Trout Stream Geomorphology Assessment

In the Lower Minnesota River Watershed District

Prepared for
Young Environmental Consulting Group

October 2019

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1 Executive Summary

In the summer of 2019, interns from Young Environmental Consulting Group and Watershed Recovery, LLC collectively completed surveys of designated trout streams and one water of special interest within the Lower Minnesota River Watershed District (LMRWD). The surveys included physical surveys of cross sections and longitudinal profiles for segments of each creek, in addition to "pebble counts" that characterize the grain size distribution in the sediment. The interns also completed habitat assessments for each creek.

Three creeks, Assumption, Eagle, and Ike's, either have current trout populations or have the high potential to have a trout population because habitat and flow characteristics for each creek provide good conditions for trout. Ike's Creek is not a designated trout stream; however, it is a water of special interest.

Assumption Creek appears to be generally stable; however, there are some potential stability issues that need to be investigated.

Eagle Creek is over-widened in many places. The Minnesota DNR has completed a project to improve one section of the stream. Additional stability issues are an ongoing concern, and Eagle Creek likely presents the best opportunity for the LMRWD to collaborate and implement projects with the DNR.

Ike's Creek has some potential stability issues that should be investigated; however, they may be a natural phenomenon.

Kennaley's Creek lacks hydrology to currently support a trout population; however, that is caused by dewatering within the immediate watershed. A change in that dewatering may result in restoring a viable hydrology to this creek. In addition, due to high water, only one cross section was surveyed on Kennaley's Creek, so an additional effort to survey more of the creek would provide more data about its condition.

Unnamed Creeks have poor base flow. Unnamed Creek 1 has some significant erosion issues.

Recommendations for additional investigations and surveys are provided in Section 9.

2 Introduction

Young Environmental Consulting Group (Young Environmental) and Watershed Recovery, LLC (WR) collectively hired six college-aged interns for the summer of 2019. The interns' primary task was to complete surveys and assessments of trout streams within the Lower Minnesota River Watershed District (LMRWD) in order to complete a geomorphic assessment of each stream. The assessments were to develop conclusions about the stability and habitat viability of each stream. Barr Engineering (Barr) provided periodic training, advice, and feedback to the interns; however, Young Environmental and WR provided the bulk of the training and oversaw the interns' day-to-day activities.

At the conclusion of their internship, the interns completed a report titled Geomorphic and Habitat Assessment of Trout Streams in the Lower Minnesota River Watershed District (Interns' Report), where they summarized the data gathered and conclusions drawn about each stream. They assessed seven historic trout streams: Assumption Creek, Eagle Creek, Ike's Creek, Kennaley's Creek, Unnamed Creek 1, Unnamed Creek 2, and Unnamed Creek 4. In addition, Unnamed Creek 7 is a historic trout stream that was initially considered for inclusion in this study; however, it was removed after consultation with the Minnesota Department of Natural Resources (DNR). They completed surveys, including cross sections and longitudinal profiles, and habitat assessment for each creek. They also characterized the sediment and assessed the groundwater inputs to each stream.

This report will provide a review of the data gathered and conclusions drawn. Barr has not completed site visits to develop a first-hand review of the condition of each creek, so this review is based solely on the data provided in the interns' report. To the extent possible, this review will reference data and figures in the Interns' Report rather than creating duplicates. The purpose of this review is to provide the following:

1) A review of the data gathered by the interns
2) Additional assessments where appropriate
3) Suggestions for additional work in future years

3 Geomorphology Overview

The geomorphology discussion in the following sections is largely based on the Rosgen methodology of stream classification. The classification system separates streams into seven different stream types, lettered A through G. Each stream type has typical characteristics related to bankfull width-depth ratio, entrenchment ratio, sinuosity, and slope. These variables are defined in Table 3-1, below. The type of substrate (clay, sand, gravel, etc) provides an additional level of classification within each stream type. Figure 3-1 shows the classic Rosgen stream types.

Table 3-1 Definitions of terms used in this report

Term	Definition
Bankfull	Level where the flow just begins to access the adjacent floodplain. Bankfull flow often occurs once every 1-1.5 years.
Width-depth ratio	Ratio the bankfull width to the bankfull depth
Entrenchment ratio	Ratio of the bankfull width to the width of the floodplain.
Sinuosity	Stream length divided by valley length
Slope	Vertical elevation change divided by stream distance. Often expressed as a percent.

Even though the stream types are defined by typical ratios and dimensions, streams are dynamic systems within a spectrum of landscapes and influences; and some segments of streams can display typical characteristics of more than one stream type.

The most common stream types found in central Minnesota are Types C and E streams. In general, a Type C stream is more often within a forested area and has a higher width-depth ratio. There is usually a very distinct pool-riffle pattern with shallow riffles and deeper pools.

Type E streams are more often found in grasslands/prairies. Their low width-depth ratio is often a function of dense root systems holding the banks together, thereby forcing the erosive forces of high water into the bed of the stream. Type E streams can also have a pear shape as the roots hold together the tops of the banks, but the stream is able to become slightly wider below the thickest portion of the root zone. Type E streams often do not display a significant difference in depth between pools and riffles, and it can often be difficult to identify riffles, especially compared to the shallow, turbulent riffles in Type C streams.

It should also be noted that all stream types can be stable streams. Streams naturally move water and sediment through the channel, and the stability of the stream is often determined by its ability to transport sediment through the channel. Watershed changes naturally occur over time, although the changes usually occur relatively slowly. Stable streams are often referred to as being in "dynamic equilibrium with the watershed, meaning the stream is able to slowly adjust to slow watershed changes without resulting in a significant change to the overall stream stability.

If the water and sediment transport is in balance, then the stream is usually stable, no matter the stream type. If the water or sediment supply changes, either naturally or through anthropogenic watershed changes, then the stream can become unstable as the stream tries to recreate its dynamic equilibrium with the watershed. Interns measured channel geometry to classify each stream; however, sediment transport was not completed.

