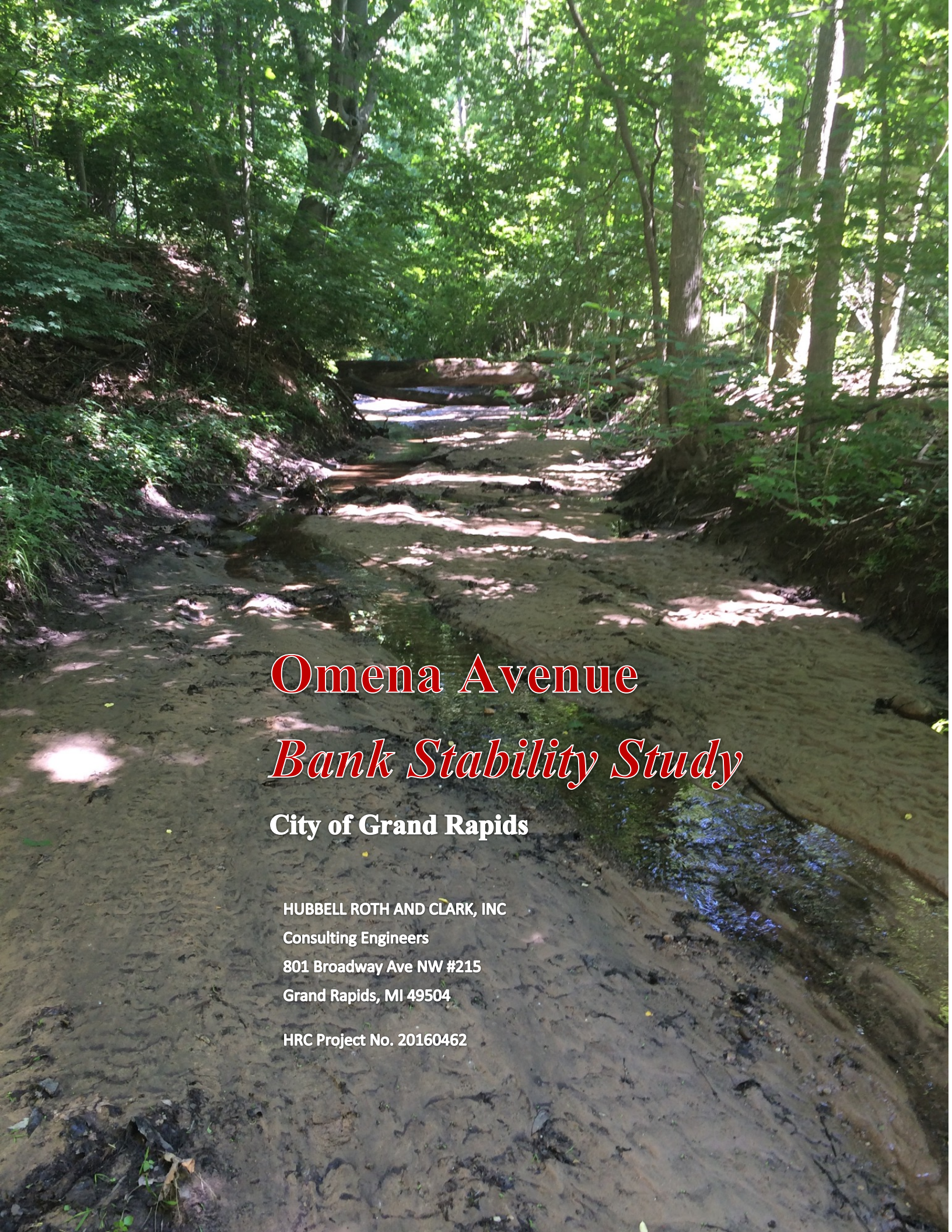

Omena Avenue

Bank Stability Study

City of Grand Rapids

HUBBELL ROTH AND CLARK, INC
Consulting Engineers
801 Broadway Ave NW #215
Grand Rapids, MI 49504

HRC Project No. 20160462

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Chapter 1 - Understanding the Project

The City of Grand Rapids was approached by a group of residents to investigate the excessive amounts of erosion that has been occurring along a reach of a natural stream near their homes. The concern is that excessive or extensive stream bank erosion is occurring which could or would jeopardize their properties and structures. Several residents stated that they are currently experiencing erosion on their properties. The residents are interested in determining what could be done to the stream to reduce or eliminate these risks and prevent the further degradation of their property.

This report and study is to evaluate these concerns and the stream corridor reach in order to locate and determine the specific causes of the erosion and to identify specific restoration and stability management practices that could be implemented to potentially rectify the situation.

The project study area is located South of Burton Street SE and west of Omena Avenue SE as shown on Map 1.

