek	1131	10	403.00	715.61	722.78	3.65			3.65	26.39	0.50			0.50
Spring Creek	1131	100	978.00	715.61	725.75	4.83			4.83	35.62	0.79			0.79
Spring Creek	1120	1	128.00	715.11	717.47	5.82			5.82	13.97	1.75			1.75
Spring Creek	1120	2	179.00	715.11	718.31	5.20			5.20	15.60	1.27			1.27
Spring Creek	1120	10	403.00	715.11	722.77	3.17			3.17	27.62	0.37			0.37
Spring Creek	1120	100	978.00	715.11	725.75	4.33			4.33	38.56	0.64			0.64
Spring Creek	1110	1	128.00	713.68	717.75	2.45			2.45	17.47	0.25			0.25
Spring Creek	1110	2	179.00	713.68	718.50	2.72			2.72	18.96	0.30			0.30
Spring Creek	1110	10	403.00	713.68	722.81	2.33			2.33	31.54	0.19			0.19
Spring Creek	1110	100	978.00	713.68	725.81	3.57	0.94	0.75	3.48	40.77	0.39	0.06	0.06	0.33
Spring Creek	1086	1	239.00	713.00	716.60	8.22			8.22	13.93	3.16			3.16
Spring Creek	1086	2	335.00	713.00	717.21	8.78			8.78	15.81	3.44			3.44
Spring Creek	1086	10	771.00	713.00	722.51	4.66			4.66	32.13	0.76			0.76
Spring Creek	1086	100	1904.00	713.00	725.04	7.42			7.42	39.89	1.79			1.79
Spring Creek	1038	1	239.00	712.14	715.93	5.78			5.78	16.41	1.47			1.47
Spring Creek	1038	2	335.00	712.14	716.60	6.30			6.30	18.32	1.67			1.67
Spring Creek	1038	10	771.00	712.14	722.51	3.67			3.67	34.84	0.45			0.45
Spring Creek	1038	100	1904.00	712.14	725.03	6.21			6.21	41.80	1.20			1.20
Spring Creek	990.8	1	239.00	711.97	714.81	7.60			7.60	14.41	2.67			2.67
Spring Creek	990.8	2	335.00	711.97	715.99	6.67			6.67	17.45	1.89			1.89
Spring Creek	990.8	10	771.00	711.97	722.45	3.60	0.82	0.52	3.55	34.12	0.41	0.05	0.03	0.36
Spring Creek	990.8	100	1904.00	711.97	724.84	6.54	2.01	1.62	6.23	40.41	1.23	0.25	0.23	0.97
Spring Creek	945		Culvert											
Spring Creek	911.5	1	239.00	711.50	714.70	5.01			5.01	18.37	1.10			1.10
Spring Creek	911.5	2	335.00	711.50	715.22	5.85			5.85	19.15	1.44			1.44
Spring Creek	911.5	10	771.00	711.50	718.29	6.25			6.25	23.81	1.40			1.40
Spring Creek	911.5	100	1904.00	711.50	722.04	8.35	1.92	1.78	7.92	45.70	2.18	0.28	0.33	1.57
Spring Creek	877	1	239.00	711.07	714.18	5.70			5.70	20.41	1.49			1.49
Spring Creek	877	2	335.00	711.07	714.81	6.02			6.02	23.07	1.58			1.58
Spring Creek	877	10	771.00	711.07	718.19	4.89			4.89	37.35	0.87			0.87
Spring Creek	877	100	1904.00	711.07	722.01	5.78			5.78	52.35	1.07			1.07
Spring Creek	842.6	1	239.00	710.61	713.53	6.50			6.50	17.70	1.95			1.95
Spring Creek	842.6	2	335.00	710.61	714.28	6.56			6.56	20.26	1.87			1.87
Spring Creek	842.6	10	771.00	710.61	718.03	5.12			5.12	33.22	0.94			0.94
