Yellow Creek Watershed Technical Memorandum

Prepared for

Summit County Engineer's Office

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Sustainable Streams LLC

Science · Service · Solutions

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Appendices

1.0 Executive Summary

This report summarizes the efforts of the Bath Township Drainage Basin Improvement General Plan completed by Sustainable Streams for the Yellow Creek Watershed in Summit and Medina counties in Ohio. The Yellow Creek Watershed is ~31.4 sq. mi. and drains to the Cuyahoga River, which drains to Lake Erie. Bath Township covers the majority of the watershed.

This project serves as a feasibility analysis/planning phase effort. Additional planning and design are necessary on these conceptual opportunities, as well as coordination with private property owners. In sum, all of the identified conceptual opportunities have the potential to contribute to a healthier Yellow Creek stream network. This includes targeted restoration of reaches with degraded habitat and at-risk infrastructure. It also includes holding back more stormwater runoff during rain events to reduce the erosive power of the flows in the streams. No amount of interventions would stop all erosion in Yellow Creek, but these opportunities collectively have the potential to meaningfully reduce the amount of excess stream erosion attributable to inadequately managed stormwater runoff.

Stormwater management efforts in the watershed include the formation of a Surface Water Management District (SWMD) in 2017, grant-funded stream restoration projects over several years, and most recently wetland restoration projects. However, natural erosion processes combined with extreme weather and/or inadequately managed stormwater in the watershed have contributed to evidence of channel erosion observed throughout stream network by both residents and stream experts. One particularly extreme event in 2014 caused widespread damage and stream instability that has continued to worsen.

There are nearly 100 miles of streams within the Yellow Creek Watershed. Inventoried stormwater infrastructure was not always available, with the majority of the mapped systems being in recent developments and/or the southern portion of the watershed. Most of the watershed is serviced by ditches, swales, and culverts that convey stormwater to the creeks. Water quality appears to be relatively good across measured sites according to Friends of Yellow Creek.

Stream slopes are varied, with a large drop across the watershed. The upper reaches tend to be quite high, with the base level fairly low, as set by the Cuyahoga River. In the steep transition zones between the upper and lower reaches, instability and knickpoints (i.e. locations with sharp changes in slope such as a small waterfall) are prevalent. Land use, soils, and stormwater management in these areas could further exacerbate instability, or conversely, contribute to reversals in such trajectories of instability if they could be optimized in a way to hold back more runoff and reduce the potential of downstream erosion.

As part of this project, Sustainable Streams conducted a rapid visual assessment of nearly 41 miles of streams in December 2018. The visual assessment provided an understanding of current stability conditions and future trajectories. The visual assessment identified many reaches that were unstable and also identified bridges, culverts, roadways, utilities, and other infrastructure that could be considered potentially “at-risk” due to stream instability. Field work also included visits to over 50 parcels with known complaints, and select data collection at representative sites to inform design targets.

Synthesizing the field data, relative stream risk was determined across the assessed reaches. Approximately 57% of the streams were considered low risk based on their relatively flat slopes and/or their location in the headwaters with relatively well-connected floodplains. An additional ~22% of streams located at the downstream end of the watershed were classified as medium risk due to the valley confinement and degradational channel trajectory (e.g. both downcutting and widening). Finally, the transitional reaches between the upstream and downstream ends of the watershed have been classified as high risk due to overly steep slopes, valley confinement, and the potential to exhibit even greater erosive power during large events. It is important to note that these risk classifications are for relative purposes only and that "low risk" does not imply no risk (i.e. evidence of channel erosion was observed even in the "low risk" reaches).

Data were collected at eight stream sites spanning a gradients of stream settings and bed material types to use industry standard methods to estimate the critical discharge ($Q_{critical}$) for streambed erosion. $Q_{critical}$ is expressed as a percentage of the undeveloped two-year discharge (Q_2) to make estimates from different sized watersheds more comparable. Based on data from representative sites, the regional estimate of $Q_{critical}$ for the Yellow Creek Watershed is ~40% of Q_2.

The culmination of data collection and analysis resulted in the development of 66 conceptual projects and 13 non-structural/programmatic efforts to improve conditions in the Yellow Creek Watershed. The concepts work towards achieving the goals of this project by proposing stream stabilization near at-risk infrastructure and stormwater-based measures designed to reduce the erosive power of the flows entering the streams. The inventory of conceptual opportunities covers several topics.

Seven public parcel groups have been identified as ideal locations to preserve forested areas with high infiltration rates. The majority of the public parcels are parks. Several other areas of the watershed under private ownership could also be considered for preservation, or, if developed, could promote stormwater measures that capitalize on the high infiltration capacity of the soils.

Eight infrastructure improvement items have been included, ranging from minor catch basin maintenance to larger-scale storm sewer outlet stabilization to culvert studies. Specifically in two locations, flooding complaints by residents could be further evaluated to better understand the impacts of increasing culvert diameters as it relates to downstream stability and current flooding issues.

Another highly cost-effective strategy would involve the optimization of existing stormwater control measures (SCMs) to mitigate excess erosion in the receiving streams. Based on available data, two relatively simple detention basin retrofits appear to provide benefits in the Arbour Green neighborhood and modification of an existing dam to create a stream/wetland complex could also contribute to reductions in downstream erosion while improving flooding conditions at the dam's spillway. Two other existing basins are recommended for additional studies and may also provide benefits for downstream erosion. As more data become available, additional basins may be identified as candidates for retrofitting.

There are also opportunities in the watershed for new SCMs, including both traditional detention and bankfull wetlands. Bankfull wetlands are located in the floodplain of a stream and are specifically designed to offload flows that would otherwise contribute to channel erosion. Approximately 45 ac-ft (~14 MG) of bankfull wetland storage appears to be possible in the watershed based on a preliminary assessment of floodplain areas. In addition to projects that offload erosive flows, this category also addresses several private property issues (e.g. yard flooding and/or erosion) that appear to be potentially attributable in part to stormwater runoff. A total of 18 new SCM concepts have been developed.

Another goal of the project was to develop stream restoration concepts for reaches with at-risk infrastructure. Twenty-eight (28) stream stabilization projects have been conceptualized. The concepts range from tributaries with low banks to concepts on Yellow Creek and its main tributaries with up to 70-foot tall, near vertical banks. Where such large/private hillslopes appear unstable, the concepts focus on restoration strategies only along the valley bottom/toe of banks via rock armoring/bioengineering. The hillslopes that are potentially geotechnically unstable would remain in an unstable condition without complementary intervention from the private property owner(s) (e.g. retaining walls or other geotechnical stabilization strategies). This approach, which has been used in other communities, keeps the public project focus on the public resource (i.e. the stream) and leaves the private property owner responsible for protecting their private property.

Several other areas of instability do not fall under the jurisdiction of Summit County's SWMD, such as streams with observed instability/erosion that potentially pose risks to bridges, culverts and select utilities. A list of these observed items has been included, and coordination with these other departments and organizations would be necessary to share the concern and work towards improvements.

Due to the relatively large costs associated with such conceptual interventions, stakeholder input is recommended to help prioritize project opportunities and funding coordination, among other roles. It is the goal that this report can help to provide a structured framework for implementation of tailored management actions that can collectively contribute to holistic improvements to the Yellow Creek Watershed in a socioeconomically and environmentally sustainable way.

2.0 Introduction

The Yellow Creek Watershed in northeastern Ohio, within Summit and Medina counties, is approximately 31 sq. mi., with approximately 97.4 miles of streams (See Appendix A, pages A1 to A4). The streams are tributary to the Cuyahoga River, which ultimately drains to Lake Erie. Within the watershed are the communities of Bath Township, Akron, Copley Township, Cuyahoga Falls, Fairlawn, Richfield Township, Richfield Village, Granger Township, and Sharon Township (Figure 1). The 2018 estimated population in Summit County was ~542,000, with essentially no change since 2010 (US Census Bureau, 2019).

Bath Township, which comprises ~58% of the watershed's area, was inhabited by Native Americans until the early 1700's, with permanent European settlement beginning in the early 1800's (National Park Service, 2010). Downtown Ghent began development by 1874. Bath Township has agricultural roots, but construction of I-77 and residential development in the late 1950's and 1960's led to a large population boom. The population in 2010 was ~9,702 (US Census Bureau American FactFinder, 2010).

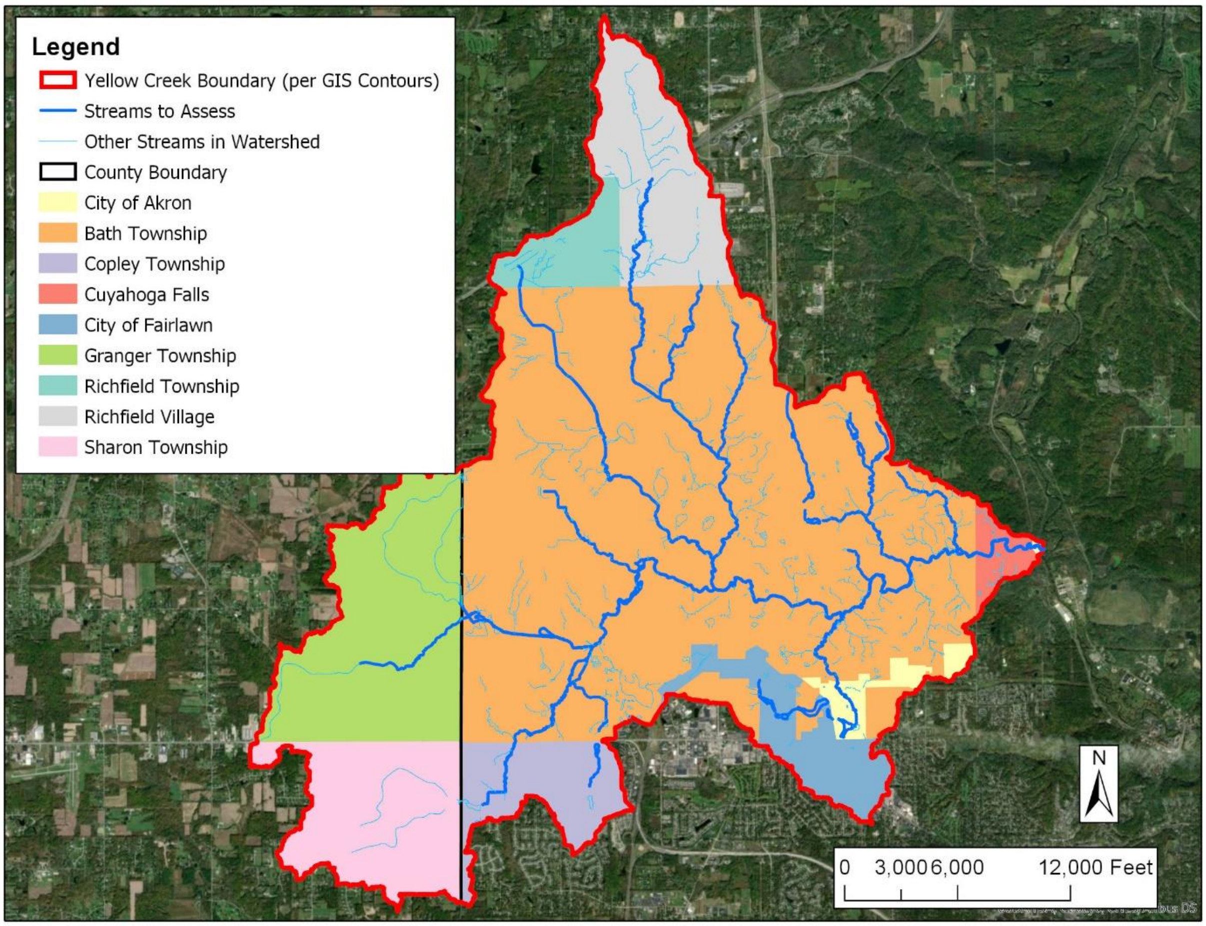

Figure 1: Jurisdictions within the Yellow Creek Watershed

The Summit County Council formed a Surface Water Management District (SWMD) in 2017, and the first community to opt into the district was Bath Township in December 2017. At the writing of this memorandum, Bath Township is the only community in the Yellow Creek Watershed to participate. The SWMD serves as a utility that charges residents a monthly fee in order to more effectively maintain and service surface water needs in the community. Prior to the implementation of the SWMD, there was no direct revenue to fund the maintenance of ditches outside of road rights-of-way in the townships, and residents had to petition the county to repair ditches and address storm water issues. (Summit County Engineer).

Previous projects have been completed to reduce flooding and improve water quality in the Yellow Creek Watershed. The Bath Creek Restoration Project took place between 2005 and 2010. The Friends of Yellow Creek chose this project from 70 target areas laid out in the NEFCO Yellow Creek Watershed Action Plan (2004). Using funds from the state and federal EPA and contributions from the township, the previously ditched channel was restored to a 2,500-linear-foot stream with sand and gravel substrate and riparian restoration via 5,200 bare root shrubs (Friends of Yellow Creek, 2009). Additional projects in the Bath Nature Preserve include floodplain and wetland restoration in the Garden Bowl and Moore's Chapel areas.

Figure 2: Hydromodification and its effects along Yellow Creek and its tributaries

Although beneficial in their own right, these efforts were not expansive enough to offset the degradational stream trajectory that was observed throughout much of the stream network (Figure 2). The degradation is at least partially attributable to both extreme weather in recent years and inadequately managed stormwater runoff from impervious surfaces such as roofs, roads, and parking lots. In Summit County and across Ohio, flooding has increased in frequency and intensity since 2003 (Delaney, 2016; Liberatore, 2013; USEPA, 2016). This increase in flood frequency, coupled with consistently increasing urbanization in the Yellow Creek Watershed, has resulted in significant hydromodification over the years (Delaney, 2016). A notable example of the increased flooding in Yellow Creek is the occurrence of a storm on May 12, 2014, which dropped approximately five inches of rain in about two hours (estimated to be around a 500-year event for those in the hardest hit areas) (National Weather Service, 2014). Per resident claims, this storm washed out culverts, eroded roadways, and caused major debris jams in addition to flooding.

2.1 Project Goals

With an understanding of current stream stability and potential future trajectories of change, this project aims to address the issues with a two-tiered approach. The extent of instability across the streams in the watershed include minor erosion in parks and forests to major instability along tall banks with infrastructure on top. Considering cost limitations, severity of erosion, and at-risk infrastructure, it is not feasible to restore every foot of stream in the watershed. However, areas of instability with at-risk infrastructure (e.g., tall bank with house on top, mass wasting near roadway, etc.) have been identified as priority areas for consideration of stream restoration opportunities. Areas with instability that were seen without at-risk infrastructure are not prioritized.

The second tier is using a stormwater-based approach to reduce the erosive power of excess stormwater. This is achieved by holding back flows that contribute to erosion (i.e., new SCM projects, detention basin retrofits, etc.). Stream erosion will never completely stop, but the goal of the stormwater-based approach is to reduce the rate of stream erosion toward more natural levels. Restoring the hydrology has widespread benefits to more than just stream stability. Streams are systems—their hydrology affects their stability, which in turn, affects their water quality and biotic integrity. This is seen in the stream function pyramid (Figure 3).

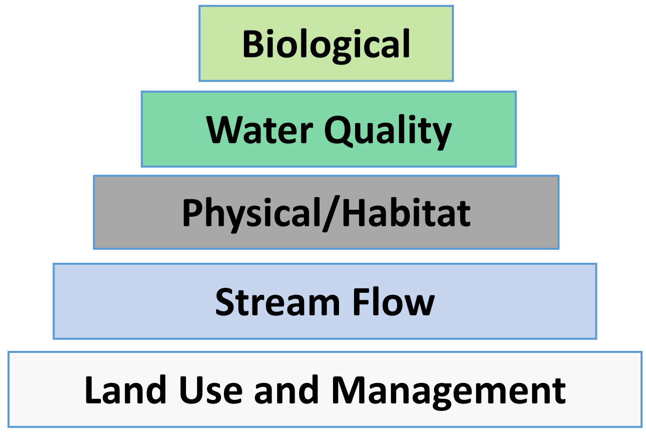

Figure 3: Stream function pyramid adapted from Harman et al. *(2012)*

3.0 Yellow Creek Watershed Characteristics

3.1 Hydrology and Drainage Paths

The ~31-sq. mi. Yellow Creek Watershed contains ~97.4 miles of streams that drain to the Cuyahoga River. There are several named tributaries within the watershed (see Appendix A, page A4). There were six USGS gages within the watershed (see Appendix A, page A5) that have been removed, with the most recent data collection stopping in 2013 at the most downstream location. Analysis of the available data at this site (USGS gage 04206220, Yellow Creek at Botzum), indicates the peak of record, or the largest recorded peak, occurred on July 21, 2003 at a flow of 2,960 cfs. An analysis of annual peak discharges at this site indicates the 2-year recurrence peak flow is ~1,100 cfs.

Approximately 593 acres, or ~3% of the watershed, is within a FEMA-mapped 100-year flood zone (see Appendix A, page A6). This flood zone extends along the entire length of Yellow Creek, as well as North Fork, Bath Creek and West Fork. Based on an aerial review, it appears three homes in the watershed fall within the 100-year flood zone: 3495 Yellow Creek Road, 3740 & 3760 Granger Road, and 990 Timberline Drive. Flooding issues are known throughout the watershed, with specific details from residents included in Appendix B.

The stormwater drainage infrastructure in the watershed consists of mostly ditches and swales that direct water to the creeks. Storm sewers do not appear to be completely mapped in the watershed, but are known to be in the southern portion of the watershed (i.e., Fairlawn, Copley and Medina County) and in select subdivisions across the watershed. The use of ditches is much more widespread, with portions of the watershed being channelized as far back as 1882 (Friends of Yellow Creek, 2009). Based on an aerial assessment of the watershed, 413 basins/lakes were identified, with 106 estimated to be designed as stormwater basins. According to the Ohio Department of Natural Resources and supplemental data from the field, there are 45 known dams/inline structures in the watershed (seven within Medina County and 38 within Summit County). Available records show that at least 32 dams are privately-owned (see Appendix A, page A7).