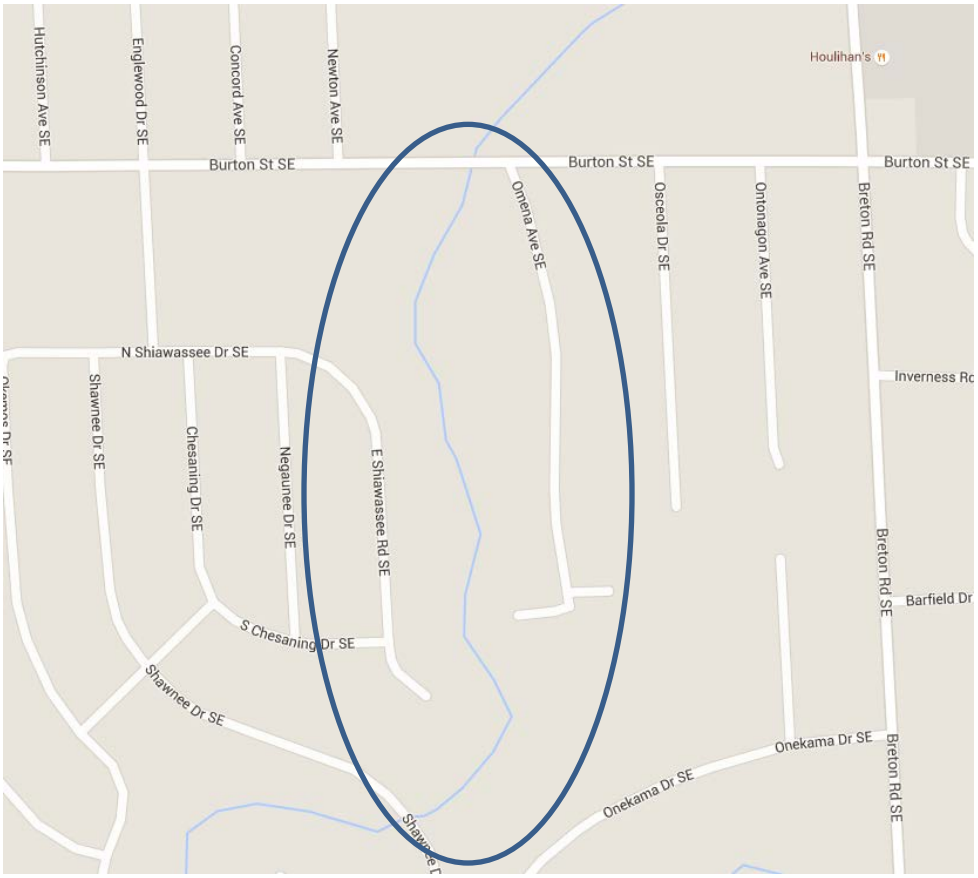


Figure 1 - Project Location Map

The study area is for a tributary stream that drains approximately 0.53 square miles of watershed above Shawnee Dr. SE. and is also known as the Burton-Breton Branch of Plaster Creek and eventually empties

into Plaster Creek just east of Kalamazoo at 32nd Street. Just northeast of Shawnee Dr. SE the stream in enclosed in a concrete culvert. Most of the drainage area just upstream of Burton Street is fully developed and enclosed within storm sewers and was likely developed between the 1950's and most recently within the last 10 years for the commercial area south of Burton and east of Breton Road. Most of the drainage area is residentially developed with commercial and office areas along Breton and Burton including the Breton Village Shopping Plaza.

Development History of the Project Area

In order to validate the concerns of excessive streambank instability and higher than normal bank erosion, an understanding of the historical disposition of the stream was conducted. Reviewing topographical and drainage maps it was determined that the watershed area contributing to this reach is approximately 0.53 square miles. Upon review the drainage characteristics of the watershed area a few significant changes have occurred over the past recent years. While the watershed's land uses have naturally changed over the years it is interesting to note that the stream's physical size is not what would be expected from a drainage area of only 0.53 square miles. The width of the active channel is much wider than what is typically found for drainage areas of this size and slope. Clearly the drainage channel was formed by flows far exceeding what one would expect from such a small watershed.

Figure 2 - Typical Drainage Channel

Figure 2 indicates what was typically observed throughout most of the study reach. The width of the active channel represented in Figure 2 measured out to be approximately 24 feet at bankfull. This suggests that the water forces and flow rates that created the channel were likely much greater at one time than what currently exists now and that water levels in the stream during discharge events are now not present and that channel slopes are steep enough so as not allow a bank full channel to form within the over widened existing channel.

Chapter 2 – Hydrology and Geomorphic Analysis

A specific task associated with understanding the erosion within the study reach is to understand what has caused the erosion, whether it is still a problem and whether improvements to the geomorphology of the stream course can be done to alleviate the bank erosion. By definition stream stability is defined by:

> "A rivers ability in the present climate to transport the flow and sediment from the watershed, over time, such that the channel maintains its dimension, pattern, and profile without aggrading or degrading." *Dave Rosgen, 2000*

On June 27, 2016 a site visit was conducted to preliminarily measure the plan, profile, and dimension of this stream, to determine if and where excessive bank erosion is occurring and to determine if the stream has, and is continuing to, depart from its historical reference condition. The following observations were made:

- A modified Rosgen Level II field evaluation was conducted to determine an understanding of the type stream and stability issues. Based on our preliminary measurements and observations we have determined that the stream is extremely over widened and incised. There are areas of the study reach where, in the past, large boulders have been placed in an effort to reduce the erosive nature of the flows. Those armored areas appeared relatively stable and were generally not over-widened.
- A bankfull width of approximately 8.5 feet and a bankfull depth of approximately 1.8 feet were measured in a few locations and are consistent with a stream with a contributing watershed of approximately 0.53 square miles. The stream is classified as a Rosgen B 4-5 stream. This means that the stream has significant slope (above 0.5%) and its bed is composed of predominately gravel and sand. Bankfull features were very difficult to determine within the study reaches and there was poor connection with the flood prone flood plain due to the over-widened channel and past bed incision.
- The stream has appropriate sinuosity but the width to depth ratio is excessively high which means that bankfull flows will likely not be effective at forming a new bankfull floodplain elevation.
- Overall the steam is entrenched, but is appropriate for this type of single thread channel.