Spring Creek	842.6	100	1904.00	710.61	721.79	6.30			6.30	47.27	1.27			1.27
Spring Creek	795	1	239.00	709.80	712.92	6.22			6.22	18.08	1.77			1.77
Spring Creek	795	2	335.00	709.80	713.95	5.68			5.68	21.59	1.36			1.36
Spring Creek	795	10	771.00	709.80	717.96	4.46			4.46	35.15	0.70			0.70
Spring Creek	795	100	1904.00	709.80	721.73	5.79			5.79	47.88	1.05			1.05
Spring Creek	753.9	1	239.00	709.09	713.06	2.88			2.88	30.10	0.35			0.35
Spring Creek	753.9	2	335.00	709.09	714.08	2.89			2.89	34.57	0.33			0.33
Spring Creek	753.9	10	771.00	709.09	718.04	2.95			2.95	51.72	0.27			0.27
Spring Creek	753.9	100	1904.00	709.09	721.78	4.64	0.43	0.38	4.00	380.59	0.65	0.02	0.02	0.12
Spring Creek	731.9		Culvert											
Spring Creek	684.9	1	239.00	708.10	710.10	8.99			8.99	18.78	4.23			4.23
Spring Creek	684.9	2	335.00	708.10	710.52	9.59		0.69	9.59	20.69	4.53		0.17	4.46
Spring Creek	684.9	10	771.00	708.10	712.20	10.85	3.22	2.81	10.15	28.27	4.61	1.15	1.18	3.64
Spring Creek	684.9	100	1904.00	708.10	715.12	12.95	5.13	4.77	10.78	41.06	5.34	2.05	2.32	3.82
Spring Creek	613	1	239.00	705.55	707.58	7.33	0.32	1.05	7.29	23.05	2.73		0.35	2.60
Spring Creek	613	2	335.00	705.55	707.80	8.93	0.88	1.56	8.82	23.93	3.86	0.28	0.67	3.57
Spring Creek	613	10	771.00	705.55	708.74	13.09	2.46	3.17	12.41	27.60	7.16	1.38	2.02	5.99
Spring Creek	613	100	1904.00	705.55	710.97	16.64	3.86	4.86	14.19	37.56	9.45	2.50	3.53	6.70
Spring Creek	585	1	239.00	704.61	706.35	8.11			8.11	22.25	3.47			3.47
Spring Creek	585	2	335.00	704.61	707.23	6.76	0.93	1.18	6.65	25.60	2.05	0.25	0.36	1.86
Spring Creek	585	10	771.00	704.61	707.79	12.26	2.28	2.61	11.80	27.76	6.24	1.19	1.45	5.34
Spring Creek	585	100	1904.00	704.61	709.73	17.01	4.32	4.53	15.06	35.28	10.05	3.04	3.28	7.51
Spring Creek	545	1	239.00	703.45	706.62	4.07	0.81	1.23	4.00	33.58	0.76	0.08	0.15	0.67
Spring Creek	545	2	335.00	703.45	707.18	4.40	1.30	1.61	4.21	37.67	0.81	0.15	0.21	0.67
Spring Creek	545	10	771.00	703.45	708.96	5.46	2.25	2.26	4.73	56.05	1.05	0.32	0.33	0.70
Spring Creek	545	100	1904.00	703.45	711.29	7.45	3.52	3.39	5.81	83.69	1.70	0.64	0.61	0.99
Spring Creek	533		Bridge											
Spring Creek	521	1	239.00	703.22	705.71	7.26	2.64	1.84	6.97	22.81	2.49	0.64	0.37	2.05
Spring Creek	521	2	335.00	703.22	706.17	7.93	3.23	2.61	7.38	25.85	2.76	0.84	0.61	2.12
Spring Creek	521	10	771.00	703.22	707.75	9.58	4.06	4.12	7.96	40.16	3.38	1.09	1.12	2.10

HEC-RAS Plan: Existing River: Spring Creek Reach: Spring Creek (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Vel Left	Vel Right	Vel Total	Top Width	Shear Chan	Shear LOB	Shear ROB	Shear Total