3.2 Water Quality

Water quality data within the watershed has been collected by the State of Ohio and Friends of the Yellow Creek over the years. The most recent state-collected data from 1988 to 1991 did not exceed the limits for chemical water quality impairment. Three monitoring locations (North Fork @ RM 0.3; Yellow Creek @ RM 1.7; and Yellow Creek @ RM 4.1) indicated full attainment of the warm water habitat aquatic life use designation and showed high diversity in fish communities (State of Ohio Environmental Protection Agency, 1994).

The Friends of Yellow Creek have collected more recent water quality and biological data in the watershed. Water quality sampling occurred from spring to fall 2012 to 2014 in both North Fork and Yellow Creek. Yellow Creek is a shallow stream, which can lead to vulnerability of fish and macroinvertebrates in the hotter summer months, but the creek's riparian vegetation keeps the water at an acceptable temperature. The highest temperature during this period was on Yellow Creek within O'Neill Woods in late summer 2013 with a reading of ~27.5°C, or ~81.5°F. Dissolved oxygen, which is affected by temperature, remained above the 5mg/L EPA-recommended minimum value in every sample and was often close to maximum saturation (Friends of Yellow Creek, 2018).

The values for water turbidity, which normally range from 0 – 15 NTU in Yellow Creek depending on the season, indicates good water clarity among the majority of the sample points. Of the 32 samples, five measurements appear to be above 15 NTU. Three of the five exceedances were taken in O'Neill Woods on Yellow Creek and span all years. This suggests that stream restoration projects that mitigate eroding streambanks would make a positive contribution to reducing sediment loads. The EPA-recommended pH range for healthy streams is between 6.5 and 9. The pH measurements within the watershed mostly range from 8 to 9, which sits at the higher, more alkaline side of this range. Stream conductivity, which is largely determined by stream bed composition, sits at the mid-range of U.S. streams at 600 – 1000 μm/cm (Friends of Yellow Creek, 2018).

3.3 Soils

Soil type affects drainage, flooding, permeability, slope stability, and siltation, all of which interact dynamically in the Yellow Creek Watershed. The hydrologic soil group (HSG), which is determined by the Natural Resources Conservation Service (NRCS), classifies the soil's potential for stormwater runoff. Soil groups "C" and "D" indicate relatively low infiltration rates (i.e., ~0.10 inches per hour and < 0.05 inches per hour, respectively) and create higher rates of stormwater runoff than HSG "B" or "A" (i.e., ~0.2 inches per hour and > 0.3 inches per hour, respectively). Soils in multiple categories (i.e., "A/D", "B/D", and "C/D") represent soils that are in group "D" in their natural state but can be in a different class due to changes in land use. The first letter is for drained areas and the second is for undrained areas. 75% of the watershed is classified as HSG "C", "D,", or "C/D," meaning that the majority of the watershed has soils with naturally low infiltration rates. This is important not only for natural hydrology, but also for what types of best management practices (BMPs) are appropriate for different parts of the watershed (i.e., infiltration BMPs will not work in HSG "C", "D", and "C/D" without amended soils). See Appendix A, page A8 for a soils map of the watershed categorized by HSG (Soil Survey Staff).

Another soil parameter researched was septic suitability. For septic systems with drip distribution at or below grade, ~55% of the watershed has a "very limited" rating, with only ~6% having a "not limited" rating. The remaining areas are "somewhat limited" at 35% and "not rated" at ~4%. The majority of the "not limited" areas are within Medina County. For septic systems with a leaching trench and absorption field, ~94% of the watershed has a "very limited" rating, with only ~1% having a "not limited" rating. The remaining areas are "somewhat limited" at ~1% and "not rated" at ~4%. The distribution of the "not limited" areas are throughout the watershed (Soil Survey Staff).

3.4 Land Use

Per the National Land Cover Database, developed land and forest each account for ~40% of the land use within the Yellow Creek Watershed. Just over 13% of the watershed is pasture or hay, with cultivated crops accounting for only 3% of the land (USGS, 2016). A full breakdown of land uses in the watershed are included in Table 1 and Appendix A, page A9. An analysis of impervious coverage, also per USGS (2016), shows that the watershed's imperviousness is most dense in the southern portions of the watershed, with the western boundary having the least imperviousness. Total impervious is ~8.8% in the watershed. See Appendix A, page A10.

Table 1: Yellow Creek Watershed Land Use (USGS, 2016)

Land Use Type	Total Area (sq. mi.)	Percentage of Watershed
Open Water	0.34	1.1%
Developed, Open Space	7.03	22.6%
Developed, Low Intensity	3.50	11.3%
Developed, Medium Intensity	1.13	3.7%
Developed, High Intensity	0.41	1.3%
Barren Land (Rock/Sand/Clay)	0.03	0.1%
Deciduous Forest	9.81	31.6%
Evergreen Forest	0.22	0.7%
Mixed Forest	2.65	8.5%
Shrub/Scrub	0.03	0.1%
Grassland/Herbaceous	0.19	0.6%
Pasture/Hay	4.05	13.1%
Cultivated Crops	0.92	3.0%
Woody Wetlands	0.55	1.8%
Emergent Herbaceous Wetlands	0.17	0.6%

3.5 Slopes

Slopes are varied throughout the watershed. The land in Bath Township and other upstream areas tends to be quite high (Elevation = ~1,100±), and the base level set by the Cuyahoga River is fairly low (Elevation = ~728). The streams in this watershed are gradually working to decrease the differences between the two, which can result in relatively tall banks and steep hillslopes adjacent to the streams that can be prone to geotechnical failure via mass wasting (Figure 4). Bedrock knickpoints are indicative of downcutting trajectories and are prevalent in the watershed (Figure 5), specifically at elevations ~820 and between elevation ~920 and 950 (Figure 6).

Figure 4: Geotechnical mass wasting (bank failure) along Lower Yellow Creek.

Figure 5: Knickpoint on Yellow Creek corresponding to elevations ~810-816

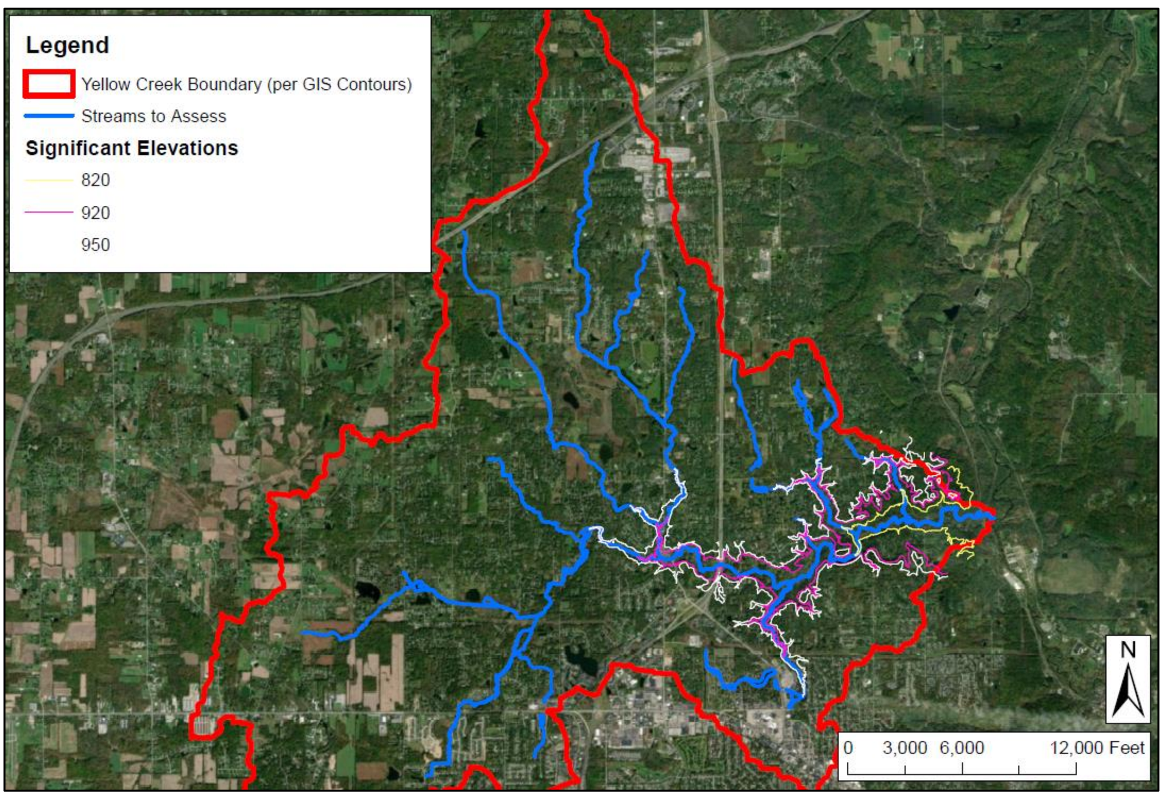

Figure 6: Valley contours in the watershed that correspond to knickpoint elevations

Plotting the profiles of each named stream in the watershed, we see clear transitions between slopes (Figure 7).

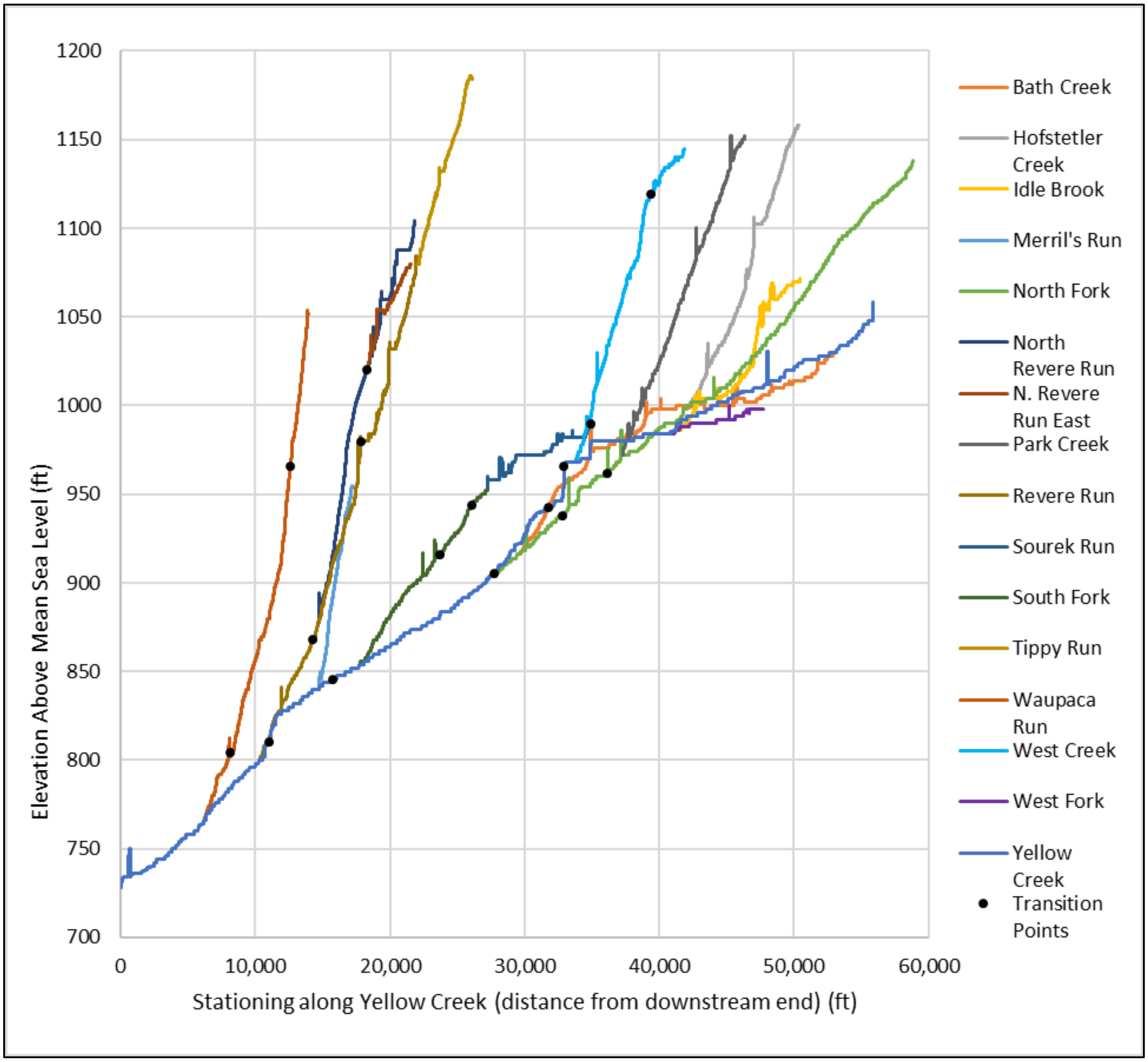

Figure 7: Profiles of each named stream with transition points between slope breaks identified. Tall peaks in the profiles correspond to road crossings.

4.0 Observations

In December 2018, Sustainable Streams visited the watershed to visually assess 40.8 miles of streams (Appendix A, page A4). This visual assessment is serving as the baseline of current stability conditions and future trajectories in the watershed and has informed the work in the remaining sections of this report.

Part of the field efforts included collecting hydrogeomorphic data at eight representative sites across the watershed (Appendix A, page A11). The sites were selected based on observed conditions, providing a range of bed material sizes and shapes, drainage areas, and slopes. The eight surveys consisted of 100-count pebble surveys and level-tape surveys of a profile with at least two riffles, one of which corresponded to the cross-section survey. These data were used to better understand bed material mobility in the watershed, which is further discussed in Section 5.0.

Figure 8: Private bridge with tall, unstable banks and flanking behind bridge abutments

During data collection, various types of infrastructure were noted along the assessed reaches, including 73 bridges, 58 culverts, and numerous stormwater outfalls, utilities, etc. Thirty-nine public bridges were observed, with 29 of them, or ~74%, having potential risks of instability, such as apparent flanking risk (Appendix A, page A12). An additional 34 private bridges were observed, with 12 of them, or ~35%, having potential risks of instability (Figure 8, Appendix A, page A14). It should be noted that these were not structural assessments by structural engineers, but rather, risks related to potential stream instability by stream experts. Stream instability has the potential to adversely impact the structure; however, a full structural assessment would need to be conducted to determine structural risks and remedial actions to protect structural integrity.

Culverts were also observed during the visual assessment, including 23 public culverts, 17 private culverts, and 18 culverts with unknown jurisdiction that were presumed to be public. Of the 41 culverts considered public, 24 exhibited potential instability from stream instability. Four culverts were potentially undersized based on discussions with residents (Appendix A, page A13); however, the observations could also be attributable in part to the recent frequency of relatively large storm events as opposed to not meeting a specific design criterion. For private culverts, seven were noted to have possible instability issues and two were potentially undersized based on discussions with residents (Appendix A, page A14). This is not an exhaustive summary of every bridge and culvert in the watershed. Again, it should be underscored that these rapid observations were made by the project team (stream experts) and should be re-visited by a qualified structural engineer to determine the amount of risk each poses.

Public utility assets, like gas mains and sanitary sewers, were also noted at ten locations during the visual assessment (Appendix A, page A15). Other at-risk assets include, but are not limited to, detention basins that exhibited potential instability, dams that appeared to be at risk of failure, and roads, parking lots, and houses that appear to be threatened by streambank erosion and mass wasting (Appendix A, page 16). Again, it must be stated that the items identified during the December 2018 field efforts are not an exhaustive list of at-risk infrastructure and assets in the watershed. Specifically related to dam safety, a qualified dam inspector should be consulted to provide a more comprehensive assessment.

In the fall of 2018 the Friends of Yellow Creek, a local environmental non-profit, circulated a stormwater-related survey in their quartely area newsletter. The survey asked residents to describe the frequency and severity of flooding, erosion, runoff, and loss of trees on their properities since 2000. Of the 50 survey responses within the watershed, 36 residents (72%) listed erosion as a problem, 24 (48%) listed runoff as an issue, and 21 residents (42%) listed incidents of flooding or yard ponding in their survey responses (Figure 9; Appendix A, page A17). Only four residents stated they had no issues. Issues ranged from stormwater problems (Appendix A, page A18) to major mass wasting of ravines. Appendix B includes a

Figure 9: Example of issue observed based on resident survey responses

summary table of the issues by street, with precise addresses removed to protect privacy. An additional eight properties were visited based on complaints received not through the survey and/or through discussions with residents.

Utilizing the data collected in the field, combined with desktop elevation data, the assessed stream reaches were classified in terms of risk (Appendix A, pages A19 to A21). Of the approximately 40.8 miles of streams assessed, 23.4 miles (~57%) were observed as low risk. These mostly headwater streams are relatively flat, above the streams that are currently downcutting, and have relatively flat slopes. Overall, their floodplains are moderately well to well-connected and the valleys are broad. A total of 8.8 miles (~22%) were observed as medium risk. These reaches are at the downstream end of the watershed, where downcutting has already occurred. The valleys are low and wide, with the surrounding land much higher. Finally, 8.6 miles (~21%) were observed as high-risk. These transitional reaches are downcutting, causing confined streams with little to no connected floodplain and over-steepened banks, similar to Stage 2 and 3 of the channel evolution model (Figure 10). It is important to note that these risk classifications are for relative purposes only, and that “low risk” does not imply “no risk.”

Figure 10: Channel evolution model (adapted from Schumm et al., 1984)

5.0 Watershed Design Target

As stated in the introduction, a goal of this project was to reduce the erosive power of the runoff from impervious areas using a stormwater-based approach. In-stream erosion is a natural process however, a lack of stormwater controls and often conventionally designed stormwater facilities often contribute to erosion occurring at a faster rate than predeveloped, or natural, conditions. Regulations for stormwater facilities across much of the country focuses on flood protection (i.e., 2-year and larger storms) and water quality (i.e., the first flush, Figure 11), but often overlook the storms that fall between the two, which can occur frequently in a typical year.