- High or very high bank erosion hazard index (BEHI) locations were noted in many locations. These locations were found where the channel was incised (just downstream of Burton Street and downstream of the armored bank reaches) or where sharp bends have occurred in the channel. The remainder of the study reach exhibits general incision but with moderate to active erosion. Dynamic equilibrium is a condition where what is naturally eroding is then deposited on the next downstream point bar (a very natural and healthy process for a stream).
- Overall, the confinement of the stream is not an issue except where heavy boulder was previously installed which creates a threshold streambank (hardened) channel. With only one exception the residential homes that are riparian to the stream corridor have all been constructed up on the high terrace, well above the flood prone area and over-widened channel.
- One home, at 2230 Shiawassee Drive SE, is near a sharp eastward bend and may be affected by bank erosion or failure due to stream bank erosion issues. Figure 3 is a picture of that location.
- The property improvements made by the riparian residents have, for the most part, not had any influence on the stability or location of the stream but may have had an effect on the stability of the stream valley's upper side slopes. Where woody vegetation has been maintained, slope stability is good. Where clearing has occurred some erosion issues were noted.
- Generally mature native vegetation has established within the flood plain and there is no evidence of surface soil erosion.

Figure 3 – Eroding Area near Eastward Channel Turn near South cul-de-sac of Shiawassee

After evaluating the entire length of the study area, there are few areas can be considered stable, with the exception of the areas hardened by boulders. The bank sections that were observed to be eroding are short in length and considered minor in that the sediment contributions from those reaches are very low. . The sediment within the bottom of the channel appears to be relatively immobile. Due to the age of the sediment and the fact that the channel is extremely over widened suggests that the stream does not have the hydraulic flow power necessary to transport the sediment which, if available, would form a much narrower baseflow bankfull channel. Boulders appear to have been placed in areas to reduce bank erosion as is shown on Figure 4 below.

Figure 4 – Stream banks and bed stabilized by heavy boulder installation

Chapter 3 Characterizing the System

Understanding Stream Evolution

It is well documented that urbanization of a watershed has a deleterious effect on the rivers and streams receiving the watershed's storm runoff. As the watershed is urbanized, flows and soil erosion runoff typically increase. Typically within an urban setting streams and rivers respond to the changing watershed by incising or down cutting and or over-widening. This is followed by the stream utilizing the excessive sediments to create a new bank full flood-prone floodplain. Table 1 is a progression chart that documents the typical transformation process that occurs when streams are affected by a change to their hydrology, sediment supply or both. There is always a degree of down cutting and widening before stability is restored. In this particular case, progression no. 6 is what we believe to be occurring in this study reach. At this time the stream channel is at stage Fb in that it's over-widened and incised.

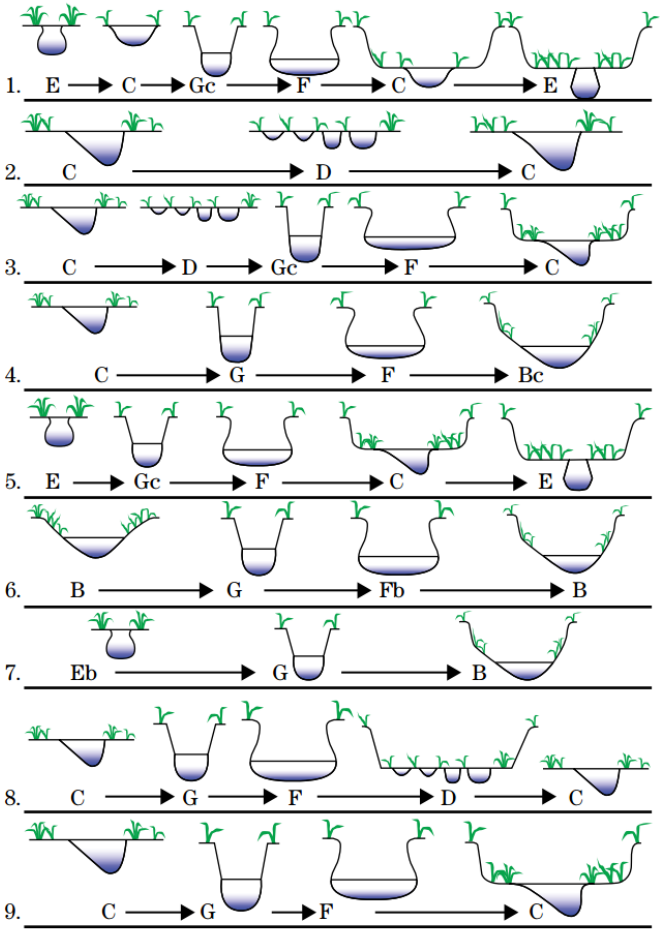


Table 1 Successional stages of channel evolution (Rosgen, 2007)

Historically, this study area's urbanized watershed contributed flows that have significantly altered this reach. The Breton Village Shopping Center, which includes a significant portion of the intensely commercially developed portion of this watershed, was originally developed without any purposeful

stormwater detention facilities. In the early 2000's, a significant redevelopment of the Center occurred and, at that time, the City required construction of an underground stormwater detention storage facility, which appears to have significantly reduced peak flows within this reach. This peak flow reduction has been observed by some of the streams riparian neighbors and was conveyed to our staff verbally during field work on this study. It is likely, that with this on-site stormwater detention facility, the storm discharge has been reduced down closer to the historical flow once present when the watershed was less developed. The typical down-cutting and reformation of a stable channel that occurred due to the unabated urban runoff was then interrupted and appears to have been substantially reduced. What has resulted from these previously un-detained peak flows is an overly widened predominately sand bed stream channel with steep slopes. Flows are now not sufficient enough to allow the stream to naturally progress (by moving sediment) as typically documented in the progression evolutions presented in Table 1. A few areas were observed to be scouring as shown in Figure 5.