			(cfs)	(ft)	(ft)	(ft/s)	(ft/s)	(ft/s)	(ft/s)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
Spring Creek	521	100	1904.00	703.22	710.31	11.01	5.73	3.66	7.43	95.49	3.76	1.66	0.85	1.58
Spring Creek	423	1	239.00	699.94	702.88	5.70	0.14	0.50	5.69	20.78	1.48		0.11	1.42
Spring Creek	423	2	335.00	699.94	703.29	6.67	0.62	0.93	6.58	22.28	1.91	0.16	0.29	1.73
Spring Creek	423	10	771.00	699.94	703.71	13.10	1.50	2.22	12.71	24.11	7.00	0.79	1.43	5.94
Spring Creek	423	100	1904.00	699.94	706.24	15.59	4.18	3.64	11.89	43.99	8.06	3.27	2.66	5.32
Spring Creek	297	1	239.00	699.41	701.58	4.74			4.74	29.80	1.09			1.09
Spring Creek	297	2	335.00	699.41	702.00	5.27			5.27	32.08	1.28			1.28
Spring Creek	297	10	771.00	699.41	703.39	6.90	0.76	0.85	6.82	39.38	1.88	0.20	0.24	1.71
Spring Creek	297	100	1904.00	699.41	705.81	9.37	1.80	1.68	8.30	60.27	2.86	0.70	0.63	1.94
Spring Creek	232.6	1	239.00	698.67	700.36	6.12			6.12	27.62	1.93			1.93
Spring Creek	232.6	2	335.00	698.67	700.71	6.85			6.85	29.20	2.28			2.28
Spring Creek	232.6	10	771.00	698.67	701.83	9.23	1.32	0.86	9.12	34.23	3.55	0.56	0.29	3.26
Spring Creek	232.6	100	1904.00	698.67	704.05	12.17	2.23	2.41	10.97	48.67	5.05	1.16	1.30	3.64

Spring Creek 2050 Conditions HEC-RAS Model Results

HEC-RAS Plan: 2050 River: Spring Creek Reach: Spring Creek

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Vel Left	Vel Right	Vel Total	Top Width	Shear Chan	Shear LOB	Shear ROB	Shear Total	
			(cfs)	(ft)	(ft)	(ft/s)	(ft/s)	(ft/s)	(ft/s)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	
Spring Creek	2567.9	1	288.00	745.20	747.72	8.34		1.60	7.89	26.76	2.64		0.51	2.06	
Spring Creek	2567.9	2	379.00	745.20	748.04	9.11		1.99	8.23	32.32	3.01		0.71	2.15	
Spring Creek	2567.9	10	714.00	745.20	748.92	11.02		3.62	9.22	38.23	4.01		1.75	3.05	
Spring Creek	2567.9	100	1528.00	745.20	750.32	14.29	1.65	5.61	11.34	43.78	5.92	0.54	3.37	4.56	
Spring Creek	2137.7	1	288.00	734.49	739.16	3.66	1.17	1.06	2.98	35.71	0.39	0.16	0.14	0.28	
Spring Creek	2137.7	2	379.00	734.49	740.18	3.63	1.17	1.12	2.79	41.58	0.36	0.15	0.14	0.24	
Spring Creek	2137.7	10	714.00	734.49	744.60	2.99	1.04	1.00	1.94	63.41	0.20	0.09	0.09	0.12	
Spring Creek	2137.7	100	1528.00	734.49	748.82	3.88	1.25	1.32	2.23	90.77	0.29	0.12	0.13	0.16	
Spring Creek	2120.5	1	288.00	734.67	738.81	5.61	1.45	1.51	4.85	26.71	0.99	0.30	0.32	0.71	
Spring Creek	2120.5	2	379.00	734.67	739.94	5.13	1.54	1.48	4.10	31.86	0.75	0.29	0.27	0.51	