To slow the rate of erosion, it is important to understand and identify the critical discharge for bed material erosion, or $Q_{critical}$, within the watershed. Determining $Q_{critical}$ provides a target for stormwater management with a goal of reducing in-stream erosion. With that goal in mind, a $Q_{critical}$ target for the Yellow Creek Watershed was calculated using field data. According to standard methods of river mechanics (Hawley and Vietz, 2016), the data collected during the stream assessment were used to inform estimates of $Q_{critical}$, which is the threshold flow when the erosive power of the stream is strong enough to dislodge the streambed material (i.e., rocks and pebbles) and move it downstream. $Q_{critical}$ estimates are extremely sensitive to sediment size and stream slope, both of which had broad ranges between data collection sites. The hydrogeomorphic data collection reaches are a mix of flatter (<1%) pool-riffle profile streams, to steeper (2-6%) profile streams with irregular step-pools and plane beds, to very steep (10-15%) highly unstable streams with step-pools and cascades (Table 2, Appendix C).

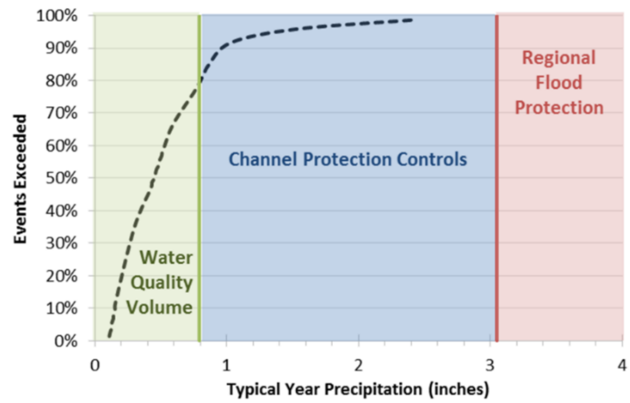

Figure 11: Stormwater management facilities often are required to manage only the small storms (i.e. water quality volume) and larger storms (i.e. regional flood protection for the 2-year storm and larger), leaving the storms that fall between the water quality volume and flood control storms, to contribute to excess stream erosion (Hawley, 2012).

Table 2: Hydrogeomorphic parameters evaluated during the $Q_{critical}$ analysis

Site Name	Stream Location	Drainage Area (sq. mi.)	Profile Form	Bed Material Type	d50[1] (mm)	d84[1] (mm)	Avg. Slope (%)	$Q_{critical}$ (% of Q_2)
2226 W. Bath Rd.	Yellow Creek	30.6	Pool-riffle	Rounded	71.4	162.6	1.15%	39%[2]
3495 Yellow Creek Rd.	Yellow Creek	23.00	Pool-riffle	Rounded	30.6	68.7	0.85	39%[2]
3757 Bath Rd.	North Fork	5.72	Pool-riffle	Rounded	37.7	65.7	0.70%	49%[2]
1405 Fox Chase Dr.	Bath Creek	3.30	Pool-riffle, plane bed	Disc-like	23.1	44.7	0.88%	38%[2]
588 Medina Line Rd.	West Fork	2.21	Pool-riffle	Rounded	19.7	35.2	0.86%	6%[3]
4023 Shaw Rd.	West Creek	0.53	Irregular step-pool, plane bed	Disc-like	32.0	87.1	1.95%	55%[2]
3139 Bath Rd.	Revere Run tributary	0.088	Irregular step-pool, plane bed	Disc-like	61.6	162.5	5.93%	47%[2]
901 Timberline Dr.	Yellow Crk tributary	0.006	Step-pool, cascade	Rounded	68.3	164.4	12.13%	34%[4]

(1) d50 is defined as the median diameter of the streambed particles. 50% of the streambed particles have a diameter smaller than this size. For d84, 84% of the streambed particles have a diameter smaller than this size. These two specific values are important in evaluating the $Q_{critical}$ value.

(2) Site $Q_{critical}$ is generally representative for the purposes of estimating a regional $Q_{critical}$.

(3) Site $Q_{critical}$ is not representative of regional $Q_{critical}$. The site was artificially flat due to an upstream concrete crossing.

(4) Site $Q_{critical}$ is not representative of regional $Q_{critical}$. There was not much representative bed material for the pebble count due to the relatively severe instability.

Based on the estimates above, a regional $Q_{critical}$ target for the Yellow Creek Watershed is ~40% of the undeveloped 2-year flow (Q_2). This means that for all stormwater controls, including both new storage and retrofits to existing facilities, the 2-year flow should be released below $0.4*Q_2$ to the extent feasible within the context of other design goals such as safely accommodating the 100-year storm for example.

6.0 Conceptual Watershed Improvements

In April, the County requested a comprehensive look across Bath Township to understand the magnitude of the issues and scale of improvements that would be needed to improve stream stability in the community. The concepts below attempt to address the bank instability and inadequate stormwater management both visually observed and extrapolated across the remaining mapped streams in the watershed. Extrapolated areas considered available aerial imagery, consideration of elevations and slopes similar to known, observed issues, and proximity of streams and banks to structures and infrastructure.

The inventory of potential project opportunities is presented under several categories (Figure 12), including:

- Improvement and/or protection of high infiltration areas (Pages 17 – 19)
- Infrastructure improvement (Pages 19 – 22)
- Optimization of existing stormwater control measures (SCMs) (Pages 22 – 25)
- Creation of new SCMs (Pages 26 – 32)
- Instability/downcutting in "seasonal channels" (Pages 32 – 34)
- Protection on streambanks that could potentially be stabilized within the scope of the SWMD (Pages 34 – 38)
- Protection on streambanks that could potentially be partially stabilized within the scope of the SWMD (Pages 38 – 44)
- Programmatic/non-structural improvements (Pages 44 – 48)

Conceptual level cost opinions have been completed for each opportunity presented. Concepts that would be considered capital improvements (i.e. those that are not programmatic in nature) include ~$6.34M in studies and design, and ~$30.4M in construction for a total of ~$36.74M. Programmatic recommendations account for an additional ~$1.2M, which is estimated to span up to 20 years, although the majority of recommendations extend one to five years. See Appendix D for a cost table of individual concepts. A preliminary list of potential project partners/primary stakeholders has been developed by the Summit County Engineer's Office (SCE)/SWMD and have been added parenthetically to each concept name.

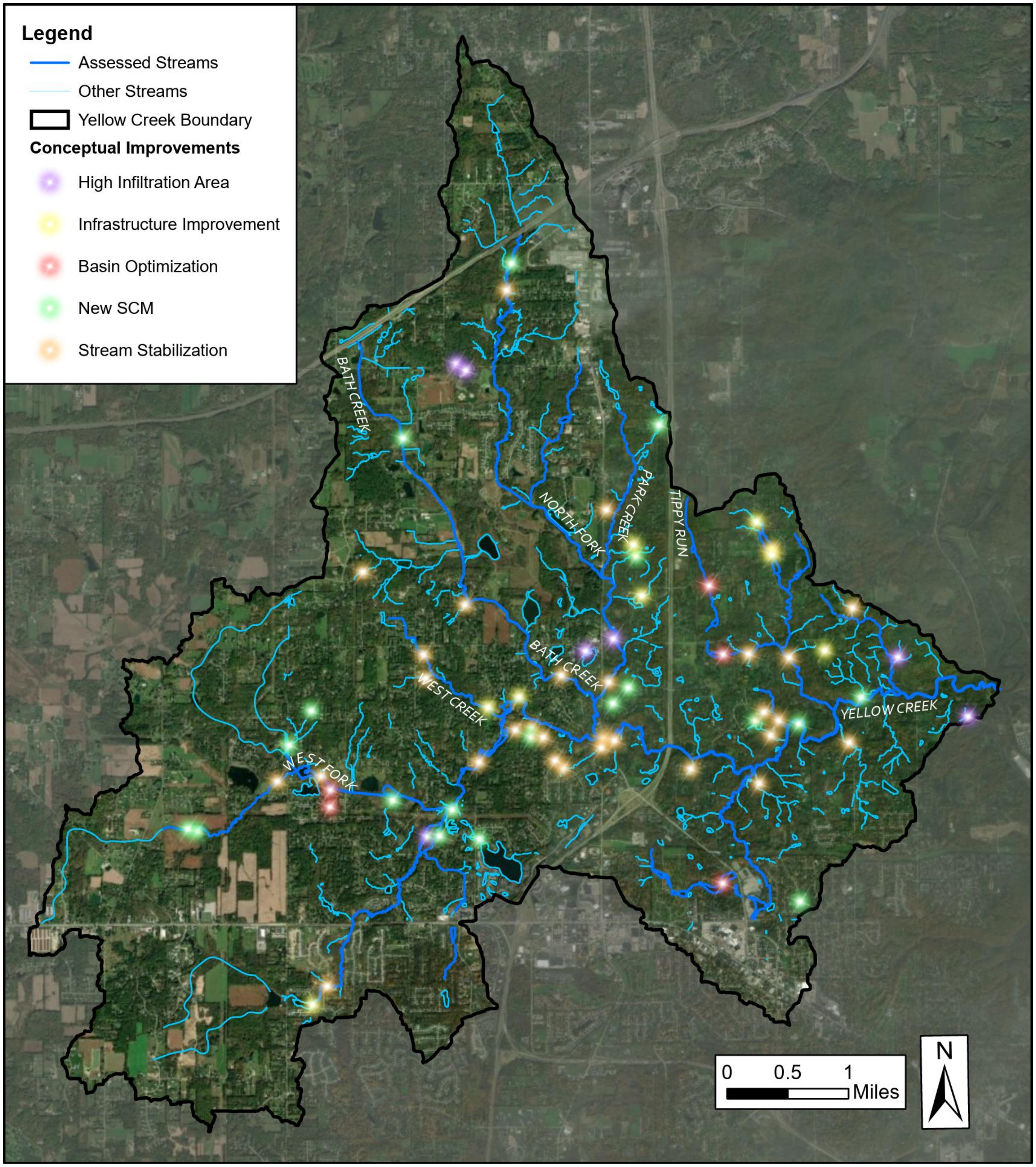

Figure 12: Conceptual watershed improvements proposed across the Yellow Creek Watershed

6.1 Improvement and/or Protection of High Infiltration Areas

In this category, public parcels have been identified that have Type A and/or B soils and are forested. Preservation of all areas with Type A and Type B soils would be ideal in order to maintain their high infiltration, which results in less runoff compared to developed areas and those with Type C and Type D soils. However, only public parcels have been included in this analysis, where it is assumed that the County has some input on future development. Seven public parcel groups have been identified.

Across the watershed, new stormwater control measures (SCMs) installed within areas with high infiltration soils (Figure 13) should focus on infiltration-based SCMs. Outside these areas, more volume-based SCMs focused on detention are likely most applicable.

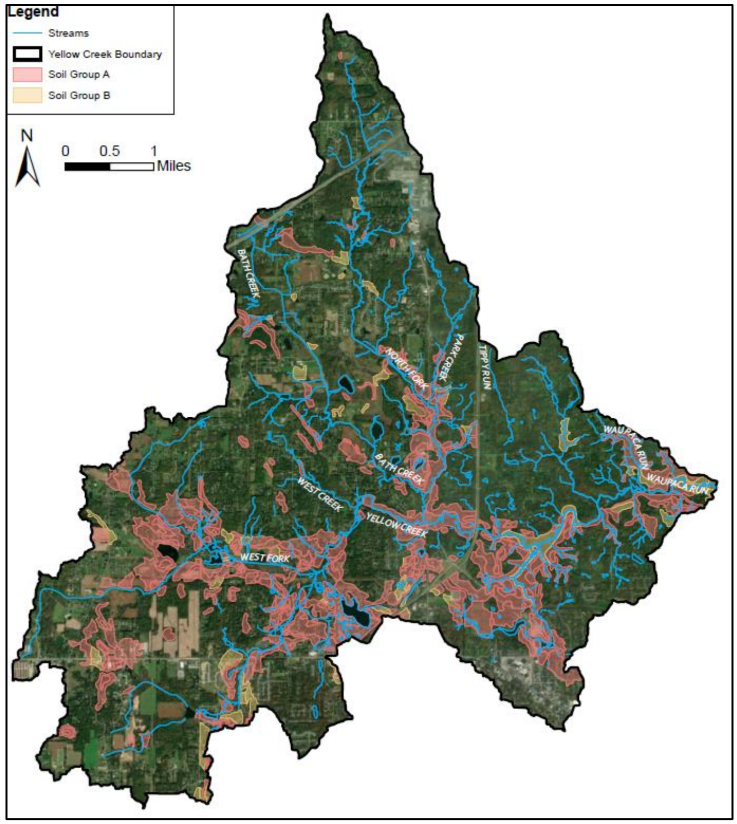

Figure 13: High infiltration soil areas within the Yellow Creek Watershed

Bath Baseball Field Forest Preservation (Bath Township)

This park, located at 4600 Everett Road in Bath Township, has ~0.8 acres of forested area with Type A soil along Everett Road that could be preserved to protect high infiltration soils. Refer to Appendix D, page D5 for this concept.

Bath Center Cemetery Forest Preservation (Bath Township)

This public parcel, located at 1241 N. Cleveland-Massillon Road in Bath Township, has ~0.7 acres of forested area with Type A soil along its eastern border that could be preserved to protect high infiltration soils. Refer to Appendix D, page D6 for this concept.

Bath Township Complex Forest Preservation (Bath Township)

Several public parcels at the southwest corner of N. Cleveland-Massillon Road & Bath Road in Bath Township, has ~41.5 acres of forested area with Type A soil behind the buildings that could be preserved to protect high infiltration soils. Refer to Appendix D, page D7 for this concept.

Botzum Forest Preservation (Bath Township)

This public parcel, located at 2928 Riverview Road in Cuyahoga Falls, has ~7.5 acres of forested area with Type A soil that could be preserved to protect high infiltration soils. Refer to Appendix D, page D8 for this concept.

Hametown Road Parcels Forest Preservation (Bath Township)

These two public parcels, located east of N. Hametown Road in Bath Township, have ~4.5 acres of forested area with Type A soil that could be preserved to protect high infiltration soils. Refer to Appendix D, page D9 for this concept.

Kniss Woods Preserve Forest Preservation (Summit MetroParks)

This public parcel, located northeast of the intersection of Everett Road and Southern Road in Richfield Township, has ~4.0 acres of forested area with Type A soil that could be preserved to protect high infiltration soils. Refer to Appendix D, page D10 for this concept.

O'Neill Woods Metropark Forest Preservation (Summit MetroParks)

Across 11 public parcels with land surrounding Bath Road in Bath Township and Cuyahoga Falls, there is ~103 acres of forested area with Type A and Type B soils that could be preserved to protect high infiltration soils. Refer to Appendix D, page D11 for this concept.

6.2 Infrastructure Improvement

Concepts in this category focus on recommended improvements to infrastructure noted to be in disrepair, needing maintenance, and/or causing resident complaints. Eight concepts have been included.

1395 Partridge Culvert Study and Upsizing (Bath Township)

Figure 14: Culvert across Partridge Lane with landscaping rocks and driveway on left

At the downstream end of this property in Bath Township, a culvert under Partridge Lane (Figure 14) conveys the streamflows from east to west. The upstream culvert under Shade Road is larger than the Partridge Lane culvert, which causes water to back up on the property and can result in washouts of the resident's driveway and landscaped areas. This may be attributable to potential differences in design criteria for County versus Township roads. Private actions by the resident have been repeated several times, but washouts still occur. A study on the Partridge Lane culvert should be performed to understand the downstream flow path, which is currently not mapped, and to evaluate the effects of upsizing this culvert. Based on the results of the study, it is possible that the culvert could be upsized to better convey the flows and reduce the amount of ponding and washouts on this property. Refer to Appendix D, page D12 for this concept.

Harmony Rd and Acacia Dr Storm Improvements (Bath Township)

Figure 15: Culvert across Partridge Lane with landscaping rocks and driveway on left

At the intersection of Harmony Road and Acacia Drive in Bath Township, several unmapped culverts are apparently causing ponding issues for local residents (Figure 15). Upon visual inspection, an excessive amount of leaf litter was clogging the infrastructure, which may be part of the problem. At a starting point, it is recommended that the connectivity of all inlets, culverts, and storm pipes at this intersection is confirmed/mapped. The clogged inlet could be replaced with a more conventional structure that may be less likely to clog, and additional benefits may be seen from upsizing and/or relaying the culverts at steeper slopes. Refer to Appendix D, page D13 for this concept.

Lakeview Dr Catch Basin Maintenance (Bath Township)

Figure 16: Erosion and concrete failure at inlet

While visually assessing the streams near Lakeview Drive in Bath Township, an inlet on the north side of the road was observed to have minor erosion around the structure as well as concrete failure (Figure 16). The state of the inlet poses some safety risk with the larger than intended current opening. It is recommended that this inlet be replaced to improve function and safety. Refer to Appendix D, page D14 for this concept.

McVey Rd Outfall Stabilization (Bath Township) ***Extrapolated***

Upon a review of aerial imagery, it is anticipated that this outfall in Bath Township is experiencing instability. As an extrapolated issue, an evaluation of the site is recommended prior to design and implementation to better understand the severity of potential erosion and tailor project extents and approach accordingly. Preliminarily, this concept assumes rock armoring downstream of the discharge. Refer to Appendix D, page D15 for this concept.

Revere Rd 3 Culvert Study & Upsizing (SCE)

Figure 17: Culvert under Revere Road reported to have overtopped during past rain events

Upon discussions with a Bath Township local resident, three culverts in series inadequately convey flows due to being undersized. Specifically, there are reports that Revere Road at a culvert (Figure 17) has overtopped, as well as a residential driveway culvert and a third, downstream culvert that has created flooding issues at a private garage. A study on these culverts should be performed to understand their sizes, the upstream drainage area and any changes to it that could have resulted in this issue. Based on the results of the study, it is possible that the culverts could be upsized to better convey the flows and reduce the amount of flooding. Refer to Appendix D, page D16 for this concept.

Shaw Rd Outfall Repair (SCE)

Figure 18: Eroded stormwater outfall next to bridge

This Bath Township outfall along West Creek has eroded, as evidenced by the lack of boulders surrounding the discharge point (Figure 18). The protection around the bridge, including the boulder drop structure, appears reasonably stable. More armoring for this outfall is recommended, including using large boulders that are appropriately sized and well-connected. Refer to Appendix D, page D17 for this concept.