Streambank Erosion Control

All stream banks erode. The question is whether or not the rate of erosion is natural or accelerated by anthropogenic (man-made) influences. Based on our observations, we do not believe that the development of the watershed that has occurred over the past 50-70 years is still causing an adequate amount of sediment for the progression presented in Table 1 to occur.

Figure 5 – Where scour forces are higher, sand is removed from the stream bed

Chapter 4 - Recommendations

HRC was retained to review the project study area stream reach west of Omena Avenue and south of Burton Street in order to identify the presence of stream bank erosion that may be potentially threatening riparian owner's properties and to develop recommendations for stabilizing any areas of concern. At the City's request, our recommendation was intended to provide a recommended strategy for stabilizing the banks and the channel by utilizing natural stream channel design protocols if possible and feasible.

Based upon our analysis of the erosion occurring within the stream valley, it appears that the majority of the erosion is limited to the over-widened stream bank-full channel initially caused by historical flows that are now not occurring due to the installation of improved detention facilities at the Breton Village Mall. It was further determined that, with the exception of one location, flows within the bankfull channel are not causing or are not likely contributing to the erosion noted by the riparian residents on the stream valley side slopes.

If the goal of this project is solely to stabilize the eroding upper valley banks, we recommend that riparian property owners address these erosion issues on an individual property basis as the erosion does not appear to be related to the streambank erosion and over-widening that is and has occurred in the stream channel. This type of erosion is primarily caused by local drainage from the individual property owners' sites and, as such, would not be considered a public responsibility provided that such erosion is not causing erosion of a neighbor's property. In addition it appears that the upper valley bank erosion is well outside of the drainage easement, which primarily covers the main conveyance channel in the lower portion of the valley. The riparian property owners have the staging space and access areas for a contractor to efficiently access the eroded areas from the terrace that their homes are built on. For the one location that is potentially experiencing a greater threat of erosion due to streambank flow and erosion concerns we recommend that this specific area be addressed as described below. It is noted that some of the homeowners have already installed flexible plastic drainage tubing along the upper valley banks to contain the erosive energy of the flowing water descending down the banks. While this may be unsightly it is effective at preventing erosion from the upland drainage as it descends into the valley.

If the goal is to address the geomorphic instability of the entire stream channel within the study area, then there are a number of techniques that can be installed within the stream channel and a number of physical alterations to the channel that can be used to create a stable stream channel as shown on Pages 11 through 14. To simplify the discussion of our recommendations, we will focus on a few principles. The first is to narrow and elevate the existing channel and the second is to address the steep channel slope.

Physical modifications to the stream reach

There are a number of issues that present themselves when contemplating an urban streambank restoration project. The following is a list of issues to be considered:

- Access. While there are public right-of-ways that provide access to the study reach where the stream is located there are many issues with utilizing these two access points. Significant modification or removal of existing vegetation would be required. Some of this may or may not be within the drainage easement currently present to this easement and additional easements would be needed to utilize this access route to reach the work areas. In addition, contractors need space to stage their equipment and materials. There is no obvious staging site location except at the school site located west of the valley on Burton but access to the stream valley from the school site will be difficult or impossible for vehicles due to the steep slopes. Possible site vehicle access locations (based on the topography) are at the south end of Omena Avenue (within the drainage easement or from the drainage area easement east of Omena Avenue south of Burton. However, it should be noted that staying within these drainage area easements will be difficult if not impossible since they do not appear to follow the topography well. In addition, significant clearing and erosion protection (both temporary and permanent) will be necessary to allow for even small off-road vehicle access to the valley.
- Permitting. The current preference by the Michigan Department of Environmental (MDEQ) Quality is, wherever possible, to remove obstructions from Michigan's streams and rivers. The MDEQ and MDNR have found that by stabilizing stream banks and beds, isolated headwater river and stream reaches become ecologically beneficial to downstream reaches. Stability of the tributary streams and rivers throughout the watershed reduces sediment loading which does affect critical habitat downstream. We believe that the regulatory preference in this situation would be for the stream to be restored to the natural channel plan, profile, and dimension that it historically had prior to the over widening process. In order to be as thorough as possible in our assumed position concerning our understanding of the MDEQ's position, we recommend petitioning the MDEQ to review the study reach and the streambank erosion.
- Costs. The primary area of concern that can be addressed using the techniques described herein include the southwest bank of the eastward turn of the channel near the cul-de-sac adjacent to 2230 Shiawassee Drive SE. Due to the fact that the stream study reach is within a very steep valley, the logistics of accessing the eroded bed and bank areas will be difficult and costly. The techniques shown below would utilize local wood and boulders in the design. It is somewhat difficult to develop a solid cost estimate for this type of stream restoration, but based on using an assumed number of the bed stabilization techniques for the area described above plus adding in the difficulty of access, our opinion of project cost is approximately $76,600 to accomplish erosion protection along this area of the stream. A breakdown of this opinion is included in the Table 2 below. The area being protected is as outlined in Figure 6, below. Full stream bed restoration along the entire stream reach included within this study is probably not warranted since the erosion that is occurring does not appear to be causing any imminent failures or immediately threatening the safety of existing structures.

