

Streambank Remediation Study Final Report

**Conesus Lake Watershed
Livingston County Planning Department**

Prepared by:



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EXECUTIVE SUMMARY

Conesus Lake represents an important asset to Livingston County. It supplies water to more than 15,000 residents, provides a range of water-based recreational opportunities and supports a variety of aquatic life. As with many lakes, Conesus has been experiencing some problems with water quality. Conesus Lake has been included on New York State's 303 (d) list of impaired waterbodies, which is an inventory of lakes, streams, and coastal areas where water quality conditions are not adequate to support a designated use.

In recognition of the importance of Conesus Lake and in recognition of increasing water quality issues, a planning process was begun in the early 1990s. Citizens, academics and local governments organized and ultimately produced the "State of Conesus Lake: Watershed Characterization Report" which documented the existing conditions and cited sediment and nutrients, including phosphorus as one of the major causes of the problem. The Conesus Lake Watershed Management Plan was created in 2003. Recommendation C-1, a high priority recommendation in the Watershed Management Plan, states the need to develop and implement a program to restore and stabilize streambanks in the watershed.

In August 2005, Livingston County was awarded a grant under the 2004-2005 New York State Quality Communities Grant Program to retain an engineering consultant for the creation of plans for the remediation of select streambanks in the Conesus Lake Watershed. Stantec Consulting Services Inc was contracted as the engineering consultant.

After the Watershed Manager secured permission from streamside landowners, Stantec staff made at least one site visit to each of the twelve selected streams and rivulets in the Conesus Lake Watershed. During the week of September 25, 2006 Stantec investigated 46,650 linear feet of selected streams and rivulets. The site investigation consisted of an initial walk-through and a detailed evaluation of geomorphic processes. Problem areas were described and the locations of each area were recorded with a GPS unit. Typical examples of problem areas on each reach were photographed. A digital verbal log was recorded and stored for each reach. Plotted aerial photography was used as a base map to mark and record location and orientation of problem areas and special consideration areas.

Each of the twelve streams was segmented into study reaches. The reaches were defined by stream type, valley type, accessibility, and the type of required remediation. The twelve streams produced a total of 41 study reaches. Of the 41 study reaches, 37 were determined to be in need of some degree of streambank remediation. This report summarizes the findings of these field investigations and provides recommendations for streambank stabilization at each of the identified problem areas.

This document also provides Conesus Lake stakeholders guidance in implementing the identified streambank remediation projects. The implementation plan consists of a

“toolbox” of ideas intended to assist the County by presenting a series of steps to reach the remediation goals. It is based on Stantec’s previous involvement with similar projects in other states, combined with input received from Livingston County officials. Implementation begins with a determination of an overall ranking/prioritization of the remediation projects; obtaining buy-in from the affected landowners; pursuing and obtaining funding; hiring an engineering firm to prepare streambank remediation design plans; and hiring/overseeing a contractor to construct each project.

The implementation section of the report outlines a stepwise process for implementation, provides a benefit-cost analysis for ranking the restoration reaches, provides ideas and suggestions for public education and community involvement, identifies potential funding sources, and describes the various state and federal permitting requirements for streambank stabilization work.

An estimated cost for the remediation of each of the 37 reaches was determined using generally accepted costs for streambank remediation design and construction work in 2006. Engineering design costs were based on estimated costs for detailed site assessments, design time and construction oversight costs. The conceptual restoration plan was used as a basis for estimating the design costs of each project. The construction costs are also based on the individual restoration plan for each respective reach. Construction costs include estimated costs for earthwork/grading, mobilization, in-stream structures, vegetation and other miscellaneous construction costs.

The average cost for streambank remediation is approximately \$116,000 per reach with the actual projected costs ranging from a low of \$24,000 to a high of \$571,000. This wide range in cost allows for a variety of grant funding opportunities. A listing of the various remediation costs for each reach is provided in this document.

Federal funding assistance for stream stabilization and restoration efforts may be obtained through numerous programs from three separate U.S. government agencies: the U.S. Environmental Protection Agency (USEPA), the U.S. Fish and Wildlife Service (USFWS) and the Natural Resource Conservation Service (NRCS) of the U.S. Department of Agriculture. State funding assistance is also available through New York State Environmental Protection Fund grants and the New York State Quality Communities Program.

For the purpose of evaluating the overall effectiveness of this project, two categories of benefits were established: water quality and property protection. The score for each reach ranged from 1-5. A score of 1 represents a site that does not provide any opportunity to protect property or improve water quality. A score of 5 represents a site that currently provides immediate opportunities to reduce the loss of property and improve water quality due to existing conditions that were at a point of severe bank erosion and mass wasting. The total benefit that can be achieved for any reach is a function of the individual scores for each benefit. Each benefit, in turn, was weighted commensurately with its ability to achieve the County’s primary goals and objectives. The water quality benefit is the primary focus of the project and, therefore, warranted the highest weighting.

The total benefit calculation generates a minimum score of 5 and a maximum score of 25. The average benefit score for the stabilization of the 37 disturbed project reaches is 14.6. The total benefit scores range from 6 to 25. Eight of the 37 reaches scored higher than 20. There are two sites that scored the maximum 25 points: the Middle Reach of North Gully Creek and Upper Middle Reach of Densmore Creek.

A cost-benefit score was then calculated for each reach. These scores were used to rank the 37 streambank remediation reaches based on cost and benefit. Projects with lower cost-benefit scores are the more cost effective and beneficial and should be pursued from the outset. (See the table below).

Finally, community involvement is key for the successful implementation of the recommendations of the Conesus Lake Watershed Streambank Remediation Report. Community involvement and education will help give residents confidence that the improvements done within the watershed will produce improvements in the Lake's water quality.

		TOTAL COST		BENEFIT* COST vs. BENEFIT			
Stream	Reach	Construction and Design	Restored Length Approximate Cost Per Linear ft	Total Benefit	Cost Benefit Score	Ranking	Priority
Long Point	Middle Reach	\$ 170,000	\$ 155	23	168	1	High
Wilkins	Upper Reach	\$ 126,000	\$ 158	23	171	2	High
Wilkins	Upper Middle Reach	\$ 239,000	\$ 149	18	207	3	High
Sand Point	Lower Middle Reach	\$ 67,000	\$ 120	14	214	4	High
Central	Upper Reach	\$ 50,000	\$ 111	13	214	5	High
Eagle Point	Lower Reach	\$ 58,000	\$ 97	11	220	6	High
Densmore	Lower Reach	\$ 77,000	\$ 91	10	226	7	High
Eagle Point	Upper Reach	\$ 99,000	\$ 83	9	229	8	High
Densmore	Lower Middle Reach	\$ 264,000	\$ 211	23	230	9	High
Central	Middle Reach	\$ 66,000	\$ 120	13	231	10	High
South Gully	Middle Reach	\$ 571,000	\$ 204	22	232	11	High
Wilkins	Lower Middle Reach	\$ 171,000	\$ 143	15	238	12	High
North Gully	Middle Reach	\$ 154,000	\$ 257	25	257	13	High
Densmore	Upper Middle Reach	\$ 143,000	\$ 260	25	260	14	High
North McMillan	Middle Reach	\$ 119,000	\$ 149	14	266	15	High
Long Point	Lower Reach	\$ 193,000	\$ 214	20	268	16	High
Groveland	Lower Middle Reach	\$ 114,000	\$ 228	21	271	17	High
Eagle Point	Lower Middle Reach	\$ 115,000	\$ 153	14	274	18	High
North McMillan	Lower Reach	\$ 141,000	\$ 188	17	276	19	High
UT Wilkins	Upper Reach	\$ 71,000	\$ 148	13	284	20	High
Sand Point	Lower Reach	\$ 65,000	\$ 186	16	290	21	High
UT Wilkins	Lower Reach	\$ 115,000	\$ 192	15	319	22	Med
Densmore	Middle Reach	\$ 39,000	\$ 177	13	341	23	Med
Groveland	Upper Reach	\$ 82,000	\$ 205	15	342	24	Med
South Gully	Upper Reach	\$ 240,000	\$ 178	13	342	25	Med
Sand Point	Upper Reach	\$ 71,000	\$ 89	6	370	26	Med
Central	Lower Reach	\$ 47,000	\$ 157	10	392	27	Med
UT Wilkins	Middle Reach	\$ 131,000	\$ 262	14	468	28	Med
Long Point	Upper Reach	\$ 332,000	\$ 279	13	537	29	Med
Eagle Point	Upper Middle Reach	\$ 226,000	\$ 283	13	543	30	Med
Sand Point	Upper Middle Reach	\$ 149,000	\$ 298	13	573	31	Med
Southwest	Lower Reach	\$ 69,000	\$ 230	10	575	32	Med
North Gully	Lower Reach	\$ 155,000	\$ 161	7	577	33	Med
Groveland	Upper Middle Reach	\$ 29,000	\$ 207	7	740	34	Low
North Gully	Upper Reach	\$ 26,000	\$ 433	13	833	35	Low
South Gully	Lower Reach	\$ 24,000	\$ 400	10	1,000	36	Low
Wilkins	Lower Reach	\$ 25,000	\$ 417	8	1,302	37	Low

Cost Benefit Score = Restored length cost per linear ft / (Total Benefit Score / 25)

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A. INTRODUCTION

The Conesus Lake watershed encompasses 70 square miles within Livingston County, New York. The watershed includes parts of seven different municipalities including Conesus, Groveland, Livonia, Springwater and Sparta. In total, the watershed is home to more than 10,000 people. The lake is fed by more than 18 streams, many of which are small and intermittent. North and South McMillan Creeks and Conesus Inlet at the southern end of the lake contribute more than 70 percent of the gauged flow into the lake. Conesus Lake is among the smallest of the Finger Lakes.

Conesus Lake represents an important asset to Livingston County. It supplies water to more than 15,000 residents, provides a range of water-based recreational opportunities and supports a variety of aquatic life. As with many lakes, Conesus has been experiencing problems with water quality. Conesus Lake has been included on New York State's Section 303(d) list of impaired water bodies, which is an inventory of lakes, streams, and coastal areas where water quality conditions are not adequate to support a designated use.

In recognition of the importance of Conesus Lake and in recognition of increasing water quality issues, a planning process was initialized in the early 1990s. Citizens, academia and local governments organized and ultimately produced the "State of Conesus Lake: Watershed Characterization Report" which can be found on the Conesus Lake website at www.livingstoncounty.us/lakerpt.htm. This report documented existing conditions and cited sediment and nutrients, including phosphorus, as the major causes of water quality problems.

Erosion from various stream reaches contributes a large amount of sediment each year to Conesus Lake. These sediments degrade water quality, degrade recreational and aesthetic quality, and diminish the suitability of the lake as a habitat for plants and animals. In 2003, the "Conesus Lake Watershed Management Plan" was published outlining a series of aggressive measures designed to bring about improvements to the quality of Conesus Lake including the recommendation that streams in the watershed be stabilized and/or restored. The plan can be found on the Conesus Lake website at www.livingstoncounty.us/clwmp.htm.

In August 2005, Livingston County was awarded a grant under the 2004-2005 New York State Quality Communities Grant Program to retain an engineering consultant for the creation of plans for the remediation of select streambanks in the Conesus Lake Watershed. Stantec Consulting Services, Inc. was contracted as the engineering consultant. Stantec staff made at least one site visit to each of the twelve selected streams and rivulets in the Conesus Lake Watershed. During the week of September 25, 2006, Stantec investigated approximately 46,650 linear feet of selected streams and rivulets. The site investigation consisted of an initial walk-through followed by a detailed evaluation of geomorphic processes. Problem areas were assessed and the locations of each area were recorded with a GPS unit. Typical examples of problem areas on each

reach were photographed. A digital verbal log was recorded and stored for each reach. Plotted aerial photography was used as a base map to mark and record location and orientation of problem areas and special consideration areas.

1.0 Technical Background

1.1 Sediment Pollution

Sediment is mineral or organic solid matter that is transported by wind or water into the surface water. It is estimated that over one billion tons of sediment pollute America's lakes, streams, and wetlands each year. Sediment is a leading cause of problems in many of New York's streams and rivers.

In Conesus Lake sediment pollution reduces the recreational value of swimming and boating. A high suspended sediment concentration causes turbid or cloudy water. Suspended sediment, as measured by turbidity and total suspended solids (TSS), can reduce in-stream photosynthesis by lowering the amount of sunlight, and alter a stream's ecology. These suspended sediments can also clog fish gills. Sediments cause the water to absorb more heat from sunlight, which raises overall water temperature. Heated water has less capacity to hold dissolved oxygen. A decrease in dissolved oxygen can result in large-scale fish kills.

Sedimentation, one form of sediment pollution, occurs when flowing water slows down enough to allow suspended soil particles to settle. Heavier sands and silts settle out sooner than finer clay particles. Sedimentation destroys fish-spawning beds, reduces the useful storage volume of reservoirs, clogs streams, and increases filtration costs for municipal water supplies.

Soil particles also carry other pollutants into waterways. Nutrients, such as phosphorus, feed algae and aquatic weeds in lakes. As the algae dies off and decomposes, it increases the demand for dissolved oxygen. This increased demand for oxygen can lead to fish kills.

1.2 Sources of Erosion

Erosion is the controlling process that dictates sediment pollution. Erosion begins when water or wind detaches soil and rock particles from the earth's surface. After detachment, air or water movement transports soil particles. Factors affecting erosion rates include climate, soil type, slope length, slope steepness, and vegetative cover. Anytime the land is disturbed the potential for soil erosion increases. Eroded soil particles carried by water often move into streams where sedimentation and suspended solids can lead to a number of problems as described in the previous section.

The two major sources of erosion sediment are classified as streambank (gully) and upland (sheet and rill) erosion. Streambank erosion is caused by an imbalance in geomorphic parameters in the stream system related to the watershed. Upland erosion is a result of land use practices within the watershed. Factors that affect upland soil

erosion include vegetation, rooting depth, strength of soil, steepness of the hill slope and surface protection. Upland erosion is a natural process that can be accelerated by human activities.

Agriculture and construction activities are the two biggest sources of upland erosion in the State of New York. These activities have historically been the source of upland sediment erosion and sediment input to Conesus Lake. Currently sediment sources from both agricultural and construction impacts are minimized due to soil conservation practices and reduction in both activities. The majority of streams evaluated are in a state of recovery from the agriculture and construction activities of the past. Most of the sediment that eroded during the intense agricultural and development periods is still trapped in the stream systems and has an important geomorphic impact on the amount of streambank erosion and channel migration. These trapped historical sediments are considered "legacy sediments".

1.3 Legacy Sediments

Stable valleys and streams received an increase in sediment load due to past agricultural and forestry practices. The stream valley system did not have the capacity to transport the additional sediments. Sediments clogged up the valleys forming sediment debris jams that evolved into sediment and debris dams after downed trees and large substrate were transported during bank erosion. These debris dams flatten local slopes causing additional sediments flowing from upstream to become trapped. As the sediment dams increase in size they reach a critical height. At this critical height the dams fail, releasing the sediment downstream. Once these sediments are released they are considered legacy sediments. These upland source sediments are slowly working toward the lake. Phosphorus and other pollutants are still attached to these legacy sediments. The steep slopes downstream of the debris dams and the failure of the dams cause channel instability downstream which leads to streambank erosion and loss of trees.

Current soil conservation practices on the twelve sites investigated in the Conesus Lake watershed appear to be appropriate for the land use. Many of the current sediment issues are related to the temporary storage of legacy sediments and the geomorphic response and recovery of the historical impacted streams.

1.4 Geomorphic Response and Channel Evolution

Stable streams are able to transport both the water and sediment supplied by the watershed. If the water or sediment supply changes, the stream reach will reach a state of disequilibrium or instability. There are adverse consequences of accelerated sediment supply such as accelerated bank erosion rates, degradation, aggradation from channel disturbance, streamflow changes, sediment budget changes, and other factors that can lead to channel instability and evolution. These changes result in stream channel morphological changes, causing changes in the dimension, pattern, and profile of the stream channel. The disturbed stream reach adjusts to a quasi-equilibrium state with current sediment and flow regimes. All disturbed streams will approach a stable form if

there are no constraints on time and space. Depending on stage in channel evolution, some reaches require large sediment supplies for recovery.

The geomorphic assessment and evaluation of channel evolution/departure is critical to understand before any remedial action should be suggested. Sediment and flow regimes should be considered and utilized if at all possible. Remedial action has a number of priority levels. There is always an option to do nothing and let the stream attain a stable form through its own devices. This option can be used when there is a low risk related to the impacts of the channel evolution model. The second option is to address problem areas only where the departure of the stream would produce a significant risk. This option includes regrading banks, rip rap, concrete armoring, deflection structures (vanes), and other bank stabilization methods. With the proper understanding of the physics and morphology of the stream this option can be a viable streambank protection technique. The final option is a complete adjustment in the channel morphology by channel relocation, which is also called stream restoration. While this option is the most dramatic, in many cases the stream constraints and departure analysis are so far conflicting that there is no other sustainable option.

The geomorphic response to anthropogenic impacts can continue for decades and centuries after the stressor has been removed from the watershed. Channel evolution is based on the amount of flow, the force of flow, vegetation, soils, geology, and degree of channel incision. Channel incision is the degree at which the channel is disconnected from the historical floodplain terrace.

1.5 Anthropogenic Impacts

Unrelated to agriculture, there are a variety of anthropogenic impacts that have been used to try to manage the sediment supply. These include but are not limited to undersized culverts, levees, buffer clearing, and dredging. Undersized culverts reduce the forces available to transport sediment which in turn can lead to aggradation. This includes clogging of the culvert and a loss of conveyance capacity. When a culvert loses conveyance capacity, the risk of failure from over-topping increases. Levees increase the local forces available for sediment transport, which results in a scouring of the streambed and flat-water inlets extending 100 yards upstream from the lake. Buffer clearing reduces the resistance to instream erosion forces. Buffer clearing is also considered detrimental for streambank stability when the buffer is replaced with shallow rooting plants such as grasses. Instead of fixing the stream process, dredging actually causes instability. The instability continues to occur making dredging an ongoing operation that is expensive and a continuous maintenance problem.

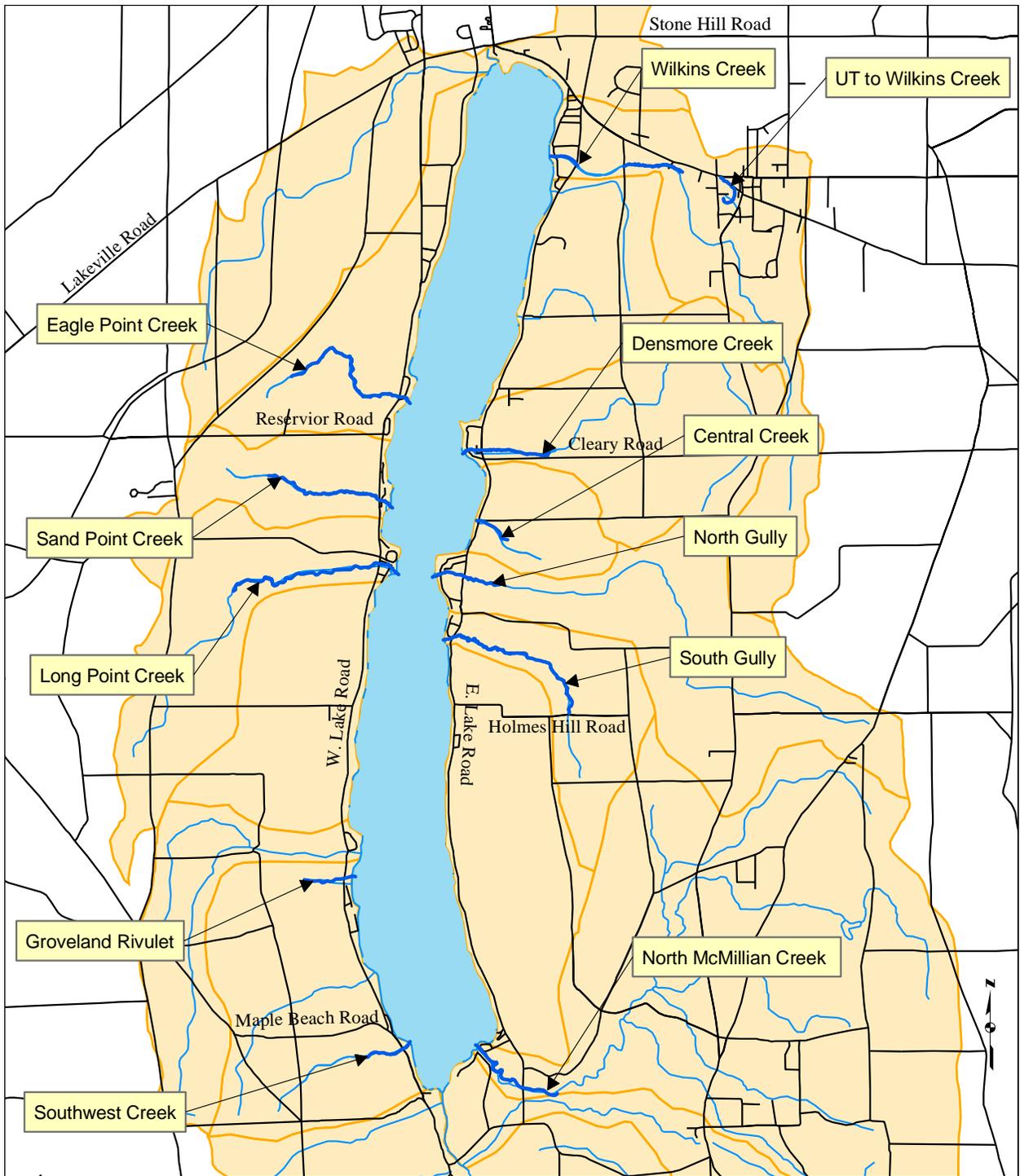
B. METHODS

1.0 Field Data Collection

Approximately 46,650 linear feet of total stream length was evaluated by walking the streams and conducting a geomorphic evaluation. The geomorphic evaluation included assessing stream hydraulics, stream planform, adjacent land uses, streambank stability, streambank vegetation, and sediment sources. Each stream reach is shown on the following map: "Conesus Lake – Stream Locations."

2.0 GIS Data Analysis

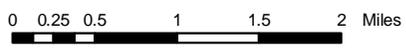
GIS was used to determine the land use in each watershed. It was also used in conjunction with GPS data gathered in the field to determine stream location.



- Legend**
- Assessed Stream Reaches
 - Streams
 - Roads
 - Conesus Lake
 - Subwatersheds



Conesus Lake - Stream Locations Livingston County, NY



C. STREAM ASSESSMENT

1.0 Wilkins Creek

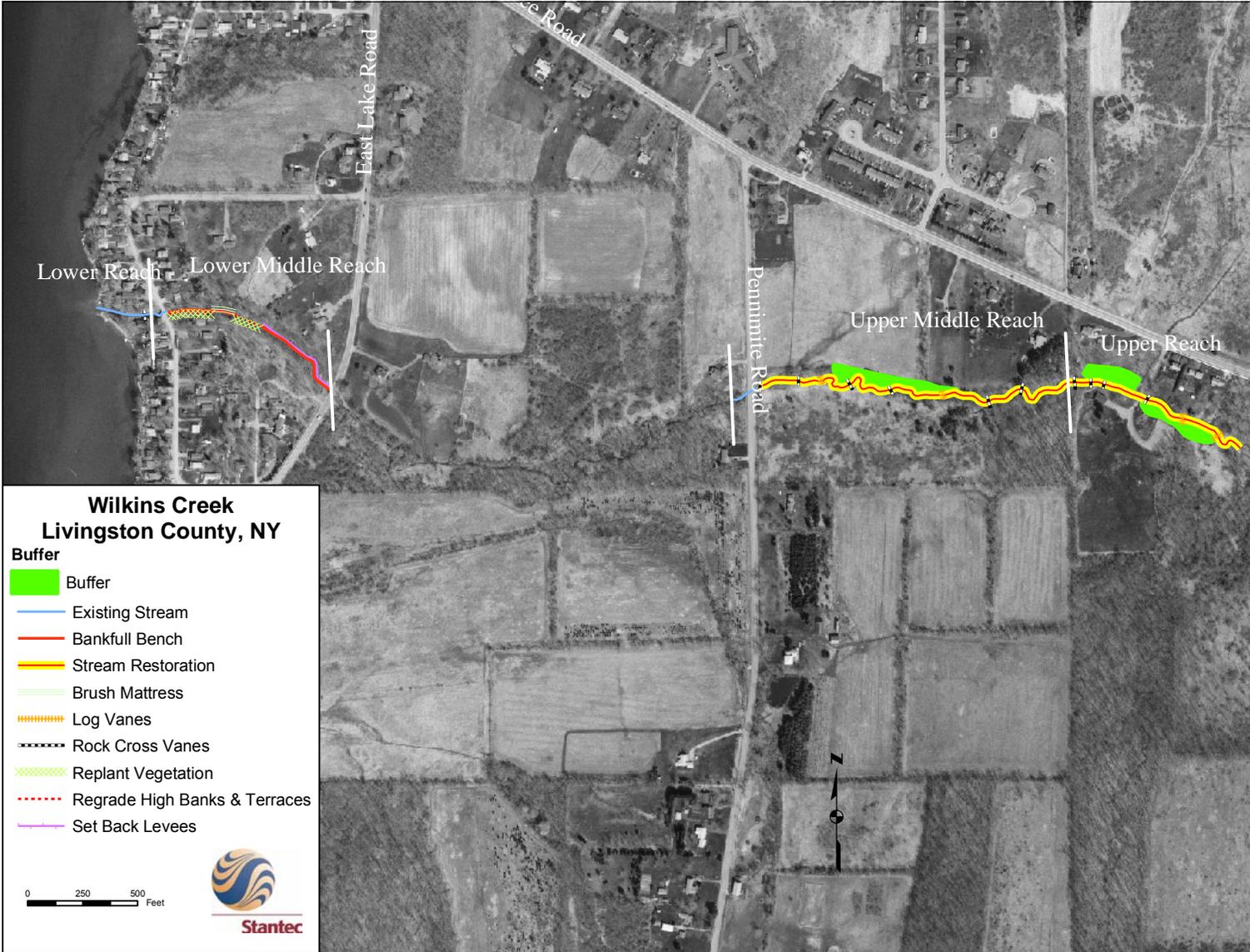
1.1 General Site Condition

Wilkins Creek is located on the east side of Conesus Lake. The original estimation of degraded stream channel to be assessed on Wilkins Creek was 4,425 linear feet. In actuality, there were 3,900 linear feet of degraded stream on which Stantec performed a geomorphic assessment. These sections of Wilkins Creek have a vertical fall of approximately 50 ft and an average slope of 1.3 %. GPS coordinates for the most downstream point of each reach are:

Upper Reach	77°40'51" W	42°49'23.25" N
Upper Middle Reach	77°41'11.58" W	42°49'22.67" N
Lower Middle Reach	77°46'96" W	42°26'81" N
Lower Reach	77°41'50" W	42°49'27" N

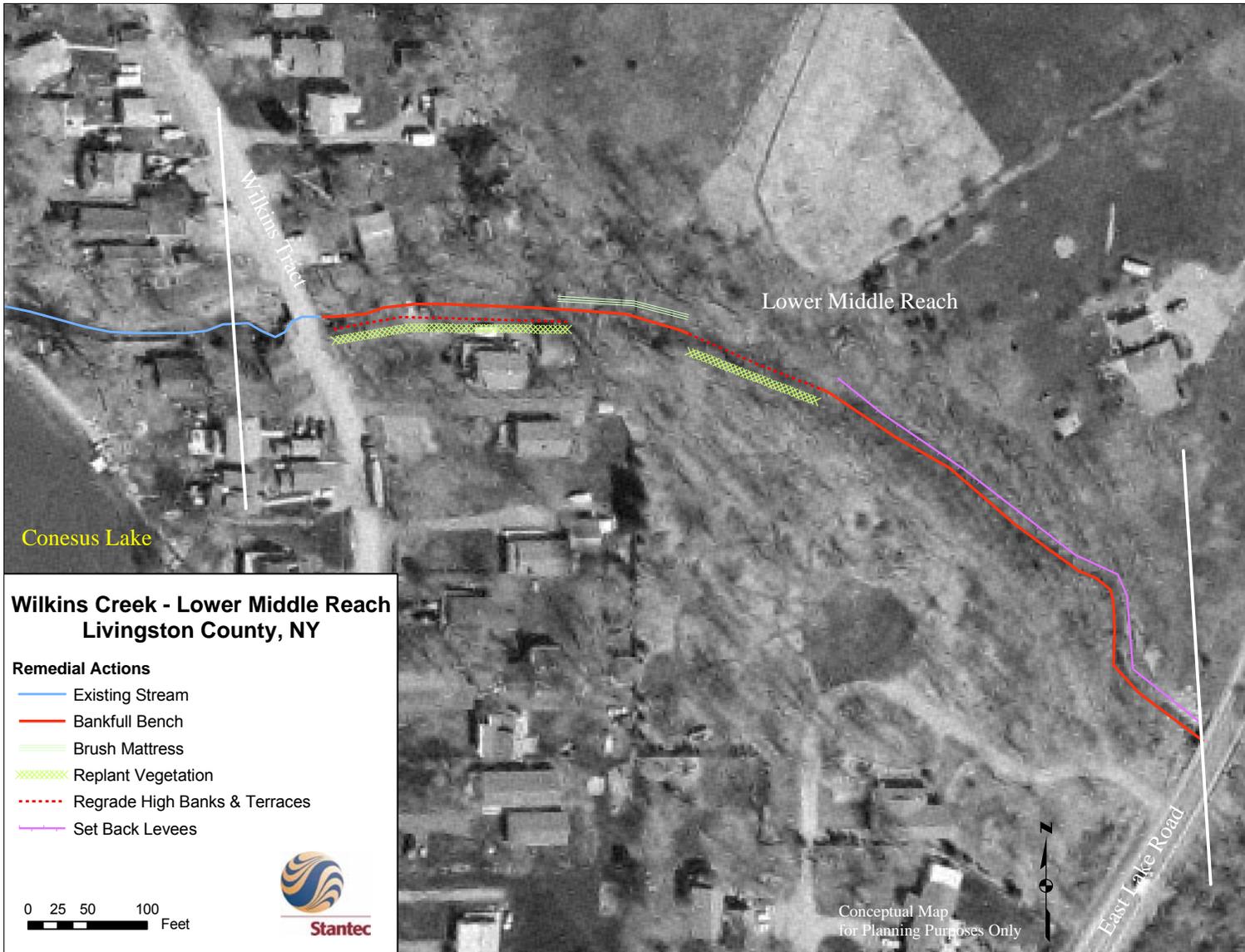
1.2 Existing Watershed Land Use

The existing 1,714-acre watershed is 15% developed, 35% forested, and 50% agriculture. The majority of the streams in the Wilkins watershed have a riparian buffer that is greater than 100 ft on either side of the channel. This project area was near Conesus Lake and does not have a well-vegetated buffer over much of the project reaches. Buffers have been cleared resulting in accelerated bank erosion. The majority of the sediment is coming from in-stream bank erosion opposed to upland watershed erosional processes.











1.3 Upper Reach Wilkins Creek

The upper reach of Wilkins Creek is flowing through a park. This reach is well connected to the floodplain. The buffer on much of this reach has been removed. Rock boulders have been placed at the toe of the bank to hold the bank toe in place. There is a double culvert that is misaligned with the stream channel and does produce scour eddies during high flow.

Photo 1 – Boulder toe protection



Photo 2 – Vegetation & floodplain connection



1.3.1 Prediction of Future Erosion Potential

The upper reach of Wilkins will remain stable as long as the buffer is maintained and soil conservation practices are employed for agriculture.

1.3.2 Remedial Action

The upstream reach could be used as an ideal demonstration area for bank stabilization measures since it is located in a park. The bolder toe protection of the streambank will remain fairly stable. A good demonstration could include channel restoration, buffer plantings and enhancement, installation of a rock vane to direct water effectively through the culvert, and stormwater/drainage BMPs installed in the buffer area. These Stormwater BMPs may include but not be limited to rain gardens and wetlands.