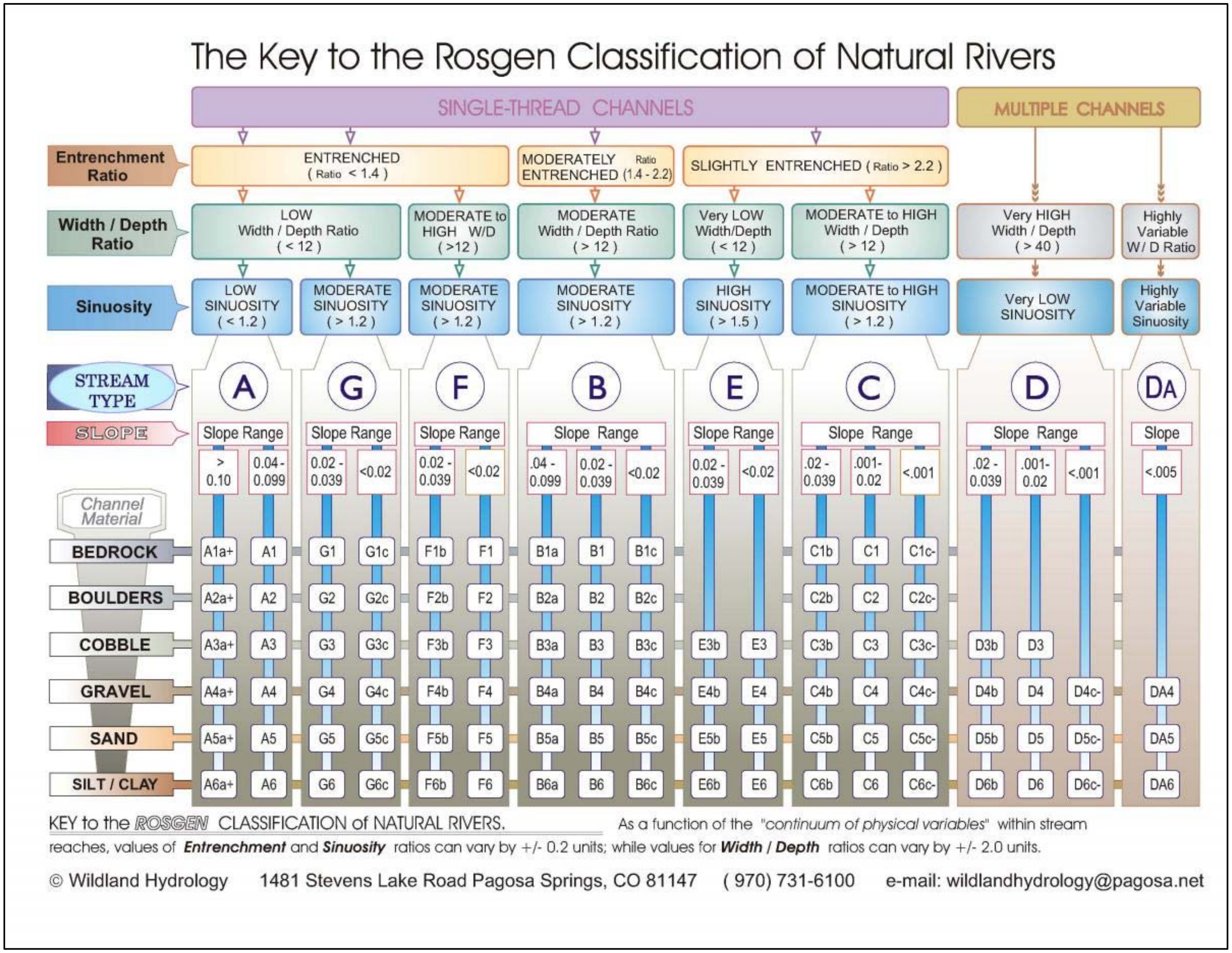

Figure 3-1 Rosgen stream types

4 Assumption Creek

Assumption Creek (Figure 4-1) has one main branch, and one small tributary between Flying Cloud Drive and the Minnesota River. The creek was divided into a west reach and east reach upstream of Flying Cloud Drive. It was not possible to assess the creek downstream of Flying Cloud Drive due to high water.

4.1 Summary of Findings

The interns' findings are summarized in the following table.

Table 4-1 Summary of findings for Assumption Creek

Variable	West Reach	East Reach	Downstream of Flying Cloud Drive
Rogen Stream Type	A and E	E	N/A
Substrate	Gravel, sand, silt	Gravel, sand, silt, cobble	N/A
Base flow	Present during first visit, largely absent during subsequent visits	Consistent	N/A
Riparian vegetation	Grasses / prairie	Forest, grasses, wetland	N/A
Erosion	Minor bank erosion	Minor	N/A
In-stream habitat	Undercut banks, woody debris, overhanging vegetation	Woody debris, deep pools, undercut banks, overhanging vegetation	N/A
Miscellaneous	Low sinuosity; channel possibly piped for some distance	Mid-channel bars	N/A
Cross Section Area (ft^2)	7.0	13.5	N/A
Max Depth (ft.)	2.0	2.2	N/A
Bankfull Width	7.4	9.5	N/A
Width-depth Ratio	7.9	7.7	N/A
D_{50} (mm)	clay	N/A	N/A
D_{84} (mm)	1.4	N/A	N/A

4.2 Analysis

The data and dimensions gathered in the cross sections were variable, and some cross sections had dimensions that appear to be outliers compared to others. That said, on average, the channel characteristics for Assumption Creek are consistent with a Rosgen Type E stream. The interns noted a low sinuosity for the western reach, and used that variable to classify the stream as a Type A stream. Type A streams are typically relatively steep, with slopes often greater than 5%. The fact that the western reach was the headwaters of the stream, it is likely to be steeper than the lower portions of the creek. Unfortunately, a longitudinal profile of the western reach was not completed, so the slope is not known at this time. Since the reach is entirely within the Minnesota River floodplain, it is unlikely that the slope is near 5%; therefore, it is more likely a Type E stream throughout both reaches, despite the low sinuosity in the western reach.

The increase in the cross sectional area between the western reach and the eastern reach can be explained more by the increase in base flow present than the slight increase in watershed area. Seminary Fen is located near the east reach, and springs from the fen feed the creek in this area. As shown in Figure 4-2, the cross sectional areas are within reason for regional curves for Minnesota. The West Reach falls almost exactly on the regression line. The East Reach is a little higher than the other data for eastern Minnesota; however, it is similar to other data points used to generate the regression line. As noted above, the base flow generated by the springs also likely increases the cross sectional area, and that may not be the case for other streams used to generate the regional curves.

4.3 Future work

The following items should be considered for future work on Assumption Creek:

1) The presence of mid-channel bars in the east reach should be investigated further to get a better understanding of their frequency and cause, because they can be an early indication of instability.
2) Additional flow measurements should be completed upstream and downstream of seminary fen to quantify the flow inputs from the fen. Since the fen is also a High Value Resource Area, this data can also be used to develop additional understanding about the fen.
3) The 2019 season was very wet, which prevented assessment of the creek downstream of Flying Cloud Drive. The fact that that portion of the stream is occasionally inundated with floodwaters will have a significant impact on the geomorphology. An assessment of this portion of the stream should be completed during a drier year.

4.4 Conclusion

The data gathered by the interns indicate that Assumption Creek is a stable Type E stream. There is decent in-stream habitat and base flow downstream of Seminary Fen. The creek upstream of Seminary Fen is unlikely to support trout year-round due to a lack of base flow.

