2024

Southern Sarpy Watershed Management Plan

Executive Summary

E-1 INTRODUCTION

The Southern Sarpy Watersheds Partnership (SSWP or Partnership) was formed in November 2016 as development pressure encroached near the topographic ridgeline that separates the Papillion Creek watershed from the drainage area that flows towards the Platte River in Sarpy County, NE. The Partnership includes the communities of Bellevue, Gretna, Papillion, Springfield, Sarpy County, and the Papio-Missouri River Natural Resources District (Papio NRD) and was formed with an Interlocal Cooperative Act Agreement (Interlocal Agreement). The Southern Sarpy watershed, shown in Figure E.1, includes almost 80 mi² of predominantly agricultural land along with the urban communities of Bellevue, Gretna, Papillion, and Springfield. The primary goal of the SSWP is to grow responsibly within the watershed as it pertains to stormwater management.

The SSWP chose to develop a Watershed Management Plan (Plan) for the Southern Sarpy watershed to protect natural resources and local infrastructure from the changes in stormwater dynamics due to development. Final plan components include clearly defined projects and policies to be enforced within the Watershed Management Area. The Interlocal Agreement included interim policies to enforce while the Plan was under development. The study area for the baseline assessments and alternatives analysis during the development of the Plan included three subbasins (Buffalo Creek, Springfield Creek, and Zwiebel Creek watersheds) as shown in Figure E.1.

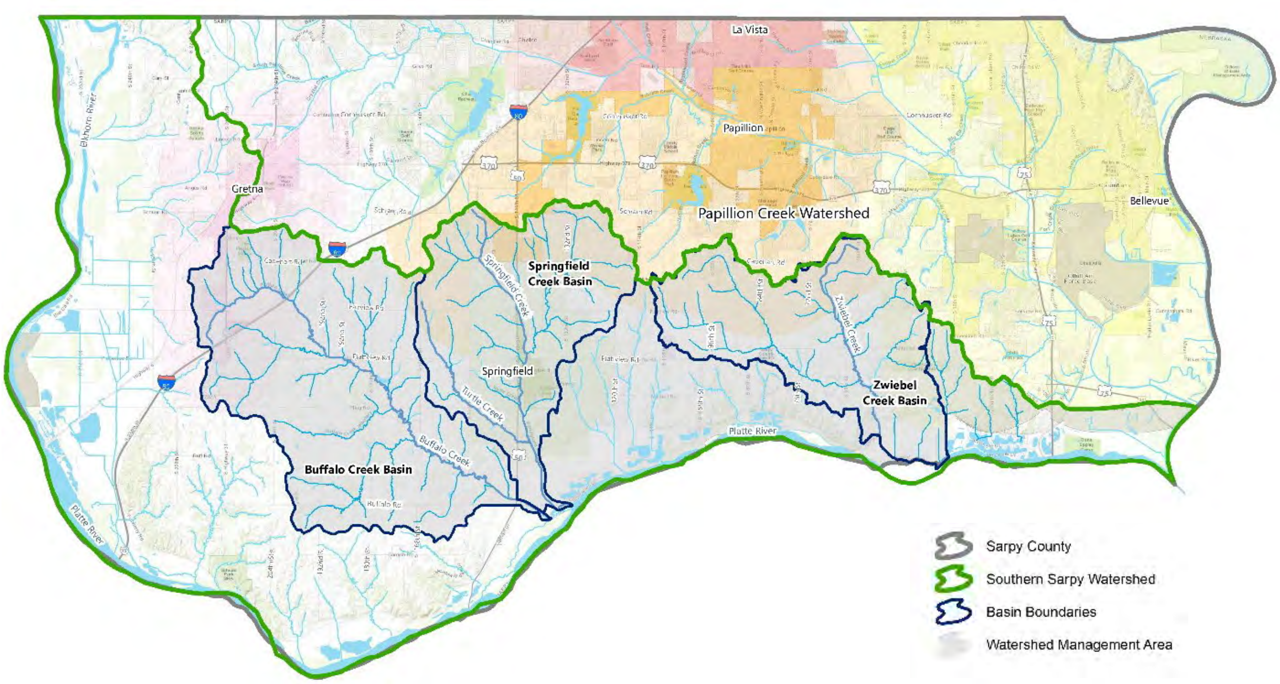


Figure E.1. Southern Sarpy Watersheds

E-2 BASELINE ASSESSMENTS

Baseline data collection and assessments were performed to inform the development or modification of policies and the development of potential projects. These included:

- Watershed Inventory
- Hydrology
- Hydraulics
- Water Quality
- Environmental Resources
- Stream Assessments

Watershed Inventory

Existing data applicable to the Plan and study area was collected, compiled, and analyzed. Information relating to topography, infrastructure, land data, environmentally important resources, and others were collected to create a database that was used for baseline assessments.

Hydrology and Hydraulics

Hydrology and stream channel hydraulics were modeled for existing and future conditions to provide an understanding of the stormwater impacts from development. Increases in impervious area and reductions in travel time create an increase in peak discharge and volume represented by the post-development hydrograph in Figure E.2. The associated increase in velocity and shear stress in the channel impacts stream conditions and can cause accelerated and increased stream degradation. The effects on the future floodplain and stream stability (i.e. future stream degradation) were investigated with the baseline assessments to provide information to guide the alternatives assessed to prevent negative impacts.

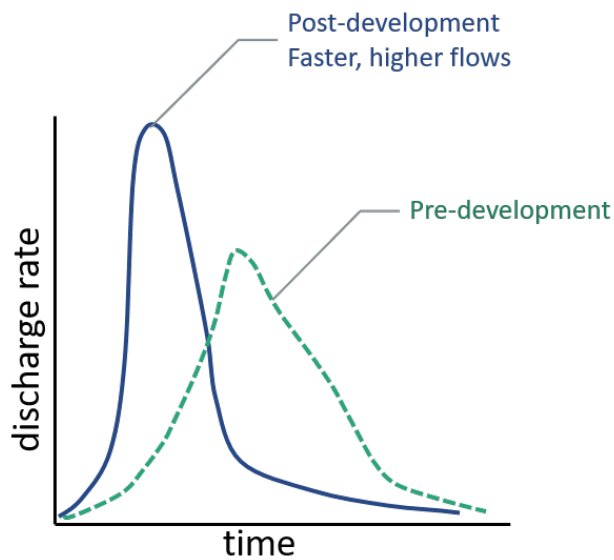


Figure E.2. Example Hydrographs

Water Quality

Water quality from a policy standpoint is described in terms of the biological, physical, and chemical characteristics of a waterbody measured against numerical benchmarks. These benchmarks are established with statewide standards based on the designated use of each waterbody. The standards and designated use for the waterbodies located within the Southern Sarpy watershed and their current water quality status documented in the Plan indicate there are currently water quality impairments in the watershed. Impact concerns from future development and the effectiveness of the interim polices to protect and improve water quality were investigated during the development of the Plan.

Environmental Resources and Stream Assessments

Environmental resources and regulations influence the development of policies and projects and helped guide decisions throughout the Plan development process. Sensitive resources to be avoided or protected and federal/local agency requirements impact the feasibility of alternatives from an environmental permitting perspective. Regulation reviews paired with an inventory of resources in the watershed helped provide information to understand permitting requirements and identify potential hurdles. Stream asset inventories and rapid field assessments were performed to collect data and inform stability assessments. Soil erosivity characteristics and stream bed slopes were investigated. Pairing a channel evolution model determination with the stream stability ratings, the stream assessments provide detailed maps that represent the conditions of streams in the watershed. A stable slope analysis was also performed to predict future stream grades and assess the future degradation potential of watershed streams. An example of the future stream profile prediction is shown in Figure E.3.

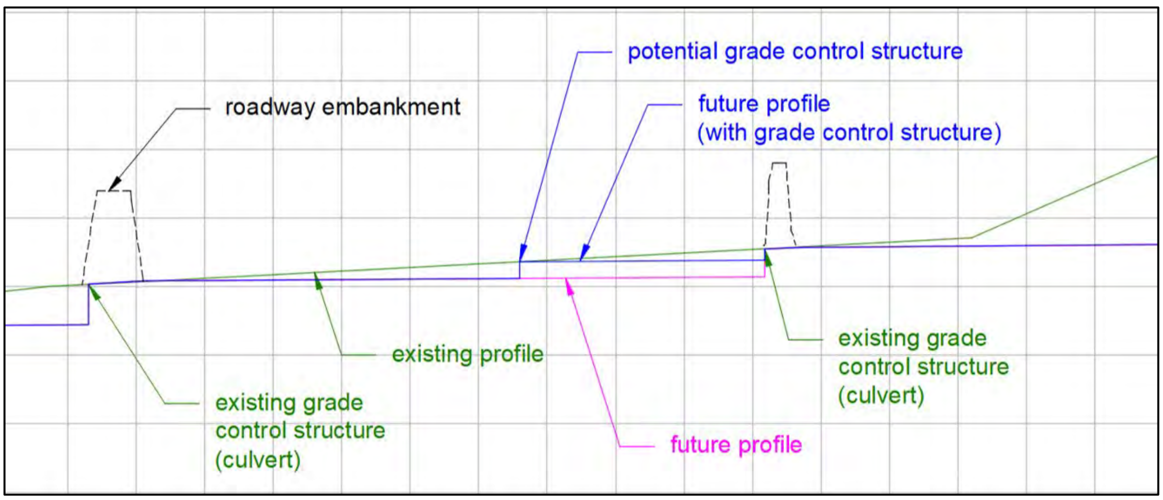


Figure E.3. Example Future Stream Profile Predictions

E-3 WATERSHED MANAGEMENT PLAN

The Plan includes actionable items that protect natural resources and local infrastructure from the changes in stormwater dynamics due to development. These include projects and policies that are clearly defined and documented to ensure consistency and compliance as the watershed develops. To develop the final recommendations, a review of the interim policies was performed to determine if Partnership goals were being met and to identify any stakeholder concerns with any specific policy. For interim policies deemed potentially insufficient or where concerns were identified, an alternatives analysis was performed to assess additional options for projects and/or policies that would satisfy the Partnership's interests and address stakeholder concerns.

Through a series of iterations, the Partnership proposed modifications to the policy language to create a more simplified document that focuses on the important, actionable items each policy aims to achieve. The Partnership and stakeholders identified concerns that could not be addressed with changes in language with the Peak Flow Management (formerly Peak Flow Reduction) and Stream Corridor Preservation (formerly Landscape Preservation, Restoration, and Conservation) policies. These policy groups were advanced into a more detailed alternatives analysis to identify and assess potential policies and projects to address the identified concerns.

The alternatives analysis for the Peak Flow Management policy group assessed methods to accomplish the goals of both floodplain management and stream protection by preventing increases in peak discharge. Controls to prevent increases can be implemented within individual developments (on-site controls) or on a regional scale. The alternatives analysis compared the resource requirements of various structural methods to achieve no-net increases in peak flows. These included on-site detention basins as well as regional detention basins and linear corridor storage sites. The locations of on-site detention structures are determined with development and feasible locations for regional detention and linear corridor storage sites were identified and modeled. The alternatives analysis concluded that regional controls for preventing increases in floodplain area would not be recommended as the structures require more land than the no action alternative (allowing for an increase in the 100-year floodplain area). The Peak Flow Management policy will instead focus on stream protection against more frequent, high velocity events that are the main driver of stream erosion. The policy shall require on-site controls that maintain the peak flow discharge rate for the 2- and 10-yr storm events.

The goal of the Stream Corridor Preservation policy group is to define a stream setback that will provide sufficient protection of public infrastructure and private property from stream erosion. The interim policy setback did not account for future degradation. Setback distances from the stream are calculated as a function of existing bank height, and a stream that degrades in the future (resulting in increased bank height) will not maintain the original setback distance when established using the interim policy. The Partnership was interested in pursuing alternatives to prevent or minimize future degradation rather than modifying the policy to account for future degradation when defining setbacks. Preventing substantial future degradation can be achieved with in-stream grade control structures. The Partnership agreed that grade control structures should be implemented and placed at locations that allow no more than four feet of streambed degradation. The Stream Corridor Preservation policy requires developers to be responsible for incorporating grade control structures into plats and installing the structures at the time of development. Special circumstances may require grade controls to be Partnership led and will be identified with each five-year implementation plan.

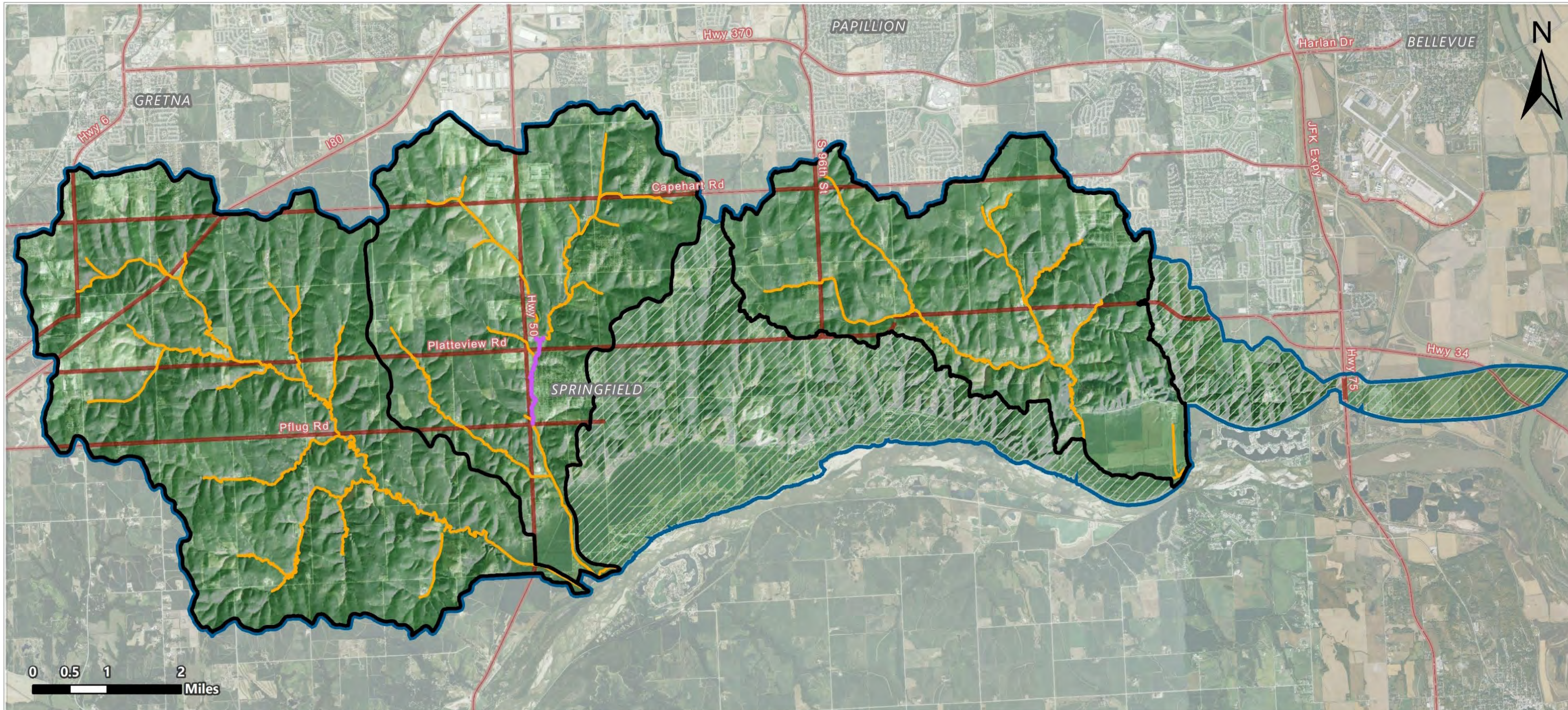
Coordination with the Partnership, stakeholder engagement, and assessing the financial feasibility of alternatives led to the following recommendations within the Plan.

Projects

The Plan recommends grade controls structures on all streams with a drainage area greater than 0.5 mi^2 as well as a specialized channel stabilization project through the City of Springfield, as shown in Figure E.3. The Partnership will lead the implementation of the Springfield channel stabilization project and grade control structures on any stream segment that was platted prior to adoption of this Plan. The remaining stream project segments shall have grade controls implemented by the developer.

Policies

Key points of the final policies are summarized in Table E.1 and the full policy document is included in Appendix I.



Watershed Boundaries

Watershed Management Area [a]

Major Roads

City of Springfield Channel Stabilization Project [b]

Stream Project Segments [c]

Future Planned Study Areas

KEY WATERSHED MANAGEMENT POLICIES

1) 2- and 10-year peak discharge maintained by new development

2) Green space corridors of 3:1 + 50' maintained along all watercourses (not mapped)

3) Grade control structures installed in all streams with a drainage area greater than 0.5 mi^2 as mapped by the Stream Project Segments.

WATERSHED MANAGEMENT COSTS: $70 Million (in 2022 Dollars)

NOTES

[a] The Watershed Management Area is the area subject to the plans and policies defined in the Watershed Plan.

[b] A proposed grade and bank stabilization project by the Partnership.

[c] 65 miles of stream were identified based on having a drainage area greater than 0.5 mi^2. Grade stabilization projects designed to prevent more than 4 ft of degradation will be constructed or funded by the SSWP in these streams.

Figure E.4. Watershed Management Plan

Table E.1. Final SSWP Policies

Policy Group	SSWP Policy Requirements
1. Water Quality Improvement	Retain first ½" of runoff and maintain peak flow rate from 2-year storm.
2. Peak Flow Management*	Maintain or reduce the 2- and 10-year storms peak discharge rates on all developments.
3. Stream Corridor Preservation*	Dedicate a stream setback (3:1 plus 50 ft.) along all streams. The outer 30 ft of the setback area may be used for passive recreation and the outer 15' may overlap with utility easements, subject to local jurisdiction approval. Construction of grade control structures is required in all streams with a drainage area greater than 0.5 mi^2.
4. Erosion & Sediment Control and BMPs	Comply with state and federal regulatory requirements, including the adoption of the Omaha Regional Stormwater Design Manual.
5. Floodplain Management	25% floodway fringe fill limitation unless approved mitigation measures are implemented. Where no FEMA flood area defined, must provide buildout base flood delineations.
6. Stormwater Management Financing	A Watershed Management Fee system shall be established to equitably distribute the capital cost of implementing the Plan. Grade control structure construction cost to be reimbursed by the Partnership.

**Policy Group name revised from interim policies included in the Interlocal Agreement*

E-4 FIVE-YEAR IMPLMENTATION PLAN

Planned projects for the first five-year implementation period are those located within urban development zones slated for development by the Sarpy County and Cities Wastewater Agency (SCCWWA) (where sanitary sewer will first be installed) as shown in Figure E.5. Approximately 10 miles of stream segments for grade control projects and one site-specific project at Capehart Rd west of Highway 50 are identified as the first projects for implementation. The estimated costs of these projects are approximately $9 million (in 2022 dollars). The projected watershed fees to be collected within the first five-years are based on the rates reported in Table E.2 and are estimated at approximately $23 million. This indicates funds should be sufficient to complete the planned projects within the first five-year implementation period at a rate that is not prohibited by available funding.

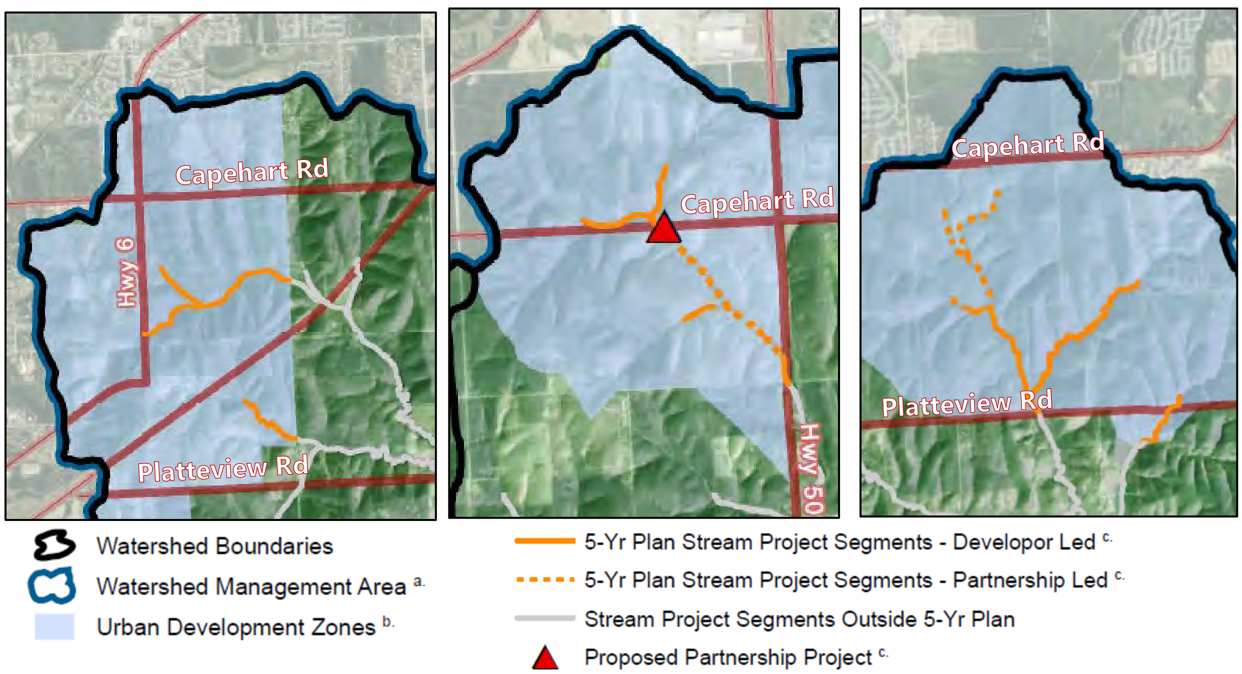


Figure E.5. Five-Year Projects in Buffalo (left), Springfield (middle), and Zwiebel (right) Creek Basins

Table E.2. Watershed Fee Schedule from Interlocal Agreement

Fee Category	FY 2025 July 1, 2024-June 30, 2025	FY 2026 July 1, 2025-June 30, 2026	FY 2027 July 1, 2026-June 30, 2027	FY 2028 July 1, 2027 June 30, 2028	FY 2029 July 1, 2028 June 30, 2029
Single Family Residential per dwelling unit (also includes low-density multi-family up to 4-plexes)	$1,058	$1,090	$1,122	$1,156	$1,191
High-Density Multi-Family Residential per gross acre (beyond 4-plexes)	$4,656	$4,795	$4,939	$5,087	$5,240
Commercial/Industrial/Institutional per gross acre	$5,642	$5,812	$5,986	$6,166	$6,351

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List of Acronyms and Abbreviations

CEM	channel evolution model
cfs	cubic feet per second
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
HMS	HEC-HMS 4.2.1
IR	Water Quality Integration Report
MAPA	Metropolitan Area Planning Agency
mi^2	square mile
MS4	Municipal Separate Storm Sewer System
NDEE	Nebraska Department of Environment and Energy
NDNR	Nebraska Department of Natural Resources
NEH	National Engineering Handbook
NGPC	Nebraska Game and Parks Commission
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
Partnership or SSWP	Southern Sarpy Watershed Partnership
Plan	Southern Sarpy Watershed Management Plan
Papio NRD	Papio-Missouri River NRD
SAI	Stream Asset Inventory
Southern Sarpy Watershed	watershed
SSWP or Partnership	Southern Sarpy Watershed Partnership
SWMP	Stormwater Management Plan
SWPPP	Stormwater Pollution Prevention Plan
TMDL	total maximum daily load
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WQMP	Water Quality Management Plan
WQS	water quality standards

I.0 INTRODUCTION

1.1 The Partnership

The Sarpy Southern Ridge Wastewater Treatment Study (2015-2016) identified potential development in southern Sarpy County which indicated a need to the communities within southern Sarpy County to proactively address impending stormwater concerns. In February 2016, these communities met to discuss the stormwater management needs that would arise from the development of the watershed. The Southern Sarpy Watersheds Partnership (SSWP or Partnership) was officially formed in November 2016. The Partnership includes the communities of Bellevue, Gretna, Papillion, Springfield, Sarpy County, and the Papio-Missouri River Natural Resources District (Papio NRD). These six entities recognize that interaction with other resource and planning agencies is crucial, but the Partnership members are limited to the six entities in the study area with planning responsibilities and taxing authority. The SSWP was formed with an Interlocal Cooperative Act Agreement.

1.2 The Plan

The SSWP chose to develop a Watershed Management Plan (Plan) for the Southern Sarpy watershed (watershed), defined in Figure 1.1 to protect natural resources and local infrastructure from the changes in stormwater dynamics due to development. Plan components will include clearly defined projects and policies to be enforced within the Watershed Management Area. In February of 2017 the Partnership contracted with FYRA Engineering (now Houston Engineering) and Vireo (and added Confluence as a subconsultant in 2020) to conduct the necessary technical work and facilitate public involvement efforts to prepare the Plan.

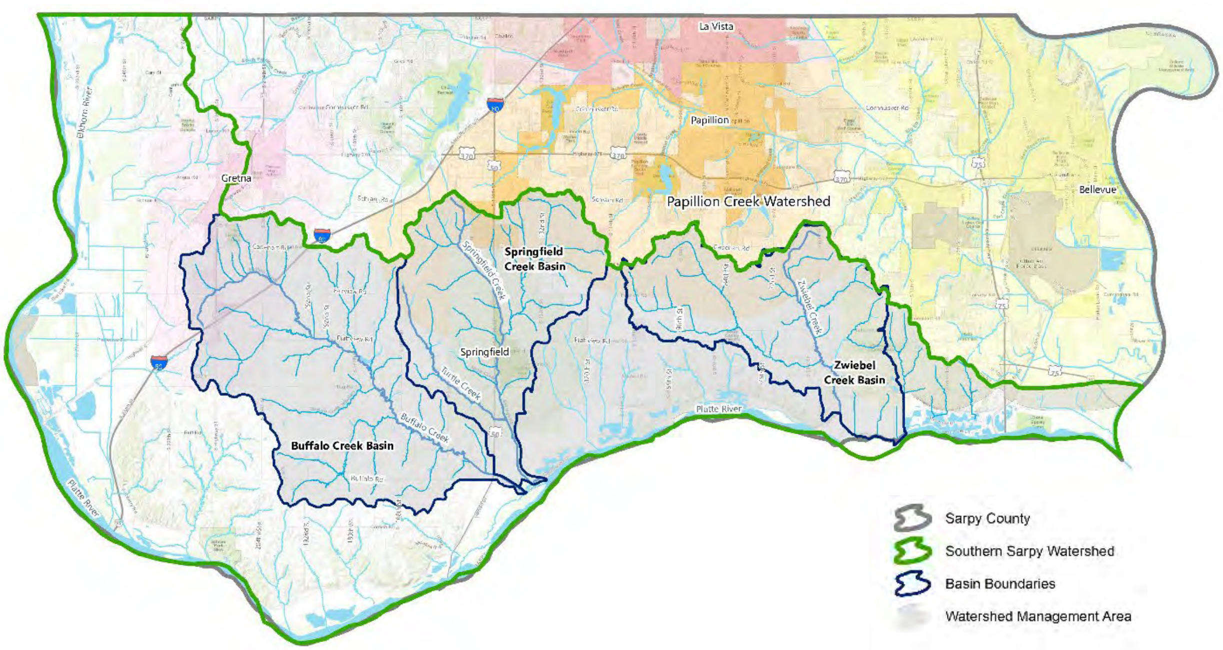


Figure 1.1. Southern Sarpy Watersheds

1.3 Goals and Objectives

The overarching goal for the Partnership is to grow responsibly within the watershed as it pertains to stormwater management. The Partnership views responsible growth as balancing the communities' desires to promote growth with ensuring the area's natural resources are protected. Responsible growth as it pertains to development-induced changes in stormwater dynamics and land use will be the focus of the Plan. Specific goals of the Partnership established in the Interlocal Agreement are listed in Figure 1.2. Developing final recommendations for policies and projects that achieve these goals is the primary objective for the Plan.

- **Water quality improvements**
- **Compliance with existing regulations**
- **Protection and restoration of streams**
- **Standardization of construction process**
- **Assessment of the watershed**
- **Environmental compliance**
- **Sediment and erosion control**
- **Floodplain management**

Figure 1.2. Interlocal Agreement Goals

1.4 Planning Approach

During the development of the Interlocal Agreement, six key policy groups were included that will be used to define requirements necessary to meet project goals. These policy groups are the same as those previously developed for the adjacent Papillion Creek Watershed Partnership (PCWP) where several Partners are also members. These groups reflect the specific goals identified by the Partnership and were based on local knowledge, experience, and anticipated potential outcomes of the watershed assessment. The definitions originally developed by the PCWP were slightly modified to make them specific to the Southern Sarpy watershed and are provided below.

1. Water Quality Improvement: Improve water quality from all contributing sources, including but not limited to, agricultural activities and urban stormwater, such that waters of the Southern Sarpy Watershed and other local watersheds can meet applicable water quality standards and community-based goals, where feasible.
2. Peak Flow Reduction: Maintain or reduce stormwater peak discharge during development and after full build-out land use conditions to that which existed under baseline land use conditions.
3. Landscape Preservation, Restoration, and Conservation: Utilize landscape preservation, restoration, and conservation techniques to meet the multi-purpose objectives of enhanced aesthetics, quality of life, recreational and educational opportunities, pollutant reduction, and overall stormwater management.
4. Erosion and Sediment Control and BMPs: Promote uniform erosion and sediment control measures by implementing consistent rules for regulatory compliance pursuant to State and Federal requirements, including the adoption of the Omaha Regional Stormwater Design Manual.
5. Floodplain Management: Participate in the FEMA National Flood Insurance Program, update FEMA floodplain mapping throughout the Southern Sarpy Watershed and enforce floodplain regulations.
6. Stormwater Management Financing: Dedicated, sustainable funding mechanisms shall be developed and implemented to meet capital and operation and maintenance obligations needed

to implement NPDES Stormwater Management Plans, Stormwater Management Policies, and the Southern Sarpy County Watershed Management Plan.

The Partnership developed interim policy requirements to be in effect for new developments that occurred as the final Plan was developed. These are included in Table 1.1.

Table 1.1. Interim SSWP Policy Requirements

Policy Group	SSWP Interim Policy Requirements
1. Water Quality Improvement	Retain LID Storm (Control first ½" of runoff; maintain peak flow from 2-year storm)
2. Peak Flow Reduction	Maintain or reduce 2, 10, and 100-year storms peak flows on all developments
3. Landscape Preservation, Restoration, & Conservation	Dedicate a stream setback (3:1 plus 50 ft) along all streams
4. Erosion & Sediment Control and BMPs	Comply with state and federal regulatory requirements
5. Floodplain Management	25 percent floodway fringe fill limitation in Springfield, Buffalo and Zwiebel Creek Basins Where no FEMA flood area defined, must provide base flood delineation
6. Stormwater Management Financing	A Watershed Management Fee system shall be established to equitably distribute the capital cost of implementing the Plan

The Plan focuses on hydrology, hydraulics, stream stability, water quality, and environmental resources to assess existing conditions. These assessments provide the baseline information used to inform the development or modification of interim policies and the development of potential projects to fulfill the intent of six policy groups.

1.5 Watershed Opportunities

The Southern Sarpy watershed presents unique opportunities due to both the natural conditions of the area and existing development. The Partnership has taken the steps to develop a Plan *before* widespread development occurs whereas, frequently, watersheds urbanize and then a Plan is implemented post-development. This watershed is also developing from upstream to downstream in terms of average elevation of the planned direction of growth. Development generally occurs downstream to upstream and therefore this Plan must consider how this difference affects stormwater management the same way the challenges of designing and financing a sanitary sewer collection and treatment are being brought to light.

2.0 WATERSHED OVERVIEW

The Southern Sarpy watershed includes almost 80 mi² that drains to the Platte River (Figure 1.1). Immediately north of the watershed is the Papillion Creek watershed. The Southern Sarpy watershed has been divided into three main drainage basins: Buffalo Creek (25.8 mi²), Springfield Creek (17.8 mi²), and Zwiebel Creek (15.6 mi²). The land use within the watershed is predominantly agriculture with urban communities of Bellevue, Gretna, Papillion, and Springfield. The Plan focuses on the Buffalo Creek, Springfield Creek, and Zwiebel Creek basins as the study area for the analyses because these three basins are the areas targeted first for growth. The existing conditions analysis is the one exception to this as it also includes all direct Platte River tributaries between the Springfield and Zwiebel Creek basins (Figure 2.1).

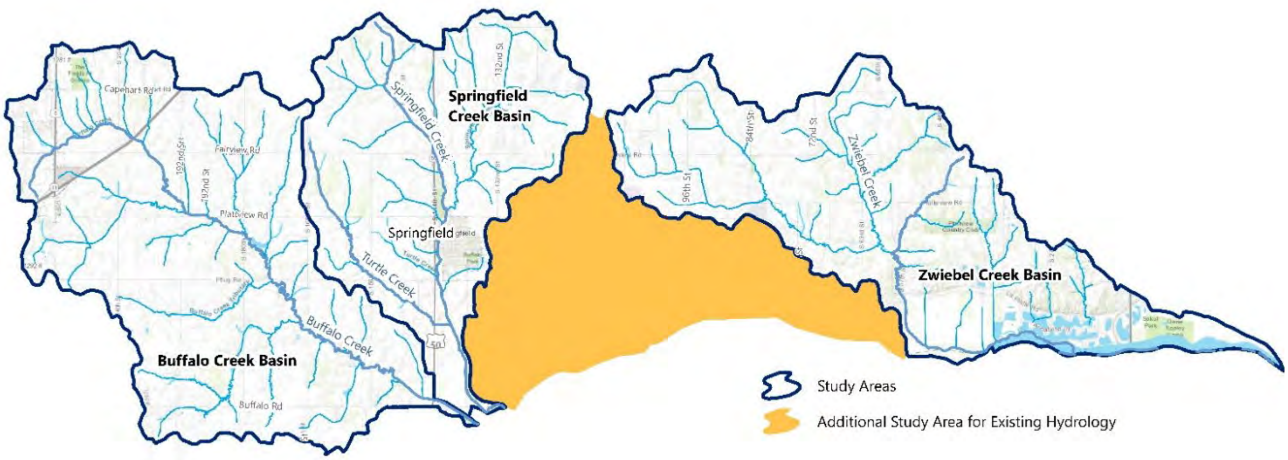


Figure 2.1. Study Area

2.1 Watershed Inventory

Existing data applicable to the Plan and study area was collected, compiled, and analyzed. Information relating to topography, infrastructure, land data, environmentally important resources, and others were collected to retain an existing database and to use during the development of the Plan. A list of collected data is included below and digital files are included in Appendix K.

- LiDAR
- Existing and future land use
- Soil types and properties
- Existing grade stabilization structures
- Existing bridge and culvert data
- TMDLs
- 303(d) streams
- FEMA floodplain
- NDNR Dam Inventory
- National Wetland Inventory
- Zoning
- Existing surface and groundwater rights as of 2021
- Threatened and Endangered Species
- Sarpy Wastewater Treatment Study Data
- Proposed Platteview Road Corridor
- USGS Stream Inventory
- National Hydrography Dataset
- MAPA Long Range Transportation Plan
- Sarpy County Comprehensive Plan
- Existing Utilities and other Infrastructure
- Sarpy County aerials
- Existing stream setback policies and ordinances around the country
- Lower Platte River Corridor Alliance data
    - Cumulative Impact Study
    - Environmental Suitability Analysis
    - Recreation Master Plan
    - Water Quality Management Plan

In addition to the desktop survey, a physical topographic survey of select bridges and culverts was conducted. These included structures accessible from public right of way and on the main channels Buffalo, Springfield, Turtle, and Zwiebel Creek. Survey information, including locations, is included in Appendix K. Land use data used for estimating acres of future development and population increases are presented in Figures 2.2 and 2.3.

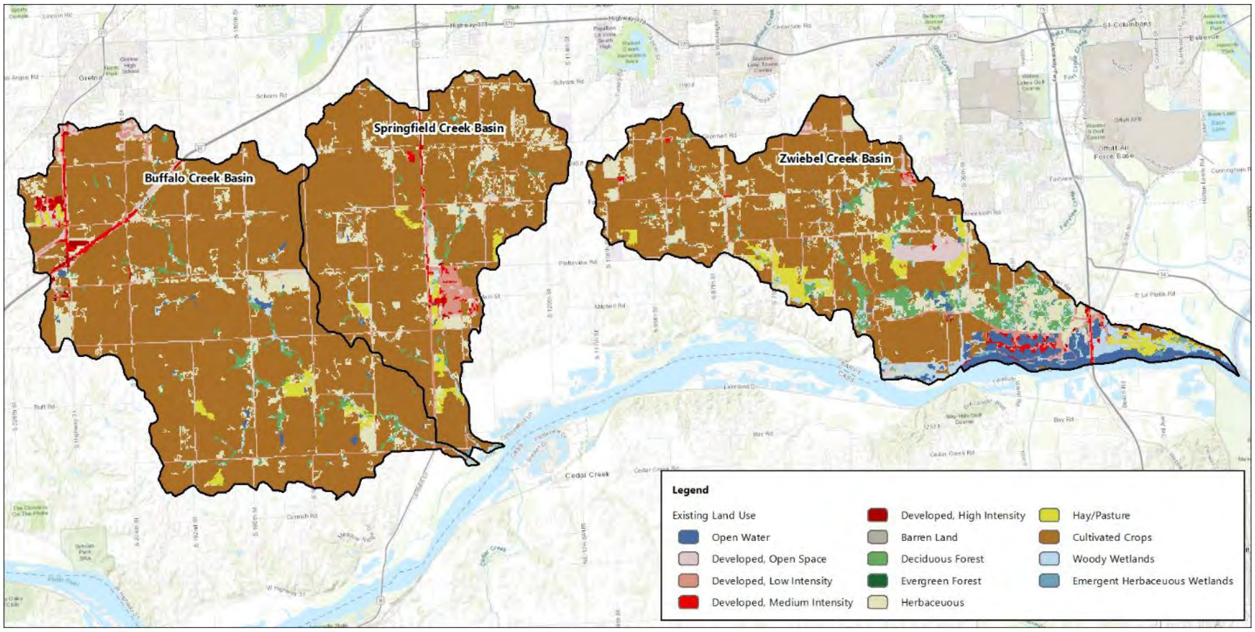


Figure 2.2. Existing Land Use

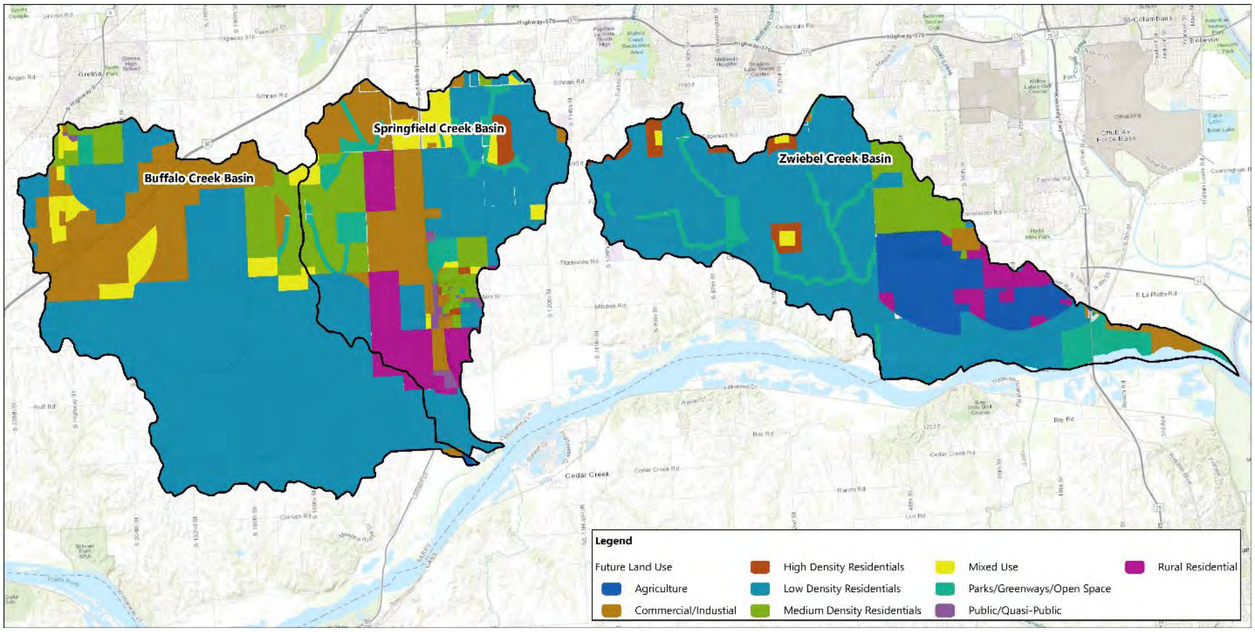


Figure 2.3. Future Land Use

The soils within the watershed predominantly exhibit a thick loess cap that is made up of over 60 percent silt and the topography includes steep grades with rolling peaks and valleys. These conditions induce rapid channel degradation and widening, as described more thoroughly in Section 7 and Appendix D. Watershed soils are shown in Figure 2.4 and in Table 2.1.

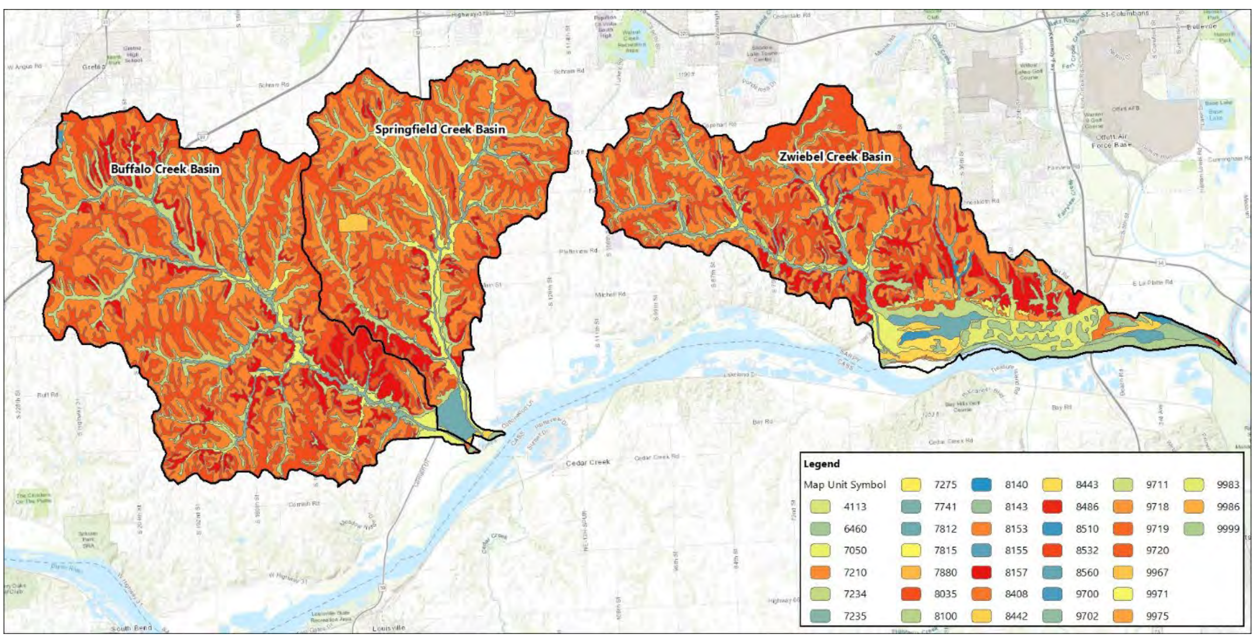


Figure 2.4. Watershed Soils

Table 2.1. Watershed Soils

Map Unit Symbol	Map Unit Name	Acres
4113	Hedville, Sogn, and Contrary soils, 12 to 75 percent slopes	84
6460	Inglewood-Novina complex, occasionally flooded	220
7050	Kennebec silt loam, occasionally flooded	1,170
7210	Burchard-Contrary-Steinauer complex, 7 to 16 percent slopes	73
7234	Judson silty clay loam, 2 to 6 percent slopes	3,923
7235	Judson-Nodaway channeled-Contrary complex, 3 to 10 percent slopes	1,150
7275	Dickinson-Monona complex, 6 to 20 percent slopes	42
7741	Haynie silt loam, 0 to 2 percent slopes, occasionally flooded	32
7812	Smithland-Kenridge silty clay loams, occasionally flooded	407
7815	Ticonic-Sarpy-Carr complex, occasionally flooded	7
7880	Onawa silty clay, occasionally flooded	2
8035	Marshall-Contrary silty clay loams, 2 to 7 percent slopes	10,169
8100	Monona-Pohocco-Ida silt loams, 17 to 33 percent slopes	299
8140	Pohocco-Judson silt loams, 11 to 40 percent slopes	34
8143	Pohocco-Monona silt loams, 11 to 54 percent slopes	7
8153	Contrary-Marshall silty clay loams, 6 to 11 percent slopes	17,121
8155	Contrary-Monona silty clay loams, 6 to 11 percent slopes	1
8157	Contrary-Monona-Ida complex, 6 to 17 percent slopes	3,634
8408	Alda-Platte complex, occasionally flooded	92
8442	Cass-Novina complex, occasionally flooded	218
8443	Cass-Wann fine sandy loams, occasionally flooded	137
8486	Gibbon loamy sand, overwash, 0 to 2 percent slopes, occasionally flooded	10
8510	Lex-Platte complex, occasionally flooded	68
8532	Novina-Gibbon complex, occasionally flooded	1
8560	Platte and Alda soils, frequently flooded	67
9700	Udarents-Urban land complex, 1 to 14 percent slopes	10
9702	Udarents-Urban land complex, summit, 0 to 8 percent slopes	12
9711	Urban land-Udarents complex, 0 to 16 percent slopes	1
9718	Urban land-Udorthents-Judson complex, 0 to 11 percent slopes	3
9719	Urban land-Udorthents-Marshall complex, 0 to 9 percent slopes	162
9720	Urban land-Udorthents-Pohocco complex, 0 to 16 percent slopes	38
9967	Sanitary landfill	83
9971	Arents, earthen dam	12
9975	Mine or quarry	126
9983	Gravel pit	451
9986	Miscellaneous water, sewage lagoon	3
9999	Water	657

3.0 HYDROLOGIC MODELING

3.1 Introduction

Hydrology is the study of the occurrence, distribution, movement and properties of water and its relationship with the environment as it travels through the hydrologic cycle pathways. The hydrologic cycle describes the process where water from earth's surface is cycled through air, earth, and water bodies. This information contained below is a broad overview of the hydrologic analysis. For an in-depth analysis, please refer to Appendix A.

Previously developed hydrologic models for the watershed are either very coarse or non-existent and therefore new model development was required. Baseline hydrologic models using the US Army Corps of Engineers (USACE) HEC HMS 4.2.1 modeling software (HMS) were developed to assess changes in runoff peaks and volumes at a planning level. Existing conditions models were created for the Buffalo, Springfield, and Zwiebel Creek basins as well as the direct Platte River tributaries between the Springfield and Zwiebel Creek basins as shown in Figure 3.1. Future conditions hydrologic models were developed for the three major drainage basins.

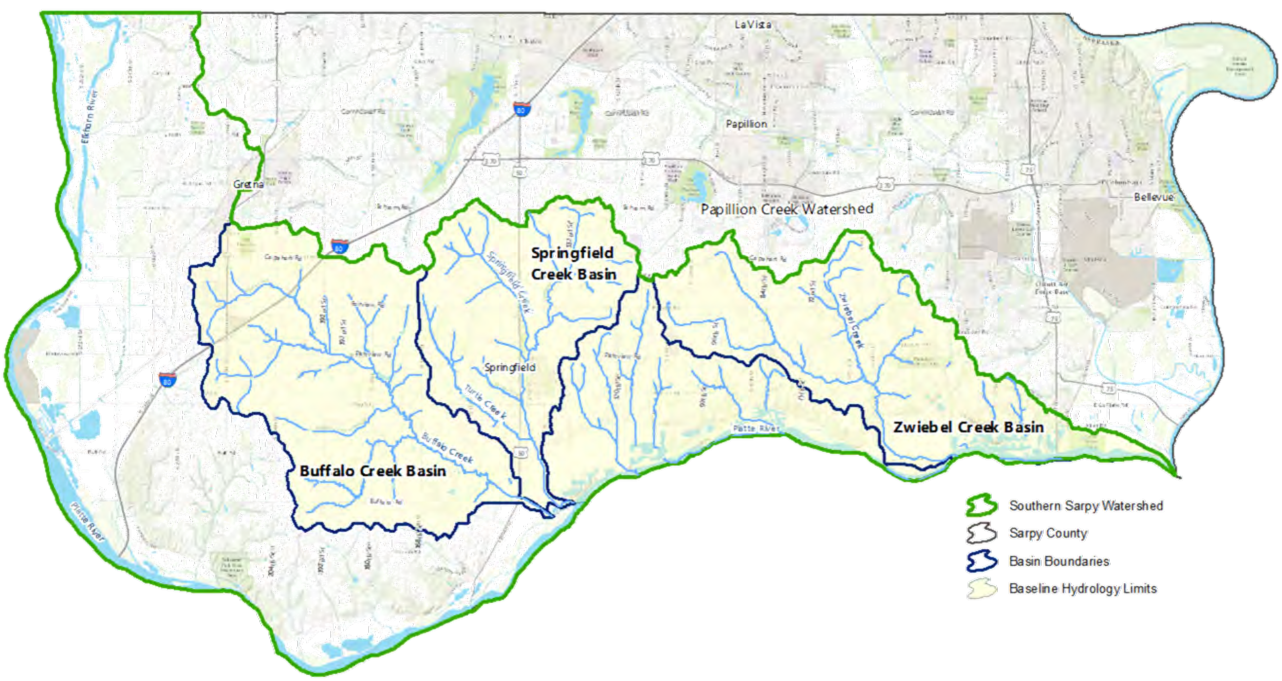


Figure 3.1. Hydrologic Model Study Areas

3.2 Subbasin Development

Subbasins with a contributing drainage area not exceeding 1 mi^2 were developed within each drainage basin to ensure sufficient hydrologic output. Due to the very flat slopes and limited opportunity for development, subbasins located in the Platte River floodplain in the southeast portion of Zwiebel Creek basin were removed from the analysis. Multiple reference points ('comparison nodes') were selected during the hydrology workshop that was conducted with the Partnership as part of the Phase I planning process.

The comparison node locations were selected at major stream confluences and downstream of areas with either predicted or planned development. This allowed the planning team to assess growth-related changes within the watershed. Figure 3.2 shows the locations of the comparison nodes within the watershed.

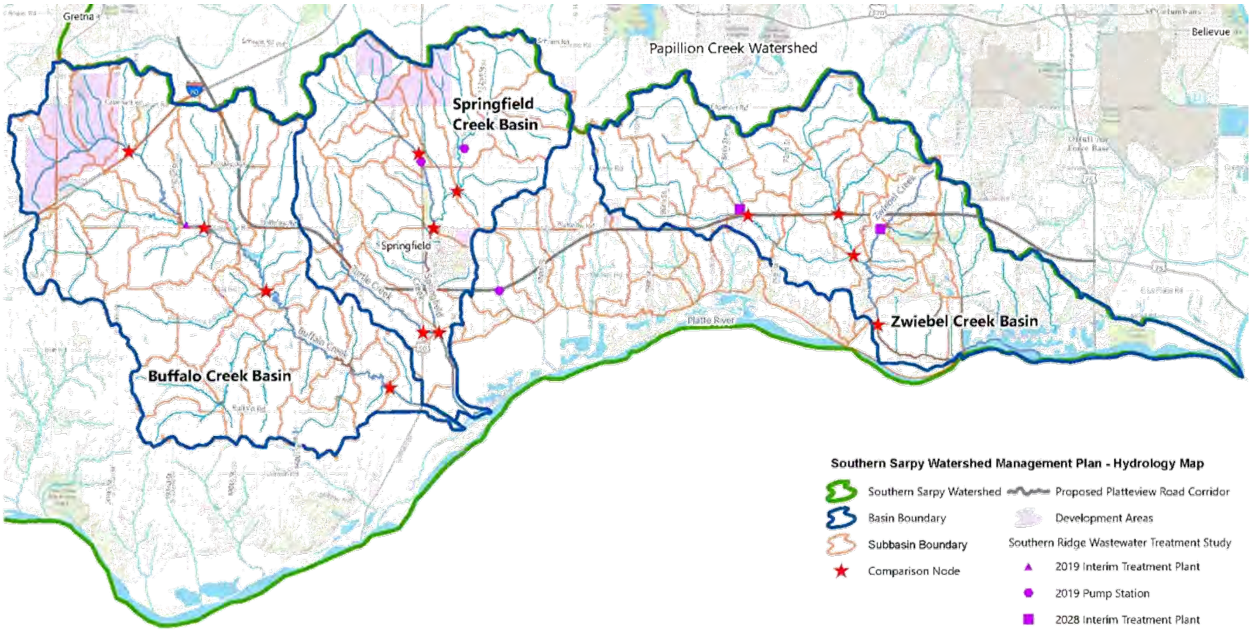


Figure 3.2. Baseline Hydrology

3.3 Existing and Future Conditions

Aerial photography from 2013 and 2016 was analyzed to determine existing conditions percent impervious values based on the six generalized land use categories shown in Table 3.1 For post-development conditions within the watershed, hereinafter referred to as future conditions, the hydrologic model percent impervious values were based on land use categories from future land use maps. Values used in the models are presented in Appendix A.

Table 3.1. Perviousness

Land Use Category	Description	Percent Impervious
Mixed Residential	Mix of low, medium, and high density residential; homes on up to 3 acres.	30
Residential Estates	Homes on 3 to 10 acres.	10
Commercial/Industrial	Commercial, retail business, and industrial areas.	80
Agricultural	Agricultural areas.	1
Open Space	Parks and open areas.	5
Water	Open water, lakes, and streams.	100

3.4 Model Results and Post-Development Impacts

Five different storm events were considered for the existing and future conditions models, including the 2-,10-, 25-, 50-, and 100-year events. The net result change in discharges at the comparison nodes previously identified are included in Table 3.2. Detailed output from the models can be found in Appendix A.

Table 3.2. Net Change (Increases) in Discharges at Comparison Nodes

		Change in Peak Flow Percentage and Volume from Baseline to Future Conditions (30 Percent Future Impervious)					
		2 Year		10 Year		100 Year	
	Comparison Node	Peak Q %	Volume (in)	Peak Q %	Volume (in)	Peak Q %	Volume (in)
Buffalo Creek	BC-1	19%	0.32	8%	0.41	4%	0.49
	BC-2	29%	0.38	8%	0.42	4%	0.50
	BC-3	27%	0.36	10%	0.46	6%	0.55
	BC-4	31%	0.36	11%	0.47	5%	0.56
Springfield Creek	SC-1-WEST	24%	0.40	9%	0.51	5%	0.61
	SC-1-EAST	25%	0.38	10%	0.50	5%	0.58
	SC-2	37%	0.43	11%	0.48	6%	0.58
	SC-3	39%	0.42	11%	0.47	6%	0.56
Turtle Creek	TC-1	30%	0.39	12%	0.50	6%	0.59
Zwiebel Creek	ZC-1-WEST	21%	0.39	9%	0.50	4%	0.59
	ZC-1-EAST	22%	0.38	8%	0.49	5%	0.58
	ZC-3	20%	0.38	8%	0.49	4%	0.57
	ZC-2	35%	0.43	9%	0.48	5%	0.57
Average		**28%**	**0.39**	**10%**	**0.48**	**5%**	**0.56**

While the shape (peak, duration, temporal distribution, etc.) of the hydrographs at the comparison nodes are unique to each subbasin, a generalized discussion can be made about the effects of development on the watershed. Figure 3.3 shows some generalizations of the effects of development on the hydrograph and is intended to represent potential changes without considering any stormwater projects and policies that accompany them.

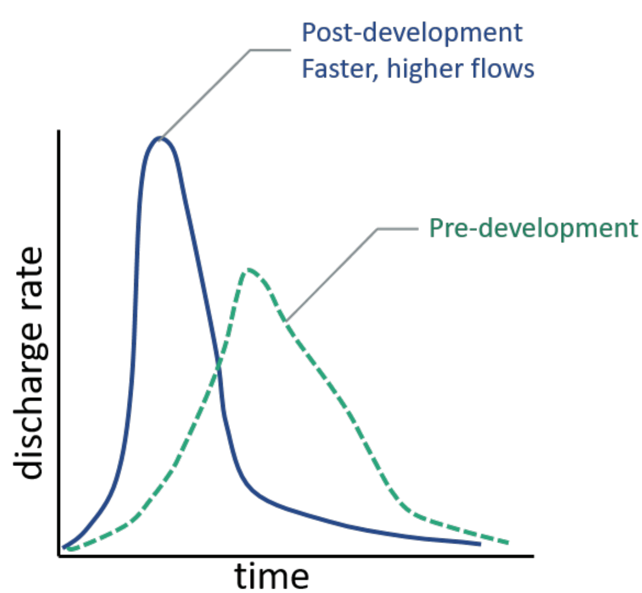
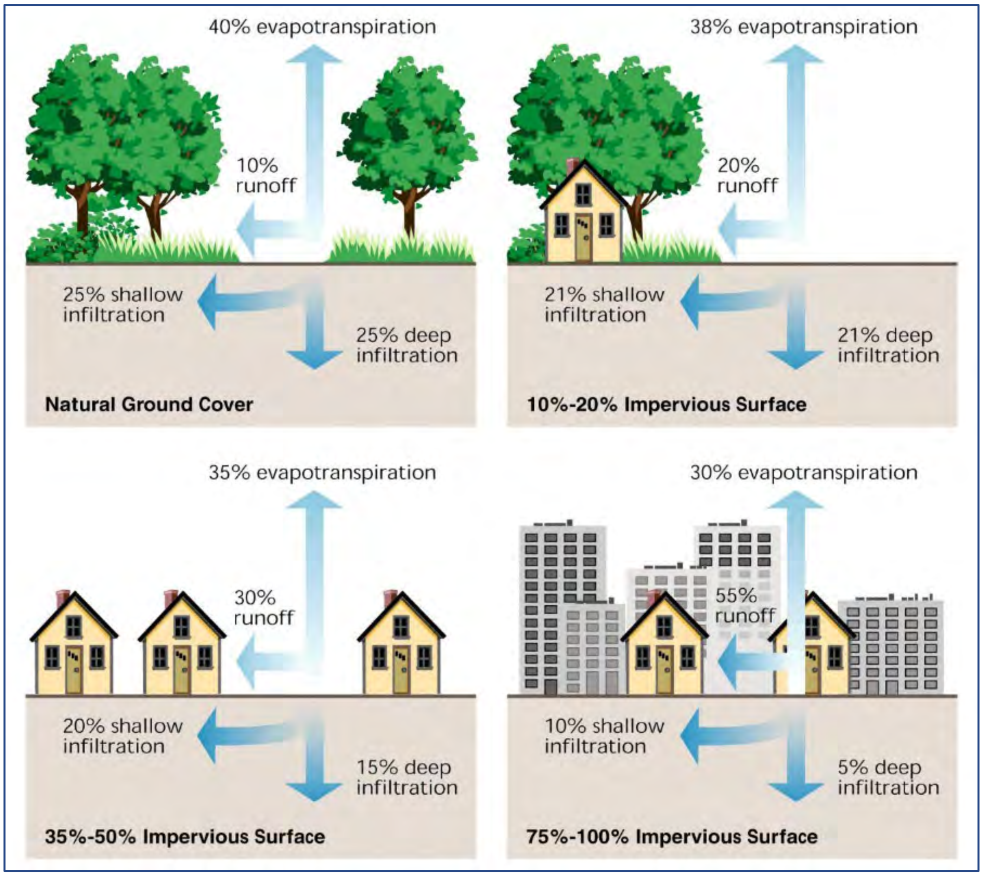


Figure 3.3. Example Existing and Future Conditions Hydrographs

The reduction in time of concentration within each subbasin can be attributed to the decrease in travel time for frequent (less than 10-year return period) storms caused by the anticipated storm sewers that accompany development. For less frequent storms, the overland flow paths are now comprised mainly of roadway corridors or engineered channels instead of pre-development (predominantly agriculture) land use and natural stream channels. This reduction in the time of concentration for the basin is represented by a shorter time to reach the peak outflow and the narrower hydrograph shape. This reduction in time of concentration also adds to the increase in peak rate, along with the increased volume of runoff. The increase in imperviousness in the developed basin adds to the increase in the peak discharge and accounts for the increase in runoff volume due to less infiltration. Figure 3.4 shows how development can impact imperviousness.



Source: Stream Corridor Restoration: Principles, Processes, and Practices. Federal Interagency Stream Restoration Working Group, 1998

Figure 3.4. Impact of Development on Imperviousness

Collectively, the decrease in duration and increase in peak discharge and volume add to the total energy represented by the future conditions hydrograph. The same channel receiving post-development flows will flow faster and deeper when compared to the channel conveying pre-development flows. Potential effects and solutions related to this are discussed throughout this document in the hydraulics, stream stability, alternatives analysis, and recommendations sections.

4.0 HYDRAULIC MODELING

4.1 Introduction

Baseline hydraulic models were developed to perform one-dimensional steady flow calculations and develop water surface profiles for the study area. The hydraulic models developed allow assessment of the impacts from future development on inundation depths and extents, changes in stream geomorphology, floodplain accessibility, and inundation times.

4.2 Model Development

The lack of existing, usable hydraulic models negated any existing inventory to use or build upon. All baseline conditions models were developed from scratch and are detailed in Appendix B. Baseline hydraulic models were created in HEC RAS for the main tributaries within the study area using a combination of LiDAR and surveyed elevation data. Channel reaches included in the analysis are shown in Figure 4.1. Future hydraulic models were developed by altering the baseline models to reflect impacts from future development to the hydrograph shape and stream geomorphology. Considerations when adjusting the existing conditions to future conditions includes a faster time of concentration, increased impervious land, and increased channel degradation and capacity. Due to unknowns regarding the future rate of channel degradation and subsequent capacity increases, the hydrologic analysis for future conditions was not altered to include this change. This may serve to under-predict discharges as floodplain connectivity decreases.

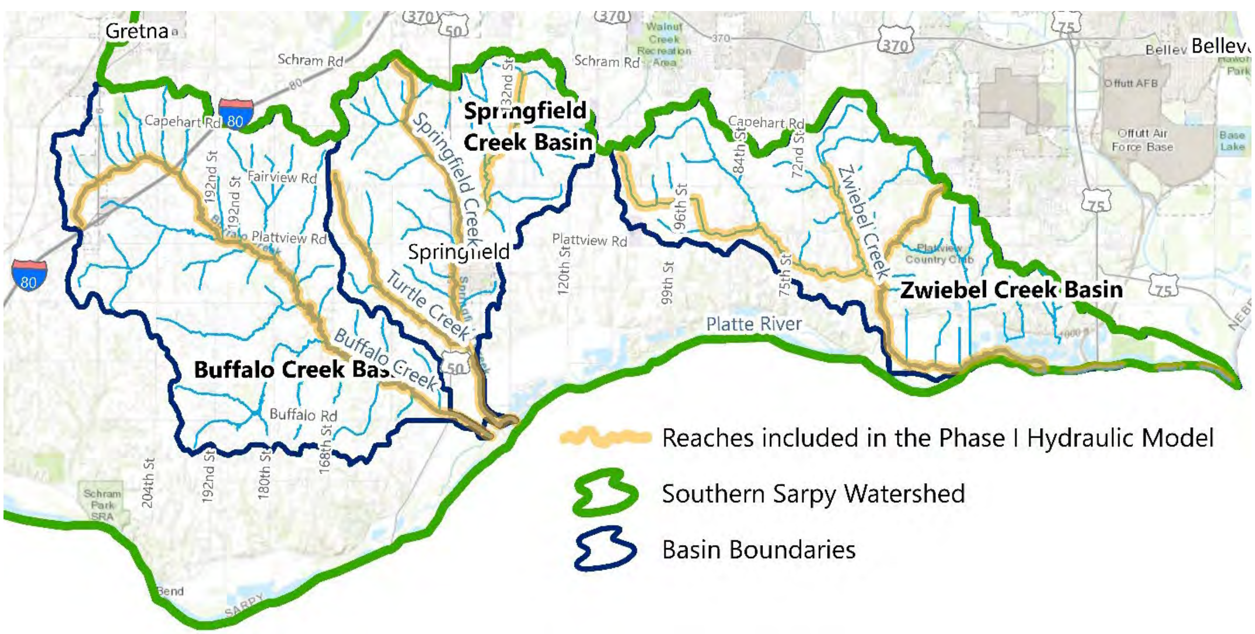


Figure 4.1. Reaches Included in Phase I Hydraulic Model

Hydraulic structure information was gathered from Sarpy County, the Nebraska Department of Transportation, and field surveys of structures on public property. Detailed information on structures included and surveyed can be found in Appendix B (Hydraulic Modeling) and Appendix K (Digital Data).

Cross sections were created from 2013 LiDAR data at a spacing of approximately 250-feet, with additional cross sections for sinuous reaches of the stream and near structures.

4.3 Model Results and Post-Development Impacts

The existing conditions model developed in Phase I provides coarse floodplain extents for the modeled reaches. These are provided in Appendix G along with future conditions floodplain extents and hydraulic profiles. Changes to the floodplain extents from existing to future conditions are minimal as the floodplain tends to extend to the valley limits; however, the floodplain inundation depths are increased by several feet in most locations. The model will be refined in future phases and Federal Emergency Management Agency (FEMA)-acceptable floodplain extents will be developed.

The hydraulic model for future conditions resulted in an increased frequency of high velocity and shear events and increased sediment mobility. The floodplain accessibility decreases due to incision and increased channel capacity, which leads to faster and more erosive events and causes bank instability and widening. Inundation times also increased, resulting in longer and more frequent saturation, theoretically increasing bank instability and therefore, potentially impacting adjacent infrastructure. Figure 4.2 is a representation of how development can impact bed shear stress. Pre-development shear stress will be less than the shear stress for the same precipitation event post-development.

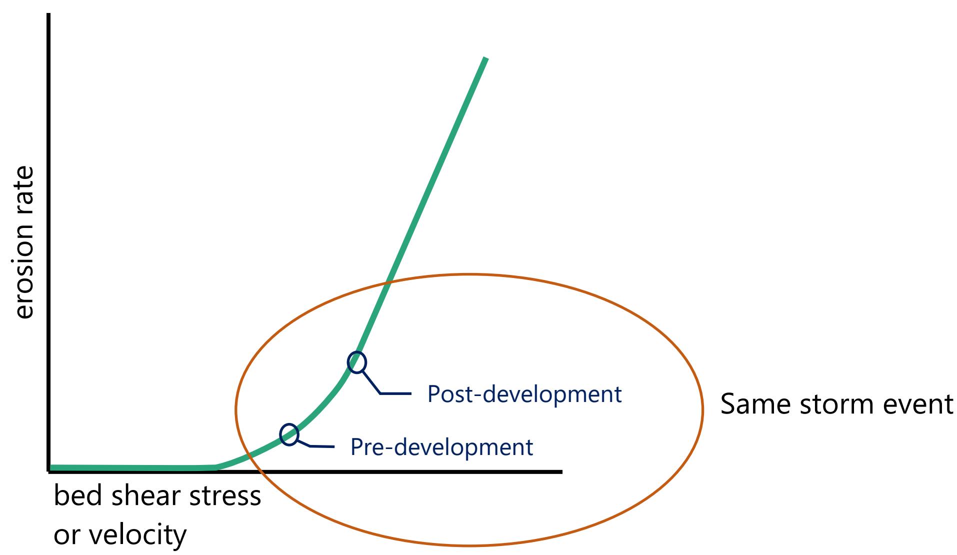


Figure 4.2. Development Impacts to Bed Shear Stress

The increased velocities and shear stresses can result in changes to channel geometry. Figure 4.3 shows a theoretical channel cross-section and how it can change post-development.

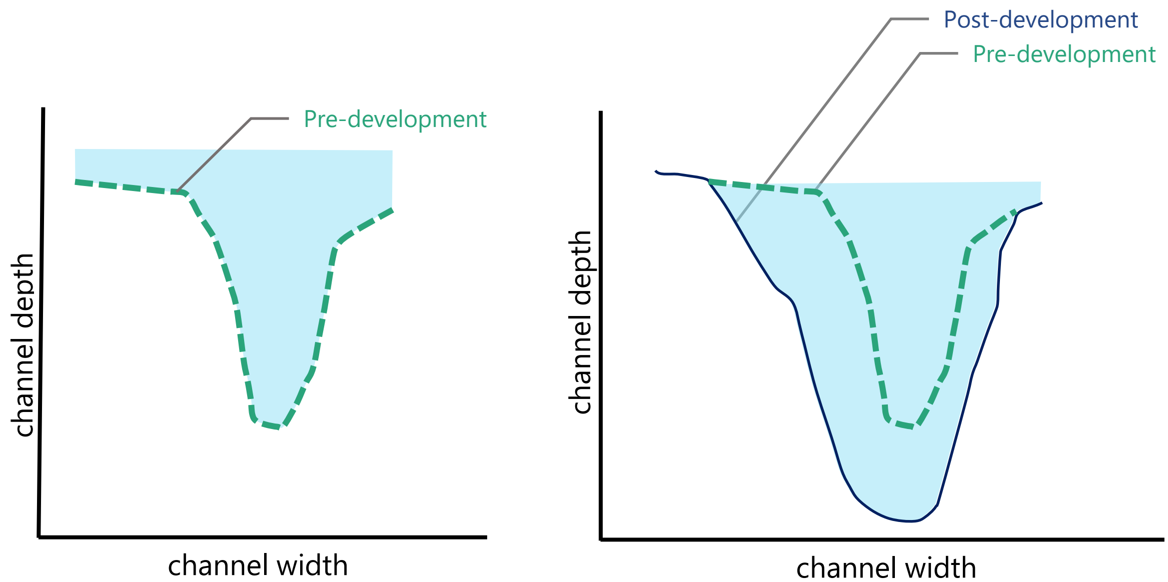


Figure 4.3. Development Impacts to Channel Geometry

Potential projects and policies related to these participated changes in the channel are discussed throughout this document in the stream assessments, alternatives analysis, and recommendations sections.

5.0 WATER QUALITY

5.1 Introduction

Although "good" water quality may be thought of as subjective or relative, from a policy standpoint water quality describes the biological, physical, and chemical characteristics of a waterbody measured against numerical benchmarks. These benchmarks (often water quality standards and criteria) are developed with the intent of linking essential or desirable functions of a given waterbody with certain levels of biological, physical, and chemical constituents. In this context, "good" water quality is present when a waterbody supports its historical or potential uses, and water quality is "poor" when one or more uses are not fully supported. From a regulatory (Clean Water Act) perspective, waterbodies that do not fully support all designated uses are impaired and warrant measures to reduce the amount of pollutants that enter the waterbody and contributed to the impairment of one or more of its designated uses.

5.2 Inventory

5.2.1 Statewide Water Quality Standards

Existing statewide standards (Title 117 – Nebraska Surface Water Quality Standards) apply to several waterbodies in the watershed. Each waterbody has one or designated uses assigned to it based on historic, current, and/or potential use, and each designated use requires attainment of a specific set of water quality standards. All stream segments in the watersheds included in this watershed have Aquatic Life (Warmwater B), Agricultural Water Supply, and Aesthetics uses. Zwiebel Creek, Buffalo Creek, and Springfield (Turtle) Creek all flow into the Lower Platte River, which also has a Primary Contact Recreation use that is impaired due to levels of bacteria (*E. coli*) that exceed the water quality standard. The water quality standards (WQS) for the above-mentioned beneficial uses in the watershed and the Lower Platte River are listed below.

Aquatic Life -Warmwater B.

- Dissolved Oxygen:
  - One day minimum of not less than 5.0 mg/L (April 1 – Sept 30)
  - One day minimum of not less than 3.0 mg/L (October 1 – March 31)
  - Seven day mean minimum of not less than 4.0 mg/L (April 1 – Sept 30)
  - Seven day mean minimum of not less than 6.0 mg/L (October 1 – March 31)
  - Thirty day mean minimum of not less than 5.5 mg/L (October 1 – March 31)
- Ammonia: One-hour average concentration in mg/L not to exceed values as function of pH as shown in Table 5.1.

Table 5.1. Ammonia Standards

pH	Total Ammonia (mg/L)
6.6	55.25
6.8	49.53
7.0	42.57
7.2	34.84
7.4	27.09
7.6	20.09
7.8	14.32
8.0	9.92
8.2	6.75
8.4	4.58
8.6	3.13
8.8	2.18
9.0	1.56

- Agricultural Water Supply – Class A:
  - Conductivity: Not to exceed 2,000 umhos/cm (April 1 – Sept 30)
  - Nitrate and Nitrite as Nitrogen: Not to exceed 100 mg/L
  - Selenium: Not to exceed 0.02 mg/L
- Aesthetics: This use applies to all surface waters of the state. To be aesthetically acceptable, waters shall be free from human-induced pollution which causes:
  - noxious odors;
  - floating, suspended, colloidal, or settleable materials that produce objectionable films, colors, turbidity, or deposits;
  - the occurrence of undesirable or nuisance aquatic life (e.g., algal blooms). Surface waters shall also be free of junk, refuse, and discarded dead animals.
- Recreation:
  - *E. coli*: Not to exceed a geometric mean of 126 colony forming units/100 mL.

Every two years, the Nebraska Department of Environment and Energy (NDEE) assesses the water quality of Title 117 streams in Nebraska and submits a Water Quality Integrated Report (IR) to the U.S. Environmental Protection Agency (EPA). The results of the 2018 IR show that no waterbodies within the watersheds are currently listed as impaired (Table 5.2). Several waterbodies were not fully assessed due to insufficient data to determine whether designated uses are being met. The impairment status of these waterbodies is subject to change with additional data collection and subsequent assessments. Additionally, because streams in the Plan area discharge into the Lower Platte River, which is impaired (Table 5.3), potential impacts to the Lower Platte should be considered when formulating alternatives for water quality protection in the tributary watersheds of Southern Sarpy County.

Table 5.2. Nebraska 2018 Water Quality Integrated Report – Waterbodies in Watershed

Waterbody ID	Waterbody Name	Designated Beneficial Use	Assessment	Overall Assessment	IR Category*
LP1-10400	Zwiebel Creek	Aquatic Life – Warmwater B Agricultural Water Supply Aesthetics	NA NA NA	NA	3
LP1-10410	Unnamed Creek (tributary to Zwiebel Creek)	Aquatic Life – Warmwater B Agricultural Water Supply Aesthetics	NA NA NA	NA	3
LP1-10500	Zwiebel Creek	Aquatic Life – Warmwater B Agricultural Water Supply Aesthetics	NA NA NA	NA	3
LP1-10900	Springfield Creek	Aquatic Life – Warmwater B Agricultural Water Supply Aesthetics	S S NA	S	2
LP1-11000	Buffalo Creek	Aquatic Life – Warmwater B Agricultural Water Supply Aesthetics	S S NA	S	2

** 2 = Waterbodies where some of the designated uses are met but there is insufficient information to determine if all uses are being met.*

3 = Waterbody where there is insufficient data to determine if any beneficial uses are being met.

Table 5.3. Nebraska 2018 Water Quality Integrated Report - Receiving Waterbody

Waterbody ID	Waterbody Name	Designated Beneficial Use	Assessment	Overall Assessment	IR Category*
LP1-10000	Platte River	Primary Contact Recreation Aquatic Life – Warmwater A Public Drinking Water Supply Agricultural Water Supply Aesthetics	I (*E. coli*) I (Fish Consumption) S S S	I	3

** 3 = Waterbody where there is insufficient data to determine if any beneficial uses are being met.*

5.2.2 Lower Platte River TMDL and Water Quality Management Plan

The Lower Platte River segments were impaired for *E. coli* in the 2006 IR and, as a result, a Lower Platte Basin total maximum daily load (TMDL) was prepared in 2007. The TMDL identified sources of *E. coli*, quantified existing *E. coli* levels, and indicated reductions required to meet WQS.

Table 5.4. TMDL Water Quality Data - Receiving Waterbody

Waterbody ID	Site Location	USGS Gage	NDEE Station	*E. coli* Geometric Mean (cfu/100mL)
LP1-10000	Platte River at Louisville	06805500	SLP1PLATTE150	314

Although the 2007 TMDL did not include a detailed implementation plan, it provided the foundation for the Lower Platte River Corridor Alliance (consisting of the Lower Platte North NRD, Lower Platte South NRD, and the Papio-Missouri River NRD) to develop a Water Quality Management Plan (WQMP) for the Lower Platte River. The NDEE Section 319 Program was a key technical and funding partner for development of the Lower Platte River WQMP. Because the 319 Program manages federal funds focused on nonpoint source pollution, the WQMP includes EPA's required nine elements (Table 5.5), which are geared towards maximizing implementation to reduce pollutant loads and meet WQS. Consideration and incorporation of these nine elements into the Southern Sarpy Watershed Plan may enhance the effectiveness of the plan in meeting downstream water quality objectives, thereby unlocking EPA funds for applicable projects/alternatives.

Table 5.5. EPA's Nine Elements of Watershed/Water Quality Plans

Element	Description / Requirement
1	Identify sources and causes of pollution
2	Estimate pollutant loads and expected pollutant reductions
3	Describe management measures that will achieve load reductions and targeted critical areas
4	Estimate amounts of technical and financial assistance and the relevant authorities needed to implement the plan
5	Develop an information/education component
6	Develop a project schedule
7	Describe the interim, measurable milestones
8	Identify indicators to measure progress
9	Develop a monitoring component

Pollutant loads for Buffalo Creek, Springfield Creek, and Zwiebel Creek basins in the watershed were estimated in the Lower Platte River WQMP, fulfilling Element 2 of EPA's required elements (Table 5.6). The load estimates are driven primarily by slope and existing land use, which is predominantly agricultural (cropland and pastureland). Springfield (referred to as Turtle in the WQMP) Creek and Buffalo Creek were given highest priority (Priority 1) and Zwiebel Creek was designated as Priority 2 according to pollutant load modeling results (Table 5.6) compared to other basins modeled in the WQMP.

Table 5.6. Pollutant Load Summary from Water Quality Management Plan (2014)

Basin (HUC12)	WQMP Priority	Total Phosphorus		Total Nitrogen		Total Suspended Solids	
		Rate (lbs/ac/yr)	Load (lbs/yr)	Rate (lbs/ac/yr)	Load (lbs/yr)	Rate (tons/ac/yr)	Load (tons/yr)
Zwiebel Creek	2	0.24	3,927	3.0	47,957	1.5	20,504
Springfield (Turtle) Creek	1	0.41	4,326	4.99	53,066	2.15	22,889
Buffalo Creek	1	0.35	5,828	4.31	71,420	1.86	30,782

5.2.3 National Pollution Discharge Elimination System Program

The National Pollutant Discharge Elimination System (NPDES) permit program was created by the Clean Water Act to address water pollution by regulating discharges into any waters of the state. The NDEE manages the NPDES program for the state of Nebraska and there are several different types of NDPES permits. Stormwater discharges are regulated and when a municipality has a population of 100,000 or more, they are required to obtain an NPDES Municipal Separate Storm Sewer System (MS4) permit to regulate the discharge from their storm sewer system. To prevent harmful pollutants from being washed into the storm sewers system, a Stormwater Management Plan (SWMP) must be developed that describes the stormwater control practices that will be implemented to minimize pollutant discharge.

The Partnership Interlocal Agreement developed in 2016 created an interim Water Quality Improvement policy and Stormwater Management Financing policy to follow until the watershed management plan is in place.

- Water Quality Improvement: improves water quality by requiring the use of low-impact development strategies (that is, design techniques that promote infiltration, filtration, storage, evaporation, and temporary detention of stormwater) to provide for water quality control of the first ½-inch of stormwater runoff and to maintain peak discharge rates during the 2-year storm event based on baseline land use conditions.
- Stormwater Management Financing: provides for a dedicated, sustainable funding mechanism (that is, a watershed fee on development) to help implement programs to address local, state, and federal regulations, including a NPDES Stormwater Management Program and the development of a SSWP. Revenues from the watershed fee during the first 5 years will fund about one-third of the annual financing of the NPDES Stormwater Management Program activities and development of a watershed plan. After 2020, funds would be used to implement the Watershed Management Plan.

By adhering to the interim water quality improvement policy (and the future watershed management plan guidelines) as development occurs in the watershed, it will proactively ensure that the proper controls are put into place to comply with the NPDES SWMP requirements. Developed areas would need to follow the Sarpy County - Section 38 Stormwater Management Regulations unless they are annexed by an adjacent City, at which time they would have to comply with that City's respective MS4 permit. The Cities of Gretna, Papillion and Bellevue each have their own MS4 permits and respective SWMPs. When developing this watershed management plan, it is imperative that the guidelines incorporated for water quality controls meet all requirements of each of the local MS4 permits and SWMPs to ensure future compliance.

Construction sites are also regulated by the NDPES program if more than 1-acre of land is disturbed. An NPDES Construction Stormwater General Permit is required and the development of a Stormwater Pollution Prevention Plan (SWPPP) that addresses erosion and sediment control is a primary condition of this permit.

If industrial facilities are part of the development within the watershed, an NPDES Industrial Stormwater General Permit would be required, which would also include a SWPPP. For any wastewater treatment facilities, an NPDES Discharge to Surface Water permit will be required.

6.0 ENVIRONMENTAL RESOURCES

6.1 Introduction

Identifying existing environmental and other sensitive resources within the watershed and areas that may be good candidates for preservation or restoration enables the Partnership to make project and policy decisions that protect existing resources during and after watershed development. Understanding existing environmental regulations and working closely with regulatory agencies throughout the planning process ensures projects and policies are chosen that protect sensitive resources and do not pose/create significant environmental permitting hurdles. Existing resources were identified using desktop reviews, field analyses, and coordination with regulatory authorities.

6.2 Existing Environmental Regulations

A desktop review was conducted of county, state, and federal level environmental regulations that may be applicable to either the Partnership or other parties that have projects identified in the Plan. A list of these regulations and their governing agencies are included below.

- Section 404 of the Clean Water Act (USACE)
- Section 401 of the Clean Water Act (NDEE)
- Section 106 of the National Historic Preservation Act (Nebraska SHPO)
- Section 7 of the Endangered Species Act (USFWS / NGPC)
- National Pollutant Discharge Elimination System (NDEE)
- Sarpy County Zoning Regulations – Sections 35, 37, 38 (Sarpy County)
- Sarpy County Subdivision Regulations – Sections 10, 11, 12 (Sarpy County)
- Platte River Depletion Regulations (NGPC)
- National Environmental Policy Act (lead federal agency)

6.3 Desktop Inventory

A desktop review of environmentally sensitive resources was conducted and digital data, when available, was collected in the project database. A list of available digital information is included in Appendix K and a more in-depth discussion on the environmental resources can be found in Appendix C. Information was collected from the Nebraska Game and Parks Commission (NGPC), U.S. Fish and Wildlife Service (USFWS), the Platte River Corridor Alliance, U.S. Geological Survey (USGS), U.S. Department of Agriculture (USDA), and Vireo. Examples of information collected are included below.

The National Wetland Inventory is a database maintained by the USFWS that includes data on areas with potential wetlands. This is not an all-inclusive database resource but can provide information on a planning level of areas that may contain wetlands and therefore may impact potential projects and policies.

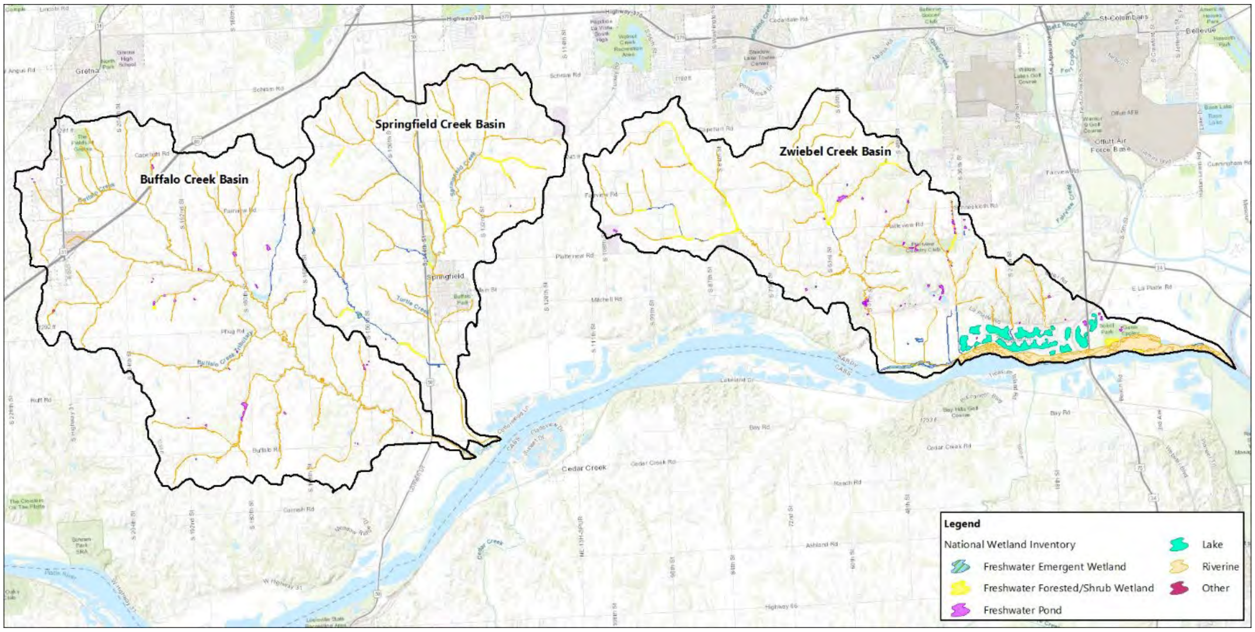


Figure 6.1. National Wetland Inventory

Another way to identify potential wetlands without performing a field survey is by looking at hydric soils, aerials, and topography. Hydric soils are those that formed of conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions (NRCS). Figure 6.2 shows hydric soils within the study area.

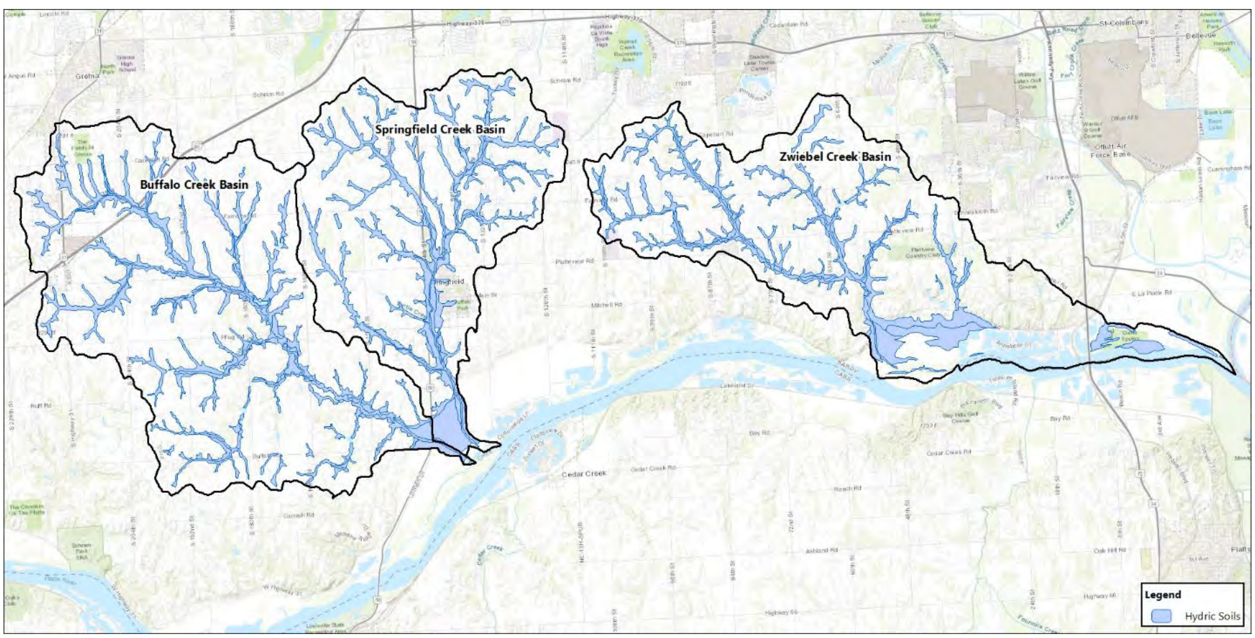


Figure 6.2. Hydric Soils within the Study Area

6.4 Field Analysis

Field assessments were conducted in May 2018 using Vireo's Stream Asset Inventory (SAI) procedure, which incorporates the best elements of a number of accepted stream and habitat assessments and local research, see Appendix C. The assessment was conducted in conjunction with the stream stability field assessment (see Section 7) and included locations accessible by public property. The SAI protocol provides rapid and scientifically defensible indicators of water quality, stream stability, and habitat qualitative conditions at a given location that is selected to be representative of a larger stream reach. It is based on lessons learned from two previous SAI versions, as well as up-to-date stream quality information and primarily focuses on physical habitat conditions deduced within the other noted indicators.

Specific assessment criteria include erosion indicators, bed and bank composition, aquatic habitat features, tree canopy and understory coverage and composition, and indirect water quality indicators such as development, structures, or adjacent topographic influences. These criteria are assigned individual weighted scores to create a composite score of stream quality at each location and a relative ranking of stream quality throughout the watershed. The assessment criteria are a blend of subjective judgment and conventional quantitative measurements allowing for a relatively comprehensive yet efficient evaluation of a stream segment. As with any assessment limited to a specific segment of stream, this protocol may not detect resource problems outside of the assessment locations or stemming from situations outside the study reach. A stream asset inventory score and environmental type was assigned to each assessment site and provides an overview of the stream's ecological condition, shown in Figures 6.3-6.5.

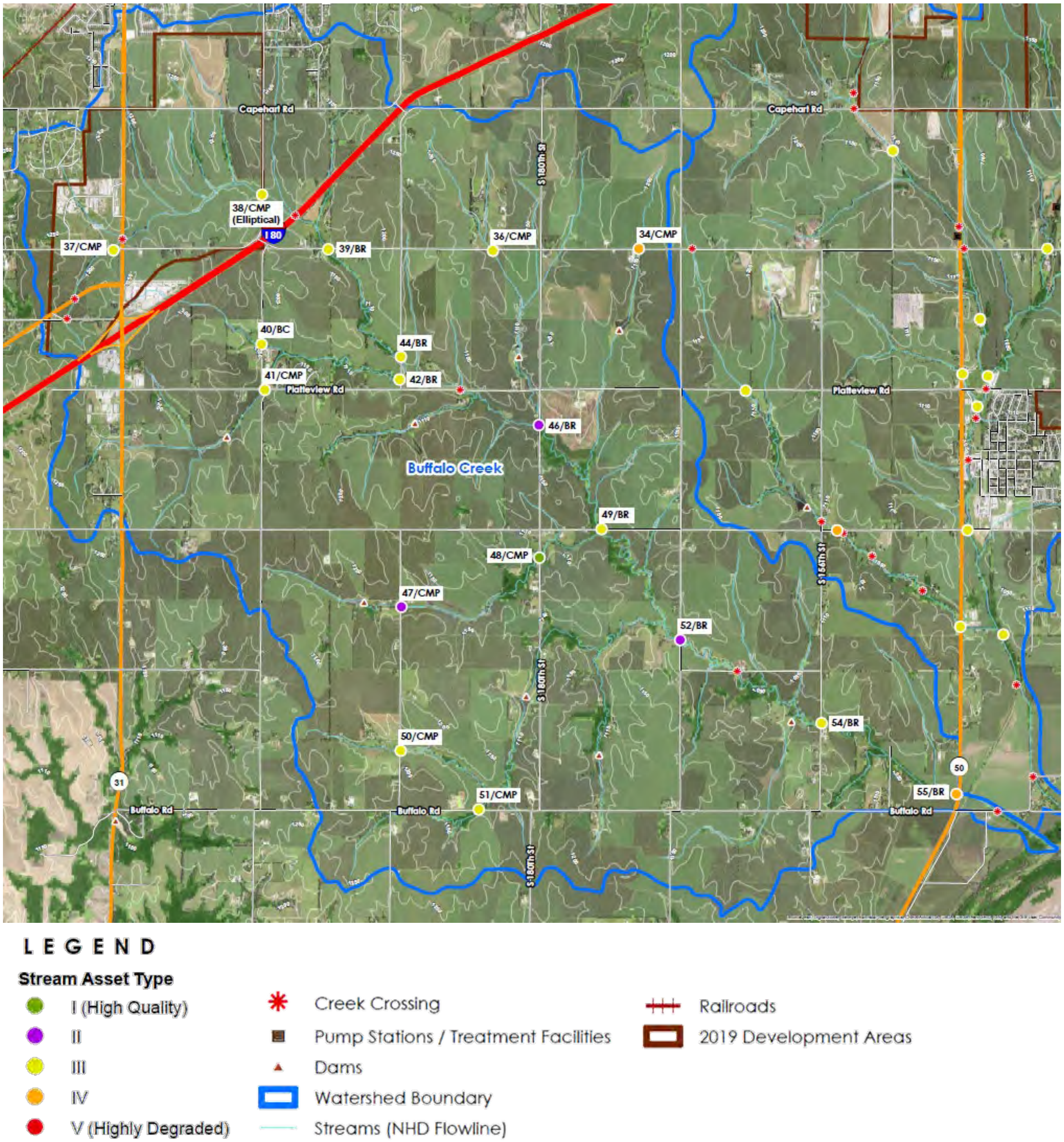


Figure 6.3. Stream Asset Inventory in Buffalo Creek Basin

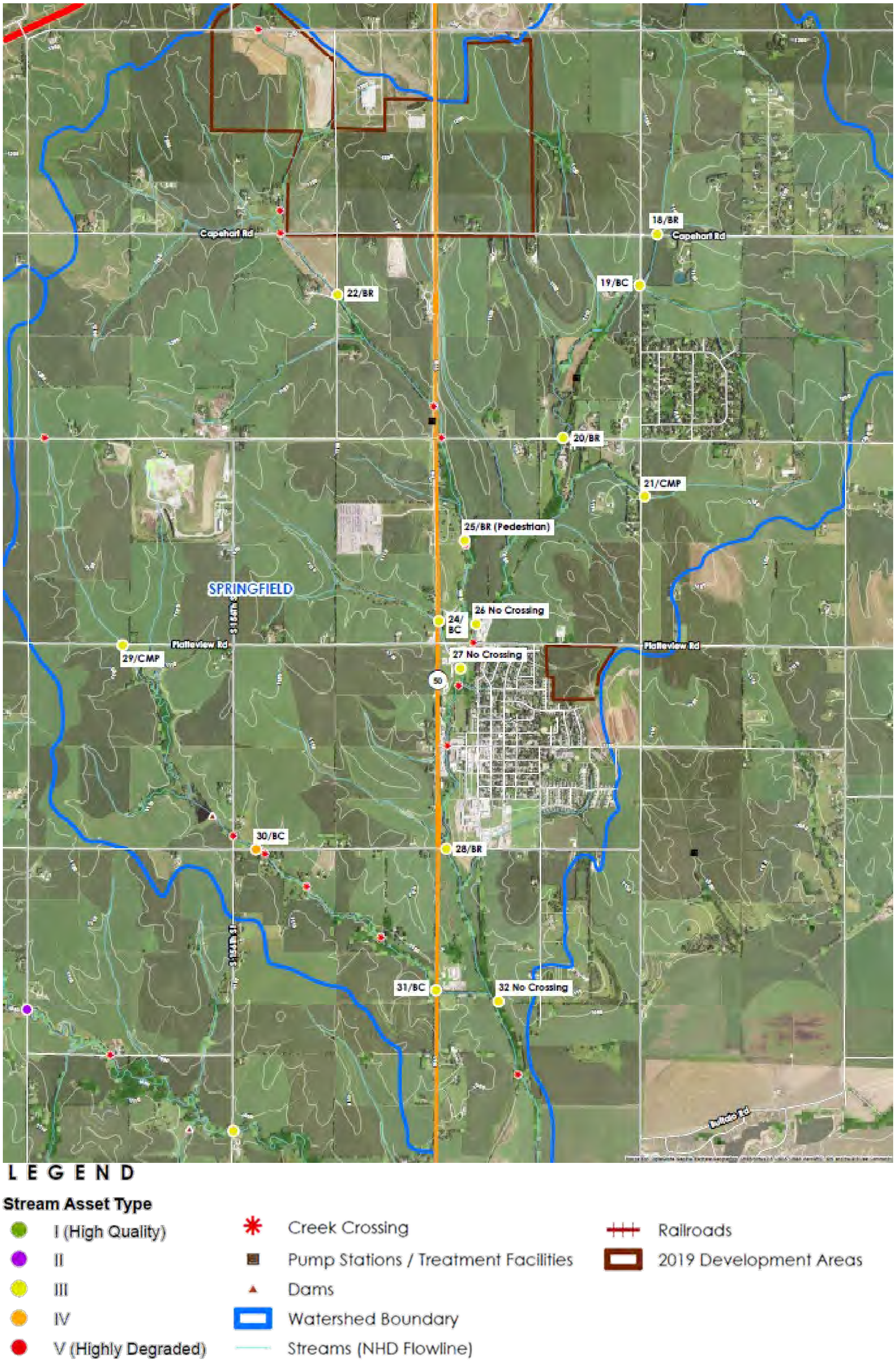


Figure 6.4. Stream Asset Inventory in Springfield Creek Basin

Figure 6.5. Stream Asset Inventory in Zwiebel Creek Basin

6.5 Agency Coordination

6.5.1 Nebraska Game and Parks Commission

A meeting was held with NGPC to open a dialogue regarding the overall planning effort of the Plan, potential threatened and endangered species, and Platte River depletions. Threatened and endangered species that are currently listed in Sarpy County are included in Table 6.1.

Table 6.1. Currently Listed Threatened and Endangered Species in Sarpy County

Federal	
Piping Plover	Interior Least Tern
Western Prairie Fringed Orchid	Pallid Sturgeon
Northern Long-eared Bat	
State	
American Ginseng	River Otter
Lake Sturgeon	Sturgeon Chub

NGPC indicated that six new species, including four fishes, a rattlesnake, and a bird, are proposed as threatened or endangered in Nebraska and that the river otter may be delisted at the end of 2019. Three of these proposed species may occur in Sarpy County including the flathead chub, plains minnow, and western silvery minnow. Practices and restrictions for the proposed species would be similar to presently listed species like the pallid sturgeon and sturgeon chub. Methods to offset potential Platte River depletions were also discussed, including retiming of flows and retiring existing water rights. NGPC indicated that they generally evaluate projects individually and not watershed-wide.

6.5.2 US Fish and Wildlife Service

To comply with the Endangered Species Act, water-related projects in the Platte River Basin require some level of consultation with the USFWS. Areas upstream of the Platte-Loup confluence can be covered under the Platte River Recovery Implementation Program. Projects occurring downstream of the confluence are not covered by the Program and each must be assessed on an individual basis. The depletive impacts of the project must be evaluated and if they are less than 25 acre-feet per year during the months of February through July, a streamlined consultation process is currently available under a “minor depletions biological opinion” prepared by the Service for such projects in the Platte River basin exclusive of the Program area.

7.0 STREAM ASSESSMENT

7.1 Introduction

The following section is a brief assessment of the current stream conditions and discussion. Detailed information and a more in-depth analysis are provided in Appendix D.

Streams are dynamic systems, continually reacting to the naturally occurring and man-induced changes in flow regimes and sediment transport and are in a continual process of moving towards dynamic equilibrium. To understand the current state of a stream, identifying the existing characteristics of the streams and understanding the geomorphologic processes within the watershed are imperative to be able to predict stream conditions of the developing watershed.

The location of a stream segment (Figure 7.1) and aerials (Figure 7.2) are shown below to provide an example of the uncertainty of the time rate of stream degradation in the watershed. The stream segment in the watershed uplands shown was (seemingly) stable for decades, and then with little to no change in the subbasin's land use, and very minor changes in drainage patterns, the stream began degrading at a very rapid rate. And while each stream segment is unique in the soils, ecology, and drainage patterns, this example highlights the inability to predict the time rate of degradation and when changes in the degradation rate may occur.

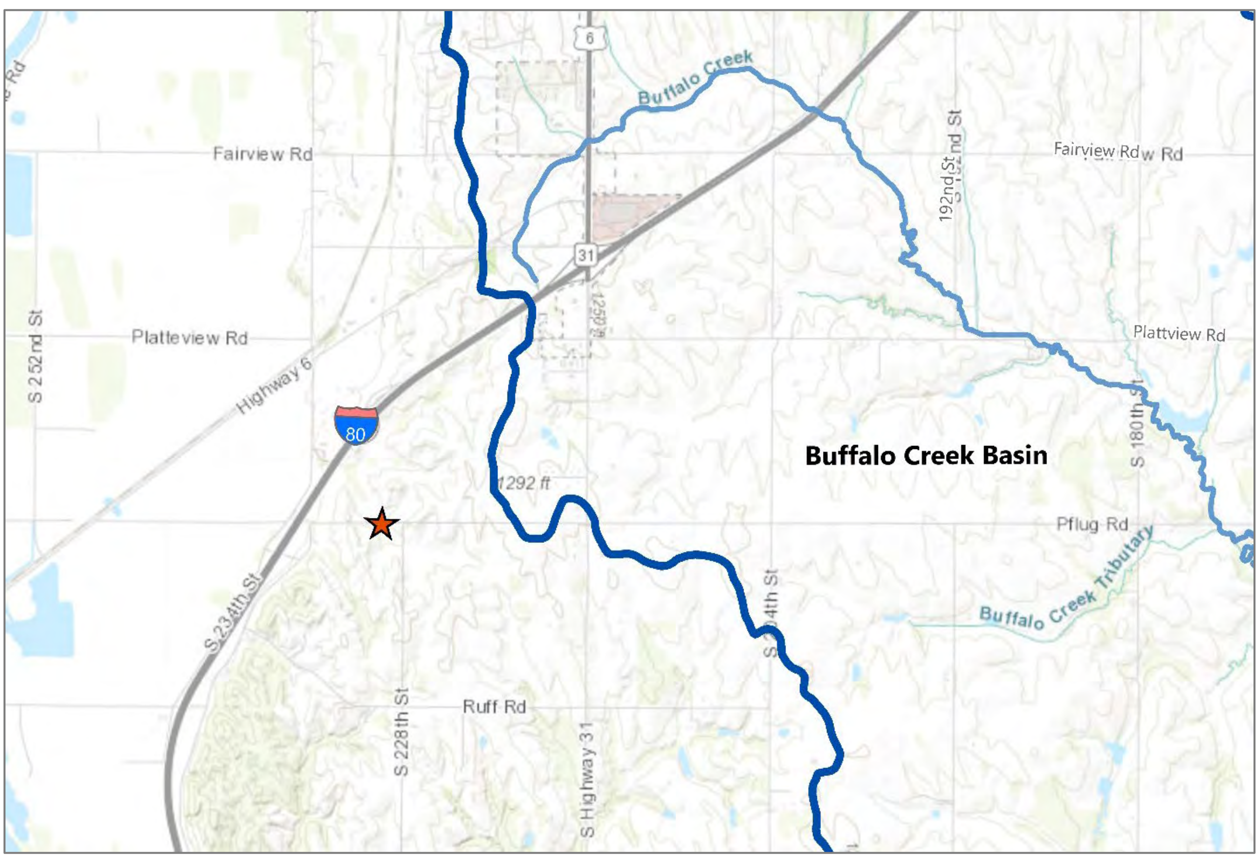


Figure 7.1. Location of Stream Segment Example of Degradation and Widening

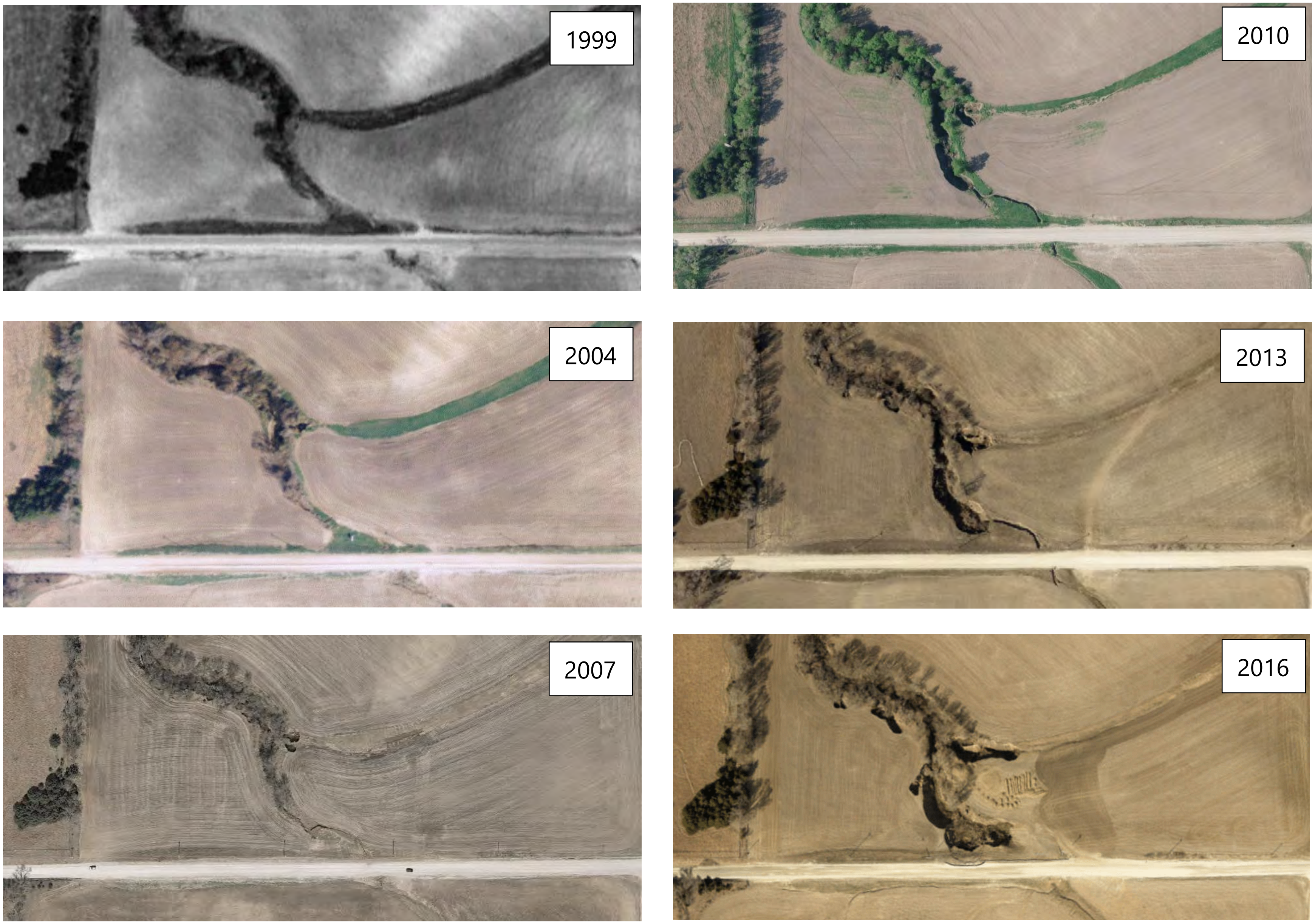


Figure 7.2. Example of Channel Degradation and Widening Over Time in the Watershed

7.2 Soil Properties and Erosivity

Soil types within the study area are predominantly Peoria Loess, which generally consist of 60 to 70 percent silt with the remainder consisting of clay and a minor portion of sand. The plasticity index (PI) is simply the range in water contents where soils exhibit a plastic behavior. Soils with a lower PI will exhibit less resistance to erosion, thereby eroding at a lower velocity. Peoria loess in the region has a low PI and therefore erodes at low velocities.

The USDA National Engineering Handbook (NEH) provides acceptable velocities for varying PIs. These can be used to estimate a channel bed slope for a given cross section that would yield a lower velocity than the NEH given value and therefore a 'stable' profile. To apply this method, 78 stream segments representing Buffalo, Springfield, and Zwiebel Creek were modeled using a custom HEC RAS toolkit with existing channel geometries. Average channel velocities were identified for 100 discharges ranging from 25 cfs up to the 100-year discharge under a range of twelve possible channel slopes beginning at each stream's existing slope down to 0.02 percent. This assessment suggests that a stable stream slope in low-plasticity silts, such as Peoria, should range from 0.05 to 0.16 percent. Using the NEH method and data collected within the watershed, a 'stable' slope within the Southern Sarpy watershed is approximately 0.08 percent. Depending on the soils encountered as the stream degrades, the stable slope will be different in each subbasin. In this region of the country, loess soils can reach a depth of 30-feet or more which implies significant degradation potential. Due to the depositional nature of loess soils, their source material greatly affects the erosive potential; as was found in Papillion Creek Watershed's Regional Detention Basin WP6 project area, dispersive clays can exist, further compounding the erosive potential of the soil. Existing stream profile figures are provided in Figures 7.3-7.5 below. Detailed discussion of the analysis is included in Appendix D.

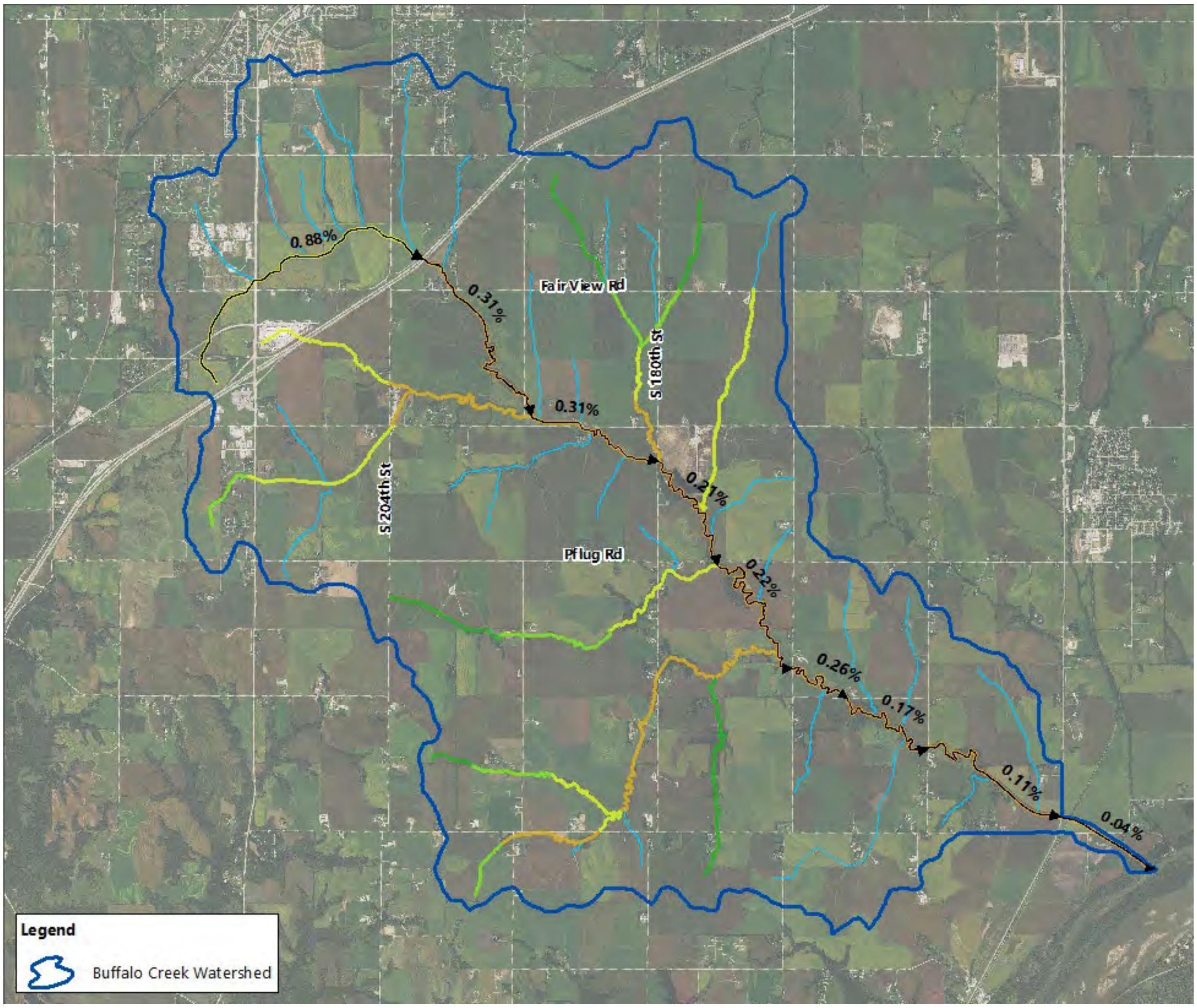


Figure 7.3. Buffalo Creek Existing Stream Slopes

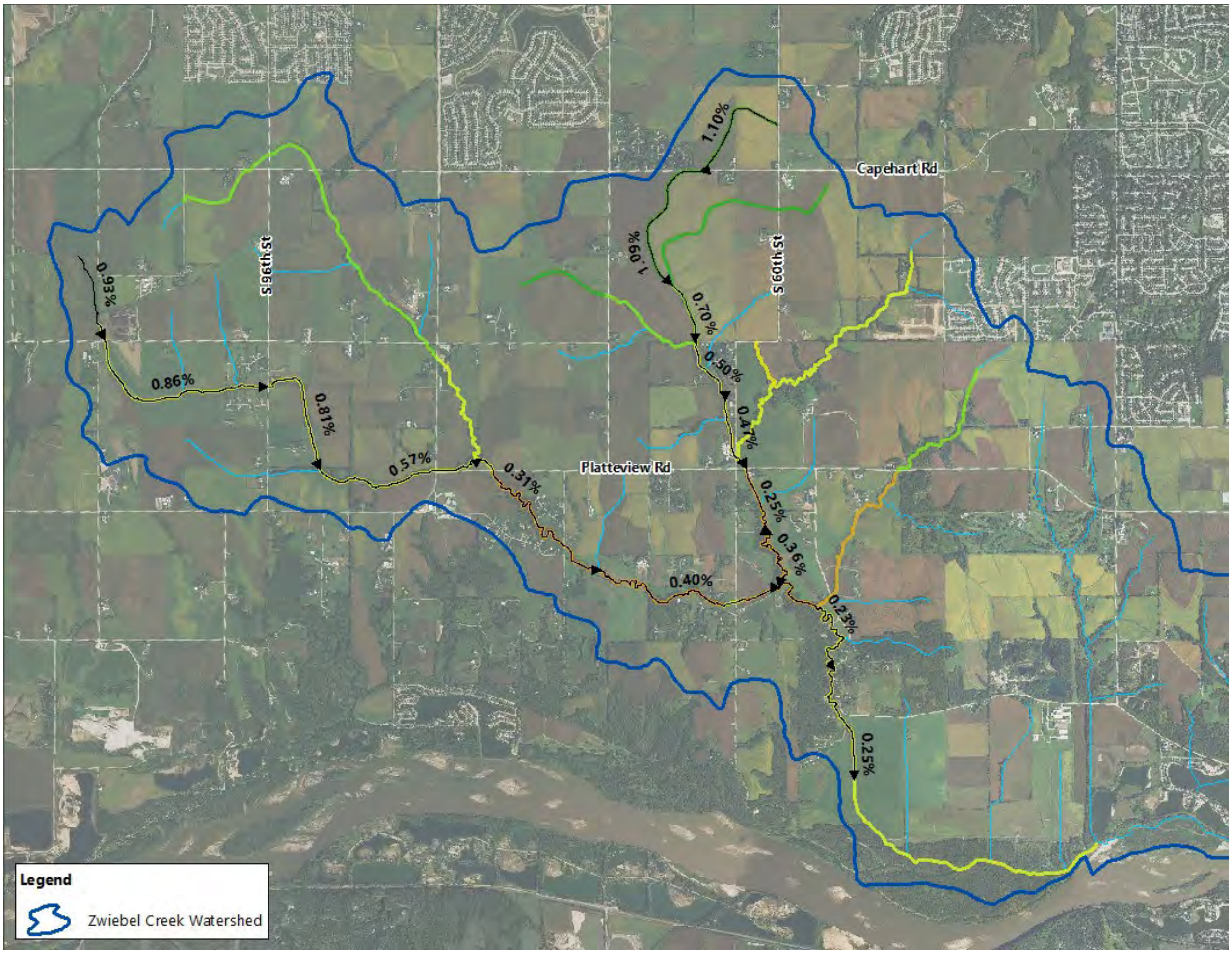


Figure 7.4. Zwiebel Creek Existing Stream Slopes

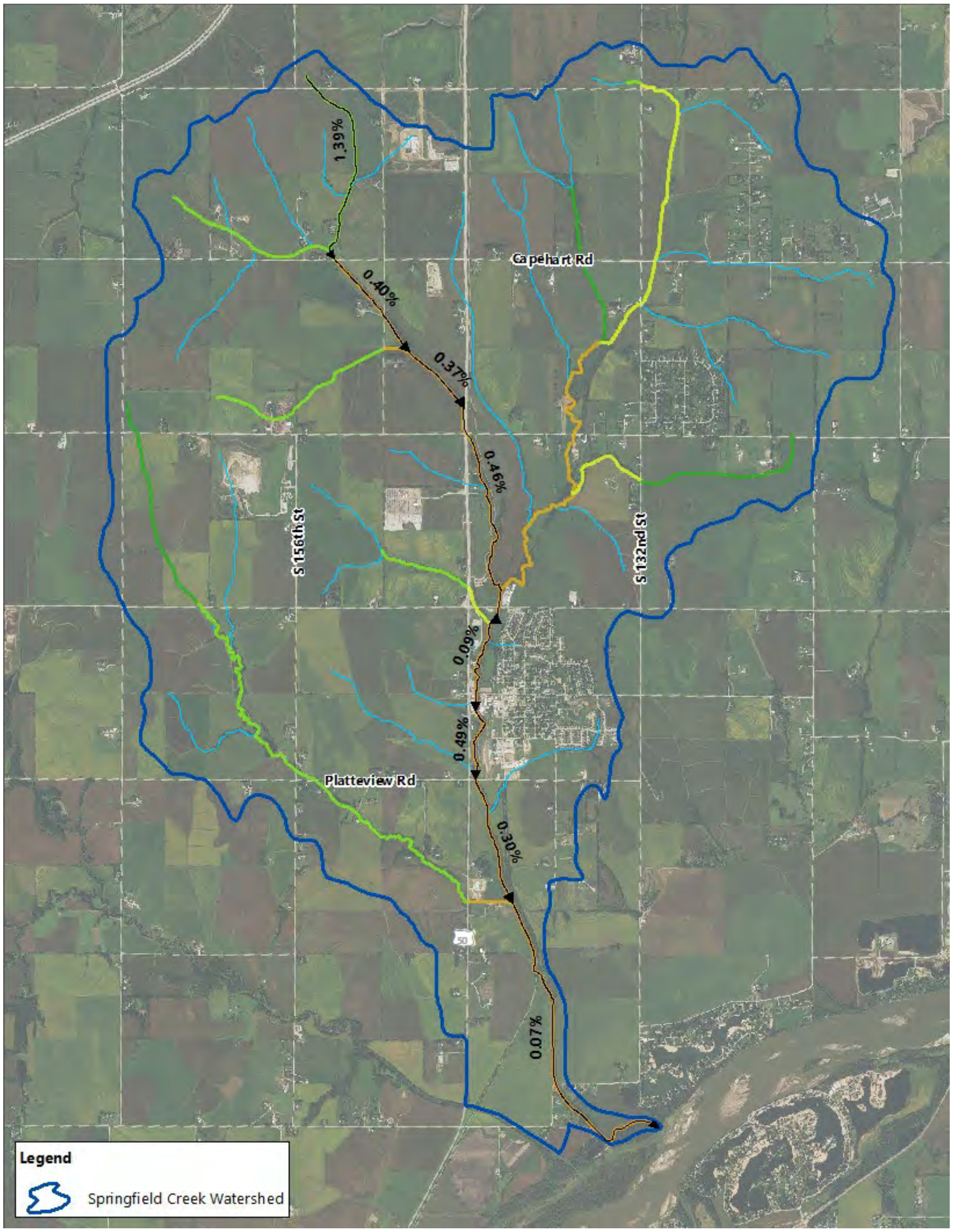


Figure 7.5. Springfield Creek Existing Stream Slopes

7.3 Predicting Future Stream Profiles

To predict future stream profiles, one can assume the stable slope within the watershed and project that slope back from the downstream limits of the stream representing a headcut progression. When developing the potential future stream profiles, the following assumptions were used:

- Streams would degrade through headcut progression, with the downstream slope driving the elevations

- The 'stable' streambed slope will be reached on all segments; a value of 0.15 percent was applied to project future stream profiles that is within the range of anticipated slopes and consistent with values applied in the Papillion Creek watershed
- Existing grade control structures are assumed to remain in-tact and therefore the elevations upstream of these structures would remain constant from present-day to future conditions
- Culverts are assumed to act as grade control structures
- Bank heights reach a maximum of 30 ft and degradation ceases due to encountering hard pan

With these assumptions, it is important to note that additional infrastructure improvements and maintenance would be required at the culverts and other grade control structures to maintain the 'set' elevations immediately upstream of these structures. Figure 7.6 shows a representation of how potential future profiles were determined. Implications of future degradation that will potentially create these future profiles are discussed in Section 8.

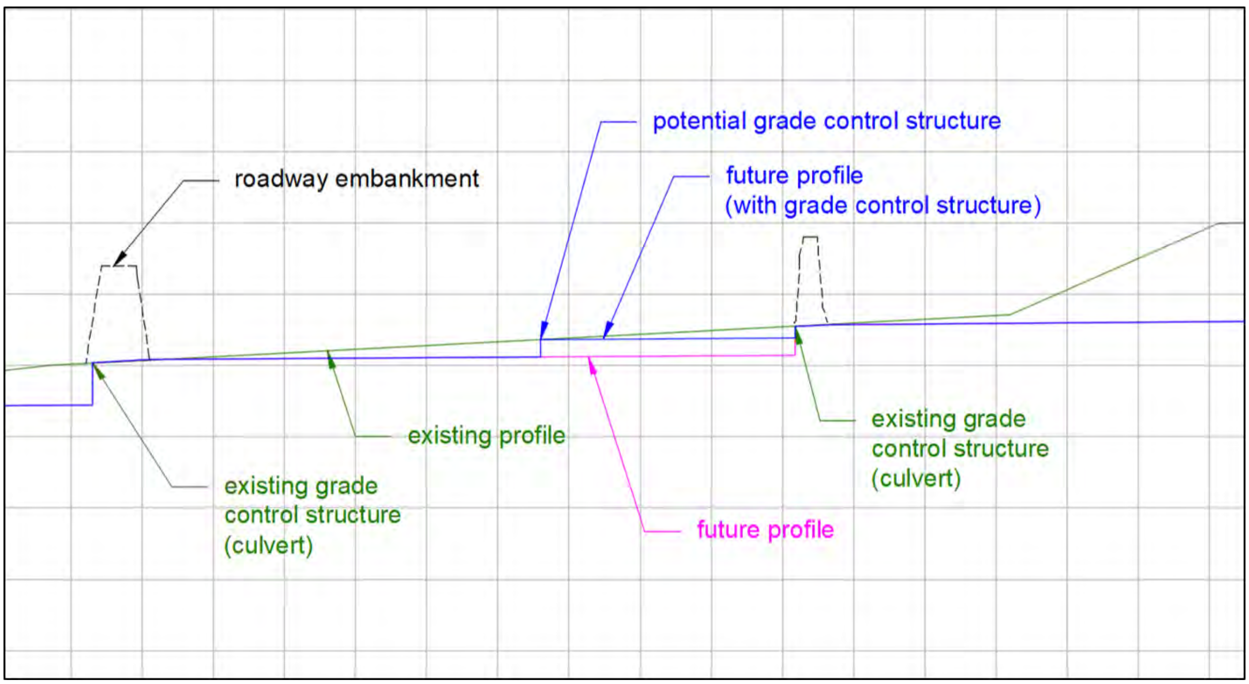
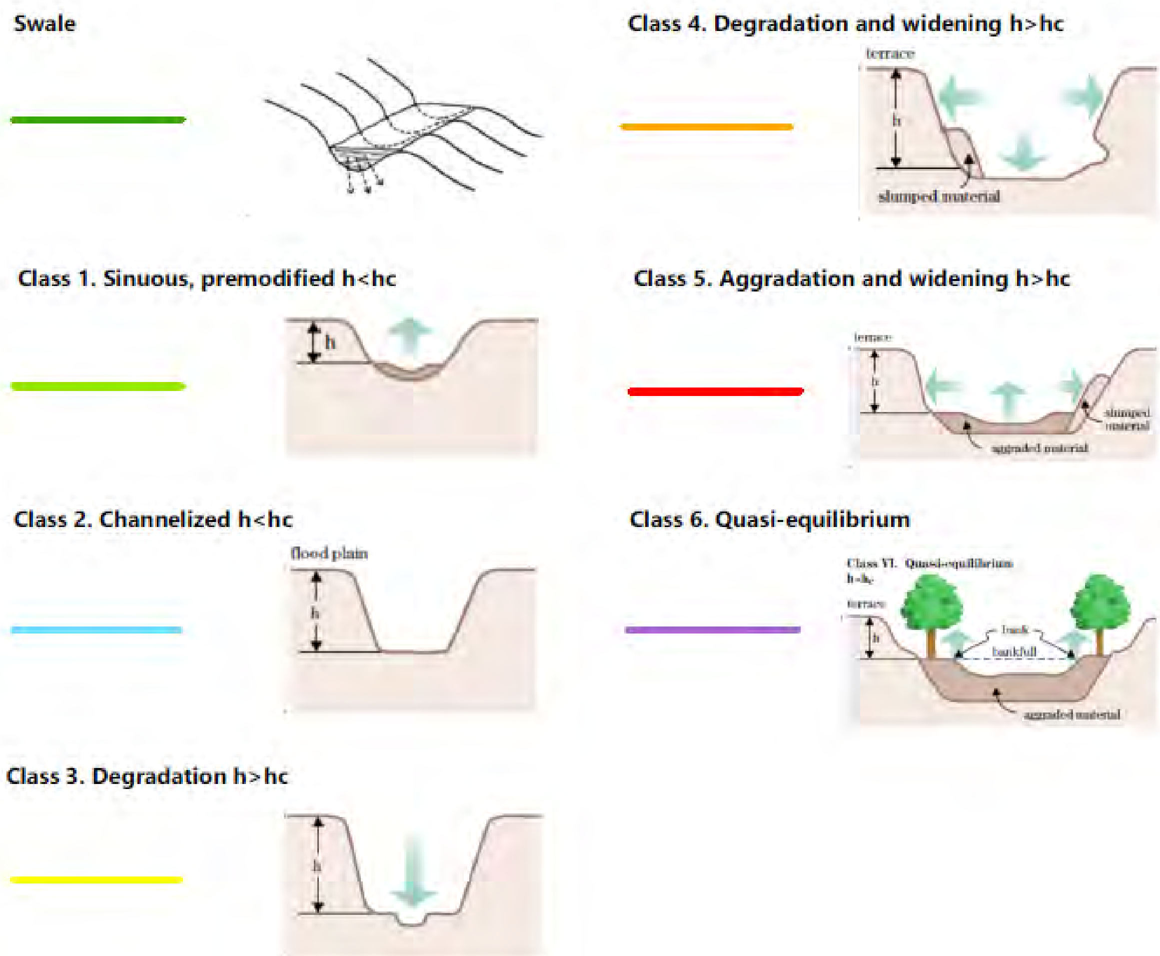


Figure 7.6. Assessing Potential Future Stream Profiles

7.4 Channel Evolution Model

The continual stream process of destabilizing and then moving towards dynamic equilibrium (or relative stability) has been described and characterized through a sequence of channel forms by many researchers in fluvial geomorphology and has been termed the 'channel evolution model' (CEM) (Figure 7.7). Conditions within the study area, including soil characteristics described above, lend to easily degraded streams and therefore Class 3 and Class 4 streams are prevalent in many reaches within the study area. A detailed description of each phase is included in Appendix D. Figures showing the CEMs within the watershed are included in Figures 7.8-7.10.