Swan Lake Catch Basin Maintenance (Copley Township)

Figure 19: Erosion at inlet

While visually assessing the streams near Swan Lake Drive in Copley Township, an inlet on the east side of the road was observed to have minor erosion around the structure (Figure 19), such that the low flow window was higher than ground level. It is recommended that rock be placed in this location to cost-effectively improve the function of this inlet. Refer to Appendix D, page D18 for this concept.

Woodthrush Storm Sewer Repair and Channel Stabilization (Private)

Figure 20: Black HDPE pipe lying in the ravine with Yellow Creek in the background

The existing HDPE pipe that discharges to Yellow Creek through a ravine between 3884 and 3906 Woodthrush Road (Figure 20) in Bath Township appears to poorly convey stormwater to Yellow Creek. Per discussions with a resident, repairs have been made to the pipe, which continues to pull apart and cause erosion in the ravine. This concept proposes to install a headwall at the upstream end of the ravine and permanently disconnect the remaining pipe segments. The steep ravine receiving and conveying the flows should be armored. Where slopes flatten out closer to Yellow Creek, an energy dissipation pool should be placed, as well as continued armoring extending to Yellow Creek. Refer to Appendix D, page D19 for this concept.

6.3 Optimization of Existing Stormwater Control Measures (SCMs)

Concepts in this category range from simple rock armoring to more detailed analysis and potential spillway improvements to conversion of a private dam to a stream/wetland complex. In evaluating several basins for potential for simple retrofits that could mitigation excess erosion in their receiving channels, the majority of the basins evaluated did not appear to be suitable for retrofit based on the available data. However, having more information on stormwater routing and/or more design-level contours could provide additional basins for consideration. Five concepts have been identified. A map of evaluated basins is included in Appendix A, page A22.

Arbour Green North Spillway and Retrofit Evaluation (SCE assessed subdivision)

Figure 21: Outlet control structure at Arbour Green North basin

During field efforts, outlet structure data (Figure 21) was collected on this basin, located northeast of the intersection of Mallard Pond Drive and Arbour Green Drive in Bath Township. This data, paired with storm sewer infrastructure data, provided enough information to complete hydrologic and hydraulic modeling of this basin. Modeling results, included in Table 3, indicate that there is essentially no freeboard in the basin during the 100-year storm, and that both the 1-year and 2-year storms are released above the pre-developed flow. With a simple retrofit that would reduce the existing water surface elevation by one foot via an extended v-notch weir, approximately three inches of freeboard would be added to the 100-year storm and both the 1- and 2-year storms would be released below pre-developed flows. Additionally, the retrofit would reduce the peak flow in the 1-year storm below $Q_{critical}$, calculated as 0.4 cfs at this basin, which would reduce the excess erosion in the receiving channel. It should be noted that there are two basins that drain to this one, and changes to their drainage areas and/or outlet configurations would impact the modeling results of this basin. For the concept and catchment specifics, refer to Appendix D, page D20.

Table 3: Preliminary modeling results for the Arbour Green North basin

Event	Pre-developed	Existing Conditions	Retrofit Conditions
1-yr Peak Flow (cfs)	0.17	0.44	0.09
2-yr Peak Flow (cfs)	0.93	1.08	0.69
5-yr Peak Flow (cfs)	6.72	2.51	1.94
10-yr Peak Flow (cfs)	16.69	4.29	3.46
25-yr Peak Flow (cfs)	39.10	7.48	6.51
50-yr Peak Flow (cfs)	62.97	9.13	8.33
100-yr Peak Flow (cfs)	92.70	13.13	10.14
100-yr Freeboard (ft)	N/A	-0.05	0.26

Arbour Green South Flooding Risk Evaluation and Retrofit (SCE assessed subdivision)

Figure 22: Outlet control structure at Arbour Green South basin

During field efforts, outlet structure data (Figure 22) was collected on this basin, located southeast of the intersection of Mallard Pond Drive and Arbour Green Drive in Bath Township. This data, paired with storm sewer infrastructure data, provided enough information to complete hydrologic and hydraulic modeling of this basin. Upon review of the contours, it appears the overflow route for this basin follows the outlet pipe. Prior to implementation of any retrofit, this should be further studied to better understand if this flow path is ever used and if it is, it is strongly recommended to lower the water surface elevation to limit overland flows in such close proximity to residences. Retrofit modeling results, included in Table 4, indicate that there are approximately four inches of freeboard in the basin during the 100-year storm, and that both the 1-year and 2-year storms are released above the pre-developed flow. With a simple retrofit that would reduce the existing water surface elevation by one-half foot via an extended v-notch weir, approximately two inches of freeboard would be added to the 100-year storm. Additionally, the retrofit would reduce the peak flow in the 1-year storm to be at $Q_{critical}$, calculated as 0.4 cfs at this basin, which would reduce the excess erosion in the receiving channel. It should be noted that there is one basin that drains to this one, and changes to its drainage areas and/or outlet configurations would impact the modeling results of this basin. For the concept and catchment specifics, refer to Appendix D, page D21.

Table 4: Preliminary modeling results for the Arbour Green North basin

Event	Pre-developed	Existing Conditions	Retrofit Conditions
1-yr Peak Flow (cfs)	0.17	0.56	0.42
2-yr Peak Flow (cfs)	0.93	1.25	1.01
5-yr Peak Flow (cfs)	6.68	3.08	2.62
10-yr Peak Flow (cfs)	15.99	5.49	4.79
25-yr Peak Flow (cfs)	36.71	10.43	9.53
50-yr Peak Flow (cfs)	58.68	15.02	14.02
100-yr Peak Flow (cfs)	85.95	20.89	19.54
100-yr Freeboard (ft)	N/A	0.33	0.52

Bonnebrook Dr Stream/Wetland Complex with Wet Weather Detention (SWMD/Private partnership)

Figure 23: Outlet control structure at Goodrich Lake Dam

The existing basin in this location is a Class III privately owned dam (Goodrich Lake Dam, file number 1114-023, Figure 23) located on Revere Run in Bath Township. The owners of the dam, located at 3320 W. Bath Road shared that the dam has overtopped, which causes extensive yard flooding and occasional basement flooding. Additionally, Revere Run downstream of the dam and Bonnebrook Drive have widespread instability with up to ~65-foot-tall banks. A proposed stream stabilization concept, Revere Run Select Stream Stabilization, has been proposed to provide some stabilization in the reach. However, reducing flows, especially to a $Q_{critical}$ threshold if possible, would be a sustainable way to continue to protect the channel downstream. The proposed concept would completely drain the dam and restore the stream to a more natural alignment in the bed of the basin. During storm events, the remaining basin area, converted to floodplain, would function as a detention area with the ability to throttle back wet weather flows without flooding concerns. It is anticipated that the existing outlet from the pond would be modified but would continue to be used. Being a private dam, coordination with private property owner(s) and possibly an easement would be required. Refer to Appendix D, page D22 for this concept.

Ghent Road Basin Spillway Evaluation and Enhancement (Fairlawn and Akron)

Figure 24: Outlet control structure at Ghent Road basin

This large, inline basin along Ghent Road in Fairlawn and Akron (Figure 24) has a surface area of over eight acres and may be an ideal opportunity to throttle back erosive flows in the downstream channel. A lack of information on upstream, inline basins and stormwater infrastructure provided several unknowns, however preliminary modeling showed an overtopping risk in this basin. The apparently unarmored spillway may be used in events as small as the 2-year storm. This concept recommends an evaluation of the upstream basins' outlet structures and drainage areas for more accurate modeling of the Ghent Road basin. Upon review of the results, spillway armoring is recommended if the spillway is modeled to be used in any storm up to the 100-year event. Furthermore, with more detailed information, additional consideration should be given for reducing the existing water surface elevation in the basin. If the basin is found to overtop, this would provide additional storage, and if the basin does not overtop, there may be freeboard available to retrofit the basin to provide additional storage and small discharges in the 2-year and smaller events, which would reduce excess erosion in the receiving channel. Refer to Appendix D, page D23 for this concept.

Solar Cir Basin Retrofit (SCE assessed subdivision)

Figure 25: Tippy Run inlet and cattails covering bottom of Solar Cir basin

This existing basin in Bath Township (Figure 25) receives neighborhood stormwater runoff and flows from Tippy Run. Upon evaluation, both the inflow from Tippy Run and the low-flow outlet show signs of instability that would benefit from some rock placement. Additionally, outlet control structure information was not gathered on this basin, but it can be said that removal of the cattails would provide additional storage within the basin. Should detailed information on the outlet structures become available, a retrofit of the structure should be considered that would reduce flows in the 2-year and smaller storm events (while maintaining the current level of service in larger events) to the $Q_{critical}$ threshold to reduce excess erosion downstream of Shade Road. Refer to Appendix D, page D24 for this concept.

6.4 Creation of New SCMs

As a region that began development long before stormwater regulations, it is easy to understand how hydromodification from inadequately managed stormwater could be a contributing factor to the instability in Yellow Creek. As such, adding new storage that is specifically designed to offload erosive flows should provide benefits to the stability of the streams. Although the grading limits and storage volumes are only conceptual in nature and design will be necessary to tailor each to its location in the watershed, the bankfull wetland concepts presented in this section aim to achieve this goal.

Bankfull wetlands are features that are located in the floodplain of a channel and are designed to reduce the depth, velocity, and erosive power of the stream flow at high flows by adding storage volume immediately adjacent to the channel. Other benefits are that these wetlands promote deposition of suspended solids, adsorb charged particles, metals, and nutrients in the trapped sediment, can improve water quality through biological uptake of nutrients, and can reduce bacteria levels through ultraviolet exposure over a longer residence time. They also expand wetland and “off-channel” habitats that can be important elements of a healthy ecosystem and are typically in short supply in much of Ohio. Figure 26 shows a conceptual cross section of a bankfull wetland.

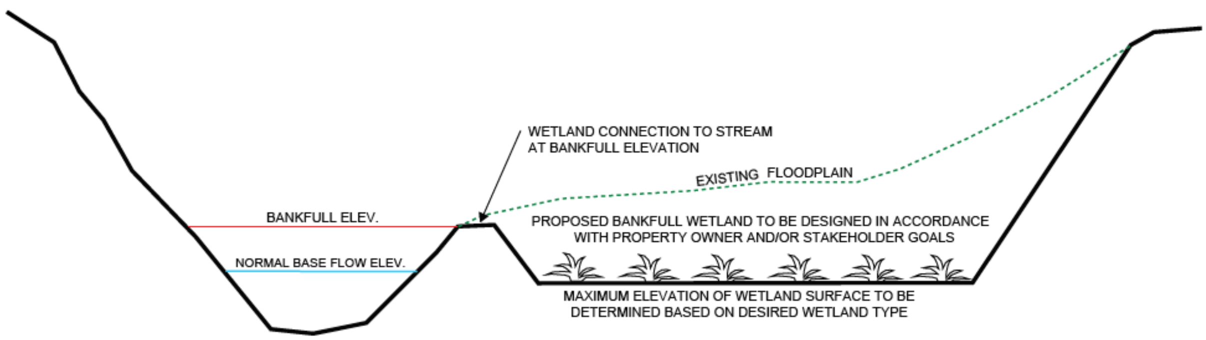

Figure 26: Bankfull wetland conceptual cross section

Based on preliminary/high-level calculations and historic USGS hydrographs, adding the proposed ~45 ac-ft (~14 MG) of new bankfull wetlands could provide a meaningful benefit to the stream network. The relative benefit is expected to be lower in winter where hydrographs are more prolonged. For example, using a hydrograph from 1/23/1999 with a peak of 696 cfs, ~98 MG exceed the estimated $Q_{critical}$ flow for streambed erosion. This implies that only ~15% of excess volume that exceeds $Q_{critical}$ during the 1-year storm could be potentially diverted into the bankfull wetlands. In the summer months when the hydrographs are much flashier, the benefits of the wetlands to the 1-year storm have the potential to be much better. For example, using a hydrograph from 7/24/2010 with a peak of 728 cfs, only ~7 MG exceed the $Q_{critical}$ threshold. This implies that the bankfull wetlands have the potential to offload about double the storm event’s excess volume. This would not stop erosion from occurring everywhere (i.e. at-risk items will remain at-risk, and large storms will still cause damage); however, the general rate of erosion would be expected to be reduced. Precise benefits are difficult to model but this relatively simple analysis suggests that the scale of the available storage opportunities have the potential to offload meaningful volumes of flow that could otherwise contribute to excess stream erosion. Additional detail on specific bankfull wetland concepts are included below, but Table 5 includes a brief summary of the amount of storage per subwatershed.

Table 5: Bankfull wetland storage by subwatershed

Subwatershed	Streams Included	Number of Bankfull Wetland Concepts	Total Conceptual Storage (ac-ft)
Lower Yellow Creek	Lower Yellow Creek, South Fork, Merril's Run, & Revere Run	2	3.9
Upper Yellow Creek	Upper Yellow Creek, West Creek, West Fork, & Idle Brook	6	29.5
Bath Creek	Bath Creek	1	4.2
North Fork	North Fork, Park Creek, & Hostetler Creek	3	7.2
Total		12	44.8

This category of concepts also includes SCMs that are a result of resident surveys and other known stormwater issues in the watershed. These concepts, including mostly conventional detention basins and amended swales, aim to reduce local flooding and erosion problems in areas that appear to be lacking in stormwater controls.

Amended swales are similar to conventional conveyance swales, but have an amended bottom comprised of a gravel trench (Figure 27). Amended swales could also include topsoil and vegetation similar to pilot applications by the Ohio Department of Transportation (ODOT) (Kearns, 2019). The top layer of gravel should be sized to resist erosion based on flow, slope etc., and the swale size should be sufficient to transport the 100-year storm. For reference, Sustainable Streams (2015) found that if the volume of stone corresponded to ~25-30 percent of the 100-year runoff, the amended swale could comply with flood control, water quality, and $Q_{critical}$ in a pilot study in Northern Kentucky.

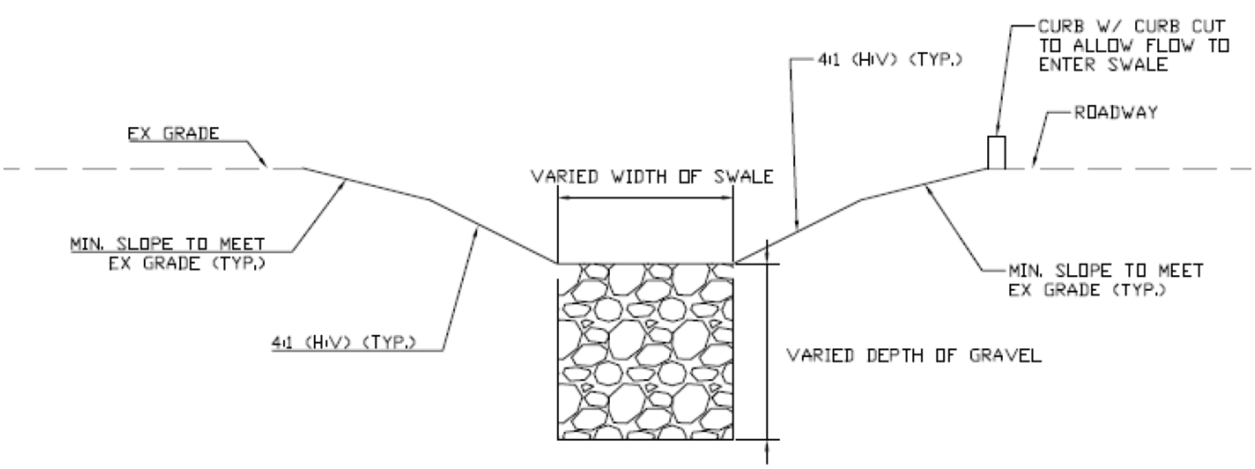

Figure 27: Bankfull wetland conceptual cross section

Bath Community Park Bankfull Wetland and Detention (Bath Township/SWMD partnership)
Evaluation of stormwater at Bath Community Park in Bath Township was a result of several downstream residents' complaints related to erosion and flooding after the soccer fields were installed. Based on a site visit, it appears the water is allowed to sheet flow off the parking areas without detention (Figure 28). Amended swales have been proposed to slow the runoff from these areas in a linear configuration. Based on property boundaries, it appears any detention may require an easement on private property.

Additionally, an ~6.7 acre-foot bankfull wetland was included to offload flows from the northern tributary around the park. This wetland would take the place of one of the soccer fields but would further reduce downstream erosion if designed with $Q_{critical}$ in mind (Figure 29). The wetland could include educational signage to inform parkgoers of the benefits these features provide. Refer to Appendix D, page D25 for this concept.


Figure 28: Undetained parking areas adjacent to soccer fields


Figure 29: Northern tributary near tennis courts exhibiting eroded banks

Camp Christopher Bankfull Wetland (Private/SWMD)
As part of the effort to increase storage in the watershed, an ~4.2-acre-foot bankfull wetland is proposed on Camp Christopher, a willing partner in Bath Township. Additional modeling is needed to design the stream connection for optimized reduction of erosive flows, and the grading is preliminary, based on aerial imagery and LiDAR contours. During design, specific concerns from Camp Christopher regarding flooding should be understood by the designer to optimize the solution to maximize stakeholder benefits. As with Bath Community Park, this wetland would provide a good opportunity for educational signage and possibly an outdoor classroom. Refer to Appendix D, page D26 for this concept.

Crystal Shores Bankfull Wetland (HOA/SWMD)
As part of the effort to increase storage in the watershed, an ~1.0-acre-foot bankfull wetland is proposed on this homeowner's association parcel in Bath Township. Additional modeling is needed to design the stream connection for optimized reduction of erosive flows, and the grading is preliminary, based on aerial imagery and LiDAR contours. Refer to Appendix D, page D27 for this concept.

Dunsha Bankfull Wetlands 1 & 2 (Private)

As part of the effort to increase storage in the watershed, two bankfull wetlands, both ~0.8-acre-feet in storage volume, are proposed on this private parcel in Granger Township (Medina County). Additional modeling is needed to design the stream connections for optimized reduction of erosive flows, and the grading is preliminary, based on aerial imagery and LiDAR contours. Refer to Appendix D, page D28 for this concept.