Spring Creek	2120.5	10	714.00	734.67	744.51	3.83	1.30	1.13	2.47	55.47	0.33	0.15	0.12	0.19	
Spring Creek	2120.5	100	1528.00	734.67	748.69	5.02	1.54	0.88	2.52	139.91	0.49	0.19	0.08	0.17	
Spring Creek	2087.7		Culvert												
Spring Creek	2011.1	1	288.00	732.64	735.16	13.64			13.64	14.77	7.64			7.64	
Spring Creek	2011.1	2	379.00	732.64	735.46	14.78			14.78	15.93	8.63			8.63	
Spring Creek	2011.1	10	714.00	732.64	736.01	20.41			20.41	17.53	15.38			15.38	
Spring Creek	2011.1	100	1528.00	732.64	740.13	12.95	4.32	3.05	11.62	30.12	4.34	1.17	1.15	3.11	
Spring Creek	1948.00*	1	288.00	731.14	734.39	7.95			7.95	18.77	2.35			2.35	
Spring Creek	1948.00*	2	379.00	731.14	734.81	8.54	0.77		8.54	19.90	2.58	0.10		2.54	
Spring Creek	1948.00*	10	714.00	731.14	735.94	10.65	2.58	1.66	10.38	23.35	3.51	0.62	0.50	3.01	
Spring Creek	1948.00*	100	1528.00	731.14	737.31	15.88	4.81	3.32	14.65	28.93	6.97	1.72	1.55	5.20	
Spring Creek	1884.90*	1	288.00	729.63	732.49	8.98			8.98	19.15	3.13			3.13	
Spring Creek	1884.90*	2	379.00	729.63	732.81	9.88	0.25		9.88	20.28	3.64			3.63	
Spring Creek	1884.90*	10	714.00	729.63	733.63	12.72	2.63	1.88	11.60	39.09	5.36	0.77	0.71	3.19	
Spring Creek	1884.90*	100	1528.00	729.63	734.69	17.67	4.96	4.73	13.52	52.83	9.27	2.10	2.98	5.41	
Spring Creek	1834.33*	1	288.00	728.13	730.80	9.03			9.03	20.40	3.23			3.23	112 5th Street
Spring Creek	1834.33*	2	379.00	728.13	731.10	9.91	0.87	0.47	9.90	22.03	3.71	0.16	0.09	3.55	* Garage El. 73
Spring Creek	1834.33*	10	714.00	728.13	731.92	12.68	2.86	2.30	12.00	29.72	5.36	0.93	0.96	4.09	* Residence El. 74
Spring Creek	1834.33*	100	1528.00	728.13	733.45	16.05	4.85	4.15	13.19	44.54	7.37	1.97	2.24	4.66	
Spring Creek	1758.70*	1	288.00	726.63	729.27	7.07	0.67	1.91	5.15	63.44	1.95	0.10	0.63	1.10	
Spring Creek	1758.70*	2	379.00	726.63	729.41	8.21	1.10	2.46	5.83	64.14	2.56	0.21	0.97	1.51	
Spring Creek	1758.70*	10	714.00	726.63	731.12	5.92	1.70	2.56	3.93	72.70	1.06	0.28	0.70	0.78	
Spring Creek	1758.70*	100	1528.00	726.63	734.87	4.94	1.60	2.34	3.10	96.04	0.58	0.18	0.44	0.41	
Spring Creek	1695.60*	1	288.00	725.12	727.63	7.74	1.21	1.55	6.85	41.67	2.34	0.25	0.48	1.49	
Spring Creek	1695.60*	2	379.00	725.12	727.98	8.01	1.73	1.98	6.54	49.38	2.34	0.41	0.67	1.43	
Spring Creek	1695.60*	10	714.00	725.12	731.08	4.22	1.36	1.73	2.81	75.40	0.47	0.15	0.29	0.32	
Spring Creek	1695.60*	100	1528.00	725.12	734.86	4.21	1.37	1.87	2.54	111.91	0.39	0.13	0.27	0.24	
Spring Creek	1632.5	1	339.00	723.62	726.26	7.73	1.82	1.74	7.44	28.20	2.21	0.47	0.55	1.89	