Figure 4-1 Assumption Creek

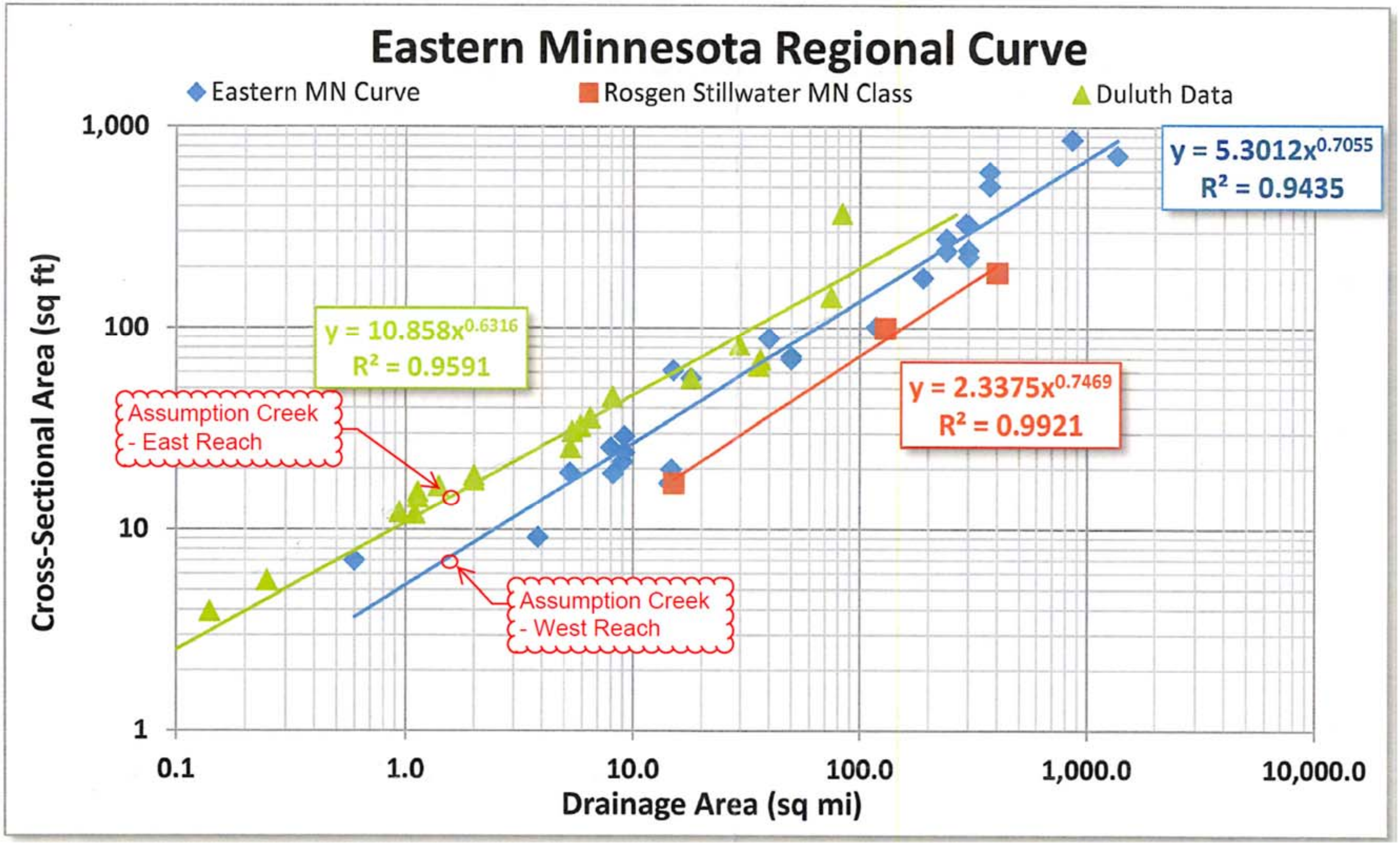

Figure 4-2 **Assumption Creek dimensions plotted on MN DNR regional curve**

5 Eagle Creek

Eagle Creek (Figure 5-1) has one main branch, and two main tributaries. The East Branch tributary is an open channel, whereas the west branch is largely through ponds and storage areas. A third tributary is primarily ephemeral flow through backyards and storm sewers.

5.1 Summary of Findings

The interns' findings are summarized in the following table.

Table 5-1 Summary of findings for Eagle Creek

Variable	Main Branch	East Branch	Reconstructed Reach
Rogen Stream Type	B, E, and D	E and B	C
Substrate	Gravel, sand	sand	sand
Base flow	Present throughout	Present throughout	Present throughout
Riparian vegetation	Variable - Grasses / prairie in some areas, forested in others	Variable - Grasses / prairie in some areas, forested in others	Grasses / prairie immediately adjacent to the channel
Erosion	Minor bank erosion; slope erosion in campground	Minor	Minor
In-stream habitat	Logs, instream vegetation, woody debris, overhanging vegetation	Woody debris, undercut banks, overhanging vegetation	Overhanding vegetation
Miscellaneous	Channel appears to be over-widened in many areas downstream of the reconstructed reach	Mid-channel bars	N/A
Cross Section Area (ft^2)	20.2	18.9	13.6
Max Depth (ft.)	1.8	2.2	1.7
Bankfull Width	21.2	16.6	13.5
Width-depth Ratio	22.7	15.7	14.5
D_{50} (mm)	0.16	0.22	0.33
D_{84} (mm)	0.23	0.62	0.48

5.2 Analysis

The data and dimensions gathered in the cross sections were variable, as evidenced by the multiple stream types identified for each reach. The Interns' Report concludes that some cross sections in the east reach are Type G; however, after further investigation, it appears that the bankfull elevation may have been misidentified. The result is that the cross sections in the east reach are Type B or E.

The reconstructed reach on the main stem of Eagle Creek was completed in 2013, and the smaller cross sectional area for that reach compared to the others is very notable. The design was completed with the Minnesota Department of Natural Resources (DNR) to improve trout habitat. The cross section area was sized carefully account for current hydrology. Using Figure 5-2, it appears that the cross section area for the reconstructed reach is similar to other values on the regression lines; however, the cross sectional areas for the other two reaches are larger than would be expected. If the channel is too large, it may lack necessary sediment carrying capacity, which can contribute to the other items identified in the Interns' Report, notably mid-channel bars and wide, shallow cross sections. It can also contribute to the creation of braided, Type D streams, identified in one cross sections.

Only relatively minor erosion was noted, except for bank failures near the campground on the main stem. Discussion about sand sources

5.3 Future work

The following items should be considered for future work on Eagle Creek:

1) The over widened channel and the presence of mid-channel bars is a concern. We recommend the District work with the DNR to review and understand the causes of this situation. Given that the DNR has invested money into trout habitat improvement in this area; they have a vested interest in finding a sustainable solution as well.
2) Stabilizing the eroding bank at the campground should be evaluated to determine how much sediment is contributing to the stream and what stabilization options may be feasible.
3) The 2019 season was very wet, which prevented assessment of the creek downstream of Highway 13. The fact that that portion of the stream is occasionally inundated with floodwaters will have a significant impact on the geomorphology. An assessment of this portion of the stream should be completed during a drier year.