Ghent Hills Amended Swales (Bath Township)

Resident complaints in the area indicate there is a need for better management of stormwater along Ghent Hills Road in Bath Township. Local complaints include eroded channels and ravines downstream of these swales and ponding along the roadway and driveways. With the existing swales already in place, conversion to amended swales should be a fairly simple process that will slow runoff and provide some detention in an area that currently has none. Refer to Appendix D, page D29 for this concept.

Ghent Hills Detention (SWMD)

Just south of the previous concept, additional resident complaints further indicate the need for better management of stormwater along Ghent Hills Road. The ravines behind 1046 Ghent Hills Road and 1021 N. Cleveland-Massillon Road in Bath Township have undergone extensive erosion and mass wasting, placing a driveway and at least one shed at risk (Figure 30). This concept proposed a new detention basin between 1026 and 1046 Ghent Hills Road in the exact location where consolidated flows from a culvert currently are directed (Figure 31). This basin should be able to be designed for $Q_{critical}$, which will reduce the excess erosion in the receiving ravines. Refer to Appendix D, page D30 for this concept.

Figure 30: Confluence of tributaries with mass wasting and compromised retaining walls

Figure 31: Existing swale/flow path from Ghent Hill Road

I-77 Rest Area Bankfull Wetland (ODOT/SWMD)

As part of the effort to increase storage in the watershed, a ~0.05-acre-foot bankfull wetland is proposed on this public parcel in Bath Township. Additional modeling is needed to design the stream connection for optimized reduction of erosive flows, and the grading is preliminary, based on aerial imagery and LiDAR contours. Depending on goals and stakeholder input, this concept may be able to be expanded to mitigate even more stormwater. Refer to Appendix D, page D31 for this concept.

Idle Brook Bankfull Wetland (SWMD)

As part of the effort to increase storage in the watershed, a ~4.2-acre-foot bankfull wetland is proposed on this public parcel in Bath Township. Additional modeling is needed to design the stream connection for optimized reduction of erosive flows, and the grading is preliminary, based on aerial imagery and LiDAR contours. Refer to Appendix D, page D32 for this concept.

Medina Line Ponded Water Study and Improvements (SCE)

Figure 32: Driveway and existing swales on Medina Line Road (looking south)

Drainage issues along Medina Line Road were reported by a resident on the Bath Township side of the road, including large pools of water at the street and an impassable driveway with erosion (approximate location shown in Figure 32). The immediate cause of these issues was not identified during a field visit, and the resident was not home to collect more information. It is possible that the issue is a result of stormwater coming from the north along Medina Line Road or from the channel that runs through their property. It is recommended that an additional study of the area and problem is conducted prior to identifying solution(s). However, potential solutions could include upsizing the culverts downstream at the intersection of Granger and Medina Line roads, amended swales along Medina Line Road, or SCMs upstream on their tributary. Refer to Appendix D, page D33 for this concept.

Nester Bankfull Wetland (SWMD)

As part of the effort to increase storage in the watershed, a ~5.0-acre-foot bankfull wetland is proposed on this private, land-locked parcel in Bath Township. Additional modeling is needed to design the stream connection for optimized reduction of erosive flows, and the grading is preliminary, based on aerial imagery and LiDAR contours. Refer to Appendix D, page D34 for this concept.

North Fork Bankfull Wetland (Village Richfield/SWMD)

As part of the effort to increase storage in the watershed, a ~0.6-acre-foot bankfull wetland is proposed on this public parcel in the Village of Richfield. Additional modeling is needed to design the stream connection for optimized reduction of erosive flows, and the grading is preliminary, based on aerial imagery and LiDAR contours. Refer to Appendix D, page D35 for this concept.

O'Neill Woods Bankfull Wetland (SWMD/Summit Metro Parks)

As part of the effort to increase storage in the watershed, a ~2.4-acre-foot bankfull wetland is proposed on these public parcels in Bath Township. Additional modeling is needed to design the stream connection for optimized reduction of erosive flows, and the grading is preliminary, based on aerial imagery and LiDAR contours. Refer to Appendix D, page D36 for this concept.

Preston Bankfull Wetland (SWMD)

As part of the effort to increase storage in the watershed, a ~1.5-acre-foot bankfull wetland is proposed on this private parcel in Bath Township. Additional modeling is needed to design the stream connection for optimized reduction of erosive flows, and the grading is preliminary, based on aerial imagery and LiDAR contours. Refer to Appendix D, page D37 for this concept.

Ranchwood Stormwater Improvements (SWMD/Private)

Drainage issues at two properties along Ranchwood Road in Bath Township indicated that the volume of stormwater may be overwhelming the existing system. A resident on the north side of Ranchwood Road stated that basement flooding was a result of runoff from Pin Oak, and a resident on the south side of Ranchwood Road has reported flooding through their yard due to upstream, overwhelmed inlets and swales (Figures 33 and 34). This flooding, which reportedly occurs about three times per year, has resulted in a partially exposed septic system and a flooded driveway during events.

Figure 33: Culvert along Ranchwood that directs flows onto driveway at 4826 Ranchwood

Figure 34: Flooding looking from backyard with partially exposed septic location identified

To help to reduce the severity of the reported issues, new detention and new stormwater routing is proposed. Two vacant lots on the north side of Ranchwood Road, which currently appear to allow flow through of water from Pin Oak Road, are proposed for conceptual detention basins. Based on drainage area delineations and available contours, these basins may or may not be able to substantially reduce the flows from Pin Oak Road but would at a minimum consolidate the flows. From these basins, the flows could enter storm sewers (including existing and new) that could direct the flows to the natural flow paths south of Ranchwood Road, which may need armoring to resist erosion. To redirect additional flows from Pin Oak Road, armored stormwater routing is proposed along several backyards on the north side of Ranchwood Road that would be directed to the more western proposed basin. Refer to Appendix D, page D38 for this concept.

Timberline Part A: Detention (SWMD/Private)

Figure 35: Open yard area for proposed basin with existing culverts shown in bottom right

Flows from Timberline Drive and Westridge Road in Bath Township enter a culvert that directs the flows under Timberline Drive toward 901 Timberline Drive. Due to the stormwater issues at 901 Timberline Drive, discussed later in this section under the stream stabilization category (i.e. Timberline Part B: Swale Stabilization), upstream detention was evaluated. It appears there is enough area in the front yard of 850 Timberline Drive (Figure 35) to install a detention basin that could substantially reduce the flows from the drainage area, ultimately reducing the erosive flows in the receiving channel and on 901 Timberline Drive. Refer to Appendix D, page D39 for this concept.

Top of the Hill Site Detention (Bath Township/SWMD)

Figure 36: Undercut stormwater pipes document erosion in ravine

Erosion/instability and tree loss concerns at Top of the Hill Road in Bath Township suggest a potential lack of adequate stormwater controls for the neighborhood. Stormwater runoff is currently directed to swales along the road, which discharge to the tributaries surrounding 1135 Top of the Hill Road (Figure 36). With the existing swales already in place, conversion to amended swales should be a fairly simple process that will slow runoff and provide some detention in an area that currently has none. At the end of the court, there appears to be an existing depression that receives flows from the north side of Top of the Hill Road. Enhancement of this area is proposed to further reduce peak flows to the receiving channel. Modeling efforts would be necessary to ensure flooding of the roadway and/or nearby residences would not occur as a result of the enhanced detention. Potentially in combination with or, as an alternative to this project, the receiving ravines could be investigated for potential armoring needs. Refer to Appendix D, page D40 for this concept.

West Fork Bankfull Wetland (SWMD)

As part of the effort to increase storage in the watershed, a ~17.7-acre-foot bankfull wetland is proposed on these private parcels in Bath Township. Additional modeling is needed to design the stream connection for optimized reduction of erosive flows, and the grading is preliminary, based on aerial imagery and LiDAR contours. Refer to Appendix D, page D41 for this concept.

6.5 Instability/downcutting in "Seasonal Channels"

Concepts in this category aim to address more localized instability mostly on private properties.

Timberline Part B: Swale Stabilization (SWMD/Private)

Figure 37: Eroded ravine downstream of driveway

The system of ravines and culverts on 901 Timberline Drive in Bath Township receive runoff from Timberline and Westridge drives (see Timberline Part A: Detention concept for partial drainage area.) When it rains, the stormwater runoff appears to potentially contribute to erosion in the ravines and a loss of trees. Additionally, the resident reports various debris from the runoff, ranging from bottles to construction debris and a car battery and also flooding of an outbuilding. Major erosion on the property is threatening the private driveway and culverts (Figure 37). The proposed concept on this property creates a new channel to take flows to Yellow Creek by bypassing the existing ravine and culverts. The new channel would be armored with large rock due to its steep nature. Refer to Appendix D, page D42 for this advanced concept.

Timberline Part C: Headcut Repair (SWMD/Private)

Figure 38: Headcut currently checked by tree root

There is a drainage swale on 946 Timberline Drive in Bath Township that conveys runoff from Timberline Drive to Yellow Creek. The County was aware of instability complaints from the resident, and visual observation confirms a small headcut on the property that is currently checked by a tree root (Figure 38). Armoring this swale with rock should be a cost-effective measure that will protect the channel from further headcut migration moving forward. Refer to Appendix D, page D43 for this concept.

Timberline Part D: Tributary Stabilization (SWMD/Private) ***Extrapolated***

This concept, located off Yellow Creek Road in Bath Township, appears to have a similar setting to 901 Timberline Drive, where runoff from Yellow Creek Road passes along/between houses via a steep ravine down to Yellow Creek. As an extrapolated issue based on setting, an evaluation of the site is recommended prior to design and implementation to better understand the severity of potential erosion and tailor project extents and approach accordingly. Preliminarily, this concept assumes stream stabilization/rehabilitation of the existing ravine. Refer to Appendix D, page D44 for this concept.

Tributary Stabilization (SWMD/Private)

Figure 39: ~4-ft headcut in tributary

A small tributary in Bath Township flows from N. Cleveland-Massillon Road to Park Creek north of Bath Community Park. While accessing Park Creek, this tributary was discovered, which had extensive erosion, some undercut banks, and at least one four-foot headcut (Figure 39). Stabilization of at least part of this reach would reduce sediment flows to Park Creek. Refer to Appendix D, page D45 for this concept.

6.6 Protection on Streambanks that could Potentially Be Stabilized within the Scope of the SWMD

Concepts within this category aim to address reach instability on private parcels that might also have risks to public infrastructure. Criteria for these concepts includes full-scale restoration on stream reaches where the total bank height was relatively small and did not directly connect to an excessively large/steep adjacent hillslope.

Crystal Lake Stream Re-alignment (SCE/SWMD)

Figure 40: Yellow Creek along Crystal Lake Road, looking downstream at alignment and erosion

Along Crystal Lake Road in Bath Township, Yellow Creek's current alignment appears to be threatening a shared driveway and Crystal Lake Road at the bridge and one other location due it its close proximity (Figure 40). The stream has eroded the toe of the bank along the road. This concept was advanced to a level beyond many of the other concepts in order to provide a more detailed cost estimate that could be used/extrapolated for other concepts in this watershed. The concept proposes to re-align Yellow Creek, providing bed and bank armoring via riffles and rock toe. Buried rock grade control is proposed to provide stability along the entire floodplain. Refer to Appendix D, page D46 for this advanced concept.

Downtown Ghent Restoration (SWMD/Private)

As stated previously, Ghent was initially established in the 1870's. Development is in close proximity to the banks of Yellow Creek and North Fork, and instability along these reaches is beginning to impact the improvements in this downtown. Two parking lots have begun to crumble into the streams (Figure 41), there are large scour holes downstream of the bridges (Figure 42), mass wasting along unprotected banks, and a retaining wall that appears to be failing. The owner of Lanning's Restaurant has spent a significant sum to place riprap along his bank. Being a complex project, this concept was advanced to a level beyond many of the other concepts. With tight space, this concept aims to armor the channel (both bed and bank) in place without re-alignment. Refer to Appendix D, page D47 for this advanced concept.

Figure 41: Erosion in parking lot creating safety issue for users

Figure 42: Scour hole downstream of bridge and rock protection along Lanning's

Fox Chase Tributary Stabilization (Private) ***Extrapolated***

This concept, located in Bath Township, appears to be unstable based on a review of aerial imagery. Additionally, the tributary appears to be in close proximity to a couple houses. As an extrapolated issue, an evaluation of the site is recommended prior to design and implementation to better understand the severity of potential erosion and to tailor project extents and approach accordingly. Preliminarily, this concept assumes stream stabilization/rehabilitation of the existing ravine. Refer to Appendix D, page D48 for this concept.

Lakeview Dr Stream Stabilization (Assessed subdivision)

Figure 43: Bare bank areas downstream from the outfall indicate mobilized armoring

Instability along the receiving stream from a large, inline basin in Bath Township appears to be exhibiting signs of erosion. The basin appears to have had recent work completed on the spillway; a review of recent aerial imagery shows much more riparian cover along this reach and the basin spillway in as recent as 2018. The rock armoring near the outfall from the basin appears to have mobilized (Figure 43). An additional concern is the stability of the basin along the offline basin adjacent to the channel. The concept for this location includes bed and bank stabilization. Refer to Appendix D, page D49 for this concept.

Maple Dr Hand-Placed Log Stabilization (Village Richfield)

Figure 44: Some bank erosion and lateral migration in this reach

In this upper reach of North Fork in the Village of Richfield, intermittent bank erosion and lateral migration are apparent (Figure 44), although the streambed appears stable, with good riffle-pool sequences. Although not a large contributor of sediment to the system, stabilizing these banks with a low-cost method could be an excellent training activity that would benefit the system. In addition to reduced sediment entering North Fork, hand-placed log structures can improve habitat and can be installed with no disturbance to the existing riparian vegetation onsite. Refer to Appendix D, page D50 for this concept.

Ghent/Yellow Creek Tributary Stabilization (SWMD) ***Extrapolated***

This tributary, located in Bath Township, appears to be in close proximity to a gas station per a review of aerial imagery. As an extrapolated issue, an evaluation of the site is recommended prior to design and implementation to better understand the severity of potential erosion and tailor project extents and approach accordingly. Preliminarily, this concept assumes stream stabilization/rehabilitation of the existing ravine. Refer to Appendix D, page D51 for this concept.

Pine Point Drive Outfall Channel Stabilization (SWMD/Private) ***Extrapolated***

Figure 45: Pre-project photo courtesy of Summit County

In 2016, an affected owner approached Summit County about severe erosion in her backyard (Figure 45), downstream of the public storm drainage system. Because it was beyond the storm drainage easement included on the subdivision plat, the County could not repair it. The owner, subsequently joined by a neighbor, proceeded with a ditch petition. The County calculated preliminary assessments; however, due to overwhelming negative response from many of the 42 upstream landowners to be assessed, County Council did not authorize proceeding with the design. In 2017, the two owners hired an engineer to prepare an improvement plan and subdivision replat in conformance with County criteria, and in 2018, they hired a contractor to construct the improvements. It has been determined that the aerial imagery initially used to identify this extrapolated issue was taken before the repairs were constructed. Because the stream team did not visit this ditch in person, the concept and cost have been included in Appendix D (page D52) as a placeholder in the event that the issue has migrated to other portions of the ditch.

Stabilization near WWTP (Private – Granger Lake Condos)

Figure 46: Exposed pipes in bank show extents of bank erosion along WWTP fence

This Granger Township tributary to West Fork exhibits widening and downcutting with vertical banks in close proximity to small wastewater treatment plant (WWTP, Figure 46). This instability puts the WWTP at risk. This concept proposes to protect the bank for improved stability and lowered risk of compromising the WWTP. Refer to Appendix D, page D53 for this concept.

Stone Gate Blvd Tributary Stabilization (SWMD/Private) ***Extrapolated***

This Bath Township tributary receives flow from the local neighborhood, which appears to lack detention. Based on the apparent lack of upstream detention, proximity to houses, and known erosion nearby, this reach is assumed to have instability issues. As an extrapolated issue, an evaluation of the site is recommended prior to design and implementation to better understand the severity of potential erosion and tailor project extents and approach accordingly. Preliminarily, this concept proposes to protect the streambed and toes of the bank for improved stability. Where residents along this reach are concerned about stability, separate action(s) may need to be taken by them for full protection of the entire hillslope (via retaining walls or other methods). Refer to Appendix D, page D54 for this concept.

Trellis Green Stream Stabilization (SWMD/assessed subdivision)

Figure 47: Basin embankment with ~5-8 feet between pond and West Fork

West Fork's instability in this location in Bath Township is threatening a basin embankment (Figure 47) and an outbuilding. The stream has eroded the toe of the bank along the reach. This concept was advanced to a level beyond many of the other concepts in order to provide a more detailed cost estimate that could be used/extrapolated for other concepts in this watershed. The concept proposes slight re-alignment of West Fork, providing bed and bank armoring via riffles and rock toe. Buried rock grade control is proposed to provide stability along the entire floodplain. Additionally, the outfall from the basin will be armored. Refer to Appendix D, page D55 for this advanced concept. Alternatively, if hand-placed log structures prove to be successful in lower risk settings such as the Maple Dr. Hand Placed Log Stabilization concept discussed above, a similar approach could provide a low-cost alternative for addressing bank instability in the more challenging setting of Trellis

Green. Although additional efforts such as grading and rock armoring may still be necessary to stabilize the basin outfall and provide more permanent protection of the berm during overtopping flows.

West Creek Stabilization along Basin (Private)

Figure 48: Basin embankment with erosion on the bank of West Creek

Similar to the last concept, the instability in this reach of West Creek in Bath Township has created a risk of berm failure along an existing basin (Figure 48). The approximately six-foot-tall bank is ~15 feet from the pond. Upstream of here, the stream lacks riparian vegetation. This concept proposes to protect the streambed and bank for improved stability and lowered risk of compromising the basin. Refer to Appendix D, page D56 for this concept.