Spring Creek	1632.5	2	439.00	723.62	726.60	8.42	2.17	2.03	7.94	30.52	2.49	0.60	0.68	2.02	
Spring Creek	1632.5	10	797.00	723.62	731.01	3.91	1.43	1.18	2.69	75.48	0.37	0.15	0.14	0.22	
Spring Creek	1632.5	100	1655.00	723.62	734.80	4.20	1.82	1.29	2.70	92.59	0.37	0.19	0.15	0.23	
Spring Creek	1509	1	339.00	722.24	725.40	3.76	1.66	0.69	3.15	54.89	0.47	0.25	0.09	0.37	
Spring Creek	1509	2	439.00	722.24	726.46	3.32	1.03	0.74	2.37	98.67	0.33	0.10	0.08	0.17	
Spring Creek	1509	10	797.00	722.24	731.09	1.67	0.73	0.46	1.02	155.10	0.06	0.03	0.02	0.04	
Spring Creek	1509	100	1655.00	722.24	734.88	1.95	0.91	0.58	1.16	184.82	0.08	0.04	0.03	0.05	
Spring Creek	1455.5	1	339.00	720.68	725.15	4.43	0.84	1.54	3.86	34.68	0.59	0.09	0.28	0.41	
Spring Creek	1455.5	2	439.00	720.68	726.29	4.03	0.90	1.22	2.92	69.79	0.44	0.09	0.17	0.20	
Spring Creek	1455.5	10	797.00	720.68	731.07	2.18	0.80	0.66	1.15	153.44	0.10	0.04	0.04	0.05	
Spring Creek	1455.5	100	1655.00	720.68	734.86	2.38	0.99	0.83	1.23	187.16	0.11	0.05	0.05	0.06	
Spring Creek	1389	1	339.00	719.94	725.26	2.15	0.42	0.66	1.97	41.78	0.13	0.02	0.05	0.10	404 Broadway
Spring Creek	1389	2	439.00	719.94	726.37	2.23	0.36	0.72	1.93	60.57	0.13	0.02	0.05	0.08	* Garage El. 725.4
Spring Creek	1389	10	797.00	719.94	731.06	1.80	0.58	0.41	1.13	143.84	0.07	0.02	0.02	0.03	
Spring Creek	1389	100	1655.00	719.94	734.85	2.18	0.79	0.61	1.21	199.38	0.09	0.04	0.03	0.04	
Spring Creek	1319	1	339.00	719.82	725.05	3.68	0.63	0.48	3.62	21.25	0.38	0.04	0.03	0.32	
Spring Creek	1319	2	439.00	719.82	726.15	3.84	0.58	0.54	3.71	25.74	0.39	0.03	0.04	0.28	
Spring Creek	1319	10	797.00	719.82	730.88	3.61	1.55	0.64	3.27	58.00	0.28	0.11	0.04	0.20	
Spring Creek	1319	100	1655.00	719.82	734.44	5.39	0.71	1.22	3.34	281.11	0.57	0.04	0.11	0.08	
Spring Creek	1282.2		Culvert												
Spring Creek	1243.2	1	339.00	719.14	722.70	6.13	3.28	1.75	5.88	23.74	1.50	0.69	0.35	1.29	
Spring Creek	1243.2	2	439.00	719.14	723.41	6.35	3.81	2.06	5.98	26.34	1.50	0.82	0.43	1.25	
Spring Creek	1243.2	10	797.00	719.14	725.76	6.75	4.73	3.15	6.18	35.63	1.44	0.99	0.71	1.25	
Spring Creek	1243.2	100	1655.00	719.14	727.39	10.79	7.91	5.65	9.87	50.60	3.42	2.51	2.00	3.03	
Spring Creek	1206	1	339.00	717.25	721.17	8.83			8.83	15.85	3.47			3.47	
Spring Creek	1206	2	439.00	717.25	723.17	5.78			5.78	21.70	1.32			1.32	
Spring Creek	1206	10	797.00	717.25	725.63	5.76			5.76	29.27	1.19			1.19	
Spring Creek	1206	100	1655.00	717.25	727.19	8.84	1.28	0.98	8.81	34.28	2.61	0.17	0.15	2.45	
Spring Creek	1177	1	339.00	716.11	721.02	6.09			6.09	19.79	1.56			1.56	