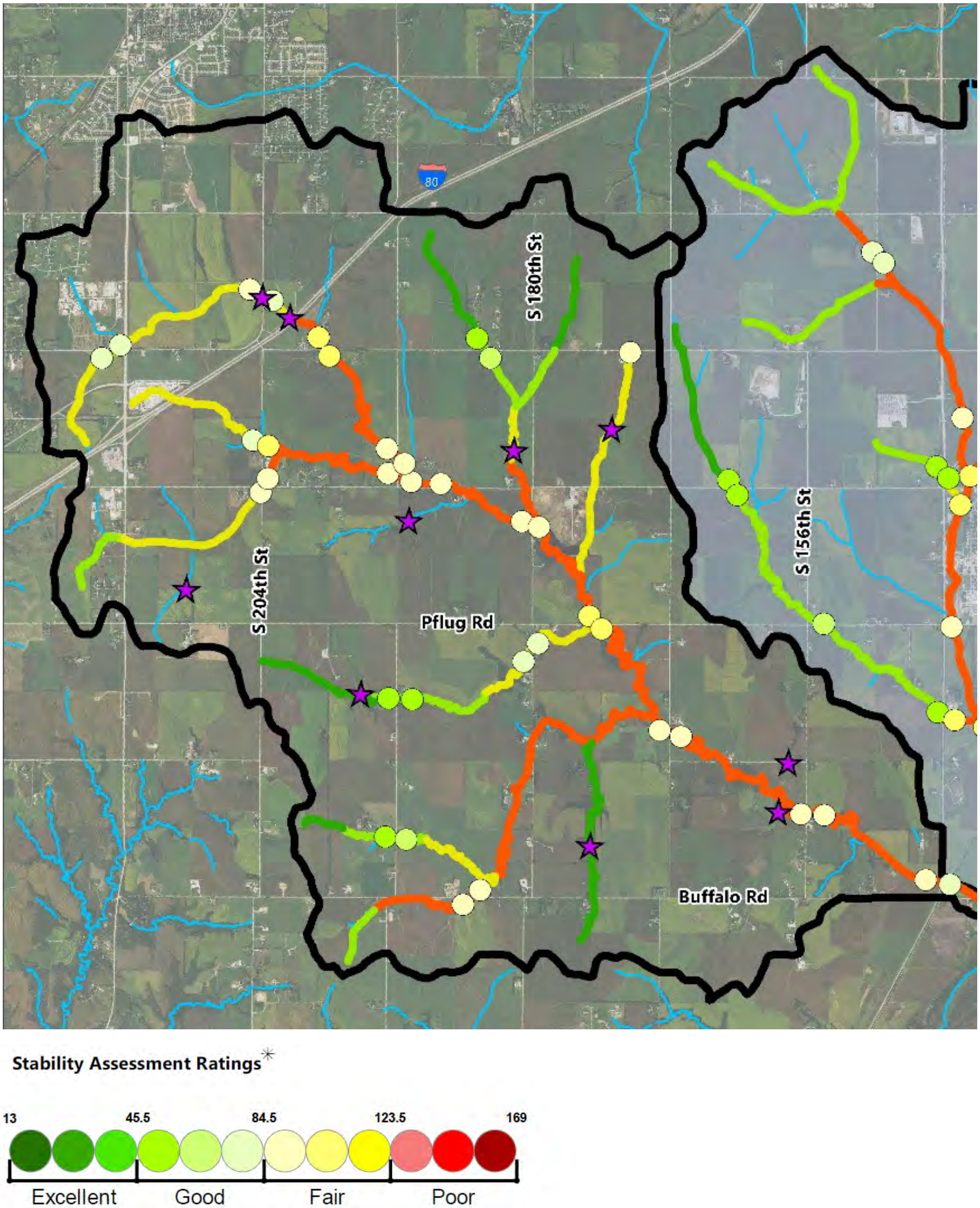


Source: Adapted from NRCS, 2010 and Simon.

Figure 7.7. Phases of the Channel Evolution Model and Symbology

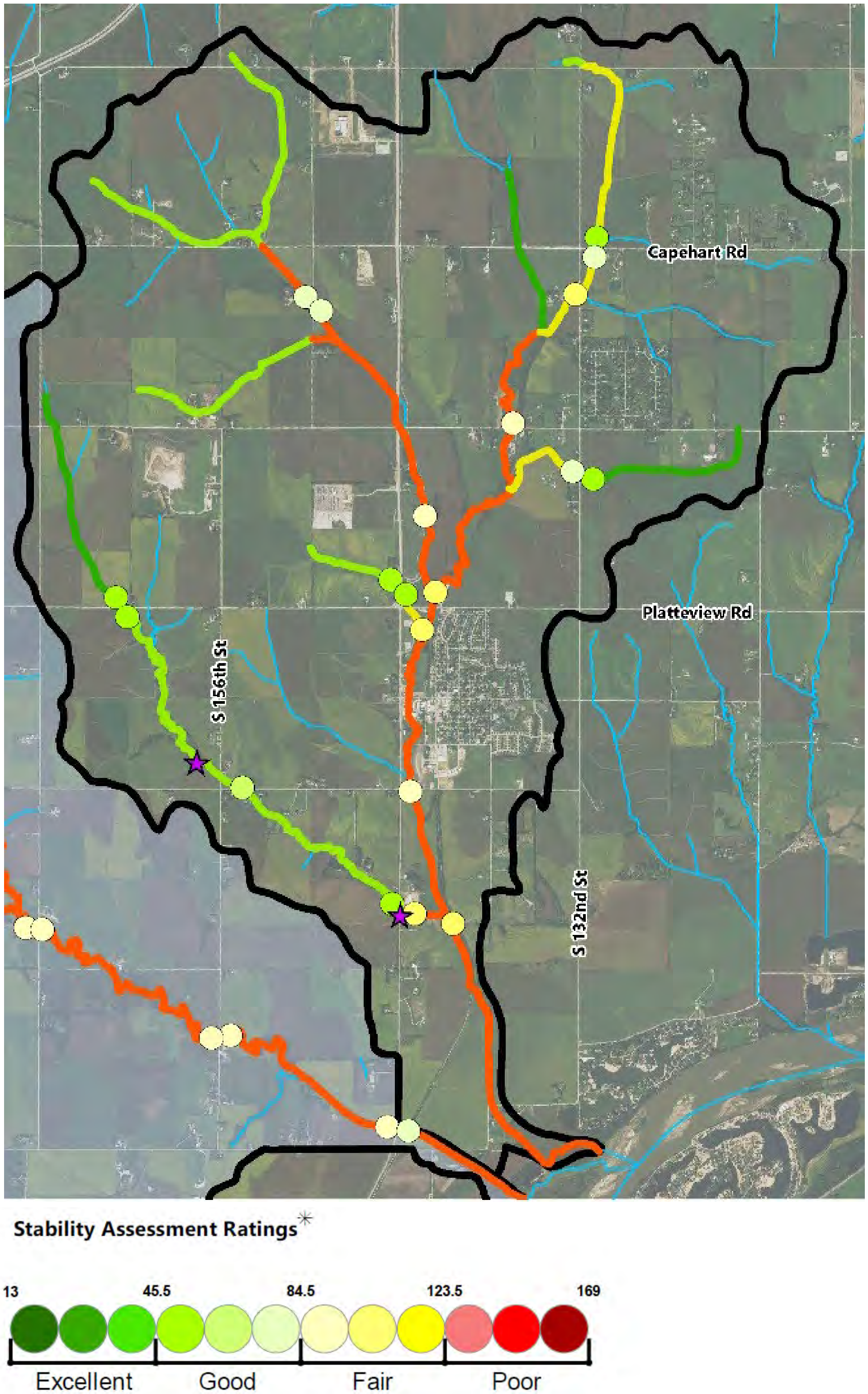
7.5 Rapid Field Assessment

A field inventory stream assessment was conducted by FYRA Engineering and Vireo in May 2018 to assess current stream conditions and the CEMs. The stream assessment had multiple goals relating to assessing and quantifying existing conditions and predicting potential future conditions. Stream assessment locations were limited to areas with public access and therefore most stream assessment locations were located at culverts and bridges where access was available on public road crossings. Aerial images, LiDAR, and existing infrastructure information were analyzed with Vireo staff prior to the field reconnaissance to select priority areas to assess and that would offer stream view accessibility from public roads. Figures showing assessment locations are included in Appendix D. FYRA utilized the stability indicators collected in the field analysis and the Federal Highway Administration (FHWA) 2006 Method (FHWA, 2006) to calculate a stream stability assessment score at each location. The results of this analysis are given in detail in Appendix D and are included in Figures 7.8-7.10.



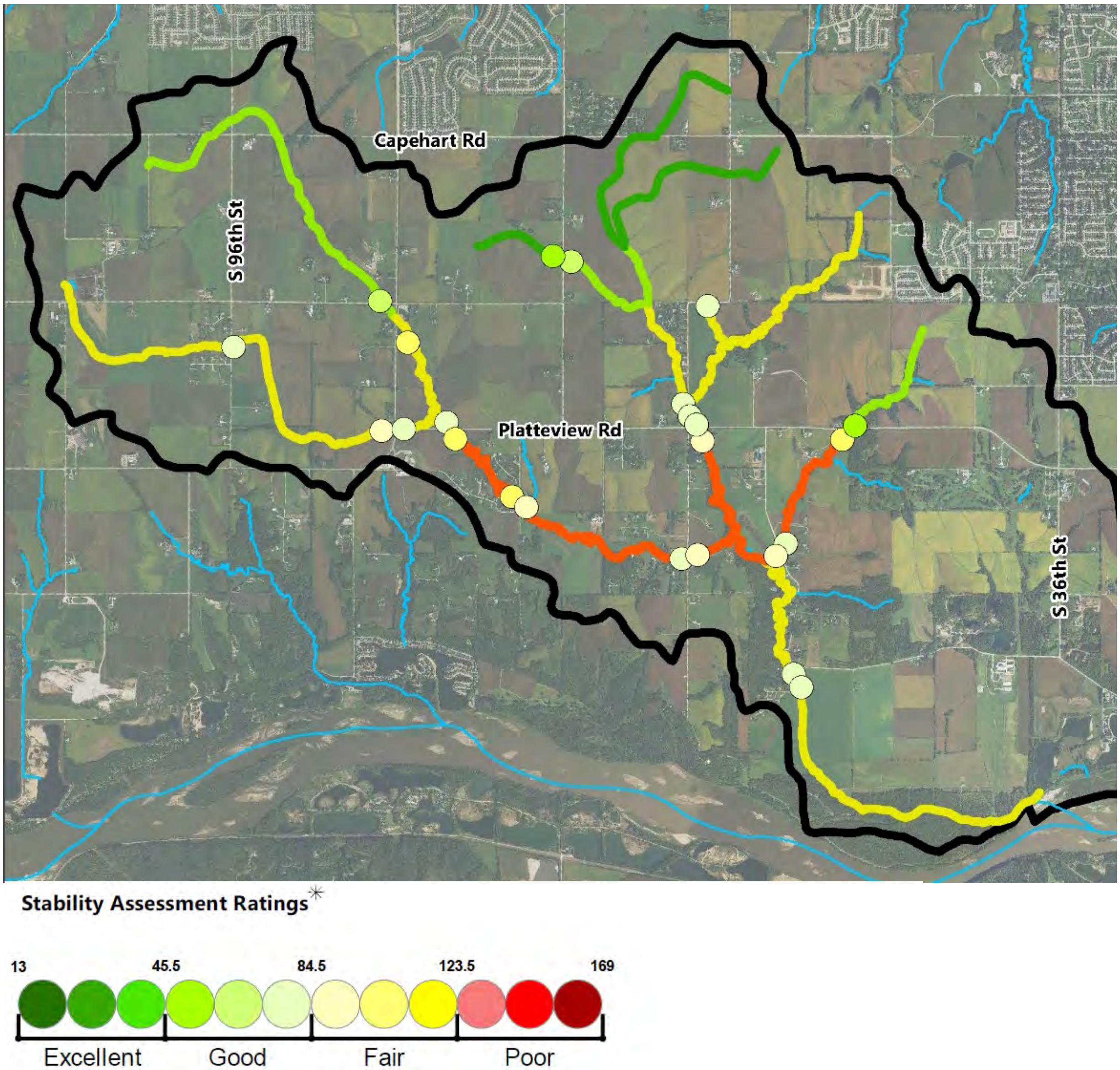
* Based on Thorne. "Geomorphological river channel reconnaissance for river analysis, engineering, and management." (1996) and Montgomery and Macdonald "Diagnostic approach to stream channel assessment and monitoring." (2002).

Figure 7.8. Stream Assessment in Buffalo Creek Basin



* Based on Thorne. "Geomorphological river channel reconnaissance for river analysis, engineering, and management." (1996) and Montgomery and Macdonald "Diagnostic approach to stream channel assessment and monitoring." (2002).

Figure 7.9. Stream Assessment in Springfield Creek Basin



* Based on Thorne. "Geomorphological river channel reconnaissance for river analysis, engineering, and management." (1996) and Montgomery and Macdonald "Diagnostic approach to stream channel assessment and monitoring." (2002).

Figure 7.10. Stream Assessment in Zwiebel Creek Basin

8.0 WATERSHED MANAGEMENT PLAN

8.1 Introduction

The components of the watershed management plan include actionable items that entities developing or making improvements within the watershed are required to follow. All projects and policies are clearly defined and documented so that the expectations are clear. To develop the final recommendations, a review of the interim policies was performed to determine if Partnership goals are currently being met or if there were stakeholder concerns with any of the policies. For interim policies deemed potentially insufficient or concerns were identified, an alternatives analysis was performed to assess additional options for projects and/or policies that would satisfy the Partnership's interests. The Partnership used the results of this analysis to guide the development of the final recommendations included in the Plan.

8.2 Policy Assessment

The following steps were taken to complete a review of the interim policies:

1. Review policies and modify language as necessary to provide clarity and remove non-essential actions/requirements while ensuring policy intent remains unchanged.
2. Identify concerns that would deem a policy insufficient or unsatisfactory based on Partnership or stakeholder feedback.
3. Advance insufficient/unsatisfactory policies into an alternatives analysis.

Through a series of iterations, the Partnership proposed modifications to the policy language to create a more simplified document that focuses on the important, actionable items each policy aims to achieve. Modifications to language that created new allowances within the policies included allowing passive recreation within the outer 30' of the stream setback and allowing overlap of utility easements within the outer 15' of the stream setback. These two items were added to help reduce the total area within a plat that cannot be placed into lots. This addresses developer concerns with return on investments that can cause potential increases in lot prices and the impact on affordable housing.

The Partnership and stakeholders identified concerns that could not be addressed with changes in language with the Peak Flow Management (formerly Peak Flow Reduction) and Stream Corridor Preservation (formerly Landscape Preservation, Restoration, and Conservation) policies, and these are listed in Table 8.1. These policy groups were advanced into a more detailed alternatives analysis to identify and assess potential policies and projects to address the identified concerns identified.

Table 8.1. Interim Policies Advanced to Alternatives Analysis

Policy Group	SSWP Interim Policy	Identified Concern
2. Peak Flow Management*	Maintain or reduce 2, 10, and 100-year storms peak flows on all developments.	• All detention occurring on individual developments; consider regional detention structures. • Concerns with potentially large land requirements dedicated to the detention of the 100-yr event.
3. Stream Corridor Preservation*	Dedicate a stream setback (3:1 plus 50 ft.) along all streams.	• Future degradation is not accounted for, which could increase setback area.

**Policy Group name revised during Step 1*

8.3 Alternatives Analysis

Although there may be some secondary benefits that would apply to both policy groups, the alternatives analyses for Peak Flow Management and Stream Corridor Preservation were handled separately to identify and assess potential solutions.

8.3.1 Peak Flow Management

The Peak Flow Management policy group is intended to help accomplish goals of both floodplain management and protection of streams. Peak discharge rates will increase corresponding to development due to the increase in impervious surfaces that will create more overland runoff and alter hydrology. Maintaining existing peak flow rates after land has been developed will help prevent increases in floodplain area and prevent increases in velocities that would accelerate erosion and stream degradation. This can be achieved by implementing structural controls designed for a no-net increase in the runoff rate. The most common approach is to hold runoff in detention basins and release slowly through properly designed outlet structures that will not exceed pre-construction rates. This also creates a longer duration hydrograph due to the increased runoff volume from new developments that must be released at existing rates. This is shown in Figure 8.1 in addition to the un-modified pre- and post-development hydrographs.

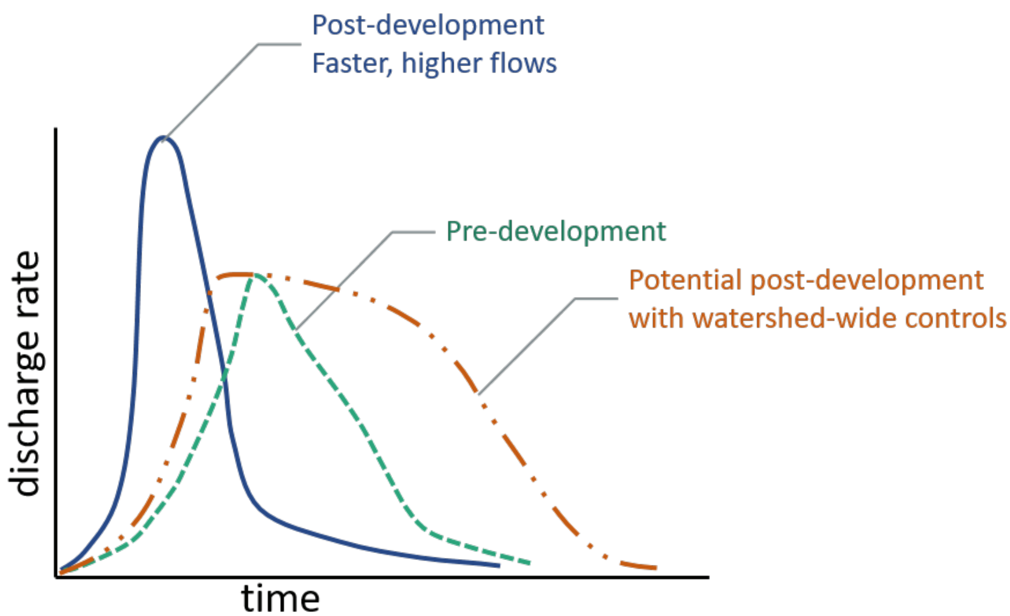


Figure 8.1. Example Existing, Future, and Future with Controls Hydrographs

The interim policy requirement is to maintain or reduce peak discharge rates with controls placed on each individual development. The Partnership wanted to further investigate:

1. Where is the best location for controls (on-site, regional or hybrid)?
2. What storm frequency should be controlled?

Location

Detention basins can be implemented within individual developments (on-site controls) or on a regional scale. Regional controls refer to management of stormwater on a broader geographic scale. This consists of larger structures in the watershed that would control the runoff from the drainage area above with a single structure, rather than several individual structures on each developed property. The interim policy relied solely on on-site controls as a requirement for the developer to include on each new plat until peak flow management on a regional basis could be investigated as part of this Plan and final recommendation developed. To implement regional controls, the Partnership would need to identify feasible locations, obtain land; and lead the design, permitting and construction of regional structures.

One consideration of on-site controls compared to regional detention is the location where the benefits are realized throughout the watershed. On-site controls are designed and measured for each discharge point from an individual development. These controls provide consistent coverage of runoff through storm sewers, overland drainage paths, and tributaries throughout watershed. Regional detention structures are located on larger tributaries that keep peak flow rates on the main stream segments within the pre-development rates. This allows increases in runoff through the uplands and tributaries, and the peaks are only mitigated along the main stems. Regional controls are highly suitable for preventing increases in floodplain area along major stream corridors, but do not prevent reductions in the overland runoff volume or provide protection for storm sewer collection systems, overland drainage paths, and tributaries that are susceptible to increased degradation with development. Therefore, the regional detention analysis focuses on floodplain management and maintaining the 100-yr peak flow rates.

The Peak Flow Management assessment in Appendix E identified potential alternatives and feasible project locations. To compare regional detention alternatives, peak flows were analyzed at 'comparison nodes' within each basin boundary as shown in Figure 8.2.

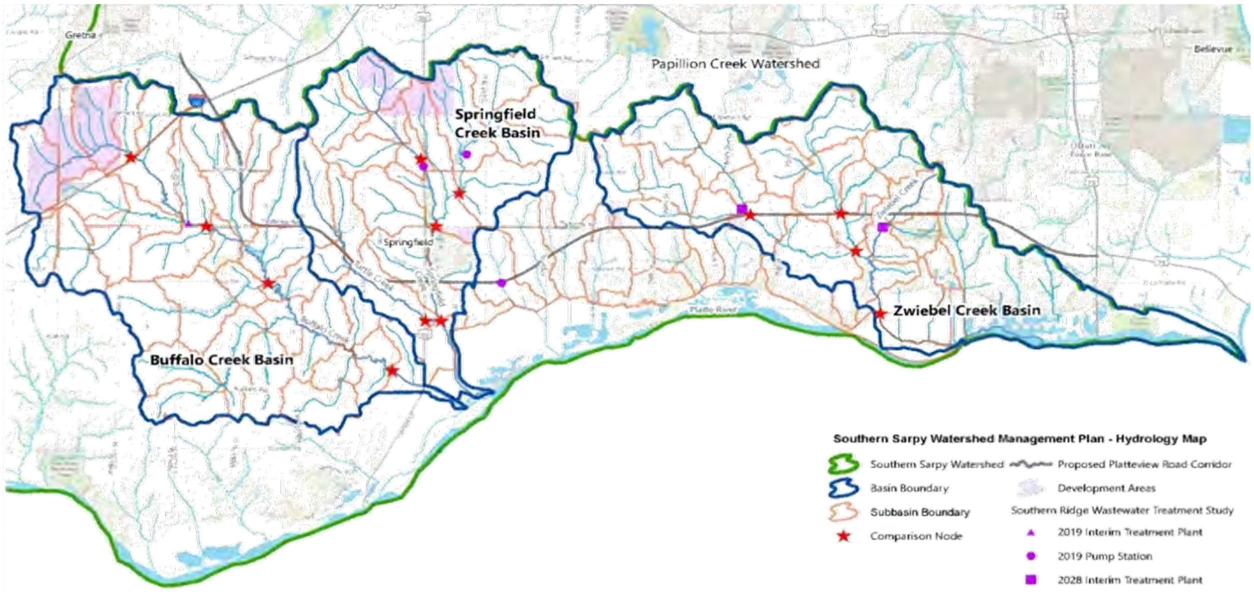


Figure 8.2. Comparison Node Locations

Potential alternatives included regional detention, linear corridor storage, and on-site controls. Feasible locations for regional and linear corridor storage sites were assessed with consideration to existing infrastructure (homes, roads, utilities, etc.), topography, known future development locations (approved plats), and existing land use. Existing, future, and future with projects peak flows were modeled for all potential alternatives identified. A prioritization and site selection methodology was developed that determined the preferred combination of structures that prevent increases in peak flow rates at comparison nodes. These are summarized in Table 8.2 and details of these results are included in Appendix E.

Table 8.2. Preferred Regional Detention Structures

Watershed	Regional Detention Basins Sites	Linear Corridor Storage Sites
Springfield Creek	SC-2, SC-9	LCS-S3, S5, S6, S7, S8
Zwiebel Creek	ZC-6	LCS-Z1, Z3
Buffalo Creek	BC-4	LCS-B1, B2, B5, B7, B8, B9, B11, B12
Total # of Sites	4	15

Modeling of existing and future floodplain area was performed to map the extents of how the floodplain area would increase with a fully developed watershed without any controls (no action alternative) in place, see Appendix G. It is assumed that the existing floodplain area does not increase (or is minimal) with the structural controls in place because peak flow discharges remain the same. It is prudent to compare the increase in future floodplain land area with the land required to implement controls to prevent the expansion. Several plats submitted under the interim policy that included 100-yr on-site detention were analyzed to understand the land requirements. On average, 5% of the site was dedicated to detention. With approximately 30,000 acres of land to develop within the watershed, this would equate to around 1,500 total acres dedicated to detaining the 100-yr peak flow increases. Table 8.3 summarizes the land required to implement the regional controls identified above compared to future floodplain area increases without any controls. This indicates over three times the amount of land to implement regional controls than the actual increase in future floodplain area.

Table 8.3. Regional Detention Land Comparison

Watershed	Total Regional Detention Land Requirement (ac)	Future Floodplain Area Increase (ac)
Springfield Creek	109.7	51.1
Zwiebel Creek	109.7	13.1
Buffalo Creek	218.3	76.7
Total	**437.7**	**140.9**

Storm Frequency

Preventing increases in peak flows is also important for future stream stability. By maintaining discharge rates, this prevents increases in stream power and does not accelerate the rate at which the channel bed can be expected to degrade. By limiting the channel bed degradation, the rate at which the channel banks will be expected to fail due to slope instability (steepness) will also decrease. More frequent events (2- and 10-yr) that experience velocities above 3-4 ft per second in the channel contribute to stream erosion and degradation with the soil types in the watershed. Maintaining or reducing discharge rates for these more frequent runoff events will help with maintaining stream stability. Furthermore, the elongation of the runoff hydrograph has potential to cause an increase in bank instability due to increased saturation time and depth if large volumes are detained. Detention of larger volumes (associated with larger events such as the 100-yr requirement) create long duration outflows that allow more time for soil saturation that results in massive bank failure and channel widening.

Conclusions

The information above was used to develop the following decisions and conclusions amongst the Partnership:

- Regional detention controls for preventing increases in floodplain area will not be recommended as the structures require more land than the no action alternative.
- Controls to provide stream stability must be widespread throughout the watershed to provide protection to all drainageways and tributaries that are susceptible to degradation. This requires on-site controls and not regionalizing the locations and associated benefits.
- The focus for peak flow management will be stream protection. These should include more frequent, high velocity events that are the main driver of stream erosion and not the larger events

that could have potential negative impacts associated with long duration hydrographs. This removes the requirement to maintain peak flow increases from the 100-yr storm event.

- In conclusions, the Peak Flow Management policy shall require on-site controls that maintain the peak flow discharge rate for the 2- and 10-yr storm events.
- Partnership to continue to coordinate on how to address floodplain increases with development and preventing development in future floodplain.

8.3.2 Stream Corridor Preservation

Stream setbacks are determined from existing conditions with the interim policy. Previous experience in the Papillion Creek watershed has identified a shortfall with this approach because it does not account for future stream degradation. Based on the method in which the setback areas are calculated, the deeper the channel, the wider the setback needs to be. A stream that degrades in the future and becomes deeper will not maintain a sufficient setback distance from the stream bank when established using the interim policy. Setback areas were mapped based on existing conditions and estimated future, degraded depths for main stream segments for comparative purposes. These maps are located in Appendix G but are not to be used to for establishing setbacks during the development of plat, and setbacks are not limited to the mapped stream segments.

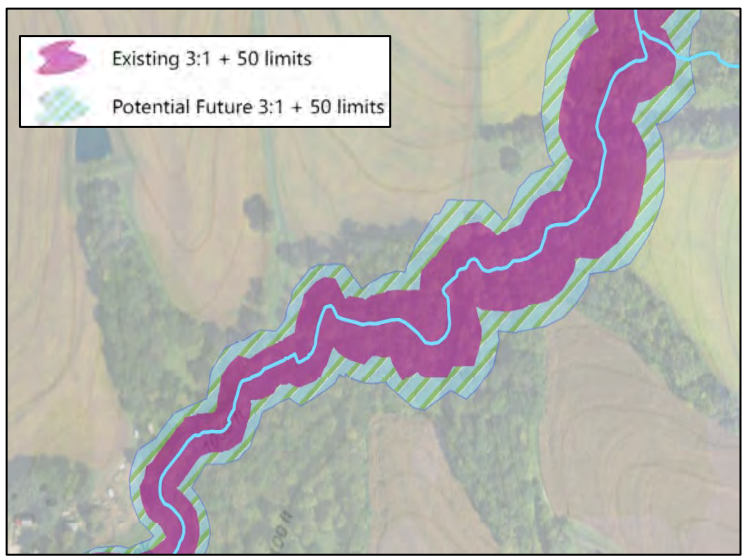


Figure 8.3. Example Stream Setback

Peak flow management will help with preventing conditions from becoming more erosive, but as can be seen in the existing stream assessments, streams are experiencing degradation under existing conditions and will continue to do so. The Partnership was interested in pursuing alternatives to prevent or minimize future degradation. The goal is not to perform stream restoration but to investigate approaches to prevent continued degradation. This will prevent damage to infrastructure and the loss of property, avoiding the need for future repair or restoration projects. Once development is in place, there are numerous complications for implementing a project on the stream, including site access and sufficient land requirements. The Partnership agrees it would be in the public's best interest to keep degradation under control. Preventing substantial future degradation can be achieved with in-stream grade control structures. With this approach, grade controls are not intended to raise the stream grade but to pin the streambed at the existing elevation at the location of the structure. It is understood that degradation will be experienced between structures, but grade control structures will be placed in series that are designed to account for the estimated degradation from the downstream hard point.

The Partnership agreed that grade control structures should be implemented and placed at locations that allows no more than four feet of degradation along the streambed. This limit was established as the maximum height of a grade control structure that is acceptable from a safety standpoint for instream vertical drops. Appendix F summarizes a detailed stream stability analysis of the structures that would be required for the streams in the watershed to meet this goal. Additionally, the only community located downstream of the anticipated development in the headwaters of the watershed is the City of Springfield. Existing infrastructure and private improvements are already located within what would be the stream setback limits. Development upstream increases potential for erosion on streams that are already experiencing significant bank loss and widening under existing conditions, and the area that is not setback sufficiently from the stream is at higher risk for damage. Areas along Springfield Creek though the City of Springfield were assessed and discussed in Appendix F. Based on this information, the Partnership agree to recommended site-specific channel stabilization project along this stream segment.

The largest challenge with this approach is the implementation of the structures. Prior to development, land would not be owned by anyone with resources or requirements to stabilize grades. Land would have to be purchased along miles of stream ahead of time and pursued as an entirely separate project. Alternatively, the structures could be designed and implemented with development. This provides efficiencies in the effort and cost effectiveness of a single design and permitting package, as well as having one construction contract to cover all aspects of work on site. The Partnership could lead the design, permitting, and construction efforts, or place these requirements on the developer similar to implementing peak flow management controls through policies.

Conclusions

The information above was used to develop the following decisions and conclusions amongst the Partnership:

- The interim policy will not be modified and still require a dedicated stream setback of 3:1 plus 50 ft along all streams.
- Grade control structures shall be implemented to minimize stream degradation and a channel stabilization project shall be implemented through the City of Springfield.
- Grade controls are to be installed at the time of development and incorporated into plats as the responsibility of the developer. Special circumstances may require grade controls to be Partnership led and will be identified with each five-year implementation plan.
- A guidance document will be developed that will provide direction and requirements for developers on the implementation of grade control structures.
- Costs for construction will be 100% reimbursed by the Partnership if implemented according to the guidance document.
- The Stormwater Financing Policy shall be updated to reflect the grade control construction cost reimbursement.

8.4 Stakeholder Engagement

Partnership meetings were held monthly (with adjustments as needed) from May 2017 through June 2024. Discussions were held between Partners regarding project goals, alternatives analysis, modifications to policy language and requirements, and making decisions for the Plan. Agency correspondence regarding permitting requirements was conducted over the planning period. In conjunction with the PCWP, the United States Army Corps of Engineers (USACE) was consulted to provide input on the development of permitting procedures to guide implementation of grade controls structures in streams. This information will be included in the guidance documentation.

The development community will be most greatly impacted by the recommendations in this Plan, therefore the Partners wanted to perform outreach targeted specifically at developers. This included local development companies, engineers, architects, and lawyers hired to work on development projects. A series of two meetings were held for the development community. The initial meeting was held in June 2023, where Partners presented proposed policy modifications, and a draft of the project recommendations and responsibilities for implementation. Supporting materials and follow up questions and answers from this meeting are located in Appendix H. Information and feedback received at this meeting was incorporated to help finalize the recommended policies and projects. The second meeting (February 2024) was used to review a draft of the guidance document being developed to assist developers through the implementation of grade control structures. Feedback received was used for finalizing the document.

8.5 Final Plan Recommendations

The Plan components focus on protecting stream stability with projects and policies. A figure summarizing the projects and key policies is included in Appendix I.

8.5.1 Projects

Grade controls structures on all streams with a 0.5 mi^2 drainage area and a specialized channel stabilization through the City of Springfield have been identified as projects to be implemented as part of the Plan. The Partnership will lead the implementation of the Springfield channel stabilization and any stream segment that was platted prior to adoption of this Plan. The remaining stream projects segments shall have grade controls implemented by the developer. This has been included as a requirement through the Stream Corridor Preservation policy and the reimbursement of construction costs has been included in the Stormwater Management Financing policy. The Grade Control Implementation Guidance Document is located in Appendix J that developers are required to use for the implementation of grade control structures.

8.5.2 Policies

Key points of the final policies are summarized in Table 8.4 and the full policy document is included in Appendix I.

Table 8.4. Final SSWP Policies

Policy Group	Modification	SSWP Policy Requirements
7. Water Quality Improvement	None.	Retain first ½” of runoff and maintain peak flow rate from 2-year storm.
8. Peak Flow Management*	Remove 100-yr requirement.	Maintain or reduce the 2- and 10-year storms peak discharge rates on all developments.
9. Stream Corridor Preservation*	Allow passive recreation within the outer 30' of the setback. Allow outer 15' of setback to overlap with utility easements, subject to local jurisdiction approval. Require grade control for of all streams with a drainage area greater than 0.5 mi^2.	Dedicate a stream setback of 3:1 plus 50 ft along all streams. The outer 30 ft of the setback area may be used for passive recreation and the outer 15' may overlap with utility easements, subject to local jurisdiction approval. Construction of grade control structures is required in all streams with a drainage area greater than 0.5 mi^2.
10. Erosion & Sediment Control and BMPs	None.	Comply with state and federal regulatory requirements, including the adoption of the Omaha Regional Stormwater Design Manual.
11. Floodplain Management	None.	25% floodway fringe fill limitation unless approved mitigation measures are implemented. Where no FEMA flood area defined, must provide buildout base flood delineations.
12. Stormwater Management Financing	Cost of grade control construction on private developments will be reimbursed by the Partnership.	A Watershed Management Fee system shall be established to equitably distribute the capital cost of implementing the Plan. Grade control structure construction cost to be reimbursed by the Partnership.

**Policy Group name revised from interim policies included in the Interlocal Agreement*

8.6 Financing

The costs associated with implementing the Plan were investigated to guide the financial feasibility of the recommended project components. Watershed fees on all developments are required by each jurisdiction in the Partnership per the Stormwater Management Financing policy. The rates included in the Interlocal Agreement are listed in Table 8.5 and will be revisited every five years. High level cost estimating for projects to be funded by the Partnership was performed as well as projections of anticipated fees. All cost assessments were performed in 2022 dollars. This analysis was used to determine if sufficient funds would be collected to cover project costs. No detailed projections on the timing in which the fees would be collected was performed, as this is heavily dependent upon future sanitary sewer installation phasing that was being developed during the development of this Plan.

Table 8.5. Watershed Fee Schedule from Interlocal Agreement

Fee Category	FY 2025 July 1, 2024- June 30, 2025	FY 2026 July 1, 2025- June 30, 2026	FY 2027 July 1, 2026- June 30, 2027	FY 2028 July 1, 2027 June 30, 2028	FY 2029 July 1, 2028 June 30, 2029
Single Family Residential per dwelling unit (also includes low-density multi-family up to 4-plexes)	$1,058	$1,090	$1,122	$1,156	$1,191
High-Density Multi-Family Residential per gross acre (beyond 4-plexes)	$4,656	$4,795	$4,939	$5,087	$5,240
Commercial/Industrial/Institutional per gross acre	$5,642	$5,812	$5,986	$6,166	$6,351

Watershed fee collection estimates were developed by performing an assessment of the changes in land use once full buildout is complete. A comparison of existing land use to future land use provides an estimated change in land use area where fees will be collected. The Sarpy County and Cities Wastewater Agency (SCCWWA) has studied the watershed to understand the future needs for the wastewater system and estimate taxed based revenues to support the infrastructure. Their studies assumed 60% of residential area will be placed into taxable parcels, and this same assumption was applied to estimate the future developable area. Fee rates were applied to the respective land use to estimate the total watershed fees anticipated with full buildout, see Table 8.6.

Table 8.6. Land Use Change and Watershed Fee Collection Summary

Land Use	Pre-Development Area (acres)	Future Area (acres)	Area Change (acres)	Future Developable Area (acres)	2022 Fee Rate ($/acre)	Estimated Watershed Fees
Commercial/ Industrial	710	4,190	3,480	3,480	$5,220	$18,165,600
Residential*	1,450	27,200	25,750	15,450	$3,540	$54,693,000
Total	2,160	31,390	29,230	18,930	---	**$72,858,600**

Assumes 60% of area within a plat are 'developable' acres subject to lot level fees consistent with SCCWWA

Project costs were developed for the structures identified in Appendix F -Stream Stability Management. These were estimated prior to the development of various templates included in the Grade Control Implementation Guidance Document (Appendix J), and only reflect the design template included in the Stream Stability Management appendix. There will be cost variances upon implementation, but the order of magnitude for planning purposes was assumed sufficient. It is understood that road crossings implemented with developments will provide grade controls and the number of structures will reduce, but it is unknown how those will be placed within individual parcels. Therefore, a conservative estimate was developed that did not account for the reduction in the number of required grade controls that will occur with future road crossings. Additionally, design and permitting services land rights purchase were included if the need arose to implement projects prior to development. Additional costs that are covered by the Partnership include MS4 permitting assistance, annual SWPPP inspections, and Plan updates. All costs are summarized in Table 8.7.

Table 8.7. Partnership Costs (2022 Dollars)

Project Type	Design and Permitting	Land Rights	Construction	Total
Grade Control Structures	$7,729,000	$2,932,000	$38,645,000	$49,306,000
Bank Protection	$1,569,000	$357,500	$7,844,000	$9,770,500
Annual MS4 and Partnership Planning*	$7,000,000	---	---	$7,000,000
Total	$9,298,000	$3,289,500	$46,489,000	**$66,076,500**

**Annual MS4 and Partnership Planning (~$350k/year over 20 years)*

The comparison of total project costs to anticipate watershed fees indicate that there should be adequate funds to implement the Plan. With the implementation approach of projects incorporated into developments, the rate in which project costs are expended will generally follow development patterns. A basic projection of cumulative costs and revenues (watershed fees) assuming a 20-yr buildout of the watershed is depicted in Figure 8.4. Fees were collected during the planning process through the interim policies, so a cash buildup was achieved that can cover project costs as development continues and watershed fees replenish the expenditures.

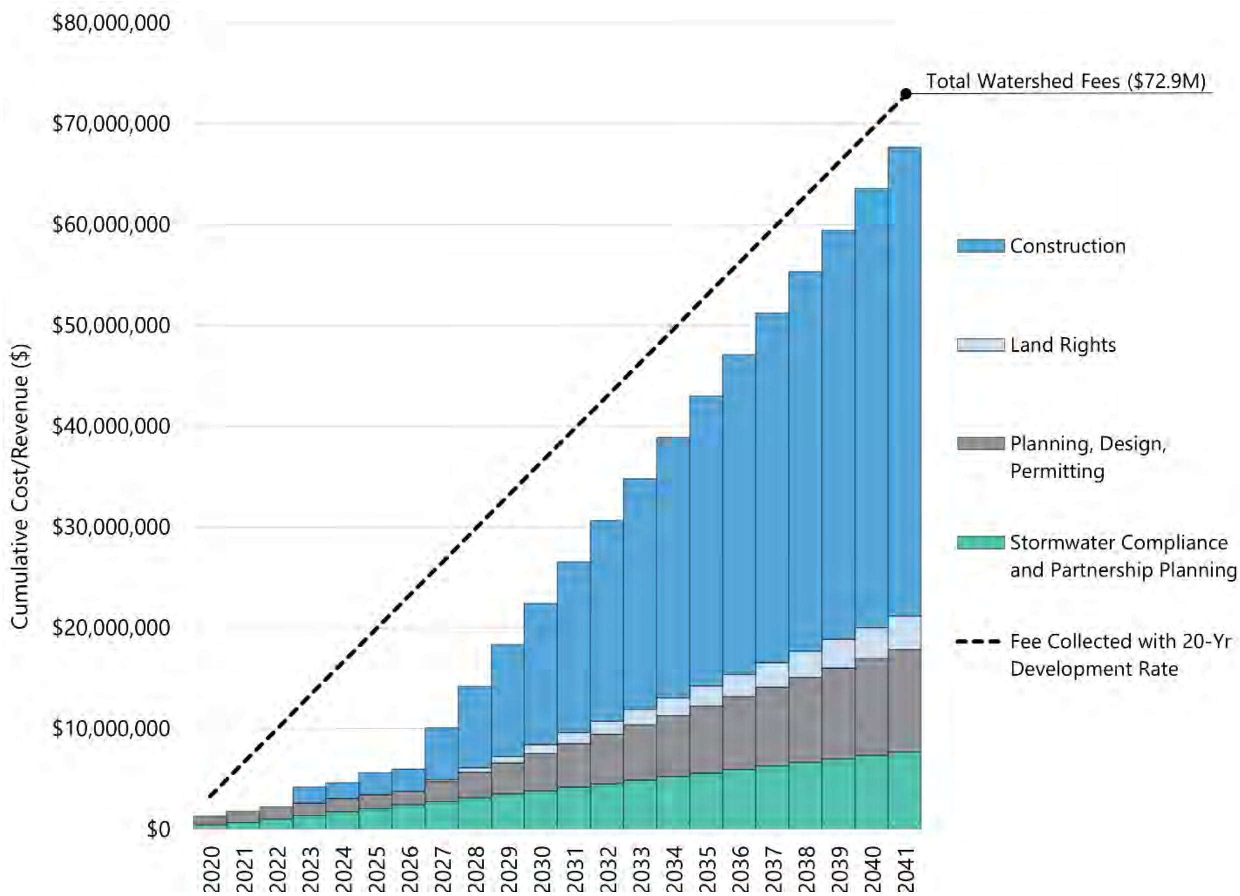


Figure 8.4. Cumulative Costs Over 20-yr Full Watershed Build-Out

9.0 FIVE-YEAR IMPLEMENTATION PLAN

The first five-year increment will be Fiscal Year (FY) 2024 through FY 2029, with each FY starting on July 1st. The SCCWWA has identified urban development zones based on the phased installation plan of the sanitary sewer systems. These areas are projected to be the first to develop, and it has been estimated for planning purposes that it will occur over a five-year period. Planned projects located within the urban development zone have been included in the five-year implementation shown in Appendix I and below. Approximately 10 miles of stream segments for grade control projects and one site-specific was project identified at Capehart Rd to the west of Highway 50 as the first projects for implementation. The site-specific project was identified due to the high-level security nature and land use of the developed parcel encompassing the downstream project segment. If the landowner is not interested in grade controls on their property, this project will be implemented to provide protection for upstream infrastructure.

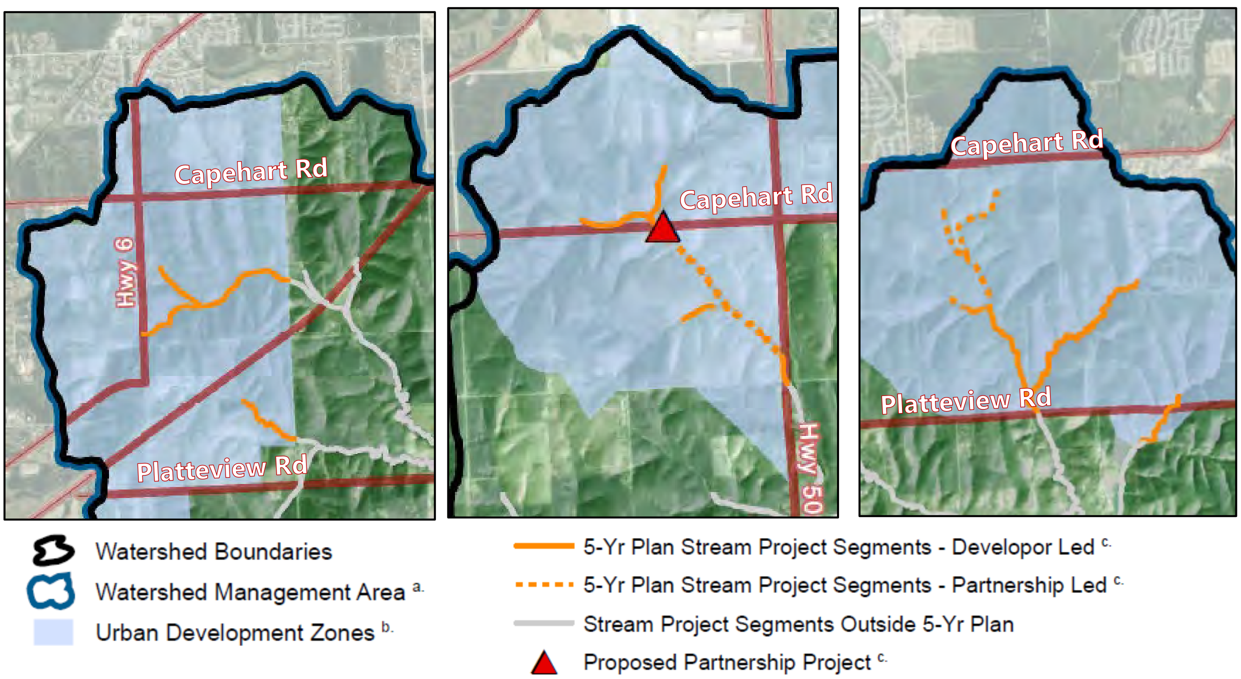


Figure 9.1. Five-Year Projects in Buffalo (left), Springfield (middle), and Zwiebel (right) Creek Basins

9.1 Responsibilities

All policies must be abided by any entity developing, implementing new infrastructure, or improving existing infrastructure within the watershed. The five-year implementation plan identifies stream projects as developer led or Partnership led. A project was selected to be Partnership led if the parcels that encompasses a stream project segment already has a plat submitted for development prior to adoption of the Plan. The stand-alone project at Capehart Rd would be Partnership led if the downstream grade controls are not implemented. The remaining stream project segments are delegated as developer led. This requires that the developer leads the planning, design, permitting, and construction of grade control structures for streams located within their development. Per the Stormwater Management Financing policy, the developer will be reimbursed for 100% of the construction costs.

9.2 Implementation Approach

Partnership led projects and developer led projects can be implemented concurrently. The rate and location of development will drive the timing of grade control structures. The Partnership will begin the process of coordinating with landowners and proceed in locations once agreements have been reached. Starting in the preliminary plat phase, developers are required to follow the procedures outlined in the Grade Control Implementation Guidance Document located in Appendix J. Local jurisdictions will not approve plats if they do not provide the information required and cost reimbursement for the construction of grade controls will not be provided if the requirements in the document are not met.

The Partnership will need to monitor the condition of streams downstream of any grade controls structures implemented that do not have protection from head cut progression greater than 4 ft. If a there is a large head cut progression that threatens a grade control project, the Partnership will have to assess the potential threat and prioritize projects to determine if additional Partnership led projects should be implemented with the funding available at the time.

9.3 Financial Requirements

The Partnership has been collecting watershed fees from development occurring in the watershed during the development of this Plan. With funds available upfront, this will allow the Partnership to provide reimbursement to developers and begin Partnership led projects. A summary of all the fees to be collected within the urban development zone are summarized in Tables 9.1.

Table 9.1. Land Use Change and Watershed Fee Collection Summary

Land Use	Pre-Development Area (acres)	Future Area (acres)	Area Change (acres)	Future Developable Area (acres)	2022 Fee Rate ($/acre)	Estimated Watershed Fees
Commercial/ Industrial	793	3,269	2,476	2,476	$5,214	$12,909,500
Residential*	524	5,381	4,857	2,914	$3,538	$10,309,500
Total	1,766	9,093	7,327	5,390	---	**$23,000,000**

**Assumes 60% of area within a plat are 'developable' acres subject to lot level fees consistent with SCCWWA*

The cost for Partnership and developer led projects located within the urban development zone is approximately $9 million. The Partnership has no control over when the developer led projects will be implemented, but Table 9.2 provides an example timeline of how project expenditures could be distributed. A comparison of watershed fees to project costs indicate funds should be sufficient to complete the planned project within the first five-year implementation period. The following timeline assumptions were used to develop the cost projections:

- Partnership led – project in platted parcels
  - 2025-2026: Oak Leaf Subdivision (Zwiebel Creek watershed)
  - 2027-2028: Facebook (Springfield Creek watershed)
- Developer led – projects remaining in unplatted parcels
  - Evenly distributed throughout five-years

Table 9.2. Five-Year Implementation Plan Costs (2022 Dollars)

Fiscal Year	Partnership Led				Developer Led	Total Plan Expenditures
	Annual MS4 + Partnership Planning	Design and Permitting	Land Rights*	Construction	Construction	
2025	$275,000	$315,300	$0	$0	$980,900	$1,571,200
2026	$275,000	$0	$0	$1,576,100	$980,900	$2,832,000
2027	$275,000	$124,000	$0	$0	$980,900	$1,379,900
2028	$350,000	$0	$0	$620,000	$980,900	$1,950,900
2029	$350,000	$0	$0	$0	$980,900	$1,330,900
TOTAL	**$1,525,000**	**$439,300**	**$0**	**$2,196,100**	**$4,904,500**	**$9,064,900**

**Assumes Partnership led projects will occur in outlots and easements granted by developer*

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Appendix A. Hydrologic Modeling

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1.0 HYDROLOGIC MODELING

Rainfall runoff analysis for the Southern Sarpy Watershed Management Plan was computed using the US Army Corps of Engineers (USACE) HEC HMS 4.2.1 modeling software (HMS). Hydrologic analysis procedures such as event infiltration, unit hydrographs, and hydrologic routing were found for a range of design storm sizes through HMS. The following sections describe the components involved in the HMS hydrologic analysis method.

1.1 Rainfall Runoff Model Construction

For future Phases of this project, there is a desire to provide hydraulic modeling to a 1 mi^2 contributing drainage area. To ensure sufficient hydrologic output to meet this modeling requirement, the drainage areas were delineated to not exceed approximately 1 mi^2 with an average drainage area nearing 0.8 mi^2. The basin delineations were determined using 2-foot elevation contours derived from the 2013 Sarpy County LiDAR. ArcMap GIS hydrology tools were used to establish an initial set of delineations which were manually altered as needed to capture specific points of interest and minimize the delineated basin size. Subbasins boundaries are mapped in Figure A.1.

ArcMap GIS hydrology tools were utilized to analyze the raster surface to determine each flow path within the watershed. The longest flow path in each basin was used to calculate the time of concentration. The flow path lines were refined in AutoCAD to match a Sarpy County 2016 Aerial.

National Oceanic and Atmospheric Administration (NOAA) Atlas 14 values were used for the 2-, 10-, 25-, 50-, and 100-year precipitation values for the HMS model. A 12-hour local thunderstorm temporal distribution was used from the recently approved Papillion Creek hydrology study (FYRA 2016). As the contributing drainage area increases, the corresponding storm size increases; for these watersheds, five different storm sizes were found to adequately cover the range of storm sizes necessary. Table A.1 shows the associated rainfall depths with the centroid of the project area.

Figure A.1 Delineated Subbasins

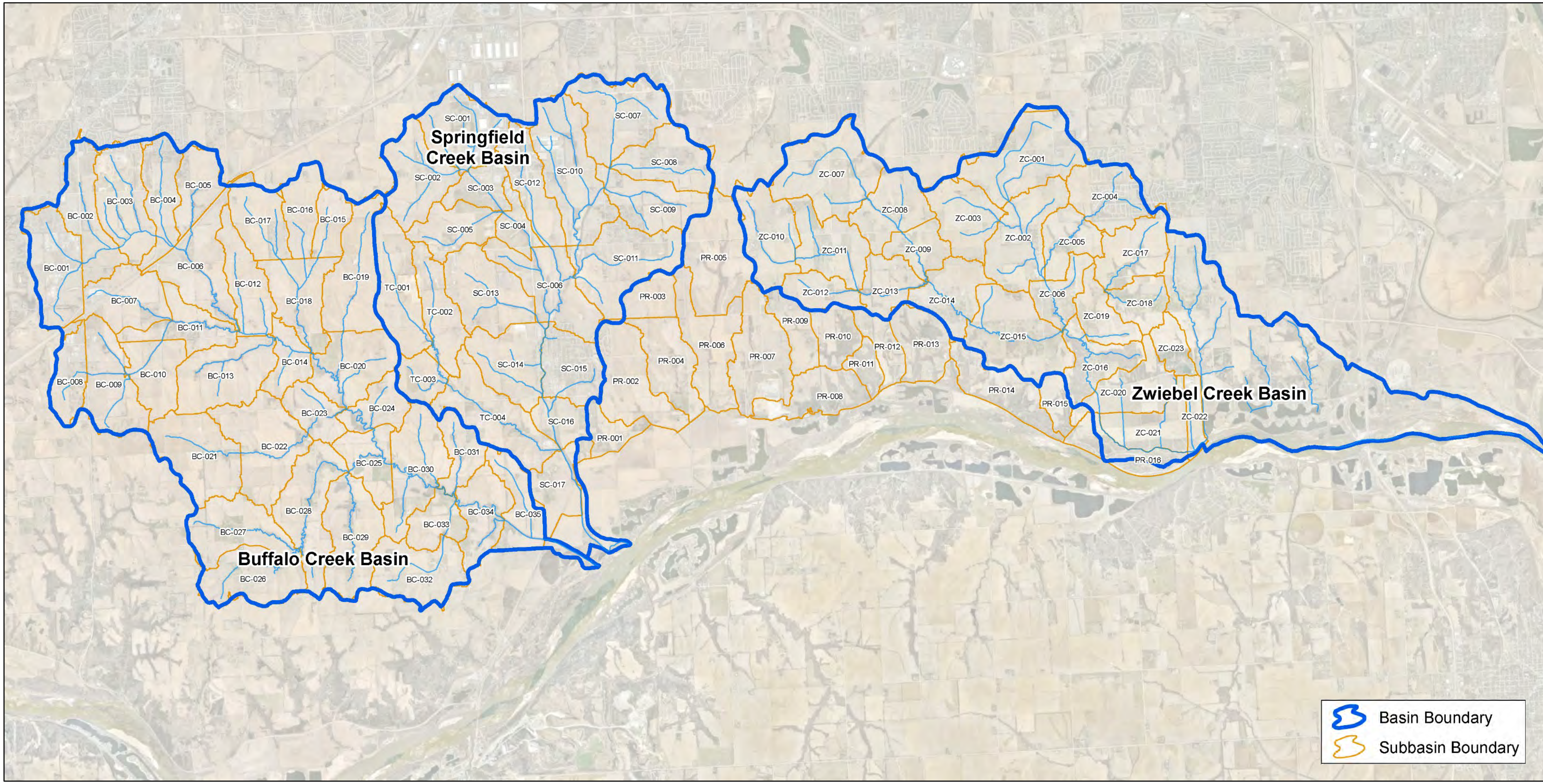

Table A.1 NOAA Rainfall Depths – Atlas 14

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.376** (0.304-0.465)	**0.444** (0.359-0.549)	**0.558** (0.449-0.691)	**0.655** (0.524-0.814)	**0.792** (0.612-1.01)	**0.900** (0.679-1.17)	**1.01** (0.736-1.34)	**1.13** (0.785-1.53)	**1.28** (0.858-1.78)	**1.40** (0.914-1.97)
10-min	**0.551** (0.446-0.681)	**0.651** (0.526-0.804)	**0.817** (0.658-1.01)	**0.959** (0.767-1.19)	**1.16** (0.897-1.49)	**1.32** (0.995-1.71)	**1.48** (1.08-1.96)	**1.65** (1.15-2.23)	**1.88** (1.26-2.60)	**2.05** (1.34-2.88)
15-min	**0.672** (0.543-0.830)	**0.793** (0.641-0.981)	**0.997** (0.802-1.24)	**1.17** (0.936-1.45)	**1.41** (1.09-1.81)	**1.61** (1.21-2.08)	**1.81** (1.32-2.39)	**2.01** (1.40-2.72)	**2.29** (1.53-3.18)	**2.51** (1.63-3.52)
30-min	**0.966** (0.782-1.19)	**1.15** (0.925-1.42)	**1.44** (1.16-1.79)	**1.70** (1.36-2.11)	**2.06** (1.59-2.63)	**2.34** (1.76-3.03)	**2.63** (1.91-3.48)	**2.93** (2.04-3.96)	**3.33** (2.23-4.62)	**3.64** (2.37-5.12)
60-min	**1.26** (1.02-1.55)	**1.50** (1.21-1.85)	**1.91** (1.54-2.37)	**2.27** (1.82-2.82)	**2.78** (2.16-3.59)	**3.20** (2.42-4.16)	**3.64** (2.65-4.83)	**4.09** (2.86-5.56)	**4.72** (3.17-6.57)	**5.22** (3.40-7.33)
2-hr	**1.55** (1.26-1.90)	**1.85** (1.51-2.27)	**2.38** (1.93-2.92)	**2.84** (2.29-3.50)	**3.51** (2.75-4.50)	**4.07** (3.10-5.26)	**4.64** (3.41-6.13)	**5.26** (3.70-7.11)	**6.12** (4.13-8.46)	**6.80** (4.46-9.48)
3-hr	**1.71** (1.40-2.09)	**2.05** (1.68-2.51)	**2.65** (2.15-3.24)	**3.18** (2.57-3.91)	**3.97** (3.13-5.09)	**4.63** (3.55-5.98)	**5.32** (3.94-7.02)	**6.07** (4.30-8.19)	**7.12** (4.84-9.82)	**7.97** (5.25-11.1)
6-hr	**2.01** (1.65-2.43)	**2.38** (1.96-2.89)	**3.07** (2.51-3.72)	**3.69** (3.01-4.50)	**4.63** (3.68-5.91)	**5.43** (4.20-6.98)	**6.28** (4.69-8.24)	**7.21** (5.15-9.68)	**8.53** (5.85-11.7)	**9.61** (6.38-13.3)
12-hr	**2.31** (1.92-2.78)	**2.70** (2.24-3.25)	**3.41** (2.82-4.12)	**4.07** (3.34-4.93)	**5.09** (4.08-6.45)	**5.95** (4.63-7.59)	**6.88** (5.17-8.96)	**7.89** (5.69-10.5)	**9.35** (6.46-12.7)	**10.5** (7.05-14.4)
24-hr	**2.64** (2.20-3.15)	**3.04** (2.53-3.62)	**3.77** (3.13-4.50)	**4.44** (3.67-5.34)	**5.49** (4.43-6.90)	**6.37** (5.01-8.08)	**7.34** (5.56-9.49)	**8.39** (6.10-11.1)	**9.90** (6.91-13.4)	**11.1** (7.52-15.2)

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

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

Please refer to NOAA Atlas 14 document for more information.

Table A.2 summarizes the storm size selected for each junction within the HEC HMS model. Due to the size of the hydrologic tables, all are included after the hydrology text. These storm sizes were selected based on 2.5:1 elliptical storm sizes and fit for each junction manually to maximize storm coverage to basin area.

1.2 Hydrologic Parameters and Channel Routing

The storage coefficient for each subbasin is used to account for storage effects as a linear reservoir. A dimensionless ratio was used to find the storage coefficient. The ratio is R/(R+Tc), where R is the storage coefficient and Tc is the time of concentration. A value of 0.52 was used for the ratio, which was procured by the USACE and utilized in the 2010 USACE Papillion Creek Hydrology Analysis. It was found by analyzing hydrographs from the Environmental Protection Agency's original 1985 Storm Water Management Model and hydrographs from the 2010 USACE Stage 1 HMS Model. Time of concentration values were calculated for existing and future conditions based on land use maps and delineated flow paths. Table A.3 summarizes the basin parameters utilized within HEC HMS.

An initial loss value of 0.8-inches and a constant rate loss value of 0.3 in/hr were used for each subbasin within the HMS model for existing and future conditions. These were assumed values based on the 2010 USACE model and preceding models. Existing and future impervious condition values were calculated based off land use categories in Table A.4 based on existing and future land use maps. Soil loss parameters are summarized in Table A.5.

The United States Geological Survey (USGS) Water-Supply Paper 2339, "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains" was used in calculating the Manning's roughness coefficient for channel routing within HMS. A Manning's roughness coefficient was found for each channel segment by comparing 2016 County Aerials to the Chow 1959 table, "Manning's n for

Channels" and a base roughness value was set with the Chow, 1959 table. Muskingum-Cunge routing method was used for the reaches. The reach lengths and average reach slopes were found using ArcMap GIS. Eight-point cross-sections were obtained in Global Mapper. If the cross-section was inconsistence along a reach, the reach was broken into two reaches by placing a junction at the transition point. Manning's roughness values and associated routing parameters are shown in Table A.6. The development assessment for Manning's 'n' values is presented in Table A.8.

1.3 Hydrologic Results

Results from the existing and future conditions rainfall-runoff analyses are presented in Table A.7.

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Table A.2: Storm Size at Junction

Junction	Drainage Area (mi2)	Storm Size (mi2)
BC-JCT-001	0.95	10
BC-JCT-002	1.78	10
BC-JCT-003	2.72	10
BC-JCT-004	3.37	10
BC-JCT-004A	3.89	10
BC-JCT-005	0.52	10
BC-JCT-006	4.85	30
BC-JCT-006B	3.89	30
BC-JCT-007	0.75	10
BC-JCT-007A	2.75	10
BC-JCT-008	0.47	10
BC-JCT-009	1.37	10
BC-JCT-010	2	10
BC-JCT-011	3.35	10
BC-JCT-011A	8.2	30
BC-JCT-011B	2.75	10
BC-JCT-012	8.89	30
BC-JCT-013	1.01	10
BC-JCT-013A	9.9	30
BC-JCT-014	12.62	30
BC-JCT-014B	9.9	30
BC-JCT-015	0.37	10
BC-JCT-016	0.5	10
BC-JCT-017	0.66	10
BC-JCT-018	2.31	10
BC-JCT-018A	1.53	10
BC-JCT-018B	0.87	10
BC-JCT-018C	1.53	10
BC-JCT-018D	1.53	10
BC-JCT-019	1	10
BC-JCT-020A	12.62	50
BC-JCT-020B	13.62	50
BC-JCT-020C	1	10
BC-JCT-020D	13.62	50
BC-JCT-021	1.04	10
BC-JCT-022	2.19	10
BC-JCT-023	2.62	10
BC-JCT-023A	17.1	50

Table A.2: Storm Size at Junction

Junction	Drainage Area (mi2)	Storm Size (mi2)
BC-JCT-024	17.54	50
BC-JCT-025	21.82	50
BC-JCT-025A	21.28	50
BC-JCT-026	0.84	10
BC-JCT-027	1.73	10
BC-JCT-028	1.02	10
BC-JCT-028A	1.73	10
BC-JCT-029	3.74	10
BC-JCT-030	22.81	50
BC-JCT-031	23.25	50
BC-JCT-032	0.89	10
BC-JCT-033	1.32	10
BC-JCT-033A	24.57	50
BC-JCT-034	25.22	50
BC-JCT-034B	24.57	50
BC-JCT-035	25.81	50
PR-JCT-001	0.31	10
PR-JCT-002	0.98	10
PR-JCT-003	0.37	10
PR-JCT-004	1.11	10
PR-JCT-004A	0.37	10
PR-JCT-005	1.09	10
PR-JCT-006	2	10
PR-JCT-007	0.99	10
PR-JCT-008	0.66	10
PR-JCT-009	0.42	10
PR-JCT-010	0.84	10
PR-JCT-011	1.07	10
PR-JCT-012	0.35	10
PR-JCT-013	0.61	10
PR-JCT-014	0.72	10
PR-JCT-015	0.25	10
SC-JCT-001	1.73	10
SC-JCT-002	0.85	10
SC-JCT-003	2.74	10
SC-JCT-004	3.05	10
SC-JCT-006	9.81	30
SC-JCT-006A	5.78	30
SC-JCT-006C	8.83	30

Table A.2: Storm Size at Junction

Junction	Drainage Area (mi2)	Storm Size (mi2)
SC-JCT-007	1.07	10
SC-JCT-008	0.77	10
SC-JCT-009	2.62	10
SC-JCT-009B	1.84	10
SC-JCT-010	3.94	10
SC-JCT-011	5.1	10
SC-JCT-011A	3.94	10
SC-JCT-012	0.68	10
SC-JCT-013	0.98	10
SC-JCT-014A	10.79	30
SC-JCT-015	12.33	30
SC-JCT-016	12.71	30
SC-JCT-016A	15.73	30
SC-JCT-017	16.31	30
TC-JCT-001	0.93	10
TC-JCT-002	1.6	10
TC-JCT-003	1.96	10
TC-JCT-004	3.02	10
TC-JCT-004B	1.96	10
ZC-JCT-001	1.18	10
ZC-JCT-002	4.19	10
ZC-JCT-002A	1.93	10
ZC-JCT-003	0.75	10
ZC-JCT-004	0.75	10
ZC-JCT-005	1.28	10
ZC-JCT-005A	3.21	10
ZC-JCT-006	4.62	30
ZC-JCT-007	1.23	10
ZC-JCT-008	1.94	10
ZC-JCT-009	2.36	10
ZC-JCT-010	0.84	10
ZC-JCT-011	1.62	10
ZC-JCT-012	2.02	10
ZC-JCT-013	4.86	10
ZC-JCT-013B	2.02	10
ZC-JCT-014	5.54	10
ZC-JCT-015	6.75	30
ZC-JCT-015A	11.37	30
ZC-JCT-016	13.59	30

Table A.2: Storm Size at Junction

Junction	Drainage Area (mi2)	Storm Size (mi2)
ZC-JCT-016A	12.98	30
ZC-JCT-017	1.14	10
ZC-JCT-018	0.43	10
ZC-JCT-019	1.61	10
ZC-JCT-019A	1.14	10
ZC-JCT-020	0.72	10
ZC-JCT-020A	13.59	30
ZC-JCT-021	1.33	10
ZC-JCT-022	15.45	30
ZC-JCT-022A	14.92	30
ZC-JCT-022C	15.22	30
ZC-JCT-023	0.3	10

Table A.3: Basin Parameters

Sub-basin Name	Drainage Area (mi^2)	TC (hr)			R, Storage Coefficient		
		Current	Future	Δ	Current	Future	Δ
BC-001	0.95	0.67	0.51	-24%	0.72	0.55	-24%
BC-002	0.83	2.00	1.59	-21%	2.17	1.72	-21%
BC-003	0.94	0.76	0.63	-17%	0.82	0.68	-17%
BC-004	0.65	1.15	0.95	-17%	1.25	1.03	-18%
BC-005	0.52	0.73	0.58	-20%	0.80	0.63	-21%
BC-006	0.96	0.69	0.59	-15%	0.75	0.64	-15%
BC-007	0.75	0.49	0.38	-22%	0.53	0.41	-22%
BC-008	0.47	0.74	0.55	-25%	0.80	0.60	-25%
BC-009	0.90	0.69	0.54	-22%	0.75	0.59	-22%
BC-010	0.63	0.69	0.52	-25%	0.74	0.56	-24%
BC-011	0.60	0.96	0.88	-8%	1.04	0.95	-8%
BC-012	0.69	1.59	1.22	-23%	1.73	1.32	-24%
BC-013	1.01	0.74	0.61	-18%	0.80	0.66	-17%
BC-014	0.41	0.5	0.38	-24%	0.54	0.41	-24%
BC-015	0.37	0.87	0.64	-26%	0.95	0.70	-27%
BC-016	0.50	1.38	1.00	-28%	1.49	1.08	-28%
BC-017	0.66	1.29	0.96	-26%	1.40	1.04	-26%
BC-018	0.78	0.81	0.70	-14%	0.88	0.75	-14%
BC-019	1.00	1.56	1.35	-13%	1.69	1.47	-13%
BC-020	0.86	1.01	0.87	-14%	1.09	0.94	-14%
BC-021	1.04	0.94	0.81	-14%	1.02	0.87	-14%
BC-022	1.15	0.97	0.77	-20%	1.05	0.84	-20%
BC-023	0.43	0.55	0.45	-18%	0.6	0.49	-19%
BC-024	0.44	0.37	0.28	-25%	0.41	0.30	-27%
BC-025	0.54	0.36	0.30	-18%	0.39	0.32	-18%
BC-026	0.84	0.51	0.40	-21%	0.55	0.44	-20%
BC-027	0.89	0.85	0.70	-17%	0.93	0.76	-18%
BC-028	1.02	1.08	0.97	-10%	1.17	1.05	-10%
BC-029	0.99	1.00	0.88	-12%	1.09	0.96	-12%
BC-030	0.99	0.95	0.83	-12%	1.03	0.90	-12%
BC-031	0.44	0.77	0.68	-11%	0.84	0.74	-12%
BC-032	0.89	0.81	0.67	-18%	0.88	0.72	-18%
BC-033	0.43	0.88	0.83	-5%	0.95	0.90	-5%
BC-034	0.65	0.64	0.53	-18%	0.70	0.57	-19%
BC-035	0.59	0.81	0.62	-23%	0.88	0.67	-23%
SC-001	0.88	1.10	0.89	-19%	1.19	0.96	-19%
SC-002	0.85	0.96	0.90	-6%	1.04	0.97	-6%

Sub-basin Name	Drainage Area (mi^2)	TC (hr)			R, Storage Coefficient		
		Current	Future	Δ	Current	Future	Δ
SC-003	0.41	1.00	0.97	-3%	1.08	1.05	-3%
SC-004	0.31	1.18	1.12	-5%	1.27	1.21	-5%
SC-005	0.60	0.85	0.72	-16%	0.93	0.78	-16%
SC-006	0.98	0.42	0.42	-1%	0.46	0.45	-2%
SC-007	1.07	1.33	1.11	-16%	1.44	1.20	-16%
SC-008	0.77	0.80	0.72	-10%	0.87	0.78	-10%
SC-009	0.78	0.80	0.65	-19%	0.86	0.70	-18%
SC-010	1.32	1.54	1.25	-19%	1.67	1.35	-19%
SC-011	1.16	1.12	0.88	-21%	1.21	0.96	-21%
SC-012	0.68	1.35	1.27	-6%	1.46	1.37	-6%
SC-013	0.98	0.57	0.48	-15%	0.61	0.53	-14%
SC-014	0.85	1.02	0.76	-25%	1.11	0.83	-25%
SC-015	0.69	0.49	0.47	-5%	0.53	0.51	-5%
SC-016	0.38	0.23	0.23	-1%	0.25	0.25	-2%
SC-017	0.58	1.11	1.03	-7%	1.20	1.12	-7%
TC-001	0.93	2.02	1.60	-21%	2.18	1.73	-21%
TC-002	0.67	1.61	1.41	-13%	1.74	1.52	-13%
TC-003	0.36	0.57	0.43	-24%	0.62	0.47	-24%
TC-004	1.06	1.31	1.12	-14%	1.42	1.22	-14%
ZC-001	1.18	1.13	0.96	-15%	1.23	1.04	-16%
ZC-002	0.98	0.76	0.60	-20%	0.83	0.65	-21%
ZC-003	0.75	0.89	0.69	-23%	0.96	0.74	-22%
ZC-004	0.75	0.62	0.48	-22%	0.67	0.52	-22%
ZC-005	0.53	0.61	0.55	-9%	0.66	0.60	-9%
ZC-006	0.43	1.55	1.45	-6%	1.68	1.58	-6%
ZC-007	1.23	0.88	0.71	-19%	0.96	0.77	-19%
ZC-008	0.71	0.54	0.45	-16%	0.59	0.49	-17%
ZC-009	0.42	0.68	0.66	-3%	0.73	0.72	-2%
ZC-010	0.84	0.80	0.68	-15%	0.87	0.73	-16%
ZC-011	0.78	0.98	0.79	-20%	1.07	0.85	-20%
ZC-012	0.40	0.91	0.77	-16%	0.99	0.83	-16%
ZC-013	0.48	0.75	0.67	-10%	0.82	0.73	-11%
ZC-014	0.68	0.51	0.50	-2%	0.55	0.54	-2%
ZC-015	1.21	1.08	0.96	-11%	1.17	1.04	-11%
ZC-016	0.61	0.52	0.52	-1%	0.57	0.56	-2%
ZC-017	0.71	0.72	0.60	-17%	0.78	0.65	-17%
ZC-018	0.43	0.63	0.63	1%	0.69	0.69	-1%
ZC-019	0.47	0.30	0.28	-7%	0.33	0.30	-8%

Sub-basin Name	Drainage Area (mi^2)	TC (hr)			R, Storage Coefficient		
		Current	Future	Δ	Current	Future	Δ
ZC-020	0.72	0.86	0.65	-24%	0.93	0.70	-24%
ZC-021	0.61	4.11	3.20	-22%	4.46	4.36	-2%
ZC-022	0.23	0.5	0.49	-3%	0.54	0.53	-3%
ZC-023	0.3	0.36	0.36	0%	0.39	0.39	0%
PR-001	0.31	0.67	0.46	-31%	0.73	0.50	-31%
PR-002	0.98	1.30	1.04	-20%	1.41	1.12	-20%
PR-003	0.37	0.43	0.32	-25%	0.47	0.35	-26%
PR-004	0.74	1.29	1.14	-12%	1.40	1.23	-12%
PR-005	1.09	1.08	0.86	-20%	1.17	0.94	-20%
PR-006	0.91	1.03	0.83	-19%	1.11	0.90	-19%
PR-007	0.99	0.88	0.77	-13%	0.95	0.83	-12%
PR-008	0.66	0.47	0.34	-28%	0.51	0.37	-28%
PR-009	0.42	0.39	0.30	-23%	0.42	0.33	-22%
PR-010	0.42	0.45	0.37	-18%	0.49	0.40	-18%
PR-011	0.23	0.4	0.33	-17%	0.43	0.36	-17%
PR-012	0.35	0.49	0.37	-25%	0.53	0.40	-24%
PR-013	0.61	0.67	0.56	-17%	0.73	0.60	-17%
PR-014	0.72	0.16	0.16	-3%	0.17	0.17	-1%
PR-015	0.25	0.64	0.48	-25%	0.69	0.52	-25%

Table A.4 Perviousness Values

Land Use Category	Description	Percent Impervious
Mixed Residential	Mix of low, medium, and high density residential; homes on up to 3 acres.	30
Residential Estates	Homes on 3 to 10 acres.	10
Commercial/Industrial	Commercial, retail business, and industrial areas.	80
Agricultural	Agricultural areas.	1
Open Space	Parks and open areas.	5
Water	Open water, lakes, and streams.	100

Table A.5: Loss Parameters

Sub-basin Name	Initial Loss (in)		Constant Rate (in/hr)		Impervious (%)	
	Current	Future	Current	Future	Current	Future
BC-001	0.80	0.80	0.30	0.30	12	51
BC-002	0.80	0.80	0.30	0.30	8	43
BC-003	0.80	0.80	0.30	0.30	2	27
BC-004	0.80	0.80	0.30	0.30	6	41
BC-005	0.80	0.80	0.30	0.30	4	64
BC-006	0.80	0.80	0.30	0.30	4	73
BC-009	0.80	0.80	0.30	0.30	3	32
BC-008	0.80	0.80	0.30	0.30	13	32
BC-010	0.80	0.80	0.30	0.30	2	19
BC-007	0.80	0.80	0.30	0.30	15	76
BC-011	0.80	0.80	0.30	0.30	3	51
BC-012	0.80	0.80	0.30	0.30	2	41
BC-013	0.80	0.80	0.30	0.30	1	30
BC-016	0.80	0.80	0.30	0.30	1	63
BC-015	0.80	0.80	0.30	0.30	1	48
BC-017	0.80	0.80	0.30	0.30	2	60
BC-018	0.80	0.80	0.30	0.30	2	30
BC-014	0.80	0.80	0.30	0.30	1	30
BC-019	0.80	0.80	0.30	0.30	1	38
BC-022	0.80	0.80	0.30	0.30	1	30
BC-021	0.80	0.80	0.30	0.30	2	30
BC-023	0.80	0.80	0.30	0.30	2	30
BC-020	0.80	0.80	0.30	0.30	2	30
BC-024	0.80	0.80	0.30	0.30	2	30
BC-027	0.80	0.80	0.30	0.30	2	30
BC-026	0.80	0.80	0.30	0.30	2	29
BC-028	0.80	0.80	0.30	0.30	2	30
BC-029	0.80	0.80	0.30	0.30	1	30
BC-025	0.80	0.80	0.30	0.30	1	30
BC-030	0.80	0.80	0.30	0.30	1	30
BC-031	0.80	0.80	0.30	0.30	2	26
BC-032	0.80	0.80	0.30	0.30	2	29
BC-033	0.80	0.80	0.30	0.30	1	30
BC-034	0.80	0.80	0.30	0.30	2	30
BC-035	0.80	0.80	0.30	0.30	2	25

Table A.5: Loss Parameters

Sub-basin Name	Initial Loss (in)		Constant Rate (in/hr)		Impervious (%)	
	Current	Future	Current	Future	Current	Future
SC-007	0.80	0.80	0.30	0.30	2	30
SC-008	0.80	0.80	0.30	0.30	3	33
SC-009	0.80	0.80	0.30	0.30	2	27
SC-010	0.80	0.80	0.30	0.30	2	41
SC-011	0.80	0.80	0.30	0.30	4	30
SC-012	0.80	0.80	0.30	0.30	5	56
SC-001	0.80	0.80	0.30	0.30	2	71
SC-002	0.80	0.80	0.30	0.30	1	49
SC-005	0.80	0.80	0.30	0.30	1	22
SC-003	0.80	0.80	0.30	0.30	2	42
SC-004	0.80	0.80	0.30	0.30	2	76
SC-006	0.80	0.80	0.30	0.30	3	36
SC-013	0.80	0.80	0.30	0.30	6	67
SC-014	0.80	0.80	0.30	0.30	3	34
SC-015	0.80	0.80	0.30	0.30	18	30
SC-016	0.80	0.80	0.30	0.30	2	33
TC-001	0.80	0.80	0.30	0.30	2	29
TC-002	0.80	0.80	0.30	0.30	4	27
TC-003	0.80	0.80	0.30	0.30	1	30
TC-004	0.80	0.80	0.30	0.30	2	16
SC-017	0.80	0.80	0.30	0.30	2	10
ZC-007	0.80	0.80	0.30	0.30	2	29
ZC-008	0.80	0.80	0.30	0.30	2	28
ZC-009	0.80	0.80	0.30	0.30	2	21
ZC-010	0.80	0.80	0.30	0.30	3	29
ZC-011	0.80	0.80	0.30	0.30	3	27
ZC-012	0.80	0.80	0.30	0.30	1	30
ZC-013	0.80	0.80	0.30	0.30	1	25
ZC-014	0.80	0.80	0.30	0.30	4	27
ZC-015	0.80	0.80	0.30	0.30	2	28
ZC-001	0.80	0.80	0.30	0.30	2	31
ZC-003	0.80	0.80	0.30	0.30	2	30
ZC-004	0.80	0.80	0.30	0.30	5	30
ZC-005	0.80	0.80	0.30	0.30	2	26
ZC-002	0.80	0.80	0.30	0.30	3	27
ZC-006	0.80	0.80	0.30	0.30	5	26

Table A.5: Loss Parameters

Sub-basin Name	Initial Loss (in)		Constant Rate (in/hr)		Impervious (%)	
	Current	Future	Current	Future	Current	Future
ZC-017	0.80	0.80	0.30	0.30	2	28
ZC-018	0.80	0.80	0.30	0.30	2	1
ZC-019	0.80	0.80	0.30	0.30	2	12
ZC-016	0.80	0.80	0.30	0.30	2	19
ZC-020	0.80	0.80	0.30	0.30	3	9
ZC-021	0.80	0.80	0.30	0.30	1	9
ZC-023	0.80	0.80	0.30	0.30	2	1
ZC-022	0.80	0.80	0.30	0.30	7	7
PR-005	0.80	0.80	0.30	0.30	2	28
PR-006	0.80	0.80	0.30	0.30	2	18
PR-004	0.80	0.80	0.30	0.30	3	10
PR-003	0.80	0.80	0.30	0.30	1	20
PR-010	0.80	0.80	0.30	0.30	3	24
PR-009	0.80	0.80	0.30	0.30	4	21
PR-011	0.80	0.80	0.30	0.30	1	20
PR-007	0.80	0.80	0.30	0.30	4	12
PR-002	0.80	0.80	0.30	0.30	2	13
PR-014	0.80	0.80	0.30	0.30	1	19
PR-008	0.80	0.80	0.30	0.30	11	18
PR-013	0.80	0.80	0.30	0.30	2	21
PR-012	0.80	0.80	0.30	0.30	3	30
PR-001	0.80	0.80	0.30	0.30	2	10
PR-015	0.80	0.80	0.30	0.30	2	22

Table A.6: Muskingum-Cunge Routing

Reach	Length (FT)	Slope (FT/FT)	Manning's Coefficient, n			Cross Section Table
			Channel	Left Bank	Right Bank	
BC-RCH-002	3210	0.0059	0.035	0.050	0.050	XS BC-RCH-002
BC-RCH-003	1540	0.0032	0.035	0.050	0.050	XS BC-RCH-003
BC-RCH-004	920	0.0152	0.035	0.050	0.050	XS BC-RCH-004
BC-RCH-005	1830	0.0121	0.035	0.050	0.050	XS BC-RCH-005
BC-RCH-004A	7460	0.0023	0.035	0.050	0.050	XS BC-RCH-004A
BC-RCH-006B	960	0.0042	0.035	0.050	0.050	XS BC-RCH-006B
BC-RCH-008	2680	0.0099	0.035	0.050	0.050	XS BC-RCH-008
BC-RCH-009	3900	0.0090	0.035	0.050	0.050	XS BC-RCH-009
BC-RCH-010	1680	0.0047	0.035	0.050	0.050	XS BC-RCH-010
BC-RCH-007A	7010	0.0032	0.035	0.050	0.050	XS BC-RCH-007
BC-RCH-011B	320	0.0020	0.035	0.050	0.050	XS BC-RCH-011B
BC-RCH-011A	2040	0.0023	0.035	0.050	0.050	XS BC-RCH-011A
BC-RCH-012	770	0.0034	0.035	0.050	0.050	XS BC-RCH-012
BC-RCH-013A	3250	0.0040	0.035	0.050	0.050	XS BC-RCH-013
BC-RCH-016	1430	0.0098	0.035	0.050	0.050	XS BC-RCH-016
BC-RCH-015	1680	0.0074	0.035	0.050	0.050	XS BC-RCH-015
BC-RCH-018B	1000	0.0057	0.035	0.050	0.050	XS BC-RCH-018B
BC-RCH-017	2480	0.0101	0.035	0.050	0.050	XS BC-RCH-017
BC-RCH-018A	2150	0.0017	0.035	0.050	0.050	XS BC-RCH-018A
BC-RCH-018D	3080	0.0040	0.035	0.050	0.050	XS BC-RCH-018D
BC-RCH-018C	540	0.0048	0.035	0.050	0.050	XS BC-RCH-018C
BC-RCH-014	3880	0.0028	0.035	0.050	0.050	XS BC-RCH-014A
BC-RCH-019	4030	0.0086	0.035	0.050	0.050	XS BC-RCH-019
BC-RCH-020D	2380	0.0011	0.035	0.050	0.050	XS BC-RCH-020A
BC-RCH-021	5860	0.0075	0.035	0.050	0.050	XS BC-RCH-021
BC-RCH-022	4200	0.0077	0.035	0.050	0.050	XS BC-RCH-022
BC-RCH-023A	3700	0.0025	0.035	0.050	0.050	XS BC-RCH-023A
BC-RCH-024	2620	0.0011	0.035	0.050	0.050	XS BC-RCH-024
BC-RCH-026	1880	0.0035	0.035	0.050	0.050	XS BC-RCH-026
BC-RCH-027	5130	0.0037	0.035	0.050	0.050	XS BC-RCH-027
BC-RCH-028A	5210	0.0025	0.035	0.050	0.050	XS BC-RCH-028A
BC-RCH-029	4080	0.0050	0.035	0.050	0.050	XS BC-RCH-029
BC-RCH-025A	1190	0.0028	0.035	0.050	0.050	XS BC-RCH-025A
BC-RCH-025	5350	0.0011	0.035	0.050	0.050	XS BC-RCH-025
BC-RCH-030	2670	0.0027	0.035	0.050	0.050	XS BC-RCH-030

Table A.6: Muskingum-Cunge Routing

Reach	Length (FT)	Slope (FT/FT)	Manning's Coefficient, n			Cross Section Table
			Channel	Left Bank	Right Bank	
BC-RCH-032	2890	0.0044	0.035	0.050	0.050	XS BC-RCH-032
BC-RCH-033A	1420	0.0011	0.035	0.050	0.050	XS BC-RCH-033A
BC-RCH-034B	4380	0.0017	0.035	0.050	0.050	XS BC-RCH-034B
BC-RCH-034	3280	0.0010	0.035	0.050	0.050	XS BC-RCH-034
SC-RCH-009B	1390	0.0031	0.035	0.050	0.050	XS SC-RCH-009B
SC-RCH-009	5940	0.0026	0.035	0.050	0.050	XS SC-RCH-009
SC-RCH-010	1970	0.0048	0.035	0.050	0.050	XS SC-RCH-010
SC-RCH-011A	650	0.0021	0.035	0.050	0.050	XS SC-RCH-011A
SC-RCH-011	1300	0.0033	0.035	0.050	0.050	XS SC-RCH-011
SC-RCH-012	3020	0.0049	0.035	0.050	0.050	XS SC-RCH-012
SC-RCH-006A	3390	0.0027	0.035	0.050	0.050	XS SC-RCH-006A
SC-RCH-002	650	0.0076	0.035	0.050	0.050	XS SC-RCH-002
SC-RCH-001	3700	0.0030	0.035	0.050	0.050	XS SC-RCH-001
SC-RCH-003	3580	0.0032	0.035	0.050	0.050	XS SC-RCH-003
SC-RCH-004	5450	0.0034	0.035	0.050	0.050	XS SC-RCH-004
SC-RCH-006C	550	0.0036	0.035	0.050	0.050	XS SC-RCH-006C
SC-RCH-006	600	0.0086	0.035	0.050	0.050	XS SC-RCH-006
SC-RCH-013	1420	0.0062	0.035	0.050	0.050	XS SC-RCH-013
SC-RCH-014A	5160	0.0019	0.035	0.050	0.050	XS SC-RCH-014A
SC-RCH-015	4150	0.0019	0.035	0.050	0.050	XS SC-RCH-015
TC-RCH-001	2070	0.0019	0.035	0.050	0.050	XS TC-RCH-001
TC-RCH-002	2140	0.0029	0.035	0.050	0.050	XS TC-RCH-002
TC-RCH-003	3960	0.0023	0.035	0.050	0.050	XS TC-RCH-003
TC-RCH-004B	6760	0.0060	0.035	0.050	0.050	XS TC-RCH-004B
SC-RCH-016A	5070	0.0013	0.035	0.050	0.050	XS SC-RCH-016A
ZC-RCH-007	3720	0.0029	0.035	0.050	0.050	XS ZC-RCH-007
ZC-RCH-008	5120	0.0036	0.035	0.050	0.050	XS ZC-RCH-008
ZC-RCH-010	7150	0.0063	0.035	0.050	0.050	XS ZC-RCH-010
ZC-RCH-012	3760	0.0052	0.035	0.050	0.050	XS ZC-RCH-012
ZC-RCH-013B	1790	0.0031	0.035	0.050	0.050	XS ZC-RCH-013B
ZC-RCH-013	5640	0.0028	0.035	0.050	0.050	XS ZC-RCH-013
ZC-RCH-014	8520	0.0033	0.035	0.050	0.050	XS ZC-RCH-014
ZC-RCH-001	2160	0.0071	0.035	0.050	0.050	XS ZC-RCH-001
ZC-RCH-003	1750	0.0106	0.035	0.050	0.050	XS ZC-RCH-003
ZC-RCH-002A	4380	0.0029	0.035	0.050	0.050	XS ZC-RCH-002A

Table A.6: Muskingum-Cunge Routing

Reach	Length (FT)	Slope (FT/FT)	Manning's Coefficient, n			Cross Section Table
			Channel	Left Bank	Right Bank	
ZC-RCH-004	6190	0.0062	0.035	0.050	0.050	XS ZC-RCH-004
ZC-RCH-005	830	0.0045	0.035	0.050	0.050	XS ZC-RCH-005
ZC-RCH-002	5710	0.0034	0.035	0.050	0.050	XS ZC-RCH-002
ZC-RCH-015A	1950	0.0025	0.035	0.050	0.050	XS ZC-RCH-015A
ZC-RCH-017	2770	0.0066	0.035	0.050	0.050	XS ZC-RCH-017
ZC-RCH-019A	1250	0.0039	0.035	0.050	0.050	XS ZC-RCH-019A
ZC-RCH-016A	6210	0.0022	0.035	0.050	0.050	XS ZC-RCH-016A
ZC-RCH-016	1690	0.0047	0.035	0.050	0.050	XS ZC-RCH-016
ZC-RCH-020A	8260	0.0008	0.035	0.050	0.050	XS ZC-RCH-020A
ZC-RCH-020	4420	0.0004	0.035	0.050	0.050	XS ZC-RCH-020
ZC-RCH-023	5650	0.0052	0.035	0.050	0.050	XS ZC-RCH-023
ZC-RCH-022A	1140	0.0011	0.035	0.050	0.050	XS ZC-RCH-022A
PR-RCH-005	8120	0.0029	0.035	0.050	0.050	XS PR-RCH-005
PR-RCH-003	3200	0.0061	0.035	0.050	0.050	XS PR-RCH-003
PR-RCH-004A	6020	0.0037	0.035	0.050	0.050	XS PR-RCH-004A
PR-RCH-009	4340	0.0058	0.035	0.050	0.050	XS PR-RCH-009
PR-RCH-010	3960	0.0042	0.035	0.050	0.050	XS PR-RCH-010

Table A.7. HEC HMS Computed Discharge by Junction

Model Location	Area (mi^2)	Storm Size (mi^2)	Existing Discharge (cfs)					Future Discharge (cfs)
			2_Year	10_Year	25_Year	50_Year	100_Year	100_Year
BC-JCT-001	0.95	10	260	690	910	1,090	1,290	1,460
BC-JCT-002	1.78	10	330	940	1,240	1,500	1,790	2,130
BC-JCT-003	2.72	10	530	1,530	2,040	2,470	2,940	3,410
BC-JCT-004	3.37	10	650	1,880	2,510	3,040	3,620	4,200
BC-JCT-004A	3.89	10	770	2,220	2,950	3,580	4,260	4,960
BC-JCT-005	0.52	10	130	360	470	570	670	790
BC-JCT-006	4.85	30	840	2,570	3,470	4,240	5,060	5,940
BC-JCT-006B	3.89	30	700	2,080	2,780	3,380	4,030	4,700
BC-JCT-007	0.75	10	240	610	790	940	1,110	1,270
BC-JCT-007A	2.75	10	700	1,950	2,570	3,100	3,670	4,130
BC-JCT-008	0.47	10	120	330	430	520	620	690
BC-JCT-009	1.37	10	340	950	1,260	1,520	1,800	2,020
BC-JCT-010	2	10	490	1,390	1,830	2,210	2,620	2,930
BC-JCT-011	3.35	10	810	2,290	3,020	3,650	4,330	4,870
BC-JCT-011A	8.2	30	1,580	4,710	6,320	7,690	9,150	10,550
BC-JCT-011B	2.75	10	690	1,930	2,550	3,070	3,640	4,100
BC-JCT-012	8.89	30	1,650	4,970	6,640	8,030	9,600	11,160
BC-JCT-013	1.01	10	240	680	910	1,100	1,300	1,440
BC-JCT-013A	9.9	30	1,820	5,530	7,410	8,960	10,700	12,400
BC-JCT-014	12.62	30	2,170	6,790	9,160	11,090	13,260	15,480
BC-JCT-014B	9.9	30	1,810	5,510	7,390	8,930	10,660	12,320
BC-JCT-015	0.37	10	80	230	310	370	450	530
BC-JCT-016	0.5	10	80	240	330	400	480	630
BC-JCT-017	0.66	10	110	340	450	550	650	840
BC-JCT-018	2.31	10	350	1,160	1,580	1,930	2,310	2,890
BC-JCT-018A	1.53	10	260	790	1,070	1,300	1,550	1,980
BC-JCT-018B	0.87	10	150	460	620	760	900	1,150
BC-JCT-018C	1.53	10	250	780	1,050	1,280	1,530	1,950
BC-JCT-018D	1.53	10	260	780	1,050	1,280	1,530	1,960
BC-JCT-019	1	10	140	450	600	740	880	1,040
BC-JCT-020A	12.62	50	1,960	6,420	8,740	10,580	12,650	14,860
BC-JCT-020B	13.62	50	2,040	6,710	8,820	10,840	13,050	15,420
BC-JCT-020C	1	10	140	450	600	740	880	1,030
BC-JCT-020D	13.62	50	2,080	6,810	9,260	11,220	13,420	15,790

Table A.7. HEC HMS Computed Discharge by Junction

Model Location	Area (mi^2)	Storm Size (mi^2)	Existing Discharge (cfs)					Future Discharge (cfs)
			2_Year	10_Year	25_Year	50_Year	100_Year	100_Year
BC-JCT-021	1.04	10	220	630	840	1,020	1,210	1,350
BC-JCT-022	2.19	10	440	1,310	1,750	2,120	2,530	2,860
BC-JCT-023	2.62	10	520	1,570	2,090	2,540	3,030	3,420
BC-JCT-023A	17.1	50	2,520	8,470	11,140	13,630	16,400	19,240
BC-JCT-024	17.54	50	2,520	8,550	11,250	13,770	16,570	19,400
BC-JCT-025	21.82	50	3,060	10,560	13,650	16,520	19,940	23,340
BC-JCT-025A	21.28	50	3,060	10,460	13,490	16,430	19,830	23,160
BC-JCT-026	0.84	10	240	650	850	1,030	1,210	1,320
BC-JCT-027	1.73	10	430	1,200	1,580	1,910	2,270	2,510
BC-JCT-028	1.02	10	190	580	770	940	1,110	1,230
BC-JCT-028A	1.73	10	430	1,190	1,570	1,900	2,260	2,500
BC-JCT-029	3.74	10	790	2,330	3,100	3,760	4,470	4,940
BC-JCT-030	22.81	50	3,030	10,730	14,040	16,970	19,840	22,780
BC-JCT-031	23.25	50	3,060	10,860	14,260	17,230	20,100	23,070
BC-JCT-032	0.89	10	200	580	770	930	1,110	1,240
BC-JCT-033	1.32	10	290	850	1,120	1,360	1,620	1,790
BC-JCT-033A	24.57	50	3,180	11,470	15,110	18,210	21,190	24,250
BC-JCT-034	25.22	50	3,140	11,470	15,230	18,170	20,980	23,860
BC-JCT-034B	24.57	50	3,150	11,380	15,030	18,010	20,900	23,900
BC-JCT-035	25.81	50	3,100	11,470	15,020	18,030	20,960	23,760
PR-JCT-001	0.31	10	80	220	290	350	410	460
PR-JCT-002	0.98	10	160	500	670	810	970	1,110
PR-JCT-003	0.37	10	110	300	390	470	560	600
PR-JCT-004	1.11	10	230	670	880	1,070	1,270	1,370
PR-JCT-004A	0.37	10	110	300	390	470	550	600
PR-JCT-005	1.09	10	210	620	820	1,000	1,190	1,380
PR-JCT-006	2	10	350	1,090	1,470	1,800	2,150	2,450
PR-JCT-007	0.99	10	220	630	830	1,010	1,200	1,280
PR-JCT-008	0.66	10	210	530	700	830	980	1,060
PR-JCT-009	0.42	10	130	350	460	550	650	690
PR-JCT-010	0.84	10	260	680	890	1,070	1,270	1,350
PR-JCT-011	1.07	10	320	860	1,120	1,350	1,600	1,700
PR-JCT-012	0.35	10	100	270	360	430	510	560
PR-JCT-013	0.61	10	150	430	570	690	810	890

Table A.7. HEC HMS Computed Discharge by Junction

Model Location	Area (mi^2)	Storm Size (mi^2)	Existing Discharge (cfs)					Future Discharge (cfs)
			2_Year	10_Year	25_Year	50_Year	100_Year	100_Year
PR-JCT-014	0.72	10	270	680	890	1,060	1,250	1,270
PR-JCT-015	0.25	10	60	180	240	290	340	380
SC-JCT-001	1.73	10	340	1,000	1,340	1,620	1,930	2,270
SC-JCT-002	0.85	10	170	510	680	830	980	1,090
SC-JCT-003	2.74	10	530	1,590	2,130	2,590	3,090	3,530
SC-JCT-004	3.05	10	580	1,750	2,340	2,840	3,370	3,870
SC-JCT-006	9.81	30	1,510	4,820	6,480	7,810	9,330	10,880
SC-JCT-006A	5.78	30	920	2,880	3,880	4,720	5,620	6,500
SC-JCT-006C	8.83	30	1,450	4,520	6,070	7,360	8,790	10,160
SC-JCT-007	1.07	10	170	530	720	870	1,040	1,210
SC-JCT-008	0.77	10	180	510	670	810	960	1,050
SC-JCT-009	2.62	10	510	1,510	2,010	2,430	2,900	3,260
SC-JCT-009B	1.84	10	340	1,010	1,350	1,640	1,950	2,230
SC-JCT-010	3.94	10	690	2,080	2,780	3,380	4,030	4,660
SC-JCT-011	5.1	10	890	2,700	3,620	4,400	5,240	6,060
SC-JCT-011A	3.94	10	690	2,070	2,780	3,370	4,020	4,660
SC-JCT-012	0.68	10	110	340	460	550	660	760
SC-JCT-013	0.98	10	280	740	970	1,170	1,390	1,560
SC-JCT-014A	10.79	30	1,630	5,310	7,180	8,600	10,250	11,960
SC-JCT-015	12.33	30	1,780	6,000	8,140	9,790	11,530	13,270
SC-JCT-016	12.71	30	1,770	6,000	8,160	9,810	11,420	13,160
SC-JCT-016A	15.73	30	2,050	7,080	9,660	11,680	13,710	15,820
SC-JCT-017	16.31	30	2,070	7,240	9,510	11,620	13,820	15,950
TC-JCT-001	0.93	10	110	350	470	580	690	860
TC-JCT-002	1.6	10	190	620	850	1,040	1,240	1,500
TC-JCT-003	1.96	10	210	700	960	1,190	1,430	1,710
TC-JCT-004	3.02	10	320	1,170	1,610	2,000	2,400	2,800
TC-JCT-004B	1.96	10	210	700	960	1,190	1,430	1,700
ZC-JCT-001	1.18	10	220	650	870	1,050	1,260	1,430
ZC-JCT-002	4.19	10	880	2,490	3,300	4,050	4,860	5,470
ZC-JCT-002A	1.93	10	370	1,110	1,480	1,800	2,140	2,450
ZC-JCT-003	0.75	10	160	470	620	760	900	1,030
ZC-JCT-004	0.75	10	200	550	720	870	1,030	1,140
ZC-JCT-005	1.28	10	330	930	1,220	1,470	1,740	1,910

Table A.7. HEC HMS Computed Discharge by Junction

Model Location	Area (mi^2)	Storm Size (mi^2)	Existing Discharge (cfs)					Future Discharge (cfs)
			2_Year	10_Year	25_Year	50_Year	100_Year	100_Year
ZC-JCT-005A	3.21	10	660	1,870	2,470	3,050	3,670	4,130
ZC-JCT-006	4.62	30	860	2,530	3,380	4,130	4,980	5,580
ZC-JCT-007	1.23	10	260	770	1,020	1,240	1,480	1,670
ZC-JCT-008	1.94	10	430	1,250	1,660	2,010	2,360	2,610
ZC-JCT-009	2.36	10	520	1,470	1,970	2,400	2,840	3,110
ZC-JCT-010	0.84	10	190	550	730	880	1,050	1,160
ZC-JCT-011	1.62	10	350	1,010	1,350	1,630	1,940	2,170
ZC-JCT-012	2.02	10	430	1,260	1,670	2,030	2,410	2,690
ZC-JCT-013	4.86	10	1,020	2,980	4,000	4,850	5,720	6,350
ZC-JCT-013B	2.02	10	430	1,250	1,660	2,020	2,390	2,680
ZC-JCT-014	5.54	10	1,100	3,140	4,280	5,220	6,200	7,020
ZC-JCT-015	6.75	30	1,170	3,480	4,480	5,760	6,890	7,750
ZC-JCT-015A	11.37	30	1,990	5,920	7,680	9,630	11,610	12,920
ZC-JCT-016	13.59	30	2,200	6,590	8,630	10,580	12,870	14,380
ZC-JCT-016A	12.98	30	2,190	6,520	8,580	10,490	12,740	14,180
ZC-JCT-017	1.14	10	280	800	1,050	1,270	1,500	1,600
ZC-JCT-018	0.43	10	110	310	410	490	580	580
ZC-JCT-019	1.61	10	400	1,130	1,490	1,800	2,120	2,240
ZC-JCT-019A	1.14	10	280	790	1,050	1,270	1,500	1,590
ZC-JCT-020	0.72	10	160	460	610	740	880	980
ZC-JCT-020A	13.59	30	2,190	6,580	8,620	10,560	12,850	14,360
ZC-JCT-021	1.33	10	120	400	540	670	810	900
ZC-JCT-022	15.45	30	1,920	6,580	8,670	10,630	12,970	14,590
ZC-JCT-022A	14.92	30	1,930	6,570	8,650	10,600	12,930	14,500
ZC-JCT-022C	15.22	30	1,930	6,600	8,680	10,630	12,970	14,580
ZC-JCT-023	0.3	10	100	250	330	400	470	470

Table A.8. Manning's 'n' Value Assessment

	Main Channel Base Roughness		Main Channel Roughness Adjustments						Left Overbank (Floodplain) Base n		Left Overbank (Floodplain) Roughness Adjustments				Right Overbank (Floodplain) Base n		Right Overbank (Floodplain) Roughness Adjustments									
Sub-Basin FID #	Override n_b	Use base roughness, n_b	n_1	n_2	n_3	n_4	$m_{1\&2}$	Adjusted n_{chl}	Override LOB n_b	Use base roughness, n_b	n_1	n_3	n_4	Adjusted n_{LOB}	Override ROB n_b	Use base roughness, n_b	n_1			n_3			n_4			Adjusted n_{ROB}
			Conditions								Conditions						Conditions							0	0	
0	0.04	0.04	Minor	Gradual	Negligible	Small	Appreciable	0.059		0.025	Smooth	Minor	Medium	0.055		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
1	0.04	0.04	Minor	Alternating occasionally	Negligible	Small	Appreciable	0.062		0.025	Moderate	Minor	Large	0.0825		0.025	Smooth	Average	0	Minor	Average	0.012	Medium	Average	0.018	0.055
2		Select channel material!								0.025						0.025		Average	#N/A		Average	#N/A		Average	#N/A	
3	0.04	0.04	Minor	Alternating occasionally	Minor	Small	Minor	0.062		0.025	Smooth	Minor	Large	0.0745		0.025	Minor	Average	0.003	Minor	Average	0.012	Large	Average	0.0375	0.0775
4		Select channel material!								0.025						0.025			#N/A			#N/A		Average	#N/A	
5	0.04	0.04	Smooth	Alternating frequently	Appreciable	Small	Minor	0.084		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
6	0.04	0.04	Moderate	Alternating occasionally	Negligible	Small	Minor	0.059		0.025	Smooth	Minor	Medium	0.055		0.025	Smooth	Average	0	Minor	Average	0.012	Medium	Average	0.018	0.055
7	0.04	0.04	Minor	Gradual	Negligible	Small	Minor	0.051		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
8	0.04	0.04	Minor	Alternating occasionally	Minor	Small	Severe	0.081		0.025	Smooth	Negligible	Small	0.0325		0.025	Minor	Average	0.003	Minor	Average	0.012	Large	Average	0.0375	0.0775
9	0.045	0.045	Minor	Gradual	Minor	Small	Minor	0.064		0.025	Smooth	Minor	Medium	0.055		0.025	Smooth	Average	0	Minor	Average	0.012	Medium	Average	0.018	0.055
10	0.045	0.045	Minor	Alternating occasionally	Minor	Medium	Minor	0.079		0.025	Smooth	Appreciable	Medium	0.068		0.025	Smooth	Average	0	Appreciab	Average	0.025	Medium	Average	0.018	0.068
11	0.045	0.045	Minor	Gradual	Minor	Small	Minor	0.064		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Minor	Average	0.012	Medium	Average	0.018	0.055
12		Select channel material!								0.025						0.025			#N/A			#N/A		Average	#N/A	
14	0.045	0.045	Minor	Gradual	Negligible	Small	Minor	0.056		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
15	0.04	0.04	Minor	Alternating occasionally	Minor	Medium	Minor	0.074		0.025	Smooth	Minor	Medium	0.055		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
16	0.04	0.04	Minor	Alternating frequently	Appreciable	Medium	Minor	0.098		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
17	0.04	0.04	Minor	Alternating frequently	Appreciable	Medium	Minor	0.098		0.025	Smooth	Minor	Medium	0.055		0.025	Smooth	Average	0	Minor	Average	0.012	Small	Average	0.0055	0.0425
18	0.035	0.035	Minor	Gradual	Negligible	Small	Minor	0.046		0.025	Smooth	Negligible	Small	0.0325		0.025	Moderate	Average	0.008	Minor	Average	0.012	Large	Average	0.0375	0.0825
19	0.045	0.045	Minor	Alternating occasionally	Minor	Small	Minor	0.067		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
20	0.045	0.045	Minor	Alternating occasionally	Negligible	Medium	Minor	0.071		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
21	0.03	0.03	Minor	Gradual	Minor	Medium	Minor	0.061		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
22	0.04	0.04	Minor	Alternating occasionally	Minor	Small	Minor	0.062		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
23		Select channel material!								0.025						0.025			#N/A			#N/A		Average	#N/A	
24		Select channel material!								0.025						0.025			#N/A			#N/A		Average	#N/A	
29	0.04	0.04	Minor	Gradual	Minor	Small	Minor	0.059		0.025	Smooth	Appreciable	Very Large	0.125		0.025	Smooth	Average	0	Appreciab	Average	0.025	Very Large	Average	0.075	0.125
30	0.04	0.04	Minor	Alternating occasionally	Minor	Medium	Minor	0.074		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
31	0.04	0.04	Minor	Alternating frequently	Appreciable	Medium	Minor	0.098		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
32	0.04	0.04	Minor	Gradual	Minor	Small	Minor	0.059		0.025	Smooth	Minor	Small	0.0425		0.025	Smooth	Average	0	Minor	Average	0.012	Small	Average	0.0055	0.0425
33	0.04	0.04	Minor	Gradual	Negligible	Small	Severe	0.066		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
34	0.04	0.04	Minor	Gradual	Minor	Small	Appreciable	0.068		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
35	0.04	0.04	Minor	Gradual	Minor	Small	Appreciable	0.068		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Medium	Average	0.018	0.055
36	0.04	0.04	Minor	Gradual	Negligible	Medium	Minor	0.063		0.025	Smooth	Minor	Medium	0.055		0.025	Smooth	Average	0	Minor	Average	0.012	Medium	Average	0.018	0.055
37	0.04	0.04	Minor	Alternating occasionally	Appreciable	Small	Minor	0.077		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
38	0.04	0.04	Minor	Gradual	Minor	Small	Minor	0.059		0.025	Smooth	Minor	Small	0.0425		0.025	Smooth	Average	0	Minor	Average	0.012	Small	Average	0.0055	0.0425
39	0.04	0.04	Minor	Gradual	Minor	Small	Minor	0.059		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Very Large	Average	0.075	0.125
40	0.03	0.03	Minor	Gradual	Negligible	Small	Minor	0.041		0.025	Smooth	Negligible	Small	0.0325		0.025	Moderate	Average	0.008	Minor	Average	0.012	Small	Average	0.0055	0.0505
41	0.04	0.04	Minor	Gradual	Negligible	Small	Appreciable	0.059		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
46	0.04	0.04	Minor	Alternating occasionally	Appreciable	Small	Appreciable	0.089		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
47	0.03	0.03	Minor	Gradual	Minor	Small	Minor	0.049		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
51	0.04	0.04	Minor	Gradual	Negligible	Small	Severe	0.066		0.025	Smooth	Minor	Small	0.0425		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
52	0.04	0.04	Minor	Gradual	Negligible	Small	Minor	0.051		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
53	0.04	0.04	Minor	Gradual	Negligible	Small	Minor	0.051		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
54	0.04	0.04	Minor	Gradual	Negligible	Medium	Minor	0.063		0.025	Smooth	Minor	Medium	0.055		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
55	0.04	0.04	Minor	Gradual	Minor	Small	Appreciable	0.068		0.025	Smooth	Minor	Medium	0.055		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
56	0.04	0.04	Minor	Gradual	Minor	Small	Minor	0.059		0.025	Smooth	Minor	Medium	0.055		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
57	0.04	0.04	Minor	Gradual	Negligible	Small	Minor	0.051		0.025	Smooth	Appreciable	Medium	0.068		0.025	Smooth	Average	0	Appreciab	Average	0.025	Medium	Average	0.018	0.068
58	0.035	0.035	Minor	Gradual	Minor	Small	Minor	0.054		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
59	0.035	0.035	Minor	Gradual	Minor	Small	Minor	0.054		0.025	Smooth	Negligible	Medium	0.045		0.025	Smooth	Average	0	Negligible	Average	0.002	Medium	Average	0.018	0.045
60	0.035	0.035	Minor	Alternating occasionally	Minor	Small	Minor	0.057		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
61	0.04	0.04	Minor	Gradual	Negligible	Small	Minor	0.051		0.025	Smooth	Minor	Medium	0.055		0.025	Smooth	Average	0	Negligible	Average	0.002	Medium	Average	0.018	0.045
62	0.04	0.04	Minor	Alternating occasionally	Negligible	Small	Appreciable	0.062		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
63	0.04	0.04	Minor	Gradual	Minor	Small	Minor	0.059		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
64	0.035	0.035	Minor	Gradual	Negligible	Small	Minor	0.046		0.025	Smooth	Minor	Medium	0.055		0.025	Smooth	Average	0	Minor	Average	0.012	Medium	Average	0.018	0.055

Table A.8. Manning's 'n' Value Assessment

Sub-Basin FID #	Main Channel Base Roughness: Override n_b	Use base roughness, n_b	Main Channel Roughness Adjustments (Conditions): n_1	n_2	n_3	n_4	$m_{1\&2}$	Adjusted n_{chl}	Left Overbank (Floodplain) Base n: Override LOB n_b	Use base roughness, n_b	Left Overbank (Floodplain) Roughness Adjustments (Conditions): n_1	n_3	n_4	Adjusted n_{LOB}	Right Overbank (Floodplain) Base n: Override ROB n_b	Use base roughness, n_b	Right Overbank (Floodplain) Roughness Adjustments (Conditions): n_1			n_3			n_4	0	0	Adjusted n_{ROB}
65	0.04	0.04	Minor	Alternating occasionally	Minor	Small	Minor	0.062		0.025	Smooth	Minor	Medium	0.055		0.025	Smooth	Average	0	Negligible	Average	0.002	Medium	Average	0.018	0.045
67	0.04	0.04	Minor	Alternating occasionally	Minor	Medium	Minor	0.074		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
68	0.04	0.04	Minor	Gradual	Minor	Small	Minor	0.059		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
69	0.045	0.045	Minor	Gradual	Appreciable	Small	Appreciable	0.091		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
70	0.045	0.045	Minor	Gradual	Minor	Small	Appreciable	0.074		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
71	0.045	0.045	Minor	Alternating occasionally	Minor	Small	Appreciable	0.077		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
72	0.04	0.04	Minor	Alternating occasionally	Negligible	Small	Appreciable	0.062		0.025	Smooth	Negligible	Large	0.0645		0.025	Smooth	Average	0	Negligible	Average	0.002	Large	Average	0.0375	0.0645
73	0.035	0.035	Minor	Gradual	Minor	Small	Minor	0.054		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
74	0.03	0.03	Minor	Gradual	Minor	Small	Minor	0.049		0.025	Smooth	Minor	Small	0.0425		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
75	0.03	0.03	Minor	Gradual	Minor	Medium	Minor	0.061		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Minor	Average	0.012	Small	Average	0.0055	0.0425
76	0.03	0.03	Minor	Gradual	Negligible	Medium	Minor	0.053		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
77	0.035	0.035	Minor	Gradual	Negligible	Small	Minor	0.046		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
78	0.04	0.04	Minor	Gradual	Minor	Small	Minor	0.059		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
79	0.032	0.032	Minor	Gradual	Negligible	Small	Minor	0.043		0.025	Smooth	Negligible	Medium	0.045		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
80	0.03	0.03	Minor	Gradual	Negligible	Small	Minor	0.041		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
81	0.03	0.03	Minor	Gradual	Negligible	Small	Minor	0.041		0.025	Smooth	Negligible	Small	0.0325		0.025	Smooth	Average	0	Negligible	Average	0.002	Small	Average	0.0055	0.0325
82	0.03	0.03	Minor	Gradual	Negligible	Medium	Minor	0.053		0.025	Smooth	Negligible	Medium	0.045		0.025	Smooth	Average	0	Negligible	Average	0.002	Medium	Average	0.018	0.045
83	0.04	0.04	Minor	Gradual	Negligible	Small	Severe	0.066		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
84	0.035	0.035	Minor	Gradual	Negligible	Small	Minor	0.046		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
85		Select channel material!								0.025						0.025			#N/A			#N/A		Average	#N/A	
86		Select channel material!								0.025						0.025			#N/A			#N/A		Average	#N/A	
87	0.04	0.04	Minor	Alternating occasionally	Minor	Small	Appreciable	0.071		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
88	0.045	0.045	Minor	Alternating occasionally	Appreciable	Small	Minor	0.082		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
89	0.04	0.04	Minor	Gradual	Negligible	Small	Minor	0.051		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
93	0.035	0.035	Minor	Gradual	Negligible	Small	Minor	0.046		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Medium	Average	0.018	0.055
95	0.04	0.04	Minor	Alternating occasionally	Minor	Small	Minor	0.062		0.025	Smooth	Minor	Large	0.0745		0.025	Smooth	Average	0	Minor	Average	0.012	Large	Average	0.0375	0.0745
96	0.04	0.04	Minor	Gradual	Appreciable	Small	Minor	0.074		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
98	0.04	0.04	Minor	Alternating occasionally	Minor	Small	Minor	0.062		0.025	Smooth	Appreciable	Medium	0.068		0.025	Smooth	Average	0	Appreciab	Average	0.025	Medium	Average	0.018	0.068
100	0.04	0.04	Minor	Alternating occasionally	Minor	Small	Appreciable	0.071		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
101		Select channel material!								0.025						0.025			#N/A			#N/A		Average	#N/A	
105		Select channel material!								0.025						0.025			#N/A			#N/A		Average	#N/A	
106	0.04	0.04	Minor	Gradual	Minor	Small	Appreciable	0.068		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
107	0.04	0.04	Minor	Gradual	Minor	Small	Minor	0.059		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
108	0.04	0.04	Minor	Alternating occasionally	Minor	Small	Minor	0.062		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
109	0.04	0.04	Minor	Alternating occasionally	Negligible	Small	Minor	0.054		0.025	Smooth	Appreciable	Large	0.0875		0.025	Smooth	Average	0	Appreciab	Average	0.025	Large	Average	0.0375	0.0875
110	0.04	0.04	Minor	Gradual	Negligible	Small	Minor	0.051		0.025	Smooth	Appreciable	Very Large	0.125		0.025	Smooth	Average	0	Appreciab	Average	0.025	Very Larg	Average	0.075	0.125
111	0.04	0.04	Minor	Alternating occasionally	Minor	Small	Severe	0.081		0.025	Smooth	Appreciable	Very Large	0.125		0.025	Smooth	Average	0	Appreciab	Average	0.025	Very Larg	Average	0.075	0.125
112	0.04	0.04	Minor	Alternating occasionally	Negligible	Medium	Minor	0.066		0.025	Smooth	Negligible	Medium	0.043		0.025	Smooth	Average		Negligible	Average	0.002	Large	Average	0.0375	0.0645
113		Select channel material!								0.025						0.025					Average	#N/A		Average	#N/A	
114	0.04	0.04	Minor	Gradual	Negligible	Small	Severe	0.066		0.025	Minor	Minor	Very Large	0.1		0.025	Smooth	Average		Minor	Average	0.012	Very Larg	Average	0.075	0.112
115	0.04	0.04	Smooth	Alternating occasionally	Negligible	Medium	Minor	0.063		0.025	Smooth	Negligible	Very Large	0.1		0.025	Smooth	Average		Negligible	Average	0.002	Very Larg	Average	0.075	0.102
116	0.04	0.04	Smooth	Gradual	Negligible	Small	Minor	0.048		0.025	Smooth	Negligible	Small	0.0305		0.025	Smooth	Average		Negligible	Average	0.002	Small	Average	0.0055	0.0325

Appendix B. Hydraulic Modeling

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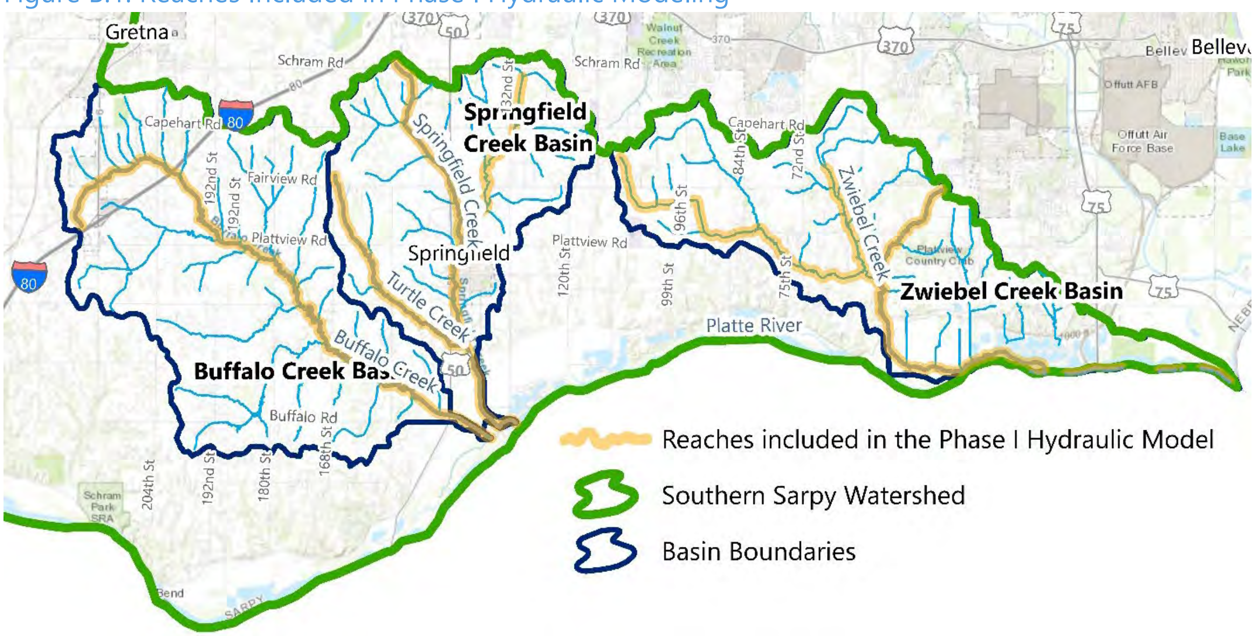
1.0 HYDRAULIC MODELING

A hydraulic model for existing and future conditions was developed for the main reaches within the Buffalo, Springfield, and Zwiebel Creek basins, as shown in Figure B.1. This model provided coarse floodplain limits; however, the model will be refined in future phases of Plan development with Federal Emergency Management Agency (FEMA)-compliant floodplain maps produced with the completion of the Plan. A one-dimensional steady-state HEC RAS model was utilized for hydraulic modeling as this is the current expectation for FEMA mapping products. Given the relatively uncomplicated floodplains, a one-dimensional steady-state model is appropriate and will provide more than adequate hydraulic modeling of these systems.

Figure B.1. Reaches Included in Phase I Hydraulic Modeling



Hydraulic structure information was gathered from Sarpy County and the Nebraska Department of Transportation for all available structures in the three main watersheds, which provided some information on 13 of the 44 structures. Where information was unavailable or incomplete, survey information was supplemented using a RTK GPS exceeding 0.1-foot vertical accuracy. The combined structure information was incorporated into the HEC RAS model. With exception of structures located on private property, all structures located in the hydraulic models were surveyed. Further refinement of the modeling will be necessary in subsequent phases. Locations of the structures in the current iteration of the HEC RAS model are provided in Figures B.3 and B.4. A summary of Sarpy County structures is provided in Figure B.5. All page-sized figures for this appendix are included at the end of the text to provide a more reader-friendly document.

Cross-section geometry was created from the 2013 LiDAR data, the most up-to-date LIDAR available at the time of the analysis. Cross sections were defined along the stream centerline (sourced from the TIGER dataset) at an approximate spacing of 250-feet with particular attention paid to perpendicular orientation of the section against the predominant flow direction which resulted in multiple dog-legged sections. Cross sections were extended to approximately 50-feet beyond the estimated extents of the 500-year floodplain elevation. Once initial routings were completed, some of these lengths were adjusted for consistency. Banklines were defined based on contour breaks and vegetation extents from the 2013 and 2016 aerial imagery and recorded as polyline objects for future monitoring of bankline extents. Cross sections were appropriately placed a distance upstream and downstream from hydraulic structures based on 1:1 contraction and 1:3 expansion complying with current hydraulic modeling guidance. Cross section maps have been provided for each watershed as Figures B.6 and B.7.

Comparison nodes were defined early in Phase I to provide comparisons in water surface elevations (WSEs), discharges, volumes, and floodplain extents. Figure 2 provides a summary map of the comparison nodes.