5.4 Conclusion

The data gathered by the interns indicate that Eagle Creek has multiple stream types. The reconstructed reach appears to be a stable reach; however, the over-widened, over-large channel in other areas indicate that the stream may be unstable. Additional investigation into this situation is warranted.

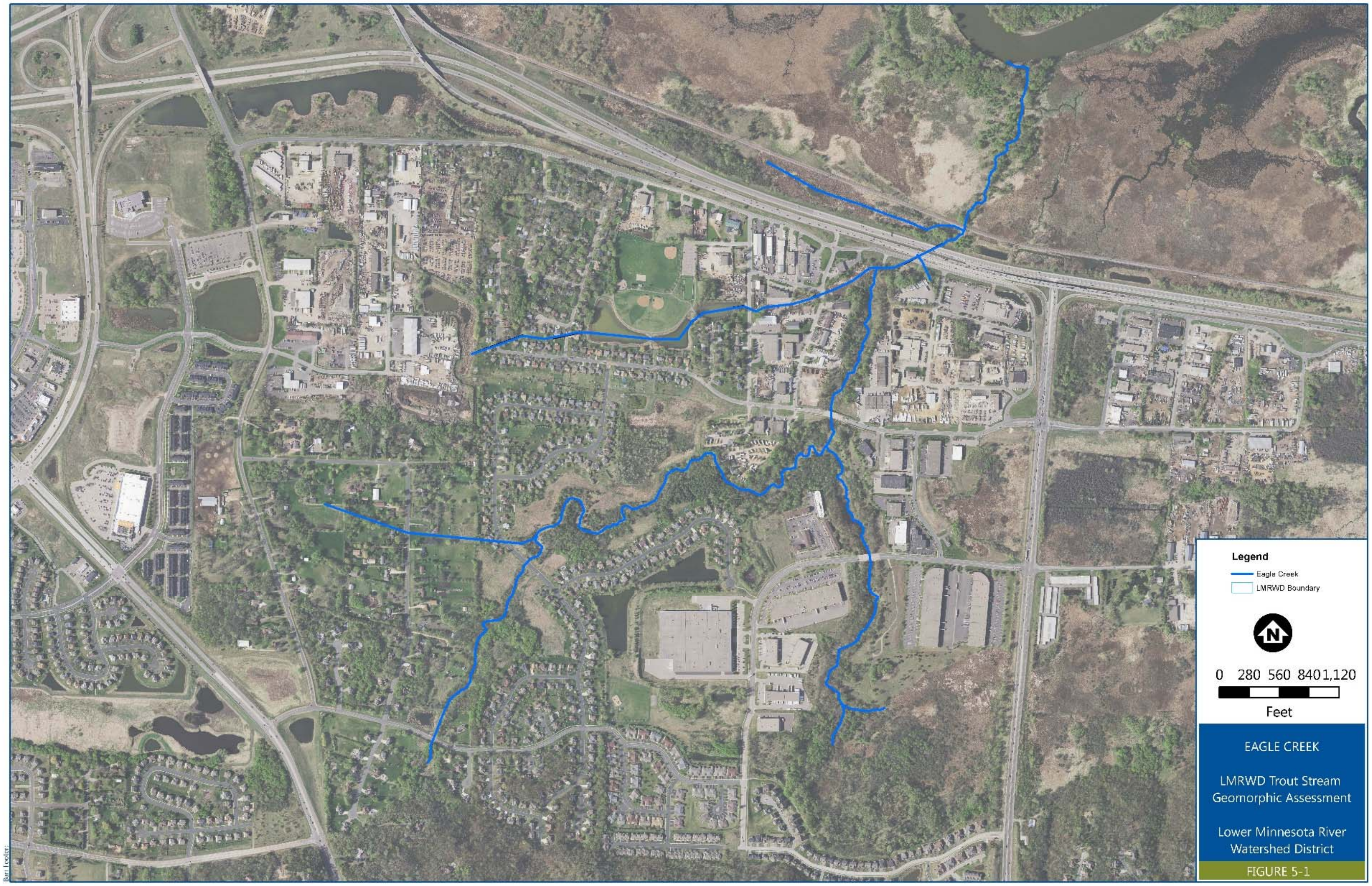

Figure 5-1 Eagle Creek

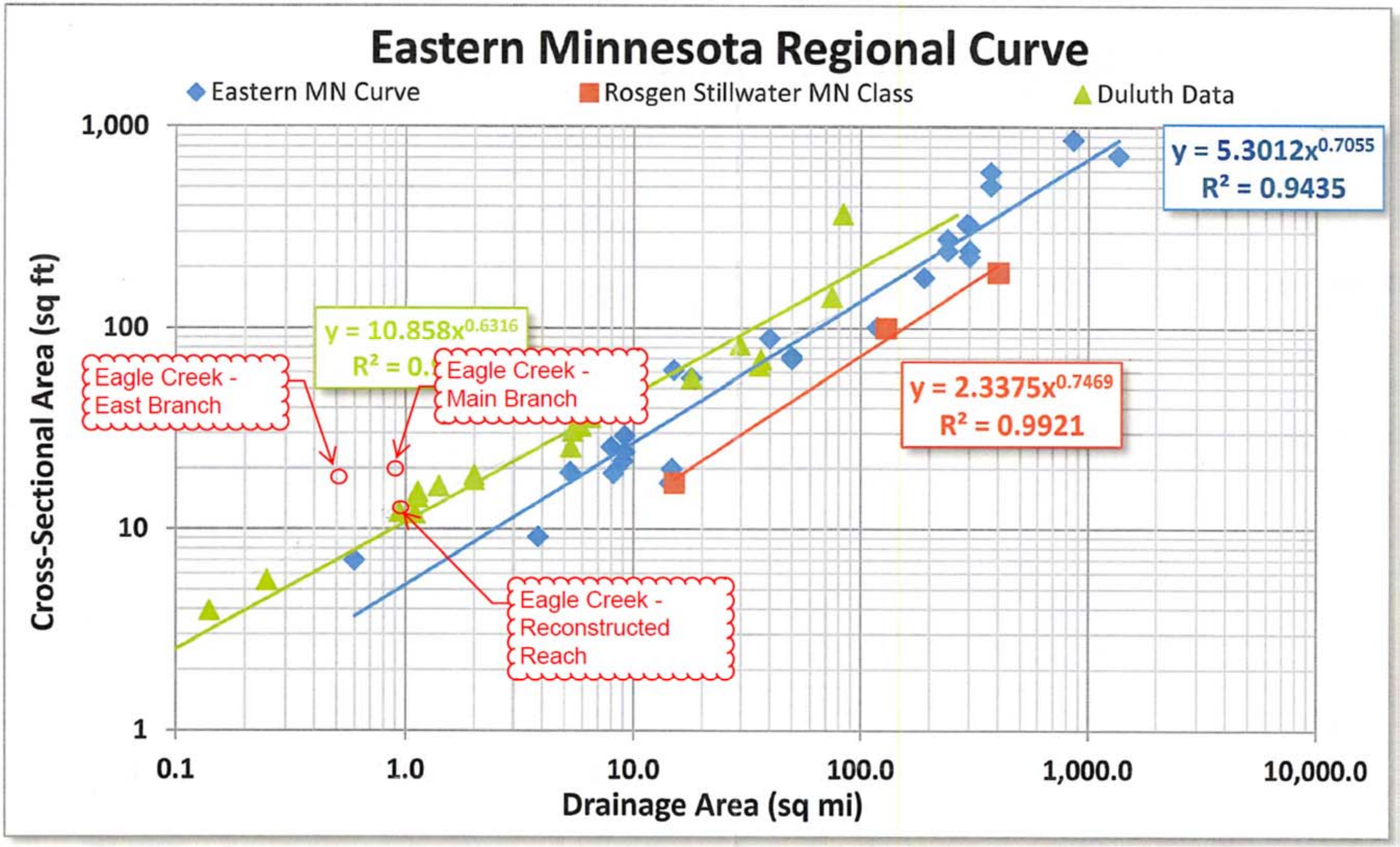

Figure 5-2 **Eagle Creek dimensions plotted on MN DNR regional curve**

6 Ike's Creek

Ike's Creek (Figure 6-1) has one main branch. Other potential tributaries have been identified by others; however, the field reconnaissance for this study did not find any tributaries.

6.1 Summary of Findings

The interns' findings are summarized in the following table.

Table 6-1 Summary of findings for Ike's Creek

Variable	Main Branch
Rogen Stream Type	C and D
Substrate	Gravel, sand
Base flow	Present throughout
Riparian vegetation	Variable - wetlands in some areas, forested in others
Erosion	Multiple knickpoints observed; moderate bank erosion
In-stream habitat	Logs, instream vegetation, woody debris, root wads, deep pools, overhanging vegetation
Miscellaneous	N/A
Cross Section Area (ft^2)	17.5
Max Depth (ft.)	1.5
Bankfull Width	9.9
Width-depth Ratio	10.7
D_{50} (mm)	8.6
D_{84} (mm)	16

6.2 Analysis

The data and dimensions gathered in the cross sections were variable, as evidenced by the multiple stream types identified for each reach. The Interns' Report concludes that some cross sections are Type D; however, Type D channels are typically associated with braided streams. The channel in these areas may be a very wide, shallow Type C, instead. The result is that most of the cross sections in this creek appear to be Type C or Type E.

A conversation with Mark Nemeth from the DNR in September 2019 provided information that the identified knickpoints may be more likely to be accumulated marl on debris in the stream. Marl is a calcium carbonate deposit and can deposit on organic material in the stream. DNR has observed several marl deposits on fallen trees, and they speculate that it could be mistaken for a knickpoint.

If the interns correctly identified knickpoints in the stream, then that is a significant stability concern. If the identified knickpoints are actually a natural phenomenon, then the stream may be relatively stable. The regional curve data indicates that the channel may be oversized, but that could be influenced by the over-widened cross sections.

6.3 Future work

The following items should be considered for future work on Ike's Creek:

1) We recommend investigating knickpoints / marl issue to determine if a stability issue is present.
2) The 2019 season was very wet, which prevented assessment of the creek into the Minnesota River Valley. The fact that that portion of the stream is occasionally inundated with floodwaters will have a significant impact on the geomorphology. An assessment of this portion of the stream should be completed during a drier year.

6.4 Conclusion

The data gathered by the interns indicate that Ike's Creek has multiple stream types, but that may be strongly influenced by marl deposition. Additional investigation into this situation is warranted to develop a definitive conclusion regarding channel stability in this creek.