1.4 Upper Middle Reach Wilkins Creek

The upper middle reach of Wilkins is approximately 1,700ft. The upper middle reach of Wilkins Creek has a broad historic floodplain terrace. The existing invert of the reach has departed from the floodplain. This incised reach displays a very sinuous channel that has down cut from the historic elevation. This reach has considerable bank migration and channel evolutions. A Holocene terrace confines the bank migration. The lower section of the upper reach of Wilkins Creek has a couple landowners that are experiencing land loss of their yards and the loss of large trees due to bank erosion and bank lateral migration. This reach has significant bank migration, chute cut offs, traverse bars and channel evolutions. In some locations the grade has hit bedrock and is vertically confined. There is a 100ft or greater buffer on the left bank of this reach. The right bank of this reach has areas of no woody buffer as it is mostly residential lawn. An increase in shear stress and a decrease in riparian vegetation will result in an increase in

bank erosion and instability. At the lower end of the reach the stream approaches re-connection to the floodplain.

Photo 3 – Bank erosion detached from floodplain



Photo 4 – Bank erosion - attached floodplain



1.4.1 Prediction of Future Erosion Potential

The upper middle reach will continue to be unstable until the floodplain has reached a stable form. The upper middle reach has significant bank migration. The upper middle reach will continue to be laterally unstable until the floodplain has reached a stable form. The water and sediment supply of the watershed will dictate the stable form of the stream channel. The current bank migration, bank erosion, and chute cutoffs will continue to add to the sediment supply of this reach.

1.4.2 Remedial Action

The upper middle reach of Wilkins has significant bank erosion which in turn dominates the sediment load. It is recommended that the middle reach be relocated, the related floodplain be re-graded and the banks be stabilized to deal with the current watershed. The 2,000 ft channel relocation/restoration will utilize ***log vanes*** and ***rock vanes*** to stabilize and hold grade for the relocated channel. ***Rock vanes*** will be used to divert flows from foundations. ***Brush mattresses*** and cutting a ***bankfull bench*** will provide bank stability and reduce the near bank stress. (Specifications and details for bold/italicized items can be found in the Appendix).

The stabilization and re-grading of this reach will enable the stream to transport the sediment supplied from upstream without contributing additional sediment to the system. The channel relocation will also reduce the erosional forces that are contributing to the property loss at the lower end of the middle reach of Wilkins. It is also recommended that a minimum 25ft buffer be maintained over the entire reach.

1.5 Lower Middle Reach Wilkins Creek

The lower middle reach of Wilkins is downstream from East Lake Road. The lower reach has historically been modified and dredged to encourage drainage and reduce flooding. The left bank of this reach has a levee constructed of sand bags and dredged cobbles. The property on the right bank has a berm to prevent flooding on the property. There is

evidence that this reach has been dredged to remove the aggradation. A terrace on the left bank confines the channel and there is severe bank erosion in multiple locations. The channel has a limited buffer and there is bank erosion on the outside of the meander bends due to bank migration.

Photo 5 – Levee and meandering channel



Photo 6 – Bank erosion cut terrace



1.5.1 Prediction of Future Erosion Potential

The lower middle reach will continue to be laterally unstable until the floodplain has reached a stable form. The floodplain is beginning to form in this reach. The water and sediment supply of the watershed will dictate the stable form of the stream channel. Once the upstream section has eroded enough material to carve a floodplain at a lower elevation, the sediment transported will aggrade and form sediment bars that will accelerate the bank migration rate. There will continue to be large quantities of mass wasting of banks and terraces.

1.5.2 Remedial Action

On the lower middle reach flood protection and property protection are the primary goals. The bank stabilization approach will include relocation of the channel as needed, grading of a **bankfull bench**, installation of instream structures, and plantings. This will limit the risk to property by dealing with sediment supply and providing a stable channel form. The restored reach will have a **bankfull bench** and utilize **rock vanes**. The right bank will require rebuilding levees as set back levees (set back approximately 45 ft).

If it is not possible to relocate the channel in this section, then at a minimum **rock vanes** should be installed to deflect flow away from eroding banks, and a **bankfull bench** should be created to reduce erosional forces.

1.6 Lower Reach Wilkins Creek

The lower reach of Wilkins Creek is 250 ft in length and is straightened until it enters into Conesus Lake. The lower reach has historically been modified to encourage drainage and reduce flooding. A gabion rock wall is being used to prevent the channel from meandering and eroding the streambanks. This section of the stream is currently at a low gradient due to a headcut that has worked its way up the channel. Further

movement of the headcut is limited by the roadway culvert. The lower reach of this stream is under backwater influence for 200 ft.

Photo 7 – Headcut and culvert



Photo 8- Wilkins Creek and Conesus Lake



1.6.1 Prediction of Future Erosion Potential

The lower reach of Wilkins Creek will continue be fairly stable. The headcut has reached the culvert and there is no significant drop over this reach with the exception of the drop coming out of the culvert.

1.6.2 Remedial Action

There should be a **rock cross vane** installed to hold grade on the culvert and direct flows downstream without excess bank erosion.

2.0 Unnamed Tributary to Wilkins Creek

2.1 General Site Condition

The Unnamed Tributary to Wilkins Creek (UT Wilkins Creek) is located on the northeast side of Conesus Lake. Stantec performed a geomorphic assessment on 1,700 linear feet of degraded stream channel. This section of UT Wilkins Creek had a vertical fall of approximately 50 ft and an average slope of 2.3%. GPS coordinates for the most downstream point of each reach are:

Upper Reach	77°40'13.32" W	42°49'10.40" N
Middle Reach	77°40'15.16" W	42°49'14.99" N
Lower Reach	77°41'20.50" W	42°49'18.02" N

2.2 Existing Watershed Land Use

The existing 25-acre watershed is 95% developed and 5% forested. In the majority of the UT Wilkins watershed streams do not have good riparian buffers. Buffers have been cleared resulting in accelerated bank erosion. Numerous stormwater outfalls to the channel were noted. This watershed is a low sediment producing watershed. The majority of the sediment is coming from in-stream bank erosion.









2.3 Upper Reach UT Wilkins Creek

The upper reach of UT Wilkins is an ephemeral channel and starts as a perimeter ditch for the maintenance yard and stockpile area. This reach is 600 ft in length and is a v-shaped drainage ditch that is vertically confined by two culverts and has a nearly flat slope. The banks of the reach are not well vegetated. This reach is part of a perimeter ditch for a maintenance yard and stockpile area.

Photo 1 – Maintenance yard



Photo 2 – V shaped perimeter ditch



2.3.1 Prediction of Future Erosion

The upper reach of UT Wilkins has no sediment loading. The channel also has limited hydraulic forces to erode the banks. This channel will not transport sediment and it is currently in a configuration that does not convey all of the water from the system. There will be standing water in the channel for a period after stormflow has ended.

2.3.2 Remedial Action

This reach should be graded and replanted as a stormwater wetland. The existing culvert crossings will hold grade for the development of two linear wetlands.

2.4 Middle Reach UT Wilkins Creek

The middle reach of the UT to Wilkins Creek is a transitional steep gradient channel. The maintenance yard is at a higher elevation than the former floodplain valley. The valley was filled and graded to create a level maintenance yard. The drop from the top of the maintenance yard and the perimeter ditch is about 30 ft over a length of 100 ft. Even with low flow rates this is an incredibly unstable feature. The concentrated flows from stormdrains accelerate the local erosion and scour in this reach. Large rocks and boulders have been placed at the toe of the headcut or transition to hold grade. There is a very poor quality riparian buffer over most of this reach.

Photo 3 – Outfalls and pipes



Photo 4 – Grade drop and related headcut



2.4.1 Prediction of Future Erosion

The middle reach will continue to be both vertically and laterally unstable until the channel carves a new valley through the fill material. Currently the sediment supply on this reach is dominated by sediment from bank erosion. There is very little chance of this channel stabilizing naturally. The placed rock will slow the rate of vertical migration.

2.4.2 Remedial Action

The valley should be re-graded over a longer length to decrease the slope and structures should be installed to hold grade and protect the banks. The 600 ft relocation/restoration will utilize **rock cross vanes** to stabilize and hold grade for the relocated channel. **Brush mattresses** and cutting a new floodplain valley will provide bank stability and reduce the near bank stress. (Specifications and details for bold/italicized items can be found in the Appendix)

The stabilization and re-grading of this middle reach will reduce the sediment supplied downstream of this transitional area. The channel relocation will also reduce the erosional forces that are contributing to the property loss at the lower section of the middle reach of UT Wilkins Creek. It is also recommended that a minimum 25ft buffer be maintained over the entire reach.

2.5 Lower Reach UT Wilkins Creek

The lower reach of UT Wilkins is 600 ft. This reach is detached from the floodplain and has significant bank erosion. There is very little riparian buffer where the UT flows through the backyards of 4-8 residential dwellings. There is a residential out-building that is located above the stream channel. A 24" elliptical culvert vertically confines the lower end of this reach.

Photo 5 – Bank erosion residential backyards Photo 6- Residential out-building



2.5.1 Prediction of Future Erosion

The lower reach of UT Wilkins will continue to cut away at both banks. While bank erosion will continue the stream is confined laterally and will not have a greater departure from the floodplain.

2.5.2 Remedial Action

On the lower reach, flood protection and property protection are the primary goals. The existing channel is detached from the floodplain and there is bank erosion. A small **bankfull bench** should be constructed on the left bank. In addition the landowners should be informed about stream restoration and riparian buffer function. It is also recommended that a minimum 25ft buffer be maintained over the entire reach.

3.0 Densmore Creek

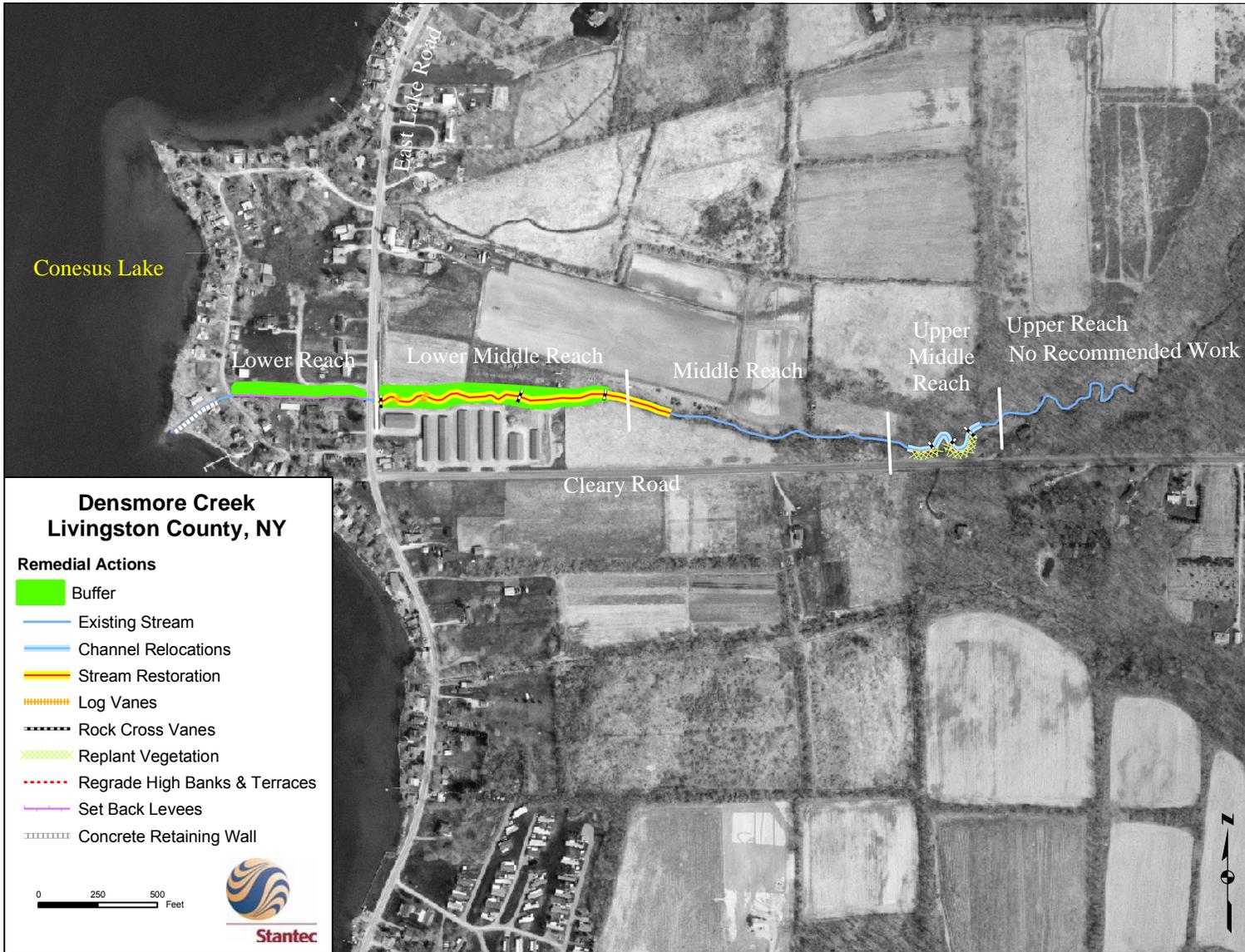
3.1 General Site Condition

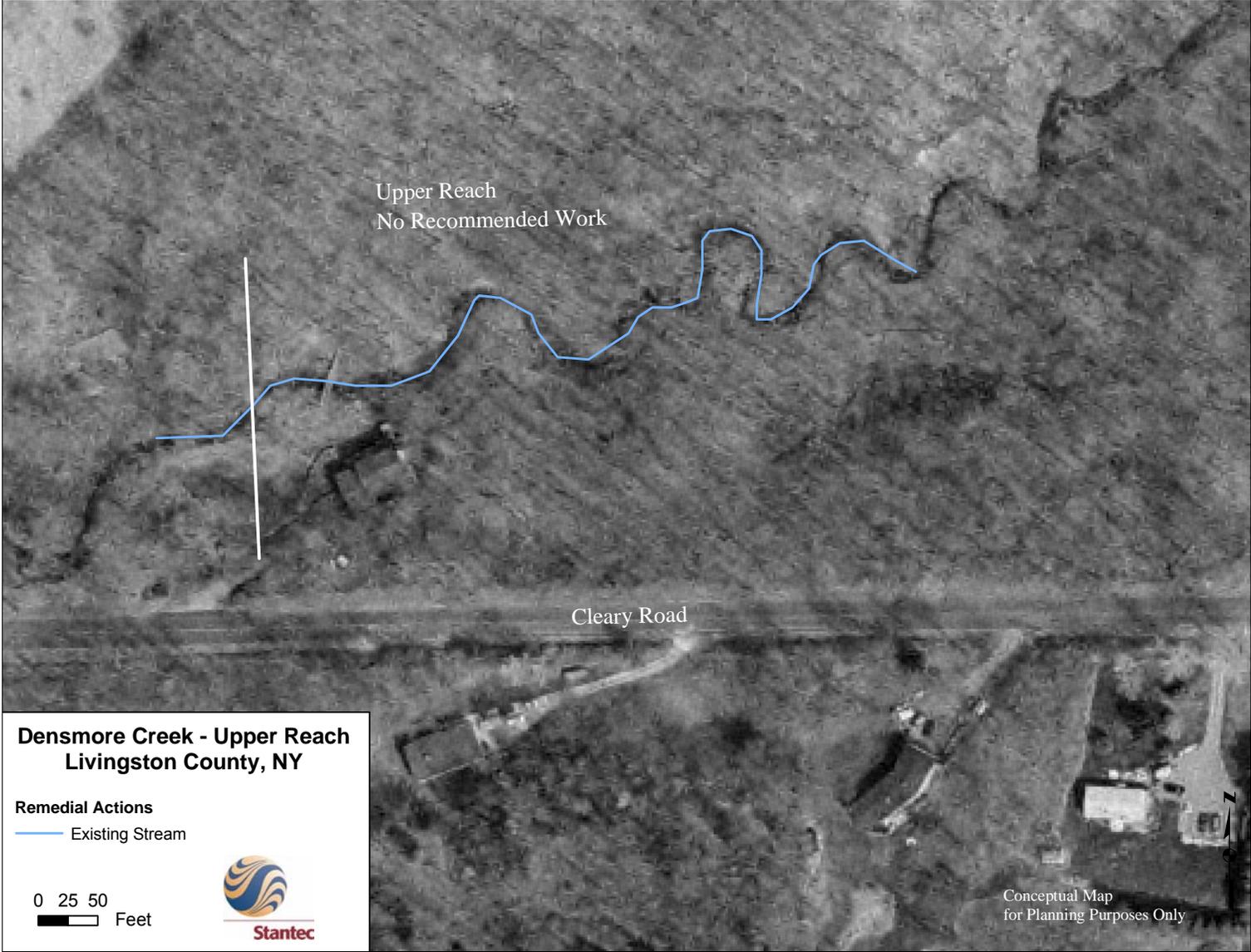
Densmore Creek is located on the east side of Conesus Lake. The original estimation of degraded stream channel to be assessed on Densmore Creek was 3,800 linear feet. In actuality, there were 4,450 linear feet of degraded stream on which Stantec performed a geomorphic assessment. This section of Densmore Creek had a vertical fall of approximately 50 ft and an average slope of 1.1 %. GPS coordinates for the most downstream point of each reach are:

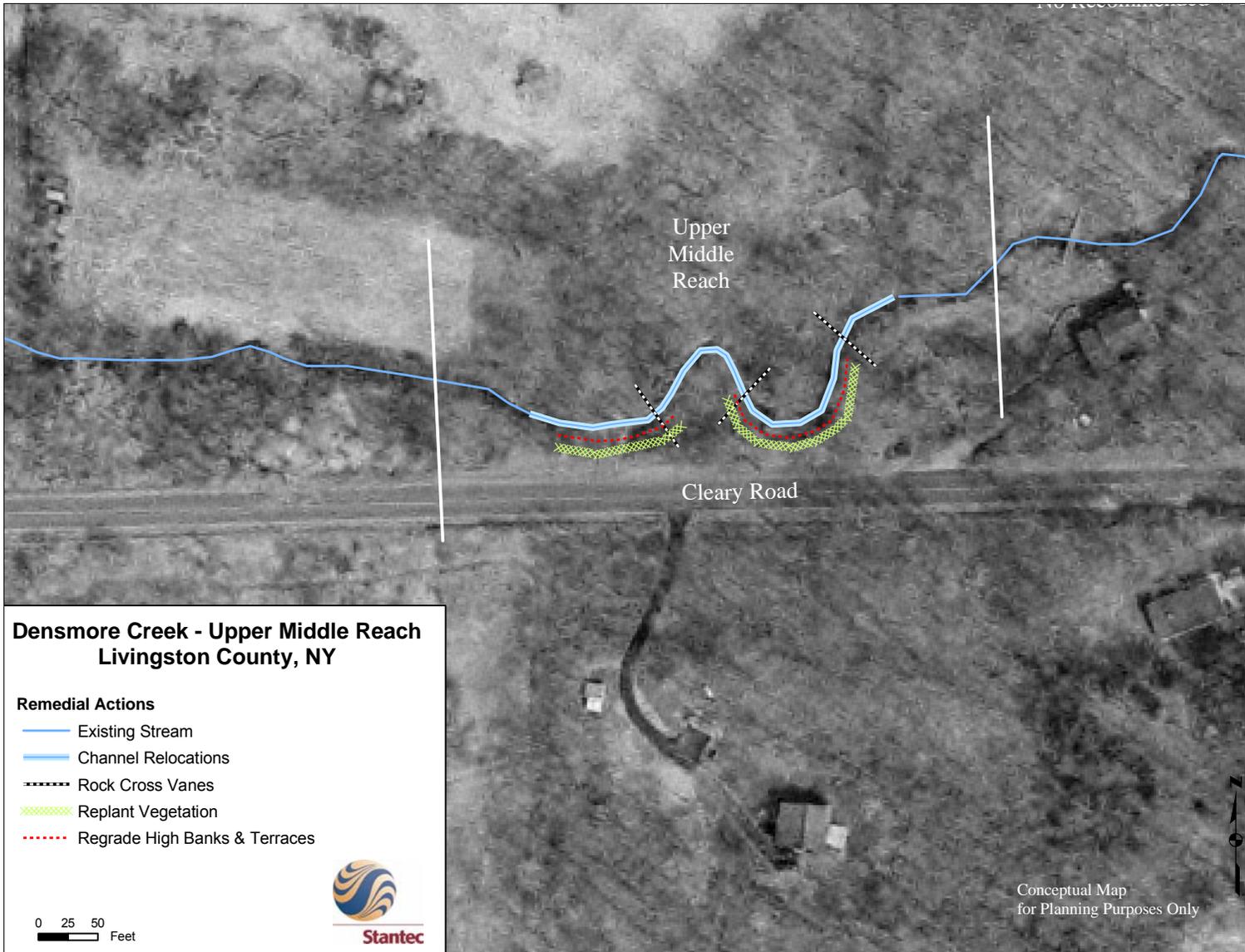
Upper Reach	77°41'51.39" W	42°47'31.50" N
Upper Middle Reach	77°41'57.70" W	42°47'30.63" N
Middle Reach	77°42'12.35" W	42°47'32.49" N
Lower Middle Reach	77°42'26.40" W	42°47'32.60" N
Lower Reach	77°42'38.09" W	42°47'31.32" N

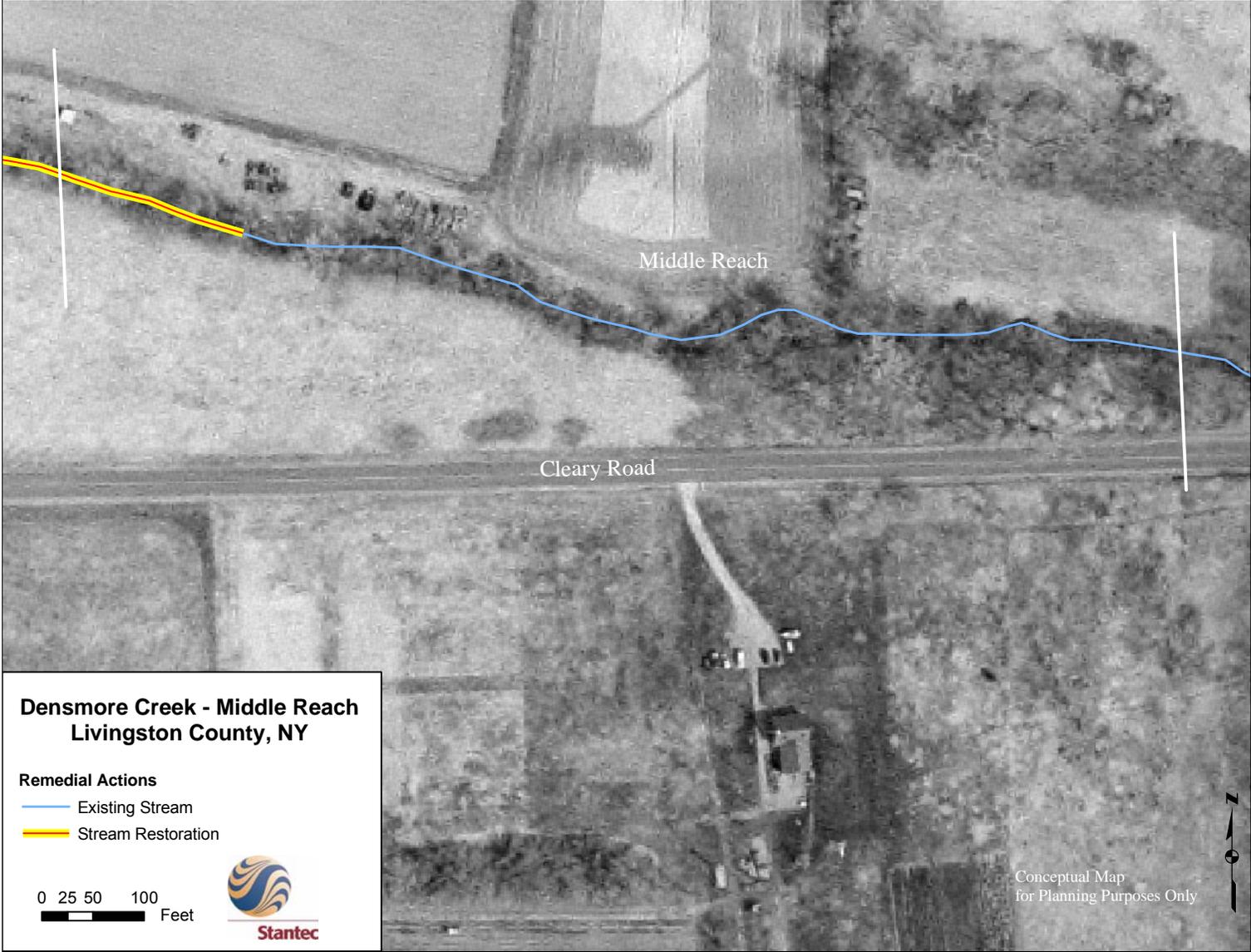
3.2 Existing Watershed Land Use

The existing 1,615-acre watershed is 5% developed, 15% forested, and 70% agriculture. The majority of Densmore Creek has a riparian buffer that is greater than 100 ft on either side of the channel. This project area was near Conesus Lake and does not have a well-vegetated buffer over much of the project reaches. Buffers have been cleared in this reach resulting in accelerated bank erosion. Beyond the pollutant sources noted in the lower middle reach, there were no other noted signs of significant point or non-point sources of sediment or of any other pollution from the existing watershed during the site visit. There was a drainage pipe and that directed both drainage and runoff from impervious areas. The majority of the sediment is coming from in-stream bank erosion.













3.3 Upper Reach Densmore Creek

The upper reach of Densmore is a stable channel connected to its floodplain. This results in a low shear stress. The banks are well vegetated and stable. There is very little bank erosion on this reach. There is an embankment and 12 inch culvert set at grade at the lower end of the upper reach of Densmore Creek. This reach is approximately 700ft in length.

Photo 1 – Upstream stable reach



Photo 2 –vegetation & floodplain connection



3.3.1 Prediction of Future Erosion

The upper reach of Densmore will remain stable as long as the buffer is maintained and soil conservation practices are employed for agriculture.

3.3.2 Remedial Action

There should be minimal actions taken in the upper reach since this reach is stable and well vegetated. The buffer in the watershed should be planted and maintained. There should be a buffer around significant tributaries in the watershed.

3.4 Upper Middle Reach Densmore Creek

The upper middle reach of Densmore is approximately 600 ft. This reach has significant bank erosion and bank migration. The eroding banks are composed of alluvium not shale outcrops. The left bank migration is threatening the stability of Cleary Road. There is a 50ft or greater buffer on both banks of this reach. This incised reach displays a very sinuous channel that is moderately down cut from the historic elevation.

Photo 3 – Bank erosion near road



Photo 4 –Bank erosion and migration



3.4.1 Prediction of Future Erosion

The upper middle reach of Densmore Creek has moderate sediment loading. The bank migration will continue on the left bank and increase chance for hillslope erosion and possible failure of the subgrade and berm of Cleary Road. The major source of eroded sediment from the bank migration is at low production rate and limited to a 400 ft section of stream.

3.4.2 Remedial Action

This reach should be observed with bank erosion pins over the next couple of years to assess the risk of roadway damage due bank erosion. Bank erosion pins allow for measurement of the annual bank migration rate. If the bank migration rate is at a rate that will risk the integrity of Cleary Road, then the channel should be relocated or structures should be installed to protect the bank from erosion and accelerated bank migration.

3.5 Middle Reach Densmore Creek

The middle reach of Densmore is approximately 1,100ft. This stream reach is moderately stable and slightly incised. The channel does not have a high percentage of embedded fine sediments. There are various field drains and rooftop runoff drains that are directly discharging to the stream.

Photo 5 –Rooftop runoff and drainage



Photo 6 – Moderately stable channel



3.5.1 Prediction of Future Erosion

The middle reach will continue to be moderately stable and will become more stable as the lateral sediment bars and point bars continue to shape the channel and vegetation develops on these bars. The floodplain connection is adequate to limit shear stress in this reach.

3.5.2 Remedial Action

The middle reach of Densmore has minimal bank erosion. The buffer in the watershed should be planted and maintained. There should be a buffer around significant tributaries in the watershed.

3.6 Lower Middle Reach Densmore Creek

The lower middle reach of Densmore is 1,300 ft in length and has been altered during construction activity of storage units on the parcel adjacent to the left streambank. The downspouts for rooftop drainage are piped directly to the stream. This stream channel has been reshaped and the floodplain has been filled and raised to contain higher flows within the banks of the channel. The buffer has been eliminated and rip rap has been placed to try to armor the streambanks and protect against excess bank migration. It is evident that rip rap has been replaced as much of the formerly placed rip rap has been transported and deposited downstream. The deposited rip rap is producing a tailwater condition on the culvert that passes under East Lake Road. This reach has moderate sinuosity and bank material that is formed from alluvial deposits.

Photo 7 – Rip Rap protection active drains



Photo 8- Floodplain filled and maintained



3.6.1 Prediction of Future Erosion

The lower middle reach will continue to be unstable until the channel and floodplain have reached a stable form. Bank migration will continue and large storms will transport the armoring rip rap down stream. When the rip rap is transported from the banks there will be severe bank erosion due to the lack of a riparian buffer. Currently the sediment supply on this reach is low dominated by bank erosion within the reach sediment supply. The water and sediment supply of the watershed will dictate the stable form of the stream channel.

3.6.2 Remedial Action

The lower middle reach should have the former floodplain re-excavated and the channel width should be increased related to the depth of the channel. The pattern of this reach should be adjusted by relocating the channel and re-grading the dimension of the channel. There should also be a minimum of a 25ft buffer planted on both banks of the relocated channel with direct drainage to the channel. All stormwater and drainage outfalls should be treated with stormwater best management practices such as grassed waterways, wetlands, or level spreaders, within the buffer area. The channel relocation/restoration will utilize **rock cross vanes** to stabilize and hold grade for the relocated channel. **Brush mattresses** and cutting a new floodplain valley will provide bank stability and reduce the near bank stress. (Specifications and details for bold/italicized items can be found in the Appendix)

3.7 Lower Reach Densmore Creek

The lower reach of Densmore is 900 ft in length and has been straightened until it enters into Conesus Lake. The lower reach has historically been modified to encourage drainage and reduce flooding. Concrete and rip rap are being used to prevent the channel from meandering and eroding the streambanks. The right bank has a retaining wall to protect the bank from erosion and protect property. The concrete retaining wall allows for floodplain interaction while the channel is fairly wide to encourage bar formation within the hardened banks of the channel. Due to the channel dimension relative to the concrete wall, excess scour on the streambed has not been observed.

Photo 9 – Wide channel with bar formation



Photo 10 – Concrete Retaining wall



3.7.1 Prediction of Future Erosion

In the lower reach of Densmore the channel is straightened and levied, but the channel still has access to a floodplain for large flows. The channel is also wide enough to spread out the flow and limit the shear stress that causes erosion. This reach will continue to build lateral sediment bars.

3.7.2 Remedial Action

There should also be a minimum of a 25ft buffer planted on both banks of the channel. The existing levees should be repaired as setback levees to allow for overbank flooding.

When retaining walls are repaired or rebuilt they should be constructed to a height of no greater than the natural floodplain elevation.