- If no action is taken at this time, the existing rate of streambank erosion in the area of the eastward turn of the channel will continue. However it appears that it will likely take several years before the erosion will threaten any of the existing homes along the top of the banks. Assuming that the closest home to the south of the channel has a basement with a foundation elevation at least 6 feet below grade, the foundation elevation at the northeast corner of this home (Closest point to the channel) appears to be about 14 feet above the channel elevation and about 50 feet horizontal from base of the stream based on the REGIS topographic information. This resulting slope is only about 1V:3H which would not threaten the stability of the structure until the stream encroaches well further south. However, the stability of the land surface around the home may be threatened sooner since the average bluff slope at this location is about 1V:2.5H above the stream bottom. If the stream bank encroaches southward about 10 feet further, the stability of the land surface near the home might be threatened since the average slope would then approach 1V:2H and surface erosion from water flowing down the bluff slope as well streambank erosion might hasten the steepness. In any event the bluff slope would be hazardous and protective fencing might be necessary but this is inherent to a lot such as this with steep slopes.

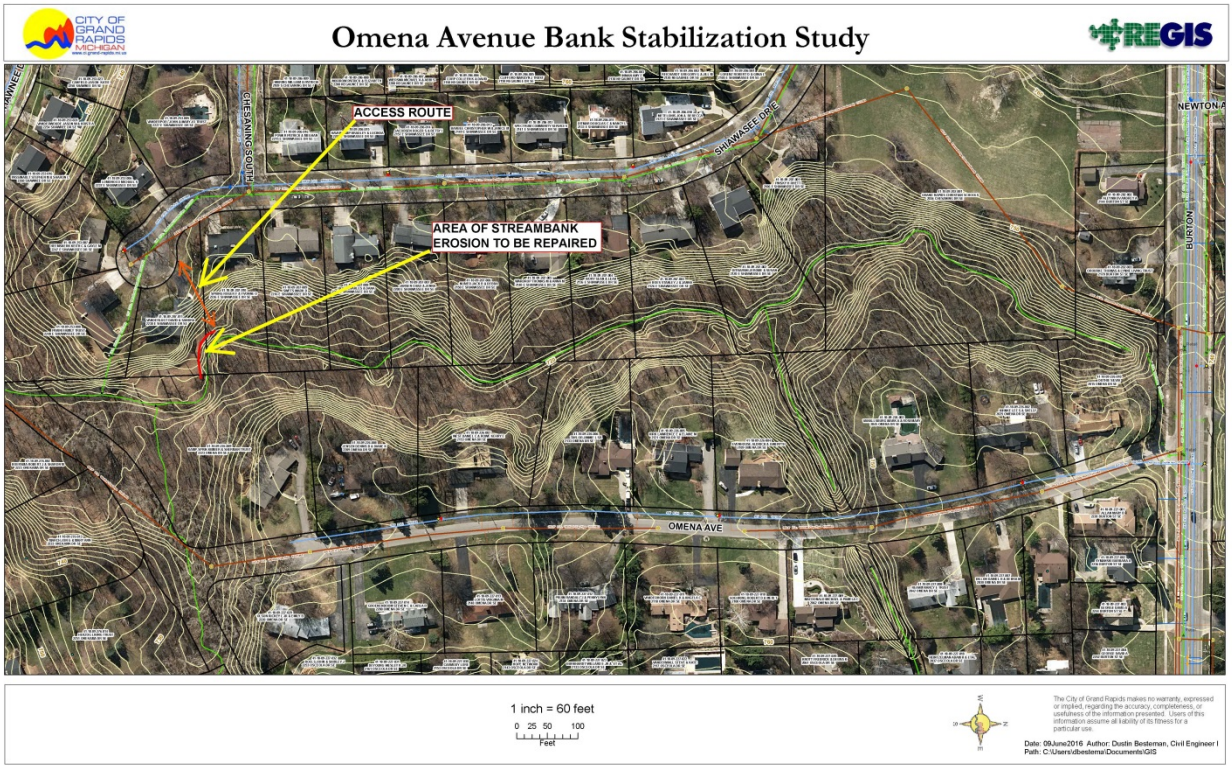


Figure 6 - Proposed Area of Streambank Stabilization and Potential Access Route

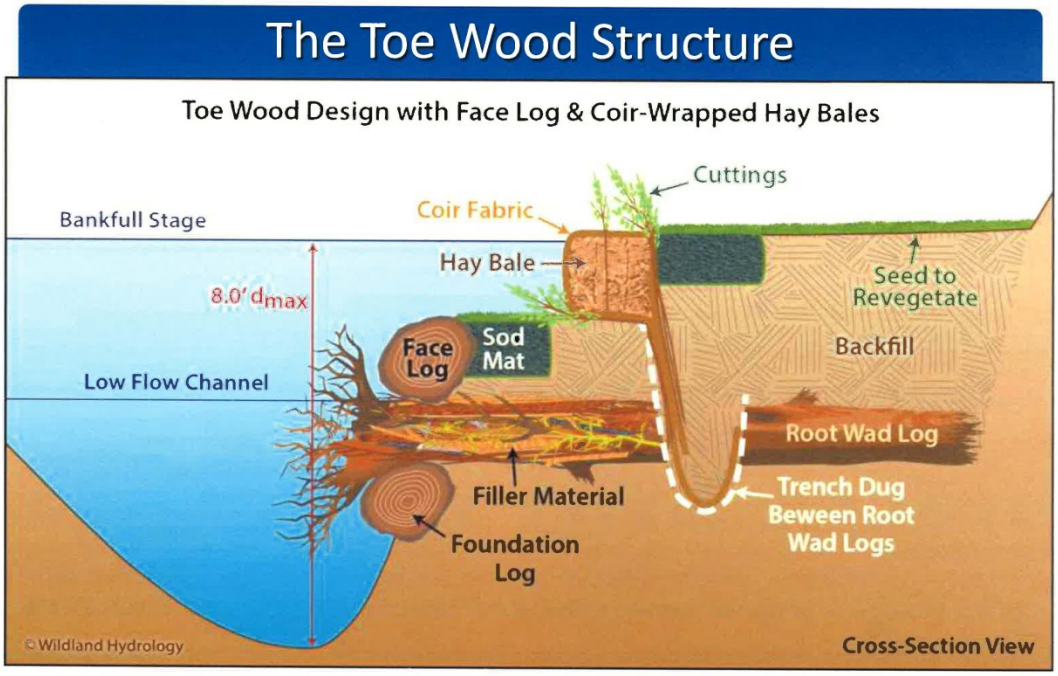
Table 2

Project Cost Opinion for Streambank Stabilization – Omena Avenue

Description	Units	Unit Price	Quantity	Total Price
Mobilization	lsum	Lump Sum		$ 5,500
Remove Tree, over 6 inch to 18 inch	ea	$500	10	$ 5,000
Remove Tree, 19 inch to 36 inch	ea	$1800	3	$ 5,400
Clearing & Grubbing and Tree Removal	lsum	$3,500	1	$ 3,500
Earth Excavation and Embankment	cyd	$19	120	$ 2,280
Vegetated Reinforced Soil Slope (VRSS)	lft	$150	120	$ 18,000
Log Vane	ea	$3595	1	$ 3,595
Toe Wood Structure	lft	$230	20	$ 4,600
Erosion Control Blanket (C 250)	syd	$4	150	$ 600
Turf Restoration w/4" Topsoil, Fertilizer & Straw Blanket	acres	$5,000	0.5	$ 2,500
Seed Mix – Woodland Streambank Mix	acres	$4,500	0.5	$ 2,250
Live Stake Shrubs 3 ft. to 4 ft.	ea	4.5	150	$ 675
Rock Cutoff Sill	ea	4420	1	$ 4,420
Estimating Contingencies	lsum	5%		$ 2,920
TOTAL CONSTRUCTION COST OPINION				**$ 61,240**
Engineering and Construction Contingencies	lsum	25%		$ 15,310
TOTAL PROJECT COST OPINION				**$ 76,600**

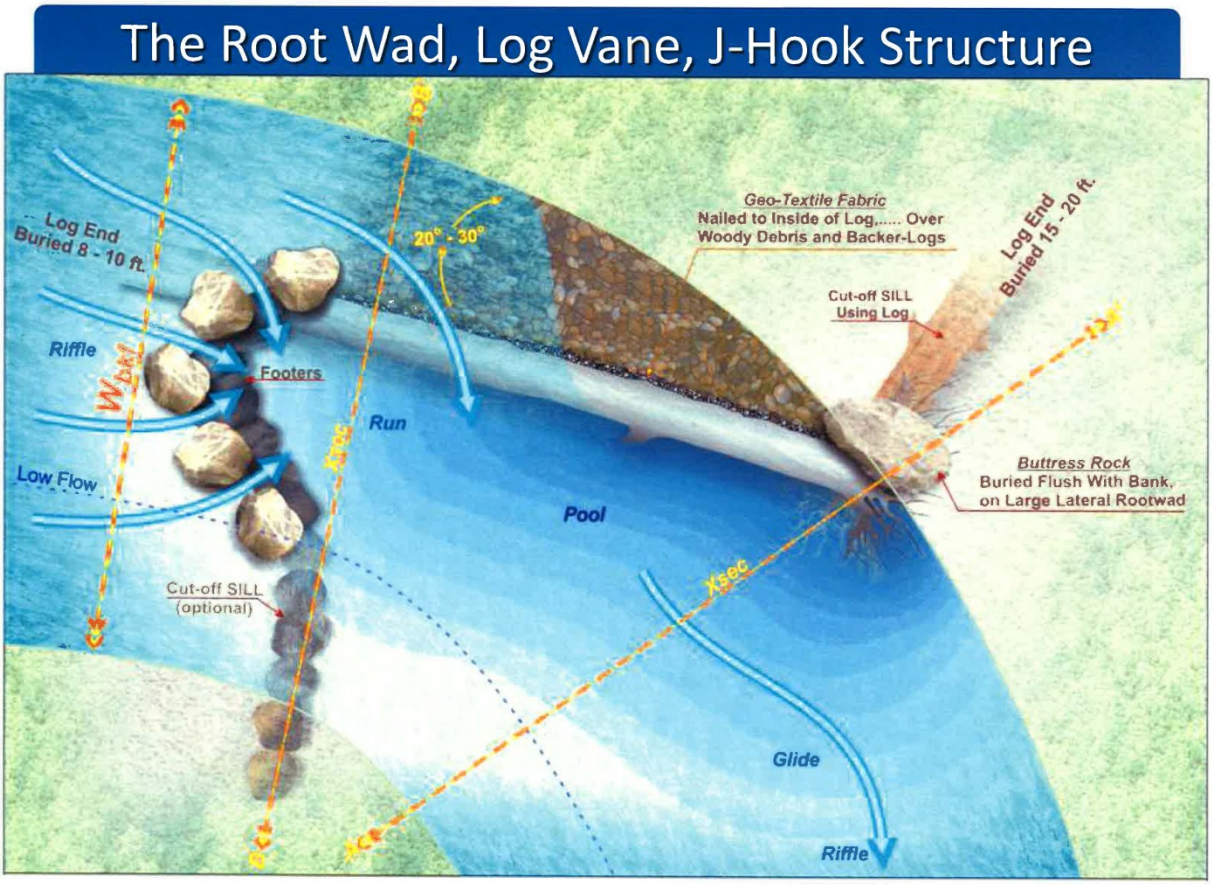
Recommended Streambank and Bed Stabilization Techniques

The specific installation of each of the following structures is dependent on further design and geomorphic calculations.