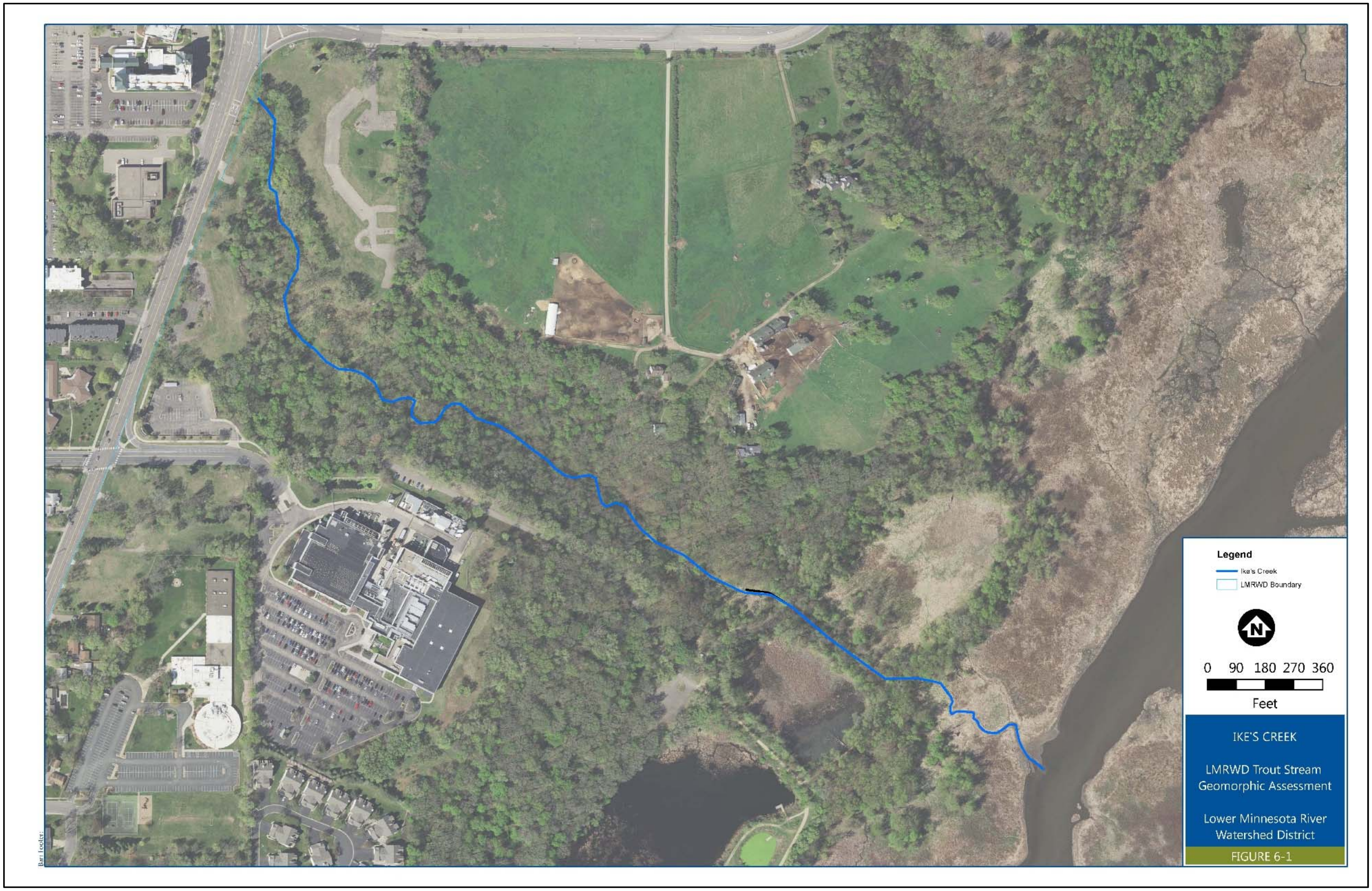

Figure 6-1 Ike’s Creek

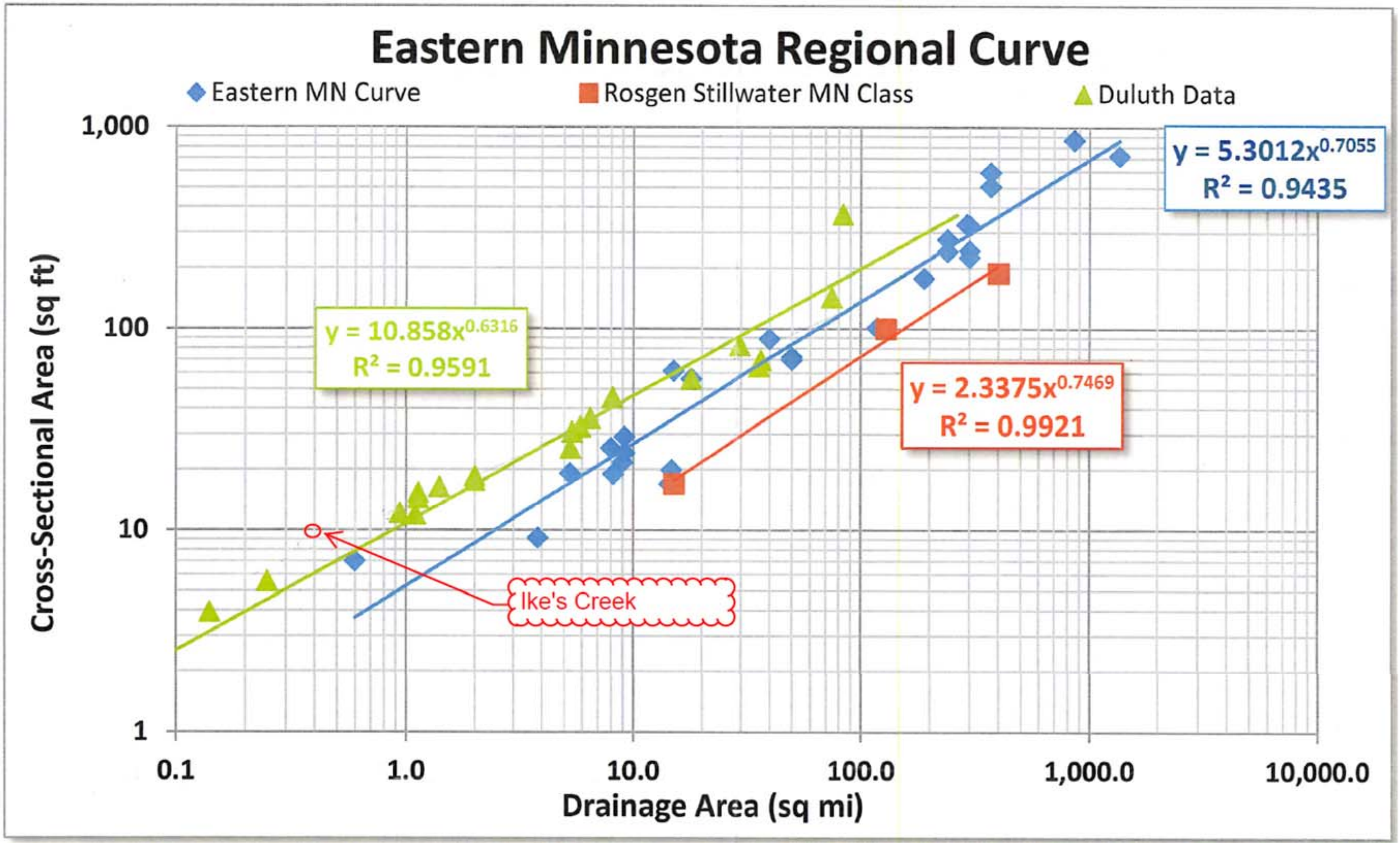

Figure 6-2 **Ike's Creek dimensions plotted on MN DNR regional curve**

7 Kennaley's Creek

Kennaley's Creek (Figure 8-1) has two main tributaries of roughly equivalent length that join to form a main channel that connects to the Minnesota River.

7.1 Summary of Findings

The interns' findings are summarized in the following table.

Table 7-1 Summary of findings for Kennaley's Creek

Variable	West Branch	East Branch	Main Stem
Rogen Stream Type	A	N/A	N/A
Substrate	Gravel, Sand, silt, muck	N/A	N/A
Base flow	Present throughout	N/A	N/A
Riparian vegetation	Grasses/ wetland	N/A	N/A
Erosion	None noted	N/A	N/A
In-stream habitat	Undercut banks, root mats, woody debris, overhanging vegetation	N/A	N/A
Miscellaneous	Very little sinuosity. Mucky bottom in many places	N/A	N/A
Cross Section Area (ft^2)	8	N/A	N/A
Max Depth (ft.)	2.6	N/A	N/A
Bankfull Width	5.8	N/A	N/A
Width-depth Ratio	4.2	N/A	N/A
D_{50} (mm)	0.22	N/A	N/A
D_{84} (mm)	2.8	N/A	N/A

7.2 Analysis

Only one cross section was completed for Kennaley's Creek, and it is a Type E channel.

As noted in the Interns' Report, many portions of the channel have excessive silt and muck. Information from the DNR has indicated that even though this is an historic trout stream the changes to the watershed have altered the flows into the stream. Groundwater is pumped for dewatering to accommodate the nearby Seneca Wastewater Treatment Plant. If dewatering pumping rates are reduced in the future, then it may be possible to restore base flow levels to sustain trout population. As it is, the groundwater inputs are not enough to keep the stream cool in the summer and warm in the winter.

From a geomorphological perspective, the stream appears to be a Rogen Type E channel. There is not much sinuosity in the western branch. The interns noted that the channel was becoming deeper and that some incision may be present; however, no other erosion issues were noted. The cross section appears to be a little larger than would be expected for the watershed size, but not out of a typical range, especially if there is a consistent base flow.

7.3 Future work

The following items should be considered for future work on Kennaley's Creek:

1) Walking the stream to the extent possible in drier conditions may provide some additional insight into the stream and its morphology. Due to the extensive grass cover, late winter and early spring may be the best time to complete this work.

7.4 Conclusion

Some additional reconnaissance is necessary to reach definitive conclusions about this stream because it was not possible to complete a thorough investigation in the summer of 2019. Due to the reduced base flow to this stream, it does not currently support a trout population, so additional work can be a lower priority.