Figure B.2. Comparison Nodes

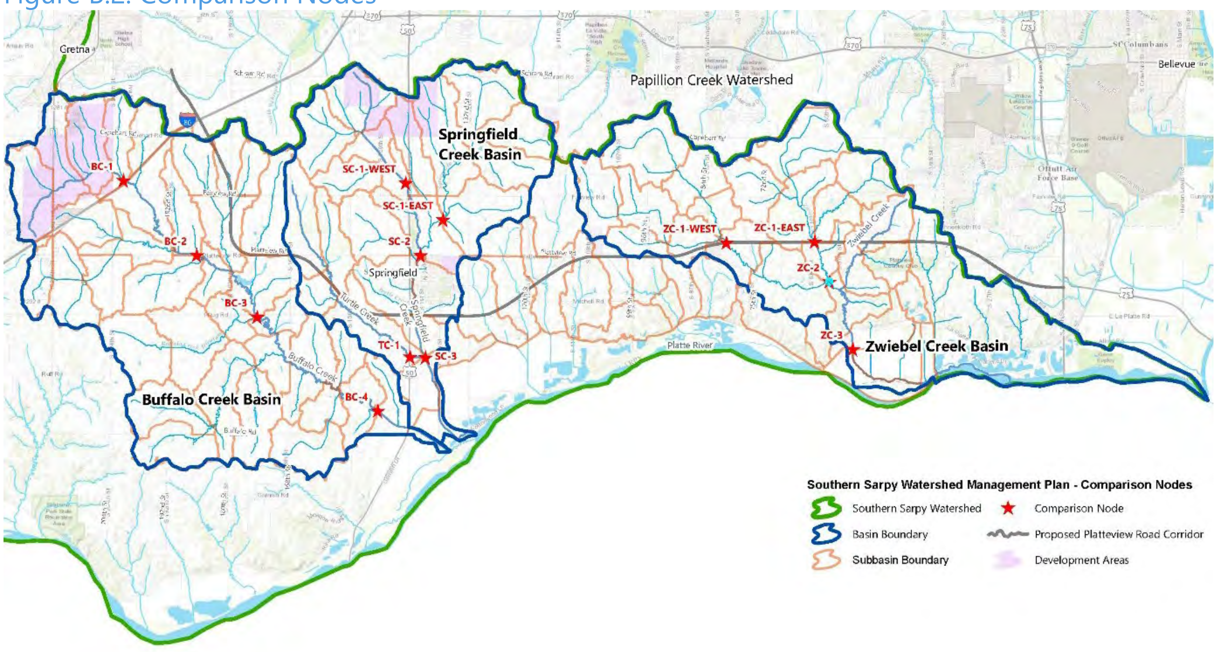


Table B.1 below provides a summary of the HEC RAS modeling filenames and run configurations.

Table B.1. HEC RAS Filenames

Stream Name	HEC RAS Project	Geometry File	Flow File	Steady State Run
Buffalo Creek	SSarpy_BC.prj	EXS_BC.g01	Steady_BC.f01	EXS_SS_BC
Springfield Creek	SSarpy_SC.prj	EXS_SC.g01	Steady_SC.f01	EXS_SS_SC
Zwiebel Creek	SSarpy_ZC.prj	EXS_ZC.g01	Steady_ZC.f01	EXS_SS_ZC
Turtle Creek	SSarpy_TC.prj	EXS_TC.g01	Steady_TC.f01	EXS_SS_TC

Inundation maps have been created for these three systems and included as Figure B.8. Hydraulic profiles have been provided for Zwiebel, Springfield, and Buffalo Creeks as Figures B.10 through B.20.

2.0 REFERENCES

US Army Corps of Engineers. HEC-RAS. http://www.hec.usace.army.mil/software/hec-ras/features.aspx. Accessed January 2018.

United States Census Bureau. Geography – TIGER/Line Shapefiles and TIGER/Line Files. https://www.census.gov/geo/maps-data/data/tiger-line.html. Accessed January 2018.

Figure B.3. Structures in Current Iteration of HEC RAS Model

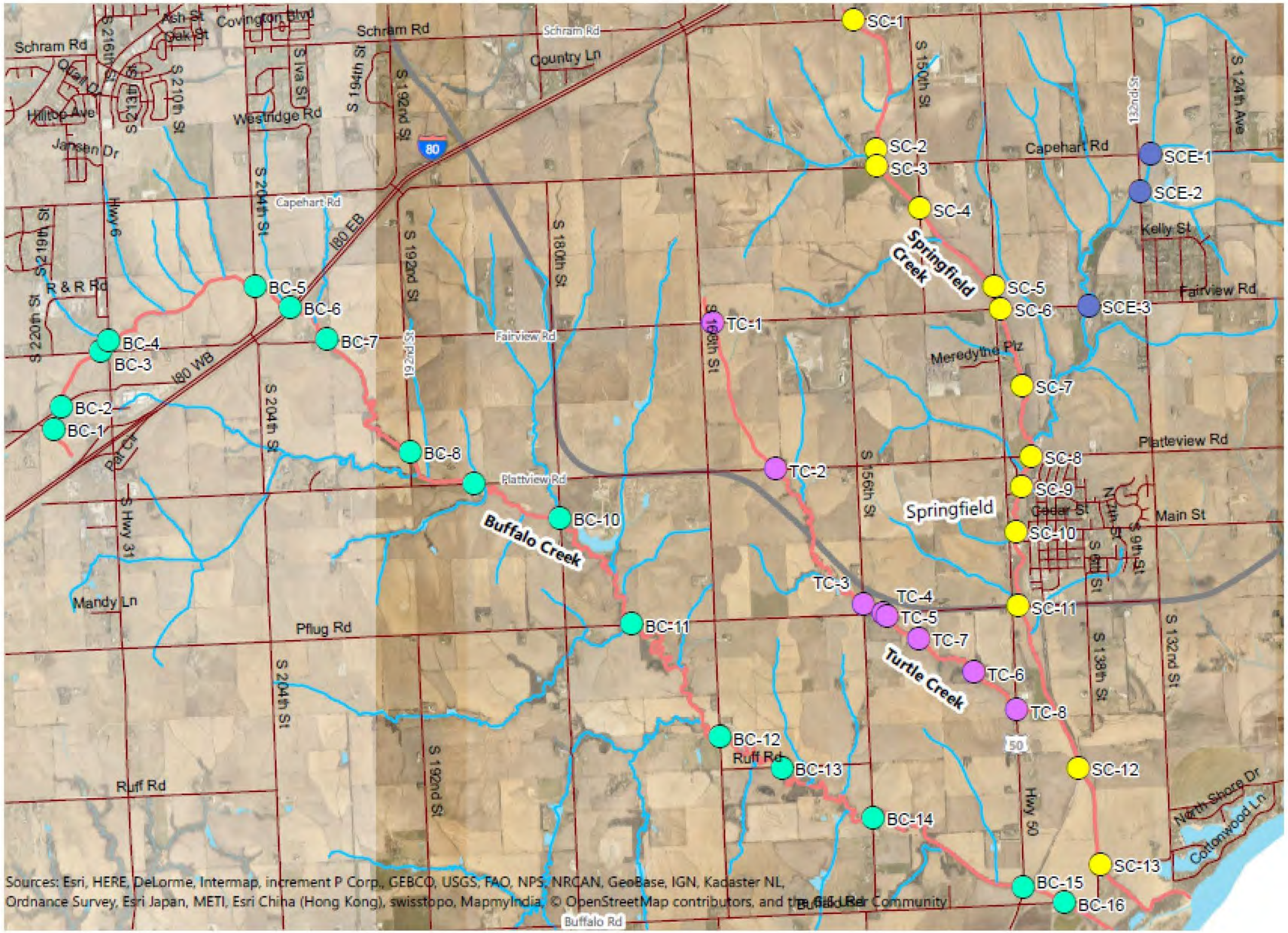


Figure B.4. Structures in Current Iteration of HEC RAS Model

Figure B.5. Sarpy County Structures

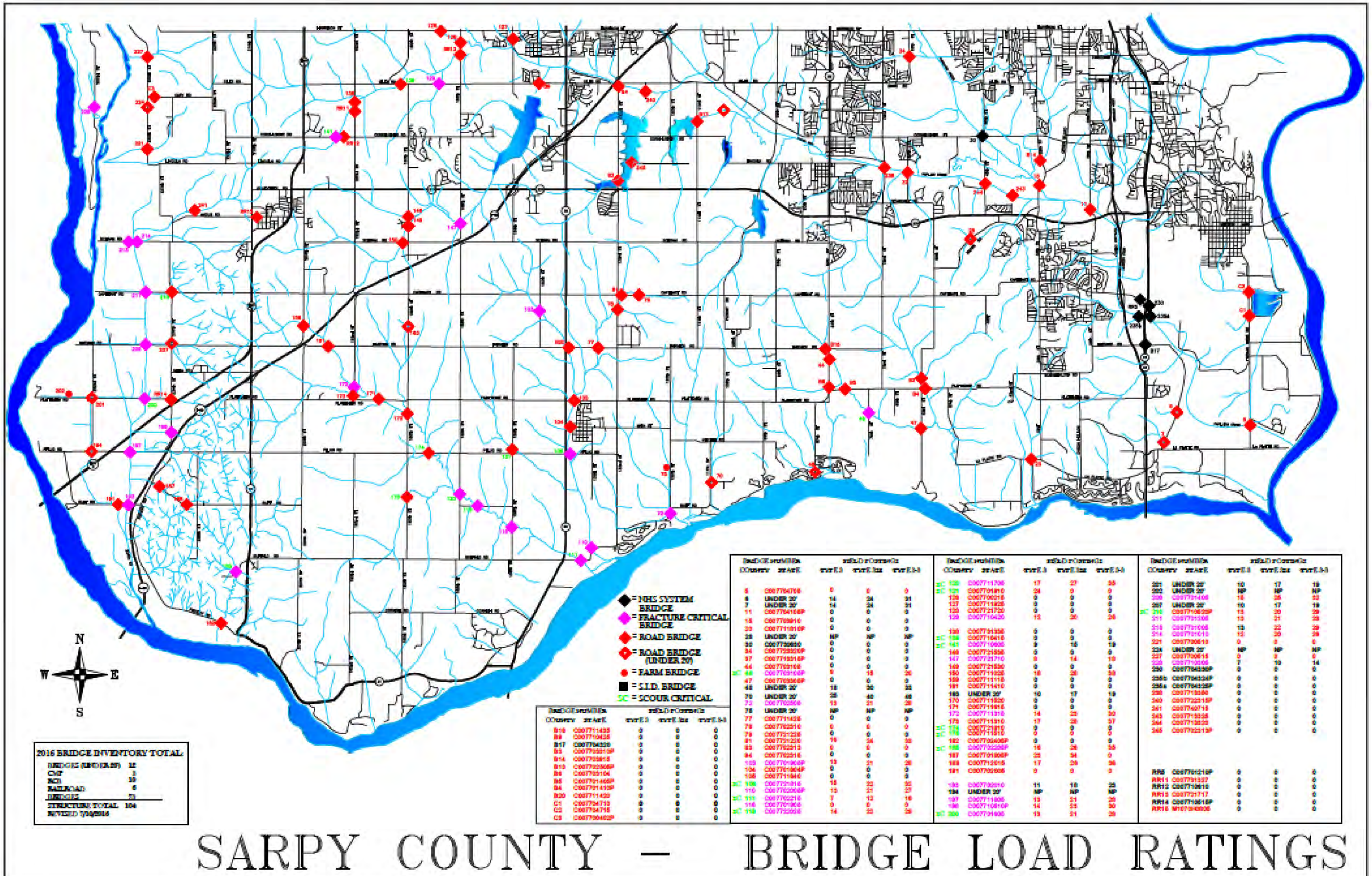


Figure B.6. Cross Section Maps

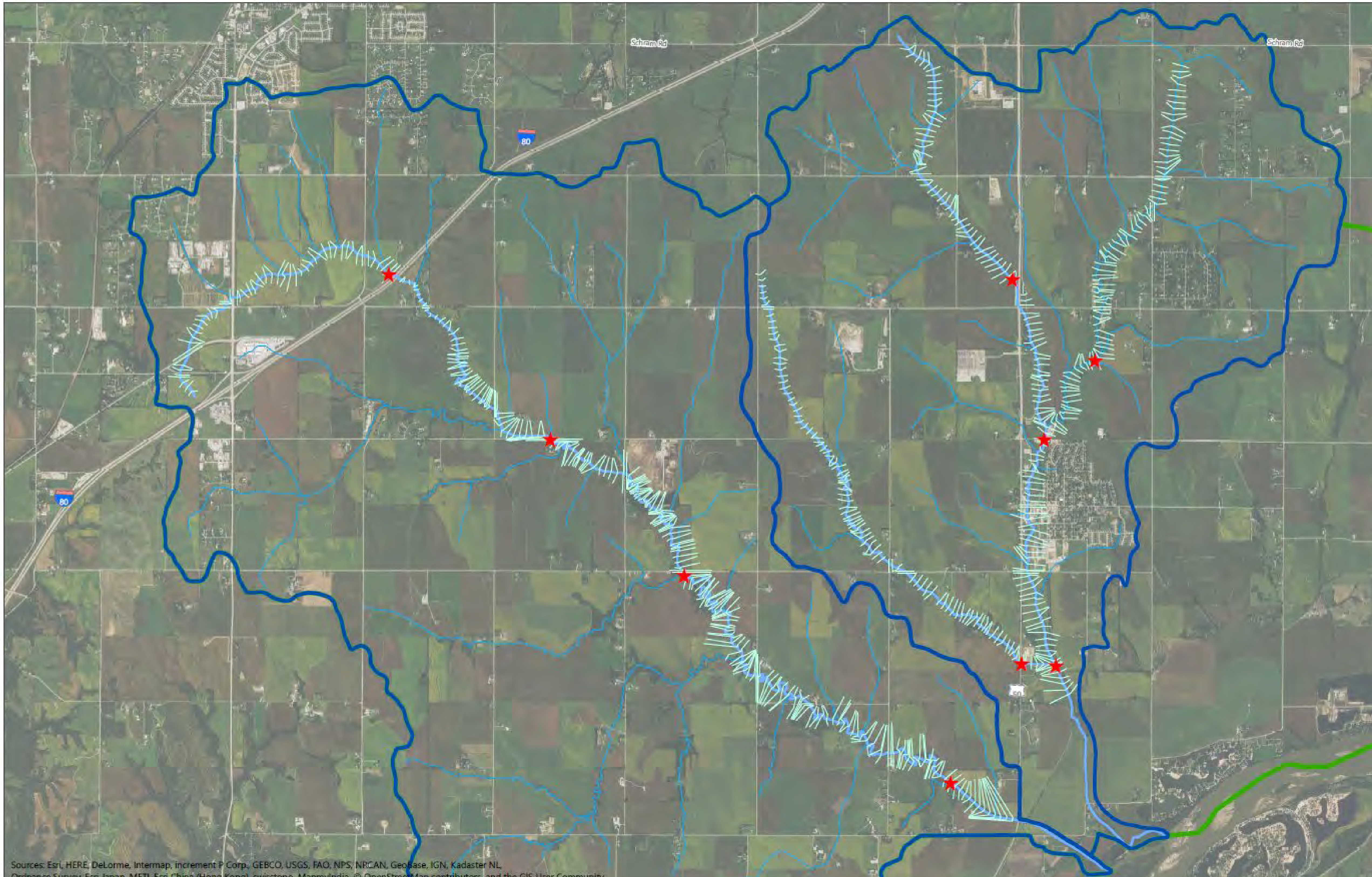


Figure B.7. Cross Section Maps

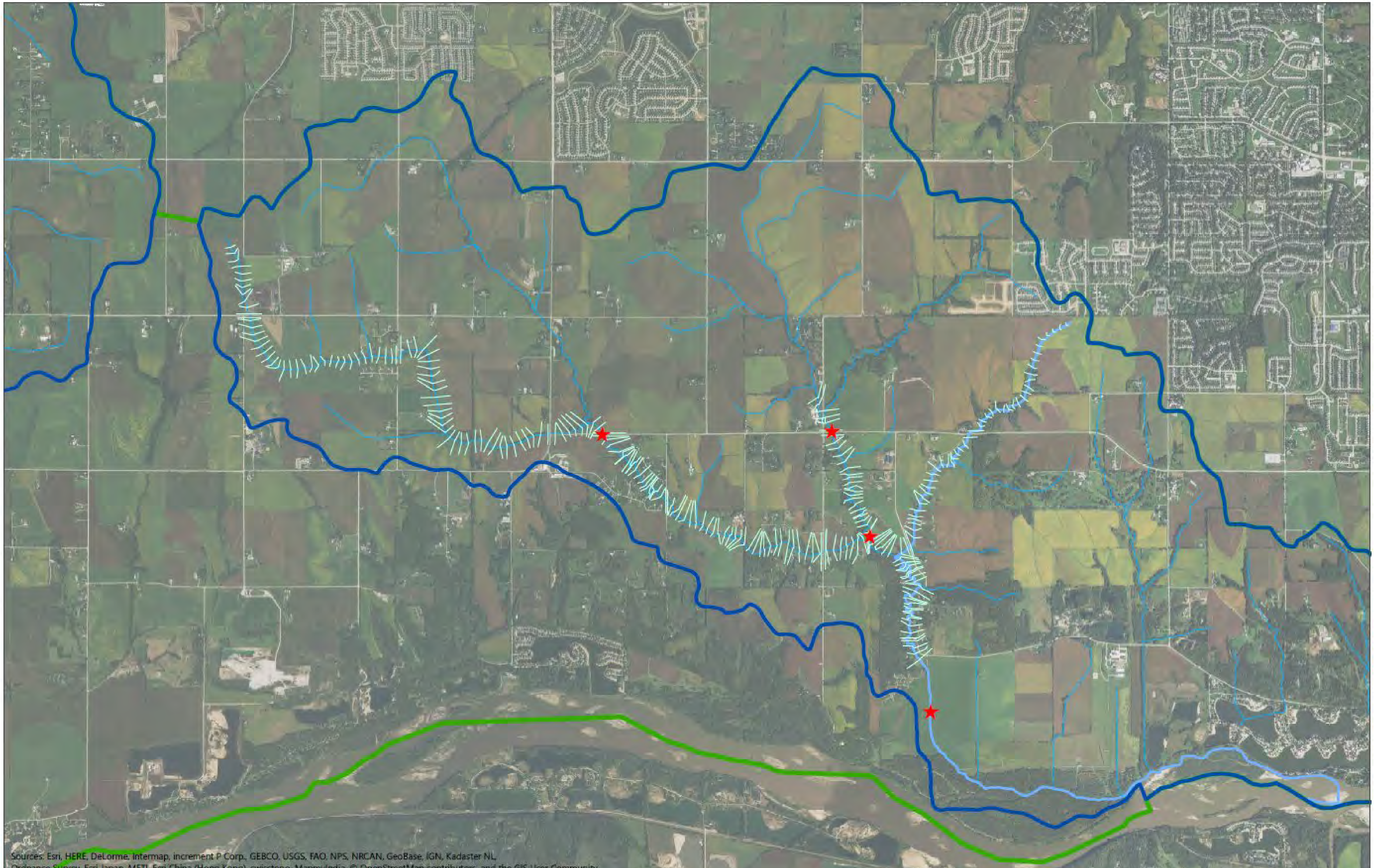


Figure B.8. Inundation Extents for Future 100-Year

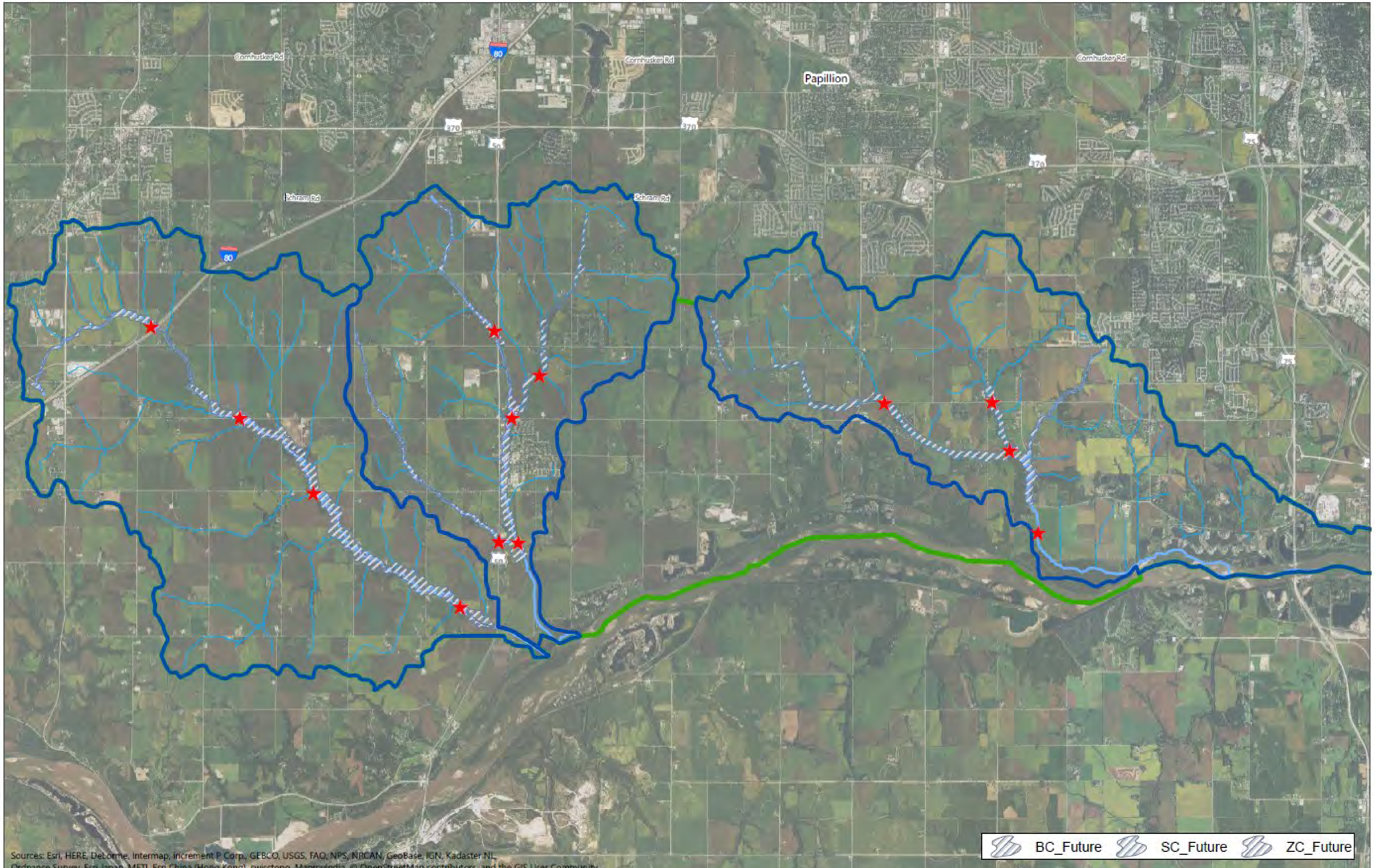


Figure B.9. Stream Profile Alignment Locations

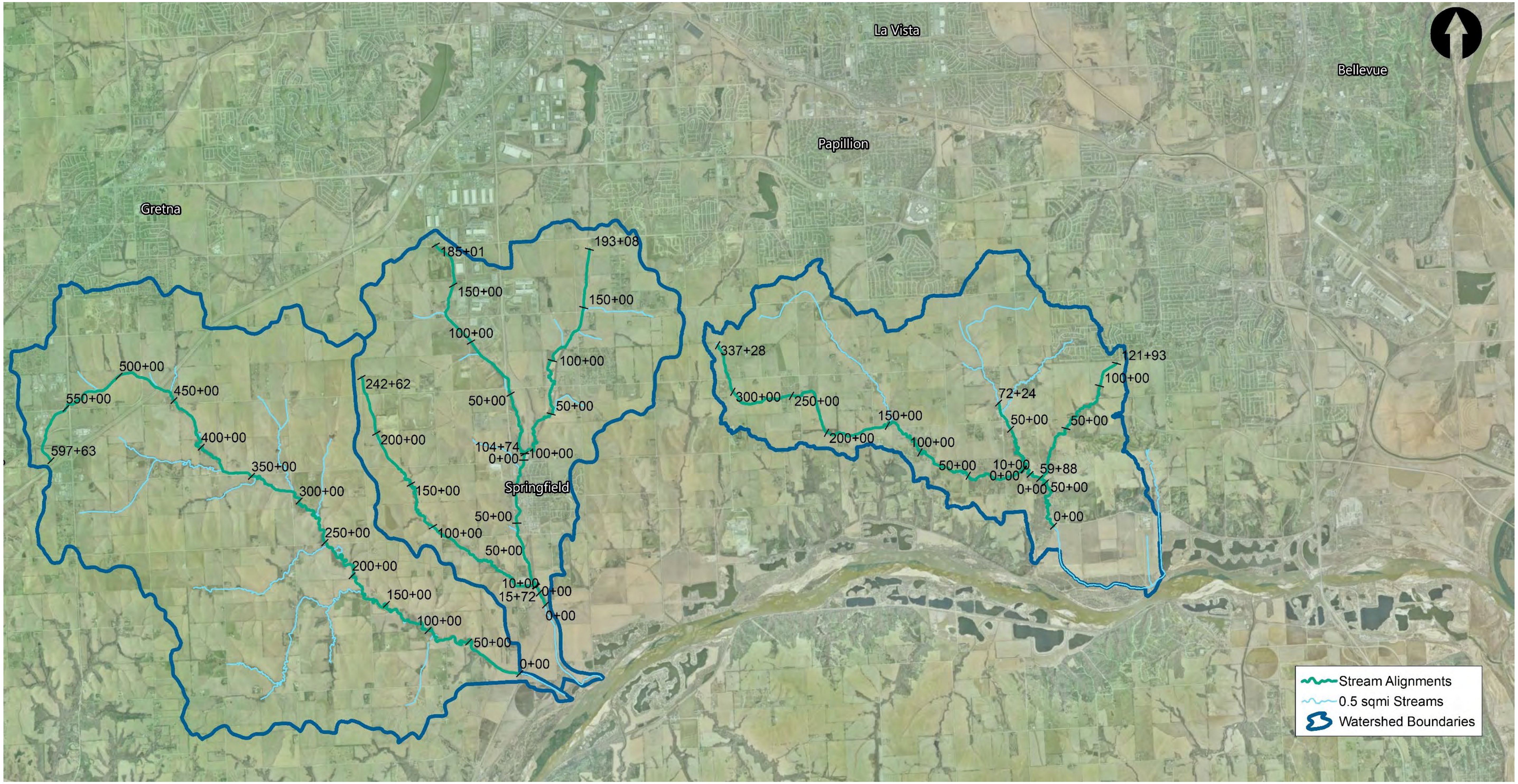


Figure B.10. Stream Profile with 100-Year BFE for Buffalo Creek

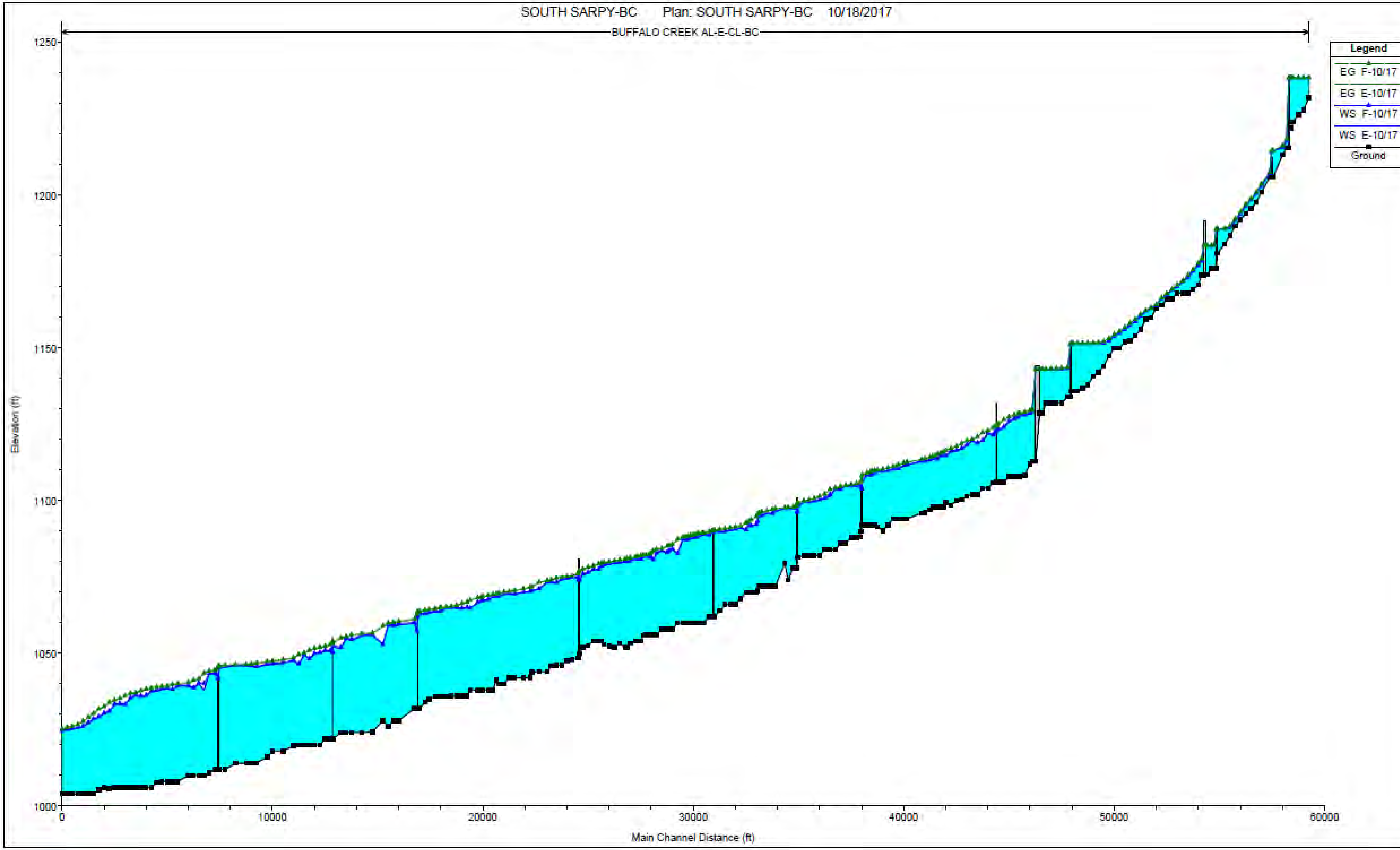


Figure B.11. Stream Profile with 100-Year BFE for Turtle Creek

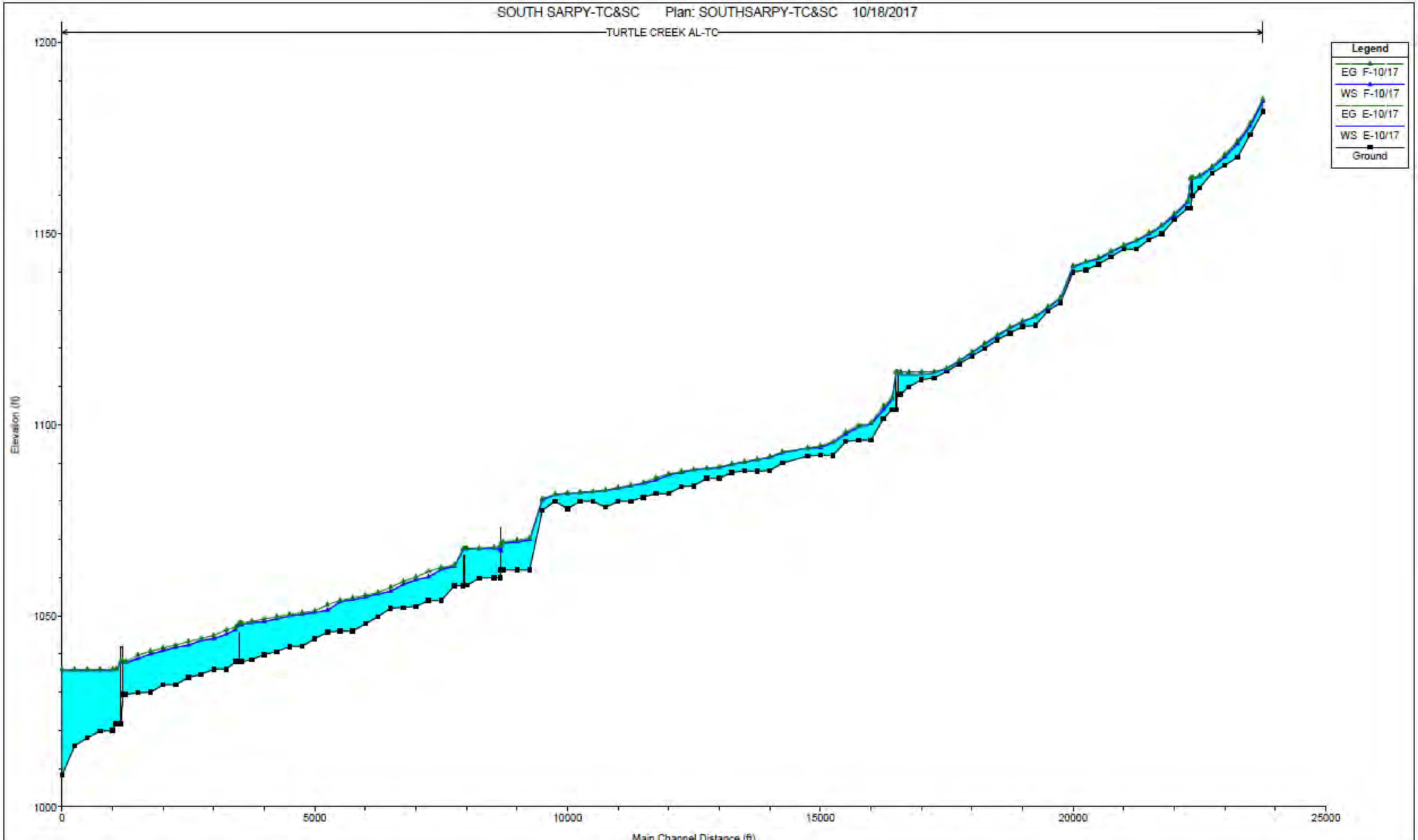


Figure B.12. Stream Profile with 100-Year BFE for Springfield Creek

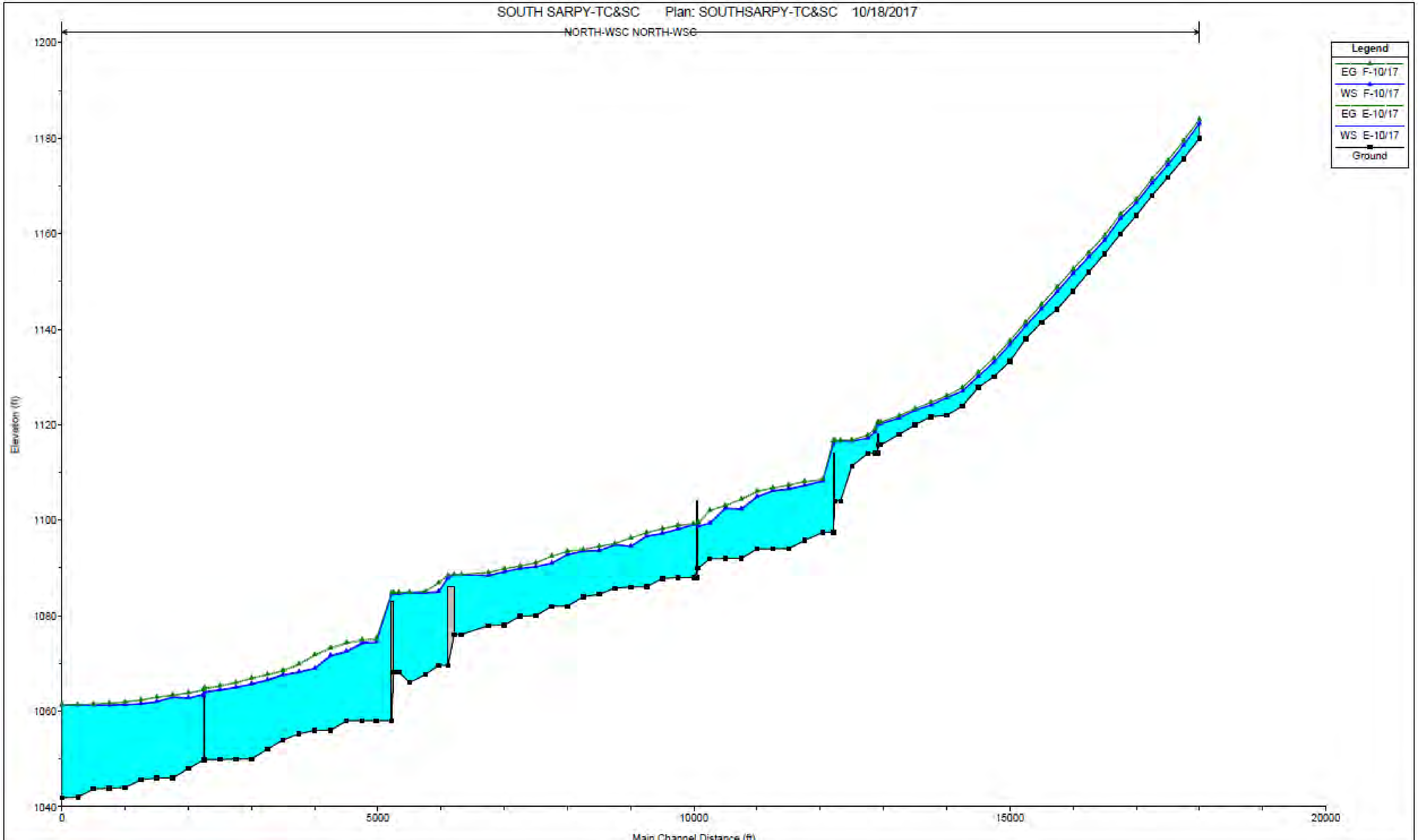


Figure B.13. Stream Profile with 100-Year BFE for Springfield Creek

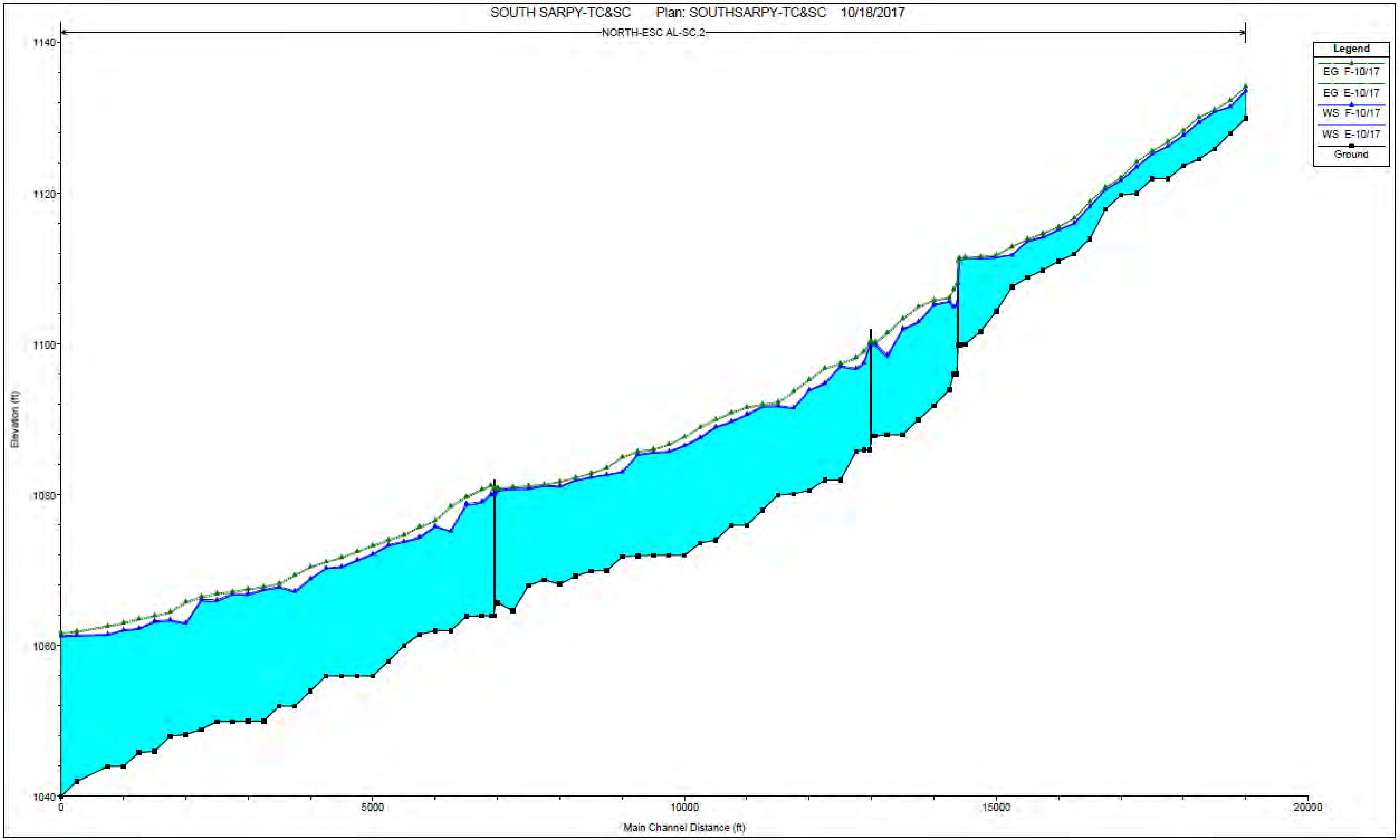


Figure B.14. Stream Profile with 100-Year BFE for Springfield Creek

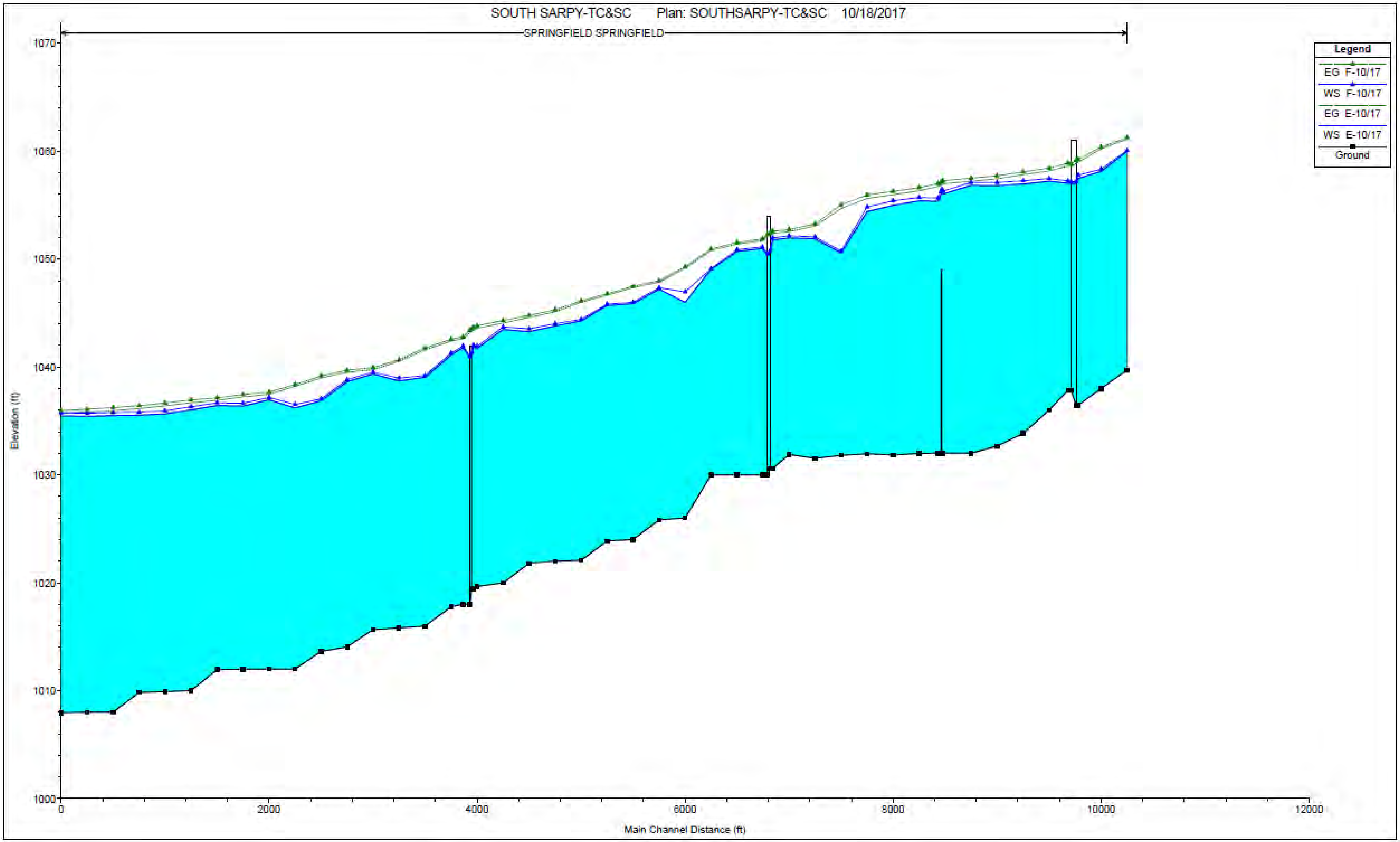


Figure B.15. Stream Profile with 100-Year BFE for Springfield Creek

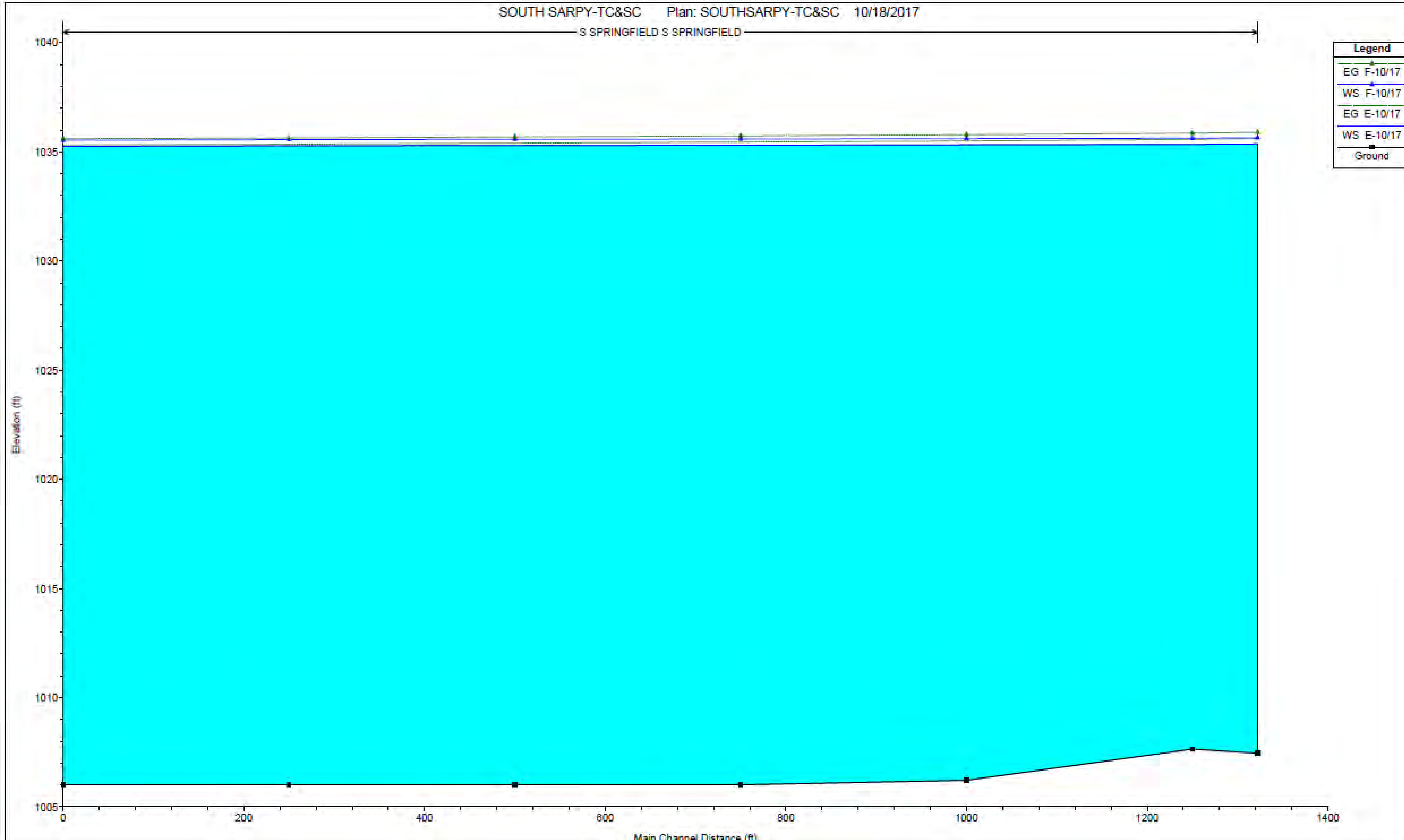


Figure B.16. Stream Profile with 100-Year BFE for Zwiebel Creek

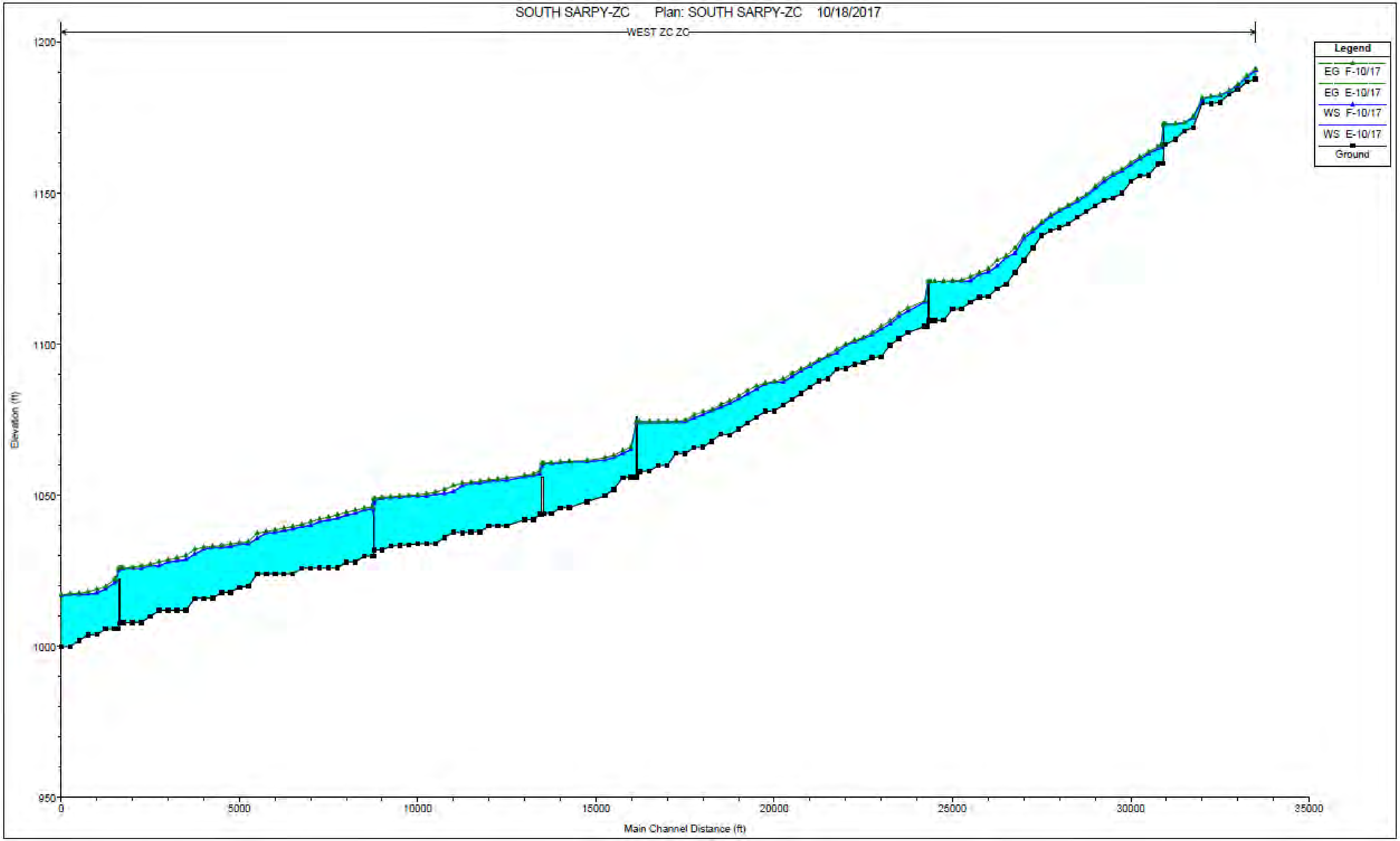


Figure B.17. Stream Profile with 100-Year BFE for Zwiebel Creek

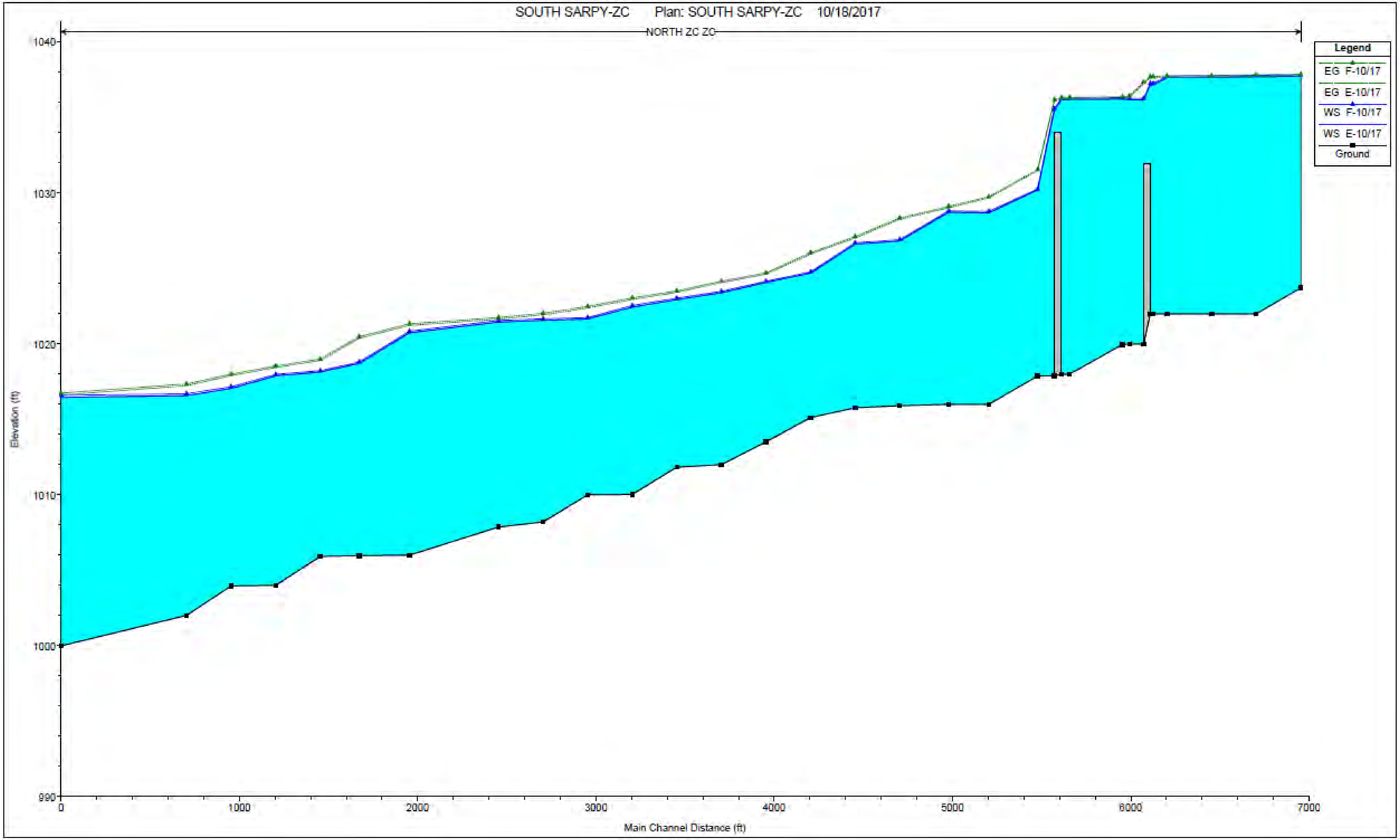


Figure B.18. Stream Profile with 100-Year BFE for Zwiebel Creek

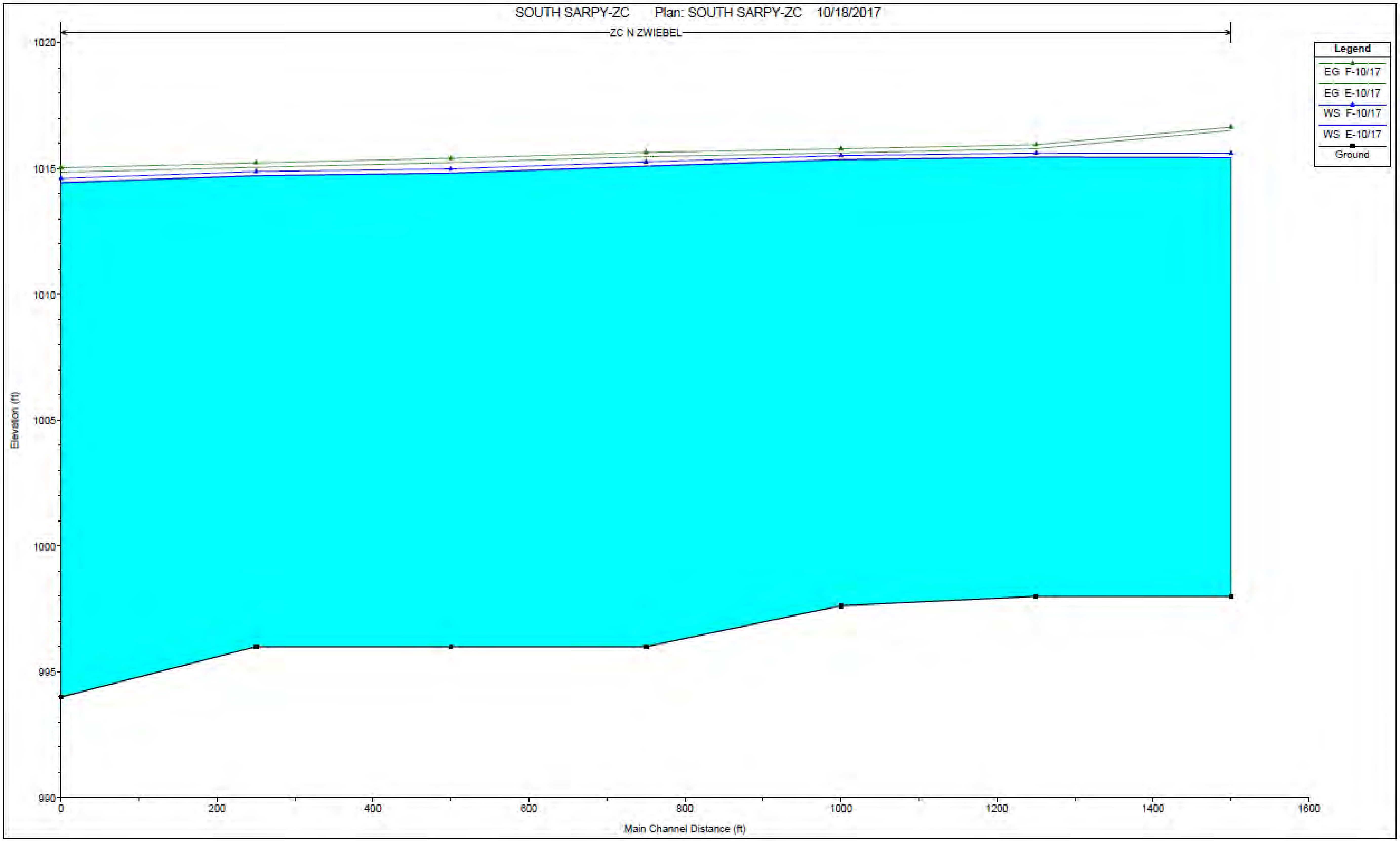


Figure B.19. Stream Profile with 100-Year BFE for Zwiebel Creek

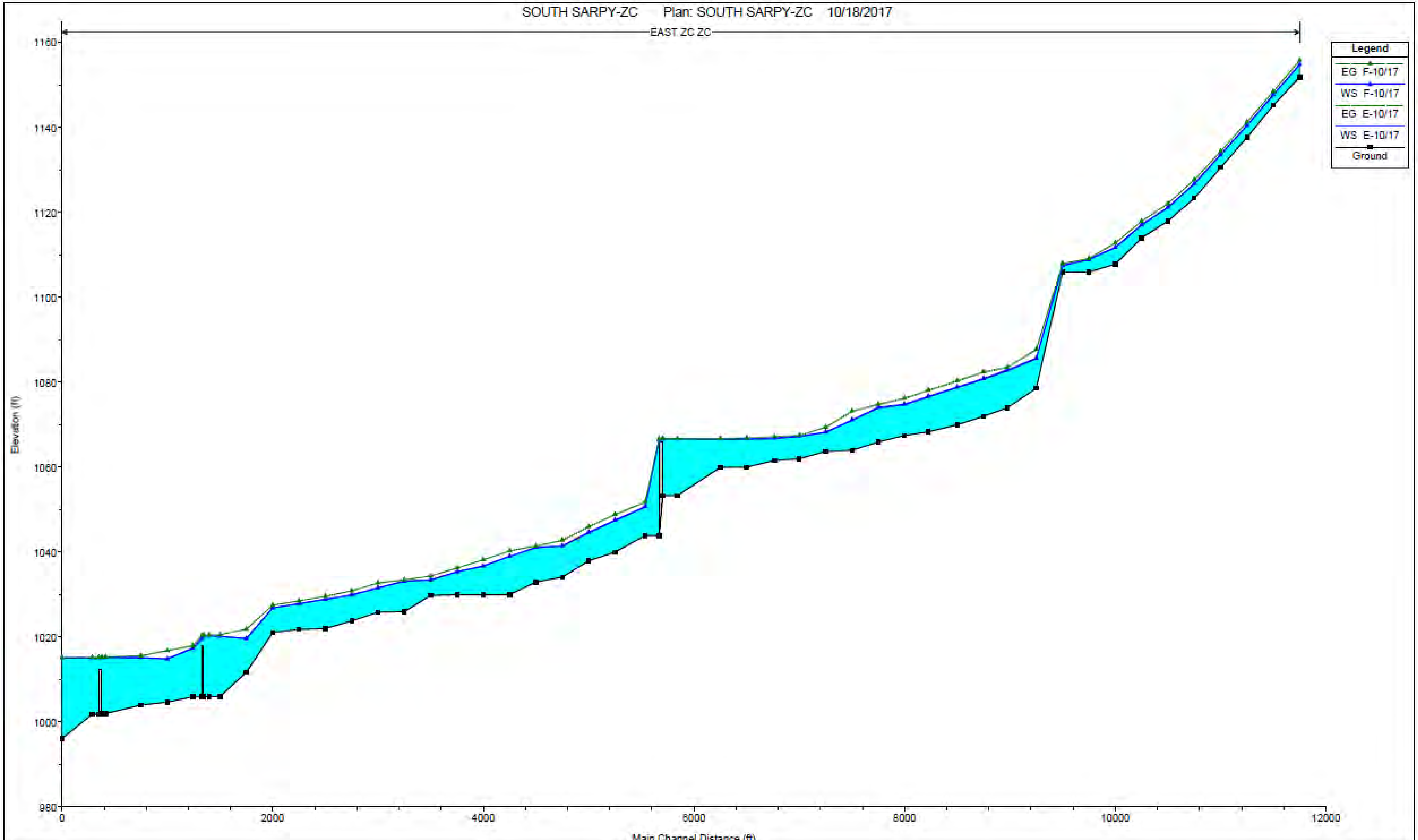
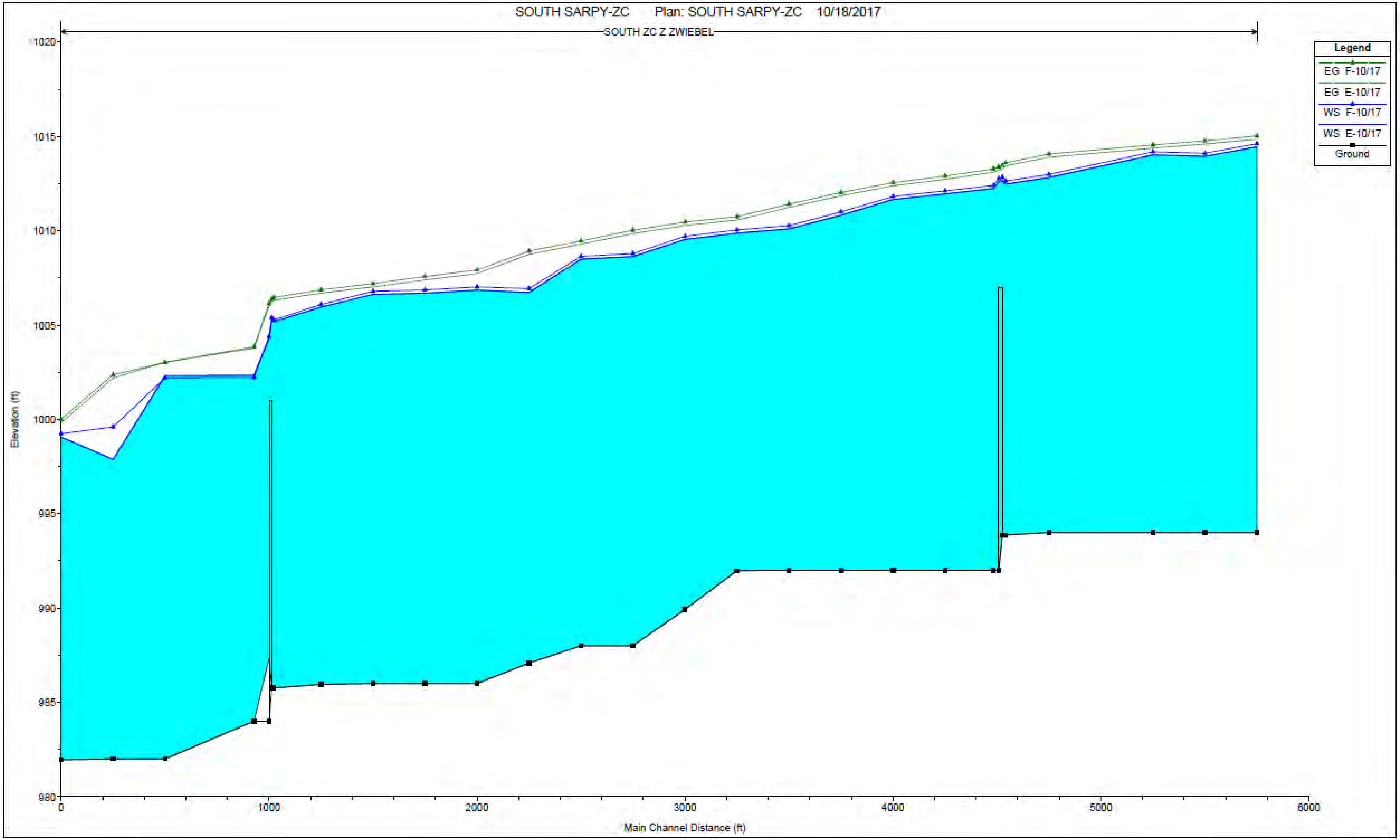


Figure B.20. Stream Profile with 100-Year BFE for Zwiebel Creek



Appendix C. Environmental Resources

Planning & Design

Vireo

BeVireo.com

MEMORANDUM

Project Name | Southern Sarpy County Watershed Management Plan

Project No | 15160

Date | August 29, 2018

To | Janel Kaufman – FYRA Engineering

From | Laurie Brown and Tom Bentley - Vireo

Re | Environmentally Sensitive Resources and Environmental Regulations Memo

I. Introduction

At the request of FYRA Engineering (FYRA) and the Papio-Missouri River Natural Resources District (NRD), Vireo completed a desktop review of environmentally sensitive resources and applicable environmental regulations for three watersheds (Buffalo, Springfield, and Zweibel) in southern Sarpy County, Nebraska. The following provides a brief summary of the results of this review.

II. Environmentally Sensitive Resources

Vireo conducted the environmentally sensitive resources review using desktop resources developed by the Nebraska Natural Heritage Program, which is under the Nebraska Game and Parks Commission (NGPC). The Nebraska Natural Heritage Program provides data on rare and at-risk species and natural communities. The Sarpy County Trail Master Plan was also used as part of this review.

Nebraska Conservation and Environmental Review Tool (CERT)

The Cert provides geographic information system (GIS) mapping and information about mapped features that overlay spatially with a defined project review area. Locations for some species and natural communities may be mapped more broadly and not be site-specific, dependent upon the available information. The purpose of this tool is to provide information that can be used to describe the conservation and legal status of species and natural communities in the vicinity of the project area. Registered users can identify areas for potential conservation projects and receive reports detailing features in the project area, or submit projects for environmental review by NGPC and the US Fish and Wildlife Service (USFWS). In addition to maps, information provided includes:

- Scientific and common name of species.
- Status under the federal Endangered Species Act.
- State status under the Nebraska Nongame and Endangered Species Conservation Act or the Nebraska Administrative Code.
- Species of Greatest Conservation Need (SGCN) as defined in Nebraska's State Wildlife Action Plan (SWAP): Tier 1 – species that are globally or nationally most at risk of extinction, and Tier 2 – rare or imperiled in Nebraska.

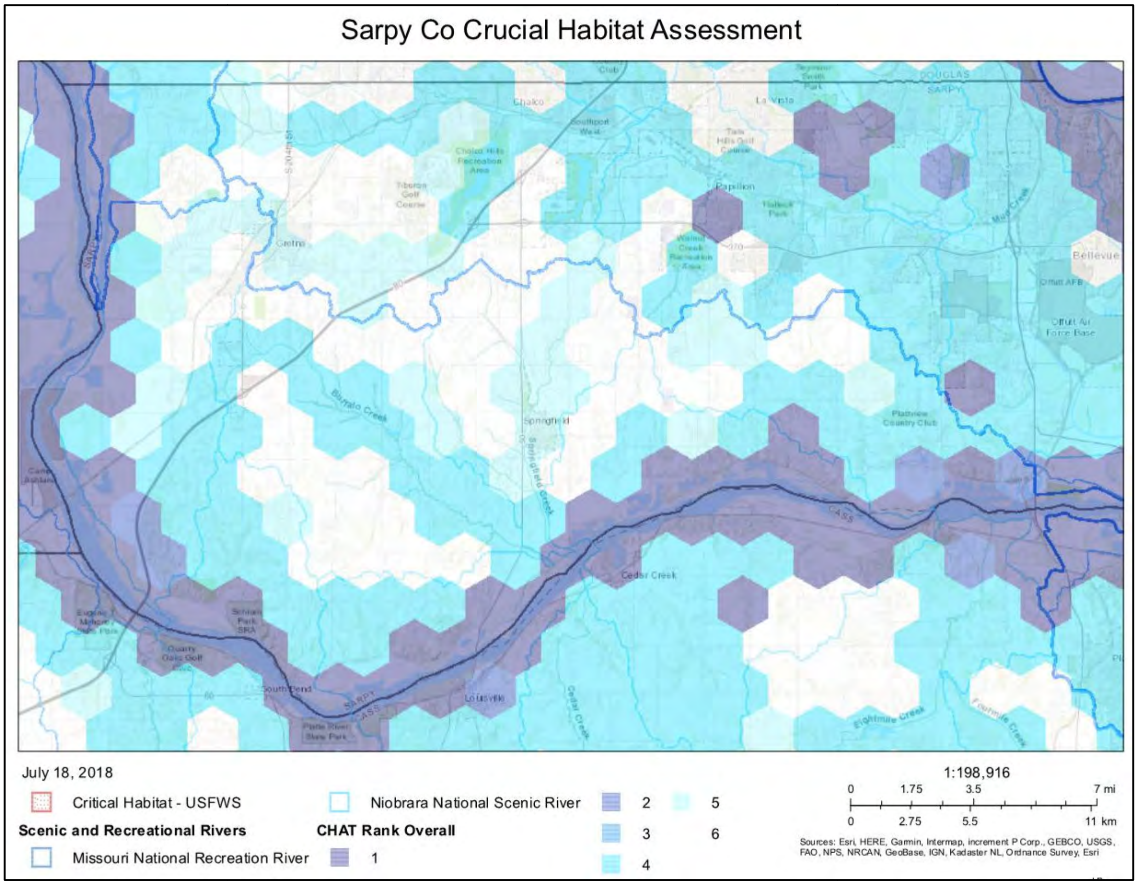
The Cert can also provide maps and information on Biologically Unique Landscapes (BULs), which are priority landscapes that if properly managed, would conserve the majority of Nebraska's biological diversity. The map below illustrates BULs within the state as of June 2011 (NGPC 2018). The general watershed planning area is indicated within the orange circle marked on the map.

Crucial Habitat Assessment Tool for Nebraska (CHAT)

The CHAT provides coarse-scale, landscape-level information related to habitats for at-risk species and natural plant communities that can be used for land use planning. The CHAT is an online GIS mapping tool that provides access to credible scientific data on a broad scale for use in project analysis, siting, and planning, and that is non-regulatory. The following data components were identified as important for delineating crucial habitats.

- Species of Concern: terrestrial and aquatic
- Species of Economic and Recreational Importance: terrestrial and aquatic
- Native and Unfragmented Habitat: large natural areas, natural communities, ecological systems of concern, landscape corridors
- Riparian and Wetland Habitat
- Wildlife Corridors

The CHAT uses a relative six-level prioritization scheme where a score of 1 represents areas that are most important and 6 represents those least important areas. In the case of Nebraska, the data incorporates information for most of the Natural Legacy Project Tier 1 species, including all state and federally listed species. The map below illustrates the CHAT results for Sarpy County.



<u>Estimated Current Ranges of Threatened & Endangered Species</u>

The Nebraska Natural Heritage Program compiled and edited a list of threatened and endangered species by county for the state of Nebraska in December 2017. The list is accompanied by maps that illustrate the distribution of species and suitable habitat based on documented occurrences and expert knowledge. The information includes federal and state listed species. The list below is for species within Sarpy County. Maps for these species are attached.

Sarpy	American Ginseng	Panax quinquefolium	ST
	Interior Least Tern	Sternula antillarum athalassos	FE, SE
	Lake Sturgeon	Acipenser fulvescens	ST
	Northern Long-eared Bat	Myotis septentrionalis	FT, ST
	Pallid Sturgeon	Scaphirhynchus albus	FE, SE
	Piping Plover	Charadrius melodus	FT, ST
	River Otter	Lontra canadensis	ST
	Sturgeon Chub	Macrhybopsis gelida	SE
	Western Prairie Fringed Orchid	Platanthera praeclara	FT, ST

FE – Federally endangered; FT – Federally threatened; SE – State endangered; ST – State threatened

Sarpy County Environmental Sensitivity Index

As part of the County's trail master planning effort, Vireo performed a natural resources assessment to identify sensitive natural areas that could be linked through a system of greenways, which would help protect these valuable resources while providing public access for recreation. An Environmental Sensitivity Index (ESI) was developed by identifying high-quality natural resources such as vegetation, soils, water bodies, topography, and sensitive habitats; and evaluating the relative and cumulative value of these resources using a geographic information systems (GIS) model. Vireo mapped the results, which provides planners and designers with a simple but powerful visual indication of natural resource value. The resulting ESI map illustrates that most areas of high sensitivity are located along the Platte River and Buffalo Creek corridors and moderately high sensitivity along the Springfield and Zweibel Creek stream corridors respectively. See the attached map.

This model was then used by County staff and stakeholders to identify the most desirable greenways based on the ESI results and current and future development and park plans. The resulting Trail Master Plan Phase 2 identified educational, recreational, and cultural destinations, as well as planned and proposed trail networks (see attached maps).

III. Environmental Regulations

Vireo also conducted a desktop review of environmental regulations at the county, state, and federal level that could be applicable to implementation of this Watershed Plan, or for outside parties to carry out policies identified in the watershed master plan.

STATE and FEDERAL

Section 404 of the Clean Water Act: Establishes a program to regulate the discharge of dredge or fill material into waters of the U.S., including wetlands. The basic premise of the program is that no discharge of dredged or fill material may be permitted if: (1) a practicable alternative exists that is less damaging to the aquatic environment or (2) the nation's waters would be significantly degraded. At the federal level, the US Army Corps of Engineers handles permit applications.

U.S. Army Corps of Engineers-Omaha District Contact: (402) 896-0997

Section 401 of the Clean Water Act: The Nebraska Department of Environmental Quality (NDEQ) Planning Unit administers the Section 401 Water Quality Certification Program in accordance with Section 401 of the Clean Water Act. This program evaluates applications for federal permits and licenses that involve a discharge to waters of the state and determines whether the proposed activity complies with Title 117 – Nebraska Surface Water Quality Standards. If a Section 404 Permit is needed, this will trigger the Section 401 Water Quality Certification.

NDEQ Planning Unit Contact: (402) 471-2186

National Pollutant Discharge Elimination System (NPDES): All persons discharging or proposing to discharge pollutants from a point source into any waters of the state are required to apply for and have a permit under the National Pollutant Discharge Elimination System (NPDES) to discharge including all significant industrial users discharging to a publicly owned treatment works.

A NPDES Construction Storm Water General Permit – Notice of Intent (CSW-NOI) is needed if construction disturbs over one acre of land. This includes a disturbance to the land that results in a change in the topography, existing soil cover (both vegetative and non-vegetative), or the existing soil topography that may result in accelerated Storm Water runoff, leading to soil erosion and movement of sediment into Waters of the State or urban drainage systems.

NDEQ Contact: (402) 471-8330

COUNTY

Sarpy County Zoning Regulations: The following Zoning Regulations (see attached) relate to environmental conditions (e.g., sediment and erosion control) within project sites, including but not limited to:

- Section 35 – Supplementary Regulations
- Section 37 – Landscaping Regulations

Stormwater Management Regulation: Sarpy County Zoning Regulation 38 – Stormwater Management Regulations states that all activities requiring a NDEQ NPDES permit will adhere to those permit requirements and to the requirements of the Sarpy County Zoning Regulation, including:

- Post-Construction Stormwater Management Plan
- Grading permit
- Maintenance and post-construction Best Management Practices (BMPs)
- Compliance with County/Papillion Creek Watershed Partnership Stormwater Management Policies.

Sarpy County Subdivision Regulations: The following Subdivision Regulations (see attached) relate to environmental conditions (e.g., sediment and erosion control) within project sites, including but not limited to:

- Section 10 – Minimum Design Standards
- Section 11 – Public Sites and Open Spaces
- Section 12 – Standards for Design Plans and Specifications

IV. References

Nebraska Game and Parks Commission (NGPC) Nebraska, Natural Heritage Program. 2018. Nebraska Conservation and Environmental Review Tool (CERT). Available at: https://cert.outdoornebraska.gov/. Accessed July 18, 2018.

NGPC. 2018. Crucial Habitat Assessment Tool for Nebraska (CHAT). Available at: http://outdoornebraska.ne.gov/wildlife/programs/nongame/Heritage/NatlHeritageHabitat.asp. Accessed July 18, 2018.

NGPC. 2017. Estimated Current Ranges of Threatened & Endangered Species: List of Species by County. Available at: http://outdoornebraska.gov/naturalheritageprogram. Accessed July 18, 2018.

Rolfsmeier, S.B., G. Steinauer., and R. Simpson. 2014. Range Maps for the Terrestrial Natural Communities of Nebraska. Version I. September 2014. Nebraska Natural Heritage Program, Nebraska Game and Parks Commission, Lincoln, NE. Available at: http://outdoornebraska.gov/naturalheritageprogram. Accessed July 18, 2018.

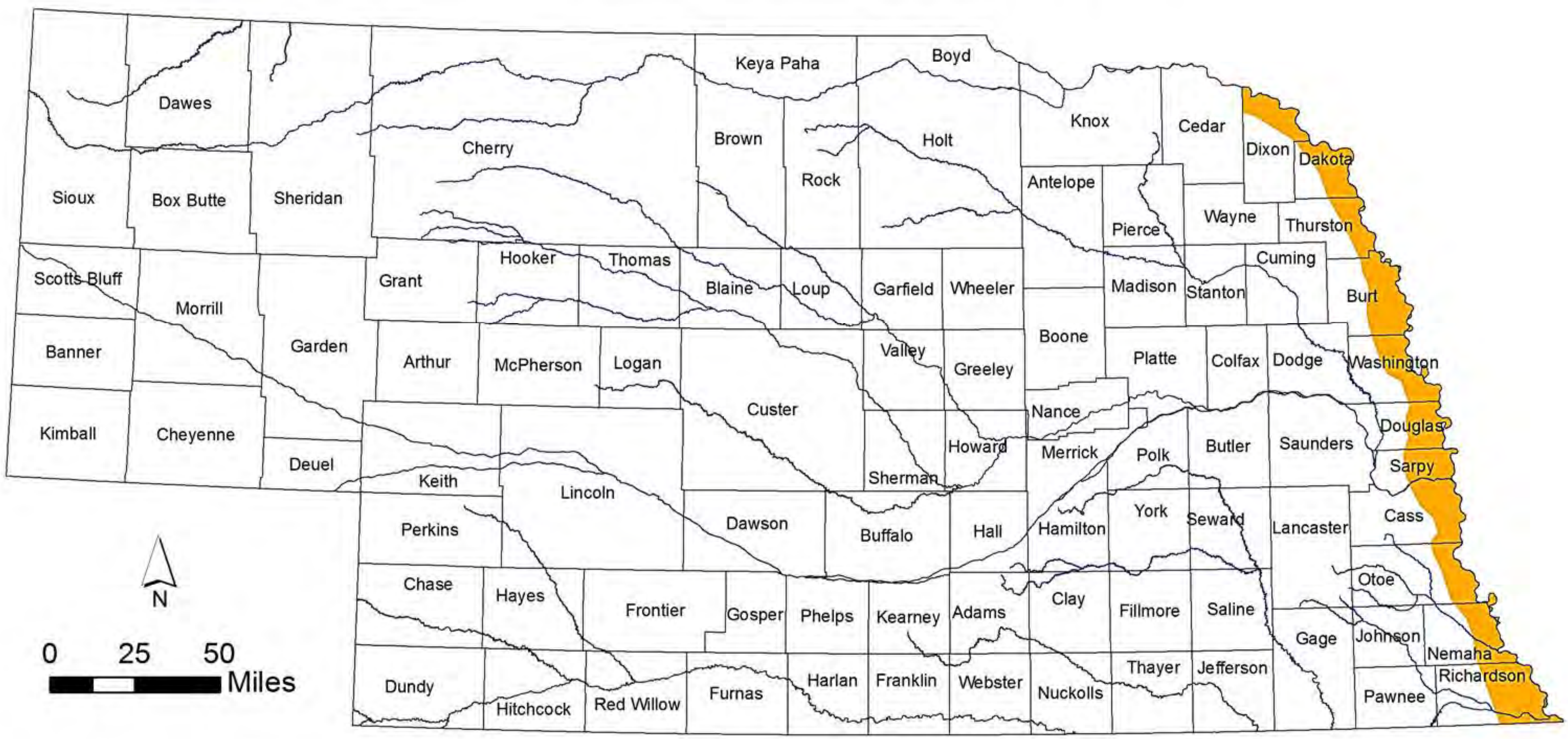
Sarpy County, Nebraska Planning Department. Available at: https://www.sarpy.com/offices/planning-department/regulations. Accessed July 18, 2018.

Vireo. 2017. Sarpy County Trails Master Plan, Phase 2. Plan prepared for Sarpy County, January.

ATTACHMENTS

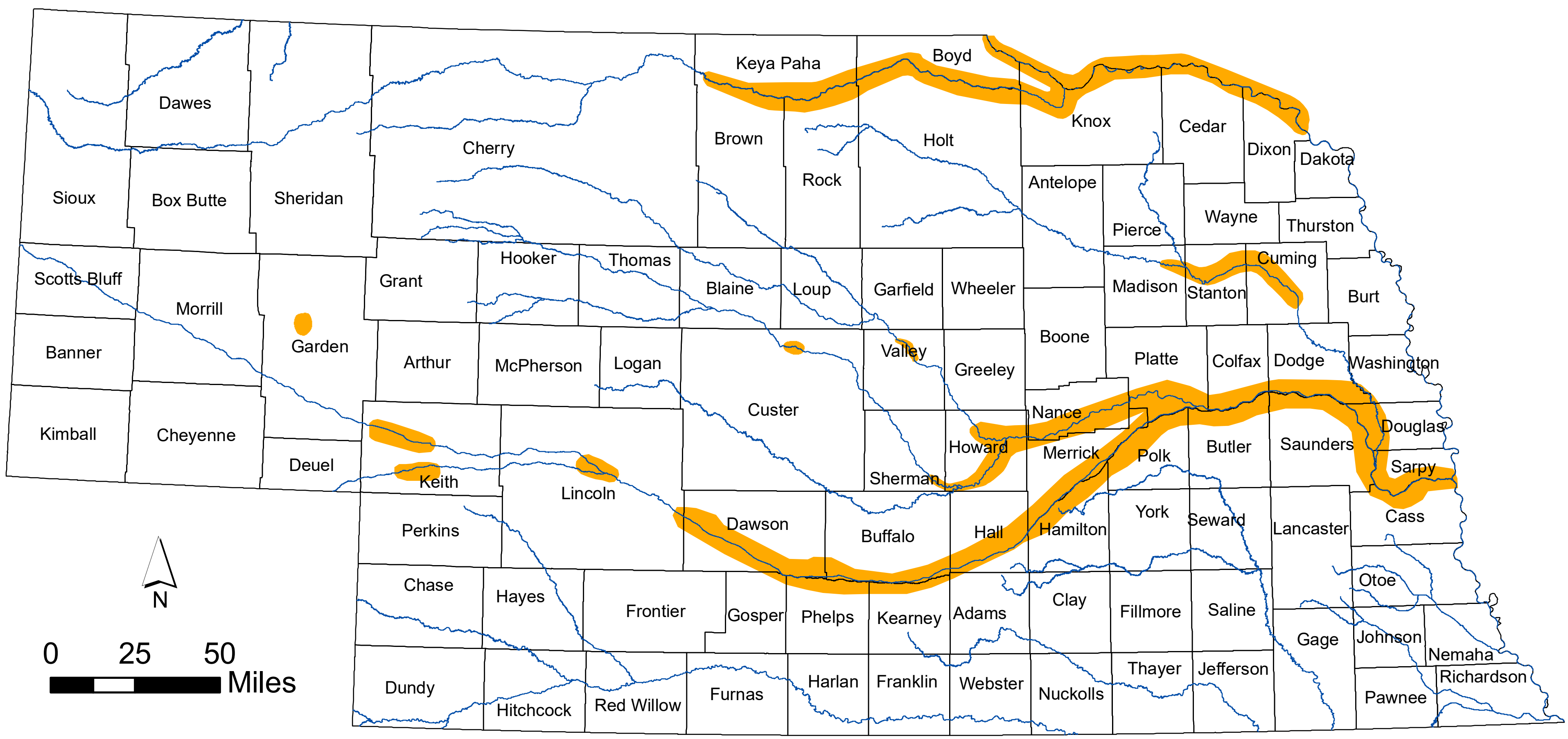
Range Maps for Threatened and Endangered Species in Sarpy County, Nebraska

Estimated Current Range of American Ginseng (*Panax quinquefolius*)



Nebraska Natural Heritage Program,
Nebraska Game and Parks Commission
June 2015

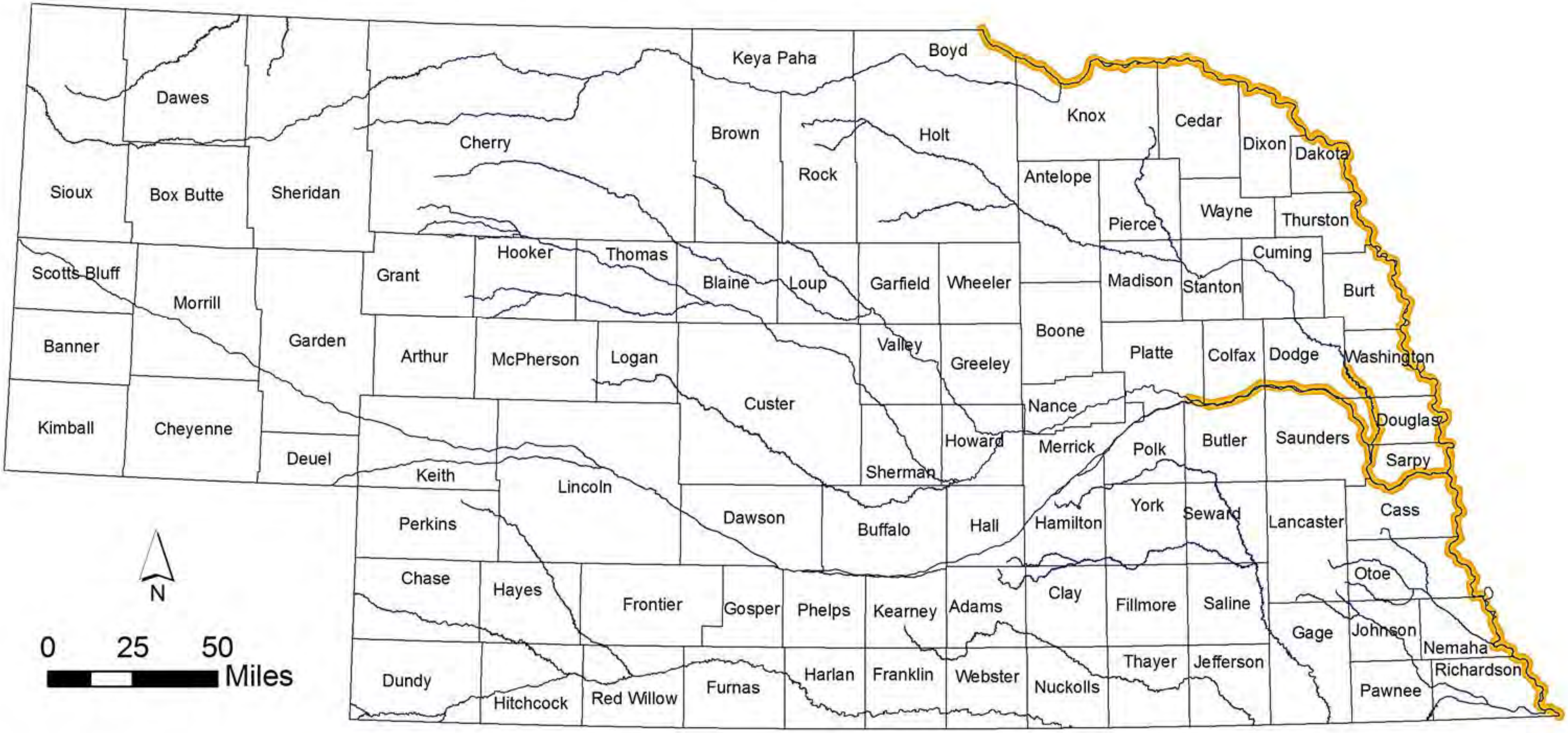
Estimated Current Breeding Range of Piping Plover (*Charadrius melodus*) and Interior Least Tern (*Sternula antillarum athalassos*)



Garden County portion of map pertains to Piping Plover only.

Nebraska Natural Heritage Program,
Nebraska Game and Parks Commission
August 2011

Estimated Current Range of Lake Sturgeon (*Acipenser fulvescens*)

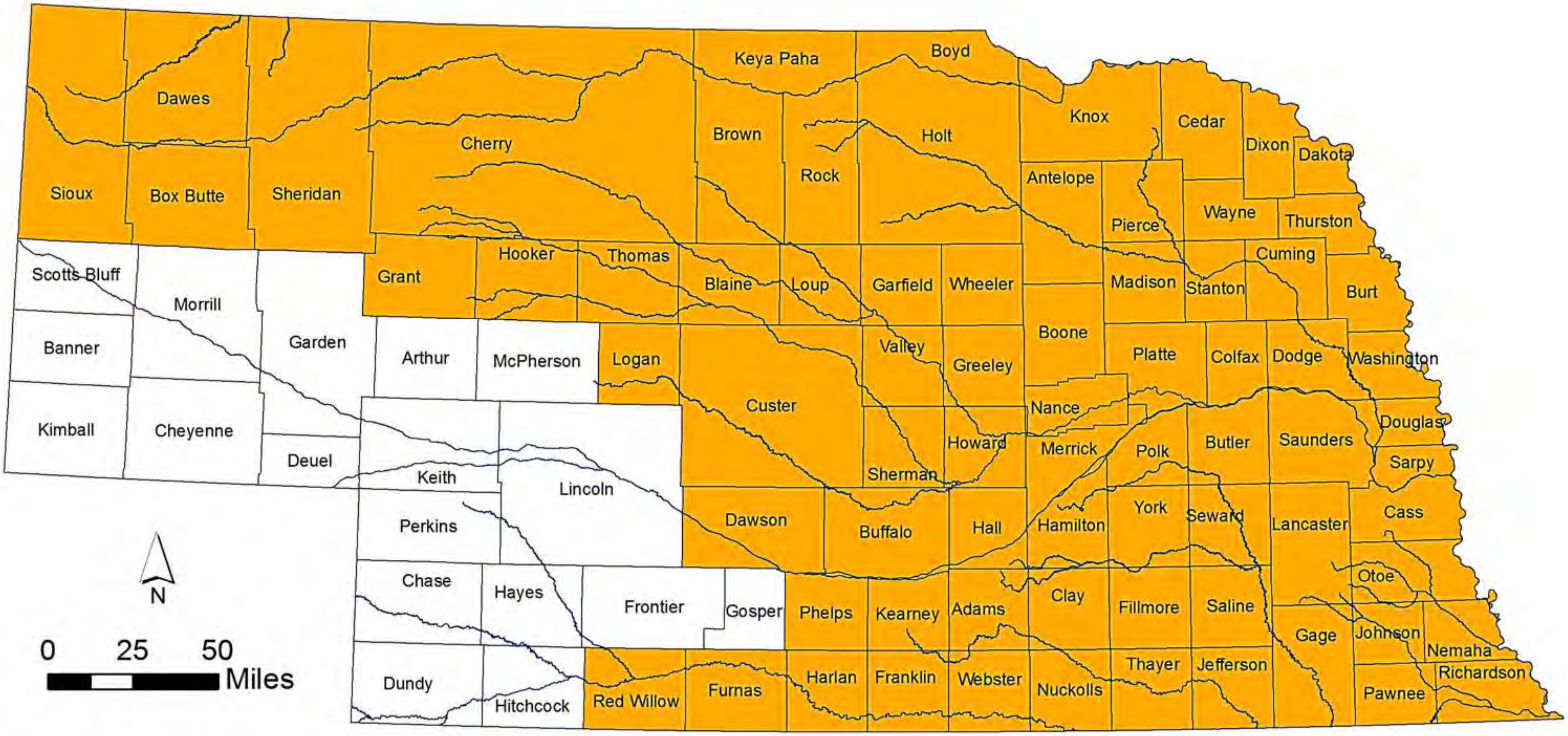


NEBRASKA
GAME PARKS

NEBRASKA
Natural Heritage Program

Nebraska Natural Heritage Program,
Nebraska Game and Parks Commission
May 2011

Estimated Current Range of
Northern Long-eared Bat (*Myotis septentrionalis*)

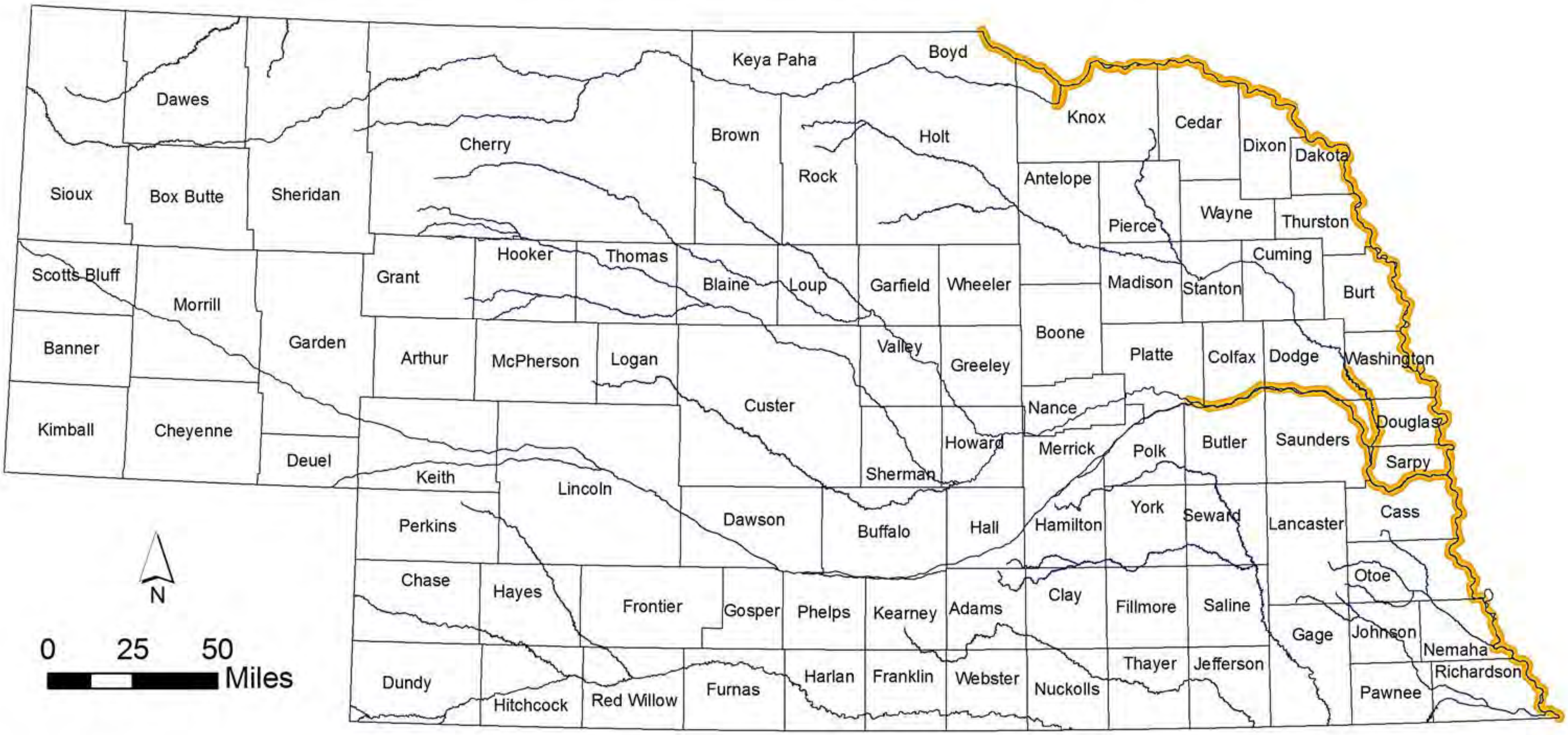


NEBRASKA
GAME PARKS

NEBRASKA
Natural Heritage Program

Nebraska Natural Heritage Program,
Nebraska Game and Parks Commission
June 2015

Estimated Current Range of Pallid Sturgeon (*Scaphirhynchus albus*)

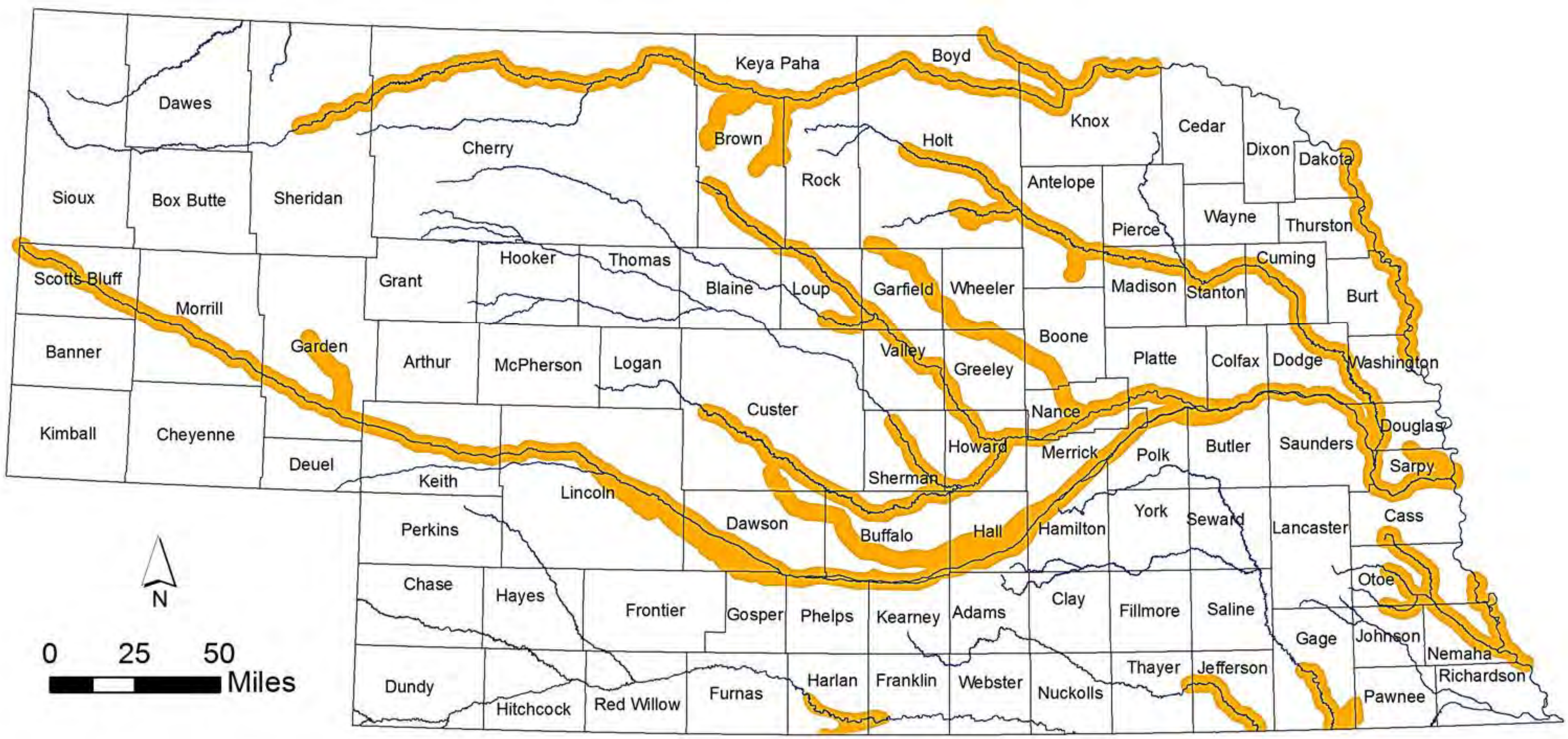


NEBRASKA
GAME PARKS

NEBRASKA
Natural Heritage Program

Nebraska Natural Heritage Program,
Nebraska Game and Parks Commission
August 2011

Estimated Current Range of River Otter (*Lontra canadensis*)

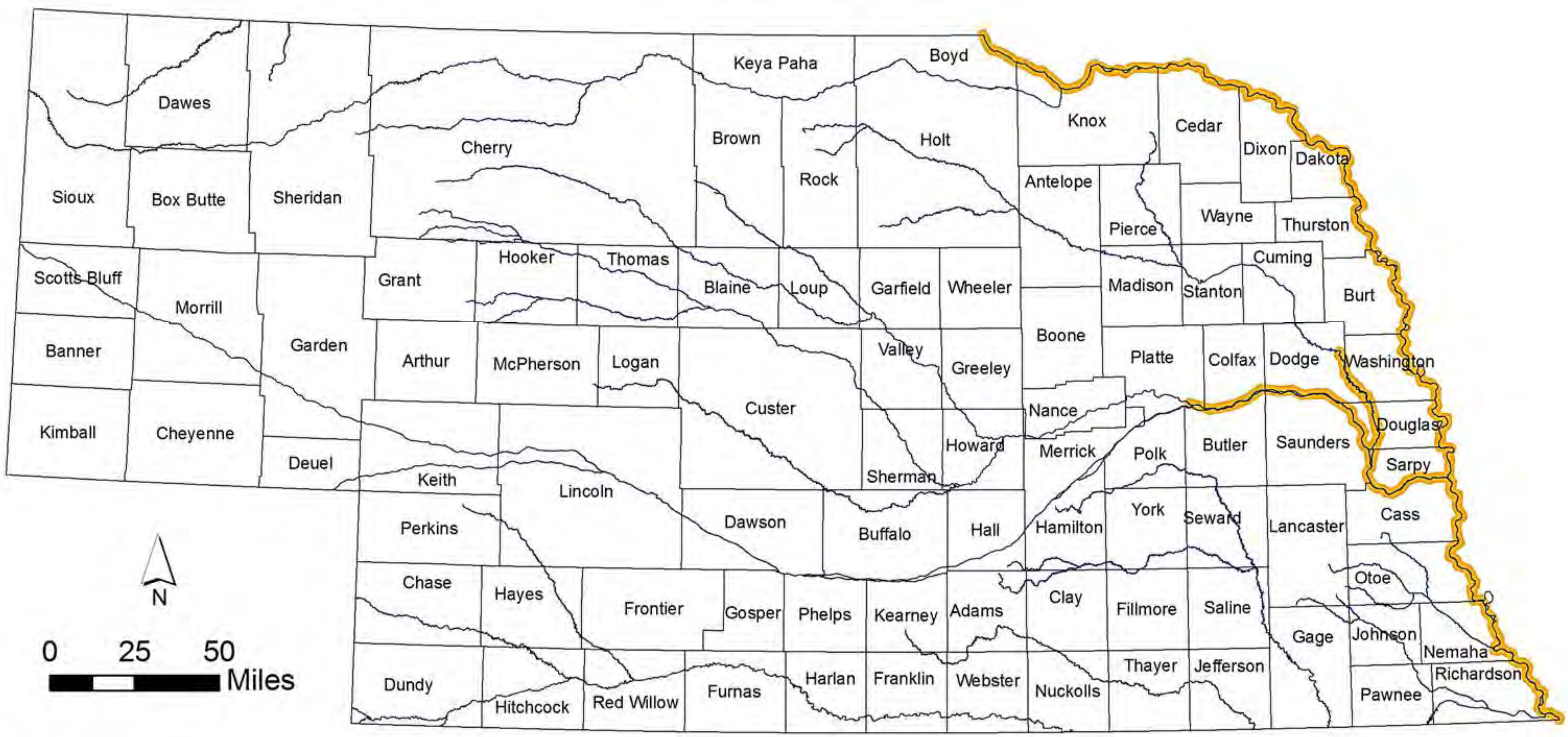


NEBRASKA
GAME PARKS

NEBRASKA
Natural Heritage Program

Nebraska Natural Heritage Program,
Nebraska Game and Parks Commission
June 2015

Estimated Current Range of Sturgeon Chub (*Macrhybopsis gelida*)

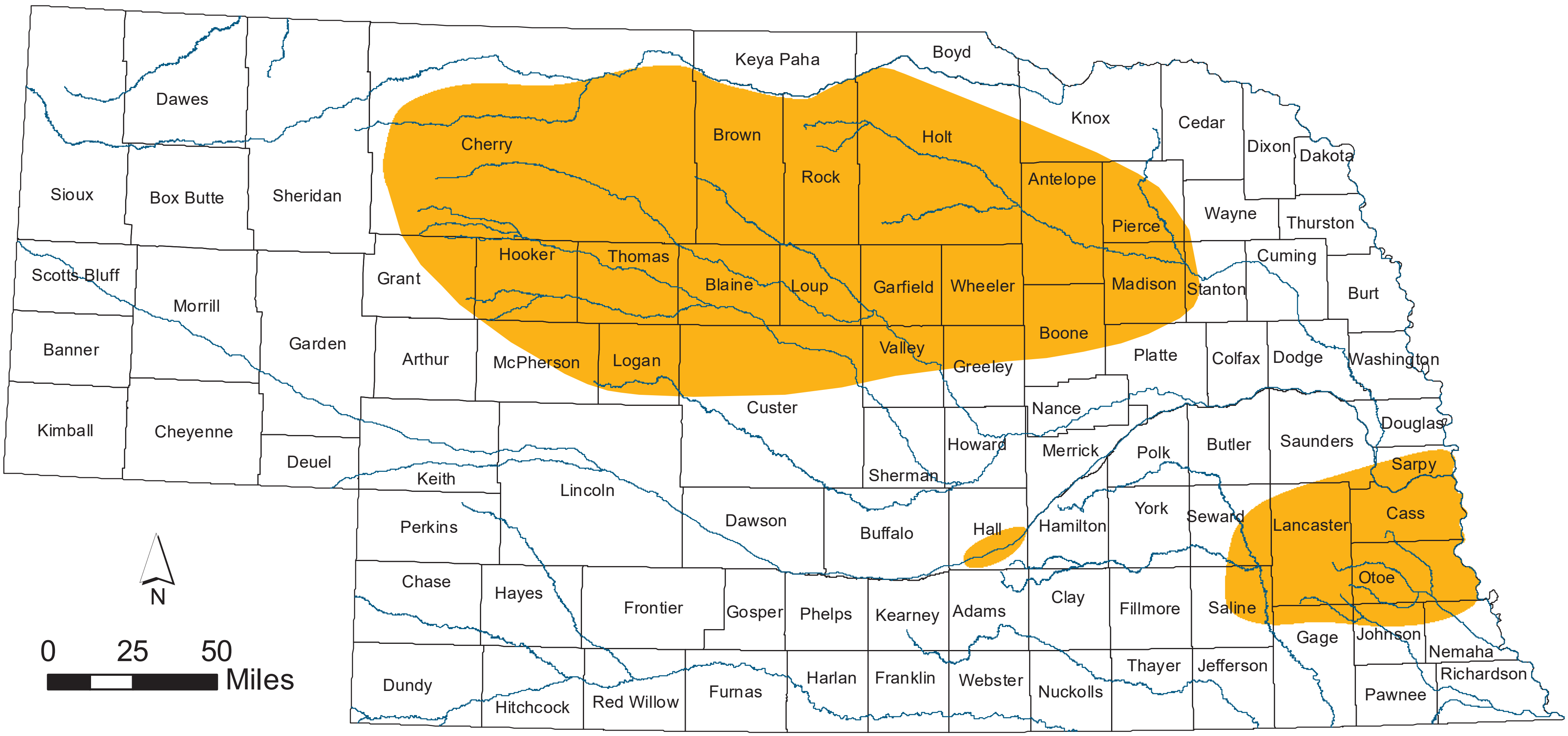


NEBRASKA GAME PARKS

NEBRASKA Natural Heritage Program

Nebraska Natural Heritage Program,
Nebraska Game and Parks Commission
May 2011

Estimated Current Range of
Western Prairie Fringed Orchid (*Platanthera praeclara*)



Nebraska Natural Heritage Program,
Nebraska Game and Parks Commission
January 2017

Sarpy County Trails Master Plan Maps

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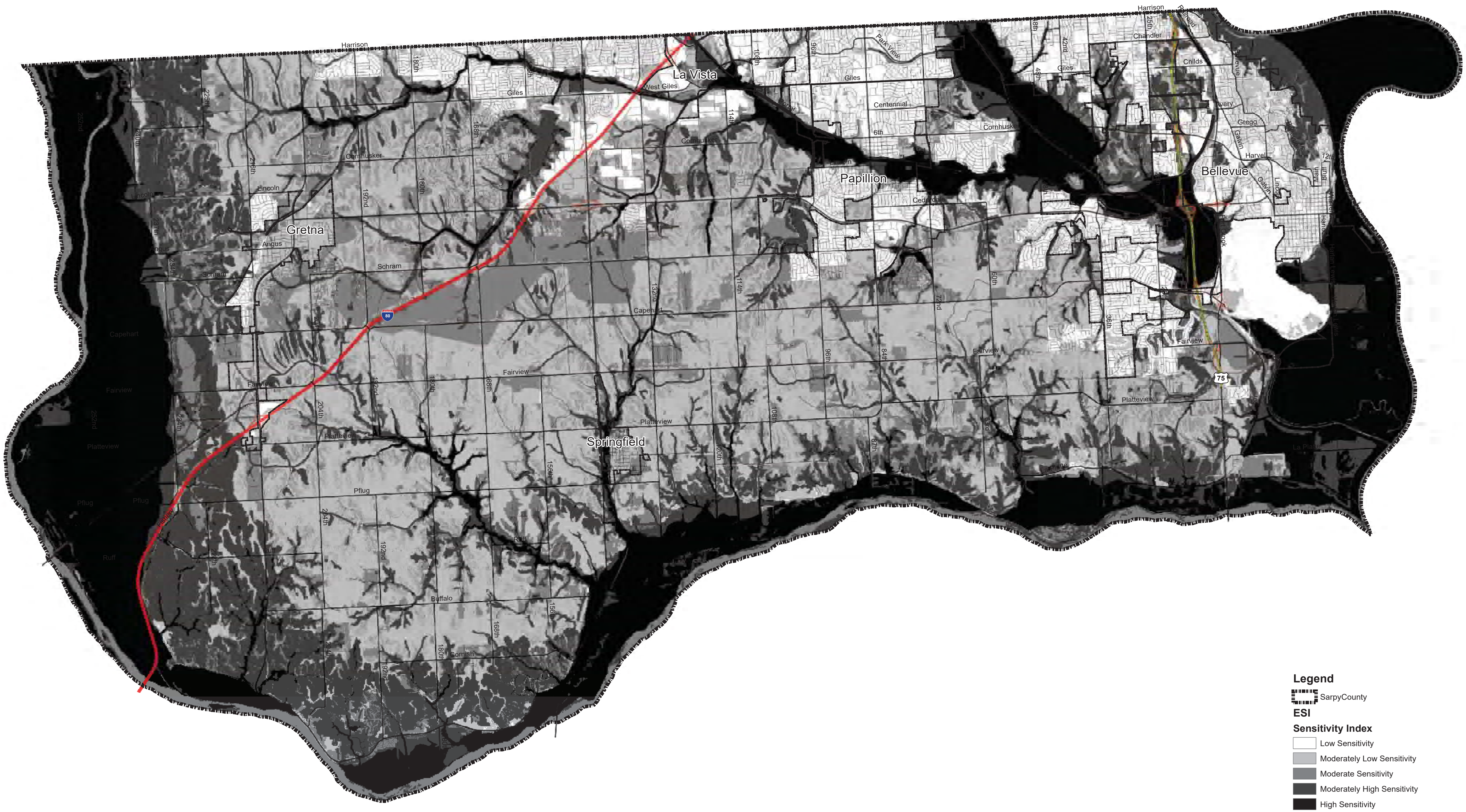
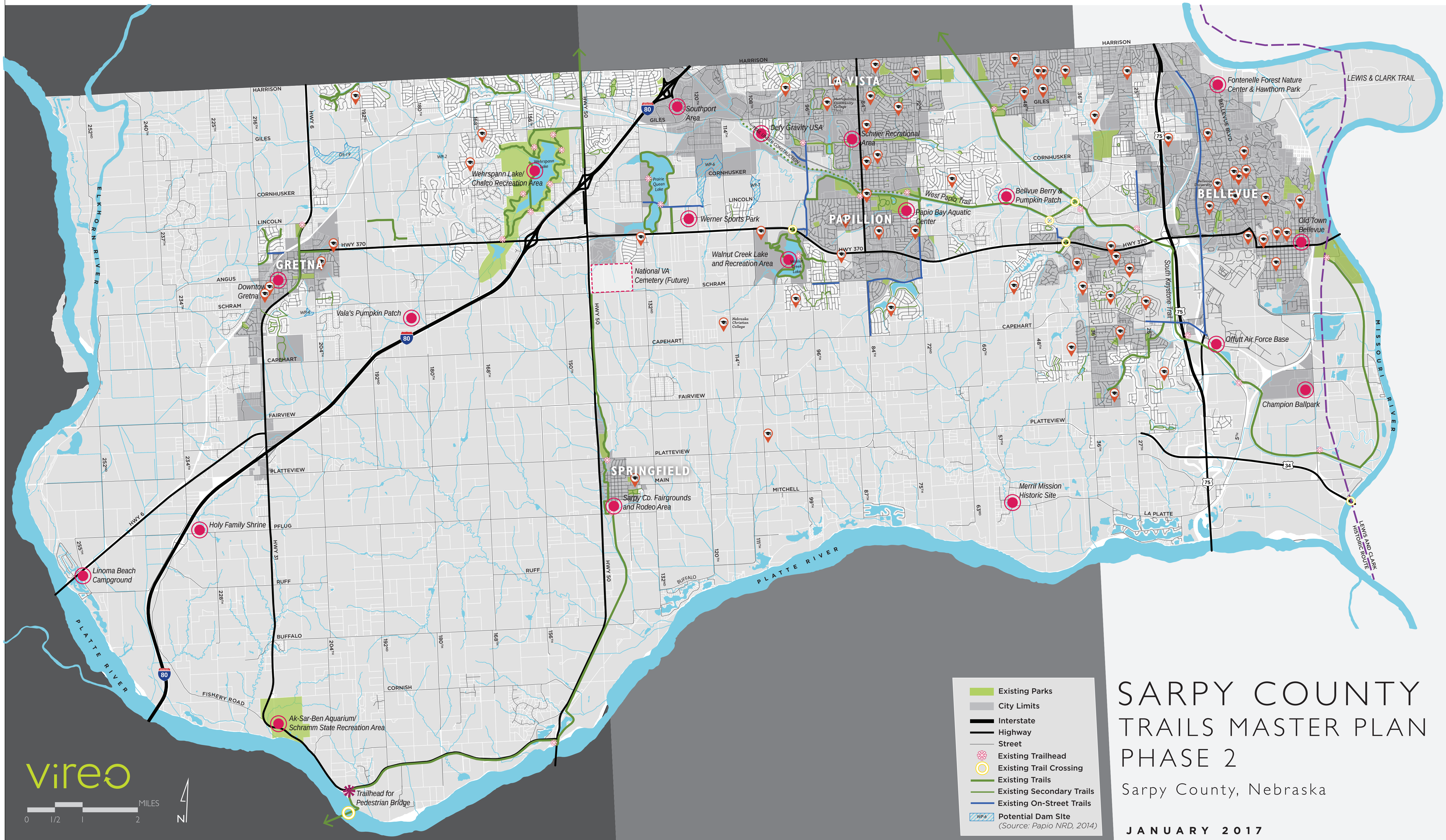
The GIS resource inventory resulted in a composite "Environmental Sensitivity Index" shown here. This ESI provided one important component on which future trail routing would be based.



Existing significant recreational and cultural destinations were located for possible connectivity by trails. In addition, connectivity to education centers were evaluated.

WEST CENTRAL EAST



EDUCATIONAL, RECREATIONAL & CULTURAL DESTINATIONS

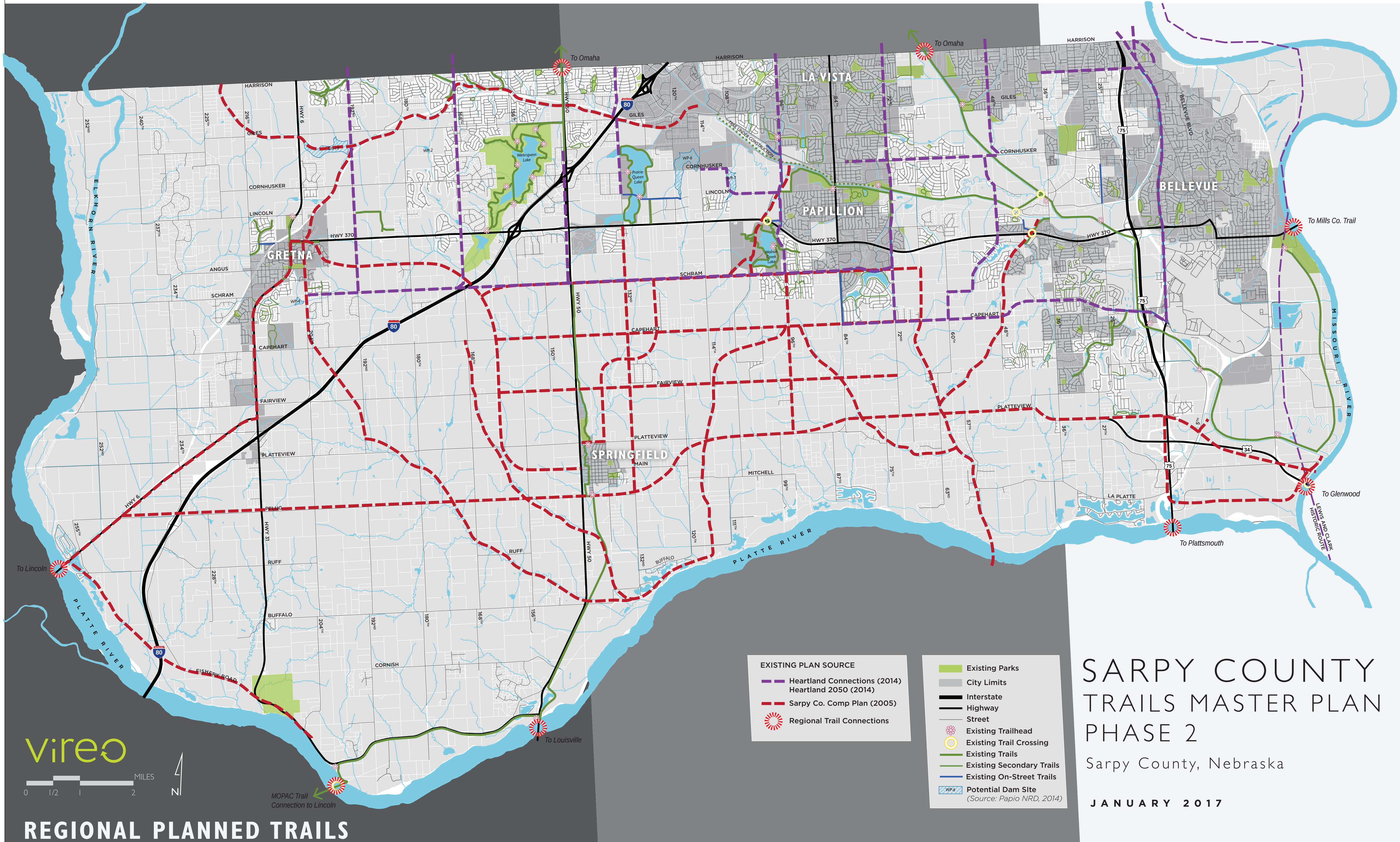
SARPY COUNTY
TRAILS MASTER PLAN
PHASE 2

Sarpy County, Nebraska

JANUARY 2017

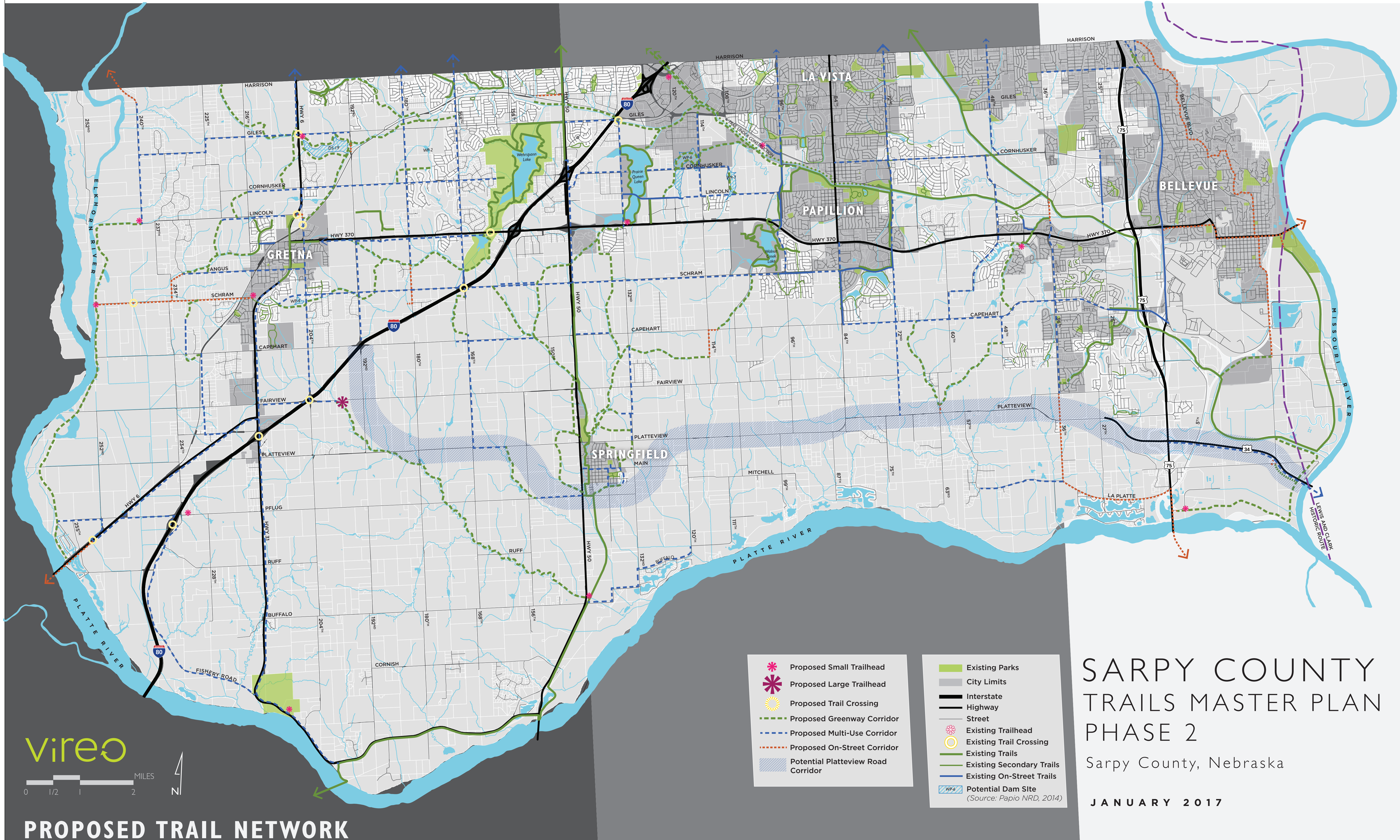
Upon completion of review of all regional plans, the following map graphically depicts all previous plan recommendations. Upon mapping, it became evident that redundancy in trail routings should be eliminated.