4.0 Central Creek

4.1 General Site Condition

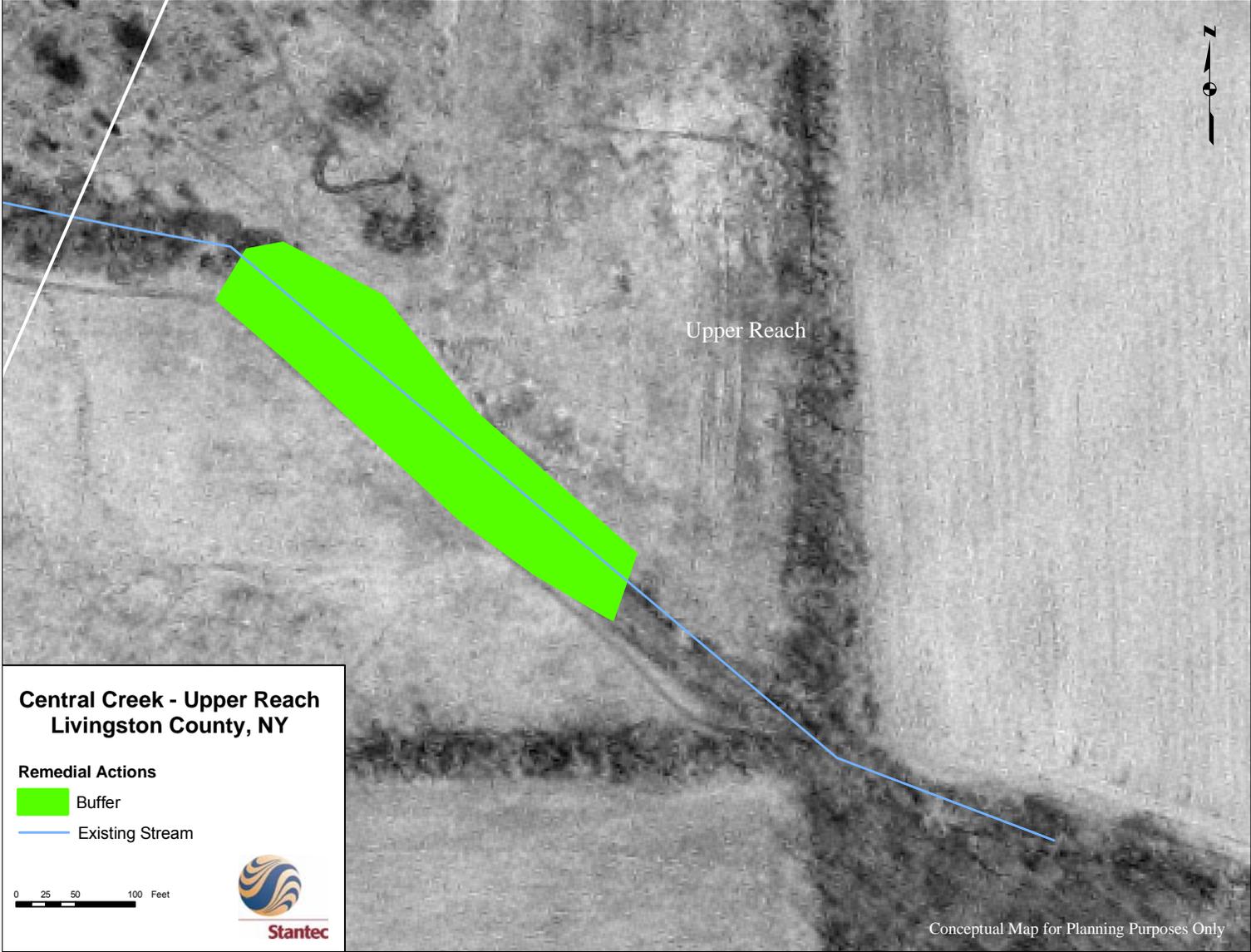
Central Creek is located on the east side of Conesus Lake. The original estimation of degraded stream channel to be assessed on Central Creek was 3,100 linear feet. In actuality, there was 2,700 linear feet of degraded stream on which Stantec performed a geomorphic assessment. This section of Central Creek has a vertical fall of approximately 80 ft and an average slope of 3.3 %. GPS coordinates for the most downstream point of each reach are:

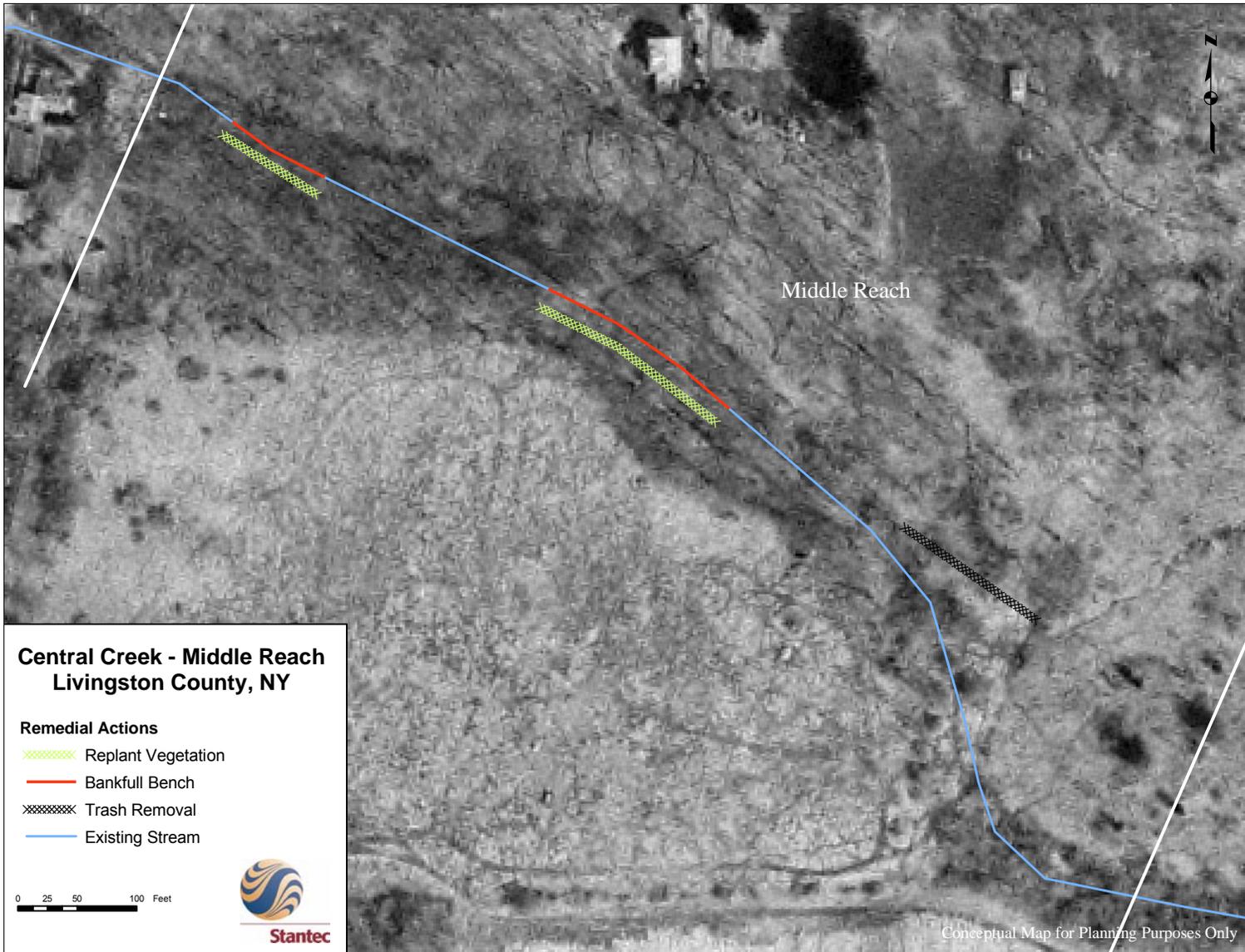
Upper Reach	77°42'16.66" W	42°46'57.80" N
Middle Reach	77°42'27.53" W	42°47'4.68" N
Lower Reach	77°42'31.42" W	42°47'5.21" N

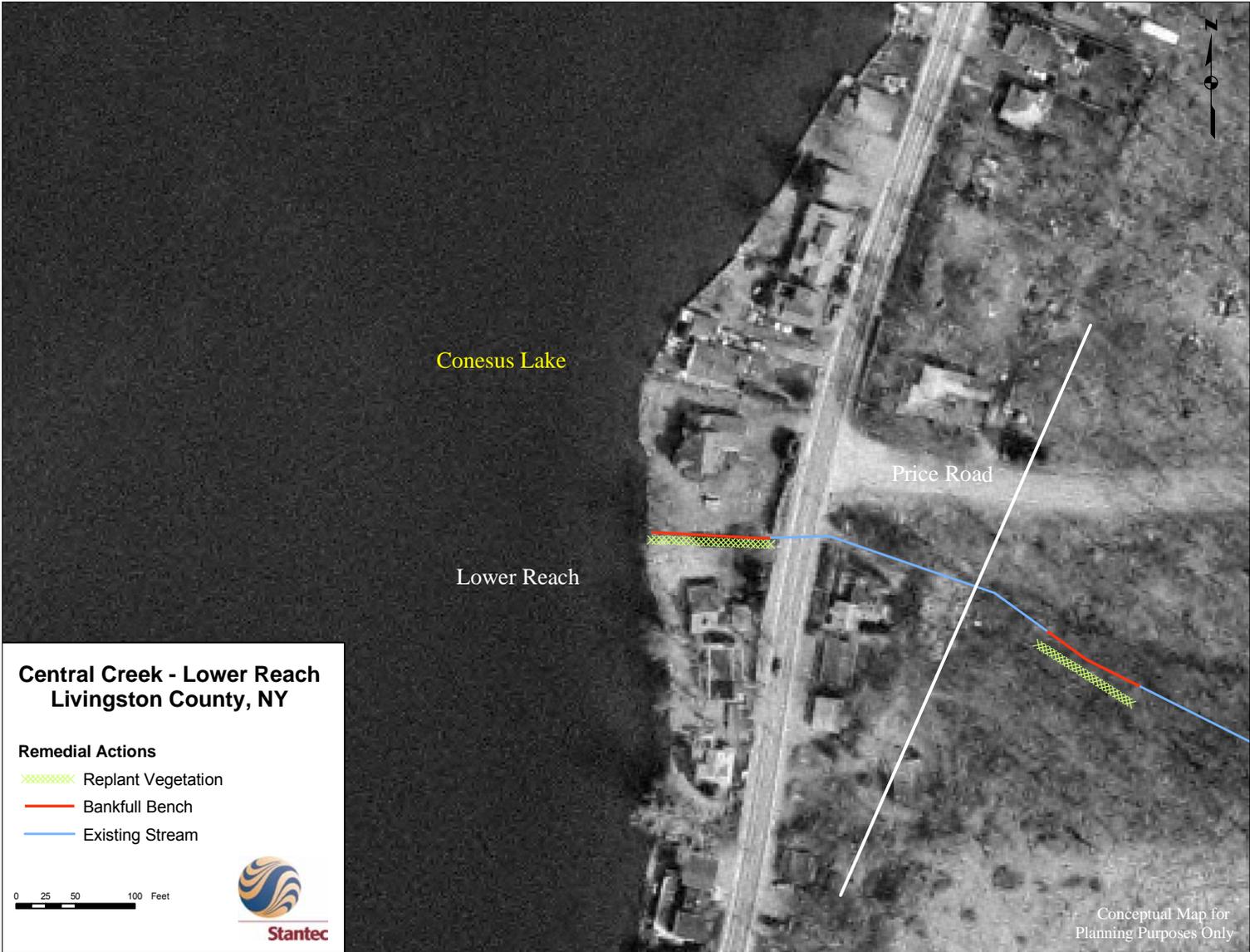
4.2 Existing Watershed Land Use

The existing 458-acre watershed is 2% developed, 33% forested and 65% agriculture. The majority of the streams in the Central watershed have a riparian buffer that is greater than 100 ft on either side of the channel. In areas it is a low quality buffer consisting of agricultural land that is no longer in production. The reach watershed area near Conesus Lake and does not have a well-vegetated buffer. The majority of the sediment is coming from in-stream bank erosion and legacy sediments from debris dams.









4.3 Upper Reach Central Creek

The upper reach of Central Creek is a low gradient wetland system with a low flow pilot channel. The banks are well vegetated and stable. There is very good connection to the floodplain and as a result there is low shear stress. There is very little bank erosion on this reach. This reach is approximately 1000ft in length and has areas of little to no buffer. The land use of this reach was formerly intensive agriculture with a lack of soil conservation practices. This reach is currently fallow and out of production.

Photo 1 – Wetland with low flow channel



Photo 2 – Vegetation & floodplain connection



4.3.1 Prediction of Future Erosion Potential

The upper reach of Central Creek will become more stable as the buffer is maintained and soil conservation practices are employed for future agriculture. This reach has dense vegetation and the banks that had been impacted by hoof shear from cattle are now rebuilding and recovering.

4.3.2 Remedial Action Upper

There should be minimal actions taken in the upper reach since this reach is stable and well vegetated. Some sections of buffer in this reach should be replanted with woody vegetation.

4.4 Middle Reach Central Creek

The middle reach of Central Creek is approximately 1,100ft. This reach of stream has a sediment dam step pool profile. In much of the valley the sediment dam is formed on an outcrop of bedrock by logs and boulders getting trapped behind the bedrock pinch point in the valley. These alternating debris fans have shale deposits as well as legacy sediments embedded into the deposited materials. These legacy sediments have been transported from the upland areas during intensive agricultural and tilling periods. This reach is the steepest reach of this segment of stream. There is active erosion of banks and shale outcrops. There are currently many sediment and debris dams that accelerate local instability. There is a 100ft or greater buffer on both banks of this reach. Sediment deposition and mass wasting of the banks results in localized contraction of low flows and high shear forces. There is a broad floodplain in this reach. The stream is slightly incised but still accesses the historic floodplain during high stormflow.

Photo 3 – Concrete weir and sediment dam



Photo 4 –Bank erosion valley wall



4.4.1 Prediction of Future Erosion Potential

The middle reach of Central Creek has moderate sediment loading. The debris and log jam profile of this reach will begin to migrate sediments downstream as the dams break down and reform at lower elevations in the valley. This reach has a moderate connection to a broad floodplain valley and high storm flows are able to flow over the floodplain and dissipate energy. There will continue to be quantities of mass wasting from banks and terraces where the channel flows at the valley toe. Shale valley walls and terraces that confine the left streambank will continue to shear and shale deposits will be transported downstream. The current water and sediment supply of the watershed will dictate the stable form of the stream channel.

4.4.2 Remedial Action

There should be minimal actions taken in the middle reach as much of this reach is confined and has access to the floodplain. Some selected shale outcrops and terraces that are confining the stream should be removed. In these locations the channel could also be relocated away from these cut banks to limit the shear force applied to the banks from stormflows.

4.5 Lower Reach Central Creek

The lower reach of Central Creek is 600 ft in length and is straightened until it enters into Conesus Lake. The lower reach has historically been modified to encourage drainage and reduce flooding. Rip rap has been used to prevent the channel from meandering and eroding the streambanks. There is a dwelling on the right bank and no riparian buffer.

Photo 5 – Rip rap and low right bank



Photo 6- Poor riparian buffer



4.5.1 Prediction of Future Erosion Potential

The lower reach of Central Creel will continue to degrade and there will be bank erosion and possible bank migration on the right bank. The bank migration rate will be limited since the reach is flat. The foundation of the residential dwelling on the right bank is currently at risk of being undermined. The left bank is higher than the right bank and directs flooding to the right overbank area.

4.5.2 Remedial Action

A low vegetated **bankfull bench** should be constructed on the left bank. The **bankfull bench** will relieve pressure from the right bank. A small buffer should be planted on the right bank with the use of a brush mattress and other buffer plantings.

5.0 North Gully Creek

5.1 General Site Condition

North Gully Creek is located on the east side of Conesus Lake. The original estimation of degraded stream channel to be assessed on North Gully Creek was 1400 linear feet. In actuality, there were 2,400 linear feet of degraded stream on which Stantec performed a geomorphic assessment. This section of the creek has a vertical fall of approximately 30 ft and an average slope of 1.3 %. GPS coordinates for the most downstream point of each reach are:

Upper Reach	77°42'31.27" W	42°46'42.15" N
Middle Reach	77°42'37.28" W	42°46'43.11" N
Lower Reach	77°42'55.05" W	42°46'43.20" N

5.2 Existing Watershed Land Use

The existing 1802-acre watershed is 10% developed, 45% forested and 55% agriculture. The majority of the North Gully stream has a riparian buffer that is greater than 200ft on either side of the channel. The project reaches are near Conesus Lake and do not have well-vegetated buffers as landowners have cleared them. The lack of buffers has resulted in accelerated bank erosion. There were no signs noted of significant point or non-point sources of sediment or any other pollution from the existing watershed during the site visit. The majority of the sediment is coming from in-stream bank erosion opposed to soil loss from hill slope erosion. There are two undersized culverts on the study area of North Gully Creek; the first culvert is located at East Lake Road and the other culvert is under McPherson's Point Road.









5.3 Upper Reach North Gully Creek

The upper reach of the evaluated section of North Gully Creek started approximately 1,200 ft east of East Lake Road and is approximately 600 ft long. The channel is moderately stable in this reach with a developed floodplain bench although there are areas of cut and eroding terraces. The substrate is coarse with a low percentage of embeddedness. The grade of North Gully Creek has encountered shale and bedrock vertical confinement. Although the invert of the stream has struck bedrock in some locations there is significant bank erosion due to excess forces during large storm events. Two cut terraces contribute to the majority of the sediment from this reach. There is a 50-100 ft buffer on both sides of this reach. A glacial terrace on the right bank laterally confines the upper reach of North Gully.

Photo 1 – Stable with vegetated bench



Photo 2 - Unstable eroding terrace



5.3.1 Prediction of Future Erosion Potential

The upper reach of North Gully will continue to be a significant sediment source from the mass wasting and bank erosion of high terraces that confine the stream laterally. The upper reach of North Gully will continue to erode the existing valley and create a new floodplain that will transport sediment downstream until the shear forces of the stream are not in direct contact with the terraces.

5.3.2 Remedial Action

Minimal amount of restoration should be attempted in this reach due to the bedrock and shale confinement. Sections of the upper reach should be re-graded and re-vegetated at the locations where the stream is cutting into glacial and Holocene terraces, supplying the majority of the sediment. The re-grading and re-vegetation should be concentrated in two locations located in the first 600 ft of the reach.

5.4 Middle Reach North Gully Creek

The middle reach of North Gully, from the end of the upper reach to East Lake Road, has a broad historic floodplain terrace. This reach is approximately 600ft of highly sinuous incised channel that has lost its connection with the floodplain. The reach has had significant bank migration and channel evolutions. Terraces and residential property in the middle reach of North Gully confine bank migration. The bank erosion resulting from the current instability weakens the streambanks causing large trees to fall into the

stream. One landowner is experiencing structural foundation undermining, land loss, and the loss of large trees due to bank erosion and bank lateral migration. The undersized culvert at East Lake Road is in risk of failing if the direction constriction of flood flow is not addressed.

Photo 3 - Property loss residential yard



Photo 4 - Property loss foundation failure



5.4.1 Prediction of Future Erosion Potential

The middle reach will continue to be laterally unstable until the floodplain has reached a stable form. The water and sediment supply of the watershed will dictate the stable form of the stream channel. The current bank migration and bank erosion will continue to add to the sediment supply of this reach of North Gully. The foundation of the residential dwelling will be undermined and the land loss will continue until the right bank is stabilized.

5.4.2 Remedial Action

The middle reach of North Gully has significant bank erosion that in turn leads to a high sediment load. Relocation and restoration of approximately 600 ft of stream including new dimension, pattern, and profile are recommended for this reach. This is the most effective way to deal with the current watershed flow and sediment supply. **Log vanes** and **rock vanes** should be used to stabilize and hold grade of the newly relocated channel. The **rock vanes** will also be utilized to divert flows from undermined foundations. **Brush mattresses** and a **bankfull bench** will be utilized to stabilize banks and reduce stress on the channel sides. (Specifications and details for bold/italicized items can be found in the Appendix)

The stabilization and re-grading of this lower reach will enable the stream to transport sediment supplied from upstream without contributing additional sediment to the system. The channel relocation will also reduce the erosional forces that are contributing to the property loss at the lower section of the middle reach of North Gully.

The culvert under East Lake Road should be replaced and floodplain relief culverts should be added to help minimize erosional forces during floods. The upstream and downstream grade of the stream and direction of flow should be set by the installation of rock cross vanes.

5.5 Lower Reach North Gully Creek

The lower reach of North Gully is from the west side of East Lake Road downstream to the Lake. The lower reach has historically been modified and dredged to encourage drainage and reduce flooding. The left bank of this reach has a levee constructed of sand bags and dredged cobbles. The property on the right bank has been bermed to prevent flooding on the property. An undersized concrete bridge is a significant cause of the aggradation in the reach. There is evidence that this reach has been dredged to remove the aggradation.

Photo 5 – Left bank failing levee



Photo 6- Right bank failing retaining wall



5.5.1 Prediction of Future Erosion Potential

The lower reach of North Gully will continue to flood and dredging will be required to continue drainage until the sediment in the watershed is stabilized. The right bank erosion will progress leading to possible failure of retaining walls and structures. The levees will assist in increasing the forces for sediment transport but as more sediment is transported downstream more sediment will accumulate behind the undersized culvert.

5.5.2 Remedial Action

On the lower reach, flood protection is the primary goal. The upstream reduction of sediment from the re-grading, re-vegetation, and restoration will reduce sediment loading and the rate of aggradation. Establishing a low flow channel will be essential to transport the remaining sediment load. Levees should be rebuilt as set back levees (approximately 25 ft back). It will also be necessary to remove and replace the undersized bridge.

6.0 South Gully Creek

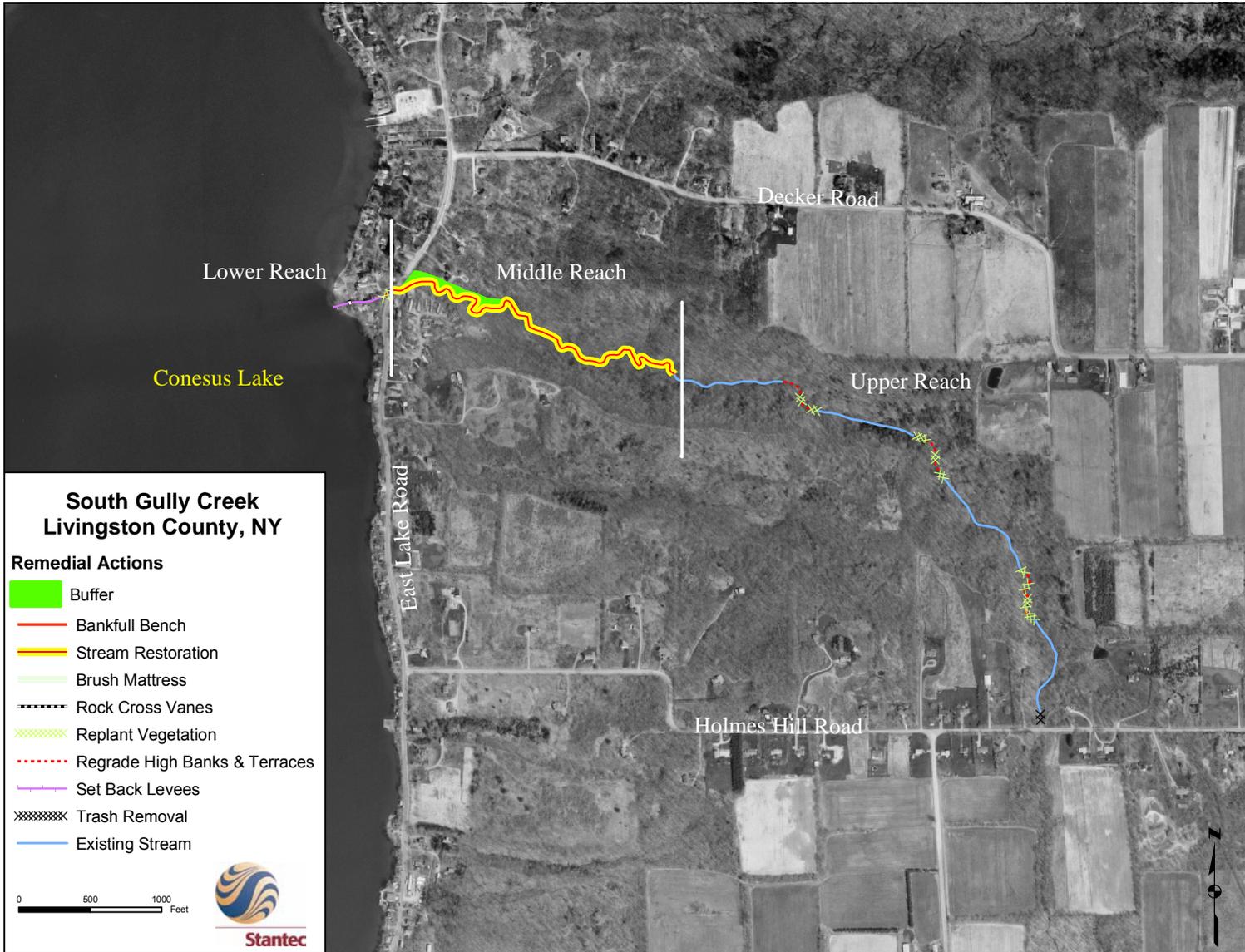
6.1 General Site Condition

South Gully Creek is located on the east side of Conesus Lake. The original estimation of degraded stream channel to be assessed on South Gully Creek was 6,600 linear feet. In actuality, there were 7,600 linear feet of degraded stream on which Stantec performed a geomorphic assessment. This section of South Gully has a vertical fall of approximately 260 ft and an average slope of 3.9%. GPS coordinates for the most downstream point of each reach are:

Upper Reach	77°42'16.60" W	42°46'13.47" N
Middle Reach	77°42'43.86" W	42°46'19.89" N
Lower Reach	77°42'50.77" W	42°46'18.29" N

6.2 Existing Watershed Land Use

The existing 766-acre watershed is 10% developed, 45% forested and 55% agriculture. The majority of the South Gully stream segments on this project reach have a riparian buffer that is greater than 200ft on either side of the channel. The areas that do not have significant buffers are within 1,000 ft of Conesus Lake. There were no signs noted of significant point or non-point sources of sediment or of any other pollution from the existing watershed during the site visit. The majority of the sediment is coming from in-stream bank erosion opposed to soil loss from hill slope erosion.









6.3 Upper Reach South Gully Creek

The entire South Gully creek is in a state of high bank erosion and sediment production. This gravel and cobble bed stream is highly embedded with fine sediments from both bank erosion and hill slope erosion from agricultural practices of the past. These sediments that remain in a stream system from historical watershed disturbances are referred to as legacy sediments. Legacy sediments that are embedded may take decades to transport downstream because the sediment particles are hidden in between large cobble and boulder that is rarely transported.

The upper reach of section of South Gully that was evaluated starts at Holmes Hill Road where there is a ~30ft drop from the invert of the roadway culvert to the invert of the channel. This area has been historically used as a trash dump. There is a large quantity of trash and debris in the channel and downstream of the dumpsite. There has also been large armoring rock placed in an attempt to stabilize the actively eroding banks near the roadway culvert. Holmes Hill road is at risk of failing from large storm events.

South Gully is currently a high sediment producing system with active bank erosion and migration. The existing stream is not connected to the historic floodplain and the channel has significantly down cut from former floodplain terraces. In the higher elevation reaches of this segment of South Gully there are numerous locations where the grade has hit shale and bedrock vertical confinement. Although the invert of the stream has hit bedrock in some locations there is significant bank erosion due to excess forces during large storm events.

The anthropogenic influences and stressors of South Gully have historically included dumping, agriculture, forestry, and residential dwellings. There are various abandoned logging roads and stream crossings that have had a significant impact on the hydraulics of the stream flow, sediment transport, and bank erosion of the stream. There are currently no existing residents on South Gully until it approaches East Lake Road.

Photo 1 - Confined shale bedrock



Photo 2 - Unstable eroding terrace



6.3.1 Prediction of Future Erosion Potential Upper Reach South Gully Creek

The upper reach of South Gully will continue to be unstable and experience a large amount of bank erosion until a new floodplain is formed in the existing valley. To allow the upper reach of South Gully to erode enough to create a new floodplain would result in a massive transport of sediment downstream.

6.3.2 Remedial Action Upper Reach of South Gully Creek

The opportunity to restore the stream in this reach is minimal due to the reach being confined by bedrock and shale. There are approximately 5 locations of cut glacial and Holocene terraces in the first 4,000 ft of stream that can be re-graded and re-vegetated. These locations are the foremost sources of sediment. The majority of sediment generated in the upper reach should be managed in the middle reach (Section 6.4.2), due to the aforementioned constraints. The large debris and trash near Holmes Hill Road should be removed and disposed of properly. The only sustainable solutions for Holmes Hill Road culvert would include culvert replacement and possible complete removal of the crossing. If the culvert was replaced or removed the valley could be regarded to a quasi-equilibrium state.

6.4 Middle Reach South Gully Creek

The middle reach of South Gully has a broad historic floodplain terrace. This incised reach displays a very sinuous channel that has significantly down cut from the historic elevation and has departed from the floodplain. The reach has had considerable bank migration and channel evolutions. Twenty-foot high glacial terraces confine the bank migration and erosion, these terraces have led to an especially high sediment supply. Large downed trees and glacially transported cobble and boulder are exposed and form debris and sediment jams in the lower energy segments of this reach. There is localized contraction of flow and large energy drops over these in-stream debris jams that then cause bank erosion near the debris jam structures. The lower section of the middle reach of South Gully has one landowner who is experiencing land loss of his yard and the loss of large trees due to bank erosion and bank lateral migration.

Photo 7 - Channel migration & bank erosion **Photo 4 - Property loss residential yard**



6.4.1 Prediction of Future Erosion Potential Middle Reach South Gully Creek

The middle reach will continue to be laterally unstable until the floodplain has reached a stable form. The water and sediment supply of the watershed will dictate the stable form of the stream channel. The current bank migration, bank erosion and chute cut offs will continue to add to the sediment supply of this reach.

6.4.2 Remedial Action Middle Reach of South Gully Creek

The middle reach of South Gully has significant bank erosion resulting in a high sediment load. It is recommended that the middle reach and the related floodplain be re-graded and the banks be stabilized to deal with the current watershed. The stabilization and re-grading of this reach will enable the stream to transport the sediment supplied from upstream without contributing additional sediment to the system. The relocation and regrading of the channel will also allow for the reduction of erosional forces that are contributing to the property loss at the lower section of the middle reach of South Gully.

A sediment debris fan will be formed from the sediment upstream. A low flow channel will be created in the debris fan with a horizontal and terrace confinement. A relocated channel approximately 3,000 ft in length, of new dimension, pattern and profile will be designed to cope with the current watershed conditions.

Log vanes and **rock vanes** will be used in the relocated channel to stabilize and hold grade in the new channel. **Brush mattresses** and a **bankfull bench** will be utilized to stabilize banks and reduce stress on the channel sides. (Specifications and details for bold/italicized items can be found in the Appendix).

6.5 Lower Reach South Gully Creek

The lower reach of South Gully is from East Lake Road downstream to the lake. The culvert under East Lake Road is misaligned and the stream has to turn to enter the culvert leading to significant bank erosion. The reach then flows between two property lines. The property on the right bank has a berm on the streambank to prevent flooding. The property on the left bank has a retaining wall that is currently failing. The left bank is the lower bank and overtops during high flow. The left bank properties, consisting of a mobile home community, have experienced flooding. Some of the homes are actually on

the failing retaining wall. Due to the high sediment load there is a sediment fan that continues to form at the mouth of the creek where it meets the lake. The sediment fan does not allow for fish passage up South Gully.

Photo 5 – Left bank failing retaining wall



Photo 5- Sediment fan & Conesus Lake



6.5.1 Prediction of Future Erosion Potential Lower Reach South Gully Creek

The lower reach of South Gully will continue to flood and the sediment fan will continue to control the water surface elevation of the creek, unless the sediment source upstream is reduced. The left bank erosion and possible failure of retaining walls and structures will progress unless flow is deflected from the banks and the bank is vegetated and/or armored.

6.5.2 Remedial Action Lower Reach of South Gully Creek

On the lower reach property protection is the primary goal. The upstream reduction of sediment will reduce sediment loading and the rate of aggradation of the sediment fan. Proposed work includes re-grading and planting the left bank and grading a **bankfull bench**/set bank levee for approximately 300 ft on the right bank. The left bank will require the installation of a new retaining wall or a gabion basket, in combination with a **rock vane**. The right bank should have bank stabilization structures such as a **rock vane** that will help divert flows. Re-grading and vegetation of both the right and left bank should be done to help reduce the sediment produced in this small reach during flood flows.