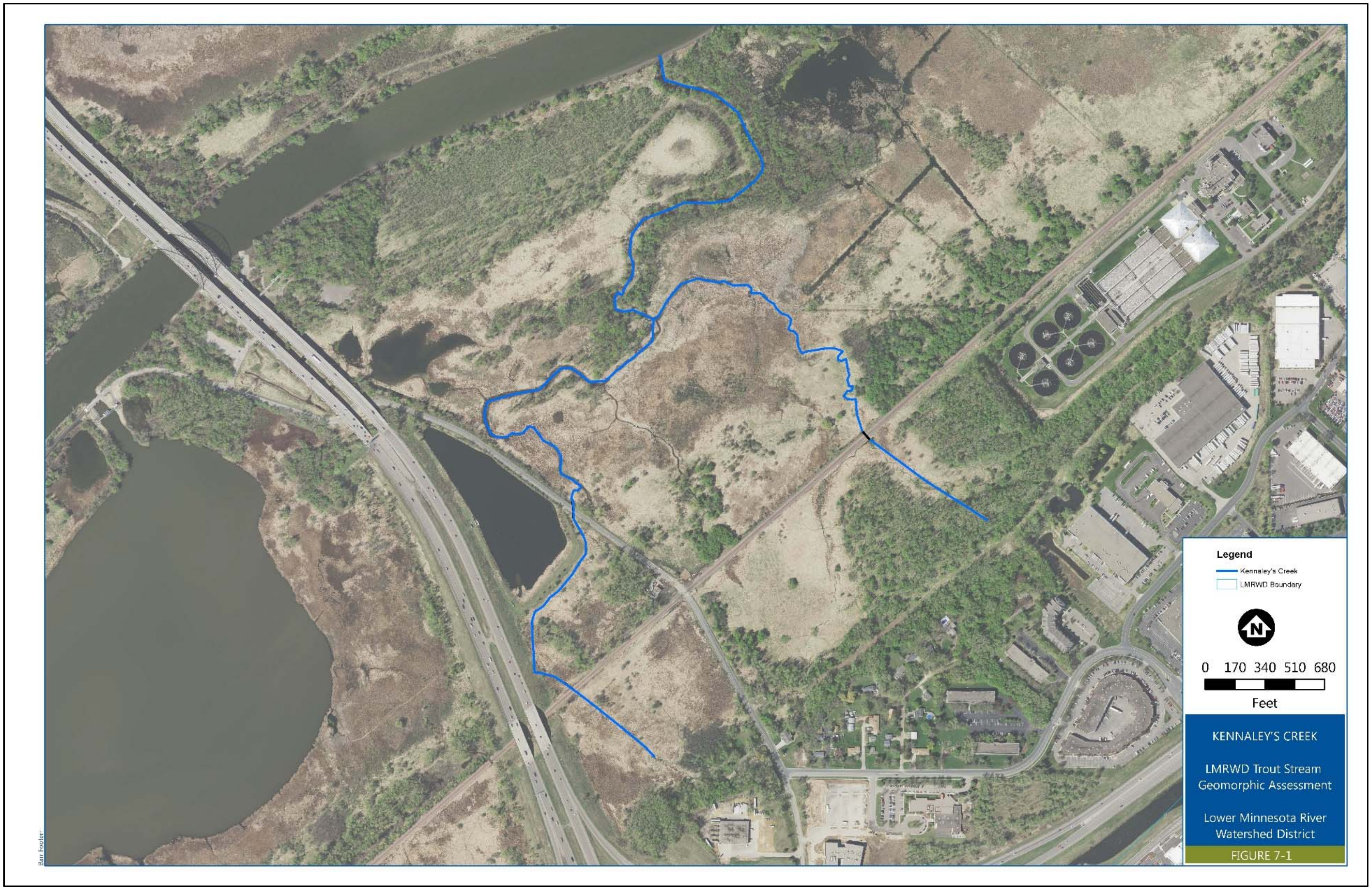

Figure 7-1 Kennaley's Creek

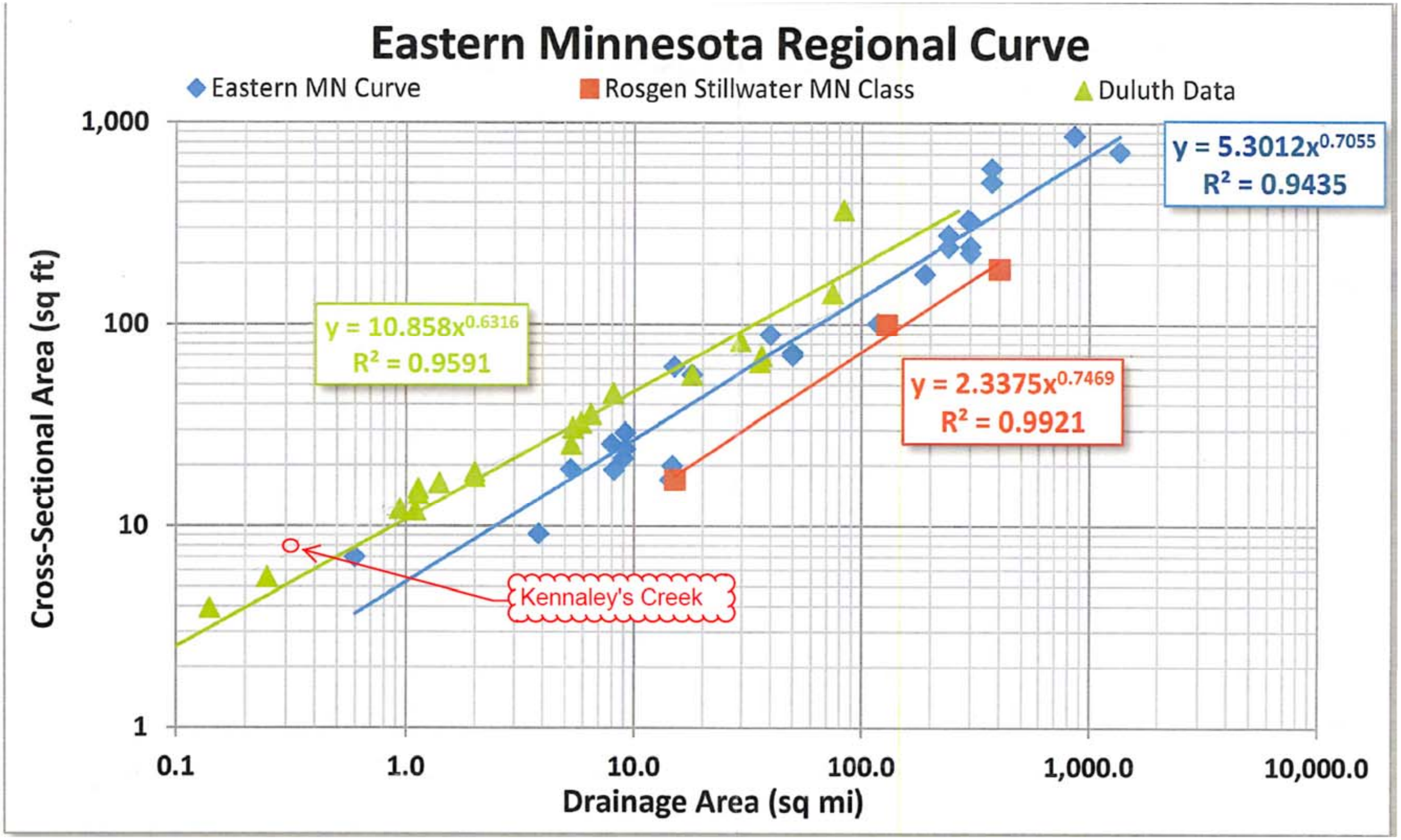

Figure 7-2 Kennaley's Creek dimensions plotted on MN DNR regional curve

8 Unnamed Creek 1

Unnamed Creek 1 (Figure 8-1) has one main branch that empties into one of the cooling ponds for the Black Dog Power Plant, adjacent to the Minnesota River.

8.1 Summary of Findings

The interns' findings are summarized in the following table.

Table 8-1 Summary of findings for Unnamed Creek 1

Variable	Main Steam
Rogen Stream Type	F
Substrate	Gravel, Sand
Base flow	Present intermittently
Riparian vegetation	Trees
Erosion	Significant bank erosion
In-stream habitat	Logs, woody debris
Miscellaneous	Significant erosion detrimental to the channel and in-stream habitat.
Cross Section Area (ft^2)	N/A
Max Depth (ft.)	N/A
Bankfull Width	N/A
Width-depth Ratio	N/A
D_{50} (mm)	2.3
D_{84} (mm)	6.9

8.2 Analysis

The interns surveyed four cross sections in the creek, however, due to the excessive erosion, bankfull indicators are very difficult to find. As noted in the Interns' Report, eroding banks of over 9 feet tall were common on this reach, despite a past effort to stabilize portions of the creek. The cross sections show channel bottom widths of approximately 10-20 feet wide, which is inconsistent with the relatively small watershed. Therefore, the classification is likely a Type F channel.

8.3 Future work

The following items should be considered for future work on Unnamed Creek 1:

1) We recommend additional investigation into the observed erosion to determine if there are feasible options for stabilizing the stream and reducing sediment load. Fortunately, the stream empties into a reservoir prior to entering the Minnesota River, so it is possible that much of the sediment settles out prior to entering the river.
2) There are other sections of Unnamed Creek(s) in this same vicinity; however they were not investigated due to high water from the Minnesota River. Additional discussions with the DNR should be completed to determine the feasibility of investigating the additional segments during low flow.

8.4 Conclusion

This segment of stream appears to be highly unstable, and the feasibility of stabilization should be investigated.

Figure 8-1 Unnamed Creeks

9 Recommendations for Future Work

The surveys and assessments completed in 2019 provided a good baseline for understanding the geomorphological condition. As noted above, high water levels in the Minnesota River prevented assessments from being completed in the lower portions of all of the stream; however, the high water also provided a physical indication of where the Minnesota River tailwater will have a noticeable influence on the geomorphology. This allowed the interns to focus attention on the areas of the streams that are not directly influenced by the River.

In previous sections, specific recommendations are included for each stream, and those are summarized in the following table. Additional recommendations are also included in the table and discussed in more detail below.

The surveyed cross sections can be re-surveyed to determine how the cross sections are changing over time. It is not necessary to complete an annual survey because cross sections usually do not change that quickly, and the annual foot traffic can have an adverse impact on the cross sections. In 2019, the interns surveyed one cross section within one longitudinal profile, and the cross sections and profiles were spread along the length of the stream such that there were gaps between the longitudinal profiles. This same approach can be repeated, which would provide a snapshot at