WEST CENTRAL EAST



The plan of trail routings was then prepared. Trail routes created a county-wide inter-connected system linking each community and most recreational, educational and cultural destinations. The trail system adjoins municipal limits where each city's individual trail plan denotes a trail connection. More detailed trail routing inside each municipal area is then governed by that municipality's trail plan.

WEST CENTRAL EAST



Sarpy County Subdivision and Zoning Regulations

SECTION 35 - SUPPLEMENTARY REGULATIONS

35.1 GENERAL YARD REGULATIONS

35.1.1 The ordinary projections from buildings including eaves, sills, cornices, or other similar architectural features may project or extend not more than 2 feet into a required yard.

35.1.2 Every part of a required yard or court shall be opened from its lowest point to the sky, unobstructed, except for ordinary projection of sills, belt courses, cornices, ornamental features, and eaves; provided, that none of the above projections shall project into a court more than six inches nor into a side yard more than twenty-four inches.

35.1.3 Open or enclosed fire escapes, fireproof outside stairways, or balconies shall not project into a yard more than five feet or into a court more than three and one-half feet, and the ordinary projection of chimneys and flues may be permitted by the Director of Planning where the same are so placed as not to obstruct the light and ventilation.

35.2 FRONT YARD

35.2.1 Where 30 percent or more of the block front is improved with buildings, then no part of any new building shall project beyond a line joining the two adjacent corners of the existing buildings on either side thereof, except that no building shall be required to provide a front yard greater than 40 feet, in any event. Where an official line has been established for future widening or opening of a street upon which lots abut, then the depth of a front or side yard shall be measured from such official line.

35.2.2 In any case where the block front improved with buildings amounts to less than 30 percent of the total number of lots, including vacant lots, on one side of the street between two intersecting streets, the required minimum front yard of the district shall be observed.

35.2.3 On through lots, running from street to street, both streets shall be considered front streets.

35.3 REAR YARD

35.3.1 Rear yard exceptions for residential uses. For the purpose of determining compliance with the rear yard requirements on irregular lots used for residential purposes, the rear yard is measured as the distance between the building line and the rear property line. However, the shortest distance between the primary building and any rear property line shall be no less than 80% of the rear yard required for the district.

35.4 YARD REQUIREMENTS ON CORNER LOTS

35.4.1 In the case of a corner lot, the owner shall, for the purpose of these regulations, have the privilege of electing any street line as the front lot line, as long as, in the opinion of the Director of Planning, that choice will not be injurious to the development of adjoining properties.

(A) On any corner lot in a residence zone, the least width of any side yard along the street lot line shall not be less than one half (1 /2) of the sum of the minimum side and front yards required.

(B) On any corner lot in a business zone, the minimum width of the side yard on the street side shall be ten (10) feet.

35.5 **YARD REQUIREMENTS ALONG ZONE BOUNDARY LINES**

35.5.1 Where a lot adjoins a lot in a more restricted zone, any adjoining side yard of such lot shall have a width at least equal to the required minimum side yard in the more restricted zone. Any adjoining front yard shall have a depth at least equal to the minimum required depth of the front yard in the more restricted zone.

35.6 **HEIGHT ADJUSTMENTS:**

These provisions allow exceptions to the height restrictions in any zoning district in certain situations.

35.6.1 Vertical Projections. Church spires, belfries, monuments, farm buildings, flag poles, tanks, cooling towers, building mechanical equipment, elevator bulkheads, grain storage bins, elevator legs, silos, water and fire towers, and stage towers or scenery lofts may be built to any height in accordance with existing regulations.

35.6.2 Amateur radio towers:

(A) Radio towers, antennas and other appurtenances operated by licensed amateur radio operators, here permitted and when, may not exceed 75 feet in height. This height has been determined by the County to reasonably accommodate amateur service communications, and further represents the minimum practicable regulation to accomplish legitimate land use regulation purpose, as recognized under published guidelines of the Federal Communications Commission.

(B) Special instances may require that amateur radio tower heights exceed 75 feet to achieve effective and reliable communications. In such cases, the County may grant a special use permit to a licensed amateur radio operator for a specific tower height that exceeds 75 feet. In determining whether to grant such permission, the County shall consider the federal guidelines contained in PRB-1 (Amateur Radio Preemption), 101 FCC 2d (1985); codified at CFR Section 97.15(e).

(C) Such radio towers shall not be located within any front yard of the primary use.

35.6.3 Certain uses may require additional height on a case by case basis. A special use permit may be granted to increase the height of hotels/motels, recreational facilities, hospitals, wind energy generation systems, and civic uses. Recognizing that the increase in height may be appropriate in some areas and not in others the County Board of Commissioners may review a request for increased height when an applicant for any of the aforementioned uses utilizes the special use permit process outlined in Chapter 41 of the Zoning Regulations.

35.7 **BUILDING AREA; LOT COVERAGE**

35.7.1 All buildings, including accessory buildings on any lot, shall not cover more than forty percent of the area of such lot, outlot, or parcel if in a Residential District, nor more than seventy-five percent if in any other district.

35.8 **GENERAL PROVISIONS**

35.8.1 Every building hereafter erected or structurally altered for commercial or industrial purposes in the Commercial Districts or in the Industrial Districts shall provide adequate facilities for the loading and unloading of merchandise and goods in compliance with all of the district regulations established by these Regulations for the district in which the building or land is located.

35.8.2 No building or premises in any part of the County shall be used for any trade, industry, or purpose that is noxious or offensive by reasons of the emission of odor, dust, smoke, gas, fumes, or noise that is detrimental to the public health, safety, and welfare.

35.8.3 No unsightly buildings shall be erected of old materials nor shall buildings or houses be allowed to remain in an unfinished condition in any District, except an Agricultural District, for a period of more than 180 days. It shall be unlawful to allow building materials or brick to be stored on any lot or lots in said residential districts except for building on said lot or to permit or allow any debris to be stored upon any lot in said districts.

35.9 FENCES AND RETAINING WALLS

No fence or retaining wall (three feet in height or more) shall be constructed within the zoning jurisdiction of the County unless a permit therefore is approved and issued by the building inspector and is constructed in conformance with the following requirements:

35.9.1 The height limitation for fences and retaining walls in residential zoning districts shall be six feet above ground level except as provided herein:

(A) A fence or retaining wall constructed within a sight triangle or front yard of a residential lot or vegetation used as a barrier, screen, or fence shall be open (at least 50% of the surface area in open spaces), shall not exceed 36 inches in height.

(B) If the property is a corner lot, as defined in Section 44 of these regulations, a fence constructed within a side yard along the side lot line which is adjacent to a street shall not exceed four feet in height. However, a fence with a maximum height of six feet may be constructed in this area provided it is set back a minimum of 5 feet from the property line adjacent to the street.

(C) Fences constructed along and parallel to lot lines separating a residential lot from property located in a Commercial or Industrial District shall be a minimum of six feet and shall not exceed eight feet in height.

(D) Fences constructed along and parallel to rear and side lot lines adjoining major streets, as designated by the Nebraska Department of Roads, shall not exceed eight feet in height.

(E) Fences or retaining walls in a Commercial or Industrial District shall have a maximum height of 8 feet. However, a greater height may be approved by Special Use Permit where it is demonstrated that for security purposes or due to particular site characteristics it is warranted.

35.9.2 No fence, wall, vegetation or obstruction to vision considered in the judgment of the Director of Planning or certified by the Sheriff's Department to be hazardous to vehicular safety shall be placed or maintained within the sight triangle.

35.9.3 Fences Surrounding Pools: Every outdoor pool shall be completely surrounded by a fence or wall not less than 60 inches in height, which shall be so constructed as not to have openings, holes, or gaps larger than 4 inches in any dimension except for doors and gates; and if a picket fence is erected or maintained, the horizontal dimension shall not exceed 4 inches. A dwelling or accessory building may be used as part of such enclosure. All gates or doors opening through such enclosure shall be equipped with a self-closing and self-latching device located at least 45 inches above grade level for keeping the gate or door securely closed at all times, except that the door of any dwelling which forms a part of the enclosure need not be so equipped. The provisions of this section shall be applicable to all outdoor pools which have a depth of 24 inches as regulated under the International Plumbing Code. No person either as owner, purchaser, lessee, tenant or licensee, in control of the property having such pool shall fail to provide and maintain such fence or wall as herein provided.

35.9.4 Hot tub/Spa Enclosure: Every outdoor spa shall be equipped with a rigid cover and be covered at all times when not in use or an enclosure shall be provided that complies with Section 35.8.3.

35.9.5 Electric Fences. No above ground electric fence shall be constructed or maintained within the County zoning jurisdiction except in the Agricultural Farming District (AG), Agricultural Development District (AGD), and Agricultural Residential District (AGR) provided they are not adjacent to a residential zoning district (RE, RS, RD, RG, or RMH). An owner or lessee of such property may, upon application to the County and approval by the Building Inspector, maintain electrified fencing provided same shall not be energized to the extent that it is capable of causing bodily harm to persons, be they children or adults, or to animals.

35.9.6 The finished surfaces of any fence shall face toward adjacent properties and street frontage. Fence posts and supporting structure, when visible on one side and not the other or more visible on one side than the other, should face inward. The Planning Director may make a determination as to which side of a fence is the finished surface.

35.9.7 All fences shall be maintained in good repair.

35.9.8 Any existing fence constructed pursuant to a permit issued and approved by the County which was in conformity with the prior provisions of this Section, may remain without change in accordance with this section notwithstanding same may be in conflict with one or more provisions of this section as amended; provided, however, any replacement or change of said existing fence or addition of a new fence, must hereby meet the requirements of this section as amended hereby.

35.10 CREEK SETBACK REQUIREMENTS

35.10.1 No person shall be granted a permit for the construction of any structure, exclusive of bank stabilization structures, poles or sign structures adjacent to any creek or stream unless such structure is located so that no portion thereof is any closer to the stream than will allow a maximum three-to-one slope plus 50 feet between the water's edge of the stream and the closet point on the structure at grade. As used here, the edge of water of the stream shall be that point constituting the edge of the water during normal flow conditions.

A property shall be exempt from the provision of the above requirement upon a showing by a registered professional engineer that adequate bank stabilization structures or slope protection will be installed in the construction of said structure, having an estimated useful life equal to that of the structure, which will provide adequate erosion control conditions coupled with adequate lateral support so that no portion of said structure adjacent to the stream will be endangered by erosion or lack of lateral support. In the event that the structure is adjacent to any stream which has been channelized or otherwise improved by any agency of government, then such certification providing an exception to the above requirement may take the form of a certification as to the adequacy and protection of the improvements installed by such governmental agency.

35.11 **PUBLIC SAFETY RADIO AMPLIFICATION SYSTEMS (TOWERS)**

35.11.1 GENERAL

Except as otherwise provided, no person shall maintain, own, erect, construct, remodel, renovate, or provide an addition of more than twenty (20) percent to, any building or structure or any part thereof or cause the same to be done which fails to support adequate radio coverage for the Sarpy County Radio Communications System (SCRCS), including but not limited to emergency service workers, firefighters and police officers. Descriptively, adequate coverage means the ability for SCRCS users to transmit into the building an intelligible voice signal that may be heard; the ability to receive an intelligible voice signal transmitted and originating from within the building; and, the ability to transmit and receive intelligible voice signals among users who are within the building. For purposes of this section, adequate radio coverage shall include all of the following:

(A) A minimum received signal strength in the building of one (1) micro volts (-107 dBm) available in ninety (90) percent of the area of each floor when transmitted from the SCRCS;

(B) A minimum signal strength of one (1) micro volts (-107 dBm) received by the SCRCS when transmitted from ninety (90) percent of the area of each floor of the building;

(C) The frequency range that must be supported shall be 806 MHz to 869 MHz; and,

(D) A ninety (90) percent reliability factor shall be required.

35.11.2 TESTING PROCEDURES

Initial Tests: It will be the building owner's responsibility to have the building tested to ensure that two-way coverage on each floor of the building is a minimum of ninety (90) percent. At a minimum, the test shall be conducted using a Motorola MTS 2000, or equivalent portable radio, talking through the SCRCS. Radios may be obtained for conduct of the tests from the Sarpy County Communications Department (SCCD). The gain values of all amplifiers shall be measured and the test measurement results shall be provided to the SCCD and kept on file so that the measurements can be verified each year during the annual tests. The SCCD will be informed of the schedule for such testing, and, at its discretion may participate as an observer. A Certificate of Occupancy shall not be issued to any structure if the building fails to comply with this section.
Annual Tests: The building owner shall be responsible to conduct annual tests. Such tests shall follow the guidance outlined in paragraph 35.12.1 (General) and 35.12.2 (Initial Tests) above.

35.11.3 AMPLIFICATION SYSTEMS ALLOWED

Buildings and structures that cannot support the required level of radio coverage shall be equipped with any of the following in order to achieve the required adequate radio coverage: a radiating cable system or an internal multiple antenna system with or without FCC accepted bi-directional amplifiers as needed. If used, bi-directional amplifiers shall include filters to reduce adjacent frequency interference at least 35 dB below the National Public Safety Planning Advisory Committee (NPSPAC) band. The filters shall be tuned to 825 MHz and to 870 MHz so that they will be 35 dB below the NPSPAC frequencies of 824 MHz and 869 MHZ respectively. Other settings may be used provided that they do not attenuate the NPSPAC frequencies and further provided that they are not more than one (1) MHz from the NPSPAC frequencies. If any part of the installed system or systems contains an electrically powered component, the system shall be capable of operating on an independent battery and/or generator system for a period of at least twelve (12) hours without external power input. The battery system shall automatically charge in the presence of an external power input.

35.11.4 FIELD TESTING

SCCD personnel, after providing reasonable notice to the owner or his representative, shall have the right to enter onto the property to conduct field testing to be certain the required level of radio coverage is present.

35.11.5 EXEMPTIONS

This section shall not apply to: buildings permitted in residential districts; any building constructed of wood frame; any building thirty five (35) feet high or less; as long as none of the aforementioned buildings make use of any metal construction or any underground storage or parking areas. For purposes of this section, parking structures and stairwells are included in the definition of “building” and stair shafts are included in the definition of “all parts of a building”, but elevators may be excluded.

35.12 HOME OCCUPATIONS

The following are the minimum standards required for a home occupation:

35.12.1 EXTENT OF USE

No more that 30% of the home may be used for the home occupation,
except for a Child Care Facility. This percentage is inclusive of any detached accessory buildings used for the home occupation as well.

35.12.2 EXTERNAL EFFECTS

(A) There shall be no external evidence of the home occupation with the exception of vehicles as allowed under Section 35.11.3 and signage as allowed under Section 35.11.4.

(B) No noise, vibration, smoke, odor, heat, glare, or bright lights shall be noticeable at or beyond the property line.

(C) Any on-site operations of the home occupation shall be carried on entirely within the principal residential structure and/or within a detached accessory structure built in compliance with these zoning regulations. All external effects criteria in Subsection 35.11.2 (A), (B), (C), (D), (E), and (F) of this section are applicable for the detached structure as well.

(D) Mechanical or electrical equipment supporting the home occupation shall be limited to that which is self-contained within the structure and normally used for office, domestic or household purposes.

(E) No exterior storage of materials, equipment or other inventory is permitted.

(F) No home occupation shall discharge into any sewer, drainage way or the ground any material which is radioactive, poisonous, detrimental to normal sewer plant operation or corrosive to sewer pipes and installations.

35.12.3 EMPLOYEES, VEHICLES AND EQUIPMENT

(A) In Residential Districts, including the AGR Agricultural Residential District, a home occupation shall employ no more than one full-time or one part-time employee traveling to or from the premises other than the residents of the dwelling unit. One off-street parking space in addition to those otherwise required by the residential use must be made available and used by that non-resident employee.

(B) In Residential Districts, including the AGR Agricultural Residential District, not more than two (2) business vehicles or one (1) employee vehicle may be parked outside or adjacent to the home occupation property at any one time; provided only one said vehicle may be allowed to park on street right-of-way. Personal vehicles of occupants of the residential dwelling shall not be included in the count of number of business or employee vehicles.

(C) Construction or maintenance equipment shall not be stored on the property other than in an enclosed garage or accessory building.

(D) Deliveries or service by commercial vehicles or trucks over 10 tons gross empty weight is prohibited for any home occupation located on a minor street.

(E) Additional off-street parking may be required for the home occupation.

35.12.4 SIGNAGE/ADVERTISING

(A) No signage advertising the home occupation may be allowed except for the following:

1. one unlighted nameplate of not more than two (2) square feet in area may be attached flat against the building if located on a local or collector street.
2. one unlighted nameplate of not more than four (4) square feet in area may be attached flat against the building if located on an arterial street.

(B) Advertising displays and advertising devises displayed through a window of the building shall not be permitted.

(C) There shall be no radio, television, newspaper, handbills, internet or similar types of advertising linking the address of the dwelling premises with the home occupation

35.12.5 OTHER REQUIREMENTS

(A) All contact by the public with the home occupation business shall be by appointment only.

(B) A Special Use Permit is required, except for Home Occupation II (see definitions) uses.

(C) Child Care Facilities shall require a certificate (CRED 9911) signed by the State of Nebraska Fire Marshall.

SECTION 37 - LANDSCAPING REGULATIONS

37.1 GENERAL PROVISIONS

All plans submitted in support of a plat application, rezoning application, site plan review, building permit or other development proposal shall include a landscape and screening plan, demonstrating compliance with the provisions of this section. The landscape and screening plan shall include the following information:

37.1.1 A planting schedule indicating symbols, quantities, common and botanical names, sizes of plant material at installation, and special planting instructions.

37.1.2 Location, type and size of all existing trees (12 inch caliper or larger, measured at six (6) feet above ground level) to be removed or preserved.

37.1.3 Planting detail, showing all species to scale at normal mature crown diameter or spread for local hardiness zone.

37.1.4 Note indicating how disturbed soil areas will be restored though the use of seeding, sodding or other techniques.

37.1.5 Existing or proposed conditions that could potentially affect landscaping and screening of the site.

37.2 LANDSCAPE DESIGN CRITERIA

Landscape design shall serve to provide visually interesting open space, to reduce the potential negative impact of development on adjacent land uses, and to facilitate the preservation and reestablishment of plants native to the region. The following design criteria should be considered as part of the landscape plan submittal.

37.2.1 Earthen berms and existing topographic features should, whenever practical, be incorporated into the landscape treatment of a site.

37.2.2 A variety of tree and shrub species shall be utilized to provide visual, four-season interest. Not more than one-third of the required number of trees or shrubs may be comprised of any one species and at least one-third of the plants must be a coniferous species.

37.2.3 Final slopes greater than a three to one ratio will not be permitted without special approval by the Planning Department.

37.3 STREET YARD REQUIREMENTS AND LANDSCAPING

37.3.1 Residential Developments adjacent to arterial streets, and/or major arterial streets shall provide, a 20' landscaped buffer along the perimeter of the development.

- (A) Plant materials shall include a combination of deciduous and coniferous trees with a minimum placement of one tree every thirty feet.
- (B) A landscaped earth berm not exceeding six feet in height may be used in combination with the plant materials.
- (C) The landscaped buffer shall contain only approved landscaped materials.
- (D) No fence shall be placed within the 20' landscaped buffer.

37.3.2 Commercial/Industrial, Office, and Business Developments shall provide a 20’ landscaped buffer adjacent to any street or highway and along the entire perimeter of the development.

(A) Plant materials shall include at least one deciduous shade or one ornamental deciduous tree and three shrubs for every forty linear feet of adjacent area.

(B) A landscaped earth berm not exceeding six feet in height may be used in combination with the plant materials but shall not substitute for trees adjacent to any street or highway.

37.3.3 Landscape Buffer requirements for subdivisions platted and recorded prior to January 1, 2004 will be exempt if 40% or more of the platted lots on the block face have landscaped areas less than 20 feet on the condition that a minimum 10 foot of green space is provided.

37.4 SEPARATION OF DISSIMILAR LAND USES

A landscaped side yard and rear yard buffer shall be provided when a more intensive land use is established adjacent to a less intensive land use. The owner, developer or operator of the more intensive land uses shall install and maintain a landscaped side yard and rear yard buffer on a lot or site of not less than 20 feet.

37.4.1 Where a street separates adjacent land uses requiring side/rear yard buffers, the size of the yard may be reduced by one-half of the requirement set forth in these guidelines.

37.4.2 Each required side/rear yard buffer shall be entirely landscaped and free of paved areas, access ways, storage or other disturbances.

37.4.3 Landscaping shall include a planting screen or a random or informal screen of plant materials substantially blocking the views and attaining a minimum height of six feet within four years.

37.4.4 Plant materials shall include one deciduous shade or coniferous tree, or one ornamental deciduous tree and three shrubs for every 40’ of adjacent area.

37.4.5 A landscaped earth berm not exceeding six feet (6') in height may be used in combination with the plant materials.

37.5 PARKING AND VEHICULAR USE AREAS

Except in areas designated for industrial use and multiple level parking structures, all parking areas shall include the following requirements in order to break up the large expanses of pavement, to provide relief from reflected glare and heat, and to guide vehicular and pedestrian traffic:

37.5.1 Not less than six percent of the interior of a public parking lot shall be landscaped. Plantings required along the perimeter of a parking area should not be considered as part of the interior landscaping requirement.

37.5.2 Landscaping and planting areas are to be reasonably dispersed throughout the parking lot. Large expanses of asphalt and concrete shall be reduced by breaking up parking lots into a series of smaller sections, through the use of landscape strips, peninsulas and grade separations, where appropriate.

37.5.3 The interior dimensions of any planting area shall be large enough to support trees which provide shade or are capable of providing shade at maturity. Shrubbery, hedges and other planting materials may be used to complement the tree landscaping, but shall not be the sole means of landscaping. Effective use of earth berms and existing topography is encouraged as a component of the landscaping plan.

37.6 SCREENING REQUIREMENTS

Site plans or landscaping plans shall include details regarding enclosure and screening methods, as required below. The phrase screened from public view means not visible to the extent possible, at any distance, from adjoining properties or any street right-of-way.

37.6.1 All waste and recycling receptacles shall be stored within the principal structure or within an accessory enclosure area subject to the following:

(A) The enclosure shall be located adjacent to the structure whenever possible.

37.6.2 The display area design shall be entirely integrated into the appearance of the building. The display area walls and/or columns shall be constructed of the same materials as the primary building facade.

37.6.3 Screening fences or walls, when utilized, shall be constructed of attractive, permanent-finished materials.

37.7 SELECTION, INSTALLATION AND MAINTENANCE REQUIREMENTS

37.7.1 All landscaping materials and screening methods depicted on development plans approved by the governing body should be considered as required elements of the project. All plant materials must meet the standards set by the American Association of Nurserymen and be a variety that is indigenous to the hardiness zone in which Sarpy County is located, except that the following trees are expressly prohibited from being planted:

Box Elder – *Acer Negundo*
Silver Maple – *Acer Saccharinum*
Northern Catalph – *Catalph Speciosa*
Mulberry – *Morus Alba*
Cottonwood – *Populus Deltiods* (Seedless varieties are acceptable)
Willow – *Salax Species*

37.7.2 All required plant materials shall meet the minimum size standards identified below at time of installation. For the purposes of determining tree trunk size, the caliper shall be measured six feet above ground level.

(A) Deciduous Shade Tree: 2" caliper Deciduous Ornamental Tree: 1.5" caliper or clumped type plant, depending on species
Coniferous/Evergreen Tree: 5' - 6' in height
Shrubs: 3 gallon containers

37.7.3 The developer, its successor, sanitary improvement district and/or subsequent owners shall be responsible for the continued maintenance of landscape materials on a continuing basis for the life of the development. Plant material that exhibits evidence of insect pests, disease, or damage shall be appropriately treated and dead plants promptly removed and replaced within the next planting season.

37.7.4 All landscaping shall be subject to periodic inspection by the Planning Department. Landscaping that is not installed, maintained, or replaced as needed to comply with the approved landscape plan shall be considered in violation of the terms of the site plan or building permit. The landowner will receive notice of such violation in accordance with code enforcement requirements contained within these zoning regulations.

SECTION 38 - STORMWATER MANAGEMENT REGULATIONS

All development, construction, and rehabilitation shall comply with the Sarpy County Stormwater Management Regulations and the Omaha Regional Stormwater Management Design.

38.1 **PURPOSE AND AUTHORITY**

The purpose of this regulation is to protect, maintain, and enhance the public health, safety, and general welfare by establishing minimum requirements and procedures to control the adverse impacts associated with increased Stormwater runoff. Proper management of Stormwater runoff will minimize damage to public and private property, reduce the harmful effects of development on land, control stream channel erosion, reduce local flooding, and maintain after development, as nearly as possible, the pre-development runoff characteristics.

The application of this regulation and provisions expressed herein shall be the minimum storm water management requirements and shall not be deemed a limitation on such management practices. Sarpy County shall be responsible for the coordination and enforcement of the provisions of this regulation.

38.2 **JURISDICTION**

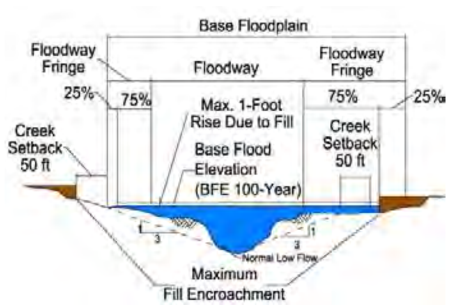
The provisions of this chapter shall be applicable to all that property within the planning and zoning jurisdiction of Sarpy County.

38.3 **INCORPORATION BY REFERENCE**

For the purpose of the Regulation, the Omaha Regional Storm Water Management Design Manual, in its most current form, is incorporated by reference.

38.4 **DEFINITIONS**

The following words, phrases and terms as used in this chapter shall have the meanings ascribed to them in this chapter. The following diagram may be referred to for illustration of several definitions.



Baseline Land Use Conditions. That which existed for Year 2001 for Big and Little Papillion Creeks and its tributaries (excluding West Papillion Creek) and for Year 2004 for West Papillion Creek and its tributaries. That which existed in 2007 for all areas not within the Papillion Creek Watershed.

Best Management Practices (BMP) shall mean pollution control practices designed and carried out to reduce the pollutants contained in discharges, including Low Impact Development techniques.

Building Drain shall mean that part of the lowest horizontal piping of a wastewater drainage system that receives the discharge from soil and waste pipes inside the walls of the building and conveys it to the building sewer, beginning two feet outside the inner face of the building wall.

Clean Water Act shall mean the Federal Water Pollution Control Act, which was enacted in the 1972 to prohibit the discharge of pollutants to receiving waters of the United States and later amended in 1987, to establish a framework for regulating municipal, industrial, and construction stormwater discharges under the NPDES Program.

Combined Sewer shall mean a sewer receiving, by designation of the director, both runoff water and sanitary sewage.

Commercial Activity shall mean any public or private activity not defined as an industrial activity in 40 Code of Federal Regulations (CFR) 122.26 (b)(14), as of the date of this regulation, involved in the storage, transportation, distribution, exchange or sale of goods, and/or commodities or providing professional and/or non-professional services.

Construction Activity shall mean any clearing, grading, or excavation that results in soil disturbance. Construction activity also includes, but is not limited to, construction, repairs, dewatering, remodeling, building, and emergency construction activities required to immediately protect public health and safety.

County Board shall mean the Sarpy County, Nebraska Board of Commissioners.

Creek Setback. A setback area equal to three (3) times the channel depth plus fifty (50) feet (3:1 plus 50 feet) from the edge of low water on both sides of channel.

Director shall mean the Director of Planning for Sarpy County or his/her authorized agent, or representative.

Discharge shall mean any release, spill, leak, pump, flow, escape, dumping, or disposal of any liquid, semi-liquid, or solid substance to the municipal storm sewer system.

Erosion Control. Land and stormwater management practices that minimize soil loss caused by surface water movement.

Full Build-Out Land Use Conditions. Fully platted developable land use conditions for the combined portions of the Papillion Creek Watershed that lie in Douglas and Sarpy Counties that are assumed to occur by the Year 2040, plus the projected 2040 land uses within the Watershed in Washington County; or as may be redefined through periodic updates to the respective County comprehensive plans.

Hazardous Substance shall mean any substance designated under 40 CFR Part 116 pursuant to section 311 of the Clean Water Act.

Illicit Connection shall mean any human made conveyance that is directly or indirectly connected to the municipal storm sewer system and allows for an illicit discharge.

Illicit Discharge shall mean any discharge to the municipal storm sewer system that is prohibited under local, state, or federal statutes, ordinances, regulations, codes, or regulations. Illicit discharges include all non-Stormwater discharges except discharges pursuant to a NPDES permit or conditionally exempted by Regulation and include those prohibited in Sections 38.4 and 38.5 below. Check reference

Industrial Activity shall mean any public or private activity which is associated with any other of the 11 categories of activities defined in 40 CFR 122.26 (b)(14).

Industrial/Commercial Facility shall mean any public or private facility involved and/or used in the production, manufacture, storage, transportation, distribution, exchange or sale of goods and/or commodities, or any facility involved and/or used in providing professional services. This category of facility includes but is not limited to, any facility defined by a Standard Industrial Code (SIC).

Low Chord Elevation. The bottom-most face elevation of horizontal support girders or similar superstructure that supports a bridge deck.

Low-Impact Development (LID). A land development and management approach whereby stormwater runoff is managed using design techniques that promote infiltration, filtration, storage, evaporation, and temporary detention close to its source. Management of such stormwater runoff sources may include open space, rooftops, streetscapes, parking lots, sidewalks, medians, etc.

Maximum LID. A level of LID using strategies, including water quality LID and on-site detention, designed not to exceed peak discharge rates of more than 0.2 cfs/acre during the 2-year storm event or 0.5 cfs/acre during the 100-year storm event based on the contributing drainage from each site, measured at every drainage (stormwater discharge) outlet from the new development or significant redevelopment.

Maximum Extent Practicable shall mean a standard for implementation of Stormwater management programs to reduce pollutants in Stormwater. It is the maximum extent possible taking into account equitable consideration of competing facts, including, but not limited to, the seriousness of the problem, public health risk, environmental benefits, pollutant removal effectiveness, regulatory compliance, ability to implement, cost and technical feasibility.

New Development shall mean as that which is undertaken to any undeveloped parcel that existed at the time of implementation of this policy.

NPDES shall mean National Pollutant Discharge Elimination System and is implemented and enforced by a permit issued by the U.S. Environmental Protection Agency, or the Nebraska Department of Environmental Quality (NDEQ) pursuant to the Clean Water Act that authorizes discharges to waters of the United States and requires the reduction of pollutants in the discharge.

Non-Stormwater Runoff shall mean any discharge to the storm sewer system that is not composed entirely from Stormwater.

Nuisance shall mean Public Nuisance as provided by the Sarpy County Nuisance regulation and also as defined in this regulation.

Pollutant shall mean the same as defined in section 502(6) of the Clean Water Act or as Pollutants include, but are not limited to the following:

a) Materials (including but not limited to fuels, solvents, chemical, detergents, plastic, pellets, hazardous substances, radioactive wastes, fertilizers, pesticides, paints, soot, slag, ash, sludge);

b) Metals and non-metals both soluble and insoluble (including but not limited to cadmium, lead, zinc, copper, silver, nickel, chromium, chlorine, phosphorous, and arsenic);

c) Petroleum Hydrocarbons (including but not limited to fuels, oils, lubricants, surfactants, waste oils, solvents, coolants, and grease);

d) Eroded soils, sediment, and particulate materials in amounts, which may adversely affect the beneficial use of the receiving waters, flora, or fauna or the state;

e) Animal wastes (including but not limited to discharge from confinement facilities, kennels, pens, recreational facilities, and stables);

f) Substances having acidic or corrosive characteristics, unusual coloration or turbidity;

g) Any domestic or industrial wastewater;

h) Any hazardous substance.

Pollutant does not include uncontaminated Stormwater, potable water, groundwater, or reclaimed water by a lawfully permitted water treatment facility.

Peak Discharge or Peak Flow. The maximum instantaneous surface water discharge rate resulting from a design storm frequency event for a particular hydrologic and hydraulic analysis, as defined in the Omaha Regional Stormwater Design Manual. The measurement of the peak discharge shall be at the lower-most drainage outlet(s) from a new development or significant redevelopment.

Private Stormwater Conveyance System shall mean a Stormwater conveyance system that is not owned or maintained by the County including any instrumentality that drains or conveys water from a building or from/through one or more properties to the environment or the County's Stormwater system.

Public Nuisance shall mean any discharge in violation of the provisions of this chapter, the County's Nuisance regulation, a wastewater discharge permit, or an order of the Sarpy County Board.

Receiving Waters shall mean all surface water bodies, including all streams, lakes, ponds, impounding reservoirs, marshes, wetlands, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations or water, natural or artificial, public or private, situated wholly or partly within or bordering upon the jurisdiction of Sarpy County.

Regional Stormwater Detention Facilities. Those facilities generally serving a drainage catchment area of 500 acres or more in size.

Runoff shall mean any Stormwater or non-Stormwater discharges from a drainage area that reaches the municipal storm sewer system. The term runoff in interchangeable with the term urban runoff.

Sanitary Sewage shall mean liquid and water carried industrial or domestic wastes from dwellings, commercial buildings, industrial facilities and institutions.

Sediment Control. Land and stormwater management practices that minimize the transport and deposition of sediment onto adjacent properties and into receiving streams and surface water impoundments.

Separate Storm Sewer shall mean pipe or conduit, which by designation of the Director, carries only Stormwater runoff, discharges pursuant to a NPDES permit or discharges conditionally exempted by regulation.

Significant Redevelopment shall mean land disturbing activity that results in the creation, addition or replacement of at least five thousand (5,000) square feet of impervious surface area on an already developed site. Significant redevelopment includes, but is not limited to, the following activities that meet the minimum standards set forth in this definition:

a) The expansion of a building footprint;

b) Addition or replacement of a structure;

c) Replacement of impervious surface that is not part of a routine maintenance activity; and,

d) Land disturbing activities related to structural or impervious surfaces.

Significant redevelopment does not include activities that are conducted to maintain original line and grade, hydraulic capacity, original purpose of facility or emergency redevelopment activity required to protect public health and safety.

Standard Industrial Classification (SIC) shall mean a classification pursuant to the current edition of the Standard Industrial Classification Manual issued by the Executive Office of the President of the United States, Office of Management and Budget.

Storm Sewer System shall mean any pipe, ditch or gully, or system or pipes, ditches, or gullies that is owned or operated by the county and used for collecting and conveying Stormwater.

Stormwater Management Plan shall mean the adopted Partnership NPDES Phase II Stormwater Management Plan.

Stormwater Management Policies. Stormwater management policies developed by the Technical Workgroup and Policy Workgroup that were commissioned by the Papillion Creek Watershed Partnership (PCWP) subsequent to the “Green, Clean, and Safe” initiatives developed through the "Watershed by Design" public forums conducted in 2004 and 2005 and subsequently revised by the PCWP in 2009. The following policy groups contain "root" policies and sub-policies for stormwater management that have been developed in addition to the Stormwater Management Financing Policy Group herein:

- Policy Group #1 – Water Quality Improvement
- Policy Group #2 – Peak Flow Reduction
- Policy Group #3 – Landscape Preservation, Restoration, and Conservation
- Policy Group #4 – Erosion and Sediment Control and Other BMPs
- Policy Group #5 – Floodplain Management

Stormwater Pollution Prevention Plan (SWPPP) shall mean a plan required by the State of Nebraska General Permit for Stormwater Discharges associated with either industrial or construction activities. The purpose of the plan is to help identify the sources of pollution that affect the quality of Stormwater discharges from a site and to describe and ensure the implementation of practices to reduce pollutants in Stormwater discharges.

Stormwater Runoff shall mean that part of precipitation (rainfall or snowmelt, including that of any frozen precipitation), which travels via flow across any surface to the storm sewer system.

Street Wash Water shall mean the water and the debris associated with it from the washing of streets and/or sidewalks.

Total Maximum Daily Load (TMDL). A calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. Water quality standards are set by States, Territories, and Tribes. They identify the uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support that use. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and non-point sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account for seasonal variation in water quality. The Clean Water Act, Section 303, establishes the water quality standards and TMDL programs, and for Nebraska such standards and programs are administered by the Nebraska Department of Environmental Quality. *[Source: EPA and Nebraska Surface Water Quality Standards, Title 117].*

Updated Flood Hazard Maps. The remapping of flooding sources within the Papillion Creek Watershed where Digital Flood Insurance Rate Maps (DFIRMs) are based on 2004 or more recent conditions hydrology and full-build out conditions hydrology.

Urban Runoff shall mean any Stormwater and non-Stormwater runoff from developed land in, or adjacent to, any municipality.

U.S. EPA shall mean the United State Environmental Protection Agency.

Watercourse. Any depression two feet or more below the surrounding land which serves to give direction to a current of water at least nine months of the year and which has a bed and well-defined banks. *[Adapted from Chapter 31 of Nebraska Statutes]*

Water Quality LID. A level of LID using strategies designed to provide for water quality control of the first ½ inch of stormwater runoff generated from each new development or significant redevelopment and to maintain the peak discharge rates during the 2-year storm event to baseline land use conditions, measured at every drainage (stormwater discharge) outlet from the new development or significant redevelopment.

38.5 WATERSHED FEES

Pursuant to the amended Papillion Creek Watershed Partnership interlocal agreement, Sarpy County shall collect watershed fees.

All new development and significant redevelopment will be required to fund the planning, implementation, and operation and maintenance of water quality LID.

Such Watershed Management Fee shall only apply to new development or significant redevelopment within the Papillion Creek Watershed and the initial framework shall consist of the following provisions.

Collection of fees and public funding shall be earmarked specifically for the construction of projects called for in the Papillion Creek Watershed Management Plan, including Maximum LID costs such as on site detention, regional detention basins, and water quality basins.

Multiple fee classifications are established which fairly and equitably distribute the cost of these projects among all undeveloped areas within the Papillion Creek Watershed. Those fees are provided within the “Master Fee Schedule for the Planning and Building Department” as adopted by the County Board.

Each subdivision or other agreements with developers for new developments or significant redevelopments, shall include the right to collect Watershed Fees at the time of building permit issuance pursuant to, and consistent with, the provisions of this regulation. The Watershed Fee specified in a subdivision agreement shall not be changed after such subdivision agreement has been approved by the Sarpy County Planning Commission, notwithstanding that the Watershed Fee framework or rates possibly may be changed before all building construction has been completed in such subdivision.

Watershed Fees shall be collected at the time of application for a building permit. The Watershed Fees shall be earmarked specifically for construction of regional detention structures and water quality basins and collected as listed below. Further, Sarpy County shall transfer the collected Watershed Fees according to the Amended Interlocal Cooperation Act Agreement for the Continuance of the Papillion Creek Watershed Partnership.

38.6 ILLICIT DISCHARGES PROHIBITED

(A) No person shall cause the discharge of non-Stormwater runoff to enter the municipal storm sewer system unless the discharge is one of the following:

1. Authorized by a NPDES permit issued by EPA, or NDEQ

2. Caused by or resulting from one of the following:

    a) Firefighting activities, where such discharges or flows contain no significant sources of pollutants;

    b) Landscape Irrigation;

    c) Diverted stream flows;

    d) Rising ground waters;

    e) Uncontaminated ground water infiltration, as defined at 40 CFR 35.2005(20);

    f) Uncontaminated pumped ground water;

    g) Discharges from potable water sources;

    h) Foundation Drains;

    i) Air Conditioning condensation;

    j) Irrigation water;

    k) Springs;

    l) Water from crawl space pumps;

    m) Footing Drains;

    n) Lawn Watering;

    o) Individual residential car washing;

    p) Flows from riparian habitats and wetlands;

    q) Dechlorinated swimming pool discharges;

    r) Street wash water;

3. Authorized by Sarpy County.

(B) All exempt discharges, as listed above, must be in conformance with all other provisions of this code.

38.7 PROHIBITION OF ILLICIT CONNECTIONS

No person shall install, maintain, or use any connection to the municipal storm sewer system that may result in the illicit discharge to the municipal storm sewer system. All connection to the municipal storm sewer system that provide for an illicit discharge from inside a building are prohibited.

This prohibition expressly includes, without limitation, illicit connections made in the past, regardless of whether the connection was permissible under law or practices applicable or prevailing at the time of connection.

38.8 REMOVAL OF ILLICIT CONNECTIONS

If any person fails to disconnect an illicit connection upon 30-day prior notification by the Director, the Director may cause the removal of such connection from the municipal storm sewer system. The owner(s) of the facility shall be assessed the cost of the work and any lawful penalties.

38.9 PRIVATE STORMWATER CONVEYANCE SYSTEMS

The owner of a property where a private Stormwater conveyance system is located shall be responsible for the maintenance and repair, and proper operation of the private Stormwater conveyance system, regardless of whether the private Stormwater conveyance system is completely located on the private property or partially within the public right-of-way. The County shall have no responsibility or obligation for the maintenance, repair, or proper operation of a private Stormwater conveyance system.

If the Director determines that a private Stormwater conveyance system is not operating properly and causes improper discharge of Stormwater to the street, sidewalk, or storm sewer system, the Director may declare this condition to constitute a public nuisance and proceed to abate that nuisance in accordance with Regulatory Actions specified in this regulation in concurrence with the Sarpy County Nuisance Regulation.

38.10 DISCHARGE OF SANITARY SEWAGE PROHIBITED

No person shall cause discharge of sanitary sewage to the storm sewer system. In addition, if the Director determines that a building drain or building sewer is not operating properly and causes discharge of sewage to the street, sidewalk, or municipal separate storm sewer system, the Director may declare this condition to constitute a public nuisance and proceed to abate that nuisance in accordance with section 38.25.

38.11 DAMAGE TO THE STORM SEWER SYSTEM

It is unlawful for any person to maliciously, willfully, or negligently break, damage, destroy, uncover, deface, or tamper with any structure, appurtenance, or equipment which is part of the storm sewer system.

38.12 WASTE DISPOSAL PROHIBITIONS

No person shall throw, deposit, place, leave, maintain, litter, keep, or permit to be thrown, deposited, left, maintained, or kept any pollutant, refuse, rubbish, food waste, yard waste, garbage, or any other discarded or abandoned objects in or upon any public or private property, driveway, parking area, street, alley, sidewalk, or other location that may result in an illicit discharge to the storm sewer system. Wastes placed in containers protected from urban runoff such as bags, cans, or recycling bins, and County-approved wastes from construction on public right-of-way are exempted from this prohibition.

38.13 PROHIBITED DISCHARGES FROM INDUSTRIAL/COMMERCIAL ACTIVITIES

The following list of discharges from industrial/commercial activities shall be considered prohibited unless permitted under a separate NPDES permit or approved by the Sarpy County Planning Department. This list is based on Section 38.5 (Illicit Discharges Prohibited), but is not an exhaustive list of prohibited discharges to the storm sewer system:

1. Water from the cleaning of gasoline station, vehicle service garages, or other types of vehicle service facilities.
2. Water, cleansers, or solvents from the cleaning of vehicles, machinery or equipment, and other such commercial and industrial operations.
3. Water from the washing or rising of vehicles containing soap, detergents, solvents, or other cleaners.
4. Water from the cleaning or rinsing of vehicle engine, undercarriage, or auto parts cleaning.
5. Vehicle fluids.
6. Mat wash water from food service facilities.
7. Food and kitchen cleaning water from food service facilities.
8. Leakage from dumpsters or trash containers.
9. Water from the cleaning or rinsing of garbage dumpster areas and areas where garbage is stored or contained.
10. Water from pressure washing, steam cleaning, and hand scrubbing of sidewalks, gutters, plazas, alleyways, outdoor eating areas, steps, building exteriors, walls, driveways, and other outdoor surfaces.
11. Wastewater or cleaning fluids from carpet cleaning.
12. Swimming pool and spa water.
13. Wash out from concrete trucks.
14. Runoff from areas where hazardous substances, including diesel fuel, gasoline and motor oil are stored.
15. Super-chlorinated, i.e., greater than 4mg/l chlorine, water normally associated with the disinfection of potable water systems.

38.14 NOTIFICATION OF PROHIBITED DISCHARGES REQUIRED

In the event of discovery of a discharge to the storm sewer system that is prohibited by this code, the discharger or permittee shall immediately notify the Director of the incident by telephone, facsimile or e-mail. The notification shall include the discharge location, type of materials discharged, estimated concentration and volume of discharge, and corrective actions taken to contain or minimize the effects of the discharge.

In addition, a written report, facsimile or e-mail, addressed to the Director detailing the date, time and cause of the discharge, the quantity and characteristics of the discharge, corrective actions taken to contain or minimize the effects of the discharge, and corrective actions taken to prevent future discharges shall be filed by the responsible person within five days of the occurrence of the non-complying discharge.

38.15 GRADING PERMIT REQUIRED

It shall be unlawful for any person to engage in or cause any grading, clearing, or excavation activities that result in the disturbance of any land areas sufficiently large to require a general NPDES construction site Stormwater permit, and larger than one (1) acre, without the property owner or easement holder, or their agent, first obtaining a grading permit from Sarpy County. This section shall not apply to grading performed solely for agricultural purposes.

38.16 APPLICATION FOR GRADING PERMIT

Any property owner or easement holder, or their agent, desiring a grading permit shall also submit to the permits and inspection division a completed NDEQ notice of intent/permit application for coverage under the general NPDES construction site Stormwater permit. Such permit application shall be made on forms provided by the NDEQ and distributed by Sarpy County. The County shall review all such completed applications and then forward the documents to the NDEQ for approval or denial.

38.17 GRADING PERMIT FEE

Before any grading permit application will be accepted by Sarpy County, the applicant shall pay to the County a fee of $500.00 for ten acres or less, or $1000.00 for more than ten acres.

38.18 ISSUANCE OF GRADING PERMIT

If, after, examination of the application for a grading permit, Sarpy County determines that the proposed plan will meet the requirements of this article and if the NDEQ approved the NPDES application for the project, or if the Permits and Inspection Division fails to review and approve or deny the application within seven days, then the grading permit shall be.

38.19 EROSION CONTROL AT CONSTRUCTION AND DEVELOPMENT SITES

The Director shall establish an erosion control manual governing erosion control at construction and development sites that require a general NPDES construction site Stormwater permit. When such an erosion control manual has been adopted by resolution of the County Board, a copy thereof shall be placed on file with the County Clerk, and the provisions thereof shall be controlling of all subjects contained therein within the County's jurisdiction in the event of any conflict between the provisions of the adopted erosion control manual, or any other regulation, and the provisions of the NPDES permit issued by the State of Nebraska, the provision that imposes the higher or highest standard or most specific practice shall prevail.

38.20 **REQUIREMENT FOR ALL NEW DEVELOPMENT AND REDEVELOPMENT PROJECTS**

Land development and significant redevelopment projects with the potential to add pollutants to Stormwater or to affect the flow rate or velocity of the Stormwater runoff after construction is completed must include provisions for the management of the increased post construction runoff in a Post-Construction Stormwater Management Plan.

38.21 **POST-CONSTRUCTION STORMWATER MANAGEMENT PLAN (PCSWMP)**

The Post-Construction Stormwater Management Plan shall be submitted to the Director, as part of any preliminary plat application, or grading permit application, or building permit application that created 5,000 square feet of more of impervious coverage, on a form or format specified by the Director, at the same time the application for a Sarpy County Grading Permit is submitted. For any significant redevelopment, a post construction Stormwater management plat shall be submitted with the building permit application.

For all development applications made after the adoption date of this ordinance, the post-construction Stormwater management plan, at a minimum, shall include Low Impact Development (LID) BMP's to provide for a water quality control of the first one-half inch of runoff from the site. The County may also require this minimum control level for significant redevelopment that increases the amount of impervious area in a previously platted parcel. For significant redevelopment projects that do not require a grading permit or that involve an increase of less than 5,000 square feet of impervious surface area, BMPs for water quality control of the first one-half inch of runoff from the site are encouraged. For significant redevelopment projects that are characterized as additions or expansions, the Planning Director may determine that the required BMPs only be applied to the area of new development.

The PCSWMP shall include the design, locations, schedules, and procedures for inspection and maintenance of selected BMPs. Temporary erosion and sediment control BMPs to be used during the construction process are to be addressed in the grading permit application. Refer to the Omaha Regional Stormwater Design Manual for information on BMPs.

38.22 **EXEMPTIONS FROM THE POST-CONSTRUCTION STORMWATER MANAGEMENT PLAN**

Systems designed to accommodate only one single family dwelling unit, duplex, triplex, or quadraplex, provided the single unit is not part of a larger common plan of development or sale, are exempt from the requirements in this Regulation to submit a Post-Construction Stormwater Management Plan.

38.23 **MAINTENANCE OF POST-CONSTRUCTION BMPs**

(A) The owners of lands on which structural post-construction BMPs have been installed to meet the requirements of this Regulation shall ensure the maintenance of these structural BMPs that should generally be installed in an outlot. Structural BMPs shall be inspected at least annually, and a written record of inspection results and any maintenance work shall be maintained and available for review by the County. Low Impact Development (LID) – type BMPs that are installed on a building lot shall be maintained by the owner/occupant of such building lot. BMPs located on a single family or duplex residential building lots are exempt from the annual inspection and reporting requirements. Such BMPs shall however be subject to County inspection, at reasonable times.

(B) The responsibility to maintain a BMP may be transferred through a contract or other agreement. The person or entity accepting a maintenance obligation in such a contract or agreement will also be legally obliged to maintain that BMP pursuant to this Regulation. However, no contract or other agreement imposing an obligation to maintain a BMP can relieve a person or entity of any obligation to maintain a BMP imposed by this Regulation.

(C) The applicant or owner shall execute an inspection and maintenance agreement, to be filed of record, binding on all subsequent owners of land served by a private storm water management facility. Such agreement shall provide for access to the BMP, at reasonable, times, for inspections by the County or its authorized representative to ensure that the facility is maintained in proper working condition to meet design standards.

D) The applicant and/or owner shall record the maintenance agreement with the Register of Deeds.

E) The maintenance agreement shall also provide that if after notice by the County to correct a violation requiring maintenance work, satisfactory corrections are not made by the owner(s) within a reasonable period of time (30 days maximum), the County may perform all necessary work to place the facility in proper working condition. The owner(s) of the facility shall be assessed the cost of the work and any lawful penalties.

38.24 STORMWATER MANAGEMENT POLICIES

Pursuant to the amended Papillion Creek Watershed Partnership interlocal agreement, Sarpy County shall adopt a Watershed Plan and amend the watershed policies. The following policies shall apply to all new developments and significant redevelopments:

1. Water Quality LID shall be required on all new developments and significant redevelopments.
2. Impacted wetlands shall be mitigated at a 3:1 ratio.
3. Regional stormwater detention facilities and other structural and non-structural BMPs shall be located in general conformance with an adopted Papillion Creek Watershed Management Plan and shall be coordinated with other related master planning efforts for parks, streets, water, sewer, etc.
4. Maximum LID shall be required to reduce peak discharge rates on all new developments and significant redevelopments as identified in the Papillion Creek Watershed Management Plan.
5. All significant redevelopment shall maintain peak discharge rates during the 2, 10, and 100-year storm event under baseline land use conditions.

6. For new development or significant redevelopment, provide a creek setback of 3:1 plus 50 feet along all streams as identified in the Papillion Creek Watershed Management Plan and a creek setback of 3:1 plus 20 feet for all other watercourses.

   Grading, stockpiling, and other construction activities are not allowed within the setback area and the setback area must be protected with adequate erosion controls or other Best Management Practices, (BMPs). The outer 30 feet adjacent to the creek setback limits may be credited toward meeting the landscaping buffer and pervious coverage requirements.

   A property can be exempt from the creek setback requirement upon a showing by a licensed professional engineer or licensed landscape architect that adequate bank stabilization structures or slope protection will be installed in the construction of said structure, having an estimated useful life equal to that of the structure, which will provide adequate erosion control conditions coupled with adequate lateral support so that no portion of said structure adjacent to the stream will be endangered by erosion or lack of lateral support. In the event that the structure is adjacent to any stream which has been channelized or otherwise improved by any agency of government, then such certificate providing an exception to the creek setback requirement may take the form of a certification as to the adequacy and protection of the improvements installed by such governmental agency. If such exemption is granted, applicable rights-of-way must be provided and a minimum 20 foot corridor adjacent thereto.

7. Construction site stormwater management controls shall include both erosion and sediment control measures.

8. Sediment storage shall be incorporated with all regional detention facilities where technically feasible.

9. Encroachments for new developments or significant redevelopments within floodway fringes shall not cause any increase greater than one (1.00) foot in the height of the full build-out base flood elevation using best available data.

10. Filling of the floodway fringe associated with new development within the Papillion Creek System shall be limited to 25% of the floodway fringe in the floodplain development application project area, unless approved mitigation measures are implemented. The remaining 75% of floodway fringe within the project area shall be designated as a floodway overlay zone. For significant redevelopment, these provisions may be modified or waived in whole or in part by the County Board.

11. The low chord elevation for bridges crossing all watercourses within FEMA designated floodplains shall be a minimum of one (1) foot above the base flood elevation for full-build out conditions hydrology using best available data.

12. The lowest first floor elevation of buildings associated with new development or significant redevelopment that are upstream of and contiguous to regional dams within the Papillion Creek Watershed shall be a minimum of one (1) foot above the 500-year flood pool elevation.

38.25 **ADMISSION TO PROPERTY**

Consistent with the provisions of Section XXII of this regulation, whenever it shall be necessary for the purposes of these rules and regulations, the Director, upon the presentation of credentials, may enter upon any property or premises at reasonable times for the purpose of:

1. Copying any records required to be kept under the provisions of this article;
2. Inspecting any BMPs, and
3. Sampling any discharge to the municipal storm sewer system.

The Director may enter upon the property at any hour under emergency circumstances but such authority is limited only to those properties designated as outlots. The authority to inspect, sample and copy records, shall be limited to only those things, and only the extent, that it has a direct bearing on the kind and source of discharges into the municipal storm sewer system.

38.26 **REGULATORY ACTIONS**

If substances in violation of this regulation are discharged or proposed to be discharged into the municipal storm sewer system of the County or any tributary thereto, the County may take action necessary to:

1. Prohibit the discharge of such effluent.
2. Require a discharger to demonstrate that modifications to such discharger's facilities will reduce or eliminate the discharge of such substances in conformity with this article.
3. Require pretreatment, including storage, detention or retention facilities necessary to reduce or eliminate the objectionable characteristics or substances so that the discharge will not violate these prohibitions and limitations.
4. Require the person making, causing, or allowing the discharge to pay an additional cost or expense incurred by the County for taking remedial actions as may be deemed to be desirable or necessary to achieve the purpose of this chapter. Such additional cost or expense may be levied as a special assessment on the property.
5. Require any combination or all of the above.
6. Require compliance with the Sarpy County Nuisance Regulation.

38.27 **NOTICE OF VIOLATION; CORRECTION OF VIOLATIONS**

Whenever the Director finds that any person has violated or is violating this article or any prohibition, limitation or requirement contained herein, such person shall be notified in writing.

38.28 **PENALTY; RECOVERY OF DAMAGES**

Any person who is found to have violated an order provided for in this article, or who willfully or negligently failed to comply with any provisions of this article and the rules and regulations issued hereunder, shall be deemed guilty of a Class III misdemeanor. Each day any such violation or failure to perform such act shall continue, shall constitute a separate offense, unless otherwise specifically provided. Except as prohibited by the State or Federal Constitutions, a prosecution under this Regulation, shall not be the exclusive penalty for such acts or omissions.

38.29 **ADDITIONAL RULES AND REGULATIONS**

The Director may make rules and regulations, which expand upon or add to the provisions of this article but are not inconsistent with them. Prior to taking effect, such rules and regulations, or any amendments thereto, shall be approved by resolution of the County Board. A copy of such rules and regulations, with any current amendments, shall be on file with the County Clerk.

38.30 **APPEALS**

Any person aggrieved by the issuance, denial, suspension, cancellation, or revocation of any permit provided for in this article or by any other order of the Director, may within ten days of the receipt of written notice of the entry of such order, appeal to the Sarpy County Zoning Board of Adjustment, consistent with the provisions of §23-168.02.

38.31 **CONFLICTS WITH OTHER CODE SECTIONS**

The provisions of this chapter shall control over any inconsistent of conflicting provision of this code.

38.32 **SEVERABILITY**

If any portion of this chapter or the applicant thereof to any person or circumstances is held invalid, the remainder of this chapter and the application of such provisions to other persons or circumstances, shall not be affected thereby.

SECTION 10 MINIMUM DESIGN STANDARDS

No subdivision plat shall be approved unless it conforms to the following minimum requirements.

10.1 General:

Land which the Planning Commission and the County Board have found to be unsuitable for subdividing due to flooding, bad drainage, steep slopes, rock formation, or other features likely to be harmful to the safety, welfare or health of the future residents, shall not be subdivided unless adequate methods for subdivision are formulated by the developer and approved by the Planning Commission and County Board.

10.2 Streets and Alleys:

10.2.1 The arrangements, classification, extent, width, grade and location of all streets and roads shall conform to the Comprehensive Plan and shall be designated in relation to existing and planned streets, topographic conditions, public convenience and safety, and the proposed uses of the land to be served by such streets.

10.2.2 Where such is not shown in the Comprehensive Plan, the arrangement of streets in a subdivision shall either:

10.2.2.1 Provide for the continuation or appropriate projection of existing principal streets in surrounding areas; or

10.2.2.2 Conform to a plan for the neighborhood approved or adopted by the Board to meet a particular situation where topographical or other conditions make continuance or conformance to existing streets impracticable.

10.2.3 Minor streets shall be so laid out that their use by through traffic will be discouraged.

10.2.4 Where a subdivision abuts or contains an existing or proposed major street or highway, the Board may require reverse frontage lots with rear service alleys abutting the major street or highway, or such other treatment as may be necessary for adequate protection of residential properties and for separation of through and local traffic.

10.2.5 Where a subdivision borders on or contains a railroad right-of-way, the Board may require a street approximately parallel to and on each side of such right-of-way, at a distance suitable for the appropriate use of the intervening land. Such land would be approximately used for park purposes in residential districts, or for commercial or industrial purposes in nonresidential districts. Such distances shall be determined with due regard for the requirements of approach grades or future grade separations.

10.2.6 Reserve strips in private ownership controlling access to streets shall be prohibited.

10.2.7 Intersections with centerline offsets of less than one hundred and fifty (150) feet shall be avoided.

10.2.8 A tangent of at least one hundred (100) feet long shall be introduced between reverse curves on major and collector streets.

10.2.9 When connecting street lines deflect from each other at any one point by more than ten (10) degrees, they shall be connected by a curve with a radius adequate to insure a sight distance of not less than four hundred (400) feet for collector streets, and of such greater or lesser radius as the Planning Commission shall determine for special cases.

10.2.10 Streets and roads shall be laid out so as to intersect as nearly as possible at right angles and no street shall intersect any other street at less than sixty (60) degrees.

10.2.11 Curb radius on all block corners shall be a minimum of twenty-five (25) feet and a minimum ten (10) foot radius shall be used at intersections of driveways and alleys.

10.2.12 Half streets shall be approved only by Board.

10.2.13 The right-of-way widths, pavement widths (back to back of curb), street grades, and the sight-distances for streets and alleys in any subdivision shall not be less than the minimum dimensions nor more than the maximum grades as set forth in the current version, including any revisions or amendments thereto, of the "Nebraska Administrative Code, Title 428, Rules and Regulations of the Board of Public Roads Classifications and Standards".

10.2.14 Cul-de-sac streets shall have a right-of-way diameter of 110 feet at their terminal end, a pavement turn around diameter of 80 feet, and a maximum length of 600 feet.

10.2.15 The horizontal alignment on all streets except in unusual cases shall be as follows:

Other Arterial Streets	700 ft. minimum
Collector Streets	300 ft. minimum
Local Streets	100 ft. minimum
Cul-de-sacs	100 ft. minimum

10.2.16 No road or street grade shall be less than one-half (½) of one (1) percent.

10.2.17 Flatter grades are preferred from fifty (50) to one hundred (100) feet from an intersection. Grades not exceeding four (4) percent for a distance of at least fifty (50) feet from an intersection are preferred. The subdivider shall provide justification in writing to the County Engineer if this requirement cannot be met.

10.2.18 Dead-end roads and streets as permanent features shall be prohibited.

10.2.19 General Considerations:

10.2.19.1 Intersection of more than two (2) roads or streets at a point shall not be permitted.

10.2.19.2 Alleys shall be discouraged in residential districts but may be provided in commercial and industrial districts.

10.2.20 Other rights-of-way easements:

10.2.20.1 Easements for utility rights-of-way shall be not less than ten (10) feet in width and wherever possible shall be provided along the rear and side property lines.

10.2.20.2 Pedestrian walks shall be at grades no greater than the adjacent street grades.

10.2.20.3 Where a subdivision is traversed by a water course, coulee, drainage way, channel, or stream, there shall be provided a minimum storm water easement or drainage right-of-way of one hundred (100) feet, conforming substantially with the lines of such water course, and such further width for construction and water flow or both that will be adequate for such purpose. Parallel streets, parkways, walkways, culverts, or bridges may be required in connection with such drainage easement.

10.3 Blocks:

10.3.1 Block length shall not exceed 800 feet. The length of blocks shall be considered to be the distance from street centerline to opposite street centerline and shall be measured through adjacent back lot lines or through the center of the block. In cases of irregular-shaped blocks, the requirements shown herein may be waived by the Planning Commission. This standard may be waived for rural/acreage subdivisions.

10.3.2 Pedestrian crosswalks not less than ten (10) feet wide may be required in blocks longer than five hundred (500) feet where such crosswalks are deemed by the Board to be essential to provide circulation, or access to schools, playgrounds, shopping centers, transportation or other community facilities.

10.3.3 The width of blocks shall generally be sufficient to allow two (2) tiers of lots and be at least two hundred forty (240) feet in width. In cases of irregular-shaped blocks, the minimum width may be waived by the Board.

10.3.4 Blocks intended for business and industrial use should be specifically designated for such purposes with adequate space set aside for off-street parking and delivery facilities. The Board may require service drives or frontage access roads along major streets for business or industry.

10.3.5 Where frontage is on a major or collector street, the long dimensions of the block should front thereon.

10.4 Lots:

10.4.1 Lot dimensions and area for lots shall conform to the requirements of the Zoning Regulations.

10.4.2 The platting of lots for commercial and industrial purposes should include adequate space for off-street parking and service areas.

10.4.3 Satisfactory access from a public street shall be provided for all lots.

10.4.4 Double frontage and reverse frontage lots shall be avoided where possible.

10.4.5 Corner lots shall be of extra width sufficient to maintain building lines on both streets.

10.4.6 Side lot lines shall be approximately at right angles or radial to street lines.

10.4.7 Excessive depth in relation to width of lots over a ratio of three-to-one shall be avoided.

10.4.8 Every lot shall abut and have access to a public street.

SECTION 11 PUBLIC SITES AND OPEN SPACES

11.1 Where a park, playground, school or other site for public use shown on the Comprehensive Plan is located in whole or in part in the applicant's subdivision, the County may require the acquisition or accept the dedication or reservation of such area within the subdivision.

11.2 Where deemed essential by the Planning Commission and the Board, upon consideration of the type of development proposed in the subdivision, and especially in a large-scale development not anticipated in the Comprehensive Plan, the County may request the dedication or reservation of such other areas or sites of a character, extent or location suitable to the needs created by such development for schools, parks and other neighborhood facilities.

11.3 Where a tract of land is being subdivided and includes land proposed to be used for parks under the duly-adopted Comprehensive Plan, the subdivider shall indicate the location of such areas on the subdivision plat.

11.4 When a tract of land is being subdivided, the developer shall submit a plat of the proposed development to the local school board.

11.5 All subdividers may be assessed the assessments for improvements to implement the public sites and open space segments of the Comprehensive Plan. The form and amount of assessment will be fixed by the Board upon recommendation of the Planning Commission when the costs for the improvements have been determined.

11.6 Where future school sites or public park sites are shown on the Comprehensive Plan and are located on a tract of land proposed to be subdivided, the sites shall be reserved for a period of six (6) months, and the applicable School and County may purchase the unplatted land at a value determined in the same manner as required by the Nebraska Statutes for proceedings under the power of eminent domain, or by negotiations with the owners of the property.

SECTION 12 STANDARDS FOR CONSTRUCTION PLANS AND SPECIFICATIONS

12.1 The subdivider shall construct and install the improvements in accordance with the current edition and any revisions or amendments thereto of the "City of Omaha Standard Specifications for Public Works Construction" and/or the current edition and any revisions or amendments thereto of the "Nebraska Department of Roads Standard Specifications for Highway Construction."

12.2 Construction plans for such improvements shall be signed/sealed and also submitted in electronic form in AutoCAD. The subdivider shall furnish "as built" construction plans within six (6) months after completion of construction in the above-described format.

12.3 No contracts for the construction of any improvements within the subdivision shall be awarded without the approval of the Board.

12.4 Staking: The following-described monuments shall be installed before the Engineer shall approve a plat, or in lieu thereof, a performance bond in an amount equal to the cost of doing such work, shall be furnished to the County before the Engineer shall certify to the Board that required improvements have been satisfactorily arranged for:

12.4.1 The external boundaries and corners of blocks shall be monumented by iron rods or pipes not less than five-eighths inch (5/8") in diameter extending at least twenty-four (24") inches below grade.

12.4.2 Lot corners, all points of curvature, points of tangency, and other points shall be monumented by iron rods or pipes not less than five-eighths inch (5/8") inch in diameter extending at least 24 inches below grade.

12.5 Street Grading: All full-width streets located entirely within the boundary of the subdivision, except major streets as noted, shall be graded to the full width to within six (6) inches of the finished grade. Such grading shall be completed, or in lieu thereof, a performance bond in an amount equal to the cost of doing such work, shall be furnished to County before the Engineer shall certify to the Board that the required improvements have been satisfactorily arranged for.

12.6 Street Surfacing: The streets shall be paved, including curbs and gutters in accordance with the Standards for Street Improvement and approved by the Board, except that in the case of a plat wherein all of the lots in the plat have a minimum frontage width of 200 feet or more, the paving requirements may be waived at the developer's request and the streets in such a plat may have a crushed rock or gravel surface meeting the specifications of the County and not less than 30 feet wide in lieu of pavement .

12.7 Sanitary Sewer: Where the County-approved sanitary sewer is accessible by gravity flow within one (1) mile of the Final Plat, the subdivider shall connect thereto and provide adequate sewer lines and stubs to benefit each lot. Where any other County -approved sanitary sewer is more than one (1) mile distance, or where an approved sanitary sewer is not accessible by gravity flow, the subdivider shall make provisions for the disposal of sewage as required by law and as approved by the Board. In the case where temporary disposal facilities shall be approved, these temporary facilities shall be approved under the following conditions:

12.7.1 The temporary facility shall only be approved and sized for that subdivision.

12.7.2 The subdivider shall enter into a formal agreement with the County stating that if and when a County-approved sanitary sewer line is constructed within one (1) mile of the subdivision, the subdivider shall connect to the sewer line and disconnect from the temporary facility, which shall be discontinued and eliminated by the subdivider as approved by the Board at the cost of subdivider.

12.8 Storm Sewers: The subdivider shall be required to provide for adequate drains, inlets, manholes, and other facilities to provide for the adequate removal of all surface drainage. Where the subdivision is located within a drainage area, and the subdivider is required to provide a Storm Water Management Plan, this plan will be subject to approval by the Engineer or a Registered Engineer, appointed by the Board, as to adequacy.

12.9 The Storm Water Management Plan shall contain the following information for the entire tract of land to be developed:

12.9.1 A vicinity map showing the proposed development in relation to roadways, jurisdictional boundaries, streams, and adjacent developed areas or land use.

12.9.2 A site plan showing predominant soil types, proposed roads, sewers, and other utilities existing and proposed water courses, and the features of the proposed development.

12.9.3 A plan showing the details of the proposed drainage system, including initial and major drainage provisions. The plan should show type and size of various elements of the system necessary to evaluate its performance, such as pipe size and slope, channel configuration and slope, detention cell volumes, etc.

12.9.4 A topographic map showing existing and proposed contours, development features, and the contour elevations of the one percent chance flood.

12.9.5 A topographic map of adjacent areas upstream and downstream of the proposed development showing contour elevations of the one percent chance flood, and any features designed to mitigate increased storm water runoff from the proposed development. Mapping shall point upstream and downstream where it can be clearly shown to the satisfaction of the Board that no additional flood problems will result from the proposed development.

12.9.6 A schedule of anticipated starting and completion dates of each stage or sequence of construction, and the estimated date of completion of all utility construction in the development.

12.9.7 A detailed description of the maintenance program for the drainage system including sediment removal from detention ponds, channel bed and bank stabilization measures, and bridge and culvert maintenance.

12.10 Water Mains: The subdivision shall be provided with an adequate water main supply system. The location of fire hydrants shall be shown on the water utility plan

12.11 Erosion Control: The subdivision shall be required to provide an Erosion and Sediment Control Plan. This plan will be subject to approval by the Engineer or a Registered Engineer, who is appointed by the Board, as to adequacy. The plan shall contain the following information for the entire tract of land to be disturbed:

12.11.1 A vicinity map indicating the proposed development in relation to roadways, jurisdictional boundaries, and streams.

12.11.2 A site plan showing soil types, existing vegetation, existing and proposed water courses, critical erosion areas, and the features of the proposed development.

12.11.3 A plan for temporary and permanent vegetative and structural practices, which specify conservation measures to be used during all phases of clearing, grading, filling, construction, and permanent development.

12.11.4 The subdivider shall be required to seed the area covered by the subdivision to control erosion of areas disturbed by grading operations; and to construct temporary terraces on slopes, temporary silting basins, sod swales and spillways, and whatever may be necessary to prevent erosion and damage to adjacent properties from surface drainage, all as approved by the Board.

12.11.5 A schedule of anticipated starting and completion dates for each sequence and stage of land-disturbing activities and for the installation of conservation measures. It shall also include the expected date when final stabilization will be completed.

12.11.6 A detailed description of the maintenance program for the erosion and sediment control facilities, including inspection programs, vegetative establishment on exposed soils, method and frequency of removal and disposal of waste materials from control facilities, and disposition of temporary structural measures.

12.11.7 Implementation of the approved sediment control plan shall be required prior to any land-disturbing activity.

12.11.8 The use of construction and demolition waste for erosion control along a water course is permitted if incorporated into an Erosion Control Plan.

12.12 Sidewalks: A concrete sidewalk shall be provided on both sides of a street within the street right-of-way with a minimum width as follows:

Zoning Districts	Sidewalk Width
RS, RD, RG	5 feet, and 4 feet minimum inside from the curb
Other Districts	As directed by Board

12.13 Other Improvements: The installation of other improvements may be required when deemed necessary in the best interest of the County. All recreation improvements shall be approved by the Board.

12.14 The subdivider shall install the required improvements in compliance with the staking of monuments, street grading and paving; and other improvements; sanitary sewer, water system, storm drainage, and erosion control requirements, all within one year after the plat has been approved by the Board, or the subdivider may post a performance bond or certified check in the amount of 100 percent of the cost of the required improvements, with approval thereof by the Engineer. If the improvements are not completed and approved within the specified time, the bond or certified check shall be forfeited and used by the County to complete the improvements. The Board may extend this period upon the showing by the subdivider of circumstances beyond his/her control or upon evidence of circumstances that create a hardship to the subdivider.

12.15 Subdivision Agreement: No plat shall be approved by the Board until a subdivision agreement shall have been entered into between the subdivider and the County. The County Attorney shall prepare such agreement to be approved by the Board. The agreement shall provide for the needs of the subdivision, including, but not limited to, pavement, water mains, sanitary sewers, storm sewers, sidewalks, grading, waste treatment, and open space requirements. Security may be required to assure performance under the agreement. The subdivision agreement's engineering details shall be furnished by the subdivider's engineer and shall also be submitted.

12.16 Paving:

12.16.1 Concrete shall be installed on all residential streets using a minimum thickness of seven (7) inches and shall be a minimum width of twenty-five (25) feet back to back of curbs. Curbs shall be six (6) inch integral rolled type. All material shall conform to the requirements of the current edition and any revisions or amendments thereto of the "City of Omaha Standard Specifications for Public Works Construction" and/or the current edition and any revisions or amendments thereto of the "Nebraska Department of Roads Standard Specifications for Highway Construction."

12.16.2 Asphalt may be installed in lieu of portland cement concrete using a minimum thickness of ten (10) inches, or nine (9) inches with a six (6) inch sub-base, and shall also be twenty-five (25) feet back to back of curbs, with two (2) foot wide, by seven (7) inch deep, and six (6) inch high, portland concrete integral rolled curb and gutter.

12.16.2.1 Asphaltic concrete and/or the six (6) inch base course shall conform to the requirements of the current edition and any revisions or amendments thereto of the "City of Omaha Standard Specifications for Public Works Construction" and/or the current edition and any revisions or amendments thereto of the "Nebraska Department of Roads Standard Specifications for Highway Construction."

12.16.3 Intersection radius requirements: shall be installed to a minimum radius of twenty-five (25) feet.

12.16.4 Paving for rural type subdivisions (200' wide acreage lots) shall meet the following requirements:

12.16.4.1 Concrete (Portland Cement Concrete) shall be seven (7) inches minimum thickness by twenty-four (24) feet in width and may be curbless.

12.16.4.2 Asphalt (Asphalt Cement Concrete) shall be nine (9) inches minimum thickness by twenty-four (24) feet in width and may be curbless.

12.16.4.3 The above concrete and asphalt paving specifications shall meet the requirements as outlined above for residential subdivisions.

12.17 Subgrade Requirements: Subgrade compaction shall meet the requirements of the current edition and any revisions or amendments thereto of the "City of Omaha Standard Specifications for Public Works Construction" and/or the current edition and any revisions or amendments thereto of the "Nebraska Department of Roads Standard Specifications for Highway Construction," or as specifically recommended by a geotechnical report specific to the project submitted to the County for review.

Planning & Design

Vireo

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MEMORANDUM

Project Name | Southern Sarpy County Watershed Management Plan

Project No | 15160

Date | July 13, 2018

To | Janel Kaufman – FYRA Engineering

From | Laurie Brown, Tom Bentley, and Scott Schulte - Vireo

Re | Stream Asset Inventory Results, Conclusions, and Recommendations – Draft Technical Memorandum

I. Introduction

At the request of FYRA Engineering (FYRA) and the Southern Sarpy Watershed Partnership (SSWP) in conjunction with the Papio-Missouri River Natural Resources District (NRD), Vireo completed a Stream Asset Inventory (SAI) of three watersheds (Buffalo, Springfield, and Zweibel) in southern Sarpy County, Nebraska. The SAI was conducted during spring of 2018 as part of the Southern Sarpy County Watershed Management Plan. Goals and objectives for the stream assessment included:

- Assessing and classifying the relative condition of streams within these watersheds
- Providing baseline natural resource conditions for sustainable stormwater management and land use planning recommendations
- Identifying stream reaches that should be protected and those that have restoration potential
- Identifying potential locations for stream bed and bank stabilization projects and predicting potential future failure locations as these watersheds develop
- Assessing and mitigating potential impacts of future watershed projects

The following sections document the SAI objectives and assessment process, summarize the inventory results, and discuss conclusions and recommendations. Where appropriate, Vireo supplemented the SAI analysis with supporting information from similar studies including the Johnson County, Kansas and Kansas City, Missouri SAIs, and relevant scientific literature. The attached figures present the type (relative condition) of each assessed stream reach on a watershed-by-watershed basis.

II. SAI Methodology

Vireo conducted the assessment using the Stream Asset Inventory (SAI) procedure, which incorporates the best elements of a number of accepted stream and habitat assessments and local research. The SAI methodology provides rapid and scientifically defensible indicators of water quality, stream stability, and habitat conditions at a given location that is selected to be representative of a larger stream reach. Assessment criteria include erosion indicators; bed and bank composition; aquatic habitat features; tree canopy and understory coverage and composition; and indirect water quality indicators. These criteria are assigned individual weighted scores to create a composite score of stream quality at each location and a relative ranking of stream quality throughout the watershed. Due to differences in soil conditions in Nebraska, additional soil characteristics (silty clay loam, silty loam, and loess) were added to the Bank and Bed Composition criteria.

Vireo developed the assessment protocol using the SAI procedure previously developed for Johnson County, Kansas and Kansas City, Missouri (Patti Banks Associates 2005a, b and 2007; Tetra Tech EMI, Patti Banks Associates, Applied Ecological Services 2004). Within this technical memorandum (TM), comparative reference is made to these previous assessments as a means of identifying consistencies, minimizing speculation or misleading indicators, and critically analyzing the assessment outcomes.

The data collection, quality review, stream classification, and analysis and conclusions are discussed below.

Data Collection

Initial survey locations were identified using a combination of geographic information system (GIS) mapping and professional analysis. Vireo acquired GIS data from FYRA and Sarpy County and worked with FYRA staff to determine priority areas to assess. Due to limited site access, survey locations were adjusted to be on public road right-of-way within priority stream corridors.

The consultant team conducted field surveys May 7-9, 2018. A two-person team visited 46 of 55 pre-selected survey reaches and completed a survey checklist at each location. The sites that were assessed represented a mix of perennial, intermittent and a few ephemeral streams. Locations that were in close proximity (opposite side of bridge/culvert) and those locations that were not accessible by public right-of-way were not assessed.

The SAI procedure has four major categories with each having five scoring components. Each component has a maximum potential score of 10 for a possible total score of 200. By dividing the total score by 20 (or by the number of measured components), the assessment provides a qualitative numerical score ranging from 0.0 to 10.0. A score of 10.0 would be considered optimal stream conditions while 0.0 would indicate poor stream conditions. Some components were not applicable or observable in certain situations, and if so, the evaluation team did not assess that component. The final quality value was calculated by dividing the total site score by the number of components scored. For example, where bed composition could not be observed due to high flows or turbid conditions, no points were assigned for the bed composition component and the total site score was divided by 19 rather than 20. A sample field data form is attached to this TM.

Quality Assurance/Quality Control

The consultant team reviewed the survey data to document the quality and usefulness of the assessment and to address deficiencies. Vireo staff first reviewed the field survey locations to determine whether all identified stream reaches were surveyed. A small number of reaches were not sampled because the assessors did not have access by public right-of-way. Vireo then reviewed the data sheets for completeness and consistency. The reviewer determined that all survey forms were complete and data were consistently recorded.

Based on this review, the consultant team determined that the SAI results are defensible and of sufficient quality to assist the SSWP in making planning decisions.

Stream Classification

Under the relative scoring system, stream reaches were assigned a score from 10 to 0 and were classified Type I (highest quality) through V (lowest quality) based on the statistical distribution of data from the study area. For example, a Type III stream score falls one standard deviation above or below the mean score, a Type II stream scores more than one standard deviation above the mean, etc. Stream segments were classified into five types, with the following general descriptions that may vary by locality and study area:

> Type I - Highest Quality: Generally described as the highest quality naturally occurring stream in a given study area, with the least negative impact. Erosion and sedimentation is generally low; water quality indicators tend to be positive; and the surrounding riparian zone is generally healthy, even including mature, successional woodland or other high-quality vegetation in the best cases.
>
> Type II - High Quality: This type of stream may have greater down- or side-cutting, but with bank and bed composition that assist in keeping the impact low. Water quality indicators are generally fairly good and the riparian zone is largely intact, although vegetation may be altered from that of a typical native plant association.
>
> Type III – Restorable: Deterioration of the channel and riparian corridor are generally more noticeable. While some remnant plant associations may be present, overall vegetative canopy cover is usually comprised of immature tree species, pasture or turf grasses. Water quality indicators may be fair to marginal. In most cases, the potential for restoration exists although erosion and sedimentation can be greater than desirable.
>
> Type IV - Low Quality: Impacts are greater on this stream type, usually with significant indicators of bank erosion and channel instability. The adjoining riparian corridor oftentimes is limited or highly fragmented and vegetation is not representative of a native plant association. Water quality indicators are typically poor.
>
> Type V - Lowest Quality: The channel in this type is the most altered or degraded. In almost all cases, the riparian corridor is impaired to the point of providing little protection or benefit, and erosion and sedimentation indicators are significant. Water quality indicators are usually very poor with degradation and absence of macroinvertebrates, fish, mollusks, and amphibians.

The surveyed stream segments were classified relative to the sample population of surveyed streams, rather than applying an absolute score. The relative ranking is used for several reasons: (1) Scoring streams on an absolute scale may imply that the break points between classes are based on some quantitative linkage between the score and stream function, which is not the case; (2) Streams should be classified in comparison to general, regional conditions so that streams are assigned scores reasonable for their physiographic and development settings; and (3) relative distribution allows the assessor to identify the truly high-quality and low-quality streams within the study area. However, comparison with surveys in other, similar communities can provide some relative indication of overall stream quality as discussed below.

III. Results

The streams in southern Sarpy County are generally considered headwater streams that feed into the Platte River. Headwater streams represent approximately 80 percent of the Nation's stream network (Meyer et al. 2003). When healthy, these stream systems provide multiple ecosystem services including flood control, wildlife habitat, and improved water quality.

The consultant team classified most of the natural, perennial stream reaches within southern Sarpy County and some larger intermittent and ephemeral tributaries. A total of 46 individual stream reaches was classified. The breakdown of stream types by scores is shown below. The summary table (attached) presents the type (relative condition) of each assessed stream reach on a watershed-by-watershed basis.

Summary Distribution by Watershed								
	Buffalo		Springfield		Zweibel		Overall	
Stream Type	**Count**	**% Total**	**Count**	**% Total**	**Count**	**% Total**	**Count**	**% Total**
Type I	1	5.5%	0	0.0%	0	0.0%	1	2.2%
Type II	3	16.7%	0	0.0%	1	7.1%	4	8.7%
Type III	12	66.7%	13	92.9%	8	57.1%	33	71.7%
Type IV	2	11.1%	1	7.1%	3	21.4%	6	13.1%
Type V	0	0%	0	0.0%	2	14.3%	2	4.3%
Total:	18	100.0%	14	100.0%	14	100.0%	46	100.0%

As would be expected, a majority of the streams within southern Sarpy County are Type III, followed by Type IV, and then Type II. Type III streams typically retain some natural character and may be restorable. Type II streams are in a more natural and stable condition, while Type IV streams are significantly lower quality. Very few Type I (very high quality) or Type V (very low quality) stream reaches were identified. One Type I reach was found during the survey: a well bedrock lined stream channel in the Buffalo watershed. Two Type V streams were found within the central portion of the Zweibel watershed. Photographs illustrating stream types are included in the attached figures.

Vireo reviewed the individual component scores and subtotals for the four major categories. The mean subtotal of three of the four categories (stream stability, aquatic habitat quality, and terrestrial habitat quality) ranged between 22 and 30 of a possible 50 points for each. The mean water quality score was 7.7 out of 50; however, due to limited site access many of the water quality criteria could not be observed and thus, were not scored. The low water quality scores resulted from a lack of fish, mollusks, amphibians, and high-quality macroinvertebrates; or the inability to observe and score these criteria.

The survey team noted the following general observations of conditions within the watersheds:

- Buffalo watershed is generally the most rural and Zweibel watershed is the most urbanized

- Springfield watershed has the most parkland adjacent to the primary stream channel
- Loess soils common to this area were most evident in the Buffalo watershed where several vertical cut banks were noted within or adjacent to the surveyed stream reaches
- Riparian corridors are generally limited in width and fragmented or non-existent in the Zweibel watershed, are more intact in the Springfield watershed, and the most intact in the Buffalo watershed
- Row crop fields are the dominant agricultural use throughout all of the watersheds
- Terraces and grassed waterways are common agricultural practices used in all of these watersheds
- Excessive downcutting and siltation was noted in numerous locations
- The County uses a mix of stream crossings including corrugated metal pipe (CMP), concrete box culverts, and bridges
- Multi-cell concrete box culverts generally had normal stream flows within one box and sediment and debris filling the other cell(s)
- Large, oval corrugated metal pipes (CMPs) are being used for roadway improvement projects
- One survey reach in the Buffalo watershed (Point 48) had an arched CMP culvert over a bedrock lined streambed
- Another surveyed reach in the Buffalo (Point 40) watershed had energy dissipaters built into the outfall of the culvert
- A number of light industrial/commercial land uses were noted immediately adjacent to streambanks resulting in negative impacts to stability

IV. Analysis and Conclusions

Vireo reviewed the SAI results to determine what preliminary conclusions it could draw from the assessment. These analyses and conclusions are described below.

First, Vireo analyzed the SAI data to identify obvious trends. Vireo also analyzed the data by correlating the component scores with the overall SAI results. The presence or absence of quality aquatic habitat appears to have the strongest correlation with overall stream quality (R=0.60). The other three general assessment factors (stream stability, terrestrial habitat quality, and indirect water quality indicators) did not strongly correlate with overall stream quality. Vireo also reviewed the results by the number of factors observed to determine whether the inability to score some criteria might bias the results, but found no trends in this regard. The summary table attached to this TM includes statistical results.

Next, Vireo reviewed the data by watershed. Stream quality was somewhat higher in the Buffalo Creek watershed and somewhat lower in the Zweibel Creek watershed. Average and median scores in the Springfield watershed closely matched the overall results. Stability and aquatic habitat factors were somewhat better in the Buffalo watershed, which resulted in higher overall scores. Terrestrial habitat conditions tended to be better in the Springfield and Buffalo watersheds than in the Zweibel watershed.

As noted previously, the SAI procedure is designed to assess the health of streams within a given study area relative to each other, rather than to provide an absolute measure of stream health or quality. Measures of stream health or quality are by nature somewhat relative and dependent on context: for example, a stream that is considered to be high-quality in an urban area might be considered only moderately healthy in a less disturbed natural area; and streams in areas with less cohesive bed and bank materials might nonetheless be considered stable in that context even though their stability score would be lower than bedrock streams in another location.

However, comparing overall scores from one area or study to another still may be useful as it allows for a more thorough review and understanding of the results. SAIs were performed at over 400 locations in the Kansas City region in 2003 and 2005, and included urban, suburban, and rural stream reaches. The mean overall score in the Kansas City region was 6.32, with a range from 8.125 to 4.088. By contrast, the mean score in Southern Sarpy County was 5.155, with a range from 6.389 to 3.882. There may be several reasons for this difference, as discussed below.

First, due to restrictions on accessing streams on private property, most observations in southern Sarpy County were taken from road right-of-way and bridges. Based on the survey team's past experience, locations within 100 feet of major infrastructure (such as a road, culvert, bridge, railroad line, or pipeline crossing) tended to be heavily influenced by impacts from the nearby infrastructure. The survey team attempted to observe conditions farther away from the sample locations using binoculars and spotting scopes but, were not able to accurately assess in-stream conditions at those distances. This could partially explain why in-stream aquatic habitat did not score well, and in-stream aquatic habitat conditions were most strongly correlated with overall stream condition.

Second, the Kansas City region SAI evaluations clearly demonstrated the value of vegetative cover within riparian corridors in mitigating stream degradation. In the assessment of over 400 locations, many of the lowest quality stream reaches were identified in agricultural areas, while some high-quality streams were noted in more urbanized areas. These observations are contrary to the "Impervious Cover Model", which predicts that streams will begin degrading with increasing imperviousness (Center for Watershed Protection [CWP] 2003). Watersheds that were 2- to 3-percent impervious scored more poorly than more developed watersheds with 8- to 10-percent imperviousness. Significant variability was observed in undeveloped and agricultural watersheds as well: the Type II streams were generally buffered by extensive and high-quality vegetation, while the Type IV stream reach buffers were either nonexistent or narrow and of poor quality. CWP notes that an intact riparian buffer can extend the impervious cover model to a modest degree, and also that impacted pervious cover (such as agricultural land) may contribute to stream degradation as well (CWP 2003). These findings support the importance of riparian buffers for protecting stream quality (Schulte, Noll, and Henson 2008). Vegetated stream buffers in the more developed areas of the Springfield, including in parks and greenways, may explain why streams in this watershed scored somewhat better than those in the Zweibel watershed.

Third, water quality indicators scored very low in southern Sarpy County particularly compared with the previous Kansas City data. The low scores were due in part to difficulties in observing in-stream conditions described above; in many cases the indicators were not observed. The SAI procedure controls for instances where some criteria cannot be recorded as the total score is divided by the number of factors observed. Other possible reasons for poor water quality indicator scores include runoff from adjoining row crop fields, encroachment of development, roadway improvements, and lack of a vegetated riparian buffer.

V. Recommendations

Vireo reviewed the SAI results and supporting studies to develop a set of recommendations to protect and enhance the county's streams and water quality. The recommendations include I general policies and practices that should be implemented county-wide to avoid further impacts and begin restoring these watersheds. The following paragraphs describe the general recommendations.

- Stream protection and restoration can have a positive influence on the county's watersheds. Protection of headwater streams is critical to maintaining these as healthy functional ecosystems. The SSWP should focus on protecting and enhancing the quantity and quality of riparian buffers, and on implementing measures to reduce runoff and pollutant loads resulting from agriculture and urbanization.
- The County should bolster Section 38.24 of their Stormwater Management Regulations to apply a minimum setback of 3:1 plus 75 for all priority streams (those assessed in this watershed management plan) and 3:1 plus 50 for all other watercourses within the watersheds located in southern Sarpy County. The County currently requires a stream setback of 3:1 plus 50 feet for streams identified within the Papillion Creek Watershed Management Plan (HDR 2014) and 3:1 plus 20 feet for all other watercourses.
- Given the current agricultural nature of southern Sarpy County, the SSWP should encourage agricultural operations to restore wooded riparian buffers within 50 feet of the edge-of-stream and discourage allowing livestock direct access to streams.
- State and federal agricultural programs for stream buffer protection and alternative livestock water supplies should be promoted and leveraged (with local funding) to assist landowners in restoring, enhancing, and preserving wooded riparian corridors.
- Grassed waterways are a common best management practice that while beneficial, could be more effective at reducing runoff and nutrient loading of the stream, if converted to native prairie grasses and wildflowers.
- The County should continue to enforce the stormwater management policy that requires water quality low impact development (LID) on all new development and significant redevelopment projects.

- Existing stands of native vegetation that preserve watershed hydrology should be preserved or designated for conservation development in lieu of green surface detention or traditional improvements.
- Where technically feasible, the County and the SSWP should implement green solutions such as naturally-vegetated surface detention (wet ponds and wetlands) in these locations even if marginally more expensive than traditional solutions if the sensitive channels will be better protected.
- The SSWP should place the greatest emphasis on protecting the highest quality (Type I and II) stream reaches. Identified streambank stabilization projects on Type II streams should receive highest priority. Implementation should also emphasize improvements that will protect Type I and II streams from further degradation, whether "green" or "gray".
- The SSWP should restore Type III stream reaches that are immediately upstream of Type I and II reaches where restoration will directly benefit the sensitive receiving streams.
- The cost of restoring Type IV streams may be prohibitive when compared with the benefits. The SSWP should focus on interventions that stabilize the downstream channel unless a relatively short reach of degraded stream is located immediately upstream of a Type I or II reach. Replanting riparian corridors with native vegetation is an inexpensive solution that should be considered in all cases.
- Type V streams reaches may provide some habitat and water quality treatment if they support vegetative growth. Given limited resources, the SSWP should apply its resources to protecting high-quality streams, conducting basic maintenance and enforcement, and restoring threatened stream reaches.
- As the development of this watershed management plan moves forward, additional stream assessments should be conducted focusing on areas that have been identified for stream protection, restoration or stabilization, and future watershed projects.

VI. References

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ATTACHMENTS

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Summary Table of SAI Scoring Criteria, Total Scores, and Stream Types

Watershed	Sample Point	Assessment Criteria: Stream Stability Score	Aquatic Habitat Quality Score	Terrestrial Habitat Quality Score	Water Quality Score	Total Score RAW	Number Observed Factors	Total Score Adjusted	STREAM TYPE	Count		
Zwiebel	1	33	18	30	4	85	17	5.000	III		Type I	0
Zweibel	2	28	22	22	8	80	17	4.706	III		Type II	1
Zweibel	3	26	38	30	6	100	17	5.882	II		Type III	8
Zwiebel	4	26	26	30	8	90	17	5.294	III		Type IV	3
Zweibel	5	25.5	34	22	10	91.5	17	5.382	III		Type V	2
Zweibel	6	20.5	30	12	10	72.5	16	4.531	IV			14
Zweibel	7	35	30	12	4	81	17	4.765	III			
Zweibel	8	30	4	27	10	71	13	5.462	III			
Zwiebel	9	16	0	22	6	44	9	4.889	III			
Zweibel	10	26	26	16	4	72	17	4.235	V			
Zweibel	11	22	26	14	4	66	17	3.882	V			
Zweibel	12	17	38	34	4	93	17	5.471	III			
Zweibel	13	24.5	18	30	4	76.5	17	4.500	IV			
Zweibel	15	31	18	14	10	73	16	4.563	IV			
	Average	25.8	23.4	22.5	6.6	78.3	16.0	4.897	III	14		
	Median	26.0	26.0	22.0	6.0	78.3	17.0	4.827	III			
Springfield	18	37	22	22	8	89	17	5.235	III			
Springfield	19	20.5	34	26	8	88.5	17	5.206	III		Type I	0
Springfield	20	28	30	30	4	92	17	5.412	III		Type II	0
Springfield	21	18	0	20	0	38	7	5.429	III		Type III	13
Springfield	22	28	22	24	6	80	16	5.000	III		Type IV	1
Springfield	24	35	14	34	6	89	16	5.563	III		Type V	0
Springfield	25	24.5	36	22	8	90.5	17	5.324	III			14
Springfield	26	23	26	26	8	83	17	4.882	III			
Springfield	27	28	30	22	4	84	17	4.941	III			
Springfield	28	18	34	26	6	84	16	5.250	III			
Springfield	29	30	4	26	10	70	13	5.385	III			
Springfield	30	30	16	16	6	68	15	4.533	IV			
Springfield	31	18	30	26	8	82	17	4.824	III			
Springfield	32	23	30	26	8	87	17	5.118	III			
	Average	25.8	23.4	24.7	6.4	80.4	15.6	5.150	III	14		
	Median	26.3	28.0	26.0	7.0	84.0	17.0	5.221	III			
Buffalo	34	35	4	20	10	69	15	4.600	IV			
Buffalo	36	18	0	22	10	50	9	5.556	III		Type I	1
Buffalo	37	31	8	24	10	73	15	4.867	III		Type II	3
Buffalo	38	31	8	22	10	71	15	4.733	III		Type III	12
Buffalo	39	23	34	28	10	95	17	5.588	III		Type IV	2
Buffalo	40	30	10	28	10	78	15	5.200	III		Type V	0
Buffalo	41	23.5	34	26	8	91.5	17	5.382	III			18
Buffalo	42	26	30	26	8	90	17	5.294	III			
Buffalo	44	28	38	25	4	95	17	5.588	III			
Buffalo	46	31	34	26	8	99	17	5.824	II			
Buffalo	47	35	16	28	10	89	15	5.933	II			
Buffalo	48	39	30	24	22	115	18	6.389	I			
Buffalo	49	18	38	30	4	90	17	5.294	III			
Buffalo	50	40	8	26	10	84	15	5.600	III			
Buffalo	51	28	34	16	8	86	17	5.059	III			
Buffalo	52	26	38	28	10	102	18	5.667	II			
Buffalo	54	20.5	38	26	4	88.5	17	5.206	III			
Buffalo	55	22	30	18	14	84	18	4.667	IV			
	Average	28.1	24.0	24.6	9.4	86.1	16.1	5.358	III	18		
	Median	28.0	30.0	26.0	10.0	88.8	17.0	5.338	III			
	Average	26.7	23.7	24.0	7.7	82.0	15.9	5.155	III			
	Median	26	28	26	8	84	17	5.221	III			

				Type
Average	5.155	>	6.116	**I**
Max	6.389	5.635	6.116	**II**
Min	3.882	4.674	5.635	**III**
Median	5.221	4.193	4.674	**IV**
Std Dev	0.481	<	4.193	**V**

Stability with Total	Terrestrial Habibat with Total	Aquatic Habitat with Total	Water Quality with Total
0.19	0.15	**0.60**	0.31
0.04	0.02	0.36	0.09

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SOUTH SARPY COUNTY
STREAM ASSET INVENTORY

0 0.5 1 2 MILES

LEGEND

Stream Asset Type
- I (High Quality)
- II
- III
- IV
- V (Highly Degraded)

- Creek Crossing
- Pump Stations / Treatment Facilities
- Dams
- Watershed Boundary
- Streams (NHD Flowline)
- Railroads
- 2019 Development Areas

SOUTH SARPY COUNTY STREAM ASSET INVENTORY

ZWIEBEL CREEK-PLATTE RIVER WATERSHED

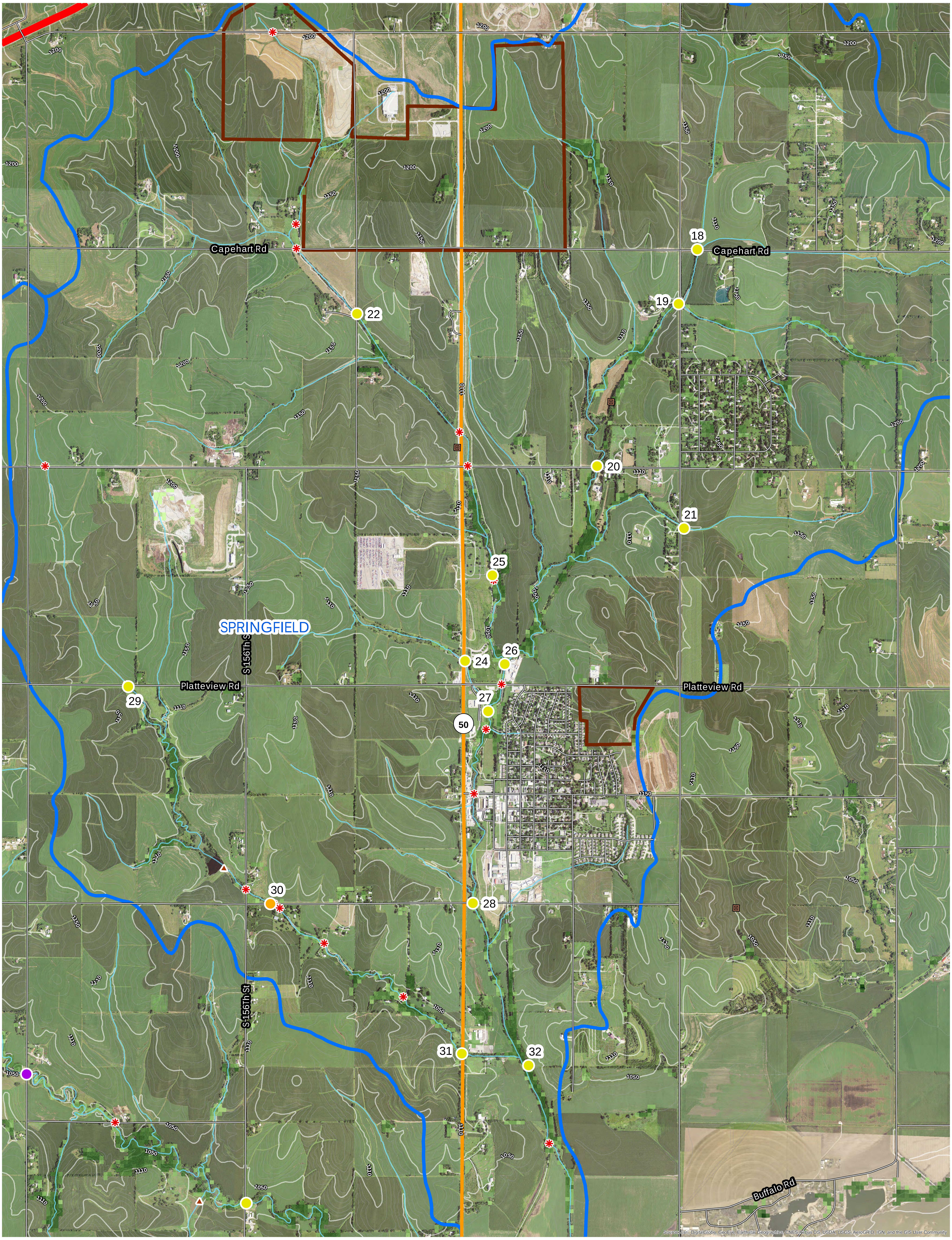
0 1,500 3,000 6,000 Feet

LEGEND

Stream Asset Type
- I (High Quality)
- II
- III
- IV
- V (Highly Degraded)

- Creek Crossing
- Pump Stations / Treatment Facilities
- Dams
- Watershed Boundary
- Streams (NHD Flowline)
- Railroads

- 2019 Development Areas



SOUTH SARPY COUNTY
STREAM ASSET INVENTORY
SPRINGFIELD WATERSHED

0 1,000 2,000 4,000 Feet

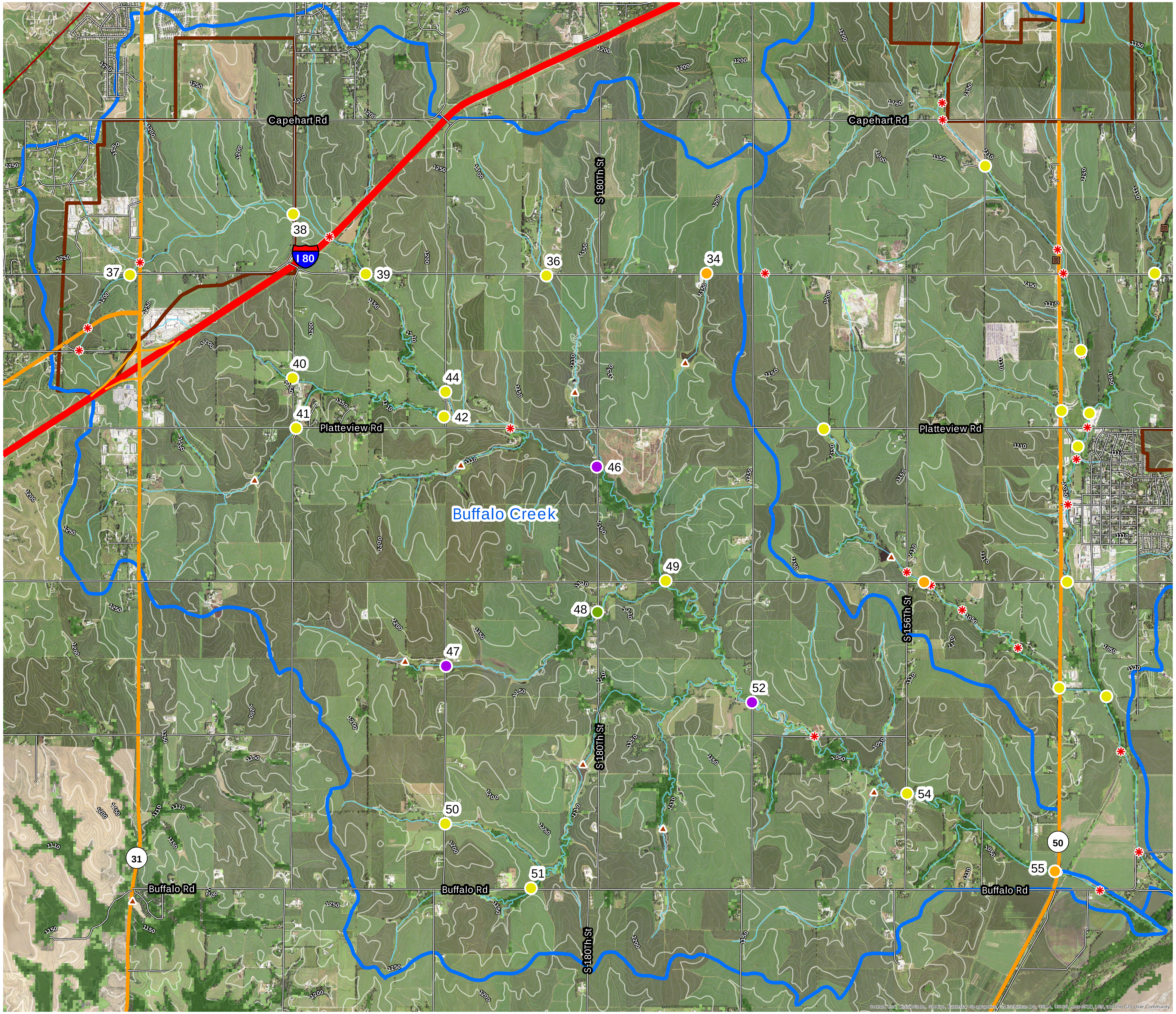
LEGEND

Stream Asset Type

- I (High Quality)
- II
- III
- IV
- V (Highly Degraded)

- Creek Crossing
- Pump Stations / Treatment Facilities
- Dams
- Watershed Boundary
- Streams (NHD Flowline)
- Railroads

- 2019 Development Areas



SOUTH SARPY COUNTY STREAM ASSET INVENTORY

BUFFALO CREEK WATERSHED

LEGEND

Stream Asset Type

- I (High Quality)
- II
- III
- IV
- V (Highly Degraded)
- Creek Crossing
- Pump Stations / Treatment Facilities
- Dams
- Watershed Boundary
- Streams (NHD Flowline)
- Railroads
- 2019 Development Areas

0 1,500 3,000 6,000
Feet


Type 1 Stream at Sample Point 48 in the Buffalo Creek watershed. Note the bedrock lined streambed.


Type 1I Streams at Sample Points 46 and 52 respectively, in the Buffalo Creek watershed.


Type 1I Stream at Sample Point 3 in the Zweibel watershed. Photo on left is downstream, photo on right is upstream.

Stream Type Photos	Stream Types I and II	
Photographer: Laurie Brown	Date of Photographs: May 7-9, 2018	vireo


Type 1II Streams at Sample Points 2 and 7 in the Zweibel watershed.


Type 1II Streams at Sample Points 31 and 25 respectively, in the Springfield watershed.


Type 1II Stream at Sample Points 38 and 49 in the Buffalo Creek watershed.

Stream Type Photos	Stream Type III	
Photographer: Laurie Brown	Date of Photographs: May 7-9, 2018	vireo

Type 1V Streams at Sample Points 6 and 13 in the Zweibel watershed.

Type V Streams at Sample Points 10 and 11 respectively, in the Zweibwl watershed.

Type IV Streams at Sample Point 30 in the Springfield watershed and 34 in the Buffalo Creek watershed.

Stream Type Photos	Stream Types IV and V	
Photographer: Laurie Brown	Date of Photographs: May 7-9, 2018	vireo

STREAM ASSET INVENTORY
Nebraska

Sample Location:						**Date:**		
Person Filling out Form:								
Afilliation:								
Watershed Name:								
Reach Length:				Ft. (Greater of 10 x Active Stream Width or visible distance)				
GPS:				Northing		**Photos:**		
				Easting				

Stream Stability

Bank Cut Depth (Ft.):			Left Bank		Right Bank			
			None = 5		None = 5		***Score:***	
			1-2 ft. = 3.5		1-2 ft. = 3.5			
			3-6 ft. = 1.5		3-6 ft. = 1.5			
			>7 = 0		>7 = 0			
Root Depth:			Left Bank		Right Bank			
(Root depth/Bank height)			0.5 -1.0 = 5		0.5 -1.0 = 5		***Score:***	
			0.49-0.15 = 2.5		0.49-0.15 = 2.5			
			<0.15 = 0		<0.15 = 0			
Bank Composition:			Left Bank		Right Bank			
			Bedrock/Boulder = 5		Bedrock/Boulder = 5		***Score:***	
			Clay = 4		Clay = 4			
			Silty Clay Loam = 3		Silty Clay Loam = 3			
			Silty Loam = 2		Silty Loam = 2			
			Loess = 1		Loess = 1			
			Sand = 0		Sand = 0			
Bed Compostion			Bedrock = 10		Boulder/Cobble = 8	Clay = 6		
		Gravel = 4		Silty Loam = 2	Sand = 0		***Score:***	
Erosion or Deposition		Overland runoff				Water turbulence		
Indicators:		Midbar/point bar				Tree fall/debris jam		
		Bank slump				Culvert/bridge		
		Toe erosion				Downcut/incision		
		Outfall structure				Other		
Check all the types of erosion observed and total the number. Apply the appropriate value. (Number = Value)								
0 = 10		1-2 = 8		3-5 = 6		>5 = 1	***Score:***	
Sum the five Stream Stability scores.								0

STREAM ASSET INVENTORY
Nebraska

Sample Location: ______________________ **Date:** __________

Habitat Quality - Aquatic

Flow:	Perennial w/springs		= 10	Perennial	= 8	Int. w/perm. pools = 6		
		Intermittent	= 4	Ephemeral	= 0		***Score:***	
Substrate:		Cobble/Gravel Mix	= 10		Silt/Sand/Clay Mix	= 6		
		Bedrock/Clay hardpan	= 2				***Score:***	
	(Determine the 2 predominant types and average the score)							
Macrohabitat Types:		(Pool, Riffle, Run)		3 present = 10		2 present = 6		
		1 present = 2					***Score:***	
Instream Fish Cover:		Available cover types						
		deep pools				riffles		
		logs/large woody debris				undercut banks		
		overhanging veg.				vegetated shallows		
		rootwads				backwater pools		
		boulders/cobbles						
	>6 types available = 10			3-5 types	= 6			
	1-2 types	= 2		No cover available	= 0		***Score:***	
Instream Macroinvertebrate Cover:				Available cover types				
		fine woody debris				macrophyte beds		
		submerged logs				algal mats		
		submerged tree roots or				leaf packs		
		bank vegetation				course gravel/cobbles		
		>5 types available	= 10		3-4 types	= 6		
		1-2 types	= 2		No cover available	= 0	***Score:***	
Sum the five Habitat Quality - Aquatic scores.								0

STREAM ASSET INVENTORY
Nebraska

Sample Location: ______ **Date:** ______

Habitat Quality - Terrestrial

Vegetation Width:		Left bank	Right bank
	Vegetation extends > 2 active channel widths	5	5
	Vegetation extends > 1 active channel width	3	3
	Vegetation extends < 1 active channel width	1	1
	No vegetation	0	0
	(Sum left and right bank scores)	***Score:***	
Adjacent Land Uses:		Left bank	Right bank
	Ungrazed woodland, wetland, or native grass	5	5
	Grazed woodland, wetland, or native grass	3	3
	Domestic grass pasture, park, residential, or agriculture	1	1
	Impervious or unvegetated surfaces (pavement, gravel)	0	0
	(Sum left and right bank scores)	***Score:***	

Woodland Richness: *(Number of trees, shrubs or woody vines observed)*

>15 species = 10	
5-15 species = 6	
<5 species = 2	***Score:***

Grassland Richness: *(Number of grass or other herbaceous species observed.)*

>15 = 10	5-15 = 6	<5 = 2	***Score:***

Undesirable Vegetation: *(% of undesirable species relative to the total number of plant species counted in the two previous categories.)*

<10% = 10	10-20% = 6	>20% = 2	
			Score:

Sum the five Habitat Quality - Terrestrial scores. 0

		Left Bank	Right bank
Predominant Canopy Species:	1.		
	2.		
	3.		
Predominant Understory Species:	1.		
	2.		
	3.		

Average DBH (canopy):	**6-12 inches**	**12-18-inches**	**18-24 inches**
		24+ inches	

STREAM ASSET INVENTORY
Nebraska

Sample Location: ____________________ **Date:** __________

Water Quality

Silt Cover:	*(% of substrate surrounded or covered by fine sediment)*			< 20% = 10
	20%-40% = 6	40%-60% = 0	>60% = -2	**Score:**

Undesirable Conditions:	Filamentous Algae		Waste Dump	
	Turbidity		Oil/Grease	
	Foam		Human Trash	
	Septic Odor		Channel Modification	
	Livestock Waste		Other	

Check all the conditions observed and total the number. Apply the appropriate value.

(Number = Value)	0-2 = 10	3-5 = 6	>5 = 0	**Score:**

Aquatic Organisms: *(Apply the appropriate score for each animal group)*

Predaceous /sunfish/ minnows = 10		Sunfish/ minnnows only = 6	Fish	**Score:**
Roughfish (carp) only or none = 0				
> 6 Species = 10	4-6 species = 6	2-3 species = 3	Mollusks	**Score:**
0 or 1 species = 0				
> 3 species = 10	1 - 3 species = 6	0 species = 0	Ampibians	**Score:**

Sum the five Water Quality scores. 0

TOTAL SCORE

Add the sum of each category then divide by 20 (or the total number of observed components):
(Stream Stability + Aquatic + Terrestrial + Water Quality) / # assessed factors = Assessment Score

If macroinvertebrates are sampled, add to the other four categories then divide by 21
(or the total number of observed components):
(Stream Stability + Aquatic + Terrestrial + Water Quality + Macroinvertebrate) / # assessed factors
= Assessment Score

Raw:	0
n =	0
TOTAL SCORE	**#DIV/0!**

Comments:

Appendix D. Stream Assessments

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1.0 INTRODUCTION

Streams are dynamic systems, continually reacting to the naturally occurring and man-induced changes in flow regimes and sediment transport and are in a continual process of moving towards dynamic equilibrium. To understand the current state of a stream, identifying the existing characteristics of the streams and understanding the geomorphologic processes within the watershed are imperative to be able to predict stream conditions of the developing watershed.

2.0 BACKGROUND

2.1 Stream Stability

Stream stability is a term encompassing many different aspects of the alluvial system. Stream stability can include: degree of meandering, thalweg degradation through slope moderation and/or headcut progression, and bank instability and subsequent widening. In the Southern Sarpy watershed, all of these factors play a role in the overall stream stability to some extent. Throughout this document, 'stable' and 'quasi-stable' terms are used interchangeably.

Stream meandering is a process where sediment erosion and deposition work in concert to laterally migrate a stream channel across a floodplain. The outer bends tend to erode, and deposition occurs on the inner bend creating a feedback loop. Over time, the bends gradually increase in length with a curvature that reduces until the bend pinches off, leaving an oxbow. This migration across the floodplain is an action that temporarily changes the energy dynamic short stretches of stream slope and length, but generally doesn't alter the overall channel capacity significantly. In order for a stream to meander, a source of material that is capable of aggradation is required, as such, most meandering streams have a reasonable proportion of sandy material present in the watershed to provide a semi-constant source to feed the mobile bed.

Slope moderation is the overall decreasing of stream thalweg slope either through gradual erosion or headcut progression. While runoff changes within a tributary can lead to hastening of the slope moderation, in younger geologic deposits, this process can occur naturally.

Headcut progression is typically seen as a series of knickpoints in smaller tributaries due to the thalweg degradation of the primary stream. Knickpoints can form in predominantly clayey soils as drops several feet in height. These drops gradually migrate upstream as the knickpoint is eroded from the base of the drop. No alterations of the runoff characteristics to the tributary watershed are necessary to facilitate the migration of a knickpoint upstream.

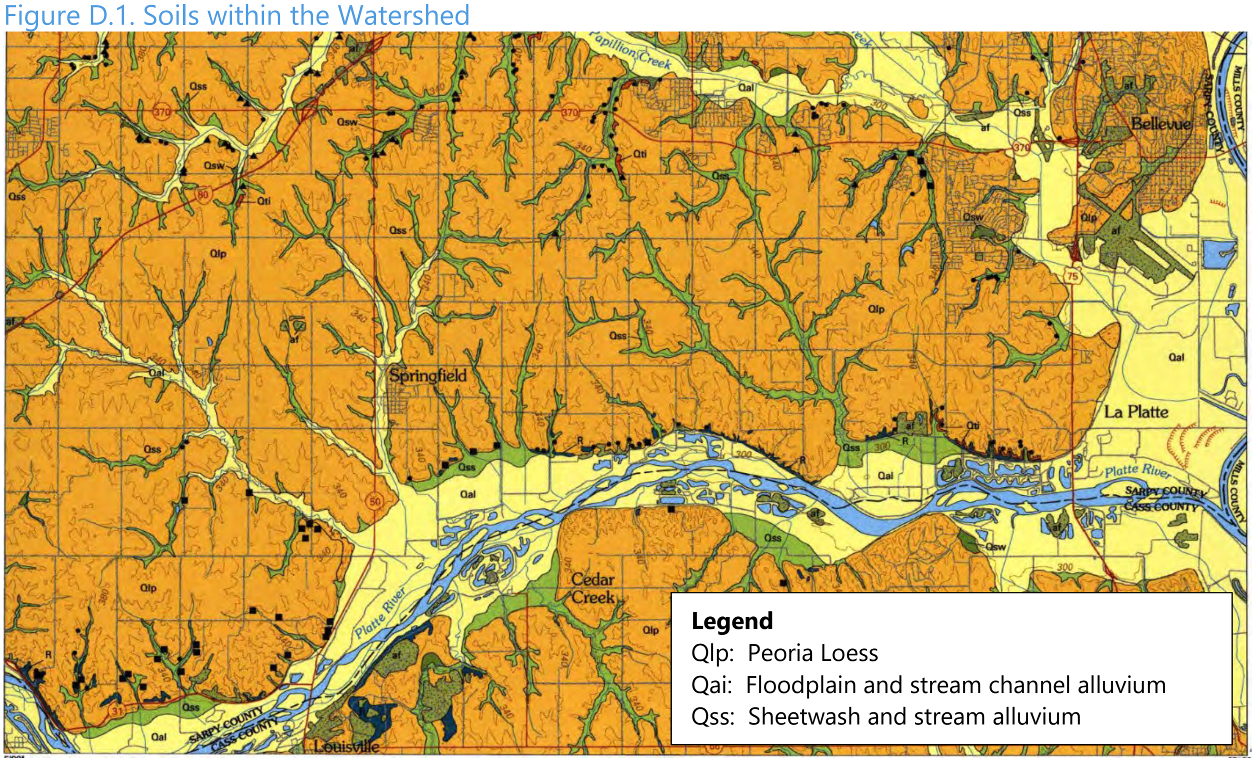
Bank instability is a complex issue related to both thalweg degradation and geotechnical characteristics of the soils on-site. As slopes moderate, stream banks will naturally become higher and steeper, leading to unstable banks. Soil saturation, general toe erosion, as well as freeze/thaw can lead to bank failures which further increase the bank slopes. In Peoria Loess soils, the banks can withstand a vertical slope due to the deposition method and angular particle shapes. However, once these soils become saturated, they can quickly fail due to low cohesive strength.

2.2 Soil Properties and Erosivity

2.2.1 Soils within the Study Area

Within the Southern Sarpy watershed's many streams, general material types range from Peoria Loess to Alluvial outwash made up of Loess and silty sands (Figure D.1). Much like the Hungry Canyons of Iowa, these valleys are made up of highly erosive materials without an upstream coarse sediment load that can aggrade. Aggradation is uncommon in this watershed as explained in the following sections. Information beyond a desktop review was not collected to ascertain the soils beneath the streams and in adjacent stream banks. Given the uniformity of Peoria Loess deposition in Douglas and Sarpy Counties, the following approach should be generally applicable for much of the area.

Figure D.1. Soils within the Watershed



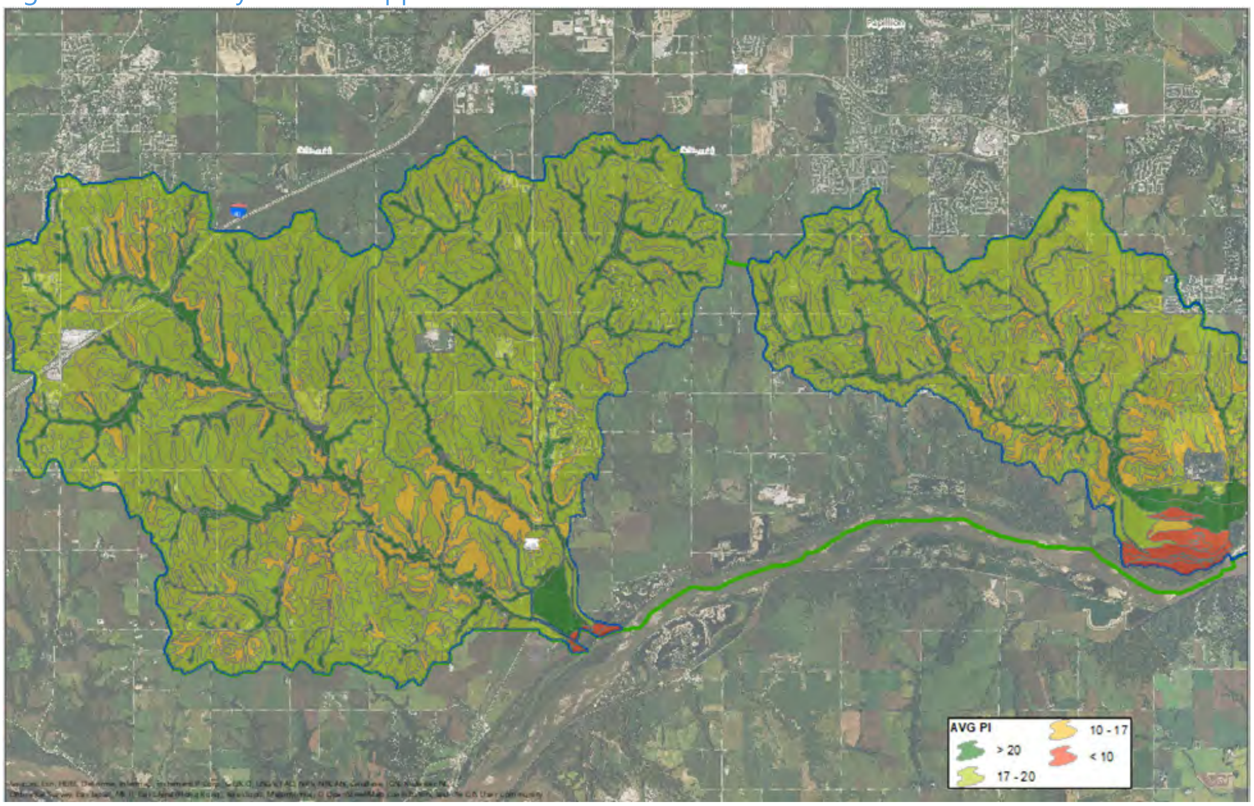
Source: Surficial Geologic Map of the Greater Omaha Area, Nebraska and Iowa. USGS April 10, 2002

Soil type QSS is a sheetwash and stream alluvium made up of both Qlp and Qai. These strata can range from highly erosive (Peoria Loess) to moderately erosive (alluvium). Peoria Loess generally consists of 60-70 percent silt with the remainder consisting of clay and a minor portion of sand.

2.2.2 Plasticity Index

Plasticity Index (PI) is essentially the range in water contents whereby the soil exhibits a plastic characteristic. PI ranges for the watershed are shown in Figure D.2.

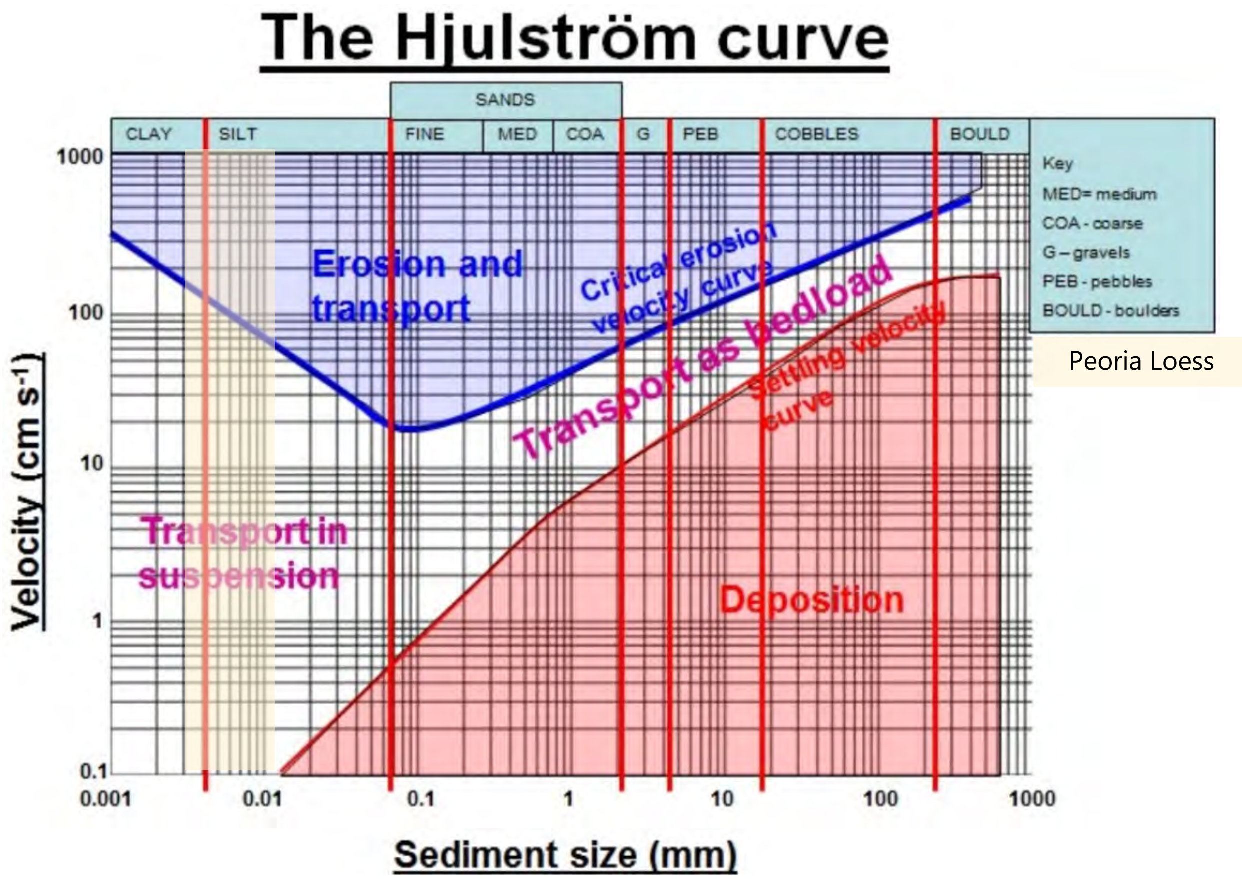
Figure D.2. Plasticity Index of Upper 80-inches of Soils



Source: Adapted from USDA Soil Maps for Sarpy County, NE

As the silt content of clayey-silts and silty-clays increases from clayey soils, the plasticity index of the material and the cohesive strength generally decreases indicating that silts tend to have lower cohesive strength than clays. As has been described by the U.S. Department of Agriculture (USDA) National Engineering Handbook (NEH), as the soil's plasticity decreases (lower clay content), the erosion rate of the material increases. Therefore, for materials with low plasticity, the plastic range of behavior is either confined to a low range of water contents, or is non-existent. The plastic behavior is linked to the clay particles and the increasing ratio of electric charge strength to particle size. As particle size increases, the strength of attraction between soil particles decreases thereby making liberation of individual particles easier. The best visualization of this comes from the Hjulstrom Curve and the Shield's Diagram (Figure D.3).