Westmont Woods Subdivision Restoration (Private or Swan Lake Developer)

Figure 49: Steep slope and close proximity to structures

This reach of Yellow Creek, along Fernway Drive and Forest Brook Drive in Copley Township, appears to exhibit instability, putting several private properties at risk (Figure 49). These properties appear to be built on fill with steep embankments immediately adjacent to a stream. The instability may have been prevented with alternative subdivision planning that, for example, included wider stream buffers and avoided fill in floodplains. Restoration of this reach would include armored bed and banks to improve habitat and stream stability and reduce the risk of future erosion along the toe of slope. Refer to Appendix D, page D57 for this concept.

6.7 Protection on Streambanks that could Potentially Be Partially Stabilized within the Scope of the SWMD

Concepts within this category aim to address extreme reach instability on private parcels. Conceptual project opportunities in this category did not evaluate full-scale hillslope stabilization due to tall, unstable hillslopes. Under these circumstances, the conceptual evaluations focused on stream restoration strategies along the valley bottom/toe of banks. Projects that have tall banks/hillslopes with structures at the top of the bank propose to stabilize only the toe of the slope/toe of the bank via rock armoring/bioengineering. Sustainable Streams would also recommend moving the stream off the toe of the hillslope to the extent feasible and designing the toe protection robustly for the 100-year storm plus a factor of safety (see Hawley 2018 for more detail). This approach should reduce the risk of the toe of bank retreating farther into the hillslope; however, the hillslopes that are geotechnically unstable would remain in an unstable condition without complementary intervention from the residents (e.g. retaining walls or other geotechnical stabilization strategies). The approach, which has been used in other communities, keeps the public projects focused on the public resource (i.e. the stream) and leaves the private property owner responsible for protecting their private property.

Bath Creek Select Stream Stabilization (SWMD/Private)

Bath Creek, downstream of Nina Lane to its confluence with North Fork (in Bath Township), showed extensive instability, with tall, vertical banks, mass wasting and slumped hillslopes, and large tree loss (Figures 50 and 51). One area armored with rock exhibited continued instability. This concept addresses the worst banks along this reach in Bath Township and proposes to protect select sections of streambed and toes of the bank for improved stability. Where residents along this reach are concerned about stability, separate action(s) would need to be taken by them for full protection of the entire hillslope (via retaining walls or other methods). Refer to Appendix D, page D58 for this concept.

Figure 50: ~40-ft tall near vertical bank with mass wasting and tree loss

Figure 51: Major erosion and mass wasting at pipe outfall

Lower South Fork Tributary Stabilization (SWMD/Private) ***Extrapolated***

Figure 52: Erosion and tree loss visible from the top of the valley

This reach, located in Bath Township, was partially viewed from Treecrest Drive, where instability and tree loss were noted (Figure 52). Additionally, a review of aerial imagery showed apparent instability along much of the reach. As an extrapolated issue, an evaluation of the site is recommended prior to design and implementation to better understand the severity of potential erosion and tailor project extents and approach accordingly. Preliminarily, this concept proposes to protect the streambed and toes of the bank for improved stability. Where residents along this reach are concerned about stability, separate action(s) would need to be taken by them for full protection of the entire hillslope (via retaining walls or other methods). Refer to Appendix D, page D59 for this concept.

Merrill's Run Stabilization (SWMD/Private)

Merrill's Run, located in Bath Township, is an extremely unstable, entrenched stream. Some residents have dumped rock to an effort to provide some protection, although tree loss is extensive and private bridges and sheds have been lost to erosion (Figures 53 and 54). The extreme cost to address the instability in this reach is estimated to be too costly to implement. Refer to Appendix D, page D60 for this concept.

Figure 53: Extensive tree loss along Merrill's Run with shed at top of bank

Figure 54: Mass wasting along banks

North Fork Stream Re-alignment (SWMD/Private)

Figure 55: Mass wasting along ~70-ft-tall bank on North Fork

This reach of North Fork in Bath Township exhibits extreme mass wasting along several banks, the tallest being ~70 feet (Figure 55). This instability is along a private property, with a highly sinuous bend upstream that is in proximity to N. Cleveland-Massillon Road. Stabilization of this reach is recommended to greatly reduce sediment loading, tree loss, and property risk. This concept proposes to protect the streambed and toes of the bank for improved stability. Where residents along this reach are concerned about stability, separate action(s) would need to be taken by them for full protection of the entire hillslope (via retaining walls or other methods). Refer to Appendix D, page D61 for this concept.

Revere Rd Stabilization (SCE/SWMD)

Figure 56: Revere Run valley in close proximity to Revere Road

This section of Revere Run, located along Revere Road in Bath Township, exhibits signs of instability that is threatening Revere Road (Figure 56) and some residences. Along the roadway, bank erosion is apparent at the edge of the floodplain, although the low flow channel is farther away from the road. The opposite bank has tall, steep banks that appear to be slumping below the houses at the top. This concept proposes to protect the streambed and toes of the bank for improved stability. Where residents along this reach are concerned about stability, separate action(s) would need to be taken by them for full protection of the entire hillslope (via retaining walls or other methods). Refer to Appendix D, page D62 for this concept.

Revere Run Select Stream Stabilization (SWMD/Private)

Figure 57: Mass wasting and tree loss on Revere Run

Revere Run downstream of Bonnebrook Drive (Bath Township) is exhibiting extreme mass wasting, channel migration, downcutting, mass wasting, and tree loss (Figure 57). One resident with a large frontage on Revere Run and a tributary noted regular tree loss, flooding from Bath Road, and erosion in the channels. Banks along this reach are up to ~65 feet tall. This concept addresses the worst banks along this reach in Bath Township and proposes to protect select sections of streambed and toes of the bank for improved stability. Where residents along this reach are concerned about stability, separate action(s) would need to be taken by them for full protection of the entire hillslope (via retaining walls or other methods). Refer to Appendix D, page D63 for this concept.

Revere Rd to Yellow Creek Tributary Stabilization (SWMD/Private) ***Extrapolated***

Figure 58: Bank erosion, damaged deck, and tree loss prevalent on this tributary

The downstream end of this reach was visually assessed, and extreme instability, mass wasting, property damage, tree loss, and over-widening was noted (Figure 58). Based on slopes and elevations, similar issues are expected to be along the majority of this reach from the confluence with Yellow Creek up to Revere Road (Bath Township). As an extrapolated issue, an evaluation of the full reach is recommended prior to design and implementation to better understand the severity of potential erosion and tailor project extents and approach accordingly. Preliminarily, this concept assumes stream stabilization/rehabilitation of the existing ravine. Refer to Appendix D, page D64 for this concept.

Ridge Drive Tributary Stabilization (SWMD/Private) ***Extrapolated***

This Bath Township tributary receives flow from two stormwater outfalls along S. Ridge Drive. The upstream catchments appear to collect neighborhood runoff without providing detention. Based on the apparent lack of upstream detention and elevations/slopes, this reach is assumed to have instability issues. As an extrapolated issue, an evaluation of the site is recommended prior to design and implementation to better understand the severity of potential erosion and tailor project extents and approach accordingly. Preliminarily, this concept proposes to protect the streambed and toes of the bank for improved stability. Where residents along this reach are concerned about stability, separate action(s) would need to be taken by them for full protection of the entire hillslope (via retaining walls or other methods). Refer to Appendix D, page D65 for this concept.

Timber Creek Drive Tributary Stabilization (SWMD/Private) ***Extrapolated***

These two Bath Township tributaries receive flow from the local neighborhood, which unfortunately has its detention downstream of the low point of the allotment. Based on the lack of upstream detention, proximity to houses, and review of aerial imagery, these reaches are assumed to have instability issues. As an extrapolated issue, an evaluation of the reach is recommended prior to design and implementation to better understand the severity of potential erosion and tailor project extents and approach accordingly. Preliminarily, this concept proposes to protect the streambed and toes of the bank for improved stability. Where residents along this reach are concerned about stability, separate action(s) would need to be taken by them for full protection of the entire hillslope (via retaining walls or other methods). Refer to Appendix D, page D66 for this concept. This stream segment is among the upper reaches of the Wye Road Flood Mitigation and Alternatives Study (ms consultants, 2019), and coincides with solution(s) presented for the study area.

Top of the Hill North Tributary Stabilization (SWMD/Private) ***Extrapolated***

This Bath Township tributary receives flow from the local neighborhood, which appears to lack detention. Additionally, this tributary appears to have the same setting as a reach with known erosion issues nearby on another tributary as well as the issues on Merrill's Run, which this tributary feeds into. For these reasons, this reach is assumed to have instability issues. As an extrapolated issue, an evaluation of the reach is recommended prior to design and implementation to better understand the severity of potential erosion and tailor project extents and approach accordingly. Preliminarily, this concept proposes to protect the streambed and toes of the bank for improved stability. Where residents along this reach are concerned about stability, separate action(s) would need to be taken by them for full protection of the entire hillslope (via retaining walls or other methods). Refer to Appendix D, page D67 for this concept.

Top of the Hill South Tributary Stabilization (SWMD/Private) ***Extrapolated***

This Bath Township tributary receives flow from the local neighborhood, which appears to lack detention. Additionally, this tributary is just downstream of known erosion issues (see Top of the Hill Site Detention concept). For these reasons, this reach is assumed to have instability issues. As an extrapolated issue, an evaluation of the reach is recommended prior to design and implementation to better understand the severity of potential erosion and tailor project extents and approach accordingly. Preliminarily, this concept proposes to protect the streambed and toes of the bank for improved stability. Where residents along this reach are concerned about stability, separate action(s) would need to be taken by them for full protection of the entire hillslope (via retaining walls or other methods). Refer to Appendix D, page D68 for this concept.

West Creek Tributary to Hametown Rd Stabilization (SWMD/Private) ***Extrapolated***

This Bath Township tributary appears to be in close proximity to a house and is located in a steep setting. For these reasons, as well as a review of available aerial imagery, this reach is assumed to have instability issues. As an extrapolated issue, an evaluation of the reach is recommended prior to design and implementation to better understand the severity of potential erosion and tailor project extents and approach accordingly. Preliminarily, this concept proposes to protect the streambed and toes of the bank for improved stability. Where residents along this reach are concerned about stability, separate action(s) would need to be taken by them for full protection of the entire hillslope (via retaining walls or other methods). Refer to Appendix D, page D69 for this concept.

6.8 Programmatic/Non-structural improvements

The following items have been compiled as programmatic elements and other non-structural improvements, which should be extremely valuable for Summit County's stormwater management program. The compiled list is based on best practices employed with other organizations, needs identified during the visual assessment, and through talking with residents.

Homeowner Education - Septic Maintenance

Figure 59: Yard within the watershed where septic has been smelled

A common theme from talking to local residents was septic smells in yards (e.g. Figure 59). Proper septic maintenance can not only protect property value and the environment, it will save money long term. The Summit County Public Health Department has several informational presentations to help spread best practices on septic system management and help residents understand how their systems work. This item assumes one homeowner education event per year for three years could be held, in conjunction with the health department, to inform citizens of appropriate maintenance activities, phone numbers and other resources for help, and available grant funding opportunities. Grant funding is available to homeowners to through the Summit County Department of Community and Economic Development to ensure proper septic system maintenance (Summit County Public Health).

Homeowner Education - Streamside Management

During the visual assessment, it was obvious that many homeowners have taken their own actions to protect their properties from the erosive nature of the streams in this watershed (Figure 60). Providing residents with do-it-yourself knowhow via a workshop and/or pilot project would likely provide real benefit to the system. The workshop should highlight the use of loose material over hardscape products, which are more forgiving in a natural setting. It would also be prudent to touch on the importance of riparian buffers in stream stability (Figure 61), from no-mow native seed buffers to live stakes and trees. From a budget standpoint, one workshop per year for three years has been assumed. An example workshop handout and workshop flyer have been included in Appendix E.

Figure 60: Loose rock bank protection on a private property

Figure 61: ~6-foot slump in residential backyard lacking riparian vegetation.

Homeowner Education – Onsite Stormwater Management

Figure 62: Resident complaint of wet spots that are slow to drain in yard.

Based on feedback in the resident surveys, local drainage issues (e.g. Figure 62) seem to be prevalent in the watershed. For those residents with soggy yards and/or poor drainage, an educational workshop on practices that could improve conditions could be valuable. The workshop could cover simple modifications, such as splash blocks on downspouts, but could also include pocket rain gardens and other green infrastructure that homeowners can do themselves. Materials could be developed that list local regulations and resources pertaining to stormwater drainage can empower open dialogue between neighbors and personal actions to remediate issues. From a budget standpoint, one workshop per year for three years has been assumed.

Staff Training - Streamside Management

Similar to the homeowner education on the same topic, training provided for Summit County staff could help staff recognize common problems in the watershed. As staff out in the watershed, visible issues could be reported and possibly addressed quicker as a result. From a budget standpoint, one workshop has been assumed.

Yellow Creek Nine-element Nonpoint Source Implementation Strategic Plan (NPS-IS Plan)

Summit Soil and Water Conservation District (SWCD) is currently working on the Yellow Creek NPS-IS Plan, which will serve as the watershed plan for the Yellow Creek Watershed. These plans summarize causes and sources of impairments, critical areas in the watershed, outlines objectives, and describes proposed projects. With the recent efforts by SWMD in the watershed, as outlined in this report, SWMD could assist with the completion of the report. Additionally, projects listed herein could be ideal candidates to list in the NPS-IS Plan. An OEPA/USEPA-approved NPS-IS Plan for Yellow Creek is in the best interest of SWMD and other stakeholders as they are required in order to obtain 319(h) grant funding, which is a funding source that has been commonly used for stream restoration projects throughout Ohio.

Live Stake Program

Summit County could begin a live stake program that would provide harvested live stakes to residents for free. The County has ample public land in parks and nature preserves that are sure to have dogwoods, willows, and other common live stake species that could be harvested by County staff. Handing these out with educational material (example in Appendix E) to residents would encourage more riparian buffers and should improve stability. From a budget standpoint, this program has been assumed to last five years. Several areas in the watershed have been identified as lacking riparian buffers, including along Heatherleigh Drive, Janwood Drive, Meadow Park, Roberts Drive, and Yellow Creek Road.

Culvert Mapping

It is apparent that not all culverts in the watershed have been mapped, for example the intersection of Harmony Road and Acacia Drive. Having a complete database of all culverts in the watershed, regardless of jurisdiction, would provide a comprehensive list for annual maintenance inspections, documentation, and a helpful tool to use if questions/issues arise. At a minimum, location, size, and material are recommended information to collect. This is assumed to be a one-time cost.

Culvert Inspections

After the culverts have been mapped across the watershed, it will be important to schedule and conduct routine inspections of the culverts. Unstable culverts due to undermining and/or flanking can cause major safety issues. Clogged culverts can cause ponding on roads and in yards, which can be a safety risk from flooding and an annoyance to people. Regular inspections to assess condition and criticality will help prioritize repairs and potential retrofits in the future. Maintenance as a result of these inspections will ensure that they continue to function with minimal risk for their intended lifespan. Inspections are expected to cover a percentage of the service area every year for 20 years.

Storm Sewer Mapping

It is apparent that not all storm sewers in the watershed have been mapped, for example on Top of the Hill Road. Having a complete database of all storm sewers, structures, and detention basins in the watershed, regardless of jurisdiction, would provide a comprehensive list for annual maintenance inspections, documentation, and a helpful tool to use if questions/issues arise. At a minimum, location, size, and material are recommended information to collect, but inverts and slope, if available, would also be extremely useful data. This is assumed to be a one-time cost.

Stormwater Basin Inspections

Once inventoried across the watershed, routine inspections would be prudent to ensure functionality and stability of the basins. Many basins require routine maintenance, and even those not under Summit County's management would benefit from an annual check. Regular inspections to assess condition and criticality will help prioritize repairs and potential retrofits in the future. Inspections are expected to cover a percentage of the service area every year for 20 years. Maintenance as a result of these inspections will ensure that they continue to function with minimal risk for their intended lifespan. An example inspection form, completed by a different Ohio community, is included in Appendix E.

Detention Basin Retrofit Opportunities Evaluation

To build upon the preliminary concepts identified earlier in this report, a more comprehensive analysis of detention basin opportunities for potential retrofits would be a useful first step in further modifying basins to reduce erosive flows. To effectively evaluate more detention basins, outlet control structures and stormwater infrastructure into the basins would be necessary. Design drawings to confirm stage-storage and outlet designs would be beneficial. This is assumed to be a one-time cost.

Follow-Up – Detention Basin Retrofit Implementation

As a follow-up to evaluating detention basins for retrofit opportunities, this item covers implementation of many retrofits. For the purposes of conceptual budgetary planning, it is estimated that approximately ten to 20 simple retrofits that do not include regrading could be implemented. This is assumed to be a one-time cost.

Standard Detail Development for Outfall Protection with Rock

With the extensive number of culverts and other outfalls within the Yellow Creek Watershed, development of a standard detail of protection of these outfalls could be a valuable tool for those doing work in the watershed. The standard detail could include plan and section views of rock protection in a stable configuration that does not use grout. The loose-rock structures, potentially in combination with bioengineered bank armoring can not only be more durable than grouted/rigid structures but also have greater habitat value and are typically more agreeable to permit reviewers. It may be necessary to complete rock sizing calculations and extents of armor on a site- or project-specific basis, but already having a detail should ensure the correct construction techniques are used that will work in the setting.

Rules and Regulations Review

A one-time review of Summit County's rules and regulations with a focus on stream stability is recommended. Experience shows that these documents can easily become outdated for current best management practices. For example, the Yellow Creek Watershed had a watershed-wide $Q_{critical}$ estimate calculated (see Section 5.0), and it would be prudent to include this in the regulations. When revisiting the design guidance, consider the critical storm methodology and how it impacts $Q_{critical}$. The more restrictive flow (i.e. 40% of Q_2 or Q_1) could be used in cases where they are different.

Additionally, three homes appear to be built in the FEMA 100-year flood zone (3495 Yellow Creek Road, 3760 Granger Road, and 990 Timberline Drive), and at least one of them is a relatively recent build. Protecting the public from flooding with floodplain construction regulations could also be evaluated through this review as well as conservation and recharge requirements in areas of Type A and Type B soils. This is assumed to be a one-time cost.