7.0 North McMillan Creek

7.1 General Site Condition

North McMillan Creek is located on the southeast side of Conesus Lake. The original estimation of degraded stream channel to be assessed on North McMillan Creek was 2,800 linear feet. In actuality, there were 4,700 linear feet of degraded stream on which Stantec performed a geomorphic assessment. This section of North McMillan Creek has a vertical fall of approximately 50 ft. and an average slope of 1.0 %. GPS coordinates for the most downstream point of each reach are:

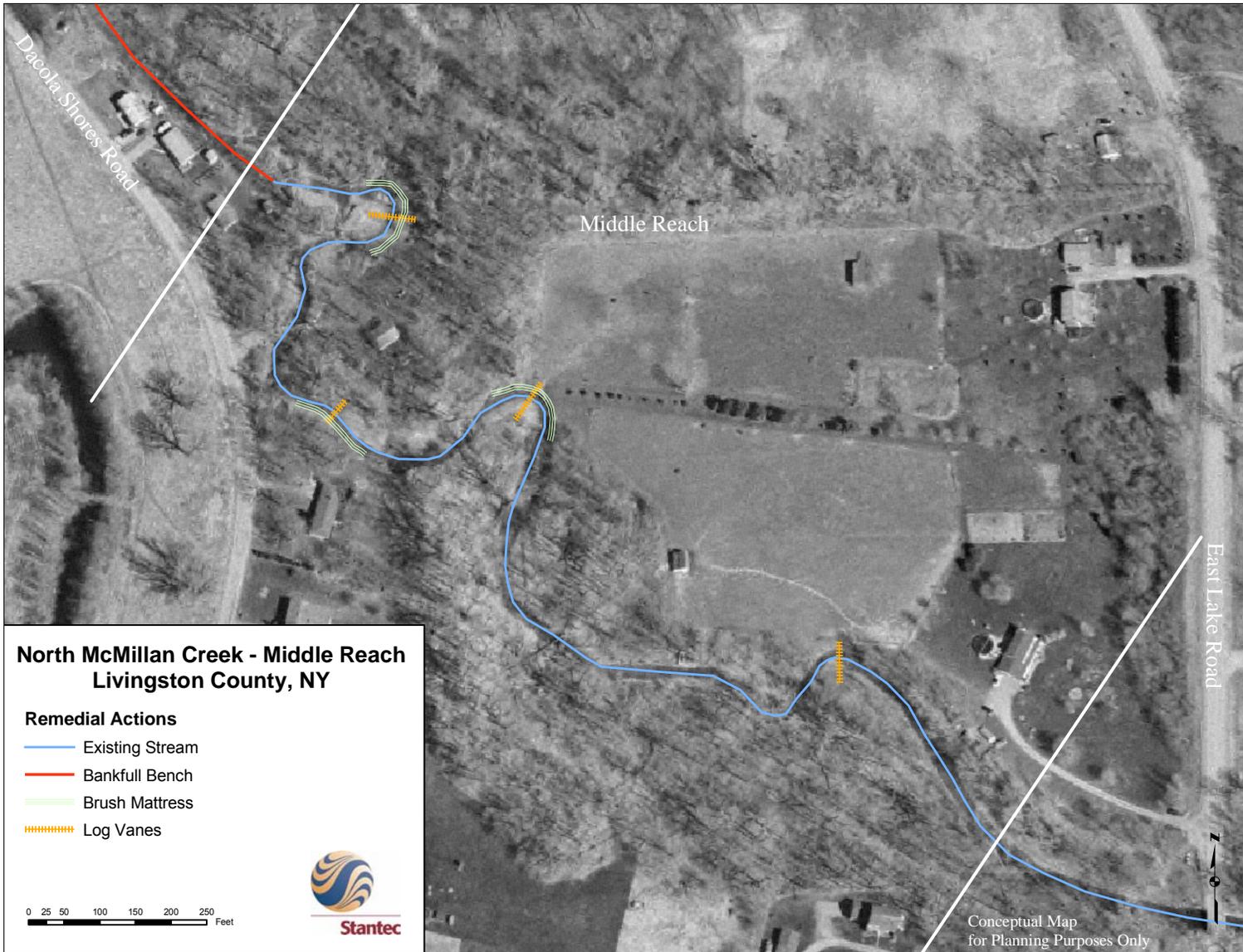
Upper Reach	77°42'12.39" W	42°43'24.43" N
Middle Reach	77°42'26.29" W	42°43'34.05" N
Lower Reach	77°42'34.76" W	42°43'40.50" N

7.2 Existing Watershed Land Use

The existing 5,150-acre watershed is 5% developed, 35% forested, and 60% agriculture. In the majority of the North McMillan watershed streams have riparian buffers that are greater than 200ft on either side of the channel. The reaches in this project are near Conesus Lake and do not have a well-vegetated buffers. Buffers have been cleared resulting in accelerated bank erosion. There were no noted signs of significant point or non-point sources of sediment or of any other pollution from the existing watershed during the site visit. The majority of the sediment is coming from in-stream bank erosion.









7.3 Upper Reach North McMillan Creek

The upper reach of North McMillan starts approximately 1,400 ft east of East Lake Road and is approximately 1,700 ft in length. Approximately 1,400 ft from East Lake Road there is a 100ft high valley wall that is actively eroding. During large storm events there is high sediment loading from the cut valley wall with shale deposits shearing from the bank. This reach has downcut and struck shale and bedrock vertical confinement. Although the invert of the stream has hit bedrock in some locations there are significant amounts of bank erosion due to excess forces during large storm events. There are two cut terraces that contribute the majority of the sediment from this reach. There is a 50-100 ft buffer on the left bank of this reach and a 0-25ft buffer on the right bank. There are signs of levees and dredging on both the right and left banks. The stream reach downstream from the cut valley wall is an over widened channel with one mid-channel bar and lateral bar formation from the supplied sediment upstream.

Photo 1 – Unstable eroding valley wall



Photo 2 - Unstable over-wide channel



7.3.1 Prediction of Future Erosion Potential Upper Reach North McMillan Creek

The upper reach of North McMillan Creek has moderate sediment loading. The over widened channel depends on the sediment supply to support formation of lateral bars that will eventually become a lower confined floodplain. The current state of channel evolution depends on a high sediment source for recovery. The mid-channel bar in this reach will transition to a lateral bar with the replenishment of sediment. There will continue to be bank erosion if the stream buffers remain narrow or non-existent. As a floodplain forms and the lateral bank expands, flows will be concentrated on the channel side. Concentration of flow, causing near bank stress, will erode the streambanks. To allow the upper reach of North McMillan to deposit sediment and form a new floodplain in the existing valley would be a fairly low probability of recovery, assuming levees and dredging was maintained or continued.

7.3.2 Remedial Action Upper Reach of North McMillan Creek

The opportunity to restore the stream in this reach is minimal due to the reach being confined by bedrock and shale. The sediment source is aiding in the recovery of this

reach. The buffer on the opposite side of the lateral bars should be planted and a buffer of at least 25ft should be considered.

7.4 Middle Reach North McMillan Creek

The middle reach of North McMillan is west of East Lake Road. This reach has a broad historic floodplain terrace. This reach is approximately 2,000ft of high sinuous moderately incised channel that is no longer connected to the historic floodplain. With the sediment supply, current vegetation, and the existing sinuosity, the channel is unstable. This reach has significant bank migration, chute cut offs, traverse bars and channel evolutions. The bank erosion resulting from the current instability is causing large trees to fall into the streambank. There is a landowner who is experiencing structural foundation undermining, land loss and loss of large trees. There is a 100-200 ft buffer on the left bank of this reach and a 0-50ft buffer on the right bank.

Photo 3 - Unstable over-wide channel



Photo 4 – Bank migration and erosion



7.4.1 Prediction of Future Erosion Potential Middle Reach North McMillan Creek

The middle reach will continue to be laterally unstable until the floodplain has reached a stable form. Currently the sediment supply on this reach is dominated by sediment from bank erosion. The bank erosion, channel migration and lack of buffer will lead to a chute cut off and significant channel evolutions. The water and sediment supply of the watershed will dictate the stable form of the stream channel.

7.4.2 Remedial Action Middle Reach of North McMillan Creek

The middle reach of North McMillan has significant bank erosion and that dominates the sediment load. It is recommended that the middle reach be relocated, the related floodplain be re-graded, and the banks be stabilized to deal with current watershed conditions. The 2,000 ft relocation/restoration will utilize **log vanes** and **rock vanes** to stabilize and hold grade for the relocated channel. **Rock vanes** will be used to divert flows from foundations. **Brush mattresses** and cutting a **bankfull bench** will provide bank stability and reduce the near bank stress. (Specifications and details for bold/italicized items can be found in the Appendix).

The stabilization and re-grading of this lower reach will enable the stream to transport the sediment supplied from upstream without contributing additional sediment to the system. The channel relocation will also reduce the erosional forces that are contributing to the property loss at the lower section of the middle reach of North McMillan. It is also recommended that a minimum 25ft buffer be maintained over the entire reach

7.5 Lower Reach North McMillan Creek

The lower reach of North McMillan Creek is 1,000 feet of straightened channel to the confluence with Conesus Lake. The lower reach has historically been modified to encourage drainage and reduce flooding. Both banks have retaining walls and large boulders to protect the banks from erosion and protect structural foundations. The right bank of this reach is within 30 ft of causing severe structural foundation damage. The last 500 ft of the stream is under backwater influence.

Photo 5 - Left bank boulder toe protection



Photo 6- Right bank retaining wall



7.5.1 Prediction of Future Erosion Potential Lower Reach North McMillan Creek

The lower reach of North McMillan will continue to cut away at both banks in the upper 500ft of the free flowing section of this reach. The channel will continue to deposit sediment and redirect flows with a result of channel meandering. The natural stable form and pattern of North McMillan Creek would be a sinuous channel with a dimension of near 75 square ft. In the lower reach of North McMillan the channel is straightened and levied. The channel does not have access to a floodplain for relief from large flows, nor does it have a meandering pattern to dissipate excess energy. The result will be continued bank erosion as the channel carves a stable pattern and new floodplain. The foundation of the residential dwelling will be undermined and the land loss will continue until the left bank is stabilized. The right bank erosion and possible failure of retaining walls and structures will also progress. The levees assist in increasing the forces for sediment transport and bank erosion.

7.5.2 Remedial Action Lower Reach of North McMillan Creek

On the lower reach, flood protection and property protection are the primary goals. Relocation and restoration of dimension, pattern and profile is recommended for this reach. This will limit the risk to property by dealing with sediment supply and providing a

stable channel form. The restored reach will have a **bankfull bench** and utilize **rock vanes**. The left bank will require rebuilding levees as set back levees (set back approximately 45 ft). A **bankfull bench** should provide protection for the right bank.

If it is not possible to relocate the channel in this section, then the channel should, at a minimum, have **rock vanes** installed to deflect flow away from eroding banks, boulder rock toe armoring and a **bankfull bench** to reduce erosional forces.

8.0 Southwest Creek

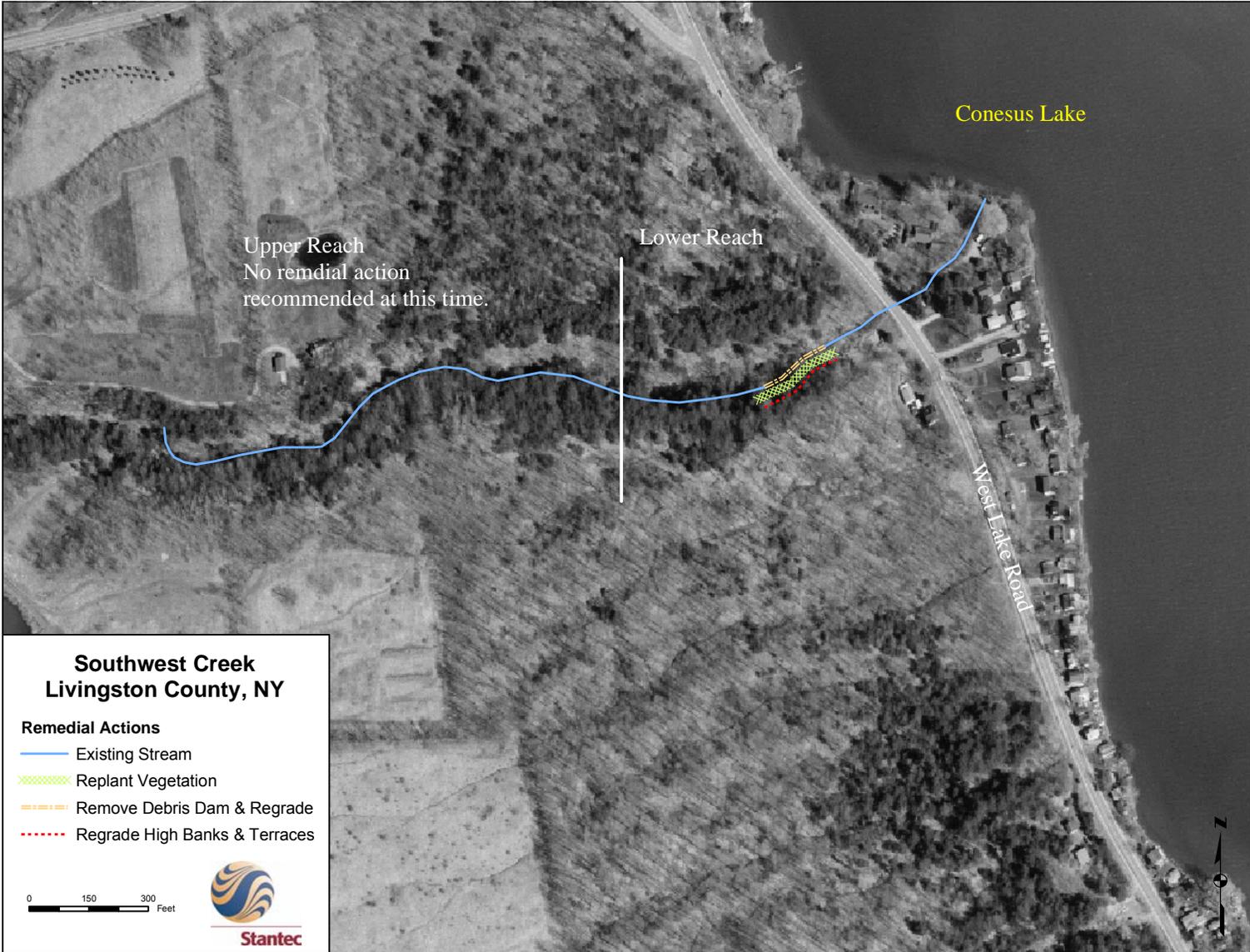
8.1 General Site Condition

Southwest Creek is located on the southwest side of Conesus Lake. The original estimation of degraded stream channel to be assessed on Southwest Creek was 4,800 linear feet. In actuality, there were 2,450 linear feet of degraded stream on which Stantec performed a geomorphic assessment. This section of Southwest Creek has a vertical fall of approximately 160 ft and an average slope of 6.5 %. This segment of Southwest Creek also includes a reach of waterfalls and cascades that have a maximum vertical drop of 80ft per geologic formation. GPS coordinates for the most downstream point of each reach are:

Upper Reach	77°43'21.66" W	42°43'37.33" N
Lower Reach	77°43'09.28" W	42°43'42.17" N

8.2 Existing Watershed Land Use

The existing 320-acre watershed is 2% developed, 33% forested and 65% agriculture. The majority of the Southwest Creek has a riparian buffer that is greater than 100ft on either side of the channel. The reaches that fall beyond the project scope have less riparian buffer and more intensive agriculture. The land use observations are assumptions from aerial photography of the entire watershed. There were no signs noted of significant point or non-point sources of sediment or any other pollution from the existing watershed during the site visit. The majority of the sediment is a result of processes throughout the observed project reach. Sediment is being efficiently transported through the steep upper reach and then deposited in the lower reach. There is a significant sediment source, most likely from streambank erosion compounded with a high sediment load from agriculturally related hill slope erosion.







8.3 Upper Reach Southwest Creek

The upper reach of Southwest Creek is a very high gradient cascade and waterfall system that is vertically confined by bedrock. This reach is approximately 1,500ft in length. This reach is stable for the valley, there are small debris dams that form behind geologic formation but these are typical of high-energy systems like this reach. There is one major waterfall and several 5-15ft cascades and geologic formations.

Photo 1 – Waterfall ~80ft drop



Photo 2 –Stable confined valley type



8.3.1 Prediction of Future Erosion Potential

The upper reach of Southwest Creek will remain stable as long as the buffers are maintained.

8.3.2 Remedial Action

There should be minimal done in the upper reach since this reach is stable and well vegetated. The buffer in the watershed should be maintained and buffers should be established for major tributaries of the creek.

8.4 Lower Reach Southwest Creek

The lower reach of Southwest Creek is 1,000 ft in length and characterized by sediment debris dams and an over wide channel. The lower reach has historically been levied on the right bank to encourage drainage and reduce flooding. This reach starts at the beginning of a valley change. The valley goes from a severely confined valley to a moderately confined valley. The sediment deposits are dominated by shale.

Photo 3 – Over wide incised channel



Photo 4- Sediment debris dam



8.4.1 Prediction of Future Erosion Potential

The lower reach will continue to be unstable until the floodplain has reached a stable form. The lower reach is serving as sediment sink with the sediment deposition occurring on the bars and benches to fill in the over wide channel. Currently the sediment supply on this reach is from upstream bank erosion. The water and sediment supply of the watershed will dictate the stable form of the stream channel. The lower sediment debris dam is within 150 ft of West Lake Road. A major dam break would cause debris to flow downstream and jam the roadway culvert. If the roadway culvert is jammed the roadway would be overtopped and risk of roadway failure would be increased.

8.4.2 Remedial Action

The lower reach of Southwest Creek has minimal bank erosion and is currently aggrading. Transported sediments from upstream dominate the sediment load of this reach. It is recommended that the unstable sediment dam near the roadway be removed and re-graded as needed. Artificial sediment dams can be constructed that allow for a preferential low flow channel. The stabilization and re-grading of sediment dams on the lower reach will enable the stream to transport the sediment supplied from upstream without contributing additional sediment and to the system. Removal of some large trees and replanting of understory vegetation may be needed to stabilize the banks. The right bank of the channel should be lowered and re-graded adding a setback levee (setback approximately 30 ft).

9.0 Groveland Rivulet

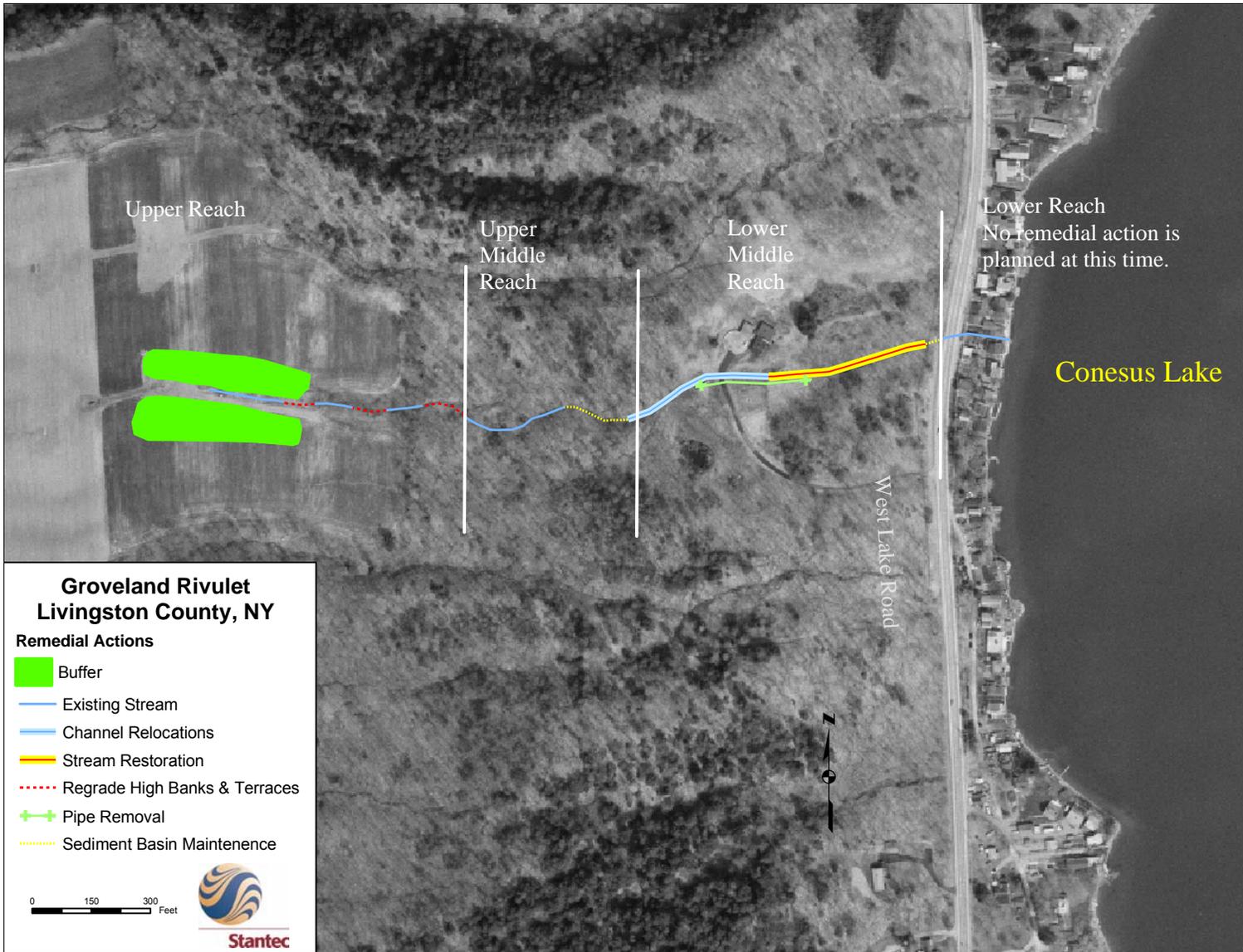
9.1 General Site Condition

Groveland Rivulet is located on the west side of Conesus Lake. The original estimation of degraded stream channel to be assessed on Groveland Rivulet was 1,800 linear feet. In actuality, there was 2,100 linear feet of degraded stream on which Stantec performed a geomorphic assessment. This section of Groveland Rivulet has a vertical fall of approximately 210 ft and an average slope of 10%. GPS coordinates for the most downstream point of each reach are:

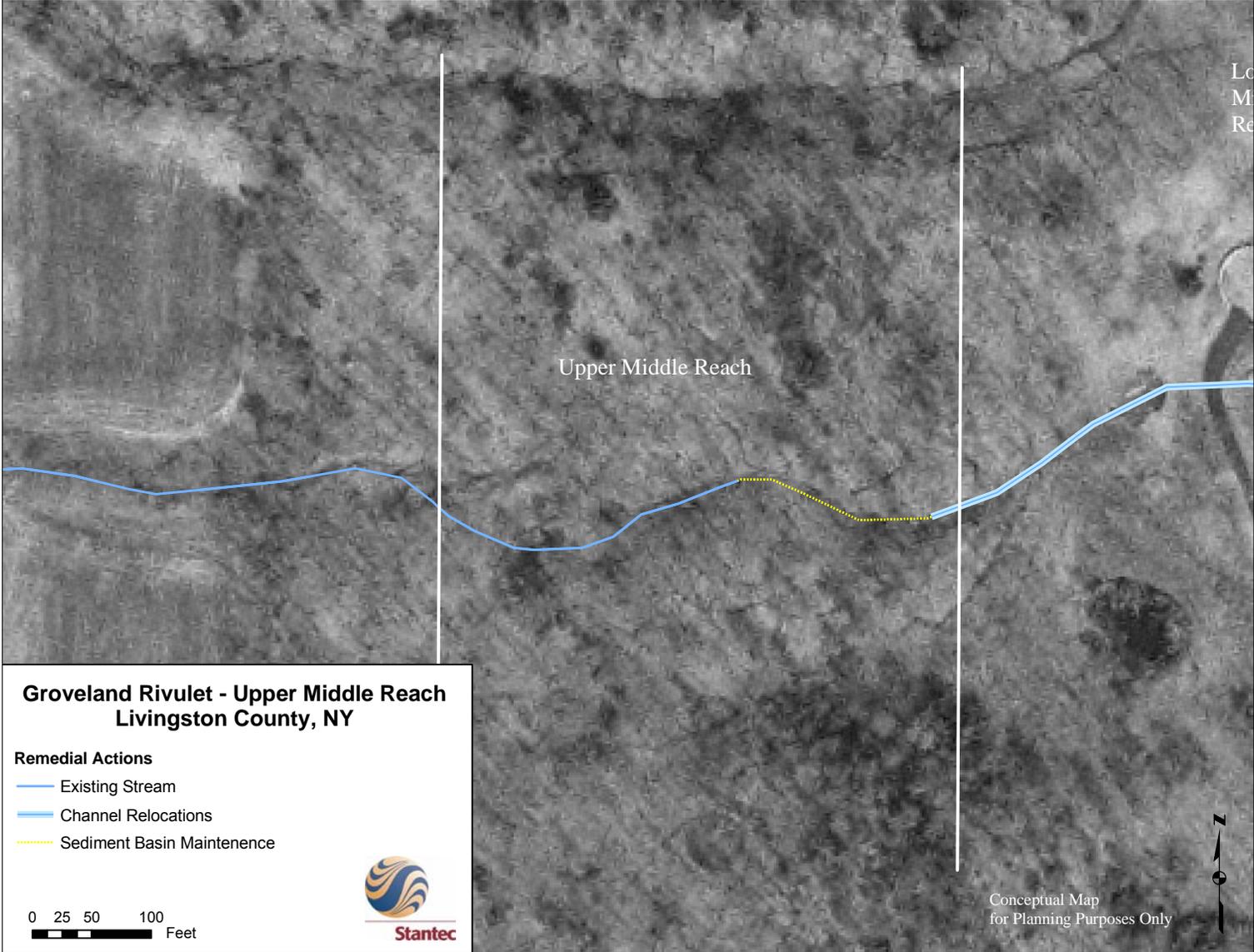
Upper Reach	77°43'55.70" W	42°44'44.89" N
Upper Middle Reach	77°43'49.91" W	42°44'44.89" N
Lower Middle Reach	77°43'39.56" W	42°44'46.69" N
Lower Reach	77°43'37.20" W	42°44'46.68" N

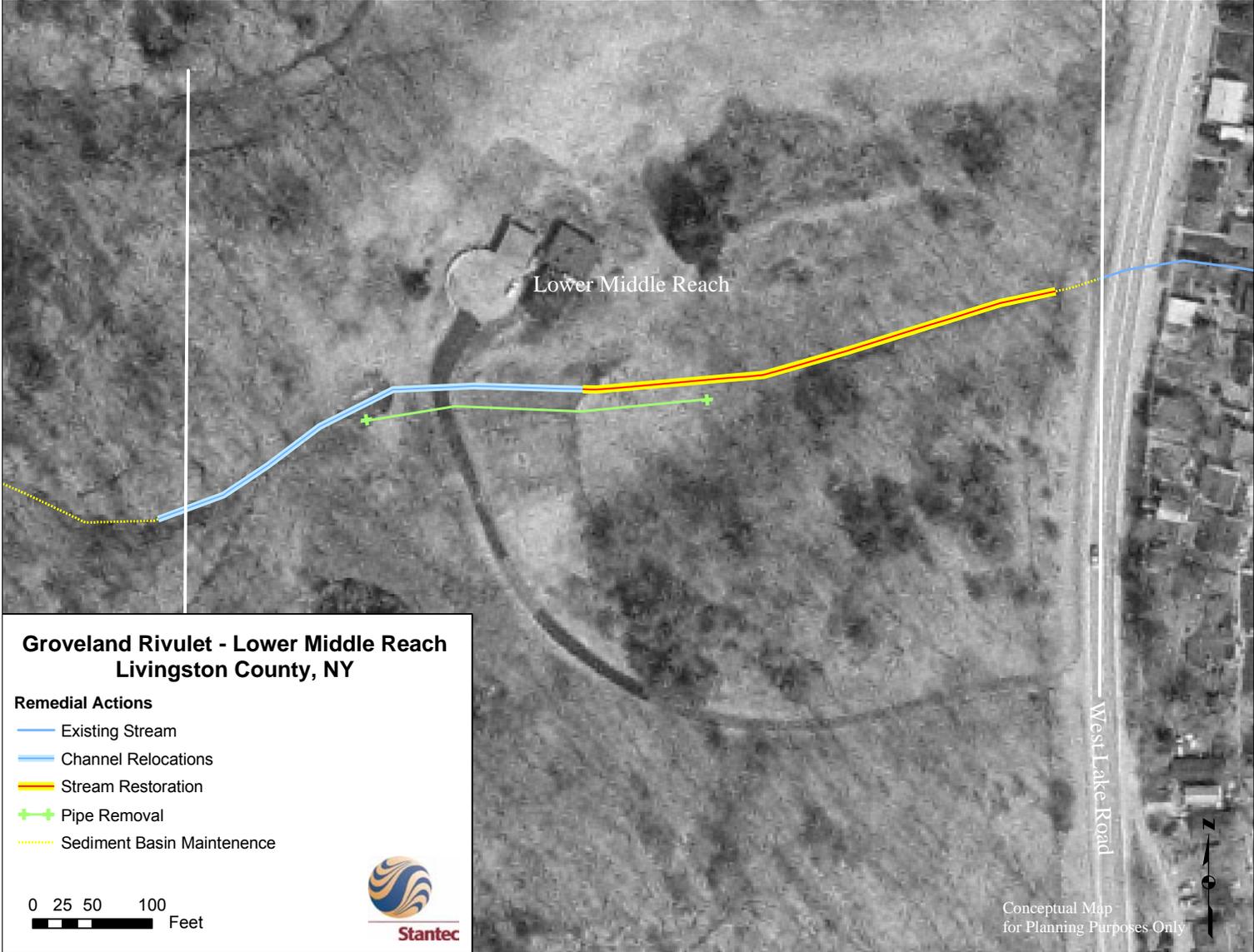
9.2 Existing Watershed Land Use

The existing 80-acre watershed is 5% developed, 60% forested and 35% agriculture. The majority of the lower reaches of Groveland Rivulet watershed have a riparian buffer that is greater than 100 ft on either side of the channel. The headwaters of the reach are in agriculture and do not have a well-established buffer. The farmland in the watershed of the upper reach has been actively managed and is still currently in production. The reach flowing into Conesus Lake is piped and does not have a buffer. There were no other noted signs of significant point or non-point sources of sediment or of any other pollution from the existing watershed during the site visit. The majority of the sediment is coming from in-stream bank erosion and legacy sediment in the sediment dams.











9.3 Upper Reach Groveland Rivulet

The upper reach of Groveland Rivulet has been historically modified and converted to farmland. The past agricultural practice has produced massive amounts of sediment inputs to the downstream rivulet. Many of the fine sediments detached during tilling and agriculture are still in sediment dams and deposits within the downstream valley. These sediments are considered legacy sediments; they may still have nutrients and pesticides attached to the soil particle. Conservation techniques are being employed by the farmer that limits the amount of sediment loss from hillslope erosion. There are catchments installed with underdrains to allow sediment to settle while the water is conveyed to the rivulet. In the lower half of this reach a 20ft buffer has been reestablished. This reach is approximately 500ft in length.

Photo 1 – Catchment basin and standpipe



Photo 2 –Tile drain outfall to the rivulet



9.3.1 Prediction of Future Erosion Potential

The upper reach of Groveland Rivulet will remain stable as long as the buffer is maintained and soil conservation practices are employed for agriculture. The increased drainage from the tile drains will produce a localized scour and erosion near the drain outlets but this scour will be local.

9.3.2 Remedial Action

There should be minimal actions taken in the upper reach since this reach is moderately stable and well vegetated. The buffer in the watershed should be planted and maintained. There should be a buffer around significant tributaries in the watershed. The existing buffer should be expanded both laterally and longitudinally.

9.4 Upper Middle Reach Groveland Rivulet

The upper middle reach of Groveland Rivulet is approximately 700ft. This reach of stream has a sediment dam step pool profile. In much of the valley the sediment dam is formed on an outcrop of bedrock by logs and boulders getting trapped behind the bedrock pinch point in the valley. These alternating debris fans have shale deposits as well as legacy sediments embedded into the deposited materials. These legacy

sediments have been transported from the upland areas during intensive agricultural and tilling periods. This reach is the steepest reach of this segment of stream. There is active erosion of banks and shale outcrops. There are currently many sediment and debris dams that accelerate local instability. There are also locations of a headcut through a formed sediment dam. This reach has significant bank migration, chute cut offs, traverse bars and channel evolutions. In many locations the grade has hit shale and bedrock vertical confinement. Although the invert of the stream has hit bedrock in some locations there is significant bank erosion due to excess forces during large storm events. There is a 100ft or greater buffer on both banks of this reach. Sediment deposition and mass wasting of the banks has resulted in localized contraction of low flows and high shear forces. An increase in shear stress and a decrease in riparian vegetation will result in an increase in bank erosion and instability.