Spring Creek	1177	2	439.00	716.11	723.23	4.08			4.08	27.13	0.63			0.63	
Spring Creek	1177	10	797.00	716.11	725.69	4.33			4.33	35.14	0.65			0.65	
Spring Creek	1177	100	1655.00	716.11	727.39	6.66	0.52		6.63	48.76	1.46	0.04		1.25	

HEC-RAS Plan: 2050 River: Spring Creek Reach: Spring Creek (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Vel Left	Vel Right	Vel Total	Top Width	Shear Chan	Shear LOB	Shear ROB	Shear Total
			(cfs)	(ft)	(ft)	(ft/s)	(ft/s)	(ft/s)	(ft/s)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
Spring Creek	1149	1	339.00	715.72	720.80	5.85			5.85	19.53	1.42			1.42
Spring Creek	1149	2	439.00	715.72	723.18	3.87			3.87	26.98	0.56			0.56
Spring Creek	1149	10	797.00	715.72	725.64	4.21			4.21	34.70	0.61			0.61
Spring Creek	1149	100	1655.00	715.72	727.27	6.62	0.71		6.57	48.33	1.42	0.06		1.17
Spring Creek	1131	1	339.00	715.61	720.69	5.46			5.46	20.08	1.23			1.23
Spring Creek	1131	2	439.00	715.61	723.15	3.64			3.64	27.57	0.49			0.49
Spring Creek	1131	10	797.00	715.61	725.63	4.02			4.02	35.22	0.55			0.55
Spring Creek	1131	100	1655.00	715.61	727.23	6.44	0.87	1.04	6.40	40.24	1.31	0.08	0.13	1.20
Spring Creek	1120	1	339.00	715.11	720.68	4.42			4.42	20.49	0.78			0.78
Spring Creek	1120	2	439.00	715.11	723.15	3.19			3.19	29.00	0.37			0.37
Spring Creek	1120	10	797.00	715.11	725.62	3.61			3.61	38.08	0.44			0.44
Spring Creek	1120	100	1655.00	715.11	727.25	5.76	0.10	0.25	5.76	44.22	1.08		0.02	1.06
Spring Creek	1110	1	339.00	713.68	720.79	2.93			2.93	25.36	0.32			0.32
Spring Creek	1110	2	439.00	713.68	723.19	2.37			2.37	32.69	0.19			0.19
Spring Creek	1110	10	797.00	713.68	725.66	2.96	0.76	0.61	2.89	40.32	0.27	0.04	0.04	0.23
Spring Creek	1110	100	1655.00	713.68	727.32	5.04	1.04	1.29	4.75	54.61	0.73	0.08	0.15	0.50
Spring Creek	1086	1	624.00	713.00	720.21	6.26			6.26	25.07	1.49			1.49
Spring Creek	1086	2	816.00	713.00	722.91	4.58			4.58	33.34	0.72			0.72
Spring Creek	1086	10	1511.00	713.00	725.23	5.72			5.72	40.45	1.06			1.06
Spring Creek	1086	100	3187.00	713.00	724.97	12.56			12.56	39.66	5.13			5.13
Spring Creek	1038	1	624.00	712.14	720.21	4.54			4.54	28.43	0.74			0.74
Spring Creek	1038	2	816.00	712.14	722.90	3.64			3.64	35.95	0.44			0.44
Spring Creek	1038	10	1511.00	712.14	725.22	4.80			4.80	42.30	0.72			0.72
Spring Creek	1038	100	3187.00	712.14	724.92	10.54			10.54	41.52	3.48			3.48
Spring Creek	990.8	1	624.00	711.97	720.10	4.34			4.34	28.08	0.67			0.67
Spring Creek	990.8	2	816.00	711.97	722.85	3.60	0.89	0.61	3.54	35.14	0.40	0.06	0.04	0.35