Figure D.3. The Hjulstrom Curve



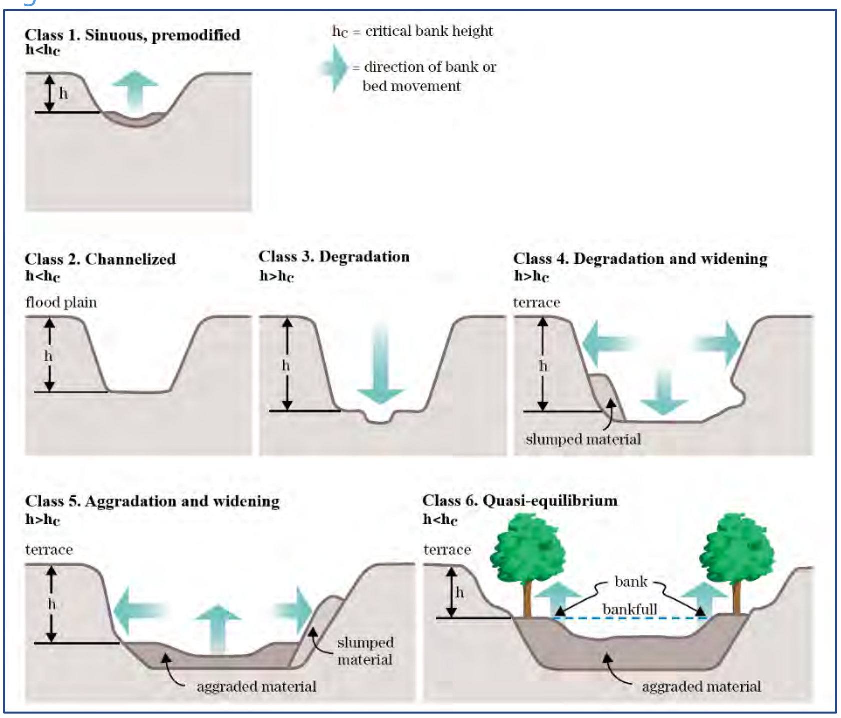
Source: Hjulstrom, 1939

As the Hjulstrom Curve shows, with increasing sediment size from clays to silts, the velocity required to erode the material decreases. This chart suggests that for fine silts the erosive velocity should be 3.9 fps and with larger silts erosive velocities should be near 1 fps. By comparison, USDA NEH suggests that 2 fps should be the minimum stable design velocity for silts with a PI of less than 10. Rarely do these materials exist in a pure form in nature, and even Peoria Loess generally consists of 60-70 percent silt with the remainder consisting of clay and a minor portion of sand. Charts like this explain the fundamental process but are difficult to apply in engineering because homogenous soil types are not found in the field. Worth noting on this figure is the lack of a depositional region for medium silts and finer materials; under flowing conditions, these materials do not aggrade.

2.3 CHANNEL EVOLUTION MODELS

Fluvial geomorphology is the study of the interaction between the physical form of rivers and the landforms around them both with and without human-induced changes to a watershed. The continual stream process of destabilizing and then moving towards dynamic equilibrium (or quasi-stability) has been described and characterized through a sequence of channel forms by many researchers in fluvial geomorphology and has been termed the 'channel evolution model' (CEM). One of the most popular models is the six-phase model by Simon and Hupp (Simon and Hupp 1986) which has been adapted by many others, including the USACE Regulatory Omaha District in their Nebraska Stream Conditions Assessment Protocol (NeSCAP) (USACE 2017). The CEM identifies multiple idealized stream phases or classes to describe the channel evolution process. Cross sectional views of these classes are shown in Figure D.4. These phases do not represent streams at each minor form change or over the continuum of stream change. Instead, they represent discrete stages characterized by the dominance of a specific adjustment process that allows interpretation of past, present, and future processes (Simon and Rinaldi 2006). This makes the CEM methodology ideal for visually identifying and predicting stream characteristics in the changing watershed.

Figure D.4. Phases of the Channel Evolution Model



Source: Adapted from NRCS, 2010 and Simon.

Class 1 represents a pre-disturbance condition where the stream is connected to the floodplain, well-vegetated, and sinuous. Streams of this type are rare in the watershed due to the highly erodible soils. Land use changes from natural prairies and woodlands to agricultural development and urbanization may also contribute to the rarity of Class 1 streams within the watershed due to an induced increase in flows and velocities. However, some researchers suggest that these disturbances may have had minimal effect on streams in eastern Nebraska (USGS 2003). It is likely that with the highly erodible and deep deposits of loess in the area, natural disturbances and human factors such as straightening and removal of grasses and woody vegetation near the turn of the century combined to accelerate the phase change from Class 1 in eastern Nebraska and western Iowa (Simon and Rinaldi, 2000). Class 1 streams are found at headwaters and upstream of man-made grade control structures in this watershed.

Class 2 shows the beginning of stream disequilibrium, generally brought on by an excess in stream power (USACE 2016) due to channelization. Although watershed-wide stream channelization and straightening is not prevalent, localized stream channelization and straightening and straightening near the Platte River floodplain could have induced Class 2 conditions in the past. Class 2 conditions are rarely found within watershed as streams move quickly into Class 3 due to low resistance to erosion at the channel bed.

Class 3 streams exhibit streambed degradation and are more prevalent within the watershed. Banks are approaching or have reached critical bank height. Class 3 streams are generally prevalent as tributaries to the major streams within the watershed. Stream widening due to toe erosion and/or mass wasting of the stream banks as they exceed stable bank height generally occurs after a high-velocity flow event and the streams move into a **Class 4** stream. Class 4 streams show signs of degradation and widening and represent the most stream-miles within the watershed.

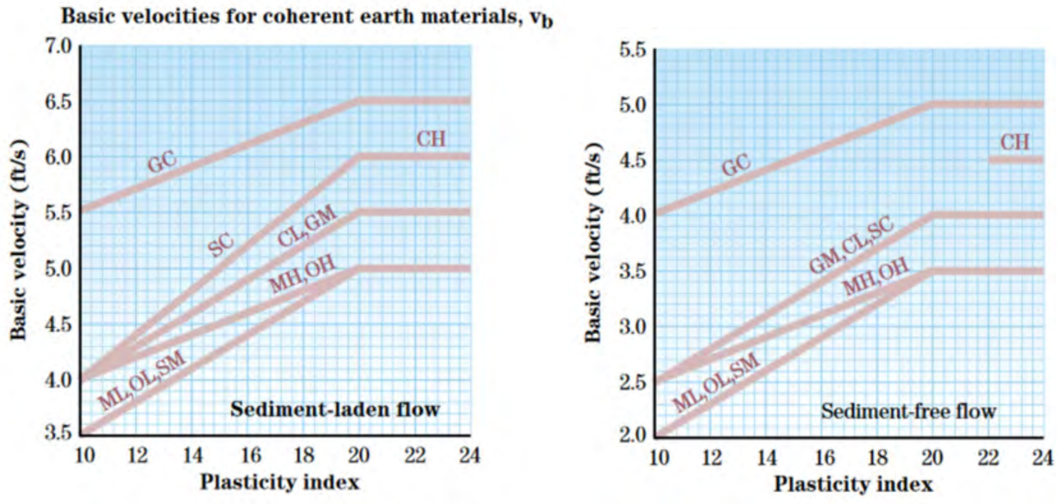
Aggradation is not a phenomenon that generally occurs within this watershed without a human-induced sediment deposit of coarser material due to the fine sediment size of the clays and silts of the natural soils, as shown in the Hjulstrom Curve in Figure D.3. **Class 5**, aggradation and widening, is rarely (if ever) present within the watershed. **Class 6** represents a channel moving back to a quasi-equilibrium state and moving towards stabilization. This would occur when a stable stream profile is reached and the slumped bank material acts as the new channel bed. A new low-flow channel forms along the new channel bed and a floodplain is created below the original floodplain elevation, with the previous floodplain now acting as a terrace. Class 6 streams are not prevalent within the watershed.

3.0 STREAM STABILITY ASSESSMENT METHODOLOGY

3.1 Stable Slope Assessment Method 1

As discussed above, particle size is associated with soil plasticity and its corresponding plasticity index. The plasticity index provides a single value encompassing the behavior of the soil complex. Using the NEH's guide for stable channel design can provide an easy to apply method to assess the existing channel stability and future stable grade.

Figure D.5. Plasticity Index and Erosive Velocities



Source: USDA NEH

To apply the NEH method, 78 stream segments representing Buffalo, Springfield, and Zwiebel Creek were modeled using a custom HEC RAS toolkit. It can't be predicted how the stream will degrade or how the bank slopes will change, so the existing section geometry was held constant. To ensure this wouldn't skew the results, tests were performed with channel cross sections to see how altering the side slopes would affect average channel velocity; because many of the existing channels were already beginning to incise, the overall impact to the analysis was found to be minimal. While this negates the eventual widening that would occur following degradation; it was assumed for the purpose of this study that widening is ancillary to degradation. It should be noted that the average channel velocity was assessed. Insufficient time was available to assert a reliable horizontal velocity distribution; because of this, the velocity computed is lower than the maximum channel velocity.

Each of the 78 sample stream sections were modeled under a range of twelve possible channel slopes beginning with each stream's existing slope down to 0.02 percent to assess the resulting average flow velocity for 100 discharges ranging from 25 cfs up to the 100-year discharge (based on a corresponding HEC HMS model). The range in discharges was designed to allow flexibility in the assessment protocol. However, NEH adjustments integral to the approach are based on design flow recurrence intervals.

Following this analysis, the NEH design method was used to assess the suitability of each stream segment based on area soil types. It was found that more than 80 percent of the streams were likely a Peoria Loess-derived alluvium. USDA soil databases provide a range of PIs for Peoria Loess from non-plastic (NP) to approximately 30 with a representative average being around 16. Laboratory data from recent borings for Papillion Creek Watershed Regional Detention Basins WP6, WP7 and WP2 (several miles north of the Southern Sarpy watershed), suggest that Peoria Loess will likely yield PIs within a range of 16 to 24. While loess does make up a large portion of the youngest materials within each stream valley, significant differences can occur from valley section to valley section which could significantly alter the PI. While a PI of 16 may be approximately average, the large range implies that this coarse analysis should yield a range of answers for consideration.

The assessment suggests that a stable stream slope in low-plasticity silts like Peoria Loess (PI range of 10 to 20) should range from 0.05 to 0.16 percent. Using the average PI of 16 yields a stable slope of 0.12 percent. Representative calculations for Method 1 stable slope analysis are shown in Figure D.6.

Figure D.6. Method 1 Stable Slope Calculations

		Summary Statistics										
			95%	0.00224	0.00397	0.00638	0.00956	0.01361	0.01862	0.02468	0.03187	0.04029
			avg	0.00071	0.00121	0.00188	0.00275	0.00383	0.00514	0.00670	0.00852	0.01063
			stdev	0.00077	0.00138	0.00225	0.00341	0.00489	0.00674	0.00899	0.01167	0.01483
			avg <95%	**0.00051**	**0.00088**	**0.00135**	**0.00193**	**0.00265**	**0.00371**	**0.00478**	**0.00602**	**0.00788**
			Outliers Removed	7	6	6	6	6	5	5	5	4
	Minimum Plasticity Index to be Stable at Indicated Velocity Based on NEH Design Guide											
CL	Sediment Free		Plasticity Index	10.0	10.0	13.5	17.1	24.0	24.0	24.0	24.0	24.0
	Sediment Laden			10.0	10.0	10.0	10.0	10.0	13.3	16.7	20.0	24.0
ML	Sediment Free			10.0	13.5	17.1	24.0	24.0	24.0	24.0	24.0	24.0
	Sediment Laden			10.0	10.0	10.0	10.0	13.5	17.1	24.0	24.0	24.0
Slope of Stream at Selected Velocity				Selected Velocity (ft/sec)								
Reach	**Regression**		***Exs Slope***	2	2.5	3	3.5	4	4.5	5	5.5	6
1	16.8735	0.3565	*0.0124414*	0.00252	0.00472	0.00787	0.01213	0.01764	0.02455	0.03299	0.04310	0.05502
2	38.0011	0.4071	*0.005915*	0.00072	0.00125	0.00196	0.00286	0.00397	0.00530	0.00686	0.00867	0.01074
3	38.3986	0.3922	*0.0032381*	0.00053	0.00094	0.00150	0.00223	0.00313	0.00423	0.00553	0.00705	0.00880
4	47.0934	0.3538	*0.0152315*	0.00013	0.00025	0.00042	0.00064	0.00094	0.00131	0.00177	0.00231	0.00296
5	53.6521	0.3640	*0.0023471*	0.00012	0.00022	0.00036	0.00055	0.00080	0.00110	0.00147	0.00192	0.00243
6	31.6802	0.3585	*0.0120626*	0.00045	0.00084	0.00139	0.00214	0.00311	0.00432	0.00580	0.00756	0.00964
7	54.4387	0.3818	*0.0041781*	0.00017	0.00031	0.00050	0.00076	0.00107	0.00146	0.00192	0.00247	0.00310
8	89.5626	0.4399	*0.0031544*	0.00018	0.00029	0.00044	0.00063	0.00085	0.00112	0.00142	0.00176	0.00215
9	24.7834	0.3925	*0.0098587*	0.00164	0.00290	0.00461	0.00682	0.00959	0.01294	0.01693	0.02158	0.02694
10	35.9570	0.3373	*0.0089655*	0.00019	0.00037	0.00063	0.00100	0.00149	0.00211	0.00288	0.00382	0.00495
11	47.8702	0.3577	*0.0046821*	0.00014	0.00026	0.00043	0.00067	0.00097	0.00135	0.00181	0.00236	0.00301
12	342.4228	0.6420	*0.0023267*	0.00033	0.00047	0.00062	0.00079	0.00098	0.00117	0.00138	0.00160	0.00184
13	51.5283	0.3709	*0.0019736*	0.00016	0.00029	0.00047	0.00071	0.00102	0.00140	0.00186	0.00240	0.00304
14	149.5211	0.4968	*0.0034221*	0.00017	0.00027	0.00038	0.00052	0.00068	0.00087	0.00107	0.00130	0.00155
15	294.9825	0.5911	*0.0039674*	0.00021	0.00031	0.00043	0.00055	0.00069	0.00084	0.00101	0.00119	0.00137
16	158.2295	0.4810	*0.0028364*	0.00011	0.00018	0.00026	0.00036	0.00048	0.00061	0.00076	0.00093	0.00111
17	15.6519	0.3402	*0.0073789*	0.00236	0.00456	0.00778	0.01225	0.01813	0.02563	0.03494	0.04624	0.05971
18	25.0564	0.3822	*0.0097891*	0.00134	0.00240	0.00387	0.00580	0.00822	0.01119	0.01474	0.01892	0.02375
19	23.5306	0.4129	*0.0100635*	0.00255	0.00438	0.00682	0.00990	0.01369	0.01820	0.02349	0.02959	0.03654
20	19.2779	0.3630	*0.0016835*	0.00194	0.00360	0.00594	0.00909	0.01313	0.01816	0.02428	0.03157	0.04012
21	31.9158	0.4029	*0.0057412*	0.00103	0.00180	0.00283	0.00414	0.00577	0.00773	0.01004	0.01272	0.01579
22	34.1515	0.3607	*0.0048238*	0.00038	0.00071	0.00118	0.00181	0.00262	0.00363	0.00486	0.00633	0.00806
23	38.6188	0.3728	*0.0040168*	0.00036	0.00065	0.00106	0.00160	0.00228	0.00313	0.00415	0.00536	0.00677
24	33.2783	0.3533	*0.0086313*	0.00035	0.00066	0.00110	0.00170	0.00249	0.00347	0.00468	0.00613	0.00784
25	346.0084	0.6304	*0.0011051*	0.00028	0.00040	0.00054	0.00068	0.00085	0.00102	0.00120	0.00140	0.00161
26	38.4133	0.3743	*0.0074853*	0.00037	0.00068	0.00110	0.00166	0.00237	0.00325	0.00431	0.00556	0.00701
27	43.9415	0.3575	*0.0077025*	0.00018	0.00033	0.00055	0.00084	0.00123	0.00170	0.00229	0.00299	0.00381
28	65.2644	0.3496	*0.0025339*	0.00005	0.00009	0.00015	0.00023	0.00034	0.00048	0.00064	0.00085	0.00108
29	106.4936	0.4055	*0.0011449*	0.00006	0.00010	0.00015	0.00022	0.00031	0.00041	0.00053	0.00067	0.00083
30	52.3964	0.3087	*0.0011459*	0.00003	0.00005	0.00009	0.00016	0.00024	0.00035	0.00049	0.00067	0.00089
31	2612.2893	0.9251	*0.0028336*	0.00043	0.00055	0.00066	0.00078	0.00091	0.00103	0.00115	0.00128	0.00140
32	37.3615	0.3624	*0.0034588*	0.00031	0.00057	0.00095	0.00145	0.00210	0.00291	0.00389	0.00506	0.00643
33	67.7883	0.4612	*0.0037278*	0.00048	0.00078	0.00116	0.00162	0.00216	0.00279	0.00351	0.00431	0.00521
34	41.9295	0.3589	*0.0024974*	0.00021	0.00039	0.00064	0.00099	0.00144	0.00199	0.00267	0.00349	0.00444
35	148.4152	0.5234	*0.0050268*	0.00027	0.00041	0.00058	0.00078	0.00100	0.00126	0.00154	0.00184	0.00218
36			*0.0027131*									
37	27.4916	0.3982	*0.0044075*	0.00139	0.00243	0.00384	0.00565	0.00790	0.01062	0.01384	0.01758	0.02187
38	62.2434	0.3313	*0.0010554*	0.00003	0.00006	0.00011	0.00017	0.00025	0.00036	0.00050	0.00066	0.00086
39			*0.0010281*									
40	63.0063	0.3262	*0.0016544*	0.00003	0.00005	0.00009	0.00014	0.00021	0.00031	0.00042	0.00057	0.00074
41	16.8063	0.3775	*0.0061005*	0.00356	0.00642	0.01041	0.01566	0.02231	0.03048	0.04029	0.05187	0.06531
42	28.7532	0.3550	*0.0036744*	0.00055	0.00103	0.00172	0.00265	0.00386	0.00538	0.00724	0.00947	0.01210
43	30.9160	0.3714	*0.0029092*	0.00063	0.00115	0.00187	0.00284	0.00406	0.00558	0.00741	0.00958	0.01211
44	34.0124	0.3727	*0.0057617*	0.00050	0.00091	0.00148	0.00224	0.00321	0.00440	0.00584	0.00754	0.00952
45	40.8769	0.3786	*0.0041661*	0.00035	0.00062	0.00101	0.00152	0.00216	0.00294	0.00389	0.00500	0.00629
46	42.4917	0.3751	*0.0029726*	0.00029	0.00052	0.00085	0.00129	0.00184	0.00251	0.00333	0.00429	0.00541
47	22.9567	0.4165	*0.0076472*	0.00285	0.00488	0.00755	0.01094	0.01507	0.02000	0.02575	0.03237	0.03989
48	153.7067	0.5932	*0.0031739*	0.00066	0.00096	0.00131	0.00170	0.00213	0.00260	0.00310	0.00364	0.00422
49	97.2185	0.4800	*0.0033708*	0.00031	0.00049	0.00071	0.00098	0.00130	0.00166	0.00207	0.00252	0.00302
50	196.9693	0.5873	*0.0027324*	0.00040	0.00059	0.00081	0.00105	0.00131	0.00161	0.00192	0.00226	0.00262
51	419.6082	0.6714	*0.0036263*	0.00035	0.00049	0.00064	0.00080	0.00098	0.00117	0.00136	0.00157	0.00179
52	86.4046	0.4728	*0.0025894*	0.00035	0.00056	0.00082	0.00113	0.00150	0.00193	0.00241	0.00295	0.00355
53	228.1205	0.6320	*0.003058*	0.00056	0.00079	0.00106	0.00135	0.00166	0.00201	0.00237	0.00275	0.00316
54	120.5226	0.5114	*0.0048116*	0.00033	0.00051	0.00073	0.00099	0.00128	0.00161	0.00198	0.00239	0.00283
55	190.1497	0.6064	*0.0032645*	0.00055	0.00079	0.00107	0.00138	0.00172	0.00208	0.00248	0.00290	0.00335
56	140.2155	0.5180	*0.0021195*	0.00027	0.00042	0.00060	0.00081	0.00104	0.00131	0.00160	0.00193	0.00228
57	31.3064	0.3619	*0.0048773*	0.00050	0.00093	0.00153	0.00235	0.00339	0.00470	0.00629	0.00818	0.01041
58	146.5641	0.5198	*0.0085901*	0.00026	0.00040	0.00056	0.00076	0.00098	0.00123	0.00150	0.00181	0.00214
59	36.5796	0.3693	*0.0061598*	0.00038	0.00070	0.00115	0.00174	0.00250	0.00344	0.00457	0.00592	0.00749
60	235.6574	0.5699	*0.0018664*	0.00023	0.00034	0.00047	0.00062	0.00078	0.00096	0.00116	0.00137	0.00160
61	937.8304	0.7547	*0.0019257*	0.00029	0.00039	0.00049	0.00061	0.00072	0.00085	0.00097	0.00110	0.00124
62	410.2822	0.6671	*0.0013302*	0.00034	0.00048	0.00063	0.00079	0.00097	0.00115	0.00135	0.00156	0.00178
63	33.5741	0.4507	*0.0019338*	0.00191	0.00314	0.00471	0.00662	0.00891	0.01157	0.01462	0.01806	0.02191
64	15.5495	0.3512	*0.0029272*	0.00291	0.00549	0.00923	0.01432	0.02094	0.02928	0.03953	0.05185	0.06643
65	24.8328	0.3475	*0.0023333*	0.00071	0.00135	0.00228	0.00356	0.00523	0.00733	0.00993	0.01306	0.01678
66	66.5754	0.4736	*0.0060098*	0.00061	0.00098	0.00144	0.00199	0.00264	0.00338	0.00423	0.00517	0.00621
67	71.4459	0.4848	*0.0071207*	0.00063	0.00099	0.00145	0.00199	0.00262	0.00334	0.00415	0.00505	0.00604
68	38.7681	0.4162	*0.0033722*	0.00081	0.00138	0.00214	0.00310	0.00427	0.00566	0.00729	0.00917	0.01130
69	137.5425	0.5778	*0.0028528*	0.00066	0.00097	0.00133	0.00174	0.00219	0.00269	0.00323	0.00381	0.00443
70	35.5639	0.4758	*0.0105994*	0.00236	0.00377	0.00553	0.00765	0.01013	0.01298	0.01619	0.01978	0.02375
71	113.6001	0.5636	*0.0062213*	0.00077	0.00115	0.00158	0.00208	0.00264	0.00325	0.00392	0.00464	0.00542
72	159.1933	0.6462	*0.0045291*	0.00114	0.00162	0.00214	0.00272	0.00334	0.00401	0.00472	0.00547	0.00626
73	286.1237	0.6807	*0.0028937*	0.00068	0.00095	0.00124	0.00155	0.00189	0.00224	0.00262	0.00301	0.00342
74	25.3431	0.3926	*0.0036135*	0.00155	0.00274	0.00436	0.00645	0.00907	0.01224	0.01601	0.02041	0.02547

3.2 Stable Slope Assessment Method 2

The best indication of stable stream slope is to utilize information from the region to establish a representative stable slope. Stream segments that have begun to widen may have reached a quasi-stable slope. This is not to infer that the stream has degraded to its lowest possible elevation, but that the soils are at a grade which doesn't appear to support further degradation. Changes downstream of this segment could cause further thalweg degradation as the Channel Evolution Model (CEM) suggests.

A site investigation was performed from public ROW for most of the streams present in the watershed. The current state of the channel in reference to the CEM were recorded, along with other stream stability indicators and general site information. By locating stream segments that were entering, or were within a widening phase, the quasi-stable slope was found for that reach. Investigating the channel slopes and channel states within the Southern Sarpy subbasins, suggests a stable slope of approximately 0.08 percent.

Other empirical relationships exist for cohesive materials, but all are based on similar methods and are more broadly applied to include other soil types. These methods do not necessarily reflect the conditions within the watershed because of differing soil types. Therefore, it was felt for this assessment, the data collected within the watershed would be the most accurate to establish a quasi-stable slope for this watershed. The stream slopes used to establish this quasi-stable stream slope estimate are shown in Figures D.7 through D.9.

Figure D.7. Springfield Creek Existing Stream Slopes

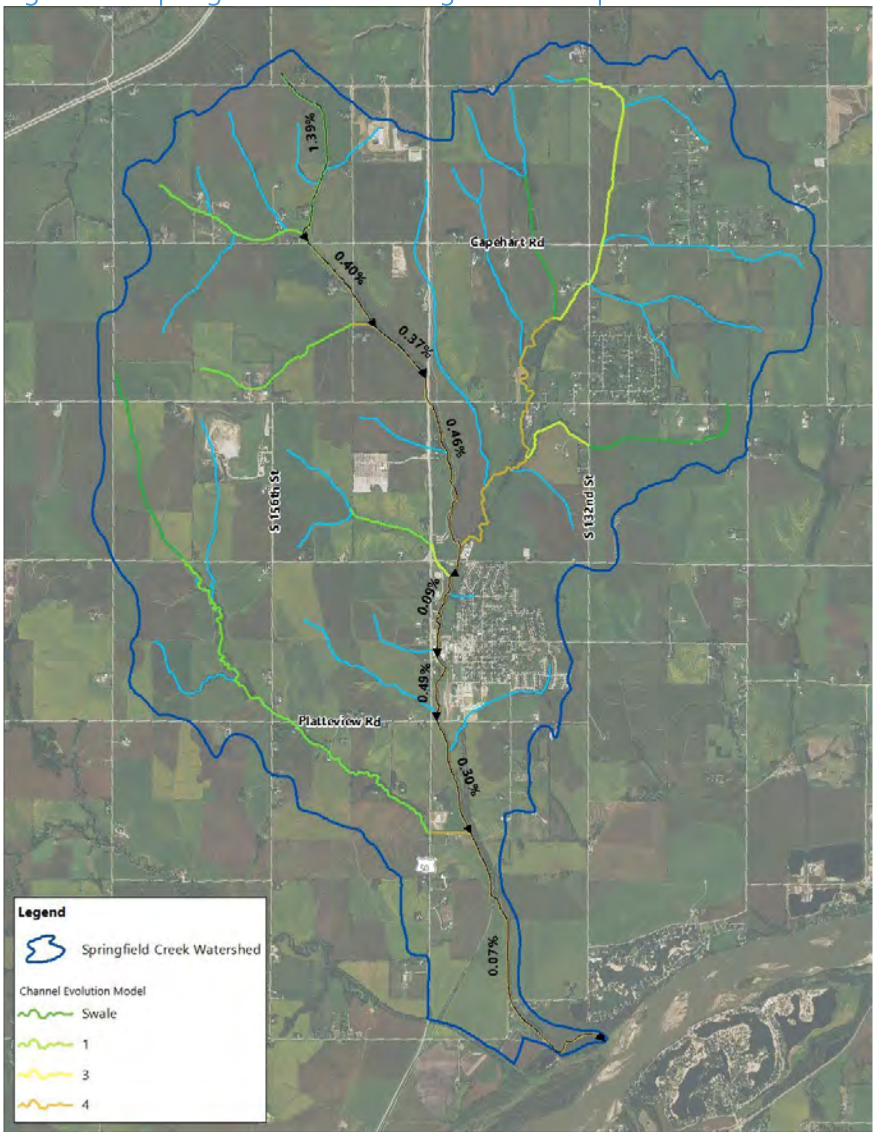


Figure D.8. Buffalo Creek Existing Stream Slopes

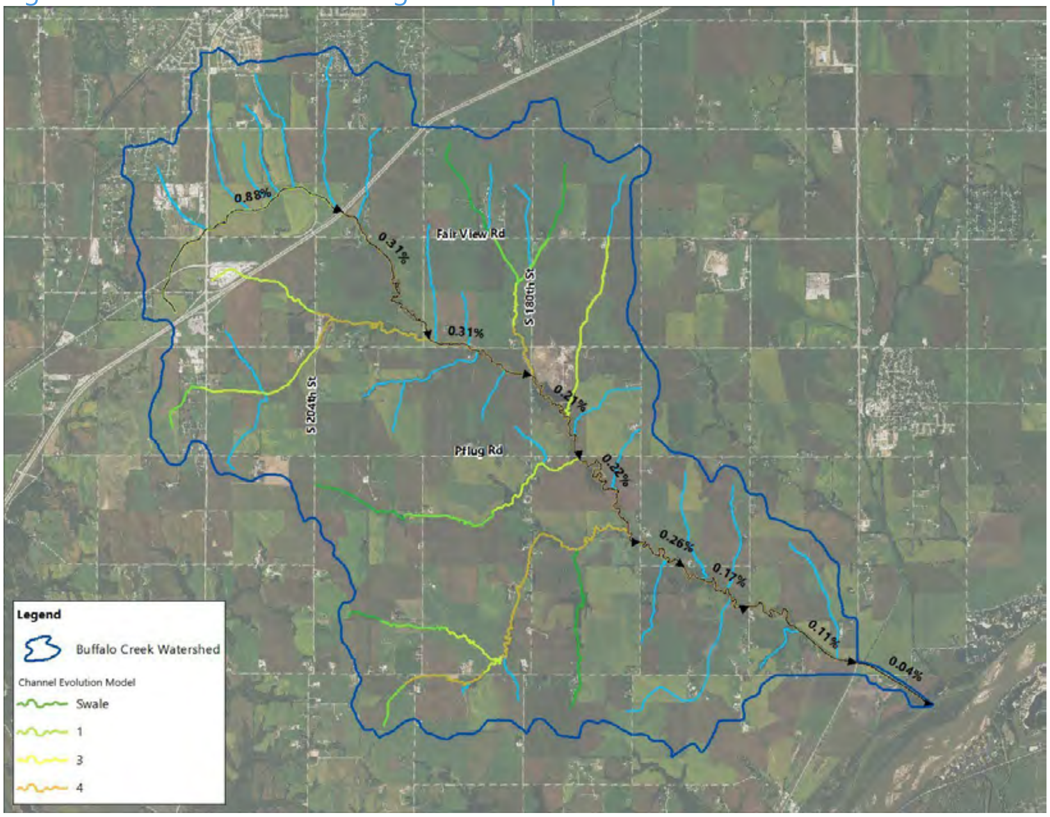
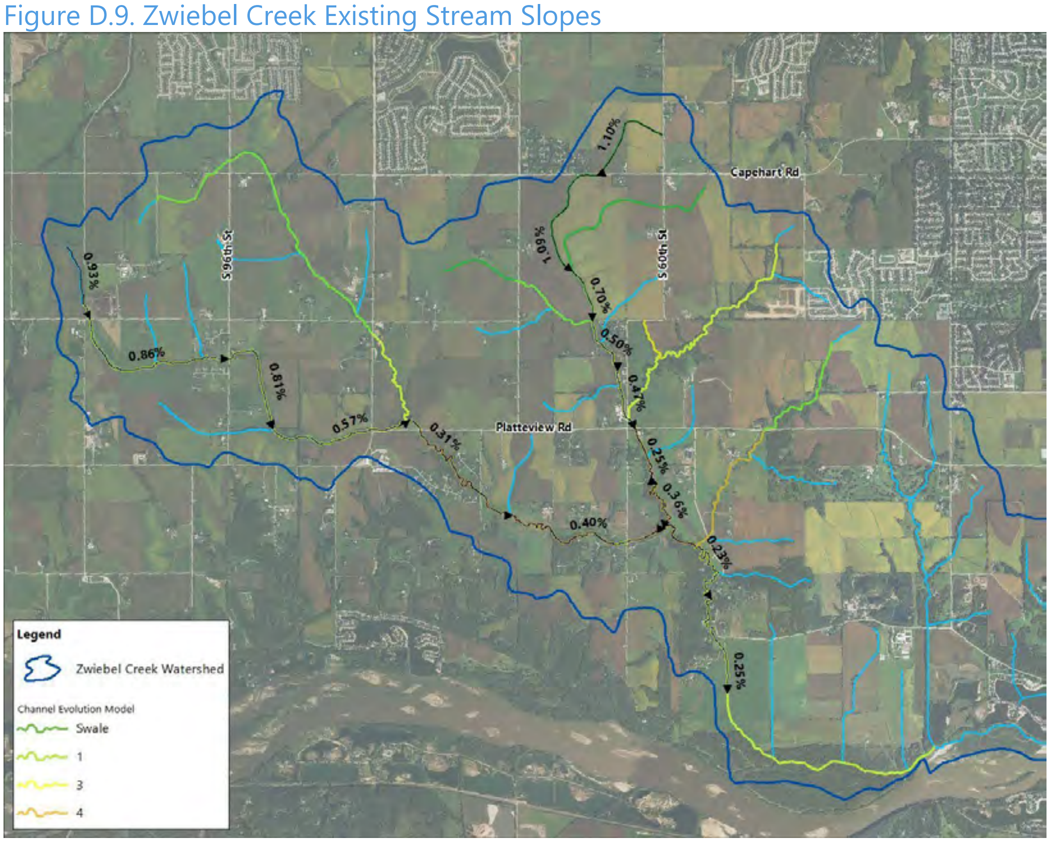


Figure D.9. Zwiebel Creek Existing Stream Slopes



3.3 Rapid Assessment of Stream Stability

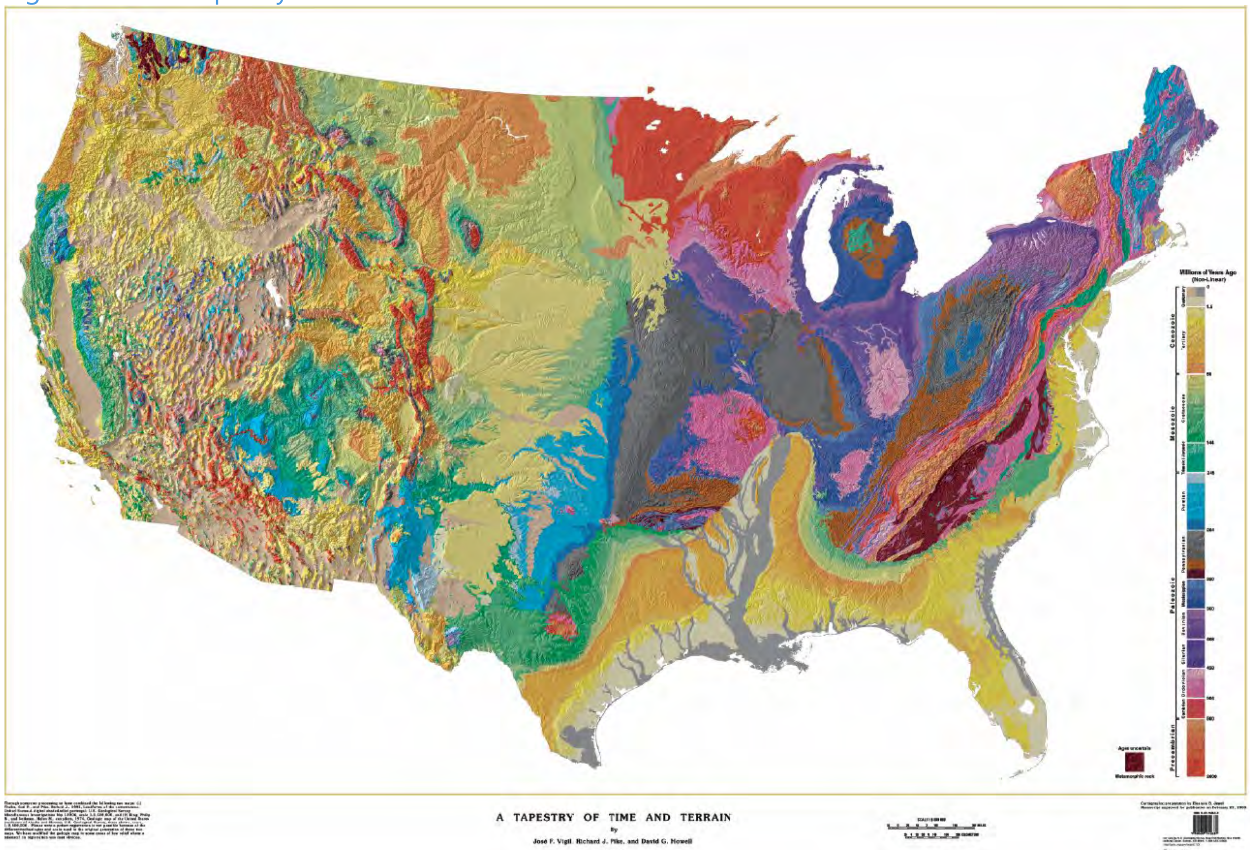
While CEM provides an available and widely used methodology to assess and predict stream morphology, further field reconnaissance of existing stream stability characteristics is warranted to evaluate existing stream stability within the watershed. Although there are various methodologies accepted and available to evaluate stream stability with field work, deciding which methodology to use for this analysis was driven by access constraints and known soil characteristics. Stream assessment locations were limited to areas with public access and therefore most stream assessment locations would be located at culverts and bridges where access was available on public road crossings. The discussion below describes the method selected for the field assessment for this Plan, inventory, and results.

3.3.1 FHWA 2006 Method

The Federal Highway Administration sponsored a study, published in July 2006, to expand and improve on previously developed rapid channel stability assessment methods (FHWA 2006). The study expanded on methodology developed by Johnson et al. and Thorne. The Johnson et al. rapid assessment at bridges methodology was based largely on previous assessment methods and included in HEC-20 as a method to provide semi-quantitative analyses by collecting thirteen qualitative and quantitative stability indicators that are weighted and summed to yield a stream stability rating (FHWA 2006). However, it was calibrated and tested in gravel bed streams in the Piedmont of Maryland and the Appalachian Plateau area of northern Pennsylvania and therefore had limitations when used outside of those areas. The Thorne method is based on extensive data collection at bridges, including primarily qualitative geomorphic data. Although the data collected is complete, there is no systematic method for synthesizing the data to obtain and compare stream stability ratings at each site.

The United states can be divided into different regions based on major physiographic changes (Figure D.10), including eight major physiographic regions and 25 sub-regions throughout the country (FHWA 2006).

Figure D.10. A Tapestry of Time and Terrain



Source: José F. Vigil, Richard J. Pike, and David G. Howell 2000

The FHWA 2006 study collected qualitative and quantitative information at 57 sites within 13 physiographic regions and sub-regions throughout the country to develop and test the stability assessment method. The stability method intended to identify stability within the constraints of identifying characteristics at bridges and 'stability' defined in light of stability as it pertains to bridge engineering issues. Therefore, the methodology is based on the relationship between stream characteristics and short-term stability in terms of lateral and vertical movement over a short distance upstream and downstream from the bridge.

The study yielded a methodology that utilizes thirteen stability indicators assessed at each site and gives a score based on descriptions and ratings of excellent (score of 1-3), good (4-6), fair (7-9), and poor (10-12) to yield a semi-quantitative assessment of stability at the inspection site. The indicator scores are summed and produce an overall ranking of excellent, good, fair, or poor based on the summation. The stability indicators are listed below.

1. Watershed/floodplain activity & characteristics
2. Flow habitat
3. Channel pattern
4. Entrenchment/channel confinement
5. Bed material

6. Bar development
7. Obstructions
8. Bank soil texture and coherence
9. Average bank slope angle
10. Vegetative or engineered bank protection
11. Bank cutting
12. Mass wasting or bank failure
13. Upstream distance to bridge from meander impact point and alignment

3.3.2 Field Inventory

A field inventory stream assessment was conducted by FYRA Engineering and Vireo in May 2018 to assess current stream conditions and stability. The stream assessment had multiple goals relating to assessing and quantifying existing conditions and predicting potential future conditions. Objectives of the analysis included:

- Assess and quantify existing stream conditions using the FHWA 2006 Method
- Identify existing CEM phase
- Locate and identify threatened infrastructure
- Locate existing knickpoints
- Identify existing bank failure mechanisms
- Record information on existing sensitive resources

Overall goals of the analysis were in-line with the overall goals of the Plan and included:

- Predict future stream conditions that may occur with time and/or development
- Identify locations that could need immediate bed or bank stability projects to protect existing infrastructure or to halt major knickpoints
- Locate potential locations for restoration, rehabilitation, or preservation
- Identify areas that are connected to the floodplain and could be used and protected for conservation or open space planning
- Locate potential locations for stream bed or bank stabilization projects

Stream assessment locations were limited to areas with public access and therefore most stream assessment locations were located at culverts and bridges where access was available on public road crossings. Aerial images, LiDAR, and existing infrastructure information were analyzed with Vireo staff prior to the field reconnaissance to select priority areas to assess and that would offer stream view accessibility from public roads. Figures D.11 through D.13 below identifies the assessment locations.

Figure D.11. Buffalo Creek Stream Assessment Locations

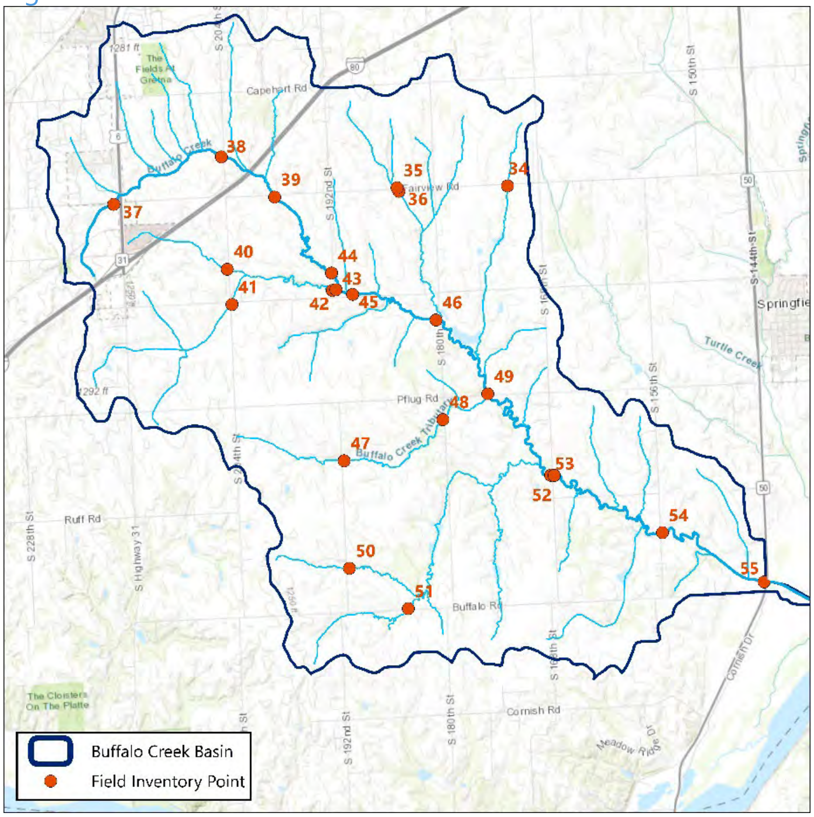


Figure D.12. Springfield Creek Stream Assessment Locations

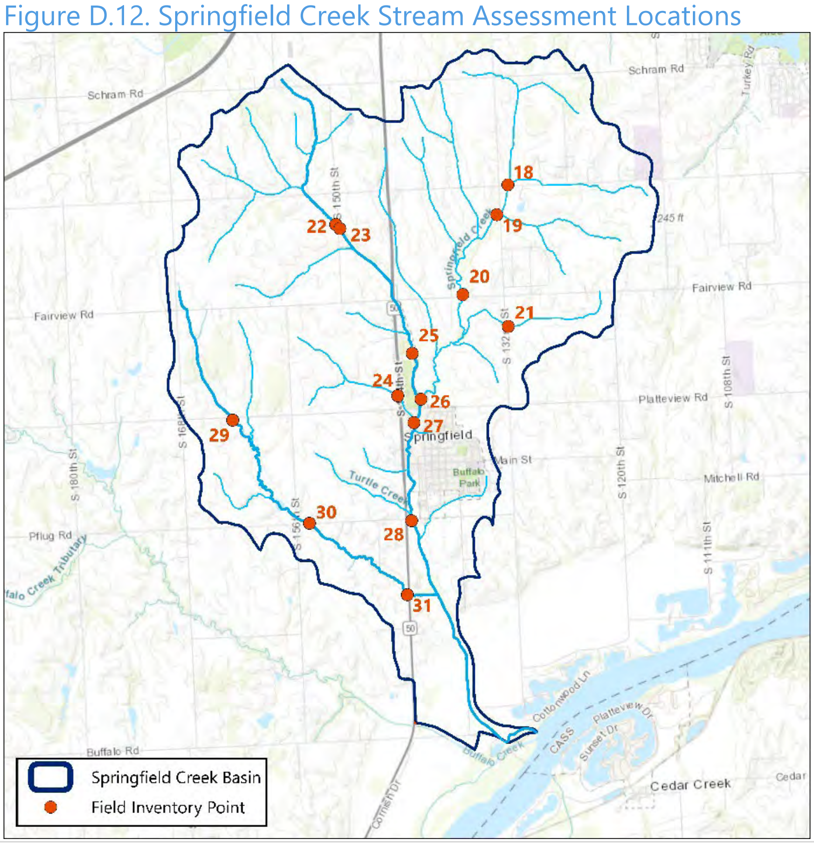
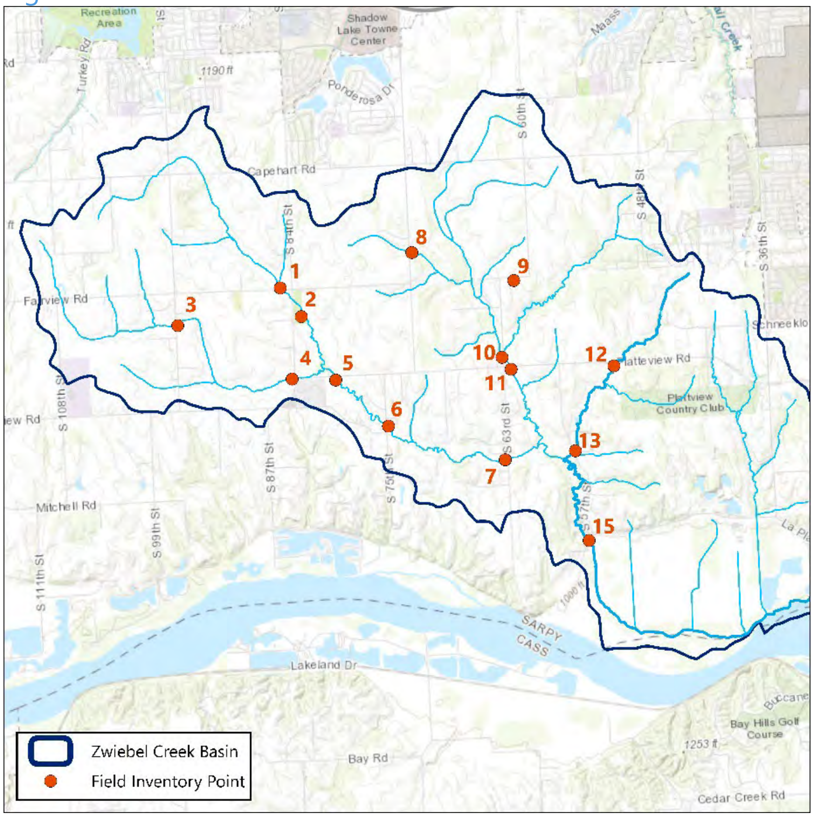


Figure D.13. Zwiebel Creek Stream Assessment Locations



FYRA and Vireo evaluated and recorded stream characteristics at each site from a geomorphic and habitat assessment lens (see Appendix C for information on the habitat assessment). The stream CEM class was evaluated at each assessment site to classify the existing stream profile and predict future changes. Other stability indicators such as changes in elevation, adjacent land use, bank slopes, root depth, vegetation, and failure types were recorded during the stream assessment.

3.3.3 Rapid Assessment Results

A stability assessment score, based on the FHWA 2006 Method, was calculated for each stream assessment site according to recorded stability indicators. The stream CEM classes and site stability assessment scores are shown in Figures D.14 through D.16 and included in Tables D.1 through D.3.

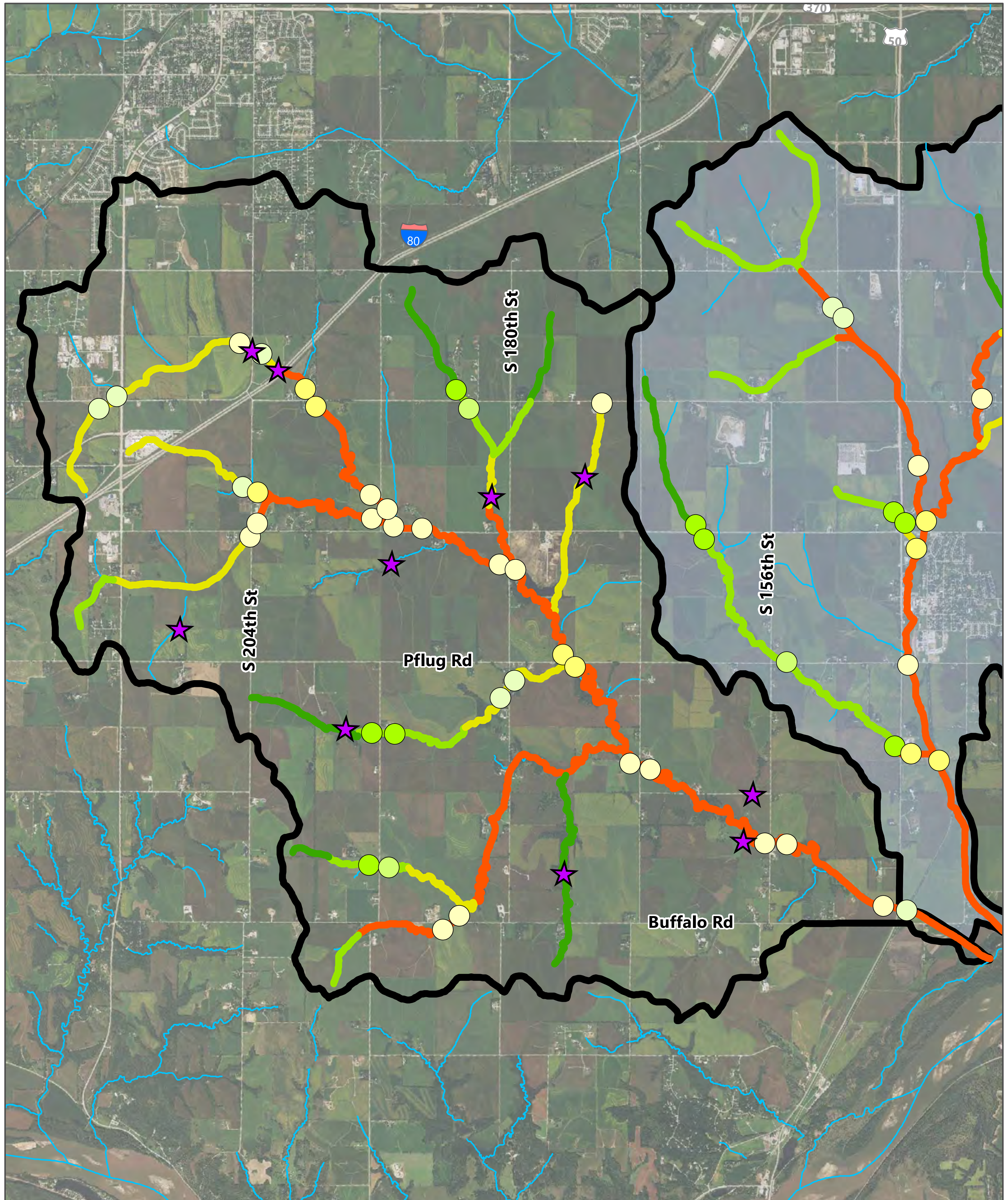


Figure D.14. Buffalo Creek Watershed Stream Stability Map
Southern Sarpy Watershed Management Plan
Papio-Missouri River Natural Resources District

N

0 0.5 1 Mile

Legend

Stability Assessment Ratings✳

13 | 45.5 | 84.5 | 123.5 | 169

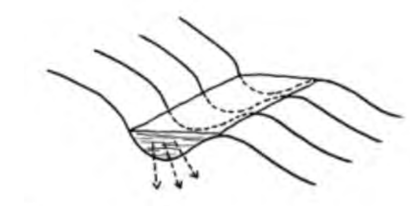
Excellent | Good | Fair | Poor

✳ Based on Thorne. "Geomorphological river channel reconnaissance for river analysis, engineering, and management." (1996) and Montgomery and Macdonald "Diagnostic approach to stream channel assessment and monitoring." (2002).

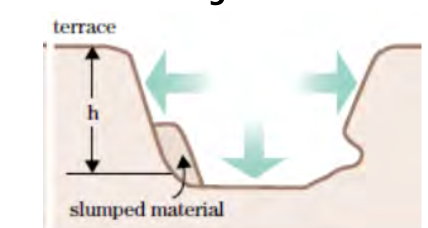
NRD Structures ★

Class Evolution Models (CEM)

Swale

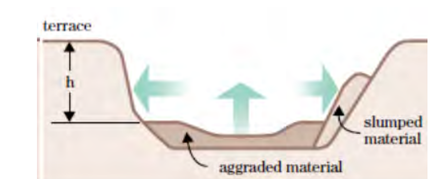


Class 4. Degradation and widening h>hc

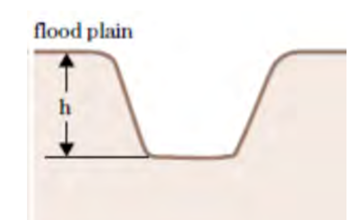


Class 1. Sinuous, premodified h<hc

Class 5. Aggradation and widening h>hc



Class 2. Channelized h<hc



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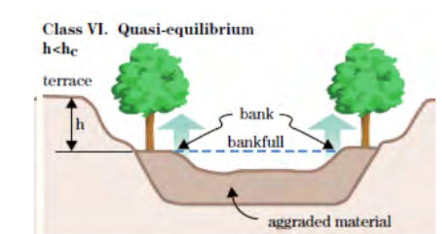

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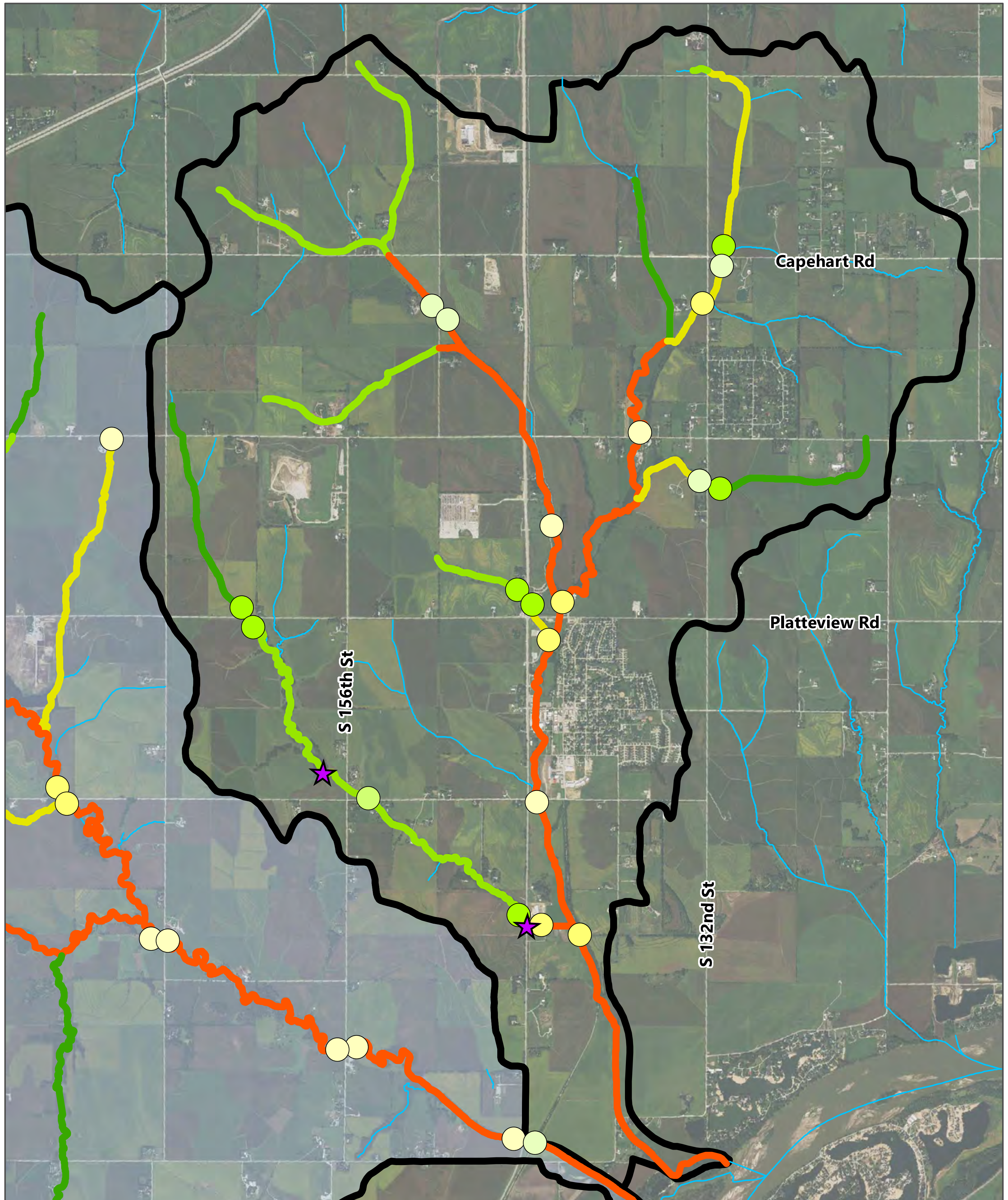
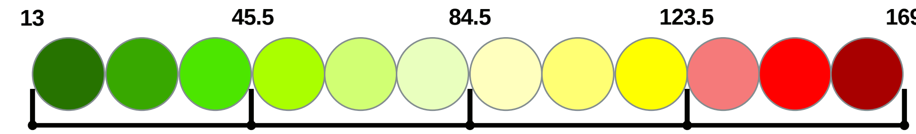


Figure D.15. Springfield Creek Watershed Stream Stability Map
Southern Sarpy Watershed Management Plan
Papio-Missouri River Natural Resources District

Legend

Stability Assessment Ratings✳

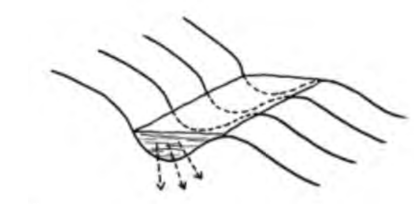


✳ Based on Thorne. "Geomorphological river channel reconnaissance for river analysis, engineering, and management." (1996) and Montgomery and Macdonald "Diagnostic approach to stream channel assessment and monitoring." (2002).

NRCS Structures ★

Class Evolution Models (CEM)

Swale



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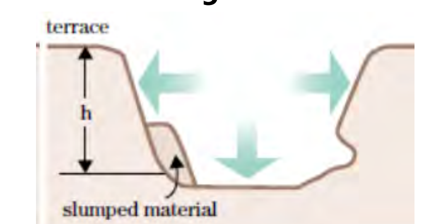
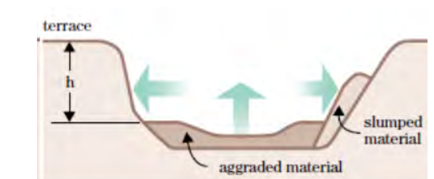


Class 1. Sinuous, premodified h<hc

Class 5. Aggradation and widening h>hc



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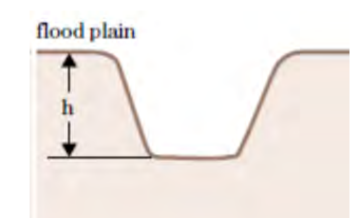

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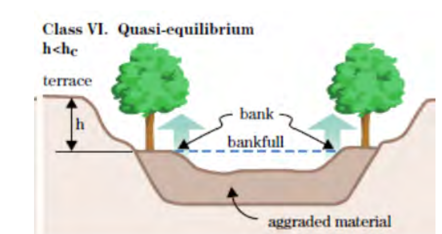


Class 3. Degradation h>hc

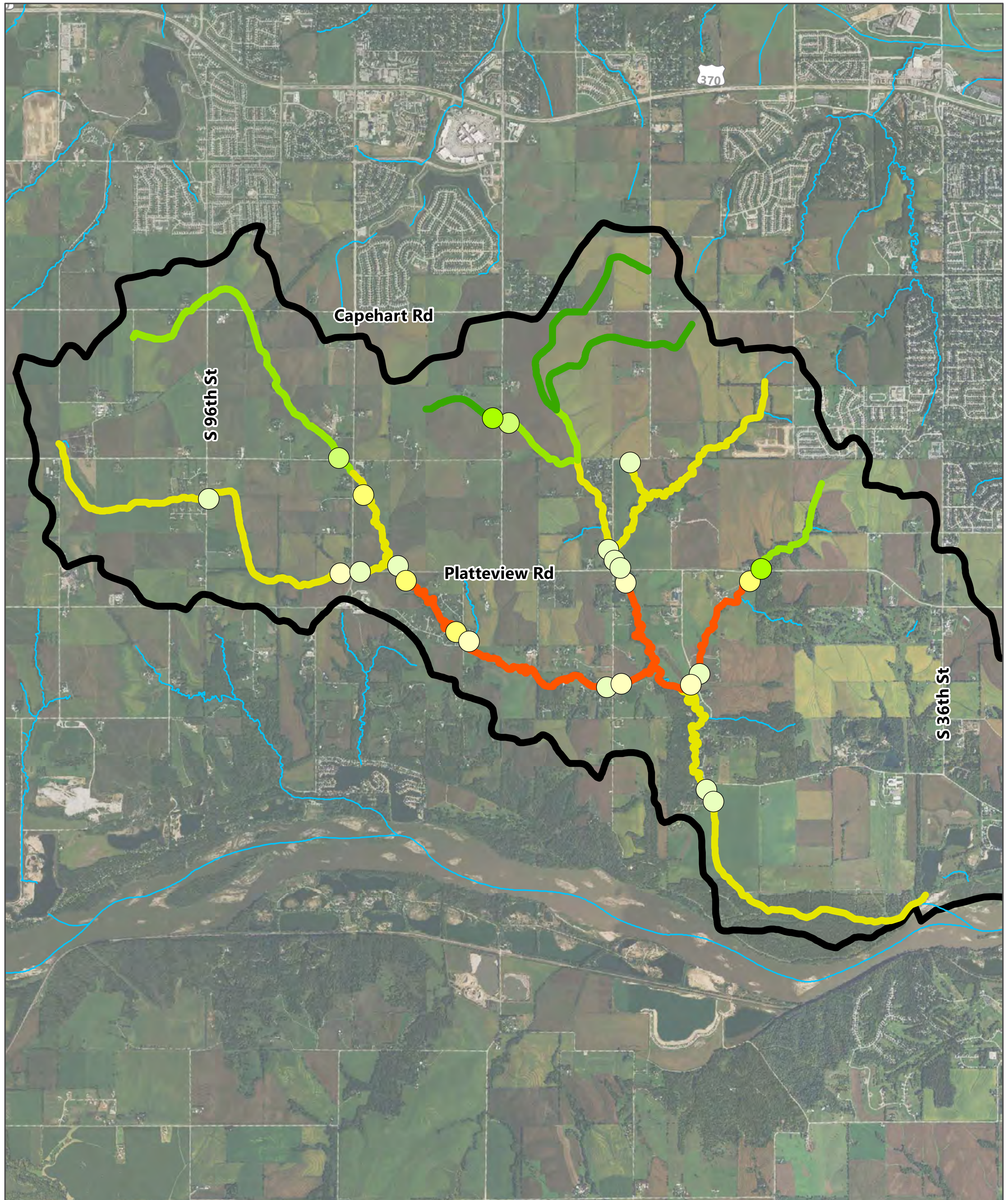


Figure D.16 Zwiebel Creek Watershed Stream Stability Map
Southern Sarpy Watershed Management Plan
Papio-Missouri River Natural Resources District

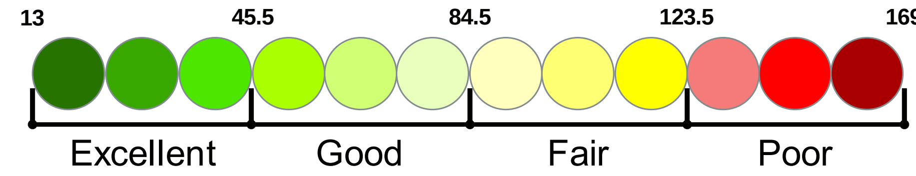
N

0 0.5 1 Mile

FYRA ENGINEERING

Legend

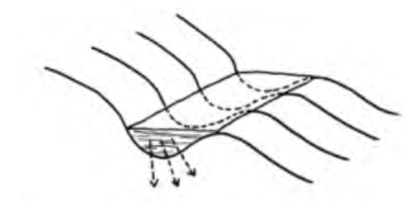
Stability Assessment Ratings*



* Based on Thorne. "Geomorphological river channel reconnaissance for river analysis, engineering, and management." (1996) and Montgomery and Macdonald "Diagnostic approach to stream channel assessment and monitoring." (2002).

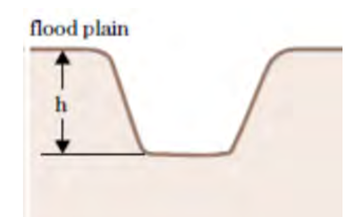
Class Evolution Models (CEM)

Swale



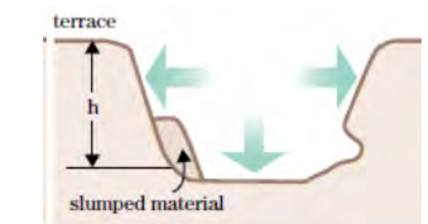
Class 1. Sinuous, premodified h<hc

Class 2. Channelized h<hc

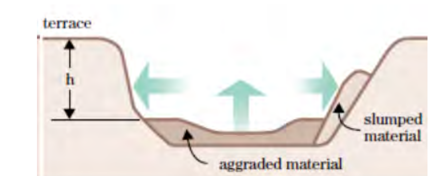


Class 3. Degradation h>hc

Class 4. Degradation and widening h>hc



Class 5. Aggradation and widening h>hc



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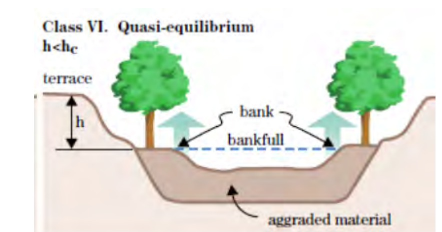


Table D.1. Stream Stability Ratings for Buffalo Creek Basin

Assessment Location	CEM	Stream Stability Indicator*													Total Score	Stability Rating
		1	2	3	4	5	6	7	8	9	10	11	12	13		
SP34 - DS	3	7	8	2	6	8	2	2	8	10	9	9	9	5	85	Fair
SP35	0	7	8	2	1	8	1	2	8	2	6	2	2	4	53	Good
SP36	1	7	8	2	2	8	1	2	8	2	6	2	2	10	60	Good
SP37 - US	3	7	8	2	7	8	2	2	8	9	7	8	6	5	79	Good
SP37 - DS	3	7	8	2	7	8	2	3	8	10	10	8	6	3	82	Good
SP38 - US	3	7	8	4	7	8	3	2	8	4	7	10	6	11	85	Fair
SP38 - DS	3	7	8	4	6	8	7	2	8	3	7	8	6	8	82	Good
SP39 - US	4	7	8	4	10	8	8	3	8	11	9	10	8	8	102	Fair
SP39 - DS	4	7	8	4	10	8	8	5	8	11	9	10	9	6	103	Fair
SP40 - US	3	7	8	3	7	8	2	3	8	6	5	8	6	8	79	Good
SP40 - DS	4	7	8	4	10	8	4	6	8	11	9	8	10	7	100	Fair
SP41 - US	3	7	8	3	9	8	3	3	8	10	8	10	6	4	87	Fair
SP41 - DS	4	7	8	3	10	8	3	3	8	10	11	9	10	4	94	Fair
SP42 - US	4	7	8	5	10	8	10	4	8	10	5	8	6	8	97	Fair
SP43 - DS	4	7	8	4	10	8	2	2	8	10	10	4	9	6	88	Fair
SP44 - US	4	7	8	4	10	8	2	6	8	10	7	8	5	5	88	Fair
SP44 - DS	4	7	8	4	10	8	3	4	8	10	10	7	8	4	91	Fair
SP45	4	7	8	4	10	8	2	2	8	10	8	8	6	6.5	88	Fair
SP46 - US	4	7	8	4	10	8	8	3	8	10	9	8	5	6	94	Fair
SP46 - DS	4	7	8	4	10	8	8	4	8	10	8	9	5	5	94	Fair
SP47 - US	1	7	8	2	2	8	2	2	8	2	4	1	2	4	52	Good
SP47 - DS	1	7	8	2	5	8	2	2	8	5	7	2	4	2	62	Good
SP48 - US	3	7	8	4	7	8	3	2	8	7	5	6	5	9	79	Good
SP48 - DS	3	7	8	2	7	8	1	4	8	9	5	4	7	5	75	Good
SP49 - US	4	7	8	3	10	8	10	4	8	11	8	10	10	10	107	Fair
SP49 - DS	4	7	8	3	10	8	9	4	8	11	8	10	10	2	98	Fair
SP50 - US	1	7	8	2	2	8	1	2	8	2	7	2	2	4	55	Good
SP50 - DS	1	7	8	2	3	8	1	2	8	3	4	2	2	10	60	Good
SP51 - US	4	7	8	4	10	8	7	4	8	10	6	9	6	6	93	Fair
SP51 - DS	3	7	8	4	9	8	8	5	8	9	6	9	9	6	96	Fair
SP52 - US	4	7	8	4	10	8	8	3	8	10	7	8	8	3	92	Fair
SP53 - DS	4	7	8	5	10	8	6	3	8	10	9	8	9	6	97	Fair
SP54 - US	4	7	8	4	10	8	5	2	8	10	9	6	5	4	86	Fair
SP54 - DS	4	7	8	4	10	8	8	4	8	11	7	8	8	3	94	Fair
SP55 - US	4	7	8	2	10	8	6	4	8	11	8	7	6	2	87	Fair
SP55 - DS	4	7	8	2	10	8	4	4	8	10	8	7	6	2	84	Good

* 1. Watershed/floodplain activity & characteristics
2. Flow habitat
3. Channel pattern
4. Entrenchment/channel confinement
5. Bed material
6. Bar development
7. Obstructions
8. Bank soil texture & coherence
9. Average bank slope angle
10. Vegetative or engineered bank protection
11. Bank Cutting
12. Mass wasting or bank failure
13. Upstream meander distance to bridge

Table D.2. Stream Stability Ratings for Springfield Creek Basin

Assessment Location	CEM	Stream Stability Indicator*													Total Score	Stability Rating
		1	2	3	4	5	6	7	8	9	10	11	12	13		
SP18 - US	5	7	8	1	4	8	1	2	8	7	4	4	1	2	57	Good
SP18 - DS	3	7	8	1	8	8	1	6	8	9	6	7	7	6	82	Good
SP19	3	7	8	6	8	8	2	3	8	11	8	10	9	10	98	Fair
SP20	4	7	8	5	9	8	7	4	8	10	8	8	8	5	95	Fair
SP21 - US	0	7	8	2	1	8	1	1	8	1	5	1	1	3	47	Good
SP21 - DS	3	7	8	4	8	8	1	3	8	7	6	6	5	5	76	Good
SP22	4	7	8	2	8	8	2	6	8	8	8	5	6	6	82	Good
SP23	4	7	8	2	8	8	1	2	8	9	7	7	7	9	83	Good
SP24 - US	1	7	8	3	3	8	1	2	8	4	3	1	1	3	52	Good
SP24 - DS	1	7	8	3	3	8	1	2	8	4	4	1	1	4	54	Good
SP25	4	7	8	3	9	8	2	2	8	10	10	7	6	8	88	Fair
SP26	4	7	8	3	11	8	8	2	8	12	11	8	10	6.5	104	Fair
SP27	4	7	8	3	11	8	8	2	8	11	10	9	9	6.5	102	Fair
SP28	4	7	8	3	10	8	5	3	8	10	10	9	9	6.5	94	Fair
SP29 - US	0	7	8	2	1	8	1	1	8	1	5	2	1	5	50	Good
SP29 - DS	1	7	8	3	2	8	1	2	8	2	5	2	1	3	52	Good
SP30	1	7	8	2	3	8	1	2	8	4	4	2	1	11	61	Good
SP31 - US	1	7	8	3	3	8	1	3	8	4	4	3	1	1	54	Good
SP31 - DS	4	7	8	3	10	8	7	3	8	11	10	8	10	8	101	Fair
SP32	4	7	8	4	11	8	8	2	8	10	8	8	10	6.5	100	Fair

* 1. Watershed/floodplain activity & characteristics
2. Flow habitat
3. Channel pattern
4. Entrenchment/channel confinement
5. Bed material
6. Bar development
7. Obstructions
8. Bank soil texture & coherence
9. Average bank slope angle
10. Vegetative or engineered bank protection
11. Bank Cutting
12. Mass wasting or bank failure
13. Upstream meander distance to bridge

Table D.3. Stream Stability Ratings for Zwiebel Creek Basin

Assessment Location	CEM	Stream Stability Indicator*													Total Score	Stability Rating
		1	2	3	4	5	6	7	8	9	10	11	12	13		
SP1	1	7	8	2	2	8	1	1	8	8	4	5	2	7	63	Good
SP2	3	7	8	6	8	8	5	6	8	11	9	8	6	6.5	98	Fair
SP3	3	7	8	4	8	8	5	5	8	10	7	5	5	4	84	Good
SP4 - US	3	7	8	2	7	8	5	7	8	10	7	8	3	7	87	Fair
SP4 - DS	3	7	8	2	7	8	3	2	8	8	10	8	3	9	83	Good
SP5 - US	3	7	8	2	9	8	2	2	8	10	11	7	2	4	80	Good
SP5 - DS	4	7	8	4	11	8	2	8	8	11	10	9	6	8	100	Fair
SP6 - US	4	7	8	6	10	8	6	6	8	10	9	9	7	7	101	Fair
SP6 - DS	4	7	8	4	9	8	2	6	8	10	11	7	7	9	96	Fair
SP7 - US	3	7	8	2	8	8	2	2	8	10	10	4	2	3	74	Good
SP7 - DS	3	7	8	2	8	8	4	2	8	10	10	9	8	8	92	Fair
SP8 - US	0	7	8	1	1	8	1	4	8	1	10	1	1	4	55	Good
SP8 - DS	1	7	8	2	2	8	1	4	8	3	9	3	1	5	61	Good
SP9 - DS	3	7	8	3	9	8	2	7	8	10	5	4	4	7	82	Good
SP10 - US	3	7	8	1	8	8	7	2	8	9	8	3	2	10	81	Good
SP10 - DS	3	7	8	1	8	8	2	2	8	10	10	2	2	10	78	Good
SP11 - US	3	7	8	1	8	8	2	2	8	10	10	2	2	5	73	Good
SP11 - DS	4	7	8	1	9	8	2	4	8	10	10	6	8	5	86	Fair
SP12 - US	1	7	8	3	1	8	1	1	8	1	6	2	1	6	53	Good
SP12 - DS	4	7	8	3	10	8	9	4	8	11	10	8	8	5	99	Fair
SP13 - US	4	7	8	3	9	8	2	3	8	10	7	5	4	10	84	Good
SP13 - DS	4	7	8	3	11	8	3	4	8	11	9	8	7	5	92	Fair
SP15 - US	3	7	8	2	8	8	2	1	8	10	9	7	4	2	76	Good
SP15 - DS	3	7	8	2	8	8	2	1	8	10	9	7	4	1	75	Good

* 1. Watershed/floodplain activity & characteristics
2. Flow habitat
3. Channel pattern
4. Entrenchment/channel confinement
5. Bed material
6. Bar development
7. Obstructions
8. Bank soil texture & coherence
9. Average bank slope angle
10. Vegetative or engineered bank protection
11. Bank Cutting
12. Mass wasting or bank failure
13. Upstream meander distance to bridge

Additional information collected during the field investigation included knickpoints evident from the assessment locations and threatened infrastructure. These locations are shown in Figures D.17 and D.18 and Tables D.4 and D.5 provide more detailed information.

Figure D.17. Observed Knickpoints and Threatened Infrastructure in Springfield and Buffalo Creek Basins

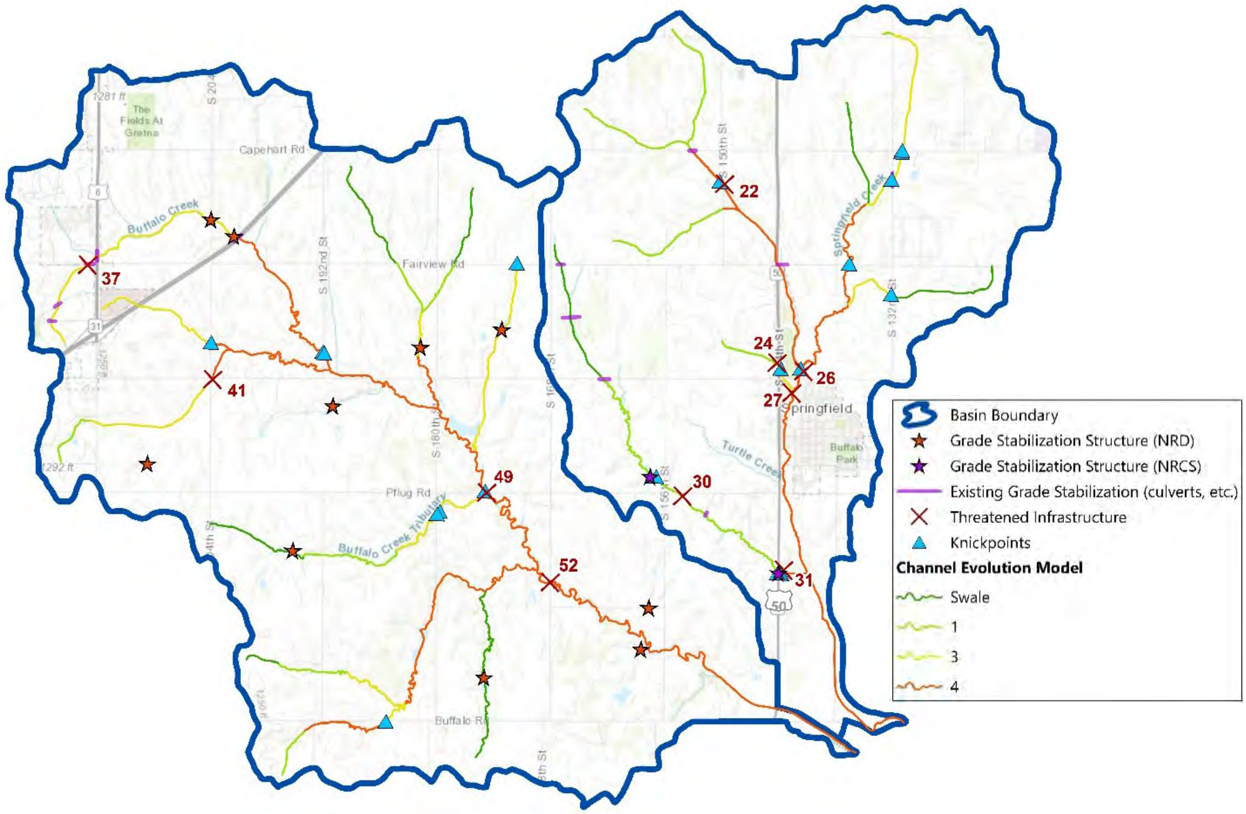


Table D.4. Threatened Infrastructure in Springfield and Buffalo Creek Basins

Assessment Location	Threatened Infrastructure
22	Power pole near knickpoint
24	Utility box
26	Property on left bank
27	Sidewalk and culvert
30	Bridge/road
31	Property on both banks
37	Power pole
41	Perched outfall
49	Potential issue at bridge
52	Bridge

Figure D.18. Observed Knickpoints and Threatened Infrastructure in Zwiebel Creek Basin

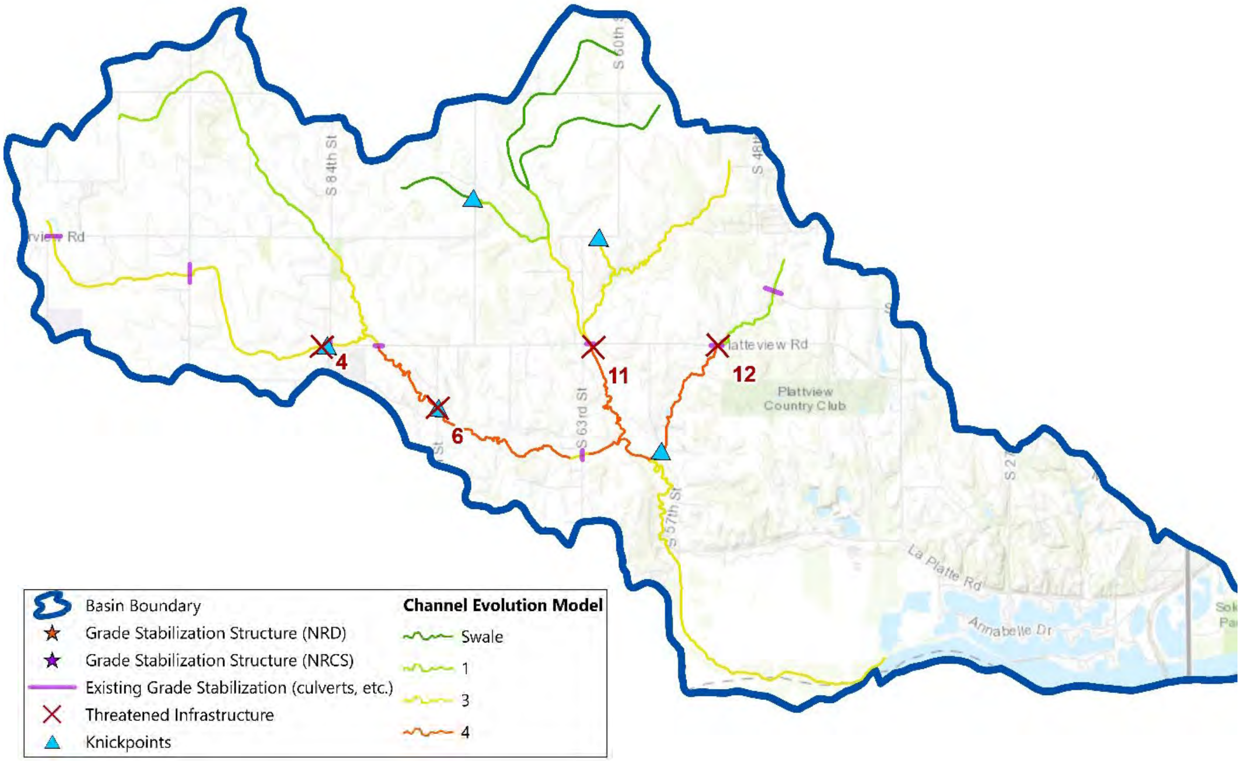


Table D.5. Threatened Infrastructure in Zwiebel Creek Basin

Assessment Location	Threatened Infrastructure
4	Outfall
6	Bridge/road
11	Potential issue at bridge
12	Bridge

Preservation and restoration are defined goals for the Partnership and the field investigation included identifying potential locations for these efforts. Potential preservation sites included streams that are currently in CEM phase 1 or exhibit other rare environmental characteristics. These are often locations that are sensitive to development and would benefit from protection prior to increased velocities or progressing headcuts. When looking for potential restoration sites, proximity to CEM phase 1 streams, proximity to development, potential land available for restoration, and location within the watershed were all considered. Constraints primarily relating to site access and viewing streams from engineered crossings yield results that inherently do not consider the entire watershed. However, eleven sites were identified as potential preservation locations and one site was identified as a potential restoration location. These are shown in Figures D.19 and D.20 below.

Figure D.19. Potential Sites for Preservation in Springfield and Buffalo Creek Basins

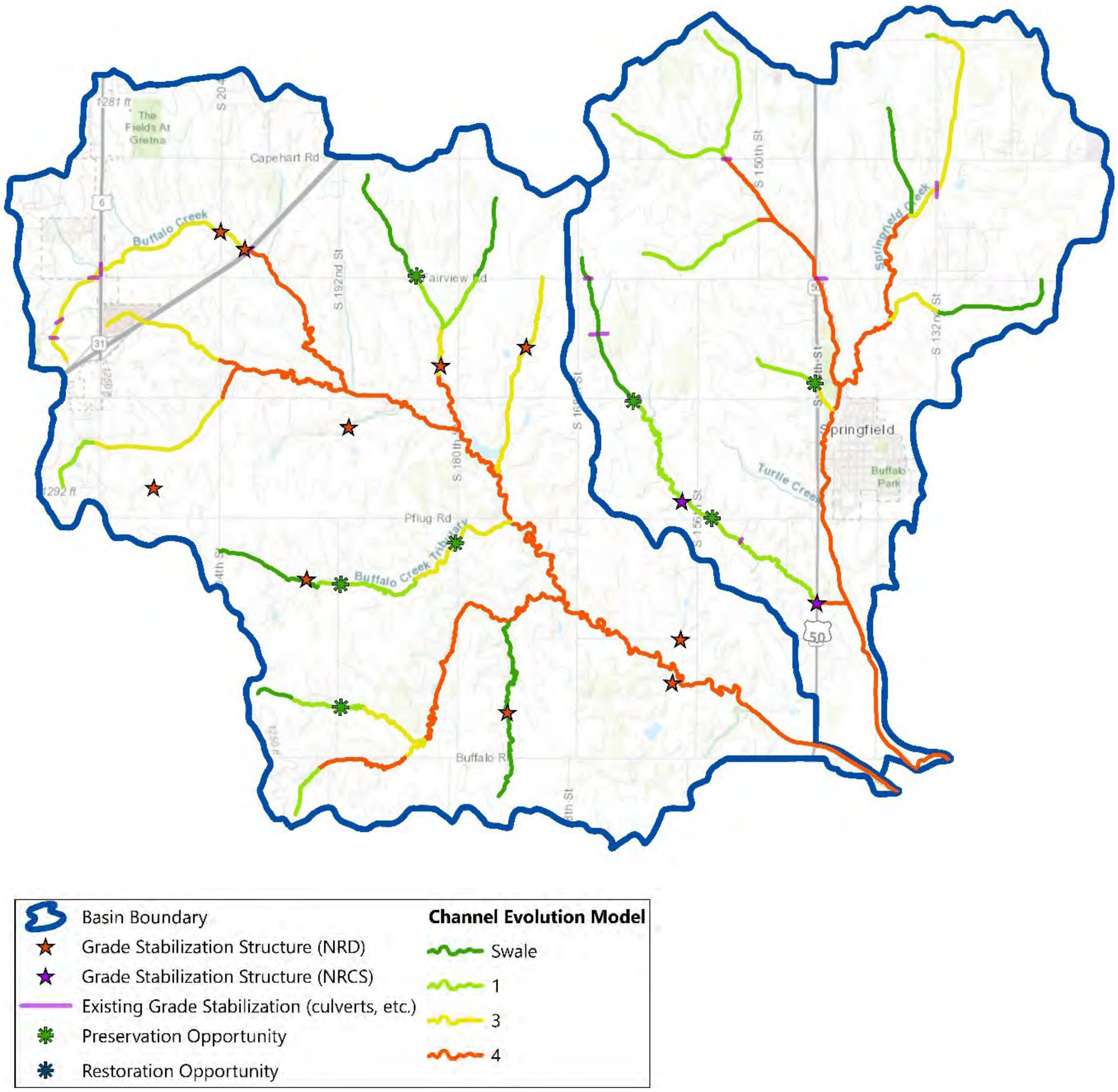
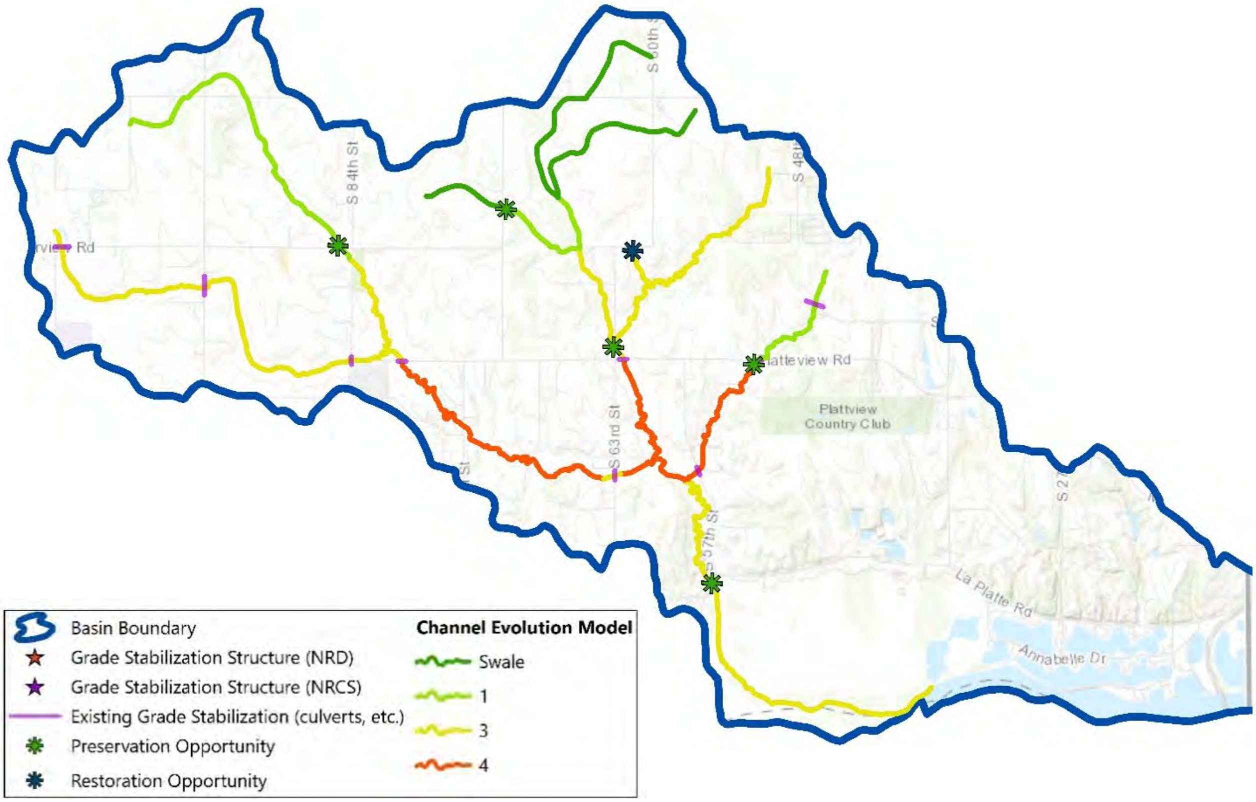


Figure D.20. Potential Sites for Preservation and Restoration in Zwiebel Creek Basins



4.0 PREDICTING POTENTIAL FUTURE STREAM PROFILES

Predicting future stream degradation and widening is important when assessing the existing interim Partnership setback policy of 3:1 plus 50-feet. Future potential stream profiles were developed utilizing the analyses discussed above to compare potential future conditions with existing interim policy. These profiles were then used to estimate future potential stream setbacks of 3:1 plus 50-feet, which were mapped together with the existing setback limits (Appendix G). These maps are not to be used to set the setback limits, but for analysis and comparison to understand the implications of future degradation. Discussions on the alternatives analysis, policies, and recommendations are found in Section 8 of the Plan. Discussions and figures herein are included to list assumptions and to show the results of the analysis.

When developing the potential future stream profiles, the following assumptions were used:

- Streams would degrade through headcut progression, with the downstream slope driving the elevations
- The 'stable' streambed slope will be reached on all segments; a value of 0.15 percent was applied to project future stream profiles that is within the range of anticipated slopes and consistent with values applied in the Papillion Creek watershed
- Existing grade control structures are assumed to remain in-tact and therefore the elevations upstream of these structures would remain constant from present-day to future conditions
- Culverts are assumed to act as grade control structures
- Bank heights reach a maximum of 30 ft and degradation ceases due to encountering hard pan

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Appendix E. Peak Flow Management

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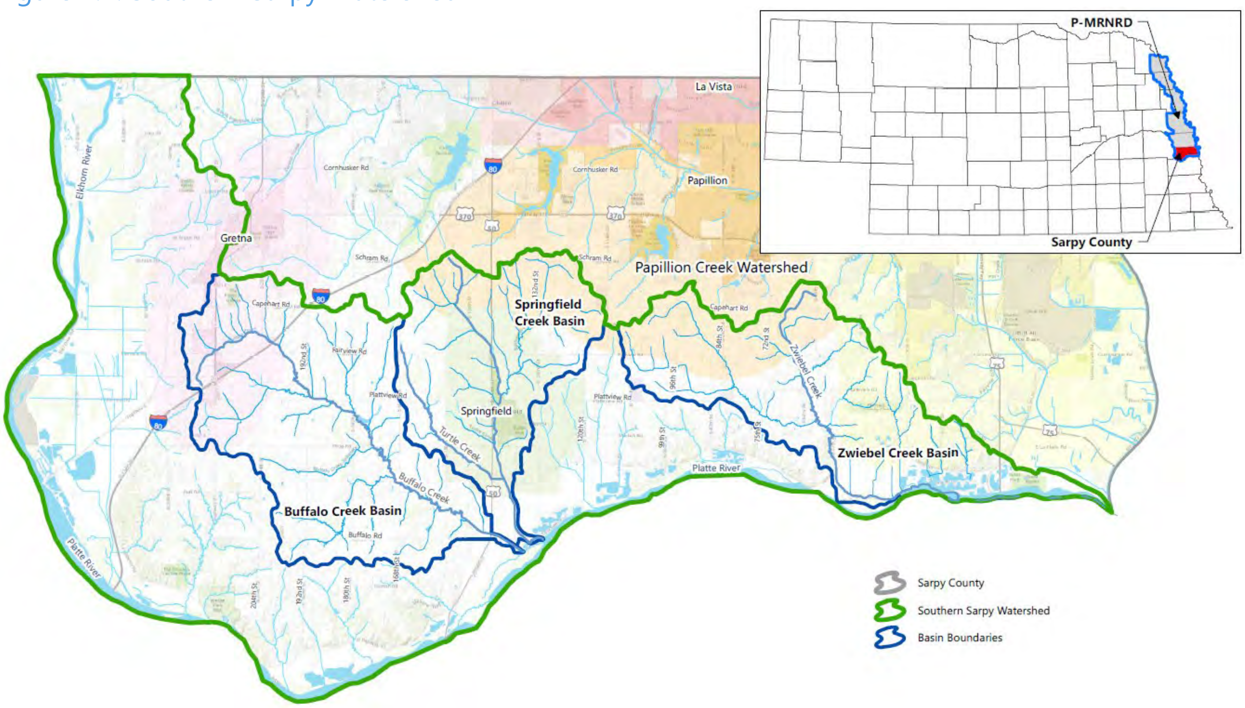
1.0 INTRODUCTION

The Interlocal Cooperation Act Agreement for the Southern Sarpy Watershed Partnership (Agreement) was signed in 2017 that established a Partnership of interested governments located within the watershed, which includes the Cities of Bellevue, Gretna, Papillion, Springfield, Sarpy County and the Papio-Missouri River Natural Resources District (P-MRNRD) (see Figure E.1).

Figure E.1. Southern Sarpy Watershed



The Agreement identified the 6 policy groups below, and defined issues and interim policies to be adopted by the Southern Sarpy Watershed Partnership (Partnership) governments while the South Sarpy Watershed Management Plan (Plan) was being developed.

1. Water Quality Improvement
2. Peak Flow Reduction
3. Landscape Preservation, Restoration, and Conservation
4. Erosion and sediment Control and Other BMPs
5. Floodplain Management
6. Storm Water Management Financing

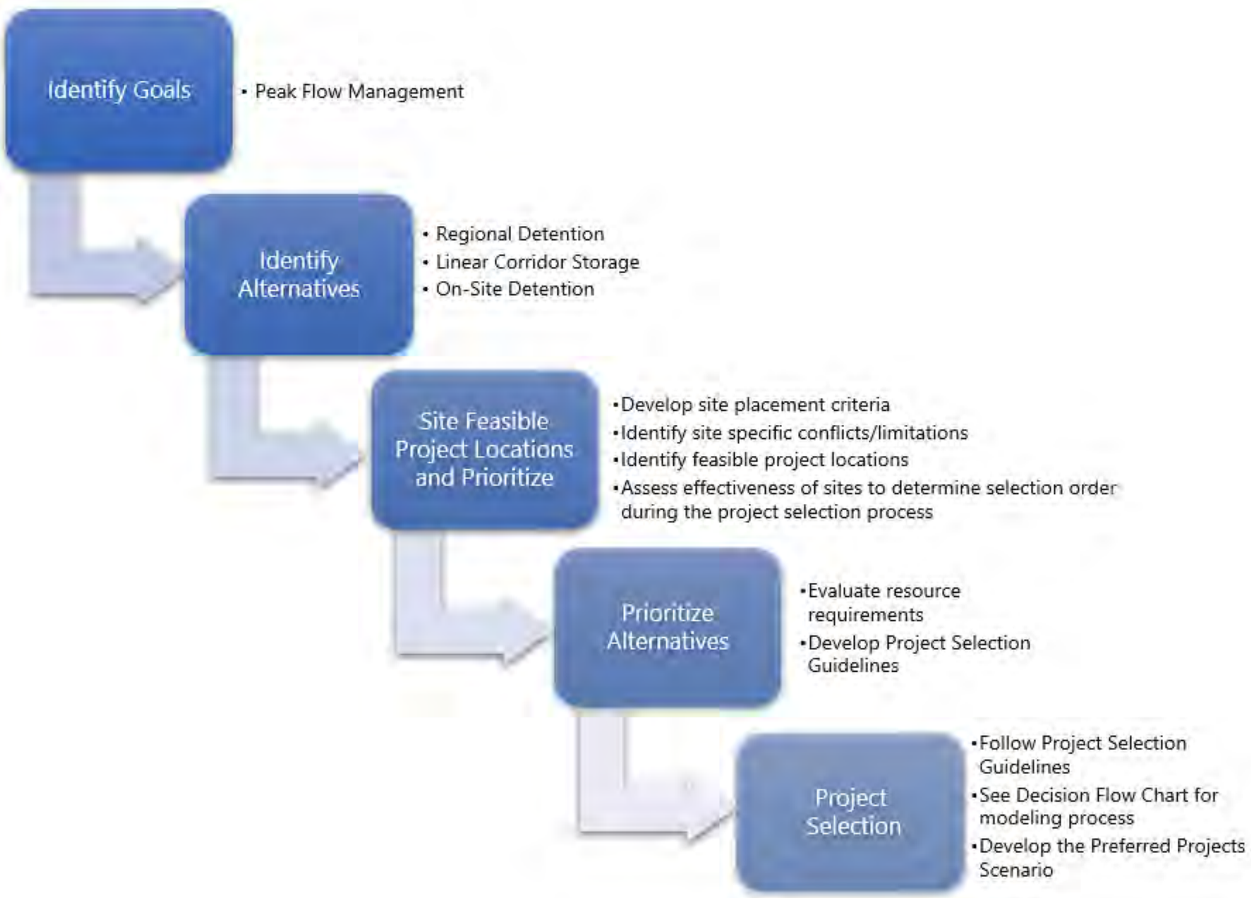
As the planning process progressed for the Plan, the rate of development in the watershed continued to cause the Partnership concerns about the land requirements for potential projects recommended as part of the Plan. Understanding that projects associated with storing large volumes of stormwater runoff to control peak flows require the greatest amount of area, the Partnership needed to investigate the structural alternatives for controlling peak flows with regionalized detention to achieve the Peak

Flow Reduction requirements. This will determine the associated land requirements and allow the Partnership to make informed decisions on project and policy recommendations.

1.1 Project Selection Process

This investigation analyzed projects that the Partnership would implement for regionalized control of the 100-yr storm event peak flow increases. Throughout the development of this Plan there was active coordination with the Partnership to develop an overarching process for determining Partnership led projects in the watershed for Peak Flow Management. The graphic in Figure E.2 details the process that was developed and followed for the analysis and selection of recommended Partnership projects for each of the three basins (Buffalo Creek, Springfield Creek, and Zwiebel Creek) included in the Plan.

Figure E.2. Project Selection Process Summary



2.0 IDENTIFY GOALS

The definition for the current peak flow reduction policy group requires the developers to *"maintain or reduce peak discharge rates"* as the wording should not limit the developers from incorporating additional reductions above and beyond bringing future conditions back to existing. However, simply maintaining the existing condition is acceptable. For the purpose of assessing the Partnership projects required to manage the 100-yr storm event increases, the following goals were specified:

- Projects (in combination) must prevent or mitigate peak flow (100-yr) increases from existing to future conditions
- Peak flows to be monitored at 'comparison nodes' (see below) identified in Phase 1 along the main tributaries

A hydrology workshop was conducted with the Partnership as part of the Phase I planning process during which multiple reference points ('comparison nodes') were selected. The comparison node locations were designated at major stream confluences and downstream of areas with either predicted or planned development. This allowed the planning team to assess growth-related changes within the watershed. Figure E.3 shows the locations of the comparison nodes within the watershed. Tables 1-3 show drainage area, current peak flows, and future condition peak flows at each comparison node.

Figure E.3. Comparison Node Locations

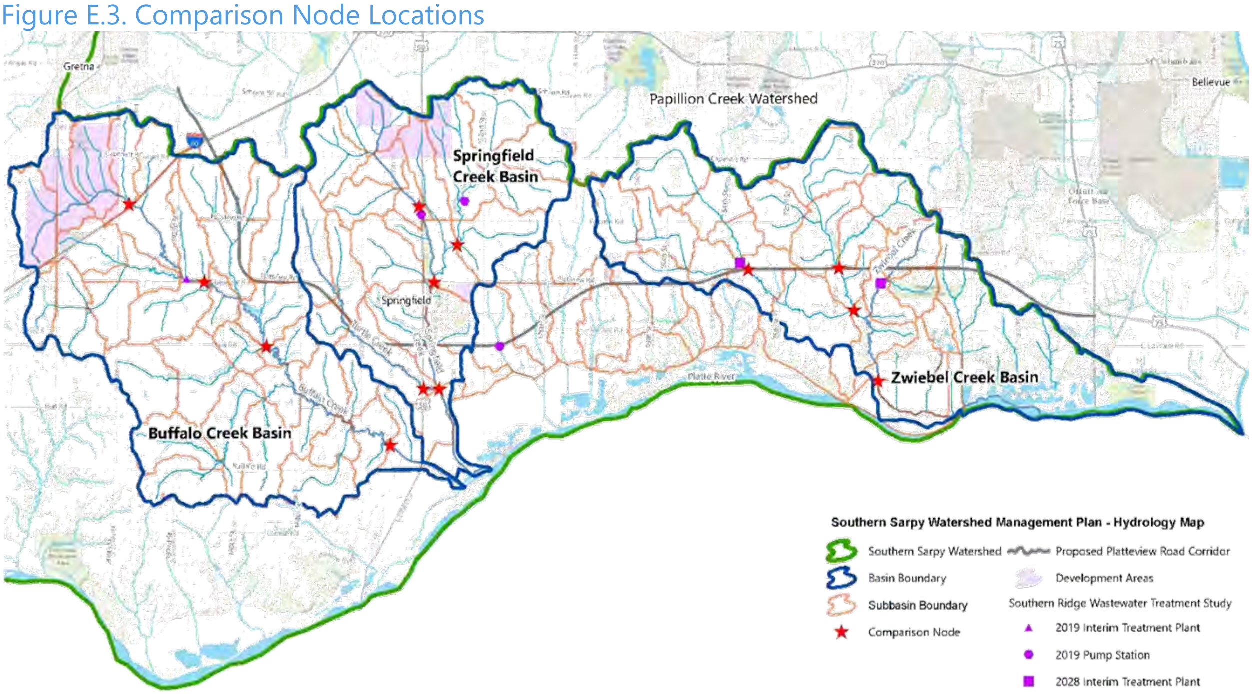


Table E.1. Springfield Creek Comparison Node Data

Node Location	Total Drainage Area (mi²)	Existing Conditions	Future Conditions	
		Peak Flow (cfs)	Peak Flow (cfs)	Δ from Existing
CN-S1	5.1	5,240	6,060	16%
CN-S2	3.05	3,370	3,960	18%
CN-S3	9.81	9,330	10,980	18%
CN-S4	3.02	2,400	2,800	17%
CN-S5	15.73	13,710	16,060	17%

Table E.2. Zwiebel Creek Comparison Node Data

Node Location	Total Drainage Area (mi²)	Existing Conditions	Future Conditions	
		Peak Flow (cfs)	Peak Flow (cfs)	Δ from Existing
CN-Z1	4.19	4,860	5,740	18%
CN-Z2	4.86	5,720	6,350	11%
CN-Z3	11.37	11,610	12,760	10%
CN-Z4	13.59	12,850	14,430	12%

Table E.3. Buffalo Creek Comparison Node Data

Node Location	Total Drainage Area (mi²)	Existing Conditions	Future Conditions	
		Peak Flow (cfs)	Peak Flow (cfs)	Δ from Existing
CN-B1	3.37	3,620	4,230	17%
CN-B2	8.89	9,600	11,230	17%
CN-B3	17.10	16,400	19,330	18%
CN-B4	25.22	20,980	23,940	14%

3.0 IDENTIFY ALTERNATIVES AND FEASIBLE PROJECT LOCATIONS

The types of alternatives considered for Partnership projects are geared towards larger, regionalized controls that achieve peak flow reduction through economies of scale. A combination of projects (of potentially varying alternative types) shall be selected to be placed in series to collectively achieve the 100-yr storm event peak flow management goals. Coordination with the Partnership resulted in the alternatives to be considered below, which are described in further detail in the following sections:

- Regional Detention
- Linear Corridor Storage
- On-Site Controls
- Do Nothing – Allow Floodplain Expansion

Feasible project site locations to be considered for implementation were selected for each alternative type. To determine the most effective combination of Partnership projects, hydraulic and hydrologic modeling was performed to determine the impact each project has on the peak flows for the downstream comparison node(s). This process is described in more detail in Section 5.0 Project Selection below.

3.1 Regional Detention

Regional detention projects will be on-line stream impoundments that temporarily store stormwater runoff and release the storage volume through outlet works, resulting in a reduced peak flow rate in the downstream channel. Each structure will control runoff from the drainage area above the project site and will contribute to reducing peak flow rates at the comparison node(s) located downstream.

Each basin was assessed for feasible regional detention project site locations. Placement criteria were developed, and projects were sited accordingly. The placement criteria include:

- Avoid roads with permanent pool
- Avoid utilities with permanent pool
- Avoid homes within top of dam elevation
- Avoid existing plats
- Controls a minimum of 200 acres

A summary of the feasible locations is provided in Table E.4 and mapped on Figures E.4- E.6. Seven feasible sites were identified for the Springfield Creek, six for Zwiebel Creek, and eight for Buffalo Creek basins. Site IDs were assigned during very preliminary assessments and some were ruled out do to site specific conflict, which explains any gaps in the site ID numbering system. Springfield Creek's basin had more conflicts because it is slightly more populated than Zwiebel Creek and particularly Buffalo Creek. This resulted in sites in the Springfield Creek basin that control smaller drainage areas, as they had to be placed higher up in the watershed or on smaller tributaries to meet the placement criteria.

Table E.4. Feasible Locations for Regional Detention

Basin	Site ID	Drainage Area (ac)	Permanent Pool Area (ac)	Significant Hazard Top of Dam Area (ac)	High Hazard Top of Dam Area (ac)
Springfield Creek	**SC-1**	281	8	23	29
	SC-2	555	21	51	62
	SC-6	373	15	35	44
	SC-7	445	18	42	52
	SC-8	635	26	60	74
	SC-9	219	9	21	26
	SC-10	461	19	43	54
Zwiebel Creek	**ZC-3**	830	24	56	68
	ZC-4	205	8	23	30
	ZC-5	331	13	31	39
	ZC-6	781	31	74	92
	ZC-7	806	32	76	94
	ZC-8	570	23	54	67
Buffalo Creek	**BC-1**	610	25	57	72
	BC-2	531	21	50	62
	BC-3	1230	49	116	144
	BC-4	1145	46	108	134
	BC-5	289	12	27	34
	BC-6	551	22	52	65
	BC-7	788	32	74	92
	BC-8	498	20	47	58

Figure E.4. Springfield Creek Feasible Regional Detention Project Locations

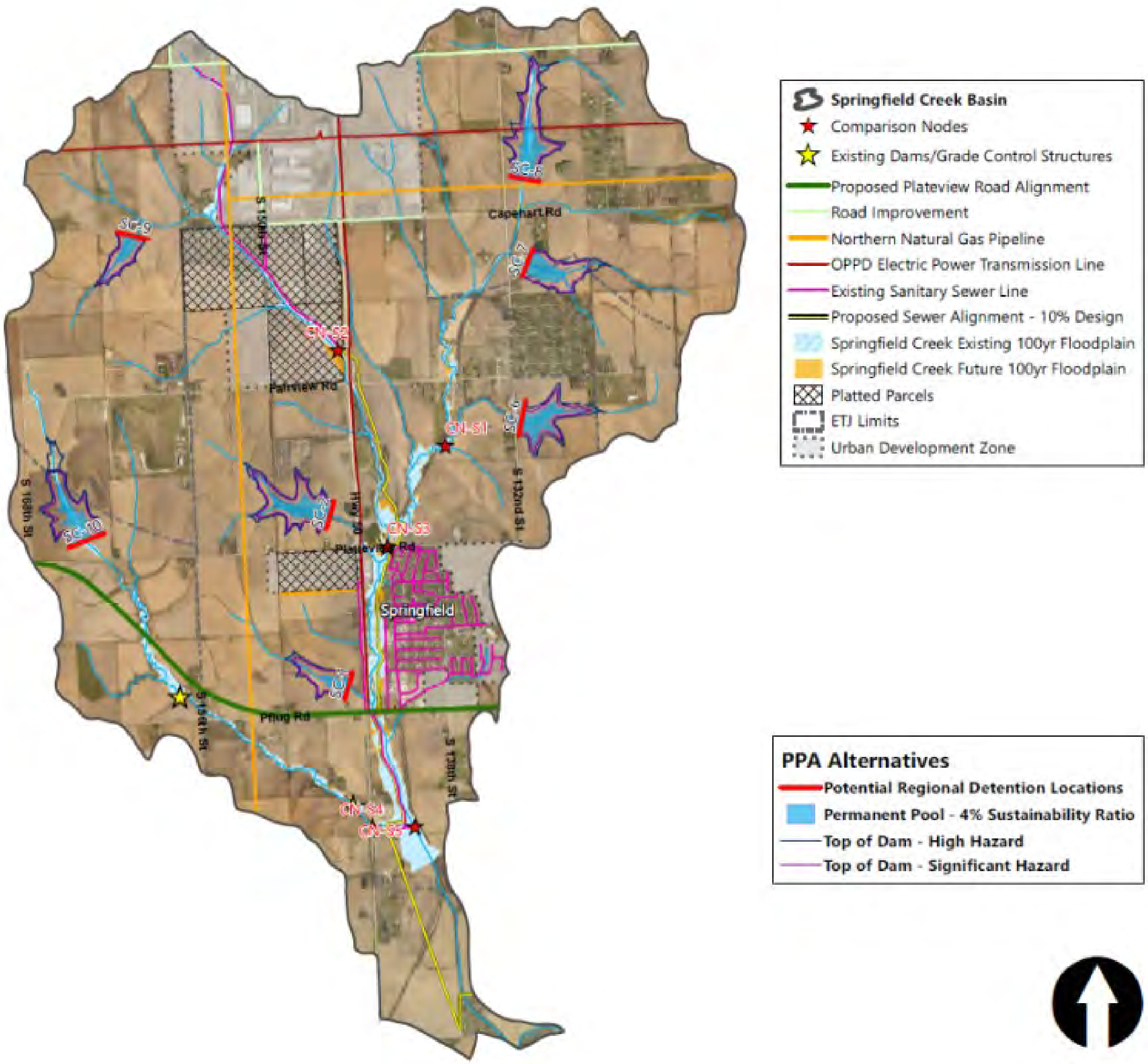


Figure E.5. Zwiebel Creek Feasible Regional Detention Project Locations

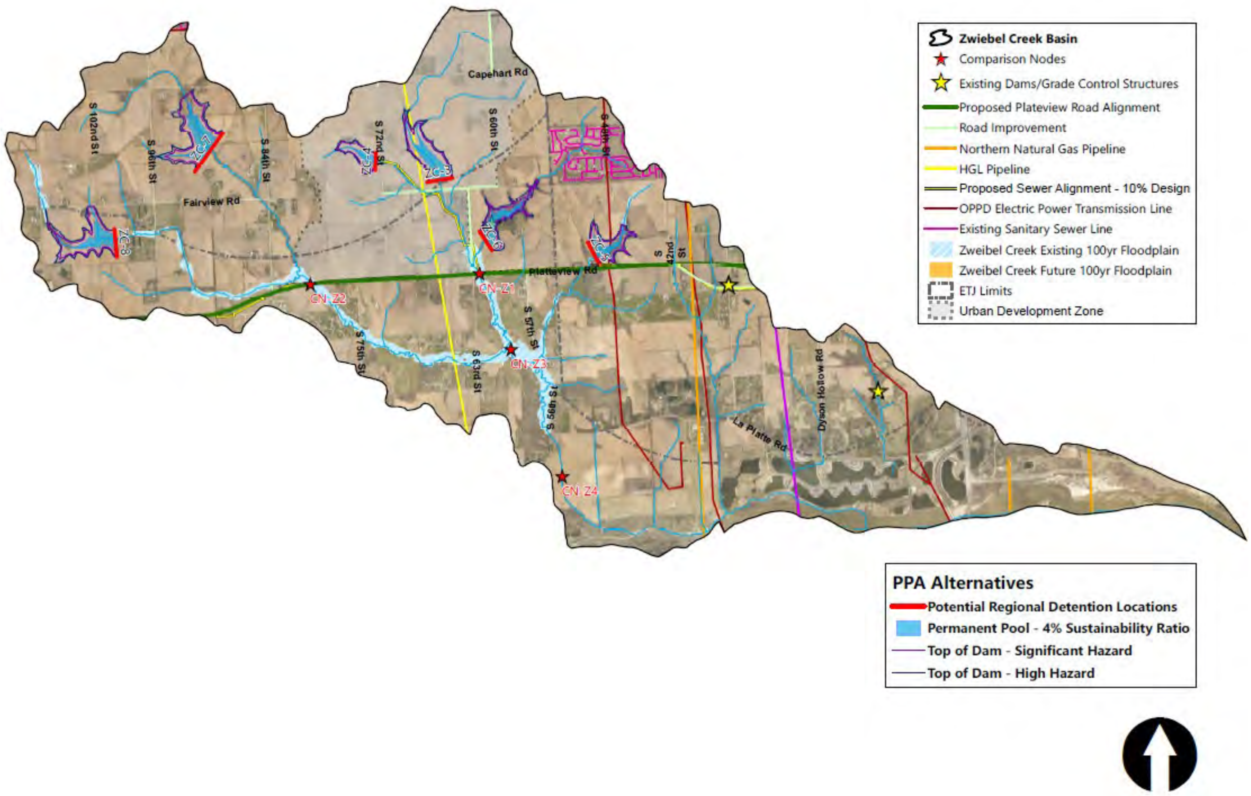
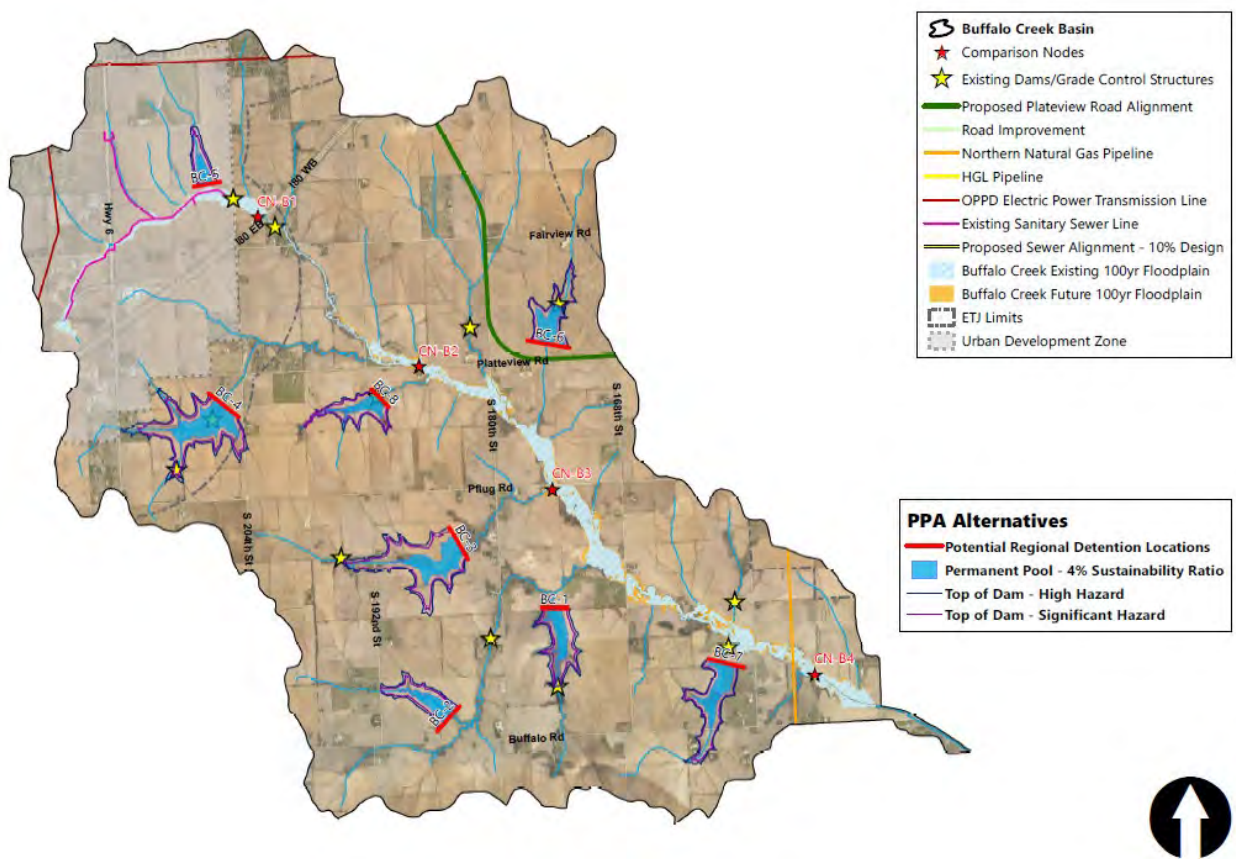


Figure E.6. Buffalo Creek Feasible Regional Detention Project Locations



Preliminary analysis was performed on the feasible sites to provide perspective on the magnitude of change each individual project would have on peak flow reduction. This was a precursory investigation to prioritize the site locations. This determined the preferential order for selecting sites to incorporate into the detailed hydrologic and hydraulic modeling performed to determine the projects required to meet the peak flow management goals (see Section 5.0 Project Selection).

Table E.5. Regional Detention Project Site Selection Order

Priority	Springfield Creek		Zwiebel Creek		Buffalo Creek	
	Site	% Reduction at Downstream Comparison Node	Site	% Reduction at Downstream Comparison Node	Site	% Reduction at Downstream Comparison Node
High	SC-10	-21%	ZC-6	-31%	BC-4	-24%
	SC-8	-17%	ZC-3	-24%	BC-5	-18%
	SC-7	-16%	ZC-7	-23%	BC-3	-13%
	SC-6	-10%	ZC-8	-16%	BC-7	-5%
	SC-9	-10%	ZC-4	-7%	BC-1*	(-5%)
	SC-2	-7%	ZC-5*	(-5%)	BC-2*	(-5%)
	SC-1	-5%	---	---	BC-6*	(-5%)
Low	---	---	---	---	BC-8*	(-5%)

**Sites not modeled; estimates based on relationships developed as a function of drainage area*

3.2 Linear Corridor Storage

Linear corridor storage projects will consist of off-line storage basins located along the stream corridors. High flows will be diverted from the stream into the storage basin through an inflow structure/diversion channel to detain stormwater to contribute towards the peak flow management goal. These concepts are reflected in the Figure E.7 and E.8 images.

Figure E.7.a. Linear Corridor Storage Plan View Schematic

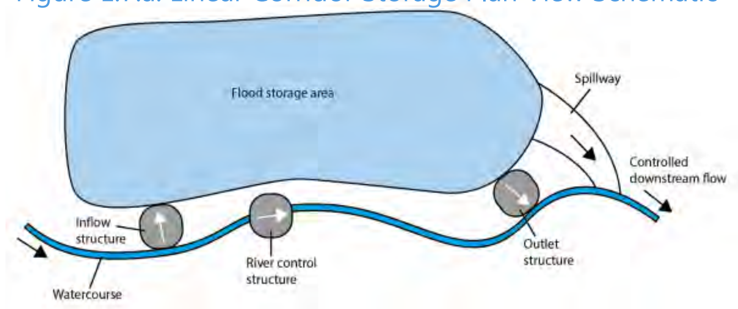


Figure E.7.b. Linear Corridor Storage Example

Figure E.7.c. Linear Corridor Storage Profile View

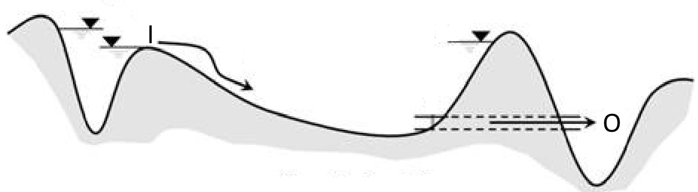
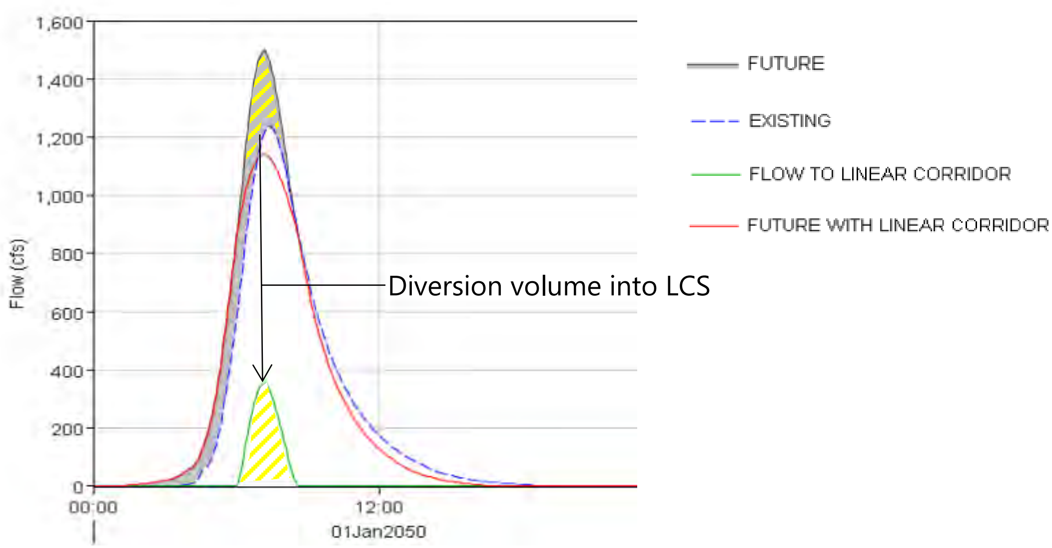
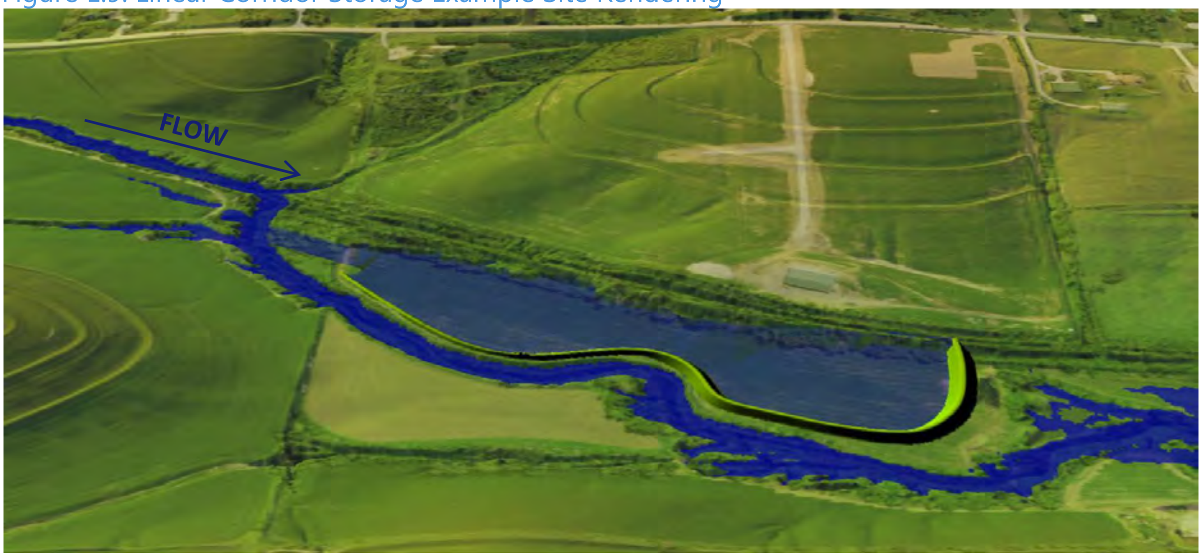


Figure E.8. Existing and Future Hydrographs with Linear Corridor Storage Example



The off-line storage basins will primarily involve earthwork grading and inlet/outlet works for project construction. A berm will be constructed to create a holding cell, paired with excavation of the diversion channel and any additional excavation required to obtain borrow for the berm within the storage basin (Figure E.9). A cut-fill balance would maximize the cost-effectiveness of individual sites, but additional excavation can be performed to increase the storage capacity within the holding cell if needed to meet the peak flow management goals. The outlet works will be designed to hold and release the required storage volume back into the stream, likely through an inlet structure and pipe that discharges into the bottom of the stream channel. The rate of release will be a function of the basin hydrograph. Other key features of the linear storage corridor projects will include grade controls at the downstream end and at the inlet structure/diversion channel locations, and any stream bank stabilization deemed necessary to prevent erosion and bank migration towards the constructed berm.