Plan review

Stream-related construction drawings received by the County could be reviewed with stream stability and channel erosion in mind. Having a list of requirements for each submittal will help ensure a fair review of every project. Items such as bank slope, structure selection, rock size, and sinuosity could all be reviewed. From a budget standpoint, it is assumed that such a program might require outside assistance for up to four years, and after which be entirely handled by County staff.

Onsite Drainage Complaint Consultant

A person, whether County staff or a hired consultant, could be identified to receive, review, visit, and document drainage complaints from residents and businesses in the watershed. In some circumstances, preliminary solutions to the issues may be conceptually developed. From a budget standpoint, it is assumed that such a program might require outside assistance for up to three years, and after which be entirely handled by County staff.

Other/Management/Planning

This item serves to cover additional unforeseen items that may arise over a 20-year period.

7.0 Notifications to Others

During the visual assessment several issues and areas of concern were identified that do not fall under the jurisdiction of Summit County Surface Water Management District. The following list of items have already been partially conveyed to others, but are compiled here and in Appendix D to provide a complete list. A preliminary list of potential project partners/primary stakeholders has been developed by SCE/SWMD and have been added parenthetically to each concept name.

Bridge and Culvert Inspections (Varies)

As stated in Section 4.0, there were numerous bridges and culverts that exhibited signs of instability (Figures 63 and 64). However, the project team is not qualified as structural engineers and only noted items that were visually apparent. If a bridge or culvert were to fail, it could cause harm to human life and property and create transportation complications during repair. Regular inspections of these assets will help responsible parties keep track of their condition and prioritize repairs as necessary. It would be helpful to create standard details, like wingwall protection with loose riprap or armored energy dissipation pools, for culvert repairs. Photos and a GIS database of all public and private bridges and culverts observed in December 2018 were provided to the Summit County Engineer's Office, to both the surface water and bridge groups.

Figure 63: Culvert outfall with large scour pool that potentially risks exposing and/or undermining the culvert

Figure 64: Cracked bridge abutments

Routine Dam Inspections (Varies)

Several dams exhibited what appeared to be notable instability during the December 2018 visual assessment (Figures 65 and 66). Should one of these assets fail, it might result in damage to property and human life, as well as geomorphic damage to Yellow Creek. The majority of these dams are privately owned, but inspections and necessary maintenance on all dams are important. Performing regular inspections will ensure that these assets and their condition are recorded by responsible parties and repairs are prioritized. Coordination on dam inspections began by sharing data in December 2018 and contacting Ohio Department of Natural Resources (ODNR).

Figure 65: Right abutment is leaning with a home under construction downstream.

Figure 66: Dam is patched with a piece of plywood & chain-link fence.

The following list of items include noted instability from the December 2018 visual assessment that should be shared with the responsible party to facilitate notification of issues.

Bonnebrook Dr Gabion Instability (Bath Township)

Figure 67: Slumping gabions along Bonnebrook Dr.

The gabions on the west side of Bonnebrook Drive appear to be slumping (Figure 67). Additionally, there is some erosion on the left side of the gabions towards the top that appears to be caused from roadway runoff. This bridge is downstream of a dam that has been overtopped and caused flooding issues. Per a local resident, this bridge was blown out during the May 2012 storm, and the entire roadway, culvert, and gabions are relatively new. This issue should be shared with the transportation group.

Cleve-Mass Bridge at North Fork (SCE)

Figure 68: Bank erosion downstream of bridge

The bridge that crosses Cleveland-Massillon Road on North Fork is aligned such that the flows run into the right bank on the downstream side of the bridge, causing bank erosion (Figure 68). Through discussions with a resident, this bridge is believed to have been replaced after the May 2012 storm. Bank armoring is recommended. This issue should be shared with the transportation group.

Eastern Granger Rd Culvert Protection & Western Granger Rd Culvert Protection (SCE) ***Extrapolated***

These two culverts, not originally included in the extents of visual assessment, are believed to have stability issues, as the majority of the culverts included in the visual assessment did exhibit some instability. As an extrapolated issue, an evaluation of these culverts is recommended as an initial step to better understand the severity of potential erosion and tailor project extents and approach accordingly. This issue should be shared with the transportation group.

Martin Rd Culvert Instability (SCE) ***Extrapolated***

This culvert, not originally included in the extents of visual assessment, is believed to have stability issues, as the majority of the culverts included in the visual assessment did exhibit some instability. As an extrapolated issue, an evaluation of this culvert is recommended as an initial step to better understand the severity of potential erosion and tailor project extents and approach accordingly. This issue should be shared with the transportation group.

Medina Line Rd Riprap Instability (SCE)

Figure 69: Exposed geotextile in the foreground

Downstream of the intersection of Medina Line Road and Granger Road, there is exposed geotextile fabric along a bank that is otherwise protected with rock (Figure 69). It is assumed that the riprap has mobilized in this area. As this is not specifically a bridge or culvert issue, this issue was not previously passed onto the transportation group. However, since it is related to bridge and roadway stability, it is recommended to share this additional location with them.

N Hametown Channel Instability (Private)

Figure 70: Eroded channel with partially exposed power pole

Erosion along the right bank of this channelized swale along N. Hametown Road is potentially compromising a power pole within the bank (Figure 70). This issue should be shared with the power company.

North Fork Instability at Cleve-Mass (SCE)

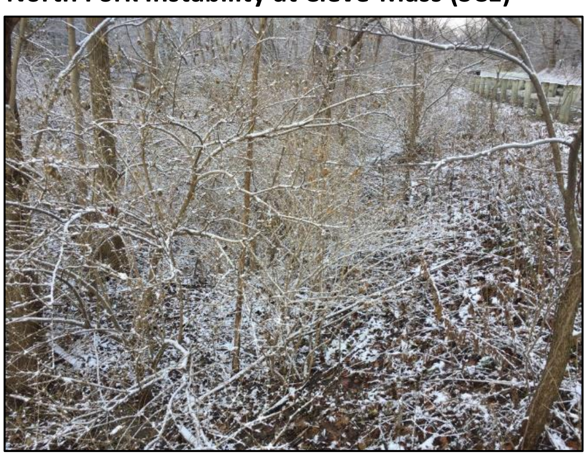

Figure 71: Steep bank with N. Cleveland-Massillon Road on the right

Along N. Cleveland-Massillon Road, one North Fork meander comes in close proximity to the road (Figure 71). Additionally, the bank is steep. At this location, the low flow channel is farther away from the toe of the slope, but it is still recommended for review by the transportation group due to the potential risk to N. Cleveland-Massillon Road. As this is not specifically a bridge or culvert issue, this issue was not previously passed onto the transportation group.

Revere Rd Riprap Instability (SCE)

Figure 72: Steep bank with N. Cleveland-Massillon Road on the right

Near the intersection of W. Bath Road and N. Revere Road, there is a section of stream that is protected with grouted riprap. The riprap is currently undercut (Figure 72), which impacts its stability. This location is just downstream of a culvert under W. Bath Road that appears to also need additional stabilization. As the undercut riprap is not specifically a bridge or culvert issue, this issue was not previously passed onto the transportation group. However, since it is related to roadway stability, it is recommended to share this additional location with them.

Sourek Rd Swale Instability (SCE)

Figure 73: Leaning power pole

On the upstream (southern) side of Sourek Road, the eastern swale along the road appears to have some erosion, which places the power pole(s) next to the ditch at risk (Figure 73). This issue should be shared with the power company.

Swan Lake Outlet Improvement (Developer)

Figure 74: Outlet structure without protective measures

The outlet structure from this lake (Figure 74) is a large, open concrete weir. The lake provides a fence around the downstream end, however there is an unlocked gate that is not a major deterrent to trespassing. Additionally, it appears some residents may kayak on the lake and sit aside it on docks. The outlet structure should provide protective measures that would prohibit a person from accidentally being drawn over the edge, where there would be a multiple-foot fall to a concrete surface. This safety concern should be shared with the homeowner's association, the parcel owner, and/or Copley Township. Further study of this basin, including drainage area and additional upstream controls could identified additional improvements for consideration, such as potentially lowering the permanent pool elevation with a "V-notch" weir (or equivalent) to enhance the basin's function as it relates to reducing the erosive power of the flows that are discharged from the basin and/or lowering the risk of large events overtopping the basin.

Tributary Instability at Wye Rd (SWMD) ***Extrapolated***

This tributary, not originally included in the extents of visual assessment, is believed to have stability issues due to its proximity to Wye Road. As an extrapolated issue, an evaluation of this reach is recommended as an initial step to better understand the severity of potential erosion and tailor project extents and approach accordingly. This issue should be shared with the transportation group.

Yellow Creek Exposed Gas Main (East Ohio Gas Company (EOG))

Figure 75: Exposed gas main on Yellow Creek

The visual assessment identified an exposed gas main crossing Yellow Creek (see yellow spray paint in Figure 75). Per signage, it is assumed that the main is owned by Pine Top Oil & Gas. Being exposed, woody debris, rocks, or other items within the channel could potentially puncture the line, creating instream pollution. Protective measures should be taken to bury the gas main, which may include re-burying the line deeper below the stream bed and/or protecting the main with a grade control structure such as a Newberry riffle. This safety concern should be shared with the gas company.

Private Residences (Private)

Several private residences appear to have instability issues that were either noted via visual observation or assumed via an aerial imagery review. These properties include: 2226 W. Bath Road in Cuyahoga Falls (Figure 76); 2364 Berrywood Drive in Bath Township (Figure 77); 4023 Shaw Road in Bath Township (Figure 78); 4191 Janwood Drive in Copley Township (Figure 79); 4595 Larkspur Ln N. in Bath Township; 4737 Granger Road in Bath Township, and; 750 Spring Water Drive in Bath Township. The stream is also encroaching the road near the Berrywood Drive location. The three properties on Larkspur Ln N., Granger Road, and Spring Water Drive were extrapolated via aerial imagery review, and as such, evaluations of these reaches/properties are recommended as an initial step to better understand the severity of potential erosion prior to discussing unknown issues with the residents. Notifying homeowners of risks and the prioritization of safety in planning mitigation and repairs needs to be considered to protect property and ensure that critical assets are properly maintained.

Figure 76: 2226 W. Bath Road with vertical, ~30-foot tall bank

Figure 77: 2364 Berrywood Drive with encroaching deck and house on top of opposite bank

Figure 78: 4023 Shaw Road, where house may only be ~10 feet from the top of a potentially failing bank

Figure 79: 4191 Janwood Drive with house ~10 to 12 feet from the top of bank

8.0 Preliminary Implementation Plan of Potentially High-Impact Projects

There are many aspects of the projects listed in this report that should be considered when determining the best projects for the community, including costs, access, cost-effectiveness, infrastructure protection, public safety, etc. The list below, shown in Figure 80, focuses on arguably the greatest opportunities for reducing stream erosion. They include two distinct strategies: 1) stormwater management interventions to intercept large volumes of potentially erosive flow upstream of actively eroding stream reaches, and 2) stream restoration projects to rehabilitate large sections of unstable channel.

The stormwater management projects will arguably have greater benefits to the overall stream network, including flow and sediment reduction and long-term reductions to stream erosion. However, a geotechnically unstable bank will remain a risk, especially in the near-term, without physical stabilization. In contrast, the stream restoration concepts listed below have arguably lower network benefits, but can more immediately reduce sediment loads from high-priority banks and protect imperiled infrastructure. Integrating the projects could potentially have even greater benefits than individual stream restoration and stormwater projects (Lammers *et al.*, 2019). The ultimate implementation of stakeholder-selected projects should attempt to maximize overall stakeholder objectives (e.g. reduced erosion, protected infrastructure, improved water quality, etc.) within available financing, feasibility, access, and other potentially constraining factors. For example, the Wye Road Flood Mitigation and Alternatives Study may be an even higher priority because of the chronic flooding in the vicinity. This project aims to address flooding through upstream detention for concepts ranging in cost from $250,000 to $600,000 (ms consultants, 2019). The stormwater detention approach in the Wye Road study aligns with the objectives of this watershed-wide study by holding back more stormwater, resulting in reduced erosion in Yellow Creek.

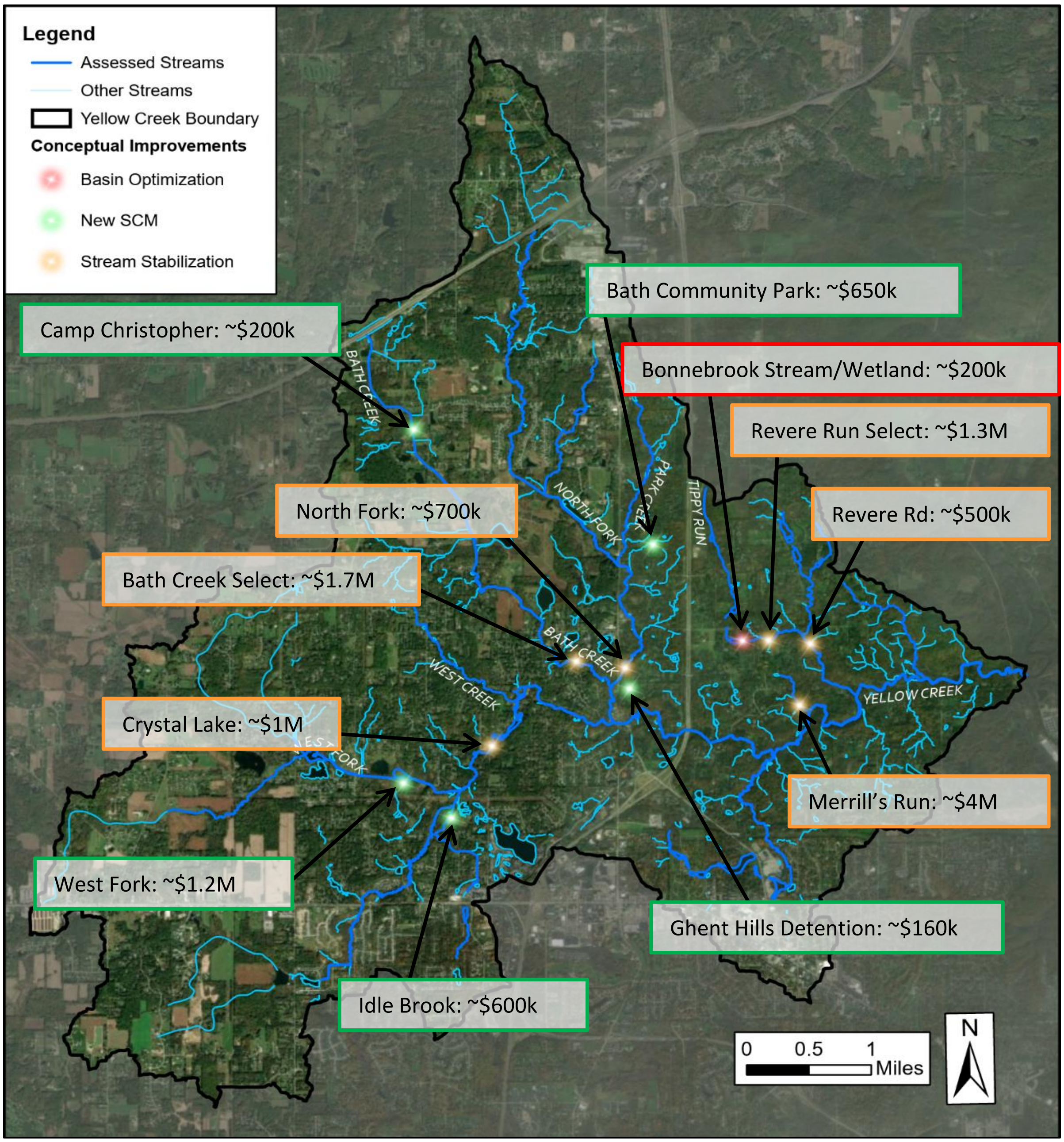

Figure 80: Potentially high-impact projects in the Yellow Creek Watershed

8.1 Stormwater Control Concepts

Bonnebrook Dr Stream/Wetland Complex with Wet Weather Detention

This proposed concept is at an existing private pond that reportedly has overtopping/safety risks and related erosion issues. Provided the owners are agreeable to lowering the pond, the concept could mitigate the chronic safety issue associated with overtopping and potentially be highly beneficial to the immediate receiving stream reaches. With a surface area of ~2.5 acres and an assumed average depth of approximately four to five feet, ~10 to 12 acre-feet of new storage could be created by converting this existing pond into a stream and wetland complex with a large amount of freeboard for wet weather detention. This highly cost-effective concept (~$200k) is located ~1,000 feet upstream of the Revere Run Select Stream Stabilization concept and ~3,350 feet upstream of the Revere Rd Stabilization concept (which have combined budgets of ~$1.8M).

Bath Community Park Bankfull Wetland and Detention

If agreeable to project stakeholders, this ~$650k concept would substantially improve storage at the upstream end of the park using amended swales to intercept undetained runoff from parking lot and a bankfull wetland (to replace a soccer field) to offload erosive flows on a separate tributary. This project is upstream of the North Fork Stream Re-alignment concept, which has ~70-foot banks and active migration. It should be noted that the concept only intercepts ~28 acres of a much larger drainage area to North Fork (located ~1.5 river miles upstream of the ~$700k re-alignment concept).

Camp Christopher Bankfull Wetland

Located in the headwaters of Bath Creek, this ~$200k concept could potentially create up to ~4 acre-feet of new storage. By locating bankfull wetlands in the headwaters, the concept could benefit larger portions of the downstream network than if it were located lower in the watershed. This project is located ~2.9 river miles upstream of the Bath Creek Select Stream Stabilization concept (~$1.7M).

Ghent Hills Detention

This ~$160k concept intercepts approximately nine acres of undetained runoff in an approximately one-acre-foot detention basin immediately upstream of a ravine with extensive erosion. The drainage is already collected and conveyed across Ghent Hills Road via a culvert and swale.

Idle Brook Bankfull Wetland

Located on Idle Brook, this project could create up to ~4 acre-feet of new, highly optimized storage on a public parcel. This ~$600k project is located ~0.9 river miles upstream of the Crystal Lake Stream Re-alignment concept (~$1M). It should be mentioned that the Nester Bankfull Wetland is a similar opportunity to the Idle Brook Bankfull Wetland, although it is not on a public parcel.