Spring Creek	990.8	10	1511.00	711.97	725.11	5.03	1.57	1.28	4.77	41.33	0.72	0.15	0.14	0.56
Spring Creek	990.8	100	3187.00	711.97	722.47	14.83	3.41	2.16	14.64	34.17	6.97	0.90	0.60	6.18
Spring Creek	945		Culvert											
Spring Creek	911.5	1	624.00	711.50	717.12	6.47			6.47	22.03	1.57			1.57
Spring Creek	911.5	2	816.00	711.50	718.65	6.18			6.18	24.35	1.35			1.35
Spring Creek	911.5	10	1511.00	711.50	721.88	6.78	1.49	1.37	6.48	44.32	1.45	0.17	0.20	1.06
Spring Creek	911.5	100	3187.00	711.50	722.68	12.75	3.42	3.05	11.73	52.56	4.95	0.81	0.89	3.31
Spring Creek	877	1	624.00	711.07	716.94	5.46			5.46	32.05	1.15			1.15
Spring Creek	877	2	816.00	711.07	718.56	4.75			4.75	38.90	0.81			0.81
Spring Creek	877	10	1511.00	711.07	721.86	4.70			4.70	51.78	0.71			0.71
Spring Creek	877	100	3187.00	711.07	722.64	8.78			8.78	54.74	2.42			2.42
Spring Creek	842.6	1	624.00	710.61	716.71	5.67			5.67	28.44	1.21			1.21
Spring Creek	842.6	2	816.00	710.61	718.41	4.99			4.99	34.62	0.88			0.88
Spring Creek	842.6	10	1511.00	710.61	721.73	5.05			5.05	47.04	0.82			0.82
Spring Creek	842.6	100	3187.00	710.61	721.76	10.60			10.60	47.14	3.61			3.61
Spring Creek	795	1	624.00	709.80	716.61	4.87			4.87	30.57	0.87			0.87
Spring Creek	795	2	816.00	709.80	718.35	4.37			4.37	36.46	0.66			0.66
Spring Creek	795	10	1511.00	709.80	721.69	4.62			4.62	47.76	0.67			0.67
Spring Creek	795	100	3187.00	709.80	721.49	10.02			10.02	47.10	3.17			3.17
Spring Creek	753.9	1	624.00	709.09	716.71	2.94			2.94	46.27	0.28			0.28
Spring Creek	753.9	2	816.00	709.09	718.42	2.96			2.96	53.17	0.26			0.26
Spring Creek	753.9	10	1511.00	709.09	721.72	3.74	0.28	0.27	3.33	376.92	0.42	0.01	0.01	0.07
Spring Creek	753.9	100	3187.00	709.09	721.64	8.02	0.39	0.44	7.53	371.88	1.96	0.03	0.04	0.33
Spring Creek	731.9		Culvert											
Spring Creek	684.9	1	624.00	708.10	711.75	10.26	2.71	2.43	9.82	26.14	4.33	0.90	0.97	3.57
Spring Creek	684.9	2	816.00	708.10	712.36	10.93	3.34	2.91	10.14	28.98	4.61	1.20	1.23	3.59
Spring Creek	684.9	10	1511.00	708.10	714.36	12.08	4.47	3.93	10.25	38.22	4.85	1.68	1.74	3.40
Spring Creek	684.9	100	3187.00	708.10	717.09	15.32	7.38	6.72	12.57	46.41	6.83	3.51	3.85	5.29
Spring Creek	613	1	624.00	705.55	708.40	12.19	2.04	2.76	11.75	26.26	6.51	1.06	1.66	5.62
Spring Creek	613	2	816.00	705.55	708.83	13.33	2.57	3.28	12.59	27.98	7.35	1.48	2.13	6.09
Spring Creek	613	10	1511.00	705.55	710.24	15.83	3.62	4.46	13.99	33.75	9.02	2.34	3.20	6.75
Spring Creek	613	100	3187.00	705.55	712.93	18.81	4.86	5.87	14.70	46.77	10.79	3.36	4.46	7.06