Figure E.9. Linear Corridor Storage Example Site Rendering



Each basin was assessed for feasible linear corridor storage project site locations. Placement criteria were developed, and projects were sited accordingly. The placement criteria include:

- Avoids roads, utilities, homes, and existing plats with diversion channels and storage basin
- Continuous stretches of flat valley floor adjacent to stream channel
- Rule out sites that require greater than 4 ft of excavation to achieve sufficient storage capacity for the volume required to mitigate the peak increases

The feasible locations area mapped on Figures E.10- E.12. Nine feasible sites were identified for Springfield Creek, six for Zwiebel Creek, and twelve for Buffalo Creek.

Figure E.10. Springfield Creek Feasible Linear Corridor Storage Project Locations

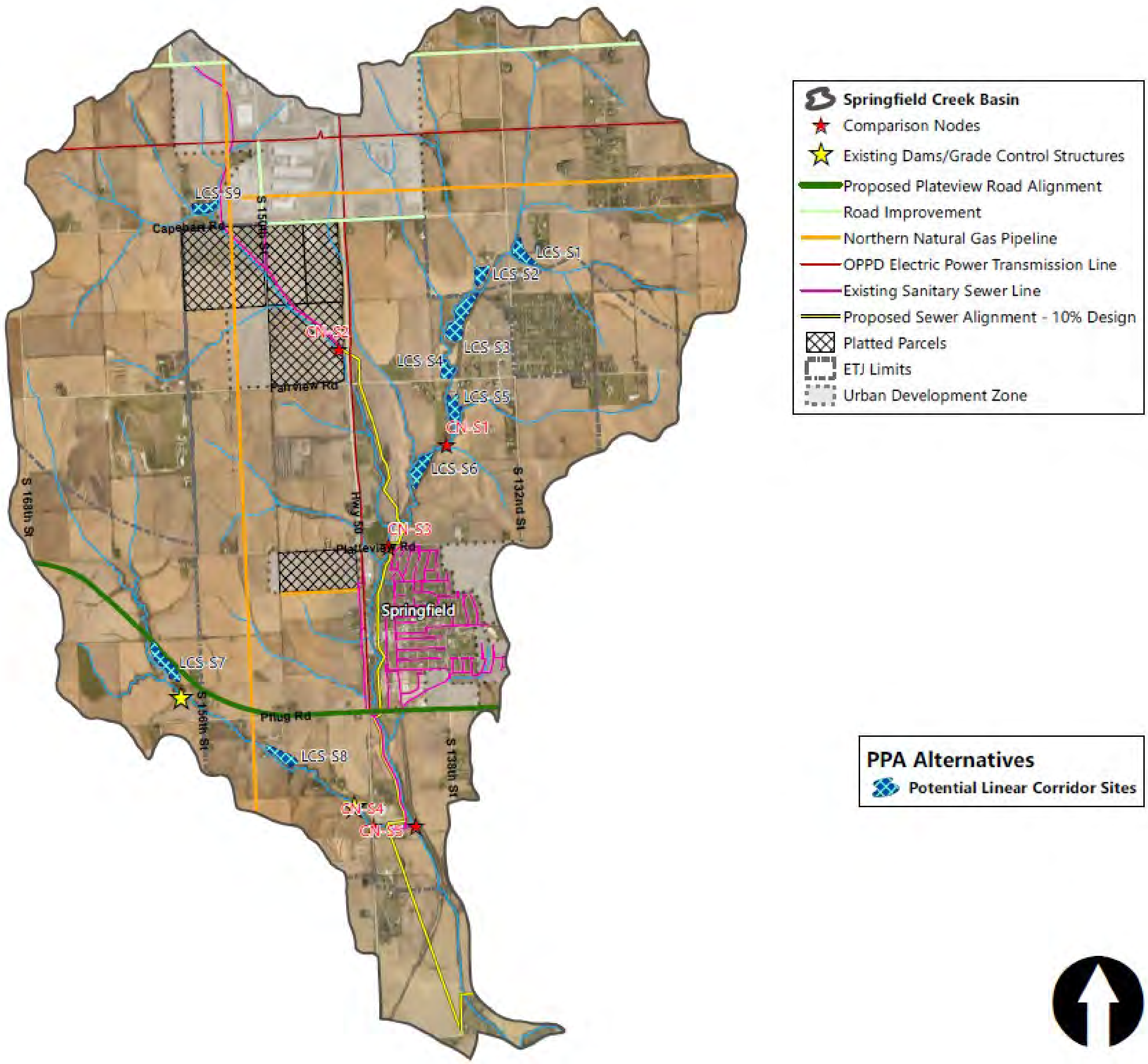


Figure E.11. Zwiebel Creek Feasible Linear Corridor Storage Project Locations

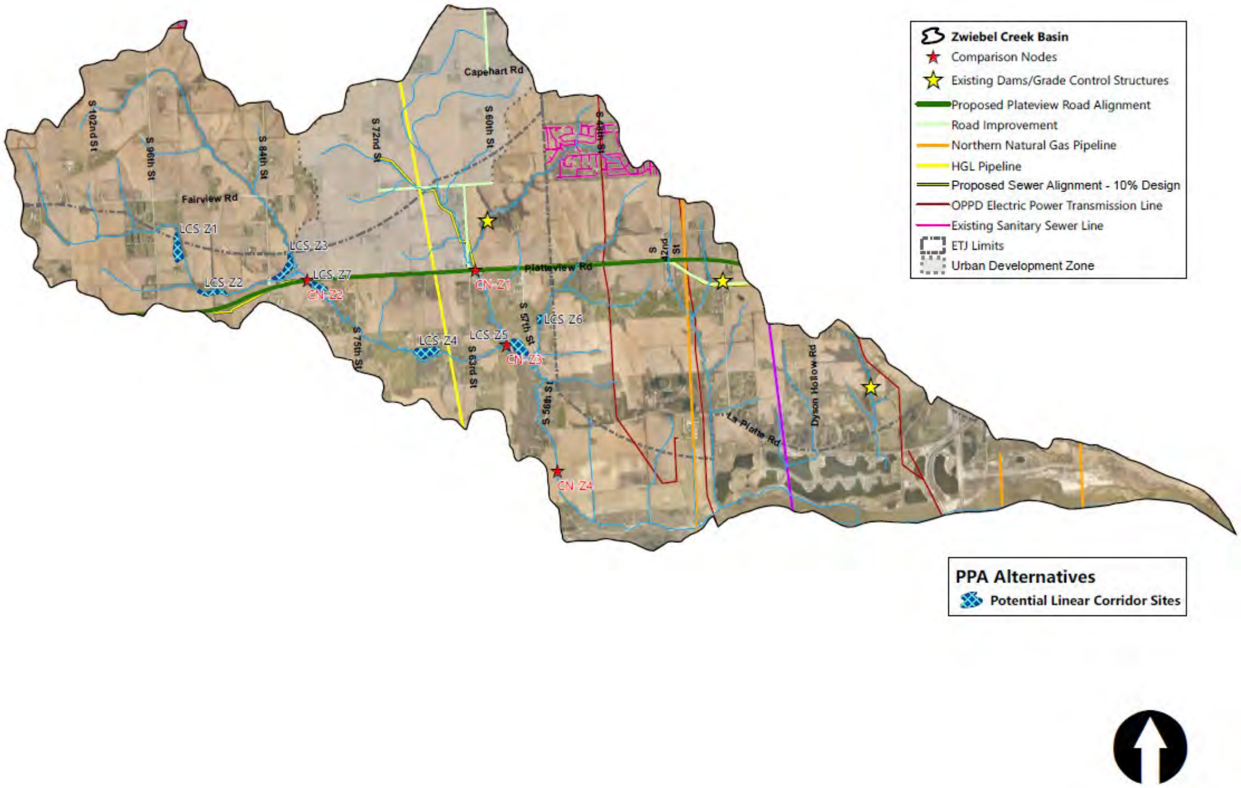
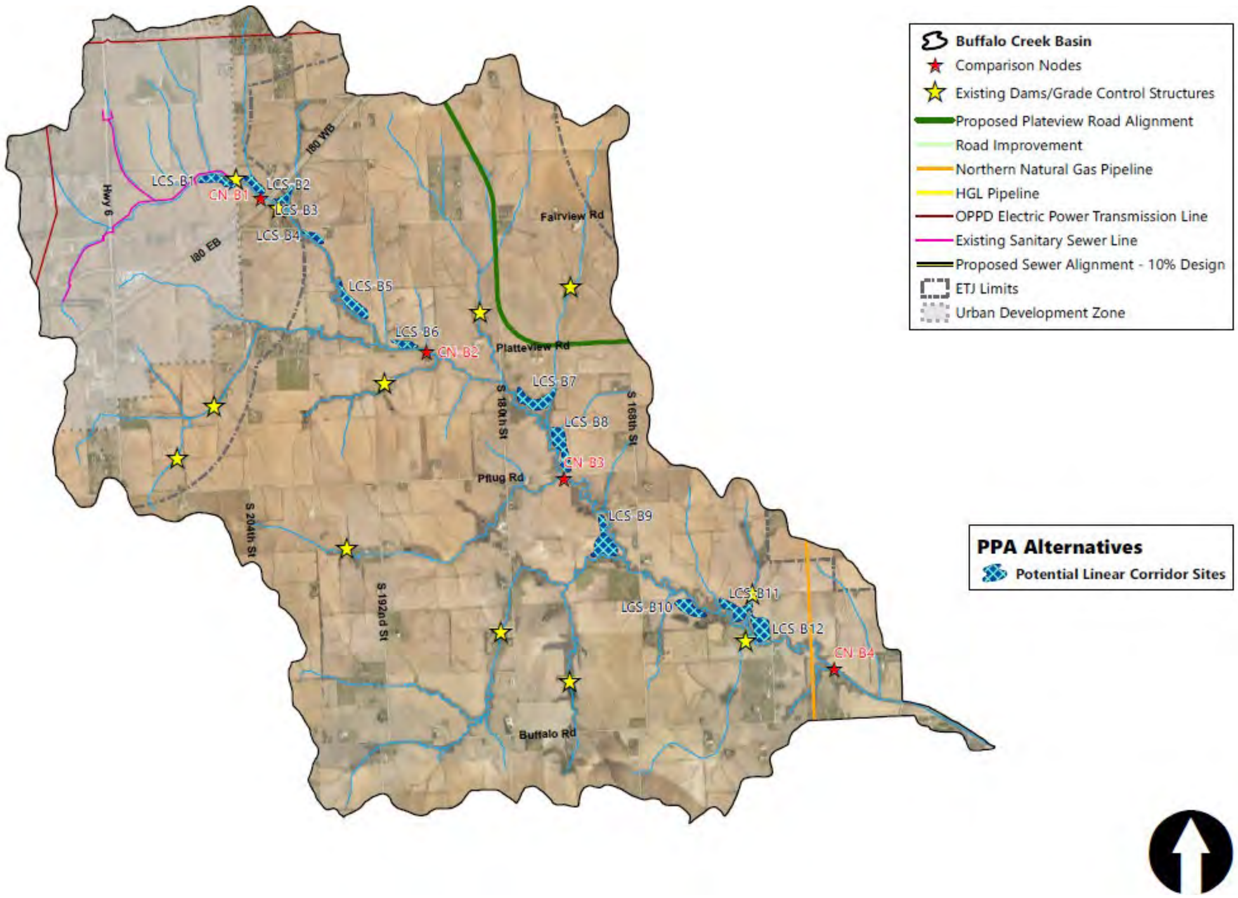


Figure E.12. Buffalo Creek Feasible Linear Corridor Storage Project Locations



Preliminary analysis was performed on the feasible sites to provide perspective on the storage capacity for each individual project and ability to contribute to peak flow reductions. This was a precursory investigation to prioritize the site locations. This determined the preferential order for selecting sites to incorporate into the detailed hydrologic and hydraulic modeling performed to determine the projects required to meet the peak flow management goals (see Section 5.0 Project Selection). Table 6 shows the project site selection order.

Table E.6. Linear Corridor Storage Project Site Selection Order

Priority	Springfield Creek			Zwiebel Creek			Buffalo Creek		
	Site	Storage Basin Volume (acre-ft)	Area (acre)	Site	Storage Basin Volume (acre-ft)	Area (acre)	Site	Storage Basin Volume (acre-ft)	Area (acre)
	LCS-S3	22.3	13	LCS-Z5	43.6	12	LCS-B9	68.9	24
	LCS-S7	11.2	12	LCS-Z2	34.0	12	LCS-B8	60.9	20
High	LCS-S6	7.8	10	LCS-Z1	30.1	10	LCS-B7	41.3	16
	LCS-S5	6.54	9	LCS-Z4	24.0	12	LCS-B2	28.2	10
	LCS-S1*	4.2	6	LCS-Z3	23.6	8	LCS-B1	25.5	11
	LCS-S4*	3.8	8	LCS-Z6	23.2	9	LCS-B11	24.1	14
	LCS-S2*	2.8	4	LCS-Z7	10.0	6	LCS-B12	15.9	14
	LCS-S9*	2.4	6	---	---	---	LCS-B10*	14.2	15
	LCS-S8	2.1	7	---	---	---	LCS-B5	13.2	14
Low	---	---	---	---	---	---	LCS-B3*	13.2	5
	---	---	---	---	---	---	LCS-B6*	7.9	6
	---	---	---	---	---	---	LCS-B4*	4.9	6

**Site not modeled/site specific stage storage not developed; based on area and average depths*

3.3 On-Site Controls

On-site controls would place the requirement the developers to prevent increases to the 100-yr storm event peak flow rates. On-site controls can be implemented though a variety of best management practices that do not need to be defined by this Plan. The developer is required to provide the design documentation during the platting processes that shows on-site controls were designed and sized adequately and will be incorporated into their site during construction.

4.0 PRIORITIZE ALTERNATIVES

A comparison of the alternatives was performed to help prioritize project selection. Projects of each alternative type would be sized/placed in combination to meet the peak flow management goal of preventing 100-yr storm event peak flow increases, so the benefit of each alternative type is the same. Table 7 below shows a qualitative assessment of the resources required for projects of each alternative type in combination to meet the goal. The ratings are based on preliminary assessments of the quantity/size of projects of each alternative type that would be needed to meet the goal.

Table E.7. Peak Flow Management Alternatives Resources Comparison

		Regional Detention	Linear Corridor Storage	On-Site Controls
Resource Requirements	Land requirements	++	+	+++
	Partnership financing and management	+++	++	+
	Construction costs	+++	++	+++
	Operation and maintenance	++	+	+++
	Design and permitting effort	+++	++	++
Symbol	**Description**			
+	Alternative will have minimal resource requirements			
++	Alternative will have moderate resource requirements			
+++	Alternative will have large resource requirements			

Based on the information above, the generalized Project Selection Guidelines were developed to apply to each basin in the watershed. Linear corridor storage projects proved to require the least amount of resources to achieve the same goal and were therefore placed as the top priority to incorporate into models used to select the necessary combination of projects to meet the goals. These will be followed by regional detention projects, and on-site controls will only be required if the feasible project sites identified above in combination cannot meet the goals. This will provide the first version of projects required to meet the goals from a technical standpoint. Partnership input and feedback will be gathered to ensure that local preferences are being met, and modifications can be made accordingly.

Project Selection Guidelines

1. Maximize feasible linear corridor storage opportunities above each comparison node until the 100-yr peak has been mitigated or there are no more feasible locations. Project site selection order identified in Table E.6 is to be followed.

2. Supplement with regional detention projects as needed until the 100-yr peaks are mitigated. Project site selection order identified in Table E.5 is to be followed.

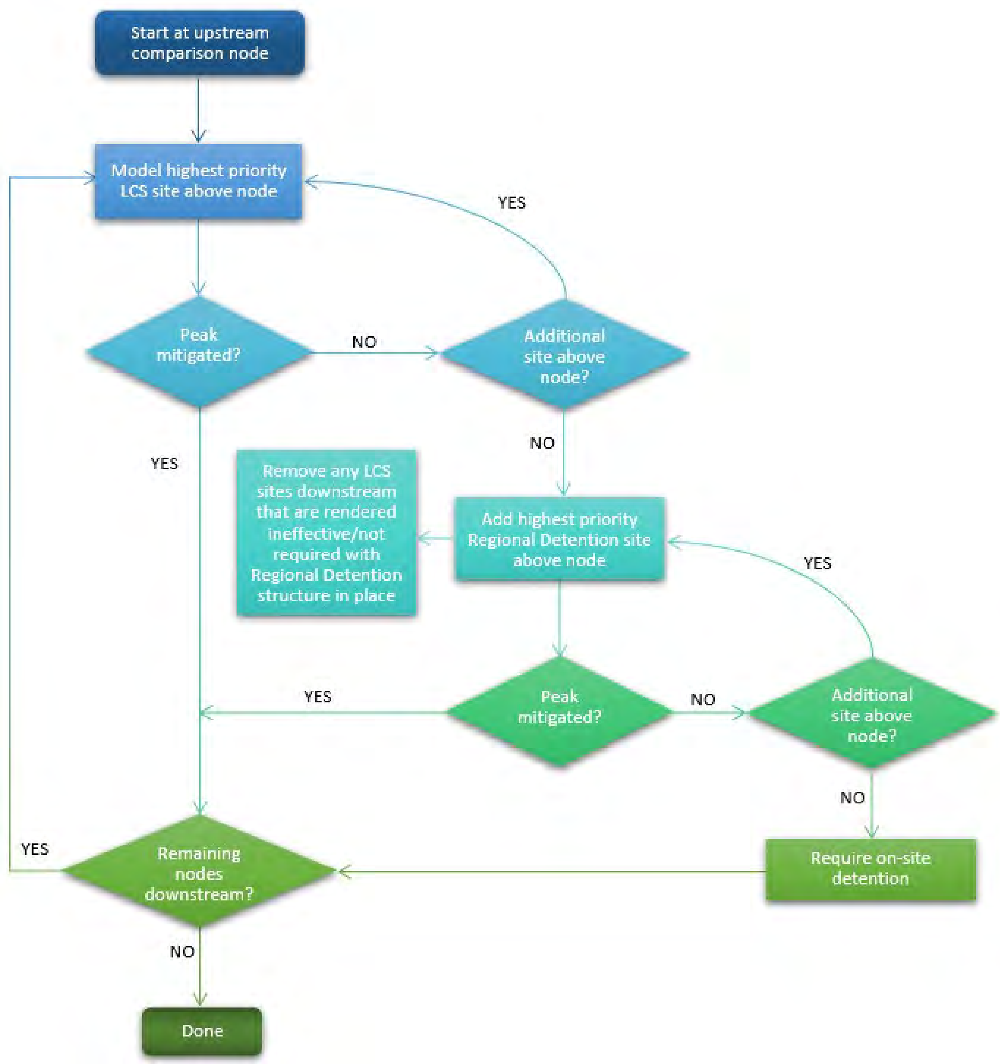
3. If peaks cannot be mitigated by structures, implement on-site controls or detention in the contributing watersheds only.

4. Evaluate Partnership goals and local interests to ensure resulting combination of project sites provide diverse/satisfactory recreation and habitat opportunities.

5.0 PROJECT SELECTION

The Project Selection Guidelines develop in Section 4 were used to guide the hydrologic and hydraulic modeling that determined the most effective combination of Partnership projects to mitigate the peak flow increases from existing to future conditions at each comparison node. The linear corridor storage sites were designed to place the inlet to the diversion channel in strategic locations to ensure sufficient volume is available in the hydrograph to fill the storage cell without requiring overabundant amounts of excavation to achieve the storage capacity. They are highly sensitive to any structures placed in the watershed above that would attenuate/reduce peak flows. It is not feasible to place a linear corridor storage site directly downstream of a regional detention site because of the large attenuations the detention provides. Linear corridor storage sites placed in series often require lowering the inlet elevation (determined during site specific modeling) and a limit to how much the inlet can be reduced was developed to prevent excavation beyond 4 ft depths to achieve the required storage capacity. The flow chart in Figure E.13 was developed to reflect this modeling process.

Figure E.13. Peak Flow Management Modeling Flow Chart



5.1 Springfield Creek

The following is a summary of any site-specific circumstances and results of the modeling effort to select the most effective combination of Partnership projects to mitigate the peak flow increases from existing to future conditions at each comparison node (CN).

CN-S1

- Mitigate peak with two linear corridor sites, LCS-S3 and LCS-S5
    - Lower crest of LCS-S5 one foot from original/individual design to account for attenuation of upstream structure

CN-S2

- Approved plats in place limit project opportunities, no LCS sites available
- SC-9 only partially able to mitigate the peak
- Plats approved under interim watershed agreement that requires on-site detention of 100-yr, assume on-site detention will mitigate remaining peak

CN-S3

- Node partially mitigated with upstream structures
- Added one linear corridor site, LCS-S6
    - Lower crest of LCS-S6 two ft from original/individual design to account for attenuation of two upstream structures
- Still slightly short of full peak mitigation, assume on-site detention of plats approved under interim watershed agreement will mitigate remaining peak

CN-S4

- Mitigate peak with two linear corridor sites, LCS-S7 and LCS-S8
    - Pursue investigations on LCS-S7 that is located within top of dam pool elevation of grade control/low hazard dam. Consider improving existing structure instead of linear corridor site.
- Regional detention option SC-10 would also be an option to mitigate the peak. It would be on/near OPPD solar farm property and adjustments may be needed, but still an option if needed

CN-S5

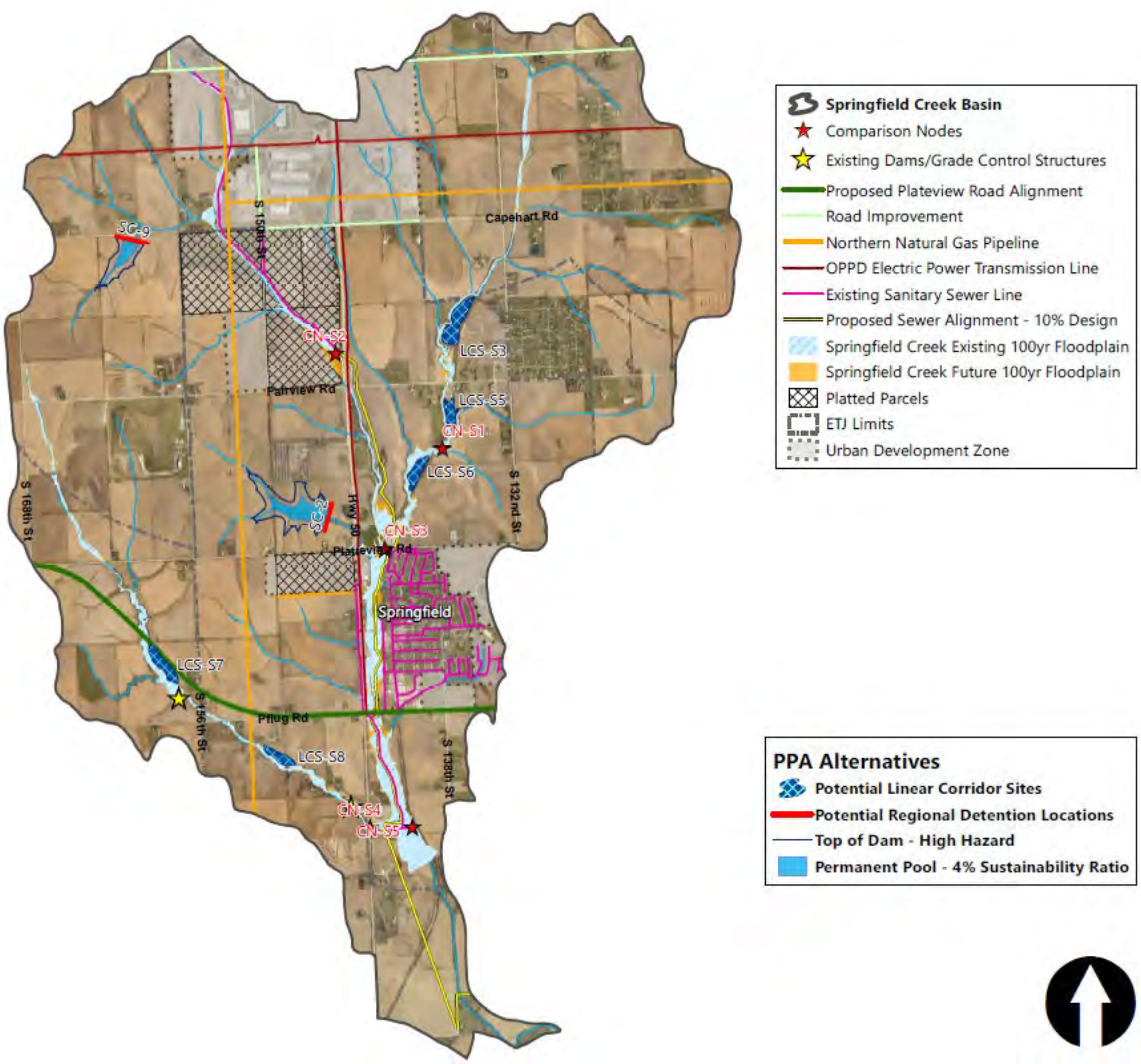
- No more linear corridor sites available
- Although regional detention sites SC-6,7,8 are higher in the Project Site Selection table, these would eliminate the linear corridor sites already placed directly downstream. Able to add SC-2 to finish peak mitigation without removing linear corridor sites

Table E.8. Springfield Creek Peak Flow Mitigation Scenario

	Existing Conditions	Future Conditions		Future + LC-S3,5	Future + LCS-S3,5 and SC-9	Future + LCS-S3,5,6 and SC-9	Future + LCS-S3,5,6,7,8 and SC-9	Future + LCS-S3,5,6,7,8 and SC-2, SC-9
Node ID	Peak Flow (cfs)	Peak Flow (cfs)	Δ from Existing	Peak Mitigated	Peak Mitigated	Peak Mitigated	Peak Mitigated	Peak Mitigated
CN-S1	5,240	6,060	16%	Yes	Yes	Yes	Yes	Yes
CN-S2	3,370	3,960	18%	No	Yes*	Yes*	Yes*	Yes*
CN-S3	9,330	10,980	18%	Partial	Partial	Yes*	Yes*	Yes*
CN-S4	2,400	2,800	17%	No	No	No	Yes	Yes
CN-S5	13,710	16,070	17%	No	Partial	Partial	Partial	Yes

**Peak flow increases aren't fully mitigated by structures; assumed to be handled by on-site controls by plats approved under the interim policies that require 100-yr peak increases to be detained*

Figure E.14. Springfield Creek Peak Flow Mitigation Scenario



5.2 Zwiebel Creek

The following is a summary of any site-specific circumstances and results of the modeling effort to select the most effective combination of Partnership projects to mitigate the peak flow increases from existing to future conditions at each comparison node.

CN-Z1

- No linear corridor storage sites were available above this node
- Peaks were mitigated with ZC-6, the highest priority regional detention site above the node

CN-Z2

- Mitigate with two linear corridor storage sites, LCS-Z1 and LCS-Z3

CN-Z3

- Reductions from ZC-6 carried down past CN-Z1 and also mitigated at this node

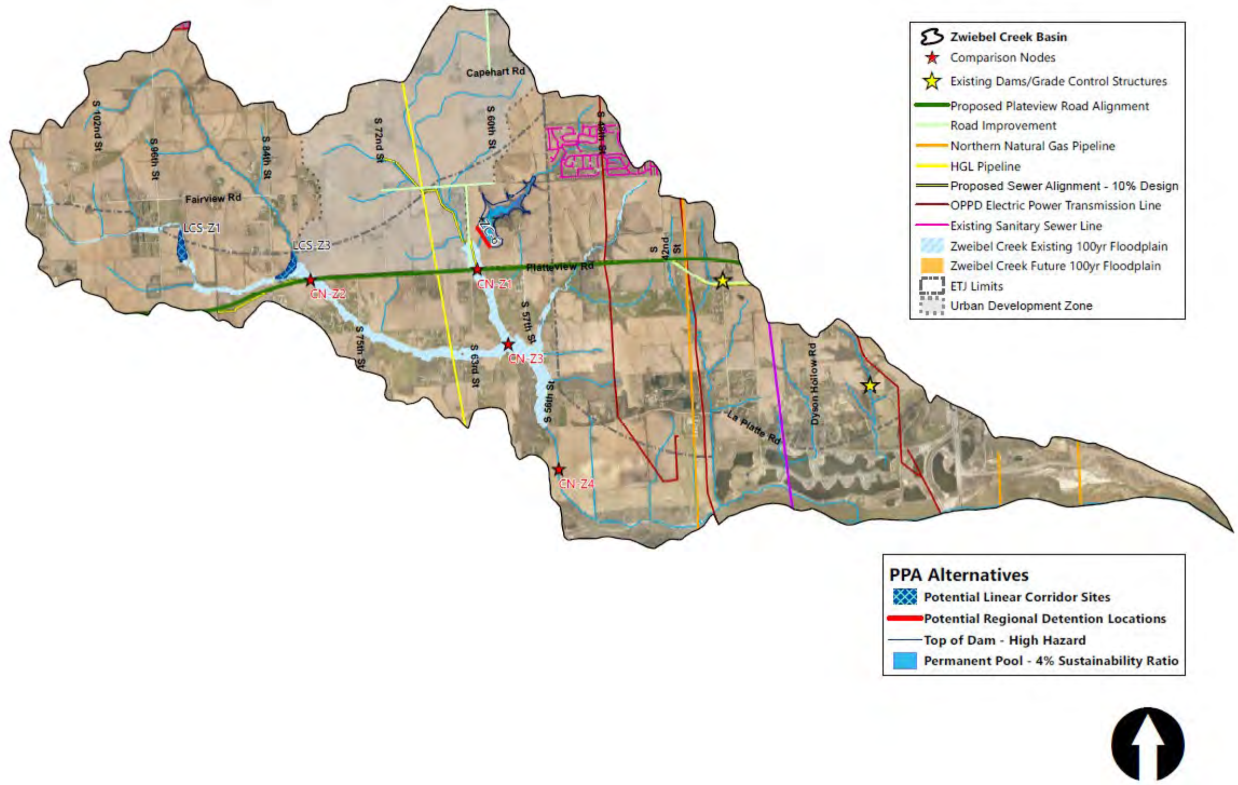
CN-Z4

- Reductions from ZC-6 carried down past CN-Z1 and partially mitigated this node
- Mitigation was complete when the two linear corridor sites above CN-Z2 were added

Table E.9. Zwiebel Creek Peak Flow Mitigation Scenario

Node ID	Existing Conditions	Future Conditions		Future + ZC-6	Future+ ZC-6 and LCS-Z1,3
	Peak Flow (cfs)	Peak Flow (cfs)	Δ from Existing	Peak Mitigated	Peak Mitigated
CN-Z1	4,860	5,740	18%	Yes	Yes
CN-Z2	5,720	6,350	11%	No	Yes
CN-Z3	11,610	12,600	9%	Yes	Yes
CN-Z4	12,850	14,220	11%	Partial	Yes

Figure E.15. Zwiebel Creek Peak Flow Mitigation Scenario



5.3 Buffalo Creek

The following is a summary of any site-specific circumstances and results of the modeling effort to select the most effective combination of Partnership projects to mitigate the peak flow increases from existing to future conditions at each comparison node.

CN-B1

- Peaks were mitigated above this node with two linear corridor sites, LCS-B1 and LCS-B2
  - o Each site required additional excavation to achieve sufficient storage capacity to fully mitigate the peak above and beyond the standard approach to sizing the LCS sites

CN-B2

- Mitigation could not be achieved with all linear corridor sites above this node in combination (LCS-B1 through LCS-B6)
- Regional detention site BC-4 was able to mitigate the peak

CN-B3

- Peaks were partially mitigated from LCS-B1, 2 and regional detention site BC-4
- Adding in LCS-B5, 7 and 8 fully mitigated the peak at this node

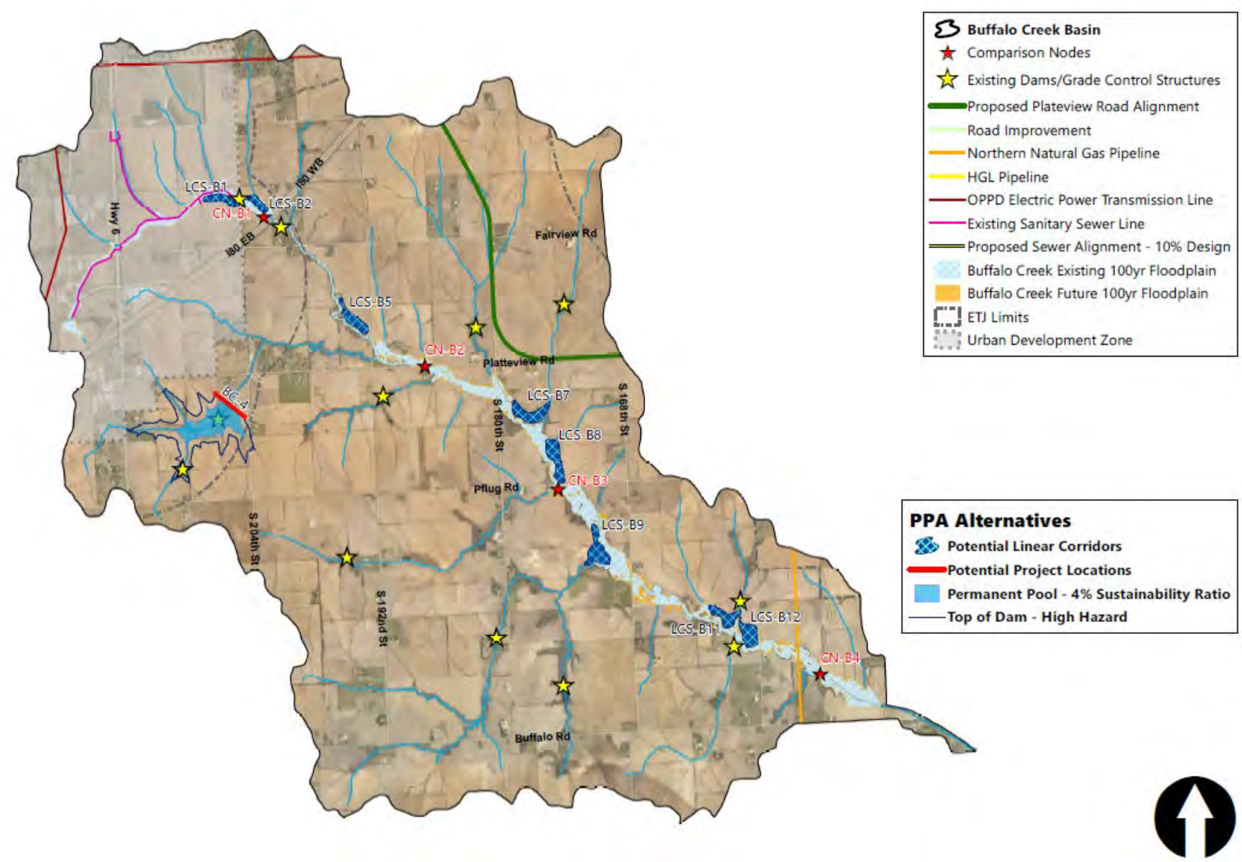
CN-B4

- Peaks were partially mitigated from LCS-B1, 2, 5, 7, 8 and regional detention site BC-4
- Adding in LCS-B9, 11 and 12 fully mitigated the peak at this node

Table E.10. Buffalo Creek Peak Flow Mitigation Scenario

	Existing Conditions	Future Conditions		Future+ LCS-B1,2	Future+ LCS-B1,2 and BC-4	Future+ LCS-B1,2,5,7,8 and BC-4	Future+ LCS-B1,2,5,7,8,9,11, 12, and BC-4
Node ID	Peak Flow (cfs)	Peak Flow (cfs)	Δ from Existing	Peak Mitigated	Peak Mitigated	Peak Mitigated	Peak Mitigated
CN-B1	3,620	4,230	17%	Yes	Yes	Yes	Yes
CN-B2	9,600	11,230	17%	No	Yes	Yes	Yes
CN-B3	16,400	19,330	18%	No	Partial	Yes	Yes
CN-B4	20,980	23,940	14%	No	Partial	Partial	Yes

Figure E.16. Buffalo Creek Peak Flow Mitigation Scenario



5.4 Conclusions

Following the project selection guidelines, the following is a summary of the project sites that would be required to mitigate the peak flow increases from existing to future conditions within each of the studied watersheds.

Table E.11. Required Peak Flow Management Projects

Watershed	Structure Type	Site	Site Area (acre)
Springfield Creek	Regional Detention	SC-2	62
		SC-9	26
	Linear Corridor Storage	LCS-S3	13
		LCS-S5	9
		LCS-S6	10
		LCS-S7	12
		LCS-S8	6
		Springfield Subtotal	**138**
Zwiebel Creek	Regional Detention	ZC-6	92
	Linear Corridor Storage	LCS-Z1	12
		LCS-Z3	12
		Zwiebel Subtotal	**116**
Buffalo Creek	Regional Detention	BC-4	134
	Linear Corridor Storage	LCS-B1	11
		LCS-B2	10
		LCS-B5	14
		LCS-B7	16
		LCS-B8	20
		LCS-B9	24
		LCS-B11	14
		LCS-B12	14
		Buffalo Subtotal	**257**
		Total	**511**

Appendix F. Stream Stability Management

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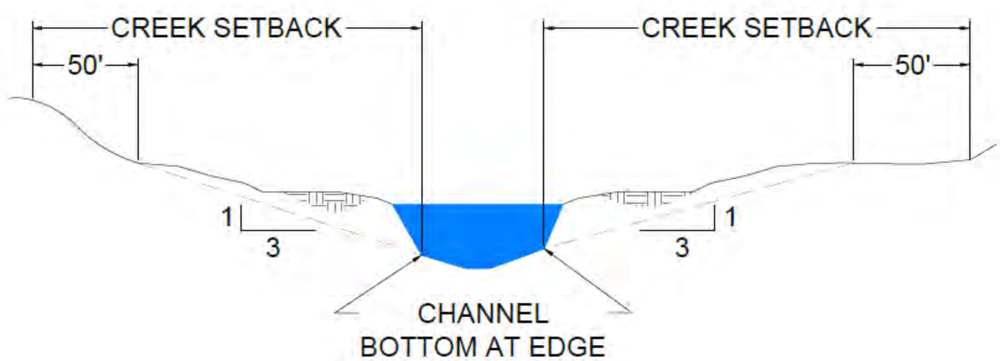
1.0 INTRODUCTION

Streams in southern Sarpy County watershed are experiencing deteriorating stream health as it pertains to water quality, stream stability, and habitat conditions (see Appendix D). Stream conditions vary throughout the Watershed, with a general trend of relatively stable swales and small channels in the headwaters, active stream degradation occurring within the tributaries to the main streams, and active streambed degradation and widening in the main streams. The anticipated development in the watershed is expected to amplify these trends, and degradation and widening will continue to move upstream towards the headwaters. Land development and the associated increase in impervious area will result in an increase in stormwater runoff volume and peak flow rates (see Appendix A). This will lead to an increase in channel velocities and shear stress, causing increased damage to local infrastructure, loss of land, and loss of habitat and stream function. The purpose of this assessment is to understand the potential severity of the collective future stream degradation and widening to and develop recommendations for actions to reduce and mitigate anticipated damages.

1.1 Stream Setback Policy

An interim policy included in the Southern Sarpy Watershed Partnership (Partnership) agreement defines a stream setback to prevent private property boundaries and infrastructure from being constructed too close to the channel to protect against future widening or meandering. The interim policy defines the setback as the distance equal to three (3) times the channel depth plus fifty (50) feet (3:1 plus 50 feet) from the edge of the existing channel bottom on both sides of channel (Figure F.1).

Figure F.1. Interim Policy Stream Setback Definition



Channel depth used to calculate the setback distance is measured at the time the plat is developed and therefore the policy does not account for future degradation. To account for this, the Partnership agrees that if structural stream stability projects (as discussed Sections 2.0 - 5.0 below) are not included as part of this Plan, a final policy would need to be adjusted to include the following additional considerations.

1. Require future degradation estimates to be included in the channel depth variable used to calculate the setback.

2. Installation of structural practices to prevent/minimize degradation and maintain the existing channel grade.

1.2 Future Grade Estimates

To understand the severity of potential future stream degradation, future degraded streambed elevation profiles were developed for the main stems. These were developed utilizing the following methodology.

1. Identify the nearest downstream hardpoint/grade control structure, including the following examples:
   a. Road culverts (does not include bridges without incorporated grade control)
   b. Existing in-stream grade control structures
   c. Planned grade control structures that will be installed for the protection of currently planned future utility crossings
2. Apply an assumed stable slope (see Stream Assessment in Appendix D) upstream of the hard point as the future (degraded) stream grade
3. Cap the maximum bank height at 30 feet; once a 30-foot bank height is reached, the future stream grade mimics the existing streambed slope
4. Reset/end future profile elevations when a subsequent grade control is encountered

Based on local soils data, the depth of highly erodible loess soils is approximately 30 feet, at which point a harder clay material is encountered and degradation is limited. Observations of existing degradation within the developed Papillion Creek watershed show that total bank heights rarely exceed 30 feet. Capping total bank height helps to ensure a realistic future (degraded) stream profile, particularly in the headwaters where degradation would reach 50 to 60 feet without this cap. This assumption and future stream profiles should be revisited during the final design of any structure. It is difficult to predict how long it will take for the future degradation to occur as varying soils, unpredictable climate patterns, and the rate of development ultimately dictate the rate and severity of the degradation.

Below are example stream profiles that display existing grade and estimated future (stable slope) stream profiles for various scenarios. Figure F.2.a shows the future stream profile projected upstream from a aculvert that serves as a downstream hardpoint for grade control. The stable slope diverges from the existing grade, indicating the amount of future anticipated degradation. Figure F.2.b displays the upstream end of this same stream profile, illustrating the extreme potential degradation depths as the stable slope migrates further from the downstream hardpoint and also how the profile is 'reset' to existing conditions at the existing upstream culvert. If the future degradation is allowed to occur, the upstream culvert outlet will be elevated 25 feet above the stream bed. Figure F.2.c shows an example of how a planned grade control structure can protect a future sanitary sewer forcemain at the stream crossing. The Sarpy County and Cities Wastewater Agency is responsible for the installation of this (and all major) sewer lines, and an agreement has been made with the Partnership to install a grade control strucuture at the sewer crossing that will secure the streambed at the existing elevation.

Figure F.2.a. Stream Profile Example (downstream hardpoint)

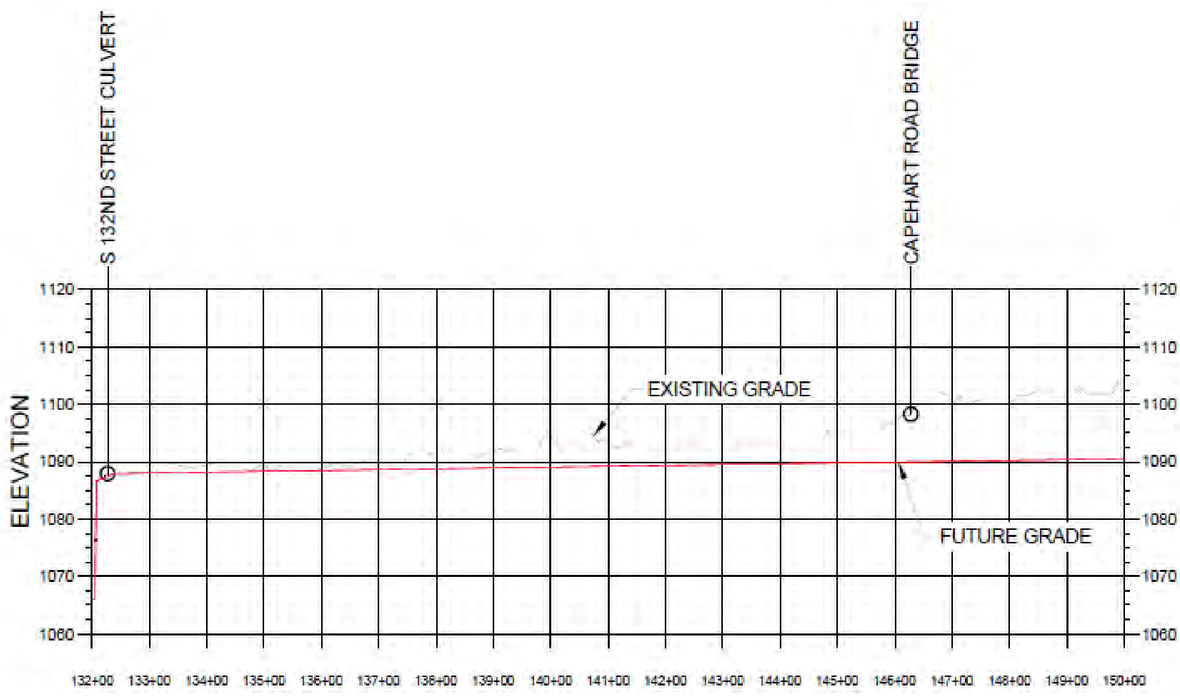


Figure F.2.b. Stream Profile Example (upstream hardpoint)

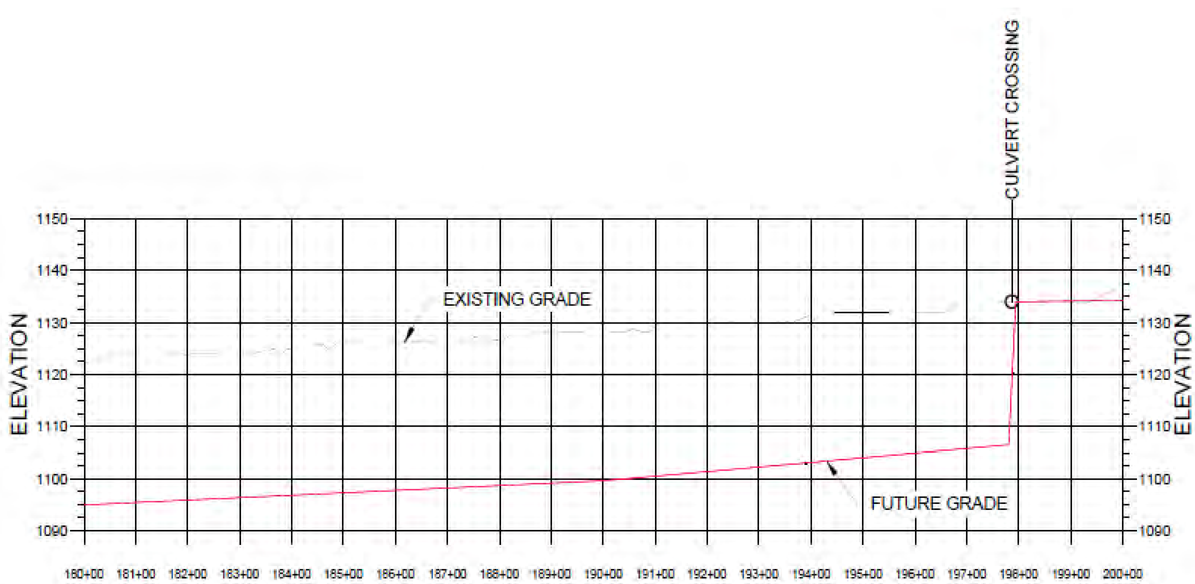
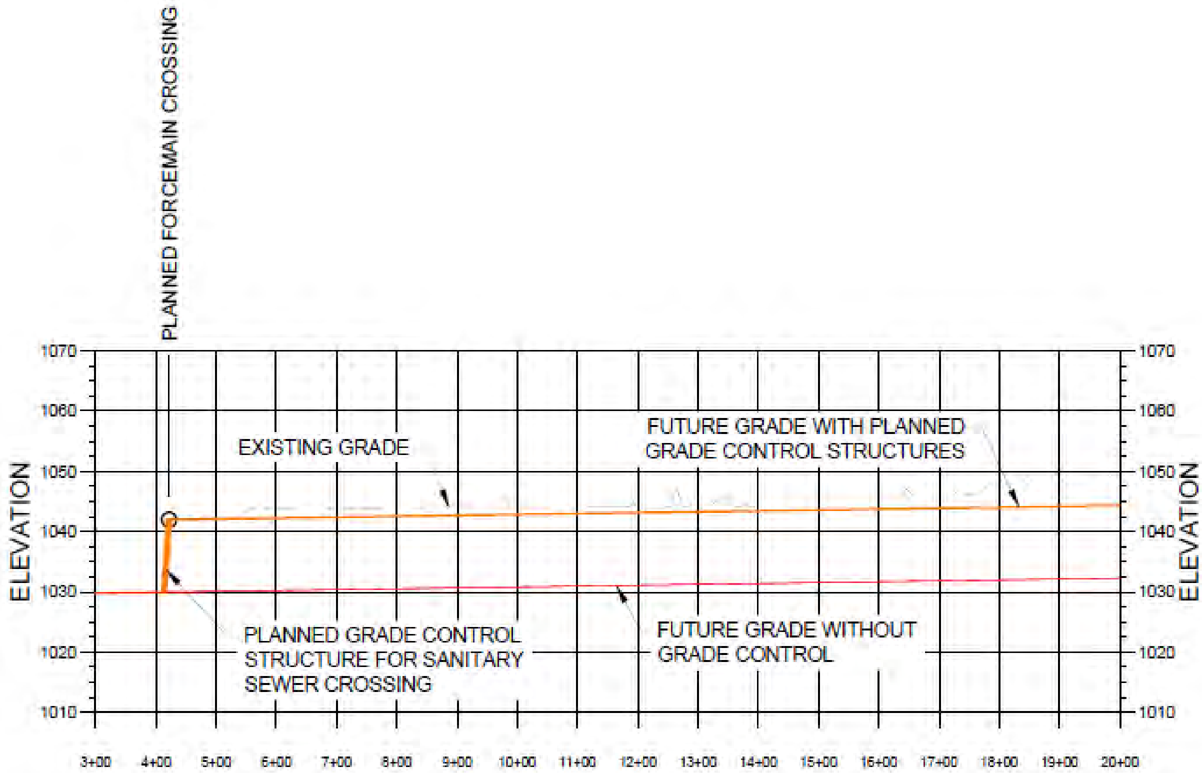


Figure F.2.c. Stream Profile Example with Planned Grade Control Structure



Existing and future profiles were developed along the major streams in the watershed to estimate the severity of anticipated degradation at road crossings and existing utilities without controls. The data in Figures F.3.a-3.c and Tables F.1.a- F.1.c below reflects the potential for damage along the main streams at locations of high priority/consequences if degradation were allowed to occur.

Figure F.3.a. Buffalo Creek Infrastructure and Degradation Map

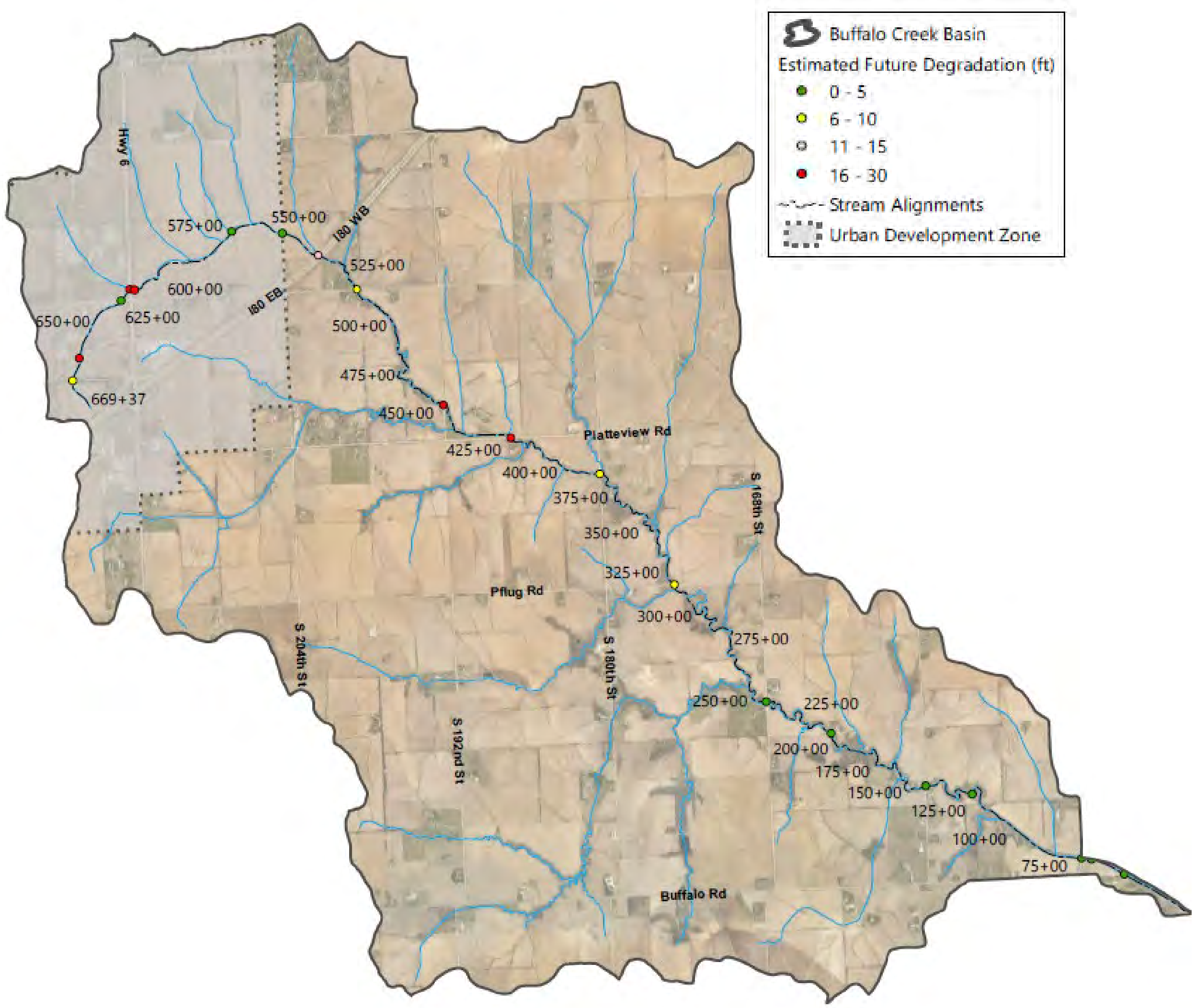


Table F.1.a. Buffalo Creek Infrastructure and Degradation Estimates

Infrastructure Description	Station	Estimated degradation depth at downstream end (ft)
Buffalo Creek		
Buffalo Rd. Bridge	56+14	0
MoPac Trail Bridge	68+53	0
S 144th St. Bridge	71+86	0
Natural Gas Crossing	122+64	1
S 156th St. Bridge	148+49	1
Ruff Rd. Bridge	202+78	2
S 168th St Culvert	243+10	5
Pflug Rd. Bridge	319+88	10
S 180th St. Bridge	383+72	9
Platteview Rd. Bridge	423+62	18
S 192nd St. Bridge	454+26	17
Fairview Rd. Bridge	518+24	9
I-80 RCB Culvert	536+20	11
S 240th St. Culvert	553+00	4
Sanitary Sewer Crossing	572+98	11
Sanitary Sewer Crossing	615+72	29
Hwy 6 RCB Culvert	616+38	29
Fairview Rd. CMP Culvert	622+64	3
Hwy 6 RCB Culvert	649+50	22
Melia Rd. RCB Culvert	656+80	7

Figure F.3.b. Springfield Creek Infrastructure and Degradation Map

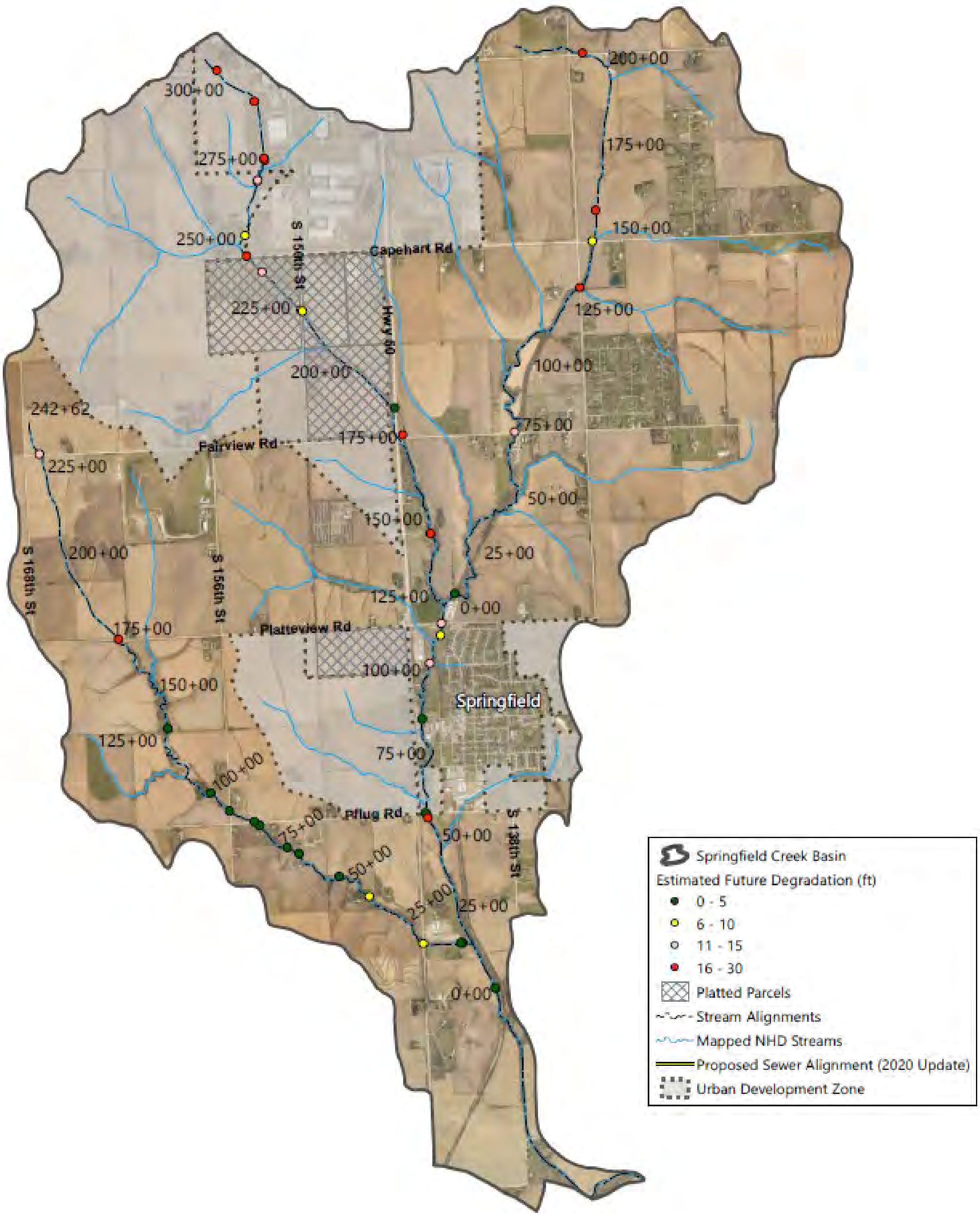


Table F.1.b. Springfield and Turtle Creek Infrastructure and Degradation Estimates

Infrastructure	Station	Estimated degradation depth at downstream end (ft)
Springfield Creek West		
Future Sanitary Sewer Crossing	0+00	12
Future Sanitary Sewer Crossing	55+37	12
Pflug Rd. Bridge	57+00	14
Main St. Bridge	85+71	15
Trail bridge	102+20	15
Platteview Rd. Bridge	115+10	13
Trail bridge	145+10	18
Fairview Rd. RCB Culvert	175+48	21
Hwy 50/144th St. RCB Culvert	185+17	2
150th St. Bridge	223+12	9
Power Pole	222+78	9
Gas Line Crossing	238+66	14
Capehart Rd. RCB Culvert	245+01	16
Private Drive Culvert	251+72	8
Sanitary Sewer Crossing	267+62	11
Gas Line Crossing	268+06	11
Power Pole	274+18	20
Sanitary Sewer Crossing	274+66	21
Gas Line Crossing	291+05	28
Schram Rd. RCP Culvert	304+95	29
Springfield Creek East		
Future Sanitary Sewer Crossing	04+50	15
Fairview Rd. Bridge	72+19	18
132nd St. RCB Culvert	132+62	21
Capehart Rd. Bridge	146+38	9
Gas Line Crossing	155+40	18
Private Drive Culvert	197+90	29
Schram Rd. CMP Culvert	205+57	30
Turtle Creek		
Sanitary Sewer Crossing	3+12	12

Future Sanitary Sewer Crossing	3+70	13
S 144th St. Culvert	14+39	21
Private Drive Culvert	37+65	9
Private Drive Culvert	51+29	2
Private Drive Culvert	67+51	4
Natural Gas Pipeline	71+31	0
Private Drive Culvert	81+80	2
Pflug Rd. Culvert	83+61	4
S 156th St. Bridge	91+75	3
Turtle Creek Reservoir 2	99+40	4
Platteview Rd. Culvert	170+13	17
Fairview Rd. Culvert	228+34	14

Figure F.3.c. Zwiebel Creek Infrastructure and Degradation Map

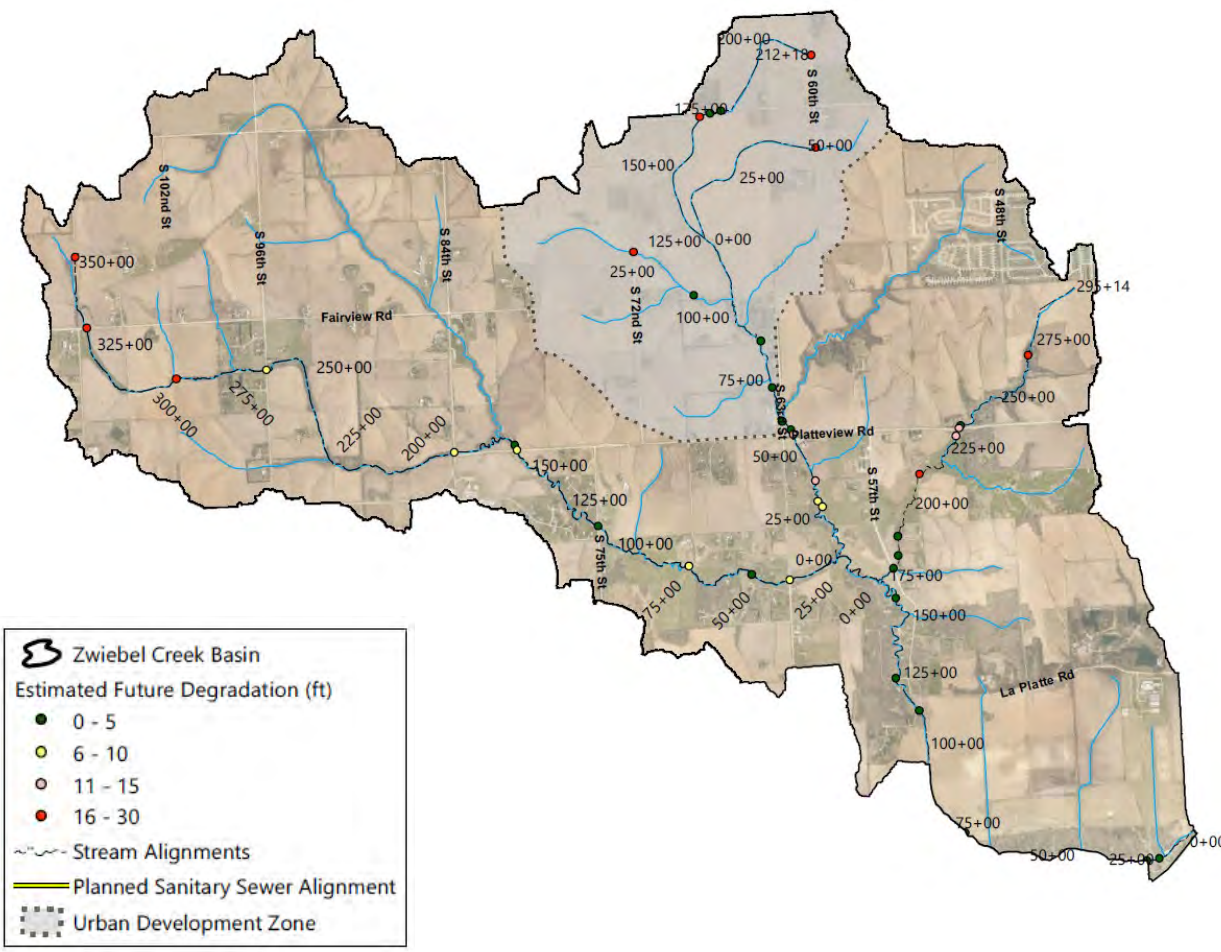


Table F.1.c. Zwiebel Creek Infrastructure and Degradation Estimates

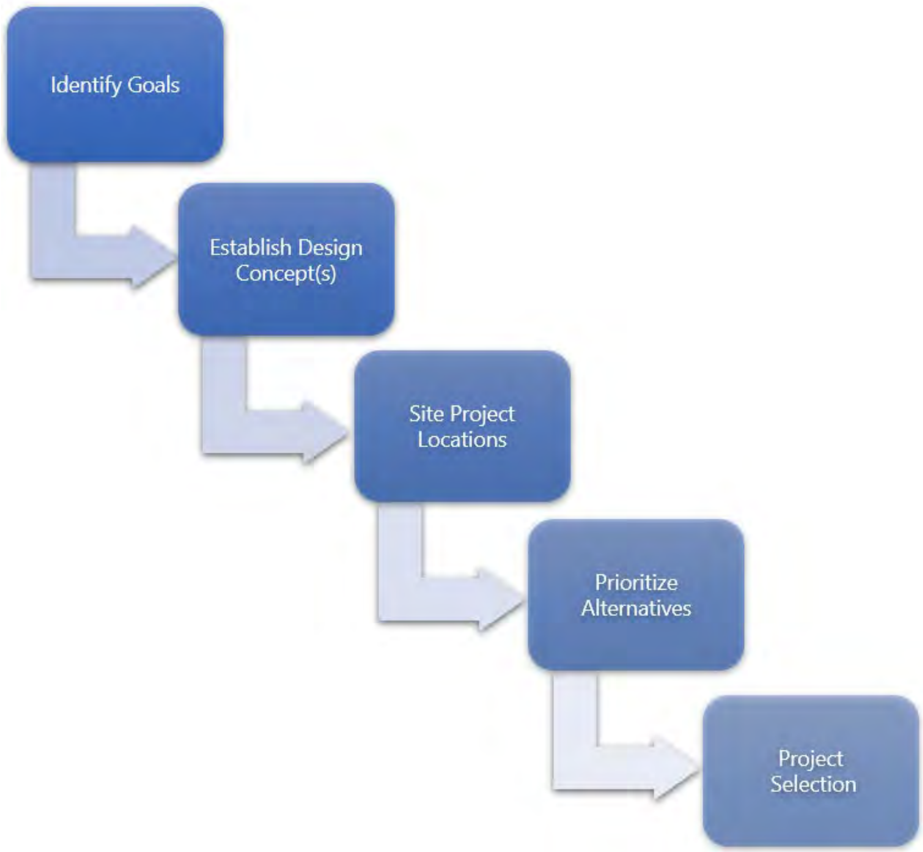
Infrastructure/Improvement	Station	Estimated degradation depth at downstream end (ft)
West Zwiebel Creek		
S 63rd St. Culvert	36+63	9
Trail Bridge	47+75	2
Private Culvert Crossing	72+95	10
S 75th St. Bridge Crossing	107+81	2
Platteview Rd. RCB Culvert	155+22.6	8
Future Sanitary Sewer Crossing	156+66	0
S 84th St. RCB Culvert	182+00	10
S 96th St. Culvert	263+62	24
Trail Bridge	290+64	18
Fairview Rd. Culvert	329+44	28
Sutter Ave. Culvert	350+87	17
North Zwiebel Creek		
Private Drive Bridge	29+74	9
Private Drive Bridge	33+00	9
Private Drive Bridge	41+80	13
Fairview Rd. RCB Culvert	56+67.5	13
Future Sanitary Sewer Crossing	58+25	2
S 84th St. RCB Culvert	61+58	2
Future Sanitary Sewer Crossing	72+58	2
Private Drive Bridge	87+34	6
Capehart Rd. Culvert	165+96	26
S 67th St. Culvert	169+13	0
Capehart Rd. Culvert	172+13	0
County Road 91 Culvert	211+76	30
East Zwiebel Creek		
Natural Gas Pipeline	9+49	0
Private Drive Bridge	13+12	0

Private Drive Bridge	70+11	0
Merrill Mission Rd. Bridge	109+66	0
Riverview Forest Rd. Bridge	122+69	0
Private Drive Bridge	157+80	0
S 57th St. Culvert	178+79	4
Private Drive Bridge	182+90	1
Private Drive Culvert	188+49	2
Private Drive Culvert	209+60	19
Private Drive Bridge	229+93	11
Platteview Rd. Culvert	232+26	13
Future Sanitary Sewer Crossing	233+29	0
Local Embankment/Pond	270+15	23

1.3 Projects Assessment

Active coordination occurred with the Partnership to understand the structural project alternatives available for stream stability management throughout the development of this Plan. The graphic in Figure F.4 shows the process developed for the analysis in each of the three basins (Buffalo Creek, Springfield Creek, and Zwiebel Creek).

Figure F.4. Project Assessment Process



2.0 IDENTIFY GOALS

Setting clear and common goals across the watershed was desired to ensure that structural projects would provide a similar level of protection throughout the different subbasins. The goals below guided the design requirements and placement of potential projects.

1. Provide protection for stream segments with drainage areas up to 0.5 mi^2 that are anticipated to experience future degradation as depicted in Figure F.5.a- F.5.c.

2. Maintain future stream bed elevations near the existing grade. Limit future degradation that would lead to:
   - Damage to infrastructure
   - Bank failure/stream widening and resulting loss of land
   - Reduction of habitat and floodplain connectivity

3. Stabilize streambanks where existing infrastructure is within the defined stream setback area and cannot be protected by a stream setback policy.

Figure F.5.a. Buffalo Creek Stream Stability Protection Locations Map

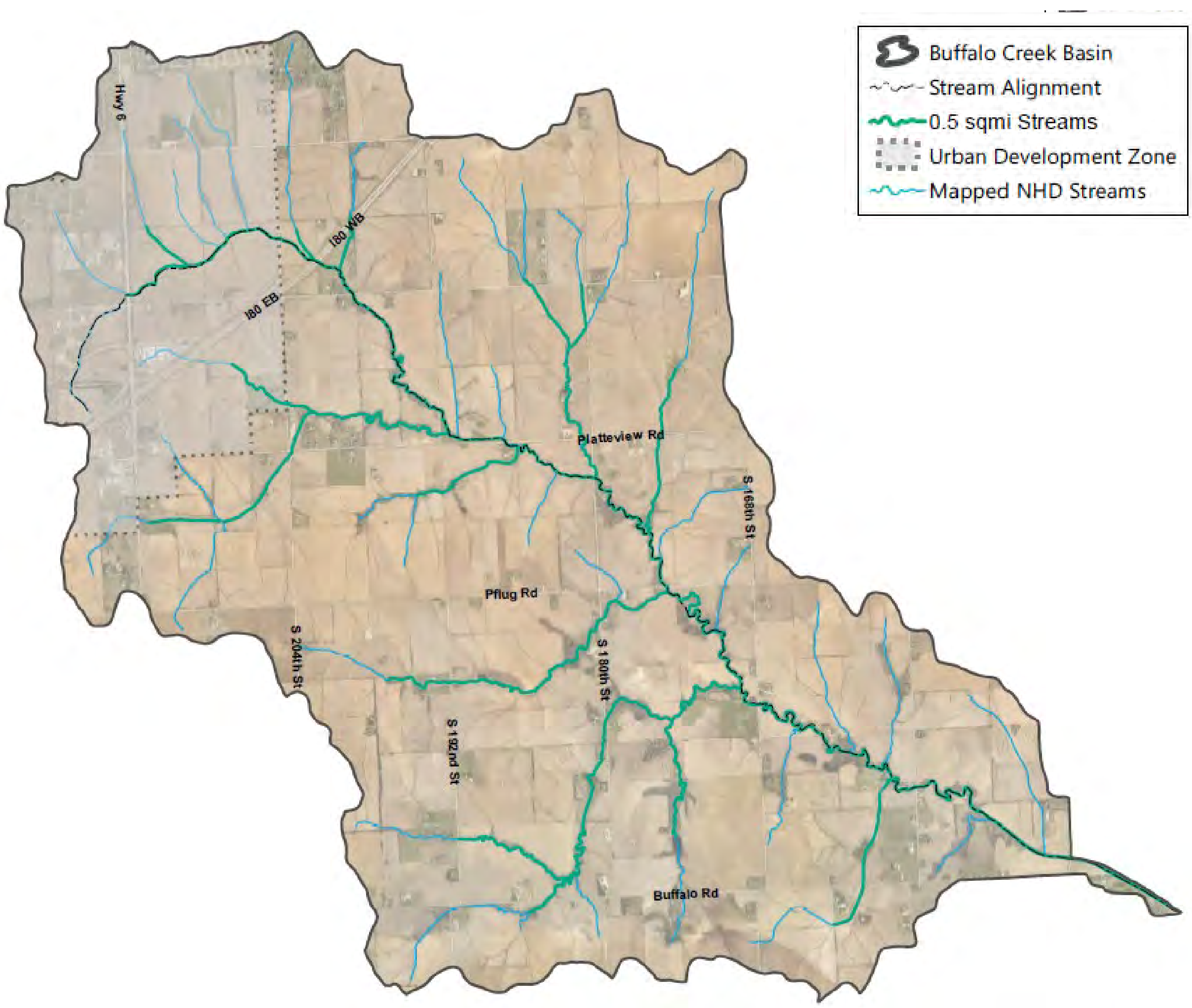


Figure F.5.b. Springfield Creek Stream Stability Protection Locations Map

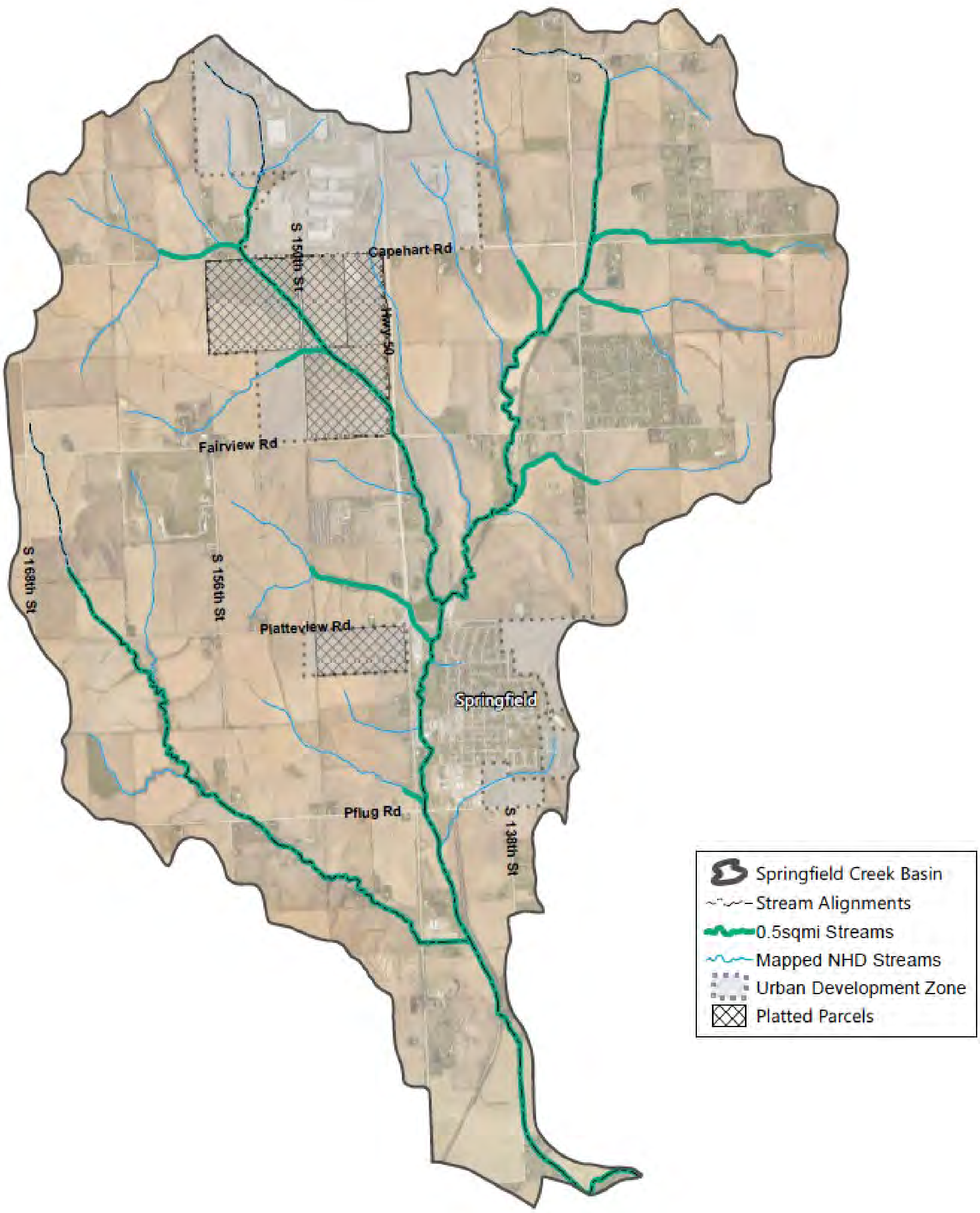
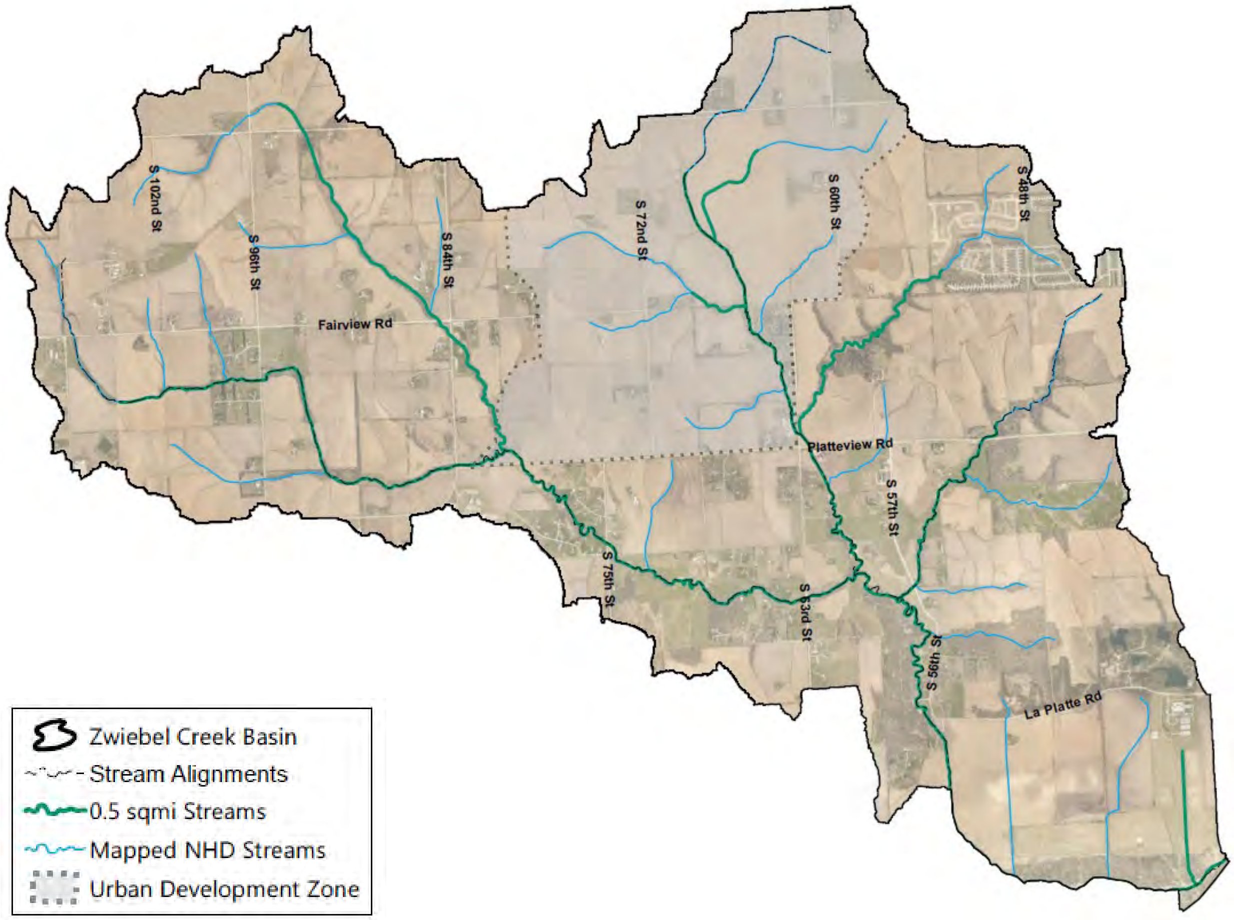


Figure F.5.c. Zwiebel Creek Stream Stability Protection Locations Map



Substantial degradation and erosion have occurred in portions of the streams throughout the watersheds (see Appendix D - Stream Assessment for existing conditions). However, stream restoration and habitat improvements were not identified as specific goals for this planning effort. The Partnership is focused on preventing degrading conditions resulting from development and full-scale stream restoration is beyond that effort and the defined goals of the Partnership. Ancillary stream health and habitat benefits will occur with the identified stream improvements within this Plan and further stream restoration activities may be managed by individual agencies or if additional funding becomes available.

3.0 DESIGN CONCEPTS

3.1 Grade Control

Rock ramp grade control design details were developed for a structure that will pin the stream grade at the existing bed elevation on the upstream end (Figure F.6.a- F.6.c). The concept is to place rock level with the stream bed that will launch into a gently sloped rock riffle as channel incision encroaches from the downstream end (also known as headcut progression). This prevention technique is relatively easy to implement at current stream grade. The structures are sized to protect against a 4-foot headcut progression and to launch with a resulting (average) rock ramp slope of 15:1. This will not prevent all degradation along the entire stream bed, but it will limit the degradation to less than 4 feet dependent on the distance upstream of each hard point. Final sizing and design of each structure prior to implementation will be required to ensure the dimensions and rock size will create stable conditions under peak flow conditions. A grade control design guidance document was also developed and is included in Appendix J.

Figure F.6.a. Rock Ramp Grade Control - Plan and Profile

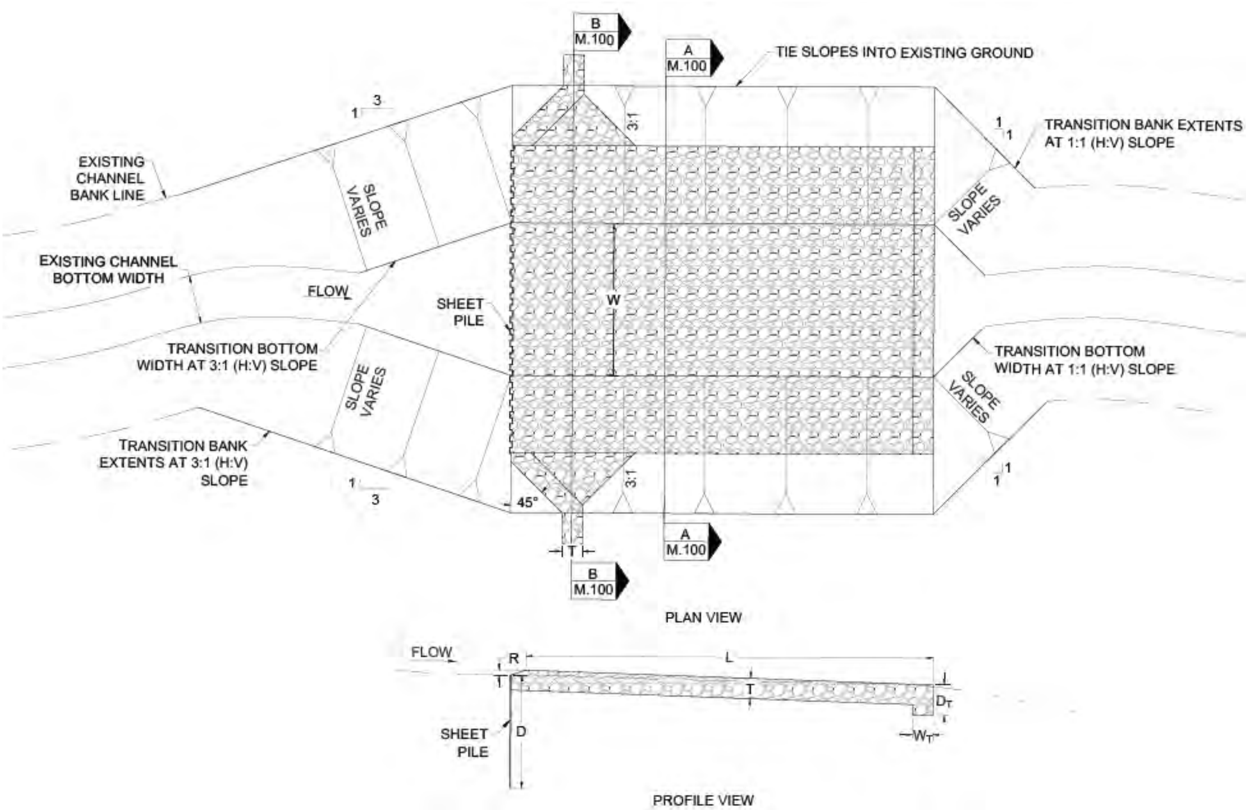


Figure F.6.b. Rock Ramp Grade Control – Typical Cross Section

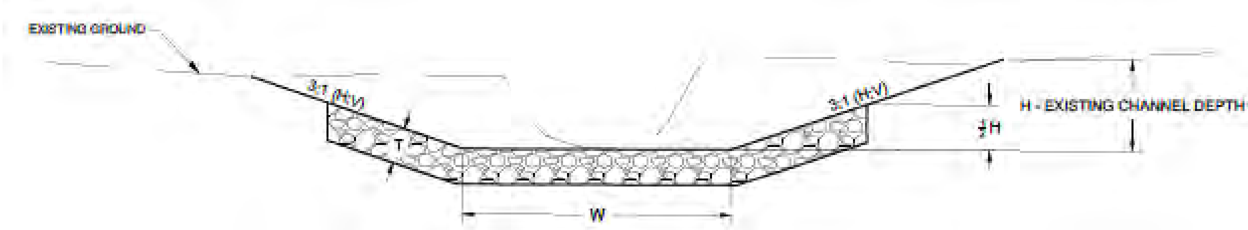


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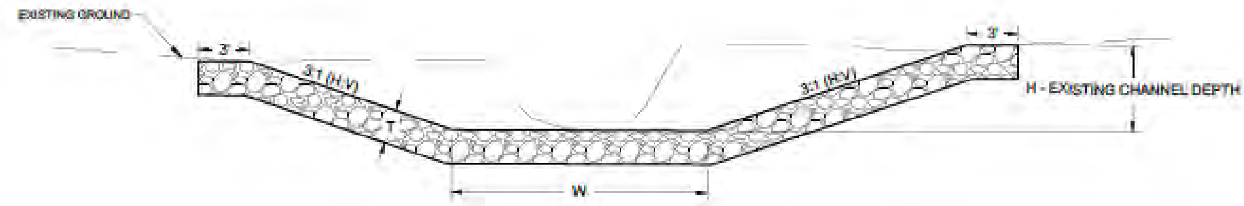
Figure F.6.c. Rock Ramp Grade Control – Upstream Sill Cross Section



3.2 Bank Protection

Locations along the identified streams where existing infrastructure is at risk from future stream widening will receive bank stabilization. Two bank stabilization concepts were developed for planning purposes. If it is determined during final design that practices requiring less hard armoring provide sufficient stabilization, these should be considered. The typical bank stabilization concept depicted in Figure F.7.a should be applied where there is sufficient area for the required grading without conflicts. In locations where space is limited, a vertical wall design would be required to stabilize the banks without encroaching on existing infrastructure or private lands (see Figure F.7.b). This method is more expensive and results in greater permitting challenges and should therefore only be used if necessary. If alternative approaches are identified during final design that can reduce space limitations, those should be investigated.

Figure F.7.a. Bank Stabilization – Typical Cross Section

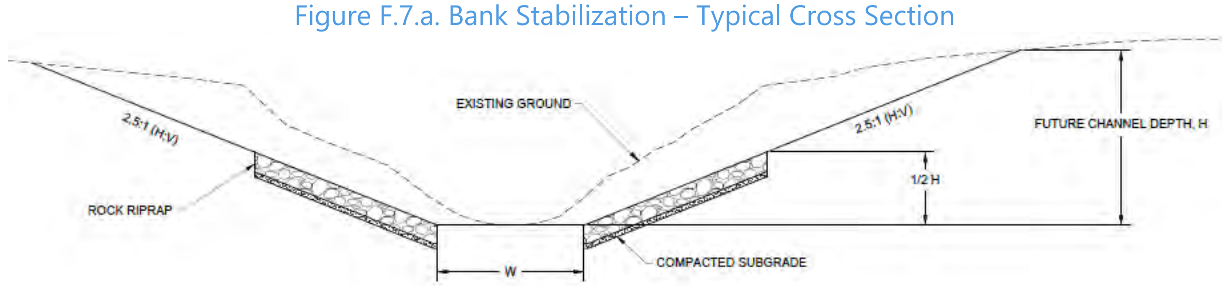
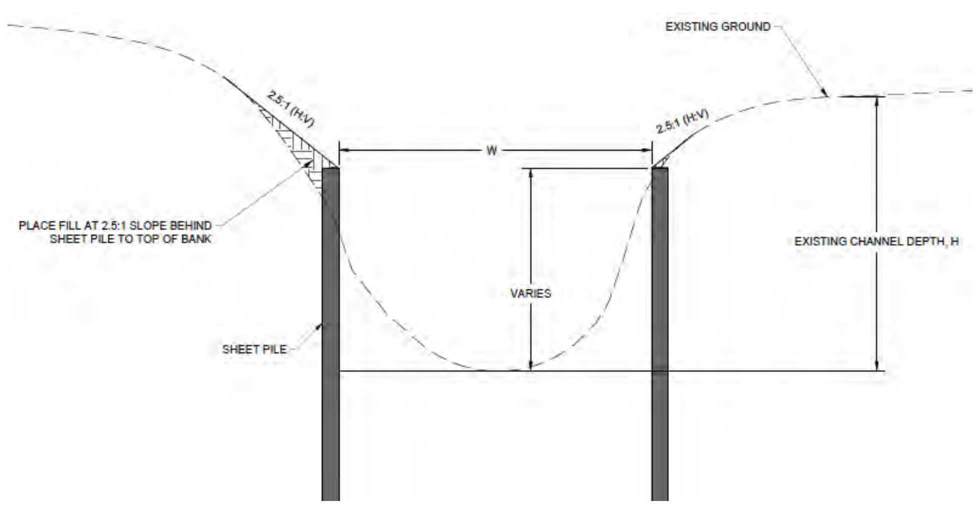


Figure 7.b. Bank Stabilization - Space Limitations Cross Section

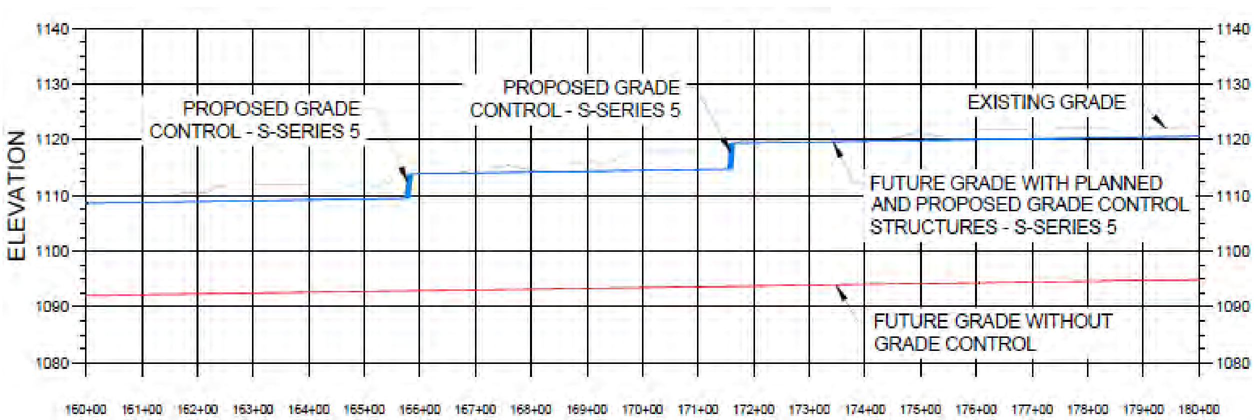


4.0 SITING PROJECT LOCATIONS

4.1 Grade Control

Structural grade control locations were identified utilizing the rock ramp design concepts, existing stream profiles, future (stable) stream slope, and existing and planned grade control/hardpoint locations as identified in Section 1.2 above. The process begins at a downstream hardpoint and projects the future (stable) stream slope upstream until there is a 4-foot difference in elevation from the existing stream grade to the future stream grade, where a grade control structure is placed. The future stable grade is 'reset' at that location and the process is continued throughout the stream reach. Figure F.8 illustrates how grade control structures are located. It should be noted that these structures are dependent upon one another and cannot be placed individually; each downstream grade control provides the hardpoint for the next structure upstream in the series.

Figure F.8. Grade Controls on Stream Profile Example



Grade control structures were located along the main stems previously identified as stream alignments in Figures F.5.a- F.5.c. The structures between two existing hardpoints that are dependent upon one another were grouped into a series with an assigned number, as shown in Figures F.9.a- F.9.c. This analysis was only performed on the main stem stream alignments and did not include all tributaries within the 0.5 mi^2 threshold identified in Figures F.5.a- F.5.c. Cost estimates (presented in Section 9 of the Plan) for the tributaries were extrapolated based on results for segments on the main stem with similar characteristics. Placement of grade control structures will need to be modified in the future as development-driven grade control is implemented (culverts, bridges with grade control, sewer crossings, etc.). One evaluation of a platted property within the watershed identified grade controls were reduced by 30% once the road locations and associated drainage structures were placed. This will need to be coordinated and accounted for at each site during final design of a grade control series within a platted development. Additionally, all stream crossing designs should consider downstream headcut advancement.

Figure 9.a. Buffalo Creek Watershed Main Stem Grade Control Locations

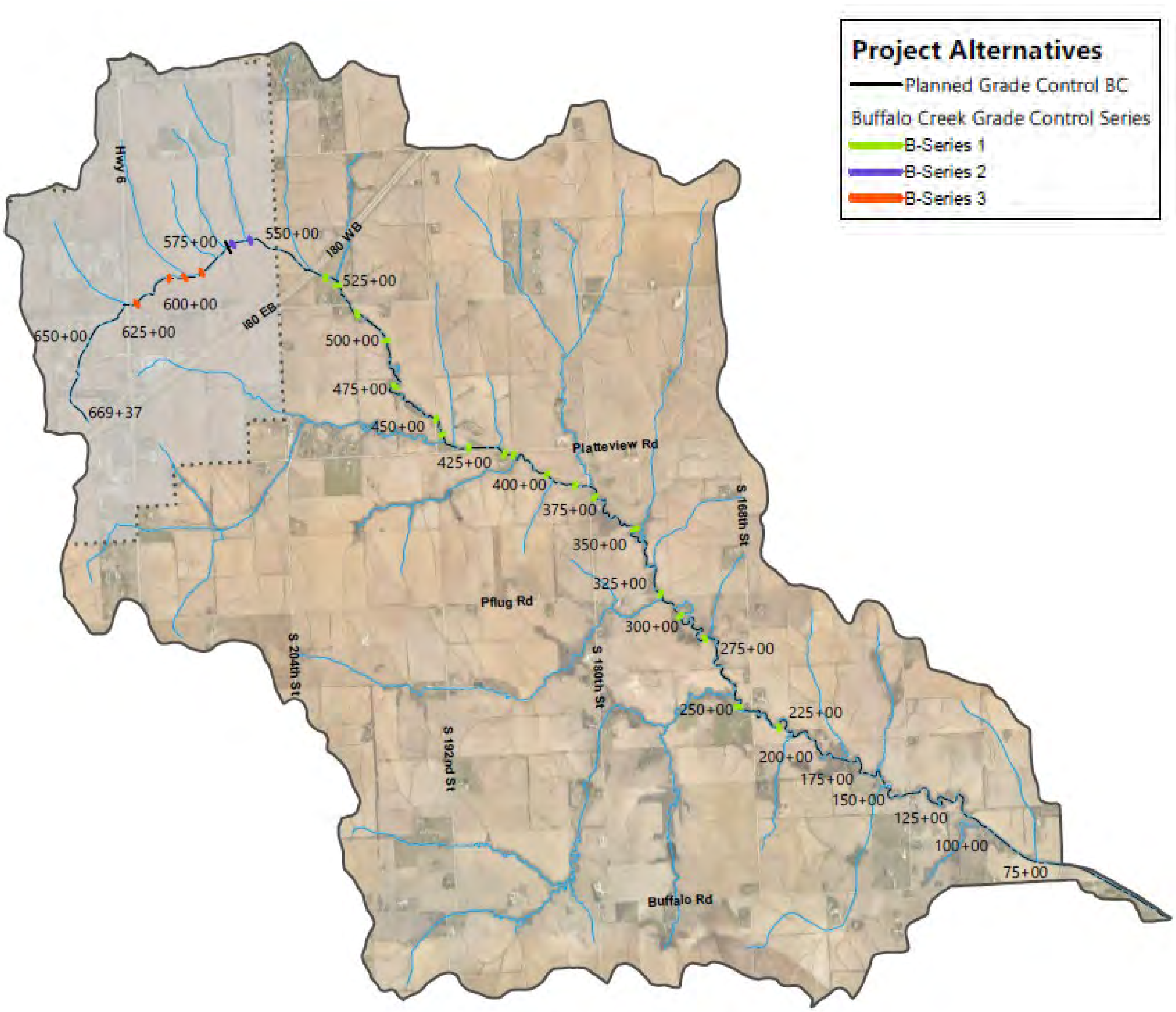


Figure 9.b. Springfield Creek Watershed Main Stem Grade Control Locations

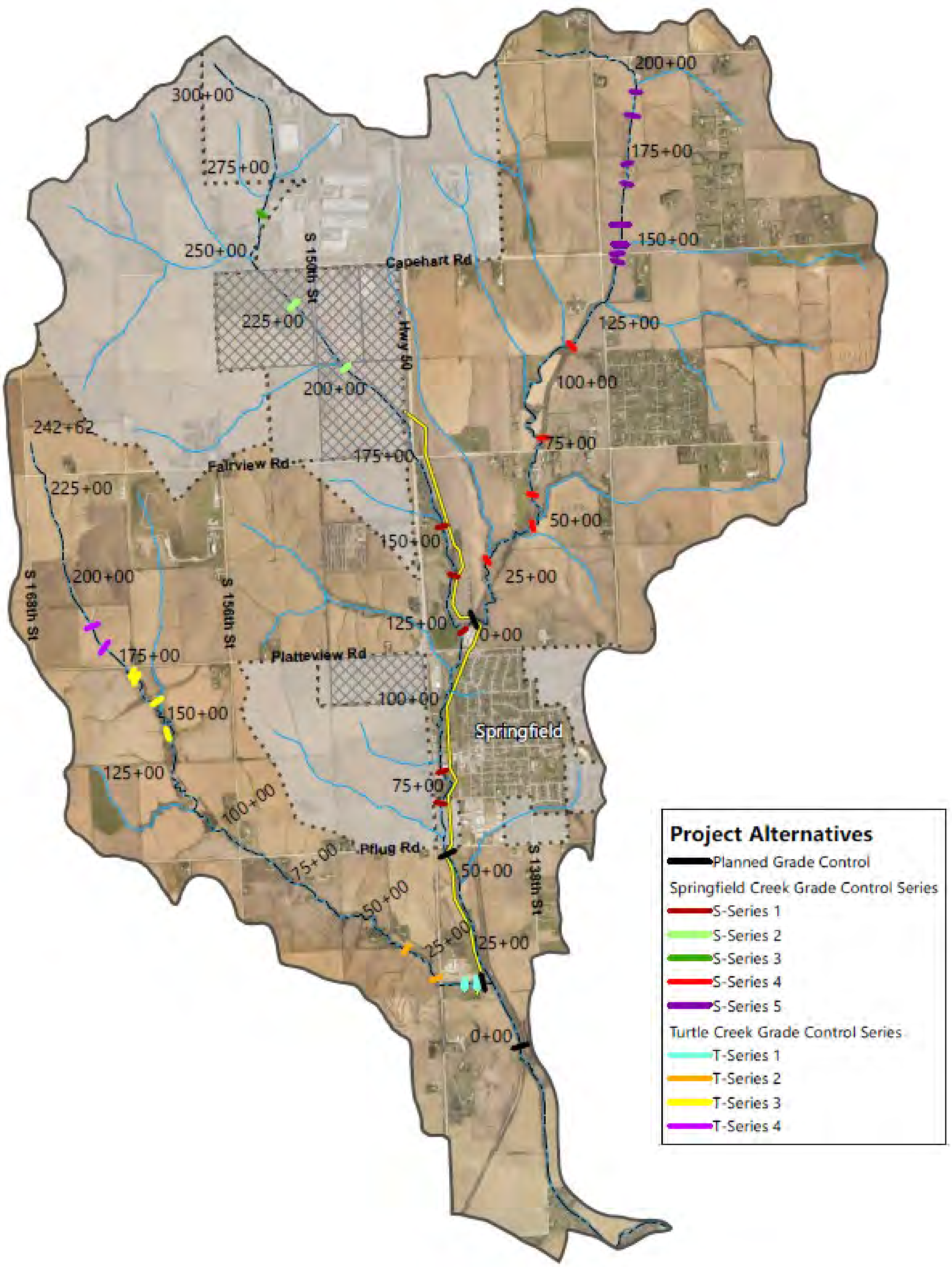
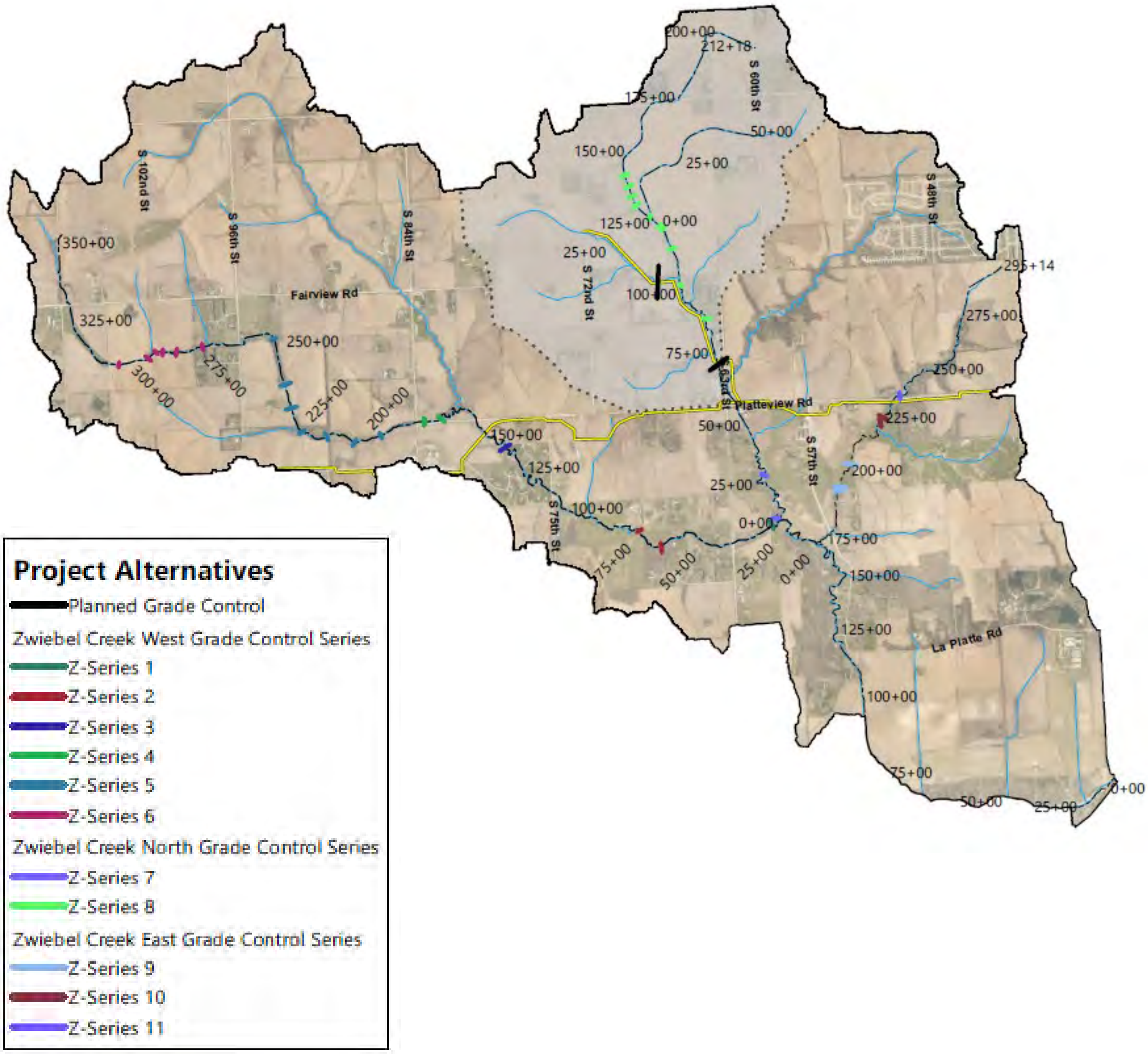


Figure 9.c. Zwiebel Creek Watershed Main Stem Grade Control Locations



4.2 Bank Protection

Aerial assessments and on-site investigations identified one continuous stream segment on Springfield Creek through the City of Springfield where several infrastructure and improvements are located within the defined stream setback. Property at risk through this segment is documented in Figure F.9. Bank stabilization on the segment depicted in Figure F.10 is recommended to be incorporated as part of this Plan.

Figure F.9. Infrastructure and Improvements within Existing Springfield Creek Setback Area

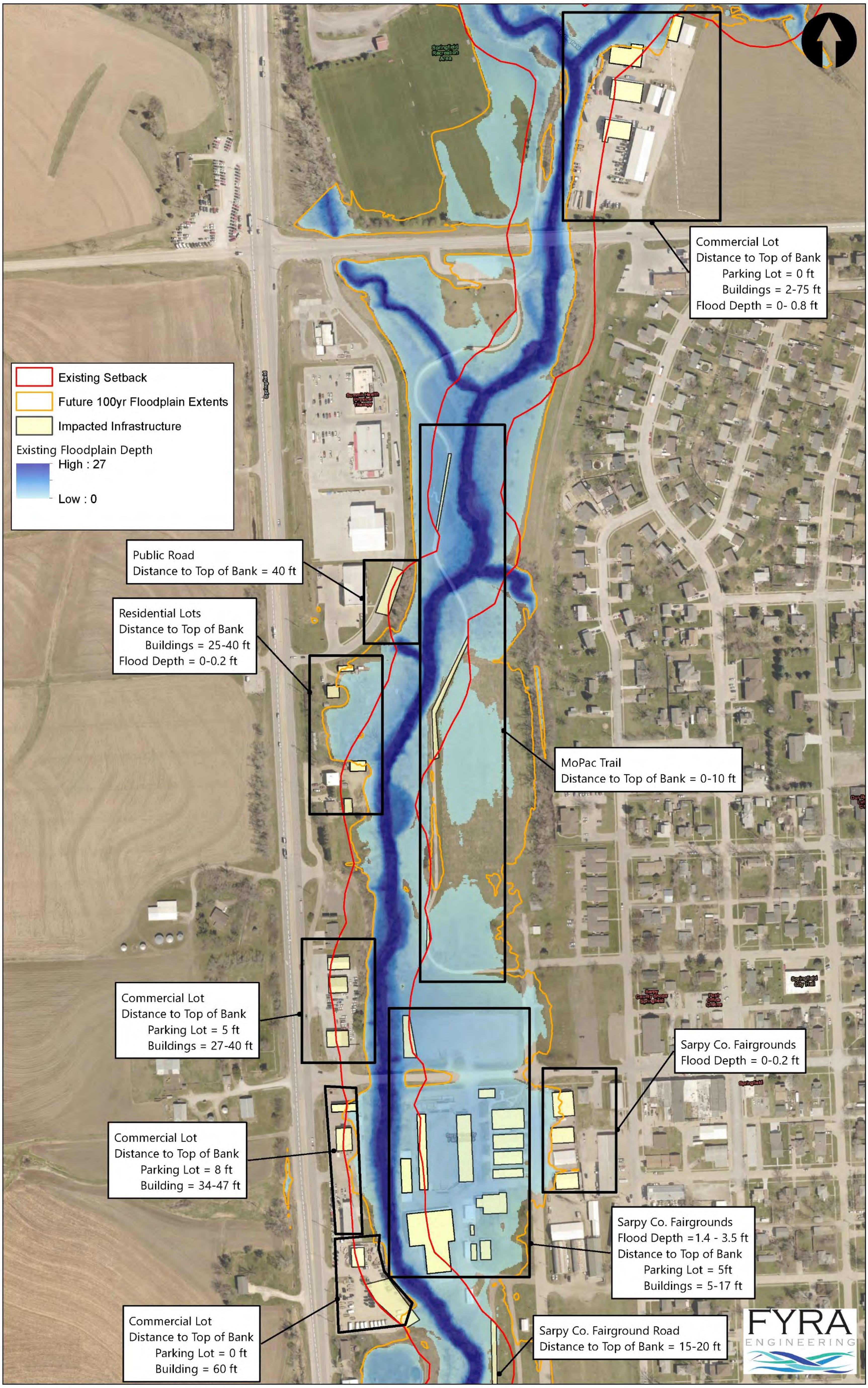
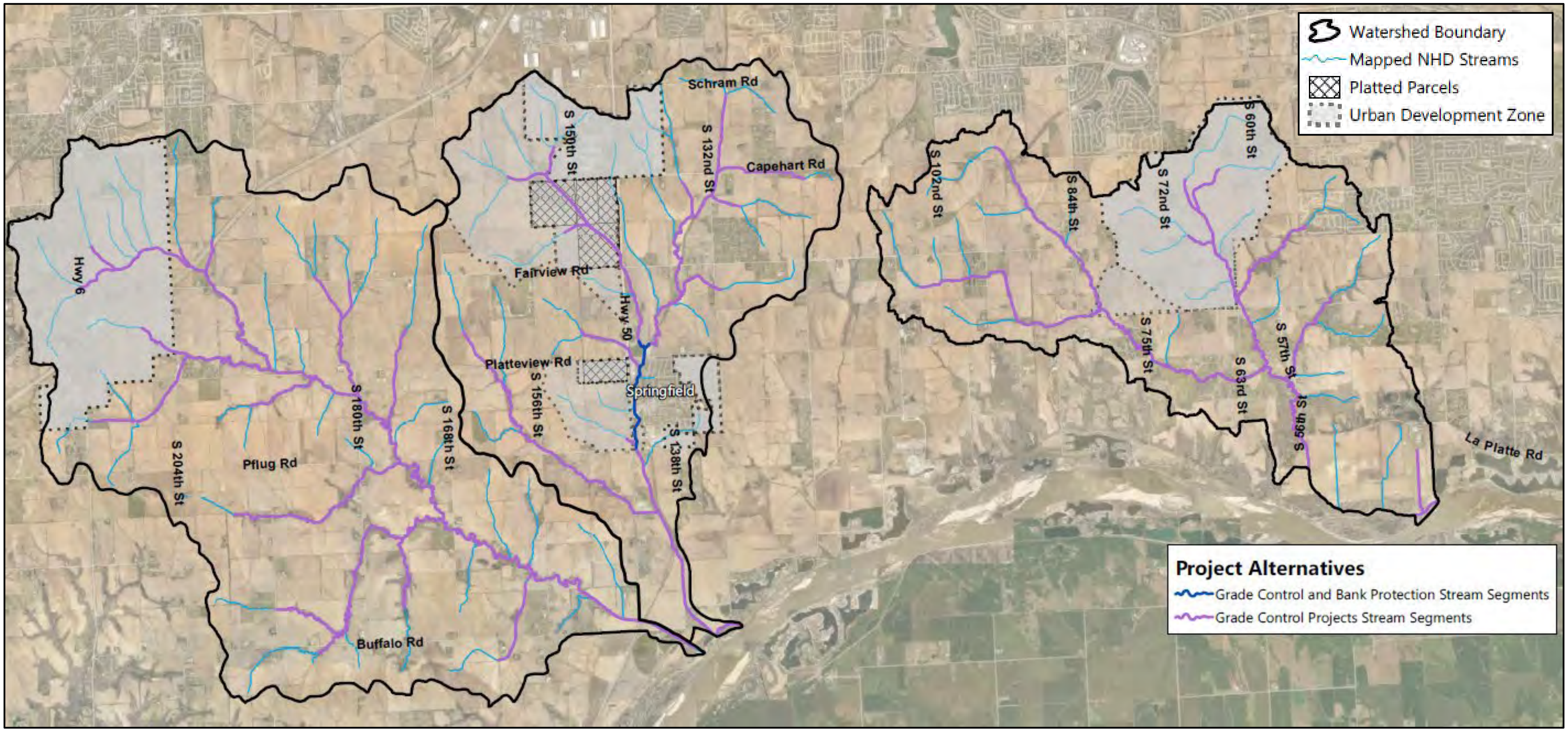


Figure F.10. Springfield Creek Bank Stabilization Location

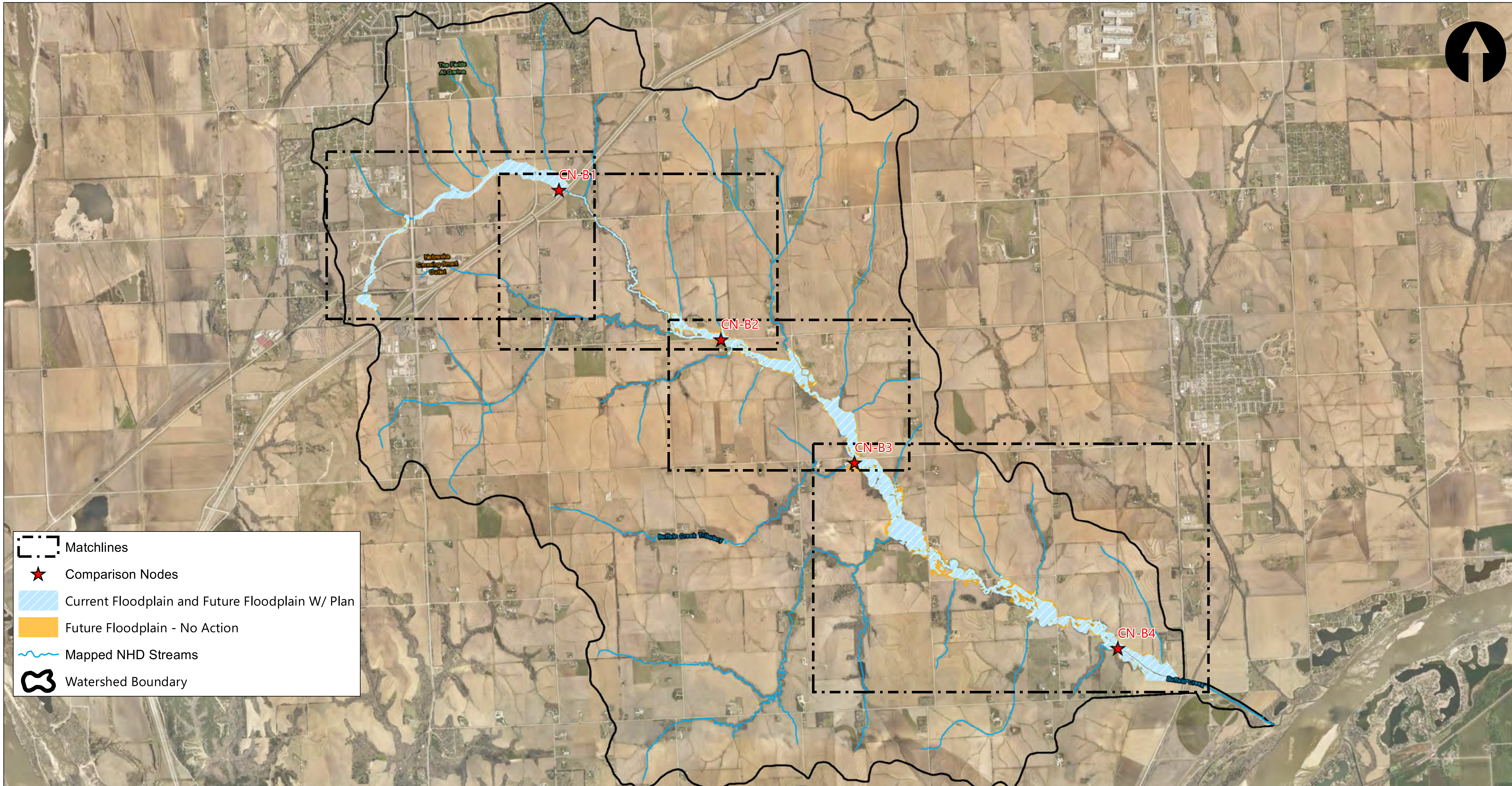
5.0 PROJECT PRIORITIZATION AND SELECTION

Partnership goals for improving stream stability within the watershed identified stream segments to focus on for this planning effort, as described in Section 2.0 above. All projects sited in Section 4.0 are required to meet the goals. Therefore, a prioritization process for selecting grade control structures was not necessary, and all structures are recommended for implementation in locations summarized in Figure F.11 below. The order of implementation can be prioritized by severity of existing conditions, development pressures, and potential grant/funding requirements and opportunities. This is described in the Implementation Plan located in Section 9 of the Plan.