Photo 3 – Confined Valley



Photo 4 –Bank erosion



9.4.1 Prediction of Future Erosion Potential

The upper middle reach of Groveland Rivulet has high sediment loading. The debris and log jam profile of this reach will continue until bedrock confinement is reached or the sediment from upstream is deposited on the downstream sediment fans to hold grade. The latter will occur once the upstream section has eroded enough material to carve a floodplain at a lower elevation. There will continue to be large quantities of mass wasting of banks and terraces. Shale valley walls that confine the stream will continue to shear and shale deposits will be transported downstream.

9.4.2 Remedial Action

There should be minimal actions taken in the upper middle reach as much of this reach is confined by bedrock and shale. Some selected shale outcrops that are confining the stream should be removed. It is recommended that unstable sediment dams be removed and re-graded as needed. It will be more efficient to deal with the sediment source on the downstream reaches. The buffer in the watershed should be planted and maintained. There should be a buffer around significant tributaries in the watershed.

9.5 Lower Middle Reach Groveland Rivulet

The lower middle reach of Groveland Rivulet is approximately 500ft. This reach of Groveland Rivulet has a broad floodplain terrace. The existing reach has been piped and

buried. The 12" ductile iron pipe has been separated and clogged and is now failing to convey water efficiently. The former stream channel is being activated and there are areas of small sinkholes where the storm flows are starting to flow subterranean along the outside surface of the pipe. There is some erosion and scour due to the contraction of flow around the pipe and the subterranean erosion.

Photo 5 – Culvert under driveway & rip rap



Photo 6 – Exposed and failing pipe



9.5.1 Prediction of Future Erosion Potential

The lower middle reach will continue to be unstable with the exposed pipe deflecting and constricting flow. There is a stable floodplain but the channel will not be able to stabilize without the removal of the drainage pipe. The landowners yard will collapse into a new stream channel as the material is eroded downstream.

9.5.2 Remedial Action

The lower middle reach of Groveland Rivulet should be daylighted. The channel design for this section should be a grass-lined waterway with turf reinforcement within the lawn of the property owner. The lower reach should also be daylighted and re-graded to serve as a sediment fan with a stable relocated stream channel but this would require the removal of residential dwellings. Transported sediments from upstream dominate the sediment load of this reach. An artificial sediment dam can be constructed that will allow for a preferential low flow channel. **Rock cross vanes** may be required to stabilize and provide grade control to the newly formed channel. (Specifications and details for bold/italicized items can be found in the Appendix). This reach should have the buffer replanted and vegetated upon relocation of the channel.

9.6 Lower Reach Groveland Rivulet

The lower reach of Groveland Rivulet is 400 ft in length and piped until Groveland Rivulet enters into Conesus Lake. There is a 50-year or older sediment trap that was built to limit the sediment loading entering in to the lake. The concrete sediment trap is the only area of the lower two reaches that was designed to be daylighted. A contractor could easily maintain the sediment trap from West Lake Road if needed.

Photo 7 – Sediment trap



Photo 8- Outfall of the Groveland Rivulet



9.6.1 Prediction of Future Erosion Potential

The lower reach of Groveland Rivulet is piped and the sediment trap will eventually fill and need to be maintained.

9.6.2 Remedial Action

The lower reach of Groveland Rivulet is piped. The sediment trap should be maintained as needed. The lower reach should also be daylighted and re-graded to serve as a sediment fan with a stable relocated stream channel but this would require the removal of residential dwellings.

10.0 Long Point Creek

10.1 General Site Condition

Long Point Creek is located on the west side of Conesus Lake. The original estimation of degraded stream channel to be assessed on Long Point Creek was 6,400 linear feet. In actuality, there were 7,950 linear feet of degraded stream on which Stantec performed a geomorphic assessment. This section of Long Point Creek has a vertical fall of approximately 130 ft and an average slope of 1.6 %. GPS coordinates for the most downstream point of each reach are:

Upper Reach	77°43'38.16" W	42°46'46.60" N
Middle Reach	77°43'21.93" W	42°46'48.51" N
Lower Reach	77°43'13.36" W	42°46'44.51" N

10.2 Existing Watershed Land Use

The existing 1,350-acre watershed is 5% developed, 25% forested and 70% agriculture. The majority of the streams in the Long Point watershed have a riparian buffer that is greater than 100 ft on either side of the channel. The project segment is near Conesus Lake and does not have a well-vegetated buffer over much of the project reaches. Buffers have been cleared resulting in accelerated bank erosion. There were no noted signs of significant point or non-point sources of sediment or any other pollution from the existing watershed during the site visit. The majority of the sediment is coming from in-stream bank erosion.









10.3 Upper Reach Long Point Creek

The upper reach starts approximately 7,000 ft west of West Lake Road. This reach is approximately 5,950 ft in length. The combinations of existing sinuosity, current sediment supply, and bank vegetation make this reach exceedingly unstable. This reach has significant bank migration, chute cut offs, traverse bars, and channel evolutions. In some locations the reach has downcut and hit shale and bedrock vertical confinement. The high sediment load of this reach produces sediment and debris jams in the valley where the valley expands. Although the invert of the stream has hit bedrock in some locations there is significant bank erosion due to excess forces during large storm events. Sediment deposition and mass wasting of the banks results in localized contraction of low flows and high shear forces. There is a 100+ ft buffer on both banks of this reach.

Photo 1 – Unstable eroding streambanks



Photo 2 – Sediment and debris fan



10.3.1 Prediction of Future Erosion Potential

The upper reach of Long Point has high sediment loading. The debris and log jam profile of this reach will continue until bedrock confinement is reached or sediment from upstream is deposited on downstream sediment fans to hold grade. The latter will occur once the upstream section has eroded enough material to carve a floodplain at a lower elevation. There will continue to be large quantities of mass wasting of banks and terraces.

10.3.2 Remedial Action

The opportunity to restore the stream in this reach is minimal due to the reach being confined by bedrock and shale. The sediment source is adding to the recovery of the downstream reach. The buffer in the watershed should be planted and maintained. There should also be a buffer around significant tributaries to this reach.

10.4 Middle Reach Long Point Creek

The middle reach of Long Point is east of West Lake Road. This reach has a broad historic floodplain and consists of 1,100ft of moderately sinuous and moderately incised

channel. The stream has downcut, departing from the historic floodplain. There is evidence of bank erosion and bank migration. The bank erosion is resulting in instability in the streambanks causing large trees to fall into the stream channel. There is a 100-200 ft buffer on both streambanks.

Photo 3 – Bank erosion cut terrace



Photo 4 – Bank erosion and floodplain



10.4.1 Prediction of Future Erosion Potential

The middle reach will continue to be laterally unstable until the floodplain has reached a stable form. The middle reach is serving as a sediment sink as the valley opens and deposition occurs on the bars and benches to fill in the over wide channel. Currently the sediment supply on this reach is dominated by upstream sediment. The water and sediment supply of the watershed will dictate the stable form of the stream channel.

10.4.2 Remedial Action

The middle reach of Long Point has bank erosion but is currently aggrading. Relocation and restoration of 1,100 ft of stream, changing the dimension, pattern and profile to deal with current watershed sediment supply, is recommended.

Log vanes and **rock vanes** will be used in the relocated channel to stabilize and hold grade in the new channel. **Brush mattresses** and a **bankfull bench** will be utilized to stabilize banks and reduce stress on the channel sides. (Specifications and details for bold/italicized items can be found in the Appendix).

10.5 Lower Reach Long Point Creek

The lower reach of Long Point is 900 ft of straightened channel and the confluence with Conesus Lake. The lower reach has historically been modified to encourage drainage and reduce flooding. Concrete, riprap and metal barrels are being used to prevent the channel from meandering and eroding the streambanks. Both banks have retaining walls to protect from erosion and protect structural foundations. These retaining walls or levees contain large storms which then lead to scour the streambed. Large amounts of scour are causing the water to slow and become essentially stagnant. This effect is undesirable for adjacent landowners. The stream is under backwater influence for the lower 500 ft.

Photo 5 – Driveway and bank erosion



Photo 6- Retaining walls and levees



10.5.1 Prediction of Future Erosion Potential

The lower reach of Long Point will continue to cut away at both banks in the upper 900ft of the free flowing section of this reach. The channel will continue to meander. The natural stable form and pattern of Long Point Creek would be a sinuous channel with a dimension of nearly 30 ft². In the lower reach of Long Point Creek the channel is straightened and leved and therefore has no access to a floodplain for large flows. The result will be continued bank erosion as the channel carves a stable pattern and new floodplain. The foundation of the residential dwelling will be undermined, the driveway on the left bank will slump into the stream and the land loss will continue until the left bank is stabilized. The right bank erosion and possible failure of retaining walls and structures will also progress. Levees will increase the shear forces causing bank erosion and scour, increasing the propensity of stagnant water.

10.5.2 Remedial Action

On the lower reach, flood protection and property protection are the primary goals. Relocation and restoration of dimension, pattern, and profile is recommended for this reach. This will limit the risk to property by dealing with sediment supply and providing a stable channel form. The restored reach will have a **bankfull bench** and utilize **rock vanes**. The left bank will require rebuilding levees as set back levees (set back approximately 20 ft). A **bankfull bench** should reduce the stress on the right bank.

If it is not possible to relocate the channel in this section, **rock vanes** should be installed to deflect flow away from eroding banks, and a **bankfull bench** should be created to reduce erosional forces.

11.0 Sand Point Creek

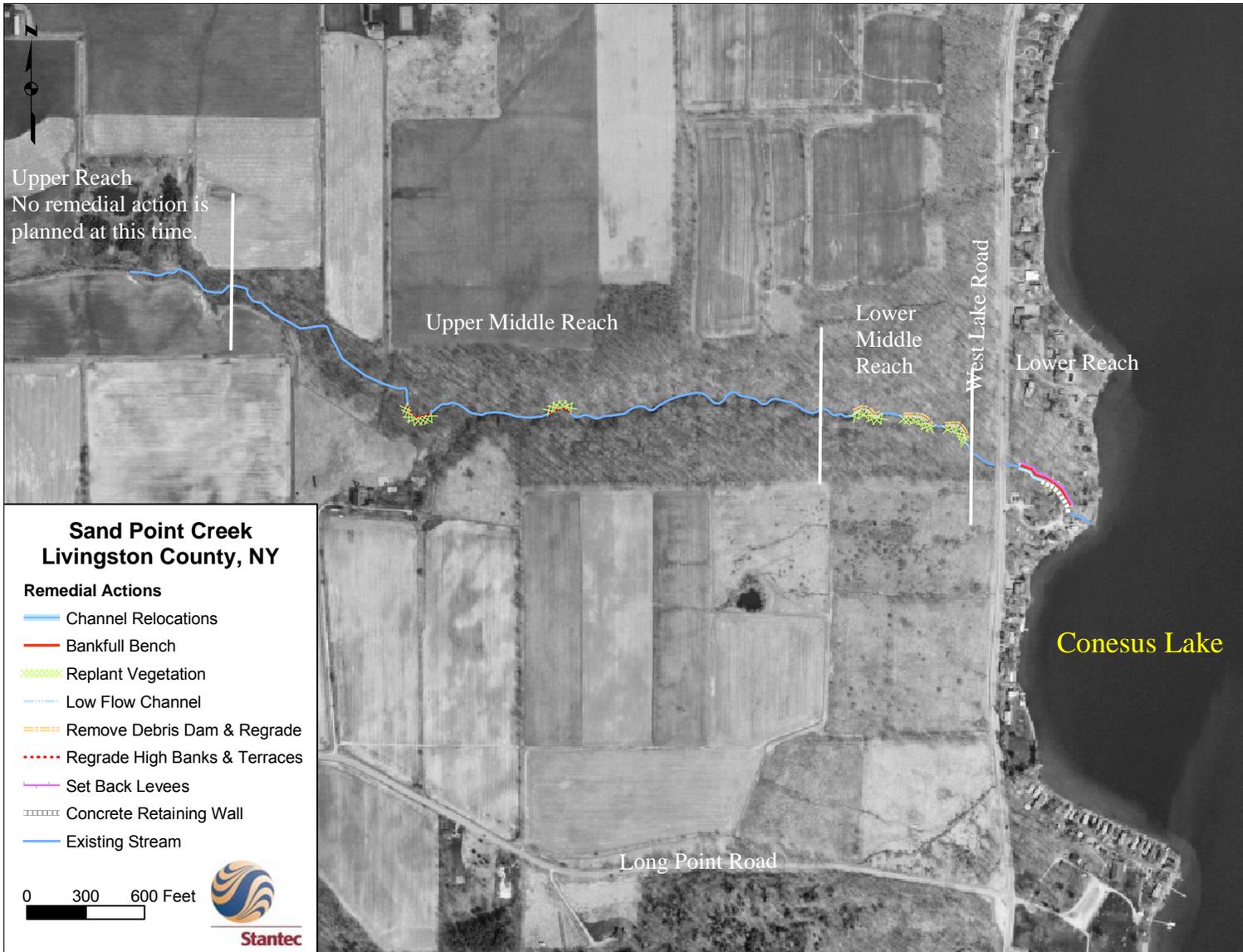
11.1 General Site Condition

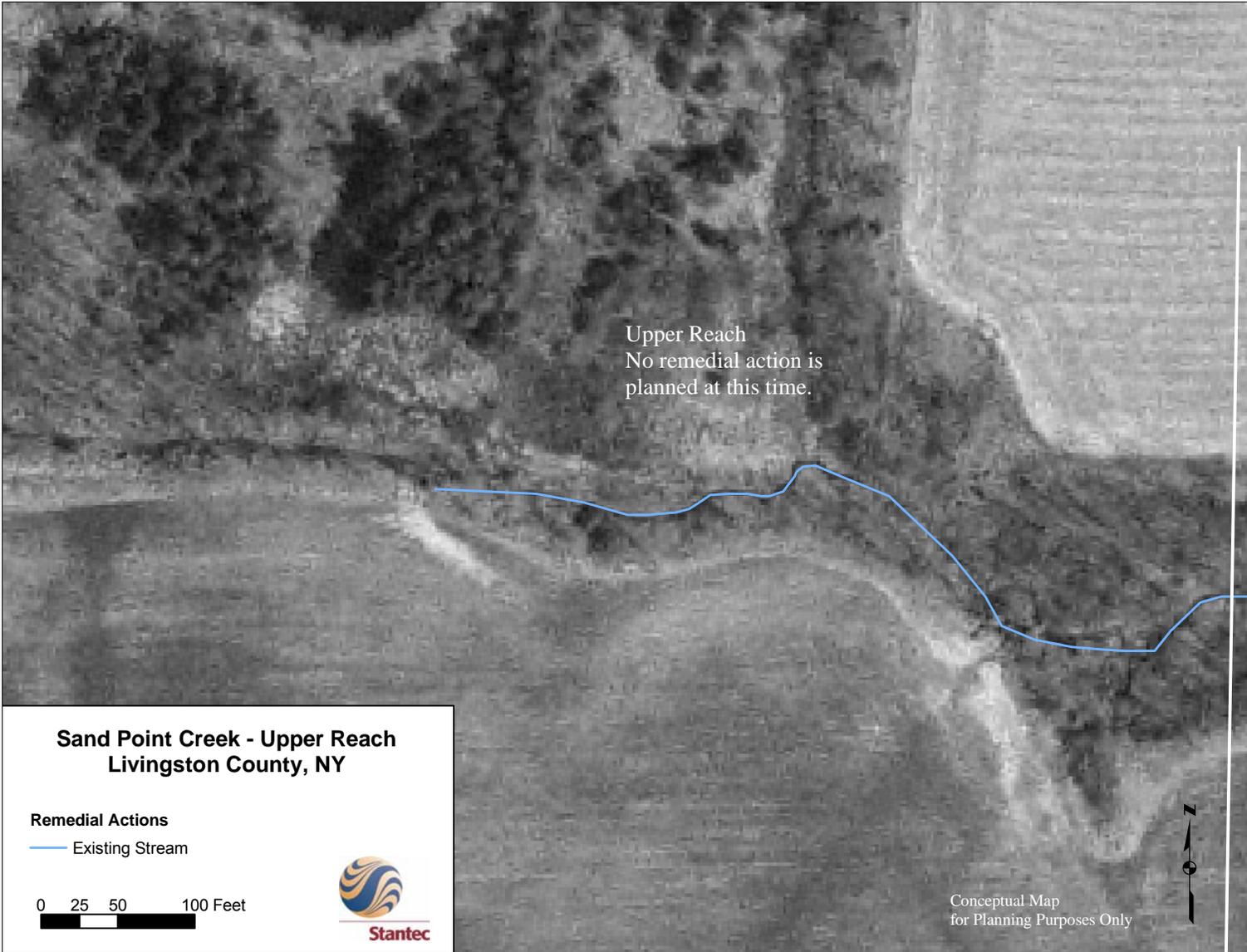
Sand Point Creek is located on the west side of Conesus Lake. The original estimation of degraded stream channel to be assessed on Sand Point Creek was 7,000 linear feet. In actuality, there was 5,800 linear feet of degraded stream on which Stantec performed a geomorphic assessment. This section of Sand Point Creek had a vertical fall of approximately 80 ft and an average slope of 1.4 %. GPS coordinates for the most downstream point of each reach are:

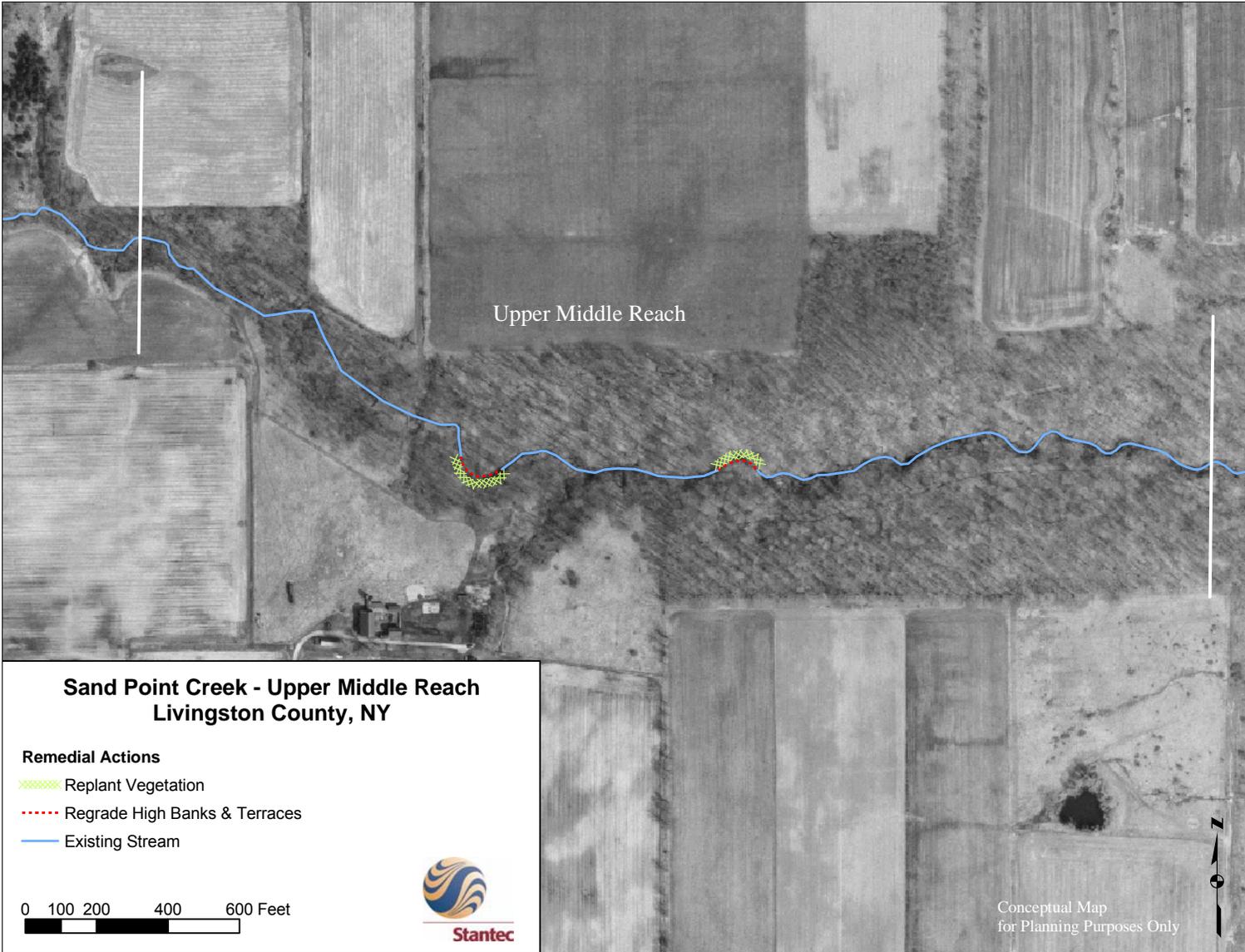
Upper Reach	77°44'14.23" W	42°47'22.68" N
Upper Middle Reach	77°43'34.22" W	42°47'16.20" N
Lower Middle Reach	77°43'23.59" W	42°47'14.37" N
Lower Reach	77°43'15.75" W	42°47'10.52" N

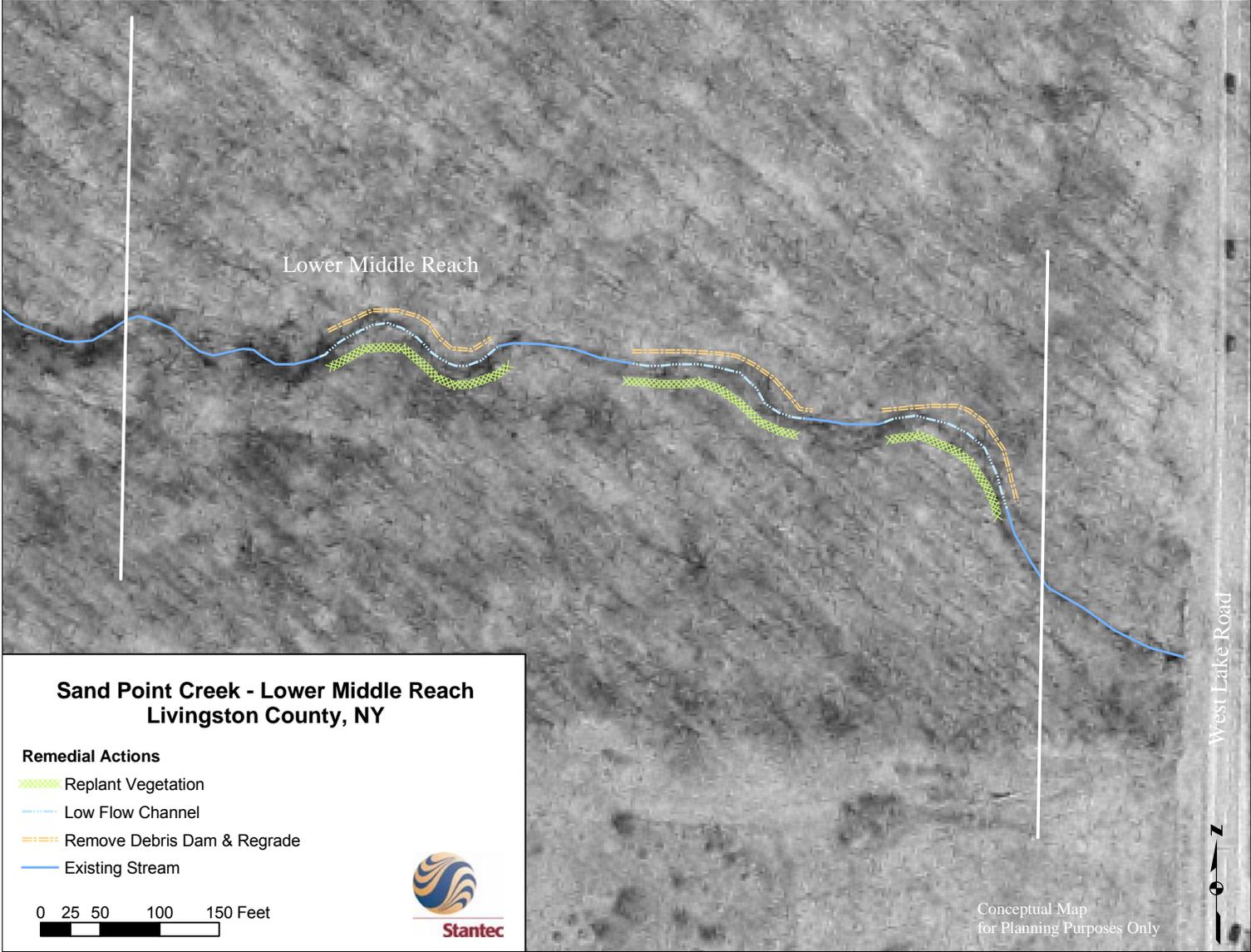
11.2 Existing Watershed Land Use

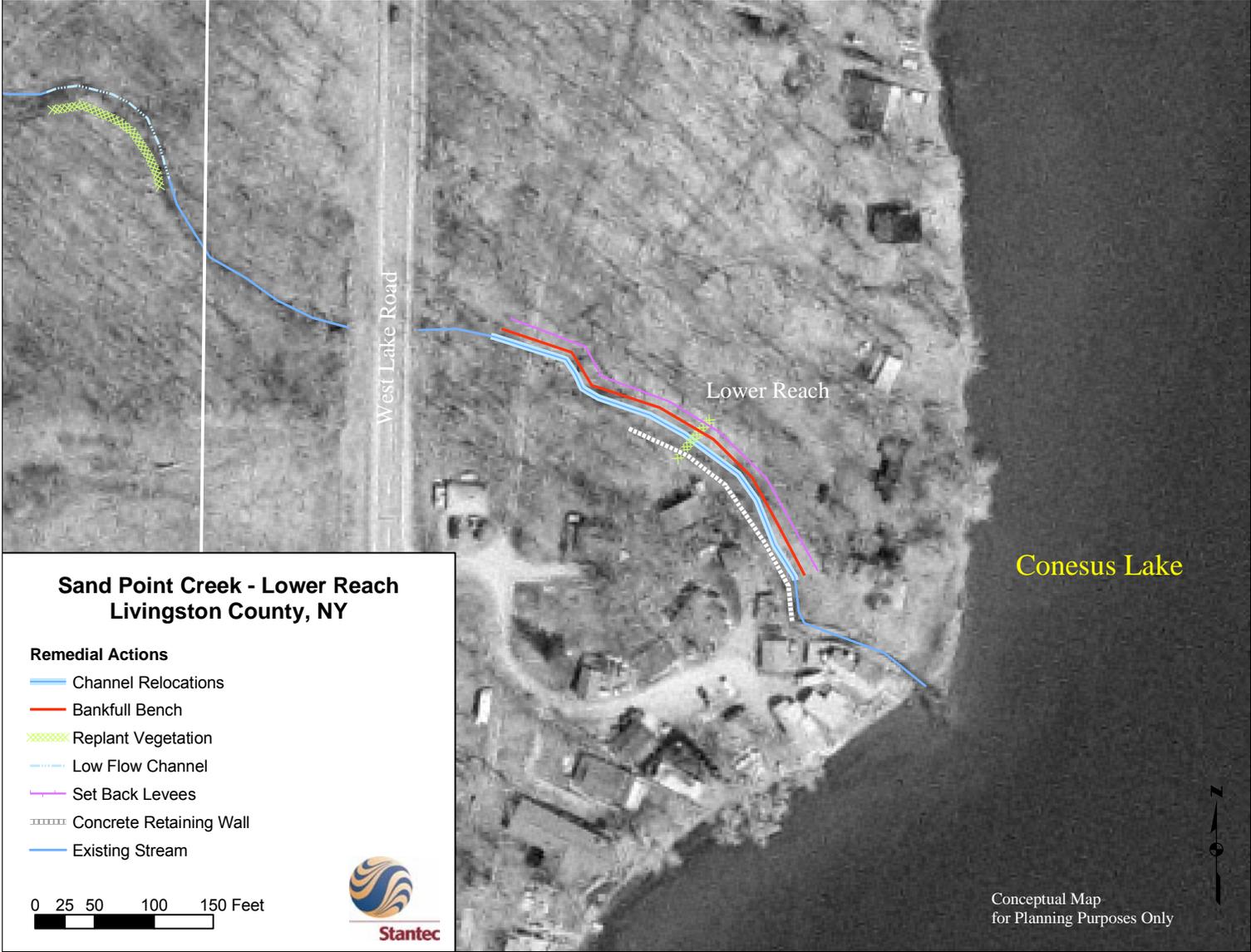
The existing 738-acre watershed is 5% developed, 15% forested and 70% agriculture. The majority of the streams in the Sand Point watershed have a riparian buffer that is greater than 100 ft on either side of the channel. This project area was near Conesus Lake and does not have a well-vegetated buffer over much of the project reaches. Buffers have been cleared resulting in accelerated bank erosion. There were no noted signs of significant point or non-point sources of sediment or of any other pollution from the existing watershed during the site visit. The majority of the sediment is coming from in-stream bank erosion.











11.3 Upper Reach Sand Point Creek

The upper reach of Sand Point is a low gradient wetland system with a low flow pilot channel. The banks are well vegetated and stable. There is very good connection to the floodplain and as a result there is low shear stress. There is very little bank erosion on this reach. There is an embankment and 12 inch culvert that is set at grade at the lower end of the upper reach of Sand Point Creek. This reach is approximately 800ft in length.

Photo 1 – Wetland with low flow channel



Photo 2 –vegetation & floodplain connection



11.3.1 Prediction of Future Erosion Potential

The upper reach of Sand Point will remain stable as long as the buffer is maintained and soil conservation practices are employed for agriculture.

11.3.2 Remedial Action

There should be minimal actions taken in the upper reach since this reach is stable and well vegetated. The buffer in the riparian corridor should be planted and maintained, in addition the buffer of tributaries to Sand Point within the watershed should also be enhanced.

11.4 Upper Middle Reach Sand Point Creek

The upper middle reach of Sand Point Creek is approximately 2,500 ft. This is the steepest reach of the four studied reaches. There is active erosion of banks and shale outcrops. There are currently many sediment and debris dams that accelerate local instability. There is also a headcut through a formed sediment dam. This reach has significant bank migration, chute cut offs, traverse bars, and channel evolutions. In many locations the grade has hit shale and bedrock vertical confinement. Although the invert of the stream has hit bedrock in some locations there is significant bank erosion due to excess forces during large storm events. There is a 100ft or greater buffer on both banks of this reach. Sediment deposition and mass wasting of the banks results in localized contraction of low flows and high shear forces. An increase in shear stress and a decrease in riparian vegetation will result in an increase in bank erosion and instability.

Photo 3 – Eroding shale banks



Photo 4 – Headcut – former sediment dam



11.4.1 Prediction of Future Erosion Potential

The upper middle reach of Sand Point has high sediment loading. The debris and log jam profile of this reach will continue until bedrock confinement is reached or the sediment from upstream is deposited on downstream sediment fans to hold grade. The latter will occur once the upstream section has eroded enough material to carve a floodplain at a lower elevation. There will continue to be large quantities of mass wasting of banks and terraces. Shale valley walls that confine the stream will continue to shear and shale deposits will be transported downstream.

11.4.2 Remedial Action

There should be minimal actions taken in this reach as it is confined by bedrock and shale. Some selected shale outcrops that are confining the stream should be removed. The sediment source is adding to the recovery of the downstream reach. The riparian buffers within the watershed should be planted and maintained.

11.5 Lower Middle Reach Sand Point Creek

The lower middle reach of Sand Point is approximately 1,900ft. This reach of stream has a sediment dam step pool profile. In much of the valley the sediment dam is formed on an outcrop of bedrock by logs and boulders getting trapped behind the bedrock pinch point in the valley. These alternating debris fans have shale deposits as well as legacy sediments embedded into the deposited materials. These legacy sediments have been transported from the upland areas during intensive agricultural and tilling periods.