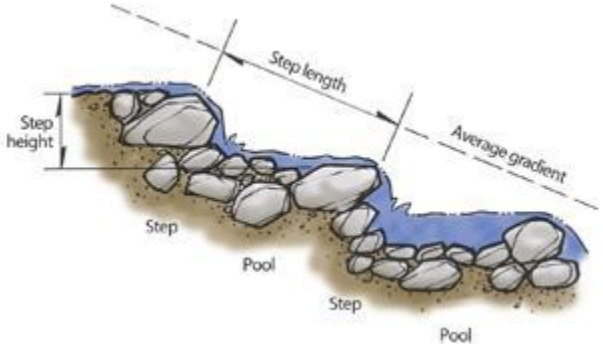


- Sod Mats can be replaced by Woody Transplants
- Coir-Wrapped Hay Bales can be replaced with Soil Lifts

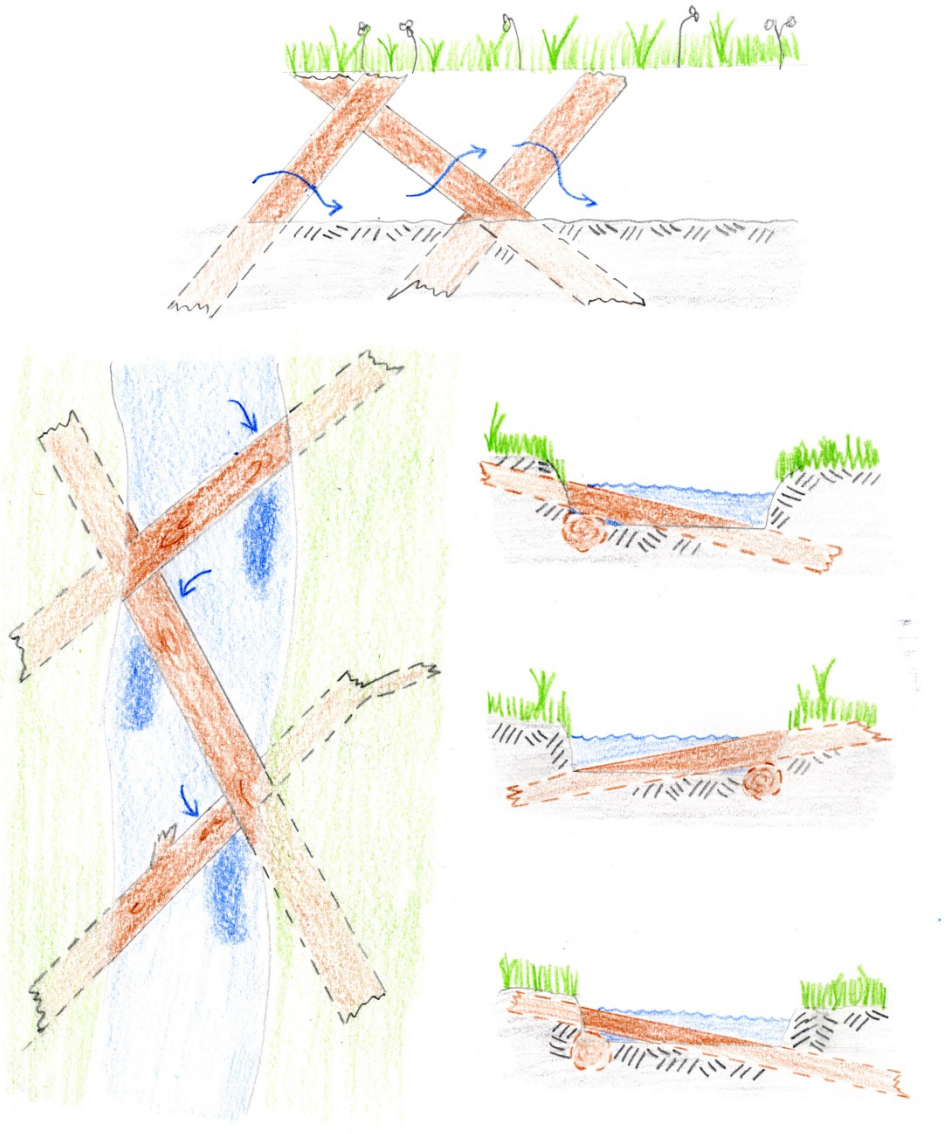
The Toe Wood Structure is typically used on the outside bends of a stream channel. These features use existing wood found within the construction area.