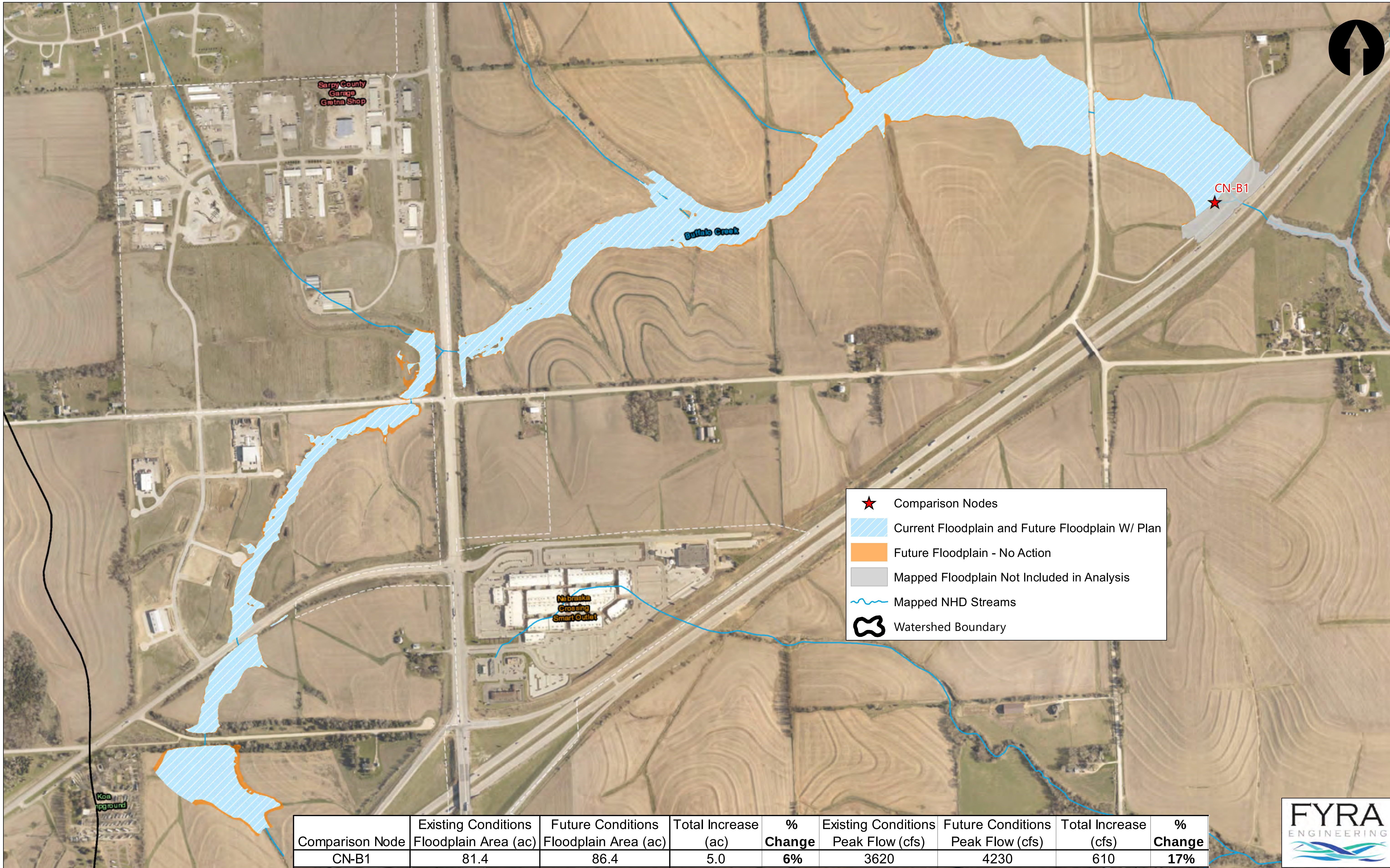
Figure F.11. Stream Stability Projects Map



Appendix G. Comparison Figures

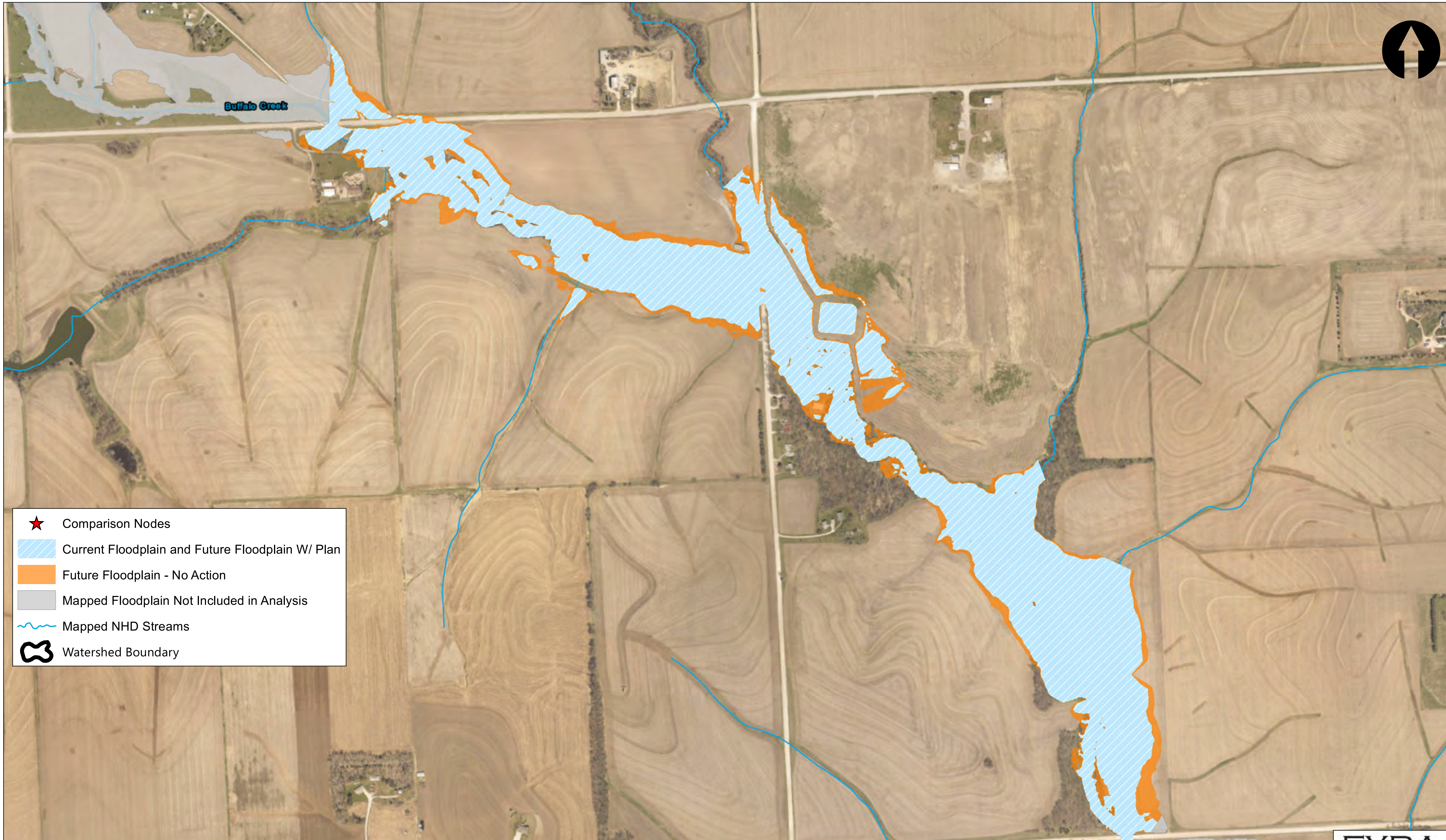


Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	% Change	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	% Change
CN-B1	81.4	86.4	5.0	**6%**	3620	4230	610	**17%**
CN-B2	37.6	44.9	7.4	**20%**	9600	11230	1630	**17%**
CN-B3	88.4	105.3	16.9	**19%**	16400	19330	2930	**18%**
CN-B4	216.3	263.7	47.4	**22%**	20980	23940	2960	**14%**
Total	423.7	500.4	76.7	**18%**	---	---	---	---

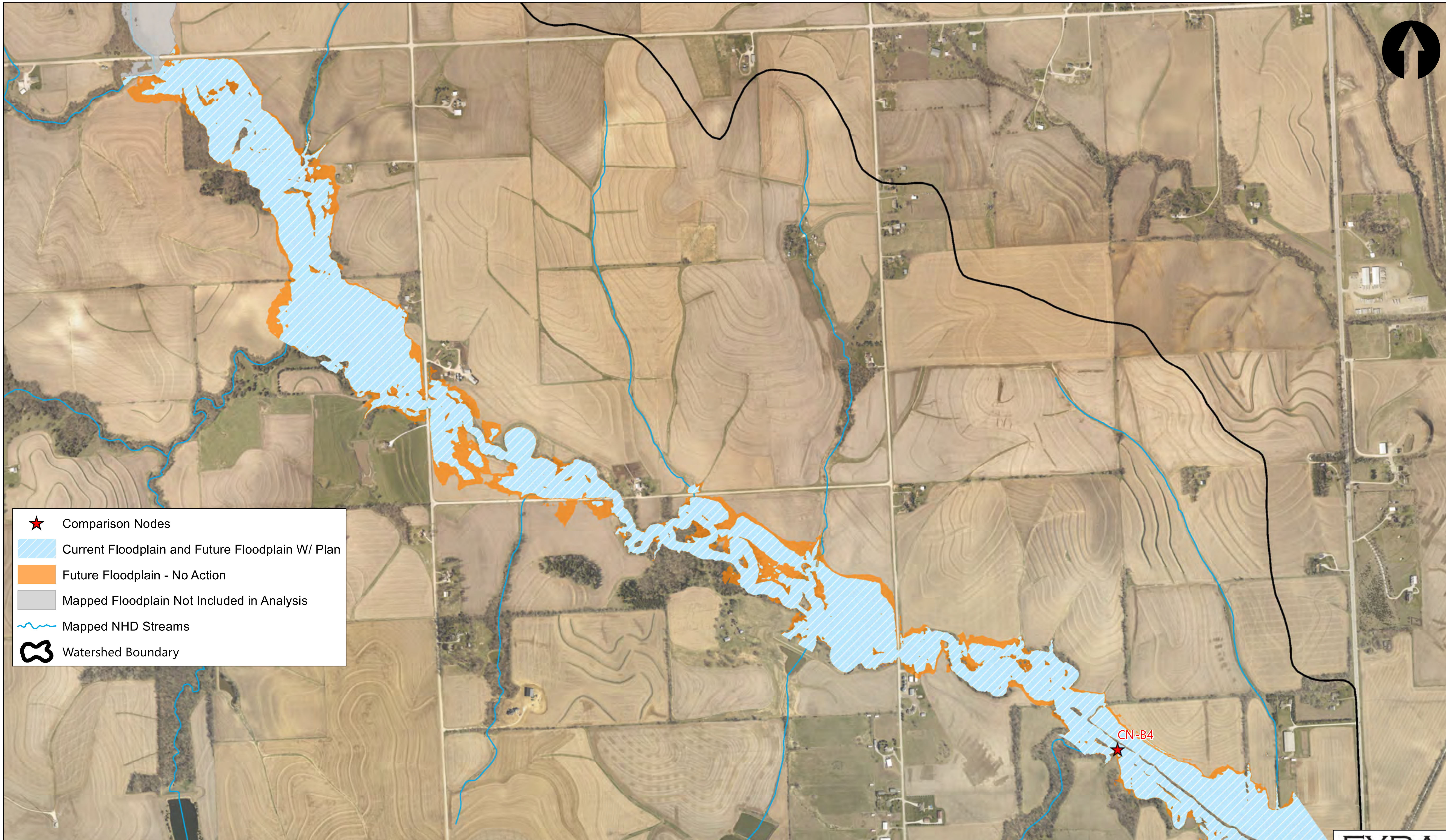


Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	**% Change**	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	**% Change**
CN-B1	81.4	86.4	5.0	**6%**	3620	4230	610	**17%**

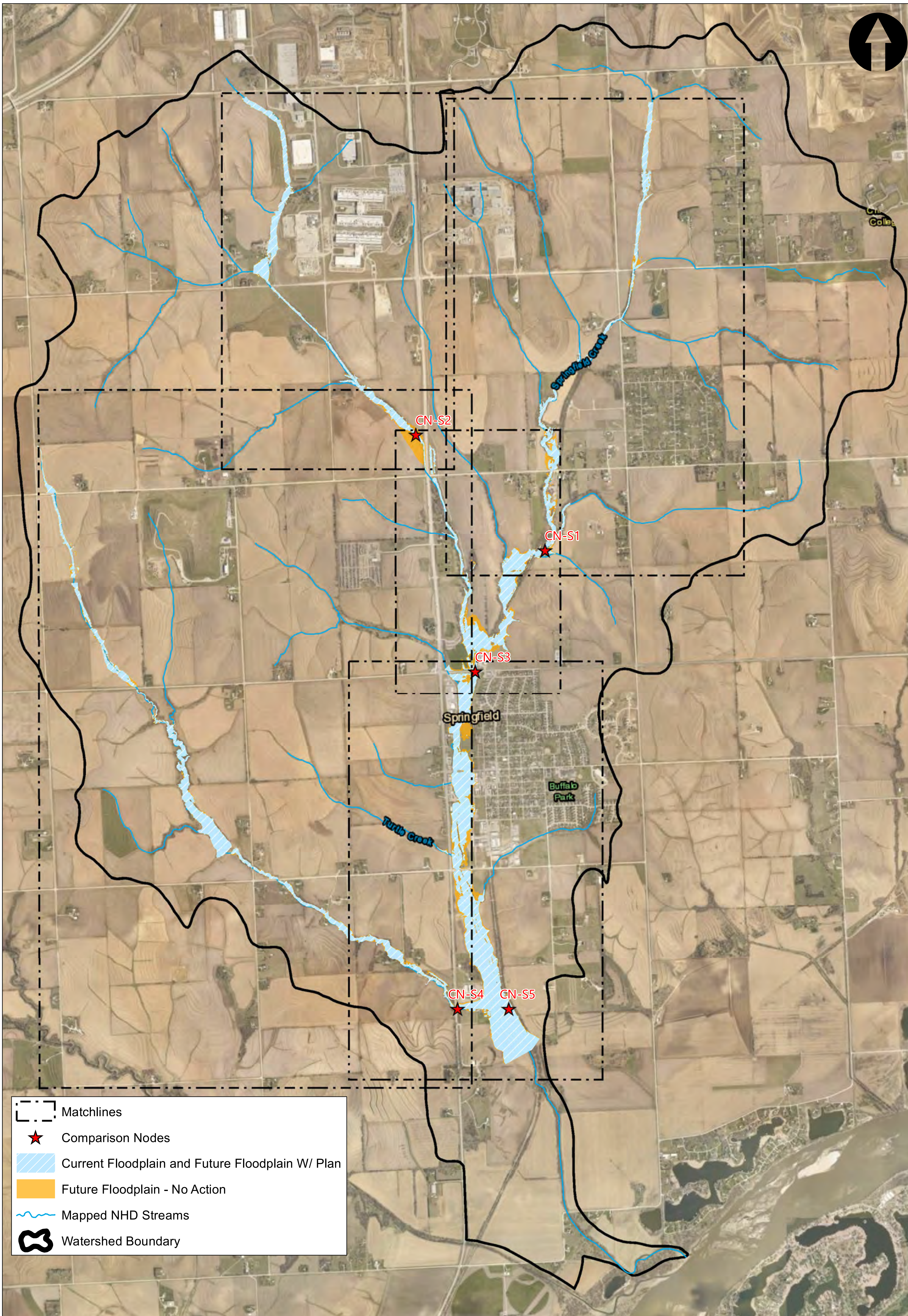
Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	% Change	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	% Change
CN-B2	37.6	44.9	7.4	**20%**	9600	11230	1630	**17%**



Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	**% Change**	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	**% Change**
CN-B3	88.4	105.3	16.9	**19%**	16400	19330	2930	**18%**



Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	% Change	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	% Change
CN-B4	216.3	263.7	47.4	**22%**	20980	23940	2960	**14%**



Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	% Change	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	% Change
CN-S1	35.6	43.2	7.7	**22%**	5240	6060	820	**16%**
CN-S2	34.1	39.0	5.0	**15%**	3370	3960	590	**18%**
CN-S3	46.9	63.5	16.6	**35%**	9330	10980	1650	**18%**
CN-S4	57.1	64.4	7.4	**13%**	2400	2800	400	**17%**
CN-S5	123.1	141.7	18.5	**15%**	13710	16070	2360	**17%**
Total	296.8	351.9	55.1	**19%**	---	---	---	---

FYRA ENGINEERING

Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	% Change	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	% Change
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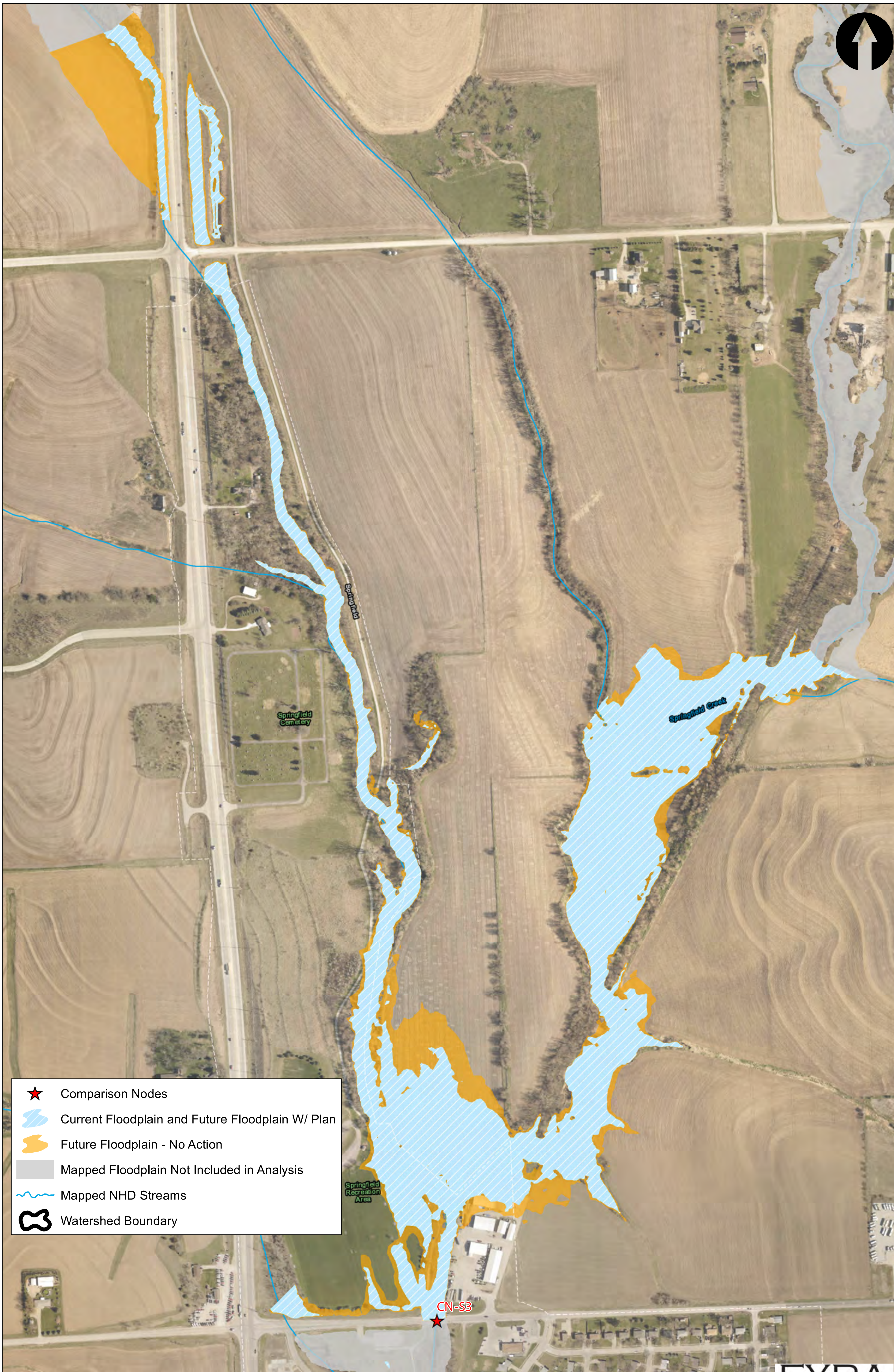

Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	% Change	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	% Change
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Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	% Change	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	% Change
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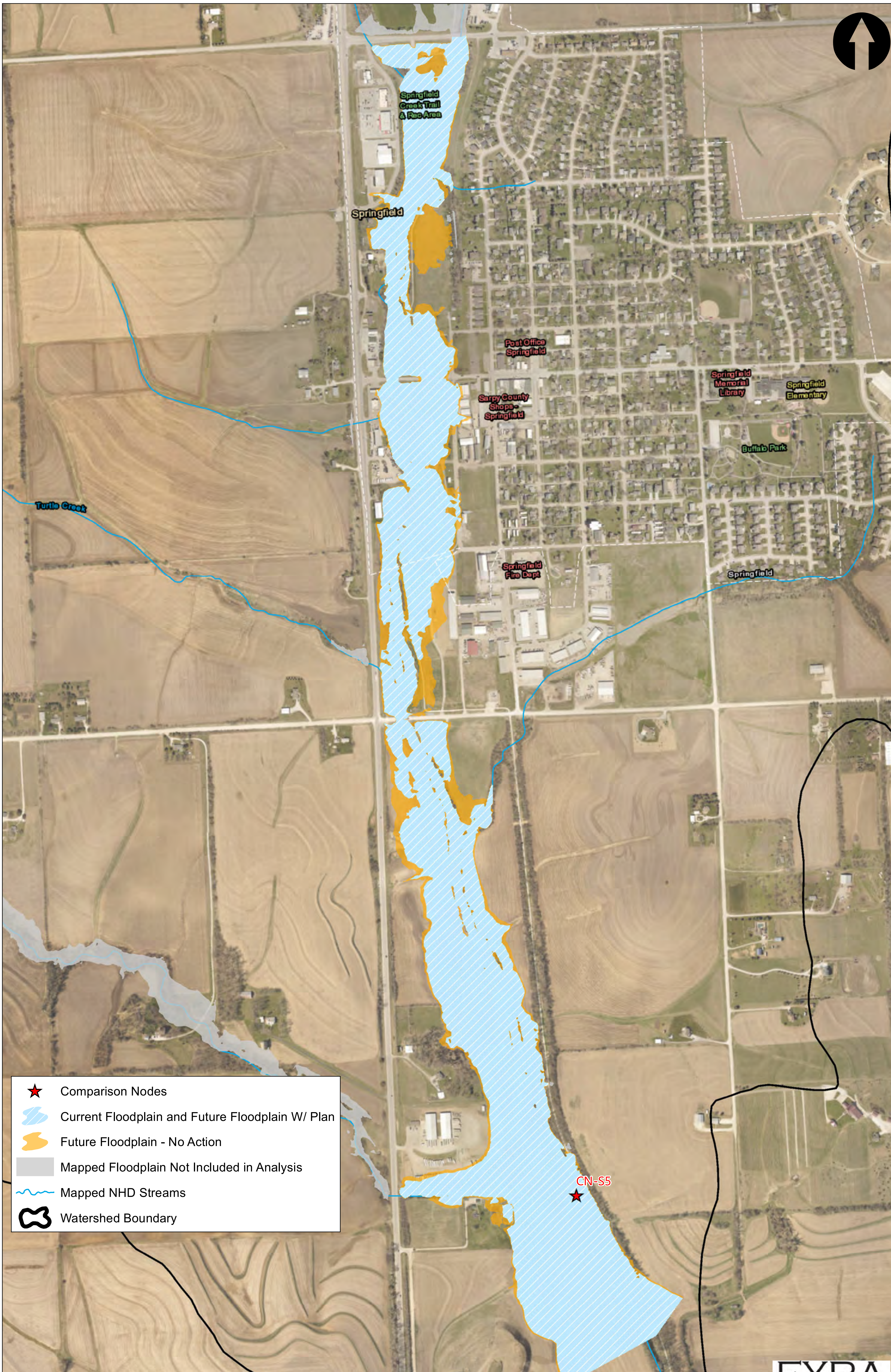
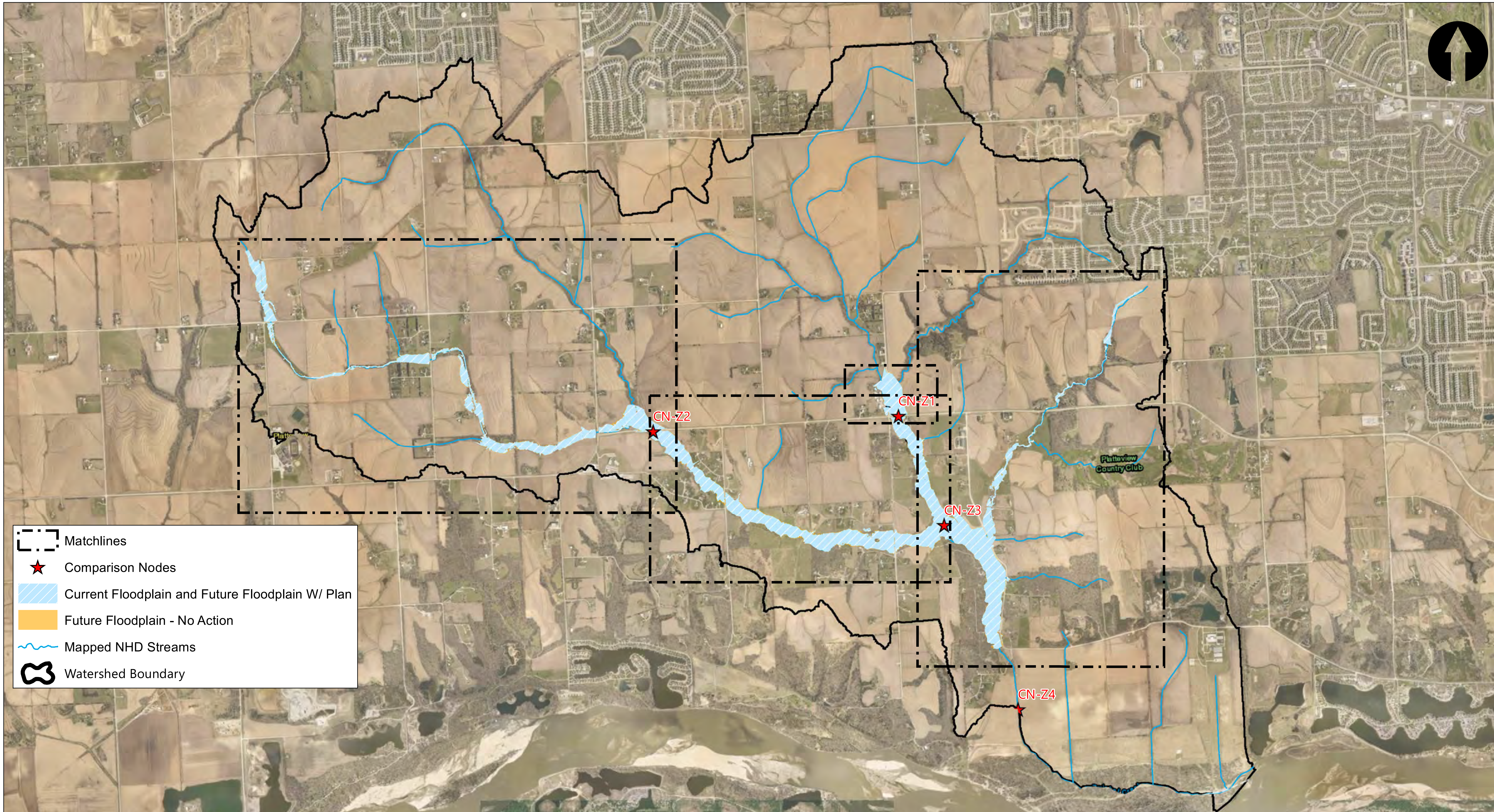
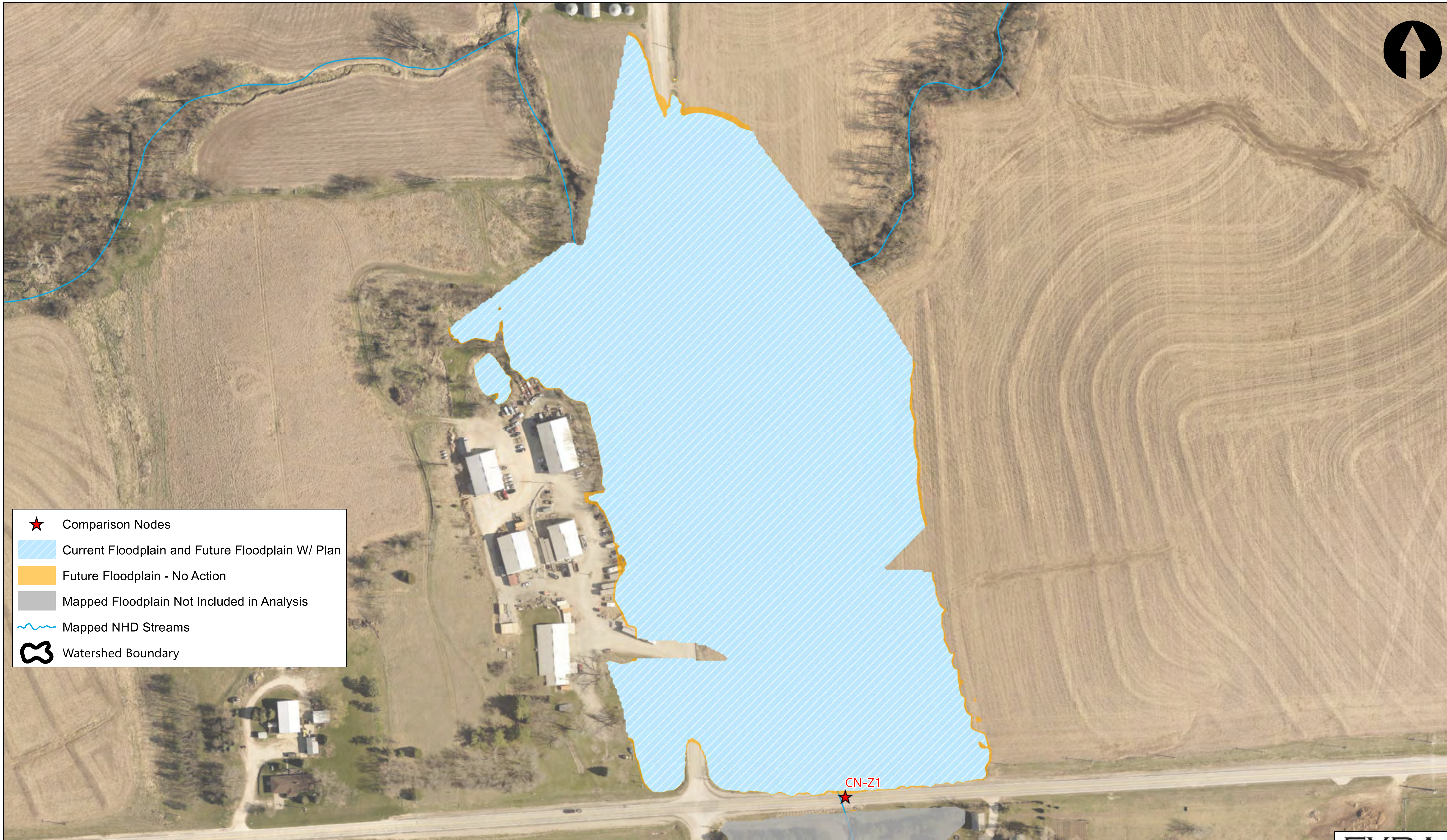


Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	% Change	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	% Change
CN-S5	123.1	141.7	18.5	**15%**	13710	16070	2360	**17%**

FYRA ENGINEERING



Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	% Change	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	% Change
CN-Z1	19.9	20.2	0.3	**2%**	4860	5740	880	**18%**
CN-Z2	86.2	90.9	4.7	**5%**	5720	6350	630	**11%**
CN-Z3	137.4	143.2	5.8	**4%**	11610	12600	990	**9%**
CN-Z4	89.4	91.8	2.4	**3%**	12850	14220	1370	**11%**
Total	332.9	346.0	13.1	**4%**	---	---	---	---



Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	**% Change**	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	**% Change**
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FYRA ENGINEERING

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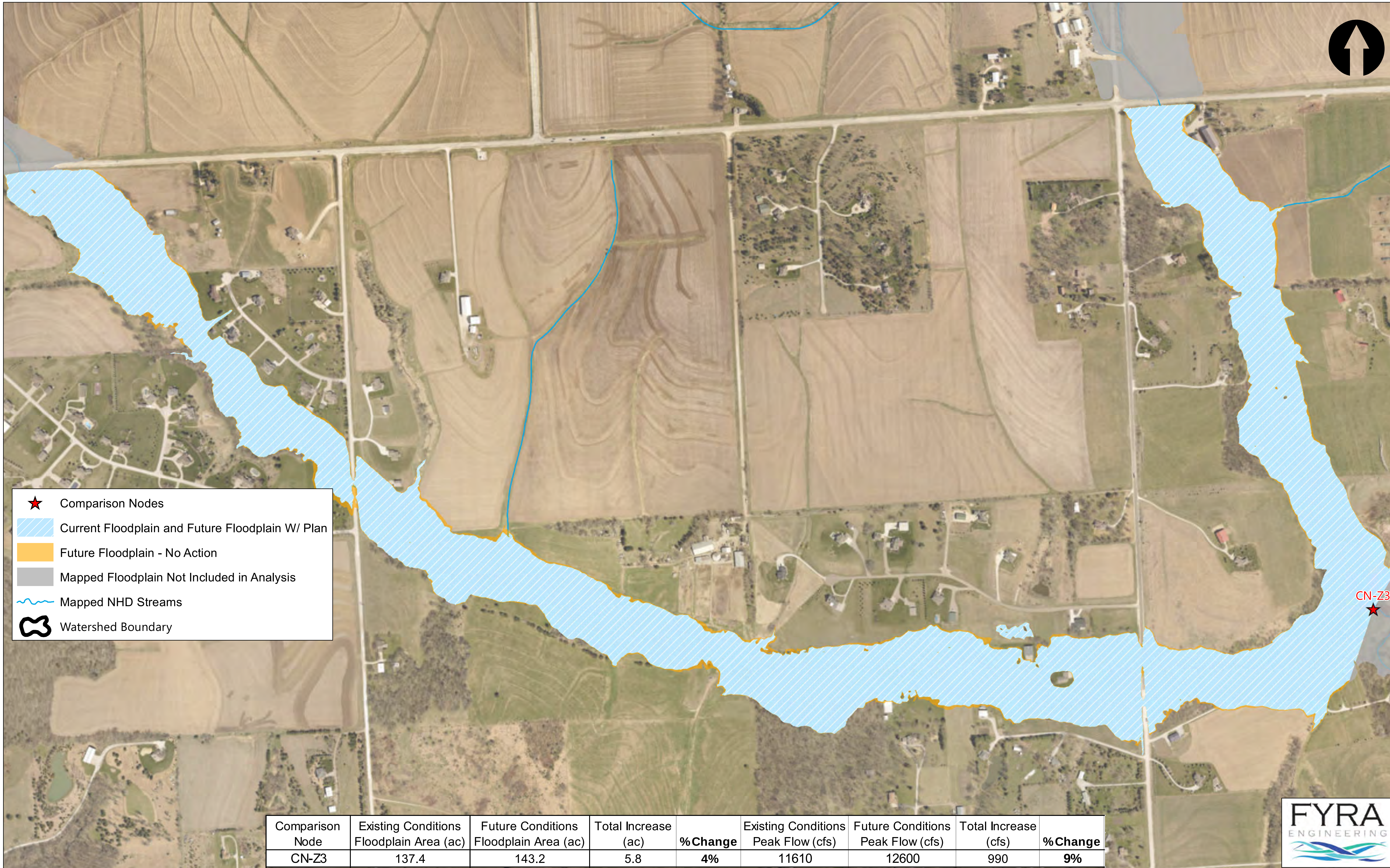

Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	%Change	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	%Change
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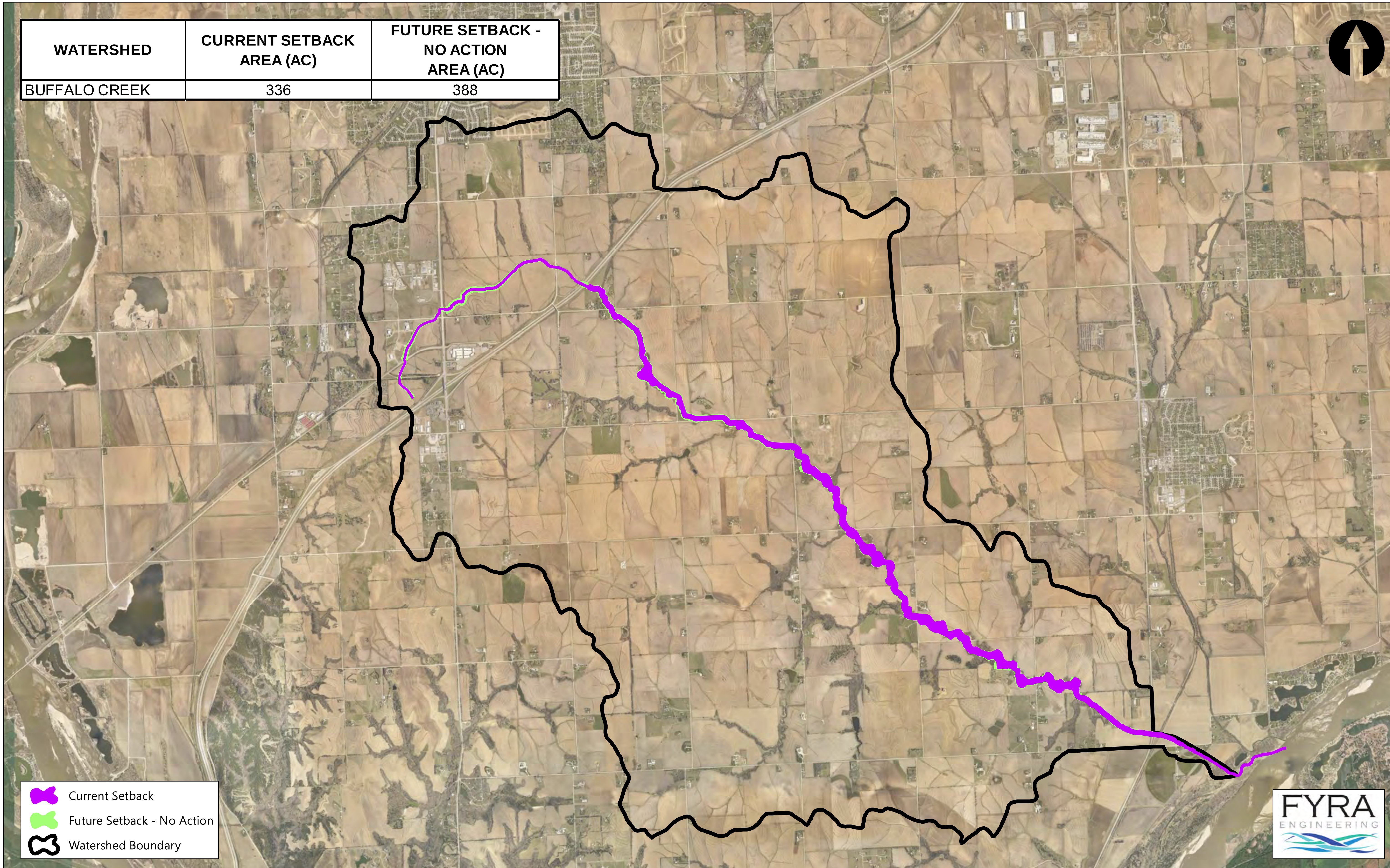
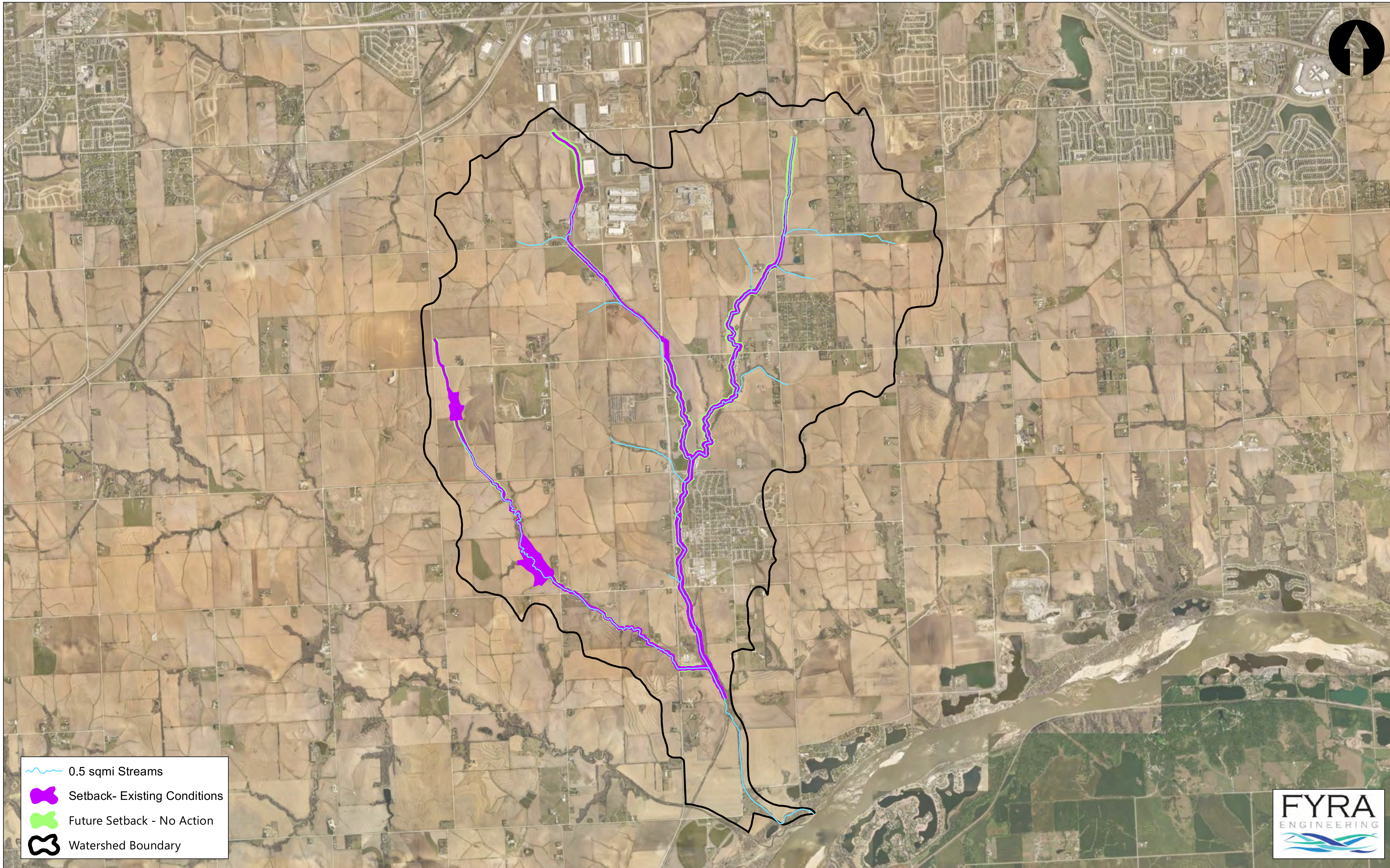
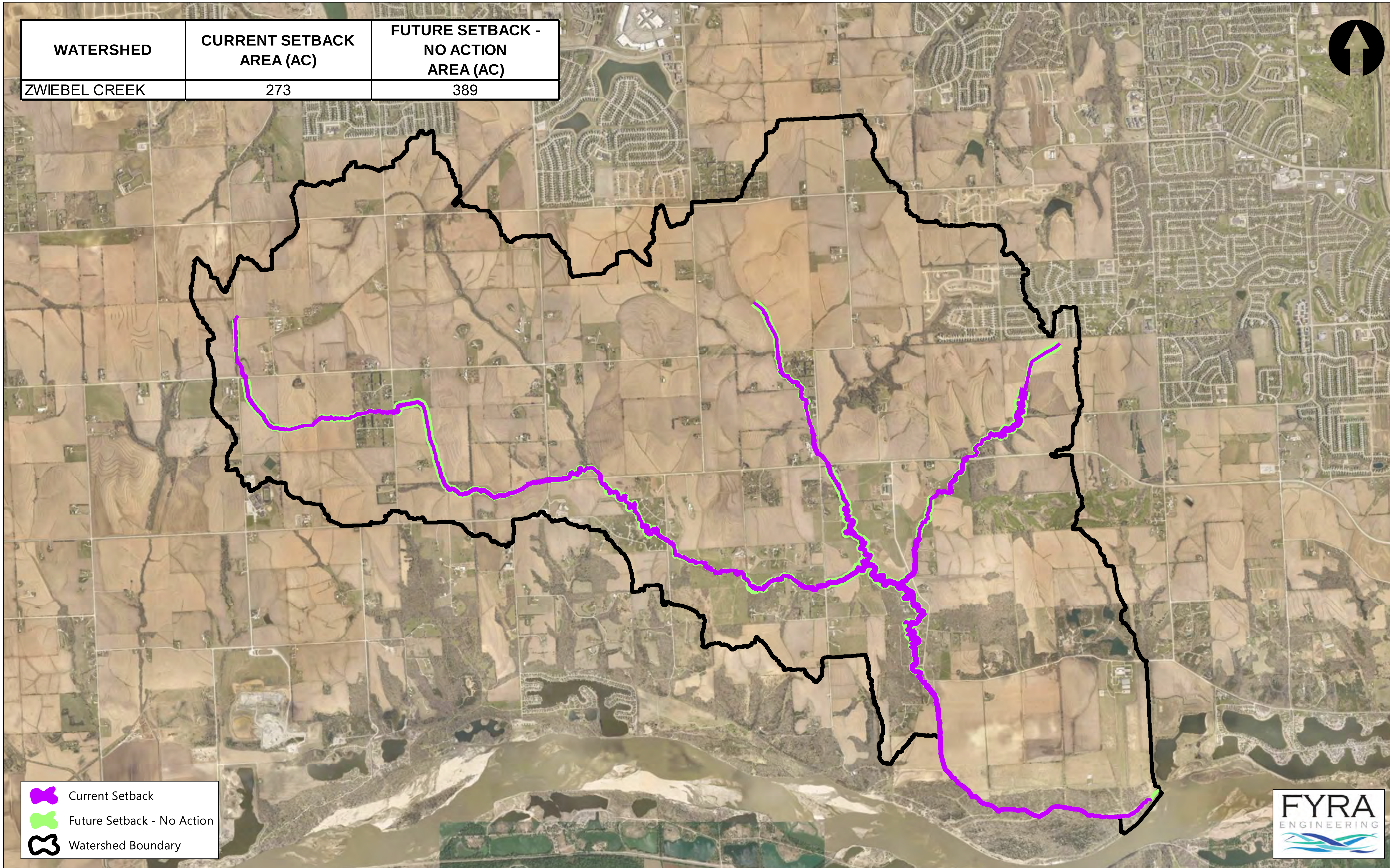
Comparison Node	Existing Conditions Floodplain Area (ac)	Future Conditions Floodplain Area (ac)	Total Increase (ac)	%Change	Existing Conditions Peak Flow (cfs)	Future Conditions Peak Flow (cfs)	Total Increase (cfs)	%Change
CN-Z4	89.4	91.8	2.4	**3%**	12850	14220	1370	**11%**

WATERSHED	CURRENT SETBACK AREA (AC)	FUTURE SETBACK - NO ACTION AREA (AC)
BUFFALO CREEK	336	388




0.5 sqmi Streams
Setback- Existing Conditions
Future Setback - No Action
Watershed Boundary
FYRA ENGINEERING

WATERSHED	CURRENT SETBACK AREA (AC)	FUTURE SETBACK - NO ACTION AREA (AC)
ZWIEBEL CREEK	273	389



Appendix H. Stakeholder Engagement Materials

SOUTHERN SARPY WATERSHEDS PARTNERSHIP

CREATING A WATERSHED PLAN TO PROACTIVELY ADDRESS STORMWATER ISSUES

The Southern Sarpy Watershed Management Area encompasses 75.6 square miles that drain into the Platte River. This area includes the Buffalo Creek, Springfield Creek, Turkey Creek, and Zwiebel Creek Basins.
See map on reverse page.

Planning is crucial in managing stormwater. As development occurs runoff increases and our streams are flooded, roads are overtopped, and low-lying areas are inundated, causing damage to both public and private properties. Creating and implementing a watershed plan can minimize the damaging effects of high runoff events. The Southern Sarpy Watersheds Partnership (SSWP) was created in early 2016 to establish the framework for a stormwater management program and to develop a watershed master plan.

Knowing the risks and understanding the resources within the watershed are essential in making sound stormwater decisions in developing watersheds.

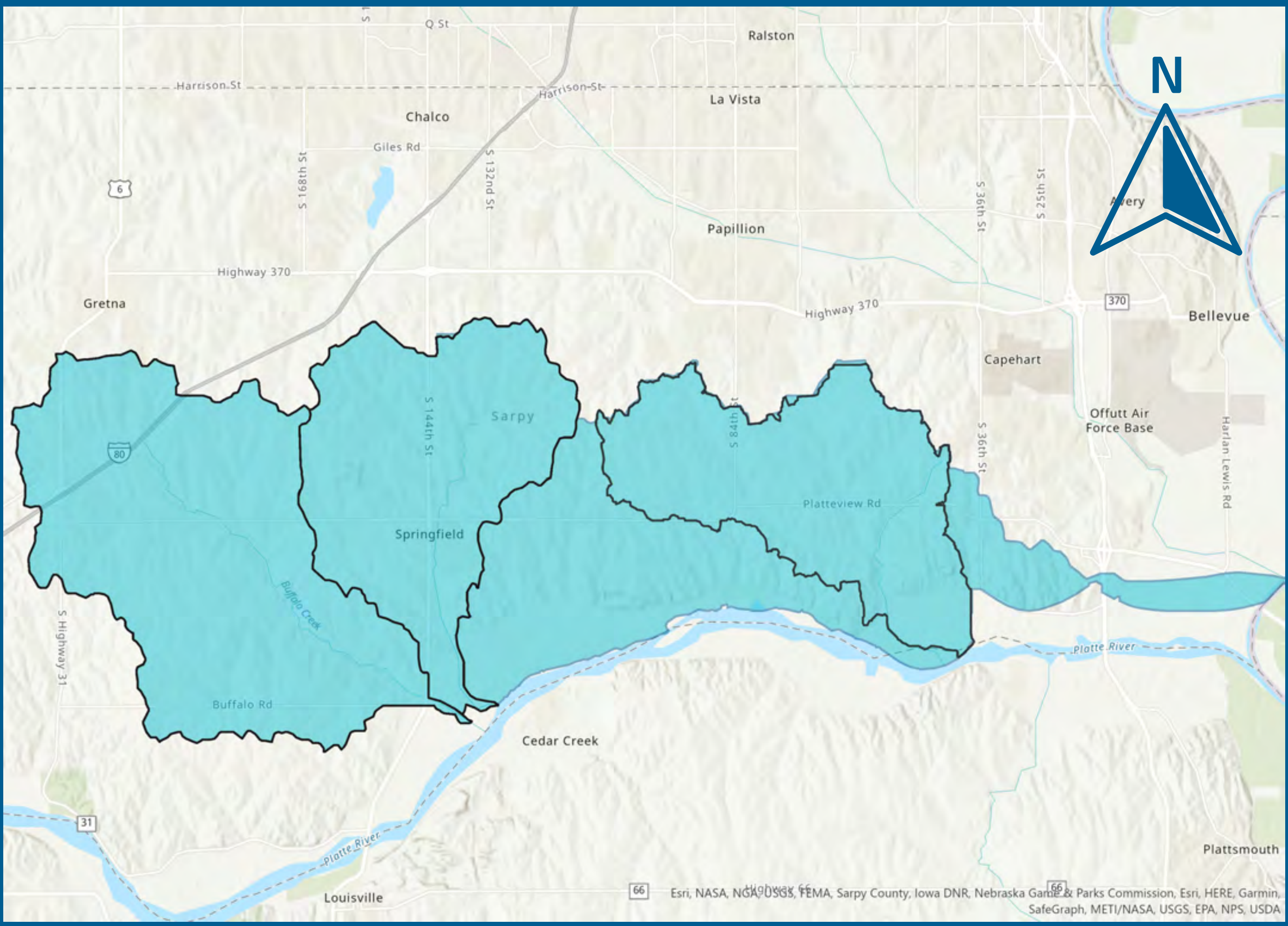
Initial stormwater policies were based on the Papillion Creek Watershed Partnership policies. After more specific analysis of the Southern Sarpy Watersheds, changes to some of the policies are being recommended by the Partnership.

- Reduce peak flow maintenance requirements to the 2-year and 10-year peak runoff events. No longer require maintenance of the 100-year peak runoff for each new development.
- A green space corridor along all streams equal to three times the channel depth plus 50 feet (3:1 plus 50 feet) on both sides of the channel is required. Within the green space corridor, the outer 30 feet of the corridor may be used for passive recreation features, such as trails.
- Grade control structures will be required on streams identified in the Watershed Management Plan. These structures are intended to prevent stream bed degradation in excess of four feet. The construction costs will be reimbursed by the Partnership.

Knowing the challenges that come with 404 Permits through the U.S. Army Corps of Engineers (USACE), the Papio NRD has begun an effort to prepare a permitting template for five common grade control structures. This template will be reviewed by USACE to ensure that common issues are addressed and a clear process for permitting is understood by both the applicants and USACE. In addition to the permitting template, a full design guidance document will be available to make the design of grade control structures simple and consistent throughout the Watershed Management Area.

SOUTHERN SARPY WATERSHED MANAGEMENT AREA

The Watershed Management Area is the area where the Partnership collects watershed fees and the area where the Partner jurisdictions enforce the Stormwater Management Policies.



Southern Sarpy Watersheds Partnership Stakeholder Meeting

Wednesday, May 8, 2024 10:48 AM

Subject	**Southern Sarpy Watersheds Partnership Stakeholder Meeting**
Link to Outlook Item	Click here
From	Ghanavati, Ian
Required attendees	Jeff Thompson (Accepted in Outlook) Sara Mechtenberg (Accepted in Outlook) Zachary Hergenrader (Accepted in Outlook) Mike Sotak (Accepted in Outlook) Jason Kubicek (Accepted in Outlook) Kristine Stokes (Accepted in Outlook) sullivan@adamsandsullivan.com (Accepted in Outlook) Larry Jobeun (Accepted in Outlook) mike.mcintosh@lamprynearson.com Kyle Vohl (Accepted in Outlook) Caleb Beasley (Accepted in Outlook) dkellner@td2co.com (Accepted in Outlook) mark@moba.com Gene@GoNebraska.com Jerry@bhicompanies.com pniewohner@olsson.com EWilliams@Olsson.com (Accepted in Outlook) john.hughes@newstreetprop.biz (Tentative in Outlook) ljohnson@celebrityhomesomaha.com paul@mccunedevelopment.com mjohnson@fjjblaw.com (Accepted in Outlook) Alex Evans (Accepted in Outlook) Grint, Amanda Cole DeBerg Dan Gittinger Dan Hoins Wilson Dennis (dwilson@sarpy.com) Derek Goff Don Simon (Accepted in Outlook) Williams, Eric (Accepted in Outlook) Jason Kubicek Jeff Thompson Kathleen Gottsch (Accepted in Outlook) Kelly Jeck Laster, Lori Ann (Accepted in Outlook) Mark Stursma Matt Knight (Accepted in Outlook) Mike Kleffner (Tentative in Outlook) Travis Gibbons Zachary Hergenrader Dave Goedeken Sara Mechtenberg Mike Sotak Kevin Balentine Ghanavati, Ian
Optional attendees	Denny Wilson (Accepted in Outlook) Joe T. Flaxbeard (Accepted in Outlook) jeanne@acecnebraska.org
Meeting Date	**6/21/2023, 10:00:00 AM**

Attachments

20230522 SSWP

The Southern Sarpy Watersheds Partnership will be holding a stakeholder engagement meeting to present on and discuss the progress made in developing a Watershed Management Plan and Policies. Please join us on **Wednesday, June 21st at 10 AM in the Papio NRD Board Room.** Pastries and coffee will be provided!

See the attached Plan Infographic for more information. Additional materials will be shared for review prior to the meeting. Please forward this invitation along to other individuals who may have an interest in attending.

Thank you!

Notes

SSWP Stakeholder Meeting – Sign In Sheet
June 21, 2022 – 10 am
Papio-Missouri River NRD

SOUTHERN SARPY WATERSHED PARTNERSHIP

	NAME & EMPLOYER	EMAIL ADDRESS	PHONE
	Adam Charlsen Husch Blackwell	adam.charlsen@huschblackwell.com	402-964-5013
	Jason Fubicek Sarpy County	jfubicek@gmail.com	402-593-1556
	Kris Davenport olsson	Kdavenport@olsson.com	402-714-2258
	Bradley Huyck TD2	bhuyck@td2co.com	402-679-3600
	Kristine Stokes City of Gretna	Kristine@cityofgretna.com	
	Joe Flaxbeard Lamp Rynearson	joe.flaxbeard@lamprynearson.com	402-496-2498
	Randy Kuszak Lamp Rynearson	Randy.Kuszak@LampRynearson.com	402-496-2498
	Caleb Beasley E & A	cbeasley@eacg.com	402-895-4700
	Eric Williams Olsson	ewilliams@olsson.com	402-970-2311
	Kathleen Gottsch Springfield	Kathleen@springfieldne.org	402-253-2204
	Jon McCarville Olsson	jmccarville@olsson.com	531-999-4146
	Larry Jobeun FJJB LAW	larry@fjjblaw.com	402-334-0700
	Pat Sullivan Adams + Sullivan	sullivan@adamsandsullivan.com	402-339-9550
	Matt Knight City of Bellevue	matt.knight@bellevue.net	402-293-3028

SSWP Stakeholder Meeting – Sign In Sheet
June 21, 2022 – 10 am
Papio-Missouri River NRD

SOUTHERN SARPY WATERSHED PARTNERSHIP

	NAME & EMPLOYER	EMAIL ADDRESS	PHONE
	Greg Perry	gregp@eagleengineeringgroup.com	(402)399-0227
	JEANNE MCCLURE ACECNEBRASKA	jeanne@acecnebraska.org	402-432-6752
	Jeff Thompson	Jthompson@sccwwg.org	402-415-6734
	ALEX EVANS	aevans@papillion.org	402-597-2044
	Amanda Grint	agrint@papionrd.org	402-315-1722
	MIKE [illegible]	[illegible]	402.[illegible].5328
	KEVIN BALENTINE, SARPY	kbalentine@sarpy.gov	402-964-2430
	Kelly Zeek	Kzeek at sarpy.gov	402 593-2315
	JASON KUBICEK	jkubicek@"	593 1556
	Zach Hergenrader	zhergenrader@sarpy.gov	402-537-6917


Southern Sarpy Watersheds Partnership
Stakeholder Engagement Meeting
SOUTHERN SARPY
WATERSHEDS
PARTNERSHIP

Background & Introduction

What is the Partnership, who is involved, where does it work, and what are its goals?

The Southern Sarpy Watersheds Partnership

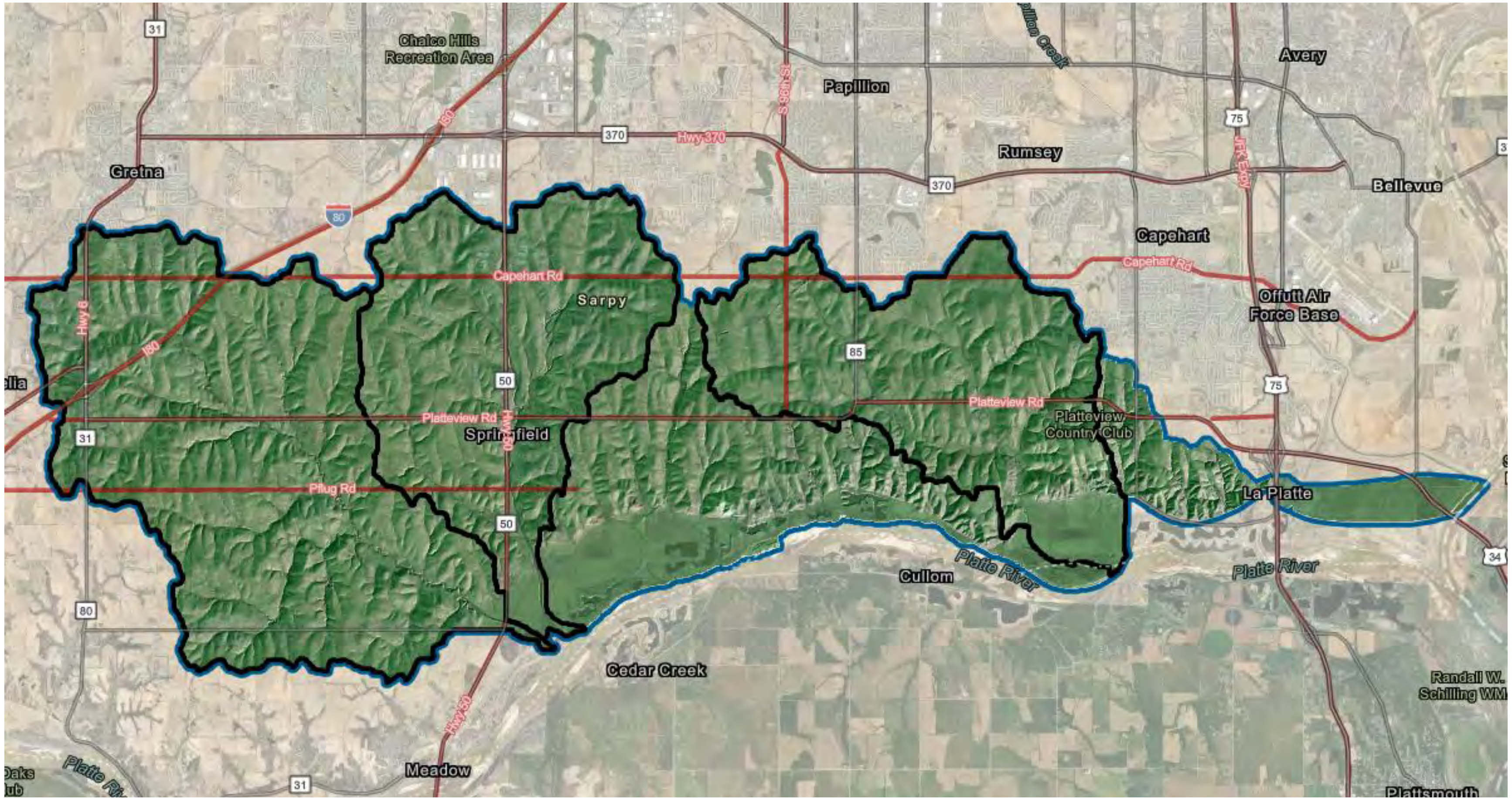
The Partnership was created in 2016 to establish the framework for a stormwater management program and to develop a watershed master plan. The plan addresses surface water quality, stormwater quantity and stream stability.

The Partnership utilized the existing Papillion Creek Watershed Partnership (PCWP) as its foundation for interim policies while a Southern Sarpy specific Plan was developed.

The Watershed Management Area

The plan to provide sewer service in Southern Sarpy County is spurring urban and suburban development. This development is the basis for the Watershed Management Area, where the Partner jurisdictions enforce the Stormwater Management Policies and collect Watershed Fees.

This area contains the Buffalo, Springfield, and Zwiebel Creek Watersheds which were studied during development of the plan.

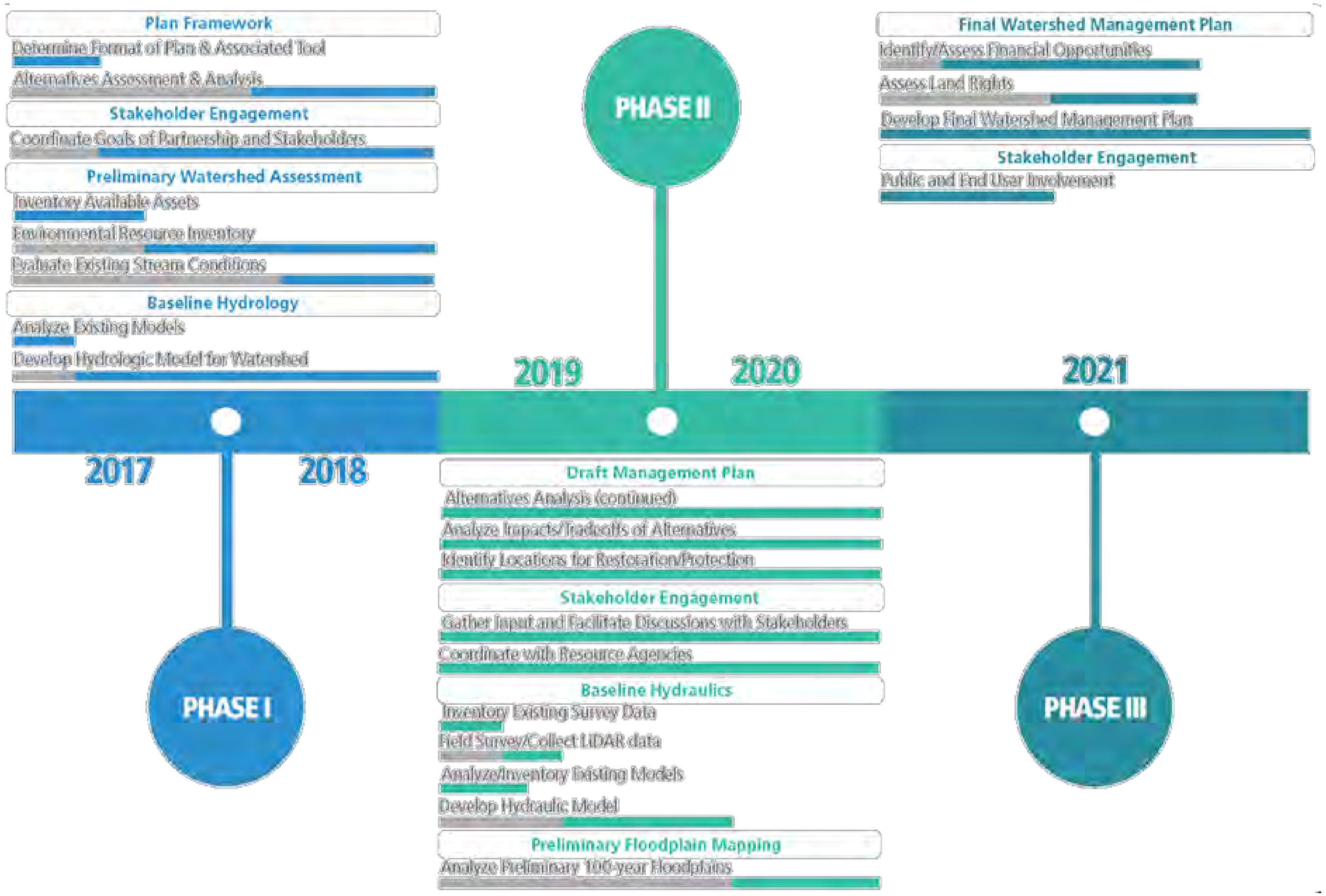


The Study Process

In 2017, FYRA Engineering (now Houston Engineering) was selected to study hydraulics and hydrology and the effects of anticipated development in the Watershed Management Area to help inform the Plan.

The study showed that flood risk would minimally increase with new development due to physical watershed characteristics. The benefit-cost analysis of providing peak flow management determined that the cost was significantly disproportionate to the benefits of reducing or maintaining increased discharges associated with future land use within the floodplain.

An investigation of the soils in the watersheds revealed that the riparian areas largely contain highly erosive soils which will create challenges with increasing development and the increased discharges associated with the changing land use.



Stream Degradation in the Southern Sarpy Watersheds

Streams in the Watershed Management Area have already begun to degrade making stream stability a key issue for the Partnership. As the Watershed Management Area continues to develop, the risk of degradation increases the threat to public infrastructure and private property.

Photo: MoPac Trail Bridge Springfield Creek Degradation

Planning and taking action proactively helps to prevent increased challenges in the future.

While the two areas differ, examples from the more developed Papillion Creek Watershed clearly show the impact excessive degradation can have on public infrastructure and private property.

Photo: Cole Creek in the Papillion Creek Watershed

The Partnership's Goal

The goal of the Partnership is **proactive management** within the Watershed Management Area to **protect infrastructure** and **preserve natural resources** by establishing regionally common goals and standards for storm water.

This presentation will detail the Partnership's efforts and future plans to meet this goal.

Photo: DS-24 in Buffalo Creek Watershed

Policy Recommendations

In 2016 the Partnership adopted interim policies based on the Papillion Creek Watershed Partnership's Policies, for use while the Southern Sarpy Watershed Plan was being developed.

The Partnership's Interim Policy Groups are:

1. Water Quality Improvement
2. Peak Flow Reduction
3. Landscape Preservation, Restoration, and Conservation
4. Erosion and Sediment Control and Other Best Management Practices (BMPs)
5. Floodplain Management
6. Stormwater Management Financing

EXHIBIT B
SOUTHERN SARPY WATERSHED
STORMWATER MANAGEMENT POLICIES

POLICY GROUP #2: PEAK FLOW REDUCTION

ISSUE
Urbanization within the Southern Sarpy Watershed will increase runoff leading to flooding problems and diminished water quality.

ROOT POLICY
Maintain or reduce stormwater peak discharge during development and after full build-out land use conditions from that which existed under baseline land use conditions.

SUB-POLICY

1) Regional stormwater detention facilities and other structural and non-structural BMPs shall be located in general conformance with an adopted Southern Sarpy Watershed Management Plan and shall be coordinated with other related master planning efforts for parks, streets, water, sewer, etc.
2) All new developments and significant redevelopments shall maintain or reduce peak discharge rates during the 2, 10, and 100-year storm event under baseline land use conditions.

REFERENCE INFORMATION

DEFINITIONS

1) Low-Impact Development (LID). A land development and management approach whereby stormwater runoff is managed using design techniques that promote infiltration, filtration, storage, evaporation, and temporary detention close to its source. Management of such stormwater runoff sources may include open space, rooftops, streetscapes, parking lots, sidewalks, medians, etc.
2) Water Quality LID. A level of LID using strategies designed to provide for water quality control of the first ½ inch of stormwater runoff generated from each new development or significant redevelopment and to maintain the peak discharge rates during the 2-year storm event to baseline land use condition, measured at every drainage (stormwater discharge) outlet from the new development or significant redevelopment.
3) Peak Discharge or Peak Flow. The maximum instantaneous surface water discharge rate resulting from a design storm frequency event for a particular hydrologic and hydraulic analysis, as defined in the Omaha Regional Stormwater Design Manual. The measurement of the peak discharge shall be at the lower-most drainage outlet(s) from a new development or significant redevelopment.
4) Regional Stormwater Detention Facilities. Those facilities generally serving a drainage catchment area of 500 acres or more in size.
5) Baseline Land Use Conditions. The pre-developed conditions which existed in Year 2014.
6) Full Build-Out Land Use Conditions. Fully platted developable land use conditions for the Southern Sarpy Watershed are assumed to occur by the Year 2055; or as may be redefined through periodic updates to the respective community and county comprehensive plans.

The Partnership's Recommended Policy Groups are:

1. Water Quality Improvement
2. Peak Flow Management
3. Stream Corridor Preservation
4. Erosion and Sediment Control and Other Best Management Practices (BMPs)
5. Floodplain Management
6. Stormwater Management Financing

These recommendations were developed collaboratively by the Partners based on the study completed by Houston Engineering.

EXHIBIT B
SOUTHERN SARPY WATERSHED
STORMWATER MANAGEMENT POLICIES

POLICY GROUP #2: PEAK FLOW MANAGEMENT

POLICY: Maintain stormwater *peak discharge* during development and after *full build-out land use conditions* from that which existed under *baseline land use conditions*.

REQUIREMENTS:

1) All *new developments* and *significant redevelopments* shall maintain or reduce peak discharge rates during the 2- and 10-year storm event under baseline land use conditions.

GOALS:

1) Limit increases in *peak flow* for frequent storm events to prevent excessive flooding and erosion.
2) Reduce the potential risk of damage to infrastructure.

SEE APPENDIX A – DEFINITIONS FOR *REFERENCED INFORMATION*

Substantial Policy Recommendations

Many of the policies will remain the same, however there will be some key changes. Where the PCWP has focused on reservoirs for flood reduction, the SSWP will focus on grade control for stream stability.

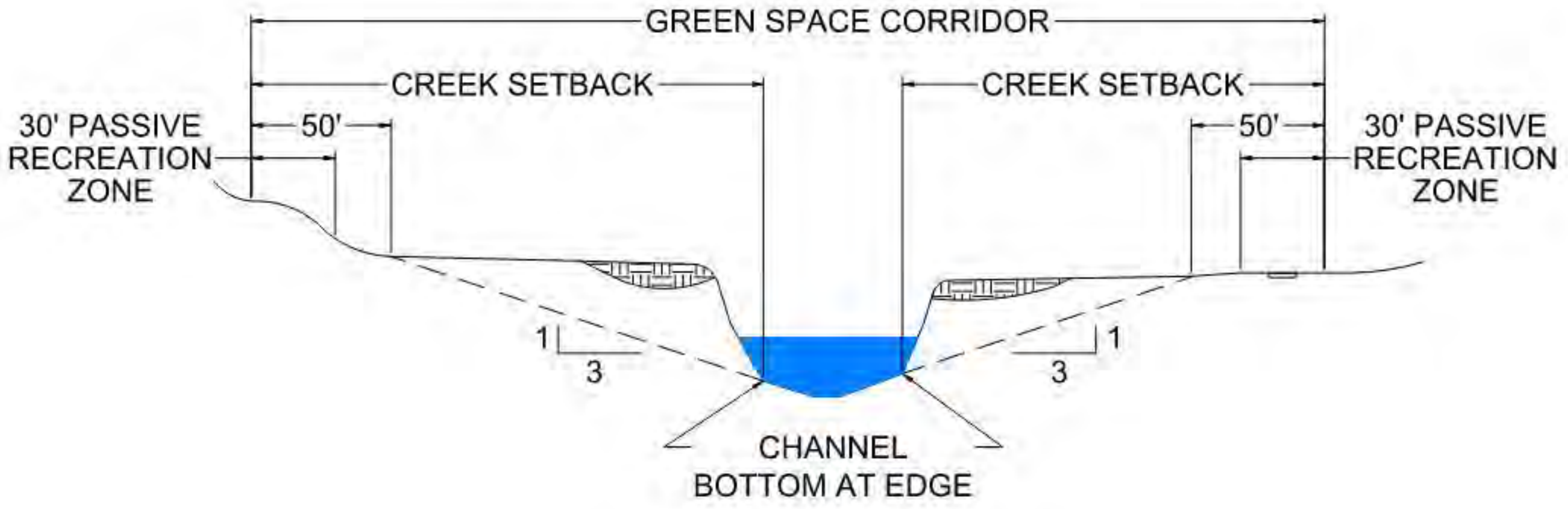
1. Reduce the peak flow maintenance requirement to the 2-year and 10-year peak runoff events for new developments. Maintenance of the 100-year peak runoff is no longer required.
2. Within the creek setback, the outer 30 feet may be used for passive recreation features such as trails.
3. Grade control structures designed to prevent stream bed degradation in excess of four feet will be required on streams identified in the Watershed Management Plan. The construction costs for these structures will be reimbursed by the Partnership with Watershed Fees.

Policy Group	Interim Policy	Recommended Policy
1) Water Quality Improvement	• Retain LID Storm (Control first $\frac{1}{2}$" of runoff; maintain peak flow from 2-year storm)	• Retain LID Storm (Control first $\frac{1}{2}$" of runoff; maintain peak flow from 2-year storm)
2) Peak Flow Management	• Maintain or reduce peak discharge rates of the 2-, 10-, and 100-year storm events on all new development	• Maintain peak discharge rates of the 2- and 10-year storm events on all new development
3) Stream Corridor Preservation	• Dedicate a creek setback (3:1 + 50') along all streams	• Dedicate a creek setback (3:1 + 50') along all streams and allow passive recreation in the outer 30' • Construction of grade control structures required in all streams with a drainage area of 0.5 mi^2 or greater
4) Erosion and Sediment Control and Other BMPs	• Comply with state and federal regulatory requirements	• Comply with state and federal regulatory requirements
5) Floodplain Management	• 25% floodway fringe fill limitation	• 25% floodway fringe fill limitation
6) Stormwater Management Financing	• Private (1/3) and Public (2/3) to support Stormwater Program and development of Watershed Management Plan	• Grade control structure construction cost to be reimbursed by the Partnership

Setback Area

A setback area of three times the channel depth plus fifty feet from the edge of the channel bottom on both sides of the channel is required. The setback area provides:

- Protection from stream widening and meander
- Space in the outer 30 feet where passive recreation can be incorporated, creating a green space corridor for communities

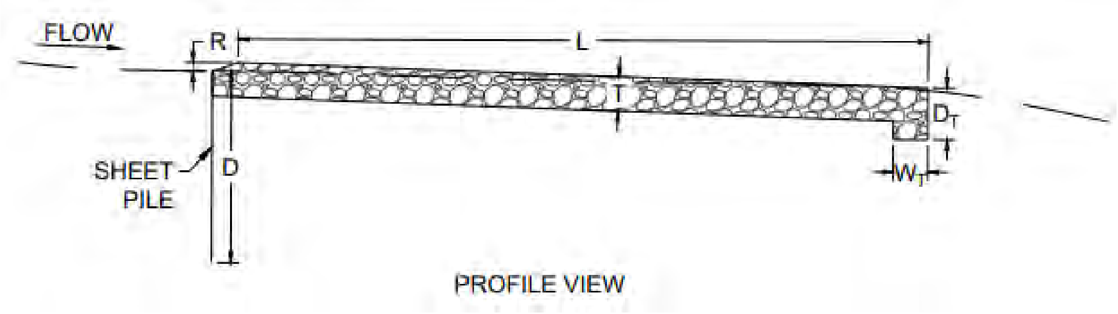


Grade Control Structure Recommended Policies

- Grade control structures are required to be installed along all streams with a drainage area of at least 0.5 square miles at the time of development.
- Grade control structures must be designed to prevent stream degradation of more than four feet.
- The construction costs of the grade control structures will be reimbursed by the Partnership with Watershed Fees.
- In areas that have been platted prior to the adoption of the new policies, the Partnership will construct the necessary grade control structures.

These policies will prevent substantial stream degradation from occurring and help support the construction of projects at the time of development.

Grade Control Structure Example

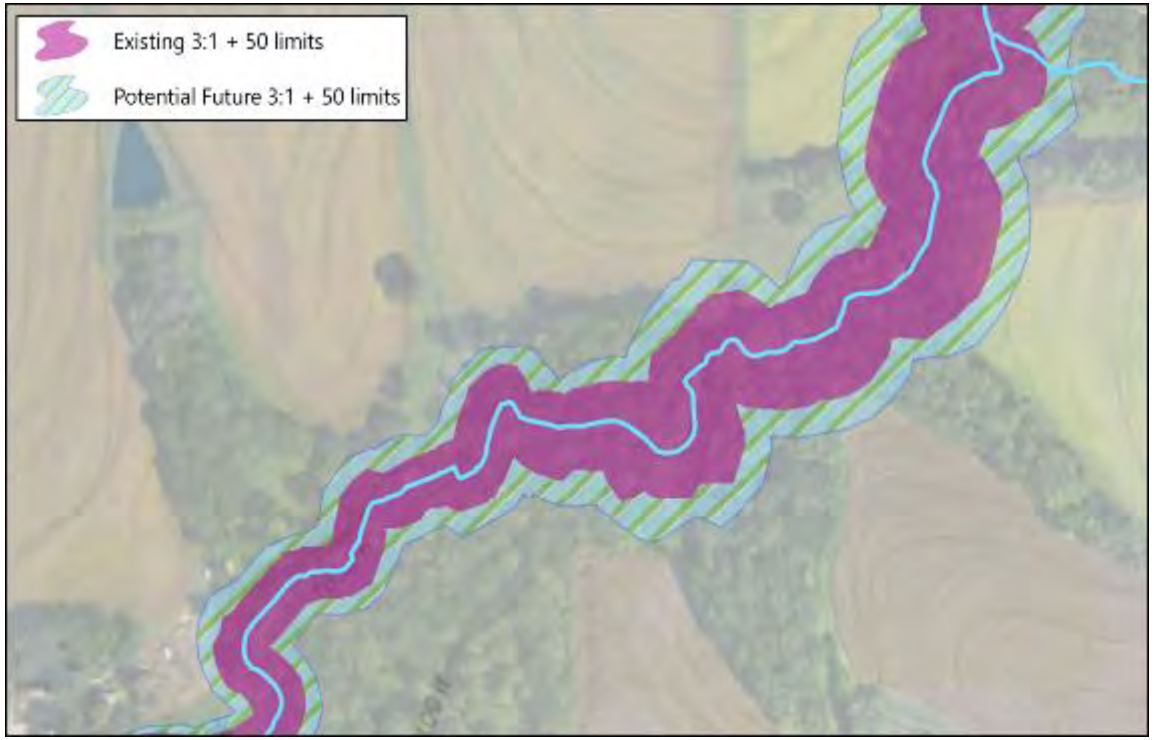


Grade Control Policy Alternatives

1. Accept damage from stream degradation
2. Increase setback area to account for future degradation
3. Grade control for stream stability

Grade Control Policy Key Benefits

1. Cost savings through a single design, permitting, and construction process (economy of scale)
2. Project construction can happen at the pace of development in the watersheds



Grade Control Implementation General Approach

The Partnership does not have the resources to manage the number of anticipated projects. By collaborating with the development community, the recommended grade control projects can occur more efficiently at the pace of development.

- **Developer Led Implementation**
  - Required per SSWP Policy
  - Same time as development (single design, permitting, & construction process)
- **Partnership Led Implementation**
  - Special Projects
  - Developments platted prior to new policies

Developer Led Implementation Process

Design & Review

- Developer responsible for design
- Local jurisdiction responsible for reviewing and approving project design along with plat application; Papio NRD can assist with technical input on reviews
- Design guidance document will be available to aid in design and review

Permitting

- Developer responsible for obtaining permits
- Design & permitting guidance document will be available to expedite application

Developer Led Implementation Process

O&M Enforcement

- SID responsible for O&M until annexation by local jurisdiction
- O&M easement and maintenance agreement signed prior to reimbursement

Reimbursement

- Papio NRD will administer reimbursement with Partnership funds
- 100% reimbursement of construction costs after review and approval
  - Guidance document will include pre-approved material unit cost range

Developer Led Implementation Process Outline

Component	Responsible Party
Design	Developer
Review	Local jurisdiction
Permitting	Developer
O&M	SID/Local jurisdiction
Reimbursement	Partnership

Partnership Led Implementation

Project Identification

- Partnership will maintain a list of potential projects (parcels platted prior to new requirements, special projects, etc.)
- Priority projects will be selected based on available budget, impact and partner feedback

Project Management

- Papio NRD will manage design and construction of Partnership projects
- O&M responsibility will vary based on project specific agreements

Grade Control Structure Design & Permitting Guidance

The Partnership understands that for effective execution of new policies and procedures guidance is required. To support the design, permitting, and construction of grade control structures as part of the Watershed Plan, the Partnership is developing a full design guidance document and permitting template.

Additionally, the Guidance Document will detail the process by which developments may be reimbursed by the Partnership for the construction of required grade control structures. The Partnership will fund reimbursement with Watershed Fees.

Southern Sarpy Watershed

SWMP Design and Permitting Guidance Document

Table of Contents

1. OVERVIEW AND DESIGN INTENT
2. USACE 404 PERMITTING PROCESS
3. GRADE CONTROL STRUCTURE SUBMITTAL
4. COST REIMBURSEMENT
5. OPERATION AND MAINTENANCE
6. APPENDICES

Guidance Document Further Details

Design & Permitting

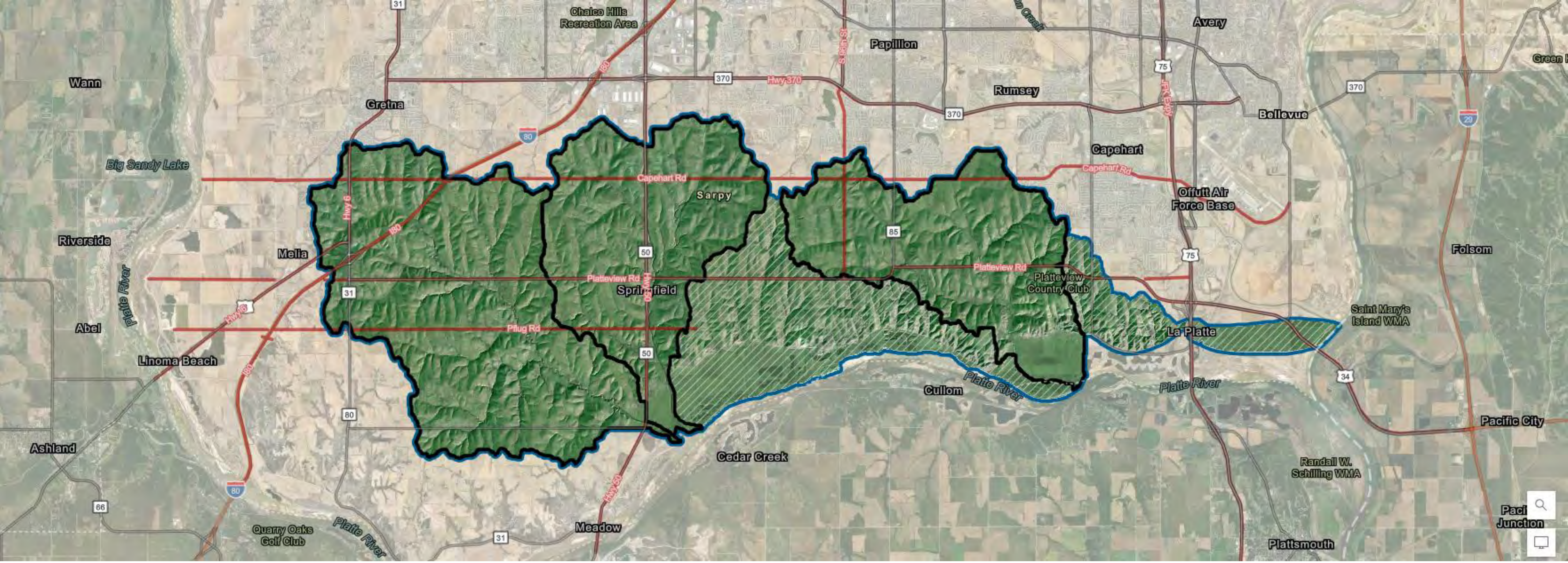
- 5 standard grade control template designs
- Guidance for multiple potential types of permits
- Developed collaboratively with the USACE and the Technical Advisory Group

Reimbursement

- 100% of construction costs reimbursed
- Acceptable range of unit costs provided
- Reimbursement processed within 60 days of Public Improvement Inspection

The Watershed Management Plan

The Watershed Management Plan details Partnership projects and policies which address issues related to surface water quality, stormwater quantity, and stream stability in the Watershed Management Area.



The Watershed Management Area

Blue Outline - The Watershed Management Area where the Partner jurisdictions enforce the Stormwater Management Policies and collect Watershed Fees.

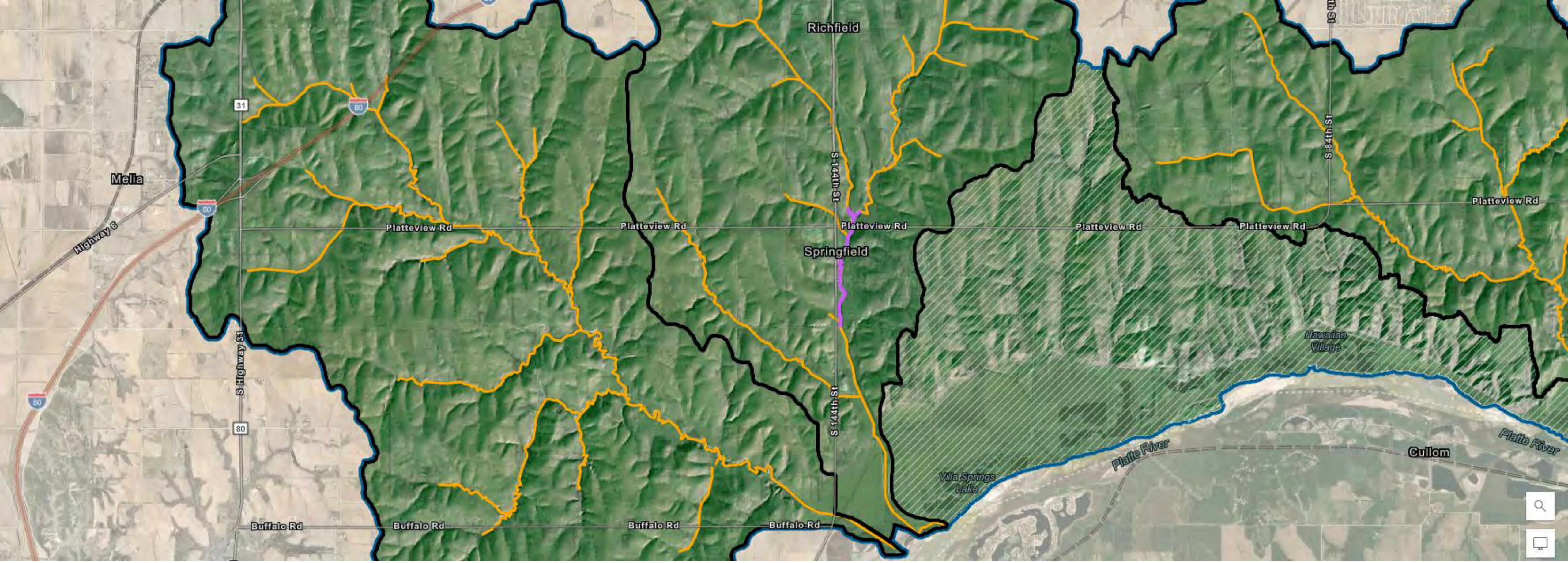
Black Outlines - Buffalo, Springfield, and Zwiebel Creek Watersheds

Striped Areas - The entire Watershed Management Area has not been studied. The striped areas shown on the map are future planned study areas where the need for additional projects is undetermined.

Stream Project Segments

One component of the Watershed Plan is the construction of grade control structures on streams with a drainage area of at least 0.5 square miles. **65.2 miles** of stream (shown in orange) meet this requirement.

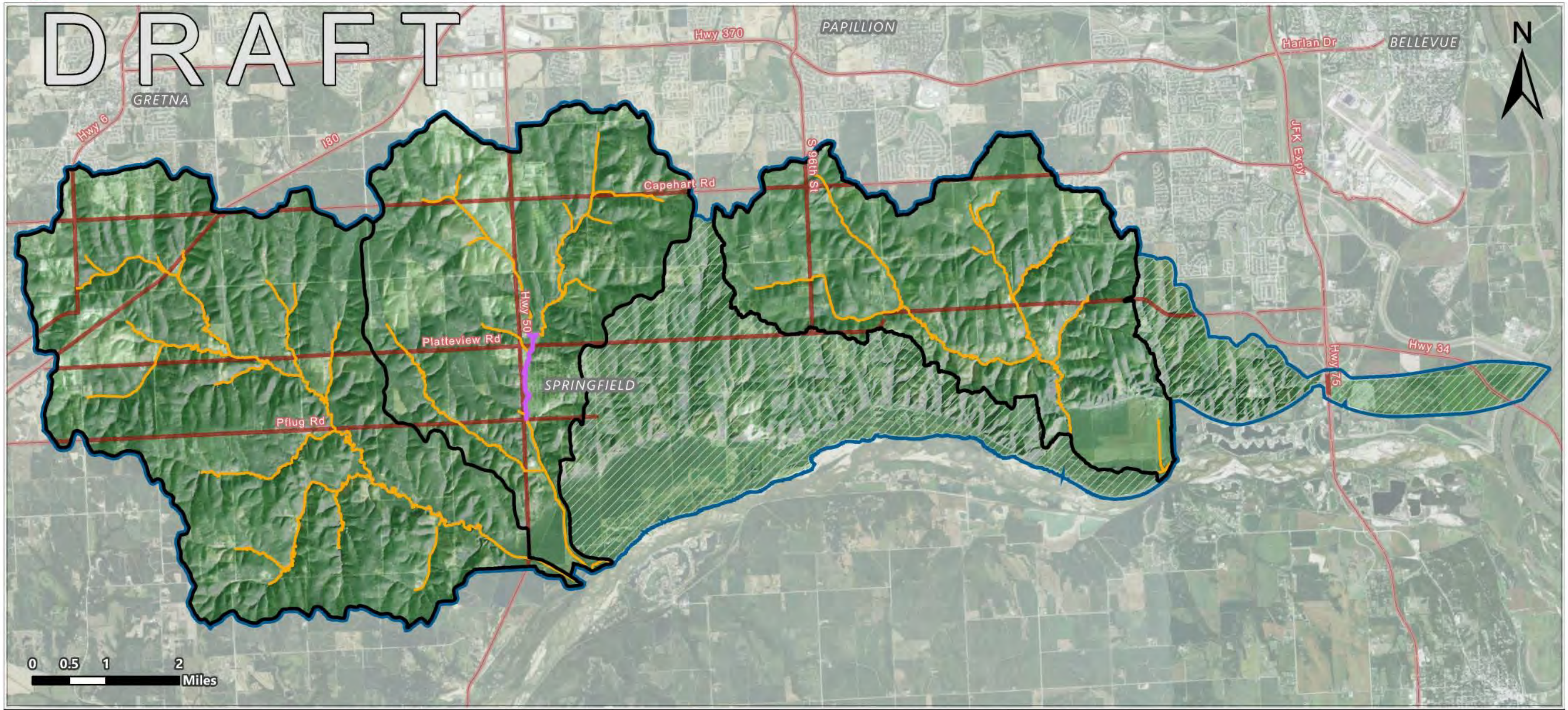
Developments adjacent to the displayed stream segments will be required to construct grade control structures per the policy requirements. Construction costs will be reimbursed by the Partnership with Watershed Fees.



City of Springfield Channel Stabilization Project

The Partnership has also proposed a grade and bank stabilization project through the City of Springfield to protect public infrastructure and private property along the stream section shown in purple.

Southern Sarpy Watersheds Partnership (SSWP) Watershed Management Plan



- Watershed Boundaries
- Watershed Management Area [a]
- Major Roads
- City of Springfield Channel Stabilization Project [b]
- Stream Project Segments [c]
- Future Planned Study Areas

KEY WATERSHED MANAGEMENT POLICIES

1) 2- and 10-year peak discharge maintained by new development

2) Green space corridors of 3:1 + 50' maintained along all watercourses (not mapped)

3) Grade control structures installed in all streams with a drainage area greater than 0.5 mi^2 as mapped by the Stream Project Segments.

WATERSHED MANAGEMENT COSTS: $70 Million (in 2022 Dollars)

NOTES

[a] The Watershed Management Area is the area subject to the plans and policies defined in the Watershed Plan.

[b] A proposed grade and bank stabilization project by the Partnership.

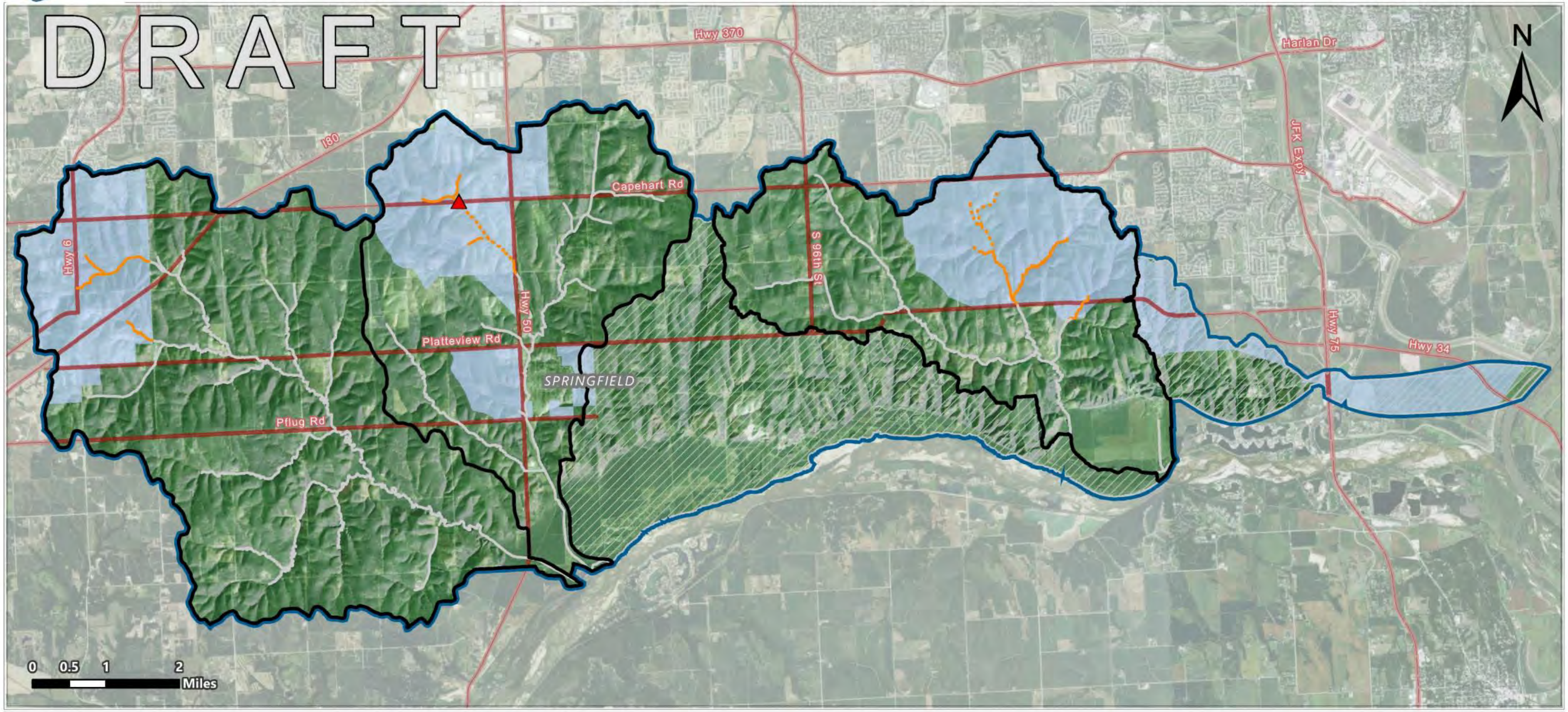
[c] 65 miles of stream were identified based on having a drainage area greater than 0.5 mi^2. Grade stabilization projects designed to prevent more than 4 ft of degradation will be constructed or funded by the SSWP in these streams.

June 2023

The Implementation Plan

The Implementation Plan more specifically details the projects that the Partnership intends to complete over the next five year plan period (July 2024 - July 2029) and distinguishes where grade control projects are to be constructed by developers or by the Partnership based on existing development.

Southern Sarpy Watersheds Partnership (SSWP) Five Year Implementation Plan (2024-2029)



- Watershed Boundaries
- Watershed Management Area [a]
- Urban Development Zones [b]
- 5-Yr Plan Stream Project Segments - Developor Led [c]
- 5-Yr Plan Stream Project Segments - Partnership Led [c]
- Stream Project Segments Outside 5-Yr Plan
- Proposed Partnership Project [c]
- Future Planned Study Areas

KEY WATERSHED MANAGEMENT POLICIES

1) 2- and 10-year peak discharge maintained by new development

2) Green space corridors of 3:1 + 50' maintained along all watercourses (not mapped)

3) Grade control structures installed in all streams with a drainage area greater than 0.5 mi^2 as mapped by the Stream Project Segments.

IMPLEMENTATION PLAN COSTS: $9 Million (in 2022 Dollars)

NOTES

[a] The Watershed Management Area is the area subject to the plans and policies defined in the Watershed Plan.

[b] Sarpy County Sewer Agency projection of area anticipated for development used for five-year implementation planning purposes.

[c] 10 miles of stream were identified based on having a drainage area greater than 0.5 mi^2 within the Urban Development Zone. Grade stabilization projects designed to prevent more than 4 ft of degradation will be led or funded by the SSWP in these streams.

June 2023

Important Dates

Between now and July 1st, 2024 when the new interlocal agreement must be adopted, the Partnership will be working on developing the Guidance Document and finalizing the Watershed Management Plan.

2023 July 28th

- Deadline for comments on plan recommendations (submitted via https://southernsarpy.org/submit-comments/)

2023 December 31st

- Watershed Management Plan finalized based on stakeholder feedback.

2024 July 1st

- Interlocal Agreement adopted by all Partner jurisdictions. Policies incorporated into local regulations.

Questions?

SOUTHERN SARPY WATERSHEDS PARTNERSHIP

Submit comments via https://southernsarpy.org/submit-comments/

PAPIO MISSOURI RIVER NATURAL RESOURCES DISTRICT

Southern Sarpy Watersheds Partnership
Stakeholder Engagement Questions & Responses

Detention Requirements:

Q: Please provide more specifics on water quality LID. Will it be the same as the Papio Creek Partnership where the 1/2" storm is detained and released over 24-48 hours?

A: Yes, this policy is the same as in the Papillion Creek Watershed Partnership. For more information, see the Omaha Regional Stormwater Design Manual: https://www.omahastormwater.org/orsdm/.

Q: Why is 2- and 10-year on-site detention still required?

A:The 2- and 10-year on-site detention requirement avoids adverse impact to other infrastructure which follows a similar design standard (e.g. sewers) and supports stream stabilization which is a central goal of the Partnership.

Creek Setback:

Q: Is the 3:1 creek setback required for all streams whether they have a 2-foot or 20-foot depression?

A: Yes.

Q: Can utilities go in the outer 30 foot of creek setback that can be used for trail or passive recreation corridor?

A: No.

Q: Will utility easements be allowed to overlap with the 3:1 + 50' setback area?

A: The Partnership is considering this and will make a decision in an upcoming meeting.

Q: If a watercourse is high in the watershed and the creek setback is very restrictive for such a small depression, could the watercourse be piped?

A: The recommended policies do not change the ability to pipe a portion of a waterway. Be sure to review the SSWP Policy Document for the full definition of a watercourse.

Guidance Document & Permitting:

Q: Will the U.S. Army Corps of Engineers and/or Nebraska Department of Environment and Energy be involved in the creation of the permitting guidance?

A: Yes, both the USACE and NDEE have been and/or will be involved in the development of the permitting guidance.

Design Review, Operation & Maintenance:

Q: Who will review grade control structures for construction plans?

A: The Partnership is considering using a single reviewer for all grade control structures. A final decision and more details will be available on this after upcoming meetings.

Q: What is the channel survey requirement and is there a grace period if it is known that field conditions have not changed?

A: The channel survey requirement has been increased to be within 12 months of preliminary plat submittal. The channel survey will set the outlot boundaries and site conditions will be verified at the time of construction to ensure the grade control design is adequate. There is not a grace period.

Q: How will there be consistency in what is required across jurisdictions?

A: The Guidance Document and design templates should provide consistency across most situations. The Partnership is also considering a single reviewer for all designs which would provide further consistency. Despite this, the Partnership recognizes that not every situation can be accounted for and will look at additions to the Guidance Document or Policy Document which cover unexpected situations.

Q: Is there or will there be a mechanism to appeal for reimbursement on more robust projects that go beyond the template project designs? Particularly in the case that a local jurisdiction requires a development to go beyond a template design?

A: The expectation is that the Guidance Document and template designs will cover the majority of projects. However, the Partnership recognizes that not every situation can be accounted for and will look at additions to the Guidance Document or Policy Document which cover unexpected situations such as more robust projects.

Q: How will O&M be handled for a development that is not part of an SID such as a private development?

A: This will be handled in much the same way as the Post Construction Stormwater best management practices in that there will be some agreement between the owner and zoning jurisdiction to maintain the structure.

Fees:

Q: Where can an approximate fee schedule be found?

A: An updated fee schedule will be posted to the SSWP website once finalized. We anticipate the watershed fees will be the same as the PCWP watershed fees.

Q: Will engineering fees and other soft costs for the grade control measures be a general obligation cost for SIDs?

A: Yes.

SSWP Grade Control Guidance Document Feedback

Wednesday, May 8, 2024 10:58 AM

Subject	**SSWP Grade Control Guidance Document Feedback**
Link to Outlook Item	**Click here**
From	**Ghanavati, Ian**
Required attendees	**Laster, Lori Ann (Accepted in Outlook)** **Sara Mechtenberg (Accepted in Outlook)** **bhuyck@td2co.com (Accepted in Outlook)** **joe.flaxbeard@lamprynearson.com (Accepted in Outlook)** **cbeasley@eacg.com (Accepted in Outlook)** **kvohl@eacg.com (Declined in Outlook)** **pniewohner@olsson.com (Accepted in Outlook)** **Ghanavati, Ian**
Optional attendees	**Aaron J. Grote (Accepted in Outlook)**
Meeting Date	**2/6/2024, 1:00:00 PM**
Location	**Small Conference Room**

Attachments

20240105

Guidance

Hello everyone -

Based on the Doodle Poll this was the best available time for those who responded. The Guidance Document is attached again for your review and the meeting agenda will be discussing any feedback/questions you may have.

If you are unable to attend, you are welcome to provide written feedback or give me a call. Thanks for your participation in this effort!

Ian

Notes

Re: Southern Sarpy Watersheds Partnership - Draft Grade Control Guidance Document

Ghanavati, Ian <IGhanavati@papionrd.org>

Tue 2/6/2024 11:49 AM

To:Joe T. Flaxbeard <Joe.Flaxbeard@LampRynearson.com>;Laster, Lori Ann <llaster@papionrd.org>
Cc:Sara Mechtenberg <smechtenberg@houstoneng.com>

Hey Joe -

Thanks for the feedback in advance, there are some good discussion points there. I do want to make clear that the goal for the meeting today is to collect feedback on the Guidance Document specifically to ensure that the technical and logistical support provided by the Partnership makes implementation of the SSWP Policies as smooth as possible. The actual Policies themselves are not a focus of discussion or subject to change; we completed the outreach effort on those with our Stakeholder Meeting in June of 2023. I wanted to mention this because some of the feedback pertains more to the Policies, namely:

- *Page 4, Identify Structure Locations, bullet 2: New development will be required to implement at property line assuming 4' of degradation.*
  - **This is per SSWP Proposed Policy Group #3, Requirement #4.**
- *Sheet 5 Maintenance Agreement and draft maintenance agreement page 32: Why would the long-term maintenance of these structures not be an obligation of the NRD or annexing jurisdiction?*
  - **This is per SSWP Proposed Policy Group #6, Sponsor Responsibilities and is based on the City of Omaha PCSMP Maintenance Agreement & Easement**
- *Sheet 6 Project Quantities and Cost Estimates: Design, Construction Admin, testing, as-built survey not reimbursable?*
  - **This is per SSWP Proposed Policy Group #6, Partnership Responsibilities - 100% construction reimbursement, "soft" costs not reimbursed**

I think the points on the hydrology guidance are something that we should discuss more today. Hope this makes sense, thanks!

Ian O. Ghanavati, CFM
Water Resources Engineer
Papio-Missouri River Natural Resources District
m. 402-315-1716

From: Joe T. Flaxbeard <Joe.Flaxbeard@LampRynearson.com>
Sent: Tuesday, February 6, 2024 10:44 AM
To: Ghanavati, Ian <IGhanavati@papionrd.org>; Laster, Lori Ann <llaster@papionrd.org>
Cc: Sara Mechtenberg <smechtenberg@houstoneng.com>
Subject: RE: Southern Sarpy Watersheds Partnership - Draft Grade Control Guidance Document

We gathered some feedback/ questions to share prior tot eh meeting today. See below. Thanks.

- Page 4, Identify Structure Locations, bullet 2: New development will be required to implement at property line assuming 4' of degradation. This approach puts more responsibility on the first party to develop. Theoretically, a more fair approach would be to split the 4' allowable degradation between the properties. For example, if you assumed future degradation of 2' at the property line, then projecting from there.

- Sheet 5 Maintenance Agreement and draft maintenance agreement page 32: Why would the long-term maintenance of these structures not be an obligation of the NRD or annexing jurisdiction? Aren't we doing a creek setback maintenance corridor at the NRD's requirement so they can maintain it? I think in practice, these drainageway are public conveyance of stormwater, and should be an obligation of the jurisdiction to maintain long-term.
- Sheet 5 Grade Control Design Hydrology:
    - It would be nice to have a baseline of assumptions or methodology to be used for the peak flow determination. As these will likely be large watersheds, there could be large variance in 100 year peak flow depending on the methodology utilized for analysis of the drainage basins.
    - Have the drainageways that require grade control been modeled previously? If so, is there set data that could be used?
    - Lists requirement to follow future conditions, we will only be in control of a small portion of the, at minimum 320 acre, drainage area, how can we project future 100 year conditions since only the 2 and 10 will be required to meet the pre-existing flow rate?
- Sheet 6 Project Quantities and Cost Estimates: Design, Construction Admin, testing, as-built survey not reimbursable?

Joe Flaxbeard, PE
Private Practice Lead

LAMP RYNEARSON

From: Ghanavati, Ian <IGhanavati@papionrd.org>
Sent: Tuesday, January 16, 2024 2:32 PM
To: Laster, Lori Ann <llaster@papionrd.org>
Cc: Sara Mechtenberg <smechtenberg@houstoneng.com>
Subject: Southern Sarpy Watersheds Partnership - Draft Grade Control Guidance Document

[EXTERNAL EMAIL]
Hello -

The Southern Sarpy Watersheds Partnership (SSWP) is in the process of drafting a Watershed Management Plan for the area. Some of you may have been involved in the outreach process thus far and more details on the Partnership, Plan, and Policies can be found at the SSWP website: [Draft Watershed Management Plan – Southern Sarpy Watersheds Partnership]

A major component of the proposed policies is the construction of grade control measures as a part of new developments, with construction costs reimbursed by the Partnership. To support the implementation of such structures, the SSWP is drafting a Guidance Document (attached) which includes procedural guidance, design templates, permitting guidance, and relevant forms. You have been recommended to participate as part of an Advisory Group to provide feedback on the document.

Please review the document and fill out this poll to select a meeting time to discuss: Doodle. If you think someone else from your organization should be included, please let me know.

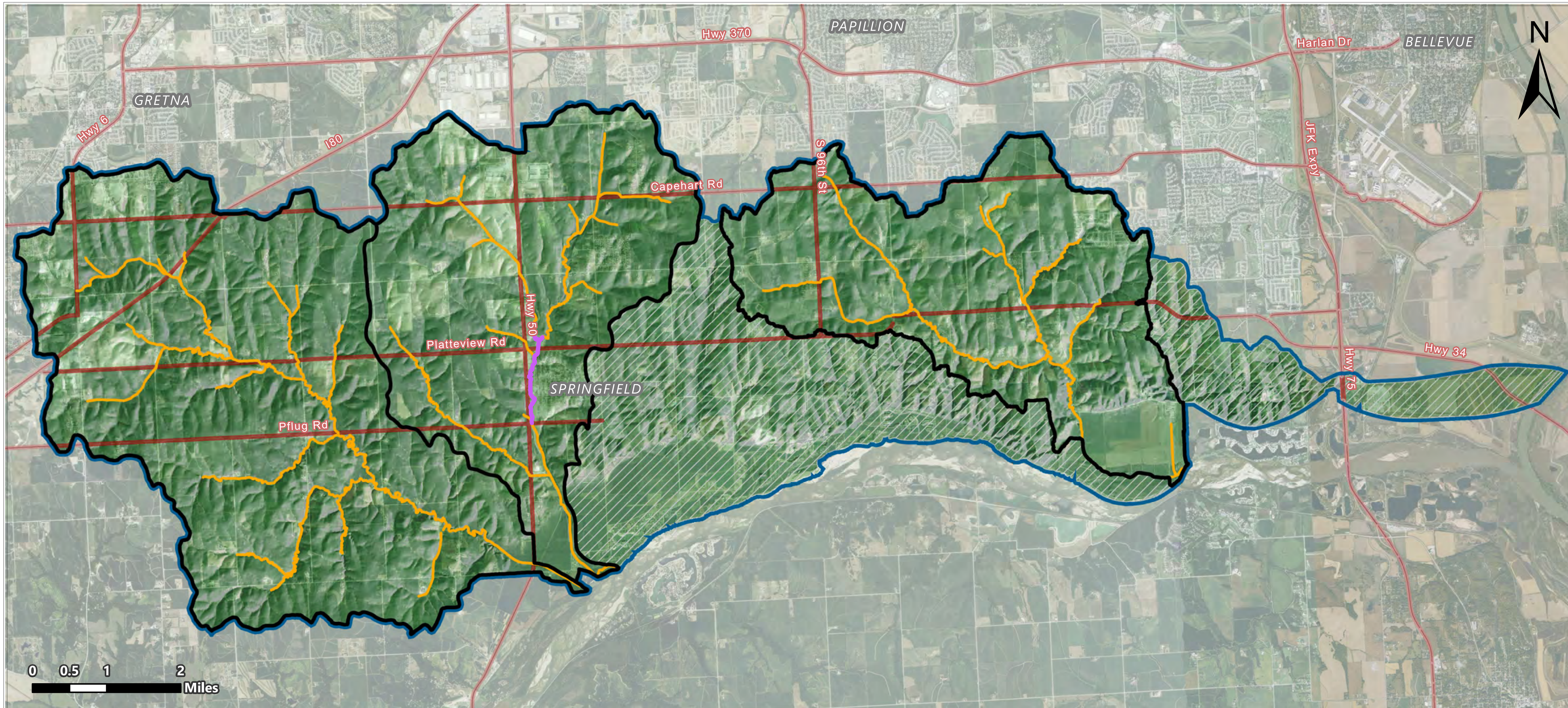
Thanks in advance for your collaboration!

Ian O. Ghanavati, CFM
Water Resources Engineer
m. 402-315-1716

Papio-Missouri River Natural Resources District
8901 S. 154th Street
Omaha, NE 68138
o. 402-444-6222

Appendix I. Final Watershed Plan and Policies

Southern Sarpy Watersheds Partnership (SSWP) Watershed Management Plan



Watershed Boundaries

Watershed Management Area [a]

Major Roads

City of Springfield Channel Stabilization Project [b]

Stream Project Segments [c]

Future Planned Study Areas

KEY WATERSHED MANAGEMENT POLICIES

1) 2- and 10-year peak discharge maintained by new development

2) Green space corridors of 3:1 + 50' maintained along all watercourses (not mapped)

3) Grade control structures installed in all streams with a drainage area greater than 0.5 mi^2 as mapped by the Stream Project Segments.

WATERSHED MANAGEMENT COSTS: $70 Million (in 2022 Dollars)

NOTES

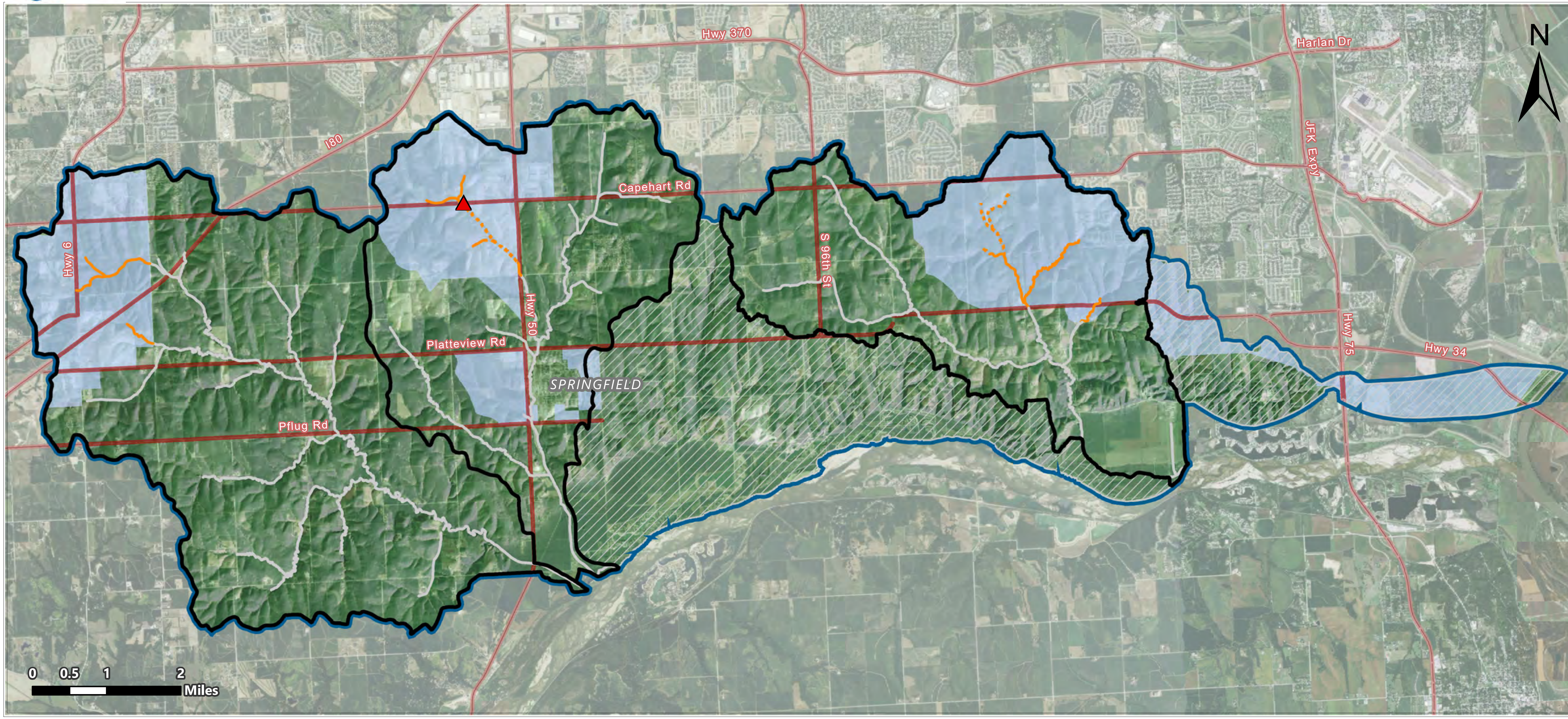
[a] The Watershed Management Area is the area subject to the plans and policies defined in the Watershed Plan.

[b] A proposed grade and bank stabilization project by the Partnership.

[c] 65 miles of stream were identified based on having a drainage area greater than 0.5 mi^2. Grade stabilization projects designed to prevent more than 4 ft of degradation will be constructed or funded by the SSWP in these streams.

June 2023

Southern Sarpy Watersheds Partnership (SSWP) Five Year Implementation Plan (2024-2029)



Watershed Boundaries

Watershed Management Area [a.]

Urban Development Zones [b.]

5-Yr Plan Stream Project Segments - Developor Led [c.]

5-Yr Plan Stream Project Segments - Partnership Led [c.]

Stream Project Segments Outside 5-Yr Plan

Proposed Partnership Project [c.]

Future Planned Study Areas

KEY WATERSHED MANAGEMENT POLICIES

1) 2- and 10-year peak discharge maintained by new development

2) Green space corridors of 3:1 + 50' maintained along all watercourses (not mapped)

3) Grade control structures installed in all streams with a drainage area greater than 0.5 mi^2 as mapped by the Stream Project Segments.

IMPLEMENTATION PLAN COSTS: $9 Million (in 2022 Dollars)

NOTES

[a.] The Watershed Management Area is the area subject to the plans and policies defined in the Watershed Plan.

[b.] Sarpy County Sewer Agency projection of area anticipated for development used for five-year implementation planning purposes.

[c.] 10 miles of stream were identified based on having a drainage area greater than 0.5 mi^2 within the Urban Development Zone. Grade stabilization projects designed to prevent more than 4 ft of degradation will be led or funded by the SSWP in these streams.

June 2023

EXHIBIT B
SOUTHERN SARPY WATERSHED
STORMWATER MANAGEMENT POLICIES

POLICY GROUP #1: WATER QUALITY IMPROVEMENT

POLICY: Improve water quality from all contributing sources, including but not limited to, agricultural activities and urban stormwater, such that waters of the Southern Sarpy Watershed and other local watersheds can meet applicable water quality standards and community-based goals, where feasible.

REQUIREMENTS:

1) *Water Quality LID* shall be required on all *new developments* and *significant redevelopments*.

GOALS:

1) Protect surface and groundwater resources from soil erosion (sheet and rill, wind erosion, gully and stream bank erosion), sedimentation, nutrient and chemical contamination. Buffer strips and riparian corridors should be established along all stream segments.
2) Preserve and protect wetland areas to the fullest extent possible to maintain natural hydrology and improve water quality by minimizing the downstream transport of sediment, nutrients, bacteria, etc. borne by surface water runoff.
3) Support the Nebraska Department of Environment and Energy (NDEE) in an accelerated *TMDL* development process that addresses potential pollutant sources in a fair and reasonable manner based on sound technical data and scientific approach.
4) Implement *Best Management Practices (BMPs)*, as identified in the Lower Platte River Basin *Water Quality Management Plan (WQMP)*, to reduce both urban and rural pollution sources, maintain or restore designated beneficial uses of streams and surface water impoundments, minimize soil loss, and provide sustainable production levels.

SEE APPENDIX A – DEFINITIONS FOR *REFERENCED INFORMATION*

EXHIBIT B
SOUTHERN SARPY WATERSHED
STORMWATER MANAGEMENT POLICIES

POLICY GROUP #2: PEAK FLOW MANAGEMENT

POLICY: Maintain stormwater *peak discharge* during development and after *full build-out land use conditions* from that which existed under *baseline land use conditions*.

REQUIREMENTS:

1) All *new developments* and *significant redevelopments* shall maintain or reduce peak discharge rates during the 2- and 10-year storm event under baseline land use conditions.

GOALS:

1) Limit increases in *peak flow* for frequent storm events to prevent excessive flooding and erosion.
2) Reduce the potential risk of damage to infrastructure.

SEE APPENDIX A – DEFINITIONS FOR *REFERENCED INFORMATION*

EXHIBIT B
SOUTHERN SARPY WATERSHED
STORMWATER MANAGEMENT POLICIES

POLICY GROUP #3: STREAM CORRIDOR PRESERVATION

POLICY: Utilize landscape preservation, restoration, and conservation techniques to meet the multi-purpose objectives of enhanced aesthetics, quality of life, recreational and educational opportunities, pollutant reduction, and overall stormwater management.

REQUIREMENTS:

1) For *new development* or *significant redevelopment*, provide a *stream setback* of 3:1 plus a minimum 50 feet along all *streams* based upon a current channel survey (within 12 months of preliminary plat submission).
2) All landscape preservation features as required in this policy or other policies, including all stormwater and LID strategies, stream setbacks, existing or mitigated wetlands, etc., identified in new or significant redevelopment shall be placed into an outlot, within public right of way or otherwise approved easement.
3) All new or improved stream crossings of roads and utilities must incorporate grade control measures designed to prevent stream degradation of more than four (4) feet. Such measures shall be designed, permitted and installed according to the Guidance Document in this Plan. Site conditions shall be verified before construction. These road and utility crossings are not eligible for Partnership reimbursement.
4) Grade control measures shall be installed along all streams with a drainage area of at least 0.5 square miles as identified in the Southern Sarpy Watershed Management Plan. Beginning at the downstream end of all new developments and significant redevelopments, approved grade control structure(s) designed to prevent stream degradation of more than four (4) feet shall be designed, permitted and installed according to the Guidance Document in this Plan. Site conditions shall be verified before construction. Construction costs of grade control measures shall be reimbursed by the Partnership subject to the Grade Stabilization Reimbursement Policy, which is detailed in Policy Group #6: Stormwater Management Financing.
5) These policies are intended to provide a minimum requirement for new development or significant redevelopment. Site conditions may warrant additional setback distance or other stream stabilization measures.

GOALS:

1) Prevent stream degradation of more than four (4) feet along any stream with a drainage area of at least 0.5 square miles.
2) Develop a continuous stream corridor for multi-purpose benefits including ecosystem restoration and recreation.

SEE APPENDIX A – DEFINITIONS FOR *REFERENCED INFORMATION*

EXHIBIT B
SOUTHERN SARPY WATERSHED
STORMWATER MANAGEMENT POLICIES

POLICY GROUP #4: EROSION AND SEDIMENT CONTROL AND OTHER BMPs

POLICY: Promote uniform *erosion and sediment control* measures by implementing consistent rules for regulatory compliance pursuant to State and Federal requirements, including the adoption of the Omaha Regional Stormwater Design Manual.

REQUIREMENTS:

1) Construction site stormwater management controls shall include both erosion and sediment control measures.
2) The design and implementation of post-construction, permanent erosion and sediment controls shall be considered in conjunction with meeting the intent of other Stormwater Management Policies.

GOALS:

1) Protect valuable land resources, stream and drainage corridors, and other surface waters from excessive erosion and sedimentation.

SEE APPENDIX A – DEFINITIONS FOR *REFERENCED INFORMATION*

EXHIBIT B
SOUTHERN SARPY WATERSHED
STORMWATER MANAGEMENT POLICIES

POLICY GROUP #5: FLOODPLAIN MANAGEMENT

POLICY: Participate in the FEMA National Flood Insurance Program, update FEMA *floodplain* mapping throughout the Southern Sarpy Watershed and enforce floodplain regulations.

REQUIREMENTS:

1) Floodplain management coordination among all jurisdictions within the Southern Sarpy Watershed and the Papio-Missouri River Natural Resources District (Papio NRD) is required.
2) Filling of the *floodway fringe* associated with *new development* within the Southern Sarpy Watershed's stream system (Platte and Elkhorn Rivers not included) shall be limited to 25% of the floodway fringe in the floodplain development application project area unless approved mitigation measures are implemented. The remaining 75% of floodway fringe within the project area shall be designated as a *floodway* overlay zone. For redevelopment, these provisions may be modified or waived in whole or in part by the local jurisdiction.
3) The *low chord elevation* for bridges crossing all *streams* within FEMA designated floodplains shall be a minimum of one (1) foot above the *base flood* elevation for existing conditions hydrology using best available data.
4) Developments in areas with no FEMA Special Flood Hazard Area defined must provide hydrologic and hydraulic analyses which utilize full build-out conditions to ensure new development will be reasonably safe from flooding during the base flood.

GOALS:

1) Holistic floodplain management applied throughout the watershed to protect its citizens, property, and natural resources.

SEE APPENDIX A – DEFINITIONS FOR *REFERENCED INFORMATION*

EXHIBIT B
SOUTHERN SARPY WATERSHED
STORMWATER MANAGEMENT POLICIES

POLICY GROUP #6: STORMWATER MANAGEMENT FINANCING

POLICY: Dedicated, sustainable funding mechanisms shall be developed and implemented to meet capital and operation and maintenance obligations needed to implement NPDES *Stormwater Management Plans*, Stormwater Management Policies, and the Southern Sarpy Watershed Management Plan.

REQUIREMENTS:

1) All *new development* and *significant redevelopment* will be required to fund the planning, implementation, and operation and maintenance of *Water Quality LID*.
2) A Watershed Management Fee System shall be established to equitably reimburse the construction cost of implementing the Southern Sarpy Watershed Management Plan in the watershed by the distribution of fees collected for that purpose. Such Watershed Management Fees shall only apply to new development or significant redevelopment within the Southern Sarpy Watershed and the initial framework shall consist of the following provisions:
    a. Collection of fees and public funding shall be earmarked specifically for the construction of projects called for in the Southern Sarpy Watershed Management Plan. Fees may also be used to fund tasks such as construction site inspection, water quality monitoring, and reporting activities. Furthermore, the fee may be used to commission studies for the purposes of watershed planning, flood hazard mapping, and other planning activities.
    b. Multiple fee classifications shall be established which fairly and equitably distribute the cost of these projects among all undeveloped areas in the Southern Sarpy Watershed.
    c. Watershed Management Fees shall be paid to the applicable local zoning jurisdiction with building permit applications.
    d. Watershed Management Fee revenues shall be transferred from the applicable local zoning jurisdiction to a special Papio NRD account via inter-local agreements.
    e. Watershed Management Fee revenues are intended to provide the construction costs of grade control measures required for new development and significant redevelopment. Revenues may also be used for Partnership led projects deemed necessary by the Partnership as defined in the Watershed Management Plan. On approximately three-year intervals, the Southern Sarpy Watershed Management Plan and Watershed Management Fee framework shall be reviewed with respect to availability of needed funds and rate of development within the Southern Sarpy Watershed by the parties involved (local zoning jurisdictions, Papio NRD, and the development community). Subsequent changes thereto shall be formally approved by the respective local zoning jurisdictions and the Papio NRD.

GOALS:

1) The Partnership will continue to work towards establishing a Stormwater Utility Fee System to equitably distribute the costs for ongoing operation and maintenance of all stormwater BMPs and infrastructure among all existing property owners within NPDES MS4 permittees.

EXHIBIT B
SOUTHERN SARPY WATERSHED
STORMWATER MANAGEMENT POLICIES

GRADE STABILIZATION REIMBURSEMENT POLICY *(see Policy 3)***:**

Grade control measures required for this policy for all new development and significant redevelopment are eligible for reimbursement of construction costs from Watershed Management Fee revenues. This does not apply to utility crossings, road crossings, or maintenance of existing crossings.

Partnership Responsibilities:

1) Each community will be responsible for review of the proposed grade control measures for each new development or significant redevelopment to ensure compliance with the guidelines of the Watershed Management Plan.
2) The Partnership will maintain a database of approved line items and reasonable unit costs for construction of approved grade control measures. This database will be regularly reviewed and updated as needed, no less than once per year.
3) The Papio NRD will accept applications for reimbursement of the construction costs of grade control measures. 100% reimbursement of construction costs will be paid based on review of project costs versus the database of reasonable costs, subject to availability of funding.
4) If funding is limited, the project will be placed on a waiting list for reimbursement when funds become available.

Sponsor Responsibilities:

1) The Sponsor shall obtain all land rights for the project at no cost to the Partnership.
2) The Sponsor shall follow design guidance provided or referenced within this document.
3) The Sponsor shall administer all contracts for design, construction, and construction inspection.
4) The Sponsor must obtain all local, state, and federal permits necessary for the project.
5) The Sponsor must execute a Maintenance and Easement Agreement for the project.
6) The Sponsor shall hold and save the Partnership Members free from damages or claims due to the design, construction, or operation and maintenance of the project.