Photo 5 – Sediment and debris deposition



Photo 6 – Sediment and debris dam



11.5.1 Prediction of Future Erosion Potential

The lower middle reach will continue to be unstable until the floodplain has reached a stable form. The lower middle reach is serving as sediment sink with deposition occurring on the bars and benches to fill in the over wide channel. Currently the sediment supply on this reach is dominated by upstream sediment. The water and sediment supply of the watershed will dictate the stable form of the stream channel.

11.5.2 Remedial Action

The middle reach of Sand Point Creek has minimal bank erosion and is currently aggrading. Transported sediments from upstream dominate the sediment load of this reach. It is recommended that unstable sediment dams be removed and re-graded as needed. Artificial sediment dams can be constructed that allow for a preferential low flow channel. ***Rock cross vanes*** may be required to stabilize and provide grade control to the newly formed channel. (Specifications and details for bold/italicized items can be found in the Appendix).

11.6 Lower Reach Sand Point Creek

The lower reach of Sand Point Creek is 700 ft in length and is straightened until Sand Point enters into Conesus Lake. The lower reach has historically been modified to encourage drainage and reduce flooding. Concrete and rip rap are being used to prevent the channel from meandering and eroding the streambanks. The right bank has a retaining wall to protect the bank from erosion and protect structure foundations. These retaining walls or levees contain large storms resulting in scour of the streambed. The extended scour of the streambed causes stagnant water that is undesirable for the adjacent landowners. There is a sediment fan that is controlling grade of the Sand Point Creek. The stream is under backwater influence for the lower 300 ft.

Photo 7 – Failing Concrete Retaining walls



Photo 8- Sediment Fan Conesus Lake



11.6.1 Prediction of Future Erosion Potential

The lower reach of Sand Point will continue to cut away at both banks in the upper, free flowing section of the reach. The channel will continue to meander. The natural stable form and pattern of Sand Point Creek would be a sinuous channel with a dimension of near 30 ft². In the lower reach of Sand Point the channel does not have access to the floodplain during large flows as it has been straightened and levied. The foundation of the residential dwelling will be undermined and land loss will continue until the left bank is stabilized. The right bank erosion and possible failure of retaining walls and structures will also progress. Levees will increase the shear forces causing bank erosion and scour, increasing the propensity of stagnant water.

11.6.2 Remedial Action

On the lower reach flood protection and property protection are the primary goals. Relocation and restoration of dimension, pattern, and profile is recommended for this reach. This will limit the risk to property by dealing with sediment supply and providing a stable channel form. The restored reach will have a **bankfull bench** and utilize **rock vanes**. The left bank will require rebuilding levees as set back levees (set back approximately 20 ft). A **bankfull bench** will reduce excess shear forces on the right bank.

If it is not possible to relocate the channel in this section, **rock vanes** should be installed to deflect flow away from eroding banks, and a **bankfull bench** should be created to reduce erosional forces.

12.0 Eagle Point Creek

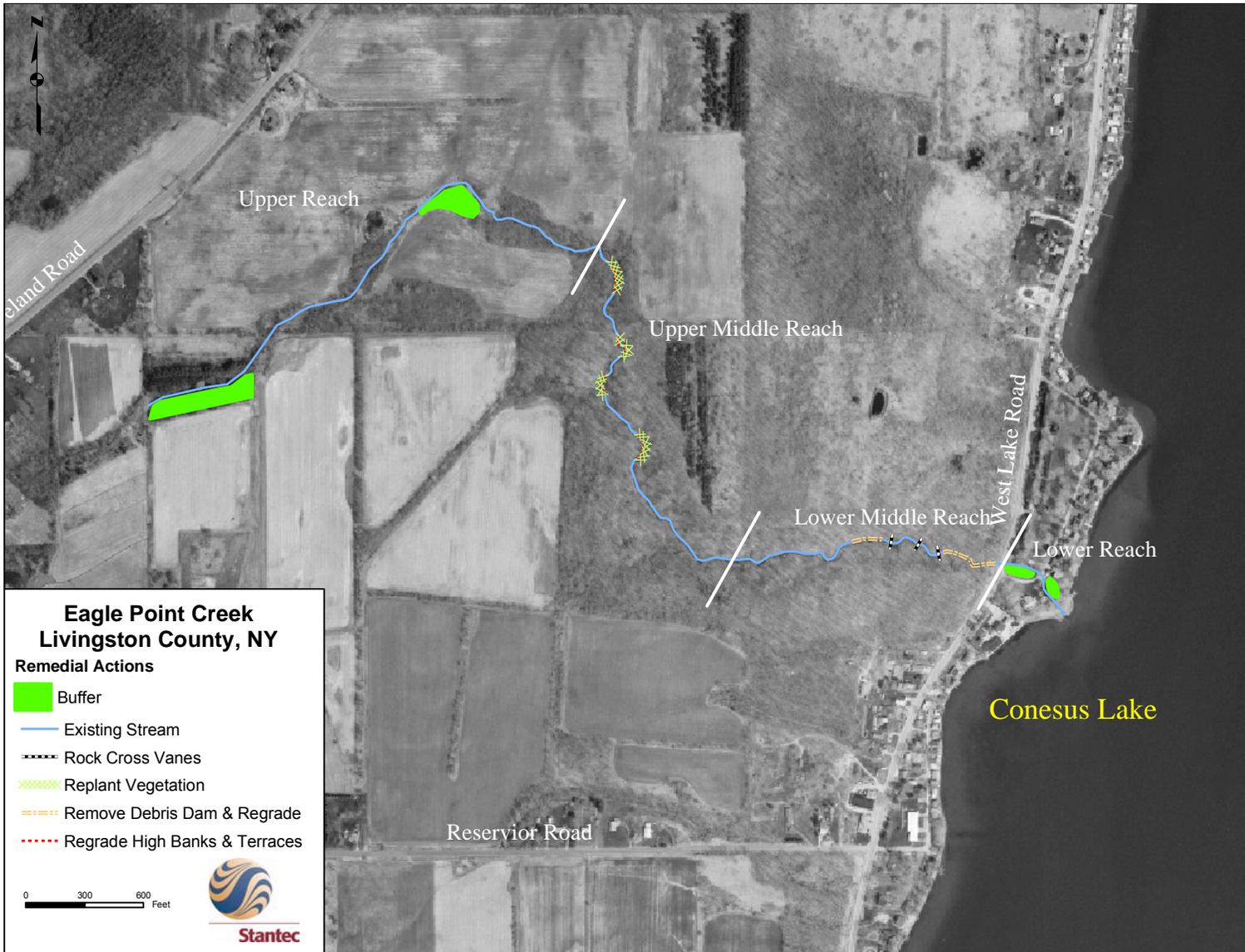
12.1 General Site Condition

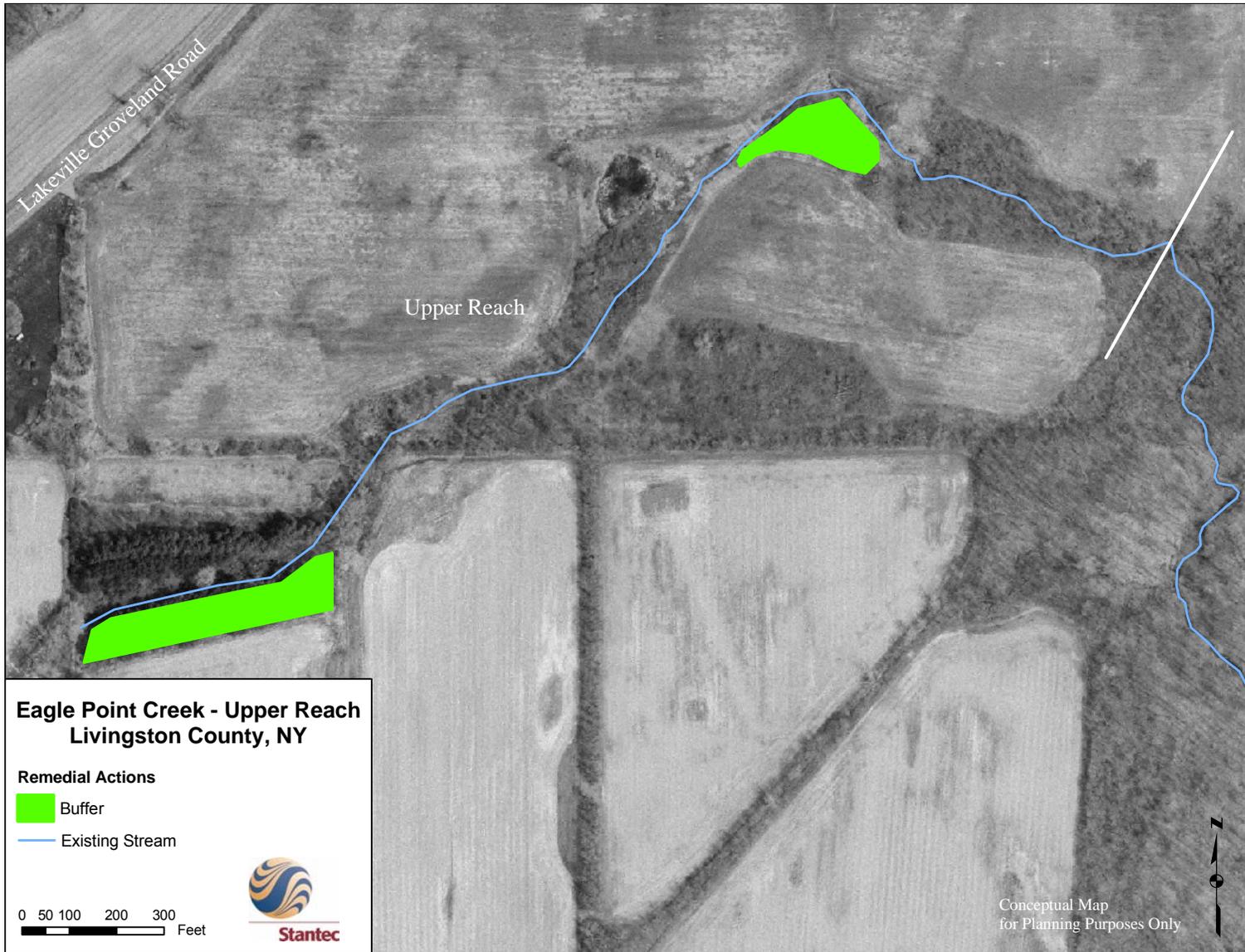
Eagle Point Creek is located on the west side of Conesus Lake. The original estimation of degraded stream channel to be assessed on Eagle Point Creek was 4,800 linear feet. In actuality, there was 7,100 linear feet of degraded stream on which Stantec performed a geomorphic assessment. This section of Eagle Point Creek has a vertical fall of approximately 80 ft and an average slope of 2.1%. GPS coordinates for the most downstream point of each reach are:

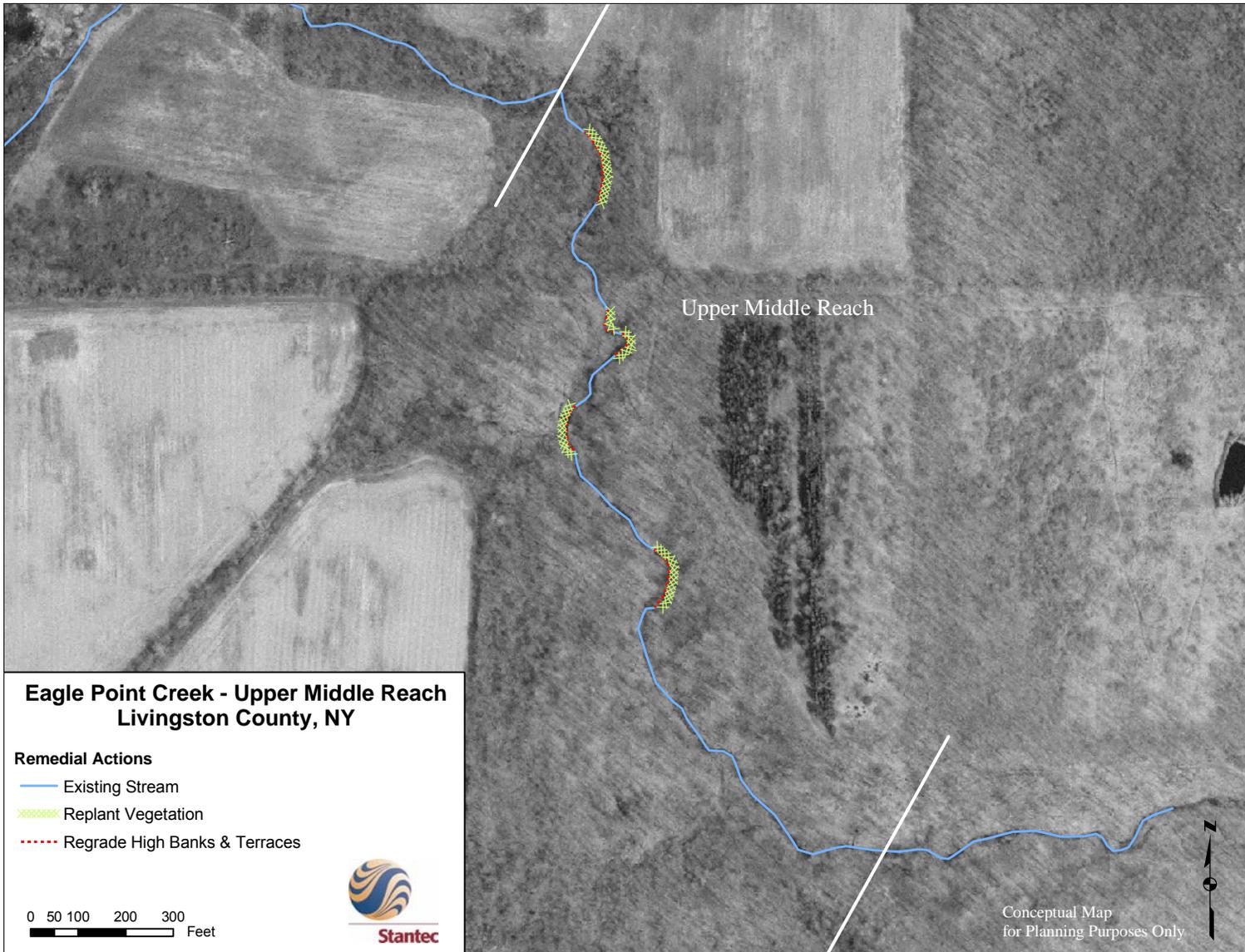
Upper Reach	77°43'37.72" W	42°48'09.72" N
Upper Middle Reach	77°43'28.57" W	42°47'54.10" N
Lower Middle Reach	77°43'10.45" W	42°47'53.59" N
Lower Reach	77°43'05.86" W	42°47'51.08" N

12.2 Existing Watershed Land Use

The existing 1,094-acre watershed is 2% developed, 33% forested and 65% agriculture. The majority of the streams in the Eagle Point watershed have a riparian buffer that is greater than 100 ft on either side of the channel. The riparian buffer of the upper reaches of the watershed is fallow farmland. This project area was near Conesus Lake and does not have a well-vegetated buffer over much of the project reaches. Buffers have been cleared resulting in accelerated bank erosion. There were no noted signs of significant point or non-point sources of sediment or of any other pollution from the existing watershed during the site visit. The majority of the sediment is coming from in-stream bank erosion.











12.3 Upper Reach Eagle Point Creek

The upper reach of Eagle Point is a low gradient wetland system with a low flow pilot channel. The banks are well vegetated and stable. There is very good connection to the floodplain and as a result there is low shear stress. There is very little bank erosion on this reach. This reach is approximately 3000ft in length and has areas of little to no buffer.

Photo 3 – Wetland with low flow channel



Photo 4 – Vegetation & floodplain connection



12.3.1 Prediction of Future Erosion Potential

The upper reach of Eagle Point Creek will remain stable as long as the buffer is maintained and soil conservation practices are employed for agriculture.

12.3.2 Remedial Action

There should be minimal actions taken in the upper reach since this reach is stable and well vegetated. The riparian buffers in the watershed should be planted. There should also be a buffer around significant tributaries in the watershed.

12.4 Upper Middle Reach Eagle Point Creek

The upper middle reach of Eagle Point is approximately 2000ft. This reach of stream has a sediment dam step pool profile. In much of the valley the sediment dam is formed on an outcrop of bedrock by logs and boulders getting trapped behind the bedrock pinch point in the valley. These alternating debris fans have shale deposits as well as legacy sediments embedded into the deposited materials. These legacy sediments have been transported from the upland areas during intensive agricultural and tilling periods. This reach is the steepest reach of this segment of stream. There is active erosion of banks and shale outcrops. There are currently many sediment and debris dams that accelerate local instability. This reach has significant bank migration, chute cut offs, traverse bars and channel evolutions. In many locations the grade has hit shale and bedrock vertical confinement, yet there is still significant bank erosion in some locations due to excess forces during large storm events. There is a 100ft or greater buffer on both banks of this reach. Sediment deposition and mass wasting of the banks results in localized contraction of low flows and high shear forces. An increase in shear stress and a decrease in riparian vegetation will result in an increase in bank erosion and instability.

Photo 3 – Sediment debris fan



Photo 4 –Bank erosion valley wall



12.4.1 Prediction of Future Erosion Potential

The upper middle reach of Eagle Point Creek has high sediment loading. The debris and log jam profile of this reach will continue until bedrock confinement is reached or the sediment from upstream is deposited on downstream sediment fans to hold grade. The latter will occur once the upstream section has eroded enough material to carve a floodplain at a lower elevation. There will continue to be large quantities of mass wasting of banks and terraces. Shale valley walls that confine the stream will continue to shear and shale deposits will be transported downstream.

12.4.2 Remedial Action

There should be minimal actions taken in the upper middle reach as much of this reach is confined by bedrock and shale. Some selected shale outcrops that are confining the stream should be removed. The sediment source is adding to the recovery of the downstream reach. The riparian buffers within the watershed should be planted with non- invasive vegetation.

12.5 Lower Middle Reach Eagle Point Creek

The lower middle reach of Eagle Point is approximately 1500ft. This reach of Eagle Point has a broad floodplain terrace. The existing invert of the reach has departed from the floodplain but the channel has evolved and is aggrading to a new floodplain elevation. This reach has considerable bank migration and channel evolutions. Twenty-foot high glacial terraces confine the bank migration and erosion of these terraces has led to an especially high sediment supply. Large downed trees and glacially transported cobble and boulder are exposed and form debris and sediment jams in the lower energy segments of this reach. There is localized contraction of flow and large energy drops over these in-stream debris jams that cause bank erosion near the debris jam structures. This reach of stream has sediment dam step pool profile. In much of the valley the sediment dam is formed on an outcrop of bedrock by logs and boulders getting trapped behind the bedrock pinch point in the valley. These alternating debris fans have shale deposits as well as legacy sediments embedded into the deposited materials. These legacy sediments have been transported from the upland areas during intensive

agricultural and tilling periods. This reach ends at West Lake Road where boulders have been placed in the stream for bank protection near the road.

Photo 5 – Sediment and debris deposition



Photo 6 – Culvert under West Lake Road



12.5.1 Prediction of Future Erosion Potential

The lower middle reach will continue to be unstable until the floodplain has reached a stable form. The lower middle reach is serving as a sediment sink with deposition occurring on the bars and benches to fill in the over wide channel. Currently the sediment supply on this reach is dominated by upstream sediment supply. The water and sediment supply of the watershed will dictate the stable form of the stream channel.

12.5.2 Remedial Action Low Middle Reach of Eagle Point Creek

The lower middle reach of Eagle Point has minimal bank erosion and is currently aggrading. Transported sediments from upstream dominate the sediment load of this reach. It is recommended that unstable sediment dams be removed and re-graded as needed. Artificial sediment dams can be constructed that allow for a preferential low flow channel. ***Rock cross vanes*** may be required to stabilize and provide grade control to the newly formed channel. (Specifications and details for bold/italicized items can be found in the Appendix).

12.6 Lower Reach Eagle Point Creek

The lower reach of Eagle Point is 600 ft in length and is straightened until Eagle Point enters into Conesus Lake. The lower reach has historically been modified to encourage drainage and reduce flooding. Rip rap has been used to prevent the channel from meandering and eroding the streambanks. The channel has been over dug and as a result there is severe aggradation with areas in this reach where base flow is limited to subsurface flow between deposited materials. There is a sediment fan that is controlling grade of Eagle Point Creek. The stream is under backwater influence for the lower 200 ft.

Photo 7 – Unstable over wide channel



Photo 8- Sediment fan Conesus Lake



12.6.1 Prediction of Future Erosion Potential

The lower reach of Eagle Point will continue to aggrade in the upper, free flowing section of this reach. The channel will continue to meander. The natural stable form and pattern of Eagle Point Creek would be a sinuous channel with a dimension of nearly 30 ft². In the lower reach of Eagle Point the channel is straightened and levied, resulting in the channel not having access to a floodplain for large flows. The foundations of the residential dwellings are not currently at risk of being undermined while this reach continues to be in a state of aggradation. There are three stream crossing and culverts on this section that hold grade and back up water during high flows.

12.6.2 Remedial Action

While the lower reach is oversized and aggrading it is not currently increasing sediment loading downstream. There is also very minimal bank erosion on this reach. At this point the only recommendation for bank stabilization is to increase the width of the riparian buffer to 25ft.

D. IMPLEMENTATION PLAN

This section is intended to provide Conesus Lake stakeholders some guidance in implementing the streambank remediation projects identified in this report. The plan as outlined below is intended to represent more of a “toolbox” than a “blueprint”. The stakeholders know the watershed dynamics and the landowners and are, therefore, in the best position to develop a plan for implementation. The material presented in this section is intended to assist the County by presenting a series of steps to reach the remediation goals. It is based on Stantec’s previous involvement with similar projects in other states, combined with input received from Livingston County officials.

The implementation section is presented in five separate sub-sections. The first sub-section outlines a step wise process for implementation. The second sub-section provides a benefit-cost analysis for ranking the restoration reaches. The third sub-section provides ideas and suggestions for public education and community involvement. The fourth sub-section identifies potential funding sources. The last sub-section describes the various state and federal permitting requirements for streambank stabilization work.

1.0 Implementation Steps and Processes

Livingston County, working in concert with the Towns of Livonia, Conesus, Geneseo and Groveland and the Village of Livonia, is best suited to lead and oversee the implementation of the various streambank remediation projects. Implementation begins with a determination of an overall ranking/prioritization of the remediation projects; obtaining buy-in from the affected landowners; pursuing and obtaining funding; hiring an engineering firm to prepare streambank remediation design plans; and hiring/overseeing a contractor to construct each project.

Confirm Project Rankings:

The ranking of the remediation reaches should be used as a starting point for implementation. Section 2.0 identifies and explains the methodology used in determining a Cost Benefit Analysis for each reach, followed by an overall ranking. This list can serve as the basis in applying for grants.

Obtain “Buy In” from Affected Landowners:

After the County and the Technical Team finalize the ranking of the remediation reaches, the next step is for the Conesus Lake Watershed Manager and/or other designees to approach the affected landowners and explain the conceptual plans to them. The landowners need to be informed of the project benefits and be made aware of the construction impacts. It is recommended that the County obtain construction easements to reduce the likelihood of misunderstandings and negative publicity for the program. Funding for remediation work may be contingent on the establishment of some sort of

permanent easement to protect the improvements. Once again, it is vital that the landowners understand the implications of granting an easement. If the affected landowners are not receptive or interested in cooperating, the reaches should be re-ranked accordingly. At the beginning it is vital to build momentum by focusing on cooperative landowners. Landowners that are reluctant to participate at the beginning may become more interested after some remediation projects have been successfully implemented.

Pursue and Obtain Project Funding:

The County should use these relationships with various interest groups to seek and apply for grants to fund the remediation work. Potential sources of funding are identified in Section 4.0 of this chapter. It should be noted that grant writing and securing funding takes significant time, effort and political involvement. The County should consider retaining the services of a dedicated grant writer to assist in this effort and increase the likelihood of obtaining grants.

Select Engineering Firm:

The next step in the process is for the County to retain the services of a qualified engineering consulting firm to work on one or more of the remediation reaches. It should be noted that by grouping several reaches together, some economy of scale can be obtained. The County can issue a request for proposals to perform an engineering assessment and prepare a design for one or more stream reaches.

After the County selects an engineering firm, there should be a series of meetings held with the County, the affected property owners and the engineering design firm. The engineering firm should spend time with the affected landowners to ensure that they understand the remediation measures proposed for their property and that their expectations are met. The engineer should incorporate the landowners' concerns in the final design. The final design should also include applicable permit applications, construction plans, sequence of construction, cost estimates and bid documents. Section 5.0 of this chapter contains information on the various regulatory permits and approvals for this project.

Select Contractor(s):

After the engineer has completed the final remediation design, it will be necessary to obtain the services of a contractor(s). The County should put the work out for bid, however, the engineering firm can assist the County in the administration of construction bids and the review of contractor qualifications. It is recommended that for the initial projects, the County focus first on the qualifications and experience of the contractors and second on the actual price.

Upon completion of construction, the County, contractor and engineering firm should walk through the project and sign off on the project's completion. During construction, the engineering firm should be present for 50-100% of the time. This will help ensure

that the construction is done properly and in accordance with the design. It will also allow the engineer to respond to questions by the contractor and adjust the design in response to local conditions or landowner concerns.

2.0 Cost-Benefit Analysis

This section explains the methodologies used in ranking the restoration reaches based on a cost-benefit analysis. Each of the twelve streams was segmented into study reaches. The reaches were defined by stream type, valley type, accessibility, and the type of required remediation. The twelve streams produced a total of 41 study reaches. Of the 41 study reaches, 37 were determined to be in need of some degree of streambank remediation.

2.1 Reach Cost Estimates

An estimated cost for the remediation of each of the 37 reaches is presented in Table 2.0 using generally accepted costs for streambank remediation design and construction work in 2006. A remedial action or restoration plan was identified for each reach and is presented in Section C of this report.

Engineering design costs are based on estimated costs for detailed site assessments, design time and construction oversight costs. The conceptual restoration plan was used as a basis for estimating the design costs of each project. The total design cost was then divided by the restored reach length to generate a design cost per restored/stabilized linear foot.

The construction costs are also based on the individual restoration plan for each respective reach. Construction costs include estimated costs for earthwork/grading, mobilization, in-stream structures, vegetation and other miscellaneous construction costs (i.e. boundary stakeouts, mud mats, fiber matting, drainage tiles). The total construction cost was divided by the restored reach length to generate a construction cost per restored/stabilized length per linear foot.

Again, the restoration plan for each reach is included in Section C. For the sake of brevity, the various restoration plans for each reach are identified by one of ten "stabilization codes". These stabilization codes are explained below.

2.2 Stabilization Codes

BUF: This stabilization code represents planting and maintaining a stream buffer. Stream buffer plantings should consist of herbaceous shrubs and woody vegetation that are native and non-invasive. There is minimal design and site grading required for buffer planting, and as a result this is a relatively low cost option. Typical design and construction costs for BUF coded projects range from \$80/lf - \$115/lf, depending on the particular project constraints.

P-ISR: This stabilization code represents stream restoration with minimal floodplain grading and the installation of a limited number of in-stream stability structures. This stabilization would include abandoning an existing stream channel, re-aligning the stream and connecting it back to an abandoned floodplain. The pathway and profile of the realigned channel would be defined by the dimension, pattern and profile data from stable streams in the region with a similar valley slope. Stream restoration includes buffer planting and regrading of banks. This option is typically the lowest cost for those options involving stream restoration and channel relocation. Typical design and construction costs for P-ISR coded projects range from \$150/lf - \$170/lf, depending on the particular project constraints.

P-IISR: This code represents stream restoration with grading a new floodplain and installation of some in-stream stability structures. This stabilization would include abandoning an existing stream channel and re-aligning the stream while creating a new floodplain. The pathway and profile of the realigned channel would be defined by the dimension, pattern and profile data from stable streams in the region with a similar valley slope. This restoration option requires large quantities of earthwork but typically will reduce flooding on adjacent land. Stream restoration includes buffer planting and regrading of banks. This option is typically more expensive than stream restoration that reconnects the stream back to an abandoned floodplain (P-ISR). Typical design and construction costs for P-IISR coded projects range from \$200/lf - \$230/lf, depending on the particular constraints for the reach.

P-IIISR: This code represents stream restoration with grading a new partial floodplain where available, and placement of large numbers of in-stream stability structures. This stabilization does not completely abandon the existing stream channel but does involve re-aligning the stream and creating a new floodplain. The pathway and profile of the realigned channel would be defined by the dimension pattern and profile data from stable streams in the region with a similar valley slope. This restoration option requires large quantities of earthwork, and large quantities of boulder and logs for structures but typically will reduce flooding on adjacent land. This restoration option requires more structures because there are limitations to the size and constraints of the newly created floodplain. Stream restoration also includes buffer planting and regrading of banks. This option is typically more expensive than stream restoration that reconnects the stream back to an abandoned floodplain. Typical design and construction costs for P-IIISR coded projects range from \$200/lf - \$265/lf, depending on the particular constraints for the reach.

SBEI: This code represents stream bank enhancement with minimal grading and buffer plantings. Streambank enhancement requires bank grading, placement of soil erosion matting, placement of an armoring agent and buffer planting. This code represents low bank heights and fairly good accessibility. Typical design and construction costs for SBEI coded projects range from \$120/lf - \$260/lf, depending on the particular constraints for the reach.

SBEII: This code represents stream bank enhancement with moderate grading and buffer plantings. Streambank enhancement requires bank grading, placement of soil erosion matting, placement of an armoring agent and buffer planting. This code represents moderate bank heights and moderate accessibility to the site. Typical design and construction costs for SBEII coded projects range from \$145/lf - \$280/lf, depending on the particular constraints for the reach.

SBEIII: This code represents stream bank enhancement with major grading and buffer plantings. Streambank enhancement requires bank grading, placement of soil erosion matting, placement of an armoring agent and buffer planting. This code represents high bank heights and moderate accessibility to the site. Typical design and construction costs for SBEIII coded projects range from \$175/lf - \$300/lf, depending on the particular constraints for the reach.

SBEIV: This code represents stream bank enhancement with major grading and buffer plantings. Streambank enhancement requires bank grading, placement of soil erosion matting, placement of an armoring agent and buffer planting. This code represents high bank heights and poor accessibility to the site. Typical design and construction costs for SBEIV coded projects range from \$275/lf - \$300/lf, depending on the particular constraints for the reach.

SBL: This code represents construction of new levees to replace existing flood protection levees. A new setback levee is constructed back from the top of the existing bank at a distance roughly equal to one to two times the width of the existing channel. This option creates a larger floodplain by setting the flood control levees back away from the streambanks. Typical design and construction costs for SBL coded projects range from \$160/lf - \$170/lf, depending on the particular constraints for the reach.

WTL: This code represents construction of a wetland. Grading, wetland vegetation planting and flow control structures are required for the completion of a constructed wetland. Typical design and construction costs for WTL coded projects range from \$150/lf - \$160/lf, depending on the particular constraints for the reach.

For short restored/stabilized stream lengths (i.e. less than 100 feet), the approximate costs may exceed the ranges noted above.

2.3 Cost Summary

The average cost for streambank remediation is approximately \$116,000 per reach with the actual projected costs ranging from a low of \$24,000 to a high of \$571,000. This wide range in cost allows for a variety of grant funding opportunities. The total estimated cost to remediate all 41 degraded reaches would require a funding commitment of approximately 4.8 million dollars. The estimated cost per linear foot of bank stabilization ranges from \$80/lf to \$430/lf. The average unit cost per linear foot of bank stabilization will be approximately \$180/lf. A listing of the various remediation costs for each reach is provided in Table 2.1. A ranking of the “restored length per linear foot” is presented in Table 2.2 in the event that the prioritization of the project reaches are based on cost alone.