West Fork Bankfull Wetland

Located on privately-owned floodplain in West Fork, this project could create up to ~18 acre-feet of new, highly optimized storage in the headwaters of the watershed. This ~$1.2M-concept appears to potentially be the largest opportunity for new storage in the watershed and could potentially create substantial benefits to the downstream network. This project is located ~1.1 river miles upstream of the Crystal Lake Stream Re-alignment concept (~$1M).

8.2 Stream Stabilization Concepts

The four stream stabilization projects that appear to have the biggest opportunities for reducing stream erosion include: Bath Creek Select Stream Stabilization (~$1.7M), Merrill's Run Stabilization (~$4M), North Fork Stream Re-alignment (~$700k), and Revere Run Select Stream Stabilization (~$1.3M). With the exception of Merrill's Run, these stream stabilization projects have SCM opportunities upstream that could potentially complement and/or reduce the need for the stream stabilization investments by reducing erosive flows. Furthermore, the prioritization of the projects included in this list would likely be affected if other factors such as infrastructure protection, public safety aspects, etc. were considered in addition to stream erosion.

9.0 Funding Sources

Current SWMD revenue does not provide the resources to pay for all improvements as envisioned herein, but there are potential funding sources that exist. It is anticipated that the Ohio petition ditch process will be utilized to obtain easements, pay for some portion of the improvement, and establish maintenance revenue. In addition, funding may be available from outside agencies.

The Ditch Petition process defined by the Ohio Revised Code (chapters 6131, 6133 and 6137) establishes a step-by-step procedure for advancing a drainage improvement project. It requires a preliminary engineering report, holding public hearings, obtaining easements for construction and maintenance, calculating assessments and sets an appeals process. The assessment guidelines assure that all benefited properties within the drainage area pay their fair proportion of the cost of construction and maintenance of the proposed drainage improvement. ORC 6133 addresses petition ditches that involve more than one county, which may occur for projects in the Yellow Creek watershed, as it extends into Medina County. The construction cost-share for properties within the SWMD can be reduced by funding provided by the SWMD revenue, loans, and outside sources.

A non-exhaustive list of resources has been included in this section, but it should be stated that funding sources, including those listed, fluctuate as funding is available. Obtaining grant money can be a long process, which often requires extensive efforts on the part of the grant applicants and/or stakeholders. It is important to understand the goals of each grant that is applied for, as well as the priorities of reviewers/grant administrators. A conservation easement is also often required as part of the grant agreement. Additionally, some grant funding sources have a track-record of awarding funds to nonprofits, such as watershed groups or soil and water conservation districts. Developing those partnerships could be in the best interest of getting projects implemented.

There does appear to be an increasing trend in separate funding sources/grant agencies supporting the same programmatic initiatives for watershed-scale restoration. A webinar in March 2019 presented two pilot projects involving cooperation of FEMA and USEPA using "green" solutions, particularly restoring streams to more natural conditions, resulted in both reduction of flood risk and improvements to water quality, making it eligible for funds from both sources (USEPA, 2019b). Such “layering” and “partnering” are becoming more popular.

In addition to the resources in this section, loans and/or bonds could be other alternatives. Finally, public-private partnerships may be another option for financing. For example, Lexington, KY uses a portion of their stormwater revenue to fund a competitive “Incentive Grant Program” (LFUCG, 2019) that requires applicants to fund a portion of each project through alternative funds (e.g. private funds, alternatively sourced grants, etc.).

Section 319(h) Grants – Ohio Environmental Protection Agency (OEPA)

To reduce nonpoint source (NPS) pollution and associated water quality impairments, 319 grants fund projects that restore surface waters impaired by NPS pollution. The strategies that Ohio targets includes urban sediment and nutrient reduction, altered stream and habitat restoration, NPS reduction, and high-quality waters protection. These grants have a three-year duration and require a 40% local match. Historically, applications have been due in March. An NPS-IS Plan, currently underway by Summit SWCD, must be submitted and approved by US EPA and Ohio EPA prior to using this funding option (OEPA, 2019a).

Surface Water Improvement Funds (SWIF) – OEPA

The SWIF awards grants for implementation projects that address NPS and/or stormwater runoff to improve Ohio’s surface waters. Eligible projects include smaller-scale stream restoration, wetland restoration, publicly visible stormwater demonstration projects, riparian restoration, invasive species removal, and public, inland lake management and restoration. Since 2014, applications for funding have not been solicited. In the past, grant amounts have been limited to $150,000 or less, with no local match requirements, to be spent over a two-year timespan (OEPA, 2019b).

Water Resource Restoration Sponsorship Program (WRRSP) – OEPA

Within the Water Pollution Control Loan Fund (WPCLF), the WRRSP is a specialized sponsorship program as opposed to a traditional grant program. Funding is generated by interest on individual WPCLF loans that sponsor WRRSP protection and/or restoration projects that must result in attainment of warmwater habitat or higher aquatic life use (streams) or Ohio Rapid Assessment Method Category 3 status (wetlands). Key stakeholders in the WRRSP program include implementers and sponsors. Most projects have a two-year timeline, with July as the typical month for nominations (OEPA, 2019c).

Clean Ohio Fund – Ohio Public Works Commission (OPWC) and Natural Resources Assistance Commission (NRAC)

This fund is dedicated to conservation of the environment through acquisition of green space and protection and enhancement of river and stream corridors. Funding of projects may include up to 75% of the estimated cost for open space acquisition and/or related development or riparian corridor projects such as reforestation (Ohio Public Works, 2019a). Applications must be received by the NRAC district office, and Summit County is in District 8, and Medina County is in District 9. Project scoring and application due dates are based on each district, but most applications are due in the fall (Ohio Public

Works, 2019b). One requirement of the grant is that the property must be maintained for conservation in perpetuity by the grant recipient.

ODOT National Pollutant Discharge Elimination System (NPDES)

ODOT has a National Pollutant Discharge Elimination System (NPDES) general permit for stormwater associated with construction activity (ODOT, 2019). It may be possible to coordinate with ODOT on select projects, such as the I- I-77 Rest Area Bankfull Wetland, to create much greater water quality benefits to Ohio's natural resources than traditional NPDES strategies on small impervious expansions.

Great Lakes Restoration Initiative (GLRI) – USEPA

This funding source for projects within the Great Lakes Basin covers various focus areas, with the two most likely categories for the Yellow Creek Watershed including green infrastructure to reduce stormwater runoff and water quality trading for phosphorus reduction, based on the 2019 grant categories. Project funding and completion timeframes are dependent on the category, but local match is not required. In 2019, applications were due in July. Shovel-ready projects that implement an approved watershed plan are considered more favorably (USEPA, 2019a).

Pre-Disaster Mitigation Grant Program – Federal Emergency Management Agency (FEMA)

This program funds grants that aim to reduce reliance on Federal funding in future disasters by reducing the overall risk to the population and structures by planning and implementation projects. Specifically, this may include flooding and landslides in the Yellow Creek Watershed. A hazard mitigation plan must be adopted by the jurisdiction(s) and approved by FEMA to be considered (FEMA, 2019). As for performance metrics, a benefit-cost analysis (BCA) is required for projects, with a resultant benefit-cost ratio (BCR) of 1.0 or greater for the project to be eligible. Federal funding may cover up to 75% of eligible costs, and the grant has a 36-month timeframe for completion (Department of Homeland Security, 2019). Summit County would be required to submit an application to the state, who would review and may submit the application to FEMA and would ultimately be responsible to allocate the funds to local jurisdictions. It may be possible to coordinate with the Summit County Emergency Management Agency and/or the Ohio Department of Natural Resources (ODNR) Floodplain Management Program. 2019 applications are accepted September 30, 2019 through January 31, 2020.

Environmental Quality Incentives Program (EQIP) – USDA NRCS

This assistance program helps producers improve conservation on their agricultural land for cleaner air and water, healthier soil, and better wildlife habitat. NRCS works with producers to develop a conservation plan and implement measures on working farms, ranches, and forests. Popular practices for implementation include cover crops, forest stand improvement, prescribed grazing, and irrigation projects. In 2019, specific NRCS landscape conservation initiatives in the project area include the Great Lakes Restoration Initiative and the Monarch Butterfly Effort. The local NRCS office should be contacted for assistance with an application (NRCS, 2019a).

Watershed and Flood Prevention Operations Program – USDA NRCS

This program's focus is to complete watershed projects that prevent erosion, floodwater and sediment damage, further conservation development, and proper use of land. An approved watershed plan must be in place and benefits directly related to agriculture must be at least 20% of the total benefit of the project. NRCS may prepare the designs and specifications for implementation, with project sponsors working with land owners to apply the projects/practices (NRCS, 2019b).

Wetland Reserve Enhancement Partnership (WREP) – US Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS)

This voluntary program, under the Agricultural Conservation Easement Program (ACEP), places easements to protect, restore, and enhance wetlands on partner property. Land eligible for wetland reserve easements includes farmed or converted wetland that can be successfully and cost-effectively restored. Improvements to the wetlands are funding through cost-sharing. Applications for this partnership are accepted at any time of year at the local USDA Service Center (NRCS, 2019c).

Sustain Our Great Lakes Program – National Fish and Wildlife Foundation (NFWF)

This program is a private-public partnership that is designed to address habitat loss and fragmentation, invasive species, and pollution to improve the ecological health of the Great Lakes Basin through habitat restoration and enhancement projects. Funding priorities include aquatic connectivity, riparian and stream habitat, wetlands, and green stormwater infrastructure. Projects should be large in nature (i.e. tens of acres of wetlands, hundreds of feet of stream, and/or hundreds of thousands of gallons of stormwater storage). The typical grant implementation timeframe is two years, and project match should be at least 1:1 to remain competitive (NFWR, 2019b). Grant amounts range from $100,000 to $1,000,000. Initial applications were due in February 2019 (NFWR, 2019a).

Great Lakes Protection Fund (GLPF)

The Fund's mission is to identify, demonstrate and promote regional action to enhance the health of the Great Lakes' ecosystem. The governors of the Great Lakes states created the Fund in 1989 to help them protect and restore their shared natural resource. The Fund is the first private, permanent endowment created to benefit a specific ecosystem (GLPF, 2019). Funding is based on projects with measurable, large-scale benefits, innovative approaches, and scientific rigor. Project concepts are accepted year-round.

Freshwater Future

This organization works at the local community level to ensure a healthy future for waters in the Great Lakes region. They offer several grant opportunities for their members that promote aquatic habitat protection along shorelines, inland lakes, rivers, and wetlands. Members may submit one application each grant cycle and must have a 501 (c)(3) nonprofit fiscal sponsor (Freshwater Future, 2019).

Private Foundations

There are an innumerable number of private foundations that offer financial backing for environmental projects. Local foundations include Akron Community Foundation, GAR Foundation, and Akron-Knight

Foundation. National and international foundations could also be explored, although funding through these organizations is likely highly competitive.

Mitigation Banking

Summit County may create a mitigation bank to mitigate the disturbance of streams and wetlands in other locations in an appropriate service area (potentially the Cuyahoga River Watershed). The County would be able to sell generated credits to local developers after restoring, creating, enhancing, and/or preserving streams or wetlands. This type of funding could have a large return on investment, but requires a large amount of upfront capital if undertaken without partners. Mitigation banks also require permanent conservation easements and typically include a ~7- to 10-year permitting, design, construction, and success monitoring process prior to being able to sell all the mitigation credits. Conservation banks, which offset the loss of endangered species and/or their habitats, may be another option.

10.0 Conclusions

This project serves as a feasibility analysis/planning phase effort for the Yellow Creek Watershed in response to degradation from combinations of natural erosion processes, extreme weather and/or inadequately managed stormwater. A visual assessment of ~41 miles of stream paired with data analysis has culminated in several conceptual projects to improve conditions along reaches in the watershed. Some of the most potentially impactful concepts include flow reduction/offloading concepts such as bankfull wetlands and both new and retrofitted storage that would be optimized to contribute to collective reductions in excess erosion in the stream network. A second major conceptual strategy includes stream stabilization concepts that could mitigate large sediment sources from eroding banks and improve in-stream habitat and water quality among other outcomes. Finally, programmatic strategies could also play a role in educating citizens for grassroots efforts on private properties among other benefits. Prior to potential implementation, additional planning and design of these concepts would be necessary, as well as coordination with private property owners. Given the scale of the potential costs of these concepts, project prioritization and funding will need to be coordinated among stakeholders, along with other components of the SWMD overall program(s). Full-scale implementation may be a multi-year, or even multi-decade process; however, the concepts presented herein could provide a means to collectively contribute to more holistic solutions to the most prevalent and highly prioritized issues observed throughout the watershed.

Glossary

Bed material: The sediment, rocks, and other material on the bed, or bottom, of the stream

Best management practice: See *Stormwater control measure*

Bioengineering: A bank stabilization treatment that includes rock, vegetation, and/or other natural materials for bank protection

Conductivity: A measure of the degree to which electricity is conducted

Culvert: A conveyance structure such as a corrugated metal pipe under a driveway or a concrete box structure under a roadway

d50: The median diameter of the streambed particles. 50% of the streambed particles have a diameter smaller than this size

d84: The streambed particle size where 84% of the streambed particles have a smaller diameter

Detention basin: A type of stormwater control measure that temporarily detains, or holds back, stormwater during a precipitation event, and in some cases, for an extended period of time following the event

Dissolved oxygen: The measure of the amount of oxygen in the water

Downcutting: Erosion downward through a streambed

Flanking: In the context of this report, water bypassing the normal flow path to erode and undermine bank stability

Floodplain: An area adjacent to a river or stream that is relatively low and flat, allowing water to spread out during periods of high flow

Freeboard: The available space between the top of a berm or spillway and the water surface elevation

Gabion: A wire basket filled with rock used to stabilize a bank or hillslope

Geotechnical: Of or relating to earth materials—in the context of this report, often related to the stability of earthen slopes or tall banks (see *Mass wasting*)

Grade control: In the context of this report, an engineered stream structure such as a constructed riffle or a buried vane of boulders that is intended to “hold the grade,” or elevation, of the streambed and provide resistance against future downcutting

Habitat: In the context of this report, the aquatic environment and related quality of that environment for the bugs and fish that live there

Headcut: A short section of stream that has an overly steepened slope relative to the rest of the streambed (e.g. a “mini waterfall”) that can be a sign of channel downcutting

Headwaters: Upstream, or higher, portions of a creek or stream that feed the main channel

Hydrogeomorphic: In the context of this report, relating to how flowing water shapes the earth's surface via erosion processes, and, more specifically for this report, relating to the associated data such as the channel geometry and size of the bed material that is relevant for mobilization of a stream's bed material

Hydrograph: The graphical representation of the rate of flow (discharge) over time for a stream or SCM

Hydrologic soil group: A classification which identifies the soil's potential for stormwater runoff based on infiltration capacity, determined by NRCS

Hydrology: The study of the movement of water on the Earth

Infiltration: Permeation of a liquid into another media (in this report, this refers to water permeating into the ground)

Knickpoint: Stream locations with sharp changes in slope such as a waterfall or cascade, often associated with an exposed seam of bedrock

LiDAR (Light detection and ranging): A method for collecting ground elevation from the air, somewhat similar to radar

Live stake: A dormant tree or shrub cutting that can be installed in a streambank to establish new trees/shrubs that can increase the root strength in a bank among other ecosystem/aesthetic benefits

Mass wasting: A geomorphic process which moves earth downslope based on gravity

Plane bed: A stream setting with relatively uniform bed material and a featureless/homogeneous habitat

$Q_{critical}$: The critical discharge for mobilization (erosion) of a majority of a stream's surficial bed material at a given location

Retention Basin: A type of stormwater control measure that permanently retains enough water to create a permanent pool/pond, and temporarily detains additional stormwater during a precipitation events

Retrofit: A modification made after a facility's initial construction (in this report, this refers to changes to a detention basin or other SCM)

Riffles: A rocky, shallow part of a stream with more rapid flow

Riparian: Of or relating to the banks of a stream or river and the land immediately adjacent to the banks (often used in conjunction with *Floodplain*)

Scour hole (or scour pool): The result of concentrated erosion that causes the bed of a stream to downcut in a localized way (often found downstream of a culvert outfall or bridge where the energy of high flows might be concentrated) to carve out a section of stream that is deeper than the adjacent reaches

Seasonal channel: A ravine or channel that receives flow only during (and immediately following) precipitation events

Spillway: A defined passageway for impounded water to "spill over" a dam or the berm of a detention basin

Step-pool: A natural feature that can occur in steep stream settings with a series of elevation changes that somewhat resembles the shape of a staircase (i.e. a steep drop followed by a short pool, followed by another steep drop, etc.)

Stormwater control measure (SCM): A method and/or material that manages stormwater runoff such as a detention basin

Substrate: See *Bed material*

Synthesize: To combine several items together through comparison, analysis, and correlation

Trajectory: In the context of this report, the future progression of a stream. Often related to the Channel Evolution Model (see Figure 10)

Turbidity: Cloudiness, or opaqueness in the water

Two-year flow (or 2-year flow): The volumetric discharge (e.g. cubic feet per second) that occurs with an average recurrence interval equivalent to once every two years. It has a 50% chance of occurring every year. This same definition can be applied to other recurrence intervals (e.g. the 10-year discharge has a one in ten (10%) probability of occurring in any given year, the 25-year discharge has a one in twenty five (4%) chance of occurring in any given year, the 100-year discharge has a one in one hundred (1%) chance of occurring in any given year, etc.). It is important to note that the conventional methods for estimating the magnitude of such recurrence events are based on the discharges that have been observed in the past, making them dependent on the record length in a given region. In many cases, recurrence interval flows have not yet been updated to account for the recently observed increases in more extreme weather events.

Wetlands: This term is typically used in the broader sense of a marshy or boggy area with at least seasonally saturated soils. The uses of the term within this report, such as “bankfull wetland,” do not necessarily imply the legal definition of a wetland (i.e. land that has hydric soils, wetland vegetation, and wetland hydrology).

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