Requesting Reimbursement:

1) Upon completion of construction, reimbursement may be requested by the sponsor by providing the following:
    a. A letter of acceptance of improvements from the local jurisdiction
    b. Copies of final pay estimates which show total units, unit costs, and total component costs
    c. Signed and recorded Maintenance Agreements
    d. As-built plans
2) Project unit costs will be limited to a reasonable range to be determined by the Partnership, reviewable upon noticeable changes in unit costs provided on local, similar projects.
3) Progress payments on individual components will not be allowed.

SEE APPENDIX A – DEFINITIONS FOR *REFERENCED INFORMATION*

EXHIBIT B
SOUTHERN SARPY WATERSHED
STORMWATER MANAGEMENT POLICIES

APPENDIX A – DEFINITIONS

1 *Base Flood* – The flood having a one percent chance of being equaled or exceeded in magnitude in any given year (commonly called a 1% Annual Chance flood or 100-year flood). *[Adapted from Chapter 31 of Nebraska Statutes]*

2 *Baseline Land Use Conditions* – The pre-developed conditions which existed in Year 2022 based on the NIROC aerial photography and LiDAR survey.

3 *Best Management Practice (BMP)* – "A technique, measure or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff in the most cost-effective manner." *[Source: U.S. Environmental Protection Agency (EPA)]*

4 *Channel Bottom Edge* – The physical transition of the channel bed to the channel bank where there is a noticeable change in slope. This is not intended to be the edge of any flowage in the channel at any one time, but rather the base of the vertical component of the channel bank.

5 *Comprehensive Development Plans* – Existing plans developed by local jurisdictions that serve as the basis for zoning and other land use regulations and ordinances. The Stormwater Management Policies are to be incorporated into the respective Comprehensive Development Plans.

6 *Stream Setback* – See Figure 1 below. A green space corridor comprised of stream setbacks equal to three (3) times the channel depth plus fifty (50) feet (3:1 plus 50 feet) from the edge of the channel bottom on both sides of channel shall be required for any above or below ground structure exclusive of bank stabilization structures, poles, or sign structures adjacent to any stream defined within the watershed drainage plan. Grading, stockpiling, and other construction activities are not allowed within the setback area. The setback area must be protected with adequate erosion controls or other Best Management Practices (BMPs). The outer 30 feet adjacent to the stream setback limits may be credited toward meeting the landscaping buffer and pervious coverage requirements. The outer 30 feet of the setback area may be used for *passive recreation*. The outer 15 feet of the setback area may overlap with utility easements, subject to prior approval by the local jurisdiction.

A property can be exempt from the stream setback requirement upon a showing by a licensed professional engineer that adequate bank stabilization structures or slope protection will be installed in the construction of said structure, having an estimated useful life equal to that of the structure, which will provide adequate erosion control conditions coupled with adequate lateral support so that no portion of said structure adjacent to the stream will be endangered by erosion or lack of lateral support. In the event that the structure is adjacent to any stream which has been channelized or otherwise improved by any agency of government, then such certificate providing an exception to the stream setback requirement may take the form of a certification as to the adequacy and protection of the improvements installed by such governmental agency. If such exemption is granted, a 20-foot setback measured from the top of the bank is required.

EXHIBIT B
SOUTHERN SARPY WATERSHED
STORMWATER MANAGEMENT POLICIES

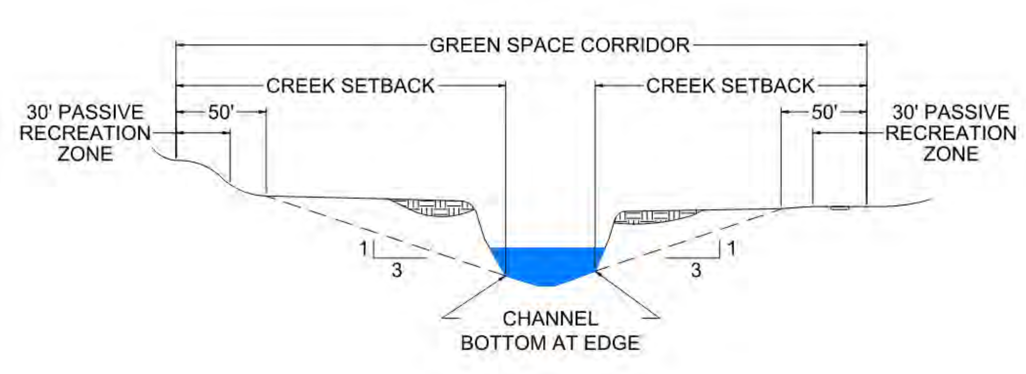


Figure 1 – Green Space Corridor Schematic

7 *Erosion Control* – Land and stormwater management practices that minimize soil loss caused by surface water movement.

8 *Floodplain* – See Figure 2 below. The area adjoining a stream, which has been or may be covered by flood waters. [Adapted from Chapter 31 of Nebraska Statutes]

9 *Floodway* – See Figure 2 below. The channel of a stream and the adjacent land areas that are necessary to be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot. [Adapted from Chapter 31 of Nebraska Statutes].

10 *Floodway Fringe* – See Figure 2 below. That portion of the floodplain of the base flood, which is outside of the *floodway*. [Adapted from Chapter 31 of Nebraska Statutes]

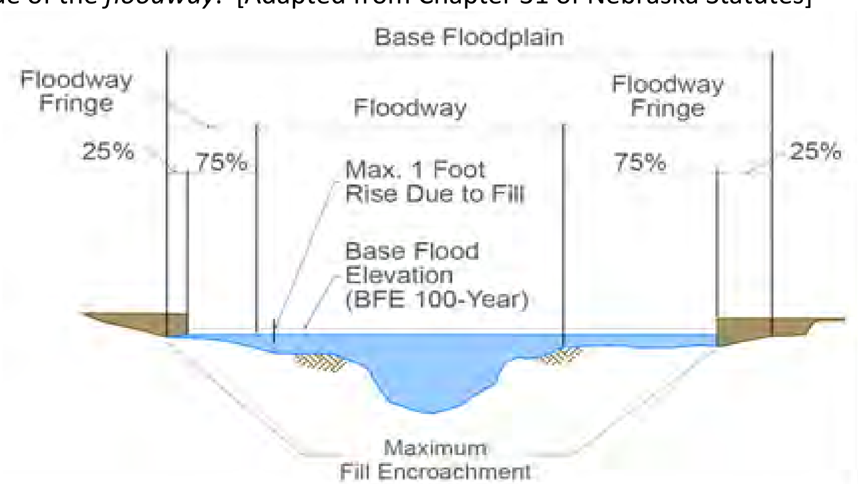


Figure 2 – Floodway Fringe Encroachment Schematic

EXHIBIT B
SOUTHERN SARPY WATERSHED
STORMWATER MANAGEMENT POLICIES

11 *Full Build-Out Land Use Conditions* – Fully platted developable land use conditions for the Southern Sarpy Watershed are assumed to occur by the Year 2055; or as may be redefined through periodic updates to the respective community and county comprehensive plans.

12 *Low Chord Elevation* – The bottom-most face elevation of horizontal support girders or similar superstructure that supports a bridge deck.

13 *New Development* – New development shall be defined as that which is undertaken to any undeveloped parcel that existed at the time of implementation of this policy.

14 *Passive Recreation* – Passive recreation shall mean features that are constructed at grade and require minimal ground disturbance (no permanent structures or footings, de minimis cut/fill).

15 *Peak Discharge or Peak Flow* – The maximum instantaneous surface water discharge rate resulting from a design storm frequency event for a particular hydrologic and hydraulic analysis, as defined in the Omaha Regional Stormwater Design Manual. The measurement of the peak discharge shall be at the lower-most drainage outlet(s) from a new development or significant redevelopment.

16 *Sediment Control* – Land and stormwater management practices that minimize the transport and deposition of sediment onto adjacent properties and into receiving streams and surface water impoundments.

17 *Significant Redevelopment* – Land disturbing activity that results in the creation, addition, or replacement of at least five thousand (5,000) square feet of impervious surface area on an already developed site.

18 *Stable Slope Projection* – A channel bed slope of 0.08% in the Southern Sarpy Watershed. The stable slope projection is based on a hydraulic assessment which utilizes data from the USDA National Engineering Handbook and a field survey of the existing condition of stream segments in the Southern Sarpy Watershed as of May 2018. For more information, see the Southern Sarpy Watershed Management Plan Appendix on Stream Stability Assessment Methodology.

19 *Stormwater Management Plan (SWMP*) – A SWMP is a required part of the NPDES Municipal Separate Storm Sewer System (MS4) permits for the urbanized portion of Sarpy County. Development of Stormwater Management Policies is an integral part of the SWMP, and such policies are to be adopted by respective SSWP partners.

20 *Total Maximum Daily Load (TMDL)* – A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. Water quality standards are set by States, Territories, and Tribes. They identify the uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support that use. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and non-point sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account for seasonal variation in water quality. The Clean Water Act, Section 303, establishes the water quality standards and TMDL programs, and for Nebraska such standards and programs are administered by the Nebraska Department of Environment and Energy. *[Source: EPA and Nebraska Surface Water Quality Standards, Title 117].*

21 *Water Quality LID* – A level of Low-Impact Development (LID) using strategies designed to provide for water quality control of the first ½ inch of stormwater runoff generated from each new development or significant redevelopment and to maintain the peak discharge rates during

the 2-year storm event to baseline land use conditions, measured at every drainage (stormwater discharge) outlet from the new development or significant redevelopment.

22 *Water Quality Management Plan (WQMP)* – Plan based on EPA's nine key elements to achieve improvements in water quality. A WQMP for the Lower Platte River Basin, which includes the Southern Sarpy Watershed, was approved in April 2019 by the EPA and lays out a strategy to systematically address water resource deficiencies in the basin and allows for the management of individual watersheds or other targeted areas. The focus of the Plan is to address impaired waterbodies and satisfy the EPA requirements to be eligible for Section 319 funding. Implementation will be guided on a watershed scale by a comprehensive strategy to address water and land use deficiencies that contribute to the degradation of surface water resources, groundwater resources, and aquatic and terrestrial habitat. The ultimate goal is to delist impaired waterbodies from the 303(d) list.

23 *Stream* – Any depression two feet or more below the surrounding land which serves to give direction to a current of water at least nine months of the year and which has a bed and well-defined banks. [Adapted from Chapter 31 of Nebraska Statutes]

Appendix J. Grade Control Guidance Document

Grade Control Implementation Guidance Document

Prepared as part of the
Southern Sarpy Watersheds Management Plan

SECTION 1
Overview and Intent

The Southern Sarpy Watersheds Partnership (SSWP) has a developed a set of six (6) policies to include in the Southern Sarpy Watersheds Management Plan (Plan). The Stream Corridor Preservation policy requires that grade control structures are incorporated into developments on stream segments with a drainage area of 0.5 mi^2 or greater. The purpose of this document is to guide developers through incorporating grade control structures into developments as required by the policy.

The process for completing major tasks during the different phases of development (grouped as platting, public improvements, and project closeout) is summarized in the diagram below. Details for completing each task are provided in the subsequent sections of this document that can be accessed by clicking each cell. Design templates, permitting guidance, checklists, and forms referenced throughout the guidance document are included as appendices and linked below. Click the logo on each page to return to the flow chart.

Figure 1. Grade Control Implementation Process

Platting
- Topographic Survey
- Define Stream Setback Area
- Identify Structure Locations
  Determine Grade Control Design Template
- Draft Maintenance & Easement Agreement
- Initiate Section 404 Permitting Requirements

Public Improvements
- Grade Control Design
- Obtain Required Permits
- Develop Project Quantities and Cost Estimates
- Develop Construction Documents

Project Close Out
- Execute and Record Maintenance & Easement Agreement
- Acceptance of Public Improvements
- Project Reimbursement Request

Appendices
- Appendix A – Design Guidance
- Appendix B – Section 404 Permit Guidance
- Appendix C - Forms

SECTION 2
Grade Control Implementation Procedures

The grade controls structures are intended to limit future degradation from the existing stream bed elevations to a maximum of 4 ft. There are pre-approved design templates that pin the stream bed at existing grade and are designed to prevent downstream head cuts from progressing upstream. The Grade Control Submittal Checklist – Appendix C provides a summary of the submittals required for each phase.

2.1 Platting Phase

Steps to complete the design of the grade control structure are outlined below.

- Topographic Survey

  Collect elevation data within the channel less than twelve (12) months prior to preliminary plat submission. This survey will be used for defining the stream setback area and determining the number and location of grade control structures. Survey should adequately reflect the channel geometry and grades as required to accurately determine stream setback area, primarily the channel bottom at edge. Survey data should accurately reflect a stream profile that will be used for grade control determinations. Any hard point located downstream (even if off-site) that will be used for establishing the future stable grade (see section Identify Structure Locations) should be surveyed to collect the invert elevation of the structure that is used in the development of the future stable grade. Supplemental survey of the stream at the selected grade control locations will be required during final design to develop accurate designs and quantity calculations.

- Define Stream Setback Area

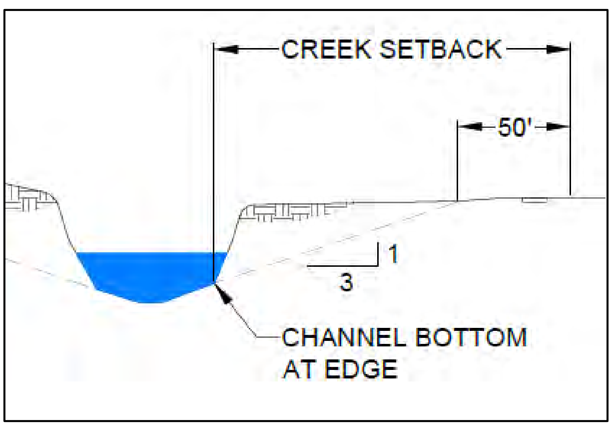


Figure 2. Stream Setback Definition

Use the channel survey data to define the creek setback distance at each surveyed cross section.

- ✓ Project a 3:1 slope from the channel bottom at edge (not the edge of water since this varies) on each side of the channel located on the property until it daylights with existing ground. If survey data doesn't extend into uplands, LiDAR can be used for determining the daylight location.
- ✓ Add 50 ft horizontally (perpendicular to channel alignment) from the daylight point to locate the setback boundary.
- ✓ Plot the setback boundary in plan view and ensure a single continuous setback area is accessible via public right of way.

❖ Identify Structure Locations

The location of grade controls are determined with an exercise that compares the existing (surveyed) bed slope with the projected future stable slope. Grade controls will be placed to prevent future degradation depths (D) from exceeding 4 ft. Structure locations should consider impacts to the Waters of the United States and thresholds for the USACE 404 permits that are required for all in-stream structures located within the development. Strategic placement of structures to minimize stream impacts should be applied to stay within permit thresholds.

- ✓ Create a profile along the stream flowline.
- ✓ Start at the nearest downstream existing hard point (i.e. culvert or grade control structure). If there is no hard point on the property, an off-site hard point can be used, or a new grade control structure can be implemented on the downstream end of the parcel. This grade control structure should be designed with the assumption of a future degradation depth of 4 ft.
- ✓ Project a future stable slope line of **0.15%** and identify grade control locations that prevent D from exceeding 4 ft and minimizes permitting impacts along the stream length within the platted property
- ✓ Establish an identification number and D for each grade control structure location to be used for design

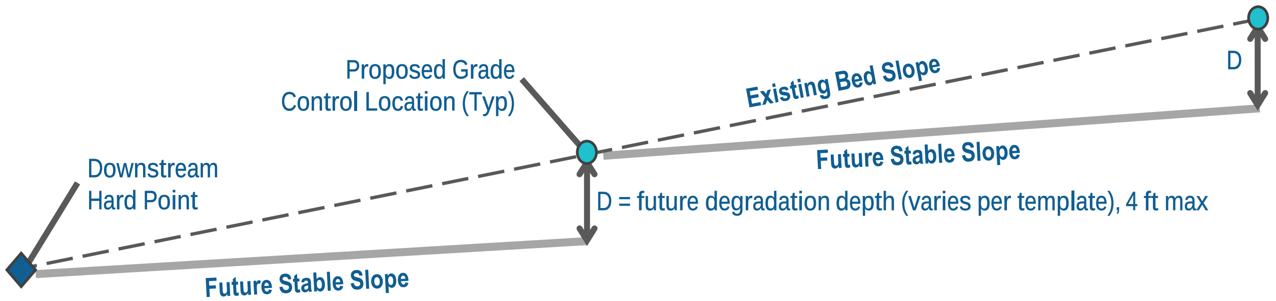


Figure 3. Stream Profile for Locating Grade Controls

❖ Determine Grade Control Design Template

Design templates for three different grade stabilization structures are located in Appendix A-Design Templates. The future degradation depth (D) that each structure can be designed for varies per template. The acceptable range of D for each structure is identified below and on the design templates.

- Rock Riprap Riffle with Sheet Pile, D= 0-4 ft
- Rock Slab Drop Structure, D= 0-1.5 ft (placement limited to ephemeral streams)
- Grouted Boulder Drop Structure, D= 0-4 ft

The D at each structure location must fall within the acceptable range of Ds for the selected design template.

- Draft Maintenance and Easement Agreement

  The Maintenance Agreement - Appendix C shall be developed that documents the responsibilities of the owner, the Sanitary Improvement District or Homeowners Association, and the local jurisdiction as applicable. The maintenance agreement shall be approved by the local jurisdiction. Exhibits to be included with the agreement are:

  - Exhibit A – Real Property Depiction shall provide lot certificate or platted subdivision with legal description
  - Exhibit B – Grade Control Maintenance Requirements including site and grade control structure information, a description of maintenance repair tasks, and a maintenance schedule

- Initiate Section 404 Permitting Requirements
  - Complete jurisdictional waters of the United States determination
  - Schedule pre-application meeting with the USACE

2.2 Public Improvements Phase

- Grade Control Design
  - Hydrology
    - Develop peak flow rates according to the Omaha Regional Stormwater Design Manual
      - Design event = future conditions, 24-hr, 100-yr frequency
      - Design discharge to be the rate at the top of the bank or the 100-year discharge, whichever is the lesser
      - A Design Discharge Rate Approximations Figure – Appendix A is provided that approximates peak flows at selected points with the future land use used to develop the estimates. This figure can be used as a check to determine if the calculated design rates are within reason.
  - Structure Design and Calculations
    - See Appendix A - Design Templates for establishing structure dimensions and stable rock size
    - Develop table with design parameters and final structure information
  - Document the design information identified in the Grade Control Submittal Checklist - Appendix C. This can be a stand along report or added into or as an appendix to the Drainage Report that is required for the Post Construction Stormwater Management Plan.

- Obtain Required Permits
  - Include pertinent information for the grade controls in all permits required for the project
  - For Section 404 permitting requirements, follow Appendix B – Section 404 Permitting Guidance

- Develop Project Quantities and Cost Estimates
  - Separate quantities and costs specific to grade controls
  - Only materials in the design template and bid line items below will be approved for reimbursement, which include:
    - Rock riprap (*Nebraska Type A-C*) (ton)
    - Rock riprap (*South Dakota Class A-F*) (ton)*
    - Limestone slabs (tons)*
    - Boulders (tons)*
    - Grout (*NDOT - flowable fill concrete*) (CY)
    - Steel Sheet pile (SF)
    - Earth fill (*NDOT - earthwork measured in emban*kment) (CY)
    - Excavation (CY)
    - Geotextile fabric (*NDOT - riprap filter fabric*) (SY)
    - Weep drains (*NDOT hose clamp* and PVC conduit*)
    - Seeding (ac or SY)
    - Extra SWPPP measures required for in-stream work*
    - Dewatering*
  - Nebraska Department of Transportation (NDOT) Average Unit Prices from the previous fiscal year (Bid Item History & Information - NDOT (nebraska.gov)) shall be used as the basis for established acceptable prices for reimbursement. Unit prices within 15% of the NDOTs shall be considered the approved cost range. Line items with an asterisk (*) are not currently listed in the NDOT's average prices and shall be reviewed independently.

- Develop Construction Documents
  - Construction plans sheets specific to each individual grade control structure that include but are not limited to grading plan views, profiles, cross sections, and relevant details required to accurately convey the design of each structure.
  - Construction specification and/or bid document information that needs to be included due the addition of the grade controls to the construction project:
    - Add specifications for materials that were otherwise not included in the project
    - If the specifications do not already include a Performance Bond, one is required for the grade control structures. An example is included in Performance Bond - Appendix C.
  - Bid forms and pay applications
    - Must have separate line items for all grade control materials, even if duplicating materials already used on the project, with no lump sum or each units.
    - Line items labeled with Grade Control pre-curser (i.e. GRADE CONTROL – TYPE "B" ROCK RIPRAP)

2.3 Project Close Out Phase

Construction costs for grade stabilization structure installed by developer are reimbursable as long as the procedures are followed.

- Execute and Record Maintenance and Easement Agreement

  The Maintenance Agreement - Appendix C and associated exhibits shall be finalized, approved by the local jurisdiction, and recorded with the Register of Deeds.

- Acceptance of Public Improvements

  Upon construction completion, the grade control structures need to be inspected and shall be certified by a licensed professional engineer registered in the State of Nebraska. The following documents shall be provided:

  - Request inspection walk through with local jurisdiction and obtain Letter of Acceptance.
  - Complete Grade Control Certification Form – Appendix C
  - Develop Record Drawings – plan sheets specific to grade control structures with "As-Built" stamp, date, and name of engineer. Any change in function must be verified and documented within the as-builts.

- Project Reimbursement Request

  Once the public improvements have been accepted, provide the following items in an electronic submittal to the Papio-Missouri River Natural Resources District via the Southern Sarpy Watersheds Partnership website:

  Grade Control Reimbursement Request – Southern Sarpy Watersheds Partnership (https://southernsarpy.org/grade-control-reimbursement-request)

  Required attachments include:

  - Letter of Acceptance from local jurisdiction
  - Executed versions of Maintenance Agreement
  - Signed Grade Control Certification Form and Photolog
  - Record Drawings
  - Final Pay Application

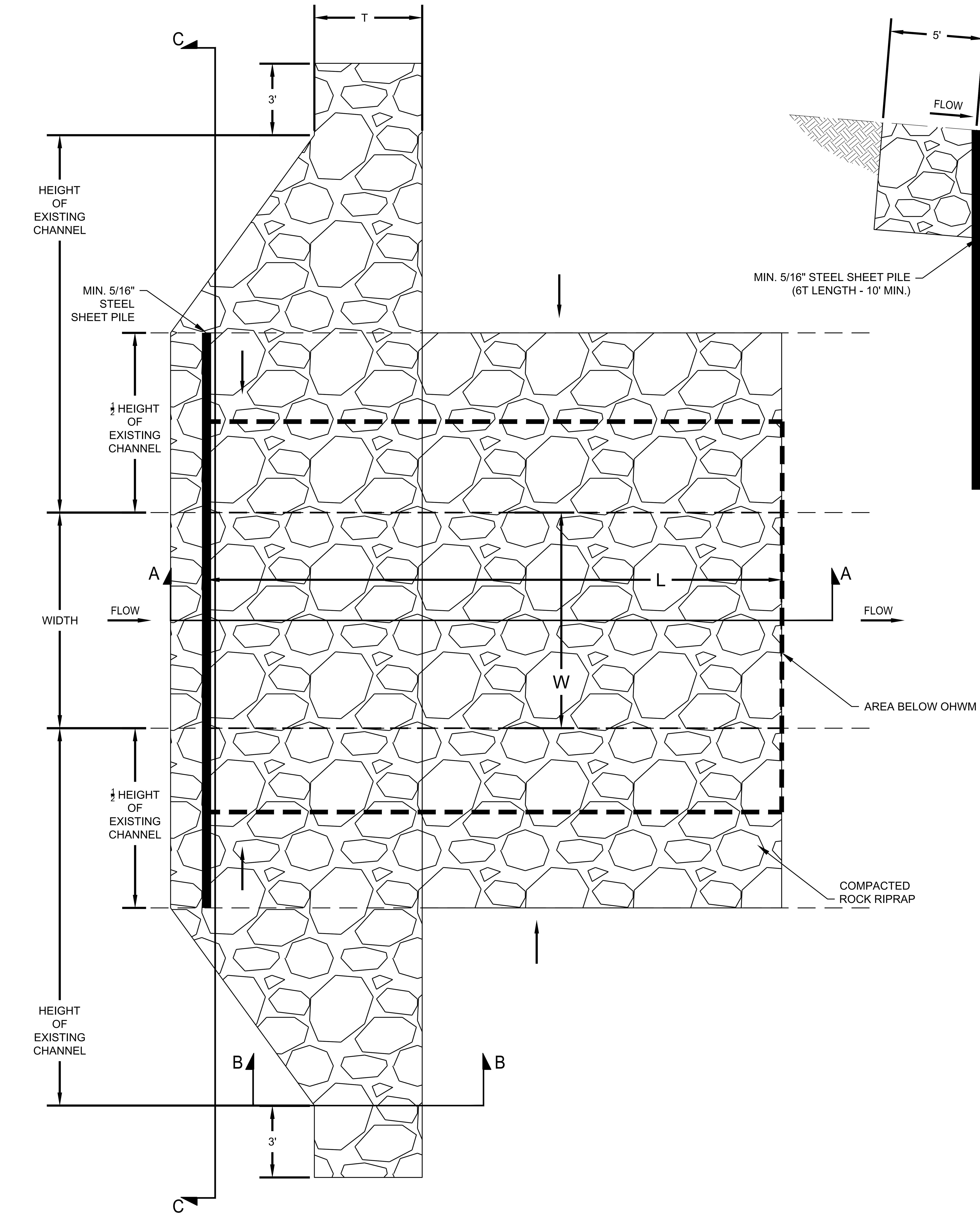
APPENDIX A

DESIGN GUIDANCE

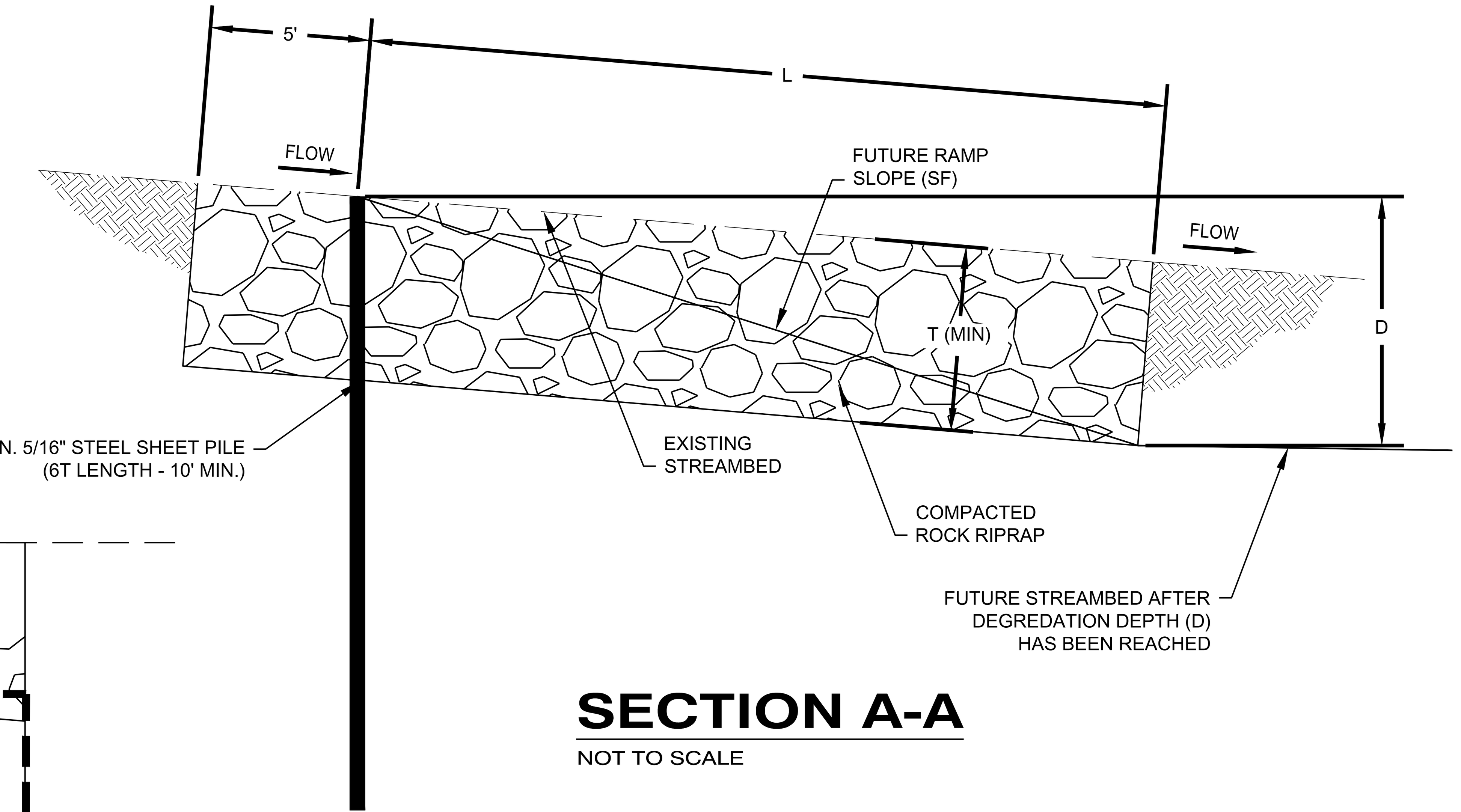
APPENDIX A

DESIGN TEMPLATES

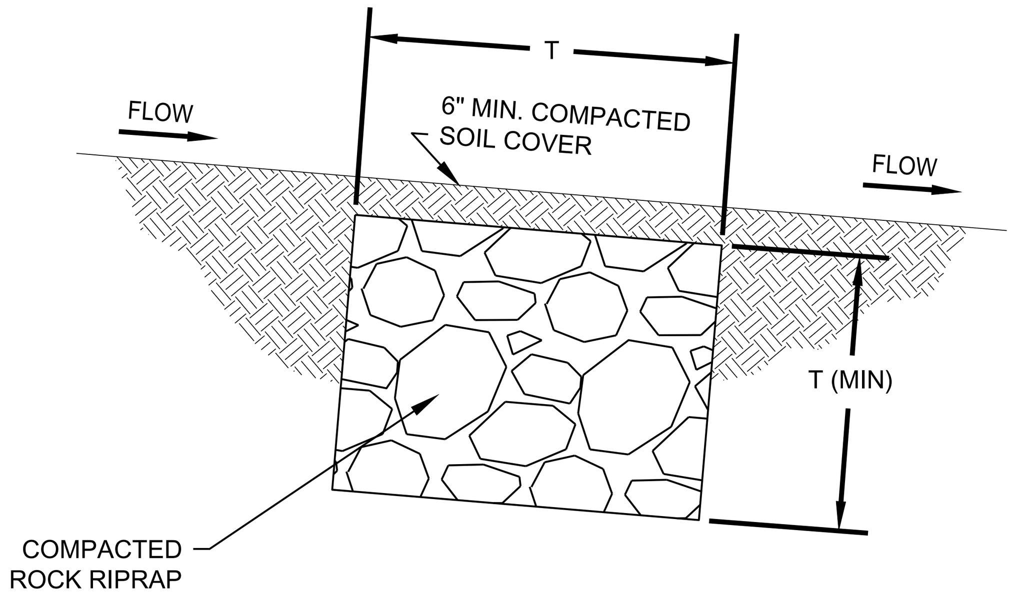
- Rock Riprap Riffle with Sheet Pile
- Rock Slab Drop Structure
- Grouted Boulder Drop Structure



PLAN VIEW
NOT TO SCALE



SECTION A-A
NOT TO SCALE



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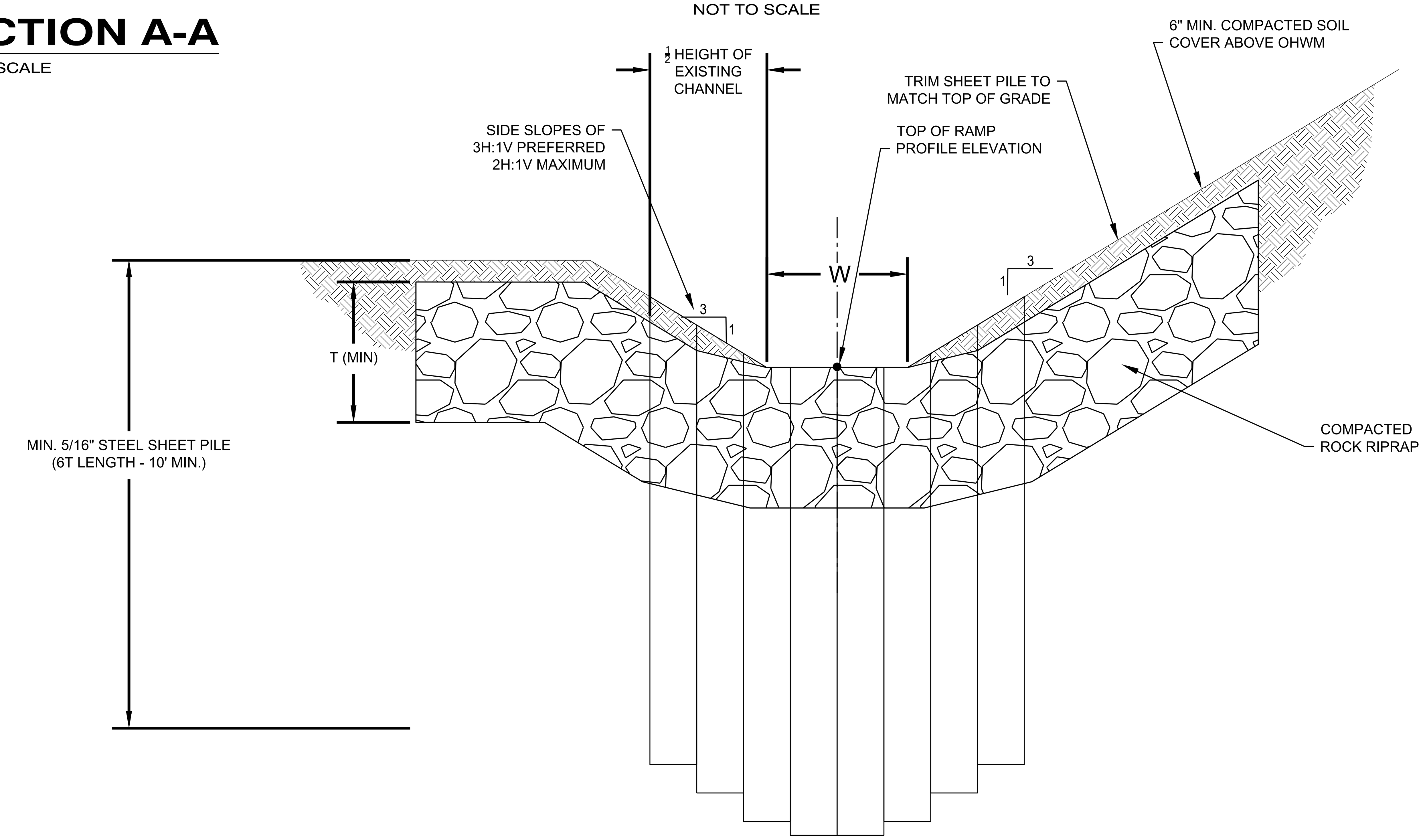


SECTION C-C
NOT TO SCALE

REVISIONS			
	ROCK RIPRAP RAMP WITH SHEET PILE	SOUTHERN SARPY WATERSHEDS PARTNERSHIP IN-STREAM GRADE CONTROL STRUCTURES	ISSUE DATE 11/1/2023 DESIGN BY JLG DRAWN BY JLG SHEET GC-01

FILENAME: H:\FYRA\Projects\001-16-03\DWG\PCWP permitting Structures\Grade_Control_Structures Updated.dwg
DATE PLOTTED: 11/2/2023 1:19 PM DRAWN BY: XXX PLOT SCALE: 1:1

NOTES:

1. DIMENSION DEFINITIONS
   - 1.1 "W" EQUALS THE WIDTH OF THE ROCK RAMP BOTTOM. RAMP WIDTH DOES NOT HAVE TO EQUAL EXISTING CHANNEL WIDTH. "W" MAY NEED TO INCREASE TO CREATE STABLE ROCK CONDITIONS
   - 1.2 "L" EQUALS LENGTH OF ROCK RIPRAP RAMP
   - 1.3 "D" EQUALS FUTURE DEGRADATION DEPTH AS DETERMINED WHEN IDENTIFYING STRUCTURE LOCATIONS
   - 1.4 "S_F" EQUALS THE FUTURE SLOPE OF THE ROCK RIPRAP RAMP
   - 1.5 "T" EQUALS THE MINIMUM ROCK RIPRAP LAYER THICKNESS

2. DESIGN DIMENSIONS AND ROCK SIZING
   - 2.1 ITERATIVE PROCESS TO ESTABLISH STABLE ROCK CONDITIONS
     - A. SELECT DESIGN "W"
     - B. SELECT DESIGN "L"
     - C. CALCULATE "S_F" AS A FUNCTION OF "L" AND "D"
     - D. DETEREMINE STABLE ROCK SIZE (D50) USING SELECTED DESIGN DIMENSIONS AND FUTURE SLOPE OF RAMP PER GUIDANCE IN NOTE 2.2.
     - E. ITERATE UNTIL STABLE CONDITIONS ARE REACHED FOR THE ROCK RIPRAP SIZE THAT WILL BE SPECIFIED FOR THE DESIGN
   - 2.2 ROCK RIPRAP SHALL BE SIZED USING US ARMY CORPS OF ENGINEERS EM-1110-2-1601: HYDRAULIC DESIGN OF FLOOD CONTROL CHANNELS MANUAL (USACE EM-1110-2-1601) FOR THE DESIGN DISCHARGE (Q).
     - A. FIGURE 1 WAS DEVELOPED FROM EQUATION 3-5 IN USACE EM-1110-2-1601 AND CAN BE USED TO DETERMINE STABLE ROCK FOR THE ROCK RIPRAP RAMP DESIGN TEMPLATE ONLY.
     - B. FIGURE 1 DOES NOT ACCOUNT FOR TAILWATER CONDITIONS. IF TAILWATER IS CONSIDERED, MORE FREQUENT RECURRENCE INTERVALS (10-, 25- AND 50-YR) NEED TO BE ASSESSED TO DETERMINE IF THE DESIGN DISCHARGE (Q) IS GREATER FOR EVENTS LESS THAN THE 100-YR WITH LESSER TAILWATER CONDITIONS. PROVIDE CALCULATIONS IN DESIGN REPORT.
     - C. IF FIGURE 1 IS NOT USED, USE METHODS IN USACE EM-1110-2-1601 AND PROVIDE CALCULATIONS FOR ROCK SIZING IN DESIGN REPORT.

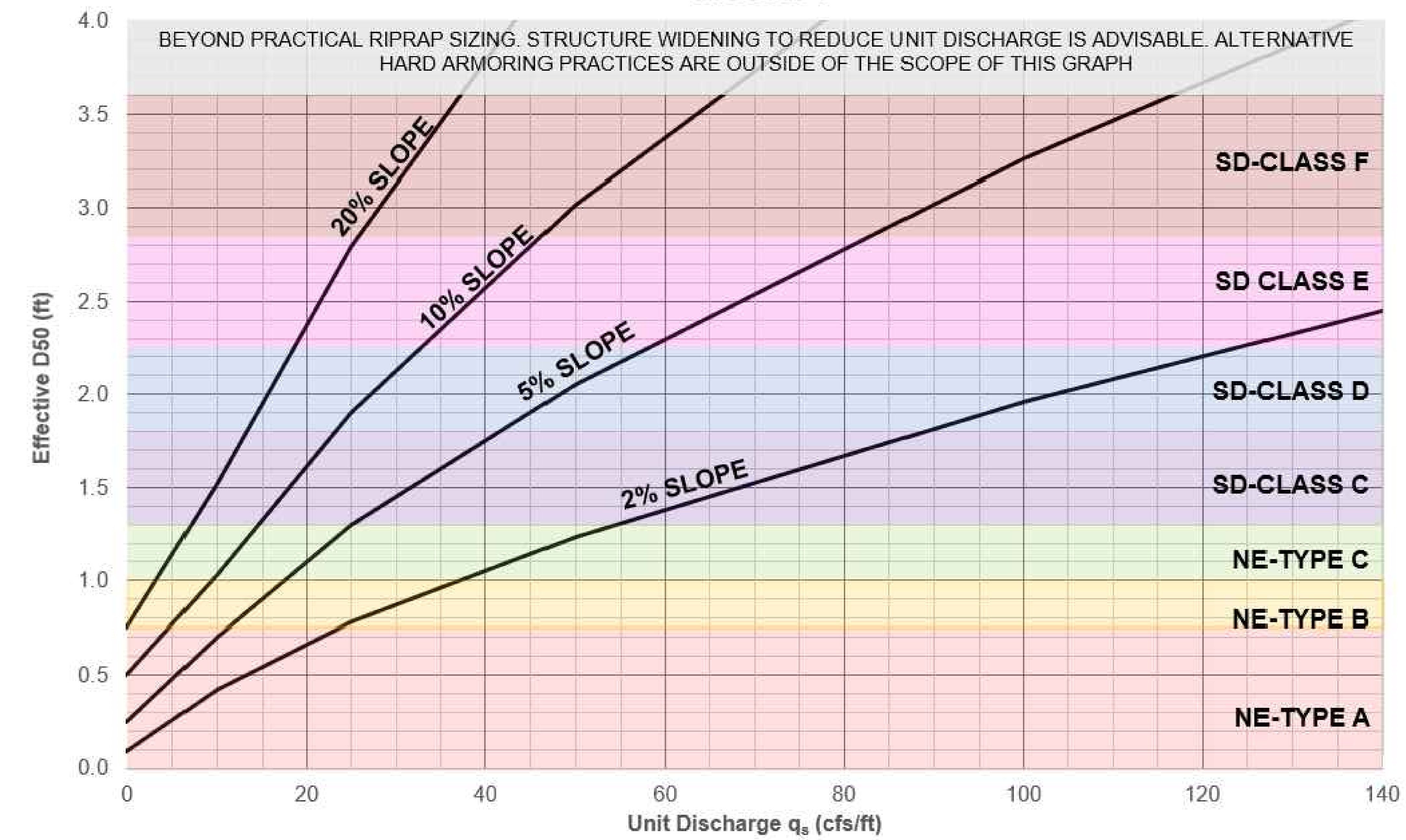
3. DEFINING "T"
   - 3.1. "T" SHALL BE 2 TIMES THE D50
   - 3.2. "T" SHALL NOT BE LESS THAN 1-FT.
   - 3.3 "T" SHALL BE INCREASED BY 50% WHEN THE RIPRAP IS PLACED IN UNDERWATER CONDITIONS TO COMPENSATE FOR UNCERTAINTIES ASSOCIATED WITH THIS PLACEMENT CONDITION.

4. ROCK RIPRAP MATERIALS
   - 4.1. ALL RIPRAP, INCLUDING BROKEN CONCRETE, MUST MEET THE SIZING REQUIREMENTS DETERMINED ABOVE AND MUST BE ACCEPTABLE MATERIAL, FREE OF PROTRUDING REINFORCING STEEL OR WIRE MESH OR OTHER CONSTRUCTION DEBRIS (I.E. LATHE, PLASTER, ASPHALT, SCRAP IRON, ETC.) AND FROM A NON-STREAMBED SOURCE
   - 4.2. ANY MATERIAL USED SHALL BE REASONABLY WELL-GRADED MATERIAL TO CREATE A DENSE EROSION RESISTANT STRUCTURE.
   - 4.3. THE MATERIAL SHALL BE ANGULAR IN SHAPE. NO MORE THAN 30% OF THE MATERIAL SHALL HAVE THE MAXIMUM DIMENSION MORE THAN 2.5 TIMES THE MINIMUM DIMENSION AND NO MATERIAL SHALL HAVE THE MAXIMUM DIMENSION MORE THAN 3.5 TIMES THE MINIMUM.
   - 4.4. RIPRAP MATERIALS SHOULD HAVE THE FOLLOWING PROPERTIES
     - A. BULK SPECIFIC GRAVITY (SATURATED SURFACE-DRY BASIS) NOT LESS THAN 2.5 AS DETERMINED BY ASTM C127
     - B. ABSORPTION NOT MORE THAN 2% AS DETERMINED BY ASTM C127
     - C. SOUNDLESS LOSS NO GREATER THAN 10% IN 20 FREEZE AND THAWING CYCLES IN ACCORDANCE WITH COE CRD-C144 AND THE COMBINED LOSS OF SOUNDESS IN MAGNESIUM SULFATE AT 5 CYCLES SHALL NOT EXCEED 12% IN ACCORDANCE WITH ASTM C88.

5. THE RIPRAP SHALL BE COVERED ON THE BANKS WITH A MINIMUM OF 6-INCHES OF SOIL COMPACTED INTO THE VOIDS OF THE RIPRAP AND IMMEDIATELY SEEDED WITH AN ANNUAL COVER CROP AND A MIXTURE OF NATIVE GRASS SPECIES.
6. ALL EXCAVATED MATERIALS SHALL BE PLACED ON AN UPLAND SITE ABOVE THE ORDINARY HIGH WATER MARK IN A CONFINED AREA, NOT CLASSIFIED AS A WETLAND, TO PREVENT THE RETURN OF SUCH MATERIALS TO THE WATERWAY. ALL CONSTRUCTION DEBRIS SHALL BE DISPOSED OF IN UPLANDS IN SUCH A MANNER THAT IT CANNOT ENTER A WATERWAY OR WETLAND.
7. MINIMUM STEEL SHEET PILE THICKNESS IS 5/16". THE 5/16" TOTAL THICKNESS REPRESENTS A MINIMUM DESIGN THICKNESS OF 1/4" + 1/16" SACRIFICIAL THICKNESS FOR CORROSION CONTROL. SEE US ARMY CORPS OF ENGINEERS ETL 1110-2-584: DESIGN OF HYDRAULIC STEEL STRUCTURES FOR ADDITIONAL GUIDANCE.

Parameters – provide values per structure on detail sheets	Unit	Value
Design Event Peak Flow (Q)	cfs	
Channel X-Sectional Area	ft2	
Future Degradation Depth (D)	ft	
Future Grade Control Slope (SF)	ft/ft	
Grade Control Width (W)	ft	
Grade Control Length (L)	ft	
Design Velocity or Unit Discharge	ft/s or cfs/ft	
Riprap Size, D50 Weight	lbs	
Riprap Classification (indicate Nebraska or South Dakota specification)	--	

FIGURE 1



DIRECTIONS FOR FIGURE 1:

i. PER USACE EM-1110-2-1601:

q=Q/W.

q = UNIT DISCHARGE (CFS/FT)

Q = 100-YR FLOW RATE (CFS)

W = RAMP BOTTOM WIDTH (FT)

THIS METHOD MAY RESULT IN OVERESTIMATED ROCK SIZES FOR HIGHER DISCHARGE RATES. REFINE q BY REPLACING WITH q_s PER BELOW.

ii. USE q_s EQUATION TO REFINE THE UNIT DISCHARGE. VARIABLE q_s IS AN APPROXIMATION OF THE UNIT DISCHARGE WITH AN ESTIMATED ERROR WITHIN BOUND OF GRAPH IS +/- 10%. EQUATION ONLY APPLIES TO DESIGNS COMPLIENT WITH STANDARD TEMPLATES PROVIDED. UNIT DISCHARGE VALUE MAY ALSO BE EXTRACTED FROM MODELING SOFTWARE. DOCUMENT ALTERNATIVE METHODS IF USED.

$$q_s = \frac{Q}{W * \sqrt{\frac{W + 6Y}{W}}}$$

q_s = APPROXIMATED UNIT DISCHARGE (CFS/FT)

Q = 100-YR FLOW RATE (CFS)

W = RAMP BOTTOM WIDTH (FT)

Y = 100-YR FLOW DEPTH (FT)

iii. Y TO BE CALCULATED USING MANNING'S EQUATION OR MODELING SOFTWARE.

iv. USE GRAPH TO IDENTIFY ACCEPTABLE D50 AND ROCK CLASSIFICATION FOR SPECIFICATIONS. USE SLOPE LINE OR INTERPOLATE BETWEEN SLOPE LINES THAT REPRESENT FUTURE RAMP SLOPE CONDITIONS (S_F).

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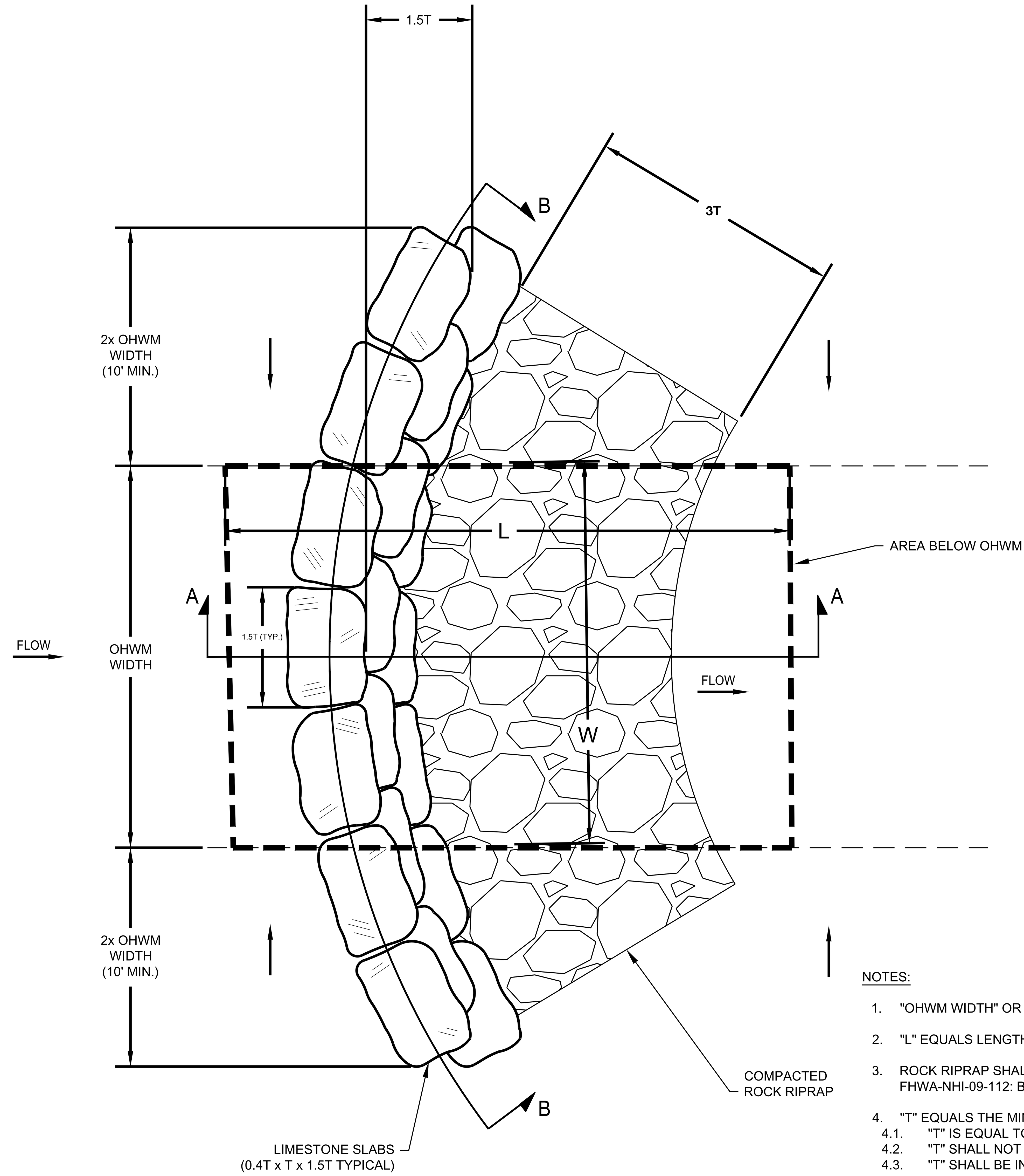
REVISIONS

ROCK RIPRAP RAMP WITH SHEET PILE NOTES

SOUTHERN SARPY WATERSHEDS PARTNERSHIP
IN-STREAM GRADE CONTROL STRUCTURES

ISSUE DATE 11/1/2023
DESIGN BY JLG
DRAWN BY JLG

SHEET GC-02



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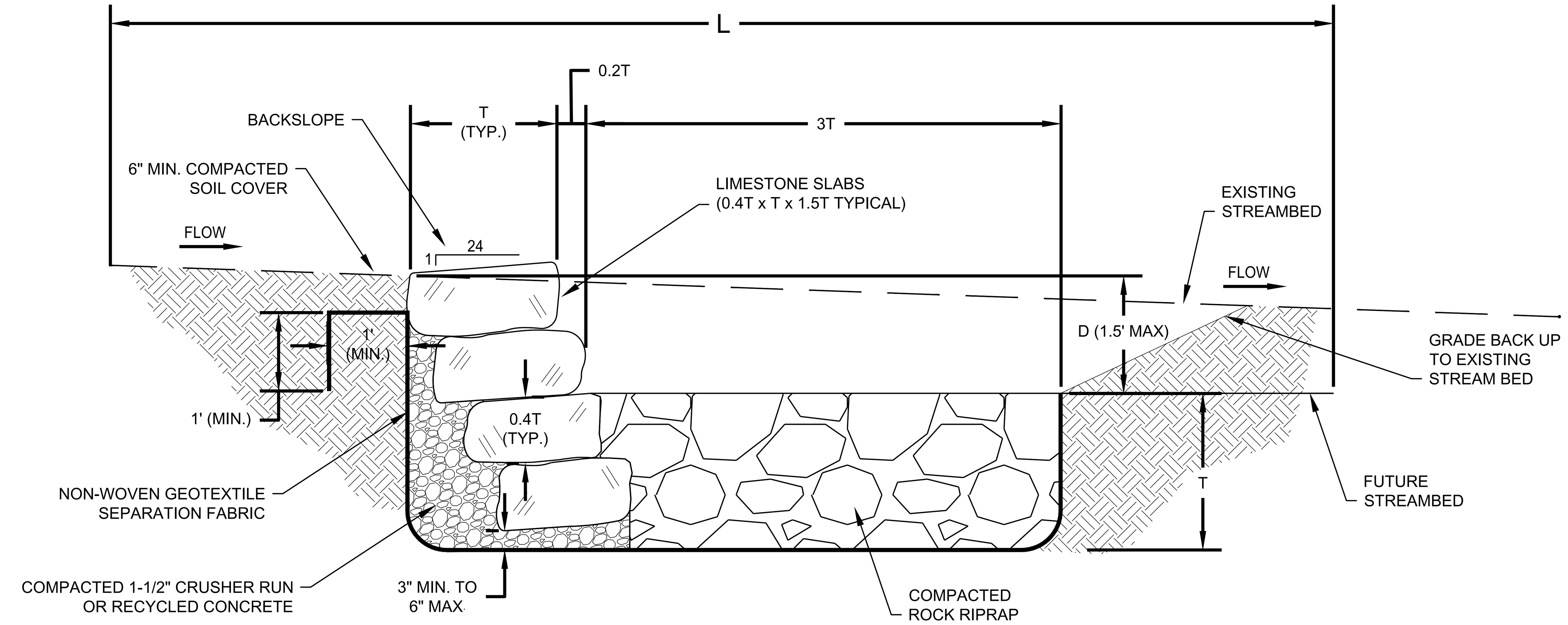
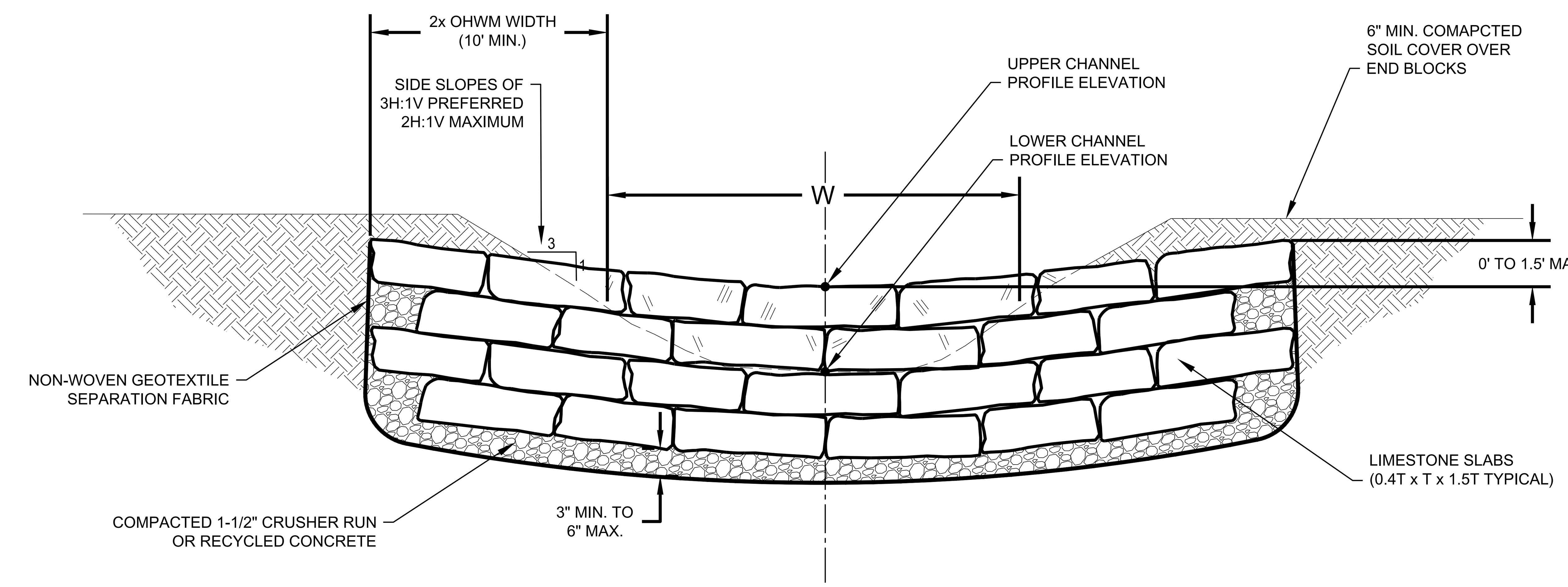


SECTION A-A

NOT TO SCALE



SECTION B-B

NOT TO SCALE

NOTES:

1. "OHWM WIDTH" OR "W" EQUALS THE WIDTH OF THE ORDINARY HIGH WATER MARK OF THE STREAM.

2. "L" EQUALS LENGTH OF ROCK RIPRAP NEEDED ON STREAM LENGTH AND IS A COMPONENT OF FUTURE CONDITION SLOPE.

3. ROCK RIPRAP SHALL BE SIZED USING EQUATION 3-3 FROM US ARMY CORPS OF ENGINEERS EM-1110-2-1601: HYDRAULIC DESIGN OF FLOOD CONTROL CHANNELS MANUAL OR EQUATION 4.1 FROM THE FHWA-NHI-09-112: BRIDGE SCOUR AND STREAM INSTABILITY COUNTERMEASURES MANUAL.

4. "T" EQUALS THE MINIMUM ROCK RIPRAP LAYER THICKNESS.
   - 4.1. "T" IS EQUAL TO THE SPHERICAL DIAMETER D50 OF THE STONE.
   - 4.2. "T" SHALL NOT BE LESS THAN 1-FT.
   - 4.3. "T" SHALL BE INCREASED BY 50% WHEN THE RIPRAP IS PLACED IN UNDERWATER CONDITIONS TO COMPENSATE FOR UNCERTAINTIES ASSOCIATED WITH THIS PLACEMENT CONDITION.

5. IF USING ANY RIPRAP OTHER THAN QUARRY FRADED/SIZED ROCK RIPRAP, THE FOLLOWING CONDITIONS WILL APPLY:
   - 5.1. ALL RIPRAP, INCLUDING BROKEN CONCRETE, MUST MEET THE SIZING REQUIREMENTS DETERMINED ABOVE AND MUST BE ACCEPTABLE MATERIAL, FREE OF PROTRUDING REINFORCING STEEL OR WIRE MESH OR OTHER CONSTRUCTION DEBRIS (I.E. LATHE, PLASTER, ASPHALT, SCRAP IRON, ETC.) AND FROM A NON-STREAMBED SOURCE.
   - 5.2. ANY MATERIAL USED SHALL BE REASONABLY WELL-GRADED MATERIAL TO CREATE A DENSE EROSION RESISTANT STRUCTURE.
   - 5.3. THE MATERIAL SHALL BE ANGULAR IN SHAPE. NO MORE THAN 30% OF THE MATERIAL SHALL HAVE THE MAXIMUM DIMENSION MORE THAN 2.5 TIMES THE MINIMUM DIMENSION AND NO MATERIAL SHALL HAVE THE MAXIMUM DIMENSION MORE THAN 3.5 TIMES THE MINIMUM.
   - 5.4. THE TOP ELEVATION OF THE RIPRAP SHALL NOT EXCEED THE TOP ELEVATION OF THE BANK.

6. THE RIPRAP SHALL BE COVERED, FROM THE TOP OF THE STRUCTURE DOWN TO THE ORDINARY HIGH WATER MARK, WITH A MINIMUM OF 6-INCHES OF SOIL COMPACTED INTO THE VOIDS OF THE RIPRAP AND IMMEDIATELY SEEDED WITH AN ANNUAL COVER CROP AND A MIXTURE OF NATIVE GRASS SPECIES.

7. ALL DREDGED OR EXCAVATED MATERIALS SHALL BE PLACED ON AN UPLAND SITE ABOVE THE ORDINARY HIGH WATER MARK IN A CONFINED AREA, NOT CLASSIFIED AS A WETLAND, TO PREVENT THE RETURN OF SUCH MATERIALS TO THE WATERWAY. ALL CONSTRUCTION DEBRIS SHALL BE DISPOSED OF IN UPLANDS IN SUCH A MANNER THAT IT CANNOT ENTER A WATERWAY OR WETLAND.

8. MINIMUM STEEL SHEET PILE THICKNESS IS 5/16". THE 5/16" TOTAL THICKNESS REPRESENTS A MINIMUM DESIGN THICKNESS OF 1/4" + 1/16" SACRIFICAL THICKNESS FOR CORROSION CONTROL. SEE US ARMY CORPS OF ENGINEERS ETL 1110-2-584: DESIGN OF HYDRAULIC STEEL STRUCTURES FOR ADDITIONAL GUIDANCE.

REVISIONS	ROCK SLAB DROP	SOUTHERN SARPY WATERSHEDS PARTNERSHIP IN-STREAM GRADE CONTROL STRUCTURES	ISSUE DATE 11/1/2023 DESIGN BY JLG DRAWN BY JLG SHEET GC-03

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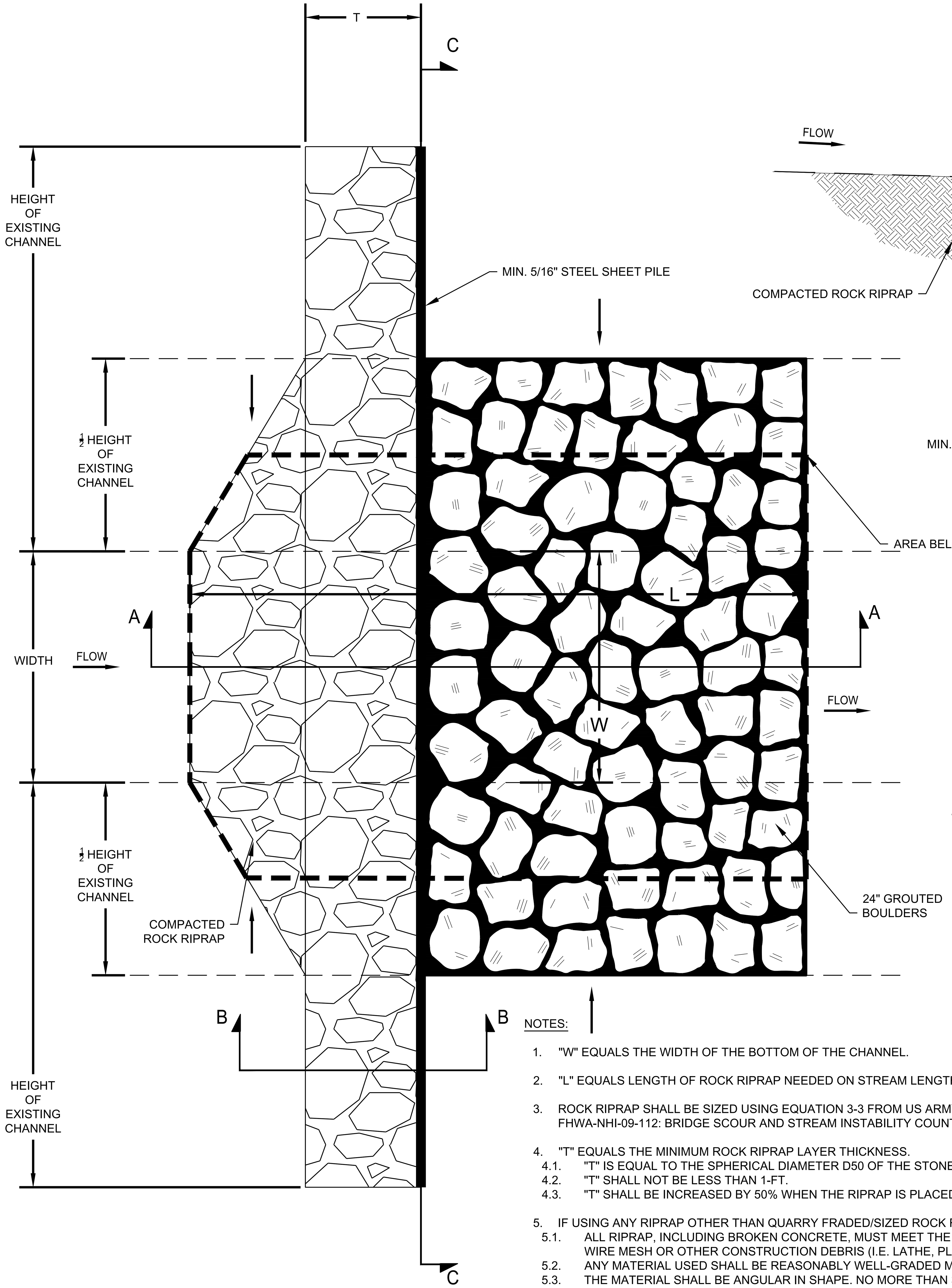

PLAN VIEW
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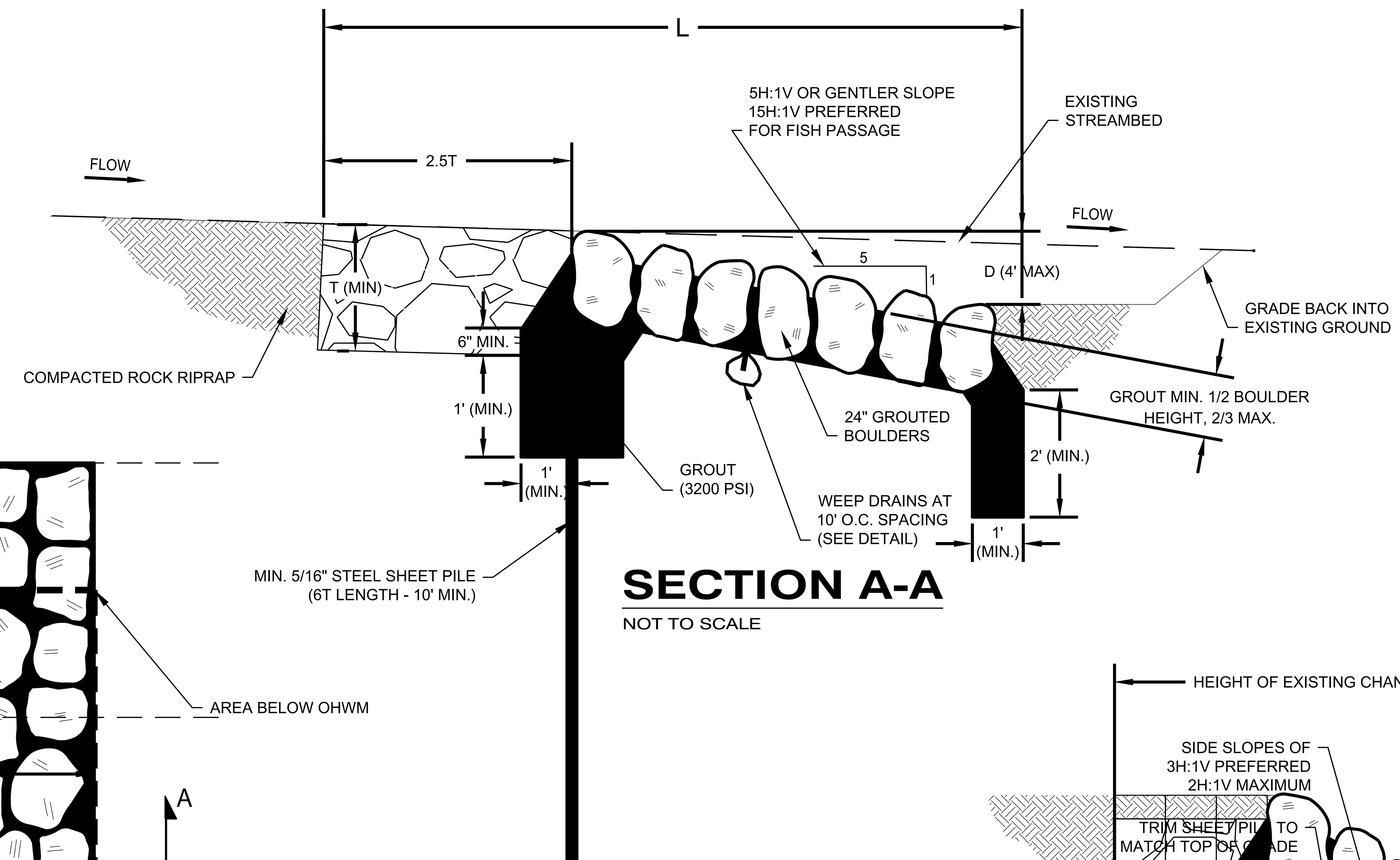

SECTION A-A
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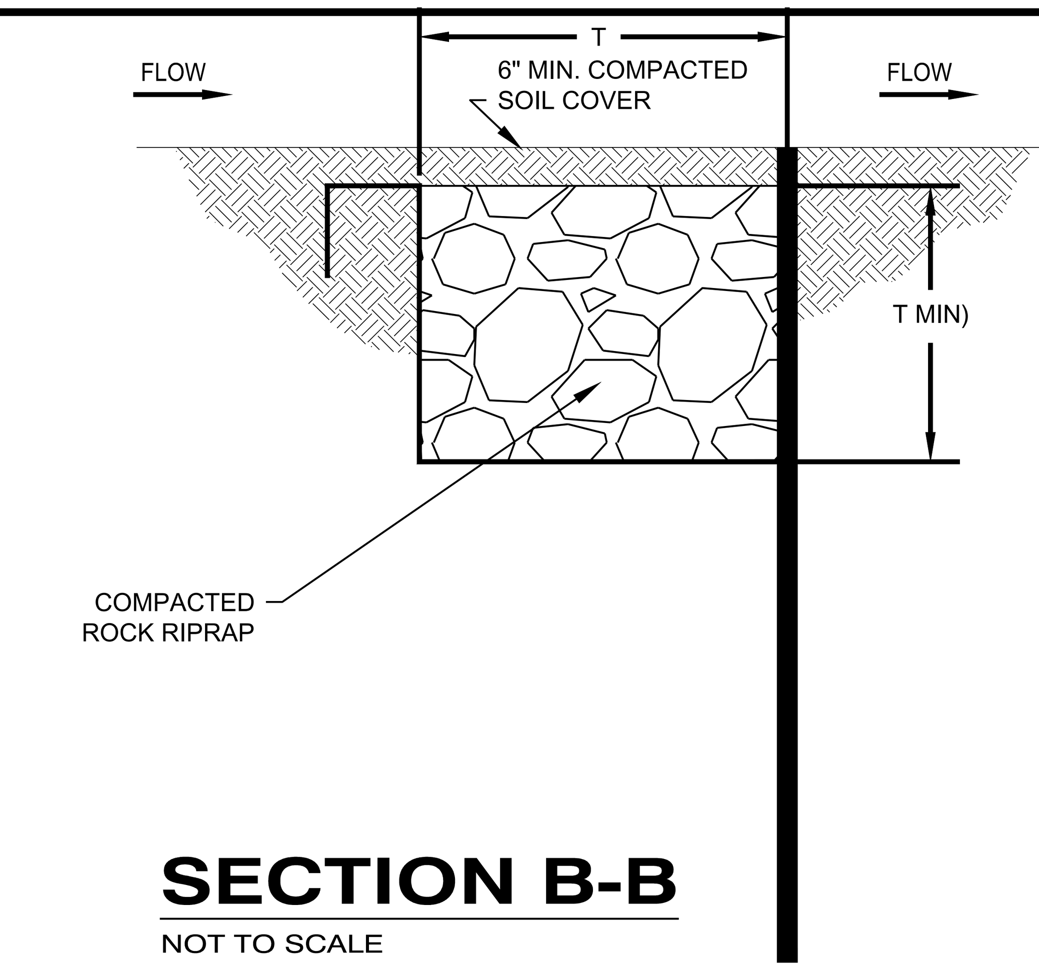

SECTION B-B
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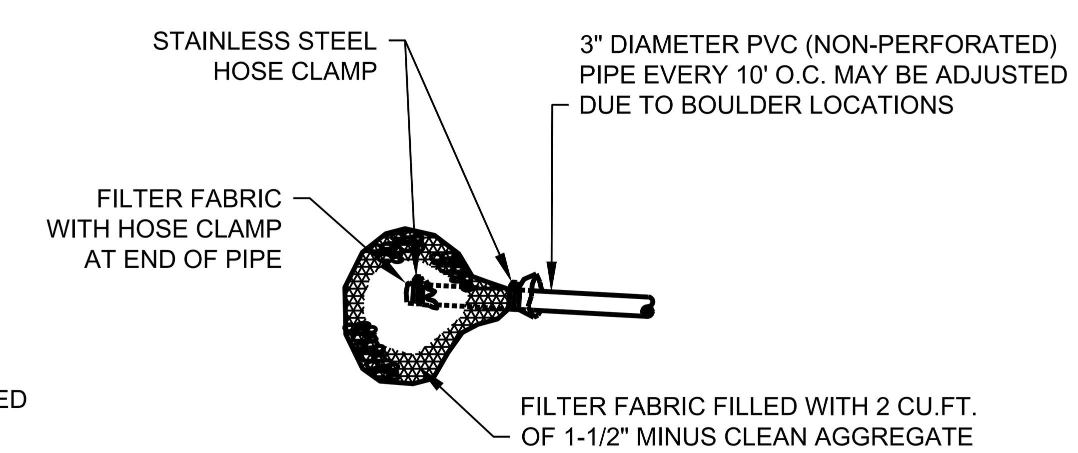
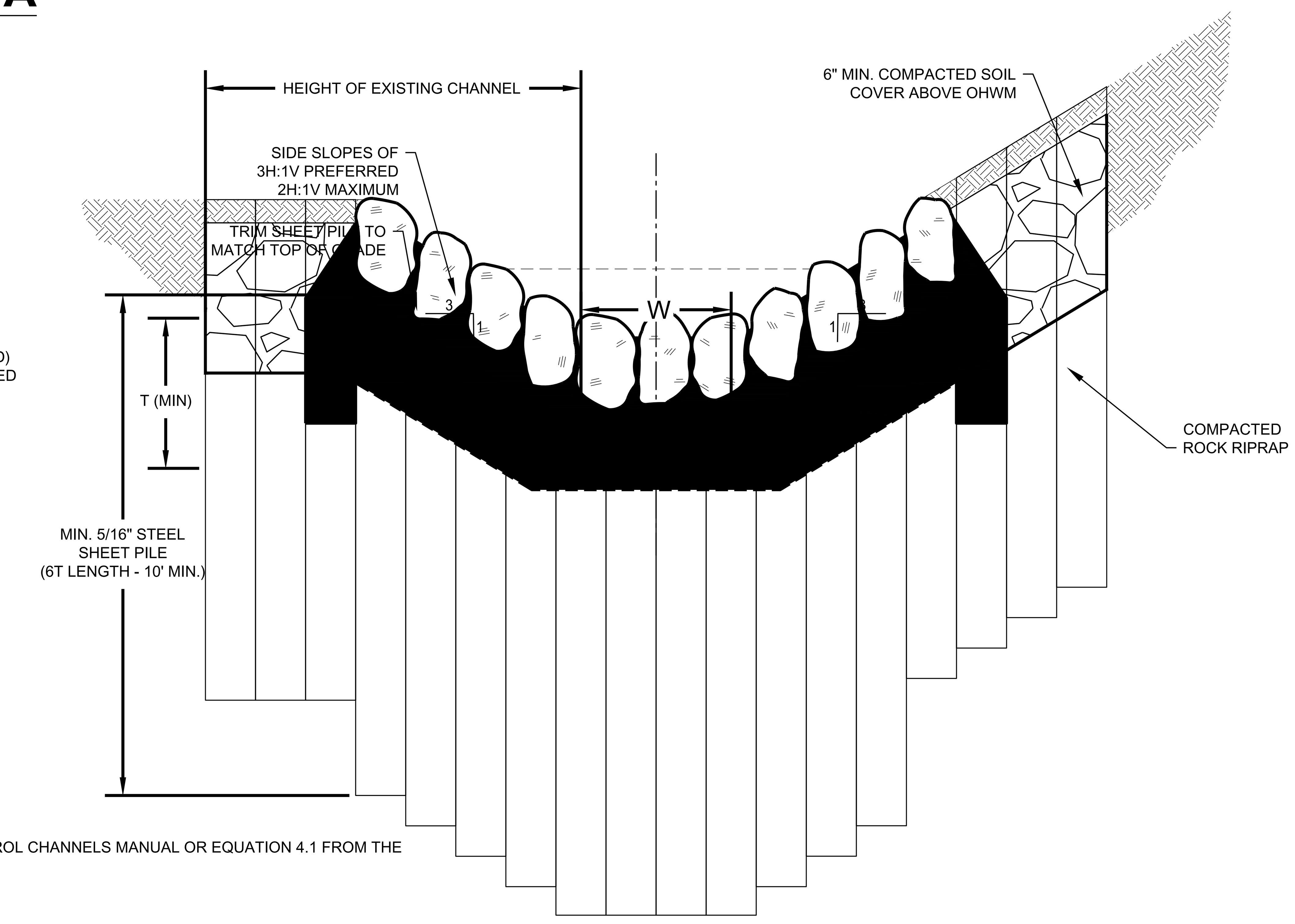


WEEP DRAIN DETAIL
NOT TO SCALE



SECTION C-C
NOT TO SCALE

NOTES:

1. "W" EQUALS THE WIDTH OF THE BOTTOM OF THE CHANNEL.
2. "L" EQUALS LENGTH OF ROCK RIPRAP NEEDED ON STREAM LENGTH AND IS A COMPONENT OF FUTURE CONDITION SLOPE.
3. ROCK RIPRAP SHALL BE SIZED USING EQUATION 3-3 FROM US ARMY CORPS OF ENGINEERS EM-1110-2-1601: HYDRAULIC DESIGN OF FLOOD CONTROL CHANNELS MANUAL OR EQUATION 4.1 FROM THE FHWA-NHI-09-112: BRIDGE SCOUR AND STREAM INSTABILITY COUNTERMEASURES MANUAL.
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   - 4.1. "T" IS EQUAL TO THE SPHERICAL DIAMETER D50 OF THE STONE.
   - 4.2. "T" SHALL NOT BE LESS THAN 1-FT.
   - 4.3. "T" SHALL BE INCREASED BY 50% WHEN THE RIPRAP IS PLACED IN UNDERWATER CONDITIONS TO COMPENSATE FOR UNCERTAINTIES ASSOCIATED WITH THIS PLACEMENT CONDITION.
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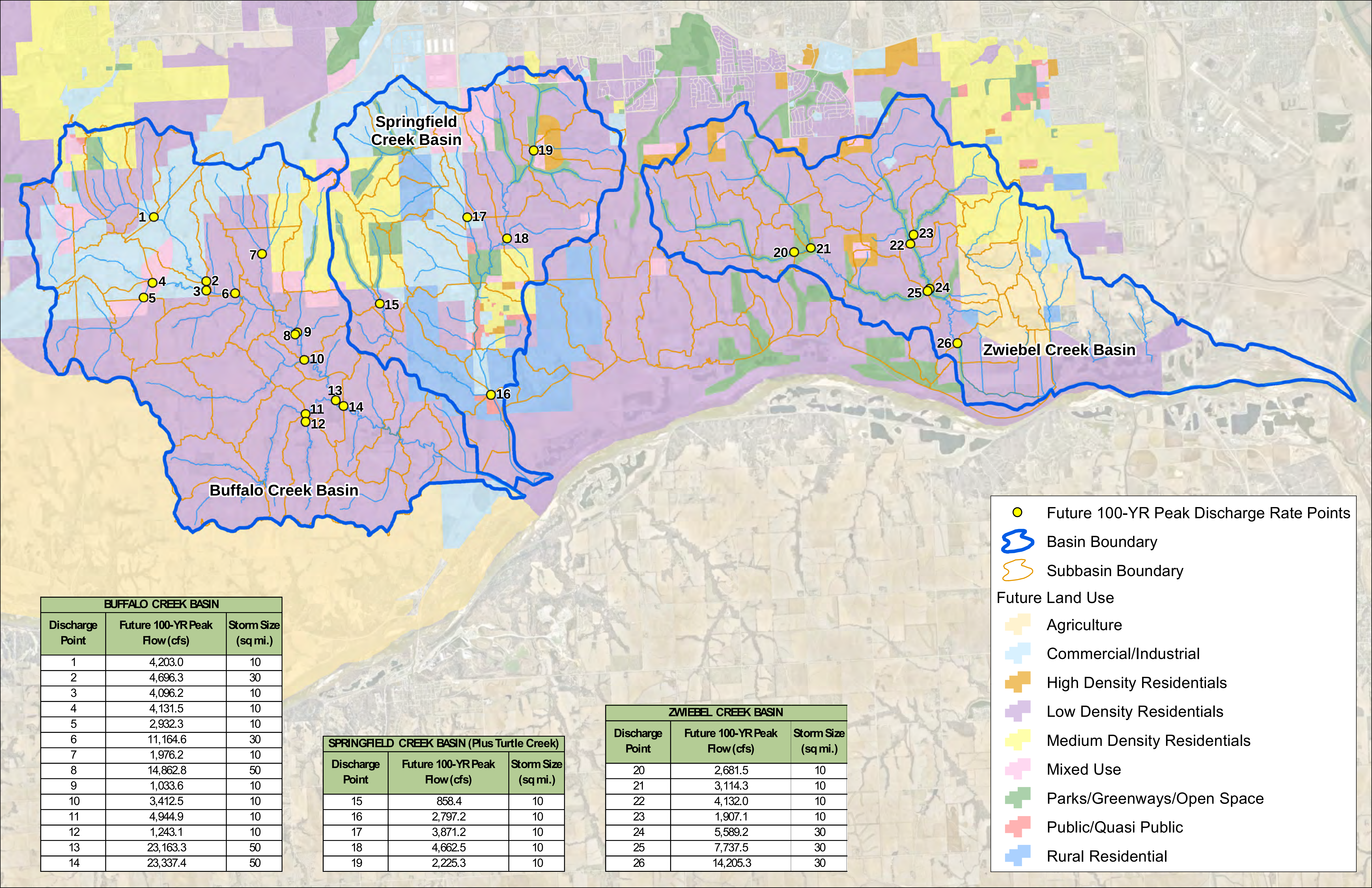
   - 5.1. ALL RIPRAP, INCLUDING BROKEN CONCRETE, MUST MEET THE SIZING REQUIREMENTS DETERMINED ABOVE AND MUST BE ACCEPTABLE MATERIAL, FREE OF PROTRUDING REINFORCING STEEL OR WIRE MESH OR OTHER CONSTRUCTION DEBRIS (I.E. LATHE, PLASTER, ASPHALT, SCRAP IRON, ETC.) AND FROM A NON-STREAMBED SOURCE.
   - 5.2. ANY MATERIAL USED SHALL BE REASONABLY WELL-GRADED MATERIAL TO CREATE A DENSE EROSION RESISTANT STRUCTURE.
   - 5.3. THE MATERIAL SHALL BE ANGULAR IN SHAPE. NO MORE THAN 30% OF THE MATERIAL SHALL HAVE THE MAXIMUM DIMENSION MORE THAN 2.5 TIMES THE MINIMUM DIMENSION AND NO MATERIAL SHALL HAVE THE MAXIMUM DIMENSION MORE THAN 3.5 TIMES THE MINIMUM.
   - 5.4. THE TOP ELEVATION OF THE RIPRAP SHALL NOT EXCEED THE TOP ELEVATION OF THE BANK.
6. THE RIPRAP SHALL BE COVERED, FROM THE TOP OF THE STRUCTURE DOWN TO THE ORDINARY HIGH WATER MARK, WITH A MINIMUM OF 6-INCHES OF SOIL COMPACTED INTO THE VOIDS OF THE RIPRAP AND IMMEDIATELY SEEDED WITH AN ANNUAL COVER CROP AND A MIXTURE OF NATIVE GRASS SPECIES.
7. ALL DREDGED OR EXCAVATED MATERIALS SHALL BE PLACED ON AN UPLAND SITE ABOVE THE ORDINARY HIGH WATER MARK IN A CONFINED AREA, NOT CLASSIFIED AS A WETLAND, TO PREVENT THE RETURN OF SUCH MATERIALS TO THE WATERWAY. ALL CONSTRUCTION DEBRIS SHALL BE DISPOSED OF IN UPLANDS IN SUCH A MANNER THAT IT CANNOT ENTER A WATERWAY OR WETLAND.
8. MINIMUM STEEL SHEET PILE THICKNESS IS 5/16". THE 5/16" TOTAL THICKNESS REPRESENTS A MINIMUM DESIGN THICKNESS OF 1/4" + 1/16" SACRIFICAL THICKNESS FOR CORROSION CONTROL. SEE US ARMY CORPS OF ENGINEERS ETL 1110-2-584: DESIGN OF HYDRAULIC STEEL STRUCTURES FOR ADDITIONAL GUIDANCE.

REVISIONS			
	GROUTED BOULDER DROP STRUCTURE	SOUTHERN SARPY WATERSHEDS PARTNERSHIP IN-STREAM GRADE CONTROL STRUCTURES	ISSUE DATE 11/1/2023 DESIGN BY JLG DRAWN BY JLG
			SHEET GC-04

APPENDIX A

DESIGN DISCHARGE RATE APPROXIMATIONS FIGURE



BUFFALO CREEK BASIN		
Discharge Point	Future 100-YR Peak Flow (cfs)	Storm Size (sq mi.)
1	4,203.0	10
2	4,696.3	30
3	4,096.2	10
4	4,131.5	10
5	2,932.3	10
6	11,164.6	30
7	1,976.2	10
8	14,862.8	50
9	1,033.6	10
10	3,412.5	10
11	4,944.9	10
12	1,243.1	10
13	23,163.3	50
14	23,337.4	50

SPRINGFIELD CREEK BASIN (Plus Turtle Creek)		
Discharge Point	Future 100-YR Peak Flow (cfs)	Storm Size (sq mi.)
15	858.4	10
16	2,797.2	10
17	3,871.2	10
18	4,662.5	10
19	2,225.3	10

ZWIEBEL CREEK BASIN		
Discharge Point	Future 100-YR Peak Flow (cfs)	Storm Size (sq mi.)
20	2,681.5	10
21	3,114.3	10
22	4,132.0	10
23	1,907.1	10
24	5,589.2	30
25	7,737.5	30
26	14,205.3	30

APPENDIX B

SECTION 404 PERMIT GUIDANCE

Application Guide for Department of the Army Permit to include Southern Sarpy Watersheds Partnership (SSWP) In-Stream Grade Control Structure(s)

Contents

- **Purpose of Application Guide**
- **Section 404 Permit Application Template Form**
    - **Part I: Project Information**
    - **Part II: Alternatives Analysis**
    - **Part III: Impacts and Mitigation**
    - **Part IV: Signature of Applicant and / or Agent**
    - **Part V: Attachments**
- **Section 404 Permit Application Template Form Instructions**
- **Attachment B – Example Impact Table**
- **Attachment C – Information on General and Individual Permits**

This document was adapted for the Southern Sarpy Watersheds Partnership from the Papillion Creek Watershed Partnership Application Guide developed by HDR.

Purpose of Application Guide

The purpose of this Department of the Army Permit Guide is to provide Applicants information on typical in-stream grade control structures that could be used for a stand-alone Section 404 of the Clean Water Act permit (permit) application or as part of a permit application that includes other project related activities that may require a permit authorization. The three in-stream grade control structures included in this application guide are 1) rock riprap ramp with sheet pile, 2) rock slab drop, and 3) grouted boulder drop structure.

This application guide is intended to serve as the basis for either a General Permit (in the form of a Nationwide Permit) or an Individual Permit. Information on these permit types can be found at the end of this application guide. The Section 404 Application Template Form may be incorporated into Eng Form 6082 for a Nationwide permit or 4345 for an Individual Permit. Please refer to the U.S. Army Corps of Engineers Regulatory Program and Permits (https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/Obtain-a-Permit/). The Instructions provide details regarding information needed for each of the numbered blocks within each part. Guidance to permit other waters of the US under either a Nationwide or Individual Permit, outside of the in-stream grade control structures are not specifically addressed in this application guide.

In-stream grade control structure templates for each of the three types are provided in Appendix A of the Grade Control Implementation Guidance Document for the Southern Sarpy Watersheds Management Plan. These templates are referenced within the instructions to the application guide. Attachment B provides an example of an impact table. Attachment C provides additional information on General Permits and Individual Permits.

Section 404 Permit Application Template Form for In-Stream Grade Control Structure(s)

Part I: Project Information

1. Project Name or Title							
2. Applicant's Name				**5. Authorized Agent's Name and Title (agent is not required)**			
First	Middle	Last		First	Middle	Last	
Company:				Company:			
Company Title:				Company Title:			
E-mail Address:				E-mail Address:			
3. Applicant's Address				**6. Agent's Address**			
Address				Address			
City	State	Zip	Country	City	State	Zip	Country
4. Applicant's Phone Nos. with Area Code				**7. Agent's Phone Nos. with Area Code**			
Business		Mobile		Business		Mobile	

8. Statement of Authorization	
I hereby authorize,_______________________________to act in my behalf as my agent in the processing of this application and to furnish, upon request, supplemental information in support of this application.	
SIGNATURE OF APPLICANT	DATE

9. Name of Waterbody, If Known *(if applicable)*				**10. Proposed Activity Street Address** *(if applicable)*		
11. Location of Proposed Activity (see instructions)				City	State	Zip
Latitude	°N	Longitude	°W			

12. Other Location Descriptions, If Known (see instructions)		
State Tax Parcel ID	Municipality	
Section	Township	Range
13. Directions to the Site		
14. Names of adjoining property owner, lessee, etc. whose property adjoins the project site (applicable for individual permits)		

15. Identify the Specific Nationwide Permit(s) you proposed to use or an Individual Permit
16. Description of Proposed Activity
17. Purpose of Permit Activity

Part II: Alternatives Analysis

18. Alternatives Analysis (applicable for Individual Permit applications)

Part III: Impacts and Mitigation

19. Quantity of Wetlands, Streams, or Other Types of Waters Directly Affected by Proposed Activity (see instructions)		
Acres	Linear Feet	Cubic Yards Dredge or Discharged
Each Application must include a delineation of wetlands, other special aquatic sites, and other waters, such as lakes and ponds, and perennial, intermittent, and ephemeral streams, on the project site.		
20. Describe All Impact Minimization Measures implemented as part of the Activity.		
21. If the proposed activity will result in the loss of greater than 1/10-acre of wetlands and/ or 3/100-acre of waterways, explain how the compensatory mitigation requirement will be satisfied, or explain why the adverse environmental effects are no more than minimal and why compensatory mitigation should not be required for the proposed activity. Identify if Nebraska Stream Condition Assessment Procedures (NeSCAP) have been applied to identify if stream mitigation will be required and if so, describe how stream mitigation will be accomplished.		

22. Is any portion of the Permit activity already complete?		YES		NO	If Yes, describe the completed work:

23. List the name(s) of any species listed as endangered or threatened under the Endangered Species Act that might be affected by the proposed activity
24. List any historic properties that have the potential to be affected by the proposed activity or include a vicinity map indicating the location of the historic property or properties
25. If the proposed activity also requires permission from the USACE pursuant to 33 United States Code [U.S.C.] 408 because it will alter or temporarily or permanently occupy or use a USACE federally authorized civil works project, have you submitted a written request for Section 408 permission from the USACE district having jurisdiction over that project?

	YES		NO	If “Yes”, please provide the date your request was submitted to the USACE District.	

Part IV: **Permit Application Certification**

Application is hereby made for permit or permits to authorize the work described in this application. I certify that the information in this application is complete and accurate. I further certify that I possess the authority to undertake the work described herein or am acting as the duly authorized agent of the applicant.			
Signature of Applicant	Date	Signature of Agent	Date
The application must be signed by the person who desires to undertake the proposed activity (applicant), and if the statement in Block 5 has been filled out and signed, the authorized agent. 18 U.S.C Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals, or covers up any trick, scheme, or disguises a material fact or makes any false, fictitious, or fraudulent statements or entry, shall be fined not more than $10,000 or imprisoned not more than five years or both.			

Part V: Attachments

Include the following attachments:

- Project Vicinity Map
- Design Drawings (see template for In-Stream Grade Control Structures)
    - o To-scale plan view drawing(s)
    - o To-scale elevation and / or cross section drawing(s)
- Figures showing impacts on waters of the US
- Wetland Delineation Report
- Compensatory Mitigation Plan
- Federally Threatened or Endangered Species Information
- Historic Properties and Cultural Resources Information

Instructions

Instructions for Preparing a Department of the Army
Section 404 Permit Application

Block 1 Project Name or Title.

Block 2. Applicant's Name. Enter the name and the e-mail address of the responsible party or parties. If the responsible party is an agency, company, corporation, or other organization, indicate the name of the organization and responsible officer and title. If more than one party is associated with the application, please attach a sheet of paper with the necessary information market Block 2.

Block 3. Address of Applicant. Please provide the full address of the party or parties responsible for the application. If more space is needed, attach an extra sheet of paper marked Block 3.

Block 4. Applicant's Phone Number(s) with Area Code. Please provide the telephone number where you can usually be reached during normal business hours.

Blocks 5 through 8. To be completed if an agent is being used for development and coordination of the application.

Block 9. Name of Waterbody. Please provide the name (if it has a name) of any stream, lake, marsh, or other waterway to be directly impacted by the activity. If it is a minor (no name) stream, identify the waterbody the minor stream enters.

Block 10. Proposed Activity Street Address. If the proposed activity is located at a site having a street address (not a box number), please enter it here.

Block 11. Location of Proposed Activity. Enter the latitude and longitude of where the proposed activity is located. Indicate whether the project location provided is the center of the project or whether the project location is provided as the latitude and longitude for each of the "corners" of the project area requiring evaluation. If there are multiple sites, please list the latitude and longitude of each site (center or corners) on a separate sheet of paper and mark as Block 11.

Block 12. Other Location Descriptions. If available, provide the Tax Parcel Identification number of the site, Section, Township, and Range of the site (if known), and/ or local Municipality where the site is located.

Block 13. Directions to the Site. Provide directions to the site from a known location or landmark. Include highway and street numbers as well as names. Also provide distances from known locations and any other information that would assist in locating the site. You may also provide a description of the location of the proposed activity, such as lot numbers, tract numbers, or you may choose to locate the proposed activity site from a known point (such as the right descending bank of Smith Creek, one mile downstream from the Highway 14 bridge). If a large river or stream, include the river mile of the proposed activity site if known. If there are multiple locations, please indicate directions to each location on a separate sheet of paper and mark as Block 13.

Block 14. Names of adjoining property owner, lessee, etc. whose property adjoins the project site. For Individual Permits only, provide names and full mailing addresses of the adjacent property owners (public and private), lessees, etc., whose property adjoins the waterbody(ies) or aquatic site(s) where the activity is being proposed so that they may be notified of the proposed activity.

Block 15. Identify the specific nationwide permit(s) proposed to use or if an Individual Permit is anticipated. Listing of the current Nationwide Permit(s) can be found on USACE's Regulatory home page.

Block 16. Description of Proposed Activity. Describe the overall activity or project. Give appropriate dimensions of structures. Provide the materials to be used in construction as well as the methods for which the work is to be done. Provide length, width, and height of excavations. The application must include all activities the applicant proposes to undertake that are reasonable related to the project, including temporary construction measures, borrow and disposal sites, access roads, staging and laydown areas, etc. Include a project schedule and other available information that will assist USACE in a review of the proposed activity or interested parties in evaluating the likely effect of the activity on factors of public interest.

Provide sketches when necessary to show that the proposed activity. Sketches usually clarify the activity and result in a quicker decision. Sketches should contain sufficient detail to provide an illustrative description of the proposed (that is, a conceptual plan), but do not need to be detailed engineering plans.

IN-STREAM GRADE STABILIZATION STRUCTURE DESCRIPTONS AND DETAIL

The following information is provided for providing the information on in-stream grade stabilization structures individually or as a component of the overall activity.

- Rock Riprap Ramp with Sheet Pile – The Rock Riprap Ramp structure is a buried riprap structure that is constructed at grade with the existing streambed. The buried riprap serves as self-armoring protection from head cuts working their way upstream. The structure will maintain the existing elevation on the upstream end of the structure and allows the rock to adjust into a steeper rock ramp as future streambed degradation lowers the elevation of the downstream end. A sill is incorporated up to the top of the banks that helps redirect high flows into the center of the channel while preventing flanking.

- Rock Slab Drop - Rock Slab Drops are designed to maintain existing stream grade on the upstream end and constructed below grade to depths that will protect against anticipated future degradation. Structures are limestone ledge rock or similar rock and serve as a type of cross vane structure to protect small drops on ephemeral channels. The rock slabs help to redirect flows into the center of the channel while preventing flanking while the downstream rock riprap apron provides protection from downstream scour.

- Grouted Boulder Drop Structure - Grouted Boulder Drop Structures provide robust hard armoring of large drops in stream elevation. Due to the application of high strength grout between the boulders, these structures can provide drops with steeper slopes than loose rock riprap riffles. The large boulders serve as energy dissipation, while the sheet pile weir provides protection against deep head cuts and can protect upstream infrastructure.

A table, such as the following can be used to provide dimensions and material types for in-stream grade control structures. The design templates identify each in-stream grade control structure and related cross-sections (Section A-A, Section B-B, and Section C-C, respectively) that can be used to identify structure dimensions.

XXX Grade Control Structure			
Length, L (measured parallel to stream flow)	Width, W (measured perpendicular to stream flow)	Material Type(s)	T, thickness of fill
Plan View and Section A-A – identify total length	Plan View and Section B-B, or Section C-C – identify width within the Ordinary High Water Mark (OHWM) and total width	See typical details in templates	Section A-A – Identify thickness of fill

Block 17. Purpose of Permit Activity. Describe the purpose and need for the proposed activity. What will it be used for and why? Also include a brief description of any related activities associated with the proposed project. Provide the approximate dates you plan to begin and complete all work.

It is assumed that most permit applications that would utilize/require an in-stream grade control structure would be part of a larger project that would have impacts on waters of the US in addition to those of an in-stream grade control structure. In those instances, the project purpose would need to address the broader purpose of the project.

If the grade control activity is the sole action involving an impact on a waters of the US, the following is example text for use as purpose statement for the in-stream grade control structure(s):

The purpose of the (*enter in-stream grade control structure type(s) here*) Grade Control Structure(s) are to provide a permanent means of prevention existing and future streambed degradation. Streambed degradation is caused by a multitude of factors, including stream bed and bank soil types/characteristics and land use changes and associated changes in runoff volume and velocity. In-stream grade control structures provide a solution that protects further stream degradation and the potential to expose adjacent utilities and potential human safety risks.

The project is needed due to *(insert details documenting the historic stream degradation and anticipated future degradation if grade control measures are not implemented*).

Block 18. Alternatives Analysis. An alternatives analysis is required for Individual Permit Applications. If applicable, describe the alternatives that would meet your overall project purpose in accordance with the Clean Water Act Section 404(b)(1) guidelines to demonstrate the proposed activity represents the least environmentally damaging practicable alternative.

It is assumed that most Individual Permit Applications that would utilize/require an in-stream grade control structure would be part of a larger project that would have impacts to waters of the US in addition to those of an in-stream grade control structure. In those instances, the alternatives analysis would be related to the broader project purpose. The range of alternatives would be project specific.

If the in-stream grade control structure activity is the sole action involving an impact on a waters of the US, the following is example text for use for formulation of an alternatives analysis:

Alternative	Description	Disposition
XXXXX In-Stream Grade Control Structure	Use corresponding description in Block 16	Meets the project purpose and is practicable. Advance for evaluation for impacts to waters of the US and other environmental consequences
Stream Setbacks (this alternative is included as this is the other option available as part of a development project being reviewed by members of the PCWP)	Restrict development within XXX feet. (utilize stream setback policy for description of setback distance)	Does not meet project purpose of grade control. Dismissed from further analysis.
Upstream Best Management Practices	Implementation of best management practices within the basin upstream of the project area to address the factors that are creating stream degradation. This can include: • Land use changes to more intensive to less intensive (agricultural production to pasture/native grasses) • Riparian buffers • Other?	Meets purpose and need but is not logistically practicable as the applicant does not have the authority to acquire the land necessary to implement best management practices. Additionally, not logistically practicable as this alternative is not currently an option available as part of the PCWP policies.

Block 19. Quantity of Wetlands, Streams, or Other Types of Waters Directly Affected by the Proposed Activity. For discharges of dredged or fill material into waters of the United States, provide the amount of wetlands, streams, or other types of waters filled, flooded, excavated, or drained by the proposed activity. For structures or work in navigable waters of the United States subject to Section 10 of the Rivers and Harbors Act of 1899, provide the amount of navigable waters filled, dredged, or occupied by one or more structures (e.g., aids to navigation, mooring buoys) by the proposed activity.

The design templates and table provided in **Attachment B** provides information of how impacts should be shown and described for In-stream Grade Control Structures.

A wetland delineation performed in accordance with the *1987 Wetland Delineation Manual* and Midwest Regional Supplement is needed (refer to USACE Regulatory Programs and Permits (https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/reg_supp/). Other Waters of the U.S., such as streams, also need to be identified. Refer to guidance from the USACE Engineer Research and Development Center and Design Ordinary High Water Mark (OHWM) Research, Development, and Training (https://www.erdc.usace.army.mil/Media/Fact-Sheets/Fact-Sheet-Article-View/Article/486085/ordinary-high-water-mark-ohwm-research-development-and-training/). In addition, based on coordination with the USACE Nebraska Regulatory Office, data should be collected for implementation of the Nebraska Stream Condition Assessment Procedure (NeSCAP). Refer to the USACE Nebraska Regulatory website for wetland mitigation (https://www.nwo.usace.army.mil/Missions/Regulatory-Program/Nebraska/Mitigation/).

Block 20. Describe All Impact Minimization Measures implemented as part of the Activity. Describe any proposed minimization measures intended to reduce the adverse environmental effects caused by the proposed activity. The description of any proposed minimization measures should be sufficiently detailed to allow the district engineer to determine that the adverse environmental effects of the activity will be no more than minimal and to determine the need for compensatory mitigation or additional mitigation measures.

Block 21. If the proposed activity will result in the loss of greater than 1/10-acre of wetlands and/ or 3/100-acre of stream bed, explain how the compensatory mitigation requirement will be satisfied, or explain why the adverse environmental effects are no more than minimal and why compensatory mitigation should not be required for the proposed activity. Refer to General Condition 23 of the currently issued Nationwide Permits for mitigation definitions). Identify if Nebraska Stream Condition Assessment Procedures (NeSCAP) have been applied to identify if stream mitigation (a negative balance of functional units between pre- and post-project) will be required and if so, describe how stream mitigation will be accomplished.

Paragraph (c) of NWP general condition 23 requires compensatory mitigation at a minimum one-for-one replacement ratio will be required for all wetland losses that exceed 1/10-acre and require pre-construction notification, unless the district engineer determines in writing that either some other form of mitigation is more environmentally appropriate or the adverse environmental effects of the proposed NWP activity are no more than minimal without compensatory mitigation, and provides an activity-specific waiver of this requirement. Mitigation would also be required for Individual Permits.

Describe the proposed compensatory mitigation for wetland losses greater than 1 /1O acre, or provide an explanation of why the district engineer should not require wetland compensatory mitigation for the proposed NWP activity or Individual Permit. If NeSCAP was utilized, identify stream mitigation using the mitigation tab. Utilize the 2008 Final Rule – Compensatory Mitigation for Losses of Aquatic Resources (33 Code of Federal Regulations [CFR] Parts 325 and 332).

The preferred mechanism for providing compensatory mitigation is mitigation banking credits or in-lieu fee program credits. However, if an appropriate number and type of mitigation bank or in-lieu fee credits are not available or if it is determined that the mitigation bank or in-lieu fee credits are determined to be inappropriate by the USACE, then permittee-responsible mitigation may be approved to offset adverse environmental effects.

If permittee-responsible mitigation is proposed, the prospective permittee is responsible for submitting a mitigation plan. A separate mitigation attachment is recommended. If mitigation bank or in-lieu fee program credits are proposed, the mitigation plan needs to address only the baseline conditions at the impact site and the number of credits to be provided (statement of credit availability).

Block 22. Is any portion of the Permit activity already complete? Describe any work that has already been completed.

Block 23. List the name(s) of any species listed as endangered or threatened under the Endangered Species Act that might be affected by the proposed activity. If you are not a federal agency, and if any listed species or designated critical habitat might be affected or is in the vicinity of the proposed activity, or if the proposed activity is located in designated critical habitat, list the name(s) of those endangered or threatened species that might be affected by the proposed activity or utilize the designated critical habitat that might be affected by the proposed activity

Block 24. List any historic properties that have the potential to be affected by the proposed activity or include a vicinity map indicating the location of the historic property or properties. List the name(s) of those historic properties that have the potential to be affected by the proposed activity.

Block 25. Permit Activities that also Require Permission from the Corps Under 33 U.S.C. 408. If the proposed activity also requires permission from the Corps under 33 U.S.C. 408 because it will temporarily or permanently alter, occupy, or use a Corps federal authorized civil works project, indicate whether you have submitted a written request for Section 408 permission from the Corps district having jurisdiction over that project.

Signature of Applicant or Agent. The application must be signed by the person proposing to undertake the proposed activity, and if applicable, the authorized party (agent) that prepared the application. The signature of the person proposing to undertake the proposed activity shall be an affirmation that the party submitting the application possesses the requisite property rights to undertake the proposed activity (including compliance with special conditions, mitigation, etc.).

DRAWINGS AND ILLUSTRATIONS

General Information.

Three types of illustrations are needed to properly depict the work to be undertaken. These illustrations or drawings are identified as a Project Vicinity Map, a Plan View or a Typical Cross-Section drawing. Identify each illustration with a figure or attachment number. For linear projects (that is, roads, subsurface utility lines, etc.) gradient drawings should also be included. Please submit one original, or good quality copy, of all drawings on 8½x11 inch plain white paper (electronic media may be substituted). Use the fewest number of sheets necessary for your drawings or illustrations. Each illustration should identify the project, the applicant, and the type of illustration (vicinity map, plan view, or cross-section). While illustrations need not be professional (many small, private project illustrations are prepared by hand), they should be clear, accurate, and contain all necessary information.

ADDITIONAL INFORMATION AND REQUIREMENTS

For proposed activities that involve discharges into waters of the US, water quality certification from the State, Tribe, or EPA must be obtained or waived. Some States, Tribes, or EPA have issued water quality certification for one or more NWPs. Please check the appropriate Corps district web site to see if water quality certification has already been issued for the NWP(s) you propose to use. Individual Permits will require an Individual Section 401 Water Quality Certification. For more information about Water Quality Certification please contact:

CWA Section 401 Coordinator
Nebraska Department of Environment and Energy
P.O. Box 98922
Lincoln, NE 68509-8922
Phone: 402-471-2875
Email: ndee.401certification@nebraska.gov

Attachment B – Example Impact Table

Example Impact Table for Grade Control Structures

Impact Area	Lat/Long (approx.)	Section, Township, Range	Report ID (reference to wetland delineation report for wetland/stream reference)	Temporary Wetland Impact[1] (wetlands adjacent/abutting relatively permanent waters)			Permanent[2] Wetland Impact (wetlands adjacent/abutting relatively permanent waters			Temporary impact on Waterway Impact (fill up to the OHWM[3]) (Identify all construction related short-term impacts)			Permanent Impact on Waterway (fill up to the OHWM)			Type of Fill / Discharge	Fill Volume[4]
				Cowardin[5]	NE Subclass[6]	Acres	Cowardin[5]	NE Subclass[6]	Acres	Type[7]	Linear Feet	Acres	Type[7]	Linear Feet[8]	Acres[9]		Cu. Yards
Rock Riprap Ramp with Sheet Pile														Linear feet of impact is identifie d in template Plan View	Impact area is identified in template Plan View	Rock Riprap	Fill volume area is identified in template Section A-A
Rock Slab Drop																Compacted 1-1/2" crusher run or recycled concrete Rock Rip Rap Limestone slabs	
Grouted Boulder Drop Structure																Grouted Boulders	
Temporary Construction Crossings																	
					Total												

Notes: [1]Tempoary – A temporary impact occurs for a limited time, typically during construction, and the area will be restored to pre-existing contours after the temporary disturbance is complete. This includes construction access and limits of stormwater pollution prevention practices.

[2]Permanent – A permanent impact is part of the project that will impact the resource permanently.

[3]OHWM – This is the Ordinary High Water Mark. The ordinary high water mark defines the boundaries of aquatic features for regulatory purposes**.** The federal regulatory definition of the OHWM, 33 CFR 328.3(c)(7), states the OHWM is "that line on the shore established by the fluctuations of water and indicated by physical characteristics such as [a] clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas." Multiple forms of guidance on identifying the OHWM are available.

[4]List volume by type to the existing bottom elevation wetland or waterway to exiting bottom elevation. Fill volume area is identified in template Section A-A of In-Stream Grade Control Structure Templates

[5]Cowardin – A hierarchical system of wetland classification used to name wetland types.

[6]Nebraska Subclass – Nebraska subclass provides the landform or environmental setting that a wetland exists within.

[7]Stream Type – Stream type should be listed as perineal, intermittent, or ephemeral. Definitions can vary. Consult with USACE for current definitions as they apply to potential jurisdiction. However, definitions may include: Perennial: surface water flowing continuously year-round. Intermittent: surface water flowing continuously during certain times of the year and more than in direct response to precipitation (e.g. , seasonally when the groundwater table is elevated or when snowpack melts). Ephemeral: surface water flowing or pooling only in direct response to precipitation (e.g., rain or snow fall).

[8] Linear feet of stream below fill as determined from the In-Stream Grade Control Structure Templates

[9] Impact area below the ordinary high water mark is identified in Plan View of In-Stream Grade Control Structure Templates

Attachment C – Information on Nationwide and Individual Permits

Information on Nationwide and Individual Permits

Nationwide Permits

Nationwide permits (NWPs) are general permits that streamline USACE authorization of certain activities under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899 that have no more than minimal individual and cumulative adverse environmental effects. To qualify for the use of a NWP, perspective permittees must comply with all the terms, general conditions (GCs), and regional conditions (RCs) of the NWP, including any requirements for the submittal of a pre-construction notification (PCN).

Individual Permits

Authorities: 33 USC 401, Section 10 of the Rivers and Harbors Act of 1899; Section 404 of the Clean Water Act, and Section 103 of the Marine Protection Research and Sanctuaries Act of 1976 (not applicable in the Fort Worth District). Principal Purpose: These laws require permits authorizing activities in, or affecting, navigable waters of the U.S.; the discharge of dredged or fill material into waters of the US; and the transportation of dredged material for the purpose of dumping it into ocean waters. Routine Uses: Information provided on this form will be used in evaluating the application for a permit. Disclosure: Disclosure of requested information is voluntary. If information is not provided, however, the permit application cannot be processed, nor can a permit be issued.

Activities that do not qualify for authorization under the General Permit program may qualify for authorization by Individual Permit (IP). Authorization under IP may be obtained only through application with the USACE. These permits are issued for activities that have more than minimal adverse impacts to waters of the US, and evaluation of each permit application involves more thorough review of the potential environmental and socioeconomic effects of the proposed activity.

An application for a Department of the Army IP under Section 404 or Section 10 will be determined to be complete when the USACE receives sufficient information to issue a public notice (see 33 CFR 325.1(d) and 325.3(a) for details and supporting information). The applicant should address all activities that the applicant plans to undertake that are reasonably related to the same project and for which a Department of the Army permit would be required. An alternatives analysis and a mitigation plan are not required for a complete application to prepare a public notice but are very helpful.

One set of original drawings or good reproducible copies which show the location and character of the proposed activity must be attached to this application (see sample drawings and instructions) and be submitted to the District Engineer having jurisdiction over the location of the proposed activity. An application that is not completed in full will be returned.

APPENDIX C

FORMS

APPENDIX C

GRADE CONTROLS SUBMITTALS CHECKLIST

GRADE CONTROL SUBMITTALS CHECKLIST

All materials in the checklist below are to be submitted as described during each phase of the project to the designated locations. Approvals must be provided as described in order to receive reimbursement for the construction of the grade control structures.

Platting Phases

Submit the following information to the local jurisdiction as part of the standard platting process.

- ❑ Plats shall include setback area.
- ❑ Cross sections of existing ground survey data at representative locations used to calculate the setback area with a minimum spacing every 200 ft, showing the calculations and dimensions of the setback.
- ❑ Plan and profile of the entire stream length on the property showing existing streambed survey data, proposed grade controls, and the future degradation profiles between.
- ❑ Draft Maintenance and Easement Agreement.

Public Improvements Phase

Include the following information within or as an appendix to the Drainage Report when submitted to the local jurisdiction as part of the public improvements process.

- ❑ Design Information
  - Site layout with grade control structure locations and identification numbers.
  - Hydrology specific to each individual grade control structure.
  - Design calculations used for determining design velocities, structure dimensions, and stable rock sizing.
  - Design details with table of design parameters and final design information requested on the design templates.
- ❑ Table of quantities per grade control structure and estimated costs.
- ❑ Public improvement plans for grade control structures and contract documents.

Approvals must be obtained prior to construction.

Project Closeout

- ❑ Maintenance Agreement (and Exhibits) - shall be approved by the local jurisdiction and recorded with the Register of Deeds.
- ❑ Grade Control Certification Form and Record Drawings – both shall be electronically submitted in conjunction to the local jurisdiction.
- ❑ Submit a reimbursement request and attachments (executed project closeout documents listed above and final pay application) to the Papio NRD on the following website: Grade Control Reimbursement Request – Southern Sarpy Watersheds Partnership

APPENDIX C

EXAMPLE PERFORMANCE BOND

Performance Bond

KNOW ALL MEN BY THESE PRESENTS: That ____

____

as principal, and ____

____, as surety, are held and firmly bound unto the City of Omaha, Nebraska, in the penal and full sum of ____ Thousand Dollars ($______________________________), for the payment of which well and truly to be made we hereby jointly and severally bind ourselves, our heirs, executors, administrators, personal representatives, successors and assigns.

The conditions of the above obligation are such that, whereas the above bounden principal has applied for a Certificate of Occupancy, for the property located at ____ Omaha, Nebraska, prior to the installation of ____

____

____

as required by the Ordinances, Rules and Regulations of the City of Omaha, and other laws. That said Certificate must be obtained prior to occupancy of the property.

NOW, THEREFORE, in consideration of a Certificate of Occupancy being issued, said principal shall:

1) Complete the required installation of____ ____ ____by the _______ day of ___________________________, 20_____.
2) Indemnify and save harmless the City of Omaha, its officials, employees, and any members of the applicable Department or Board, and their successors, from and on account of any and all judgments, claims, demands, losses, costs, expenses, or liabilities of any kind whatsoever which said City and any or all of the persons above enumerated may sustain or which may be recovered from it or them, from or by reason of the issuance of such Certificate, or by reason of any act, neglect or thing done under or by virtue of the authority given in any such Certificate, or in any way connected with, relating to, or growing out of any work performed by said principal, his or its agents and employees, or any sub-contractor or anyone in any way under his or its supervision and direction.
3) In all respects be bound hereby to any and all applicable requirements and provisions required to be in this bond by existing and hereafter existing Ordinances, Rules and Regulations of the City of Omaha, and other laws, the same as though such requirements and provisions were fully set forth in this bond, and by reference such requirements and provisions are made a part hereof;
4) Comply with and faithfully observe and obey all applicable Rules and Regulations and Ordinances of the City of Omaha now or hereafter existing and all other applicable laws now or hereafter existing affecting or relating to the issuance of the Certificate of Occupancy.
5) Pay all damages or loss that may occur from any act, neglect, or carelessness of said principal, his or its agents or employees, anyone under his or its supervision or direction, or any subcontractor, from such work pertaining to said Certificate of Occupancy, or from poor or defective work or material;
6) Properly perform and execute and fully protect any and all work undertaken by principal or under his or its direction and supervision, or by any agent or employee, or by any subcontractor.

Compliance with all and several of the above enumerated items shall make this bond void. Otherwise, it shall remain in full force and effect within the City of Omaha, Nebraska.

IN WITNESS WHEREOF, we have hereunto set our hands this ______ day of ____, 20_____.

In Presence of	______________________________
______________________________	______________________________
	Principal
Address of Witness ______________________________	______________________________
______________________________	______________________________
Street	Surety
______________________________	______________________________
City State Zip	Attorney-In-Fact
	APPROVED AS TO FORM:
______________________________	
______________________________	______________________________
Resident Agent	Assistant City Attorney

APPENDIX C

MAINTENANCE AGREEMENT

Grade Control Structures
MAINTENANCE AGREEMENT AND EASEMENT

WHEREAS, The Property Owner, _____________________, recognizes that grade control structure must be maintained for the development called ____located in the jurisdiction of; ____ and,

WHEREAS, the Property Owner (whether one of more) is the owner of real property depicted on Exhibit "A" (hereinafter referred to as "the Property"), and,

WHEREAS, the ____________________________ (hereinafter referred to as "the Jurisdiction") requires and the Property Owner, and its administrators, executors, successors, heirs, or assigns, agree that the health, safety and welfare of the citizens of the Jurisdiction require that the facilities be constructed and maintained on the property, and,

WHEREAS, the Grade Control Structures for,

____

should be constructed and maintained by the Property Owner, its administrators, executors, successors, heirs, or assigns.

NOW, THEREFORE, in consideration of the foregoing premises, the covenants contained herein, and the following terms and conditions, the property owner agrees as follows:

1. The grade control structures shall be constructed by the Property Owner in accordance with the design, which has been reviewed and accepted by the Jurisdiction or its designee.
2. The Property Owner must develop and provide the "Grade Control Maintenance Requirements", attached here to as Exhibit "B", which have been reviewed and accepted by the Jurisdiction or its designee. The Grade Control Maintenance Requirements shall describe the specific maintenance practices to be performed for the facilities and include a schedule for implementation of these practices. The Plan shall indicate that the facility or facilities shall be inspected by a professional qualified in stormwater BMP function and maintenance at least annually to ensure that it is operating properly. A written record of inspection results and any maintenance work shall be maintained and available for review by the Jurisdiction.
3. The Property Owner, its administrators, executors, successors, heirs, or assigns, shall construct and perpetually operate and maintain, at its sole expense, the facilities in strict accordance with the attached Grade Control Maintenance Requirements accepted by the Jurisdiction or its designee.
4. The Property Owner, its administrators, executors, successors, heirs, or assigns hereby grants permission to the Jurisdiction, its authorized agents and employees, to enter upon the property and to inspect the facilities whenever the Jurisdiction deems necessary. The Jurisdiction shall provide the Owner copies of the inspection findings and a directive to commence with the repairs if necessary.

The Jurisdiction will require the Property Owner to provide, within 7 calendar days, a written response addressing what actions will be taken to correct any deficiencies and provide a schedule of repairs within a reasonable time frame. Whenever possible, the Jurisdiction shall provide notice prior to entry. The Jurisdiction shall indemnify and hold the Property Owner harmless from any damage by reason of the Jurisdiction's negligent or intentional acts during such entry upon the property.

5. The Property Owner its administrators, executors, successors, heirs, or assigns, agrees that should it fail to correct any defects in the facility or facilities within reasonable time frame agreed to in the response by the Property Owner for corrective actions, or shall fail to maintain the structure in accordance with the attached Grade Control Maintenance Requirements and with the law and applicable executive regulation or, in the event of an emergency as determined by the Jurisdiction or its designee in its sole discretion, the Jurisdiction or its designee is authorized to enter the property to make all repairs, and to perform all maintenance, construction and reconstruction as the Jurisdiction or its designee deems necessary. Notwithstanding the foregoing, the Jurisdiction shall indemnify and hold the Property Owner harmless from any damage by reason of the Jurisdiction's negligent or intentional acts during such entry upon the property.
   The Jurisdiction or its designee shall have the right to recover from the Property Owner any and all reasonable costs the Jurisdiction expends to maintain or repair the facility or facilities or to correct any operational deficiencies subject to the provisions of the immediately preceding sentence relating to negligence or intentional acts of the Jurisdiction. Failure to pay the Jurisdiction or its designee all of its expended costs, after forty-five days written notice, shall constitute a breach of the agreement. The Jurisdiction or its designee shall thereafter be entitled to bring an action against the Property Owner to pay, or foreclose upon the lien hereby authorized by this agreement against the property, or both. Interest, collection costs, and reasonable attorney fees shall be added to the recovery to the successful party.
6. The Property Owner shall not obligate the Jurisdiction to maintain or repair the facility or facilities, and the Jurisdiction shall not be liable to any person for the condition or operation of the facility or facilities.
7. The Property Owner, its administrators, executors, successors, heirs, or assigns, hereby indemnifies and holds harmless the Jurisdiction and its authorized agents and employees for any and all damages, accidents, casualties, occurrences or claims that may arise or be asserted against the Jurisdiction from the construction, presence, existence or maintenance of the facility or facilities by the Property Owner. In the event a claim is asserted against the Jurisdiction, its authorized agents or employees, the Jurisdiction shall promptly notify the Property Owner and the Property Owner shall defend at its own expense any suit based on such claim unless due solely to the negligence of the Jurisdiction in which event the Jurisdiction shall be required to defend any such suit at its own expense. Notwithstanding the foregoing, if any claims are made against both the Jurisdiction and the Property Owner, each will be required to defend any such suit or claim against it at its own expense. Each shall be responsible for payment of any recovery to the extent determined in such suit. If any

judgment or claims against the Jurisdiction, its authorized agents or employees shall be allowed, the Property Owner shall pay for all costs and expenses in connection herewith except to the extent of the negligence or intentional act of the Jurisdiction.

8. The Property Owner shall not in any way diminish, limit, or restrict the right of the Jurisdiction to enforce any of its ordinances as authorized by law.
9. This Agreement shall be recorded with the Register of Deeds of Sarpy County, Nebraska and shall constitute a covenant running with the land and shall be binding on the Property Owner, its administrators, executors, successors, heirs, or assigns, including any homeowners or business association and any other successors in interest.

IN WITNESS WHEREOF, the Property Owner (s) has/ have executed this agreement this day of _____, 20_____.

INDIVIDUAL and/or PARTNERSHIP

Name	Name
Title	Title
Signature	Signature

Name	Name
Title	Title
Signature	Signature

ACKNOWLEDGMENT

_____________________________)
State

_____________________________)
County

On this ______day of _, 20__________before me, a Notary Public, in and for said County, personally came the above named: ______who is (are) personally known to me to be the identical person(s) whose name(s) is (are) affixed to the above instrument and acknowledged the instrument to be his, her (their) voluntary act and deed for the purpose therein stated.

WITNESS my hand and Notarial Seal the day and year last above written.

____
Notary Public

____
Notary Seal

Exhibit "A"

Insert Real Property Depiction

Exhibit "B"

Insert BMP Maintenance Requirements

A template for potential maintenance activities is provided in Table B.1. The activities may include but are not limited to the item in the template and needs to be developed with and approved by the local jurisdiction. The frequency of maintenance activities needs to be agreed upon and defined in this agreement; minimum of six months is required.

Table B.1 – Maintenance Requirements Template

Maintenance Activity	**Responsible Party**
Remove trash and debris	
Inspect stream banks for erosion; install erosion control matting if erosion cannot be controlled with establishing vegetation	
Maintain rock riprap in place; any rock washed away should be supplemented/replaced	
Frequency of Maintenance Activities:	

APPENDIX C

GRADE CONTROL CERTIFICATION FORM

GRADE CONTROL STRUCTURE CERTIFICATION

For Grade Controls Constructed in the Southern Sarpy Watersheds

All submittals should be provided electronically to the local jurisdiction. Attach a photolog with a minimum of one photo of each grade control structure and the Record Drawings of the Grade Control Structure Plan Sheets.

Project Information

Project Name	
Project Address	
Subdivision Name	
SID #	
Number of Grade Controls	

This certification must be executed and sealed by a licensed professional civil engineer registered in the State of Nebraska.

Certification Statement

Based upon MY inspection of the constructed grade control structure(s) for the above-referenced project, I hereby certify that the grade control structure(s) are in general compliance with the intent of the original design plans and with Southern Sarpy Watersheds Grade Control Implementation Guidance Document requirements.

Name (Signature): ______________________________ Date:____________

Name (Printed): ______________________________

Qualifications: ______________________________

PE Seal:

(Attachments)