Table 2.1 Project Costs by Reach

Stream	Reach	Total Reach Length (ft)	Stabilization Code	Percent of Reach Impaired	Restored/ Stabilized Length (ft)	CONSTRUCTION COSTS						ENGINEERING DESIGN COSTS					TOTAL COST		BENEFIT*			COST vs. BENEFIT		
						Earthwork/ Grading	Mobilization	Vegetation	Structures	Misc.	Total Construction Cost	Construction Cost Per Restored/ Stabilized Linear ft	Assessment	Design	Oversight	Total Design Cost	Design Cost Per Restored/ Stabilized Linear ft	Construction and Design	Restored Length Approximate Cost Per Linear ft	Property Protection (1-5)	Water Quality (1-5)	Total Benefit	COST BENEFIT SCORE	Ranking
Wilkins	Upper Reach	800	P-ISR	100%	800	24,000	6,000	24,000	21,000	15,000	\$ 90,000	\$ 112.50	8,000	15,000	13,000	\$ 36,000	\$ 45	\$ 126,000	\$ 158	3	5	23	171	2
Wilkins	Upper Middle Reach	1,600	P-ISR	100%	1600	48,000	10,000	48,000	37,000	29,000	\$ 172,000	\$ 107.50	16,000	26,000	25,000	\$ 67,000	\$ 42	\$ 239,000	\$ 149	2	4	18	207	3
Wilkins	Lower Middle Reach	1,200	SBEII	100%	1200	36,000	14,000	36,000	29,000	23,000	\$ 138,000	\$ 115.00	12,000	11,000	10,000	\$ 33,000	\$ 28	\$ 171,000	\$ 143	3	3	15	238	12
Wilkins	Lower Reach	300	SBEII	20%	60	2,000	3,000	2,000	7,000	3,000	\$ 17,000	\$ 283.33	1,000	5,000	2,000	\$ 8,000	\$ 133	\$ 25,000	\$ 417	4	1	8	1,302	37
UT Wilkins	Upper Reach	600	WTL	80%	480	20,000	5,000	5,000	10,000	8,000	\$ 48,000	\$ 100.00	8,000	9,000	6,000	\$ 23,000	\$ 48	\$ 71,000	\$ 148	1	3	13	284	20
UT Wilkins	Middle Reach	500	P-IIISR	100%	500	30,000	6,000	20,000	25,000	17,000	\$ 98,000	\$ 196.00	8,000	14,000	11,000	\$ 33,000	\$ 66	\$ 131,000	\$ 262	2	3	14	468	28
UT Wilkins	Lower Reach	600	SBEIII	100%	600	24,000	11,000	18,000	23,000	16,000	\$ 92,000	\$ 153.33	9,000	8,000	6,000	\$ 23,000	\$ 38	\$ 115,000	\$ 192	3	3	15	319	22
Densmore	Upper Reach	700	N/A	0%																				
Densmore	Upper Middle Reach	550	P-IIISR	100%	550	33,000	7,000	22,000	27,000	18,000	\$ 107,000	\$ 194.55	9,000	15,000	12,000	\$ 36,000	\$ 65	\$ 143,000	\$ 260	5	5	25	260	14
Densmore	Middle Reach	1,100	BUF	20%	220	-	5,000	7,000	5,000	4,000	\$ 21,000	\$ 95.45	2,000	12,000	4,000	\$ 18,000	\$ 82	\$ 39,000	\$ 177	1	3	13	341	23
Densmore	Lower Middle Reach	1,250	P-IIISR	100%	1250	63,000	9,000	50,000	43,000	33,000	\$ 198,000	\$ 158.40	13,000	27,000	26,000	\$ 66,000	\$ 53	\$ 264,000	\$ 211	3	5	23	230	9
Densmore	Lower Reach	850	BUF	100%	850	-	11,000	26,000	5,000	9,000	\$ 51,000	\$ 60.00	5,000	11,000	10,000	\$ 26,000	\$ 31	\$ 77,000	\$ 91	2	2	10	226	7
Central	Upper Reach	900	BUF	50%	450	-	7,000	14,000	5,000	6,000	\$ 32,000	\$ 71.11	3,000	9,000	6,000	\$ 18,000	\$ 40	\$ 50,000	\$ 111	1	3	13	214	5
Central	Middle Reach	1,100	SBEI	50%	550	11,000	5,000	17,000	8,000	9,000	\$ 50,000	\$ 90.91	3,000	8,000	5,000	\$ 16,000	\$ 29	\$ 66,000	\$ 120	1	3	13	231	10
Central	Lower Reach	300	SBEI	100%	300	6,000	4,000	9,000	7,000	6,000	\$ 32,000	\$ 106.67	2,000	9,000	4,000	\$ 15,000	\$ 50	\$ 47,000	\$ 157	2	2	10	392	27
North Gully	Upper Reach	600	SBEIII	10%	60	3,000	3,000	2,000	7,000	3,000	\$ 18,000	\$ 300.00	1,000	5,000	2,000	\$ 8,000	\$ 133	\$ 26,000	\$ 433	1	3	13	833	35
North Gully	Middle Reach	600	P-IIISR	100%	600	36,000	7,000	24,000	29,000	20,000	\$ 116,000	\$ 193.33	9,000	16,000	13,000	\$ 38,000	\$ 63	\$ 154,000	\$ 257	5	5	25	257	13
North Gully	Lower Reach	1,200	SBL	80%	960	39,000	12,000	29,000	5,000	17,000	\$ 102,000	\$ 106.25	20,000	17,000	16,000	\$ 53,000	\$ 55	\$ 155,000	\$ 161	3	1	7	577	33
South Gully	Upper Reach	4,500	SBEIII	30%	1350	54,000	23,000	41,000	46,000	33,000	\$ 197,000	\$ 145.93	21,000	11,000	11,000	\$ 43,000	\$ 32	\$ 240,000	\$ 178	1	3	13	342	25
South Gully	Middle Reach	2,800	P-IIISR	100%	2800	140,000	16,000	112,000	89,000	72,000	\$ 429,000	\$ 153.21	28,000	57,000	57,000	\$ 142,000	\$ 51	\$ 571,000	\$ 204	2	5	22	232	11
South Gully	Lower Reach	300	SBEI	20%	60	2,000	3,000	2,000	6,000	3,000	\$ 16,000	\$ 266.67	1,000	5,000	2,000	\$ 8,000	\$ 133	\$ 24,000	\$ 400	2	2	10	1,000	36
North McMillan	Upper Reach	1,700	N/A	0%																				
North McMillan	Middle Reach	2,000	P-ISR	40%	800	24,000	6,000	24,000	21,000	15,000	\$ 90,000	\$ 112.50	8,000	15,000	13,000	\$ 36,000	\$ 45	\$ 126,000	\$ 158	2	3	14	281	19
North McMillan	Lower Reach	1,000	SBEIII	75%	750	30,000	14,000	23,000	28,000	19,000	\$ 114,000	\$ 152.00	12,000	8,000	7,000	\$ 27,000	\$ 36	\$ 141,000	\$ 188	5	3	17	276	18
Southwest	Upper Reach	1,450	N/A	0%																				
Southwest	Lower Reach	1,000	SBEIII	30%	300	12,000	7,000	9,000	14,000	9,000	\$ 51,000	\$ 170.00	5,000	9,000	4,000	\$ 18,000	\$ 60	\$ 69,000	\$ 230	2	2	10	575	32
Groveland	Upper Reach	500	SBEIII	80%	400	16,000	8,000	12,000	17,000	11,000	\$ 64,000	\$ 160.00	6,000	8,000	4,000	\$ 18,000	\$ 45	\$ 82,000	\$ 205	3	3	15	342	24
Groveland	Upper Middle Reach	700	SBEI	20%	140	3,000	3,000	5,000	6,000	4,000	\$ 21,000	\$ 150.00	1,000	5,000	2,000	\$ 8,000	\$ 57	\$ 29,000	\$ 207	3	1	7	740	34
Groveland	Lower Middle Reach	500	P-IIISR	100%	500	25,000	5,000	20,000	20,000	14,000	\$ 84,000	\$ 168.00	5,000	14,000	11,000	\$ 30,000	\$ 60	\$ 114,000	\$ 228	1	5	21	271	16
Groveland	Lower Reach	400	N/A	0%																				
Long Point	Upper Reach	5,950	SBEIV	20%	1190	72,000	32,000	72,000	53,000	46,000	\$ 275,000	\$ 231.09	18,000	20,000	19,000	\$ 57,000	\$ 48	\$ 332,000	\$ 279	1	3	13	537	29
Long Point	Middle Reach	1,100	P-ISR	100%	1100	33,000	8,000	33,000	27,000	21,000	\$ 122,000	\$ 110.91	11,000	19,000	18,000	\$ 48,000	\$ 44	\$ 170,000	\$ 155	3	5	23	168	1
Long Point	Lower Reach	900	P-IIISR	100%	900	45,000	7,000	36,000	32,000	24,000	\$ 144,000	\$ 160.00	9,000	21,000	19,000	\$ 49,000	\$ 54	\$ 193,000	\$ 214	4	4	20	268	15
Sand Point	Upper Reach	800	BUF	100%	800	-	10,000	24,000	5,000	8,000	\$ 47,000	\$ 58.75	4,000	11,000	9,000	\$ 24,000	\$ 30	\$ 71,000	\$ 89	2	1	6	370	26
Sand Point	Upper Middle Reach	2,500	SBEIV	20%	500	30,000	15,000	30,000	25,000	20,000	\$ 120,000	\$ 240.00	8,000	12,000	9,000	\$ 29,000	\$ 58	\$ 149,000	\$ 298	1	3	13	573	31
Sand Point	Lower Middle Reach	1,400	SBEI	40%	560	12,000	5,000	17,000	8,000	9,000	\$ 51,000	\$ 91.07	3,000	8,000	5,000	\$ 16,000	\$ 29	\$ 67,000	\$ 120	2	3	14	214	4
Sand Point	Lower Reach	700	SBEII	50%	350	11,000	6,000	11,000	12,000	8,000	\$ 48,000	\$ 137.14	4,000	9,000	4,000	\$ 17,000	\$ 49	\$ 65,000	\$ 186	4	3	16	290	21
Eagle Point	Upper Reach	3,000	BUF	40%	1200	-	14,000	36,000	5,000	11,000	\$ 66,000	\$ 55.00	6,000	14,000	13,000	\$ 33,000	\$ 28	\$ 99,000	\$ 83	1	2	9	229	8
Eagle Point	Upper Middle Reach	2,000	SBEIV	40%	800	48,000	22,000	48,000	37,000	31,000	\$ 186,000	\$ 232.50	12,000	15,000	13,000	\$ 40,000	\$ 50	\$ 226,000	\$ 283	1	3	13	543	30
Eagle Point	Lower Middle Reach	1,500	SBEII	50%	750	23,000	10,000	23,000	20,000	16,000	\$ 92,000	\$ 122.67	8,000	8,000	7,000	\$ 23,000	\$ 31	\$ 115,000	\$ 153	2	3	14	274	17
Eagle Point	Lower Reach	600	BUF	100%	600	-	8,000	18,000	5,000	7,000	\$ 38,000	\$ 63.33	3,000	10,000	7,000	\$ 20,000	\$ 33	\$ 58,000	\$ 97	3	2	11	220	6
Total		52,050			26,880						\$ 3,637,000					\$ 1,203,000		\$ 4,840,000						

*Benefit weighting factors for property protection and water quality are shown in blue in first row. Maximum Benefit is shown in first row of Total Benefit column.

Table 2.2 Ranking by Cost

		TOTAL COST				
Stream	Reach	Total Reach Length (ft)	Stabilization Code	Restored/Stabilized Length (ft)	Construction and Design	Restored Length Approximate Cost Per Linear ft
Eagle Point	Upper Reach	3,000	BUF	1200	\$ 99,000	\$ 83
Sand Point	Upper Reach	800	BUF	800	\$ 71,000	\$ 89
Densmore	Lower Reach	850	BUF	850	\$ 77,000	\$ 91
Eagle Point	Lower Reach	600	BUF	600	\$ 58,000	\$ 97
Central	Upper Reach	900	BUF	450	\$ 50,000	\$ 111
Sand Point	Lower Middle Reach	1,400	SBEI	560	\$ 67,000	\$ 120
Central	Middle Reach	1,100	SBEI	550	\$ 66,000	\$ 120
Wilkins	Lower Middle Reach	1,200	SBEII	1200	\$ 171,000	\$ 143
UT Wilkins	Upper Reach	600	WTL	480	\$ 71,000	\$ 148
Wilkins	Upper Middle Reach	1,600	P-ISR	1600	\$ 239,000	\$ 149
Eagle Point	Lower Middle Reach	1,500	SBEII	750	\$ 115,000	\$ 153
Long Point	Middle Reach	1,100	P-ISR	1100	\$ 170,000	\$ 155
Central	Lower Reach	300	SBEI	300	\$ 47,000	\$ 157
North McMillan	Middle Reach	2,000	P-ISR	800	\$ 126,000	\$ 158
Wilkins	Upper Reach	800	P-ISR	800	\$ 126,000	\$ 158
North Gully	Lower Reach	1,200	SBL	960	\$ 155,000	\$ 161
Densmore	Middle Reach	1,100	BUF	220	\$ 39,000	\$ 177
South Gully	Upper Reach	4,500	SBEIII	1350	\$ 240,000	\$ 178
Sand Point	Lower Reach	700	SBEII	350	\$ 65,000	\$ 186
North McMillan	Lower Reach	1,000	SBEIII	750	\$ 141,000	\$ 188
UT Wilkins	Lower Reach	600	SBEIII	600	\$ 115,000	\$ 192
South Gully	Middle Reach	2,800	P-IISR	2800	\$ 571,000	\$ 204
Groveland	Upper Reach	500	SBEIII	400	\$ 82,000	\$ 205
Groveland	Upper Middle Reach	700	SBEI	140	\$ 29,000	\$ 207
Densmore	Lower Middle Reach	1,250	P-IISR	1250	\$ 264,000	\$ 211
Long Point	Lower Reach	900	P-IISR	900	\$ 193,000	\$ 214
Groveland	Lower Middle Reach	500	P-IISR	500	\$ 114,000	\$ 228
Southwest	Lower Reach	1,000	SBEIII	300	\$ 69,000	\$ 230
North Gully	Middle Reach	600	P-IISR	600	\$ 154,000	\$ 257
Densmore	Upper Middle Reach	550	P-IISR	550	\$ 143,000	\$ 260
UT Wilkins	Middle Reach	500	P-IISR	500	\$ 131,000	\$ 262
Long Point	Upper Reach	5,950	SBEIV	1190	\$ 332,000	\$ 279
Eagle Point	Upper Middle Reach	2,000	SBEIV	800	\$ 226,000	\$ 283
Sand Point	Upper Middle Reach	2,500	SBEIV	500	\$ 149,000	\$ 298
South Gully	Lower Reach	300	SBEI	60	\$ 24,000	\$ 400
Wilkins	Lower Reach	300	SBEII	60	\$ 25,000	\$ 417
North Gully	Upper Reach	600	SBEIII	60	\$ 26,000	\$ 433

Table 2.3 Ranking Based on Cost Benefit

		TOTAL COST		BENEFIT*	COST vs. BENEFIT		
Stream	Reach	Construction and Design	Restored Length Approximate Cost Per Linear ft	Total Benefit	Cost Benefit Score	Ranking	Priority
Long Point	Middle Reach	\$ 170,000	\$ 155	23	168	1	High
Wilkins	Upper Reach	\$ 126,000	\$ 158	23	171	2	High
Wilkins	Upper Middle Reach	\$ 239,000	\$ 149	18	207	3	High
Sand Point	Lower Middle Reach	\$ 67,000	\$ 120	14	214	4	High
Central	Upper Reach	\$ 50,000	\$ 111	13	214	5	High
Eagle Point	Lower Reach	\$ 58,000	\$ 97	11	220	6	High
Densmore	Lower Reach	\$ 77,000	\$ 91	10	226	7	High
Eagle Point	Upper Reach	\$ 99,000	\$ 83	9	229	8	High
Densmore	Lower Middle Reach	\$ 264,000	\$ 211	23	230	9	High
Central	Middle Reach	\$ 66,000	\$ 120	13	231	10	High
South Gully	Middle Reach	\$ 571,000	\$ 204	22	232	11	High
Wilkins	Lower Middle Reach	\$ 171,000	\$ 143	15	238	12	High
North Gully	Middle Reach	\$ 154,000	\$ 257	25	257	13	High
Densmore	Upper Middle Reach	\$ 143,000	\$ 260	25	260	14	High
North McMillan	Middle Reach	\$ 119,000	\$ 149	14	266	15	High
Long Point	Lower Reach	\$ 193,000	\$ 214	20	268	16	High
Groveland	Lower Middle Reach	\$ 114,000	\$ 228	21	271	17	High
Eagle Point	Lower Middle Reach	\$ 115,000	\$ 153	14	274	18	High
North McMillan	Lower Reach	\$ 141,000	\$ 188	17	276	19	High
UT Wilkins	Upper Reach	\$ 71,000	\$ 148	13	284	20	High
Sand Point	Lower Reach	\$ 65,000	\$ 186	16	290	21	High
UT Wilkins	Lower Reach	\$ 115,000	\$ 192	15	319	22	Med
Densmore	Middle Reach	\$ 39,000	\$ 177	13	341	23	Med
Groveland	Upper Reach	\$ 82,000	\$ 205	15	342	24	Med
South Gully	Upper Reach	\$ 240,000	\$ 178	13	342	25	Med
Sand Point	Upper Reach	\$ 71,000	\$ 89	6	370	26	Med
Central	Lower Reach	\$ 47,000	\$ 157	10	392	27	Med
UT Wilkins	Middle Reach	\$ 131,000	\$ 262	14	468	28	Med
Long Point	Upper Reach	\$ 332,000	\$ 279	13	537	29	Med
Eagle Point	Upper Middle Reach	\$ 226,000	\$ 283	13	543	30	Med
Sand Point	Upper Middle Reach	\$ 149,000	\$ 298	13	573	31	Med
Southwest	Lower Reach	\$ 69,000	\$ 230	10	575	32	Med
North Gully	Lower Reach	\$ 155,000	\$ 161	7	577	33	Med
Groveland	Upper Middle Reach	\$ 29,000	\$ 207	7	740	34	Low
North Gully	Upper Reach	\$ 26,000	\$ 433	13	833	35	Low
South Gully	Lower Reach	\$ 24,000	\$ 400	10	1,000	36	Low
Wilkins	Lower Reach	\$ 25,000	\$ 417	8	1,302	37	Low

Cost Benefit Score = Restored length cost per linear ft / (Total Benefit Score / 25)

2.4 Benefit Summary

For the purpose of evaluating the overall effectiveness of this project, two categories of benefits were established: water quality and property protection. A description of each benefit follows:

Water Quality: The water quality benefit is related to long term streambank stability and decreased sediment loadings to Conesus Lake. In Conesus Lake, sediment pollution reduces the recreational value of swimming and boating. A high suspended sediment concentration causes turbid or cloudy water. Suspended sediment, as measured by turbidity and total suspended solids (TSS), can reduce in-stream photosynthesis by lowering the amount of sunlight, and alter a stream's ecology. These suspended sediments can also clog fish gills. Sediments cause the water to absorb more heat from sunlight, which raises overall water temperature. Warm water has less capacity to hold dissolved oxygen than cool water. There are many other reasons to encourage increased water quality and a decreased level of sediment pollution. The score for each reach ranges from 1-5. A score of 1 represents a site that offers few opportunities to improve water quality. A good example of such a site would be one that involves localized bank armoring. While bank armoring protects property, it would increase erosion downstream of the armoring. A site that scores a 5 would be one that significantly reduces channel instability processes. It would reduce scour and bank erosion while being sustainable over time with minimal maintenance. A water quality rating of 5 would also require existing conditions that were at a point of severe bank erosion and mass wasting. There are seven sites that scored a 5 for the water quality benefit. The two most severe sites are the Upper Middle Reach of Densmore and the Middle Reach of North Gully Creek. All seven sites currently have severe bank erosion and have a restoration plan that includes stream restoration and channel relocation.

Property Protection: In many cases, streambank erosion threatens the integrity of structures and can result in property loss. Being able to protect property from destruction is important to landowners and will help gain community support for streambank stabilization. For regions that are not very active in streambank stabilization, property protection issues can serve as a form of advertisement and education for the water quality benefits of streambank stabilization. The public can quickly see the benefits related to property protection, whereas the water quality benefits require more time and community involvement. The score for each reach ranges from 1-5. A score of 1 represents a site that does not provide any opportunity to protect property. A score of 5 represents a site that currently provides immediate opportunities to reduce the loss of property. Three sites scored a 5 for property protection; the Upper Middle Reach of Densmore, Middle Reach of North Gully and the Lower Reach of North McMillan. At all three of these sites, landowners are incurring damage or loss of property during larger storm events.

Other benefits could be considered in the future. For the purpose of this project, these categories were considered to be the most important for the Conesus Lake Watershed and its residents. In the future, other benefits such as habitat restoration, shade,

educational benefit and land owner management could be added to the cost benefit analysis matrix.

The total benefit that can be achieved for any reach is a function of the individual scores for each benefit. Each benefit, in turn, needs to be weighed commensurately with its ability to achieve the County's primary goals and objectives. The water quality benefit is the primary focus of the project and, therefore, warrants the highest weighting. Since the region is not currently active in streambank stabilization, property protection issues can serve as a form of advertisement and education for the greater water quality benefits of bank stabilization. The following equation was used to calculate the total benefit that can be generated by each reach.

$$\text{Total Benefit} = (4 \times \text{Water Quality}) + \text{Property Protection}^*$$

*this weighting is based on input from Livingston County officials. Stantec has provided a copy of the benefit cost analysis spreadsheets so that the County can adjust the weightings in the future, if needed.

This equation generates a minimum score of 5 and a maximum score of 25. The average benefit score for the stabilization of the 37 disturbed project reaches is 14.6. The total benefit scores range from 6 to 25. Eight of the 37 reaches scored higher than 20. There are two sites that scored 25 points: the Middle Reach of North Gully Creek and Upper Middle Reach of Densmore Creek.

2.5 Cost-Benefit Analysis

The best way to determine where to allocate funding is by combining both cost and benefit. The cost-benefit function used in this study is calculated from the restored reach cost per linear foot of stabilization and the total benefit score. The equation used in determining the Cost Benefit Score is:

$$\text{Cost Benefit Score} = \text{Restored length cost per linear ft} / (\text{Total Benefit Score} / 25)^*$$

*The benefit score was divided by 25 to normalize the benefit value.

A cost-benefit score was calculated for each reach. The cost-benefit scores ranged from 168 to 1302 with the lower scores being the more cost effective and beneficial projects to pursue from the outset. A ranking of 1 indicates that this reach will yield the greatest benefit at the lowest cost. These scores were used to rank the 37 streambank remediation reaches based on cost and benefit as shown in the above Table 2.3.

3.0 Community Involvement

Community involvement is the key for the successful implementation of the recommendations of the Conesus Lake Watershed Streambank Remediation Report. Community involvement and education will help give residents confidence that the improvements done within the watershed will produce improvements in the Lake's water quality. It is typically more difficult for a community to have confidence in a practice that does not show immediate results and is not directly applied to the source of the problem. Since this plan calls for a treatment that addresses sediment pollution before it reaches Conesus Lake, the basic process of streambank stability and the sediment transport should be part of a watershed educational program for the community.

The optimal time to initiate a Community Involvement Program is immediately after completion of the initial projects. Given that it is not known when the initial reaches will be completed, the following types of community involvement activities are presented for planning purposes only.

The population within the Conesus Lake Watershed consists of people from many different ages, races, genders, and social backgrounds. As such, a community involvement and education program should be flexible and multifaceted so that it can involve the different groups within the watershed. The Conesus Lake watershed educational program should consist of a demonstration project and a range of educational materials made available to the public. Details of each of these types of community involvement are outlined below.

3.1 Demonstration Projects

A project selected for demonstration should be high profile (i.e., be a good example of the extreme problems with bank stability) and easily accessible to the public. A demonstration project that deals with both water quality issues and property protection issues will serve as the best demonstration and advertisement for the streambank remediation within the Conesus Lake Watershed. The area selected for demonstration is the Wilkins Creek reach within the Village of Livonia Park. Educational signs and handouts should be available for the public to view at their convenience.

3.2 Education Materials

Educational materials could be created to support the demonstration project. These materials could include pamphlets, posters, signs, advertisements, a webpage, and handouts. Once again, materials and ideas could be borrowed from existing watershed education materials that are available from a variety of sources.

4.0 Potential Sources of Funding

Federal funding assistance for stream stabilization and restoration efforts can be obtained through numerous programs from three separate U.S. government agencies: the U.S. Environmental Protection Agency (USEPA), the U.S. Fish and Wildlife Service (USFWS) and the Natural Resource Conservation Service (NRCS) of the U.S. Department of Agriculture.

The biggest potential source of funding available from the USEPA is the Clean Water Act Section 319 Grant Program, often referred to as the “319 Program”. Grants from this program are funded by USEPA but are typically administered through the state environmental agency responsible for protecting water quality. In New York the 319 Program is administered by the N.Y. State Department of Environmental Conservation (NYSDEC) Division of Water. The 319 Program is geared toward efforts that reduce non-point sources of degradation of water quality and/or aquatic habitat, and projects that can demonstrate a quantifiable improvement in water quality by reducing non-point source pollution are eligible for funding. Projects that evaluate or demonstrate new technologies or management strategies may also be eligible. Grants from the 319 Program will cover up to 60% of project costs and require a minimum 40% non-federal match. In-kind services do count toward the non-federal match.

Several assistance programs administered by the USFWS may be available to support this effort, depending on the wildlife resources associated with the project. If the project will result in habitat improvement for sport fish, such as trout, assistance may be available through the Federal Aid in Sport Fish Restoration grant program. If the project will improve habitat on private land and is deemed beneficial for federally listed, proposed or candidate species or other species determined to be at-risk, it would be eligible for funding through the Landowner Incentive Program. Wildlife habitat improvement projects not covered by the first two programs may be eligible for funding under the State Wildlife Grants Program, also funded by the USFWS. All USFWS grant programs require a minimum 25% non-federal match.

In 2002, the U.S. Congress re-authorized the Farm Bill with over 15 billion dollars in funding for natural resource conservation programs administered by the NRCS. With that boost in funding NRCS has expanded their funding considerations to include resource improvement projects other than those strictly related to agricultural practices. The national priorities of the Environmental Quality Incentives Program (EQIP) have been expanded to include the following five areas:

- Reductions of nonpoint source pollution, such as nutrients, sediment, pesticides, or excess salinity in impaired watersheds consistent with total maximum daily loadings (TMDLs) where available as well as the reduction of groundwater contamination and reduction of point sources such as contamination from confined animal feeding operations;
- Conservation of ground and surface water resources;

- Reduction of emissions, such as particulate matter, nitrogen oxides (NO_x), volatile organic compounds, and ozone precursors and depleters that contribute to air quality impairment violations of National Ambient Air Quality Standards;
- Reduction in soil erosion and sedimentation from unacceptable levels on agricultural land; and
- Promotion of at-risk species habitat conservation.

Depending on the adjunct resource and regulatory issues associated with this project, it may be eligible for funding from EQIP under one or more of these priorities.

The project may also be eligible for federal funding through the Wildlife Habitat Incentives Program (WHIP), also administered by NRCS. The WHIP program supports projects meeting one or more of the following national priority guidelines:

- Promote the restoration of declining or important native wildlife habitats;
- Protect, restore, develop or enhance wildlife habitat of at-risk species (candidate species, and State and Federally listed threatened and endangered species);
- Reduce the impacts of invasive species on wildlife habitats; or
- Protect, restore, develop or enhance declining or important aquatic wildlife species' habitats.

Most NRCS programs do require some level of non-federal match, but that level varies depending on the program utilized and the make-up of project partners associated with the project receiving funding.

At the state level, funding for this project may be available through New York State's Water Quality Improvement Projects (WQIP) grant program. The program covers a wide range of projects and is supported by \$7 million in funding for FY 2006-2007 for water quality improvement projects, including aquatic habitat restoration. The level of funding is likely to increase in FY 2007-2008. The WQIP program also includes a separate funding pool of \$5.5 million from the New York State Environmental Protection Fund for projects, including those that exhibit "comprehensive watershed-based Water Quality Management designed to address the reduction and control of nonpoint source pollution and the improvement of water quality in waterbodies identified on the Priority Waterbodies List". Funds awarded through the WQIP program are to be used for projects that demonstrate direct environmental benefits and at least 20% of the ranking criteria for projects awarded are based on the projects' cost effectiveness.

There are also a number of private foundations that actively support environmental programs, such as those proposed for the Conesus Lake watershed. The evaluation criteria vary according to the foundation. Further investigation of such foundations would be warranted.

It should be noted that experience in other jurisdictions has shown that success in obtaining one or two grants will increase awareness of the Conesus Lake program within funding agencies. Successful implementation of one or two projects will generate momentum. Grant funding agencies like being associated with a successful program and will expect new grant applications each year. In some cases, grants from one agency can be used to leverage additional grants from other agencies. The key to a successful program will be effective implementation of the first few grants.

5.0 Permit Requirements

The proposed streambank remediation activities identified for the twelve streams are subject to regulatory approval by the US Army Corps of Engineers (Corps) and the NYSDEC. The Corps jurisdiction is under Section 404 of the federal Clean Water Act (CWA) and the NYSDEC jurisdiction is under Section 401, commonly known as “Water Quality Certification”. The proposed stream bank restoration projects will require the submission of a Joint Permit Application to the Corps and DEC. A brief description of the Army Corps and DEC regulatory jurisdiction with this project follows:

5.1 United States Army Corps of Engineers Jurisdiction

The proposed work within the twelve (12) streams and reaches can either be filed as a single and complete project (provided the work will be administered through a single or combined funding source), or separately as funding becomes available. The individual stream sections to be restored would likely qualify for Nationwide Permit #13 which applies to streambank stabilization. Nationwide Permit #27 also has applicability to several reaches of the proposed work. The conditions for compliance with Nationwide Permit 13 and 27 are as follows:

NWP #13. Bank Stabilization. Bank stabilization activities necessary for erosion prevention provided the activity meets all of the following criteria:

- a. No material is placed in excess of the minimum needed for erosion protection;
- b. The bank stabilization activity is less than 500 feet in length;
- c. The activity will not exceed an average of one cubic yard per running foot placed along the bank below the plane of the ordinary high water mark or the high tide line;
- d. No material is placed in any special aquatic site, including wetlands;
- e. No material is of the type, or is placed in any location, or in any manner, so as to impair surface water flow into or out of any wetland area;

- f. No material is placed in a manner that will be eroded by normal or expected high flows (properly anchored trees and treetops may be used in low energy areas); and,
- g. The activity is part of a single and complete project.

Bank stabilization activities in excess of 500 feet in length or greater than an average of one cubic yard per running foot may be authorized if the permittee notifies the District Engineer in accordance with the "Notification" general condition. The District Engineer determines if the activity complies with the other terms and conditions of the NWP and the adverse environmental effects are minimal both individually and cumulatively. This NWP may not be used for the channelization of a water of the United States.

NWP #27. Stream and Wetland Restoration Activities. Activities authorized by this NWP include, but are not limited to: the removal of accumulated sediments; the installation, removal, and maintenance of small water control structures, dikes, and berms; the installation of current deflectors; the enhancement, restoration, or creation of riffle and pool stream structure; the placement of in-stream habitat structures; modifications of the stream bed and/or banks to restore or create stream meanders; the backfilling of artificial channels and drainage ditches; the removal of existing drainage structures; the construction of small nesting islands; the construction of open water areas; activities needed to reestablish vegetation, including plowing or disking for seed bed preparation; mechanized land clearing to remove undesirable vegetation; and other related activities.

5.2 NYSDEC Jurisdiction

All twelve (12) streams are identified as Class C waters by the NYSDEC. Class C streams are non-navigable and are not subject to an individual NYSDEC Article 15 Protection of Waters permit. Therefore no permit is required.

E. SUMMARY

Most of the reaches in this study are at an unstable state due to the heavy sediment supplies of the past and the related geomorphic adjustment. These channels are in different states of channel evolution and will recover if there are no time or spatial constraints. The geomorphic assessment and evaluation of channel evolution/departure is critical to understand before any remedial action should be suggested.

Remedial action has a number of priority levels. There is the option to do nothing and let the stream reach a stable form. The second option is to address areas only where the departure of the stream would produce a significant risk. The final option is a complete adjustment in the channel morphology by channel relocation, which is also called stream restoration. The remedial actions recommended from this study look at each reach and evaluate the benefit and cost of remedial actions that cover the three options.

In addition, there are some underlying management practices, some of which should be avoided and some of which should be put into practice.