Spring Creek	585	1	624.00	704.61	707.50	11.14	1.84	2.18	10.86	26.63	5.35	0.85	1.10	4.71
Spring Creek	585	2	816.00	704.61	707.88	12.54	2.41	2.72	12.03	28.11	6.46	1.29	1.55	5.48
Spring Creek	585	10	1511.00	704.61	709.07	15.93	3.81	4.06	14.51	32.72	9.28	2.57	2.83	7.20
Spring Creek	585	100	3187.00	704.61	711.56	19.53	4.79	5.60	15.70	47.85	11.86	3.41	4.31	7.55
Spring Creek	545	1	624.00	703.45	708.49	5.10	2.01	2.03	4.53	51.08	0.95	0.28	0.28	0.66
Spring Creek	545	2	816.00	703.45	709.10	5.54	2.31	2.32	4.77	57.51	1.07	0.34	0.34	0.71
Spring Creek	545	10	1511.00	703.45	710.84	6.54	3.02	2.96	5.19	78.05	1.34	0.49	0.48	0.80
Spring Creek	545	100	3187.00	703.45	709.22	20.94	8.79	8.84	17.92	58.73	15.17	4.83	4.87	9.93
Spring Creek	533		Bridge											
Spring Creek	521	1	624.00	703.22	707.23	9.36	3.90	3.83	8.07	34.92	3.38	1.06	1.04	2.23
Spring Creek	521	2	816.00	703.22	707.87	9.73	4.22	4.22	8.04	40.87	3.45	1.16	1.15	2.14
Spring Creek	521	10	1511.00	703.22	709.74	10.46	5.41	3.03	7.39	84.80	3.51	1.53	0.64	1.45

HEC-RAS Plan: 2050 River: Spring Creek Reach: Spring Creek (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Vel Left	Vel Right	Vel Total	Top Width	Shear Chan	Shear LOB	Shear ROB	Shear Total
			(cfs)	(ft)	(ft)	(ft/s)	(ft/s)	(ft/s)	(ft/s)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
Spring Creek	521	100	3187.00	703.22	712.79	9.41	4.89	4.38	6.00	125.16	2.46	1.08	0.92	1.18
Spring Creek	423	1	624.00	699.94	703.32	12.27	1.18	1.75	12.09	22.39	6.44	0.56	1.01	5.79
Spring Creek	423	2	816.00	699.94	703.85	13.22	0.98	2.34	12.70	28.62	7.02	0.41	1.53	5.11
Spring Creek	423	10	1511.00	699.94	705.32	15.51	3.52	3.42	12.48	41.29	8.48	2.69	2.56	5.46
Spring Creek	423	100	3187.00	699.94	709.49	14.88	3.90	2.49	8.94	96.40	6.28	2.47	1.26	2.71
Spring Creek	297	1	624.00	699.41	702.98	6.41	0.47	0.52	6.39	37.36	1.70	0.10	0.12	1.61
Spring Creek	297	2	816.00	699.41	703.51	7.03	0.83	0.94	6.92	39.96	1.93	0.23	0.27	1.73
Spring Creek	297	10	1511.00	699.41	705.03	8.77	1.55	1.46	8.14	51.28	2.64	0.57	0.52	1.98
Spring Creek	297	100	3187.00	699.41	705.40	17.07	3.15	2.92	15.52	55.52	9.76	2.26	2.02	6.94
Spring Creek	232.6	1	624.00	698.67	701.50	8.54	0.98	0.39	8.50	32.75	3.18	0.36	0.09	3.03
Spring Creek	232.6	2	816.00	698.67	701.92	9.43	1.41	0.96	9.30	34.65	3.67	0.62	0.35	3.33
Spring Creek	232.6	10	1511.00	698.67	703.39	11.27	2.11	2.04	10.51	42.64	4.54	1.08	1.02	3.57
Spring Creek	232.6	100	3187.00	698.67	706.83	11.33	2.18	1.69	6.50	202.03	3.76	0.93	0.63	1.21