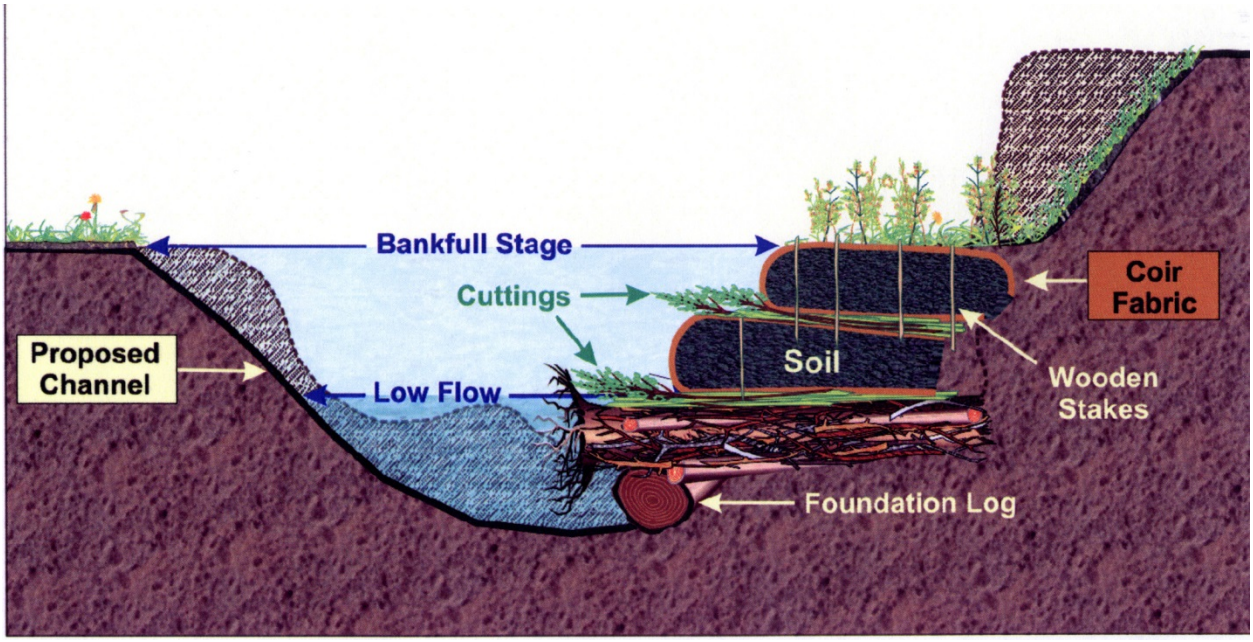
The Root Wad – Log Vane J Hook Structure is used to divert flow stress away from the outside bank of a stream channel. The flow stress is the force that accelerates bank erosion.



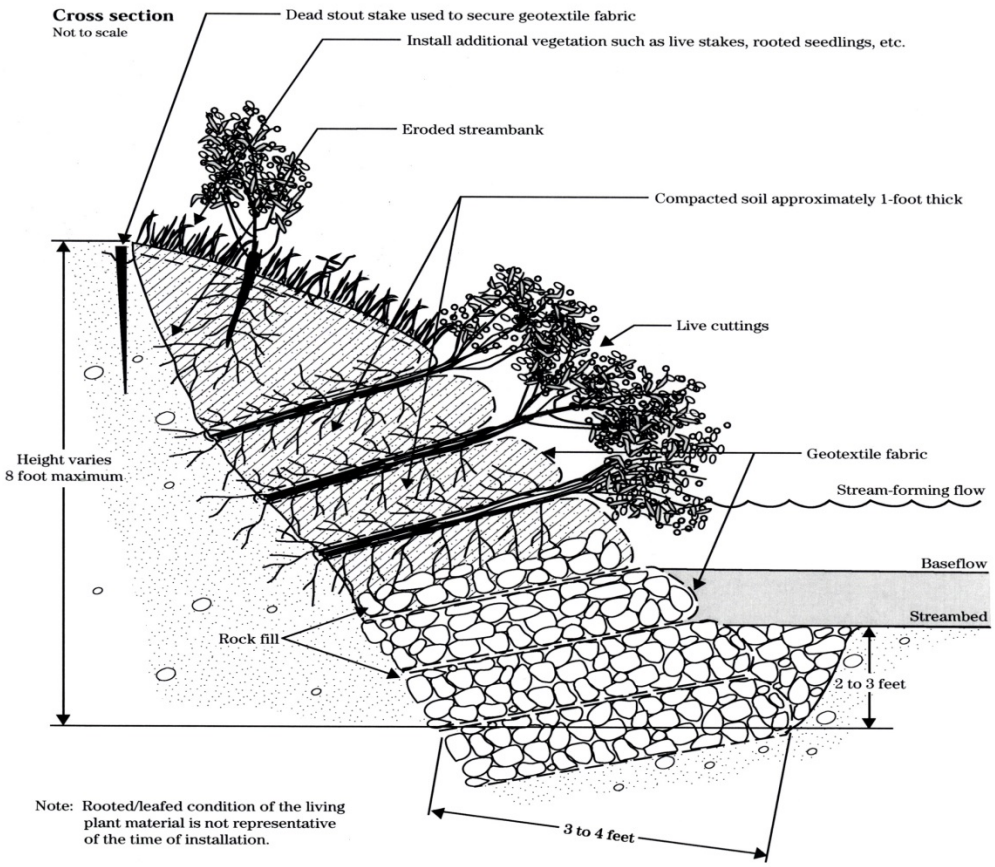
Step pools, as shown above, are installed throughout a stream reach to reduce channel slope while providing bed stability. Rock materials are sized so that the flows are not able to dislocate the steps.



Rock and Roll Structures are constructed to utilize trees found within the stream channel valley. These structures also decrease channel slope, provide roughage and reduce flow erosive forces.



Toewood used to narrow a widened stream channel.



VRSS Streambank Stabilization Structures.

Typically used on outside channel bends where expected erosive forces are higher.

Chapter 5 - Photographs

The following photographs are of selected features taken to convey the appearance of the project area. The progression of the photographs is from upstream, beginning at Burton Street and progressing downstream to Shawnee Drive.

48-inch Concrete Culvert Structure downstream of Burton Street

High Bank Erosion Immediately Downstream of Burton Street on the Bank

Bank Stability promoted with heavy boulders

Most of the stream bed is composed of sand but one section was gravel.

A small area of near reference bankfull width and depth

60-inch concrete culvert upstream of Shawnee Drive.
The small width and square edge entrance promotes debris to build up creating a small dam.