different locations of the stream. Alternatively, a single representative reach for each creek / branch can be selected to survey more intensely. This would likely include a longer longitudinal profile, but it would only be one profile for each creek / branch, with some exceptions. It would also include a minimum of three cross sections within this longer profile, in addition to pebble counts. This option, combined with a walk along the length of the stream to provide a qualitative assessment can provide good conclusions on the geomorphology of each stream. The additional information within the surveyed reach helps to develop a stronger conclusion about the geomorphology of that reach, and by choosing a representative reach, then the stronger conclusion can be extrapolated to the rest of the reach. This may ultimately require less time per stream than the 2019 work did. The exceptions noted above include situations like Assumption Creek where there is a noted groundwater input in the vicinity of Seminary Fen. In that case, an assessment upstream and downstream of the fen should be completed to better quantify the average flow input from the fen. For a stream like Eagle Creek, assessments would be recommended on each distinct branch/reach.

In addition to the above recommendations, future work should continue to evaluate the potential for fish passage along these streams. This is important for all species, and while not directly relevant to geomorphic assessment, it habitat fragmentation due to barriers to passage can have significant impacts on population viability.

Regardless of the assessments chosen some additional consultation with the DNR is justified to compare results with information the DNR has gathered. The DNR assesses these streams on a semi-regular basis so comparing to their results will provide additional context and may help to focus limited budget into the areas of greatest need and collaboration.

Table 9-1 Recommendations for future work

Task No.	Description	Creek	Priority Level	Frequency	Notes
1	Compare survey data to past surveys completed by DNR	All	Medium	Once	
2	Meet with DNR staff to review the data and potential for collaboration	All		Once	
3	Walk the length of each stream; complete a qualitative assessment; document observed erosion and habitat issues	All		Once every 2 years	Best completed in spring or early summer before vegetation is high;
4	Walk the lower sections of each stream that were unable to be accessed in 2019	All	Medium	Once	Assumption, Eagle and Ike's Creeks are highest priorities
5	Evaluate all culverts and bridges for fish passage	All	Medium	Once	
5	Investigate the formation of mid-channel bars	Assumption and Eagle	High	Once	
6	Measure flows upstream and downstream of Seminary Fen to quantify the flow input	Assumption	Low	5-10 times	This could be done while walking the stream in Task 3.
7	Investigate the diversion into a long culvert and how that may impact geomorphology	Assumption	Low	Once	
8	Assess the eroding banks at the campground and determine urgency for stabilization	Eagle	Medium	Once	
9	Determine if over-widened channel at Ike's creek is a systemic instability or a result of Marl deposits	Ike's	High	Once	
10	Assess erosion on Unnamed Stream 1 and determine if feasible stabilization options exist	Unnamed 1	High	Once	
11	Resurvey cross sections to determine if changes have occurred	All	High	Once every 3 years	Streams could be prioritized and/or different placed on a different frequency schedule
11 (alt)	Select specific subreaches on each stream to survey more intensively (see discussion)	All	Medium	Once every 3 years	This is an alternative option for Number 11.