Avoid:

Dredging: Dredging is a type of maintenance that is temporary. The source of the sediment should be addressed when possible instead of dredging.

Levees: Levees increase the ability of a stream to transport sediment, but streambed scour will result if the bed material or the sub-base material is mobile. A scoured streambed will result in a headcut and long flat stagnant water. These areas, sometimes called inlets, breed mosquitoes and other insects. If levees are required, use setback levees (see below).

Trash Dumping: When trash is dumped in a stream it does not go away.

Buffer Removal: Removal of trees in the buffer increases the rate of bank erosion.

Lawn buffers: Lawn grasses do not provide deep enough rooting depth for bank stability.

Homes and Buildings: Water can be very powerful. It is not safe to build a structure on a streambank or within the active floodplain.

Small Dams: Small dams can have a large impact on channel stability and create a risk to property. Dams should not be built on streams without proper permission from the State of New York.

Appropriate Practices:

Floodplain Relief Culverts: Culverts placed in addition to the main conveyance culvert at the floodplain elevation will reduce erosion and increase the integrity of the main culvert or bridge.

Stream Buffers: Stream buffers are ultimately what hold the stream banks together, provide function and habitat. Every stream should have woody buffer of non-invasive native trees of at least 25-50 ft wide.

Setback levees: If levees are required for flood protection they should be setback away from the top of the bank by a width equal to 0.5-1 times the width of the top of bank.

F. DEFINITIONS

Aggradations- a modification of the earth's surface in the direction of uniformity of grade by deposition

Alluvium- clay, silt, sand, gravel, or similar detrital material deposited by running water

Anthropogenic- caused by human activity

Bank erosion- the process in which individual soil particles of a stream bank are carried away as the stream channel moves

Bank erosion pins- steel bars that are driven into the river bank to measure erosion on the bank at a given location over time

Bank migration- the lateral movement of a river channel as it adjusts to balance erosion with deposition

Bankfull bench- a flat depositional area; the incised point of flooding

Buffer plantings- native vegetation that is planted in the buffer zone

Buffer zones- a strip of land area adjacent to a watercourse, used to separate agriculture or urban development from the watercourse

Channel evolutions- successional sequences of stream type change, morphological shifts with a tendency toward stable endpoints

Channel relocation- relocating a channel from its existing location

Chute cutoff- a channel that connects the converging areas of a meander bend

Geomorphic - The physical processes that relate to the formation of the relief features of the earth's surface.

Holocene terrace- a terrace formed in the present or post-Pleistocene geologic epoch

Head cut- any abrupt change in elevation in the stream channel

Incised reach- a reach that has downcut to such a degree that flow at a depth of 2 times the bankfull height cannot overtop the stream banks.

Left bank- a geomorphic term meaning the left top of bank looking downstream

Rain gardens- planted or stone covered bed specifically designed to receive stormwater and allow it to be slowly absorbed into the soil (infiltration)

Reach- a length of stream that is at least 20 times the bankfull width

Right bank- a geomorphic term meaning the right top of bank looking downstream

Riparian corridor-relating to or living or located on the bank of a natural watercourse (such as a river or stream)

Rip-rap- a foundation or sustaining wall of stones or chunks of concrete thrown together without order on an embankment slope to prevent erosion

Scour eddy- a current of water running contrary to the main current; especially a circular current causing the soil to be removed

Scour pool- a deep standing body of water found in a stream and caused by circular currents of water running contrary to the main current

Set back levee- an embankment constructed to prevent flooding that is positioned some distance from the edge of the river or channel. Setback levees allow wildlife habitat to develop between the levee and the river or stream

Shear stress- force per unit area acting parallel to a surface, in the case of stream flow it is the product of the density of water [ρ (M/L³)], the acceleration of gravity [g (L/T²)], the hydraulic radius associated with the flow [R (L)], and the average water surface slope [S (L/L)]

Soil conservation techniques- management of soil to prevent or reduce soil erosion and depletion by wind and water

Toe protection- protection used at the bottom of a slope to prevent erosion

Traverse bars- a sediment deposition feature that forms in a direction that diverts water to a cut stream bank

Wetlands- land or areas (such as marshes or swamps) that are covered often intermittently with shallow water or have soil saturated with moisture

Appendix A

Rock Cross Vane

Rock Cross Vane

Description

A Rock Cross-Vane is primarily used for grade control. This structure serves to maintain the integrity of the upstream riffle while promoting scouring in the downstream pool. The design shape is roughly that of the letter "U" with the apex located on the upstream side at the foot of the riffle. Footer boulders are placed in the channel bottom for stability. Header boulders are then placed on top of these footer boulders. Header boulders in the middle of the channel are at approximately the same depth as the riffle. On either side of the channel, wing boulders are placed at an angle to the stream bank, gradually inclining in elevation until they are located above the bankfull surface directly adjacent to the streambank. Water flowing downstream is forced over these boulders towards the middle of the channel on either side of the structure, effectively scouring out a pool below. Boulders placed at the apex hold back streambed material and prevent it from washing downstream.

Installation

A trench shall be dug in such a manner that the footer boulders, the cross header boulders and at least 1/3 of the wing boulders are buried beneath the bed surface elevation. Footer boulders shall be placed first with header boulders placed on top prior to any back filling of the trench. Boulders shall be selected and positioned such that they butt tightly together and there are multiple contact points between all boulders (flat smooth surfaces that fit together). Filter fabric shall be placed on the upstream side of structure to prevent the washout of sediment through boulder gaps. Filter fabric shall extend from bottom of footer boulder to finished grade elevation on the upstream side of the structure. Filter fabric shall be placed the entire length of the structure. Gaps between boulders shall be filled with No. 57 stone until plugged. In the center, or cross, portion of the channel, the header boulder shall be placed such that the top of the header boulder is at an elevation equal to the bed elevation. The header boulders in the side, or wing, portion shall be placed in such a manner as they slope up from bed elevation, at the cross portion, to the top of the bank at a 2 to 7 percent slope or as shown in detail. Header and footer boulders at both banks shall be tied in securely to the bank in such a way that eliminates the possibility of water diverting around them. A rock sill shall be utilized to further prevent water from cutting around the structure. The area between the streambank and both vanes on the upstream side of the structure will be backfilled with No. 57 stone.

Appendix B

Log Vane

Log Vane

Description

This structure serves to decrease stress in the near-bank region while promoting scouring in the downstream pool. Logs are placed at an angle to the stream bank, gradually inclining in elevation until they are located above the bankfull surface directly adjacent to the streambank. Water flowing downstream is forced over these logs towards the middle of the channel, effectively scouring out a pool below.

Installation

The header and footer logs shall be strapped together with strapping and its necessary materials as listed in the Materials section. Strapping shall be wrapped around the logs at two-foot intervals for the entire length of the structure. Strapping shall be taught with both logs.

A trench shall be dug in such a manner that the footer and header logs are buried beneath the bed surface elevation at least three feet on both ends.

Logs shall be tightly sealed with no gaps between the header and footer log. Filter fabric shall be placed on the upstream side of the structure and backfilled with materials as specified in detail to prevent the washout of sediment through log gaps. Filter fabric shall extend from the bottom of footer log to the finished grade elevation and shall be placed the entire length of the structure. A 12-inch diameter coir fiber log shall be placed the length of the vane arm directly behind where the header and footer log such as shown in the details in the plan sheets. The coir logs shall be nailed to the header and footer logs using 12-inch galvanized smooth spikes on 3 foot spacing. Header and footer logs shall be tied in securely to the bank in such a way that eliminates the possibility of water diverting around them.

LOG VANE

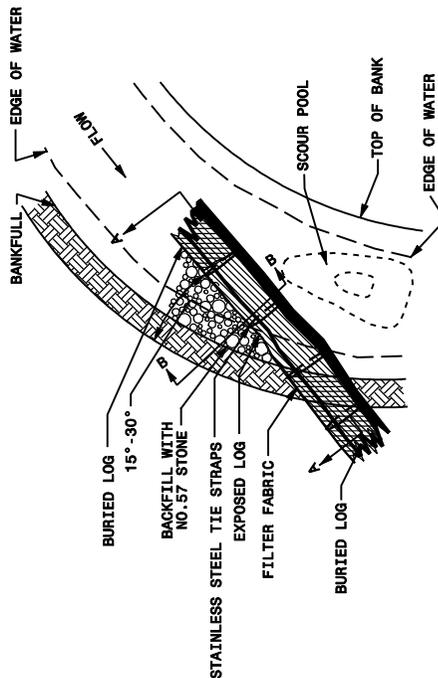
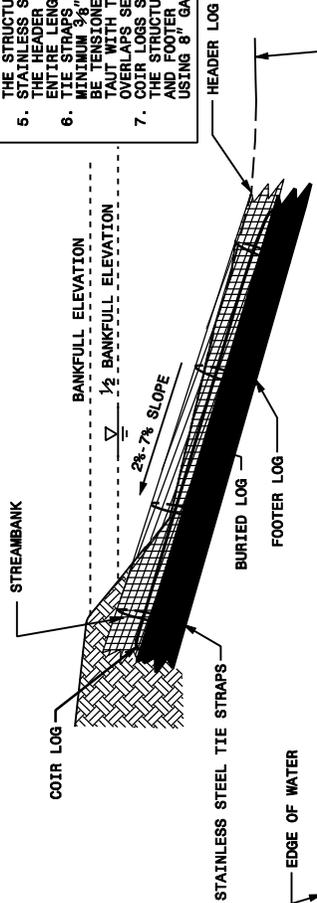
SCALE: NTS

VANE ARM LENGTH = 20'

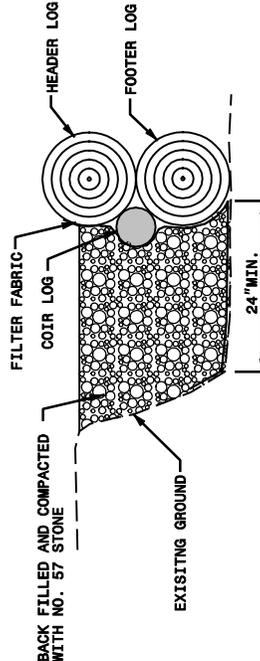
NOTE:

- LOG IS HARDWOOD MINIMUM DIAMETER OF 24" LOG IS BURIED MINIMUM OF 5 FT. ON BOTH ENDS.
- VANE ARM LENGTH IS THE LENGTH OF THE LOG EXPOSED

- FILTER FABRIC SHALL BE PLACED ON THE UPSTREAM SIDE OF THE STRUCTURE 1/4 DIAMETER FROM THE LOG.
- FILTER FABRIC SHALL BE NAILED ON 12 INCH CENTERS.
- FILTER FABRIC SHALL BE BACK FILLED WITH NO. 57 STONE TO PREVENT PIPING UNDER THE LOGS.
- FILTER FABRIC SHALL BE BURIED IN THE BOTTOM OF THE CHANNEL AND SHALL BE PLACED THE ENTIRE LENGTH OF THE STRUCTURE.
- STAINLESS STEEL TIE STRAPS SHALL BE WRAPPED AROUND THE HEADER AND FOOTER LOG AT 2' INTERVALS FOR THE ENTIRE LENGTH OF THE LOGS.
- TIE STRAPS SHALL BE STAINLESS STEEL WITH A MINIMUM 3/8" WIDTH, AND .015" THICK. STRAPPING SHALL BE TENSIONED WITH A PUSH BAR TENSOMETER (OR COMPARABLE) COVERING SEAM LOGS. REGIONS SHALL BE STRAPPED OVER LOGS SHALL BE 1/2 THE DIAMETER OF THE LOGS USED IN THE STRUCTURE. USE COIR LOG TO PLUG GAPS BETWEEN HEADER AND FOOTER LOG. MAIL COIR LOG TO HEADER AND FOOTER LOGS USING 8" GALVANIZED SMOOTH SPIKE ON 3' SPACING.



SECTION A-A



SECTION B-B

PLAN VIEW

Appendix C
Brush Mattress

Brush Mattress

Description

A brush mattress is a layer of live branches placed on a slope. Wood stakes and wire is used to anchor the material. The branches provide immediate protection against surface erosion. The live cuttings eventually root and provide permanent reinforcement. There are three (3) versions of the brush mattress that can be used: one anchored with just non-galvanized wire, one anchored with non-galvanized wire and coir fiber matting and one with non-galvanized wire and poultry netting.

Installation

- Collect and soak cuttings. Leave side branches intact.

- Excavate the bank to a slope of 2:1 or flatter. Maximum slope length is typically 10 feet. Excavate a 1 to 2 foot wide and 8 to 12 inches deep trench along the toe.

- Lay the cuttings perpendicular with the basal end in the trench and bud end upslope. The cuttings should overlap in a slight criss-cross pattern. The layer should be 6 to 12 inches thick.

- Drive stakes 1 to 3 foot into the ground. Use longer stakes in less cohesive soil. The tops of the stakes should extend above the top of the brush mattress. Space stakes a 3-foot by 3-foot grid. Live stakes may be mixed with the dead stout stakes or driven in alone.

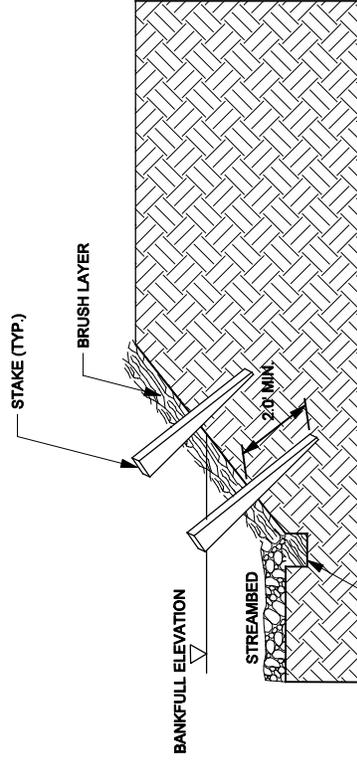
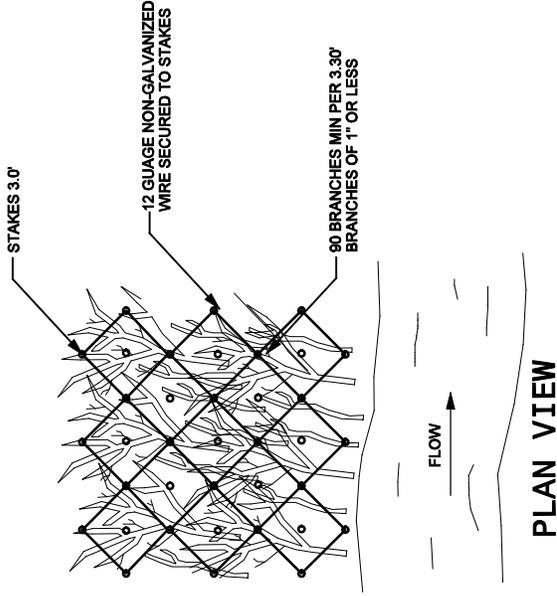
- Stand on the cuttings and secure them by tying the wire in a diamond pattern between the stakes. Place coir fiber matting or poultry netting were applicable.

- Backfill the trench with stone or suitable toe protection.

- Trim the terminal bud at the top of the bank so that the stem energy will be routed to the lateral buds for more rapid root and stem sprouting.

BRUSH MATTRESS

SCALE: NTS



- NOTES:
1. CREATE 12" DEEP TRENCH
 2. STAKE AND WIRE BRUSH LAYER INTO TRENCH
 3. BOARD FOR STAKE SHOULD BE 2" x 2" x 36"
- EXCAVATE AT TOE OF SLOPE
W= 1.5'
D= 1.0'
(BACK FILL WITH STONE)

CROSS SECTION

Appendix D

Rock Vane

Rock Vane

Description

This structure serves to decrease stress in the near-bank region while promoting scouring in the downstream pool. Footer boulders are placed in the channel bottom for stability. Header boulders are then placed on top of these footer boulders in the middle of the channel at approximately the same depth as the riffle. Boulders are placed at an angle to the stream bank, gradually inclining in elevation until they are located above the bankfull surface directly adjacent to the streambank. Water flowing downstream is forced over these boulders towards the middle of the channel, effectively scouring out a pool below.

Installation

A trench shall be dug in such a manner that the footer boulders and at least 1/3 of the header boulders are buried beneath the bed surface elevation. Footer boulders shall be placed first with header boulders placed on top prior to any back filling of the trench. Boulders shall be selected and positioned such that they butt tightly together and there are multiple contact points between all boulders (flat smooth surfaces that fit together). Filter fabric shall be placed on the upstream side of the structure to prevent the washout of sediment through boulder gaps. Filter fabric shall extend from the bottom of footer boulder to the finished grade elevation and shall be placed the entire length of the structure. Gaps between boulders shall be filled with No. 57 stone until plugged. In the center portion of the channel, the header boulder shall be placed such that the top of the header boulder is at an elevation equal to the bed elevation. The header boulders shall be placed in such a manner as they slope up from bed elevation to the top of the bank at a 2 to 7 percent slope. Header and footer boulders shall be tied in securely to the bank in such a way that eliminates the possibility of water diverting around them. A rock sill shall be utilized to further prevent water from cutting around the structure. Structures shall be built to the approval of the Owner or Owner's representative. The area between the streambank and the vane on the upstream side of the structure will be backfilled with No. 57 stone.

VANE ARM LENGTH = 20'

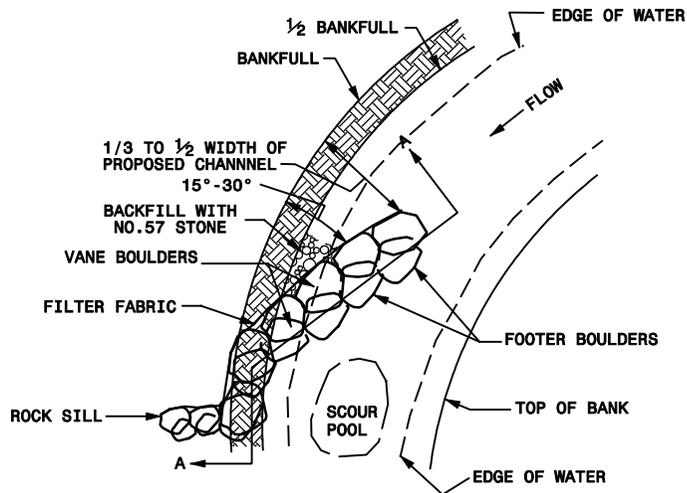
ROCK VANE

SCALE: NTS

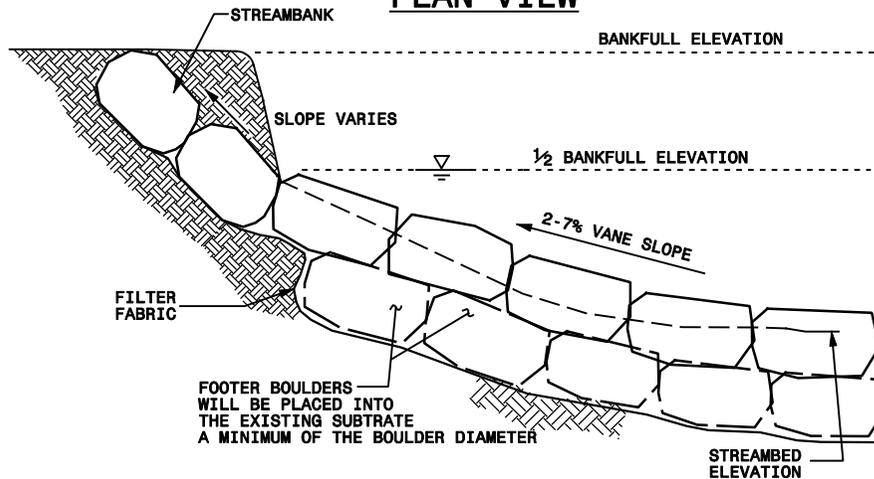
NOTES:

1. ALL STONES ARE TO BE STRUCTURE STONE.
2. GAPS BETWEEN BOULDERS SHALL BE MINIMIZED BY FITTING BOULDERS TOGETHER, PLUGGING WITH STRUCTURE STONE CLASS A AND NO.57 AND LINING WITH FILTER FABRIC.
3. DIMENSIONS AND SLOPES MAYBE ADJUSTED TO FIT BY THE ENGINEER.
4. A DOUBLE FOOTER BOULDER SHALL BE UTILIZED IN SAND BED MATERIAL.
5. CONTRACTOR WILL BE REQUIRED TO FIT BOULDERS TIGHTLY.
6. BOULDERS SHALL BE NATIVE STONE OR SHOT ROCK, CUBICAL OR RECTANGULAR IN NATURE.
7. VANE ARM SHALL TIE INTO THE BANK HALFWAY BETWEEN THE CHANNEL INVERT AND BANKFULL ELEVATIONS. THE ARM SHALL RISE AT 2-7% FROM THE CHANNEL INVERT AT AN ANGLE OF 15°-30° FROM THE ADJACENT TANGENT LINE. THE VANE ARM SHALL CONTINUE UP TO THE BANKFULL ELEVATION BUT THE ARM'S SLOPE MAY BE INCREASED TO GREATER THAN 7% AT THE DIRECTION OF THE DESIGNER. ADDITIONALLY, THE VANE ARM'S ANGLE OF DEPARTURE MAY BE ADJUSTED TO 90° TO THE FLOW DIRECTION AT THE DIRECTION OF THE DESIGNER.

FILTER FABRIC SHALL BE PLACED ON THE UPSTREAM SIDE OF THE STRUCTURE TO PREVENT WASHOUT OF SEDIMENT THROUGH BOULDER GAPS. FILTER FABRIC SHALL EXTEND FROM THE BOTTOM OF THE FOOTER BOULDER TO THE FINISHED GRADE ELEVATION AND SHALL BE PLACED THE ENTIRE LENGTH OF STRUCTURE.



PLAN VIEW



SECTION A-A

Appendix E

Live Stakes

Live Stakes

Description

The work covered by this section consists of furnishing, installing and maintaining Live Stakes as shown on the following sheet. Live stakes are live plant material used and installed in a stake-like fashion. The plants will eventually grow into larger shrubs/trees.

Materials

All plant material shall be harvested locally (within the same physiographic ecoregion and plant hardiness zone) or purchased from a local nursery, with the approval of a Planting Plan Designer. All Live Stakes shall be dormant at time of acquisition and planting. Live Stakes can be installed between November 15 and May 15. Live stakes shall be ½-1½ " (12-38 mm) in diameter. Stakes shall also be 2 - 4 feet (0.6 – 1.2 meter) in length.

During preparation, the basal ends of the Live Stakes shall be cleanly cut at an angle to facilitate easy insertion into the soil, while the tops shall be cut square or blunt for tamping. All limbs shall be removed from the sides of the live cutting prior to installation.

Installation

Cuttings for Live Stakes shall be harvested in manner such that they are cut, immediately put into water to be soaked for ten days, and then planted immediately after the ten days are completed. Cuttings shall remain wet until they are planted. Outside storage locations should be continually shaded and protected from wind and direct sunlight.

Live Stakes shall be tamped perpendicularly into the finished bank slope with a dead blow hammer, with buds oriented in an upward direction. Stakes should be tamped until approximately ¾ of the stake length is within the ground.

The area around each Live Stake shall be compacted by foot after the Live Stake has been installed.

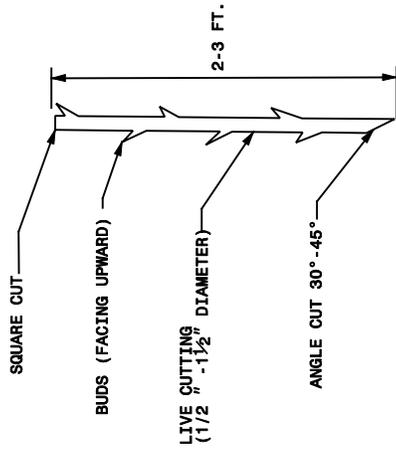
Stakes shall be spaced approximately 3 feet (0.91 meters) on center (4,840 stakes per acre). Live Stakes should be installed according to the configuration presented in the details of the plan sheets.

One to two inches shall be cut cleanly off of the top of each live stake (with loppers) at an angle of approximately 15 degrees following installation.

Any stakes that are split or damaged during installation shall be removed and replaced.

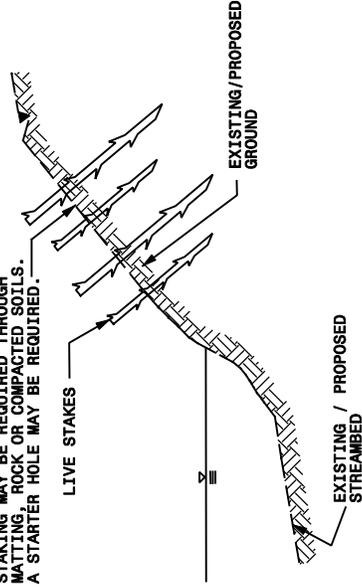
LIVE STAKE DETAIL

SCALE: NTS



LIVE STAKE

NOTE: STAKING MAY BE REQUIRED THROUGH MATTING, ROCK OR COMPACTED SOILS. A STARTER HOLE MAY BE REQUIRED.



- NOTE:
1. LIVE STAKES SHALL BE EVENLY SPACED 4 FT. APART.
 2. LIVE STAKES SHALL BE DRIVEN UNTIL APPROXIMATELY 3/4 OF LIVE STAKE IS WITHIN GROUND.
 3. IF STARTER HOLE IS NEEDED, MINIMIZE AIR POCKET.
 4. UTILIZE ALL ON SITE TRANSPLANT MATERIALS MADE AVAILABLE BY THE OWNER. ONCE SOURCE OF TRANSPLANT MATERIAL HAS BEEN HARVESTED, THEN UTILIZE LIVE STAKING.

BANK STABILIZATION WITH LIVE STAKES

Appendix F

Gabion Rock Wall

Gabion Rock Wall

Description

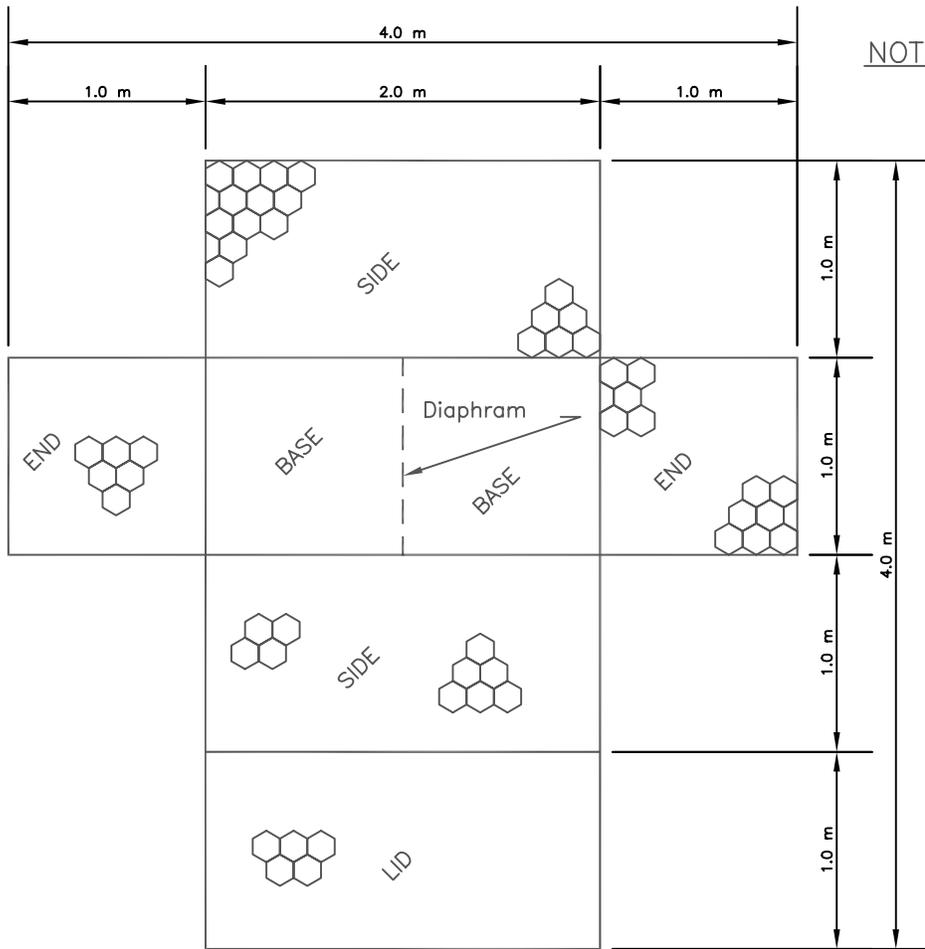
The work covered by this section consists of furnishing, installing and maintaining Gabion Rock Wall as shown on the following sheet. A gabion is a wire basket filled with rock.

Materials

Gabions shall be made of zinc coated steel wire shall be 2.9 mm diameter. The edges of the gabion shall be manufactured into securely connected selvages to prevent raveling. The perimeter wire shall be made of 3.8 mm galvanized wire. Riprap in gabion should be 230 mm to 330 mm.

Installation

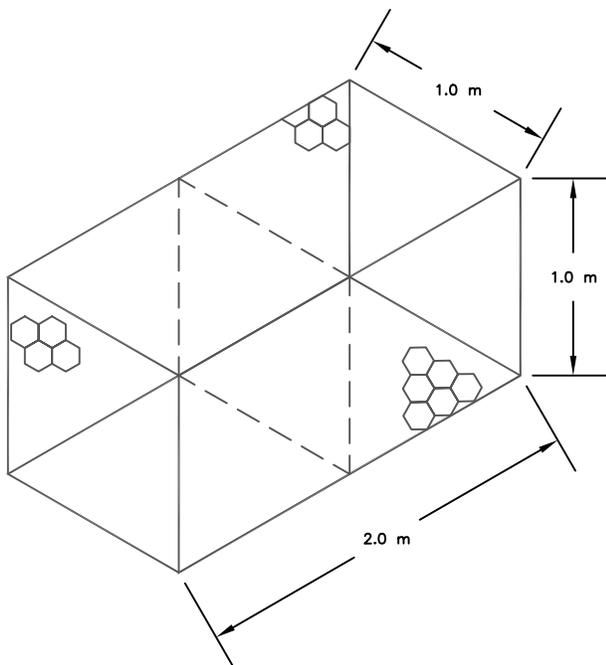
Gabion rock walls shall be installed on a graded level surface along the stream bank. The gabion can be held in place by its own weight, or anchored with duckbill anchors.



NOTES:

- 1.) Gabions shall be made of zinc coated steel wire, triple twisted, forming a uniform hexagonal mesh pattern of 80 x 100mm opening.
- 2.) Galvanized wire shall be 2.9mm diameter.
- 3.) Gabions shall be supplied folded flat to facilitate handling and transportation. They shall form rectangular baskets of specified sizes when constructed.
- 4.) When the gabion length exceeds its width, it shall be supplied with securely tied diaphragms connected to the base with material of the same composition as the gabion, to form individual cells of equal length and width.
- 5.) The edges of the gabion shall be manufactured into securely connected selvages to prevent ravelling.
- 6.) The selvaige or perimeter wire shall be made of 3.8mm galvanized wire.
- 7.) Tying and connecting wire of galvanized 2.1mm shall be supplied in the amount of not less than 8% (eight percent) of the weight of the basket.
- 8.) Zinc coating 0.26 kg/m².

GABION PLAN



ISOMETRIC

TYPE "A"

MUNICIPAL MASTER SPECIFICATIONS		
TYPE "A" GABION		
DRAWING #	SPEC. REFERENCE	DATE:
0510	02272	MARCH 1992

Appendix G
Bankfull Bench

Bankfull Bench

Description

The work covered by this section consists of, installing and maintaining Bankfull Bench as shown on the following sheet. Typically, a bankfull bench is a floodplain area constructed next to a stream.

Materials

Bankfull bench shall consist of Coir Fiber Matting, live stakes and 9" wooden stakes.

Installation

A bench will be graded at the designed bankfull elevation. The width of the bench shall be a minimum of one (1) bankfull width. The entire bench shall be covered with Coir Fiber Matting. The Coir Fiber Matting shall held in place with 9" wooden stakes. The entire bankfull bench area shall be planted with live stakes.

TYPICAL BANKFULL BENCH DETAIL

SCALE: NTS

